JAMESTOWN S'KLALLAM TRIBE
1033 Old Blyn Highway, Sequim, WA 98382 360/683-1109 FAX 360/681-4643

Jamestown S'Klallam Tribe Natural Resources Quality Assurance Project Plans (QAPPs)

Table of Contents

QUALITY ASSURANCE PROJECT PLAN

DUNGENESS DRIFT CELL PROTECTION & RESTORATION: RESEARCH AND PLANNING PHASE

Prepared for:

U.S. EPA
Puget Sound Partnership Grant
1200 Sixth Avenue
Seattle, WA 98101

Prepared by:

Jamestown S'Klallam Tribe
1033 Old Blyn Highway
Sequim, WA 98382

March 2009

APPROVAL PAGE

Quality Assurance Project Plan
for

U.S. EPA's Puget Sound Partnership Grant
Dungeness Drift Cell Protection & Restoration:
Research and Monitoring Phase

March 2009

Byron Rot, JSKT Habitat Manager	Date
Randy Johnson, JSKT Grant Project Technical Lead	Date
Shawn Hines, JSKT Grant Project Manager	Date
Michael Rylko, U.S. EPA Grant Project Manager	Date
Ginna Grepo-Grove, U.S. EPA Regional QA Manager	Date

A.2 TABLE OF CONTENTS

A.3 DISTRIBUTION LIST

Name	Organization/Address	Phone	Fax	E-mail Address
Michael Rylko	USEPA 1200 6th Ave Ste 900 Seattle, WA 98101	(206) 553-4014	(206) 553-0124	Rylko.michael@epa.gov
Ginna Grepo-Grove	USEPA 1200 6th Ave Ste 900 Seattle, WA 98101	(206) 553-1632	(206) 553-8210	Grepo-Grove.gina@epa.gov
Dietrich Schmitt	NWIFC 6730 Martin Way E Olympia, WA 98516	(360) 438-1180	(360) 753-8659	dscmitt@nwifc.org
Shawn Hines	JSKT 1033 Old Blyn Hwy. Sequim, WA 98382	(360) 681-4664	(360) 681-4611	shines@jamestowntribe.org
Randy Johnson	JSKT 1033 Old Blyn Hwy. Sequim, WA 98382	(360) 681-4631	(360) 681-4611	rjohnson@jamestowntribe.org

A.4 Project/Task Organization

This initial phase of protecting and restoring the Dungeness Drift Cell includes analysis of contemporary rates of bluff erosion within the drift cell and development of a subsequent drift cell/feeder bluff protection strategy. The strategy will include a prioritization of land parcels for protection along with a roadmap for future phases of the project. Graphic and written outreach materials will also be developed and distributed and/or presented.

The organizations involved in this project are:

Jamestown S'Klallam Tribe (JSKT or Tribe): The JSKT Technical Lead for the project is Randy Johnson, Restoration Planner for the Tribe. Mr. Johnson shall be responsible for the overall management and oversight of the measurement and interpretation of the bluff retreat within the Dungeness Drift Cell. He will also be the lead in developing and implementing this QAPP. The JSKT Grant Project Manager is Shawn Hines, Watershed Planner for the Tribe. Ms. Hines shall assist in QAPP development and be responsible for submission of the QAPP to EPA for review and approval. She will also provide assistance in preparation and submittal of grant reports and deliverables to EPA. Ms. Hines will also be the main contact for EPA or NWIFC requests, and ensuring the project proceeds in a timely manner and within the approved budget.

U.S. Environmental Protection Agency: The U.S. EPA Project Manager shall be Mr. Michael Rylko. Mr. Rylko shall be responsible for the oversight of the project and shall ensure that the goals and objectives of the projects are achieved. He shall review and approve the QAPP and subsequent addendums or amendments submitted to EPA. He shall ensure that project deliverables are complete and of necessary quality and that the project completion dates are met.

Mr. Rylko shall interface with the Puget Sound Partnership and U.S. EPA counterparts regarding the status of the approved project.

Northwest Indian Fisheries Commission (NWIFC): The NWIFC Project Managers are Terry Wright and Dietrich Schmitt. NWIFC shall administer the EPA-sponsored grant sub-award and shall provide technical assistance to Jamestown S'Klallam Tribe.

Other Entities: Although participation by resource collaborators and stakeholders in planning meetings is highly desirable, the Dungeness Drift Cell Protection & Restoration: Research and Planning Phase may proceed independent of any other entity, permit, or other funding source.

A.5 Problem Definition/Background

Problem Statement

Dungeness Bay provides approximately 5,200 acres of critical spit and estuarine habitat for a large variety of forage fish, waterfowl, shorebirds, wading birds, marine and freshwater mammals, crustaceans, shellfish and salmonids, including Puget Sound Chinook, Puget Sound steelhead, bull trout, Hood Canal/Strait of Juan de Fuca chum, and pink salmon. Dungeness Bay is wholly created by the fragile 5-mile long Dungeness Spit, a nationally recognized habitat feature, which in turn is entirely a product of massive sediment recruitment originating primarily from the approximately eight miles of continuous feeder bluffs to the west.

Although no shoreline armoring in the project area has occurred to date, existing regulations do not provide protection from the potential armoring anticipated as a result of current and future developments in upland areas adjacent to the Dungeness Drift Cell. Shoreline armoring is known to cause extensive spit erosion and loss of sediment recruitment from the feeder bluffs. Both phenomenon would significantly imperil the Dungeness Drift Cell and threaten the existence of Dungeness Spit and Dungeness Bay. Loss of the Dungeness Spit and Bay would be a catastrophic impact to the regional marine ecosystem (Gibboney, 2008). A recent study further documents the important function of the fragile Dungeness feeder bluffs and the need to preserve the bluffs and prevent shoreline modifications that disrupt sediment transport (Nabors, et. al., 2008).

The proposal represents the Research and Planning Phase of restoring and protecting the Dungeness Drift Cell and feeder bluffs. Future phases include purchase of conservation easements and fee-simple land parcels, feeder bluff buffer restoration via the relocation or decommission of buildings and infrastructure, and additional public outreach. Additional information on limiting factors addressed; relevant fish, salmonid stock, and habitat status; and, ecosystem restoration and project phasing is included in the NOPLE 2008 Three Year Workplan (Gibboney, 2008).

Objectives

Objectives of this Research and Planning Phase of Dungeness Drift Cell Protection & Restoration are:

- to develop a drift cell/feeder bluff protection strategy document for long-term protection and restoration of the Dungeness Drift Cell ecosystem, including the Dungeness Spit and Bay; and,
- to develop high quality graphic and written public outreach materials that emphasize the need for feeder bluff conservation and buffer restoration, and provide related conservation information targeted at property owners along the feeder bluff.

In order to accomplish the above objectives, contemporary feeder bluff erosion rates must be obtained.

Goals of the Puget Sound Partnership

The overall project is addressed in the Puget Sound Partnership's 2010 Action Agenda for Puget Sound. It corresponds to the Puget Sound-wide Strategic Priorities A (*Protect the intact ecosystem processes, structures, and functions that sustain Puget Sound*) and B (*Restore the ecosystem processes, structures, and functions that sustain Puget Sound*); and Primary Objectives A.2 (*Permanently protect the significant intact areas of the Puget Sound ecosystem that still function well*), A.4 (*Support long-term protection and stewardship of working farms, forests, and aquatic lands to help maintain ecosystem functions, sustained quality of life, and improved viability of rural communities*), and B.1 (*Implement and maintain priority ecosystem restoration projects for marine, marine nearshore, estuary, freshwater riparian and uplands*). The project also corresponds to No. 1 under Near-term Action B.1 (*Implement restoration projects in the salmon recovery three-year work plans and the Estuary and Salmon Restoration Program of the Nearshore Partnership*).

Strait of Juan de Fuca Action Area – High Priority Action

The overall project is listed as a Key Initial Strategic Priority (No. 9) for the Strait of Juan de Fuca Action Area (Draft 10/10/08): *Implement Protection Actions within Key Action Area Work Plans – "(a) Lead entity for salmon recovery, 3-year work plans developed by the North Olympic Peninsula…Lead Entity"*. The overall project is a part of the North Olympic Peninsula Lead Entity's salmon recovery three-year workplan for WRIA 18. Within that workplan, the overall project ranked No. 8 of 35 habitat capital projects in 2008. Six of those top eight projects are currently receiving some level of funding, making this proposal an excellent candidate for early action.

Project Location

The Dungeness Drift Cell is located along the marine shoreline of the North Olympic Peninsula and extends from Morse Creek east to the base of Dungeness Spit in Sequim, Washington (Strait of Juan de Fuca Action Area). Figure 1 highlights the regional location of the project, and Figure 2 shows the boundaries of the Dungeness Drift Cell.

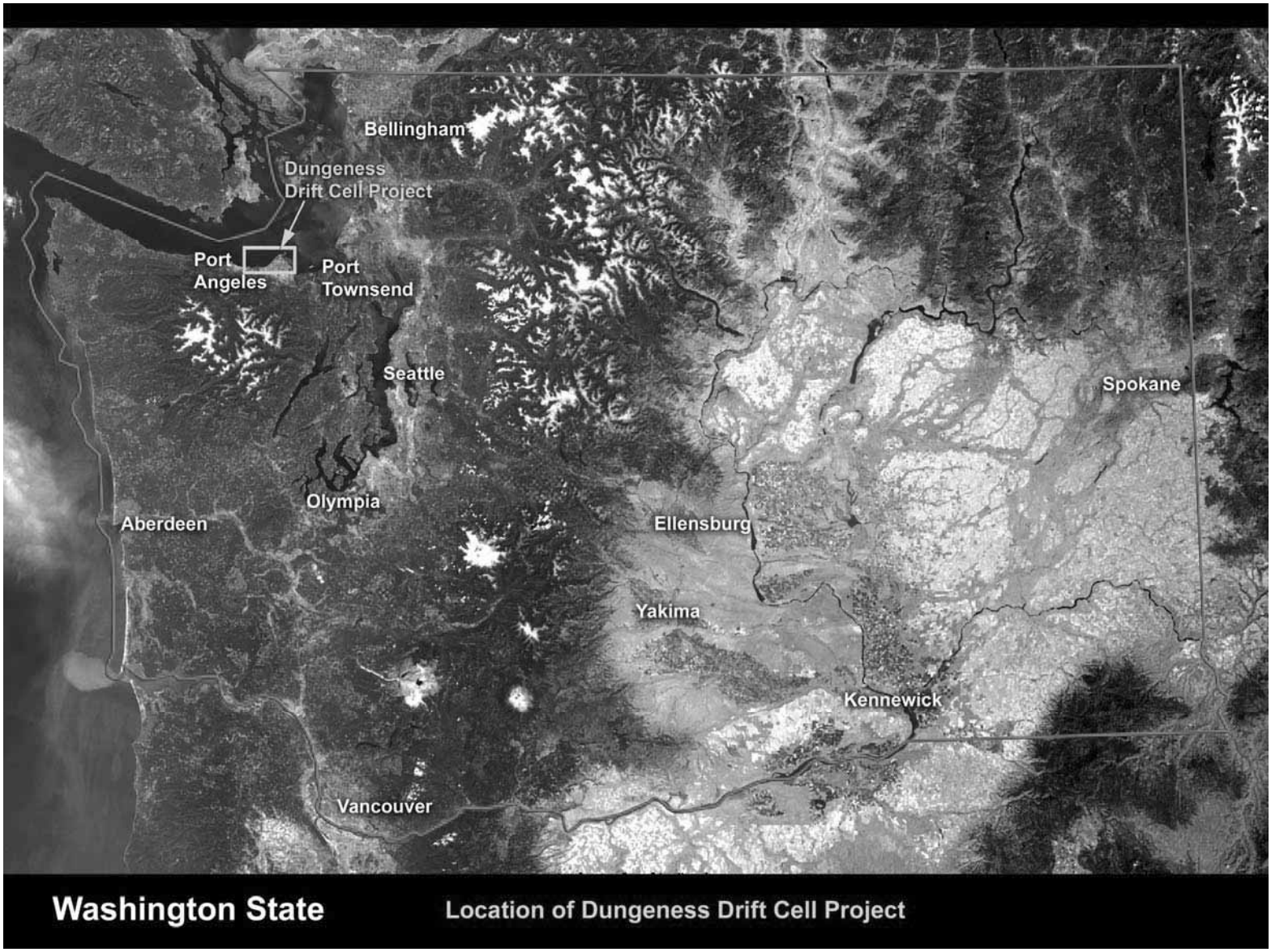


Figure 1: Project Location

Figure 2: Dungeness Drift Cell

Geographic setting (modified from Battelle Marine Sciences Laboratory, November 2005)

The Dungeness River, located in the northeast corner of the Olympic Peninsula of Washington State, is the major freshwater tributary to Dungeness Bay. The 32 mile long river drains 172,517 acres from it's headwaters in the Olympic National Park (Clark and Clark, 1996). The lower 10 to 13-mile stretch flows north primarily through private land in the Sequim-Dungeness Valley and empties into Dungeness Bay and the Strait of Juan de Fuca. Land uses in the Sequim-Dungeness valley includes residential, commercial, and agricultural, with residential use becoming more prevalent. Over 40% of homes in the area are located on or near a water body (e.g. Dungeness Bay, Dungeness River, Strait of Juan de Fuca, wetlands, creeks, and irrigation ditches) (Clean Water Workgroup, 2002). Precipitation varies from 15 inches annually near Sequim to 80 inches annually in the headwaters of the Dungeness River. To add to the complexity, the Dungeness watershed contains an extensive irrigation system (approximately 173 miles of canals and laterals). As of 2003, 118 miles were open and 54 miles were piped (HDR/EES, 2005).

A.6 Project/Task Description

Project Overview

This initial phase of protecting and restoring the Dungeness Drift Cell includes analysis of contemporary rates of bluff erosion within the drift cell and development of a subsequent drift cell/feeder bluff protection strategy. The strategy will include a prioritization of land parcels for protection along with a roadmap for future phases of the project. Graphic and written outreach materials will also be developed and distributed and/or presented. The project will involve the three tasks described below:

Task 1: Determine contemporary erosion rates of the feeder bluffs along the entire drift cell (to establish technical basis for prioritizing land parcels for protection).

(a) If necessary, prepare Quality Assurance Project Plan (QAPP) and Quality Management Plan to be approved by EPA.
(b) Obtain, scan, georectify, and color-correct six sets (years 1957, 2008, and four years in-between) of orthophotos that span the entire drift cell.
(c) Based on the above photogrammetry, calculate contemporary feeder bluff erosion rates along the entire drift cell.
(d) Prepare GIS shape files depicting (i) contemporary feeder bluff erosion rates along the entire drift cell and (ii) buffer widths required to ensure uninterrupted bluff erosion and sediment recruitment into the drift cell for 100-, 200-, and 500-year timeframes.
(e) Produce technical report on contemporary rates of feeder bluff erosion and buffer widths required to protect the Dungeness Drift Cell and associated feeder bluffs.

Task 2: Produce Dungeness Drift Cell Protection Strategy.

(a) Form resource collaborator group and convene planning meetings.
(b) Utilizing the work products from Task 1, assign parcels for protection along the feeder bluff and drift cell to one of the following categories: (i) purchase of perpetual conservation

easement, (ii) purchase of fee-simple property, or (iii) restoration of buffer (relocation or decommissioning of structures and infrastructure).

(c) Based on the above categories, prioritize land parcels for protection along the feeder bluff and drift cell.

(d) Develop high quality maps and graphics depicting parcel locations and prioritization.

(e) Prepare Dungeness Drift Cell Protection Strategy document for permanent protection of the Dungeness Drift Cell and associated feeder bluffs.

Task 3: Develop public outreach materials targeting feeder bluff property owners.

(a) Produce written and graphic outreach materials, including a high quality PowerPoint presentation, that: (i) describe the technical basis for recommended conservation and buffer restoration measures; (ii) address the need for feeder bluff conservation and buffer restoration; and, (iii) provide information on conservation easements, fee-simple purchases, and building and infrastructure relocations.

(b) Distribute and/or present outreach materials to feeder bluff and shoreline landowners and other interested parties.

Project Schedule

The project schedule is summarized below:

Dungeness Drift Cell Protection & Restoration: Research and Planning Phase	**Year 2009**				**Year 2010**		
	Jan-Mar	**Apr-Jun**	**Jul-Sep**	**Oct-Dec**	**Jan-Mar**	**Apr-Jun**	**Jul-Sep**
Task 1*: *Prepare quality assurance document(s) if necessary. Determine contemporary erosion rates of the feeder bluffs along the entire drift cell.	✓	✓	✓				
Task 2*: *Produce Dungeness Drift Cell Protection Strategy.				✓	✓	✓	
Task 3*: *Develop public outreach materials targeting feeder bluff property owners.							✓

A.7 Quality Objectives and Criteria for Measurement Data

Quality objectives for measuring bluff erosion rates from aerial photography may be expressed in terms of the accuracy of distance measurements between objects on aerial photographs. The decision to use the technique of partially georectifying aerial photos to determine bluff erosion rates was based on information described by Cheryl J. Hapke, author of topical issue paper, *The Measurement and Interpretation of Coastal Bluff Retreat*, within USGS's Professional Paper No. 1693 (2004, USGS) (Please see Appendix 1). Table 1 was excerpted from the topical issue paper within the Professional Paper, and indicates that, among other advantages, partially rectified aerial photos provide higher accuracy than ground surveys, historical maps, and unrectified aerial photos, in terms of measuring distances of objects on the aerial photograph. For the purpose of

estimating bluff erosion rates and providing recommendations for prioritizing land parcels for protection within the Dungeness Drift Cell, use of partially rectified aerial photos is appropriate.

Table 1. Advantages and disadvantages of measurement techniques commonly used in coastal cliff and bluff erosion studies.

Technique	Advantages	Disadvantages
Ground Surveys	Very Accurate Easily repeatable	Poor temporal and spatial coverage Time consuming (and therefore expensive)
Historical maps	Inexpensive Widely available Very long temporal coverage (1850's – 1979's) Good spatial coverage	Low accuracy Ambiguous cliff/bluff edge position
Aerial photographs		
Unrectified	Inexpensive Widely available Good temporal coverage (1920's – present) Good spatial coverage	Low accuracy Ambiguous cliff/bluff position in 2D
Rectified		
Partially	Widely available Good temporal coverage (1920's – present) Good spatial coverage Improved accuracy over unrectified	Ambiguous cliff/bluff position in 2D Hardware/software for processing may be expensive
Fully	Widely available Good temporal coverage (1920's – present) Good spacial coverage Very high accuracy Cliff/bluff edge can be digitized in 3D	Processing time consuming Required software expensive
Lidar	Good spacial coverage Very high accuracy	Expensive Poor temporal coverage Cliff edge may not be captured in data

A.8 Special Training Needs/Certification

The project will be conducted by the Tribe's Restoration Planner, a distinguished fisheries biologist with over 30 years of experience in his field. He also has over 10 years of experience in working with GIS and photogrammetry. The Restoration Planner is acutely familiar with the geographic region being studied and capable of employing the techniques necessary to carry out the project. No special training or certification is needed.

A.9 Documents and Records

Availability and retention of records

All records that remain the responsibility of the Jamestown S'Klallam Tribe will be kept either in hard copy or electronically at the Jamestown S'Klallam Tribe administrative offices for the length of time stipulated in the contract. This will include all data and reports associated with the project. The administrative office is located in Blyn, Washington and is maintained according to a policy of limited access. The Jamestown S'Klallam Tribe's Watershed Planner or Restoration Planner is responsible for archiving and retrieving related project materials.

Records that will be maintained in electronic or hardcopy form include:

- Quality Assurance Project Plan
- Measured and calculated data
- GIS shape files
- Maps and graphics developed
- Orthophotography
- Outreach material developed
- Documentation of problems associated with any of the project tasks
- Technical reports
- Final report

Quality Assurance Project Plan:

The final version of the QAPP will be available from Shawn Hines of the Jamestown S'Klallam Tribe. This QAPP will be distributed to those listed in Section A.3 Distribution List. The QAPP will be reviewed periodically and a determination made to either modify the document based on new or modified project requirements, or to leave as is.

B.1 Sampling Process Design

Calculating Bluff Erosion Rates

Bluff erosion rates will be calculated by comparing the location of the bluff edge during various target years represented in the high resolution, georectified orthophoto record. The earliest year represented (1957) and the most recent year represented (2008) are the most important target years for which bluff-edge locations will be determined. Average erosion rates will be calculated based primarily upon the amount of bluff retreat occurring during this 1957 to 2008 time period. Bluff edge locations for the four interval years of examination, spaced approximately every 8 to 12 years, will be used to (a) understand the episodic nature of bluff erosion, and (b) to calculate erosion rates in locations where these interval years provide significant high precision (defined below) segments not found in either/or 1957 and 2008 data sets.

Measurements for each target year will be performed as follows:

1. The top bluff edge of the feeder bluff system will be precisely mapped using digitized high resolution orthophotos (1957, 2008, and four years in-between) in a GIS application.
2. The accuracy of the bluff-edge determination will be differentiated into one of two precision levels: high precision (edge of bluff is observable to within 1 meter) and low precision (edge of bluff is not observable to within 1 meter).
3. Erosion measurements (comparisons of bluff edges between target years) will be made where high precision bluff-edge segments from different target years overlap.
   a. Erosion measurements will be made at both ends (east and west) of each overlapping high precision segment and at 30-meter intervals in-between the segment ends.
   b. Measurements will be made perpendicular to the bluff face and will be recorded to the nearest 0.1 meter.

B.2 Sampling Methods

The project does not involve field sample collection.

B.3 Sample Handling and Custody

The project does not involve field sample collection or handling.

B.4 Analytical Methods

The project does not involve laboratory analysis.

B.5 Quality Control Requirements

Orthophotos will be scanned with a graphic arts quality (2400 dpi) flatbed scanner. Scan resolution will be a minimum of 800 pixels per inch (PPI). All digitized orthophotos will be georeferenced to a common data set, the USDA Farm Service Agency National Agriculture Imagery Program (NAIP) 1-meter ground sample distance (GSD) 2006 data set.

Requirements for accuracy and precision of bluff measurements are described above in Section B.1 Sampling Process Design.

B.6 Instrument/Equipment Testing

No instrument/equipment requires testing.

B.7 Instrument/Equipment Calibration

No instrument/equipment requires calibration.

B.8 Inspection/Acceptance of Supplies and Consumables

Supplies, including publication costs, used in this study will be purchased directly by the Jamestown S'Klallam Tribe. Records will be kept of all supply purchases and/or services.

B.9 Non-direct Measurements

GIS data layers of property ownership/parcel boundaries (for use in Task 2) will be obtained from Clallam County, the official repository of this data set. Orthophotos will be obtained from county, state, tribal, and federal sources only.

B.10 Data Management

The primary datasets that will be generated are: (1) Georectified orthophoto coverages (multiple years) of the Dungeness Drift Cell feeder bluffs and, (2) GIS shape files depicting the location of the bluff edges and aerial extent of erosion during the time intervals represented by the photo sets. Data will be stored on a PC and will be backed up on a daily basis. Hard copies will be stored with other permanent records.

C.1 Assessments and Response

Shawn Hines, the Tribe's Watershed Planner and Grant Project Manager, will monitor project progress through regular communication with Randy Johnson, the Tribe's Restoration Planner and Grant Project Technical Lead. Any problem findings will be discussed with the NWIFC Grant Project Manager(s) and the EPA Grant Project Manager, and actions taken based on best professional judgment.

C.2 Reports to Management

Written and personal communications regarding project status and QA concerns will occur on a regular basis between Shawn Hines (Jamestown S'Klallam Tribe), Dietrich Schmitt and/or Terry Wright (Northwest Indian Fisheries Commission) and Michael Rylko and/or Ginna Grepo-Grove (EPA). Project status and QA concerns will be documented in writing at least quarterly for inclusion in reporting to EPA. Problems encountered will be discussed with the parties above as necessary and appropriate actions taken. A summary of such encounters will be submitted as part of a final report (as appropriate) to assist readers in interpretation of the results.

D.1 Data Review, Verification, and Validation

The data collected for this project will be reviewed by technical personnel with familiarity in the methods being employed. Data review, verification and validation will occur at the Jamestown S'Klallam Tribe.

D.2 Verification and Validation Methods

The project does not involve sample collection.

D.3 Reconciliation with User Requirements

The Drift Cell bluff erosion rate results will be reported in written format and in presentations and/or outreach materials where appropriate that is suitable for both technical and non-technical audiences. Limitations of the use of this data will be discussed as part of any presentation or written report. The project will be deemed successful when tasks and deliverables described in the workplan are completed per the QAPP and submitted and approved by EPA.

REFERENCES

Battelle Marine Sciences Laboratory. 2005. Quality Assurance Project Plan, EPA Targeted Watershed Grants Program, Dungeness River and Estuary, Task 1: Microbial Source Tracking. November 2005. 23 pages. Sequim, Washington.

Clark, W. and Clark, V. 1996. Keys to and Understanding of the Natural History of the Dungeness River System, Sequim Washington. Prepared for the Jamestown S'Klallam Tribe.

Clean Water Workgroup. 2002. Clean Water Strategy for addressing bacterial pollution in Dungeness Bay and Watershed. Clallam County, Washington.

Gibboney, S. and Pearson, W. 2008. North Olympic Peninsula Lead Entity. Three Year Workplan Narrative 2008. ISE Consultants, Port Townsend, Washington and Peapod Research, Port Angeles, Washington.

Hapke, Cheryl J. The Measurement and Interpretation of Coastal Cliff and Bluff Retreat. U.S. Geological Survey Pacific Science Center. Santa Cruz, California. Included in U.S. Geological Survey Professional Paper 1693. 2004.

HDR/EES. 2005. Comprehensive Irrigation District Management Plan for the Dungeness River Agricultural Water Users Association. Working Draft. Olympia, Washington. Prepared for the Dungeness River Agricultural Water Users Association.

Nabors , Tiffany, A. Shaffer, T. Ritchie, D. Penttila, and Dave Parks. Nearshore central strait of juan de fuca, including the Elwha and Dungeness drift cells, habitat form and function for forage fish spawning. 2008. Western Washington University; Washington Department of Fish and Wildlife; Washington Department of Natural Resources.

Puget Sound Partnership. 2008. Puget Sound Action Agenda: Protecting and Restoring the Puget Sound Ecosystem by 2020. Olympia, Washington.

U.S. Geological Survey. 2004. Formation, Evolution, and Stability of Coastal Cliffs – Status and Trends. Professional Paper 1693. Denver, Colorado.

APPENDIX 1

U.S. Geological Survey. 2004. Formation, Evolution, and Stability of Coastal Cliffs – Status and Trends. Professional Paper 1693. Denver, Colorado.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, WA 98101

November 25, 2013

Reply to
Attn of: **OEA-095**

MEMORANDUM

SUBJECT: Review the revision of Sequim Bay Drift Cell Protection & Restoration Quality Assurance Project Plan (QAPP), prepared by Jamestown S'Klallam Tribe, under Puget Sound Partnership Grant (Agreement Number NWIFC #11-PSP402), for Northwest Indian Fish Commission and USEPA, September, 2013

FROM: Raymond Wu, QA Chemist 11/25/13
Environmental Services Unit, Office of Environmental Assessment (OEA-095)
USEPA Region 10

TO: Lisa Chang, Puget Sound Grant Coordinator
ETPA Immediate Office, Office of Ecosystems Tribal and Public Affairs (ETPA-087)
USEPA Region 10

CC: Tiffany Waters, Puget Sound Recovery Project Coordinator

The review of the above referenced document has been completed. The QAPP was prepared by Jamestown S'Klallam Tribe, following the content and format requirements of the EPA QA-R5 document "*EPA Requirements for Quality Assurance Project Plans", March 2001.* The QAPP is now recommended.

If you have any questions, please email me at wu.raymond@epa.gov or call me at (206) 553-1413. Thanks.

QUALITY ASSURANCE PROJECT PLAN

SEQUIM BAY DRIFT CELL PROTECTION & RESTORATION: RESEARCH PHASE

Prepared for:

Northwest Indian Fish Commission
6730 Martin Way E
Olympia, WA 98516

And

U.S. EPA
Puget Sound Partnership Grant
1200 Sixth Avenue
Seattle, WA 98101

Prepared by:

Jamestown S'Klallam Tribe
1033 Old Blyn Highway
Sequim, WA 98382

Under Agreement number NWIFC #11-PSP402

September 2013

APPROVAL PAGE

Quality Assurance Project Plan
for

Sequim Bay Drift Cell Protection & Restoration:
Research Phase

Randy Johnson, JST Habitat Program Manager	Date
Robert Knapp, JST Grant Project Technical Lead	Date
Hansi Hals, JST Grant Project Manager	Date
Tiffany Waters, Puget Sound Recovery Project Coordinator, NWIFC	Date
Lisa Chang, USEPA Puget Sound Grant Coordinator	Date
Ginna Grepo-Grove, USEPA Region 10 QA Manager	Date

A.2 TABLE OF CONTENTS

A.3 DISTRIBUTION LIST

Name	Organization/Address	Phone	Fax	E-mail Address
Lisa Chang	USEPA 1200 6th Ave Ste 900 Seattle, WA 98101	206-553-0226	(206) 553-8210	Chang.Lisa@epamail.epa.gov
Ginna Grepo-Grove	USEPA 1200 6th Ave Ste 900 Seattle, WA 98101	(206) 553-1632	(206) 553-8210	Grepo-Grove.Gina@epamail.epa.gov
Tiffany Waters	NWIFC 6730 Martin Way E Olympia, WA 98516	(360) 528-4318	(360) 753-8659	twaters@nwifc.org
Hansi Hals	JST 1033 Old Blyn Hwy. Sequim, WA 98382	(360) 681-4601	(360) 681-4611	hhals@jamestowntribe.org
Randy Johnson	JST 1033 Old Blyn Hwy. Sequim, WA 98382	(360) 681-4631	(360) 681-4611	rjohnson@jamestowntribe.org
Robert Knapp	JST 1033 Old Blyn Hwy. Sequim, WA 98382	(360) 681-4666	(360) 681-4611	rknapp@jamestowntribe.org

A.4 Project/Task Organization

This initial phase of protecting and restoring the Sequim Bay Drift Cell sediment sources includes analysis of contemporary rates of bluff erosion within the drift cells. Addition phases may include the development of drift cell/feeder bluff protection strategies and outreach materials. These strategies will include a prioritization of land parcels for protection along with a roadmap for future phases of the project.

The organizations involved in this project are:

Jamestown S'Klallam Tribe (JSKT or Tribe): The JSKT Technical Lead for the project is Robert Knapp, Restoration Planner for the Tribe. Mr. Knapp shall be responsible for the overall management and oversight of the measurement and interpretation of the bluff retreat within the Sequim Bay Drift Cells. He will also be the lead in developing and implementing this QAPP. Randy Johnson will supervise the project and provide technical expertise. He is the Tribe's Habitat Program Manager. The JSKT Grant Project Manager is Hansi Hals, Watershed Planner for the Tribe. Ms. Hals shall assist in QAPP development and be responsible for submission of the QAPP to EPA for review and approval. She will also provide assistance in preparation and submittal of grant reports and deliverables to EPA. Ms. Hals will also be the main contact for EPA or NWIFC requests, and ensuring the project proceeds in a timely manner and within the approved budget.

U.S. Environmental Protection Agency: The US EPA Puget Sound Grant Coordinator Lisa Chang. Ms. Chang shall be responsible for the oversight of the project and shall ensure that the goals and objectives of the projects are achieved. She shall review and approve the QAPP and subsequent addendums or amendments submitted to EPA. She shall ensure that project deliverables are complete and of necessary quality and that the project completion dates are met. Ms. Chang shall interface with the Puget Sound Partnership and US EPA counterparts regarding the status of the approved project.

Northwest Indian Fisheries Commission (NWIFC): The NWIFC Puget Sound Recovery Project Coordinator shall be Tiffany Waters. She shall administer the EPA-sponsored grant sub-award and shall provide technical assistance to Jamestown S'Klallam Tribe.

Other Entities: Although participation by resource collaborators and stakeholders in future planning meetings is highly desirable, the Sequim Bay Drift Cell Protection & Restoration: Research Phase may proceed independent of any other entity, permit, or other funding source.

A.5 Problem Definition/Background

Problem Statement

Sequim Bay provides approximately 3,500 acres of critical spit and estuarine habitat for a large variety of forage fish, waterfowl, shorebirds, wading birds, marine and freshwater mammals, crustaceans, shellfish and salmonids, including Puget Sound Chinook, Puget Sound steelhead, bull trout, Hood Canal/Strait of Juan de Fuca chum, and pink salmon. This critical habitat is created by a unique arrangement of spits, estuaries, and embayments, which are maintained by sediment recruitment originating primarily from 10.5 miles of feeder bluff and other critical shoreline sediment sources. Gibson, Travis, South, Chicken Coop, and Paradise Cove spits and their associated sediment sources are the focus of this study. Protection of the 10.5 miles of sediment sources plus over 25,000 feet of spit shoreline is critical to long-term protection of the habitat in Sequim Bay.

Over 2.6 miles of shoreline armoring has already occurred in the project area and existing regulations do not provide protection from future armoring of the Sequim Bay Drift Cells. Shoreline armoring is known to cause extensive spit erosion and loss of sediment recruitment from feeder bluffs and other sediment sources. Both spit erosion and loss of sediment recruitment would significantly imperil critical habitat in Sequim Bay and threaten the existence of several of Sequim Bay's Spits. Loss of the spits would also lead to increased beach and upland erosion resulting in property damage. A recent nearby study further documents the important function of the fragile feeder bluffs and bluff backed beaches as well as the need to preserve these critical habitats and prevent shoreline modifications that disrupt sediment transport (Nabors, et. al., 2008).

The proposal represents the Research Phase of restoring and protecting the Sequim Bay Drift Cells and their sediment sources. Future phases may include development of a drift cell protection plan, purchase of conservation easements and fee-simple land parcels, feeder bluff

buffer restoration via the relocation or decommission of buildings and infrastructure, and public outreach. Additional information on limiting factors addressed; relevant fish, salmonid stock, and habitat status; and, ecosystem restoration and project phasing is included in the NOPLE 2012 Three Year Workplan (NOPLE, 2012).

Objectives

Objectives of this Research Phase of Sequim Bay Drift Cell Protection & Restoration are:

- to develop contemporary feeder bluff erosion rates.
- to perform additional spatial analysis of shoreline features and shoreline development.

These tasks lay the foundation for future planning phases with the following objectives:

- to develop a drift cell/feeder bluff protection strategy document for long-term protection and restoration of the Sequim Bay Drift Cell ecosystem, including . Gibson, Travis, South, Chicken Coop, and Paradise Cove spits plus Washington Harbor and Sequim Bay; and,
- to develop high quality graphic and written public outreach materials that emphasize the need for feeder bluff conservation and buffer restoration, and provide related conservation information targeted at property owners along the feeder bluff.

Goals of the Puget Sound Partnership

The overall project is addressed in the Puget Sound Partnership's 2010 Action Agenda for Puget Sound. It corresponds to the Puget Sound-wide Strategic Priorities A (*Protect the intact ecosystem processes, structures, and functions that sustain Puget Sound*) and B (*Restore the ecosystem processes, structures, and functions that sustain Puget Sound*); and Primary Objectives A.2 (*Permanently protect the significant intact areas of the Puget Sound ecosystem that still function well*), A.4 (*Support long-term protection and stewardship of working farms, forests, and aquatic lands to help maintain ecosystem functions, sustained quality of life, and improved viability of rural communities*), and B.1 (*Implement and maintain priority ecosystem restoration projects for marine, marine nearshore, estuary, freshwater riparian and uplands*). The project also corresponds to No. 1 under Near-term Action B.1 (*Implement restoration projects in the salmon recovery three-year work plans and the Estuary and Salmon Restoration Program of the Nearshore Partnership*).

Project Location

The Sequim Bay Drift Cell complex is located along the marine shoreline of the North Olympic Peninsula and extends from Grays Marsh east to Rocky Point on the northern edge of the Miller Peninsula. The project site is near Sequim, Washington (Strait of Juan de Fuca Action Area).

Figure 1 highlights the regional location of the project, and Figure 2 shows the boundaries of the study area sediment sources.

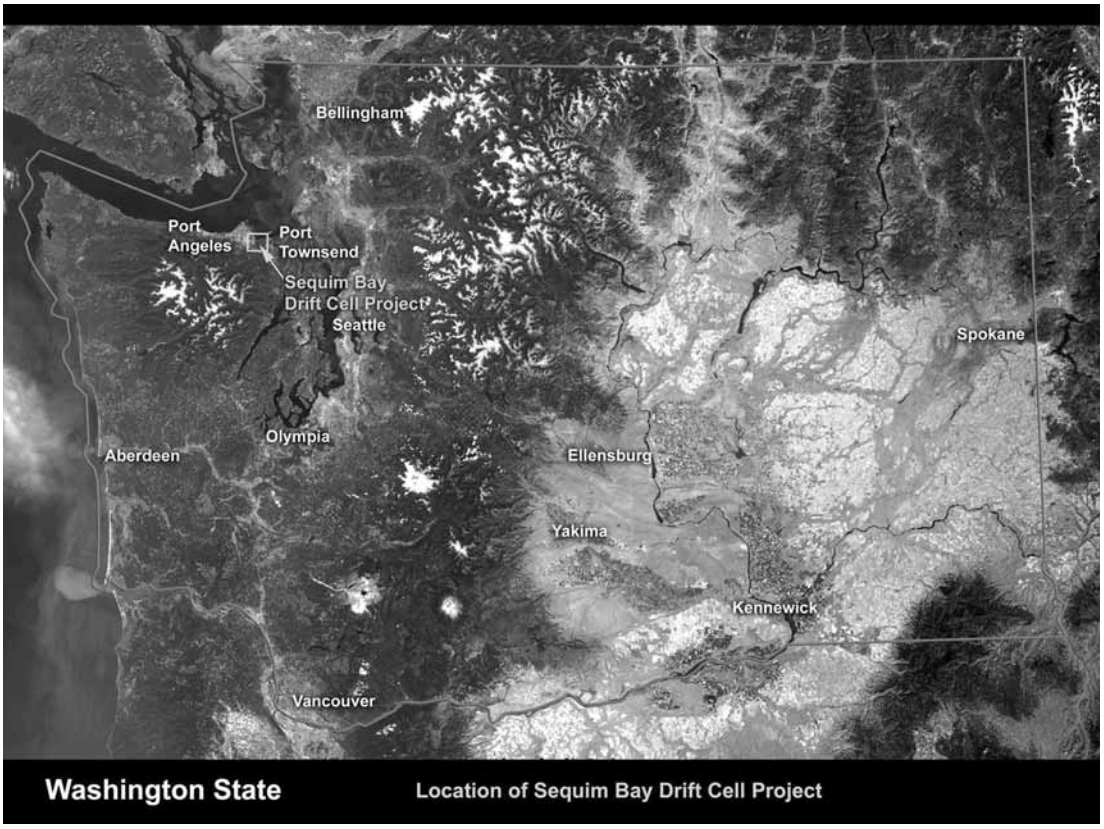


Figure 1: Project Location

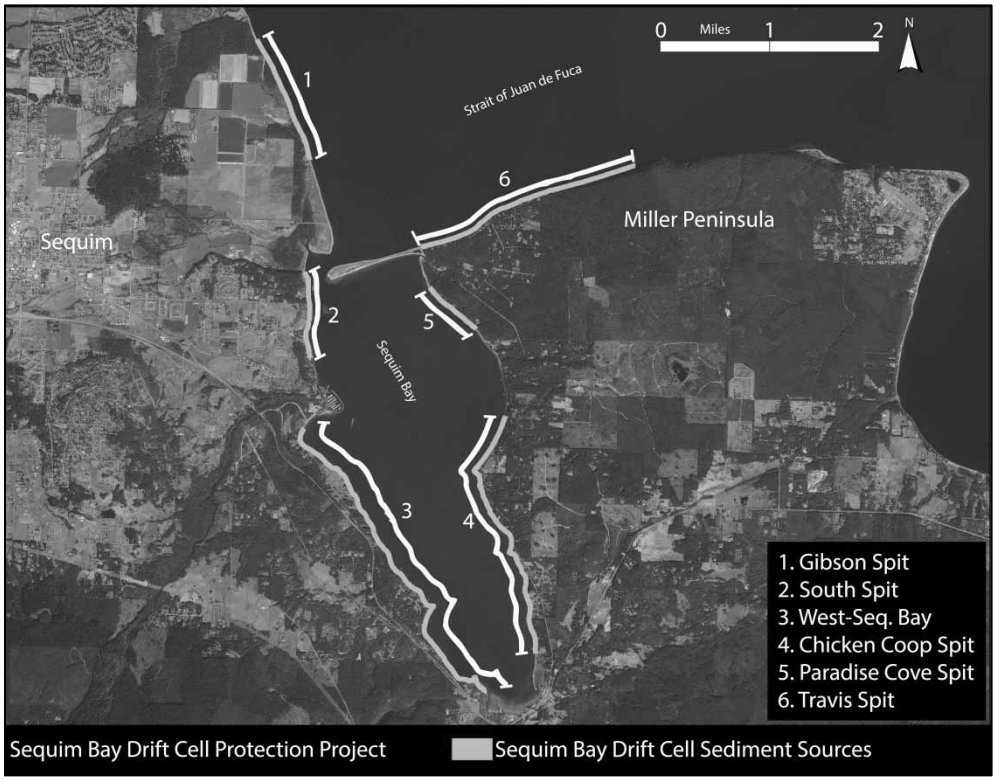


Figure 2: Sequim Bay Drift Cell

Geographic setting

Sequim Bay is located in the northeast corner of the Olympic Peninsula of Washington State. A number of creeks and small streams drain into Sequim Bay including Bell, Johnson, Dean, and Jimmycomelately Creeks. The watershed for Sequim Bay drains over 35,000 acres from Mt. Zion to the Strait of Juan de Fuca (ENTRIX, 2005). The headwaters are largely forested and include National, State, and private forest lands. The lowlands are a mix of rural residential, commercial, and agriculture. Precipitation varies from 15 inches annually near Sequim to 80 inches annually on Mt. Zion.

A.6 Project/Task Description

Project Overview

This initial research phase of protecting and restoring Sequim Bay Drift Cells includes analysis of contemporary rates of bluff erosion within multiple drift cells. Future phases may include development of a drift cell/feeder bluff protection strategy and development/delivery of education and outreach materials. The protection strategy may include a prioritization of land parcels for protection along with a roadmap for future protection phases of the project. The outreach materials may include graphic and written outreach materials. The research phase of the project includes one task with two additional tasks highlighted for the future planning phase of the project. The three task groups are described below:

Initial Research Phase:
Task 1: Determine contemporary erosion rates of the feeder bluffs along all drift cells (to establish technical basis for prioritizing land parcels for protection).

(a) Prepare Quality Assurance Project Plan (QAPP) and Quality Management Plan to be approved by EPA.
(b) Obtain, scan, georectify, and color-correct six sets (years 1957, 2012, and four years in-between) of orthophotos that span the study area.
(c) Based on the above photogrammetry, calculate contemporary feeder bluff erosion rates along the entire drift cell (see Figure 3).
(d) Prepare GIS shape files depicting (i) contemporary feeder bluff erosion rates along the entire drift cell and (ii) buffer widths required to ensure uninterrupted bluff erosion and sediment recruitment into the drift cell for 75-, 150-, and 300-year timeframes.
(e) Produce technical report on contemporary rates of feeder bluff erosion and buffer widths required to protect the Sequim Bay Drift Cell Complex and associated feeder bluffs.

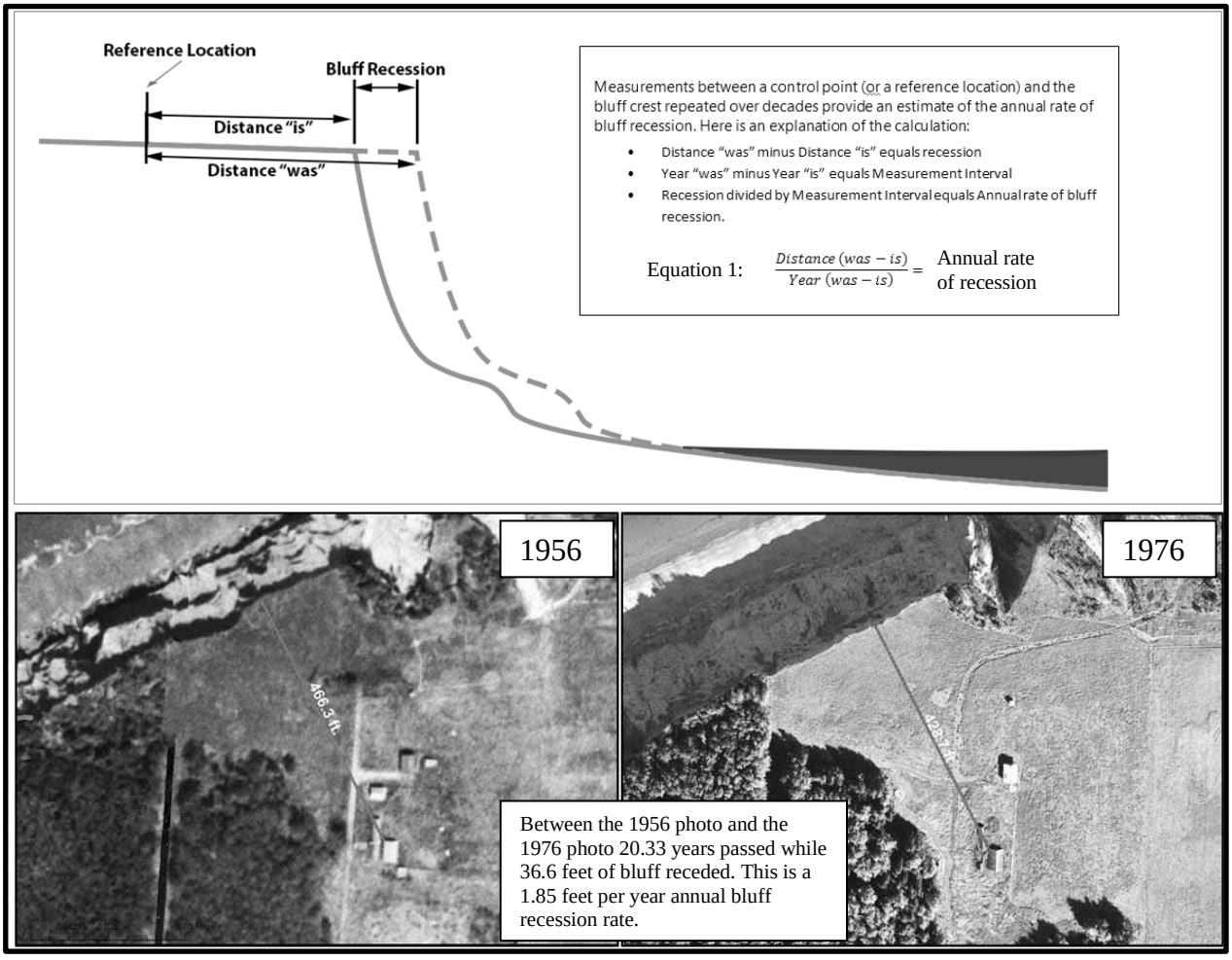


Figure 3: Bluff Recession Calculation (top) and Example (bottom). Using GIS and historic partially rectified air photos to measure the distance between bluff edge and reference location on each photo, differs from field measurements because reference locations and bluff crest must be visible on the photo. The recession values are calculated from the GIS measurements using Equation 1.

Future Planning Phases:

Task 2: Produce Sequim Bay Drift Cell Protection Strategy.

(a) Form resource collaborator group and convene planning meetings.

(b) Utilizing the work products from Task 1, assign parcels for protection along the feeder bluff and drift cell to one of the following categories: (i) purchase of perpetual conservation easement, (ii) purchase of fee-simple property, or (iii) restoration of buffer (relocation or decommissioning of structures and infrastructure).

(c) Based on the above categories, prioritize land parcels for protection along the feeder bluff and drift cell.

(d) Develop high quality maps and graphics depicting parcel locations and prioritization.

(e) Prepare Sequim Bay Drift Cell Complex Protection Strategy document for permanent protection of all Sequim Bay Drift Cells and associated feeder bluffs.

Task 3: Develop public outreach materials targeting feeder bluff property owners.

(a) Produce written and graphic outreach materials, including a high quality PowerPoint presentation, that: (i) describe the technical basis for recommended conservation and buffer restoration measures; (ii) address the need for feeder bluff conservation and buffer restoration; and, (iii) provide information on conservation easements, fee-simple purchases, and building and infrastructure relocations.

(b) Distribute and/or present outreach materials to feeder bluff and shoreline landowners and other interested parties.

Project Schedule

The project schedule is summarized below:

Sequim Bay Drift Cell Protection & Restoration: Research Phase	**Year 2013**				**Year 2014**		
	Jan-Mar	**Apr-Jun**	**Jul-Sep**	**Oct-Dec**	**Jan-Mar**	**Apr-Jun**	**Jul-Sep**
Task 1**:** *Determine contemporary erosion rates of the feeder bluffs along the entire drift cell.*			✓	✓	✓	✓	✓
Task 2**:** *Produce Sequim Bay Drift Cell Protection Strategy.*				Future Phase			
Task 3**:** *Develop public outreach materials targeting feeder bluff property owners.*				Future Phase			

A.7 Quality Objectives and Criteria for Measurement Data

Quality objectives for measuring historic bluff erosion rates from aerial photography may be expressed in terms of the accuracy of distance measurements between objects on aerial photographs. The decision to use the technique of partially georectifying aerial photos to determine bluff erosion rates was based on information described by Cheryl J. Hapke, author of topical issue paper, *The Measurement and Interpretation of Coastal Bluff Retreat*, within USGS's Professional Paper No. 1693 (Hapke, 2004) (Please see Appendix 1).

Table 1 was excerpted from the topical issue paper (Hapke, 2004). This paper indicates that among other advantages, partially rectified aerial photos provide higher accuracy than ground surveys, historical maps, and unrectified aerial photos, in terms of measuring distances of objects on the aerial photograph. Lidar is only available for 2005 and 2012 which does not provide the temporal range as historic aerial photographs. Historic aerial photographs are not available in fully rectified format. The only choices that provide the over half-century temporal range are unrectified photos and partially rectified photos. The Tribe has the skills and capacity to partially rectify the photos and to use a GIS to perform measurements superior to measurements from unrectified photos.

The disadvantages (Table 1) related to using partially rectified photos for bluff recession measurement are expense of equipment and ambiguous bluff edge in two dimensions. The Tribe possesses the appropriate equipment to make these measurements and has developed a method (See SOP: Knapp, 2013) that partially overcomes the ambiguous bluff edge problem by selecting appropriate measurement locations and using expert judgment.

Partially rectified photos provide the optimum balance of accuracy and historical range. For the purpose of estimating bluff erosion rates and providing recommendations for prioritizing land parcels for protection within the Dungeness Drift Cell, use of partially rectified aerial photos is appropriate.

Table 1. Advantages and disadvantages of measurement techniques commonly used in coastal cliff and bluff erosion studies.

Technique	Advantages	Disadvantages
Ground Surveys	Very Accurate Easily repeatable	Poor temporal and spatial coverage Time consuming (and therefore expensive)
Historical maps	Inexpensive Widely available Very long temporal coverage (1850's – 1979's) Good spatial coverage	Low accuracy Ambiguous cliff/bluff edge position
Aerial photographs		
Unrectified	Inexpensive Widely available Good temporal coverage (1920's – present) Good spatial coverage	Low accuracy Ambiguous cliff/bluff position in 2D
Rectified		
Partially	Widely available Good temporal coverage (1920's – present) Good spatial coverage Improved accuracy over unrectified	Ambiguous cliff/bluff position in 2D Hardware/software for processing may be expensive
Fully	Widely available Good temporal coverage (1920's – present) Good spacial coverage Very high accuracy Cliff/bluff edge can be digitized in 3D	Processing time consuming Required software expensive
Lidar	Good spacial coverage Very high accuracy	Expensive Poor temporal coverage Cliff edge may not be captured in data

A.8 Special Training Needs/Certification

The project will be conducted by the Tribe's Restoration Planner. He also has over 6 years of experience in working with GIS and photogrammetry. The Restoration Planner is acutely familiar with the geographic region being studied and capable of employing the techniques necessary to carry out the project. All work will be reviewed by the Habitat Program Manager, a distinguished fisheries biologist with over 30 years of experience in his field. He also has over 10 years of experience in working with GIS and photogrammetry as well as significant experience performing distance measurements of objects on partially-rectified aerial photographs.

A.9 Documents and Records

Availability and retention of records
All records that remain the responsibility of the Jamestown S'Klallam Tribe will be kept either in hard copy or electronically at the Jamestown S'Klallam Tribe administrative offices for the length of time stipulated in the contract. This will include all data and reports associated with the project. The administrative office is located in Blyn, WA and is maintained according to a policy of limited access. The Jamestown S'Klallam Tribe's Watershed Planner or Restoration Planner is responsible for archiving and retrieving related project materials.

Records that will be maintained in electronic or hardcopy form include:

- Quality Assurance Project Plan
- Measured and calculated data
- GIS shape files and metadata
- Maps and graphics developed
- Aerial photography
- Outreach material developed
- Documentation of problems associated with any of the project tasks
- Technical reports
- Final report

Quality Assurance Project Plan:

The final version of the QAPP will be available from Hansi Hals of the Jamestown S'Klallam Tribe. This QAPP will be distributed to those listed in Section A.3 Distribution List. The QAPP will be reviewed periodically and a determination made to either modify the document based on new or modified project requirements, or leave as is.

B.1 Sampling Process Design

Calculating Bluff Erosion Rates

Erosion rates will be calculated by comparing the location of the bluff edge during various target years represented in the high resolution georeferenced air photo record. The earliest year represented is 1956 and the most recent is 2013. These are the most important target years for which bluff-edge locations will be determined. Average erosion rates will be calculated based primarily upon the amount of bluff retreat occurring during this 1956 to 2013 time period. In addition, we will attempt to acquire photos for several years between 1956 and 2013. The years 1976, 1997 are likely available for our study area. If these photo records can be acquired as high quality imagery, we will produce estimates of bluff recession for the intervals 1956 to 1976, 1976 to 1997, and 1997 to 2013. If our initial investigation of these photo records shows that additional photo records are needed, we may acquire, reference, and measure additional photos creating additional time intervals.

Measurements for each target year will be performed as follows.

1. Reference locations will be identified on the available photosets.
2. The distance between each reference location and the nearest point along the top bluff edge (bluff crest) of the feeder bluff system will be precisely mapped by digitizing a line feature overlaid onto the high resolution aerial photos in a GIS application.
3. Measurements will be made perpendicular to the bluff face and will be recorded to the nearest 0.01 foot.
4. Measurements made on more recent photosets will be subtracted from measurements made using older photosets to calculate the change in distance (Δ distance).
5. Change in distance will then be divided by the number of years (Δ Time .
    a. The number of years will be computed by dividing the number of days between when the photos were taken divided by 365.
    b. The number of years will be recorded to 0.01 years.

B.2 Sampling Methods

The project does not involve field sample collection.

B.3 Sample Handling and Custody

The project does not involve field sample collection or handling.

B.4 Analytical Methods

The project does not involve laboratory analysis.

B.5 Quality Control Requirements

Aerial photos will be scanned with a graphic arts quality (2400 dpi) flatbed scanner. Scan resolution will be a minimum of 800 pixels per inch (PPI). All digitized orthophotos will be georeferenced to a common data set, the USDA Farm Service Agency National Agriculture Imagery Program (NAIP) 1-meter ground sample distance (GSD) 2011 data set or the most recent/highest Quality imagery available for the entire study area.

B.6 Instrument/Equipment Testing

No instrument/equipment requires testing.

B.7 Instrument/Equipment Calibration

No instrument/equipment requires calibration.

B.8 Inspection/Acceptance of Supplies and Consumables

Supplies, including publication costs, used in this study will be purchased directly by the Jamestown S'Klallam Tribe. Records will be kept of all supply purchases and/or services.

B.9 Non-direct Measurements

GIS data layers of property ownership/parcel boundaries (for use in Task 2) will be obtained from Clallam County, the official repository of this data set. Aerial photos (for use in Task 1) will be obtained from county, state, tribal, and federal sources. 2012 Lidar (Light intensity detection and ranging) data will be obtained from the Puget Sound Lidar Consortium.

B.10 Data Management

The primary datasets that will be generated are: (1) Partially-rectified aerial photos (multiple years) of the Sequim Bay Cell feeder bluffs and sediment source areas and, (2) GIS shape files depicting the distance from the bluff edge some reference location. Additional GIS shapefiles modeling future erosion may also be created. Data will be stored on a PC and will be backed up on a daily basis. Hard copies will be stored with other permanent records.

C.1 Assessments and Response

Hansi Hals, the Tribe's Grant Project Manager, will monitor project progress through regular communication with Robert Knapp, the Tribe's Restoration Planner and Grant Project Technical Lead. Any problem findings will be discussed with the NWIFC Grant Project Manager(s) and the EPA Grant Project Manager, and actions taken based on best professional judgment.

C.2 Reports to Management

Written and personal communications regarding project status and QA concerns will occur on a regular basis between Hansi Hals (Jamestown S'Klallam Tribe), Tiffany Waters (Northwest Indian Fisheries Commission) and Lisa Chang and/or Ginna Grepo-Grove (EPA). Project status and QA concerns will be documented in writing at least quarterly for inclusion in reporting to EPA. Problems encountered will be discussed with the parties above as necessary and appropriate actions taken. A summary of such encounters will be submitted as part of a final report (as appropriate) to assist readers in interpretation of the results.

D.1 Data Review, Verification, and Validation

The data collected for this project will be reviewed by technical personnel with familiarity in the methods being employed. Data review, verification and validation will occur at the Jamestown S'Klallam Tribe.

D.2 Verification and Validation Methods

The project does not involve sample collection.

D.3 Reconciliation with User Requirements

The Drift Cell bluff erosion rate results will be reported in written format and possibly in presentations and/or outreach materials where appropriate that is suitable for both technical and non-technical audiences. Limitations of the use of this data will be discussed as part of any presentation or written report. The project will be deemed successful when tasks and deliverables described in the workplan are completed per the QAPP and submitted and approved by EPA.

E.3 REFERENCES

ENTRIX. 2005. WRIA 18 Watershed Plan. Elwha-Dungeness Watershed Plan for Water Resource Inventory Area 18 and Sequim Bay in West WRIA 17. Prepared by Entrix, Inc. and the Clallam County Dept. of Community Development for the Elwha-Dungeness Planning Unit. Clallam County, Port Angeles, WA.

Hapke, C. 2004. The Measurement and Interpretation of Coastal Bluff Retreat. *In Formation, Evolution, and Stability of Coastal Cliffs–Status and Trends*. Professional Paper 1693. U.S. Geological Survey. M. Hampton and G. Griggs, Editors. Denver, CO.

Knapp, R. 2013. Historic Bluff Crest Recession Measurements using Partially Rectified Air Photographs. Jamestown S'Klallam Tribe GIS measurement Procedure # 001. October 28, 2013. Blyn, WA.

Nabors, T. and A. Shaffer, T. Ritchie, D. Penttila, and D. Parks. 2008. Nearshore central Strait of Juan de Fuca, including the Elwha and Dungeness drift cells, habitat form and function for forage fish spawning. Western Washington University; Washington Department of Natural Resources; WDFW Habitat Program, Science Division. Port Angeles, WA.

NOPLE. 2012. North Olympic Peninsula Lead Entity 2012 Three Year Work Plan Narrative. Clallam County Department of Community Development. Port Angeles, WA.

PNPTC. 2006 Historical Changes to Estuaries, Spits, and Associated Tidal Wetland Habitats in the Hood Canal and Strait of Juan de Fuca Regions of Washington State. Final Report by Point-No-Point Treaty Council Technical Report 06-1. Port Gamble, WA.

F.3 APPENDIX 1

U.S. Geological Survey. 2004. Formation, Evolution, and Stability of Coastal Cliffs – Status and Trends. Professional Paper 1693. Denver, Colorado. Available for download at http://pubs.usgs.gov/pp/pp1693/pp1693.pdf

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ENVIRONMENTAL
ASSESSMENT

July 6, 2015

MEMORANDUM

SUBJECT: Review of the Revised Cooperative Investigation of Diarrhetic Shellfish Toxins and other Harmful Algal Blooms in Sequim Bay QAPP, Jamestown S'Klallam Tribe (April 2015)

FROM: Donald M. Brown, QA Chemist DMB Digitally signed by Brown, Donald M. DN: cn=Brown, Donald M., email=Brown.DonaldM@epa.gov Date: 2015.07.06 10:05:25 -07'00'
USEPA Region 10, Office of Environmental Assessment, Environmental Services Unit

TO: Lisa Chang, Project Officer
USEPA Region 10, Office of Ecosystems, Tribal and Public Affairs

Tiffany Waters, Puget Sound Recovery Projects Coordinator
Northwest Indian Fisheries Commission

The QA review of the above-referenced revised QAPP has been completed. The revision has adequately addressed previous review comments and final approval is provided. If you have any questions, please call me at (206) 553-0717 or email me at Brown.DonaldM@epa.gov.

Quality Assurance Project Plan

for

Cooperative Investigation of Diarrhetic Shellfish Toxins and other Harmful Algal Blooms in Sequim Bay

April 2015

Prepared for:
Northwest Indian Fisheries Commission
6730 Martin Way E
Olympia, WA 98516

and

US Environmental Protection Agency
1200 6th Avenue
Seattle, WA 98101

under Agreement #14 EPA PSP 402

Prepared by:
Jamestown S'Klallam Tribe
1033 Old Blyn Highway
Sequim, WA 98382

Approval:

_____ _____
Hansi Hals, JST Grant Project Manager Date

_____ _____
Lisa H. Chang, PhD., USEPA Project Officer Date

_____ _____
USEPA Regional QA Manager Date

Table of Contents

Distribution List and Contact Information-

Name	Organization	Address	Phone No	Fax No	E-mail Address
Lisa H. Chang, Ph.D.	USEPA	1200 6th Ave Ste 900 Seattle, WA 98101	(206) 553-0226	(206) 553-1775	Chang.Lisa@epa.gov
Don Matheny	USEPA	1200 6th Ave Ste 900 Seattle, WA 98101	(206) 553-2599	(206) 553-8210	Matheny.Don@epa.gov
Tiffany Waters	NWIFC	6730 Martin Way E Olympia, WA 98516	(360) 528-4318	(360) 753-8659	twaters@nwifc.org
Hansi Hals	JSKT	1033 Old Blyn Hwy. Sequim, WA 98382	(360) 681-4601	(360) 681-4611	hhals@jamestowntribe.org
Neil Harrington	JSKT	1033 Old Blyn Hwy. Sequim, WA 98382	(360) 681-4634	(360) 681-4611	nharrington@jamestowntribe.org

1 Project Management and Organization

This study is a multi-agency collaboration designed to increase the capacity of the Tribe – and ultimately other shellfish growers and harvesters – to prepare for Diarrhetic Shellfish Poisoning (DSP) and other Harmful Algal Bloom (HAB) events. The organizations involved in this project are:

Jamestown S'Klallam Tribe (JSKT): The JSKT Grant Project Manager is Hansi Hals. Ms. Hals shall be responsible for submission of the QAPP to EPA for review and approval, and maintenance and preparation of grant reports and deliverables to EPA. She will also be the main contact for EPA or NWIFC requests. The JSKT Grant Project Technical Lead is Neil Harrington. Mr. Harrington shall be responsible for the sampling design and development of the QAPP, implementation of the QAPP, and overall management and oversight of the sample collection and analyses, data analysis and database input. He will also be responsible for the coordination of field and laboratory analyses of samples.

NOAA Northwest Fisheries Science Center (NWFSC): Point of Contact: Dr. Vera Trainer. The NWFSC will be responsible for cooperating and assisting the Tribe with technical expertise.

Northwest Indian Fisheries Commission: The NWIFC project contact is Tiffany Waters, Puget Sound Recovery Projects Coordinator. NWIFC shall administer the EPA-sponsored grant sub-award and shall provide technical assistance to Jamestown S'Klallam Tribe. Bob Conrad will assist the Tribe with statistical analyses.

US Environmental Protection Agency: The EPA shall provide funding for the study, review and approval of the study QAPP and technical assistance to the NWIFC and Tribe.

Washington Department of Health: The Washington State Department of Health will perform the DSP toxin analyses on shellfish tissue and collaborate with the Tribe in implementing these findings into the regulatory structure of shellfish harvest.

1.1 Roles and Responsibilities

Jamestown S'Klallam Tribe:
Points of Contact: Hansi Hals and Neil Harrington. JSKT shall be responsible for the following tasks:

- preparation and submission of the QAPP to EPA for review and approval
- phytoplankton monitoring
- collection of shellfish samples
- water quality parameters determination
- processing and shipment of shellfish samples to WDOH public health laboratory and water samples to UW ocean chemistry laboratory
- coordination of sample analyses
- data validation
- data input to database
- data analysis/interpretation (assisted by Northwest Indian Fisheries Commission)
- report writing

NOAA Northwest Fisheries Science Center (NWFSC): Point of Contact: Dr. Vera Trainer. The NWFSC will be responsible for cooperating and assisting the Tribe with technical expertise.

Northwest Indian Fisheries Commission: The NWIFC project contact is Tiffany Waters, Puget Sound Recovery Projects Coordinator. NWIFC shall administer the EPA-sponsored grant sub-award and shall provide technical assistance to Jamestown S'Klallam Tribe. Bob Conrad will assist the Tribe with statistical analyses.

1.2 Problem Definition/Background

Shellfish are a very important natural resource for the Jamestown S'Klallam Tribe. Clams and oysters are harvested for commercial, ceremonial, and subsistence purposes. To ensure the shellfish is safe for consumption, samples are collected prior to harvest and sent to the Washington State Department of Health (WDOH), Office of Shellfish and Water Protection, where they are tested for toxins associated with Paralytic Shellfish Poisoning (PSP), Amnesiac Shellfish Poisoning (ASP) and Diarrhetic Shellfish Poisoning(DSP). As research and monitoring are also essential parts of managing and protecting this resource, the Tribe partners with SoundToxins program (coordinated by NOAA's NWFSC) to monitor phytoplankton in their waters to provide advanced warning of locally-occurring algal bloom events that may ultimately impact shellfish and human health.

For the past several years the Tribe has focused its efforts on studying and characterizing DSP. This was due to the fact that little was known about this syndrome in the United State and that the first cases of DSP occurred less than two miles from the Tribal Center and the Tribe's aquaculture facilities and subsistence shellfish beds. Through this monitoring we have gained a

better but not yet full understanding of DSP and improved our monitoring scheme. In addition to DSP Sequim Bay has also experienced blooms of several other species of harmful algae both historically and over recent years. These include *Alexandrium spp*. (which cause PSP), *Pseudonitszchia spp*. (which cause ASP) and *Heterosigma* a fish killing rhaphidiophyte.

On June 28, 2011, the WDOH received a report of a Diarrhetic Shellfish Poisoning (DSP)-like illness after a family ate mussels from Sequim Bay State Park. While the phytoplankton genus, *Dinophysis*, that produces DSP toxins has been seen in Sequim Bay and other marine waters of Washington since before routine phytoplankton monitoring began in 2007, confirmed cases of DSP had not occurred in Washington. Because of this and the specialized laboratory equipment required to analyze shellfish for these and other lipophilic toxins, the WDOH had not included DSP in their routine shellfish monitoring program. After the report of illness, and over the course of several weeks, shellfish samples were collected from Sequim Bay and sent to an FDA laboratory in Alabama for DSP toxin analysis. The turn around time – from sample collection to toxin results – was several weeks. Toxin levels in mussels were well above the regulatory limit of 16 µg/100 g tissue. This prompted the WDOH to close Sequim Bay to all shellfish harvesting on August 8th. This was the first DSP commercial closure in the State of Washington and the first confirmed DSP illness case in the United States. This harvest closure had a significant impact on the Tribe. During the 30 day closure, six commercial clam digs were cancelled. Oysters had to be recalled from five different restaurants. Clams had been sold to three different buyers who in turn had to call their vendors for a recall. By 2012 shellfish samples were being analyzed at NOAA's NWFSC in Seattle and turnaround time was greatly reduced. WDOH in cooperation with NOAA and the Tribe started analyzing shellfish samples routinely for DSP toixins. In turn the bay was closed for both DSP and PSP from June through October due to shellfish samples exceeding the regulatory limit for toxins, some over ten times limit for DSP toxins. Since 2011 there have not been reported illnesses due to DSP in Sequim Bay.

Through the 2012 DSP study investigated using cell number of *Dinophysis* to predict toxic events, the use of Jellett Rapidtest strips (an ELISA based test) to give a timely indication of toxicity and also looked at toxicity of five species of shellfish. We found that the rapid test strips, using the manufacturer's extraction method, were not a reliable indicator of toxicity of the shellfish in Sequim Bay. We also found that cell density usually was a good predictor of shellfish toxicity, however there were several anomalous periods where low cell densities were observed followed by increases in shellfish toxicity. Different species of shellfish took up the DSP toxins in different amounts. In general, mussels were the most toxic followed by oysters and manila clams and lastly littleneck clams. However, at times oysters were higher in toxin than mussels and seemed to depurate (to get rid of) the toxin faster. Manila clams, were only tested twice but found to have at least twice the toxin concentration of littleneck clams. Several questions emerged from the 2012 study that we tried to address in the 2013 study:

- What is the optimal way to sample for *Dinophysis* in the water column?
- What are the relative ratios of toxin uptake between, oysters, mussels, littleneck clams and manila clams?
- What role do nutrients play in *Dinophysis* blooms and other HABs in Sequim Bay?

In 2013 a bloom of *Dinophysis* occurred in June and mussels became toxic. However the bloom quickly abated leaving some of our questions partially unanswered. We were not able to gauge the relative uptake rates between oysters, littleneck and manila clams due to these species being uniformly low in toxin (in contrast to mussels which were much more toxic). The temporal spatial study of *Dinophysis* cell abundance at 3 depths over 38 hours, was suggestive of certain patterns, however did not definitively answer where and when to sample in the water column for *Dinophysis*.

In 2014 there was a bloom of Dinophysis that led to high levels of DSP toxins (over 11 times the regulatory limit) in shellfish. During this time we were able to more fully elucidate the relative uptake and depuration rates of blue mussels, pacific oysters, littleneck clams and manila clams. We were unable to collect shellfish from the beach during this period to compare the toxicity of butter clams (which cannot be kept in cages) with the other species of shellfish. We were also able to complete two temporal spatial studies of *Dinophysis* in the water column. The results were somewhat contradictory and we propose to repeat this study , if possible, this season.
In 2015 we propose to fine tune our DSP study plan from 2014. Shellfish samples will be taken from cages hanging on the Sequim Bay State Park dock and at Blyn but also from the beach at the State Park to make sure there are no effects from hanging versus beach grown shellfish (particularly clams). Butter clams *Saxidomus gigantea*, an important species to the Tribe, will also be dug and be tested, few have been sampled by WDOH and little is known about their uptake and depuration of DSP toxins. It is known that butter clams retain the lipophilic toxins associated with PSP much longer than other species of shellfish. Butter clams are an important subsistence species of clam for the tribe.

The temporal and spatial study will be repeated and water samples will be taken at several depth over the course of a day. The objective will to see how thin layers of algae behave over the course of tidal and diurnal cycles leading to more targeted sampling techniques for *Dinophysis* that can be shared with other Soundtoxin partners (including tribes).

Also in 2014 there were two significant blooms of *Heterosigma akishawo*, a single celled rhaphidophyte (type of phytoplankton) which were identified rapidly due to our HAB monitoring program. *H. akishawo* can form dense blooms and has a history of killing salmon in fish farms. The first bloom occurred in late June during the end of the outmigration period for juvenile pink and chum salmon. It is unknown whether this event killed juvenile salmon or if they were able to avoid it. The second bloom occurred in September and killed adult returning summer chum salmon- an ESA protected species. The bloom was very dense and was concentrated at the south end of Sequim Bay around the mouth of Jimmycomelately Creek. Over the course of a week tribal and state fisheries counted 345 dead salmon, the true toll was likely higher. This event was a stark reminder that HABs can not only affect shellfish but also finfish. In 2015 we propose sampling of Heterosigma blooms (greater than 100,000 cells/L) in Sequim Bay every other day to better understand their duration and extent.

1.3 Project Definition

This scope of work will fund approximately five months of sampling (weekly samples mid May through mid to late October) at two sites in Sequim Bay. The project will focus on:

1. Monitoring for the presence of and enumerating *Dinophysis* spp. (DSP), *Pseudonitzschia* spp (ASP) and *Alexandrium* spp. (PSP) plankton cells in net tows and concentrated whole water samples.
2. Monitoring environmental conditions with an YSI multi-probe sonde.
3. Collecting shellfish for toxin analysis by WDOH.
4. Collecting water for nutrient analyses.
5. Temporal and spatial study of *Dinophysis* to determine distribution in water column throughout two daily tide cycles.
6. Statistical analyses and comparison of this year's data with past years to determine patterns and refine shellfish management strategies.

1.3.1 Measurable Project Objectives

The measurable objectives for this project are as follows:

1. Determine the optimal sampling method for determining *Dinophysis* cell abundance in seawater.
2. Assess if certain environmental conditions (including nutrients) are conducive to *Dinophysis, Alexandrium, Psuedonitzchia* and *Heterosigma* growth and maintenance.
3. Share results and management lessons with project partners

1.3.2 Expected Environmental Outcomes

The expected environmental outcome of this study is to enhance the capacity of shellfish growers and harvesters to effectively plan for commercial and cultural shellfish activity while protecting human health.

1.4 *Schedule of Project Task/Activities*

Project Task	Estimated Start Date	Estimated Completion Date	Comments
QAPP Development	April 2015	April 2015	
QAPP Review and Approval	May 2015	May 2015	
Phytoplankton monitoring	May 2015	October 2015	Weekly (minimum)
Nutrient sample collection	May 2015	October 2015	Weekly (minimum)
Shellfish Collection	May 2015	October 2015	Weekly (minimum)
Temporal-spatial study of Dinophysis	May-October 2015	May-October 2015	Twice during a Dinophysis bloom

Final Report	December 2015	September 2016	

1.5 Data Quality Objectives

Data Quality Objectives (DQOs) are the quantitative and qualitative terms inspectors and project managers use to describe how good the data needs to be in order to meet the project's objectives. DQOs for measurement data (referred to here as data quality indicators) are precision, accuracy, representativeness, completeness, comparability, and measurement range. The overall QA objective for analytical data is to ensure that data of known and acceptable quality are provided. To achieve this goal, data must be reviewed for 1) representativeness, 2) comparability, 3) precision, 4) accuracy (or bias), and 5) completeness. Precision, accuracy, completeness, sample representativeness and data comparability are necessary attributes to ensure that analytical data are reliable, scientifically sound, and legally defensible. Each analytical result or set of results generated should be fully defensible in any legal action, whether administrative, civil, or criminal.

The overall quality assurance objective is to ensure that data of known and acceptable quality are provided. All measurements will be performed to yield consistent results that are representative at the media and conditions measured.

- Accuracy: Estimates of accuracy include by definition both precision and bias. Accuracy is often assessed with analyses of laboratory prepared, matrix spikes, and control standards. All laboratories will conduct assessments internally.
- Precision: Field duplicates will be used to analyze total precision. One nutrient field duplicate will be collected and analyzed for every ten samples collected. Relative percent difference (RPD) should be less than 10%. Data variability will be taken into consideration in using the data for analysis and interpreting results. RPD will be calculated by dividing the difference between the field duplicates by the mean of the concentration of the duplicates. RPD will be taken into consideration in using the data for analysis and interpreting results.
-
- Bias: This is the difference between the measured value and true value due to errors. It is difficult to quantify and is by definition due to non-random (systematic) errors. Strict adherence to established protocols and this QAPP as well as proper technique by the respective laboratories reduce bias to acceptable levels.
- Representativeness: Sampling design will provide samples that will represent a wide range of water quality conditions. Employing consistent and standard sampling procedures will ensure sample representativeness.
- Completeness: A minimum of 95% of the samples submitted to the laboratory will be judged valid.
- Comparability: Data comparability will be ensured through the application of standard sampling procedures, analytical methods, units of measurement, and detection limits.

1.6 Special Training Requirements/Certification

Scientists (Biologists/Chemists/Technicians) performing the work for this project have extensive knowledge, skill and demonstrated experience in the execution of the analytical methods being requested and no special certifications are needed for this particular project.

1.7 Documentation and Records

Complete documentation may include but are not limited to the following forms to be completed and collated by the JSKT:

- Field Sampling Notes
- Chain of Custody Logs
- Laboratory Analysis Reports
- Photographs, Sketches, Paper Copies, Chemical Labels, MSDS, Application Records or other documentation.

The field team will maintain field notes in a bound notebook and all documents, records, and data collected will be kept in a case file. They will be submitted the program office upon request.

The following documents will be archived at the JSKT Natural Resources Department office and the designated laboratory performing the analysis: (1) signed hard copies of sampling and chain-of-custody records (2) electronic and/or hard copy of chain of custodies analytical data including extraction and sample preparation bench sheets, raw data and reduced analytical data.

The University of Washington and Washington Department of Health laboratories shall store all sample receipt, sample login, extraction/preparation, and laboratory instrument print-outs and other analytical documentation as per their standard operating procedures.

2 Measurement and Data Acquisition

2.1 Sample Locations

Sampling will be conducted weekly at two sampling stations in Sequim Bay (Figure 1). Sequim Bay State Park is the location where the 2011 DSP illness occurred and is monitored weekly by the Tribe as part of the SoundToxins phytoplankton monitoring program. Blyn is the site of the Tribe's extensive shellfish beds.

2.1.1 Biota Samples

Three species of molluscan bivalves, specifically blue mussels (*Mytilus edulis*), Pacific littleneck clams (*Protothaca staminea*), manila clams (*Venerupis philippinarum)* and Pacific oysters

(*Crassostrea gigas)* shall be collected from a cage hanging from the dock at the Sequim Bay State Park. Mussels and oysters will be collected weekly. Littleneck and manila clams will also be collected three times during a bloom period to compare their toxicity. Littleneck, manila and butter clams will be dug three times out of beach sediment three times during the study. Additionally, blue mussels (Mytilus edulis) and Pacific oysters will be collected from South End/Blyn site. These samples will be shucked and homogenized at the JSKT Fisheries laboratory according to standard operating procedure at WDOH. Briefly, shellfish will be shucked and their tissue placed in a fine mesh wire strainer and associated body fluids will be allowed to drain for five minutes. The tissue will then be placed in a standard kitchen blender for 90 to 120 seconds. The homogenate will be refrigerated at less than 4°C and then shipped overnight on ice in a cooler to WDOH for quantitative analysis of DSP toxins the next day using LC-MS. If homogenated samples need to be held longer they will be frozen before shipment. Full LC-MS methods can be found in Appendix B

2.1.2 Phytoplankton Samples

Seawater samples will be collected weekly at both sites concurrent with the biota collection and preserved and concentrated for counts of *Dinophysis spp., Alexandrium, Psuedonitzchia and Heterosigma* cells. A 20 µm plankton net will be towed vertically through the water column at each site to concentrate phytoplankton for identification. A whole water sample will be taken weekly at 1.5 meters of depth using a Niskin bottle (in the event that the Blyn site is too shallow a sample will be taken halfway between the surface and the bottom). A sub-sample (50 mL) of seawater from each site will be preserved with 1 mL of 20% buffered formalin or Lugol's solution in a glass tube and settled for a minimum of 24 hours until enumeration of HAB species. After 24 hours the top 45 ml will be decanted and remainder will be transferred to a 25ml scintillation vial. Vials will be labeled with site designation, date, and WWP 10x to indicate concentrated whole water plankton. Cell counts and identification will be completed by JSKT personnel. Net tow samples will be looked at under the microscope within 24 hrs of sampling.

2.2 Sample Collection

Two JSKT staff members will use a small boat to access the two collection sites in Sequim Bay (Figure 1). The Sequim Bay State Park site may be accessed form land if needed. Shellfish and water samples will be collected every week as described above. In the event that *Dinophysis* or *Alexandrium* cell counts increase rapidly and/or exceed 10,000 cells per liter, another water sample will be collected, preserved, and concentrated every three days thereafter - to track the growth and die-off of the bloom - until cell abundance rapidly decreases or drops below 10,000 cells per liter. In the event that *Psuedonitzschia* or *Heterosigma* cell densities exceed 250,000 cells/L additional samples will be taken every three days after until the bloom dissipates. Water quality parameters (temperature, dissolved oxygen, pH, salinity and chlorophyll) will be determined weekly and during increased monitoring by JSKT staff using a YSI 6820V2 multi-parameter water quality instrument. Environmental factors such as weather, date and time, tide, and sample depth will also be recorded.

Water samples for laboratory analysis of nutrients and total nitrogen and total phosphorous (TNP) will be collected as a subsamples from the Niskin bottle in 60 mL polyethylene bottles (only 2/3 full), supplied pre-cleaned by the UW laboratory. Each sample bottle will be pre-labeled with a unique sample number with a sharpie permanent ink marker. The samples will be placed on ice in a cooler and kept cool (4 $\pm$ 2 ºC) until their delivery to the Tribal Center. Nutrient and TNP samples will then be shipped overnight the same day to the UW Laboratory in a cooler with ice packs and held at UW Marine Chemistry Lab in cold (<4°C) and dark storage and analyzed within 7days. If same day shipping is not possible, nutrient samples will be frozen and later shipped overnight with ice packs. Samples will be shipped with a chain of custody (COC) generated by the project technical lead. The COC will specify sample numbers, date and time of collection, sample matrix, parameters for analysis, and any pertinent observations or comments.

All shellfish samples collected during this study will be analyzed for DSP toxins using LC-MS as a quantitative analysis (see Section 2.5 and Appendix 1). Shellfish cages will be pre-stocked with shellfish samples and either submerged and tied to the dock (Sequim Bay State Park) or buoyed and placed on the tidelands (South End/Blyn). Weekly samples of at least 12 individual animals of each species will be collected to yield approximately 120 grams of shellfish meat for processing. Each species will be individually bagged by site and the bag labeled with site name, species, and date/time of collection, and number of organisms. The samples will be returned to the JSKT Fisheries laboratory for processing.

During a bloom (hopefully during a period of *Dinophysis* cells/L > 5000) period a vertical-temporal study of *Dinophysis* will be conducted from the Sequim Bay State Park dock to determine the distribution of cells in the water column throughout the day. Every three hours starting at dawn and until dusk water samples will be collected with a Niskin bottle at 3 depths: 0.5, 1.5 and 2.5 meters. Water collected will be stored in 2 liter bottles and put on ice in a cooler until processed. Nutrient samples will be subsampled out of the Niskin bottle at all depths at 6AM, 12 noon and 6PM. The YSI 6820V2 multi-parameter instrument will be lowered to record a depth profile of water column chlorophyll, salinity, temperature and pH. A vertical phytoplankton tow will also be taken.

Figure 1. Sample Collection Locations in Sequim Bay

Table 2 provides a summary of the stations and monitoring parameters.

Table 2. Monitoring Description for Project Sampling Stations in Sequim Bay

Sample Site	Weekly Environmental Parameters	Weekly Water Quality	Weekly Phytoplankton	Weekly Shellfish
State Park*	- Date, time, tide, weather - Temperature, DO, pH, salinity, chlorophyll	Nitrate, Nitrite, Phosphorus, Total Nitrogen, Total Phosphorus, Silicate	- Net tows for presence/absence of *Dinophysis* spp., *Alexandrium, Heterosigma and Psedonitzchia* - Whole water samples for enumeration of *Dinophysis* spp. *Alexandrium, Heterosigma and Psedonitzchia*	- Laboratory LC-MS analysis for DSP toxins in blue mussels and oysters. Beach dug butter clams, manila clams and littleneck clams three times during bloom if possible.
South End/Blyn	- Date, time, tide, weather. - Temperature, DO, pH, salinity, chlorophyll (**tide permitting**)	Nitrate, Nitrite, Phosphorus, Total Nitrogen, Total Phosphorus, Silicate	Net tows for presence/absence of *Dinophysis* spp. *Alexandrium, Heterosigma and Psedonitzchia* Whole water samples for enumeration of *Dinophysis* spp *Alexandrium, Heterosigma and Psedonitzchia*.	- Laboratory LC-MS analysis for DSP toxins on blue mussels and oysters

*An intensive vertical- temporal sampling effort will also occur at the State Park during a *Dinophysis* bloom as detailed on page 11

2.3 Decontamination Procedures

Samples will be collected using clean sampling devices and sample collection gear. As much as possible, disposable sampling equipment and gear shall be used. Sampling devices and sample collection gear like rain gear, and rubber boots will be cleaned and decontaminated using disinfectants. Samplers will follow the proper health and safety procedures when collecting and handling samples to minimize or not to incur contamination.

2.4 Sample Handling and Shipping

Sample custody and documentation will be consistent with established EPA protocols. Sample tubes of shellfish homogenate will be labeled with a unique number or letter/number combination and that information as well as the sample collection date, time and location will be entered on a chain of custody form that will accompany the samples to the WDOH laboratory. Samples will be refrigerated prior to shipping and then sent overnight in a cooler box with blue ice. In the event that samples cannot be shipped the same day they are taken, tubes of homogenate will be frozen for later overnight shipment.

Packaging, marking, labeling, and shipping of samples will comply with all regulations promulgated by the U. S. Department of Transportation (DOT) in the Code of Federal Regulations, 49 CFR 171 – 177 and International Air Transport Association (IATA) regulations. In the event samples are hand delivered via a government owned vehicle, these regulations do not apply.

2.5 Analytical Methods

Water quality parameters (temperature, dissolved oxygen, pH, salinity and chlorophyll) will be recorded on a field data sheet and logged for each sample taken by JSKT staff using the YSI 6820V2 multi-parameter water quality instrument. Table 3 describes the specifications for this instrument.

Table 3. YSI Instrument Specifications

Parameter	Range	Resolution	Accuracy
Optical Dissolved Oxygen & Saturation	0-500%	0.10%	0-200% +/- 1% of reading or 1% air saturation, whichever is greater; 200-500% +/- 15% of reading
Optical Dissolved Oxygen mg/l	0-50mg/l	0.01mg/l	0-20mg/l +/- 0.1mg/l or 1% of reading, whichever is greater; 20-50mg/l; +/- 15% of reading
Conductivity	0-100mS/cm	0.001-mS/cm (range dependent)	+/- 0.5% of reading + 0.001 mS/cm
Salinity	0-70ppt	0.01ppt	+/- 1% of reading or 0.1 ppt, whichever is greater
Temperature	-5 to +70 degrees C	0.01 degrees C	+/- 1.5 degrees C
pH	0-14 units	0.01 units	+/- 0.2 units
Depth			
Vented Level	0-30 feet, 0-9 m	0.001 feet, 0.0003 m	0.01 feet, 0.003 m
Shallow	0-30 feet, 0-9 m	0.001 feet, 0.0003 m	+/-0.06 feet, +/- 0.02 m
Medium	0-200 feet, 0-61 m	0.001 feet, 0.001 m	+/- 0.4 feet, +/- 0.12 m
Chlorophyll	0-400 ug/L	0.1 ug/L Ch l; 0.1% FS	

JSKT staff will identify and count cells for *Dinophysis, Alexandrium, Psuedonitszchia and Heterosigma* species. For the enumeration of these HAB species sub-samples (50mL) of preserved seawater will be 10 X concentrated by settling for a minimum of 24 hours. 45mL of the overlying seawater is then aspirated and the remaining volume containing the settled cells will be quantified. 0.1mL of the settled sample will be placed in a Palmer Maloney slide and counted using a Zeiss Axiovert microscope.

The Washington Department of Health (WDOH) laboratory quantification of DSP toxins in shellfish will follow the Standard Operating Procedure as set forth by the European Union Reference Laboratory for Marine Biotoxins (Appendix 2) (EU, 2011). As chromatographic conditions are adjusted to respective laboratory conditions, the WDOH laboratory will measure under acidic conditions (Table 4).

Table 4. Possible LC Conditions for the Analysis of Lipophilic Toxins for a C8 Column under Acidic Conditions.

Column	BDS-Hypersil C8, 50 mm (length) x 2 mm (diameter), 3 µm particle size		
Flow	0.2 ml/min		
Injection volume	5 µl – 10 µl (depending on MS sensitivity)		
Column temperature	25-40 °C		
Gradient	Time (min)	Mobile Phase A (%)	Mobile Phase B (%)
	0	70	30
	8	10	90
	11	10	90
	11.5	70	30
	17	70	30

Analytical methods and the detection or precision limits for laboratory analyses of nutrients are listed in Table 5. Expected ranges are provided by the UW lab.

Table 5. Summary of Laboratory Measurements, Methods, Target Detection Limits and Expected Ranges for Nutrients

Parameter	**Method**	**Accuracy**	**Expected Range**
Laboratory Parameters			
PO_4 (µM)	UNESCO (1994)	0.02 µM	0 – 3.0µM
SiO_4 (µM)	UNESCO (1994)	0.21 µM	0 – 50 µM
NO_3 (µM)	UNESCO (1994)	0.15 µM	0 – 20µM
NO_2 (µM)	UNESCO (1994)	0.01 µM	0 – 3.0µM
NH_4 (µM)	UNESCO (1994)	0.05 µM	0 – 3.0µM
Total Phosphorus (µM)	Valderrama (1981)	0.02 µM	0 – 25 µM
Total Nitrogen (µM)	Valderrama (1981)	0.38 µM	0 – 3 µM
Urea (µM)	Strickland and Parsons (1972)	0.1µM	0-8µM

The UW Standard Operating Procedures used in the analysis of samples for this project are attached in Appendix 1 of this QAPP.

2.6 Instrument Calibration and Frequency

The YSI 6820V2 multi-parameter water quality sonde and the YSI650 multi-parameter display system will be inspected prior to each use to ensure that all probes and sensors are free from debris. After each use, the instrument will be rinsed with distilled water, dried with a soft cloth and stored in a safe, dry environment. The instrument will be calibrated according the following table (Table 6).

Table 6. YSI Instrument Calibration Frequency and Procedure

Parameter	Calibration Standard	Frequency
Optical Dissolved Oxygen mg/l	Place the sensor either into a calibration cup containing about 1/8 inch of water which is vented by loosening the threads. Wait approximately 10 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate.	Prior to field deployment
Conductivity/ Salinity	Place10 mS/cm conductivity standard (YSI 3163 is recommended) into a clean, dry or pre-rinsed calibration cup. Ensure that the sensor is as dry as possible. Rinse the conductivity sensor with a small amount of standard that can be discarded. Avoid cross-contamination of standard solutions with other solutions. Allow at least one minute for temperature equilibration.	Prior to field deployment
pH	The majority of environmental water of all types has a pH between 7 and 10. YSI recommends a two point calibration using pH 7 and pH 10 buffers. Using the correct amount of pH 7 buffer standard in a clean, dry or pre-rinsed calibration cup, carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding. Repeat with pH buffer 10.	Prior to field deployment
Depth	For the depth and level calibration, make certain that the depth sensor module is in air and not immersed in any solution. For best performance of depth measurements, users should ensure that the sonde's orientation remains constant while taking readings.	Prior to field deployment
Chlorophyll	This procedure will zero the fluorescence sensor and use the default sensitivity for calculation of chlorophyll concentration in µg/L, allowing fluorescence measurements that are only semi-quantitative with regard to chlorophyll.	Prior to field deployment

For LC-MS determination of DSP toxins, a calibration curve will be prepared each day of analysis according to the following sequence of injection:

1. One injection of each calibration curve level (first set commencing with the lowest concentration to the highest concentration;
2. one injection of the procedural blank (Blank QC), prepared during extraction of real samples;
3. sample extracts by duplicate injection including position QC (intermediate calibration standard, spiked extract, CRM);
4. one injection of the procedural blank (Blank QC);
5. second injection of each calibration curve level (second set).

See Appendix 2 for more information.

2.6.1 Quality Control

Table 7 summarizes the QC criteria for quantitative analysis of lipophilic marine biotoxins using LC-MS.

Table 7. Quality Control Criteria for Acceptance of the Quantitative Analysis of Lipophilic Marine Biotoxins.

QC Parameter	Criterion *
Chromatographic resolution	Peak resolution OA/DTX2* ≥ 1.0
Sensitivity	S/N of the product ion with the lowest intensity ≥ 3
Calibration Curve	Correlation coefficient r^2 ≥ 0.98 derived from at least five calibration points and either constructed as the mean of the first and second set of the calibration curve injected.
Response Drift	25% slope variation between the two sets of the calibration curve.
Blank QC	To be injected after high standard of calibration curve and after samples. No signal for lipophilic toxins (< LOD or < 10% of lowest calibration point.
Retention time (RT) drift	< 3%

* See Appendix 2 for more information.

3 Assessment and Response

The project shall implement the requirements set forth by this QAPP. Deviations from the QAPP shall be documented in a Sample Alteration Form (Attachment 1). Problems encountered in the field or laboratories shall be resolved and documented in a Corrective Action Form (Attachment 2). Both Sample Alteration and Corrective Action Forms shall be reviewed and approved by USEPA prior to implementation. Reports and other required documentation shall be furnished to NWIFC and EPA at the required frequency and schedule.

4 Data Validation and Interpretation

Standard laboratory procedures for analytical data reduction, review and reporting will be followed. The WDOH Lab will immediately inform the project technical lead of any problems with sample shipment conditions, or analyses. Analytical data shall be peer reviewed by the laboratory prior to submission to JSKT.

Data will be sent from laboratory to the project technical lead electronically or on paper lab reports. Lab reports, at a minimum, will list sample result, date of sample, sample location and sample number if applicable. Lab and field analytical data will be matched with sample times and locations. All data will be screened for questionable values and problems (for example nutrient sample duplicates should have an RPD below 10%) and inspected for missing or improbable data or results. If laboratory blanks show levels of analyte above reporting limits, the results will be qualified by flagging or rejection as appropriate.

All data collected during the project will be entered into an Excel database at the JSKT Natural Resources office after the data have been reviewed for quality assurance. Analyses of the three types of data collected (water chemistry, environmental, and algal cell density by species) will include basic descriptive analyses that use tables and figures to present: (1) summary statistics (mean, data range, etc.); (2) trends over time at each sample location; and (3) a comparison between the two sample locations of these data. Differences between sites will be tested using the t-test as appropriate for the homogeneous variance assumption. For data with distributions which are non-normal (e.g., the cell density data), the non-parametric Mann-Whitney test will be used to compare sites. Pearson's correlation coefficient (r) and its statistical significance will be used to initially examine relationships among the different measured parameters. Cell density samples will also be lagged one and two weeks to see if there was a delayed response in cell densities to water chemistry and environmental conditions. Finally, linear regression analysis and logistic regression analysis will be used to examine whether there is a parameter, or a set of parameters, that could be used to develop a predictive model for the density of cells (for each species). Ordinary least squares linear regression will be used to examine whether there is a relationship between the response parameter of interest (cell density) and the environmental and water chemistry parameters. Stepwise linear regression analysis will be used to screen those variables with significant ($P \leq 0.05$) Pearson's r with the response variable (both contemporaneous and lagged). Where appropriate, data transformation (usually the ln transformation) will be used to linearize data and bring homoscedasticity to the variances. Model parameters will be selected using a forward selection procedure based on the F-statistic with significance levels (P) for parameter entry and parameter removal set to 0.05 and 0.10, respectively. Where categorization of the response (Y) variable into two discrete groups is logical, with obvious breakpoints between the groups defined for the response variable, logistic regression analysis will be used to examine whether there were significant relationships between cell density levels (category, e.g., high vs low) and the environmental and water chemistry parameters (both contemporaneous and lagged samples). Stepwise logistic regression analysis will be used to screen variables and identify models. Model parameters will be selected using a forward selection procedure based on the likelihood ratio with significance levels for parameter entry and parameter removal set to 0.05 and 0.10, respectively. Significance will be determined using the chi-square statistic based on the likelihood ratio test. Competing models will be evaluated using Akaike's information criterion (AIC). Model classification accuracy will be assessed using naïve assignment.

All analyses will be provided in a final report to the NWIFC and EPA Project Managers. The report will include an introduction including the project goals and study design, methods, results and a discussion including whether the project goals were met, error analysis and areas of future research. Raw data will also be available in the final report or upon request.

5. References

EU-Harmonized Standard Operation Procedure for Determination of Lipophilic Marine Biotoxins in Molluscs by LC-MS/MS, Version 4; European Union Reference Laboratory for Marine Biotoxins (EU-RL-MB), Agencia Esponola de Seguridad Alimentaria y Nutricion (AESAN): Vigo, Spain, 2011. Available online: http://www.aesan.msps.es/CRLMB/docs/docs/metodos_analiticos_de_desarrollo/EU-Harmonised-SOP-LIPO-LCMSMS_Version4.pdf

Strickland, J.D.H. and T.R. Parsons. 1972. A practical handbook of seawater analyses. Bull. Fish. Res. Bd. Can. 167. 310 p.

Trainer, V.L.; Moore, L.; Bill, B.D.; Adams, N.G.; Harrington, N.; Borchert, J.; da Silva, D.A.M.; Eberhart, B.-T.L. Diarrhetic Shellfish Toxins and Other Lipophilic Toxins of Human Health Concern in Washington State. *Mar. Drugs* **2013**, *11*, 1815-1835.

UNESCO. 1994. Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements IOC Manual and Guides 29.

Valderrama. 1981. The simultaneous analysis of total nitrogen and total phosphorus on natural waters. *Mar.Chem.*10: 109-122.

Attachment 1 – Sample Alteration Form

Project Name and Number: _____

Sample Matrix: _____

Measurement Parameter: _____

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

_____

_____

Reason for Change in Field Procedure or Analysis Variation:

_____

_____

Variation from Field or Analytical Procedure:

_____

_____

Special Equipment, Materials or Personnel Required:

_____

_____

Initiators Name:_____ Date: _____

Project Officer:_____ Date: _____

QA Staff:_____ Date: _____

Attachment 2 – Corrective Action Form

Project Name and Number:_____

Sample Dates Involved:_____

Measurement Parameter:_____

Acceptable Data Range:_____

Problem Areas Requiring Corrective Action:__ _____

Measures Required to Correct Problem(s):

_____

Means of Detecting Problems and Verifying Correction:

_____

Initiators Name:_____ Date:_____

Project Officer:_____ Date: _____

Quality Staff:_____ Date: _____

Appendix 1: Standard Operating and QA/QC Procedures for University of Washington Marine Chemistry Laboratory

University of Washington
Marine Chemistry Lab
Oceanography Technical Services

ORGANIZATION OF THE QUALITY ASSURANCE MANUAL

Each analysis has its own specific sampling, QC, and analytical methods. It is important to see each analytical procedure as a whole, from sample bottle through data reduction. Therefore, the manual will have a general laboratory quality assurance section followed by sections for each analysis. Each analysis section will discuss the handling, analytical methods, quality control, and data reduction procedures specific to that chemistry.

The accredited analyses discussed in this manual are nutrients (o-phosphate, silicate, nitrate, nitrite, and ammonium), salinity, dissolved oxygen and particulate total and organic carbon, nitrogen, and hydrogen (CHN).

ORGANIZATION

The Marine Chemistry Lab (MCL) is part of the Oceanography Technical Services group at the School of Oceanography, University of Washington.

MCL provides seawater and freshwater analytical services to the University of Washington, the state of Washington, the national oceanographic and academic community, and, as allowed by UW policy, to the private sector.

As part of the Oceanography Technical Services team, MCL personnel participate in oceanographic research cruises worldwide. MCL provides technical expertise for and assists the faculty in training students in proper sampling and analytical procedures on shore and at sea.

PERSONNEL AND THEIR RESPONSIBILITIES

Katherine Ann Krogslund: Senior Oceanographer, Lab Manager and chief analyst

Ms. Krogslund is responsible for all aspects of work in the Marine Chemistry Lab. Administrative responsibilities include dealing with customers, supervising and training other lab personnel, implementing all lab safety protocols, preparing timesheets used by the financial officer to invoice customers for analytical services, establishing quality assurance/quality control protocols, and ordering most supplies and all major equipment.

Analytical responsibilities include supervising all analytical work done in the lab. All nutrient samples are analyzed by Ms. Krogslund using either the Technicon AutoAnalyzer II or the Alpkem RFA/2, the latter mostly at sea. As a member of the Oceanography Technical Services team she is responsible for preparing equipment and supplies to support oceanographic research operations by the UW faculty, staff, and students in their classes, labs, or at sea. When warranted, she is the primary nutrient chemist assigned to major research cruises. In addition to

the nutrient work, she analyzes salinity, oxygen, CHN, and TOC samples and is responsible for training students to use the respective analytical instruments.

A note on the use of the above mentioned analytical instruments by non-MCL personnel: these instruments were purchased by state or federal funds with joint faculty/staff/student use in mind. The Marine Chemistry Lab is responsible for training interested personnel (mostly graduate students) to use these instruments, particularly the oxygen titrators, the salinometers, and the TOC and CHN analyzers. We provide the supplies and maintenance for these machines. Nutrient analyzers are run only by MCL personnel.

James R. Postel: Senior Oceanographer, acting Manager of Oceanography Technical Services

Administrative responsibilities include preparing budgets for major research cruises involving the MCL, preparing hourly charge rates for lab personnel (yearly), and working with customers, especially those wanting CHN analyses.

Analytical responsibilities lie mainly with CHN and salinity analyses. Mr. Postel supervises the CHN analyses, including training for lab personnel and students, QA/QC protocols, and maintenance of the machine. In addition to running salinity samples, he assists Ms. Krogslund in training and maintenance of the salinometers. Mr. Postel is also the chief analyst of the enumeration and identification of marine phytoplankton (Utermöhl, 1931; Hasle, 1978), a non-accredited analytical service we offer.

As acting Manager of the Oceanography Technical Services team, he participates in the planning of, preparation for, and participating in major oceanographic field projects.

T. Aaron Morello: Oceanographer

Administrative duties include assisting the lab manager as needed.

Analytical responsibilities include running CHN and salinity analyses. Mr. Morello joined the lab in February 1998 and has been "learning the trade" since then. He assists other lab personnel as needed.

Mr. Morello is the chief analyst of phytoplankton pigments using high pressure liquid chromatography (HPLC), a non-accredited analytical service we offer.

REFERENCES

Hasle, G.R. (1978) Using the inverted microscope. In A. Sournia (ed.), *Phytoplankton Manual*: 191-196. Monographs on Oceanographic Methodology **6**. UNESCO, Paris.

Utermöhl, H. (1931) Neue Wege in der quantitativen Erfassung des Planktons (mit besonderer Berucksichtigung des Ultraplanktons). *Verh. int. Ver. theor. angew. Limnol*., **5**: 567-596.

Strickland, J.D.H. and T.R. Parsons. 1972. A practical handbook of seawater analyses. Bull. Fish. Res. Bd. Can. 167. 310 p.

POLICY FOR QUALITY ASSURANCE AND QUALITY CONTROL

The primary objective of the Marine Chemistry Lab is to provide our customers with consistently high quality, accurate data. Our customers provide samples from a wide range of aquatic environments, from pristine freshwater streams to lakes, estuaries, coastal and open ocean water, and anoxic saltwater basins like the Black Sea.

We provide the high quality analytical services our clients require by adhering to the methods described in this manual including proper sampling techniques, sample analysis, data reduction, and quality control procedures. As professional and contributing members of the research oceanographic community we employ methods widely used and accepted by oceanographers worldwide (e.g., UNESCO, 1994).

REFERENCES

UNESCO (1994) Protocols for the Joint Global Ocean Flux Study (JGOFS) core measurements. IOC Manual and Guides 29.

GENERAL LABORATORY QUALITY ASSURANCE

LABORATORY SAFETY

The Dept. of Environmental Health and Safety at the University of Washington requires every laboratory to complete a Laboratory Chemical Hygiene Plan (CHP). The CHP contains a detailed floor plan of the lab showing the locations of safety equipment (eyewash stations, emergency showers, and fire extinguishers) and chemical storage, standard operating procedures (SOPs) for hazardous chemicals, action plans for chemical spills, and a detailed plan to hazardous waste disposal. This CHP, a file containing material safety data sheets (MSDS) for all chemicals used in the laboratory and a Merck Index are kept in the lab and are easily accessible.

Safety inspections of the laboratory are done twice a year by EH&S and the Seattle Fire Department.

All MCL personnel are required to take the Laboratory Safety classes and the Fire Extinguisher classes offered by the UW Staff Training and Development Office.

Labcoats, safety glasses, and protective gloves are readily available in the lab.

REAGENTS

Water: Distilled deionized water (DIW) produced in the building's reverse osmosis system is piped directly into the lab. This water is further deionized by running it through two IWT® ionxchanger (model 2 research) columns. DIW is made fresh before use.

Chemicals: Only reagent grade chemicals are used, and in some cases only specific brands of chemicals are used; for example, Mallinckrodt sodium citrate cannot be used for the ammonium analysis because it produces a huge negative blank in seawater samples relative to DIW.

Each reagent is made up in its own designated volumetric flask to alleviate cross-contamination. Graduated cylinders used in reagent preparation are designated for that use only.

All primary standard chemicals are heated to 105˚C for at least two hours, then cooled and stored in a dessicator.

GLASSWARE AND PIPETTES

General use laboratory glassware is washed with a phosphate-free laboratory detergent and rinsed copiously with DIW.

Class "A" volumetric glassware is cleaned with chromic acid solution, then calibrated gravimetrically to determine its exact volume at 20˚C. All pipettes used in the preparation of standards are also calibrated.

The volumetric glassware is calibrated annually and before any long research cruises. Pipettes are calibrated every six months and before research cruises.

SAMPLE MANAGEMENT

No hazardous samples are accepted for analysis. Hazards include preservation with azides or mercuric chloride or samples that contain any radioactive tracer.

All samples accepted for analysis are logged on the MCL sample inventory form (Appendix A). Customers' logsheets or chain-of-custody forms must accompany the samples and include station and depth information. Bottle labels should not wash off or drip off when the sample is being thawed. MCL can provide appropriate sample bottles and supplies to customers on a rental (non-consumable items) or material issue (consumables) basis to assure that samples are collected and stored properly prior to analysis.

BALANCES

All of the analytical balances in the laboratory are maintained on a service contract with the UW Scientific Instrument Division. The balances are serviced and calibrated yearly. The Cahn electronic balance is recalibrated by the manufacturer every two years.

DATA STORAGE

All raw and final data are archived for at least 10 years. Final data are provided to the customer in hard copy and electronic formats (generally as Microsoft Excel spreadsheets).

STANDARD OPERATING PROCEDURE: NUTRIENT ANALYSES

Five major nutrients (o-phosphate, silicate, nitrate, nitrite, and ammonium) are analyzed in seawater or freshwater with a Technicon AutoAnalyzer II or Alpkem RFA/2 system.

CALIBRATION AND QUALITY CONTROL PROCEDURES FOR AutoAnalyzer II OPERATIONS

SAMPLE BOTTLES

Sample bottles are narrow mouth 60 ml Nalgene® HDPE bottles with a leakproof screw cap. The sample tray of the AutoAnalyzer II turntable has been modified to carry these bottles.

The bottles are cleaned after each use by rinsing with 10% HCl followed by several DIW rinses.

SAMPLE COLLECTION AND PRESERVATION

Samples are collected by rinsing the bottle and cap 3 times with sample and then filling the bottle no more than 2/3 full. Freshwater samples and samples with a high particulate content are filtered through 2.5 cm Whatman® GF/F glass microfibre filters (nominal pore size 0.7 μm) or Nalgene® surfactant-free cellulose acetate membrane filters (pore size 0.45 μm). Filtration is done in the field to avoid changes in the dissolved material that can occur during transportation and storage.

Samples are frozen upright as quickly as possible and stored in a freezer at -20˚C.

SAMPLE CONDITIONS

The first step to quality control is to make note of the sample conditions before analysis; have they been stored correctly, are there problems because of overfilling, do they contain H_2S, or do they contain particulates? Any problems are noted on the raw data sheet and on the data sheet header that goes to the customer.

Samples are thawed overnight in a refrigerated cold room. This method of thawing allows the silicate to depolymerize and the other nutrients to remain stable. Only one day's run of samples is thawed at a time.

REAGENTS

Consistency of methods is a key to good quality analyses. Each reagent is made up in its own designated volumetric flask to alleviate cross-contamination, especially concerning the ammonium reagents. Only reagent grade chemicals are used, and in some cases only specific brands of chemicals are used; for example, Mallinckrodt sodium citrate cannot be used for the ammonium analysis because it produces a huge negative blank in seawater samples relative to the DIW baseline. Every new batch of reagent is recorded in the lab notebook along with any surfactant added or pH adjustment. Graduated cylinders used in reagent preparation are designated for that use only. Fresh DIW is used for reagents and in the analytic stream of the AutoAnalyzer II.

SAMPLE RUNS

The AutoAnalyzer II is ready for a run when a clear non-noisy DIW+reagent baseline is established on each channel. Sample runs are usually 30-50 analyses long, including blanks, calibration standards, check standards (for QC), and samples (see Appendix G).

Working standards for calibration are made to match the expected concentrations and salinity of the samples. The ranges specified in each analytical method are linear (appendix B). At the minimum, a three-point standard curve is run containing a matrix blank plus two concentrations of standard that cover the sample range. If the concentration of the samples is expected to be wide (example: a deep-sea water column profile from 0 to 2000 m), then more standard concentrations are added to the curve.

Two check standards of concentrations different from those used in the standard curve are prepared using the same matrix water as that of the standards. These are the QC samples; their concentrations should reflect the lower and mid-high points in the analytical range. These check standards are monitored on a control chart (example, Appendix C).

Each run begins with a calibration standard curve (matrix blank, concentration 1, concentration 2, each in duplicate) followed by check standard. Samples follow the standards and QC usually grouped according to sampling stations and are arranged by increasing depth in the water column. Each station group is separated by a "lead-in" sample which is a duplicate of the first sample of the next group. This "lead-in" sample eliminates carryover between the typical high concentration sample from depth and the following low concentration surface sample. The second check standard, run in duplicate (the first of this duplicate serves as the "lead-in" sample), follows the samples. The run is finished with another calibration standard and matrix blank and allowed to go to baseline. Timing for each analysis is a 2-minute sample followed by a 40-second DIW wash.

Two sets of duplicate samples are run if enough water is provided by the customer. When at sea with an unlimited water supply and a 24-hour operation, customers are encouraged to take multiple samples at multiple depths to establish analytical precision at different concentration ranges. An example follows; the means and standard deviations for this data set are as follows:

	PO_4		$Si(OH)_4$		NO_3		NO_2		NH_4	
depth	mean	s	mean	s	mean	s	mean	s	mean	s
2 m n=5	1.79	.05	46.54	.01	19.60	.06	.35	.01	.74	.02
10 m n=5	1.97	.01	50.44	.33	21.76	.11	.36	.00	.77	.00
165 m n=10	1.72	.01	38.41	.31	17.79	.04	.25	.01	1.30	.02

All raw data (peak heights) are recorded in ink. Each raw data sheet contains the date, run ID, secondary standard batch ID, and analyst's initials. Beginning and ending factors are calculated and the data are entered onto an Excel spreadsheet which computes the final nutrient concentrations (see calculation equations, page 21).

NUTRIENT STANDARDIZATION PROTOCOLS

PREPARATION OF PRIMARY STANDARDS

Primary standards are prepared using precisely weighed (to 0.1 mg) primary standard chemicals (phosphate, silicate, nitrate, nitrite, ammonium) dissolved in deionized distilled water (DIW) and made up to accurately known volumes. The precise weights and volumes used are listed in the reagent sections of each nutrient chemistry. The weights of the standards are corrected to *in vacuo* using the buoyancy correction of the laboratory conditions. Each primary standard is made up separately and stored in a dark HDPE leakproof bottle in the refrigerator. It is identified by a sequential number and an "A" (i.e., 2A). New primary standards are made up every six months.

Concentrations of the primary standards are: 10.0 mM phosphate, 3.00 mM silicate, 100 mM nitrate, 10.0 mM nitrite, and 10.0 mM ammonium, respectively.

PREPARATION OF SECONDARY STANDARDS

A mixed secondary standard containing phosphate, nitrate, nitrite, and ammonium is made up monthly or as needed. Silicate is not included in the mixed secondary standard because the concentration varies over a wide range, especially in fresh water. Adding the primary silicate standard directly to the working (tertiary) standard gives the analyst more flexibility to choose the correct concentration range for the specific samples being analyzed.

The primary standards are allowed to come to room temperature. Separate aliquots of the phosphate, nitrate, nitrite, and ammonium standards are pipetted into a calibrated class "A" volumetric flask. The solution is brought to volume with DIW. The temperature and flask ID is noted. This secondary standard is dated, then coded using a sequential number and a "B". It is stored in a dark HDPE leakproof bottle in the refrigerator.

The typical concentrations of the secondary standard are 250 µM phosphate, 250 µM nitrite, 250 µM ammonium, and 3000 µM nitrate.

PREPARATION OF TERTIARY OR WORKING STANDARDS

Working standards are made up daily or at least every 4–6 hours when at sea. The standard matrix is made to match that of the samples. If freshwater samples are being run, the working standards are made up in DIW. Otherwise the matrix is matched to within 3 psu (practical salinity units) of the samples. Only filtered low nutrient natural seawater (LNSW) is used to make up standards. This seawater is collected at sea, stored in barrels, and is usually between 35–36 psu salinity. The LNSW is diluted with DIW to obtain other salinity matrices, i.e., standards of about 28 psu are used when running Puget Sound samples.

Aliquots from the silicate primary standard and the mixed secondary standard are combined and diluted with the appropriate matrix water in calibrated 250 ml "A" volumetric flasks. Concentrations of these working standards are adjusted to cover the expected range of the samples and to fall within the linear range of the analytical channel.

Typically the working standards are adjusted to fall within the following ranges: phosphate: 0–3 µM, silicate: 0–100 µM, nitrate: 0–40 µM, nitrite: 0–3 µM, ammonium: 0–3 µM.

CALIBRATION OF THE STANDARDS

Each new batch of primary standards, except for ammonium, is checked against the Marine Nutrients Standards Kit, available from Ocean Scientific International (OSI), containing certified nutrient standards and LNSW. A tertiary (working) standard in LNSW is made up using the new primary and secondary standards. The nutrient concentrations of this standard are 3.00 µM phosphate, 60.0 µM silicate, 39.0 µM nitrate, and 3.00 µM nitrite.

A second working standard in LNSW with the same nutrient concentrations is made up using the Marine Nutrients Standards Kit. The two standards are analyzed in the same run and the peak heights are compared. The peak heights should compare within .02 µM phosphate, .20 µM nitrate, .40 µM silicate, and .05 µM nitrite.

At this time there is no certified seawater standard for ammonium. On recent major research cruises (JGOFS), extensive cross-referencing between ammonium standards from Oregon State University, Texas A&M, Scripps Institution of Oceanography, and the University of Washington was done. All of these standards were in excellent agreement. The chemical lot of the University

of Washington standards is still in use. Commercially available ammonium calibration standards in DIW will be used for future comparisons.

New batches of "B" secondary standards are compared with the previous secondary standard. The responses (peak heights) must compare within .5% for phosphate, silicate, and nitrate and within 1% for nitrite and ammonium.

This lab has participated in the U.S. Environmental Protection Agency (EPA) Performance Evaluation program since 1990, which ends with the WP040 samples. We will continue the twice-yearly analysis of PE samples for phosphate, nitrite, nitrate, and ammonium with the ERA QuikResponse PE program offered by Environmental Resource Associates. Silicate PE samples will be obtained from Ocean Scientific International.

METHODS AND FLOW DIAGRAMS

This section contains detailed procedures for mixing reagents and flow diagrans showing the AutoAnalyzer II reagent stream pertinent to each of the following analyses:

o-phosphate, silicate, nitrate + nitrite, nitrite, ammonium

A description of the 5-channel AutoAnalyzer II system is found in Appendix H.

O-PHOSPHATE ANALYSIS

METHOD OUTLINE

O-Phosphate is analyzed using a modification of the Bernhardt and Wilhelms (1967) method. Ammonium molybdate is added to a water sample to produce phosphomolybdic acid, which is then reduced to phosphomolybdous acid (a blue compound) following the addition of dihydrazine (or hydrazine) sulfate. The sample is passed through a 50 mm flowcell and absorbance is measured at 820 nm.

REAGENTS

Ammonium molybdate

H_2SO_4 solution: Pour 420 ml of DIW into a 2 liter Ehrlenmeyer flask or beaker; place this flask or beaker into an ice bath. SLOWLY add 330 ml of concentrated H_2SO_4. This solution gets VERY HOT!! Cool in the ice bath. Make up as much as necessary in the above proportions.

stock: Dissolve 27 g ammonium molybdate in 250 ml of DIW. Bring to 1 liter volume with the cooled sulfuric acid solution. Add 0.1 ml Wiconate® surfactant. Store in a dark HDPE bottle and refrigerate.

working: Use stock as needed.

Dihydrazine sulfate

stock: Dissolve 6.4 g dihydrazine sulfate in DIW, bring to 1 liter volume with DIW and refrigerate.

working: Use stock as needed.

Note: Hydrazine sulfate may also be used. Dilute 10 g to 1 liter with DIW.

Primary Standard

.6804 g KH_2PO_4 in 500 ml DIW. Concentration = 10.0 mM.

The preparation of primary, secondary, and working standards is discussed on pages 9–11 of this section.

NUTRIENT CONCENTRATION CALCULATIONS

[UNESCO (1994), Whitledge et al. (1984)]

Nutrient concentration (in μM) = dilution factor {CF [sample peak height – (initial baseline + BC)]}

where CF = corrected factor = initial factor +

$$\left[\left(\frac{\text{sample sequence \#}}{\text{total \# samples}}\right)(\text{final factor} - \text{initial factor})\right]$$

and factor = $$\frac{\text{concentration of standard (in } \mu\text{M)}}{\text{average standard peak height} - \text{average standard blank peak height}}$$

Note that: initial factor = average of the factors for each calibration standard at the beginning of the run
final factor = average of the factors for each calibration standard at the end of the run

It is assumed that the change in the calibration factor is linear over the entire sample run.

BC = baseline correction =

$$\left[\left(\frac{\text{sample sequence \#}}{\text{total \# samples}}\right)(\text{final baseline} - \text{initial baseline}) + \text{refractive index}\right]$$

SIMULTANEOUS ANALYSIS OF TOTAL NITROGEN AND TOTAL PHOSPHOROUS IN NATURAL WATERS

METHOD OUTLINE

Total nitrogen and phosphorous are measured using a modification of the Valderrama (1981) method. The sample is treated with a potassium persulfate + boric acid reagent, digested in an autoclave, neutralized to pH 7, then analyzed for TN (as NO3) and TP (as PO4).

SAMPLE PREPARATION

20 ml of a well mixed sample is placed in a clean 60 ml wide mouth PP bottle. 2.6 ml of the peroxydisulfate/boric acid reagent is added and the sample bottle is loosely capped.

The samples are digested in an autoclave (100-120 degrees C) for 60 minutes (the actual cycle takes 90 minutes to allow for heating and a slow cool down). After the samples have cooled, 0.10 ml of 1M NaOH is added to neutralize the sample to pH 7.

The samples are analyzed using a Technicon Autoanalyzer II ; the automated method chemistries and flowcharts are described in the following section.

REAGENTS

Peroxydisulfate/boric acid solution (stock): in a clean 2000 ml volumetric flask, add 100g potassium peroxydisulfate (low N content essential; we use crystals from Alfa Aesar) and 60 g boric acid to 700 ml of 1M NaOH. Let stir for about 10 minutes to get dissolution started. Bring to 2 liter volume with DIW and stir until all crystals are dissolved. Store in 1 liter HDPE amber bottles at room temperature.

Total Nitrogen

For TN, a modification of the Armstrong et al (1967) procedure is used for the analysis of nitrate. A water sample is passed through a cadmium column where the nitrate is reduced to nitrite. This nitrite is then diazotized with sulfanilamide and coupled with N-(1-naphthyl)-ethylenediamine to form an azo dye. The sample is then passed through a 15mm flowcell and absorbance is measured at 540mm.

REAGENTS

Sulfanilamide

stock: Dissolve 10 g sulfanilamide in 1.2N HCl and bring to 1 liter volume with 1.2N HCl. Add 0.1 ml of 40% surfynol 465/485 surfactant. Store at room temperature in a dark HDPE bottle. The solution is stable indefinitely.
working: Use stock as needed.
N-(1-naphthyl)-ethylenediamine dihydrochloride (N-1-N)

stock: Dissolve 1 g N-1-N in DIW, bring to 1 liter volume with DIW. Add 0.1 ml 40% surfynol 465/485 surfactant. Store at room temperature in a dark HDPE bottle. Discard if the solution turns a reddish brown.
working: Use stock as needed.

Imidazole buffer

NOTE: Make the stock the day before use.

stock: Dissolve 13.6 g imidazole in 3.8 liters DIW. Stir for at least 30 minutes to completely dissolve. Add 60 ml of $CuSO_4$ + NH_4Cl mix (see below), bring solution to 4 liters volume with DIW. Using a calibrated pH meter, adjust to pH of 7.85 with 1.2N HCl (about 15 ml). Add 0.1 ml 40% surfynol 465/485 surfactant. Store at room temperature in a HDPE bottle. The solution is stable indefinitely.
working: Use stock as needed.

$CuSO_4$ + NH_4Cl mix

Dissolve 20 g cupric sulfate in DIW, bring to 1 liter volume with DIW (2% solution stock). Dissolve 250 g ammonium chloride in DIW, bring to 1 liter volume with DIW. Add 5 ml of 2% $CuSO_4$ solution to this NH_4Cl stock. Store at room temperature in a dark HDPE bottle. This solution is stable indefinitely.

The preparation of primary and working standards is discussed on pages 9–

CADMIUM COLUMNS

Processing the cadmium

Use cadmium granules approximately 2 mm in size. Place the necessary amount of cadmium in an oversized Erhlenmeyer flask to allow sufficient room for mixing and rinsing. Begin with several small rinses of the Cd with 2N HCl, stir with a stirring rod for a few minutes each rinse. Then rinse with DIW a few times, again using a glass stirring rod.

Rinse with 0.3N nitric acid; this pits the surface of the cadmium and increases the surface area. Rinse with DIW a few times.

Rinse a few times with 2N HCl again, then a few more rinses with DIW.

Add enough DIW to the cadmium to cover the granules, then begin adding 2% $CuSO_4$, a little at a time. Stir with a rod in between each addition, but do not decant. Keep adding until the solution remains slightly bluish in tone, and becomes slightly cloudy. This should be a slow, careful process. The cadmium should now be blackish with lots of particulates (broken-off pieces of cadmium). When preparing Cd for 5–7 columns, expect to use more than 400 ml of 2% $CuSO_4$ over the course of about 15 additions (a little at a time). Continue adding until the Cd particles develop the instant the $CuSO_4$ is added. This should be the last addition of $CuSO_4$.

The cadmium is now treated. Decant almost all of the solution from the cadmium, minimizing air exposure. Rinse and decant many times with DIW, use a stir rod during the rinses. Continue rinsing until the rinse water is no longer cloudy, and the cadmium appears dark, spotty, and grayish. During this entire procedure do not stir too vigorously to avoid breaking up the Cd granules.

Use an approximately 10–12 cm long, 6 mm diameter, glass tube with a 1 mm wall and a 4 mm ID. Pack the bottom with a small ball of glass wool and attach a nipple fitting to the bottom end with silicon tubing. Cap this fitting off with a piece of tied-off tygon tubing. Attach a small funnel to the top of the column. Fill the column and funnel with a 50% imidazole buffer solution and load the cadmium into the column. Tap gently to settle the Cd and fill until there is no dead space. Remove the funnel and insert a wetted wad of glass wool. Cap off with the appropriate nipple fitting and silicon tubing. Cap top end with tied-off tygon tubing. Store immersed in 50% imidazole buffer solution until ready to go on the NO_3 channel.

Priming the column

The column needs to be primed whenever it is new or has been topped off with new granules. If the column is not primed, the response may not be stable. For a new column, prime by running about 200 ml of 50 µM NO_3 standard through the system with the column on. Flush the column afterward by running imidazole buffer and DIW through the system for 30–45 minutes. If the column has just been topped off, run 100 ml of 25–50 µM standard through the system, then flush by running imidazole buffer and DIW through the system for about 30 minutes.

Topping off

It is very important to keep the column full of cadmium to minimize dead space. As samples are run, the cadmium volume will be reduced through use and settling. This dead space *will affect the data*. To top off the column, turn the AutoAnalyzer on and the column off. Tap the column gently to get the maximum settling. Remove the tubing cap and the glass wool from the top of the column. Attach a funnel to the top of the column and fill with buffer solution using a syringe. With a spatula, transfer prepared Cd granules to the column via the funnel, tap with a pencil, and continue filling. Leave enough space for the glass wool. Remove the excess buffer in the funnel with a syringe, remove the funnel, and insert a wetted wad of glass wool in the top of the column. Reconnect the tubing cap, turn on the column to flush the cadmium, and then prime the column.

Cadmium column efficiency

The cadmium column efficiency for reducing nitrate to nitrite is not always 100%; therefore, comparisons need to be made regularly, especially with a new column or one just topped off. While an efficiency of 100% is ideal, an efficiency of less than 100% may not have any significant effect on the accuracy of the nitrate determinations. The check standards that are analyzed during each sample run provide a measure of the accuracy of the analysis.

Prepare a 30 µM nitrite standard and a 30 µM nitrate standard. Run at least four of each, alternating one after the other through the NO_3 channel with the Cd column on. Measure the peak heights and calculate the percentage efficiency; NO_3 peak height ÷ NO_2 peak height = % efficiency.

Total Phosphorous

TP is measured as PO4 using an automated version of the Murphy and Riley (1962) procedure. Phosphate is determined as phosphmolybdic acid which in its reduced form in the presence of antimony has an absorption maximum at 880nm.

REAGENTS

Ascorbic acid (stock solution): 6.0 g of L-(+)-ascorbic acid is dissolved in 100 ml of DIW. 100 ml of reagent grade acetone is added and the solution is mixed well. The stock is stored in a dark HDPE bottle in the refrigerator
Running solution: 40 ml of the stock solution is mixed with 200 ml of DIW. This reagent is made daily.

Ammonium molybdate/antimony solution (stock): dissolve 34.0g ammonium molybdate, 4-hydrate in 1 liter of DIW. Slowly add 400 ml of conc H2SO4. Let this solution cool over ice. Dissolve 0.250g potassium antimony tartarate in about 50 ml of DIW and add to acid solution. Add 2500 ml of DIW. Add 0.5 ml Wiconate surfactant to the final solution. Store in a HDPE jug at room temperature.
Running solution: use stock as needed.

STANDARDS

A mixed primary standard is prepared by dissolving .4354g K2HPO4 and 7.445g EDTA in 500 ml DIW. Final concentration of this standard is 5.0 mM phosphorous and 80.0 nM nitrogen.

A secondary standard is prepared using 0.2ml primary standard to 200 ml DIW or low nutrient seawater (LNSW). A standard curve is created using this secondary standard; 1ml standard brought to 20 ml with DIW or LNSW equals 0.25uM P and 4 uM N.

QA/QC

A QC standard from Environmental Resource Associates is used to prepare a check standard. This standard has a known concentration of both TN and TP. It is diluted using the same water as the secondary standard (described above) to obtain concentrations falling in the middle of the standard curve.

This check standard is run at the end of every sample run. Control charts are maintained to assess drift of this check standard.

Since TNP samples are a set volume (20 ml), customers must provide additional separate samples if they want to assess sampling/analytical precision for their specific project.

Appendix 2: Washington State Public Health Laboratory, Standard Operating Procedure for the HPLC-MS/MS Method For Diarrhetic Shellfish Toxins

INTRODUCTION and METHOD SUMMARY:

This method is used to determine the identity and quantity of several Lipophilic toxins, including Okadaic Acid (OA), Dinophysis Toxins (DTX-1, -2, -3) and related esters. It can be expanded to analyze for Azaspiracid Shellfish Poisons (AZP), Pectenotoxins (PTX#), and Spirolides. At this time the major regµLatory concern is with OA(Okadaic Acid), DTX1 and DTX2 (Dinophysis toxins) and related Esters. The microorganisms that produce the other toxins have not been found in the waters of Washington to date. The OA and DTX toxins are found in mussels and clams along the salt water coast of Washington.

All the animal tissue is removed and homogenized for analysis. The extraction procedure uses methanol (MeOH). The extract is hydrolyzed with an alkaline compound (NaOH) solution at elevated temperature, then neutralized. The hydrolized product is allowed to evaporate nearly to dryness, then reconstituted with MeOH.

The HPLC is configured for a binary mobile phase program and a C8(2), 50mm X 2mm ID, 5uM Luna column from Phenomenex. Mobile phase flow rate is 0.4 mL/min. OA elutes at about 6 min and DTX1 elutes at about 8 minutes and DTX2 elutes at about 6.3minutes under our HPLC program (specified in the recent research papers).

SAFETY AND PROTECTIVE EQUIPMENT

This procedure uses a strong acid, formic acid, and a strong alkali, sodium hydroxide (lye). This procedure also uses volatile solvents (MeOH and Acetonitrile). Preparations using these materials should be performed within a Chemical Fume Hood.

This procedure uses a high-speed blender for homogenization. Use the equipment according to manufacturer's instructions to avoid injury.

PPE for this procedure includes, at minimum:

- Lab coat
- Close toe shoes
- Safety glasses
- Nitrile gloves

EQUIPMENT and SUPPLIES:

Turax Disruptor/Homogenizer
Centrifuge
Turbovap Evaporation Station
Agilent 1200 or 1290 High Performance Liquid Chromatograph
Agilent 6430 Triple Quadrupole Mass Spectrometer

Tissue collection basket
Shellfish shucking tools
50 mL polypropylene centrifuge tubes
Pipettes
16x100mm disposable glass culture tubes
3 mL disposable luer lock syringes
0.2 µm luer lock disk filters
2 mL HPLC sample vials

REAGENTS:

NRC (Canada) Certified Standards (Okadaic Acid, Dinophysis Toxins 1 and 2)
HPLC-grade Methanol
HPLC-grade Acetonitrile
18 MΩ Deionized Water (Reagent Water)
Sodium Hydroxide
Hydrochloric Acid
Formic Acid
Ammonium Formate

Pre Analytical

Reagent Preparation

2.5 M NaOH – place 10.0 g solid reagent grade NaOH in a 100 mL volumetric flask. Fill to ~60 mL with Reagent Water and dissolve all solids. Fill to mark with Reagent Water. Place in storage container, label, and store at room temperature for 1 year.

2.5 M HCl – fill a 100 mL flask to ~60 mL with Reagent Water. Slowly add 25 mL concentrated HCl (~36.5% = 10 M). Fill to mark with Reagent Water. Place in proper storage container, label, and store at room temperature for 1 year.

50 mM Formic Acid, 2 mM Ammonium Formate in Water Mobile Phase – Weigh 0.13 g ammonium formate. Add ammonium formate to a 1 L volumetric flask, then fill with ~600 mL Reagent Water. Add 1950 µL 97% high purity formic acid to the volumetric. Fill to mark with Reagent Water. Place in Mobile Phase "A" container.

Acetonitrile/50 mM Formic Acid, 2 mM Ammonium Formate solution Mobile Phase – fill a 1 L volumetric flask with ~500 mL HPLC grade acetonitrile. Add 50 mL of the 50 mM Formic Acid, 2 mM Ammonium Formate in Water Mobile Phase solution (above). Fill to mark with acetonitrile. Place in Mobile Phase "B" container.

QUALITY CONTROL

Quality Control standards (QCs) are prepared from the NRC standards. The standards are spiked individually into blank mussel tissue which is extracted and processed the same as the unknown samples. The values in the table are for example only. Each lot of the certified standards may not have the same starting concentration of analyte.

Analyte	OA	DTX-1	DTX-2
High Intermediate Standard Conc (40:1 individual dillution from standard ampoule)	356 µg/L	379 µg/L	195 µg/L
Blank Tissue	2.5 g		
Standard spike, QCL	105 µL	99 µL	106 µL
Standard spike, QCM	562 µL	594 µL	577 µL
Standard spike, QCH	1124 µL	1187 µL	1154 µL
Expectec conc, QCL	15 µg/L	15 µg/L	8 µg/L
Expectec conc, QCM	80 µg/L	90 µg/L	45 µg/L
Expectec conc, QCH	160 µg/L	180 µg/L	90 µg/L

The process yields 2 mL of each QC standard which is viable for 3 days. They can be frozen and used in more than one batch, should production require it.

The QCs are inserted in the sample schedule directly after the calibration curve and after each batch of 25 unknowns run on that calibration curve.

CALIBRATION

Mixed calibration standards are prepared in Reagent Methanol. Preparation is described in the table. The values below are for example only. Each lot of the certified standards may not have the same starting concentration of analyte.

Analyte				OA	DTX-1	DTX-2
Standard Concs as received				14,240 µg/L	15,160 µg/L	7,800 µg/L
Dillute 0.5 mL each from ampoule into MeOH to				20 mL		
High Intermediate Standard Conc				356 µg/L	379 µg/L	195 µg/L
Dillute 1 mL High Intermediate Standard to				10 mL		
Low Intermediate Standard Conc				35.6 µg/L	37.9 µg/L	19.5 µg/L
Cal 1	141 µL	Low IS	859 µL MeOH	5.0 µg/L	5.3 µg/L	2.7 µg/L
Cal 2	281 µL	Low IS	719 µL MeOH	10.0 µg/L	10.6 µg/L	5.5 µg/L
Cal 3	562 µL	Low IS	438 µL MeOH	20.0 µg/L	21.3 µg/L	11.0 µg/L
Cal 4	125 µL	High IS	875 µL MeOH	44.5 µg/l	47.4 µg/L	24.4 µg/L
Cal 5	250 µL	High IS	750 µL MeOH	89.0 µg/L	94.8 µg/L	48.8 µg/L
Cal 6	500 µL	High IS	500 µL MeOH	178 µg/L	189.5 µg/L	97.5 µg/L

The process yields 1 mL of each standard, which is viable for 1 week. The standards should be kept refrigerated between uses.

Analytical

Extraction

1. After shucking shellfish samples, collect whole tissues in wire basket and drain off salt-water.
2. Place combined tissues in blender and homogenize for 1 minute.
3. Accurately weigh 2.5 g tissue into 50 mL capped, conical plastic centrifuge tube.
4. Extract the first 2.5 g sample by adding 12mL of 100% MeOH and vortexing (vigorously) for 3 minutes. Centrifuge at 4,500 RPM for 20 min. at 10 C. Transfer supernate to a 25 mL volumetric flask.
5. The second extraction is performed with 12 mL of 100% MeOH and 1 minute of homogenization with a 14,000 RPM µLtra-Turrax tissue disrupter. Centrifuge at 4,500 RPM for 20 minutes and transfer the supernate to the same volumetric containing the first extract.
6. Make up volume to 25.0 mL with pure MeOH and mix well.

Hydrolysis

1. Transfer 5.0 mL of extract, from 25.0 mL volumetric, to a 16x100 mm disposable screw-cap culture tube.
2. Add 625 µL of 2.5M NaOH solution to the 5.0 mL of extract. Cap and mix on vortex mixer for 30 sec.
3. Place all hydrolysis tubes in 76°C, temperature-controlled oven for 40 minutes.("Circ-O-therm" oven or equivalent)
4. Cool hydrolysate tubes in ice bath, open and add 625 µL of 2.5M HCl to neutralize the NaOH solution.
5. Cap and vortex for 30 sec.
6. Uncap tubes and place in Turbovap for 15min at 76°C with nitrogen at 13 psi. (blow down just to dryness)
7. Bring volume up to 2.0 mL with pure MeOH

Final sample preparation for HPLC-MS/MS instrument

1. Each 2.0 mL samples are pulled into a 3mL syringe and filtered through 0.2 µm disk filters into labeld 2 mL HPLC injection vials. The filtrates are loaded into a 54-vial tray for use in the HPLC.

<u>HPLC/TRIPLE-QUADRUPOLE TANDEM MASS SPECTROMETER ANALYSIS</u>

HPLC Conditions
Load Agilent Mass Hunter Data Acquisition
Method Name: "**Multitox_HR_(latest date YYMMDD).m**"
1. Column: A binary mobile phase program is used with the 50mm X 2mm ID, 5 µM C-8(2) Phenomenex Luna column, which is fitted with a 0.2 µm filter/C-8(2) guard column.
   Program: Channel "A" = 2mM Ammonium Formate + 50mM Formic Acid in DI water.

Channel "B" = 95% v/vAcetonitrile: 5% v/v Reagent Water water containing 2mM Ammonium Formate + 50mM Formic Acid.

2. Mobile Phase flow: 0.4 mL/minute
3. Pump Program: Stop Time 20 minutes
   Time = 0 min 20% "B"/ 80% "A" (START of RUN, START of RAMP)
   Time = 7 min 80% "B"/ 20% "A" (END RAMP, BEGIN HOLD)
   Time = 14 min 80% "B"/ 20% "A" (END of HOLD)
   Time = 14.5 min 20% "B"/ 80% "A" (Return Ramp)
   Time = 20 min 20% "B"/ 80% "A" (END of RUN)
4. Injection size is 10µL, Draw speed 200, Ejection speed 200
5. Needle wash is 5 sec.
6. HPLC column temperature is 40 C.
7. Refer to attached Agilent software for remaining instrument control and data processing requirements.

Mass Spectrometer Settings
Ion Source: ESI
Stop: with pump
Tune File: atunes.tune.xml
Time segments:

Index	Time (min)	Scan Type	Ion Mode	Div Valve	Delta EMV	Store
1	0	MRM	ESI	to Waste	0	No
2	4	MRM	ESI	to MS	600	Yes
3	14.5	MRM	ESI	to Waste	0	No

Scan Segments for Time Index 1:

Cpd	ISTD	MS1 Prec Ion	MS2 Prod Ion	Dwell	Frag	CE	Cell Acc	Polarity
DA	No	312.2	221.1	100	150	25	3	Pos
DA	No	312.2	161.1	100	150	25	3	Pos

Source Parameters for Time Index 1

Parameter	Positive mode	Negative mode
Gas Temperature, C	350	350
Gas Flow, L/min	11.5	11.5
Nebulizer, psi	39	39
Capillary, V	2800	4200

Time Index segments are continued on the next page.

Scan Segments for Time Index 2:

Cpd	ISTD	MS1 Prec Ion (wide)	MS2 Prod Ion (unit)	Dwell	Frag	CE	Cell Acc	Polarity
DTX-1	No	**817.5**	**255.2**	60	300	52	3	Neg
DTX-1	No	**817.5**	**113.1**	60	300	66	3	Neg
OA/DTX-2	No	**803.5**	**255.2**	60	300	52	3	Neg
OA/DTX-2	No	**803.5**	**113.1**	60	300	66	3	Neg

Source Parameters for Time Index 2

Parameter	Positive mode	Negative mode
Gas Temperature, C	350	350
Gas Flow, L/min	11.5	11.5
Nebulizer, psi	39	39
Capillary, V	2800	4200

Scan Segments for Time Index 3:

Cpd	ISTD	MS1 Prec Ion	MS2 Prod Ion	Dwell	Frag	CE	Cell Acc	Polarity
Waste	No	200	221.1	200	135	0	7	Pos

Source Parameters for Time Index 3

Parameter	Positive mode	Negative mode
Gas Temperature, C	350	350
Gas Flow, L/min	11.5	11.5
Nebulizer, psi	39	39
Capillary, V	2800	4200

Post Analytical

QUANTITATION

Load Agilent Mass Hunter QQQ Quantitation = **120914_DSP_NewQuant.quantmethod.xml**. Load Quantitation Method and quantitate standard sample chromatographs. On the Total Ion Chromatograph (TIC) the compound peaks should appear in the respective Retention Time (RT) ranges:

Compound	OA	DTX-2	DTX-1
RT Range (minutes)	6.1 – 6.2	6.4 – 6.5	7.2 – 7.3

Inspect and, if necessary, edit each peak integration in the Calibration Curve. The plot should have a minimum 0.990 correlation coefficient (R^2). At most one calibrant point may be dropped to achieve this R^2 value.

Calculations

Once calibrated, the instrument displays quantitated data in µg/L = ppb. The regulatory action level is in terms of the unweighted sum of all three toxins is 16 µg/100g tissue. The conversion of the instrument concentrations to the action level units is performed as follows:

Reported value (µg/100g tissue) =
Instrument value OA (µg/L) * 2.5 / 10 +
Instrument value DTX-1 (µg/L) * 2.5 / 10 +
Instrument value DTX-2 (µg/L) * 2.5 / 10

Evaluate the Quality Control samples. Plot their values on the appropriate QC Control Chart (there is one for each analyte and each QC level, 9 total) on the Instrument Network in the DSP folder of the ELS directory. The chart contains the latest 20 QC values. The rules for acceptable QCs are:

- No value outside 3 sigma;
- No consecutive values outside 2 sigma;
- Fewer than 10 consecutive values on either side of the rolling average;
- No consecutive values more than 4 sigma apart.

If a QC sample fails one of these rules, then the batch of unknowns is rejected and must be rerun. Evaluate the integration of the unknown samples and quantitate. If the Report Value of the sum of toxins in a sample is over 12 µg/100g meat, extract another sample from the homogenate and run the sample a second time.

Report

Report sample values on StarLIMS and on the Shellfish database to one decimal place.

Quality Assurance Project Plan

Investigation of Nutrients and Phytoplankton in Admiralty Inlet and Northern Hood Canal

January 2021

NTA 2018-0295

Publication Information

Each study funded by the U.S. Environmental Protection Agency (EPA) must have an approved Quality Assurance Project Plan (QAPP). The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, the author will post the final report of the study to the Salish Sea Marine Survival Projects (SSMSP) and Jamestown S'Klallam Tribe's website. This QAPP describes a project selected by the EPA's National Estuary Program (NEP) in support of Near-Term Action (NTA) 2018-0295. This work is funded by WDFW Grant number 20-15465.

This Quality Assurance Project Plan is available by request from the author at nharrington@jamestowntribe.org.

Data for this project are available in EPA's Water Quality Exchange (WQX) database (https://www.epa.gov/waterdata/water-quality-data-wqx). This QAPP is valid through December 31, 2024.

Contact Information

Neil Harrington
Jamestown S'Klallam Tribe
1033 Old Blyn Hwy, Sequim WA 98382
Phone: (360) 681-4634

COVER PHOTO: Retrieving a phytoplankton net. PHOTO BY ROY CLARK

Quality Assurance Project Plan

Investigation of nutrients and phytoplankton in Admiralty Inlet and Hood Canal

NTA 2018-0295

By Neil Harrington

Published January 2021

Approved by:

Signature:	Date:
Neil Harrington, Environmental Biologist, Jamestown S'Klallam Tribe Signature:	Date:
Robert Knapp, Environmental Planning Manager, Jamestown S'Klallam Tribe Signature:	Date:
Aaron Morello, Oceanographer, University of Washington Signature:	Date:
Cynthia Catton, Habitat Strategic Initiative, Department of Natural Resources Signature:	Date:
Arati Kaza, Quality Assurance Officer, Department of Ecology	

1.0 Table of Contents

List of Figures

List of Tables

2.0 Abstract

While the mid trophic levels of zooplankton and forage fish are currently being studied with relation to salmon survival in the Salish Sea, limited attention has been paid to the role that phytoplankton have in supporting these mid- trophic levels. In addition, harmful algal blooms (HABs) can have a direct impact on salmon survival. This pilot study will add a phytoplankton and nutrient component to two sites that are regularly sampled for zooplankton as part of the Salish Sea Marine Survival Project (SSMSP) in an attempt to ascertain the effects of phytoplankton on the zooplankton community (bottom up impacts on salmon survival) as well as the presence of HABs that may directly affect salmon survival (top down impacts). Nutrient samples will also be taken and will shed light on this important driver of primary productivity. One site in Admiralty Inlet and one site in northern Hood Canal will be monitored bi-weekly during the 2021 sampling season and results will be integrated with zooplankton and oceanographic data collected by the Port Gamble S'Klallam Tribe (PGST) and Washington Department of Fish and Wildlife (WDFW) to build a more robust picture of the ecosystem that salmon face in migrating from their natal steams.

3.0 Background

3.1 Introduction and problem statement

Juvenile salmon growth in the marine environment is directly related to their survival and success in the ocean and eventual return to their natal streams (Davis et al., 2020). Studies are underway to understand the environment that juvenile salmon face in the Salish Sea as they out-migrate. There is a coordinated effort to understand and monitor for zooplankton at fourteen sites in Puget Sound and the Southern Georgia Strait by the SSMSP. While we are gaining an understanding of the potential zooplankton prey field that salmon encounter as juveniles, we lack an understanding of the phytoplankton "forage" these zooplankton graze on. In additional to understanding the diet of zooplankton, phytoplankton can also be directly toxic or deleterious to juvenile salmon. For example, *Heterosigma akashiwo* blooms in the Salish Sea are well known to cause mortality in farmed salmon and may also be causing mortality or impairment in wild salmon populations (Esenkulova et al., 2014; Rensel, 2007). This study aims to close these knowledge gaps at the base of the food web and gauge the potential impact of HABs on migrating salmon. See section 4 for specific hypotheses related to this study.

3.2 Study area and surroundings

The study area includes the marine waters of Admiralty Inlet and northern Hood Canal as typified by sampling stations off the south end of Marrowstone Island (ADI) and in Thorndyke Bay (TDB) (Map 1). These areas are marine waters that see large tidal fluxes and the underlying

topography is glacial fjord-like systems with both sample sites greater than 100 meters in depth. Admiralty Inlet is the primary waterway that connects the Puget Sound to the Strait of Juan de Fuca and the hence the Pacific Ocean, therefore nearly all the salmon from the rivers that flow into Puget Sound need to pass through Admiralty Inlet. Hood Canal is a fjord whose watersheds include extensive salmon and steelhead producing streams flowing off the east side of the Olympic Mountains and the western Kitsap Peninsula.

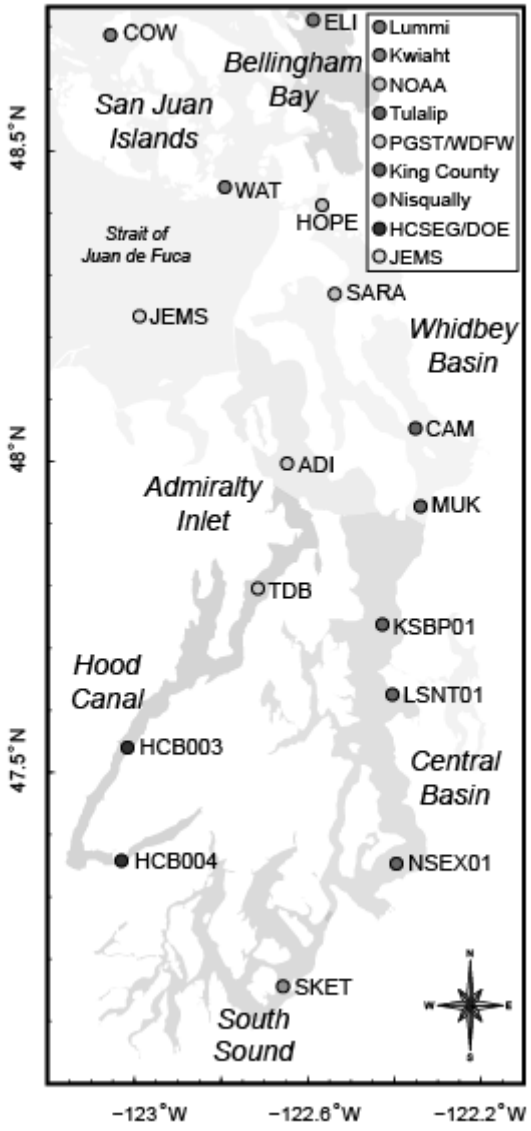


Figure 1. Map of larger study area. (from Keister 2017)

The two sites sampled for phytoplankton and nutrients will be ADI (Admiralty Inlet) and TDB (Thorndyke Bay in northern Hood Canal). Both lie in major migratory corridors for salmon leaving and entering Puget Sound and Hood Canal respectively.

3.2.1 History of study area

Admiralty Inlet and northern Hood Canal are important migratory corridors for salmon entering Puget Sound and Hood Canal. The conversion of forest to agriculture and urbanization, poor forest practices, water diversions, shoreline armoring, overfishing, and dams have all taken a toll on watershed health and salmon populations in the Puget Sound watershed. Increases in nutrient inputs and urbanization in the Puget Sound region may be negatively impacting food webs that salmon rely on and be leading to the relative abundance of jellyfish versus forage fish (Greene et al., 2015).

3.2.2 Summary of previous studies and existing data

The Port Gamble S'Klallam Tribe and WDFW have collected zooplankton and CTD data from ADI and TDB since early 2015. Washington Sea Grant volunteers have collected Sound Toxins phytoplankton data at Hood Head (one year), Fort Worden (15 years) and Port Gamble (7 years). While these Sound Toxins sites are in the same waterbodies they are located at least several kilometers away from the zooplankton monitoring locations. Data comparibility is difficult, as the Sound Toxins sites are nearshore, where sampling is done off docks in several meters of water rather then the zooplankton sites which are in water about 100 meters deep.

3.2.3 Parameters of interest and potential sources

We will be characterizing the phytoplankton community at discrete depths and collecting nutrient samples (nitrate, nitrite, ammonium, silicate, phosphate, and total nitrogen and phosphorus) via whole water sampling with a niskin bottle and taking a 15m vertical phytoplankton (20µm mesh) net tow.

In addition, other data and samples are collected at each site by our project partners: oceanographic data (temperature, salinity, dissolved oxygen, and chlorophyll by depth) with a CTD sampler as well as zooplankton net tows. Two zooplankton tows are completed: a deep vertical tow (to 100m or so) and an oblique tow to 30m at each site. Zooplankton samples are preserved and later speciated and enumerated to determine the abundance of each taxon.

3.2.4 Regulatory criteria or standards

Not applicable- we will not be assessing regulatory criteria.

3.3 Water quality impairment studies

Not applicable - this is not a water quality impairment study. However, this study may inform decisions related to the fate of nutrients in Puget Sound and the impact of nutrients on the food web.

3.4 Effectiveness monitoring studies

Not applicable

4.0 Project Description

4.1 Project goals

The reason for adding nutrient and phytoplankton data to the Salish Sea Marine Survival Project is to better understand how the prevalence of harmful algal blooms (HABs) and phytoplankton at the base of the food web impact salmon survival. This project will pilot expanding the Zooplankton Monitoring Program to include nutrients and phytoplankton at two sites – Thorndyke Bay in northern Hood Canal and Admiralty Inlet. The overall goals are:

- Determine feasibility for integrating nutrient and phytoplankton sampling and analysis into the existing Zooplankton Monitoring Program.
- Provide baseline data on seasonality of phytoplankton genera and nutrients for Hood Canal and Admiralty Inlet to support future evaluation of salmon food web dynamics and impacts of future restoration actions that may influence nutrient loading to the Salish Sea.

This project seeks to find a path forward in addressing some of the data needs for the following hypotheses of the SSMSP:

1. Harmful algae directly affect salmon survival through acute or chronic toxicity or gill damage.
2. Direct mortality increases as prevalence and intensity of *Heterosigma* and other harmful algae increase.
3. Harmful algae impoverish the food web and salmon prey, which may indirectly affect salmon survival.
4. The timing, duration, quantity, spatial extent, and/or composition/quality of zooplankton are constrained by competition for primary producers of high and low (i.e. harmful algae) nutritional value.

The first step to understanding if HABs are affecting salmon is knowing to what extent they are present in the first place. This project will generate a data set that will directly address hypotheses three and four above and inform the first two hypotheses since this project does not directly sample salmon.

4.2 Project objectives

This project will couple our sampling with the twice monthly zooplankton monitoring work at two stations that are part of the Salish Sea Marine Survival Project zooplankton monitoring network: ADI southeast of Marrowstone Island in Admiralty Inlet and TDB west of the Thorndyke Creek estuary in Hood Canal.

In specific, water will be collected from two depths twice per month between February and October (18 sampling events x 2 samples x 2 sites) for:

- Phytoplankton will be identified to genus level and harmful and potentially harmful species will be enumerated
- Analyses of dissolved nutrients (ammonium, nitrite, nitrate, silicate, and phosphate) and total nitrogen and phosphorus.

A phytoplankton net tow will also be taken from the top 10 meters to get a sample of the full range of species diversity of phytoplankton (a net tow can capture phytoplankton species present in lower densities that may be missed in a whole water sample).

Additional data collected by project partners include the deployment of a temperature/ conductivity/ chlorophyll/ depth (CTD) sensor which will also characterize the upper 30 meters of the water column by generating continuous data on temperature, salinity, dissolved oxygen and chlorophyll (see Appendix I for details) and zooplankton tows which will generate data on the abundance of zooplankton (Keister, 2017). As the zooplankton samples are preserved and analyzed at later date it is not expected that those data will be available during the timeframe of the writing of the technical report for this project.

4.3 Information needed and sources

Existing data include the CTD cast data that is currently collected with the zooplankton samples. We will also review zooplankton data for these stations and others in the network over the past four years. This work conducted by project partners follows agreed upon, standardized SOPs. Other pertinent information includes review of Sound Toxins data at the Hood Head, Fort Worden, and Port Gamble sampling sites. These data include the presence and density of harmful algal species, the relative abundance of phytoplankton down to at least the genus level, water temperature and salinity.

New data will be information on phytoplankton at stations ADI and TDB over the course of a sampling year. Information collected will be species diversity down to at least the genus level, cell densities of harmful and potentially harmful species. A harmful species is defined as creating biotoxins or otherwise having a record of harming salmonids. An estimate of the relative abundance of major taxa (i.e. diatoms or dinoflagellates) will also be generated.

Nutrient concentrations for nitrate, nitrite, ammonium, silicate, and phosphate as well as total nitrogen and phosphorus will also be determined for the two stations at two depths in the upper water column where most primary productivity and juvenile salmon occur.

4.4 Tasks required

Tasks required:

At each of the stations twice a month February through October:

- Phytoplankton net tow to 10m, fresh sample analyzed and formalin preserved samples kept

- Whole water samples from 1m and 8m taken with a niskin bottle.
    - Whole water samples preserved with formalin for phytoplankton analysis
    - Whole water samples filtered for nutrient analysis per University of Washington (UW) protocols
- Phytoplankton net tow and concentrated whole water samples will be analyzed by light microscopy.

4.5 Systematic planning process

This QAPP suffices in terms of planning for this pilot project.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 1 shows the responsibilities of those who will be involved in this project.

Table 1. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Neil Harrington Jamestown S'Klallam Tribe Phone: (360)460-9304	Project Manager and Principle Investigator	Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Analyses phytoplankton samples. Conducts QA review of data, analyzes and interprets data, and enters data into WQX. Writes the draft report and final report.
Robert Knapp Jamestown S'Klallam Tribe Phone: (360)460-9304	Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Aaron Morello University of Washington Phone: (206) 543-9235	Oceanographer and lab director	Reviews the draft QAPP and recommends the final QAPP for approval with a focus on the nutrient lab analyses
Britta Voss Department of Ecology Phone: 360-407-6070	NEP Quality Coordinator	Reviews the draft QAPP and recommends the final QAPP for approval.
Arati Kaza Department of Ecology Phone: 360-407-6964	Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

QAPP: Quality Assurance Project Plan
NEP: National Estuary Program
WQX: Water Quality Exchange

5.2 Special training and certifications

Neil Harrington, the lead investigator on this project has eight years of experience working on phytoplankton and nutrient issues in his role as an environmental biologist with the Jamestown S'Klallam Tribe (JST). He worked on similar nearshore projects with phytoplankton, HABs and nutrients for JST in Sequim Bay and also represented the Tribe on the National HAB Committee from 2017 to 2020. Previous to working for JST, he was the water quality manager for Jefferson County and a shellfish biologist for the Port Gamble S'Klallam Tribe. He earned a Master of Science in Biological Oceanography and a BA in Biology from University of California, Santa Cruz.

Staff from PGST and WDFW may sample for JST, if we are not able to join a sample cruise. They will be trained in the field sampling procedures in Appendix C in a runthrough of the procedures with the sample gear and supplies provided, such as the niskin sample bottle and phytoplankton net as well as the proper procedures of taking samples and filtering nutrient samples.

5.3 Organization chart

Not applicable - See Table 1

5.4 Proposed project schedule

Table 2. Schedule for completing field and laboratory work

Task	Due date	Lead staff
Plankton cruises	October 2021	Neil Harrington
Laboratory analyses of phytoplankton samples	November 2021	Neil Harrington
Nutrient analyes by UW Oceanography Lab	November 2021	Aaron Morello

Table 3. Schedule for data entry

Task	Due date	Lead staff
WQX data loaded	December 31,2021	Neil Harrington
WQX QA	March 15, 2021	Neil Harrington
WQX complete	March 15, 2021	Neil Harrington

WQX: Water Quality Exchange

Table 4. Schedule for final report

Task	Due date	Lead staff
Draft to supervisor	December 15, 2021	Neil Harrington
Draft to SIL and peer reviewers	January 3, 2022	Neil Harrington
Final draft to Strategic Initiative	February 15, 2022	Neil Harrington
Final report due on web	March 10, 2022	Neil Harrington

5.5 Budget and funding

Tables 5 and 6 show the budget for this pilot project. A total budget of $80,000 was awarded to the Jamestown S'Klallam Tribe from National Estuary Program funds adminstered by the State of Washington through the Washington Department of Fish and Wildlife. The project period is 4/20/2020 through 3/15/2022

Table 5. Project budget and funding

Cost Category	Cost ($)
Salary, benefits, and indirect/overhead	$73,000
Supplies	$2000
Travel	$1000
Laboratory (See Table 6 for details.)	$4000

Table 6. Laboratory budget details

Parameter	Number of Samples	Number of QA Samples	Total Number of Samples	Cost Per Sample ($)	Lab Subtotal ($)
Dissolved nutrients: NO_3, NO_2, NH_4, PO_4, $Si(OH)_4$	72	18	90	$16.80	$1512
Total Nitrogen and Phosphorus	72	18	90	$18.70	$1683
Shipping and filters					$805(est)
Total Lab and associated analytical costs					$4000

6.0 Quality Objectives

6.1 Data quality objectives

The main data quality objective (DQO) for this project is to collect 72 water samples representative of the upper water column at two sampling stations in Admiralty Inlet and northern Hood Canal and have them analyzed for nutrients that meet the MQO below. Phytoplankton analyses via light microscopy will also be completed on all of these water samples. This will result in the enumeration of harmful algal species, the presence of all species and the relative abundance of the taxa present.

6.2 Measurement quality objectives

6.2.1 Targets for precision, bias, and sensitivity

The overall quality assurance objective is to ensure that data of known and acceptable quality are provided. All measurements will be performed to yield consistent results that are representative of the locations and conditions measured.

The MQOs for project results, expressed in terms of acceptable precision, bias, and sensitivity, are described in this section and summarized in the table below.

Table 7. Measurement quality objectives (e.g., for laboratory analyses of water samples).

Parameter	Laboratory Duplicate (RPD)	Field Duplicate (RPD)	Check standard Duplicate (RPD)	Check Standard (%Recovery)	Internal Standard Recovery (% Recovery)	Level of sensitivity
PO_4	2%	Within 10%	2%	2%	2%	0.014µM, 0.0004mg/L
$Si(OH)_4$	2%	Within 10%	2%	2%	2%	0.23µM, 0.0063mg/L
NO_3	2%	Within 10%	2%	2%	2%	0.288µM, 0.0040mg/L
NO_2	2%	Within 10%	2%	2%	2%	0.011µM, 0.0002mg/L
NH_4	2%	Within 10%	2%	2%	2%	0.047µM, 0.0007mg/L
Total N	2%	Within 10%	2%	2%	2%	0.68µM, 0.0095mg/L
Total P	2%	Within 10%	2%	2%	2%	0.014µM, 0.0004mg/L
	EXO 2 Sonde pre and post calibration drift acceptability		**Accuracy**		**Precision**	
Temperature	Within 5%		+/- 0.01°C		0.001°C	
Conductivity	Within 5%		+/- 0.001mS/cm		0.01mS/cm	
Depth	Within 5%		+/- 0.1meter		Resolution of .001meter	
Dissolved Oxygen	Within 10%		+/- 0.1mg/L		0.01mg/L	
Chlorophyll	Within 5%		0.01RFU		Range 1-100 RFU	

6.2.1.1 Precision

Precision: Field duplicates will be used to analyze total precision. Field duplicates will be taken from the same niskin bottle for one field duplicate per day of sampling for both the total N and P and filtered dissolved nutrient samples. Data variability will be taken into consideration in using the data for analysis and interpreting results with a target of a relative percent difference (RPD) of field duplicates of no more than 10%. For every eight phytoplankton samples one laboratory duplicate of the whole water sample will be generated and enumerated, and RPD within 10% will be sufficient.

6.2.1.2 Bias

This is the difference between the measured value and true value due to systematic errors. It is difficult to quantify and due to non-random (systematic) errors. Strict adherence to established protocols and this QAPP as well as proper technique, use of standard reference materials in triplicate to generate calibration curves and internal QA protocols by the UW laboratory will reduce bias to acceptable levels.

6.2.1.3 Sensitivity

See Table 7 above for details for each nutrient and CTD parameter. The level of detection for the presence of harmful algal species is 2cells/L based on a 10m net tow and the level of sensitivity for enumeration is 100cells/L. Species noted as present at low levels in our net tows therefore may not end up being quantified in the concentrated whole water samples if they are below this threshhold.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Data comparability will be ensured through the application of standard sampling procedures, analytical methods, units of measurement, and detection limits. The samples generated in this study will be comparable to other nutrient samples taken and analyzed with the common methods used by the UW Marine Chemistry Laboratory. The field sampling SOPs for nutrients were taken from Department of Ecology's marine sampling program. The phytoplankton data on HAB species and species composition will be comparable to those taken by the Sound Toxins program with the same methods.

6.2.2.2 Representativeness

The sample design of two stations with biweekly samples at two depths over nine months for a total of eighteen sample days will represent the seasonality of these parameters in nutrients and phytoplankton. The biweekly schedule will be sufficient for capturing major HAB bloom

events and the seasonality of the phytoplankton community structure. The two depths sampled, along with the phytoplankton net tow, will be sufficient in capturing the top of the water column where juvenile salmon occur and at eight meters, a depth of the water column that is starting to transition to deeper water with lower phytoplankton growth. Employing consistent and standard sampling procedures will also ensure sample representativeness.

6.2.2.3 Completeness

For the project a minimum of 95% of the observations and samples must be analyzed to be considered a success. Since this project includes marine sampling from boats that may include cancellations due to weather and mechanical issues, a lower standard of 80% will be applied to the total number of successful sampling days. This means that for this project, if no more than three days are cancelled out of 18 sampling days planned, the project will be considered a success and complete.

6.3 Acceptance criteria for quality of existing data

Phytoplankton and nutrient data do not exist for these sampling locations. However, phytoplankton data from the Sound Toxins program exist for Port Gamble, Hood Head and Fort Worden that may be informative but will not be integrated into his project. CTD data for salinity, chlorophyll (relative fluorescence units), temperature, dissolved oxygen and depth will be taken during each sampling event via their establish protocol and the data will be integrated into this project. The CTD protocol is in Appendix I. Zooplankton data will also will be integrated into this study when it is available (there is a time lag that may prevent the incorporation of these data into the technical report). Both the CTD and zooplankton data follow the protocols that are regionally agreed to and accepted by the zooplankton monitoring program of the SSMSP (Keister, 2017)

6.4 Model quality objectives

Not Applicable

7.0 Study Design

7.1 Study boundaries

This project will sample at two existing Salish Sea Marine Survival Project sampling stations, one in Admiralty Inlet (ADI) off of the south end of Marrowstone Island (48.00274, -122.6374) and one in Thorndyke Bay (TDB) in northern Hood Canal (47.78343, -122.7334). The sites will be accessed by research vessels on regularly scheduled zooplankton survey cruises as part of the Salish Sea Marine Survival Project.

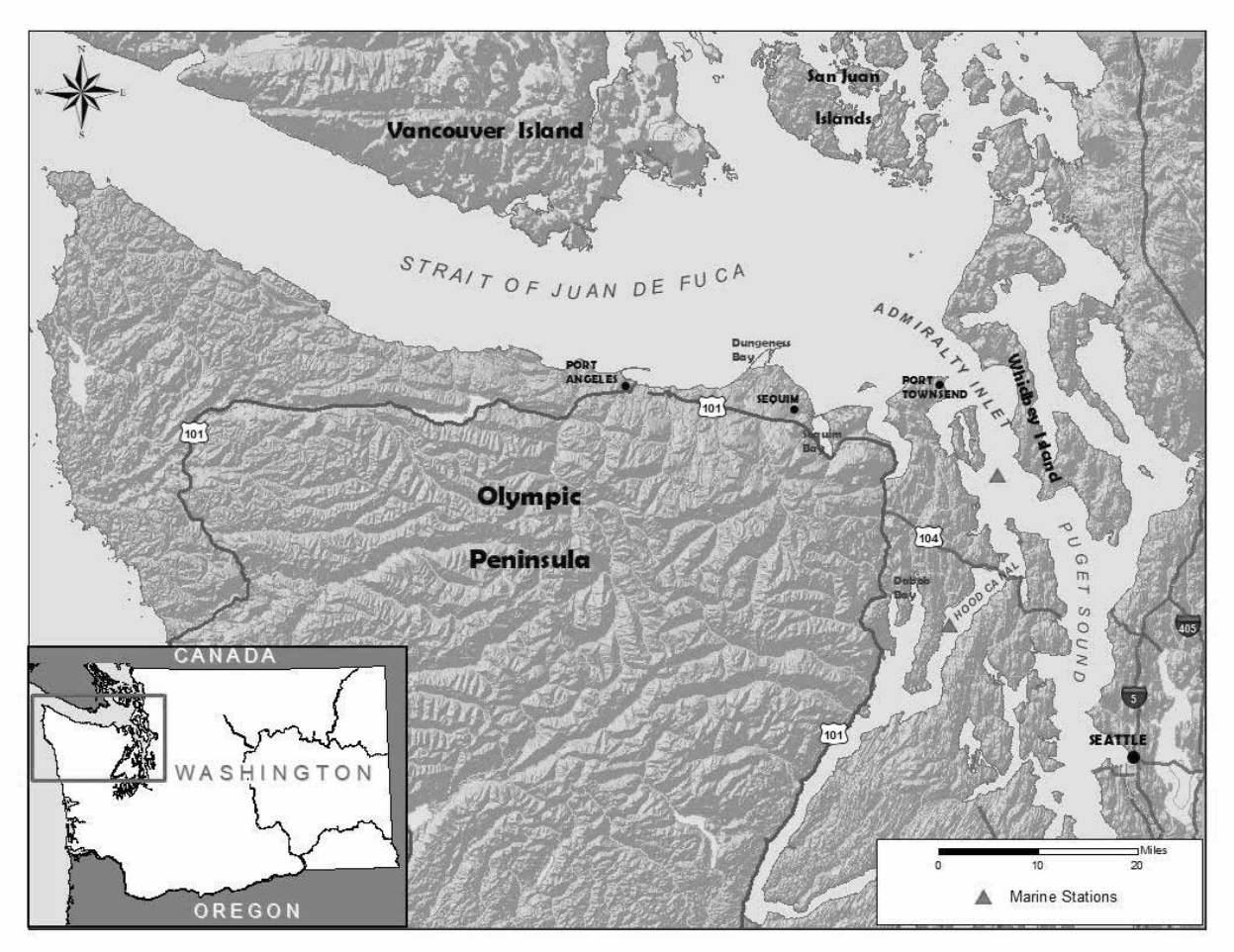


Figure 2. Map showing boundary of project study area

7.2 Field data collection

7.2.1 Sampling locations and frequency

Samples will be collected at the two points designated above. Specifically, at the deep zooplankton trawl station where the CTD is lowered and raised. A 10m vertical phytoplankton net tow, a vertical CTD cast (to 100m) and whole water samples will be collected. Whole water samples will be collected at one- and eight-meter depths for nutrients and phytoplankton analyses.

This sampling strategy was selected so that we could gain an understanding of the lower trophic levels below zooplankton. An analysis of previous CTD casts show that the Chlorophyll maximum almost always occurs in the top 10m of the water column with chlorophyll concentrations decreasing rapidly below this to near zero by 30m. For this reason, our samples will focus on the top of the water column. In terms of the sample sites these are opportunistic with willing partners, however these were chosen because they are important migratory pathways for juvenile salmon for most of Puget Sound in the case of Admiralty Inlet and Hood Canal in the case of Thorndyke Bay.

Samples will be collected twice monthly February through October, once a month off the WDFW boat and once a month off the PGST boat. Sample times are offset by roughly two weeks. Currently WDFW is allowing non-staff members to join cruises, with COVID 19 transmission precautions such as social distancing and mask wearing. All boat passengers also must complete and pass a COVID-19 attestation to be allowed on the WDFW boat. During the pandemic PGST is not allowing any non-staff on their vessels.

Cruises are scheduled with a backup date to account for weather or equipment issues that could cause cancelations.

7.2.2 Field parameters and laboratory analytes to be measured

Observed: general weather and sea state

Laboratory (UW Ocean Chemistry Laboratory)- nutrients: NO_3 ,NO_2, NH_4, PO_4, $Si(OH)_4$, total nitrogen and total phosphorus

Laboratory (Jamestown S'Klallam Tribe): phytoplankton light microscopy- cells/L of HAB species, presence down to at least genus level, relative abundance of all major taxa, total cells/l of all phytoplankton to assess total biomass.

CTD measurements (PGST and WDFW): water temperature, dissolved oxygen, salinity, and chlorophyll (continuous profile to 100m)

7.3 Modeling and analysis design

Not applicable

7.3.1 Analytical framework

Not applicable

7.3.2 Model setup and data needs

Not applicable

7.4 Assumptions of study design

Some of the assumptions are that the conditions during the sample event are representative of the period between sample events (roughly every two weeks). Conditions in the marine environment can change relatively rapidly and we may miss small-scale, short term events in time and space due to our only being able to sample at two set places during set times. This study also is assuming that, based on the analyses of previous CTD casts that most phytoplankton activity is taking place in the upper 20m of the water column.

7.5 Possible challenges and contingencies

Some of the challenges: weather, dangerous sea conditions and equipment failures. See problems with access to the boat in the following section.

7.5.1 Logistical problems

Current logistical problems include that the Port Gamble S'Klallam Tribe is not letting non-staff onto their vessel until after COVID-19 threat has passed. As long as this is in effect their staff will collect the necessary samples for Jamestown S'Klallam Tribe to process post cruise after meeting them at the dock. WDFW is allowing non-staff on their boat with precautions and we are hopeful that this will continue to be allowed. Since staff must pass a COVID-19 questionnaire, it is possible that cruises could be missed due to illness. Sampling cruises can be cancelled due to weather or equipment issues, but backup dates are scheduled in advance. JST staff will train any staff sampling for JST prior to the cruise. JST will go through the field protocol (Appendix C) and familiarize the samplers with the equipment and supplies being used.

7.5.2 Practical constraints

Currently Jamestown S'Klallam Tribe only has one staff member allocated to this project. In order to increase availability of staff due to scheduling contraints, it may be necessary to assign an additional staff member to this project in order to make sure that we have staff for all the scheduled cruises and lab work. The collection methods are straightforward and PGST and/ or WDFW have agreed to collect some of the samples in the spring due to COVID-induced space constraints on the boat.

7.5.3 Schedule limitations

We anticipate sufficient time to complete edits to the QAPP prior to sampling beginning in February. The previously mentioned COVID restrictions on the Port Gamble sampling cruises may end up having some impact on the ability to complete sampling in the first half of 2021.

8.0 Field Procedures

8.1 Invasive species evaluation

Collecting water samples with a niskin bottle and phytoplankton net off a vessel has a low possibility of collection of invasive species (perhaps one possibility would be the inadvertent collection of planktonic European green crab larvae). Whole water samples and net tows water samples that will be analyzed live in the lab will be rinsed into a sewer system after analyses. Samples preserved with formalin would kill any invasive species present and samples filtered for nutrient analyses will also remove any invasives. Equipment has a low probability of transport, regardless it will be rinsed with freshwater away from marine waters after sampling.

8.2 Measurement and sampling procedures

Marine Water Sampling

A niskin bottle will be lowered on a pre-marked line off the sampling boat to the desired depth. The messenger will be sent down the line and bottle retrieved from depth. Onboard water will be collected in a 2L polycarbonate precleaned, prelabeled bottle, it will be rinsed three times with sample water prior to filling. Headspace will be left. This bottle will be placed in a cooler with ice and maintained at a temperature less than 4°C. A CTD cast will also be performed at each site by the entity hosting the cruise (either PGST or WDFW). Please refer to Appendix A for a full description and operating procedures of the CTD.

Marine Dissolved Nutrient Sampling

Water samples are collected from the 2L polycarbonate bottles within one hour of sampling. Sample bottles are 60 ml polyethylene bottles, obtained from the University of Washington Marine Chemistry Lab. Water samples are collected into new or pre-acid-cleaned 60 ml syringes with 0.45 µm Surfactant-free Cellulose Acetate (SFCA) syringe filters attached to them. The syringe barrel and plunger are rinsed 3 times with sample water before filtering sample. Sample bottles are rinsed 3 times with approximately 5ml of clean filtrate for each rinse. The bottles are then filled about three-quarters full (35-40 ml) so that there is room for the sample to expand when frozen. Samples are stored frozen until analysis. Frozen samples should be analyzed within 3 months. Analysis is completed at the University of Washington Marine Chemistry Laboratory, according to the methods of UNESCO (1994).

Total Nitrogen / Total Phosphorus Sampling

Unfiltered water samples are collected from the 2L polycarbonate bottles into 60 ml precleaned polyethylene bottles, obtained from the University of Washington Marine Chemistry Lab, labeled with a sharpie (no tape or other labels). Prior to subsampling, the 2L sample bottle will be gently agitated to homogenize. Nutrient sample bottles are rinsed three times before being filled about 2/3 full. Samples are stored in the cooler until they are transferred to the freezer

until analysis. Analysis is completed at the University of Washington Marine Chemistry Laboratory, according to the methods of Valderrama (1981).

Phytoplankton Sampling

Within two hours of returning to the dock (and 8 hrs. of sampling), 100 ml of sample will be dispensed into pre-marked 120ml glass jars and preserved with buffered formalin to a final concentration of 1.5% formaldehyde. After letting these samples sit undisturbed for at least 24 hrs., the top 90ml of the sample will be decanted with a pipet (the 100ml and 10ml volumes will be marked on each jar before use). Harmful algal species are enumerated in either a 0.1ml Palmer Maloney volumetric slide or a 1ml gridded Sedgwick-Rafter slide. For the net tow sample approximately 100ml are saved for light microscopy of the live sample in a Palmer Maloney slide. The live sample will be analyzed no later than 24hrs after collection. 20 ml of the net tow sample will be placed in a 25ml scintillation vial and preserved with a final concentration of 1.5% buffered formaldehyde (Soundtoxins, 2016). If the raphidophyte *Hetersigma akashiwo* is noted in the live sample, in addition to the formalin preserved samples, whole water and net two samples will be preserved with Lugol's solution. These procedures are also outlined in Appendix C.

8.3 Containers, preservation methods, holding times

Table 8. Sample containers, preservation, and holding times.

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
NO_3, NO_2, PO_4, $Si(OH)_4$, NH_4	Marine Water	30ml	60 ml polyethylene bottles	None-0.45µm filtered	Frozen within 6hrs, analyzed within 3 months
Total Nitrogen and Phosphorus	Marine Water	20ml	60 ml polyethylene bottles	None	Frozen within 6hrs, analyzed within 3 months
Phytoplankton	Marine Water	150ml	120ml glass jars and 25 ml scintillation vials	1.5% formalin (see text)	Indefinite

8.4 Equipment decontamination

Not applicable.

8.5 Sample ID

Nutrient sample jars will come pre-labed from the UW Laboratory and these numbers will be recorded at the time of sampling on the field data sheet. Phytoplankton samples will be recorded with the site name abbreviation (ADM or TDB), depth (for whole water samples), six digit date, and NET for net tow and WW for whole water. For example, a whole water sample taken from one meter at Thorndyke Bay on August 6th, 2021 would be labeled thus: TDB 1m 080621 WW.

8.6 Chain of custody

The nutrient sample COC form is in Appendix B. Nutrient samples will either be directly taken to the UW Marine Chemistry Laboratory by JST or, more likely, frozen samples will be shipped overnight to UW in a cooler box with blue ice. The lab will be contacted beforehand to ensure that they will be able to receive the samples and the lab will contact JST when the samples are received.

All other samples will remain in the possession of the Jamestown S'Klallam Tribe. If a project partner samples for JST, a representative of the Tribe will meet the boat on the dock to receive the samples and sampling gear.

8.7 Field log requirements

A field log sheet, printed on waterproof paper, will be kept in a clipboard during cruises. The name of the project will be on the top of the sampling sheet and the following will be completed on each sampling day:

- Field personnel
- Environmental conditions- seastate and weather conditions
- Date, time, location, ID, and description of each sample
- Identity of QC samples collected

The following will be noted if needed:

- Any changes or deviations from the QAPP or SOPs
- Unusual circumstances that might affect interpretation of results

Water proof ink or pencil will be used and corrections will be done by strikethough and initialed.

8.8 Other activities

A briefing and training will be held for anyone other than Neil Harrington who may be taking field samples. The UW laboratory will be contacted prior to shipping samples to confirm that they are able to receive and process them in a timely manner.

9.0 Laboratory Procedures

9.1 Lab procedures table

Table 9 presents the methods that the University of Washington will use to analyze the nutrient samples and the general methods used by JST to analyse phytoplankton samples.

Table 9. Measurement methods (laboratory).

Analyte	Sample Matrix	Samples (Number/ Arrival Date)	Detection or Reporting Limit	Sample Prep Method	Analytical (Instrumental) Method
PO_4	Marine water	90 (5 per cruise)	0.014µM, 0.0004mg/L	0.45 µm filtered	SM 4500-P
$Si(OH)_4$	Marine water	90 (5 per cruise)	0.23µM, 0.0063mg/L	0.45 µm filtered	SM 4500-SiO2
NO_3	Marine water	90 (5 per cruise)	0.288µM, 0.0040mg/L	0.45 µm filtered	SM 4500-$NO3^-$
NO_2	Marine water	90 (5 per cruise)	0.011µM, 0.0002mg/L	0.45 µm filtered	SM 4500-$NO3^-$
NH_4	Marine water	90 (5 per cruise)	0.047µM, 0.0007mg/L	0.45 µm filtered	SM 4500-NH3
Total N	Marine water	90 (5 per cruise)	0.68µM, 0.0095mg/L		SM 4500-N B
Total P	Marine water	90 (5 per cruise)	0.014µM, 0.0004mg/L		SM 4500-P F
Harmful algae	Marine water	72(4 per cruise)	100 cells/L	10x concentration	Light microscopy
Relative abundance of phytoplankton taxa	Marine water (20µm Net tow)	72(4 per cruise)	2 cells/L		Light microscopy

9.2 Sample preparation method(s)

The dissolved nutrient samples will be filtered with 0.45µm SFCA filters prior to freezing. Phytoplankton samples for enumeration of harmful species will be concentrated by adding sample up to a 100ml mark in a 120 ml glass jar, adding buffered formalin to a final concentration of 1.5%. After letting this sample settle for at least 24 hrs the top is gently

decanted off with a pipet to a 10 ml mark leaving a sample that is concentrated by 10 times (Sound Toxins, 2016).

9.3 Special method requirements

None expected- the nutrient samples are of seawater and are expected to be within the range of that the UW Marine Chemistry Laboratory regularly analyzes with its standard methods. Sufficient volume will be submitted for dilutions if necessary.

9.4 Laboratories accredited for methods

Nutrient samples will be analyzed by the UW Oceanography Marine Chemistry Laboratory, accreditation number A521-20. Phytoplankton analysis methods are not subject to accreditation.

10.0 Quality Control Procedures

10.1 Table of field and laboratory quality control

Table 11 presents a summary of laboratory Quality Control samples and types.

Table 10. Quality control samples, types, and frequency.

Parameter	Field Replicates	Laboratory Check Standards	Laboratory Method Blanks	Analytical Duplicates
NO_3, NO_2, PO_4, $Si(OH)_4$, NH_4	Every 4 samples (one per sampling day)	Run at beginning and at end of sample run	DI Water at beginning and end of standard curve and beginning and end of sample run	Triplicate standards run during standard curve runs, triplicate check standards at end of sample run
Total Nitrogen and total Phosphorus	Every 4 samples (one per sampling day)	Run at end of sample run	Once per sample run and at beginning and end of run	

10.2 Corrective action processes

Every effort will be made to collect, store, transport and analyze samples in accordance with this QAPP. If samples are not meeting analytical requirements, if for example, RPD on field duplicates are greater than 5% from each other, JST will consult with the UW Marine Chemistry Laboratory to ascertain the reasons and correct them. If there are issues with phytoplankton samples, JST will consult with Brian Bill and Vera Trainer at NOAA NW Fisheries Science Center to problem solve the issue and then make corrective actions.

11.0 Data Management Procedures

11.1 Data recording and reporting requirements

Data from the field data sheets and lab data sheets for phytoplankton analyses will be inputted into Excel. Lab data received from UW will also be copied into this master Excel spreadsheet. Electronic files at JST are backed up to Synology Cloud Station Drive. The actual paper field and JST lab sheets will be stored in a fire proof filing cabinet at the JST Natural Resources office. JST will work with Northwest Indian Fisheries Commission (NWIFC) data management specialists to make sure that the initial formatting will be congruent with uploading to the WQX portal. A JST Natural Resources staff member not affiliated with this project will verify that the data in the spreadsheets match the data on the field and lab sheets and that the UW data was properly copied into the larger spreadsheet. If data was incorrectly inputted or copied it will be corrected.

11.2 Laboratory data package requirements

UW Marine Chemistry Laboratory will provide data reports in Excel that will include the date of analyses, results of blanks and standards, all sample values, information about dilutions, and the name of the analyst and equipment used.

11.3 Electronic transfer requirements

Data will be transferred from the UW Marine Chemistry Laboratory to the Tribe via files in the Excel format (.xlsx) or in .csv file format.

11.4 Data upload procedures

We will work with the NWIFC data management specialists to upload nutrient data into the WQX portal. Phytoplankton data will be uploaded as appropriate with existing data fields.

11.5 Model information management

Not applicable

12.0 Audits and Reports

12.1 Audits

The final report will describe the outcome of this pilot project and include recommendation on the feasibility of continuing this type of sampling as part of the Salish Sea Marine Survival Project. An audit is not necessary for a one-year project as long as the QA/QC plan was followed.

12.2 Responsible personnel

Not applicable

12.3 Frequency and distribution of reports

A final report will be written on the overall success of the project. This final report will examine the potential for adding nutrients and phytoplankton to the zooplankton monitoring network and include an estimate of the resources needed for this and the utility of this information.

A technical report will also be written after analyses of the data at the conclusion of the pilot year. This report will include an introduction and problem statement, methods, results of the study, analyses of the results and a discussion. This report will be distributed to not only to the granting agency but also project partners. It is expected that data form this project will be folded into the analyses and reporting of the zooplankton data for these sites.

12.4 Responsibility for reports

Neil Harrington and Robert Knapp will be responsible for the technical and final project reports.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

Field Data sheets will be examined and scrutinized within 24hrs of sampling for completeness and accuracy by either Neil Harrington (if someone else sampled) or by another JST Natural Resources staff member familiar with the project. If data fields are empty or look questionable (i.e. values are outside what would be considered normal) or if notes are not clear these issues will be resolved prior to filing and inputting the data.

13.2 Laboratory data verification

Standard laboratory procedures for analytical data reduction, review and reporting will be followed. The UW Marine Chemistry Laboratory will immediately inform the project technical lead of any problems with sample shipment conditions or analyses. Analytical data shall be peer reviewed within the UW Marine Chemistry Laboratory prior to submission to JST. Once data are received from UW by JST they will be reviewed as well for completeness (were all the samples submitted analyzed) and if the sample values are within the range to be expected.

13.3 Validation requirements, if necessary

Not applicable.

13.4 Model quality assessment

Not applicable

13.4.1 Calibration and validation

Not applicable

13.4.1.1 Precision

Not applicable

13.4.1.2 Bias

Not applicable

13.4.1.3 Representativeness

Not applicable

13.4.1.4 Qualitative assessment

Not applicable

Quality Assurance Project Plan

for the

Jamestown S'Klallam Tribe Participation in the Status and Trends Monitoring of Marine Shoreline Mussels for the Regional Stormwater Monitoring Program

October 2017

Prepared for:

US Environmental Protection Agency

1200 6th Avenue

Seattle, WA 98101

under Cooperative Agreement

Grant # 01J29401

Prepared by:

Jamestown S'Klallam Tribe

1033 Old Blyn Highway

Sequim, WA 98382

Approval:

Robert Knapp, JST Grant Project Manager — 11-17-17 (Date)

Alan Moomaw, USEPA Project Officer — 11/15/17 (Date)

Donald Brown, USEPA Regional QA Manager — 11/15/17 (Date)

Table of Contents

Distribution List and Contact Information-

Name	Organization	Address	Phone No	Fax No	E-mail Address
Lisa H. Chang, Ph.D.	USEPA	1200 6th Ave Ste 900 Seattle, WA 98101	(206) 553-0226	(206) 553-1775	Chang.Lisa@epa.gov
Donald Brown	USEPA	1200 6th Ave Ste 900 Seattle, WA 98101	(206) 553-0717	(206) 553-8210	Brown.DonaldM@epa.gov
Robert Knapp	JSKT	1033 Old Blyn Hwy. Sequim, WA 98382	(360) 681-4666	(360) 681-4611	rknapp@jamestowntribe.org
Neil Harrington	JSKT	1033 Old Blyn Hwy. Sequim, WA 98382	(360) 681-4634	(360) 681-4611	nharrington@jamestowntribe.org

Project Management and Organization

This study is a multi-agency collaboration designed to increase the capacity of the Tribe by partnering with the Washington Department of Wildlife on their Status and Trends Monitoring Trend in Nearshore Mussels program (otherwise known as Mussel Watch).

Jamestown S'Klallam Tribe (JSKT): The JSKT Grant Project Manager is Robert Knapp. Mr. Knapp shall be responsible for submission of the QAPP to EPA for review and approval, and maintenance and preparation of grant reports and deliverables to EPA. He will also be the main contact for EPA or NWIFC requests. The JSKT Grant Project Technical Lead is Neil Harrington. Mr. Harrington shall be responsible for the sampling design and development of the QAPP, implementation of the QAPP, and overall management and oversight of the shellfish sample collection and coordination with WDFW on tissue analyses, data analysis and database input. He will also be responsible for the coordination of field collection of samples.

Washington Department of Fish and Wildlife (WDFW): WDFW project lead is Jennifer Langsbury. WDFW will be responsible for providing mussels for deployment, processing of shellfish samples and analyses of shellfish tissue. All collection and tissue analyses will done in coordination with WDFW and fully aligned with WDFW's Department of Ecology approved QAPP for this project.

US Environmental Protection Agency: The EPA shall provide funding for the study, review and approval of the study QAPP and technical assistance to the Tribe.

Roles and Responsibilities

Jamestown S'Klallam Tribe:

Points of Contact: Robert Knapp and Neil Harrington. JSKT shall be responsible for the following tasks:

- preparation and submission of the QAPP to EPA for review and approval
- collection of wild shellfish samples (Littleneck clams and/or manila clams and Pacific oysters)
- deployment and retrieval of mussel cage
- coordination of sample analyses with WDFW
- Submission of final WDFW report to EPA
- Submission of technical memo to EPA with final wild collected shellfish data

Problem Definition/Background

Shellfish are an important natural resource for the Jamestown S'Klallam Tribe (Tribe). Clams and oysters are harvested for commercial, ceremonial, and subsistence purposes. While the Tribe has long monitored, in cooperation with the Washington Department of Health (WDOH), for biotoxins that poise

an immediate threat to human health to ensure the shellfish is safe for consumption, it has done very limited testing for other toxins that may accumulate in shellfish that poise a long term health hazard. As outlined in the Tribe's *Toxins Monitoring Plan for the Jamestown S'Klallam Tribe* the Tribe wishes to better understand the amounts of various anthropogenic toxins in fish and shellfish to gauge the impact of toxins on the consumers of fish and shellfish within the Tribe as well as better understand the impact on the resource of these toxins. To most efficiently sample for toxins in shellfish the Tribe has decided to partner with the WDFW Status and Trends in Marine Nearshore Mussels for the Regional Stormwater Monitoring Program (RSMP). This will allow us to directly compare contamination levels of mussels on our subsistence shellfish beach with mussel data from around Puget Sound. In addition we will submit several other species of shellfish for analyses using the same analytical methods allowing comparison of these samples with the mussel data and determining the levels of persistent organic pollutants and metals in the shellfish which our citizens eat.

Project Definition

This scope of work will cover the deployment and retrieval of a mussel cage on the Tribe's tidelands and the collection of wild shellfish for analyses through the RSMP. The deployment, retrieval of the mussel cage and the analyses of all shellfish will follow the Washington Department of Ecology approved QAPP in Appendix 1 (includes recent amendments).

The project will focus on:

1. Deployment and retrieval of a mussel cage as part of the RSMP
2. Collection of additional shellfish littleneck and/ or manila clams and Pacific oysters
3. Submitting these samples for analyses by WDFW per their approved methods
4. Writing of a technical memo comparing levels of contamination of shellfish on the Jamestown S'Klallam Tribe's subsistence shellfish beach with fish consumption standards and levels of contamination in other parts of Puget Sound.

1.1.1 Measurable Project Objectives

The measurable objectives for this project are as follows:

1. Determine the levels of toxic contamination (persistent organic pollutants and metals- Tables 11,12and 13 of Appendix1) of mussels and culturally and commercially important shellfish.
2. Inform future Tribal toxin source reduction efforts

1.1.2 Expected Environmental Outcomes

By informing toxin source reduction efforts this project is expected to reduce toxin loading in culturally and commercially important shellfish.

1.2 Schedule of Project Task/Activities

Project Task	Estimated Start Date	Estimated Completion Date
QAPP Development	October 2017	October 2017
QAPP Review and Approval	October 2017	November 2017
Shellfish Collection	February 2018	February 2018
Final Technical Memo	November 2018	September 2019

1.3 *Data Quality Objectives*

Data Quality Objectives (DQOs) are the quantitative and qualitative terms inspectors and project managers use to describe how good the data needs to be in order to meet the project's objectives. DQOs for measurement data (referred to here as data quality indicators) are precision, accuracy, representativeness, completeness, comparability, and measurement range. The overall QA objective for analytical data is to ensure that data of known and acceptable quality are provided. To achieve this goal, data must be reviewed for 1) representativeness, 2) comparability, 3) precision, 4) accuracy (or bias), and 5) completeness. Precision, accuracy, completeness, sample representativeness and data comparability are necessary attributes to ensure that analytical data are reliable, scientifically sound, and legally defensible.

Please see Quality Objectives section of Appendix 1 page 17 for more details.

1.4 *Special Training Requirements/Certification*

Scientists (Biologists/Chemists/Technicians) performing the work for this project have extensive knowledge, skill and demonstrated experience in the execution of the analytical methods being requested needed for this particular project. This includes not only the biologists at the Tribe who will be collecting the shellfish but also the biologists and chemists at WDFW, King County Environmental Laboratory and NOAA Northwest Fisheries Science center who will be doing the analytical work on this project.

1.5 *Documentation and Records*

Complete documentation may include but are not limited to the following forms to be completed and collated by the JSKT:

- Field Sampling Notes
- Chain of Custody Logs

The field team will maintain field notes on the forms provided by WDFW (examples in Appendix1). Copies of these and the COCs will be kept by the Tribe and will be submitted the program office upon request.

2 Measurement and Data Acquisition

2.1 *Sample Locations*

The mussel cage will be deployed and retrieved form the Tribe's subsistence shellfish beach adjacent to the Tribal Administrative building in Blyn, Washington (coordinates 48.026117 N -122.998325 W). Clams and oysters will also be collected from this location.

2.2 *Biota samples*

Three or four species of molluscan bivalves, specifically bay mussels (*Mytilus trossulus*), Pacific littleneck clams (*Protothaca staminea*) and/or manila clams (*Venerupis philippinarum)* and Pacific oysters (*Crassostrea gigas)* will be submitted to WDFW for toxin analyses. If budget allows, both species of clams will be submitted, if it is constrained only one species will be collected. The mussels will be deployed in a cage (please see Appendix 1 for more information) and retrieved after three months on the tidelands. They will be deployed consistent with the RSMP QAPP at about -1ft tide level on the Jamestown S'Klallam Tribe subsistence shellfish beach in Blyn WA (coordinates 48.026117 N -122.998325 W). Oysters will be collected from the surface of the beach and littleneck and/or manila clams will be dug with a clam fork from the beach substrate. Collectors will wear nitrile gloves and all shellfish will be rinsed with freshwater to remove sediment and placed in clean ziplock bags. They will then be placed on bagged ice in a cooler to be transported to the WDFW lab in Olympia Washington. Please see page 24 of Appendix 1 for specific handling procedures.

2.3 *Decontamination Procedures*

Nitrile gloves will be worn during sample collection and samples will be placed in clean plastic bags. Sampling devices and sample collection gear such as rain gear, and rubber boots will be cleaned and decontaminated by rinsing with fresh water. Samplers will follow the proper health and safety procedures when collecting and handling samples to minimize or not to incur contamination. Please see specific procedures in Appendix 1 page 35.

2.4 *Sample Handling and Shipping*

See page 34 of Appendix 1. All sample containers will be individually labeled and accompanied by a Chain of Custody (COC). Samples will be placed on bagged ice in a cooler and transported by vehicle to the WDFW laboratory in Olympia.

2.5 *Analytical Methods*

Please see Appendix 1 page 40 for analytic methods for POPs, metals, conventionals, lipids and percent dry weight.

2.5.1 Quality Control

Please see the Quality Control chapter starting Page 43 of Appendix 1

3 Assessment and Response

The project shall implement the requirements set forth by this QAPP including Appendix 1. Deviations from the QAPP shall be documented in a Sample Alteration Form (Attachment 1). Problems encountered in the field or laboratories shall be resolved and documented in a Corrective Action Form (Attachment 2). Both Sample Alteration and Corrective Action Forms shall be reviewed and approved by USEPA prior to implementation.

4 Data Validation and Interpretation

See page 48 of Appendix 1.

Appendix 1: Amended Quality Assurance Project Plan (QAPP) for Status and Trends Monitoring of Marine Nearshore Mussels for the Regional Stormwater Monitoring Program

Amendment to Quality Assurance Project Plan (QAPP) for Status and Trends Monitoring of Marine Nearshore Mussels for the Regional Stormwater Monitoring Program and Pierce County

September 11, 2017
Jennifer Lanksbury, Washington Department of Fish and Wildlife
WDFW Report Number FPT 17-07

This amendment documents changes to the QAPP for Status and Trends Monitoring of Marine Nearshore Mussels for the Regional Stormwater Monitoring Program and Pierce County (WDFW Publication no. FPT 15-04) for the 2017/18 Stormwater Action Monitoring Mussel Monitoring survey. The Regional Stormwater Monitoring Program changed its name to Stormwater Action Monitoring (SAM) in 2017 in recognition of SAM's broader role – using the results of monitoring and studies to inform policy decisions and identify the most effective management actions.

Global changes to all sections of the QAPP

- We change the acronym RSMP to SAM (Stormwater Action Monitoring).
- We change all references to the winter of 2015/16 to the winter of 2017/18.
- We change all deployment dates from October 2015 to November 2017, and all retrieval dates from February 2016 to February 2018.

WDFW, Pierce County and Ecology Roles (page 6)

The 2017/18 SAM Mussel Monitoring will occur within the period of November 2017 to February 2018.

Table 1. Key completion dates for QAPP, monitoring activities, and reports for status and trends monitoring in the Puget Sound nearshore.

Due	Item	Description
August 10, 2017	Draft QAPP amendment submitted	WDFW submits draft QAPP to Ecology for review.
August 31, 2017	Final QAPP amendment approved	Final QAPP completed and accepted by Ecology.
September 30, 2017	Site selection and verification	WDFW and Pierce County have confirmed all sites to be monitored, including sufficient additional sites to sample if sampling attempted at any of the original sites is unsuccessful. Send site list to SAM Coordinator.
November 2017	Mussel cages deployed	WDFW and Pierce County deploy mussel cages at the required number of nearshore sites.

February 2018	Mussel cages retrieved and mussels delivered to WDFW	WDFW and Pierce County retrieve mussel cages from the required number of nearshore sites and deliver the mussels, alive on ice, to the WDFW Marine Resources Laboratory in Olympia on the morning following retrieval.
February - March, 2018	Send samples to laboratories.	WDFW submits frozen mussel tissue samples to the RSMP contracted laboratories for chemical analysis.

Documentation of Site Evaluations (page 16)

Site evaluators will provide a table listing the decisions and reasons for site selection or disqualification resulting from the site evaluations to the SAM Coordinator by September 30, 2017.

Quality Objectives (page 18)

Table 2. Summary of mussel tissue composites to be collected and analyzed for chemical contaminants during this study.

Purpose	Location	Timing	Composites	Replicates
Baseline samples	Aquaculture source	November	6	6
SAM mussel sites	Various	February	40	1 per site
Pierce County sites	Various	February	8	1 per site
Lab QA samples	Various	Aliquots taken during chemical analysis	5	5[a]
Total			**59**	

[a] two QA samples per batch of 12

Field Measurements (page 19)

We will no longer measure several parameters on site during the mussel cage deployment, including the height of the most recent low tide, precipitation, aquatic vegetation coverage or type, adjacent upland land use type, or man-made structures on the beach. The shortened list of parameters to be measured is described below in the updated Table 5.

Table 3. Mussel monitoring field parameters: field methods, reporting limits, and QA/QC procedures. See 2015/16 RSMP Mussel Monitoring Datasheet (Appendix D).

Parameter	Expected Range Of Results	Technique/ Instrument	Measurement Method	QA/QC
Time of cage deployment and retrieval	12:00 – 24:00	Clock	Read from clock and reported in military time	Careful observation
GPS coordinates	N/A	GPS device or mobile device with GPS application	Set GPS device to NAD83, record in decimal degrees (e.g. 47.5893, -122.3953)	Record accuracy of coordinates at reading (e.g. ±15ft)
Wave energy	Flat, calm, wind chop, swells, breaking waves	Visual examination	Visual examination of sea near cage	Careful observation
Beach exposure level	Exposed, moderately exposed, sheltered	Visual examination	Visual examination of beach within ½ mile in either direction of cage	Careful observation
Time zero tide (MLLW)	12:00 – 24:00	NOAA tides and currents website http://www.protides.com/washington/	Read from harmonic or subordinate tidal gauge station nearest to monitoring site	Accurate reading of information from website
Majority (>50%) Substrate Type	Bedrock-hardpan, cobble-gravel mix, sand-gravel mix, sand, sand-mud mix, mud-silt	Visual examination	Visual examination within 200 foot radius of cage	Careful observation
Freshwater inputs	Natural streams, rivers, outfalls	Visual examination	Visual examination within 200 foot radius of cage	Careful observation, may include mix of types
Erosion control structures	None, hard, soft. Includes materials used	Visual examination	Visual examination of beach within ½ mile in either direction of cage	Careful observation and documentation
Abandoned or derelict structures	No/Yes, type	Visual examination	Visual examination of beach within ½ mile in either direction of cage	Careful observation and documentation

Parameter	Expected Range Of Results	Technique/ Instrument	Measurement Method	QA/QC
Current shoreline use	Wide range of choices (see Appendix C)	Visual examination	Visual examination of beach within ½ mile in either direction of cage.	Careful observation, may include mix of types
Construction of structures on beach touching water	Treated wood, concrete, steel, other	Visual examination	Visual examination of beach within ½ mile in either direction of cage.	Careful observation, may include mix of types
Outfalls	N/A	Visual examination	Visual examination of beach within ½ mile in either direction of cage.	Careful observation, may include mix of types
Potential sources of pollutants	N/A	Visual examination	Visual examination of beach within ½ mile in either direction of cage.	Careful observation, may include mix of types

*Field-measured parameters follow manufacturer's website guidelines for calibrations

Field Datasheets (page 26)

WDFW and Pierce County will make a *2017/18 SAM Mussel Monitoring Datasheet* (Appendix D) available to the volunteers and partners in digital format, as an online/mobile survey form, and on water-resistant paper for each verified and usable site.

Chain of Custody (page 26)

Chain of custody signatures will now be recorded on the retrieval portion (backside) of the revised study datasheet.

Mussel Presort (page 28)

The presorting, measuring, and bagging described below will take place during October, 2017 prior to deployment, allowing time for inclement weather.

We will select mussels that fall within the desired size range by comparing them to mussel length templates, provided by WDFW for this purpose.

Measuring (page 29)

We will no longer measure and record the individual shell length of all mussels in the study. Instead, during each day of bagging WDFW staff and volunteers will measure the shell length of 50 mussels from the presorted cooler using a digital calipers with measurement accuracy of 0.1 mm. The length measurements for these mussel will represent the average starting length of

mussels used in the 2017/18 SAM Mussel Monitoring survey. Lengths will be recorded onto a waterproof data sheet or on a digital specimen form.

Bagging (page 29)

WDFW staff will no longer affix a unique ID tag to each finished mussel bag. The ID tag was used to track the individual measured mussel lengths, which we are no longer taking.

Presoak period (page 29)

We will no longer need to indicate the range of bag ID numbers hanging on each line of finished mussel bags.

Deployment/Retrieval Dates (page 30)

Table 4. Potential deployment and retrieval dates for RSMP mussel monitoring in 2015/16. Dates are based on predicted low tides at Seattle, Elliott Bay harmonic station (NOAA).

Low Tide Event	Deployment Dates	Retrieval Dates
Preferred	November 3 – 9, 2017	February 13-15, 2018
Alternate	November 17 – 21, 2017	February 25 28, 2018

Deployment (page 30)

We will no longer initiate a chain of custody form at deployment, instead, chain of custody signatures will be collected on the retrieval portion (backside) of the revised study datasheet.

Field Measurement Procedures (page 36)

The table below no longer contains precipitation, aquatic vegetation cover and types, or adjacent upland land use. This is consistent with changes to the Field Measurements on page 19.

Table 5. Field measurement and observation parameters.

Field Measurements
Time of cage deployment/retrieval
GPS coordinates and accuracy
Field Observations/Estimates
Wave energy
Beach exposure
Substrate Type
Freshwater inputs
Erosion control structures
Shoreline use
Anthropogenic structures on beach
Outfalls present
Potential sources of pollutants

Retrieval (page 37)

Chain of custody signatures will now be collected on the retrieval portion (backside) of the revised study datasheet.

Lab Forms (page 37)

Electronic tablets (e.g., iPads) with digital versions of the WDFW Specimen Form and Tissue Resection Log will be used in place of printed paper to record all laboratory measurements.

Stable Isotopes (page 44)

We will not measure stable isotopes in mussels for the 2017/18 SAM Mussel Monitoring survey, so this section is no longer applicable.

Field QC (page 46)

We will no longer utilize the chain of custody forms.

Field Data (page 48)

Monitoring site data will be recorded either in digital format through WDFW's online/mobile survey form or printed on waterproof paper.

Laboratory Data (page 48)

WDFW staff will record laboratory data on electronic tablets (e.g., iPads) with digital versions of the Specimen Form and Tissue Resection Log.

2015/16 RSMP Mussel Monitoring Summary Report (page 51)

The 2017/18 SAM Mussel Monitoring summary report is due to Ecology on July 30, 2018. In addition, the results will be compared with results from the previous 2015/16 RSMP/SAM Mussel Monitoring efforts, and with WDFWs Toxic Contaminants in Puget Sound's Nearshore Biota: A Large-Scale Synoptic Survey Using Transplanted Mussels (*Mytilus trossulus*) (Lanksbury et al. 2014) report, where appropriate.

Appendix D. Study Datasheet

A revised study datasheet is shown below. This datasheet will be available to volunteers and study partners in digital format through WDFW's online/mobile survey form and on waterproof paper (see next page for example of datasheet).

Appendix E . Chain of Custody Form

Chain of custody signatures will now be recorded on the retrieval portion (backside) of the revised study datasheet, see below.

Washington State 2017/18 SAM
Mussel Monitoring Site Datasheet

DEPLOYMENT INFORMATION			
Site ID:	Site Name:		
Deployers name(s):			
Recorder name:			
Deployment date:			
Estimated time of zero tide:		Time cage anchored:	
Cage GPS location (decimal degrees)	Latitude:	Longitude:	Accuracy (± XX feet):
GPS make/model or app name: (please set to datum NAD83)			
Anchors Used (type and number):			
HABITAT (visible from mussel cage)			
Sea Conditions: ☐ Flat ☐ Calm ☐ Wind chop ☐ Swells ☐ Breaking waves			
Beach Exposure: ☐ Exposed ☐ Moderately exposed ☐ Sheltered			
Substrate – select ONE that describes the majority (50%) of substrate around cage: ☐ Bedrock, hardpan ☐ Cobble-gravel mix ☐ Sand-gravel mix ☐ Sand ☐ Sand-mud mix ☐ Mud, silt			
Stream or River present: ☐ No ☐Yes			
Other Habitat Comments/Observations:			
ANTHROPOGENIC STRUCTURES AT SHORELINE (visible from mussel cage)			
Erosion Control/Shoreline Armoring: ☐ None ☐ Hard (bulkhead, riprap, etc.) ☐ Creosote Included			
Abandoned/Derelict Structures on Beach (e.g. old pilings, docks, etc.) ☐ No; ☐ Yes, describe:			
Current Shoreline Use (check all that apply): ☐ Boat ramp/launch; ☐ Boathouse/shed; ☐ Bridge; ☐ Breakwater; ☐ Dock/pier/wharf; ☐ Floating home; ☐ Marina; ☐ Mooring buoy; ☐ Outfall; ☐ Piling/dolphin; ☐ Raft/float; ☐ Road; ☐ Shipyard or terminal; ☐ Utilities; ☐Other: _____			
Dock/Pier/Wharf/Piling Material (if present): ☐ Creosote ☐ Other treated wood; ☐ Concrete; ☐ Steel; ☐ Other:			
Tires present: ☐ No ☐ Yes			
Outfall Present (pipe, culvert, point of flow onto beach): ☐ No ☐ Yes			
Other obvious sources of pollution (oil slicks, seeps, etc.):			
Additional comments/observations (it's a good idea to note landmarks that will help you find the cage later!):			
TAKE PHOTOS of the deployed cage and surrounding substrate, including any interesting observations!			

1

Washington State 2017/18 SAM
Mussel Monitoring Site Datasheet

RETRIEVAL INFORMATION **(TAKE PHOTO of the mussel cage BEFORE removal, to document condition of cage.)**			
Site ID:	Site Name:		
Retrievers name(s):			
Recorder name:			
Retrieval date:		Time cage removed:	
Cage GPS location (decimal degrees)	Latitude:	Longitude:	Accuracy (± XX feet):
GPS make/model or app name: (must be set to datum NAD83)			
ANY NEW obvious sources of pollution (oil slicks, seeps, etc.)?			
Additional comments/observations (including condition of CAGE on retrieval, major changes in habitat or structures around cage):			

Mussel Chain of Custody Signatures

Mussel Cage Retriever: _____ Date : _____

Mussel Runner: _____ Date : _____

WDFW Personnel: _____ Date : _____

Washington Department of FISH and WILDLIFE

DEPARTMENT OF ECOLOGY
State of Washington

Quality Assurance Project Plan for Status and Trends Monitoring of Marine Nearshore Mussels

for the Regional Stormwater Monitoring Program and Pierce County

June 2015

WDFW Publication no. FPT 15-04

Publication information

This Quality Assurance Project Plan is available on the Department of Ecology's Regional Stormwater Monitoring Program (RSMP) website for National Pollutant Discharge Elimination System (NPDES) municipal stormwater permittees at http://www.ecy.wa.gov/programs/wq/stormwater/municipal/status.html.

Data for the RSMP will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search Study ID, RSMP_PMNM2015. Data from Pierce County will be under Study ID RSMP_PC_PMNM2015.

Contact information

Washington State Department of Fish and Wildlife

Jennifer Lanksbury, Fish & Wildlife Biologist

600 Capitol Way N, MS: 43150

Olympia, WA 98501-1091

(360) 902-2820

Shipping address:

WDFW, c/o Jennifer Lanksbury

1111 Washington St SE, 6th Floor

Olympia, WA 98504-3150

Washington State Department of Ecology

Brandi Lubliner, RSMP Coordinator

P.O. Box 47600

Olympia, WA 98504-7710

Washington State Department of Ecology - www.ecy.wa.gov

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300

Peirce County Public Works & Utilities

Surface Water Management

2702 South 42nd Street, Suite 201

Tacoma, WA 98409-7322

Any use of product or firm names in this publication is for descriptive purposes only and does not imply endorsement by the author(s) or the Department of Ecology.

To request ADA accommodation including materials in a format for the visually impaired, call the Water Quality Program at Ecology, 360-407-6600. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.

Table of Contents

Page

List of Figures and Tables

Page

Figures

Tables

Introduction

Development of a Stormwater Monitoring Strategy for the Puget Sound Region

The Stormwater Work Group (SWG) is a coalition of federal, tribal, state, and local governments; business, environmental, and agricultural entities; and academic researchers. All SWG members have interests and a stake in the Puget Sound watershed. The SWG was convened by the Puget Sound Partnership (PSP) and the Washington State Department of Ecology (Ecology) in October 2008 to develop a regional stormwater monitoring strategy and to recommend monitoring requirements in National Pollutant Discharge Elimination System (NPDES) stormwater permits issued by Ecology. In 2012, the SWG became the first “topical workgroup” included in the Puget Sound Ecosystem Monitoring Program (PSEMP), an organization designed to coordinate regional monitoring efforts to assist in providing information to support Puget Sound recovery efforts.

An overall strategy for stormwater monitoring and assessment for the Puget Sound region was developed by the SWG in 2010 (SWG, 2010a). This strategy, summarized in Appendix A, included recommendations for status and trends monitoring in small streams and in the Puget Sound nearshore, with a focus on an integrated approach to quantify stormwater pollutant impacts in Puget Sound, and providing information to efficiently, effectively, and adaptively manage stormwater to reduce harm to the ecosystem.

The SWG also recommended a specific NPDES municipal permittee-funded plan for monitoring the effects of stormwater under the permits in the Puget Sound region (SWG, 2010b). The resulting program, a subset of the overall strategy, is called the Regional Stormwater Monitoring Program (RSMP). Specifically, the RSMP includes status and trends monitoring of water quality and "watershed health" (physical habitat, sediment chemistry, and biological communities) in small streams in the Puget Sound lowlands; and of sediment quality, bacteria, and contaminants in mussels in the marine nearshore of Puget Sound. The RSMP status and trends monitoring follows a probabilistic sample design (SWG, 2010a) such that data gathered can be summarized across the Puget ecoregion. Additional information about the experimental design, the goals, and the objectives for status and trends and other monitoring in the RSMP can be found in Appendix A of this report, in SWG (2010a and 2010b), and at the RSMP website http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp/rsmp.html).

Scope of this Quality Assurance Project Plan

This Quality Assurance Project Plan (QAPP) defines the status and trends mussel monitoring in the Puget Sound nearshore that will be conducted by the Washington Department of Fish and Wildlife (WDFW) staff and volunteers for the RSMP. In addition, this QAPP defines the mussel monitoring that will be conducted by Pierce County as part of their NPDES permit Special Condition S8.B obligation. Pierce County selected permit option 2 of S8.B for status and trends monitoring and therefore will conduct mussel monitoring at a jurisdictionally intensified scale. This QAPP defines the site confirmation and sampling protocols that WDFW and Pierce County will follow while conducting mussel monitoring, as well as the data and reports that will be produced to document monitoring results. This QAPP was developed in accordance with Ecology's QAPP guidelines (Lombard and Kirchmer, 2004).

WDFW, Pierce County and Ecology Roles

WDFW staff and volunteers and Pierce County will conduct monitoring at assigned sites in Puget Sound nearshore areas along their jurisdictions within the period from October 2015 to February 2016. The key completion dates for the required monitoring activities, including site confirmation, field work, and delivery of mussels to the WDFW's Olympia laboratory are summarized in Table 1. Table 2 lists key WDFW and Ecology staff responsible for monitoring activities detailed in this QAPP. Appendix C lists the key Pierce County staff, monitoring responsibilities, and mussel sites.

Table 6. Key completion dates for QAPP, monitoring activities, and reports for status and trends monitoring in the Puget Sound nearshore.

Due	Item	Description
April 30, 2015	Draft QAPP submitted	WDFW submits draft QAPP to Ecology for review.
May 15, 2015	Revised QAPP	Pierce County submits revised draft QAPP to Ecology.
June 30, 2015	Final QAPP approved	Final QAPP completed and accepted by Ecology.
August 31, 2015	Site selection and verification	WDFW and Pierce County have confirmed all sites to be monitored, including sufficient additional sites to sample if sampling attempted at any of the original sites is unsuccessful. Send site list to RSMP Coordinator.
October 2015	Mussel cages deployed	WDFW and Pierce County deploy mussel cages at the required number of nearshore sites.
February 2016	Mussel cages retrieved and mussels delivered to WDFW	WDFW and Pierce County retrieve mussel cages from the required number of nearshore sites and deliver the mussels, alive on ice, to the WDFW Marine Resources Laboratory in Olympia on the morning following retrieval.

February - March, 2016	Send samples to laboratories.	WDFW submits frozen mussel tissue samples to the RSMP contracted laboratories for chemical analysis.
October - February, 2017 and 2018	Round 2: deploy and retrieve mussels, deliver mussels to WDFW	Pierce County will conduct a second round of mussel monitoring at the same sites sampled in 2016-2017 and delivers mussels to WDFW. WDFW submits frozen mussel tissue samples to the contracted laboratories for chemical analysis.

Table 7. Ecology and WDFW project staff and responsibilities

Ecology Staff	**Administration of Stormwater Permits and RSMP**	
Name, Program, Location	**Role**	**Responsibility**
Brandi Lubliner - WQP Lacey, WA	RSMP Coordinator	Ongoing implementation and administration of RSMP. Reviews and approves completed project deliverables from WDFW's and permittees' monitoring efforts. Coordinate for data QA.
Chris Montague-Breakwell WQP-SWRO: Lacey, WA	Permit Manager	Ecology's contact for stormwater permittees including Pierce County. Reviews monitoring reports for permit compliance.
Randall Marshall –WQP Lacey, WA	WQP Quality Assurance Officer	Draft template QAPP review and approval.
WDFW Staff	**Administration of Mussel Monitoring**	
Name, Program, Location	**Role**	**Responsibility**
Jennifer Lanksbury - WDFW Olympia, WA	Mussel Monitoring Coordinator	RSMP contractor to provide ongoing implementation and administration of mussel monitoring, including laboratory processing of mussels, data review, analysis and final report on the mussel monitoring efforts.

NWRO - Northwest Regional Office; SWRO - Southwest Regional Office; EIM - Environmental Information Management database; WQP - Water Quality Program; WDFW - Washington Department of Fish and Wildlife

WDFW will coordinate with an aquaculture facility to provide mussels for all the RSMP and Pierce County nearshore monitoring sites. WDFW will contract with analytical laboratories for all mussel tissue chemistry analyses. Pierce County will coordinate their mussel purchase and analysis through WDFW.

WDFW will obtain a Hydraulic Project Approval (HPA), a Shellfish Transfer Permit, and a Memorandum of Understanding (MOU) with the Washington Department of Natural Resources (DNR) to access State-Owned Aquatic Lands (SOAL) for all RSMP and Pierce County mussel monitoring activities. WDFW staff and volunteers and Pierce County will perform reconnaissance and verification of the RSMP and Pierce County monitoring sites, respectively, and acquire any *other* permits or permissions (outside those listed above) necessary to access their approved sites, including but not limited to permission to access privately-owned, city, county, port, or tribal property, or state or federal park lands.

WDFW will process all RSMP and Pierce County mussels for biological and chemical analysis, compile the results, conduct a quality assurance (QA) and quality control (QC) review of the data, and submit the

data to EIM. Ecology staff will review the biological and chemistry data, notify WDFW of any problems regarding data quality, and will coordinate the final upload to EIM. The RSMP Coordinator will review all monitoring reports and Ecology permit managers will review Pierce County annual reports for compliance purposes.

Coordination and Training

Pierce County will contribute data collection information and results to their permit manager and the RSMP Coordinator. During the summer of 2015 WDFW will provide training for WDFW staff and volunteers and Pierce County staff regarding mussel cage deployment and retrieval. This training will take the form of a webinar or document (i.e. self-train) to ensure comparability of results for both programs. Pierce County is required to use mussels prepared by WDFW on the day(s) of mussel cage deployment. On the morning(s) following mussel cage retrieval WDFW staff and/or volunteers and Pierce County are required to transport their mussels to the WDFW Marine Resources Laboratory in Olympia for processing. These requirements ensure comparability of results for the RSMP nearshore mussel study.

Timeline for Mussel Monitoring Field Work:

1) Determine candidate monitoring sites
2) Reconnaissance and verification of suitability for monitoring at candidate sites:
    a) Obtain permission to access site and place monitoring cage there
    b) Visit site during daylight low tide:
        i) Assess accessibility and safety
        ii) Determine type(s) of anchor(s) needed to secure mussel cage to substrate
3) Determine which permits/permissions (in addition to those mentioned below) are necessary for monitoring and obtain them prior to monitoring:
    a) The following blanket permits and permissions will be provided by WDFW – 1. HPA, 2. Shellfish Transfer Permit, and 3. MOU with DNR to access SOAL.
4) Purchase and assemble equipment and supplies (i.e. cages/anchors, GPS devices, etc.)
5) Obtain bagged mussels from WDFW at aquaculture facility:
    a) Date/time set by WDFW
6) Deploy cages with mussels to designated monitoring sites during evening October low tides:
    a) Record field measurements and site data

7) Retrieve cages during evening February low tides:
   a) Record field measurements and site data
   b) Place mussels on bags on ice in cooler, hold overnight
8) Mussels delivered in coolers to WDFW Marine Resources Laboratory in Olympia, WA the morning after collection.

---------- End of Pierce County responsibility ----------

9) WDFW post-sample processing:
   a) Determine percent mortality of mussels in cages
   b) Measure, shuck and dry subset of mussels for determination of condition index
   c) Measure, shuck and homogenize subset of mussels into wet tissue composites
   d) Freeze wet tissue composites and remaining mussels
10) WDFW will transport wet tissue composites to contract analytical laboratories for chemical analysis

Laboratory Selection

Mussel tissue composites will be analyzed for contaminants at two local laboratories recommended and contracted by WDFW (Table 3). Pierce County mussel tissue composites will be transported to these same laboratories by WDFW, along with all the other RSMP samples. To maintain quality assurance of the analytical data, analysis of mussel samples from Pierce County will occur at these same laboratories over both sampling seasons. WDFW will contract with these laboratories for the RSMP, and Pierce County can enter into this contract on a per site cost sharing basis.

Table 8. Laboratories selected for sample processing and analysis.

Laboratory Name	Analytical Purpose	Address	Phone
Northwest Fisheries Science Center Laboratory (NWFSC)	Mussel tissue conventional and organic contaminants (persistent organic pollutants – POPS), and replicate samples	2725 Montlake Blvd East Seattle, WA 98112-2097	(206) 860-3325
King County Environmental Lab (KCEL)	Mussel tissue metals and replicate samples.	322 West Ewing Street Seattle WA 98119-1507	(206) 477-7200

Site Selection and Evaluation

The sampling site selection and evaluation process is described here for suitable mussel monitoring sites for the RSMP and Pierce County. Suitability is based largely on a field visit to candidate sites in the spring months of the sampling year. WDFW and Pierce County will provide a table listing the decisions and reasons for site selection or disqualification resulting from site evaluations to the RSMP Coordinator by August 31, 2015. Additional site suitability details to be considered on the day of sampling are described in the sections of this QAPP detailing the sampling methods.

Site Lists

The 2015/16 RSMP and Pierce County mussel sampling site locations come from the RSMP's Puget Sound Mussel Monitoring sample design. The intent of the study design was to create a random list of sites, using a Generalized Random Tesselation Stratified (GRTS) model for drawing spatial samples, from a population of sites along urban growth areas (UGAs) of the Puget Sound. Each site represents an average shoreline length of 800 meters (m); a GRTS-computed weight for each site of 799.8942 m. WDFW advised the RSMP to use an 800 m length of shoreline to represent a mussel site based on criteria used by the National Centers for Coastal Ocean Science's COAST National Status & Trends Mussel Watch Contaminant Monitoring program. This shoreline length was also supported by results from a mussel contaminant study conducted in 2012/13 by the Tacoma Pierce County Health Department in collaboration with WDFW. Results of that study are available in the document titled "Mussel Watch Gradient Report - Hylebos Waterway and Ruston Way" (Callahan, Hanowell, Jensen, 2014).

The GRTS algorithm that created the Puget Sound Mussel Monitoring sample draw resulted in a total of 2,048 sites in Puget Sound's UGAs, of which 40 locations are required for RSMP monitoring in 2015/16. WDFW staff and volunteers will evaluate candidate sites from this list (with the exception of sites within Pierce County) in numerical order from lowest to highest until 45 sites have been confirmed. The five extra confirmed sites will provide a number of reserve (i.e. contingency) sites, in case one of the original 40 sites is rejected on the date of deployment.

The number of sites required for monitoring by Pierce County is stated in permit condition(s) S8.B.1.b.ii for that county. Pierce County must sample the first eight (8) qualifying shoreline sites in their unincorporated UGAs from the Puget Sound Mussel Monitoring sample draw. It is recommended that Pierce County also have two extra sites in reserve on the date of deployment.

Figure 1 shows the initial 45 RSMP candidate sites (large circles) and the remaining sites (smaller circles); the first 100 RSMP sites are also listed in Appendix B. Figure 2 shows the 41 candidate Pierce County sites in unincorporated UGAs (large circles), as well as and the remaining sites in incorporated areas of Pierce County (smaller circles); the 41 unincorporated Pierce County sites are listed in Appendix C and are also available on Ecology's RSMP website.

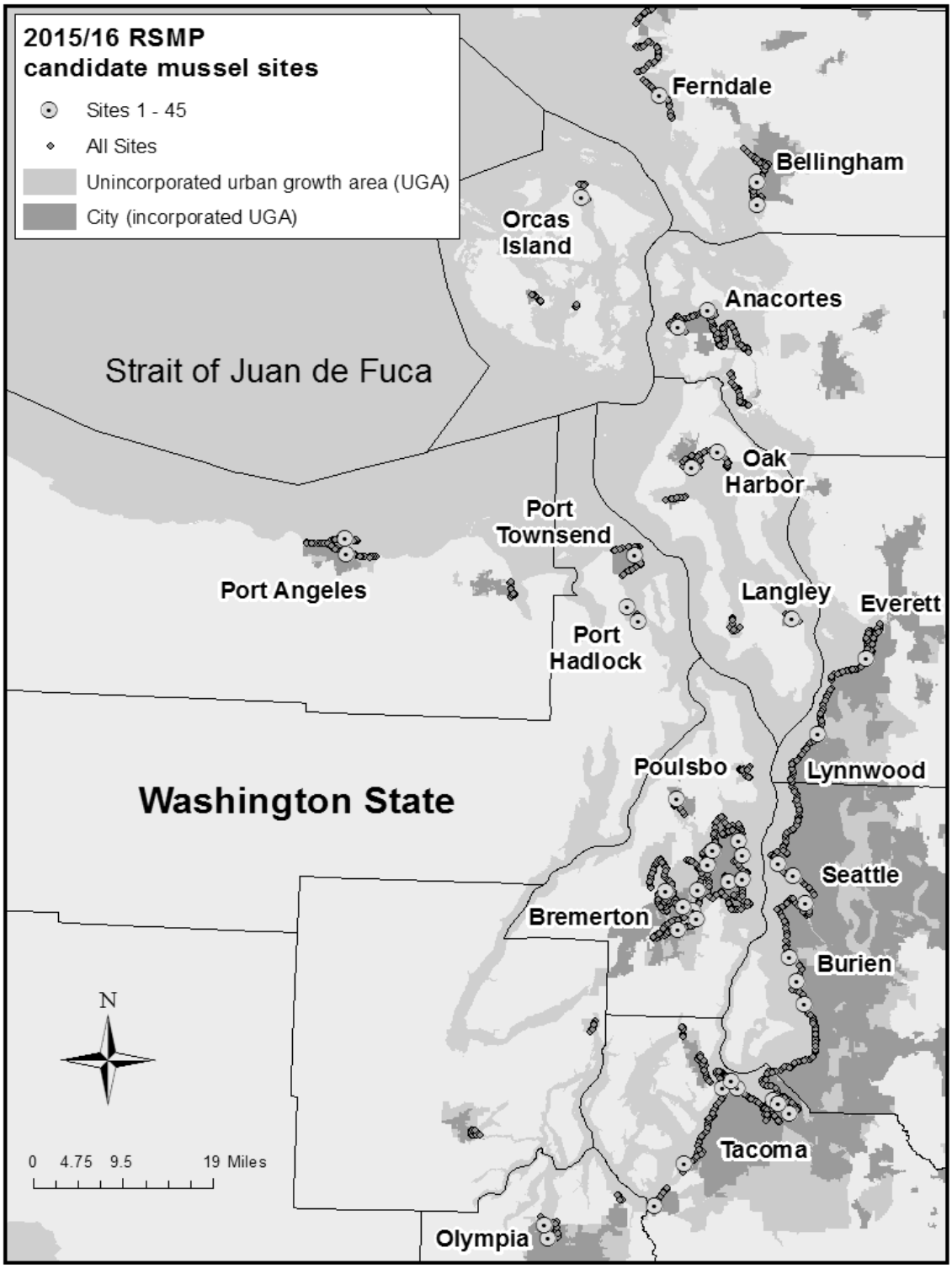


Figure 1. RSMP candidate sites for mussel monitoring located along urban growth area (UGA) shorelines.

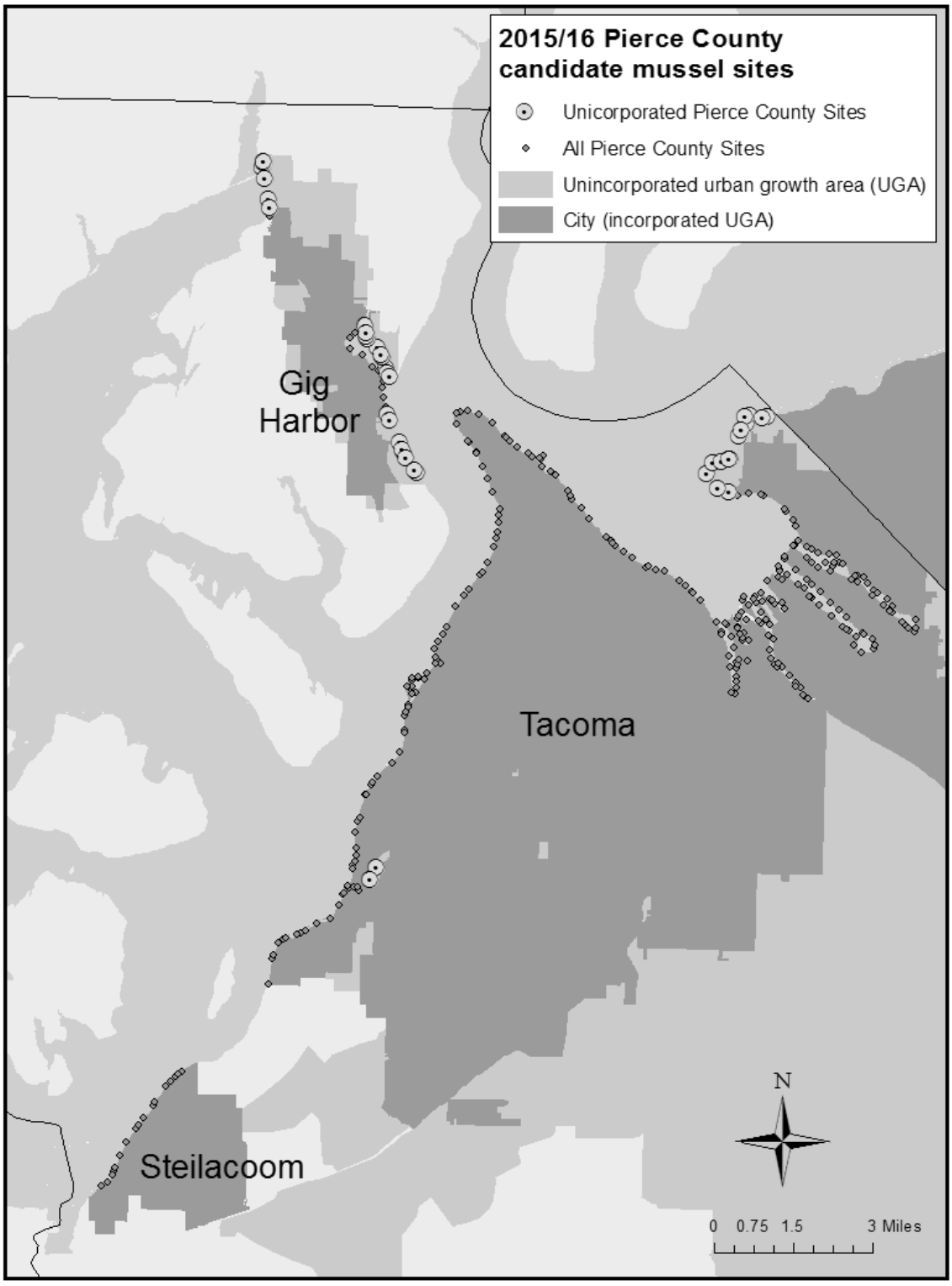


Figure 2. Pierce County candidate sites for mussel monitoring along unincorporated urban growth area (UGA) shorelines.

Site Evaluation

The initial list of required candidate sites for the RSMP and Pierce County must be verified by a field crew to determine suitability for sampling. Visiting a candidate site in the daylight during low tide, well in advance of monitoring, is important for evaluating accessibility, safety, and suitability of the site, which will include an evaluation of the intertidal substrate at 0 to -1.5 feet mean lower low water (MLLW).

Overview of Site Layout

Each candidate site's coordinates mark a location in the center of an 800 meter (m) long shoreline segment within the Puget Sound (hereafter called the candidate "site center"). The site center is located in the high intertidal zone. Figure 3 illustrates the layout of the sampling locations at each candidate marine site. Extending from the candidate site center (shown with a star in Figure 3) in a straight line perpendicular to the shoreline and into the subtidal zone are three distinct marine sampling locations.

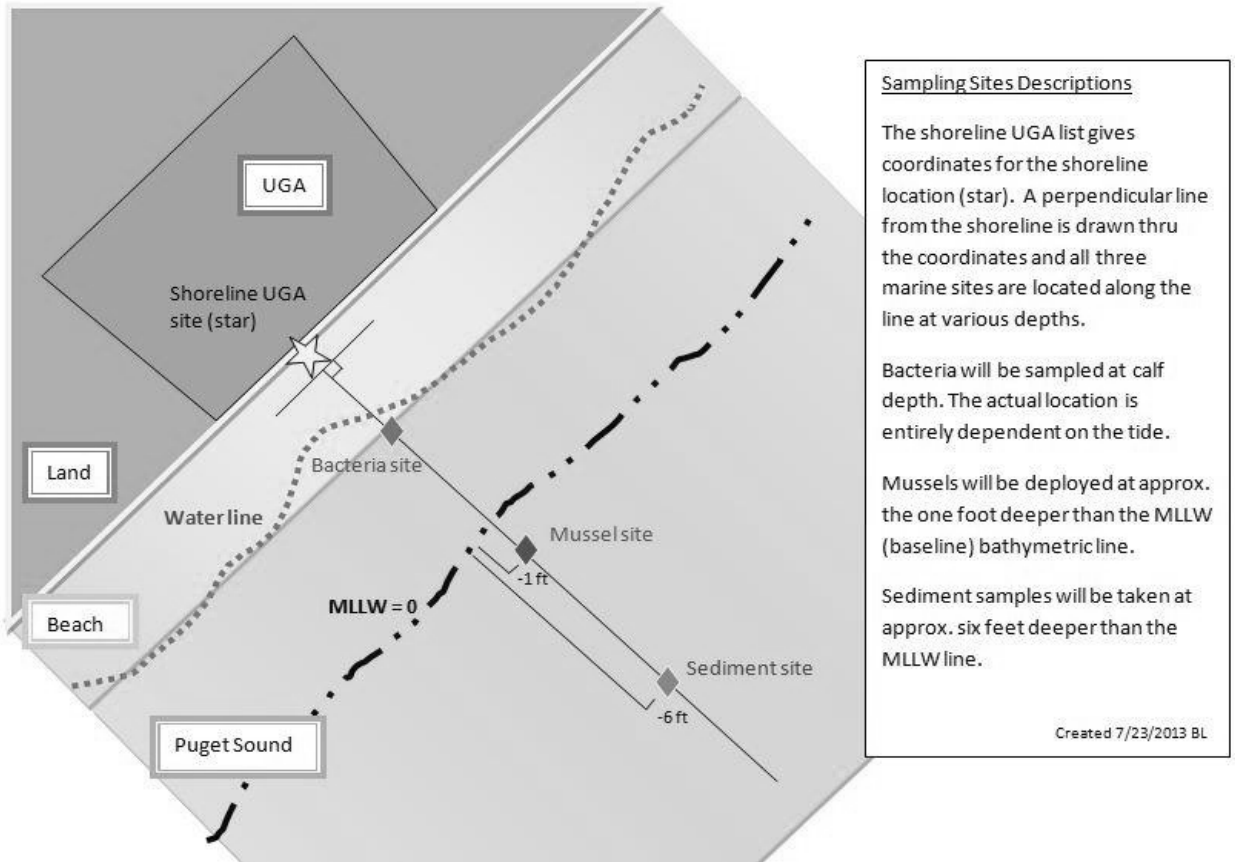


Figure 3. RSMP marine nearshore site layout along shoreline. Each nearshore site is located in the center of an 800 meter shoreline segment.

The first of the three locations (at the waterline), is intended for sampling of bacteria, the second location (in the intertidal zone) is designated for mussel cage deployment, and the third location (in the subtidal zone) is intended for sediment sampling. Bacteria and sediment sampling for the RSMP are described in separate QAPPs. The intertidal mussel monitoring site will be placed perpendicular to the target coordinates of the candidate site, at a depth of between 0 to -1.5 feet MLLW.

Criteria for Selecting a Suitable Sampling Site

The suitability of a mussel sample site will be determined using the criteria outlined below. Field crews must evaluate the suitability criteria outlined below at the site center. If the site center is not suitable, then the field crew will evaluate conditions up to 400 meters (1312 feet or 0.25 mile) in either direction along the shoreline until the *closest suitable location* relative to the site center is found.

Suitability of a candidate site is determined by the following criteria:

- Condition 1 - the site is NOT within a marina or port (i.e. where multiple motorized vessels are kept in the water), and
- Condition 2 - the site can be safely accessed and worked on in the winter, during night-time low tides, and
- Condition 3 - permission of property owners and/or tenants is granted prior to sampling, and
- Condition 4 - there is suitable substrate or a location for anchoring/securing a mussel cage at the site.

If a location other than the site center is chosen, then the reason for disqualification of the site center must be documented and the alternate site coordinates must be recorded. If all 800 m of a candidate site are not suitable, then the reason for disqualification must be documented, including photos, and alternate candidate sites must then be visited, in numerical order from the site list, and verified for replacement.

Accessibility Criteria

These criteria concern whether access to a candidate site is permitted by the land owners, and if the site can be safely accessed and sampled throughout the year. A site may also be deemed unsuitable or impracticable for sampling if more than one hour is required to access the site from the nearest parking location.

Permission

If the mussel cage is to be placed on private or commercially-owned tidelands, or private property must be traversed to gain access to public tidelands, permission must be granted from the land owner(s) prior to monitoring. Useful shoreline information can be gained from a desktop evaluation of candidate sites (i.e. search Google maps, public records, etc.) and a good faith effort to contact owners or tenants. In

some cases it might be necessary to obtain a special license, easement, or other legal document from a commercial or government property (i.e. Port Authority, City/County park, Tribe, etc.) to access and place a mussel cage on their property.

Property owners will be contacted well in advance of (i.e. several months before) cage deployment. This will ensure adequate time to explain the needs and timing of the study and to obtain permission to access the property during night-time low tides. In some cases keys or gate codes may be necessary to allow field crew access after business hours. Property owners should be reminded the day before mussel cage deployment and removal that workers will be on their property soon.

Permits

WDFW will obtain a blanket HPA, Shellfish Transfer Permit, and MOU with the DNR to access SOAL for all RSMP mussel monitoring activities. These permits and permissions will also cover sites monitored by Pierce County, as long as guidelines for mussel monitoring laid out in this QAPP are followed.

WDFW is responsible for obtaining any *other* permits or permissions (outside those listed above) necessary to conduct mussel monitoring work at the RSMP approved sites, including but not limited to site access permits for privately-owned, city, county, port authority, or tribal properties, or state or federal lands. Similarly, Pierce County is responsible for any other permits and permission at their sites. For instance, A Scientific Research Permit is required when conducting research (including mussel monitoring) within the boundaries of a Washington State Park. Application for this permit must be sent to Washington State Parks (http://www.parks.wa.gov/stewardship/) at least two weeks prior to mussel monitoring.

Safety

Field work, particularly in coastal environments, has an inherent risk of danger and environmental conditions can often be unpredictable. Mussel site reconnaissance, deployment, and retrieval pose a number of potential safety hazards including: unstable terrain (i.e. deep mud or cobbles/boulders), incoming tides, breaking waves, exposure to extreme temperatures, and sudden changes in weather. Field crews will evaluate each candidate site for safety. Appropriate reasons for disqualifying a candidate site for monitoring may include:

- route of entry or intertidal area is unstable or unsafe (e.g. sucking mud, quicksand),
- hostile people or animals are present.

Intertidal Physical Criteria

These criteria concern the conditions of the intertidal substrate at a candidate site for mussel monitoring. To be considered suitable for mussel cage placement, the intertidal area at the candidate site's center (or within 400 meters of the site center) must:

- have a substrate (i.e. mud, sand, cobble) into which a helical/screw anchor or rebar stakes can be driven, to secure the mussel cage, OR
- have some kind of structure to which the mussel cage can be tied or secured (e.g. steel or concrete pilings or other fixed points on-site) – this is especially important in high energy environments. *However, no cages will be affixed to or placed next to creosote-treated material.*

Documentation of Site Evaluations

Site evaluators must verify all sites given the suitability criteria above. Documentation of observations from both the desktop and field visits will be recorded in a Field Log. Site evaluators will provide a table listing the decisions and reasons for site selection or disqualification resulting from the site evaluations to the RSMP Coordinator by August 31, 2015.

Site ID and Site Name

Site ID

Once appropriate sample sites are identified, site evaluators will use the unique, pre-assigned "Site ID", which can be found in Appendices B and C under the "SITE_ID" column, to identify each individual site. Each "Site ID" will be entered into the *2015/16 RSMP Mussel Monitoring Datasheet* (Appendix D) during sampling. The Site ID will eventually become the "Location ID" in Ecology's EIM database and serves as the unique site identifier that relates the sampled sites to the GRTS study design, and is denoted as PSS13175-XXXXX where the "X" number changes for each site.

Location Name

Site evaluators will assign a unique and appropriate "Location Name" to each of their sampling sites. The Location Name should be succinct, and is limited to 40 characters by the EIM database. The name may be general or describe the location (e.g. Tacoma, or Commencement Bay, or Ruston Waterfront, or Steilacoom) or be more specific descriptor like a nearby stream/river, neighborhood/street, marine location, or other identifying landmark (e.g. Thea Foss, or Hylebos Waterway, or Point Defiance, or Days Island, or Ferry Terminal).

Some examples of appropriate Site Names:

- Tacoma - Titlow Park
- Commencement Bay - Blair Waterway
- Point Defiance - Ferry Terminal
- Ruston Way - Dickman Mill Park
- Thea Foss Waterway - 11th St Bridge

Order #

There is another field in EIM called the "Study_Specific_Location_ID" that is unique to the study. This field will be populated by a concatenation of the ORDER # (Column A) and the acronym "SUGA" which stands for Shoreline along Urban Growth Area; for example "044-SUGA".

Quality Objectives

The quality objectives for nearshore mussel monitoring described here are to obtain and analyze sufficient numbers of high quality mussel tissue samples to meet the goals and objectives of the RSMP program (Table 4).

Table 9. Summary of mussel tissue composites to be collected and analyzed for chemical contaminants during this study.

Purpose	Location	Timing	Composites	Replicates
Baseline samples	Aquaculture source	October	6	6
RSMP mussel sites	Various	January/February	40	1 per site
Pierce County sites	Various	January/February	8	1 per site
Lab QA samples	Various	Aliquots taken during chemical analysis	5	5[a]
Total			**59**	

[a] two QA samples per batch of 12

Field Measurements

WDFW staff and volunteers and Pierce County will record the GPS coordinates of the mussel cage at each deployment site with individual GPS units. Each field team will record the make and model of their GPS unit and the accuracy of the GPS reading when taken. In addition, all GPS devices used in this study will be set to North American Datum 83 (NAD83) for comparability and coordinates will be recorded in decimal degree format. The specifications for many GPS receivers indicate accuracy within 3 to 15 meters (10 to 50 feet) 95% of the time (http://www.gps-basics.com). Since mussel sites will be placed at least a half mile apart, this level of accuracy is acceptable for the RSMP's study purposes.

Measurements of tidal stage, substrate type, and upland and shoreline characteristics are taken by field staff during a sample collection event. WDFW staff and volunteers and Pierce County must meet measurement quality objectives (MQOs) listed in Table 5. Collection methods, reporting requirements, and quality control (QC) procedures summarized in the *Measurement Procedures* and *Quality Control Procedures* sections of this QAPP are intended to provide field measurement data that meet MQOs and RSMP objectives.

Table 10. Mussel monitoring field parameters: field methods, reporting limits, and QA/QC procedures. See 2015/16 RSMP Mussel Monitoring Datasheet (Appendix D).

Parameter	Expected Range Of Results	Technique/ Instrument	Measurement Method	QA/QC
Time of cage deployment and retrieval	12:00 – 24:00	Clock	Read from clock and reported in military time	Careful observation
GPS coordinates	N/A	GPS device or mobile device with GPS application	Set GPS device to NAD83, record in decimal degrees (e.g. 47.5893, -122.3953)	Record accuracy of coordinates at reading (e.g. ±15ft)
Wave energy	Flat, calm, wind chop, swells, breaking waves	Visual examination	Visual examination of sea near cage	Careful observation
Beach exposure level	Exposed, moderately exposed, sheltered	Visual examination	Visual examination of beach within ½ mile in either direction of cage	Careful observation
Time of most recent low tide (MLLW)	12:00 – 24:00	NOAA tides and currents website http://www.protides.com/washington/	Read from harmonic or subordinate tidal gauge station nearest to monitoring site	Accurate reading of information from website
Height of most recent low tide (MLLW)	0 to -4 ft.	NOAA tides and currents website	Read from harmonic or subordinate tidal gauge station nearest to monitoring site	Accurate reading of information from website
Precipitation	None, steady rain, showers, snow, hail	Visual examination	Visual examination of atmosphere	Careful observation
Majority (>50%) Substrate Type	Bedrock-hardpan, cobble-gravel mix, sand-gravel mix, sand, sand-	Visual examination	Visual examination within 200 foot radius of cage	Careful observation

Parameter	Expected Range Of Results	Technique/ Instrument	Measurement Method	QA/QC
	mud mix, mud-silt			
Aquatic vegetation coverage	None (<1%), 1-20%, 20-40%, 40-60%, 60-80%, 80-100%	Visual examination	Visual examination within 200 foot radius of cage	Careful observation
Aquatic vegetation type	None, eelgrass, kelps, fucus, ulva, other	Visual examination	Visual examination within 200 foot radius of cage	Careful observation, may include mix of types
Freshwater inputs	Natural streams, rivers, outfalls	Visual examination	Visual examination within 200 foot radius of cage	Careful observation, may include mix of types
Adjacent upland land-use type	Wide range of choices (see Appendix C)	Visual examination	Visual examination of beach within ½ mile in either direction of cage	Careful observation, may include mix of types
Erosion control structures	None, hard, soft. Includes materials used	Visual examination	Visual examination of beach within ½ mile in either direction of cage	Careful observation and documentation
Abandoned or derelict structures	No/Yes, type	Visual examination	Visual examination of beach within ½ mile in either direction of cage	Careful observation and documentation
Man-made structures on beach	N/A	Visual examination	Visual examination of beach within ½ mile in either direction of cage.	Careful observation, may include mix of types
Current shoreline use	Wide range of choices (see Appendix C)	Visual examination	Visual examination of beach within ½ mile in either direction of cage.	Careful observation, may include mix of types
Construction of structures on beach touching water	Treated wood, concrete, steel, other	Visual examination	Visual examination of beach within ½ mile in either direction of cage.	Careful observation, may include mix of types

Parameter	Expected Range Of Results	Technique/ Instrument	Measurement Method	QA/QC
Outfalls	N/A	Visual examination	Visual examination of beach within ½ mile in either direction of cage.	Careful observation, may include mix of types
Potential sources of pollutants	N/A	Visual examination	Visual examination of beach within ½ mile in either direction of cage.	Careful observation, may include mix of types

*Field-measured parameters follow manufacturer's website guidelines for calibrations.

Laboratory Measurements

The objective for laboratory processing is to evaluate the biological metrics (mortality and condition index) of the transplanted mussels, while the objective for analytical chemistry is to evaluate the target analytes, with limits of detection sufficient to identify and measure the analytes. The RSMP will use mussels from a single source for the cages to minimize variability. Baseline samples of the mussel stock sufficient for both RSMP and Pierce County uses will be conducted by WDFW.

Mussel tissue chemical analyses will be conducted at the Northwest Fisheries Science Center Laboratory to ensure comparability of results. All work is expected to follow the laboratory methods and meet laboratory QC requirements of the analytical methods outlined in this QAPP. These requirements can be found in detail in the Puget Sound Estuary Program protocols (PSEP, 1986, 1997a, b, c) and in the peer-reviewed standard operating procedures (SOPs) for each test. Following are three tables listing the minimum QA criteria for organic chemicals and metals analyzed in mussels for this study (Tables 6, 7 and 8).

Precision

Precision is monitored and controlled within batches using laboratory replicates of field samples and across batches by analyzing Standard Reference Materials (SRM) of applicable matrix i.e., tissue. Cross-batch precision is expressed as the relative standard deviation (RSD) for repeated measurements. The RSD of analyte responses relative to the internal standard must be ≤ 15% for the repetitions.

Bias

Bias or accuracy of samples is evaluated by comparing measured SRM values with National Institute of Standards and Technology (NIST) certified values. In addition for persistent organic pollutants (POPs), concentrations of ≥70% of individual analytes are to be within 30% of either end of the 95% confidence interval of the reference values.

Comparability

The SOPs described in this document (Sloan et al. 2014; Sloan, Brown et al. 2004; Sloan, Brown et al. 2006) are consistent with other concurrent and future sampling efforts that could be used as comparison for mussels. In addition, methods detailed here are consistent with ongoing WDFW monitoring of contaminants in other Puget Sound species.

Although not necessary for the current project, comparability with historical NOAA Mussel Watch or other data will require some targeted evaluation. The performance-based nature of current analytical procedures is designed to allow the broadest comparability with other similar programs, however some discrepancies will exist with new vs. older mussel monitoring programs. For example, PCB Aroclors vs.

PCB congeners that will be used in this study. This issue will be addressed in future efforts to fully expand and establish a mussel-monitoring program in Puget Sound.

Table 11. Quality assurance criteria for PCBs, PBDEs, PAHs, and OCPs. Reproduced from Table 8 in Sloan et al. (2006).

Quality assurance element	Minimum frequency	Acceptance criteria
Instrument calibration	Once every batch of samples or once every two batches in one continuous analytical sequence	Analyte concentrations are to be calculated using point-to-point calibration with at least four concentration levels of calibration standards.
Continuing calibration	At start and end of every analytical sequence and every 10 or fewer field samples	The RSD of the analyte responses relative to the internal standard is to be ≤15% for the repetitions.
Reference materials: Sediment: NIST SRM 1944, NIST SRM 1941b Mussel tissue NIST SRM 1974b Blubber: NIST SRM 1945 Fish tissue: NIST SRM 1946, NIST SRM 1947	One with every batch of 20 or fewer field samples	Concentrations of ≥70% of individual analytes are to be within 30% of either end of the 95% confidence interval of the reference values. These criteria do not apply to analytes with concentrations below their LOQ with the lower LOQ is within or greater than the 95% confidence interval, nor to those analytes known to have coeluting compounds.
Method blank	One with every batch of 20 or fewer field samples	No more than 5 analytes in a method blank are to exceed 2x lower LOQ. Samples are not corrected for analytes found in the blank.
Sample replicates (i.e. duplicates or triplicates)	One with every 20 or fewer field samples.	RSDs are to be ≤15% (equivalent to relative percent difference ≤30% for duplicates) for ≥90% of the analytes that have concentrations ≥1 ng/g.
Internal standards/surrogates	At least one internal standard/surrogate is added to every sample	The recoveries are to be 60-130%.
Interlaboratory comparisons	At least one per year	In conjunction with the NIST or the IAEA.

Table 12. Required batch quality control measures and quality assurance criteria for mercury via CVAA. Reproduced from KCEL SOP 604v6.

Quality Control Element	Description of Element	Frequency of Implementation	Control Limit
			Tissue
Method Blank (MB)	Interference-free matrix to assess overall method contamination	1 per sample batch	± MDL
Spike Blank (SB)	Interference-free matrix containing all target analytes	1 per sample batch	85 - 115%
Standard Reference Material (SRM)	Certified reference material from NIST or NRCC that is digested with samples.	1 per solid or tissue sample batch, if applicable	80-120% [c]
Laboratory Control Sample (LCS)	Certified reference material from a source other than NIST or NRCC	1 per solid or tissue sample batch, if applicable	80-120% [c]
Matrix Spike (MS)	Sample matrix spiked with all/subset of target analytes prior to digestion	1 per sample batch	75-125%
Lab Duplicate (LD) [a],	Self-explanatory	1 per sample batch	RPD ≤ 20%

[a] No calculation performed when both sample and duplicate values < RDL

[c] Or varies due to control charting

Table 13. Required batch quality control measures and quality assurance criteria for the ICP-MS metals As, Cd, Cu, Pb and Zn. Reproduced from KCEL SOP 624v2.

Quality Control Element	Description of Element	Frequency of Implementation	Control Limit
			Tissue
Method Blank (MB)	Interference-free matrix to assess overall method contamination	1 per QC batch	± MDL
Spike Blank (SB)	Interference-free matrix containing all target analytes	1 per QC batch	85% - 115%

Quality Control Element	Description of Element	Frequency of Implementation	Control Limit
			Tissue
Standard Reference Material (SRM)	Certified reference material from NIST or NRCC that is digested with samples.	1 per solid or tissue sample batch, if applicable	80-120% [b]
Laboratory Control Sample (LCS)	Certified reference material from a source other than NIST or NRCC	1 per solid or tissue sample batch, if applicable	80-120% [b]
Matrix Spike (MS)	Sample matrix spiked with all/subset of target analytes prior to digestion	1 per QC batch	75% -125%
Lab Duplicate (LD) [a]	Self-explanatory	1 per QC batch or MSD.	≤ 20% RPD, when at least one value is > RDL

[a] No calculation performed when both sample and duplicate values < RDL

[b] Or varies due to control charting

Representativeness

Mussels used for this study will be of the species *Mytilus trossulus* (bay or foolish mussel), which is indigenous to intertidal habitats in the Puget Sound. As recommended in the *Standard Guide for Conducting In-situ Field Bioassays with Caged Bivalves* (ASTM E2122-02, 2007), mussels for this study will come from an aquaculture facility. The source will be Penn Cove Shellfish, Inc. in Penn Cove, Whidbey Island, Washington. The advantage of using mussels from this facility is that all individuals will be of similar ages from the same population, will have a similar genetic and environmental history and are expected to be relatively uncontaminated. In addition, Penn Cove Shellfish, Inc. is the only local aquaculture farm that raises *M. trossulus.*

The target size of mussels selected for transplantation will be based on the median size (± 5 mm) of 100 randomly selected adult (approximately 11 months old and larger than 45 mm) mussels available when bagging begins. Based on previous measurements taken at Penn Cove Shellfish on August, 2012, mussels selected for transplantation will likely measure between 50 – 60 mm in shell length.

Since the Puget Sound on average receives its highest amount of rainfall in the winter months, the sampling period chosen for this study (October – January/February) represents a period when input of contaminants from stormwater runoff is at its potential highest. Mussel cages will be placed on the intertidal substrate between 0 to -1.5 feet mean lower low water (MLLW), with mussels suspended approximately 40 cm above the substrate. The placement of cages is meant to simulate contaminant conditions experienced by most nearshore biota in the intertidal zone during the winter in Puget Sound.

Completeness

The goal of this study is to collect and analyze mussel tissue from 40 randomly selected sites from the Puget Sound shoreline UGAs, however, some cages may be lost due winter storms, vandalism or theft.

Based on the number of individuals used to determine the condition of mussels from National Mussel Watch Program sites (Kim et al. 2006), a sample size of 12 mussels from each site will be selected for determination of condition index (CI). For tissue chemistry analysis a composite size of about 32 individuals (200g of soft tissue) per site (cage) was selected to optimize the amount of tissue available for analysis at the two chemistry laboratories. This mass is based on previous experience with the same laboratories, and allows enough tissue for reanalysis (if needed) and archiving small (20 g) subsamples. The number of mussels per composite was selected to balance representativeness of the population with the labor and time constraints related to processing samples. Our goal will be achieved if we are able to create a tissue composite from every site.

Sampling Procedures

This section describes field and lab sampling procedures. The following sampling procedures are outlined in time-sensitive order. Field activities should be conducted by at least two people. Activities can be parsed into tasks to be accomplished by one or more persons at a given time. Mussel monitoring methods will, in general, follow those described below. A complete list of field materials required for mussel cage deployment and retrieval can be found in Appendix H.

Preparation for Field Work

Safety

Mussel site reconnaissance, deployment, and retrieval pose a number of potential safety hazards to field crew, including unstable terrain (i.e. deep mud or cobbles/boulders), incoming tides, breaking waves, exposure to extreme temperatures, and sudden changes in weather. A contact person will be designated at the office to which field personnel report at pre-designated times.

WDFW staff/volunteers and Pierce County staff will develop a site-specific safety plan including at a minimum the following elements. To ensure their safety, all field crew members are required to follow these safety guidelines:

- Do not go to the monitoring site alone; use a minimum of two people.
- Wear appropriate clothing for thermal and water protection.
- Be alert to breaking waves - wear a life jacket if appropriate.
- Avoid falls - wet rocks and logs are slippery.
- Avoid getting stuck in deep (i.e. sucking) mud.
- Wear gloves: protect hands from cuts and samples from contamination.
- Bring a cell phone or other means of two-way communication to call for emergency response in the field if needed.

It is possible that during deployment or retrieval, invasive species (e.g. benthic invertebrates or marine plants) could collected on equipment or clothing (e.g. boot treads). All material not retained for analyses or archiving will be rinsed near the sampling location with water.

Field Log

The lead scientist at WDFW and Pierce County will maintain a water-resistant field logs with detailed notes for each major monitoring-related activity detailed below. Information recorded will include:

- Name and location of project
- Field personnel
- Sequence of events and/or changes in plans or procedures
- Unusual circumstances that may affect interpretation of results

If a candidate mussel monitoring site is found to be unsuitable, the reasons for rejecting the site must be recorded in the Field Log. Alternate candidate sites must be visited and verified.

Field Datasheets

WDFW and Pierce County will print a *2015/16 RSMP Mussel Monitoring Datasheet* (Appendix D) on water-resistant paper for each verified and usable site. These datasheets will be filled out with data from each mussel monitoring site at the time of deployment and saved to complete at the time of cage retrieval.

Chain-of-Custody

A *Mussel Chain-of-Custody form* (Appendix E) will be used to track mussel possession during the field and laboratory portion of the study. The chain-of-custody (COC) will be initiated by WDFW for each monitoring site to track possession of mussel bags (i.e. start of monitoring) and will be maintained by each party responsible for the mussels until all samples are relinquished to the WDFW Marine Resources Laboratory in Olympia.

Equipment Preparation

Decontamination, Prevention of Spread of Invasive Species

RSMP and Pierce County will conduct field work and clean equipment to prevent the spread of invasive species. Staff and equipment that contact multiple surface waters will, at a minimum, be cleaned according to Ecology's SOP EAP070, *Minimizing the Spread of Aquatic Invasive Species* (Ecology, 2012). These procedures will be followed at the end of each work day or upon leaving a water body before entering another. Some areas are designated to be of "Extreme Concern"; these areas are shown in several maps at the following link: www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html

Cages

WDFW and Pierce County will obtain plastic-coated, wire mesh cages (anti-predator cages, Figure 4) with the following attributes:

- Size = 16 x 16 x 16 inches (length x width x height)
- Mesh opening = 1.25 x 2.5cm
- Removable lids.

Acceptable cages are sold at McKay Crab and Shrimp Gear, in Brinnon, Washington.

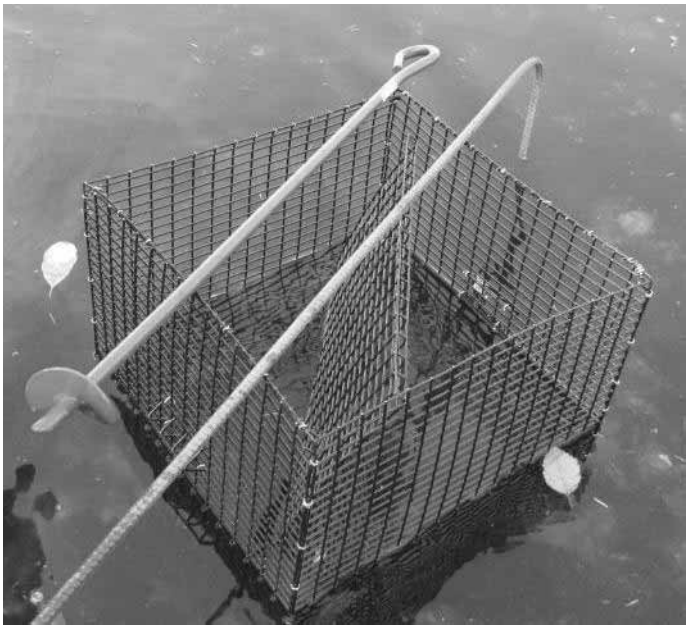


Figure 4. Anti-predator mussel monitoring cage (lid shown inside cage) with 30-inch screw anchor and bent-tip rebar stake.

To dissipate any potential surface contaminants, cage owners will either 1) soak cages and anchoring materials to be used for monitoring in water for 24 hours prior to use, or 2) wash the cages and anchoring materials with a high pressure hose using fresh water.

Anchors

WDFW and Pierce County will obtain anchoring devises suitable for anchoring their cages into the substrate at their individual monitoring sites. WDFW recommends using a screw anchor (30-inch shaft recommended) and four bent-tip rebar stakes to anchor cages in mud, sand or sand/cobble beaches. Large cable ties (3 to 5 foot long) may be used as alternate anchoring devices to secure cages to fixed objects like non-creosote pilings or boulders. In addition, cinder blocks may be purchased and used in combination with cable ties and/or rebar stakes as anchoring devices.

Mussel Preparation

WDFW will coordinate with Pierce County to arrange mussel pick-up from the aquaculture facility and delivery of mussels post-deployment to the WDFW Marine Resources Lab in Olympia. The exact location and day of pick up will be announced with at least a month notice, but is currently planned for October 2015 and January 2016.

Preparation of Study Population

The following sections describe the procedure WDFW will follow for harvesting, measuring, and bagging mussels at Penn Cove Shellfish, Inc. a commercial aquaculture facility, in preparation for subsequent deployment in anti-predator mesh cages at sites around the greater Puget Sound.

The protocols described below are based on procedures outline in the *Standard Guide for Conducting In-situ Field Bioassays with Caged Bivalves* (ASTM E2122-02, 2007). Although the *Standard Guide* initially mentions several possible cage types for in-situ field tests with caged bivalves, the majority of their subsequent field measurement and sampling methods are based on the assumption that the researcher is using individually compartmentalized mussels in cages suspended in the water column. In this study mussels will not be individually compartmentalized; they will be grouped together within their cages. In addition, cages will be deployed in the intertidal zone on the substrate, not suspended in the water column. Thus although the methods outline here are based on guidance from the *Standard Guide for Conducting In-situ Field Bioassays with Caged Bivalves* modifications have been made where necessary to accommodate the specifics needs of the RSMP.

Determination of Mussel Size Range

The target size of mussels selected for bagging and subsequent transplantation will be based on the median size (± 5 mm) of 100 randomly selected adult (approximately 11 months old and larger than 45 mm) mussels available the day before bagging begins. Based on previous measurements taken at Penn Cove Shellfish, Whidbey Island on August, 2012, mussels selected for transplantation will likely measure between 50 - 60 mm in shell length.

Mussel Presort

The presorting, measuring, and bagging described below will take place during the September prior to deployment, allowing time for inclement weather.

WDFW staff and volunteers will obtain live mussels for cage deployment during normal, periodic harvest operations conducted by Penn Cove Shellfish, Inc. aquaculture staff. Penn Cove Shellfish, Inc. grows mussels attached to 20 foot sections of rope hanging under floating docks. Penn Cove staff harvest mussels by removing them from the ropes and cleaning them with specially designed brushes aboard a

harvesting vessel. WDFW staff and volunteers will divert live, cleaned mussels from this operation to a nearby beach, where sorting, measuring and bagging will occur.

During the beach sorting, measuring and bagging mussels will be kept in the shade, so as not exposed them to direct sunlight for long periods of time. Mussels will be held in ambient seawater in coolers while they wait processing. Using a knife or scissors we will select mussels that fall within the desired size range and, if necessary, separate them from one another by cutting their byssal threads. Care will be taken not to pull or tear the byssal threads, so as not to damage the byssal glands. The cleaned and separated mussels will then be replaced into a cooler filled with ambient Penn Cove seawater.

WDFW will monitor the water temperature inside this seawater holding cooler with a thermometer, to ensure it stays within ±5° C of current Penn Cove surface temperature, and change water as needed to maintain suitable water quality.

Measuring and Bagging

WDFW staff and volunteers will take presorted mussels from the holding cooler and measure their shell length. Only intact mussels with no cracks in their shells and that respond to physical stimulation by tightly closing their shells will be selected for measuring and bagging. Mussels that do not meet these requirements will be discarded.

Measuring

Mussels will be randomly selected from the holding cooler. WDFW staff and volunteers will measure shell length (umbo to farthest posterior margin) using a digital caliper with measurement accuracy of 0.1 mm. Length measurements will be manually recorded onto a waterproof paper data sheet.

Bagging

Sixteen (16) measured mussels will be placed into a heavy duty mesh bag measuring 20 inches in length. WDFW staff and volunteers using a cable tie will divide the bag into two sections with eight mussels in each section. The finished mussel bags will have two separate sections providing ample space for the mussels to feed and grow.

WDFW staff and volunteers will affix a plastic identification tag with a unique number to each finished bag. This number will be noted alongside the measurements of the mussels for that specific bag. Once the identification tag is affixed to the filled mussel bag the bag will be placed into another holding cooler filled with ambient Penn Cove seawater. The seawater in these coolers will be maintained in the same fashion as described above.

Presoak period

Once a sufficient number of mussel bags have been processed, WDFW staff and volunteers will affix them to a 20-foot weighted line, spaced approximately six inches from each other. Approximately 40 bags will be placed along each line. When a line is filled with bags, Penn Cove Shellfish staff will hang the line under one of their aquaculture platforms. Each line of bagged mussels will be marked with an identification flag indicating the range of bag ID numbers hanging on that line. The location of the line will be noted in the Field Notebook.

The finished mussel bags will be left to soak at Penn Cove Shellfish for at least 10 days before they are removed from the water for deployment in mesh cages. The 10+ day period following mussel bagging is intended to allow the mussels a resting period after they are separated, sorted, cleaned and bagged. This allows them time to re-cluster prior to deployment (Andral et al, 2011; Benedicto et al, 2011; Galgani et al, 2011).

Mussel Cage Deployment and Retrieval

WDFW staff and volunteers and Pierce County will place their pre-bagged mussels in wire mesh cages that will be anchored to the substrate with a combination of screw anchors, rebar stakes, and/or concrete blocks as described below. If necessary and possible, some cages may be tied (using large nylon cable ties) to steel or concrete pilings or other fixed points on-site. *No cages will be affixed to creosote-treated material.*

Deployment/Retrieval Dates

WDFW staff and volunteers and Pierce County will deploy and retrieve their caged mussels during low tide times in the late fall (October 2015) and late winter (January – February 2016), respectively. Deployment and retrieval will occur during one of the preferred dates listed in Table 9 below, with alternate dates to be used only when necessary, such as in the event of a storm or other hazardous condition that precludes field work on the preferred date.

Table 14. Potential deployment and retrieval dates for RSMP mussel monitoring in 2015/16. Dates are based on predicted low tides at Seattle, Elliott Bay harmonic station (NOAA).

Low Tide Event	Deployment Dates	Retrieval Dates
Preferred	September 30-October 3, 2015	January 20-24, 2016
Alternate	October 27-31, 2015	February 6-10, 2016

Baseline Tissue Sampling

At the time of deployment WDFW will sub-sample the bagged mussels from the aquaculture facility to assess the baseline biological and chemical conditions of the starting population. Pierce County has no responsibilities for baseline sampling.

Deployment

WDFW staff and volunteers and Pierce County field crews deploying mussel cages (hereafter referred to collectively as "deployers") must be on site to deploy the mussel cage at the time of the zero MLLW on the night of deployment. Proper timing ensures that the field crew can place the mussel cage at 0 to -1.5 feet MLLW (i.e. at the water line at the moment of, or just after, the daily lowest low tide) with plenty of time to work before the incoming tide.

Pick Up and Transport RSMP-approved Mussels to the Monitoring Site

Deployers will go to Penn Cove Shellfish, Inc. on Whidbey Island on the afternoon of the low tide on which they will deploy the cage. Deployers will provide a cooler(s) of sufficient size, half filled with ice, to transport the mussels on the date of pick-up. Each deployer will get four bags of mussels (16 mussels per bag) per mussel cage to be deployed. The four mussel bags will be placed into a large plastic Ziploc bag(s) marked with the name of the site(s) where the cage(s) will be deployed. The bagged mussels will be placed in the cooler on bagged ice. Mussels must not come into contact with ice melt water during transportation.

At this time WDFW will initiate a COC form (Appendix E) unique to each monitoring site for which mussels are being transferred. The deployers must keep these forms for later use upon retrieval and delivery of mussels to the WDFW processing laboratory.

Deployers will transport the bagged mussels on ice directly to the deployment site(s) and deployed on the same night they were received from the aquaculture facility, to minimize time out of the water.

Secure the Mussels into the Cage

Deployers must wear powder-free nitrile laboratory gloves when handling the mussel bags.

At the mussel site deployers will affix the four mussel bags to the top quarter (¼) of the anti-predator cage, so that they span the width of the cage and are spaced evenly apart (Figure 5). Once installed the mussel bags should hang well above the bottom of the cage. Use 8-inch cable ties to secure the end of each bag to the sides of cage, so that the bags are stretched across the middle of the cage and all mussels are an equal height above the bottom (Figure 5). After the mussel bags are fastened inside the cage, record the four mussel bag ID numbers on the *2015/16 RSMP Mussel Monitoring Data Sheet* (Appendix D), then secure the cage's lid in place with at least eight 8-inch cable ties (two per edge,

Figure 6). Sea stars can get through relatively small (0.5 x 1 inch) openings, so it is important not to leave any gaps. If desired, cable ties can be trimmed to about one inch length after they have been fastened.

Figure 5. Mussel bags affixed to the top quarter (1/4) of an anti-predator cage, lid not shown.

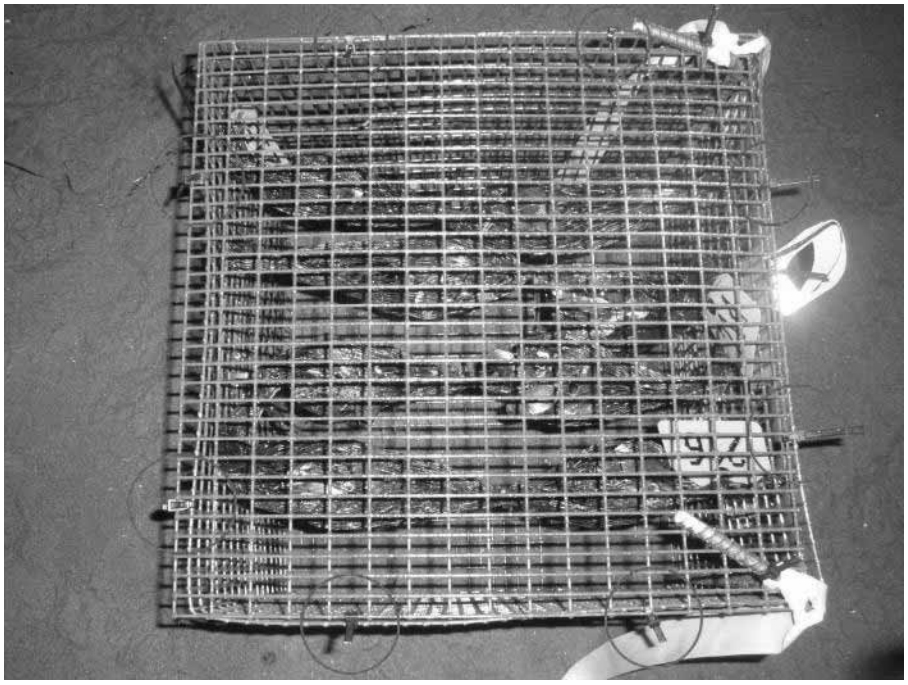


Figure 6. Anti-predator cage lid secured in place with at least two 8-inch cable ties per edge (red circles).

Secure the Cage to the Substrate

Once the mussels are attached inside the cage and the lid is secured, deployers will anchor the cage to the substrate in the intertidal zone between 0 to -1.5 feet MLLW. Timing is critical to ensure proper placement relative to tidal height; the cage must be installed at or just below the water line when the lowest low tide of the day reaches zero feet.

Whenever possible cages should be anchored to the substrate using a screw anchor (30-inch shaft recommended) and four rebar stakes. The helical anchor must be screwed as deeply into the substrate as possible, leaving only a few inches of the shaft and the top eye hole visible. Screwing in the anchor will require a lever (to turn the anchor) and substantial downward pressure. Figure 7 illustrates use of the lever. Heavy-duty gloves are recommended for installing the screw anchor and the rebar stakes.

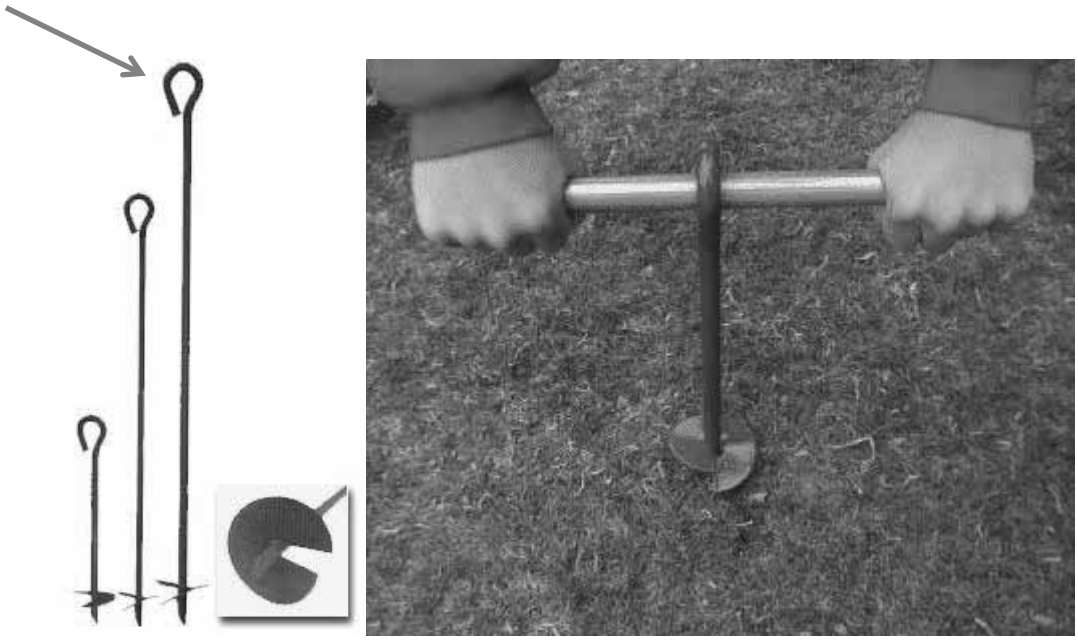


Figure 7. Helical, earth or screw anchors and lever used to screw anchor into the substrate. The red arrow indicates the 30-inch long anchor shaft that is recommended.

Once the anchor is installed, the cage will be placed next to the helical anchor and secured to the anchor using two 8-inch cable ties. In addition, rebar stakes should be pounded through the top and/or sides of

the cage, taking care to avoid driving the stakes through the mussel bags. Deployers may also cable tie the stakes to the cage (Figure 8).

Figure 8. Mussel monitoring cage driven through with bent-tip rebar stakes (on the far end) and secured to a helical anchor with cable ties. For better cage anchoring, 3-4 rebar stakes are recommended.

If a screw anchor and rebar stakes are not adequate and more or different anchoring is needed, the cage may be secured with large (3 to 5 foot long) cable ties to a non-creosote, fixed object (i.e. piling or pole) or secured to a cement block(s) that will act as a weighted anchor (Figure 9). No cages should be affixed to creosote-treated material.

Figure 9. Examples of additional cage anchoring methods.

Field Measurement Procedures

This section describes field measurement processes to be conducted by WDFW staff and/or volunteers and Pierce County (hereafter collectively called "field personnel"). Data generated as described in this section will be entered into Excel spreadsheets and verified for accuracy. The original datasheets and the Excel spreadsheets with entered and quality checked data will be delivered to WDFW within one

month of creation. Results will be entered into Ecology's EIM database along with the rest of the RSMP data by WDFW staff.

Once the mussel cage has been deployed and anchored to the site, deployers will record field measurements and observations on the *2015/16 RSMP Mussel Monitoring Site Datasheet* (Appendix D) and SAVE the datasheet to be finished during retrieval. Table 10 lists field measurements and observations deployers must make at the time of mussel cage deployment and retrieval. Deployers will also take digital photos confirming proper deployment of the mussel cage.

Table 15. Field measurement and observation parameters.

Field Measurements
Time of cage deployment/retrieval
GPS coordinates and accuracy
Field Observations/Estimates
Wave energy
Precipitation
Beach exposure
Substrate Type
Aquatic vegetation cover and types
Freshwater inputs
Adjacent upland land use
Erosion control structures
Shoreline use
Anthropogenic structures on beach
Outfalls present
Potential sources of pollutants

Global Positioning System (GPS) coordinates of the mussel cage will be recorded at each mussel monitoring site. All coordinates will be recorded in decimal degree format (e.g. 47.5893 latitude, -122.3953 longitude). Deployers will ensure that their GPS device or app has been set to use the North American Datum 83 (NAD83) geodetic reference system. The specifications for many GPS receivers

indicate accuracy within 3 to 15 meters (10 to 50 feet) for 95% of measurements (http://www.gps-basics.com). Deployers will also document the make/model of the GPS unit used to obtain GPS coordinates. If a downloadable navigation application (app) on a smart phone is used to obtain GPS coordinates, the name and manufacturer of the app must be noted.

Retrieval

Mussel retrieval will take place during MLLW periods within a specific range of dates to be announced by WDFW (see Table 9). WDFW staff and volunteers and Pierce County (hereafter collectively called the "retrievers") must remove their monitoring cages during the WDFW designated low tide period. Arriving on site at the time of MLLW ensures that retrievers can find and remove the mussel cage when it is totally exposed, with plenty of time to work before the incoming tide.

Upon arrival at the caged mussel site, the retrievers will take a digital photo of the cage, to document its condition, including structural integrity and degree of biofouling. Afterwards the retrievers will fill out the small retrieval section of the *2015/16 RSMP Mussel Monitoring Site Datasheet* (Appendix D).

After field measurements, while wearing nitrile laboratory gloves, the retrievers will remove the four bags of mussels from the cage, keeping the mussels in the bags and the mesh intact, and place the bagged mussels immediately into a large, pre-labeled Ziploc bag(s). The Ziploc bag(s) will be placed into a cooler with bagged ice. This double barrier bagging method will ensure that mussels do not come into contact with any ice melt water during holding.

The cages and ALL anchoring devices and other paraphernalia will be removed from the beach; nothing from the monitoring project should be left behind. Upon finishing the removal the retrievers will fill out the bottom half of the matching Chain of Custody (COC) form (Appendix E), which will be kept with the cooler until it is delivered to the WDFW Marine Resources Laboratory in Olympia the following morning (see address below).

Mussel Transport

Retrievers will hold the mussels overnight on ice in a cooler. Care will be taken to avoid freezing the mussels during holding (i.e. do not leave the cooler outside if the temperature drops below freezing). The retrievers will deliver the live mussels and matching COC form to WDFW for processing the morning following retrieval. Mussels should be delivered as early as possible to the WDFW Marine Resources Laboratory in Olympia (see address below), to ensure adequate time to process the mussels in the laboratory, especially if multiple cages are to be processed in one day.

Deliver mussels to:

WDFW - Marine Resources Laboratory

1111 Washington St SE, 6th Floor

Olympia, WA 98504-3150

Laboratory Processing of Mussels

This section describes the laboratory measurement processes to be conducted by WDFW staff and volunteers. Data generated as described in this section will be entered into Excel spreadsheets and verified for accuracy. Results will be entered into WDFW's PSEMP database by WDFW staff.

Lab Forms

Two forms will be used to track mussel samples as they are processed in the lab: *the Specimen Form* (Appendix F) records information and biological metrics for each mussel that is processed for a composite sample, while the *Tissue Resection Logs* (Appendix G) is used to document which individual mussels are included in each composite sample. These forms will be printed on waterproof paper to facilitate use in the lab environment. In addition a daily log (lab notebook) of operations will be maintained to record each day's activity, including the number of samples processed, observations, problems, resolutions, etc.

Equipment Cleaning Procedure

Anything that may contact portions of a mussel subject to contaminant analysis will be cleaned before use. A "clean" work surface (lab counter, cutting board, sorting tray, instruments, etc.) will be covered by at least one layer of new aluminum foil, which will be changed between composites. "Clean" stainless steel dissection tools and grinding apparatus (hand grinder and cutting blades) will be 1) washed in warm soapy water (Terg-A-Zyme®), 2) thoroughly rinsed three times under warm running tap water, 3) rinsed with deionized water (held in Teflon squeeze bottle), 4) rinsed with isopropyl alcohol (held in a Teflon squeeze bottle), and then 5) placed on aluminum foil for air drying.

The same clean instruments/surfaces will be used repeatedly, without re-cleaning, on mussels contributing to the same composite. Afterwards, these instruments/surfaces will be subjected to the complete cleaning procedure prior to the processing of a new composite. Lab personnel will change nitrile gloves between composites.

Mussels for Mortality, Condition Index, and Chemistry

Each mussel site will be represented by a cage that contains four individually numbered bags of mussels (64 individuals). WDFW lab staff will receive cages and bags of mussels the day after retrieval and complete the field portion of the COC form. WDFW lab staff will then determine the mortality in each mussel bag and select a random set of 12 mussels from the four bags to measure condition index. The remaining live mussels will be stored in a labeled plastic Ziploc type bag at -20°C until tissue resectioning for chemical analysis can take place. The length of mussel storage between retrieval and chemical analysis will not exceed three months.

Mortality

WDFW lab staff will assess individual mussel bags for dead or moribund mussels within 36 hours of receiving the mussels. Dead or moribund mussels will be counted, recorded and removed. Mussels will be considered moribund if the animal is unable to tightly close its valves when stimulated. Mussels will be considered dead if there is no soft tissue inside the valves, or if the mussel soft tissue inside is putrefied.

Condition Index

After dead mussels have been removed, condition index will be determined on 12 randomly selected mussels, according to the method reported by Kagley (2003) as follows:

Condition index (CI) = dry weight (g) of soft tissue/shell length (mm) X 100.

If needed, byssal threads and barnacles will be removed from the shell of the mussels prior to measuring, to prevent exterior debris from interfering with measurements. Shell length will be measured from the umbo to the farthest posterior margin (Figure 10) to the nearest tenth of a millimeter (0.1 mm) using a digital caliper. Total Shell Length (TSL) will be recorded on Specimen Forms.

Mussels will be opened by inserting a scalpel blade between the bivalve shells and severing the posterior and anterior adductor muscles (Figure 11). The shells will be spread apart at the hinge to reveal the soft tissue. At this point, the remaining byssal fibers will be cut from the byssal gland using scissors. Then, if necessary, the tissue will be gently rinsed of sediment and foreign material with care not to lose pieces of tissue, using a Teflon squeeze bottle filled with DI water. After draining excess water, a scalpel will be used to scrape all the mussel soft tissue (including the adductor muscle) from the shell onto a pre-weighed drying pan. The wet weight of the soft tissue will be measured to the nearest tenth of a gram (0.1g) using a bench scale and recorded on the Specimen Form. Pans of mussel tissue will then be placed in a drying oven set at 120°C until the weight is constant (approximately 18 hours). After cooling to room temperature the resulting dry weight will then be recorded to the nearest tenth of a gram (0.1g) on the Specimen Form.

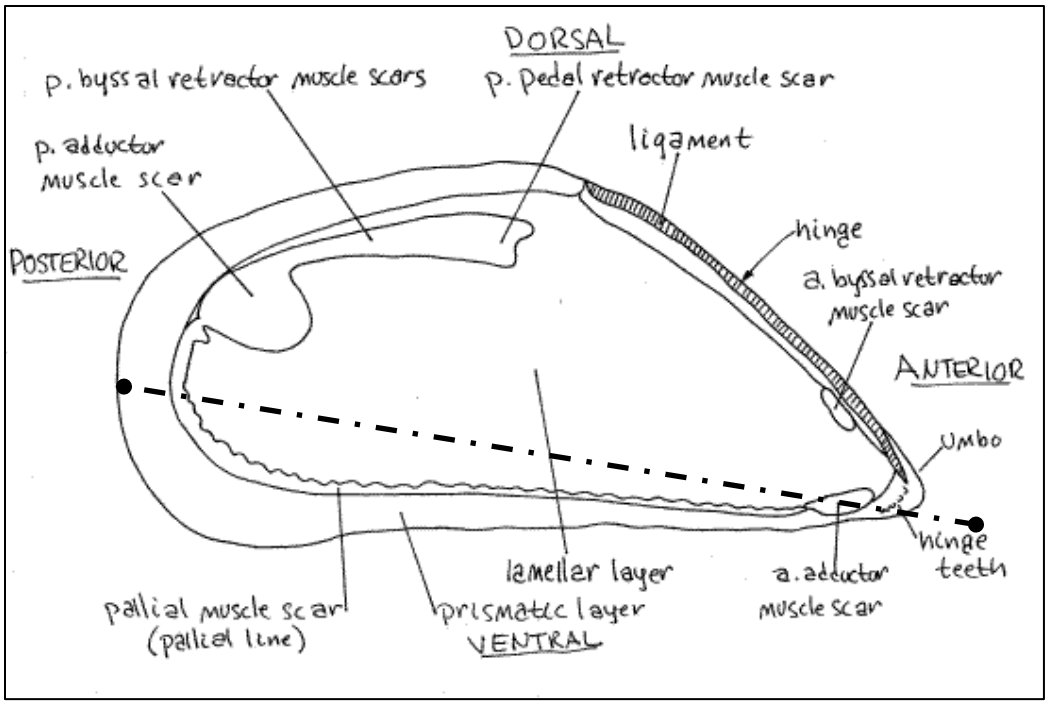


Figure 10. External anatomy of *Mytilus edulis* (Ruppert, Fox, and Barnes 2004).

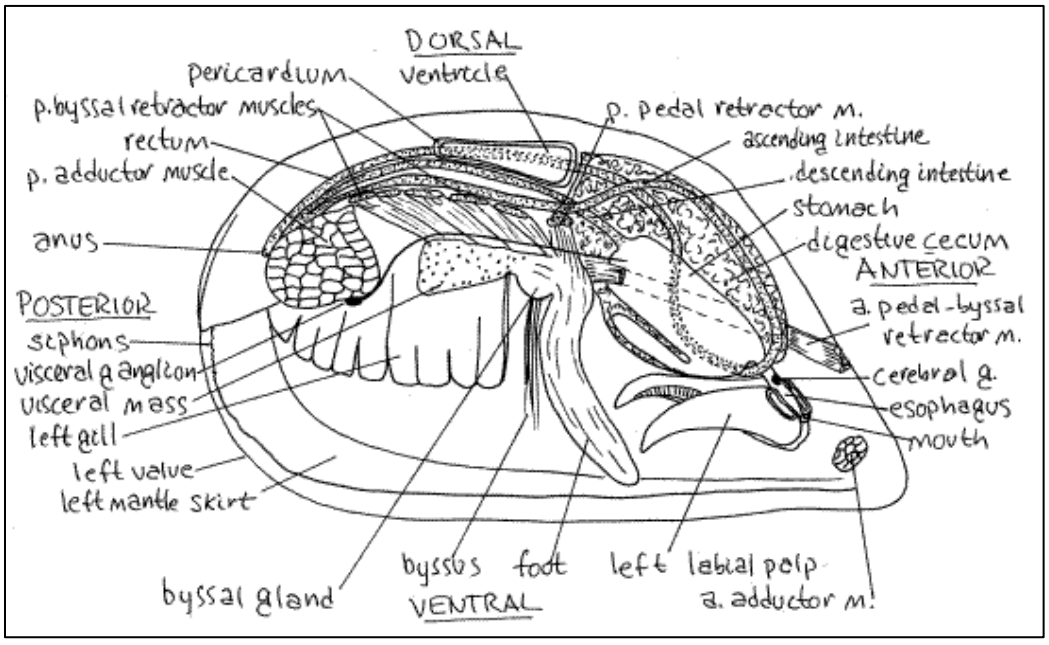


Figure 11. Internal anatomy of *Mytilus edulis* (Ruppert, Fox, and Barnes 2004).

Preparing Composite Samples for Chemical Analysis

Previously frozen mussels will be thawed and prepared for tissue resectioning using the following procedure, which is a modification of Field Procedure 11.7 from the *Standard Guide for Conducting In-situ Field Bioassays with Caged Bivalves* (ASTM E2122-02, 2007). WDFW lab staff will wear clean nitrile gloves and change gloves between each sample. Lab staff will also maintain two sets of instruments per site; one set of tools to open the mussel, and one set of tools to remove tissue from the shell into the jar.

Prior to shucking the mussels for the soft tissue, byssal threads, sediment, biofouling, and barnacles will be removed from the shell of the mussels using scissors and gloved hands. Mussels will be rinsed several times with DI water to further remove external debris to reduce the risk of cross contamination after the mussels are opened.

Once cleaned and thawed sufficiently, lab staff will open each mussel by inserting a clean scalpel blade between the bivalve shells, severing the posterior and anterior adductor muscles (Figure 22). The shells will be spread apart at the hinge to reveal the soft tissue. The remaining byssal fibers will then be trimmed from the byssal gland using scissors. If necessary, the tissue will be gently rinsed of sediment and foreign material with care not to lose pieces of soft mussel tissue using a Teflon squeeze bottle filled with DI water. Excess water will be allowed to drain from the specimen. Using a scalpel, all soft tissue (including the adductor muscle) will be scraped into a clean I-CHEM (Class 200) glass sample jar.

Tissue from approximately 32 individual mussels from each sample site will be combined into a single pre-labeled composite sample jar, with the goal of collecting approximately 200 grams of tissue for each composite sample. Each mussel's tissue weight will be recorded on the Tissue Resection Log as it is added to the jar. After 32 mussels are added to the jar the total tissue weight will also be recorded. Each composite sample will then be frozen for later homogenization. Unused whole mussels and cleaned (empty) mussel shells will be placed into a labeled Ziploc bag and re-frozen until the conclusion of the study.

After creation of composite samples, tissues will be ground in their original jars until a homogenous mixture is achieved. Partially thawed samples will be ground using a Bamix hand mixer to a consistency resembling pudding. Homogeneity will be determined by visual inspection. Once homogenized, subsamples will be placed in smaller I-Chem jars to allow for distribution of samples between several labs and for sample archiving.

Sample Storage

All mussel composite samples and subsamples will be labeled and frozen to -20ºC and held in a WDFW Marine Laboratory freezer until transfer to the analytical labs or their final archival destination. The location and conditions of all mussel composite samples will be recorded in a standard laboratory

notebook used to track tissue samples for the WDFW-PSEMP program. The temperature of the WDFW-PSEMP program freezer is set at -20° C and is continuously monitored through data loggers tracked by Washington State Enterprise Services. Any temperature anomalies will trigger an alarm, triggering on-site maintenance staff to contact a laboratory supervisor from a priority list of supervisors, for immediate attention. In addition, this freezer is backed up by emergency generators in case of power outage.

Chemical Analyses

Number of Samples

The maximum number of samples to be submitted for chemical analysis in this study is expected to be 54; 40 RSMP samples, eight Pierce County samples, and six baseline samples. It is expected that the POPs analysis will also generate five laboratory quality control samples.

Sample Preparation Method(s)

Homogenized composite mussel tissue samples will be shipped to the analytical labs frozen. The analytical labs will thaw and thoroughly mix the tissue samples with clean utensils to ensure adequate homogeneity prior to sample preparation for chemical analysis.

Analytes

The POPs, metals, and conventional analytes to be measured are listed in Tables 11, 12 and 13. Composited somatic mussel tissue will be the only matrix analyzed for chemical contaminants.

Persistent Organic Pollutants (POPs)

All POPs in this study will be analyzed according to Sloan et al. (2014). This analytical method is consistent with previous WDFW studies. In brief, this method comprises three steps: (a) extraction, (b), cleanup by silica/aluminum columns and size-exclusion high-performance liquid chromatography (SEC HPLC), and (c) quantitation of chlorinated hydrocarbons (CHs) and aromatic hydrocarbons (AHs) using gas chromatography /mass spectrometry (GC/MS) with selected-ion monitoring (SIM). Samples are extracted using accelerated solvent extraction (ASE with methylene chloride), which provides an extract that can be used for AH, CH recovery and gravimetric lipid evaluation. This method also includes alterations to typical GC/MS methods to stabilize the instrument and improve accuracy such as chemical ionization filaments (to increase source temperature), employing a cool on-column injection system in the GC, a guard column before the analytical column, and point-to-point calibration to improve data fit over the full range of GC/MS calibration standards (Sloan et al. 2014).

Sensitivity: Limit of Quantitation (LOQ) and Method Detection Limit (MDL)

For all POPs in this study the lower Limit of Quantitation (LOQ) "for a given analyte in a given sample is the concentration that would be calculated if the analyte had a GC/MS response area equivalent to that analyte's area in the lowest level CS used in the calibration for that analyte (not all levels are used for some analytes). When an analyte is not detected in a sample or has an area that is smaller than its area in the lowest level CS used, the concentration of the analyte in that sample is reported to be less than the value of its LOQ." (Sloan et al. 2014). Typically LOQ values for POPs that have been reported to WDFW by this method are in the range of 0.2 to 0.8 ng/g wet weight (Table 11).

EPA defines Method Detection Limit (MDL) in Appendix A to 40 CFR Part 136 as the "minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the element". In this study, the metal's MDLs are concentrations that cannot be detected or detected at a concentration less than the associated method detection limit considering tissue sample detection limits are affected by the sample mass used, matrix and polyatomic/isobaric interferences. The MDL is the lowest concentration at which a sample result will be reported. Table 12 lists the respective method detection limits for the metals of concern in this study (Hg, As, Cu, Zn, Cd, and Pb). They range from 0.10 to 0.00038 µg/g wet weight.

Table 16. Persistent organic pollutants (POPs) to be measured in this study.

Persistent organic pollutants (POPs):	No. Analytes	Method	Limit of Quantitation - LOQ (wet weight)	Expected Range (wet weight)
Polychlorinated biphenyl (PCB) congeners	40	Sloan et al. 2004	0.2-0.8 ng/g	LOQ to 20 ng/g
Polybrominated diphenylethers (PBDEs) congeners	11	Sloan et al. 2004	0.2-0.8 ng/g	LOQ to 20 ng/g
Organochlorine pesticides (OCPs)	25	Sloan et al. 2004	0.2-0.8 ng/g	LOQ to 20 ng/g
Polycyclic Aromatic Hydrocarbons (PAHs)	45	Sloan et al. 2004	0.2-0.8 ng/g	LOQ to 20 ng/g

Expected range of results

The range of concentrations for POPs in this study is from the LOQ (typically between 0.2 and 0.8 ng/g wet weight) to 20 ng/g wet weight for individual PCB or PBDE congeners, OCP isomers, or PAH analytes. The range of concentration of metals should be from the limit of detection (approximately 0.005 µg/g) to 5 µg/g wet weight.

Metals

All metals analyses will be performed by the King County Environmental Laboratory (KCEL). The metals mercury, arsenic, cadmium, copper, zinc, and lead will be analyzed by two methods. Mercury will be analyzed via automated cold vapor atomic absorption spectrometry following King County Environmental Laboratory Standard Operating Procedure (KCEL SOP) 604. This SOP incorporates elements of EPA 245.1 revision 3, SW-846 7470, 7471B and PSEP 1997. Arsenic, cadmium, copper, zinc,

and lead will be analyzed via Thermo Elemental X Series II CCT (Collision Cell Technology) Inductively Coupled Plasma Mass Spectrometer (ICP-MS) following KCEL SOP 624. This SOP incorporates elements of EPA 200.8 revision 5.4, SW-846 6020A February 2007, ILM05.3 Exhibit D part B, and PSEP 1997. Total solids will be analyzed via KCEL SOP 307v3 to facilitate reporting metals data in both dry and wet weight concentrations.

Table 17. Metals to be measured in this study.

Metals	No. Analytes	Method	Method Detection Limit (wet weight)	Expected Range (wet weight)
Total mercury (Hg)	1	KCEL SOP 604 [b]	0.00038 µg/g	MDL to 5 µg/g
Lead (Pb)	1	KCEL SOP 624 [c]	0.004 µg/g	MDL to 5 µg/g
Arsenic (As)	1	KCEL SOP 624	0.004 µg/g	MDL to 5 µg/g
Zinc (Zn)	1	KCEL SOP 624	0.10 µg/g	MDL to 5 µg/g
Copper (Cu)	1	KCEL SOP 624	0.008 µg/g	MDL to 5 µg/g
Cadmium (Cd)	1	KCEL SOP 624	0.002 µg/g	MDL to 5 µg/g

[b] KCEL SOP 604; [c] KCEL SOP 624

Conventionals

Lipid content will be performed by NOAA. Samples will be extracted using accelerated solvent extraction (ASE with methylene chloride), which provides an extract that can be used for gravimetric lipid evaluation (Sloan et al. 2014). Percent solids (total solids) analyses will be performed by the KCEL. Total solids will be analyzed gravimetrically using Standard Methods 2540-G as described below.

Table 18. Conventionals to be measured in this study.

Conventional parameters	No. Analytes	Method	Method Detection Limit (wet weight)	Expected Range (wet weight)
Lipid content (% total extractables)	1	gravimetric	0.1%	0.5 to 3%
Dry Weight (%)	1	gravimetric	0.005%	10-20%

Stable Isotopes

Stable isotopes of carbon (^{13}C) and nitrogen (^{15}N) will be measured by Mass Spectrometry (following Herman et al. 2005) after preparation as follows:

1. Homogenized tissue samples freeze-dried overnight
2. Freeze-dried tissue pulverized in a micro-ball mill
3. 0.4 to 0.6 mg powder of each sample placed into separate tin cups, in triplicate
4. Combusting samples in a Costech elemental analyzer attached to a Thermo-Finnegan Delta Plus Isotope Ratio Mass Spectrometer

Values are calibrated with internal standards every ten samples. Unenriched histidine is used as a control material to evaluate set-to-set reproducibility, analyzed after every 25 samples. Stable isotope results are expressed in "delta" (δ) notation in ‰:

$$\delta Z = [(R_{sample}/R_{standard}) - 1] \times 1000 \ (1),$$

where Z is ^{15}N or ^{13}C,

R_{sample} is the ratio $^{15}N/^{14}N$ or $^{13}C/^{12}C$ for the tissue sample, and

$R_{standard}$ is the ratio of $^{15}N/^{14}N$ or $^{13}C/^{12}C$ of standards (atmospheric air for nitrogen and Pee Dee Belemite limestone for carbon.

Percent Lipids

Percent lipids in each sample are represented by total extractables, according to Sloan et al. 20042014. Briefly samples from the extraction step of the POP analyses will be evaporated and compared to the mass of the original, unextracted sample (paraphrasing from Sloan et al. 2014):

- The pan containing the sample for total extractables from Section 3 is placed on a covered rack in the hood and the solvent is allowed to completely evaporate (approximately 1–2 hours).
- The pan is dried in a 50°C oven for 2 hours, then cooled in a desiccator overnight.
- The pan is weighed to the nearest 0.0001g and the weight is recorded as the "Pan w/TE" weight.
- The percent total extractables (% TE) content of the sample is calculated as follows:

  % TE = [(Pan w/TE – Pan) x (ASE Vial w/Extract – ASE Vial) x 100%]/[(ASE Vial w/Extract – ASE Vial w/o TE Extract) x Sample Weight].

Percent Solids (Dry Weight) Determination

The percent of the sample as dry weight is determined by simple drying of tissues according to Standard Methods 2540-G (paraphrasing):

- Pre-homogenized tissue (1 + 0.5 g) is placed into the pan, and the pan is weighed to the nearest 0.0001 g. The weight is recorded as the "Pan w/Wet Sample" weight.

- The pan is placed in a drying oven at 105°C for 4 hours to overnight, then cooled in a desiccator for at least an hour. The pan is weighed to the nearest 0.0001 g, and the weight is recorded as the "Pan w/Dry Sample" weight.
- The percent dry weight of the sample is determined as follows:

  % Dry Weight = [(Pan w/Dry Sample – Pan) x 100%]/(Pan w/Wet Sample – Pan).

Quality Control Procedures

All mussels used for the RSMP study and those used by Pierce County, will come from a single Puget Sound aquaculture facility (Penn Cove Shellfish, Inc., Whidbey Island). Thus all the mussels deployed to RSMP and Pierce County study sites will originate from the same population, be of a similar age, have a similar genetic and environmental history and are expected to be relatively uncontaminated. In addition, all composite samples of mussels produced from RSMP and Pierce County sites will be analyzed by the same two laboratories (see Table 8).

Once the mussels have been collected and delivered to the WDFW Marine Resources Lab they will no longer be under Pierce County control. At that point WDFW and the RSMP contracted labs will have control of the samples and responsibility for laboratory quality control (QC) procedures. Laboratory processing and analysis of both the RSMP and Pierce County mussel samples will be performed by WDFW.

Field QC

Field personnel will follow measurement and QC methods specified in Table 5, to obtain consistent field measurements specified in this QAPP. Training on mussel deployment, retrieval, and how to take field measurements will be provided by WDFW staff by the summer of 2015. This training will take the form of a webinar or document (i.e. self-train), to ensure comparability of results between the Pierce County, WDFW staff and volunteers.

Field personnel will ensure photos are taken of the fully installed mussel cage, for verification of proper technique. In addition, field personnel are expected to fill in ALL sections of the *2015/16 RSMP Mussel Monitoring Datasheet* (Appendix D), as well as in the Chain of Custody Form (Appendix E) provided in this QAPP. Field personnel will perform in-field reviews of their datasheets before leaving the study site, to ensure all data is recorded correctly.

Instrument Check

A GPS accuracy of 5-10 meters (15-30 feet) will provide adequate representation of the physical location of collected mussels. Field personnel will ensure that backup GPS units are available in the field should the unit currently in use fail.

WDFW Processing Laboratory QC

All laboratory data generated by WDFW during mussel processing will be examined visually using Excel filters and sorting procedures to identify gross formatting or transcription errors. Data values will be

compared with expected ranges to identify potential outliers. In addition preliminary tables of summary statistics and scatter plots will be created to examine the data.

Analytical Laboratory QC

Quality control procedures, quality assurance criteria and corrective actions for POPs data are detailed in Sloan et al. (2014). Briefly, precision is monitored and controlled within batches using laboratory replicates of field samples (2 replicates run for every batch of 12 samples) and across batches by analyzing Standard Reference Materials (SRMs –one per batch). Cross-batch precision is expressed as the relative standard deviation (RSD) for repeated measurements. The RSD of analyte responses relative to the internal standard must be ≤ 15% for the repetitions.

For POPs analysis, accuracy of samples is evaluated by comparing measured SRM values with National Institute of Standards and Technology (NIST) certified values. A SRM of applicable matrix will be selected to be analyzed i.e., tissue. Concentrations of ≥70% of individual analytes are to be within 30 % of either end of the 95% confidence interval of the reference values. One method blank is run for every 20 or fewer field samples. No more than 5 analytes in a method blank are to exceed 2x the lower LOQ before corrective action is taken. The corrective action will be to re-extract and re-analyze the affected samples and if necessary, qualify the sample data. At least one internal standard (surrogate) is added to each sample, with acceptable recoveries ranging from 60 to 130%.

Quality control measure and quality assurance criteria for metals data are detailed in Table 12 and
Table 13. Briefly, precision is monitored and controlled within batches using laboratory replicates of field samples (one per batch). Accuracy of analysis is evaluated by comparing measured standard reference material (SRM) values and a laboratory control sample (LCS) with the respective certified values. A SRM of applicable matrix will be selected to be analyzed i.e., tissue. Method blanks and spikes are evaluated for overall run and process contamination. These are run every batch as is applicable.

All analytical laboratory data will be examined visually using Excel filters and sorting procedures to identify gross formatting or transcription errors. Raw analyte concentrations will be compared with expected ranges to identify potential outliers. In addition preliminary tables of summary statistics, scatter plots, and time trend plots will be created to examine the new data.

Data Management

WDFW will format all digitized field and laboratory data into a structure compatible with the PSEMP-Toxics in Biota (TIB) database. The TIB database is a relational database created in Access, with separate tables for (1) field effort data, (2) biological characteristics of individuals used to create samples, (3) many-to-many cross reference for individuals-to-composites, (4) sample tracking, condition and summary statistics, and (5) chemical analyses. The TIB database is stored on a WDFW server, which is backed up nightly as part of an automated network backup service provided by WDFW Information Technology (IT) Services.

Field Data

WDFW staff and volunteers and Pierce County field personnel will be collecting and managing data from field work during deployment and retrieval of mussel samples. All data will be managed and stored by the field personnel responsible for each site. Field measurements and observations will be recorded on the *2015/16 RSMP Mussel Monitoring Site Datasheet* (Appendix D) printed on waterproof paper. A new field datasheet will be completed at every mussel monitoring site, and data on sites rejected during reconnaissance will be recorded in a separate Field Log.

Field data will be digitized (placed into Excel spreadsheets) and all entries will be independently verified for accuracy by another individual on the project team. This data will be incorporated into annual reports and electronic reports by WDFW and Pierce County (see Monitoring Reports section below). Reports and data will be submitted to Ecology in the format required.

Audits

The WDFW mussel monitoring lead will routinely coordinate all activities with staff and volunteers to ensure the field sampling locations are suitable, deployment and retrieval of mussels and the COC form is properly filled out. Laboratories will alter the WDFW lead if timeframes are not met, or samples are lost. The WDFW will take corrective actions where necessary to ensure adequate timeframes and safe sample delivery.

Laboratory Data

WDFW staff will digitize (place into Excel spreadsheets) laboratory measurements and observations recorded on Specimen Forms (Appendix F) and Tissue Resection Logs (Appendix G). All entries will be independently verified for accuracy by another individual on the project team.

Data received from the analytical laboratories will be in Excel spreadsheets in various formats. WDFW staff will format these data into a structure compatible with the TIB database and incorporate the data accordingly.

Data Storage

All datasheets, photographs, and printed or electronic data generated for this project will be stored by WDFW and Pierce County in organized filing systems for paper and electronic files. These files may be sought by Ecology for permit compliance review and audit purposes and must be maintained according to the records retention requirements for all documents related to the permits. Location and measurement data will be evaluated through the data verification process outlined in this QAPP. Acceptable results will be used by scientists to prepare a summary report and entered into Ecology's EIM database.

Data Verification and Quality Assessment

WDFW and Pierce County project leads will examine and verify all field-generated data to ensure:

- Specified methods and protocols were followed.
- Data are consistent, correct, and complete, with no errors or omissions.
- Data specified in the *Sampling Process Design* section were obtained.
- Results for QC samples as specified in the *Measurement Quality Objectives* and *Quality Control* sections accompany the sample results.
- Established criteria for QC results were met.
- Data qualifiers are properly assigned where necessary.

Field Data

Throughout the duration of field sampling, the field personnel leads and crew members are responsible for implementation of sample-collection procedures. The field lead is also responsible for a systematic review of all field documentation generated (e.g., datasheets, field logs, chain-of-custody sheets, sample labels) to ensure data entries and labels are consistent, correct, and complete, with no errors or omissions. This review should be completed prior to leaving the site where the measurements were made.

Data usability assessment follows verification. This involves a detailed examination of the data package using professional judgment to determine whether the quality objectives have been met. WDFW and Pierce County project managers will examine the complete field data packages (i.e. hard copy datasheets and Excel spreadsheets) to determine compliance with procedures outlined in this QAPP and referenced SOPs. WDFW and Pierce County project managers will also ensure that the MQOs have been met and determine if the quality of the field data is usable for the RSMP objectives.

Laboratory Data

Data generated by the analytical labs will be reviewed by analytical lab staff for out-of-bounds values, transcription errors and other problems by at least two chemists. Final review is conducted by a lab manager who approves data before they are released to the client. Prior to database entry WDFW will review the data by comparing results with similar species or matrices in the PSEMP-TIB database. Individual data, means, and standard deviations will be plotted and putative outliers evaluated for validity. Evaluation of the validity of putative outliers will include reviewing all collection, biological, and analytical data for potential transcription errors, communication with analytical labs to verify reported values are correct, and evaluation of biological covariates that might explain otherwise unanticipated values.

The success of meeting data quality objectives is evaluated based on the outcome of quality control procedures during analytical procedures. Typically if QC criteria are not met the problem is identified, corrected, and sample (or extract) re-run. In cases where QC criteria have not been met and there is not enough tissue to be reanalyzed, the data are to be censored with appropriate qualifiers to allow an objective evaluation of the usability of the final record. Rejected data are censored with an "R" or equivalent qualifier. Based on (1) a long history of employing these methods to measure target analytes in a wide range of Puget Sound biota matrices, (2) the range of data values we expect in this study, and (3) appropriate (tenth-of-ppb) limits of quantitation, we expect rejected data to be rare, with the singular possible exception of potential blank contamination for naphthalene-compounds.

Non-detected analytes will be censored with a "<LOQ" or "U" qualifier. The value reported for non-detected analytes will be the LOQ or Method Detection Limit, depending on analytical procedure. It is the responsibility of data users to decide how to use data censored as not-detected. Previous experience with data from similar studies for the target analytes in this study suggest that summed totals will be dominated by substantial concentrations of a number of individual analytes.

Monitoring Reports

2015/16 RSMP Mussel Monitoring Progress Report

WDFW staff will provide a progress report of the 2015/16 RSMP mussel monitoring effort, in the form of an oral presentation, to the Stormwater Work Group (SWG) in the summer of 2016. This progress report will include an update of work-to-date on the RSMP mussel monitoring project and recommendations for future changes to the program.

2015/16 RSMP Mussel Monitoring Summary Report

WDFW will produce a summary report on the biological, chemical, and geographic data from the 2015/16 RSMP mussel monitoring survey and Pierce County's 2015/16 mussel monitoring survey, due to Ecology on June 30, 2017. This report will include an assessment of the extent and magnitude of chemical contamination of mussels in UGAs of the Puget Sound, tables and graphs with summary statistics, maps of contaminant distributions, and recommendations for refining future rounds of RSMP monitoring. In addition, RSMP mussel monitoring results will be compared with results from WDFWs Toxic Contaminants in Puget Sound's Nearshore Biota: A Large-Scale Synoptic Survey Using Transplanted Mussels (Mytilus trossulus) (Lanksbury et al. 2014) report, where appropriate. The format will be a WDFW agency report.

Pierce County Mussel Monitoring Reports

Pierce County must provide a detailed summary of the previous calendar year's mussel monitoring activities. This detailed monitoring report is due to Ecology as an attachment to the permittee's annual stormwater monitoring report, due on March 31 of 2016, 2017, and if needed, 2018. The report must include all information listed below. All associated data will also be uploaded to Ecology's EIM database and made available to the public via Ecology's web site (www.ecy.wa.gov/eim/myEIM.htm). The information contained in Pierce County's 2015/16 mussel monitoring summary report will be incorporated into the 2015/16 mussel monitoring summary report produced by WDFW.

Pierce County's project lead is responsible for describing their mussel monitoring efforts.

The monitoring report will include a complete discussion of the mussel monitoring effort and must include the items detailed below in Table 14.

Table 19. Reporting requirements.

Category	Reporting Requirement
Site Confirmation	Documentation of the site confirmation process, including desktop evaluation and field visits for each of the required number of assigned sites.
	List of sites disqualified and specific reasons for disqualification.
	List of final sites. In a table, provide final GPS coordinates for each site and the distances from the initial GPS locations provided in the Master Sample
Site Information	Description of upland land use adjacent to the site sampled.
	Description of intertidal habitat, substrate, and vegetation at the site sampled.
	Description of man-made structures on the beach or in the water at the site sampled.
	Field measurements and observations at each site.
Site Activities	Deployment and retrieval information (date, time, weather, mussel bag numbers, anchors used etc.).
	Field measurements (water temperature, salinity).
	Photo documentation.
Concerns	Narrative description of any deviations from this QAPP, including any delays,
Costs	Estimated monitoring costs for each required monitoring program component.
Signature	Designated official (General Condition G19) signature

References

Andral B., F. Galgani, C. Tomasino, M. Bouchoucha, C. Blottiere, A. Scarpato, J. Benedicto,

S. Deudero, M. Calvo, A. Cento, S. Benbrahim, M. Boulahdid, and C. Sammari. 2011. Chemical Contamination Baseline in the Western Basin of the Mediterranean Sea Based on Transplanted Mussels. Archives of Environmental Contamination and Toxicology; 61: 261-271.

ASTM International. Standard Guide for Conducting In-situ Field Bioassays with Caged Bivalves. E2122 - 02. 2007 (reapproved). ASTM International, 100 Barr Harbor Drive, PO Box C-700, West Conshohocken, PA 19428-2959, United States, pp. 30.

Benedicto J., B. Andral, C. Martınez-Gomez, C. Guitart, S. Deudero, A. Cento, A. Scarpato, J. Caixach, S. Benbrahim, L. Chouba, M. Boulahdidi, and F. Galgani. 2011. A large scale survey of trace metal levels in coastal waters of the Western Mediterranean basin using caged mussels (*Mytilus galloprovincialis*). Journal of Environmental Monitoring; 13: 1495-1505.

Callahan C., R. Hanowell, and J. Jensen. 2014. Tacoma Pierce County Health Department: Mussel Watch Gradient Report, Hylebos Waterway and Ruston Way. Tacoma-Pierce County Health Department, Tacoma, WA.

Galgani F., C. Martínez-Gómez, F. Giovanardi, G. Romanelli, J. Caixach, A. Cento, A. Scarpato,

S. BenBrahim, S. Messaoudi, S. Deudero, M. Boulahdid, J. Benedicto, and B. Andral. 2011. Assessment of polycyclic aromatic hydrocarbon concentrations in mussels (*Mytilus galloprovincialis*) from the Western basin of the Mediterranean Sea. Environmental Monitoring and Assessment; 172: 301-317.

Kagley A.N., R.G. Snider, P.K. Krishnakumar, and E. Casillas. 2003. Assessment of Seasonal Variability of Cytochemical Responses to Contaminant Exposure in the Blue Mussel *Mytilus edulis* (Complex). Archives of Environmental Contamination and Toxicology; 44: 0043-0052.

KCEL SOP 307. King County Environmental Laboratory Standard Operating Procedure.

Total Solids and Total Volatile Solids, King County, WA.

KCEL SOP 624: King County Environmental Laboratory Standard Operating Procedure 624 – ICP-MS Analysis of Water, Wastes, Sediments and Tissues by the Thermo X Series II CCT.

KCEL SOP 604v6: King County Environmental Laboratory Standard Operating Procedure 604v6 - Instrumental Analysis for Mercury in Environmental Samples by Cold Vapor Atomic Absorption Spectrometry.

Kim, Y., K. A. Ashton-Alcox, and E.N. Powell. 2006. Histological Techniques for Marine Bivalve Molluscs: Update. NOAA. Silver Spring, MD: 76.

Lanksbury, J.A., L.A. Niewolny, A.J. Carey, and J.E. West. 2014. Toxic contaminants in Puget Sound's nearshore biota: a large-scale synoptic survey using transplanted mussels (*Mytilus trossulus*). Washington Department of Fish and Wildlife Publication #FPT 14-08. 180pp.

Lombard, S.M. and C.J. Kirchmer, 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Publication No. 04-03-030. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/biblio/0403030.html

PSEP (Puget Sound Estuary Program). 1986. Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound. Prepared for U.S. Environmental Protection Agency Region 10, Office of Puget Sound, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by Tetra Tech, Inc., Bellevue, WA. 25 pp.

PSEP. 1997a. Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment and Tissue Samples. Prepared for U.S. Environmental Protection Agency Region 10, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by King County Environmental Lab, Seattle, WA. 43 pp + appendices.

PSEP. 1997b. Recommended Guidelines for Measuring Organic Compounds in Puget Sound Water, Sediment and Tissue Samples. Prepared for U.S. Environmental Protection Agency Region 10, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by King County Environmental Lab, Seattle, WA. 30 pp + appendices.

PSEP. 1997c. Recommended Quality Assurance and Quality Control Guidelines for the Collection of Environmental Data in Puget Sound. Prepared for U.S. Environmental Protection Agency Region 10, Seattle, WA and Puget Sound Water Quality Authority, Olympia, WA by King County Environmental Lab, Seattle, WA. 108 pp.

Ruppert, E., R. Fox, R.D. Barnes. 2004. Invertebrate biology. Thomson Brooks/Cole, Belmont, CA.

Sloan, C.A., B.F. Anulacion, K.A. Baugh, J.L. Bolton, D. Boyd, R.H. Boyer, D.G. Burrows, D.P. Herman, R.W. Pearce, and G.M. Ylitalo. 2014. Northwest Fisheries Science Center's analyses of tissue, sediment, and water samples for organic contaminants by gas chromatography/ mass spectrometry and analyses of tissue for lipid classes by thin layer chromatography/flame ionization detection. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-125.

Sloan, C. A., D. W. Brown, R. W. Pearce, R. H. Boyer, J. L. Bolton, D. G. Burrows, D. P. Herman, and M. M. Krahn. 2004. Extraction, cleanup, and gas chromatography/mass spectrometry analysis of sediments and tissues for organic contaminants. U.S. Dept. Commerce. NOAA Tech. Memo. NMFS-NWFSC-59.

Sloan, C. A., D.W. Brown, G.M. Ylitalo, J. Buzitis, D.P. Herman, D.G. Burrows, G. Yanagida

R.W. Pearce, J.L. Bolton, R.H. Boyer, and M.M. Krahn. 2006. Quality assurance plan for analyses of environmental samples for polycyclic aromatic compounds, persistent organic pollutants, fatty acids, stable isotope ratios, lipid classes, and metabolites of polycyclic aromatic compounds. U.S. Dept. Commerce. NOAA Tech. Memo. NMFS-NWFSC-77: 30.

Stevens, D.L., Jr. 1997. Variable density grid-based sampling designs for continuous spatial populations. Environmetrics, 8, 167-95.

Stevens, D.L., Jr. and Olsen, A.R. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agricultural, Biological, and Environmental Statistics, 4, 415-28.Page 58

Stevens, D.L., Jr. 2003. Variance estimation for spatially balanced samples of environmental resources. Environmetrics 14:593-610.

Stevens, D.L., Jr. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

SWG, 2010a. 2010 Stormwater Monitoring and Assessment Strategy for Puget Sound Region. Written by the Puget Sound Stormwater Work Group.
http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp.html

SWG, 2010b. Recommendations for Municipal Stormwater Permit Monitoring. Written by the Puget Sound Stormwater Work Group.

http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp.html

Washington State Department of Ecology. 2012. Standard Operating Procedures to Minimize the Spread of Invasive Species Version 2.0. E. A. Program: 28.

Glossary

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Acronyms and Abbreviations

app	application (downloadable onto cellular phones)
As	Arsenic
CI	Condition index
COC	Chain of custody
Cd	Cadmium
Cu	Copper
DI	Deionized (water)
DNR	Washington Department of Natural Resources
Ecology	Washington State Department of Ecology
EAP	Environmental Assessment Program
EIM	Environmental Information Management system
EPA	U.S. Environmental Protection Agency

GIS	Geographic information system software
GPS	Global positioning system
GRTS	Generalized random tessellation stratified
Hg	Mercury
HPA	Hydraulic Project Approval
KCEL	King County Environmental Lab
MLLW	Mean lower low water
MOU	Memorandum of understanding
MQO	Measurement quality objective
NAD83	North American Datum 83, geodetic reference system
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWFSC	Northwest Fisheries Science Center
OCP	Organochlorine pesticide
PAH	Polycyclic Aromatic Hydrocarbon
Pb	Lead
PBDE	Polybrominated diphenylethers
PCB	Polychlorinated biphenyl
POPs	Persistent organic pollutants
PSAMP	Puget Sound Assessment and Monitoring Program (now PSEMP)
PSEMP	Puget Sound Ecosystem Monitoring Program (formerly PSAMP)
PSP	Puget Sound Partnership
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RSD	Relative standard deviation
RSMP	Regional Stormwater Monitoring Program
SOAL	State-Owned Aquatic Land

SOP	Standard operating procedure
SRM	Standard reference material
Subgroup	Marine Nearshore Status and Trends Subgroup
SWAMPPS	Stormwater Assessment and Monitoring Program for Puget Sound
SWG	Stormwater Work Group
TIB	Toxics in Biota group, part of PSEMP
UGA	Urban growth area
WDFW	Washington Department of Fish and Wildlife
Zn	Zinc

Units of Measurement

°C	degrees centigrade
cm	centimeter
ft	feet
g	gram
km	kilometer, a unit of length equal to 1,000 meters
m	meter

Appendices

Appendix A. Regional Stormwater Monitoring Strategy

Background

The Puget Sound Stormwater Work Group (SWG) was assembled in 2008 at the request of the Washington State Department of Ecology (Ecology) and the Puget Sound Partnership (PSP) to develop recommendations for a monitoring and assessment strategy to improve our understanding of the effects of stormwater in the Puget Sound region. In 2010, the SWG finalized the overall strategy for monitoring in the document *2010 Stormwater Monitoring and Assessment Strategy for the Puget Sound Region (SWAMPPS)* (SWG, 2010a). These recommendations (SWG, 2010b) were submitted to Ecology and the PSP for consideration in the development of an integrated stormwater monitoring program focused on the Puget Sound region. The 2010 Strategy included "55 Key Recommendations" for a new stormwater assessment and monitoring program.

The 2010 Strategy describes four components of a robust program: status and trends monitoring of receiving waters impacted by stormwater runoff; effectiveness studies to evaluate best management practices and programmatic approaches to manage stormwater; source identification and diagnostic monitoring to improve pollution reduction efforts; and research to increase knowledge of stormwater effects on biota and treatment approaches to reduce effects.

The SWG followed the 2010 Strategy with 33 recommendations for municipal permit monitoring (http://www.ecy.wa.gov/programs/wq/psmonitoring/ps_monitoring_docs/SWworkgroupDOCS/SWGfinalreportoct292010.pdf). These recommendations outlined a plan for implementing a core subset of the 2010 Strategy through municipal stormwater permits issued to local governments in Puget Sound.

Status and trends– marine mussel monitoring design

Goals

One of the goals of the RSMP nearshore status and trends monitoring program is to use marine mussels (*Mytilus* sp.) as an indicator species to evaluate contaminant conditions in Puget Sound's nearshore biota. The study design involves distributing cage-protected mussels from a common source along Puget Sound's shoreline to synoptically evaluate the geographic extent and magnitude of nearshore contamination. The goals include:

1. Assess the tissue contaminant concentrations of Puget Sound biota in the nearshore urban areas, defined as being inside established Urban Growth Area (UGA) boundaries.
2. Document geographic patterns.

3. Document natural and human-caused changes over time in Puget Sound nearshore biota.
4. Identify existing challenges to the health of nearshore biota and, where possible, provide data to help target sources.
5. Support nearshore research activities by making available uniformly collected, high quality data.
6. Provide nearshore data to assist the SWG, the PSP, and others in measuring the success of stormwater and other environmental management programs.

Objectives

Specific objectives of nearshore mussel monitoring include:

1. Characterize the spatial extent of tissue contamination in nearshore biota residing inside the UGA sampling frame using mussels (*Mytilus* sp.) as the primary indicator organism.
2. Track changes in tissue contamination over time inside the UGA sampling frame to answer the question; is biota health improving, deteriorating, or remaining the same?

Scale of Monitoring

Status and trends is intended to report results at a high level of statistical confidence; as such, a probabilistic random stratified sampling design was selected for the nearshore urban and non-UGAs. This approach was developed by EPA as a spatially-balanced, generalized random tessellation stratified (GRTS) multi-density survey design (http://epa.gov/nheerl/arm/designing/design_intro.htm) and is described by Stevens (1997, 2003, 2004), and Stevens and Olsen (1999). A Puget Sound shoreline sampling frame (which is linear) was generated by Sitka Technology Group, LLC using the stratified design and populated with sites for the stormwater permittees.

Monitoring for this QAPP is focused on a single landscape scale, the shoreline parallel to cities and UGAs. A shoreline sampling frame for Puget Sound was defined to include the basins, channels, and embayments of Puget Sound from the US/Canada border to the southern-most bays and inlets near Olympia and Shelton, to Hood Canal, and to portions of Admiralty Inlet, the San Juan Islands, and the eastern portion of the Strait of Juan de Fuca. The shoreline master sample sampling frame was targeted to the land-based UGA boundaries within the Puget Sound basin.

Sampling points were generated to populate the shoreline sampling and sub-sampling (linear) frames using the GRTS design, providing a random and spatially balanced site selection process. From this design the Puget Sound Mussel Monitoring sample draw was generated, resulted in a total of 2,048

sites in Puget Sound's UGAs. The first 100 sites in the Puget Sound Mussel Monitoring sample draw are shown in Figure 1; the first 50 sites in unincorporated Pierce Co UGAs are listed in Appendix B.

Assumptions underlying the design

This monitoring program design is based on several assumptions; #1) for the purposes of assessing stormwater impacts, the study design characteristics take into account the desire for Puget Sound-scale estimates at a high confidence level (80-90%) and potential for stratification of samples into other categories (e.g., land uses). The confidence level (i.e. the reliability of the result) is determined by the variance of the indicator variable and the sample size within populations (www.epa.gov/nheerl/arm/surdesignfaqs.htm).

The SWG also assumes #2) that two assessment regions Urban Growth Area (UGA) and non-UGA are different. This assumption is based on the differences in stormwater management efforts required by permits inside UGA boundaries, and the differences in overall land use. Shorelines and nearshore areas in Puget Sound in urban and urbanizing areas are assumed to be more (or differently) influenced than shorelines and nearshore areas outside urban and urbanizing areas. The RSMP will monitor the shoreline and nearshore within the UGA assessment area. Data from prior WDFW mussel monitoring in areas considered non-UGA will be used for comparison, where available and appropriate.

This monitoring design also assumes #3) that the sites will be useable over the long term. The site layout is designed for a long-term monitoring program rather than for a targeted study. This study design assumes that general trends in nearshore ecosystem health can be described with the parameters outlined in this QAPP.

Regional stormwater monitoring objectives

This monitoring framework is designed to answer the following core broad-scale monitoring questions:

- What are the status and trends of water quality and biota (i.e. mussel) tissue quality in Puget Sound Nearshore areas?
- What are the status and trends of the water quality and biota (i.e. mussel) tissue quality in Puget Sound nearshore areas adjacent to Urban Growth Areas (UGAs)?

In addition, site-specific evaluations of data can be useful for answering questions at local scales and will improve stormwater managers' understanding of nearshore condition and biota stressors.

Coordination

A programmatic objective of the 2010 Strategy is to efficiently allocate limited resources for monitoring activities. Toward this objective the RSMP marine mussel monitoring is being conducted by WDFW who has conducted the vast majority of other marine mussel monitoring in Washington State. As such results will be comparable to prior monitoring results.

Scale of regional monitoring

Monitoring for this QAPP is focused on monitoring marine intertidal quality, using biotic endpoints, at two landscape scales:

- Puget Sound-wide
- Adjacent to Phase I and Phase II UGAs within the Puget Sound.

These areas are the focus of important stormwater management, resource conservation and protection efforts. Information generated for each of these regions can be useful to Ecology, local governments, and agencies managing aquatic resources that are impacted by stormwater.

Since management for improvements usually occurs at a local scale, the RSMP monitoring design aims at providing information on the health of nearshore biota (i.e. mussels) and sediment quality at UGA or sub-basin scales. The focus on small watersheds in the nearshore environment is understood and readily used by local governments, who are likely to participate in data collection efforts and become users of data generated by the monitoring program.

Indicators

The SWG (SWG, 2010) recommended monitoring specific biota (i.e. mussels), habitat, and chemical indicators related to stormwater runoff and stormwater impacts. The basic list of parameters comes from existing state status and trends study designs. For this QAPP the mussel monitoring is most heavily based on findings from the recent WDFW Mussel Watch Pilot Expansion project (Lanksbury et al., 2014), which demonstrated that transplanted mussels can be used successfully on a large scale to characterize patterns of nearshore contamination in the greater Puget Sound. In that study transplanted mussels

provided data on the extent and magnitude of contamination in Puget Sound nearshore environments and offered insight into how contamination in nearshore biota is related to upland land-use patterns.

Appendix B. 2015/16 RSMP Puget Sound Mussel Monitoring Pilot Site List

This table shows the first 100 candidate sites on the mussel monitoring list. A complete RSMP site list is available on Ecology's RSMP website at http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp/rsmpdocs/RSMP2015-Musselsites.xlsx, and contains more accompanying information.

USE_ORDER	SITE_ID	REGION	COUNTY_NM	CITY_NM	UGA_NM2	LAT_DD	LON_DD
1	PSS13175-000001	South Sound	Thurston	Olympia	Olympia - Incorporated UGA	47.04765	-122.91126
2	PSS13175-000002	Central Sound	King	Seattle	Seattle - Incorporated UGA	47.50204	-122.38594
3	PSS13175-000003	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.68262	-122.50706
4	PSS13175-000004	Strait of Georgia	Whatcom		Cherry Point - Unincorporated UGA	48.85755	-122.7363
5	PSS13175-000005	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.29181	-122.52806
6	PSS13175-000006	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.61871	-122.52759
7	PSS13175-000007	Central Sound	King	Seattle	Seattle - Incorporated UGA	47.64877	-122.4175
8	PSS13175-000008	Admiralty Inlet	Jefferson		Jefferson Co. - Unincorporated UGA	48.04868	-122.77652
9	PSS13175-000009	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.25521	-122.37604
10	PSS13175-000010	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.64458	-122.57753

USE_ORDER	SITE_ID	REGION	COUNTY_NM	CITY_NM	UGA_NM2	LAT_DD	LON_DD
11	PSS13175-000011	Strait of Georgia	Whatcom	Bellingham	Bellingham - Incorporated UGA	48.72568	-122.50606
12	PSS13175-000012	Whidbey Basin	Island	Oak Harbor	Oak Harbor - Incorporated UGA	48.2969	-122.57945
13	PSS13175-000013	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.29253	-122.4951
14	PSS13175-000014	Central Sound	Kitsap	Bremerton	Bremerton - Incorporated UGA	47.57101	-122.60648
15	PSS13175-000015	Strait of Georgia	Skagit	Anacortes	Anacortes - Incorporated UGA	48.4923	-122.67746
16	PSS13175-000016	Central Sound	Snohomish	Edmonds	Edmonds - Incorporated UGA	47.85424	-122.33472
17	PSS13175-000017	South Sound	Thurston	Olympia	Olympia - Incorporated UGA	47.06878	-122.91975
18	PSS13175-000018	Central Sound	King	Burien	Burien - Incorporated UGA	47.46333	-122.36868
19	PSS13175-000019	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.66154	-122.49952
20	PSS13175-000020	Eastern Strait of Juan de Fuca	Clallam	Port Angeles	Port Angeles - Incorporated UGA	48.1178	-123.42336
21	PSS13175-000021	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.30376	-122.51146
22	PSS13175-000022	Central Sound	Kitsap		Port Orchard - Unincorporated UGA	47.55888	-122.59715

USE_ORDER	SITE_ID	REGION	COUNTY_NM	CITY_NM	UGA_NM2	LAT_DD	LON_DD
23	PSS13175-000023	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.62206	-122.49572
24	PSS13175-000024	Admiralty Inlet	Jefferson		Jefferson Co. - Unincorporated UGA	48.0268	-122.74896
25	PSS13175-000025	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.27454	-122.41519
26	PSS13175-000026	Central Sound	Kitsap		Central Kitsap - Unincorporated UGA	47.60311	-122.59829
27	PSS13175-000027	Strait of Georgia	Whatcom	Bellingham	Bellingham - Incorporated UGA	48.68975	-122.50434
28	PSS13175-000028	Whidbey Basin	Island	Oak Harbor	Oak Harbor - Incorporated UGA	48.27141	-122.63749
29	PSS13175-000029	Central Sound	Kitsap	Poulsbo	Poulsbo - Incorporated UGA	47.74626	-122.65216
30	PSS13175-000030	Central Sound	Kitsap	Port Orchard	Port Orchard - Incorporated UGA	47.54111	-122.64058
31	PSS13175-000031	San Juan Archipelago	San Juan		Eastsound - Unincorporated UGA	48.69258	-122.91127
32	PSS13175-000032	Whidbey Basin	Snohomish	Everett	Everett - Incorporated UGA	47.97529	-122.22664
33	PSS13175-000033	South Sound	Pierce	DuPont	DuPont - Incorporated UGA	47.10396	-122.67593
34	PSS13175-000034	Central Sound	King	Seattle	Seattle - Incorporated UGA	47.5871	-122.35304

USE_ORDER	SITE_ID	REGION	COUNTY_NM	CITY_NM	UGA_NM2	LAT_DD	LON_DD
35	PSS13175-000035	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.66726	-122.56549
36	PSS13175-000036	Eastern Strait of Juan de Fuca	Clallam	Port Angeles	Port Angeles - Incorporated UGA	48.14204	-123.42576
37	PSS13175-000037	South Sound	Pierce	Steilacoom	Steilacoom - Incorporated UGA	47.16998	-122.61066
38	PSS13175-000038	Central Sound	Kitsap		Bremerton - Unincorporated UGA	47.60149	-122.66985
39	PSS13175-000039	Central Sound	King	Seattle	Seattle - Incorporated UGA	47.63128	-122.38082
40	PSS13175-000040	Admiralty Inlet	Jefferson	Port Townsend	Port Townsend - Incorporated UGA	48.13084	-122.76251
41	PSS13175-000041	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.26899	-122.40166
42	PSS13175-000042	Central Sound	Kitsap	Bremerton	Bremerton - Incorporated UGA	47.57617	-122.62899
43	PSS13175-000043	Strait of Georgia	Skagit	Anacortes	Anacortes - Incorporated UGA	48.52109	-122.61104
44	PSS13175-000044	Whidbey Basin	Island	Langley	Langley - Incorporated UGA	48.03641	-122.39957
45	PSS13175-000045	Central Sound	King	Normandy Park	Normandy Park - Incorporated UGA	47.42844	-122.3508
46	PSS13175-000046	Central Sound	Kitsap		Kingston - Unincorporated UGA	47.78584	-122.49468

USE_ORDER	SITE_ID	REGION	COUNTY_NM	CITY_NM	UGA_NM2	LAT_DD	LON_DD
47	PSS13175-000047	Strait of Georgia	Whatcom		Birch Bay - Unincorporated UGA	48.89548	-122.78201
48	PSS13175-000048	Central Sound	Snohomish	Mukilteo	Mukilteo - Incorporated UGA	47.92779	-122.30929
49	PSS13175-000049	Central Sound	Pierce	Gig Harbor	Gig Harbor - Incorporated UGA	47.33837	-122.59049
50	PSS13175-000050	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.58137	-122.52673
51	PSS13175-000051	Central Sound	King	Shoreline	Shoreline - Incorporated UGA	47.73996	-122.37688
52	PSS13175-000052	Eastern Strait of Juan de Fuca	Clallam	Port Angeles	Port Angeles - Incorporated UGA	48.12584	-123.45576
53	PSS13175-000053	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.27687	-122.40846
54	PSS13175-000054	Central Sound	Kitsap		Silverdale - Unincorporated UGA	47.60765	-122.70792
55	PSS13175-000055	Strait of Georgia	Whatcom	Bellingham	Bellingham - Incorporated UGA	48.71193	-122.51908
56	PSS13175-000056	Whidbey Basin	Skagit		Swinomish - Unincorporated UGA	48.39735	-122.53921
57	PSS13175-000057	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.24649	-122.4313
58	PSS13175-000058	Central Sound	Kitsap	Bremerton	Bremerton - Incorporated UGA	47.58171	-122.63607
59	PSS13175-000059	Strait of Georgia	Skagit		Anacortes - Unincorporated UGA	48.49191	-122.5752

USE_ORDER	SITE_ID	REGION	COUNTY_NM	CITY_NM	UGA_NM2	LAT_DD	LON_DD
60	PSS13175-000060	Strait of Georgia	Skagit	Anacortes	Anacortes - Incorporated UGA	48.46759	-122.58601
61	PSS13175-000061	Central Sound	Pierce		Tacoma - Unincorporated UGA	47.31948	-122.42765
62	PSS13175-000062	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.70579	-122.51677
63	PSS13175-000063	Strait of Georgia	Whatcom	Blaine	Blaine - Incorporated UGA	48.99194	-122.76634
64	PSS13175-000064	Whidbey Basin	Snohomish	Everett	Everett - Incorporated UGA	48.00545	-122.23047
65	PSS13175-000065	South Sound	Thurston	Olympia	Olympia - Incorporated UGA	47.04624	-122.91204
66	PSS13175-000066	Central Sound	King	Seattle	Seattle - Incorporated UGA	47.52018	-122.3952
67	PSS13175-000067	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.72014	-122.5472
68	PSS13175-000068	Eastern Strait of Juan de Fuca	Clallam		Clallam Bay - Unincorporated UGA	48.2537	-124.26875
69	PSS13175-000069	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.29627	-122.53121
70	PSS13175-000070	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.60279	-122.54731
71	PSS13175-000071	Central Sound	King	Seattle	Seattle - Incorporated UGA	47.69051	-122.40332
72	PSS13175-000072	Admiralty Inlet	Jefferson	Port Townsend	Port Townsend - Incorporated UGA	48.10934	-122.76823

USE_ORDER	SITE_ID	REGION	COUNTY_NM	CITY_NM	UGA_NM2	LAT_DD	LON_DD
73	PSS13175-000073	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.24386	-122.40519
74	PSS13175-000074	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.63316	-122.5775
75	PSS13175-000075	Strait of Georgia	Whatcom	Bellingham	Bellingham - Incorporated UGA	48.74124	-122.49268
76	PSS13175-000076	Whidbey Basin	Island	Oak Harbor	Oak Harbor - Incorporated UGA	48.29186	-122.62405
77	PSS13175-000077	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.28453	-122.48499
78	PSS13175-000078	Central Sound	Kitsap	Bremerton	Bremerton - Incorporated UGA	47.5722	-122.6812
79	PSS13175-000079	Strait of Georgia	Skagit	Anacortes	Anacortes - Incorporated UGA	48.50897	-122.68452
80	PSS13175-000080	Central Sound	Snohomish	Edmonds	Edmonds - Incorporated UGA	47.84736	-122.33911
81	PSS13175-000081	South Sound	Thurston	Olympia	Olympia - Incorporated UGA	47.05885	-122.90304
82	PSS13175-000082	Central Sound	King	Burien	Burien - Incorporated UGA	47.48479	-122.36117
83	PSS13175-000083	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.6499	-122.51928
84	PSS13175-000084	Eastern Strait of Juan de Fuca	Clallam	Port Angeles	Port Angeles - Incorporated UGA	48.14039	-123.41527
85	PSS13175-000085	South Sound	Pierce	University Place	University Place - Incorporated UGA	47.21093	-122.57912

USE_ORDER	SITE_ID	REGION	COUNTY_NM	CITY_NM	UGA_NM2	LAT_DD	LON_DD
86	PSS13175-000086	Central Sound	Kitsap		Central Kitsap - Unincorporated UGA	47.64996	-122.62115
87	PSS13175-000087	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.63493	-122.49368
88	PSS13175-000088	Admiralty Inlet	Jefferson		Jefferson Co. - Unincorporated UGA	48.0262	-122.7495
89	PSS13175-000089	Central Sound	Pierce	Tacoma	Tacoma - Incorporated UGA	47.26864	-122.41851
90	PSS13175-000090	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.60749	-122.5754
91	PSS13175-000091	Strait of Georgia	Whatcom	Bellingham	Bellingham - Incorporated UGA	48.70809	-122.51623
92	PSS13175-000092	Whidbey Basin	Island	Oak Harbor	Oak Harbor - Incorporated UGA	48.26813	-122.62896
93	PSS13175-000093	Central Sound	Kitsap	Poulsbo	Poulsbo - Incorporated UGA	47.74002	-122.65058
94	PSS13175-000094	Central Sound	Kitsap		Gorst - Unincorporated UGA	47.53297	-122.68628
95	PSS13175-000095	San Juan Archipelago	San Juan		Eastsound - Unincorporated UGA	48.71375	-122.91795
96	PSS13175-000096	Whidbey Basin	Snohomish	Everett	Everett - Incorporated UGA	47.9872	-122.21815
97	PSS13175-000097	South Sound	Mason		Allyn - Unincorporated UGA	47.39273	-122.82395
98	PSS13175-000098	Central Sound	King	Seattle	Seattle - Incorporated UGA	47.58327	-122.37223

USE_ORDER	SITE_ID	REGION	COUNTY_NM	CITY_NM	UGA_NM2	LAT_DD	LON_DD
99	PSS13175-000099	Central Sound	Kitsap	Bainbridge Island	Bainbridge Island - Incorporated UGA	47.67379	-122.56095
100	PSS13175-000100	Eastern Strait of Juan de Fuca	Clallam	Port Angeles	Port Angeles - Incorporated UGA	48.14008	-123.44849

Background on Permit Defined Monitoring

Ecology issued NPDES municipal stormwater permits for Phase I and Phase II communities (Ecology, 2012a,b) effective August 2013 through July 2018. All permittees located in Puget Sound were given two options to comply with the permits' Special Condition S8.B for status and trends monitoring requirements.

Option 1: Pay a prescribed amount into a pooled fund to support RSMP Status and Trends monitoring. These permittees' role is limited to providing permit-defined amounts of funding for coordinated implementation of monitoring at sites throughout the Puget Sound region.

Or

Option 2: Conduct their own status and trends monitoring at specific, assigned sites inside their jurisdictional boundaries, following the same protocols as those used for the RSMP.

In fall 2013, Pierce County, and the City of Redmond officially selected the second option. This Quality Assurance Project Plan (QAPP) defines the permit-required small streams status and trends monitoring that will be conducted by Pierce County. The City of Redmond does not have marine shoreline and therefore does not have a nearshore monitoring requirement. This QAPP serves as the Ecology-approved "RSMP QAPP" referenced in the permits. This appendix defines Peirce County's unique monitoring program information such as staff, roles and responsibilities, and mussel monitoring sites. All other procedures and sampling protocols are defined in the QAPP will be followed by WDFW and Pierce County

Pierce County Project Staff and Responsibilities

Pierce County will conduct mussel monitoring at eight suitable nearshore sites in their jurisdictions from October 2015 through February 2016; exact timeline may vary slightly as determined by WDFW mussel monitoring lead. Pierce County must submit this completed appendix to their Ecology permit manager by May 15, 2015 (Table 1) for approval prior to sampling. Pierce County's responsibilities for mussel monitoring are defined throughout this QAPP, and are briefly summarized below.

- Conduct site suitability, secure permissions and report to the RSMP Coordinator and permit manager on the sites to be monitored.
- Collect sorted bagged mussels from WDFW when notified by WDFW mussel monitoring lead or RSMP coordinator that they are ready

- Install mussel monitoring cages and deploy mussels when notified WDFW mussel monitoring lead or RSMP coordinator to begin monitoring
- Conduct field site measurements at the time of deployment
- Retrieve mussels and remove all monitoring equipment from field when notified WDFW mussel monitoring lead or RSMP coordinator to end monitoring
- Conduct field site measurements at the time of retrieval
- Send all field data to WDFW mussel monitoring lead according to the timeline described in this QAPP.
- Enter field data into Ecology's Environmental Information Management (EIM) database
- Submit a mussel monitoring summary as part of the permit required annual report.

Permittee project staff and responsibilities.

Phase I Permittees	Implementation of Stormwater Permit Monitoring	
Name/Contact	**Role**	**Responsibility**
Carla Vincent cvince2@co.piercel.wa.us (253)798-2467	NPDES Stormwater Monitoring Project Manager	Manage overall compliance activities; verify whether QAPP is followed and monitoring data are of known and acceptable quality; ensure adequate training of staff, complies with corrective action requirements; oversees data QA/QC and submission to EIM; oversees annual report preparation
Scott Groce, Water Quality Specialist 3 (253)798-2477	Field Lead	Manage and oversee monitoring activities and sampling decisions; coordinate with WDFW mussel monitoring lead for mussel collection and delivery, manage equipment maintenance; manage internal and external field teams, prepare reports, performs data QA/QC and submission to EIM
Corrie Lee, Water Quality Specialist 2 clee@co.pierce.wa.us (253)798-6822	Field Assistant	Assist in site selection and confirmation, collecting and processing field samples; deliver samples, perform equipment maintenance, assist with report preparation and data entry into EIM.
Berl Eldridge, Water Quality Specialist 2 beldrid@co.pierce.wa.us (253)798-2248	Field Assistant	Assist in site selection and confirmation, collecting and processing field samples; deliver samples, perform equipment maintenance, assist with report preparation and data entry into EIM.
Jeff Barney, Water Quality Specialist 2 barney@co.pierce.wa.us (253)798-3073	Field Assistant	Assist in site selection and confirmation, collecting and processing field samples; deliver samples, perform equipment maintenance, assist with report preparation and data entry into EIM.

Ecology Project Staff and Responsibilities

Ecology's RSMP Coordinator will either approve or comment on the permittees' completed QAPPs and transmit approval or comments to the permittee via the permittee's Ecology Regional Permit Manager by June 15, 2015. After the sampling is completed and the permittee has completed quality assurance (QA) and quality control (QC) review of the data and submitted it to EIM, Ecology staff will review and

notify the permittees with data quality corrections and when the data is ready for final upload to EIM. The RSMP Coordinator will review monitoring reports. Ecology permit managers will review all submittals for compliance purposes. Ecology staff and their responsibilities are listed in table below.

Ecology project staff and responsibilities

Ecology Staff	**Administration of Stormwater Permits**	
Name, Program, Location	**Role**	**Responsibility**
Brandi Lubliner - WQP Lacey, WA	RSMP Coordinator	Ongoing implementation and administration of RSMP. Reviews and approves completed QAPPs and project deliverables from permittees' monitoring efforts.
Chris Montague-Breakwell WQP-SWRO: Lacey, WA	Permit Manager	Ecology's contact for stormwater permittees including Pierce County. Reviews QAPP and monitoring reports for permit compliance.
WQP staff, Lacey, WA	EIM Coordinator	Reviews and QAs data submitted by permittees and RSMP contractors.

SWRO: Southwest Regional Office
EIM: Environmental Information Management database
WQP: Water Quality Program

Pierce County's List of Sites

This table shows 41 unincorporated Pierce County sites sorted from the complete RSMP nearshore site list available on Ecology's RSMP website. The complete list also contains more accompanying information; http://www.ecy.wa.gov/programs/wq/stormwater/municipal/rsmp/status.html.

USE_ORDER	SITE_ID	REGION	COUNTY_NM	UGA_NM2	LAT_DD	LON_DD
61	PSS13175-000061	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.31948	-122.42765
113	PSS13175-000113	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.33586	-122.5785
161	PSS13175-000161	South Sound	Pierce	Gig Harbor - Unincorporated UGA	47.38545	-122.62723
177	PSS13175-000177	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.30708	-122.56682
185	PSS13175-000185	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.30314	-122.44444
249	PSS13175-000249	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.31732	-122.42943
353	PSS13175-000353	South Sound	Pierce	Gig Harbor - Unincorporated UGA	47.37649	-122.62436
433	PSS13175-000433	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.30957	-122.56843
441	PSS13175-000441	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.30621	-122.44251
481	PSS13175-000481	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.33832	-122.58275
505	PSS13175-000505	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.31375	-122.43195
625	PSS13175-000625	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.33027	-122.57511
689	PSS13175-000689	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.31741	-122.57391
697	PSS13175-000697	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.29803	-122.43569
737	PSS13175-000737	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.34197	-122.58376
817	PSS13175-000817	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.33341	-122.57648
865	PSS13175-000865	South Sound	Pierce	Gig Harbor - Unincorporated UGA	47.3866	-122.62639
881	PSS13175-000881	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.30118	-122.56156
953	PSS13175-000953	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.30738	-122.43515
1005	PSS13175-001005	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.31935	-122.42073
1085	PSS13175-001085	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.31927	-122.4296

USE_ORDER	SITE_ID	REGION	COUNTY_NM	UGA_NM2	LAT_DD	LON_DD
1121	PSS13175-001121	South Sound	Pierce	Gig Harbor - Unincorporated UGA	47.37414	-122.62384
1137	PSS13175-001137	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.32903	-122.57445
1201	PSS13175-001201	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.30783	-122.56761
1209	PSS13175-001209	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.30644	-122.43886
1273	PSS13175-001273	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.31553	-122.4311
1377	PSS13175-001377	South Sound	Pierce	Gig Harbor - Unincorporated UGA	47.38242	-122.62599
1393	PSS13175-001393	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.32796	-122.5735
1445	PSS13175-001445	South Sound	Pierce	Pierce Co. - Unincorporated UGA	47.19088	-122.57378
1457	PSS13175-001457	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.31578	-122.57286
1465	PSS13175-001465	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.2991	-122.44004
1505	PSS13175-001505	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.33907	-122.58334
1649	PSS13175-001649	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.30544	-122.56587
1841	PSS13175-001841	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.33383	-122.57684
1889	PSS13175-001889	South Sound	Pierce	Gig Harbor - Unincorporated UGA	47.38711	-122.62666
1893	PSS13175-001893	South Sound	Pierce	Pierce Co. - Unincorporated UGA	47.18725	-122.57572
1905	PSS13175-001905	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.30208	-122.56241
1977	PSS13175-001977	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.30709	-122.43604
2017	PSS13175-002017	Central Sound	Pierce	Gig Harbor - Unincorporated UGA	47.34014	-122.58342
2029	PSS13175-002029	Central Sound	Pierce	Tacoma - Unincorporated UGA	47.31903	-122.42258

Washington State 2015/16 RSMP
Mussel Monitoring Site Datasheet

DEPLOYMENT INFORMATION

Site ID:	Site Name:			
Bag numbers:				
Deployer name(s):				
Recorder name:				
Deployment date:	Time cage anchored:			
Cage GPS location (decimal degrees)	Latitude:	Longitude:	Accuracy (± XX feet):	
GPS make/model or app name: (must be set to datum NAD83)				
Anchors - type/number used:				

WATER & WEATHER CONDITIONS (at cage)

Sea conditions: Wave energy: ☐ Flat; ☐ Calm; ☐ Wind chop; ☐ Swells; ☐ Breaking waves

Beach exposure level: ☐ Exposed; ☐ Moderately exposed; ☐ Sheltered

Time of most recent LOW tide: **Height of most recent LOW tide (feet):**

Precipitation: ☐ None; ☐ Steady rain; ☐ Showers; ☐ Snow; ☐ Hail

HABITAT (within 200 foot radius of cage)

Substrate type – select ONE category that describes the majority (at least 50%) of substrate around cage:

Bedrock, hardpan ☐	Cobble-gravel mix ☐	Sand-gravel mix ☐	Sand ☐	Sand-mud mix ☐	Mud, silt ☐

Aquatic vegetation coverage – percent substrate around cage covered by seagrasses and/or algae:

None (<1%) ☐	1 - 20% ☐	20 - 40% ☐	40 - 60% ☐	60 - 80% ☐	80 - 100% ☐

Type of aquatic vegetation present: ☐ None; ☐ Eelgrass; ☐ Kelps; ☐ Fucus; ☐ Ulva; ☐ Other

Natural streams/rivers present: ☐ No; ☐ Yes; Natural spring/freshwater seep: ☐ No; ☐ Yes

Other habitat comments/observations:

ANTHROPOGENIC STRUCTURES ALONG SHORELINE
visible from cage up to 400 m (1300 feet, ¼ mile) along either side of beach

Adjacent upland use (check all that apply):

☐ Agricultural; ☐ Commercial; ☐ Industrial; ☐ Major road/highway; ☐ Park; ☐ Public access;
☐ Rural residential; ☐ Undeveloped; ☐ Urban residential; ☐ Other _____

Erosion control structures (i.e. armoring of shoreline): ☐ None;

☐ Hard (bulkhead, riprap, etc.) - _____% shoreline armored; Materials used: _____

☐ Soft (plantings, large woody debris, etc.) - _____% shoreline armored (↑ creosote in armoring?)

Abandoned or derelict structures (includes old pilings, docks, half-sunken boats, metal pieces, etc.)

☐ No; ☐ Yes, type/makeup:

Washington State 2015/16 RSMP
Mussel Monitoring Site Datasheet

Current shoreline use (check all that apply): ☐ Boat ramp/launch; ☐ Boathouse/shed; ☐ Bridge; ☐ Breakwater; ☐ Dock/pier/wharf; ☐ Floating home; ☐ Marina; ☐ Mooring buoy; ☐ Outfall; ☐ Piling/dolphin; ☐ Raft/float; ☐ Road; ☐ Shipyard or terminal; ☐ Utilities; ☐ Other: _____

Dock/pier/wharf material: ☐ Creosote ☐ Other treated wood; ☐ Concrete; ☐ Steel; ☐ Other:

Piling/dolphin material: ☐ Creosote ☐ Other treated wood; ☐ Concrete; ☐ Steel; ☐ Other:

Tires present: ☐ No; ☐ Yes - Estimated Number: Used for:

Outfall (pipe, culvert, point of flow onto beach): Size: _____ (i.e. mouth diameter);
Type: Condition:

Outfall (pipe, culvert, point of flow onto beach): Size: _____ (i.e. mouth diameter);
Type: Condition:

Outfall (pipe, culvert, point of flow onto beach): Size: _____ (i.e. mouth diameter);
Type: Condition:

Other obvious sources of pollution (oil slicks, seeps, etc.):

Additional comments/observations (it's a good idea to note landmarks that will help you find the cage later!):

TAKE PHOTOS of the deployed cage and surrounding substrate, including any interesting observations!

RETRIEVAL INFORMATION
(TAKE PHOTO of the mussel cage BEFORE removal, to document condition of cage.)

Site ID:	Site Name:			
Bag numbers:				
Retriever name(s):				
Recorder name:				
Retrieval date:	Time cage removed:			
Cage GPS location (decimal degrees)	Latitude:	Longitude:	Accuracy (± XX feet):	
GPS make/model or app name: (must be set to datum NAD83)				

ANY NEW obvious sources of pollution (oil slicks, seeps, etc.)?

Additional comments/observations (including condition of CAGE on retrieval, major changes in habitat or structures around cage):

Mussel Chain-of-Custody Form - Washington State RSMP Mussel Monitoring

Start of monitoring : receive mussels from WDFW and deploy at mussel monitoring site							
Release of bagged mussels from WDFW at aquaculture facility	Mussel bag ID numbers:					DATE	TIME
	WDFW staff name (print and sign):						
	Receiver name and affiliation (print):						

Exchange of bagged mussels - secondary mussel possession, if needed	Mussel bag ID numbers:					DATE	TIME
	Relinquisher name and affiliation (print):						
	Receiver name and affiliation (print):						

Deployment of prepared mussels at monitoring site	Mussel bag ID numbers:						
	Site name and ID:						
	Deployer name and affiliation (print):					DATE	TIME

SAVE this form and finish filling it out at the end of the monitoring period...(see below)

End of monitoring: retrieve mussels from monitoring site, hold overnight, drop off at WDFW lab							
Retrieval Instructions: Wearing lab gloves, remove mussel bags from cage (do not open mesh bags). Place whole mussel bags into pre-labelled Ziploc storage bag, seal, and put on ice in cooler overnight. DO NOT FREEZE. On the morning following retrieval deliver live mussels to WDFW Marine Resources Lab, 6th floor, Natural Resources Building, 1111 Washington St. SE, Olympia, WA 98501.							
Retrieval of mussels from monitoring site	Mussel bag ID numbers:						
	Site name and ID:						
	Retriever name and affiliation (print):					DATE	TIME

Exchange of mussels - for overnight possession or transportation, if different from retriever	Mussel bag ID numbers:					DATE	TIME
	Relinquisher name and affiliation (print):						
	Receiver name and affiliation (print):						

Release of bagged mussels to WDFW processing lab	Mussel bag ID numbers:					DATE	TIME
	Releaser name and affiliation (print):						
	WDFW staff (print and sign):						

Appendix F. Specimen Form

SPECIMEN FORM

Page _____ of _____

SURVEY ID: _____ STATION ID: _____ COLLECTION DATE: _____

	Effort ID	Species [1]	FishID	Sex 0-? 1-M 2-F	Maturity [2]	Length [3] F T S C mm	Weight gm	Age Structure [4] N ( ) O ( ) I ( ) S ( )	Origin [5] H/W	Blood Plasma Y/N	Bile (FACs) Y/N	Histo Liver / Hepato Y/N	Histo Gonad Y/N	Liver – CYP1A Y/N	Liver – DNA Y/N	Chemistry Liver Individual Y/N	Chemistry Liver Comp Y/N	Chemistry Muscle Individual Y/N	Chemistry Muscle Comp Y/N	Chemistry Whole Body Y/N	Chemistry Whole Body No Liver Y/N	Chemistry Whole Body No Entrails Y/N	Chemistry Ovary/Egg Y/N	Chemistry Spawned Eggs Y/N	Fin Clip Adipose Y/N	Fin Clip Genetics Y/N	Observations
1																												Sample ID
2																												
3																												
4																												
5																												
6																												
7																												
8																												
9																												
10																												
11																												
12																												
13																												
14																												
15																												
16																												
17																												
18																												
19																												
20																												

PSAMP 4/07

[1] ES - English sole, SF - starry flounder, SS - staghorn sculpin, CR - copper rockfish, QB - quillback rockfish, BR - brown rockfish, PH - herring, LC – lingcod X - coho salmon, T - chinook salmon, DC - Dungeness crab, GC - graceful crab, MT-*Mytilus trossulus*

[2] R - ripe NR - not ripe

[3] Circle: F - fork length T - total length S - standard length C - crab carapace width

[4] Check: N - none taken O - otolith I - interopercule S - scale

[5] For salmon origin: H - hatchery W - wild

RECORDER:_____

Appendix G. Tissue Resection Log

TISSUE RESECTION LOG

SURVEY ID:_____ STATIONID:_____ SAMPLE TYPE: Whole Fish ( ) Muscle ( ) Liver ( ) Gonad ( ) Bile ( ) Hepato ( )

	Species[1]	FishID	Wet Weight Tissue[3] (g)	Wet Weight Empty Jar (g)	Wet Weight Sample (g)	SampleID	Date Collected	Date Composited	Days to Resection	Observations
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11				_____	_____	_____	_____	_____	_____	
12										
13										
14										
15										
16										
17										
18										
19										
20										

[1]ES - English sole, SF - starry flounder, SS - staghorn sculpin, CR - copper rockfish, QB - quillback rockfish, BR - brown rockfish, PH - herring, LC – lingcod X - coho salmon, T - chinook salmon, DC - Dungeness crab, GC - graceful crab, MT-*Mytilus trossulus*

PSAMP 3/11

[2]Tissue Wt: grams of tissue taken from an individual fish.

[3]Sample Wt: total grams of tissue in a sample.

Page_____ of _____

Appendix H. Field Equipment List

Field materials required for DEPLOYMENT for each mussel monitoring site.

1. Anti-predator cage:
   a. 16x16x16 inch wire mesh cube with removable lid (Figures 5-7, 9 and 10)
      i. Cage manufactured by McKay Crab and Shrimp Gear in Brinnon, WA
   b. Anchoring devices:
      i. 4 four-foot long, bent-tip rebar stakes (Figures 5 and 10)
      ii. 1 thirty-inch long helical/ screw anchor + a short pipe (i.e. lever) to screw it in/out (Figures 5, 8 and 9)
      iii. Cinder block(s) – optional, may be necessary for high exposure sites (Figure 10)
      iv. 2 five-foot and 2 three-foot long ties – optional, to secure cage to cinder block(s) or fixed items on site (i.e. non-creosote pilings, metal pipes, etc.) (Figure 10)
   c. Cable ties (i.e. Zip ties) - includes double the amount needed, in case some ties break (Figures 7 and 9):
      i. 8 four-inch long ties - to secure RSMP-study plaque to cage (do in advance)
      ii. 52 eight-inch long ties, ~75 pound tensile strength, UVB-resistant - 8 to secure the ends of 4 mussel bags to the sides of the cage, 8 to hold lid closed, 8 to secure cage to rebar stakes, 2 to secure cage to helical anchor
   d. Reflector band and/or reflector/colored flagging – helps field crew to re-locate cage during retrieval (Figure 7, yellow band on right side of cage)
   e. Wire cutters – to remove/reposition cable ties
   f. Mallet – to pound in rebar stakes
2. Mussel Installation and Removal:
   a. Four bags of 16 live, Ecology-approved* mussels with bag ID numbers (Figure 6)
   b. Cooler with ice in sealed plastic bags
   c. Nitrile, powder-free laboratory gloves - 2 pairs for each field crew member
3. On-site Measurement:
   a. GPS device – set to North American Datum 83 (NAD83)
4. Data Recording:
   a. Deployment/Retrieval Datasheet (Appendix C) – printed on water-proof paper
   b. Clipboard with pencils

5. Other:
    a. Flashlights and/or lanterns, with extra batteries and/or a lighter
    b. Cellular telephone, fully charged
    c. Appropriate attire for the weather
    d. Heavy-duty or leather gloves to protect hands during anchor installation
    e. Printed permission and/or permits required (if any)
    f. Key(s) or pass code to access site (if needed)
    g. Garbage bag for broken zip ties

* Ecology approved mussels (*Mytilus sp.*) to be deployed at all of the RSMP study sites will come from a single aquaculture source, to ensure a uniform starting condition in the sample population.

Field materials required for RETRIEVAL at each mussel monitoring site:

229

1. Mussel Removal:
    a. Lever to unscrew helical anchor (Figure 8)
    b. Wire cutters – to remove cable ties
    c. 4 gallon-sized Ziploc bags, labeled with site name/date
    d. Cooler with ice in sealed plastic bags
    e. Nitrile, powder-free laboratory gloves - 2 pairs for each field crew member
2. On-site Measurements:
    a. GPS device – set to North American Datum 83 (NAD83)
    b. Data Recording:
    c. Retrieval form (Appendix D) – printed on water-proof paper
    d. Chain-of-custody form (Appendix E) – printed on water-proof paper
    e. Clipboard with pencils
3. Other:
    a. Flashlights and/or lanterns, with extra batteries and/or a lighter

b. Cellular telephone, fully charged
c. Appropriate attire for the weather
d. Heavy-duty or leather gloves to protect hands during anchor removal
e. Printed permission and/or permits required (if any)
f. Key(s) or pass code to access site (if needed)
g. Garbage bag for broken zip ties

Attachment 1 – Sample Alteration Form

Project Name and Number: _____

Sample Matrix: _____

Measurement Parameter: _____

231

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

_____

_____

Reason for Change in Field Procedure or Analysis Variation:

_____

_____

Variation from Field or Analytical Procedure:

_____

_____

Special Equipment, Materials or Personnel Required:

_____

_____

Initiators Name:_____ Date: _____

Project Officer:_____ Date: _____

QA Staff:_____ Date: _____

232

Attachment 2 – Corrective Action Form

Project Name and Number:_____

Sample Dates Involved:_____

Measurement Parameter:_____

Acceptable Data Range:_____

Problem Areas Requiring Corrective Action:__ _____

Measures Required to Correct Problem(s):

_____

Means of Detecting Problems and Verifying Correction:

_____

Initiators Name:_____ Date:_____

Project Officer:_____ Date: _____

Quality Staff:_____ Date: _____

234

Quality Assurance Project Plan (QAPP)

for

Continuous Temperature Monitoring of Smolt Streams, Dungeness Watershed

and

Continuous Temperature and Dissolved Oxygen (Drought Monitoring) for Fish Passage, Dungeness Watershed

Prepared by
Lori DeLorm and Shawn Hines
Jamestown S'Klallam Tribe
1033 Old Blyn Highway
Sequim, WA 98382

Prepared for
USEPA Region 10
1200 6th Avenue, Suite 155, 14-D12
Seattle, WA 98101

(EPA Grant Agreement # BG-01J29401)

Approvals Signature (required prior to project start):

_____ Date: _____
Hansi Hals, NR Director
Jamestown S'Klallam Tribe

_____ Date: _____
Robert Knapp, Environmental Planning Mgr
Jamestown S'Klallam Tribe

_____ Date: _____
Alan Moomaw, Project Officer
Environmental Protection Agency

_____ Date: _____
Donald Brown, QA Manager, Region 10
Environmental Protection Agency

Table of Contents

1.0 PROJECT MANAGEMENT

1.1 Title and Approval Page (EPA QA/R-5 A1)
See page 1.

1.2 Table of Contents (EPA QA/R-5 A2)
See pages 2-3.

1.3 Distribution List (EPA QA/R-5 A3)

Name: Robert Knapp
Title: Environmental Planning Manager
Organization: Jamestown S'Klallam Tribe
Contact Information: 1033 Old Blyn Hwy, Sequim, WA, 98382
360-681-4666, rknapp@jamestowntribe.org

Name: Alan Moomaw
Title: Grant Project Officer
Organization: EPA
Contact Information: USEPA R-10 WA Operations Office, 300 Desmond Dr., SE, Suite 102, Lacey, WA 98503
360-753-8071, moomaw.alan@epa.gov

Name: Donald Brown
Title: QA Manager, Region 10
Organization: EPA
Contact Information: 1200 6th Avenue, Suite 155, 14-D12, Seattle, WA 98101
206-553-0717, Brown.DonaldM@epa.gov

1.4 Project Organization (EPA QA/R-5 A4)
The individuals and organizations participating in the project are represented below, including specific roles and responsibilities. An organizational chart for Tribal personnel is also provided in Appendix A.

Personnel	Title	Project Responsibilities
Jamestown S'Klallam Tribe		
Robert Knapp 360-681-4666	Environmental Planning Program Manager (and designated QA Manager)	Oversees EPA-Tribal program grants. Provides technical input on proposed sampling design, analytical methodologies, and data review. Assigns appropriate personnel to complete tasks included in this QAPP. Reviews and signs QAPP.
Lori DeLorm 360-681-4619	Project Manager for *Continuous Temperature and DO Monitoring* task, and Lead Field Technician	Co-writes QAPP and related progress reports. Serves as lead field technician and project manager for continuous Temperature and DO monitoring elements of QAPP. Communicates with the Tribal Environmental Planning Program Manager and Tribal Watershed Planner on project progress, problems or deviations needing to be resolved. Manages field activities, equipment and data. Assigns specific tasks/objectives to field technicians.
Shawn Hines 360-681-4664	Project Manager for *Drought Monitoring* task	Co-writes QAPP and assists with progress reports. Administers emergency drought assistance grants from Washington Department of Ecology. Communicates with Tribal Environmental Planning Program

		Manager and technicians on project accomplishments, problems or deviations needing to be resolved. Communicates and collaborates with co-managers (WDFW) and irrigators on drought issues and low flow and/or irrigation impacts on fish.
Chris Burns	Lead Field Technician	Lead field technician for stream surveys of fish and stream habitat condition. Provides input on QAPP and project/monitoring tasks. Communicates and collaborates with co-managers (WDFW) and irrigators on drought issues and low flow and/or irrigation impacts on fish.
Casey Allen	Assistant Field Technician	Provides technical field assistance to Lead Field Technicians.
Jarrett Burns	Assistant Field Technician	Provides technical field assistance to Lead Field Technicians.
Environmental Protection Agency		
Alan Moomaw 360-753-8071	Grant Project Officer and Tribal Coordinator	Reviews and approves QAPP.
Donald Brown 206-553-0717	QA Manager, Region 10	Reviews and approves QAPP. Provides guidance on QAPP development.

1.5 Background/Problem Definition (EPA QA/R-5 A5)

Background

The Jamestown S'Klallam Tribe (Tribe) resides on the North Olympic Peninsula in Washington State, approximately 70 miles northwest of and across the Puget Sound from the city of Seattle (Figure 1). The Tribe's reservation is located at the southern tip of Sequim Bay, and all Jamestown Trust lands are within the Tribe's land consolidation area on the North Olympic Peninsula. Additional tribal properties scattered across the Tribe's Usual and Accustomed treaty area bring the Tribe's total land ownership (reservation, Trust, and fee simple) to approximately 1,675 acres, as of March 2020. The Tribe's reservation and campus are within Clallam County (population 77,331 (Est. 2019) (Wikipedia Contributors, 2020). The Tribe's primary areas of interest include the Dungeness and Sequim Bay watersheds (Water Resources Inventory Areas 18 and 17, respectively), which the Tribe has helped to protect and has relied upon for cultural and natural resources since long before its latest federal recognition. The Tribe considers the Dungeness as its home watershed and has been working for over three decades to protect and restore its aquatic resources, per our *Tribal Natural Resources Mission*:

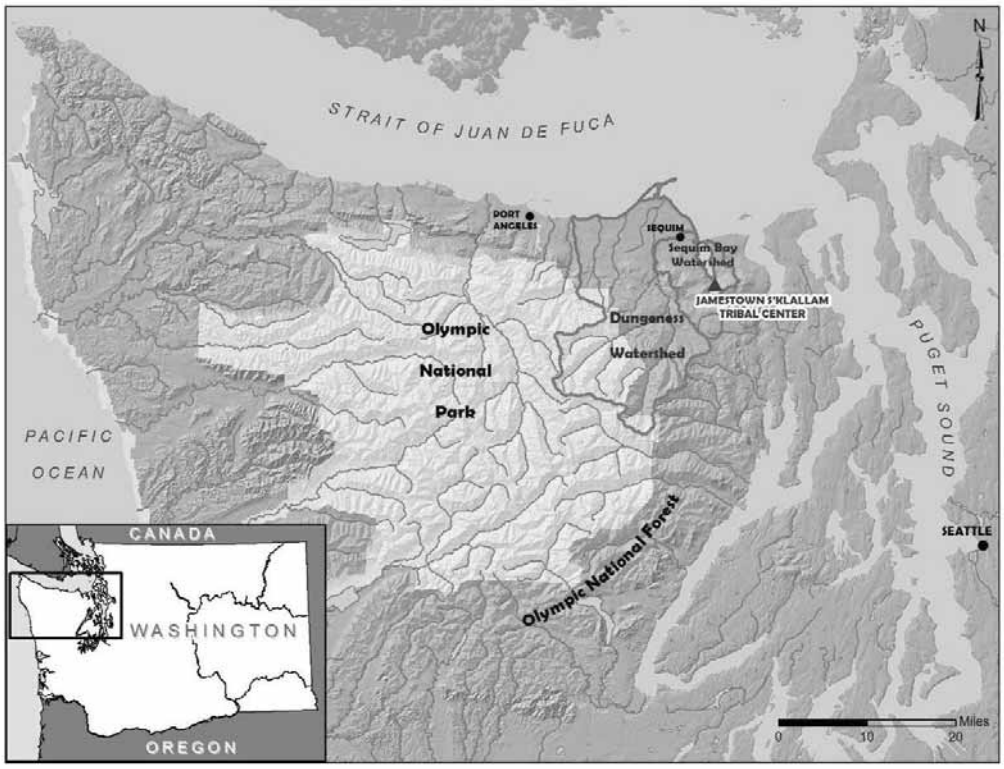
To protect treaty rights of the natural resources of the Point No Point Treaty area for the benefit of Jamestown S'Klallam Tribal citizens and future descendants. In this capacity; the [Natural Resources] Department is charged with ensuring the orderly harvest of fish, shellfish and wildlife resources, providing opportunities for Tribal citizens to derive subsistence and/or livelihood from the harvest of these resources, increasing opportunity through restoration, enhancement and scientific study, and reversing the decline of these resources resulting from environmental degradation.

~ Jamestown S'Klallam Tribe

Problem Definition

The Dungeness River, its tributaries and other streams and irrigation ditches in the Dungeness watershed have long been subjected to degraded water quality. Non-point pollution impacts from forestry; agriculture; an extensive irrigation system; construction of roads, bridges and dikes; and the loss of riparian vegetation have all contributed to declining water quality historically, along with impacts from urbanization in more recent decades. Many of these water bodies are on Washington Department of Ecology's (WDOE) 303-d list of impaired and threatened waters for high fecal coliform bacteria levels, resulting in TMDLs in both 2002 (Sargeant) and 2004 (Sargeant), as well as a Clean Water Strategy (Streeter and Hempleman, 2004), currently being implemented. A more focused approach to investigating fecal coliform sources began with a pilot project in 2015, the Pollution

Figure 1. Location of Jamestown S'Klallam Tribe and its primary watersheds of interest



Identification and Correction (PIC) program[1] coordinated by Clallam County and Clallam Conservation District. The program establishes water quality focus areas based on trends monitoring, prioritizes those areas, and then conducts segmented stream reach sampling in those areas to identify, and strategize on correcting, pollution sources.

The Dungeness River and some of the smaller streams in the Sequim-Dungeness basin are also 303d-listed for instream flows, temperature and dissolved oxygen, and the watershed is one of WDOE's 16 designated "fish critical basins" (WDOE, 2011) due to low instream flows and the presence of four Endangered Species Act (ESA) listed salmonids (*Puget Sound Chinook, Hood Canal summer chum salmon, Puget Sound steelhead,* and *bulltrout*). The watershed also supports several fish species that are state-listed as either "critical" or "depressed", and low flows continue to be the primary fish passage concern in the Dungeness (Haring, 1999).

These water quality and fish habitat impairments are compounded during drought conditions. Most recently, during both 2015 and 2019 droughts, upstream fish migration was blocked by low flows at multiple locations or, "*choke-points,*" in the Dungeness River. In 2015, partners implemented a variety of remediation efforts to aid upstream fish passage to Dungeness River spawning grounds, and flows were low enough in 2019 to prompt concerns about high temperature and low dissolved oxygen levels for fish, resulting in a coordinated effort by Washington Department of Fish and Wildlife (WDFW) to manually transport Chinook past one of the lower river choke-points.

[1] For further information on the PIC program: http://www.clallam.net/HHS/EnvironmentalHealth/PICProject.html

Purpose/Reason for Project
While partnerships and programs are ongoing in the Dungeness Watershed to identify and correct pollution associated with nutrients and fecal coliform, as well as harmful algal blooms and biotoxins, dissolved oxygen and temperature parameters have been tracked and analyzed less consistently. With climate change impacts ever more apparent, it is important to develop a baseline record of these lesser studied water quality metrics. This information will increase our understanding of current instream conditions for fish in relation to state water quality standards, and how these conditions change seasonally and with weather patterns. During drought conditions in particular, knowledge of the instream temperature and dissolved oxygen at various key locations in the river, and in real-time, will more effectively and efficiently guide co-manager decision-making about potential fish passage remediation alternatives.

1.6 Project/Task Description and Schedule (EPA QA/R-5 A6)

This QAPP has been developed to support the measurements of temperature and dissolved oxygen in the Dungeness Watershed to both determine current base-line conditions as compared with water quality standards for fish, and to help detect when stream conditions are impacting fish migration during drought conditions. As the purpose for the project is two-fold, this QAPP will be organized and detailed in some of the remaining sections according to two related tasks, described below:

> *Task 1: Continuous Monitoring of Temperature*, **focused in smolt streams in Sequim-Dungeness Watershed (hereinafter termed "***Baseline and Trend Monitoring"***)**

This task will involve collection of continuous instream temperature data in Dungeness watershed smolt streams, ideally year-round, during wet *and* dry seasons for a five year period so as to: a) Interpret a stream's monthly temperature patterns and/or do trend analyses, and b) Annually compare temperature levels with current Washington State water quality standards, per the Tribe's Monitoring Strategy (2018).

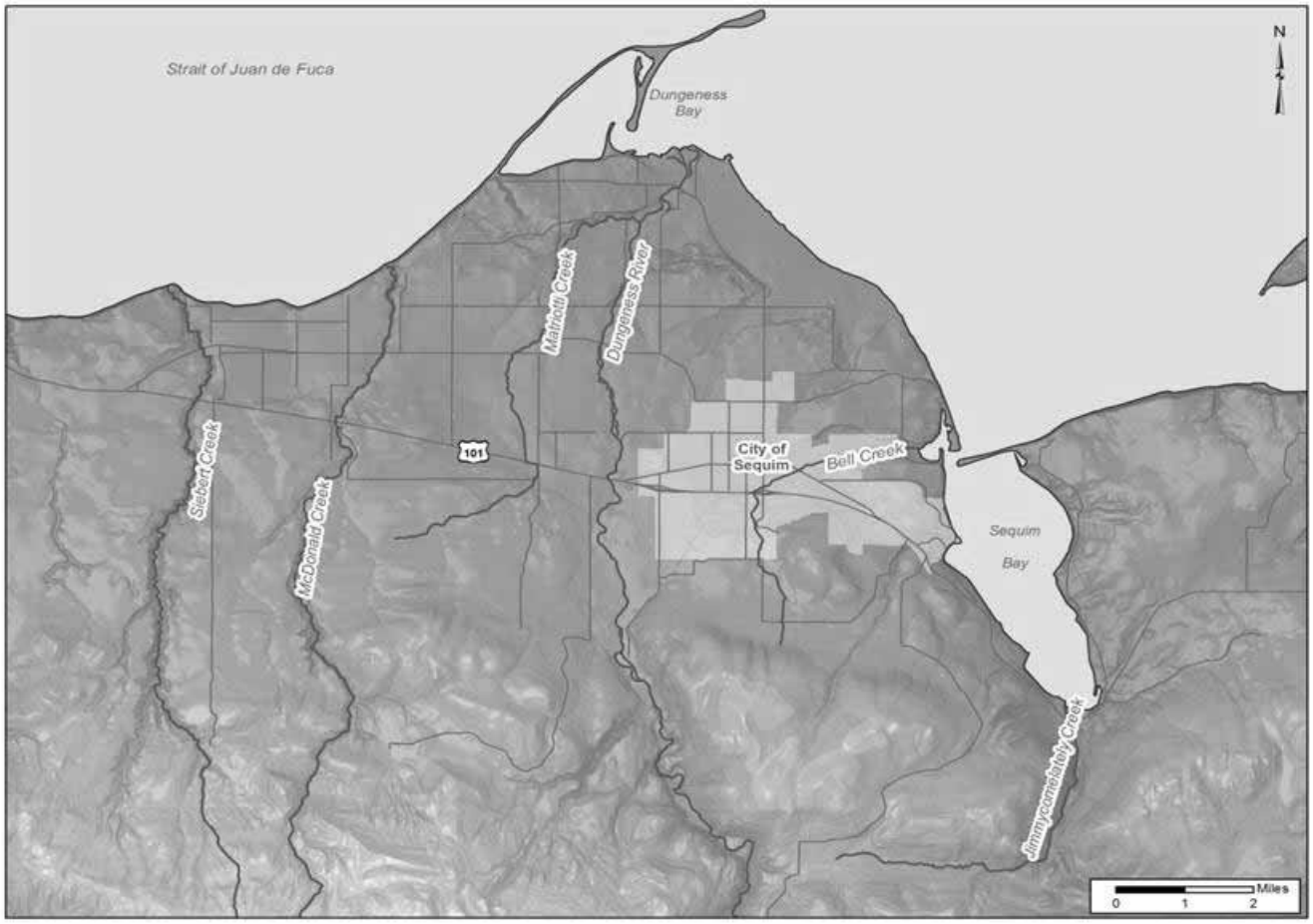
At minimum, one temperature data logger (Tidbit V2, Model UTBI-001) will be installed in each of the five streams already monitored by the Tribe for smolt production, namely: Siebert Creek (independent stream), McDonald Creek (independent stream), Matriotti Creek (tributary to Dungeness River), Bell Creek (Sequim Bay drainage), and Jimmycomelately Creek (Sequim Bay drainage). See Figure 2 for a map showing these smolt streams in relation to the Dungeness River Watershed. Additional streams may be added as resources allow. Monitoring sites within each stream will be determined during the dry season. Once the temperature data loggers are calibrated and initially installed, the devices will provide continuous hourly temperature data to be downloaded at a frequency determined by a technical team. See Table 1-1 for an estimated timeline of monitoring activities/sub-tasks.

> *Task 2: Continuous Monitoring of Temperature and Dissolved Oxygen during Drought Conditions*, **focused in the Dungeness River (hereinafter termed "***Drought Monitoring"***)**

This task will involve monitoring continuous instream temperature and continuous dissolved oxygen in the Dungeness mainstem and/or its side channels, during drought periods specifically (and at other times, as is safe and feasible), in order to detect as soon as possible when these parameters are at levels that may impede fish passage to spawning areas or that are otherwise harmful to fish. Project data will be used to track aquatic conditions for migrating salmon and to assist with potential decision-making related to emergency fish-passage remediation alternatives[2].

[2] Any implementation of fish passage remediation would occur outside the scope of this QAPP. Remediation is considered jointly by the co-managers,

Figure 2: Location of Task 1 smolt streams (Siebert Creek, McDonald Creek, Matriotti Creek, Bell Creek, Jimmycomelately Creek) in relation to the Dungeness River Watershed



Temperature and dissolved oxygen monitoring during drought periods will occur at strategic locations in the Dungeness River and/or side channels, as informed by data from either the most recent drought or the most recent spawning ground survey. The overall monitoring site-plan will attempt to include a variety of stream characteristics in order to be representative of the Dungeness River corridor. That is, monitoring devices will be placed in losing reaches, gaining reaches, tributary confluences, and near *choke points*, etc. *Choke-points*[3] are those areas of known fish migration blockages due to low flows, temperature or dissolved oxygen, or in some cases, constructed recreational dams. Data from these monitoring sites will be especially important during drought conditions. The most recent choke-point locations were mapped during the 2015 and 2019 droughts (Appendix B).

WDFW and Jamestown S'Klallam Tribe, often in cooperation with the Sequim-Dungeness Water Users Association, and with guidance from WDFW's *Drought 2015 Low-flow Blockage Remediation Project Tracking Form* (2016), the WDFW's *Drought Response 2015: Low Flow Fish Migration Blockage Remediation Program* document (2015), and the Tribe's *Drought Assistance Recipient Closeout Report for Agreement WDROU-2015-JamesST-00001* (2016). Remediation alternatives could include constructing temporary rock dams, installing temporary portable/inflatable diversion dams, creating temporary channel modifications that concentrate flow, or transporting fish passed blockages, thermal or otherwise.

[3] Note, due to the dynamic nature of the Dungeness River main-stem and side channels, choke point locations, and thus locations of monitoring devices, may change from year to year, or more frequently. The Tribe's habitat biologists are consulted for assistance in determining whether monitoring sites for emergency drought purposes should be moved, based on the most recently located choke-points.

The Tribe has five Hobo® Dissolved Oxygen/Temperature data loggers (Model U26-001), and five HOBO® Pendant® MX Temp/Light data loggers (Model MX2202), for a maximum total of 10 monitoring sites. Once the temperature and dissolved oxygen data loggers are calibrated (annually) and installed (as soon as possible in the spring), the devices will provide continuous hourly data to be downloaded at a frequency determined by a technical team, in accordance with drought- and fish condition-severity. See Table 1-1 for an estimated timeline of monitoring activities/sub-tasks.

Table 1-1: Estimated Timeline of Monitoring Sub-tasks

Activity	Timeframe
Prior to monitoring:	
Research and acquire new monitoring devices	Summer 2019 (during 2019 emergency drought)
Initial training and field testing of new monitoring devices	August-September 2019 (during emergency drought declaration)
Research and develop Draft QAPP	Spring/Summer 2020
Submit and obtain approval of QAPP	Summer/Fall 2020
Initial install and/or recalibrate monitoring devices	As soon as feasible after QAPP approval
Baseline and Trend Monitoring Task (smolt streams):	
Offload data from the 5 Continuous Temperature data loggers (Tidbits)	Annually, at minimum, to ensure battery strength and that the logger remains fully submerged in flowing water.
Field-checks/maintenance of monitoring devices	As often as technicians' field schedule permits, or matching Drought Monitoring task during drought.
Flow monitoring	As needed or useful*
Data upload/analyses	Monthly data uploads as instream flows begin to drop below 140 cfs, and monthly calculation of 7-DADMax.
Summary report of data results	Annually
Drought Monitoring Task (Dungeness River and/or side-channels):	
Calibrate and install 10 monitoring devices (5 Hobo DO/T data loggers, and 5 Hobo T data loggers)	As soon as is safely possible after QAPP approval.
Field-check monitoring devices during drought (and off-load data)	Monthly field check with secondary devises for QA, and to ensure loggers are fully submerged in water and representative of a well-mixed site.
Field surveys to determine status of choke-point locations and fish condition, and status of loggers	Bi-weekly when flows are 140 cfs or below.
Flow monitoring	As needed or useful.*
Data upload/analyses *Depending on severity of drought, flows, and results of choke-point surveys, review data daily to weekly throughout low-flow/drought period prior to potential fish passage remediation efforts***	As technicians' schedules allow, ideally bi-weekly data uploads, to determine Highest 7-DADMax for T, and the lowest 1-day minimums for DO. More frequent data-checks will proceed when flow at USGS telemetry gage approaches 140 cfs, or when drought is officially declared, whichever date comes first.
Summary report of data results and any resulting fish passage remediation activities	Depending on severity of drought, quarterly progress reports during drought period and final report 60 days following end of drought period (or at frequency determined by grant agreements, if applicable).

*For informational purposes only; not for study.
**Any remediation efforts will be conducted outside the scope of this QAPP, in coordination with co-managers and following any necessary permit requirements.

1.7 Quality Objectives and Criteria for Measurement Data (EPA QA/R-5 A7)

1.7.1 Objectives and Project Decisions

Baseline and Trend Monitoring

The objective of the project's *Baseline and Trend Monitoring* task is to establish current baseline temperature (T) data (and dissolved oxygen (DO) data, if feasible)[4] on streams in the Dungeness watershed that are already collecting smolt data in order to better understand current water quality and instream conditions for fish and how conditions may change over time, seasonally and with weather events such as drought. We also intend to compare measured levels to State Water Quality Standards, and will document when and if levels do not meet state standards as certified in WAC 173-201A-200 and WAC 173-201A-602. *If results exceed state standards, then WDFW and WDOE will be notified.*

Drought Monitoring

The objective of the project's *Drought Monitoring* task is to obtain continuous T and DO data in the Dungeness mainstem during drought conditions in order to detect drought impacts to migrating salmonids, especially fish passage blockages or other stressors, as early as possible. This task will assist co-managers in more effectively and efficiently making decisions about fish-passage remediation, if deemed appropriate. *If fish-passage remediation is deemed necessary, the co-managers will work together on implementation outside the scope of this QAPP.* The Tribe will also document when and if T and/or DO levels do not meet state standards, as certified in WAC 173-201A-200 and WAC 173-201A-602. *If results exceed state standards, then WDFW and WDOE will be notified.*

1.7.2 Action Limits/Levels

Baseline and Trend Monitoring

The main purpose of collecting T data (and DO data, if feasible) for the smolt streams is to understand year-round baseline water quality conditions in these streams and be able to compare them to future conditions to detect trends. We also intend to use state water quality standards/criteria to provide an indication of the streams' water quality. These standards will serve as Project Action Limits (PALs), as shown in Table 1-2. As this task does not include laboratory analysis, quantitation limits (QLs) and detection limits (DLs) are not applicable. However, Table 1-2 provides the measurement ranges for the project's field monitoring devices, per operating manuals provided by the device manufacturers (Appendix C). The monitoring devices selected are suitable for this task and support project objectives, as their measurement ranges bracket the PALs.

Drought Monitoring

Initiation of drought monitoring for T and DO to assess stream habitat conditions for fish and assist with decision-making on emergency fish passage remediation projects will be based upon flows tracked via the USGS and WDOE stream gaging websites (see Section 2.9 for website URLs), plus other anecdotal information, such as observations of problematic fish passage or blockages, manual flow measurements (when available) within certain stream reaches, and/or an official declaration of drought in our area. Flows at the USGS gage that reduce to 140 cfs will trigger initial drought assessment activities, i.e., review of choke-point locations and installation of monitoring devices by the Tribe's Natural Resources Department, possibly in conjunction with WDFW drought monitoring. This flow trigger value (140 cfs) can be considered a PAL and is based on recommendations provided by Jamestown fisheries technicians with extensive local field experience and

[4] Due to the fact that we only have five DO monitoring devices, priority for their use is within the Dungeness River and the Drought Monitoring task.

knowledge of fish behavior[5]. Once drought monitoring has been triggered, the decision to initiate fish passage projects will be made jointly by the Tribe and WDFW, outside the scope of this QAPP, utilizing a variety of information (e.g., flow, fish passage depth requirements[6], remediation pros and cons, etc.), supplemented by T and DO data collected under the guidelines of this QAPP.

PALs for providing an indication of water quality conditions for fish will utilize state water quality standards for the protected designated uses listed in Table 602 of WAC 173-201A-602 for the Dungeness River main-stem, tributaries and Canyon Creek. PALs are listed in Table 1-2.

[5] The Sequim-Dungeness Agricultural Water Users Association (WUA), the Washington State Department of Ecology (WDOE), and the Tribe have been tracking instream flows in the Dungeness watershed (including the river, streams, and irrigation outtakes) for many years, and especially during low flow and drought conditions. The Trust Water Right Agreement of 1998 (WUA), the Water Resources Inventory Area 18 (WRIA 18) Plan of 2005 (Elwha-Dungeness Planning Unit), the Dungeness Water Management Rule of 2013 (Washington State Legislature) and subsequent agreements between WDOE and the Water Users have been important tools to understanding and quantifying how much water is in the river for aquatic uses, and how much can be safely diverted for out of stream uses. Now more than ever, water managers keep a close eye on the flow and T data produced by the telemetry gages managed by the USGS (flow at River Mile 11.7) and WDOE (flow and T at River Mile 0.75). Outside the scope of this QAPP, staff from all agencies make spot checks of the flow data by taking periodic manual flow measurements, and notifying each other when field measurements deviate from telemetry values, and when flows are at levels that could start impacting fish behavior.

[6] Fish passage depth requirements for various species are listed in *Drought Response 2015: Low Flow Fish Migration Blockage Remediation Program, Version 2.1 (WDFW, 2015).*

Table 1-2. Project Action Limits and Quantitation Limits/Measurement Ranges

Field Measurement/ Parameter	Instrument/Method	Project Action Limit/Level (PALs)*		Quantitation Limits (Measurement Ranges of equipment)**
*Temperature (Highest 7-DADMax)****	Tidbit V2, Model UTBI-001 (for use primarily in smolt streams)	Char spawning and rearing	12° C (53.6°)	Max sustained T of 30°C (86°F) in water; -20° to 70°C (-4° to 158°F) in air
		Core summer salmon habitat	16° C (60.8°)	
		Salmonid spawning, rearing migration	17.5° C (63.5°)	
Temperature (Highest 7-DADMax)	HOBO® Pendant® MX Temp/Light data loggers (Model MX2202) (for use primarily in Dungeness main-stem and Dungeness side channels)	Same as above		-20° to 50°C (-4° to 122°F)
Temperature	NIST-calibrated thermometer (for spot checking other temperature instruments)	Same as above		-18.0° to 52.0°C (0.0 to 125.0°F)
Temperature *and* *Dissolved Oxygen (Lowest 1-Day minimum)*	Hobo® Dissolved Oxygen/Temperature data loggers (Model U26-001) (for use primarily in Dungeness main-stem and Dungeness side-channels)	Same as above (for Temp)		T: -5 to 40°C (23° to 104°F), non-freezing DO: 0 to 30 mg/L
		Char Spawning and Rearing	9.5 mg/L	
		Core Summer Salmonid Habitat	9.5 mg/L	
		Salmonid Spawning, Rearing, Migration	8.0 mg/L	
Dissolved Oxygen	Azide Modification of Winkler Method 8332 (for spot checking DO measured with Hobo data loggers)	Same as above (for DO)		1 mg/L to over 10 mg/L
Instream Flow	FlowTracker 2 (or upper USGS telemetry gage)	140 cfs ****		Velocity Range: ±0.001 to 4.0 m/s (0.003 to 13 ft/s)

*Values listed for T and DO are Aquatic Life Temperature Criteria/State Water Quality Standards as identified in WAC 173-201A-200 and WAC 173-201A-602.
**Values indicate the measurement ranges of field instruments and bracket the PALS. The ranges are supported by calibration procedures.
***Highest seven-day mean average daily maximum temperature.
****The flow value that triggers initial drought monitoring activities in the field, such as assessing choke points, etc.

1.7.3 Measurement Performance Criteria

The overall data quality objective is to ensure that data of known and acceptable quality are acquired for the purposes of the two tasks stated herein. All field measurements will be performed to yield consistent results that are representative of the media and conditions measured.

The accuracy of the continuous monitoring devices will be verified through calibration checks prior to deployment of the devices, and calibration spot checks after deployment, utilizing the recommendations and guidelines of the instrument manuals (Appendix C). Table 1-3 provides the accuracy and resolution for potential field instruments.

Table 1-3: Summary of primary and secondary field instruments, accuracy, and resolution

Field Instrument/Method (P) = Primary (S) = Secondary/QA Spot Checks)	Parameter	Accuracy*	Resolution*+
(P) Tidbit, Model UTBI-001	Temperature (Task 1 – primarily in smolt streams)	±0.21°C from 0° to 50°C (±0.38°F from 32° to 122°F)	0.02°C at 25°C (0.04°F at 77°F)
(P) HOBO® Pendant® MX Temp/ Light data loggers (Model MX2202)	Temperature (Task 2 – primarily in Dungeness)	±0.5°C from -20° to 70°C (-4° to 158°F)	0.04°C (0.072°F)
(S) NIST-Calibrated hand-held field thermometer	Temperature (Tasks 1 and 2)	±0.2°C (±0.5°F)	
(P) Hobo® Dissolved Oxygen/ Temperature data loggers (Model U26-001)	DO (Task 2)	DO: ±0.2 mg/L up to 8 mg/L; DO: ±0.5 mg/L from 8 to 20 mg/L T: 0.2°C (0.36°F)	DO: 0.02 mg/L T: 0.02°C (0.04°F)
(S) Winkler Titration	DO (Task 2)	0.1 mg/L	N/A
(S) FlowTracker 2	Streamflow (Task 1 and 2, supplementary information)	Velocity Accuracy: ±1% of measured velocity, 0.25 cm/s T Sensor Accuracy: 0.1° C	Velocity Resolution: 0.0001 m/s (0.0003 ft/s) T Sensor Resolution: 0.01° C

*Values are from the field instrument manuals (Appendix C).
+Resolution is the smallest change that a sensor can detect, or the "fineness" to which the sensor can be read.

Data Quality Indicators (DQIs), described below, and measurement performance criteria for each DQI were identified for each measurement parameter (i.e., temperature and dissolved oxygen) to ensure the collected data will be of acceptable quality to support project decisions.

Precision

Precision is the degree to which repeated measurements at the same location and time produce the same results, assuming conditions are unchanged (also referred to as variance or "tightness"). Precision for the Winkler Test Method (8332), which will be used during field checks of our DO continuous data logger for ***Drought Monitoring***, will entail collecting duplicate grab samples per that method's procedures in Appendix C-5. Precision of this method will be expressed as relative percent difference (RPD), defined below, and will be considered sufficient if RPD is not more than +/- 20%. If RPD is >20%, technician will check calibration and re-collect sample.

$$RPD = \frac{(X_1 - X_2) \times 100}{(X_1 + X_2)/2}$$

As the nature of continuous data loggers (automatic/continuous data collection) does not lend itself to precision assessments, we will rely on other DQIs in assessing logger data quality. For example, data from the continuous loggers will be compared to data from reliable secondary instruments (Table 1-3) during field checks, as mentioned in Table 1-1 and as described below for *Bias* and *Accuracy*. For **Baseline Monitoring**, this will occur as often as the technician's schedule allows, and at minimum every other month or at the same time as field checks for drought monitoring. For **Drought Monitoring**, this will occur monthly as flows safely allow.

Bias

Bias refers to whether a systematic offset occurs between the measured value and the "true" value. Bias will be minimized during sampling by consistently following the calibration and deployment procedures described in the equipment manuals (Appendix C). Since use of the continuous data-loggers will be the primary measurement method, instrument bias will be minimized by making periodic spot-checks with the secondary measurement devices listed in Table 1-3. If the sensors for the temperature data loggers fail to agree to the secondary measurement device to within + 0.2 °C (temperature), or to within 0.3 mg/L (dissolved oxygen) (Wagner, et. al., 2006), troubleshooting steps will be taken; if troubleshooting fails, the data logger sensor will be replaced.

Accuracy

Accuracy, refers to how close a measurement is to its "true" value, or its "correctness." This DQI will be assessed quantitatively with periodic "spot checks" using alternate instrumentation. For example, we will periodically spot check the Tidbit and Hobo temperature loggers with a NIST-calibrated thermometer. We will spot-check the dissolved oxygen data logger via collecting a grab sample and conducting Winkler titration methodology at our laboratory.

Additionally, a pre-deployment accuracy check on the temperature data-loggers will occur using the ice-bath method, as suggested by EPA (2014). This is further described in Section 2.7.

Representativeness

Representativeness is the degree to which data accurately and precisely portrays the actual or "true" environmental condition (e.g. water quality) measured. Representativeness is considered in project/sampling design and sample site locations. Sample locations will be GPS'd, and data sheets will describe visual land markers, increasing monitoring location accuracy.

Comparability

Comparability is the degree to which different methods, data sets, and/or decisions agree or are similar. The

use of standardized sampling methods and quality equipment helps to assure comparability. Data generated from a particular monitoring site will be compared with data from the same monitoring site, and at same time during the day. *Particular attention will be paid to temperatures measured at or after noon, to reflect middle of daily temperature/dissolved oxygen cycling.*

Completeness

Completeness is the amount of valid data acquired compared to the amount that was planned. It is often expressed as a percentage. Completeness can be maximized by properly placing sensors to ensure they will not be lost to high flows or stolen. Technicians will use best judgement in deciding whether devices should be removed based on forecasted high flows. Best practices for placement of sensors will be informed by (EPA, 2014) and by device manufacturers. The data will be considered complete if the majority of data-loggers remain in place in flowing water for at least one month.

1.8 Special Training Requirements/Certification (EPA QA/R-5 A8)

Data collection will be performed by the Tribe's Field Technicians, with assistance from Project Managers listed in Section 1.4 as necessary. In addition to their extensive experience conducting field work at all of the monitoring sites, the Tribe's water quality and fisheries technicians have participated in relevant workshops and utilized training tools provided by the manufacturers of our newer monitoring devices (Onset, for temperature and dissolved oxygen monitoring; Sontek, for flow monitoring). Technicians have also read and considered this QAPP, as well as *EPA's Best Practices for Continuous Temperature/Flow (2014)*. No additional special or non-routine training or certifications are necessary to successfully complete the project.

1.9 Documents and Records (EPA QA/R-5 A9)

All records that remain the responsibility of the Jamestown S'Klallam Tribe will be kept either in hard copy or electronically at the Jamestown S'Klallam Tribe administrative offices located in Blyn, Washington. This includes all data and reports associated with the project, such as may be required by related grants. The Jamestown S'Klallam Tribe's Lead technician will be responsible for maintaining field and instrument data or reports. The Tribe's Watershed Planner or Environmental Planning Manager will be responsible for archiving and retrieving other related project materials, and will assure the most current approved version of the QAPP (via document control format including revision number and revision date) is distributed to relevant personnel.

Records that may be maintained in electronic or hardcopy form include:

- Quality Assurance Project Plan and any approved modifications and/or updates
- Instrument specifications, user manuals, and operating procedures
- Field data records
- Measured and calculated data
- GPS data and digital photographs of monitoring sites
- Maps or other graphics that may be developed
- Written documentation of problems associated with any of the project tasks
- Progress reports on relevant tasks and data results

1.9.1 QA Project Plan Distribution

A hard-copy of the current approved QAPP, and any approved updates will be stored in the office of the Environmental Planning Manager. Electronic copies will be provided to all field technicians involved and will be stored on a shared drive on the Tribe's server. The QAPP will be reviewed every five years (or as needed) to assure objectives and procedures remain up to date. Any updates will be transmitted via email by the Tribal QA Manager to Tribal personnel involved in the project, the EPA Project Officer, and the EPA QC Manager.

1.9.2 Field Documentation and Records

Field data (date, time, field/weather conditions, flow (if applicable), other observations), as well as GPS coordinates of sample locations, will be the responsibility of the lead field technicians and will be recorded on appropriate field data sheets and transferred onto an Excel spreadsheet to be stored on the Jamestown S'Klallam Tribe's server. Field data will also be entered into the STORET system online.

1.9.3 Laboratory Documentation and Records

N/A. No laboratory will be utilized for this project.

1.9.4 Progress and/or Final Reports

Progress reports and/or final reports on project tasks and data results will be produced annually at minimum, depending on relevant grant requirements, and shared with appropriate grant agencies and partners. During official drought emergencies, which may involve the use of state funds for emergency droughts, progress reports will be submitted to WDOE according to relevant grant guidelines.

2.0 DATA GENERATION AND ACQUISITION

2.1 Sampling Design (Experimental Design) (EPA QA/R-5 B1)

Baseline and Trend Monitoring

This task will involve year-round (as is feasible) collection of continuous instream T data in Dungeness watershed smolt streams during wet *and* dry seasons for a five year period so as to: a) Interpret a stream's monthly T patterns and/or do trend analyses, and b) Compare T levels with current Washington State water quality standards, per the Tribe's Monitoring Strategy (2018).

At minimum, one T data logger (Tidbit V2, Model UTBI-001) will be installed in each of the five streams already monitored by the Tribe for smolt production, namely: Jimmycomelately Creek (Sequim Bay drainage), Matriotti Creek (tributary to Dungeness River), Siebert Creek (independent stream), McDonald Creek (independent stream), and Bell Creek (Sequim Bay drainage) (See Figure 2-1 for a map showing these smolt streams in relation to the Dungeness Watershed). Additional streams may be added as resources allow.

Each monitoring site will be marked with surveyor's tape, photographed and GPS coordinates recorded. Selection of sampling sites within each stream will be based on representative rearing habitat for juvenile salmonids, proximity to usual smolt trap location[7], suitability of the site to ensure instrument protection, etc; and with some guidance from the Stream Temperature Module in the Timber Fish and Wildlife Manual (NWIFC, 1994). Technicians will also reference the Additional sites may be added for representativeness, depending on inventory of monitoring devices.

Once the measuring equipment (Tidbits) are calibrated and installed, the devices will be programmed to provide continuous hourly[8] T data to be uploaded weekly or at a frequency determined by the technical/field team. See Table 1-1 for the estimated timeline of monitoring activities/sub-tasks. T data will be evaluated by reviewing 7-DADMAX (seven-day mean average daily maximum temperature) for comparison with state standards. Periodic

[7] Smolt traps are generally located in secure locations as close to the mouth of the stream as possible.
[8] In consideration of device battery life (the shorter the interval the shorter the battery life) and bias (the longer the interval the more bias), EPA (2014) recommends an interval under 2 hours. We will use a 1-hour interval the first year, and reevaluate for the second year.

stream surveys conducted by technicians will spot check equipment and test the continuous T data logger against an alternative method (NIST-calibrated thermometer), per instrument guidelines.

Drought Monitoring

This task will involve monitoring continuous instream T and DO in the Dungeness mainstem and/or its side channels, during drought periods specifically (and at other times, as is safe and feasible), in order to detect as soon as possible when these parameters are at levels that may impede fish passage to spawning areas or that are otherwise harmful to fish. Project data will be used by co-managers to track aquatic conditions for migrating salmon and to assist with decision-making related to fish-passage remediation alternatives[9].

Monitoring sites for T and DO monitoring during drought periods will attempt to include representative characteristics of the river, such as losing reaches, gaining reaches, side channels, tributary confluence, but priority stations will be at likely choke-point locations in the Dungeness River and/or its side channels, as informed by choke-point data from the most recent drought or spawning survey. *Choke-points* are those areas of known fish migration blockages due to low flows, T or DO, or in some cases, constructed recreational dams. For example, our next cycle of monitoring will occur at monitoring sites at or in close proximity to the most recent choke-point locations, as mapped during the 2015 and 2019 droughts (Appendix B). Due to the dynamic nature of the Dungeness River main-stem and side channels, choke point locations, and thus monitoring site locations, may change from year to year, or more frequently. The Tribe's habitat biologists are consulted for assistance in determining whether monitoring site locations for emergency drought purposes should be modified, based on the most recently located choke-points. Additional sites may be added for representativeness, depending on inventory of monitoring devices.

The Tribe has five Hobo® Dissolved Oxygen/Temperature data loggers (Model U26-001), and five HOBO® Pendant® MX Temp/Light data loggers (Model MX2202), for a maximum total of 10 monitoring sites. Once the T and DO data loggers are calibrated and installed, the devices will provide continuous hourly data to be uploaded weekly or at a frequency determined by the technical/field team, in accordance with drought- and fish-condition-severity. See Table 1-1 for the timeline of monitoring activities/sub-tasks. DO data will be evaluated by reviewing lowest one-day minimums for comparison with state standards. T data will be evaluated by reviewing 7-DADMAX (seven-day mean average daily maximum temperature) for comparison with state standards. Periodic stream surveys conducted by technicians will spot check equipment and test the continuous T and DO data loggers against an alternative method (Winkler titration), per instrument guidelines.

2.2 Sampling Methods (EPA QA/R-5 B2)

All sampling will be conducted by the Jamestown S'Klallam Tribe. Quality control samples will be conducted periodically using "secondary" instrumentation, as described below. Instruments will be prepared per the instrument manuals provided by the manufacturer (Appendix C).

Baseline and Trend Monitoring

The primary method for measuring temperature will use continuous temperature data loggers (Tidbit V2, Model UTBI-001), per the estimated timeline in Table 1-1. Accuracy of the primary measuring method will be ensured

[9] Any implementation of fish passage remediation would occur outside the scope of this QAPP. Remediation is considered jointly by the co-managers, WDFW and Jamestown S'Klallam Tribe, often in cooperation with the Sequim-Dungeness Water Users Association, and with guidance from WDFW's *Drought 2015 Low-flow Blockage Remediation Project Tracking Form* (2016), the WDFW's *Drought Response 2015: Low Flow Fish Migration Blockage Remediation Program* document (2015), and the Tribe's *Drought Assistance Recipient Closeout Report for Agreement WDROU-2015-JamesST-00001* (2016). Remediation alternatives could include: no action, constructing temporary rock dams, installing temporary portable/inflatable diversion dams, or transporting fish past blockages, thermal or otherwise.

via secondary "spot checks" at least annually, using an NIST-calibrated field thermometer for temperature, and via Winkler titration for dissolved oxygen (if applicable). Procedures for each instrument (primary and secondary) are provided in the equipment manuals (Appendix C). All recommended procedures will be followed.

Drought Monitoring

The primary method for measuring temperature (at sites not monitored for DO) will use continuous data loggers (HOBO® Pendant® MX Temp/Light data loggers (Model MX2202)), per the estimated timeline in Table 1-1. The primary method for measuring temperature at sites monitored for DO will use Hobo® Dissolved Oxygen/ Temperature data loggers (Model U26-001). Accuracy of the primary measuring method for temperature will be ensured via secondary "spot checks" at least annually, but more frequently during droughts, using an NIST-calibrated field thermometer. Procedures for each instrument (primary and secondary) are provided in the equipment manuals (Appendix C). All recommended procedures will be followed.

The primary method for measuring DO will use Hobo® Dissolved Oxygen/Temperature data loggers (Model U26-001), per the estimated schedule in Table 1-1. Accuracy of the primary measuring method will be ensured via secondary "spot checks" at least annually, but more frequently during drought periods, using the Winkler Titration method. Procedures for each instrument (primary and secondary) and for the Winkler Titration Method (8332) are provided in the equipment manuals (Appendix C). All recommended procedures will be followed.

2.3 Sample Handling and Custody (EPA QA/R-5 B3)

There are no custody requirements for measuring temperature and dissolved oxygen. When a data logger is deployed at a monitoring site, a NIST-calibrated thermometer will be used to measure temperature at the same depth and location. Spot-checks will occur at a frequency determined by technicians, and dissolved oxygen grab samples will be taken and analyzed using the Winkler Titration method. Field data (such as for spot-checks of temperature and/or dissolved oxygen) will be recorded directly onto field data sheets.

2.4 Analytical Methods (EPA QA/R-5 B4)

An optical sensor in the continuous DO data loggers measures dissolved oxygen using RDO® Basic Technology. The continuous DO loggers are shipped with a red dust cap that must be replaced with a green sensor cap that lasts for six months plus a one-month grace period. Project staff will ensure that all pertinent guidelines in the equipment user manuals will be followed.

Field measurements of DO (via grab samples) and temperature (via NIST-calibrated thermometer), in duplicate, at a frequency determined by field technicians and project managers. These field methods will be secondary to the continuous data loggers, and will serve as spot checks of the continuous data loggers. Manufacturer operational guidelines for the NIST thermometer and Winkler titration protocols (for 60 mL samples) will be followed.

2.5 Quality Control Requirements (EPA QA/R-5 B5)

The continuous collection of DO and temperature data does not lend itself to the use of quality control measures that would normally be performed with samples in a laboratory. Therefore, special attention will be given to precisely calibrating monitoring devices prior to deployment and verifying that each device maintains its calibration after installation. Verification of data accuracy will utilize the following quality control measures (which are also describe in Section 1.7.3):

- Conducting periodic spot checks at a frequency to be determined by field technicians and project managers.
- Checking continuous temperature measurements against a NIST-calibrated thermometer.
- Checking continuous DO measurements against duplicate DO grab samples taken at the same field location as the deployed monitor for use in Winkler titration method comparison.

- Following the operational, pre-deployment, and calibration guidelines of the equipment manuals (Appendix C) for each instrument and, in the case of continuous temperature measurements, using EPA's *Best Practices for Continuous Temperature and Flow in Wadeable Streams (2014)* as an additional troubleshooting reference, as needed.

Any deviation from the data quality objectives will be documented and sites will be re-sampled.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance (EPA QA/R-5 B6)
Instruments will be inspected and tested prior to use, and calibrated prior to deployment. Periodic inspection and maintenance of instruments in the field will be conducted per instrument manuals (Appendix C). Monitoring staff will document results and that testing, calibration, inspection and maintenance have been performed. A dated copy of this documentation will be kept with the instruments.

2.7 Instrument/Equipment Calibration and Frequency (EPA QA/R-5 B7)
Tidbit, Model UTBI-001*: Per the recommendation on the manufacturer's website, since all sensors drift over time, Tidbits will be tested in a controlled environment on a yearly basis to make sure that they are running within the specifications outlined in the User's Manual.

HOBO® Pendant® MX Temp/ Light data loggers (Model MX2202)*: Per the recommendation on the manufacturer's website, since all sensors drift over time, Tidbits will be tested in a controlled environment on a yearly basis to make sure that they are running within the specifications outlined in the User's Manual.

Hobo® Dissolved Oxygen/Temperature data loggers (Model U26-001)*: Per the recommendation on the manufacturer's website, since all sensors drift over time, Tidbits will be tested in a controlled environment on a yearly basis to make sure that they are running within the specifications outlined in the User's Manual. Further, during this project, the instrument will be calibrated using the "Lab Calibration Tool" method before deploying it or after replacing an expired sensor cap, per the instrument manual (Appendix C). If fouling is expected during deployment, field calibration readings will be taken at the beginning and end of deployment to adjust the data to compensate for any measurement drift due to fouling. Procedures are found in the instrument manual.

**Note: For the temperature sensors on each of the data-loggers listed above, the manufacture's website states that while the data loggers cannot be calibrated, a simple test can be run to check the temperature accuracy of the logger using the ice-bath method:*

Place crushed ice (preferably made from distilled water) in an insulated container that is large enough to hold the data loggers that you are testing. It is important to crush the ice to maintain as consistent and uniform a temperature as possible. Fill the container with distilled water to just below the level of the ice and stir the mixture around. Submerge the data loggers or thermistor probes that you are testing. Place the entire container in a refrigerator to minimize temperature gradients. Allow enough time for the data logger to acclimate. The ice will melt slowly, so the actual temperature should settle around 0."

Sontek Flow meter: Prior to each field measurement, the "Office Diagnostic" tool provided by Sontek will be used as a basic verification process of the FlowTracker2 to confirm that the instrument is operational before departure from the office. The diagnostic tests consist of the evaluation of a number of functions to verify the internal operations and probe performance of the FlowTracker2.

All field/office calibration results will be documented on field data sheets.

2.8 Inspection/Acceptance Requirements for Supplies and Consumables (EPA QA/R-5 B8)

The Tribe's lead technician will be responsible for inspecting/accepting requirements for supplies and consumables necessary for monitoring (per instrument manuals, methods and operating procedures in appendices).

2.9 Data Acquisition Requirements (Non-Direct Measurements) (EPA QA/R-5 B9)

Streamflow data can be used as an indicator of stream condition during various times of the year. Streamflow at the upper USGS Dungeness gage is used by the Water Users Association during the irrigation season to signal when they may need to reduce irrigation withdrawals in order to protect flows needed for fish. Similarly, field technicians and fisheries habitat biologists with the Tribe and WDFW track this data during the low-flow season, particularly when flows reduce to 140 cfs or below. This level alerts technicians to begin examining T and DO data (generated by the continuous data loggers) more closely and to initiate stream surveys as soon as possible for assessing potential choke-points for migrating salmon (outside the scope of this QAPP).

The Tribe will track via websites (listed below) the telemetry flow gages (and temperature gages, where applicable) administered by USGS and ECY for the following stream gaging sites, especially during drought conditions under the *Drought Monitoring* task:

USGS
Dungeness RM 11.0: https://waterdata.usgs.gov/nwis/uv?site_no=12048000

ECY
Dungeness near mouth, RM 0.75: https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=18A050
Sequim-Prairie Tri Irrigation Ditch: https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=18H250
Agnew Irrigation Ditch: https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=18F250
Highland Irrigation Ditch: https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=18J250
Independent Irrigation Ditch: https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=18K250
McDonald Irrigation Ditch: https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=18R250
McDonald Creek: https://fortress.wa.gov/ecy/eap/flows/station.asp?sta=18P070

USGS and DOE flow telemetry data is spot-checked by USGS and DOE staff, and results are provided on the telemetry websites.

2.10 Data Management (EPA QA/R-5 B10)

Site location data (GPS and field notes) will be documented on field sheets and transferred to an Excel file and stored on the Tribe's server.
Offloading data generated by continuous data loggers will follow instrument manual procedures, and will follow record-keeping guidelines suggested in Section 2.6.3 of *EPA's Best Practices for Continuous Temperature and Flow in Wadeable Streams (2014)*:

> *Both the original and the cleaned data files should be maintained and archived. Large amounts of stream temperature data will accumulate quickly so a central database should be developed and maintained from the initial stages of monitoring. Any changes made to the data should be carefully documented, and all forms should be organized, easily accessible, and archived in a way that allows for safe, long-term storage.*

T and DO data generated from the continuous data loggers will be uploaded to Excel files annually, at minimum, by the Lead Field Technician, and stored on the Tribe's server, along with statistical summaries of the data. The data will also be entered into the STORET database.

Any manual DO or flow measurements conducted in the field as spot-checks will be recorded in the field on field data sheets and transferred to an Excel file on the Tribe's server. Once data entered, the files will be double-checked against the field data sheets. Any problems with data collection will be noted on data sheets.

Data results will be summarized in our Tribal Annual Assessment Report and available upon request.

3.0 ASSESSMENT AND OVERSIGHT

3.1 Assessments/Oversight and Response Actions (EPA QA/R-5 C1)

Field oversight will entail the lead field technicians ensuring readiness prior to starting field activities. Lead field technicians will train any personnel that may assist with monitoring. Equipment maintenance records and instruments will be checked to make sure all equipment to be used is in good working condition. Adequate supplies needed for field activities will be obtained and stored appropriately prior to departing to field sites. Any issues that are noted will be corrected and addressed prior to heading to field sites.

In the field, team members will check one another's work. The lead technicians will review data sheets, and note in comments if any issues are noticed. Data from data sheets will be entered into spreadsheets by a technician, and reviewed by lead technician. Any problems noticed will be flagged in comments section.

3.2 Reports to Management (EPA QA/R-5 C2)

Progress reports will be prepared quarterly by the technicians and project managers for each task, and will include summaries of project progress, QA/QC findings, data results, any actions resulting from data results, and any potential challenges and resolutions. Annual reports will summarize the project and data, and any resulting actions, and provide recommendations for future sampling.

4.0 DATA REVIEW AND USABILITY

4.1 Data Review, Verification, and Validation Requirements (EPA QA/R-5 D1)

Raw data will be reviewed, verified and validated by the technicians conducting the measurements to ensure that all the information is complete. Any data concerns will be flagged and discussed with project managers. Any questions regarding discounting data will be discussed with EPA Project Officer.

4.2 Verification and Validation Methods (EPA QA/R-5 D2)

Calibration checks and field procedures will be documented on appropriate forms. Pre- and post-calibration check results and field measurements will be reviewed to ensure the data quality objectives are met. During field checks, data will be reviewed in the field, and again during data entry of field sheets into Excel spreadsheets. Any detected errors will be corrected, flagged with corrective actions if needed, or deleted with explanation.

4.3 Reconciliation with User Requirements (EPA QA/R-5 D3)

The project objectives include establishing current baseline temperature data on Dungeness watershed area smolt streams, and obtaining temperature and dissolved oxygen data in the Dungeness main-stem during drought

conditions. After data is review and verified, usable data will be compared to the Project Action Limits to identify whether these limits have been exceeded. Decisions made regarding exceeding the Project Action Limits (i.e., the state water quality standards), will follow the "*if….then….*" statements in Section 1.7.1.

The data generated for the *Drought Monitoring* task is not intended for study purposes, but instead for use as an alert tool for guiding co-managers on mitigation actions related to drought conditions and impacts or declared drought emergencies. Such conditions and actions are inherently time-sensitive, therefore, particularly during drought emergencies, data review related to fish passage mitigation will be streamlined as much as possible.

5.0 REFERENCES

Elwha-Dungeness Planning Unit. May 2005. *Elwha-Dungeness Watershed Plan, Water Resource Inventory Area 18 (WRIA 18) and Sequim Bay in West WRIA 17*. Published by Clallam County. Volume 1: Chapters 1-3 and 15 appendices; Volume 2: Appendix 3-E. http://www.clallam.net/environment/elwhadungenesswria.html

Haring, D. 1999. *Salmon and Steelhead Habitat Limiting Factors, Water Resources Inventory Area 18*. Washington Conservation Commission Final Report. Olympia, WA.

Jamestown S'Klallam Tribe. 2016. *Drought Assistance Recipient Closeout Report for Agreement WDROU-2015-JamesST-0001*. Blyn, WA.

Jamestown S'Klallam Tribe. 2018. *Water Monitoring Strategy for the Jamestown S'Klallam Tribe*. Blyn, WA.

Northwest Indian Fish Commission. 1994. *Timber Fish and Wildlife (TFW), Ambient Monitoring Program Manual (TFW-AM9-93-001)*. Olympia, WA. https://geo.nwifc.org/CMER/PublicDocs/TFWDocs/TFW_AM9_93_001%20TFW%20Ambient%20Monitoring%20Program%20Manual%20July%201993.pdf

Sargeant, D., 2002. *Dungeness River and Matriotti Creek Fecal Coliform Bacteria Total Maximum Daily Load Study*, Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/publications/publications/0203014.pdf

Sargeant, D., 2004. *Dungeness Bay Fecal Coliform Bacteria Daily Load Study* (Sargeant 2004), Environmental Assessment Program, Washington State Department of Ecology. Olympia, WA. https://fortress.wa.gov/ecy/publications/publications/0403012.pdf

Sequim-Dungeness Valley Agricultural Water Users Association. 1998. *Memorandum of Understanding to Transfer Water Under Trust Water Rights Program Chapter 90.42* Bibliography Page 11 ENTRIX, Inc. WRIA 18 Watershed Plan *RCW Between The State of Washington Department of Ecology and Members of the Sequim-Dungeness Valley Agricultural Water Users Association.* April 13, 1998.

Streeter, V. and C. Hempleman. 2004. Clean Water Strategy for Addressing Bacteria Pollution in Dungeness Bay and Watershed and Water Cleanup Detailed Implementation Plan. Washington Department of Ecology. Publication Number 03-10-059. Olympia, WA. https://fortress.wa.gov/ecy/publications/documents/0410059.pdf

U.S. Environmental Protection Agency (EPA). 2014. *Best Practices for Continuous Monitoring of Temperature and Flow in Wadeable Streams*. Global Change Research Program, National Center for Environmental Assessment, Washington, DC; EPA/600/R-13/170F.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A. 2006. *Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting*: U.S. Geological Survey Techniques and Methods 1–D3, 51p. http://pubs.water.usgs.gov/tm1d3

Washington Department of Ecology. 2011. *16 Fish Critical Basins*. October 2011 Map. Olympia, WA. https://appswr.ecology.wa.gov/docs/WaterRights/wrwebpdf/16fishbasins.pdf

Washington Department of Fish and Wildlife. 2015. *Drought Response 2015 Low Flow Fish Migration Blockage Remediation Program, Version 2.1 (20150728)*. Olympia, WA.

Washington Department of Fish and Wildlife. 2015. *Drought 2015 Low-flow Blockage Remediation Project Tracking From, Version 2 (20150726)*. Olympia, WA.

Washington State Legislature. 2013. Title 173. Chapter 173-518. *Water Resources Management Program for the Dungeness Portion of the Elwha-Dungeness Water Resource Inventory Area (WRIA) 18*. Olympia, WA. https://apps.leg.wa.gov/WAC/default.aspx?cite=173-518&full=true

Wikipedia contributors. (2020, June 7). Clallam County, Washington. In *Wikipedia, The Free Encyclopedia*. Retrieved 19:10, July 3, 2020, from https://en.wikipedia.org/w/index.php?title=Clallam_County,_Washington&oldid=961201408

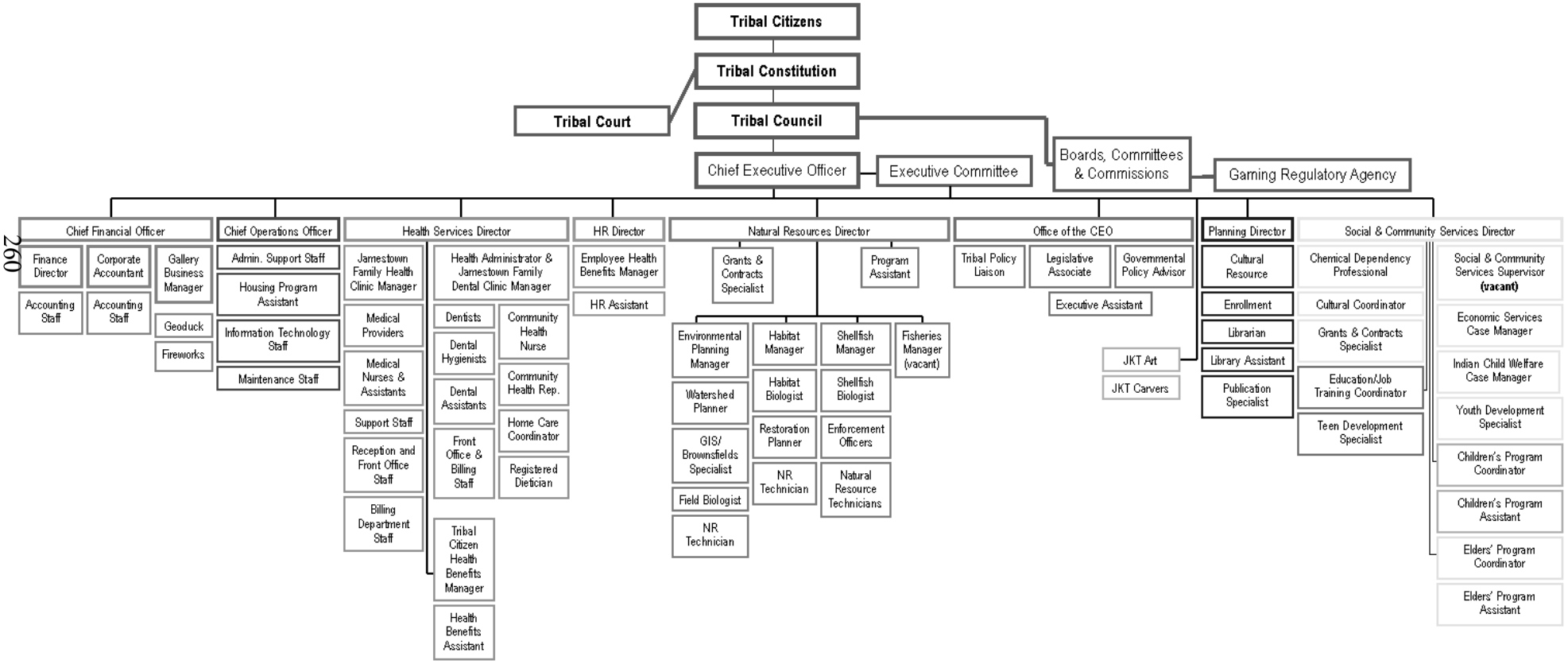
APPENDICES

APPENDIX A. Personnel Chart

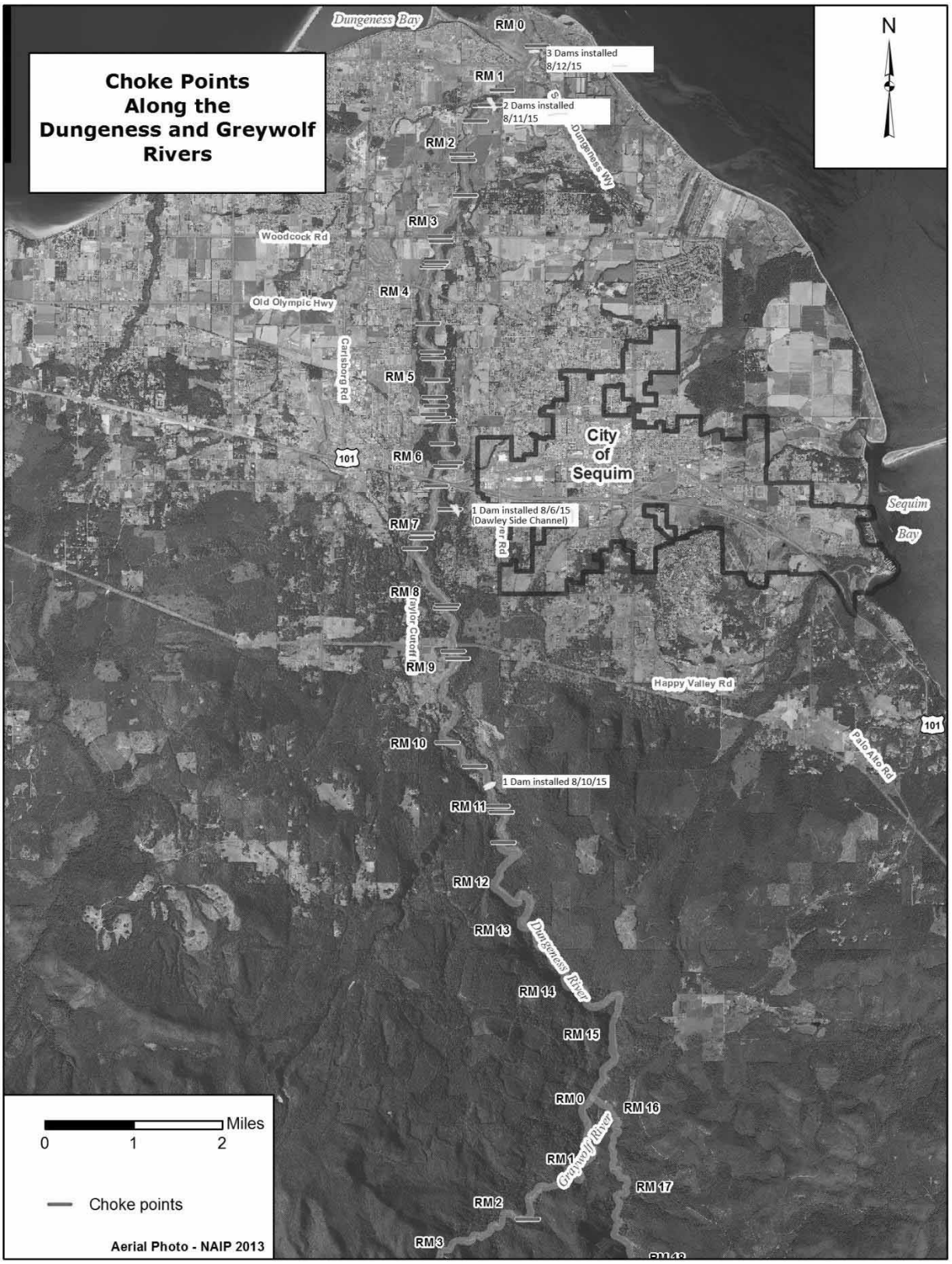
APPENDIX B. Choke Point Maps
B-1. 2015 Choke Point Map
B-2. 2019 Choke Point Map

APPENDIX C. Equipment/Instrument Manuals
C-1. Tidbit, Model UTBI-001
C-2. HOBO® Pendant® MX Temp/ Light data loggers (Model MX2202)
C-3. Hobo® Dissolved Oxygen/Temperature data loggers (Model U26-001)
C-4. SonTek Flow Tracker 2 (FT2-HH and FT2-2D)
C-5. Winkler Titration Protocol for Method 8332

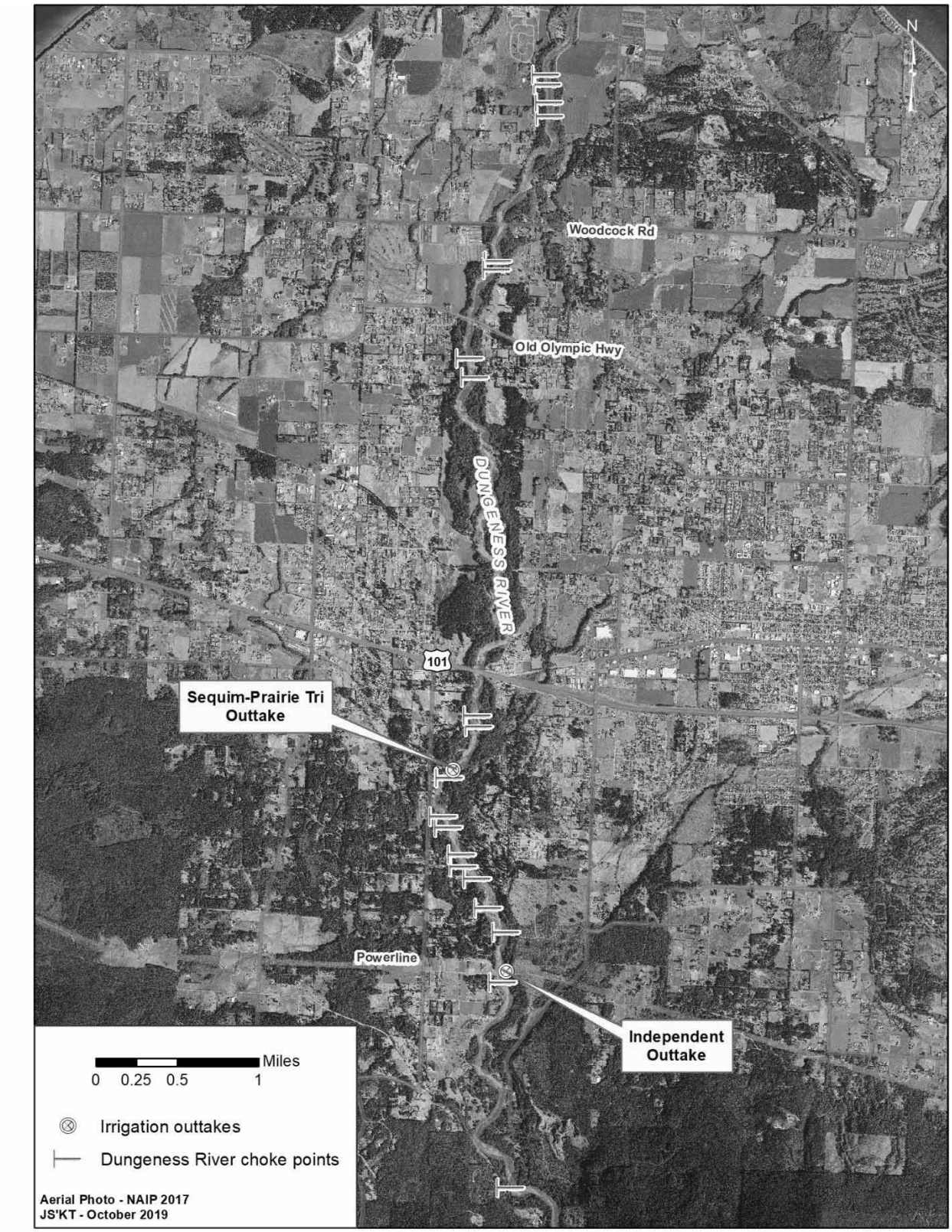
APPENDIX A. Personnel Chart



APPENDIX B-1. 2015 Dungeness River Choke Points



APPENDIX B-2. 2019 Dungeness River Choke Points



APPENDIX C-1. Temperature, Tidbit V2, Model UTBI-001, Manual

TidbiT® v2 Temp (UTBI-001) Manual

HOBO Data Loggers

The TidbiT v2 Temp logger is Onset's smallest U-Series logger. Its durable, waterproof case is designed for extended deployments measuring temperature in streams, lakes, oceans, coastal habitats, and soils. The logger's small size allows it to be easily mounted and/or hidden in the field. It is waterproof up to 305 m (1000 feet) and rugged enough to withstand years of use. It has enough memory to record over 42,000 12-bit temperature measurements.

The logger uses an optical USB communications interface (via a compatible shuttle or base station) for launching and reading out the logger. The optical interface allows the logger to be offloaded without compromising the electronics. The USB compatibility allows for easy setup and fast downloads. HOBOware® 2.2 or later is required for logger operation. Visit www.onsetcomp.com/hoboware-free-download.

TidbiT v2 Temp

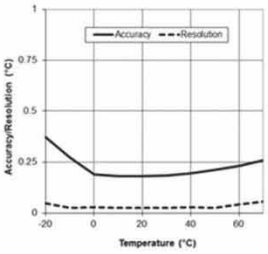
UTBI-001

Required Items:

- HOBOware 2.2 or later
- Coupler (COUPLER2-D)
- Optic USB Base Station (BASE-U-4) or HOBO Waterproof Shuttle (U-DTW-1)

Accessories:

- Black protective boot, 5-pack (BOOT-TIDBIT-BK)
- White protective boot, 5-pack (BOOT-TIDBIT-WH)



Plot A

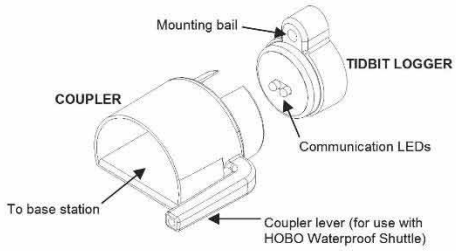
Specifications

Temperature Sensor	
Operation Range*	-20° to 70°C (-4° to 158°F) in air; maximum sustained temperature of 30°C (86°F) in water*
Accuracy	±0.21°C from 0° to 50°C (±0.38°F from 32° to 122°F), see Plot A
Resolution	0.02°C at 25°C (0.04°F at 77°F), see Plot A
Response Time	5 minutes in water; 12 minutes in air moving 2 m/sec; 20 minutes in air moving 1 m/sec (typical to 90%)
Stability (Drift)	0.1°C (0.18°F) per year
Logger	
Real-time Clock	±1 minute per month 0° to 50°C (32° to 122°F)
Battery	3 Volt lithium, non-replaceable
Battery Life (Typical Use)	5 years with 1 minute or greater logging interval
Memory (Non-volatile)	64K bytes memory (approx. 42,000 12-bit temperature measurements)
Weight	19.6 g (0.69 oz)
Dimensions	3.0 × 4.1 × 1.7 cm (1.2 × 1.6 × 0.68 in.); mounting bail 4.6 mm (3/16 in.) diameter hole
Wetted Materials	Epoxy case
Waterproof	To 305 m (1000 ft.)
Logging Interval	Fixed-rate or multiple logging intervals, with up to 8 user-defined logging intervals and durations; logging intervals from 1 second to 18 hours. Refer to HOBOware software manual.
Launch Modes	Immediate start, delayed start, triggered start
Offload Modes	Offload while logging; stop and offload
Battery Indication	Battery level can be viewed in status screen and optionally logged in datafile. Low battery indication in datafile.
Environmental Rating	IP68
NIST Certificate	Available for additional charge
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).

* To guarantee accuracy, the TidbiT v2 Temp must not be used in condensing environments and water temperatures higher than 30C (86F) for more than eight cumulative weeks over the life of the logger. Frequent or prolonged exposure will lead to measurement drift and eventual failure.

Connecting the Logger

1. Install the logger software on your computer before proceeding.
2. Follow the instructions that came with your base station or shuttle to attach the base station or shuttle to a USB port on the computer.
3. Wipe the logger with a nonabrasive cloth, if necessary, to ensure that the logger's communication LEDs are clean and dry.
4. Attach the coupler to the base station, then insert the logger into the coupler with the communication LEDs facing into the coupler, as shown in the diagram.



10385-J

When properly seated, the logger should be nearly flush with the top of the coupler.

5. If you are using the HOBO Waterproof Shuttle, briefly press the coupler lever to put the shuttle into base station mode.
6. If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer.
7. Use the logger software to launch the logger, check the logger's status, read it out, stop it manually with the software, or let it record data until the memory is full. Or, use the HOBO Waterproof Shuttle to read out and relaunch the logger in the field.

Refer to the software user's guide for complete details on launching, reading out, and viewing data from the logger.

Important: USB communications may not function properly at temperatures below 0°C (32°F) or above 50°C (122°F).

Note: The logger consumes significantly more battery power when it is "awake" and connected to a base station or shuttle. To conserve power, the logger will go into a low-power (sleep) mode if there has been no communication with your computer for 30 minutes. To wake up the logger, remove the logger from the coupler, wait a moment, then re-insert the logger.

Note: The first time you launch the logger, the deployment number will be greater than zero. Onset launches the loggers to test them prior to shipping.

Operation

An "OK" light (LED) on the front of the logger confirms logger operation. (In brightly lit areas, it may be necessary to shade the logger to see the "OK" light blink.) The following table explains when the "OK" light blinks during logger operation:

When:	The light:
The logger is logging	Blinks once every one to four seconds (the shorter the logging interval, the faster the light blinks); blinks when logging a sample
The logger is awaiting a start because it was configured to start logging At Interval, On Date/Time, or Using Coupler	Blinks once every eight seconds until logging begins

Triggered Launch

The TidbiT v2 Temp has an optional triggered launch. Launch your logger choosing the Using Coupler option. The magnetically operated reed switch is activated when the Tidbit Coupler is reconnected to the logger for 2 seconds and then removed. The base station and coupler are not necessary to trigger the launch. Any strong magnet placed near the face of the logger will trigger the launch. The TidbiT v2 Temp's red LED light will rapidly flash four times to indicate successful triggered launch.

Sample and Event Logging

The logger can record two types of data: samples and events. Samples are the sensor measurements recorded at each logging interval (for example, temperature every minute). Events are independent occurrences triggered by a logger activity, such as Bad Battery or Host Connected. Events help you determine what was happening while the logger was logging.

The logger stores 64K of data, and can record over 42,000 12-bit temperature measurements.

Deploying and Protecting the Logger

- Depending on water conditions and desired measurement location, the logger should be appropriately weighted, secured, and protected.
- The mounting bail on the logger accepts 1/8 inch (4 mm) diameter nylon cord or other strong cable. If wire is used to secure the logger, make sure the wire loop is snug to the bail. Any slack in the loop may cause excessive wear.
- This logger should not be immersed in any liquid other than fresh or salt water. To do so may damage the epoxy case and void the warranty. If you have any questions about chemical resistance, call Onset.
- To clean the logger, rinse it in warm water. Use a mild dishwashing detergent if necessary. Do not use harsh chemicals, solvents, or abrasives, especially on the communications LEDs.

Battery

The battery in the TidbiT v2 Temp is a non-replaceable 3-Volt lithium battery. The battery life of the logger should be about five years. Actual battery life is a function of the number of deployments, logging interval, and operation/storage temperature of the logger. To obtain a five-year battery life, a logging interval of one minute or greater should be used and the logger should be operated and stored at temperatures between 0° and 25°C (32° and 77°F). Frequent deployments with logging intervals of less than one minute, and continuous storage/operation at temperatures above 35°C, will result in significantly lower battery life. For example, continuous logging at a one-second logging interval will result in a battery life of approximately one month.

The logger can report and log the battery voltage. If the battery falls below 2.7 V, the logger will record a "bad battery" event in the datafile. If the battery fails, dispose of the logger according to local regulations. Do not attempt to open the logger case. The battery is not replaceable, and the logger does not contain any user-serviceable parts. If you open the case, the logger will be unusable, and the warranty will be voided.

WARNING: Do not cut open, incinerate, heat above 100°C (212°F), or recharge the lithium battery. The battery may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the battery case. Do not dispose of the logger or battery in fire. Do not expose the contents of the battery to water. Dispose of the battery according to local regulations for lithium batteries.

APPENDIX C-2. Temperature, HOBO® Pendant® MX Temp/ Light data loggers (Model MX2202), Manual

HOBO® Pendant® MX Temp (MX2201) and Temp/Light (MX2202) Logger Manual

HOBO Data Loggers

MX2201 Model Shown

HOBO Pendant MX loggers measure temperature (MX2201) or temperature/light (MX2202) in indoor and outdoor environments. Designed for durability, these compact, waterproof loggers can be used in numerous applications, including fresh and salt water. The loggers are Bluetooth® Low Energy-enabled for wireless communication with a mobile device. Using the HOBOmobile® or HOBOconnect® app, you can easily configure the loggers, download logged data to your phone or tablet, or automatically upload the data to HOBOlink® for further analysis. You can also configure the loggers to calculate statistics, set up alarms to trip at specific thresholds, or enable burst logging in which data is logged at a faster interval when sensor readings are above or below certain limits.

HOBO Pendant MX Logger

Models:

- MX Temp (MX2201)
- MX Temp/Light (MX2202)

Required Items:

- Mobile device with Bluetooth
- HOBOmobile app for devices with iOS
- HOBOconnect app for devices with Android™

Accessories:

- Mounting boot 5-pack (BOOT-MX2201-2202)
- Solar radiation shield (RS1 or M-RSA)
- Mounting bracket for solar radiation shield (MX2200-RS-BRACKET)
- Replacement O-rings (MX2201-02-ORING)

Specifications

Temperature Sensor (MX2201 and MX2202)	
Range	-20° to 70°C (-4° to 158°F) in air -20° to 50°C (-4° to 122°F) in water
Accuracy	±0.5°C from -20° to 70°C (-4° to 158°F)
Resolution	0.04°C (0.072°F)
Drift	<0.1°C (0.18°F) per year
Response Time	17 minutes typical to 90% in air moving 1 m/s, unmounted 7 minutes typical to 90% in stirred water, unmounted
Light Sensor (MX2202)	
Range	0 to 167,731 lux (15,582 lum/ft²)
Accuracy	±10% typical for direct sunlight (see *Light Measurement* on page 2 for more details)
Logger	
Logger Operating Range	-20° to 70°C (-4° to 158°F) in air
Buoyancy (Fresh Water)	2 g (0.07 oz) positive
Waterproof	To 30.5 m (100 ft)
Radio Power	1 mW (0 dBm)
Transmission Range	Approximately 30.5 m (100 ft) line-of-sight
Wireless Data Standard	Bluetooth Low Energy (Bluetooth Smart)
Logging Rate	1 second to 18 hours
Time Accuracy	±1 minute per month at 25°C (77°F)
Battery	CR2032 3V lithium, user replaceable
Battery Life	1 year typical at 25°C (77°F) with logging interval of 1 minute and Bluetooth Always On enabled in software. 2 years typical at 25°C (77°F) with logging interval of 1 minute and Bluetooth Always On disabled in software. Faster logging intervals and statistics sampling intervals, burst logging, remaining connected with the app, excessive downloads, and paging may impact battery life. To ensure proper battery installation, see *Battery Information* for detailed instructions on replacing the battery.
Memory	96,000 measurements
Full Memory Download Time	Approximately 45 seconds; may take longer the farther the device is from the logger
Wetted Materials	Polypropylene case, EPDM O-ring
Dimensions	3.35 x 5.64 x 1.8 cm (1.32 x 2.22 x 0.69 inches)
Weight	12.75 g (0.45 oz)
Environmental Rating	IP68
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).
FC	See last page

21536-K

Logger Components and Operation

MX2202 model shown

Mounting Tab: Use the tabs at the top and bottom of the logger to mount it (see *Deploying and Mounting the Logger*).

Temperature and Light Sensors: The temperature sensor (MX2201 and MX2202) and light sensor (MX2202) are located on the right side of the logger. See *Light Measurement* for more details on the light sensor.

Status LED: This LED blinks green every 4 seconds when the logger is logging (unless Show LED is disabled as described in *Configuring the Logger*). If the logger is waiting to start logging because it was configured to start "On Button Push" or with a delayed start, it will blink green every 8 seconds. Both this LED and the Alarm LED will blink once when you press the start button to wake up the logger before configuring it. If you select Page Logger LED in the HOBOmobile app or in HOBOconnect, both LEDs will be illuminated for 5 seconds (see *Getting Started* for more details).

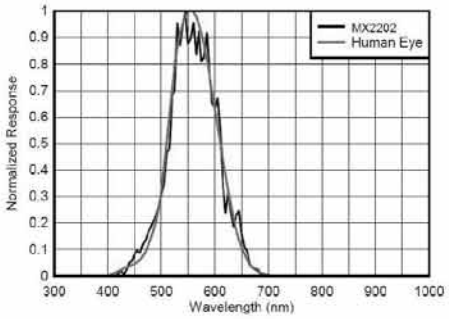
Alarm LED: This LED blinks red every 4 seconds when an alarm is tripped (unless Show LED is disabled as described in *Configuring the Logger*).

Start Button: Press the circle on the front of the logger case for 1 second to wake up the logger (unless Bluetooth Always On is enabled as described in *Configuring the Logger*). Both LEDs will blink and the logger will move to the top of the devices list in the app. You may need to press the button a second time to wake up the logger if it is logging every 5 seconds or faster and the temperature is -10°C (14°F) or below. Press this circle for 3 seconds to start or stop the logger when it is configured to start or stop "On Button Push" (see *Configuring the Logger*). Both LEDs will blink four times when you press the circle to start or stop logging. Press this circle for 10 seconds to reset a password. **Note:** The circle on the front of the logger represents the button area on the logger. You will not feel an actual button push when you press that area; this is normal.

Light Measurement (MX2202)

The logger measures light intensity in units of lumens/ft² or lux. The light sensor in the MX2202 has a spectral response that tightly matches the photopic response of the human eye. This is shown in Plot A.

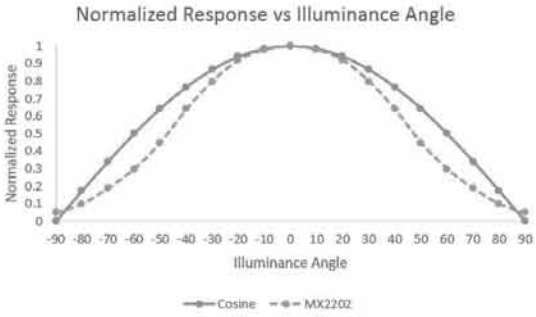
The light sensor has range of 0 to 167,731 lux (15,582 lum/ft²). The resolution of the light measurement varies from 1 unit of lux or lum/ft² in very dim light to 40 lux (4 lum/ft²) for a full scale measurement.



Plot A

Light Measurement Accuracy

Although the MX2202 is factory calibrated to account for the light attenuation of the plastic enclosure, you may notice a significant difference in the MX2202 reading compared to a commercially available lux meter. Ideally, a light meter's response should be proportional to the cosine of the angle at which the light is incident. The MX2202 does not collect light exactly according to this rule. Plot B illustrates the difference between an ideal cosine response and the approximate response of the MX2202. For example, given an incident angle of 60°, the MX2202 response is 40% lower than the ideal response. The MX2202 is calibrated to give best results for direct illumination, but this is not always the case.



Plot B

Getting Started

Install the app to connect to and work with the logger.

1. **If you are using an iPhone® or iPad®:** Download HOBOmobile from the App Store®.

   If you are using an Android phone or tablet: Download HOBOconnect from Google Play™.
2. Open the app and enable Bluetooth in the device settings if prompted.
3. Firmly press the circular button near the center of the logger to wake it up. Both LEDs on the logger will blink once when it wakes up.
4. Tap the Devices icon in the app. (In HOBOmobile, tap Loggers at the top of the screen.) Tap the logger in the app to connect to it.

If the logger does not appear in the list or if it is having trouble connecting, follow these tips.

- Make sure the logger is "awake" by pressing the circle on the case. The alarm and status LEDs will blink once when the logger wakes up. This will also bring the logger to the top of the list if you are working with multiple loggers.
- If the logger is currently logging at a fast interval (5 seconds or faster) and the temperature is -10°C (14°F) or below, you may need to press the button twice before it appears in the list.
- Make sure the logger is within range of your mobile device. The range for successful wireless communication in air is approximately 30.5 m (100 ft) with full line-of-sight.
- Change the orientation of your phone or tablet to ensure the antenna in your device is pointed toward the logger. Obstacles between the antenna in the device and the logger may result in intermittent connections.
- If your device can connect to the logger intermittently or loses its connection, move closer to the logger, within sight if possible. If the logger is in water, the connection can be unreliable. Remove it from water for a consistent connection.
- If the logger appears in the app, but you cannot connect to it, close the app and power cycle the mobile device. This forces the previous Bluetooth connection to close.

Once the logger is connected, you can select one of the following actions:

- **Configure in HOBOmobile or in HOBOconnect.** Select logger settings and load them onto the logger to start logging. See *Configuring the Logger*.
- **Readout in HOBOmobile or in HOBOconnect.** Download logger data. See *Reading Out the Logger*.
- **Full Status Details in HOBOmobile or in HOBOconnect.** Check information about the logger. In HOBOconnect, access some of the actions described in this section.
- **Start Logging in HOBOmobile or and then in HOBOconnect.** Select this option to begin logging (if the logger is configured to start "On Button Push" as described in *Configuring the Logger*).
- **Stop Logging in HOBOmobile or and then in HOBOconnect.** Stop the logger from recording data. This overrides any other Stop Logging settings that may be configured.
- **Page Logger LED in HOBOmobile or and then in HOBOconnect.** Press and hold this option to illuminate the alarm and status LEDs for 5 seconds.
- **Logger Password in HOBOmobile or and then in HOBOconnect.** Create a password for the logger that will be required if another mobile device attempts to connect to it. To reset a password, connect to the logger, tap Set Logger Passkey, and select Reset to Factory Default in HOBOmobile or tap and tap Reset in HOBOconnect. You can also press the circle on the logger for 10 seconds to reset the password.
- **Update Firmware in HOBOmobile or and then in HOBOconnect.** When new logger firmware is available, this action appears in the list. Select it and follow the instructions on the screen. A logger readout will be completed automatically at the beginning of the firmware update process. If the connection is lost between the logger and the mobile device during the firmware update, a Firmware Update Pending Status displays for the logger in the Devices list. Connect to the logger and update the firmware again (or select Restore Logger if available in HOBOmobile).

> **Important:** Before updating the firmware on the logger, check the remaining battery level by selecting Full Status Details and make sure it is no less than 30%. Make sure you have the time to complete the entire update process, which requires that the logger remains connected to the device during the upgrade.

- **Force Offload (HOBOmobile only).** This may appear if an error was encountered when loading configure settings. Select this to offload all the data on the logger before reconfiguring it.

Configuring the Logger

Use the app to set up the logger, including selecting the logging interval, start and stop logging options, and configuring alarms. These steps provide an overview of setting up the logger. For complete details, see the app user's guide.

1. In the app, tap the Devices icon (in HOBOmobile, tap Loggers at the top of the screen). Tap the logger to connect to it. If the logger was configured with Bluetooth Always On disabled, press the circle on the logger to wake it up. This will also bring the logger to the top of the logger list.
2. Tap Configure in HOBOmobile or tap in HOBOconnect.
3. Tap Name and type a name for the logger (optional). In HOBOmobile, tap Done. If no name is selected, the logger serial number is used as the name.
4. Tap Group to add the logger to a group (optional). Tap Done or Save.
5. Tap Logging Interval and choose how frequently the logger will record data unless operating in burst logging mode (see *Burst Logging*).
6. Tap Start Logging and select when logging will begin:
   - **Now.** Logging will begin immediately after configuration settings are loaded on the logger.
   - **On Next Logging Interval.** Logging will begin at the next even interval as determined by the selected logging interval.
   - **On Button Push.** Logging will begin once you press the circle on the logger for 3 seconds.
   - **On Date/Time.** Logging will begin at a date and time you specify. Select the date and time. In HOBOmobile, tap Done.

Tap Done or Save.

7. Tap Stop Logging and select the options for when logging will end.
   a. Choose one of two memory options:
      - **When Memory Fills.** The logger will continue recording data until the memory is full.
      - **Never (Wrap When Full).** The logger will continue recording data indefinitely, with newest data overwriting the oldest.
   b. Select On Button Push if you want to be able to stop logging by pushing the circle on the logger for 3 seconds. For HOBOmobile: Note that if you also choose On Button Push for the Start Logging option, then you will not be able to stop logging until 30 seconds after logging begins.
   c. Select one of the following time options for when to stop logging:
      - **Never.** Select this if you do not want the logger to stop at any predetermined time frame.
      - **On Date/Time.** Select this if you want the logger to stop logging on a specific date and time. Select the date and time. In HOBOmobile, tap Done.
      - **After.** Select this if you want to control how long the logger should continue logging once it starts. Choose the amount of time you want the logger to log data and then tap Done. For example, select 30 days if you want the logger to log data for 30 days after logging begins.
   d. Tap Done or Save.
8. Tap Logging Mode. Select either fixed or burst logging. With fixed logging, the logger records data for all enabled sensors and/or selected statistics at the logging interval selected (see *Statistics Logging* for details on choosing statistics options). In burst mode, logging occurs at a different interval when a specified condition is met. See *Burst Logging* for more information. Tap Done or Save.
9. Enable or disable Show LED. If Show LED is disabled, the alarm and status LEDs on the logger will not be illuminated while logging (the alarm LED will not blink if an alarm trips). You can temporarily turn on LEDs when Show LED is disabled by pressing the circle on the logger for 1 second.
10. Enable or disable Bluetooth Always On. When this option is enabled, the logger will "advertise" or regularly send out a Bluetooth signal for the phone or tablet to find via the app while it is logging, which uses battery power. When this option is disabled, the logger will only advertise during logging when you press the circle on the logger to wake it up, thereby preserving as much battery power as possible.
11. For the Pendant MX Temp/Light (MX2202) logger, both the temperature and light sensors are enabled by default. Disable one if desired.
12. You can set up alarms to trip when a sensor reading rises above or falls below a specified value. See *Setting up Alarms* for details on enabling sensor alarms.
13. Tap Start in the upper right corner of the Configure screen in HOBOmobile or tap  in HOBOconnect.

Logging will begin based on the settings you selected. See *Deploying and Mounting the Logger* for details on mounting and see *Reading Out the Logger* for details on downloading.

Setting up Alarms

You can set up alarms for the logger so that if a sensor reading rises above or falls below a specified value, the logger alarm LED will blink and an alarm icon will appear in the app. This can alert you to problems so you can take corrective action.

To set an alarm:

1. Tap the Devices (in HOBOmobile, tap Loggers at the top of the screen). Tap the logger in the app to connect to it. If the logger was configured with Bluetooth Always On disabled, press the circle on the logger to wake it up.
2. Tap Configure in HOBOmobile or tap  in HOBOconnect.
3. Tap a sensor (tap the Enable Logging toggle in HOBOconnect if necessary).
4. Enable the High Alarm in HOBOmobile or select High in HOBOconnect if you want an alarm to trip when the sensor reading rises above the high alarm value. Drag the slider or type a value to set the high alarm value.
5. Enable the Low Alarm in HOBOmobile or select Low in HOBOconnect if you want an alarm to trip when the sensor reading falls below the low alarm value. Drag the slider or type a value to set the low alarm value.
6. For the Duration, select how much time should elapse before the alarm trips and select one of the following:
   - Cumulative. The alarm will trip once the sensor reading is out of the acceptable range for the selected duration any time during logging. For example, if the high alarm is set to 85°F and the duration is set to 30 minutes, then the alarm will trip once the sensor readings have been above 85°F for a total of 30 minutes since the logger was configured.
   - Consecutive. The alarm will trip once the sensor reading is out of the acceptable range continuously for the selected duration. For example, the high alarm is set to 85°F and the duration is set to 30 minutes, then the alarm will only trip if all sensor readings are 85°F or above for a continuous 30-minute period.
7. Tap Done or Save and repeat steps 3–6 for the other sensor if desired. Note that when both alarms are configured, an alarm is raised when either sensor is in an alarm condition.
8. In the configuration settings, select one of the following options to determine how the alarm indications are cleared:
   - **Logger Reconfigured.** The alarm indication will display until the next time the logger is reconfigured.
   - **Sensor in Limits.** The alarm icon indication will display until the sensor reading returns to the normal range between any configured high and low alarm limits.
9. Tap Start in HOBOmobile or  in HOBOconnect.

When an alarm trips, the logger alarm LED blinks every 4 seconds (unless Show LED is disabled), an alarm icon appears in the app, and an Alarm Tripped event is logged. The alarm state will clear when the readings return to normal if you selected Sensor in Limits in step 8. Otherwise, the alarm state will remain in place until the logger is reconfigured.

Notes:

- Alarm limits are checked at every logging interval. For example, if the logging interval is set to 5 minutes, then

the logger will check the sensor readings against your configured high and low alarm setting every 5 minutes.

- The actual values for the high and low alarm limits are set to the closest value supported by the logger. In addition, alarms can trip or clear when the sensor reading is within the resolution specifications.
- When you read out the logger, alarm events can be displayed on the plot or in the data file. See *Logger Events*.

Burst Logging

Burst logging is a logging mode that allows you to set up more frequent logging when a specified condition is met. For example, a logger is recording data at a 5-minute logging interval and burst logging is configured to log every 30 seconds when the temperature rises above 85°F (the high limit) or falls below 32°F (the low limit). This means the logger will record data every 5 minutes as long as the temperature remains between 85°F and 32°F. Once the temperature rises above 85°F, the logger will switch to the faster logging rate and record data every 30 seconds until the temperature falls back to 85°F. At that time, logging then resumes every 5 minutes at the normal logging interval. Similarly, if the temperature falls below 32°F, then the logger would switch to burst logging mode again and record data every 30 seconds. Once the temperature rises back to 32°F, the logger will then return to normal mode, logging every 5 minutes. **Note:** Sensor alarms, statistics, and the Stop Logging option "Wrap When Full" are not available in burst logging mode.

To set up burst logging:

1. Tap the Devices icon (in HOBOmobile, tap Loggers at the top of the screen). Tap the logger in the app to connect to it. If the logger was configured with Bluetooth Always On disabled, press the circle on the logger to wake it up.
2. Tap Configure in HOBOmobile or tap  in HOBOconnect.
3. Tap Logging Mode and then tap Burst Logging. In HOBOmobile, tap a sensor under Burst Sensor Limits.
4. Select Low and/or High and either type or drag the slider to set the low and/or high values. Tap Done in HOBOmobile.
5. Repeat step 4 for the other sensor if desired.
6. Set the burst logging interval, which must be faster than the logging interval. Keep in mind that the faster the burst logging rate, the greater the impact on battery life and the shorter the logging duration. Because measurements are being taken at the burst logging interval throughout the deployment, the battery usage is similar to what it would be if you had selected this rate for the normal logging interval. Tap Done in HOBOmobile.
7. Tap Done or Save.
8. Tap Start in HOBOmobile or  in HOBOconnect.

Notes:

- The high and low burst limits are checked at the burst logging interval rate whether the logger is in normal or burst condition. For example, if the logging interval is set to 1 hour and the burst logging interval is set to 10 minutes, the logger will always check for burst limits every 10 minutes.
- If high and/or low limits have been configured for more than one sensor, then burst logging will begin when any high or low condition goes out of range. Burst logging will not end until all conditions on all sensors are back within normal range.
- The actual values for the burst logging limits are set to the closest value supported by the logger. In addition, burst logging can begin or end when the sensor reading is within the specified resolution. This means the value that triggers burst logging may differ slightly than the value entered.
- Once the high or low condition clears, the logging interval time will be calculated using the last recorded data point in burst logging mode, not the last data point recorded at the normal logging rate. For example, the logger has a 10-minute logging interval and logged a data point at 9:05. Then, the high limit was surpassed and burst logging began at 9:06. Burst logging then continued until 9:12 when the sensor reading fell back below the high limit. Now back in normal mode, the next logging interval will be 10 minutes from the last burst logging point, or 9:22 in this case. If burst logging had not occurred, the next data point would have been at 9:15.
- A New Interval event is created each time the logger enters or exits burst logging mode. See *Logger Events* for details on plotting and viewing the event. In addition, if the logger is stopped with a button push while in burst logging mode, then a New Interval event is automatically logged and the burst condition is cleared, even if the actual high or low condition has not cleared.

Statistics Logging

During fixed logging, the logger records data for enabled sensors and/or selected statistics at the logging interval selected. Statistics are calculated at a sampling rate you specify with the results for the sampling period recorded at each logging interval. The following statistics can be logged for each sensor:

- The maximum, or highest, sampled value,
- The minimum, or lowest, sampled value,
- An average of all sampled values, and
- The standard deviation from the average for all sampled values.

For example, a Pendant MX Temp/Light (MX2202) logger is configured with both the temperature and light sensors enabled, and the logging interval set to 5 minutes. The logging mode is set to fixed interval logging with Normal and all four statistics enabled and with a statistics sampling interval of 30 seconds. Once logging begins, the logger will measure and record the actual temperature and light values every 5 minutes. In addition, the logger will take a temperature and light sample every 30 seconds and temporarily store them in memory. The logger will then calculate the maximum, minimum, average, and standard deviation using the samples gathered over the previous 5-minute period and log the resulting values. When reading out the logger, this would result in 10 data series: two sensor series (with temperature and light data logged every 5 minutes) plus eight maximum, minimum, average, and standard deviation series (four for temperature and four for light with

values calculated and logged every 5 minutes based on the 30-second sampling).

To log statistics:

1. Tap the Devices icon (in HOBOmobile, tap Loggers at the top of the screen). Tap the logger in the app to connect to it. If the logger was configured with Bluetooth Always On disabled, press the circle on the logger to wake it up.
2. Tap Configure in HOBOmobile or tap in HOBOconnect.
3. Tap Logging Mode and then select Fixed Interval Logging in HOBOmobile or Fixed Logging in HOBOconnect.
4. Select Normal to record the current reading for each enabled sensor at the logging interval shown at the top of the screen. Do not select this if you only want to log statistics.
5. Select the statistics you want the logger to record at each logging interval: Maximum, Minimum, Average, and Standard Deviation (average is automatically enabled when selecting Standard Deviation). Statistics will be logged for all enabled sensors. In addition, the more statistics you record, the shorter the logger duration and the more memory is required.
6. Tap Statistics Sampling Interval and select the rate to use for calculating statistics. The rate must be less than, and a factor of, the logging interval. For example, if the logging interval is 1 minute and you select 5 seconds for the sampling rate, then the logger will take 12 sample readings between each logging interval (one sample every 5 seconds for a minute) and use the 12 samples to record the resulting statistics at each 1-minute logging interval. Note that the faster the sampling rate, the greater the impact on battery life. Because measurements are being taken at the statistics sampling interval throughout the deployment, the battery usage is similar to what it would be if you had selected this rate for the normal logging interval. Tap Done in HOBOmobile.
7. Tap Done or Save.
8. Tap Start in HOBOmobile or in HOBOconnect.

Setting a Password

You can create an encrypted password for the logger that will be required if another phone or tablet attempts to connect to it. This is recommended to ensure that a deployed logger is not mistakenly stopped or purposely altered by others. This password uses a proprietary encryption algorithm that changes with every connection.

To set a password:

1. Tap the Devices icon (in HOBOmobile, tap Loggers at the top of the screen). Tap a logger in the app to connect to it. If the logger was configured with Bluetooth Always On disabled, press the circle on the logger to wake it up.
2. Tap Logger Password in HOBOmobile or tap and then in HOBOconnect.
3. Type a password and then tap Save or Set.

Only the phone or tablet used to set the password can then connect to the logger without entering a password; all other mobile devices will be required to enter the password. For example, if you set the password for the logger with your tablet and then try to connect to the device later with your phone, you will be required to enter the password on the phone but not with your tablet. Similarly, if others attempt to connect to the logger with different devices, then they would also be required to enter the password. To reset a password, press the circle on the logger for 10 seconds or connect to the logger, tap Set Logger Passkey, and select Reset to Factory Default in HOBOmobile or tap , then , and tap Reset in HOBOconnect.

Reading Out the Logger

To download data from the logger:

1. Press the circle on the logger to wake it up (unless it was configured with Bluetooth Always On enabled).
2. Tap the Devices icon in HOBOmobile, tap Loggers at the top of the screen). Tap the logger in the app to connect to it.
3. Tap Readout in HOBOmobile or tap in HOBOconnect.
4. **In HOBOmobile:** Tap the Data Files icon and then tap the mini-graph to view a larger version of the graph or share the file.

   In HOBOconnect: Tap the HOBO Files icon and select the file to view it. Tap and then to export and share the data.

Data can also be uploaded automatically to HOBOlink, Onset's web-based software, via the app or the MX gateway. For details, see the app user's guide and see the HOBOlink help for details on working with data in HOBOlink.

Logger Events

The logger records the following events to track logger operation and status. You can view events in exported files or plot events in the app.

- To plot events in HOBOmobile, tap a mini-graph and then tap . Select the events you want to plot and then tap again.
- To plot events in HOBOconnect, tap the HOBO Files icon and select a file to open. Tap and then tap . Select the events you want to plot and tap OK.

Event Name	Definition
Host Connect	The logger was connected to a mobile device.
Started	The logger started logging.
Stopped	The logger stopped logging.
Chan <#> Alarm Tripped/Cleared	An alarm has occurred because the reading was outside the alarm limits or back within range. **Note:** Although the reading may return to a normal range, an alarm cleared event will not be logged if the logger was set up to maintain alarms until reconfigured.

Event Name	Definition
Button Up/Down	The circle on the logger was pressed to wake it up/bring it to the top of the loggers list in the app.
New Interval	The logger has switched to logging at the burst logging rate or back to the normal rate.
Power Warn	The battery level dropped below 2.3 V.
Safe Shutdown	The battery level dropped below a safe operating voltage and performed a safe shutdown.

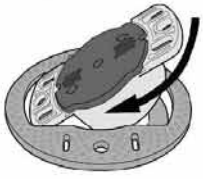
Deploying and Mounting the Logger

When mounting the logger, it is very important that the logger housing does not get distorted. If you are mounting the logger on an irregular surface, it is recommended that you use the mounting boot (BOOT-MX2201-2202).

- The logger must be mounted to a flat surface or in a way that prevents the logger housing from bowing. You can deploy the logger by using the two mounting tabs. Insert two screws through the round holes on the mounting tabs to affix the logger to a flat surface, being careful not to overtighten the screws. Alternatively, you can hang the logger using a loose zip tie loop.

Guidelines for Using the Mounting Boot

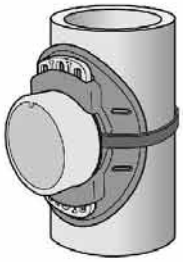
- To install the logger in a boot, hold both the boot and the logger upside down and insert the logger mounting tab into the boot as shown.



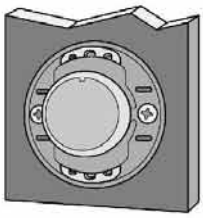
Insert the other logger mounting tab into the boot, making sure the logger is securely seated in the boot as shown.

- To mount the logger in a boot to a small pipe, use two of the zip ties included with the boot as shown.

- To mount the logger in a boot to a large pipe, use one of the zip ties included with the boot as shown.



- To mount the logger in a boot to a flat surface, use two #8 screws as shown. Do not overtighten the screws.

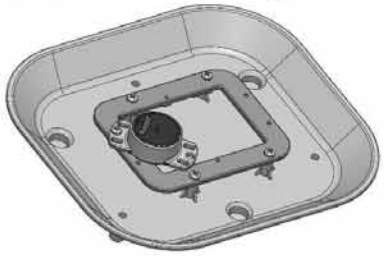


Other Deployment Guidelines

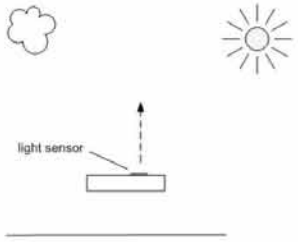
- When deploying in water, the logger should be appropriately weighted, secured, and protected depending on water conditions and desired measurement location.
- Loggers deployed in direct sunlight will heat up so that temperature readings are warmer than the ambient temperature. Use a solar radiation shield to ensure temperature readings represent the ambient temperature.

  Attach the logger to a solar radiation shield (RS1 or M-RSA) using the solar radiation shield bracket (MX2200-RS-BRACKET). Attach the logger to the underside of the mounting plate as shown in the following example. For more details on the solar radiation shield, refer to the *Solar Radiation Shield Installation Guide* at www.onsetcomp.com/manuals/rs1. **Note:** To log both temperature and sunlight, you will need two MX2202 loggers. Place one logger in a solar radiation shield to log

temperature and the other mounted flat on top of the solar radiation shield to record sunlight.



- When measuring light intensity outdoors or underwater, make sure the MX2202 logger is mounted horizontally so that the light sensor is pointing straight up towards the sky as shown in this example.



- Be careful of solvents. Check a materials compatibility chart against the wetted materials listed in the Specifications table before deploying the logger in locations where untested solvents are present. The logger has an EPDM O-ring, which is sensitive to polar solvents (acetone, keton) and oils.

Maintaining the Logger

- To clean the logger, rinse it in warm water. Use a mild dishwashing detergent if necessary. Do not use harsh chemicals, solvents, or abrasives.
- Periodically inspect the logger for biofouling if it is deployed in water and clean as described.
- Periodically inspect the O-ring on the inside of the battery cover for cracks or tears and replace it if any are detected (MX2201-02-ORING). See *Battery Information* for steps on replacing the O-ring.

Protecting the Logger

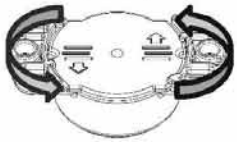
Note: Static electricity may cause the logger to stop logging. The logger has been tested to 8 KV, but avoid electrostatic discharge by grounding yourself to protect the logger. For more information, search for "static discharge" on www.onsetcomp.com.

Battery Information

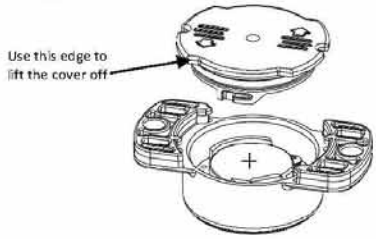
The logger requires one user-replaceable CR2032 3V lithium battery. Battery life is 1 year typical at 25°C (77°F) with a logging interval of 1 minute and Bluetooth Always On enabled or 2 years typical at 25°C (77°F) when the logger is configured with Bluetooth Always On disabled. Expected battery life varies based on the ambient temperature where the logger is deployed, the logging interval, the frequency of connections, downloads, and paging, and the use of burst mode or statistics logging. Deployments in extremely cold or hot temperatures or a logging interval faster than one minute can impact battery life. Estimates are not guaranteed due to uncertainties in initial battery conditions and operating environment.

To replace the battery:

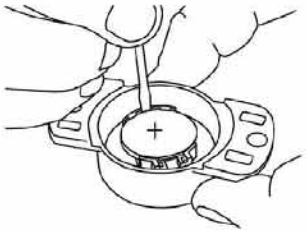
1. While pushing down with both thumbs on the back of the logger, rotate the battery cover counterclockwise until it stops moving (about a 1/8 turn).



2. Use the edge below the arrow on the cover to lift it off the logger.

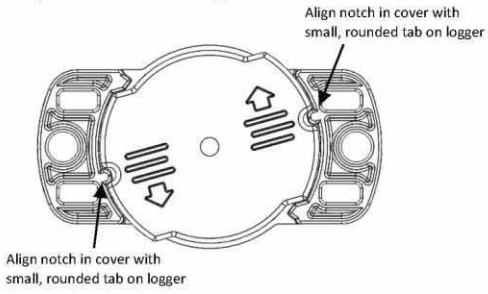


3. Remove the battery and place a new one in the battery holder, positive side facing up. Use a small flat-head screwdriver to carefully pop the battery out of its holder as shown.

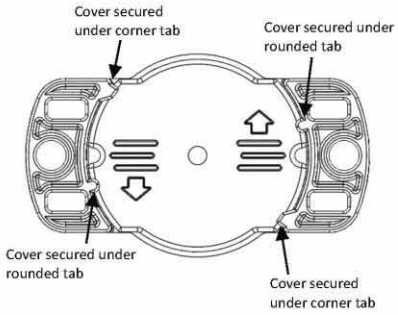


4. Inspect the O-ring on the battery cover. Make sure it is clean and seated properly. Remove any dirt, lint, hair, or debris from the O-ring. If the O-ring has any cracks or tears, replace it as follows:
   a. Spread a small dot of silicone-based grease on the O-ring with your fingers, making sure the entire O-ring surface is completely covered in grease.
   b. Place the O-ring on the cover and clean off any debris. Make sure the O-ring is fully seated and level in the groove and not pinched or twisted. This is necessary to maintain a waterproof seal.

5. Place the cover back on the logger as shown, aligning the notches in the cover with the rounded tabs on the logger case. The cover will not close properly and maintain a waterproof seal if it is misaligned.



6. While pushing down with both thumbs, rotate the battery cover clockwise until it locks in position under the two large corner tabs and the two small rounded tabs.



⚠ **WARNING:** Do not cut open, incinerate, heat above 85°C (185°F), or recharge the lithium battery. The battery may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the battery case. Do not dispose of the logger or battery in fire. Do not expose the contents of the battery to water. Dispose of the battery according to local regulations for lithium batteries.

Federal Communication Commission Interference Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TV technician for help

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

Industry Canada Statements

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Avis de conformité pour l'Industrie Canada

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

To comply with FCC and Industry Canada RF radiation exposure limits for general population, the logger must be installed to provide a separation distance of at least 20cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

KC Statement

해당 무선설비는 전파혼신 가능성이 있으므로 인명안전과 관련된 서비스는 할 수 없음

Translation:

The service related to human safety is not allowed because this device may have the possibility of the radio interference.

ONSET 1-800-LOGGERS (564-4377) • 508-759-9500
www.onsetcomp.com/support/contact

21536-K

APPENDIX C-3. Hobo® Dissolved Oxygen/Temperature data loggers (Model U26-001), Manual

HOBO® Dissolved Oxygen Logger (U26-001) Manual

HOBO Dissolved Oxygen Logger with Included Calibration Boot and Sponge (Shown Wet in Photo)

The HOBO Dissolved Oxygen logger is a standalone logger that uses RDO® Basic Technology to measure dissolved oxygen (DO). The logger has an optical sensor that provides 0.2 mg/L accuracy. The logger also features an easily replaceable sensor cap and an integrated temperature sensor. Using HOBOware® software for logger setup and a HOBO Waterproof Shuttle for quick data offload, this logger is easy to deploy in both freshwater and saltwater environments making it an ideal tool for environmental impact studies as well as ecological and oceanographic research. Using the data offloaded from the logger, the HOBOware Dissolved Oxygen Assistant can calculate percent saturation and salinity-adjusted DO concentration as well as correct for measurement drift from fouling (additional meter or logger measurements required).

HOBO Dissolved Oxygen Logger

U26-001

Included Items:

- Dissolved Oxygen Sensor Cap
- Protective Guard
- Calibration Boot and Sponge

Required Items:

- Coupler (COUPLER-2-C) with USB Optic Base Station (BASE-U-4) *or* HOBO Waterproof Shuttle (U-DTW-1)
- HOBOware Pro 3.3.1 or later

Accessories:

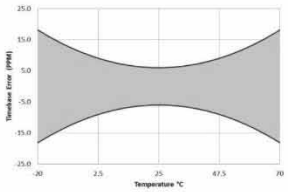
- Replacement Dissolved Oxygen Sensor Cap (U26-RDOB-1)
- Anti-Fouling Guard (U26-GUARD-2)
- Sodium Sulfite (U26-CAL-SOL)

You May Also Need:

- For salt water, salinity or conductivity measurements are required; HOBO Conductivity/Salinity Logger (U24-002-C) recommended
- For percent saturation, barometric pressure is required; HOBO Water Level Logger (U20-001-0x or U20L-0x) recommended

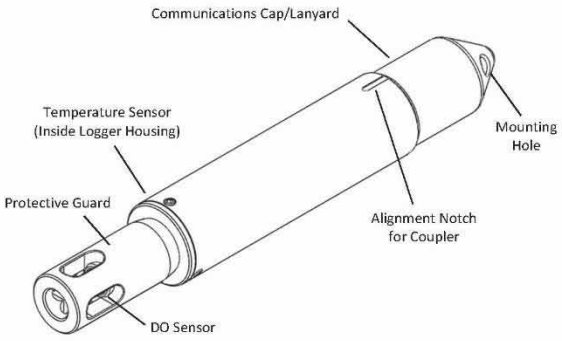
Specifications

Dissolved Oxygen	
Sensor Type	Optical (dynamic luminescence quenching)
Measurement Range	0 to 30 mg/L
Calibrated Range	0 to 20 mg/L; 0 to 35°C (32 to 95°F)
Accuracy	±0.2 mg/L up to 8 mg/L; ±0.5 mg/L from 8 to 20 mg/L
Resolution	0.02 mg/L
Response Time	To 90% in less than 2 minutes
DO Sensor Cap Life	6 months (cap expires 7 months after initialization)
Temperature	
Temperature Measurement/ Operating Range	-5 to 40°C (23 to 104°F), non-freezing
Temperature Accuracy	0.2°C (0.36°F)
Temperature Resolution	0.02°C (0.04°F)
Response Time	To 90% in less than 30 minutes
Logger	
Memory	21,700 sets of DO and temperature measurements (64 KB total memory); logging stops when memory fills
Logging Rate	1 minute to 18 hours
Time Accuracy	±1 minute per month at 0 to 50°C (32 to 122°F) (see Plot A)
Battery	3.6 V lithium battery; factory replaceable
Battery Life	3 years (at 5 minute logging)
Download Type	Optical
Depth Rating	100 m (328 ft)
Buoyancy	Salt water: 178 g (6.27 oz) negative Fresh water: 185 g (6.52 oz) negative
Wetted Materials	Black Delrin®, PVC, EPDM o-rings, silicon bronze screws; rated for saltwater use
Size	39.6 mm diameter x 266.7 mm length (1.56 x 10.5 inches); mounting hole 7.88 mm (0.31 inches)
Weight	464 g (16.37 oz)
Environmental Rating	IP68
CE	The CE Marking identifies this product as complying with all relevant directives in the European Union (EU).



Plot A: Time Accuracy

Logger Components and Operation



Communications Cap/Lanyard. This removable cap protects the optical communications window. An LED in the communications window of the logger confirms logger operation. When the logger is logging, the LED blinks once every four seconds. The LED also blinks when the logger is recording a sample. When the logger is awaiting a start because it is configured to start "At Interval," "On Date/Time," or "Using Coupler," the LED blinks once every eight seconds until logging begins. See *Connecting the Logger to a Computer or Waterproof Shuttle* for details on using the communications window.

Mounting Hole. Use the hole on the communications cap to mount the logger. See *Deploying the Logger* for more information.

Alignment Notch for Coupler. Use this notch to align the coupler when communicating with the logger. See *Connecting the Logger to a Computer or Waterproof Shuttle* for more information.

DO Sensor. This optical sensor measures dissolved oxygen using RDO® Basic Technology. It is shipped with a red dust cap that must be replaced with a green sensor cap that lasts for six months plus a one-month grace period. See *Installing the Sensor Cap* for more details.

Protective Guard. This removable guard protects the DO sensor. Unscrew it to install or replace the sensor cap as needed. See *Installing the Sensor Cap* for more details.

Temperature Sensor. This built-in sensor (not visible in diagram) measures temperature.

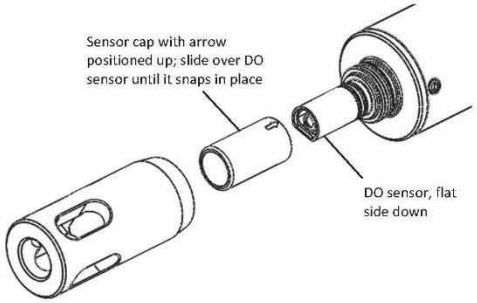
⚠ **WARNING:** This logger can be damaged by mechanical shock. Always handle the logger with care. The logger may be damaged if it is dropped. Use proper packaging when transporting or shipping the logger.

Do not attempt to open the logger case or sensor housing. Disassembling of the logger case or sensor housing will cause serious damage to the sensor and logger electronics. There are no user-serviceable parts inside the case. Contact Onset Technical Support at 1-800-LOGGERS (1-800-564-4377) or an authorized Onset dealer if your logger requires servicing.

Installing the Sensor Cap

The logger ships with a replaceable sensor cap that provides six months of continuous use. Once the cap is initialized, an internal clock within the logger will count down until the sensor cap expiration date. When the sensor cap expires, you will need to replace it with a new cap (U26-RDOB-1). The sensor cap is intended for six months of actual deployment, but the expiration date is seven months from the date the cap was initialized. This allows for any time needed between launching the logger and physically deploying as well as extra time in case you are not able to get the logger after exactly six months of deployment. To install the sensor cap:

1. Unscrew the protective guard covering the DO sensor (see diagram at left).
2. Remove the red dust cap that protects the sensor during shipping.
3. Take the green sensor cap out of the canister.
4. With the flat part of the DO sensor pointing down and the green sensor cap oriented with the arrow up, slide the sensor cap over the sensor until it snaps in place. The cap should be snug against the logger housing without any gaps. (If you see a gap, the protective guard installed in the next step will close the gap by pushing the sensor cap down into place.)



5. Screw the external protective guard back on until tight.

IMPORTANT: The sensor cap expires 7 months (to the day) after it has been initialized. The logger will record a value of -888 mg/L at each logging interval after the cap has expired. Initialization occurs automatically when the cap is installed while the logger is logging. You can also initialize it from the Status window in HOBOware or when using the Lab Calibration tool. To see when the sensor cap expires after being initialized, check the Status in HOBOware for the expiration date. The cap also has a shelf life; check the "Install By" date printed on the canister.

Connecting the Logger to a Computer or Waterproof Shuttle

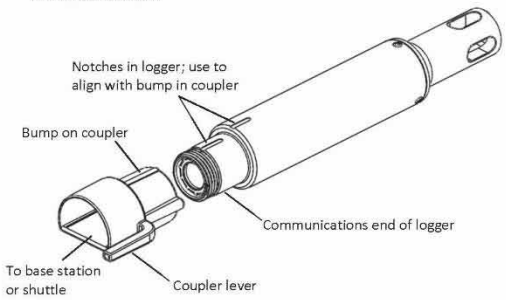
To connect the logger to a computer, use either the Optic USB Base Station (BASE-U-4) or HOBO Waterproof Shuttle (U-DTW-1) with a coupler (COUPLER2-C). To launch and read out the logger in the field, use one of these three methods:

- Laptop computer with Optic USB Base Station (BASE-U-4) and coupler (COUPLER2-C)
- HOBO Waterproof Shuttle (U-DTW-1, Firmware Version 3.2.0 or later) and coupler (COUPLER2-C)

- HOBO U-Shuttle (U-DT-1, Firmware Version 1.16 or later) with Optic USB Base Station and coupler (COUPLER2-C)

IMPORTANT: USB 2.0 specifications do not guarantee operation outside the range of 0°C (32°F) to 50°C (122°F).

1. Follow the instructions that came with your base station or Waterproof Shuttle to attach it to a USB port on the computer.
2. Unscrew the pointed cap on the communications end of the logger.
3. Attach the coupler to the base station or shuttle.
4. Insert the logger into the coupler, aligning the bump/arrow on the coupler with the notches on the logger. Be sure that it is properly seated in the coupler. If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer. **Note**: If you are using the HOBO Waterproof Shuttle as a base station with a computer, briefly press the coupler lever to put the shuttle into base station mode. A green LED on the shuttle or base station indicates good communication.



5. After logger communications are complete, remove the logger from the coupler. Make sure the o-ring is still in the groove inside the cap and then reinstall the communications cap.

IMPORTANT: When connected to a coupler, the logger is "awake" and consumes significantly more power than when it is disconnected and considered "asleep." The logger will automatically "go to sleep" after being left in the coupler for 30 minutes. It will no longer appear as a USB device connected to the computer. If this occurs, remove it from the coupler and start the instructions to connect the logger to a computer or waterproof shuttle over again.

Calibrating the Logger with the Lab Calibration Tool

Use the Lab Calibration tool in HOBOware when you need to calibrate the logger before deploying it or after replacing an expired sensor cap. The tool sets the gain and offset adjustment values for the logger by:

- Restoring logger calibration values to the factory defaults,
- Using your own gain and offset adjustment values, or
- Calculating the values with a 3-step calibration procedure.

In the three-step procedure, the logger is first calibrated to 100% saturation by placing it in water-saturated air. Then, you can calibrate the logger to 0% saturation by placing it in sodium sulfite or another 0% oxygen environment (recommended if the logger will be deployed in water with DO levels of 4 mg/L or less).

IMPORTANT: Lab calibration only affects future launches; any data saved in the logger will be based on the previous calibration values. If the sensor cap is installed and it has not yet been initialized, you will be prompted to do so. Follow the instructions on the screen.

To complete these steps, you will need fresh water, the calibration boot and sponge supplied with the logger, and a source for current barometric pressure at your current location. You will also need sodium sulfite solution and a 7.6 cm (3 inch) beaker if you will be calibrating to 0% saturation.

The fresh water, logger, and sodium sulfite (if applicable) should be left out in the lab where the calibration is being done long enough so that they are at room temperature. If the logger was deployed previously, make sure the sensor is clean and dry (see *Maintenance* for more details). To use the Lab Calibration tool:

1. Connect the logger to the computer as described in the previous section. Stop the logger if it is currently logging or awaiting a coupler or delayed start.
2. From the Device menu, click Lab Calibration.
3. The current gain and offset adjustments are displayed in the top pane of the Lab Calibration window along with the date and time the last lab calibration was completed (if applicable). Completing Steps 1 through 3 in the Lab Calibration tool will result in new gain and offset adjustment values based on the current logger conditions. Continue to the next section for details on how to complete these steps.

   If you already know what the gain and offset values should be (for example, the values from a previous calibration that you want to use again) or want to return to the default factory values, click the "I know my values, skip to Finish" button. This will automatically move you to "Step 3: Finish" in the Lab Calibration window. Either click the "Reset to Factory Defaults" button or type in the desired gain adjustment and offset adjustment values and click the "Send Calibration to the Logger" button. **Note:** If you decide you do not need to change the calibration, click Close to cancel the calibration and revert back to the last saved logger values.

Step 1: 100% Saturation

1. In "Step 1: 100% Saturation" in the Lab Calibration window, enter the barometric pressure for your current location. If the barometric pressure reading has been adjusted for sea level (such as a reading taken from the National Weather Service weather station), select the "If using sea level barometric pressure, enter elevation" checkbox and enter your elevation in either meters or feet.
2. Make sure the logger either has the protective guard or the anti-fouling guard installed (whichever guard you plan to use in the deployment) so that the sensor is covered.

3. Wet the small sponge with fresh water. Squeeze out any excess water.
4. Place the sponge in the end of the calibration boot.
5. Insert the logger in the calibration boot so that there is approximately a 1 cm (0.5 inch) overlap between the end of the boot and the body of the logger. This will ensure there is enough space between the end of the logger and the sponge (the logger should not be pressed up tightly against the sponge).
6. Wait for approximately 15 minutes until the logger reaches temperature equilibrium (and less than 30 minutes so the logger does not go to sleep).
7. Click the "Get DO value from the logger" button to display the 100% saturation results. You can click this button as often as needed. The results are updated each time you click the button. To check for equilibrium, click the "Get DO value from the logger" button several times in a row to check the current "DO Conc from logger at 100% Saturation" value. If the value remains the same or varies very little with each button click, then temperature equilibrium has likely been reached.
8. When you are satisfied with the results displaying in the "Step 1: 100% Saturation" tab, click the Next button to proceed to "Step 2: 0% Saturation."

Step 2: 0% Saturation (optional)

If the logger will be deployed in water with DO levels greater than 4 mg/L, click the "Skip this Step" button. Otherwise, continue with the following procedure.

1. Make sure the logger either has the protective guard or the anti-fouling guard installed (whichever guard you plan to use in the deployment) so that the sensor is covered.
2. Pour the sodium sulfite into the beaker so that it is about two-thirds full.
3. Place the sensor end of the logger into the solution so that the entire protective guard or anti-fouling guard and at least 2.5 cm (1 inch) of the logger body are submerged in the beaker. Allow it to rest on the bottom of the beaker.
4. Wait for approximately 15 minutes until the logger reaches temperature equilibrium (and less than 30 minutes so the logger does not go to sleep).
5. Click the "Get DO value from the logger" button to display the 0% saturation results. As with the 100% calibration, you can click this button as often as needed. The results are automatically updated each time you click the button. If the value remains the same or varies very little with each button click, then temperature equilibrium has likely been reached.
6. When you are satisfied with the results displaying in the "Step 2: 0% Saturation" tab, click the Next button to proceed to "Step 3: Finish."

Step 3: Finish

The results from the first two steps are displayed as well as the overall calibration results and the new gain and offset adjustment values. If you are satisfied with the results, click the "Send Calibration to Logger" button. The logger will then be calibrated based on the new values. These values will not take effect until the logger is launched. If you do not want to save these values, click Close to cancel the calibration and revert back to the last saved logger values. Or, click "Reset to Factory Defaults" to return to the original values. If you performed Step 2, then remove the logger from the solution and thoroughly rinse it with fresh water to remove any excess sodium sulfite. See *Maintenance* for additional details on cleaning the logger.

Launching the Logger

After calibrating the logger, it needs to be launched to configure it before taking it to the field for deployment. Once launched, the logger will record two types of data: samples and events. Samples are the sensor measurements recorded at each logging interval. Events are independent occurrences triggered by a logger activity, such as Bad Battery or Host Connected. Events help you determine what was happening while the logger was logging. To launch the logger:

1. With the logger connected to the computer, open HOBOware. From the Device menu, select Launch.
2. Select both the DO and Temperature channels to log. **Note:** HOBOware provides the option of recording the current battery voltage at each logging interval, which is disabled by default. Recording battery life at each logging interval takes up memory and therefore reduces logging duration. It is recommended that you only record battery voltage for diagnostic purposes. Even with the channel disabled, a bad battery event will still be recorded.
3. Select a logging interval.
4. Choose when to start logging and click the Start button.
5. Remove the logger from the coupler and screw the communications cap back on the logger.

IMPORTANT: If this is the first launch with a new sensor cap, the sensor cap will expire six months (plus a one-month grace period) from the time of the first sensor reading. Two caps per year are required for year-round deployment.

Deploying the Logger

The logger is designed to be easy to deploy in many environments. Follow these guidelines when deploying it:

- Remove the calibration boot before deploying the logger.
- Make sure the logger is located where it will receive an unrestricted flow of the water being monitored to the sensor.
- Make sure the logger is fully submerged and not in direct sunlight to minimize temperature changes that are unrelated to water temperature.
- When deploying the logger in rivers, streams, and ponds, insert the logger in a PVC or ABS pipe for protection from debris (if possible). The pipe should have enough holes to ensure good circulation of water to the sensor.
- If possible, position the logger so the sensor face is oriented vertically. After deploying in the water, move the logger around slightly to eliminate any bubbles that may have formed.

- Do not deploy the logger in freezing water with moving ice where the logger could be crushed.
- Use the optional anti-fouling guard to protect against fouling. Unscrew the protective guard and replace it with the anti-fouling guard.
- If fouling is expected during deployment, use field calibration readings from both the beginning and end of the deployment as described in the next section. These readings can then be entered into the HOBOware Dissolved Oxygen Assistant to compensate for any measurement drift due to fouling. Scrub fouling off the logger with a plastic bristle brush.
- When deploying the logger in salt water with small changes in salinity, you will need a conductivity or salinity value from either a conductivity meter or salinometer to enter in the Dissolved Oxygen Assistant to adjust the data from the logger for salinity. A single meter reading will add less than 1.1% DO error (assuming the conductivity changes are within ±3,000 µS/cm from the calibration point).

  If the conductivity changes, then you will need a data file with salinity or specific conductivity readings for the entire deployment. Consider deploying a HOBO Conductivity logger (U24-002-C) next to this DO logger to use the resulting data file for salinity data. For U24-002-C conductivity readings within a ±30,000 µS/cm range, there will be less than 4% error added to the DO measurements, and for readings over a narrower range, the accuracy will be even better. Refer to the *HOBO Conductivity Logger (U24-002-C) Manual* for more details. For applications that require higher accuracy conductivity data than the U24-002-C can provide, use a third-party conductivity logger.
- To generate a percent saturation series, you will need to deploy a barometric pressure logger (such as a HOBO Water Level Logger, U20-001-0x or U20L-0x) or have access to a nearby weather station to gather barometric pressure data. This data is necessary for the Dissolved Oxygen Assistant to calculate percent saturation.

Taking Field Calibration Readings

If fouling is expected during the deployment, you can take calibration readings at the beginning and end of the deployment to enter in the Dissolved Oxygen Assistant. This will adjust the data from the logger to compensate for any measurement drift due to fouling. There are two methods for taking field calibration readings: the first method involves taking readings using a dissolved oxygen meter or titration while the second method involves calibrating the logger in 100% water-saturated air. The first method is recommended because it is quicker to get the necessary calibration readings; the second method can take 40 minutes or more to achieve equilibrium with temperature extremes.

To Take Calibration Readings Using a DO Meter or Titration:

1. The logger must be logging. Take a DO measurement of the water where the logger is being deployed using either a DO meter or by titration. If using a meter, make sure it is calibrated and allow time for the meter probe to stabilize (this will occur when three meter measurements taken in a row are within your accuracy tolerance).

   If the logger is being deployed in salt water, adjust the meter measurements for salinity using a meter with both conductivity and DO probes. If the salt water has a constant salinity, you can use a DO meter where you can enter that salinity value to adjust the readings. If the salinity and/or DO are changing rapidly, then you will need to get a sample of the water in a container large enough for both the logger and meter probe to be completely submerged. Place both devices in the water long enough for them to stabilize and then for the DO logger to log at least two values, and take a concurrent meter reading.
2. Record the reading, date, and time of the measurement in a field notebook.
3. At the end of the deployment, repeat steps 1 and 2.

To Take Calibration Readings Using 100% Water-Saturated Air:

1. The logger must be logging. You will need fresh water, the included calibration boot and sponge, and the current barometric pressure from a HOBO U20 or U20L Water Level logger, a barometer, or a nearby weather station.
2. If the logger has been in salt water, clean the logger body and sensor cap as described in the *Maintenance* section. Make sure the sensor cap is dry before continuing.
3. Make sure the protective guard or anti-fouling guard is installed on the logger.
4. Wet the small sponge with fresh water. Squeeze out any excess water.
5. Place the sponge in the end of the calibration boot.
6. Insert the logger in the calibration boot so that there is approximately a 1 cm (0.5 inch) overlap between the end of the boot and the body of the logger. This will ensure there is enough space between the end of the logger and the sponge (the logger should not be pressed up tightly against the sponge).
7. Allow at least 40 minutes for the logger to reach temperature equilibrium, and then write down the date and time in a field notebook.
8. Write down the barometric pressure at that time (note the elevation if the barometric reading has been adjusted for sea level).
9. Repeat these steps at the end of the deployment.

Reading Out the Logger and Redeploying

Your readout and maintenance schedule will be determined by the amount of fouling at the site. To read out the logger in the field:

1. Take a field calibration reading as described in the *Taking Field Calibration Readings* section.
2. If the logger was in salt water and you did not deploy a HOBO Conductivity Logger, then use a conductivity meter or salinometer to take a conductivity reading. Write down the reading and the date and time.

3. Remove the logger from the water and read out the data from the logger using a shuttle or computer with a base station.
4. If you are deploying it again, clean the sensor (see *Maintenance* for details).
5. Check the expiration date for your cap and make sure it will not expire before the end of your deployment. Replace it if needed.
6. Relaunch the logger if it is not already logging.
7. Take another field calibration reading after the logger is cleaned.
8. Redeploy the logger.

Using the HOBOware Dissolved Oxygen Assistant

Use the Dissolved Oxygen Assistant to obtain accurate Dissolved Oxygen readings if the logger was deployed in a saltwater environment or if percent saturation is required. Also use this assistant if you took field calibration readings. The Dissolved Oxygen Assistant is only available in HOBOware from the Plot Setup window when you open a file from this logger. To use the assistant:

1. Offload the most recent data files from the shuttle or logger to your computer.
2. Open a data file in HOBOware.
3. In the Plot Setup window, select the Dissolved Oxygen Assistant and click Process.
4. In the Dissolved Oxygen Assistant window, enter the salinity, barometric pressure, and field calibration information as needed. Click the Help button in the Dissolved Oxygen Assistant for more details and to learn about the ranges of input data allowed.
5. Plot the data and save it as a project file.

Maintenance

To clean the sensor cap:

1. Remove the protective guard or anti-fouling guard, but leave the sensor cap on the sensor.
2. Rinse the logger with clean water from a squirt bottle or spray bottle.
3. Gently wipe the cap with a soft-bristled brush (such as a toothbrush) or soft cloth if biofouling is present. Use Alconox® to remove grease.
4. If extensive debris or mineral build-up is present, soak the cap end in vinegar for 15 minutes, then soak it in deionized (DI) water for another 15 minutes.
5. If the logger is being immediately redeployed with the same sensor cap, a field calibration is adequate. If a new sensor cap is being installed, a lab calibration with HOBOware is recommended. When storing the logger between deployments, keep it in the calibration boot (wet the small sponge with fresh water, place the sponge in the end of the calibration boot, and then insert the logger in the boot.)

WARNING: Do not use organic solvents; they will damage the sensor. Do not remove the sensor cap from the sensor prior to cleaning with a brush. Only clean the sensor when you replace the sensor cap. See the full instructions that ship with the replacement sensor cap. Do not wet the sensor optical lens area with water or any solution. Remove the cap and gently wipe the window with a soft cloth.

To clean the logger body:

1. Make sure the sensor cap is installed on the logger.
2. Gently scrub the logger body with a plastic bristle brush or nylon dish scrubber.
3. Use Alconox® to remove grease.
4. Soak in vinegar to remove mineral deposits.
5. Rinse the logger with deionized (DI) water.

Battery Guidelines

The battery life of the logger should be three years or more. Actual battery life is a function of the number of deployments, logging interval, and operation/storage temperature of the logger. Frequent deployments with fast logging intervals, continuous storage/operation at temperatures above 35°C (95°), and keeping the logger connected to the coupler will result in significantly lower battery life. For example, the battery may last less than a year with a 1-minute logging interval. To obtain a three-year battery life, a logging interval of five minutes or greater should be used and the logger should be operated and stored at temperatures between 0° and 25°C (32° and 77°F).

The logger can report and log its battery voltage. If the battery falls below 3.2 V, the logger will record a "bad battery" event in the datafile. The logger will record a second "bad battery" event and stop logging when the battery falls below 3.1 V. If the datafile contains "bad battery" events, the logger should be returned to Onset for battery replacement. Note the logger does not have to be recording the battery channel for it to detect bad battery events. The logger will record these events regardless of what channels are logged. To have your logger's battery replaced, contact Onset or your place of purchase for return arrangements. Do not attempt to replace the battery yourself. Severe damage to the logger will result if the case is opened without special tools, and the warranty will be voided.

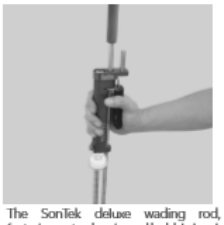
WARNING: Do not cut open, incinerate, heat above 100°C (212°F), or recharge the lithium battery. The battery may explode if the logger is exposed to extreme heat or conditions that could damage or destroy the battery case. Do not dispose of the logger or battery in fire. Do not expose the contents of the battery to water. Dispose of the battery according to local regulations for lithium batteries.

APPENDIX C-4. FlowTracker 2

URL for Users Manual: http://info.xylem.com/rs/240-UTB-146/images/FlowTracker2%20User%27s%20Manual%20v1.6%20Rev%20H.pdf?aliId=eyJpIjoiajM3Q0dSUlo5SndER29qNiIsInQiOiJtMDlnRE4zN1Jkc3BZQVJYM0k1R053PT0ifQ%253D%253D

Product Specifications:

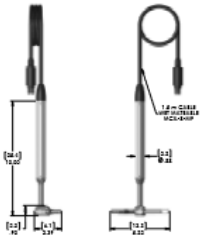
FlowTracker2 ACCESSORIES AND SPECIFICATIONS



The SonTek deluxe wading rod, featuring a sturdy grip and bubble level

Rugged case provided standard with instrument

Product Dimensions



Product Specifications Part I: Probe	
Velocity Range	±0.001 to 4.0 m/s (0.003 to 13 ft/s)
Velocity Resolution	0.0001 m/s (0.0003 ft/s)
Velocity Accuracy	±1% of measured velocity, 0.25 cm/s
Acoustic Frequency	10.0 MHz
Sampling Volume Location	10 cm (3.93 in) from the center transducer
Minimum Depth	0.02 m (0.79 in)
Temperature Sensor	Resolution: 0.01° C, Accuracy: 0.1° C
Tilt Sensor	Accuracy: 1.0°
Communication Protocol	RS-232
Operating/Storage Temperature	-20° C to 50° C (-4° F to 122° F)
Physical Specifications	
-Probe Head Dimensions	(L)13.3 cm (5.22 in); (W) 6.1 cm (2.39 in); (H) 2.3 cm (0.90 in)
-Standard Cable Length	1.5 m (4.92 ft)
-Weight in Air	0.90 kg (1.98 lbs)
-Weight in Water	0.30 kg (0.66 lbs)
Part II: Handheld	
Power	
-Input Battery Voltage	8 - 12 VDC
-Power Supply	8 X AA Batteries (Alkaline)
-Battery Life	Alkaline: 15 hours continuous use, typical settings[1]
-Power Consumption	1 W (Average)
GPS	
-H. Position Accuracy	<2.5 m (8.2 ft)
-Frequency	L1 (1.575 MHz), SBAS compensation (WAAS, EGNOS, MSAS, GAGAN)
LCD	
-Resolution	320 X 240 TFT Transmissive
Bluetooth	Class 2, Range = 10 m (33 ft) nominal
USB	Micro USB, IP-67
Probe Interface	
-Battery Power to Probe	8 - 12 VDC
-Data Transfer	RS-232
-Data Storage	16 GB. Up to 10k discharge measurements. Up to 10 million velocity samples
Operating Temperature	-20° to 50°C (-4°F to 122°F)
Storage Temperature	-30° to 70° C (-22° F to 158° F)[2]
Physical Specifications	
-Waterproof Rating	IP-67 (1m submersible)
-Handheld Dimensions	(L)10.4 cm (4.1 in); (W) 6.4 cm (2.5 in); (H) 23.7cm (9.3 in)
-Weight in Air	0.75 kg (1.65 lbs)
-Weight in Water	-0.25 kg (-0.55 lbs)

[1]Defined as power on with screen on at 100% brightness, ADV sensor pinging 50% of the time, GPS off, and no sleep periods. Actual battery life will vary depending on FT2 settings, manner of use and brand of battery.
[2]Remove batteries from FlowTracker2 handheld if storage temperatures exceeds 50°C (122°F)

xylem
Let's Solve Water

Founded in 1992 and advancing environmental science globally, SonTek manufactures acoustic Doppler instrumentation for water velocity measurement in oceans, rivers, lakes, harbors, canals, estuaries, industrial pipes and laboratories. SonTek's sophisticated and proprietary technology serves as the foundation for some of the industry's most trusted flow data collection systems. SonTek is headquartered in San Diego, California, and is a brand of Xylem Inc.

SonTek
9940 Summers Ridge Road
San Diego CA 92121
Tel +1.858.546.8327
Fax +1.858.546.8150
www.sontek.com

YSI, Inc.
1700/1725 Brannum Lane
Yellow Springs, Ohio 45387
Tel +1.937.767.7241
Fax +1.937.767.9353
www.ysi.com

Xylem, Inc.
1133 Westchester Avenue
White Plains, NY 10604
Tel +1.914.323.5700
Fax +1.914.323.5800
www.xyleminc.com

www.sontek.com

S19-01-1215

APPENDIX C-5. Winkler Titration Protocol, Method 8332, 60-mL BOD Bottle

Oxygen, Dissolved

DOC316.53.01179

Azide Modification of Winkler Method **Method 8215 and 8332**

1 to more than 10 mg/L **Digital Titrator**

Scope and application: For water, wastewater and seawater.

Test preparation

Before starting

As an alternative to stirring by hand, use the TitraStir Titration Stand to hold the Digital Titrator and stir the sample.
Review the Safety Data Sheets (MSDS/SDS) for the chemicals that are used. Use the recommended personal protective equipment.
Dispose of reacted solutions according to local, state and federal regulations. Refer to the Safety Data Sheets for disposal information for unused reagents. Refer to the environmental, health and safety staff for your facility and/or local regulatory agencies for further disposal information.

Items to collect

Description	Quantity
Digital Titrator	1
Delivery tube for Digital Titrator, J-hook tip	1
Clippers for plastic pillows	1
For Method 8215, 300-mL BOD bottle	
Dissolved Oxygen Reagent Set	1
Sodium Thiosulfate Titration Cartridge, 2.00 N	varies
Bottle, with stopper, BOD, 300-mL	1
Cylinder, graduated, 250-mL	1
Flask, Erlenmeyer, 250-mL	1
For Method 8332, 60-mL BOD bottle	
Dissolved Oxygen 1 Reagent Powder Pillows	1
Dissolved Oxygen 2 Reagent Powder Pillows	1
Dissolved Oxygen 3 Reagent Powder Pillows	1
Sodium Thiosulfate Titration Cartridge, 0.2000 N	1
Bottle, with stopper, BOD, 60-mL	1
Flask, Erlenmeyer, 125-mL	1
Beaker, polypropylene, 50-mL, low form	1

Refer to Consumables and replacement items on page 6 for order information.

Sample collection

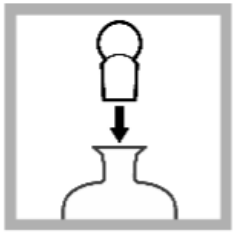
Good sample collection and handling techniques are important to get correct results. The dissolved oxygen content of the sample can change with depth, turbulence, temperature, sludge deposits, light, microbial action, mixing, travel time and other factors. A single dissolved oxygen test frequently is not an accurate reflection of the overall condition of a body of water. Several samples taken at different times, locations and depths are recommended for most reliable results.

- Collect samples in clean BOD Bottles.
- If prompt analysis is not possible, do steps 1 through 4 of the procedure and keep the samples protected from light at 10 to 20 °C (50 to 68 °F).
- Pour a small quantity of water into the flared lip area of the stopper to seal the bottle.
- Use a BOD bottle cap on the flared lip.
- Keep samples for a maximum of 8 hours. For analysis start with step 5.

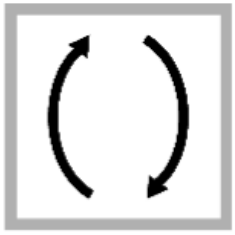
Method 8215, 300-mL BOD bottle

1. Collect a water sample in a clean 300-mL BOD bottle. Let the sample overflow the bottle for 2 or 3 minutes to make sure that a representative sample is collected.

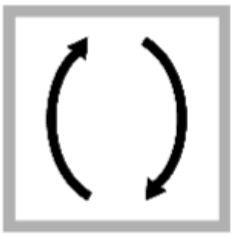
2. Add the contents of one Manganous Sulfate Powder Pillow and one Alkaline Iodide-Azide Reagent Powder Pillow to the sample.



3. Immediately put the stopper in the bottle. Make sure that no air is inside the bottle.



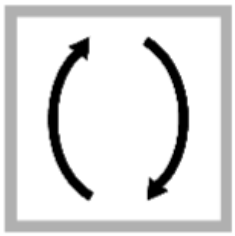
4. Invert the bottle at least 5 times to mix.
A flocculent precipitate forms. The floc is orange/brown if oxygen is in the sample or white if there is no oxygen. The floc forms slowly in salt water (approximately 5 minutes more are necessary). When the floc formation is complete, proceed to next step.



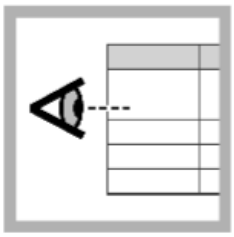
5. Again, invert the bottle at least 5 times to mix.
Wait until the top half of the solution is clear and the floc collects at the bottom to make sure that the reaction of the sample and reagents is complete.

6. Remove the stopper and add the contents of one Sulfamic Acid Powder Pillow to the sample.

7. Immediately put the stopper in the bottle. Make sure that no air is inside the bottle.



8. Invert the bottle at least 5 times to mix.
The floc dissolves and a yellow color develops if oxygen is in the sample.



9. Select a sample volume and titration cartridge from Table 1 on page 5.

10. Insert a clean delivery tube into the digital titration cartridge. Attach the cartridge to the Digital Titrator.

11. Hold the Digital Titrator vertically with the cartridge tip up. Turn the delivery knob to eject air and a few drops of titrant. Reset the counter to zero and clean the tip.

12. Use a graduated cylinder to measure the sample volume from Table 1 on page 5.

13. Pour the sample into a clean, 250-mL Erlenmeyer flask.

14. Put the delivery tube point fully into the solution and swirl the flask. Turn the knob on the Digital Titrator to add titrant to the solution. Continue to swirl the flask and add titrant until the color changes yellow to a pale yellow.

15. Add 2 mL of Starch Indicator Solution.
A dark blue color develops.

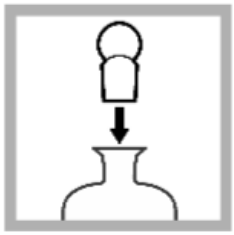
16. Put the delivery tube point fully into the solution and swirl the flask. Turn the knob on the Digital Titrator to add titrant to the solution. Continue to swirl the flask and add titrant until the color changes from a dark blue to a colorless end point. Record the number of digits on the counter.

17. Use the multiplier in Table 1 on page 5 to calculate the concentration.
Digits used × digit multiplier = mg/L Dissolved Oxygen

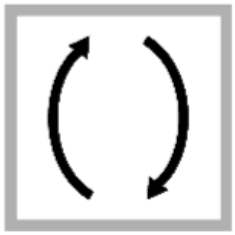
Method 8332, 60-mL BOD bottle

1. Collect a water sample in a clean 60-mL BOD bottle. Let the sample overflow the bottle for 2 or 3 minutes to make sure that a representative sample is collected.

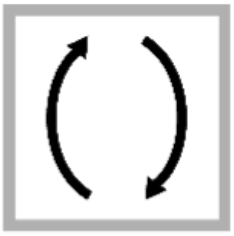
2. Add the contents of one Dissolved Oxygen 1 Powder Pillow and one Dissolved Oxygen 2 Powder Pillow to the sample.



3. Immediately put the stopper in the bottle. Make sure that no air is inside the bottle.

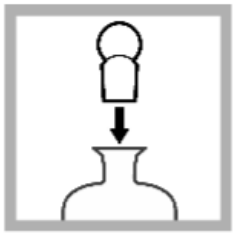


4. Invert the bottle at least 5 times to mix.
A flocculent precipitate forms. The floc is orange/brown if oxygen is in the sample or white if there is no oxygen. The floc forms slowly in salt water (approximately 5 minutes more are necessary). When the floc formation is complete, proceed to next step.

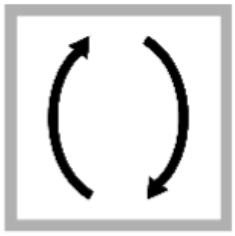


5. Again, invert the bottle at least 5 times to mix.
Wait until the top half of the solution is clear and the floc collects at the bottom to make sure that the reaction of the sample and reagents is complete.

6. Remove the stopper and add the contents of one Dissolved Oxygen 3 Powder Pillow to the sample.



7. Immediately put the stopper to the bottle. Make sure that no air is inside the bottle.



8. Invert the bottle at least 5 times to mix.
The floc dissolves and a yellow color develops if oxygen is in the sample.

9. Accurately measure 20 mL of the prepared sample and transfer it to a 50-mL Erlenmeyer flask.

10. Insert a clean delivery tube into a 0.200 N Sodium Thiosulfate Titration Cartridge. Attach the cartridge to the Digital Titrator.

11. Hold the Digital Titrator vertically with the cartridge tip up. Turn the delivery knob to eject air and a few drops of titrant. Reset the counter to zero and clean the tip.

12. Put the delivery tube point fully into the solution and swirl the flask. Turn the knob on the Digital Titrator to add titrant to the solution. Continue to swirl the flask and add titrant until the color changes yellow to a pale yellow.

13. Add 2 mL of Starch Indicator Solution.
A dark blue color develops.

14. Put the delivery tube point fully into the solution and swirl the flask. Turn the knob on the Digital Titrator to add titrant to the solution. Continue to swirl the flask and add titrant until the color changes from a dark blue to a colorless end point. Record the number of digits on the counter.

15. Calculate the concentration: digits x 0.1 = mg/L Dissolved Oxygen.

Sample volume and digit multipliers

Select a range in Table 1, then read across to find the applicable information for this test. Use the digit multiplier to calculate the concentration in the test procedure.

Table 1 Sample volumes and digit multipliers

Range (mg/L DO)	Sample volume (mL)	Titration cartridge	Digit multiplier
1–5	200	0.200	0.01
2–10	100	0.200	0.02
>10	200	2.000	0.10

Interferences

Nitrite interference is removed by the azide in the reagents. Other reducing or oxidizing substances may interfere. If these are in the sample, use an alternative method, such as the High Range Dissolved Oxygen Method (colorimetric, Method 8166) or a dissolved oxygen electrode.

Accuracy check

Standard method solution

Determine the strength of the Sodium Thiosulfate Solution with an Iodate-Iodide Standard Solution, 10 mg/L as dissolved oxygen.

Method 8215, 300-mL BOD bottle

1. Start the analysis at step 6. Add the Sulfamic Acid Powder Pillow to a 200-mL volume of Iodate-Iodide Standard Solution.
   a. Use a 100-mL sample volume with the 0.200 N Sodium Thiosulfate Titration Cartridge. 500 digits are necessary for this titration. If more than 525 digits are necessary to get to the end point, replace the Sodium Thiosulfate Cartridge.
   b. Use a 200-mL sample volume with the 2.00 N Sodium Thiosulfate Titration Cartridge. 100 digits are necessary for this titration. If more than 105 digits are necessary to get to the end point, replace the Sodium Thiosulfate Cartridge.

Method 8332, 60-mL BOD bottle

1. Start the analysis at step 6. Add the Dissolved Oxygen 3 Powder Pillow to a 60-mL volume of Iodate-Iodide Standard Solution.
2. Use a 20-mL sample volume with the 2.00 N Sodium Thiosulfate Titration Cartridge. 100 digits are necessary for this titration. If more than 105 digits are necessary to get to the end point, replace the Sodium Thiosulfate Cartridge.

Summary of method

Samples are treated with manganous sulfate and alkaline iodide-azide reagent to form an orange/brown precipitate. After acidification of the sample, this floc reacts with iodide to produce free iodine as triiodide in proportion to the oxygen concentration. The iodine is titrated with sodium thiosulfate to a colorless end point.

Consumables and replacement items

Required reagents for 300-mL BOD bottle

Description	Quantity/test	Unit	Item no.
Dissolved Oxygen Reagent Set (approximately 50 tests)	1	—	2272200
Alkaline Iodide-Azide Powder Pillows		50/pkg	107266
Manganous Sulfate Powder Pillows		50/pkg	107166
Sodium Thiosulfate Titration Cartridge, 0.2000 N		each	2267501
Starch Indicator Solution		100 mL MDB[1]	34932
Sulfamic Acid Powder Pillows		50/pkg	2076266
Sodium Thiosulfate Titration Cartridge. 2.00 N	varies	each	1440101

Required apparatus for 300-mL BOD bottle

Description	Quantity/test	Unit	Item no.
Bottle, with stopper, BOD, 300-mL	1	each	62100
Clippers for plastic pillows	1	each	96800
Cylinder, graduated, 250-mL	1	each	50846
Digital Titrator	1	each	1690001
Flask, Erlenmeyer, 250-mL	1	each	50546
Delivery tube for Digital Titrator, J-hook tip	1	5/pkg	1720500

[1] MDB is Marked Dropper Bottle

Required reagents for 60-mL BOD bottle

Description	Quantity/test	Unit	Item no.
Dissolved Oxygen 1 Reagent Powder Pillows	1	100/pkg	98199
Dissolved Oxygen 2 Reagent Powder Pillows	1	100/pkg	98299
Dissolved Oxygen 3 Reagent Powder Pillows	1	25/pkg	98768
Sodium Thiosulfate Titration Cartridge, 0.2000 N	1	each	2267501

Required apparatus for 60-mL BOD bottle

Description	Quantity/test	Unit	Item no.
Bottle, with stopper, BOD, 60-mL	1	each	190902
Clippers for plastic pillows	1	each	96800
Digital Titrator	1	each	1690001
Flask, Erlenmeyer, 125-mL	2	each	50543
Beaker, polypropylene, 50-mL, low form	1	each	108041
Delivery tube for Digital Titrator, J-hook tip	1	5/pkg	1720500

Recommended standards and apparatus

Description	Unit	Item no.
Iodate-Iodide Standard Solution, 10-mg/L as dissolved oxygen	500 mL	40149
Cap, BOD Bottle Snap-over	6/pkg	241906
BOD Bottle, Serialized (#1–24)	24/pkg	2898700
TitraStir Titration Stand, 115 VAC	each	1940000
TitraStir Titration Stand, 230 VAC	each	1940010
Delivery tube for Digital Titrator, 90-degree bend for use with TitraStir Titration Stand	5/pkg	4157800

FOR TECHNICAL ASSISTANCE, PRICE INFORMATION AND ORDERING:
In the U.S.A. – **Call toll-free 800-227-4224**
Outside the U.S.A. – **Contact the HACH office or distributor serving you.**
On the Worldwide Web – **www.hach.com**; E-mail – **techhelp@hach.com**

HACH COMPANY
WORLD HEADQUARTERS
Telephone: (970) 669-3050
FAX: (970) 669-2932

11/2014, Edition 8

European Green Crab Early Detection and Monitoring

Quality Assurance Project Plan

WDFW Grant Agreement#: 14-02055

June 2015

Prepared by
Washington Sea Grant
3716 Brooklyn Ave NE
Seattle, WA 98105

Prepared for
Washington Department of Fish and Wildlife
Washington Department of Ecology

Publication Information

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement PC 00J29801 to Washington Department of Fish and Wildlife. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. The Green Crab Early Detection and Monitoring Project will be managed by Washington Sea Grant. The QAPP and final report will be available on-line from Sea Grant (http://wsg.washington.edu/green-crab) or upon request from WDFW.

Contact Information

Jeff Adams
Marine Water Quality Specialist and Aquatic Invasive Species Coordinator
Washington Sea Grant
345 Sixth St., Suite 550
Bremerton, WA 98337
360-733-8307
jaws@uw.edu

Abstract

This document details a quality assurance plan to guide the successful implementation of the project "European Green Crab Early Detection and Monitoring". Staff associated with this project will develop protocols for trapping crabs and surveying for crab molts in prioritized locations within Washington's inland waters. Volunteers will be trained and equipped to collect the monitoring data. The presence of Green Crabs in the Salish Sea will be monitored through fall 2016.

A PROJECT MANAGEMENT

A1. Approval Sheet

_____ _____
Jeff Adams Date
Washington Sea Grant
Marine Water Quality Specialist and Aquatic Invasive Species Coordinator

_____ _____
Bill Kammin Date
Washington Department of Ecology
Quality Assurance Officer

_____ _____
Penelope Dalton Date
Washington Sea Grant
Director

_____ _____
Allen Pleus Date
Washington Department of Fish and Wildlife
Aquatic Nuisance Species Coordinator

A2. Table of Contents

List of Tables

List of Figures

Appendices

A3. Distribution List

Each person listed on the approval sheet and each person listed under Project/Task Organization will receive a copy of this Quality Assurance Project Plan (QAPP). Individuals taking part in the project may request additional copies of the QAPP from personnel listed under Section A4.

This document has been prepared according to the United States Environmental Protection Agency publication *EPA Requirements for Quality Assurance Project Plans* dated March 2001 (QA/R-5).

A4. Project/Task Organization

Personnel involved in project implementation are listed in Table 1, and shown as an organization chart in Figure 1.

Table 1: Project Implementation Personnel

Individual	Role in Project	Organizational Affiliation
Jeff Adams	Project Manager	Washington Sea Grant
Tom Gries	NEP Quality Coordinator	WA Department of Ecology
Bill Kammin	Quality Assurance Officer	WA Department of Ecology
Penelope Dalton	Principal Investigator	Washington Sea Grant
Emily Grason	Project Student Staff	UW Biology
Gwyn Hinton	Administrator	Washington Sea Grant
Kate Litle	Citizen Science Specialist	Washington Sea Grant
P. Sean McDonald	Project Scientist	UW School of Aquatic and Fishery Sciences
MaryAnn Wagner	Project Communications	Washington Sea Grant
UW Capstone Students	Project Student Interns	UW Program on the Environment
Training Partners	Training Co-coordinators	Partners TBD
Project Volunteers	Data Collectors	Volunteers TBD

The Washington Sea Grant Project Manager will be responsible for the following activities:

- Conduct outreach with regulated industry and internal/external stakeholders
- Provide project input and oversight
- Maintain official, approved QAPP
- Develop amended QAPP
- Issue quarterly and final reports to Puget Sound Marine and Nearshore Grant Manager and U.S. EPA
- Managing Project Student Interns

The Washington Department of Ecology NEP Quality Coordinator and Quality Assurance Officer are independent from Washington Sea Grant and will be responsible for review and approval of the QAPP, may elect to conduct a project-related audit, and will review and comment on a draft of the final project report.

The Washington Sea Grant Principal Investigator holds ultimate oversight for the project and budget.

The UW Biology Project Student staff will be responsible for the following activities:

- Refining prioritized potential habitat map
- Developing protocols
- Purchasing supplies
- Developing training materials
- Conducting trainings
- Identifying sampling locations
- Coordinating volunteers
- Receiving and input data

The Washington Sea Grant Administrator will monitor and manage budgets, contracts and human resources needs.

The Washington Sea Grant Citizen Science Specialist will be responsible for the following activities:

- Developing protocols
- Developing training materials
- Evaluation of training, protocols and volunteer involvement
- Project adaptation
- Managing Project Student Interns

The UW School of Aquatic and Fishery Sciences Project Scientist will be responsible for the following:

- Refining prioritized potential habitat map
- Developing protocols
- Conducting trainings
- Identifying sampling locations
- Analyzing and interpreting data
- Managing Project Student Interns

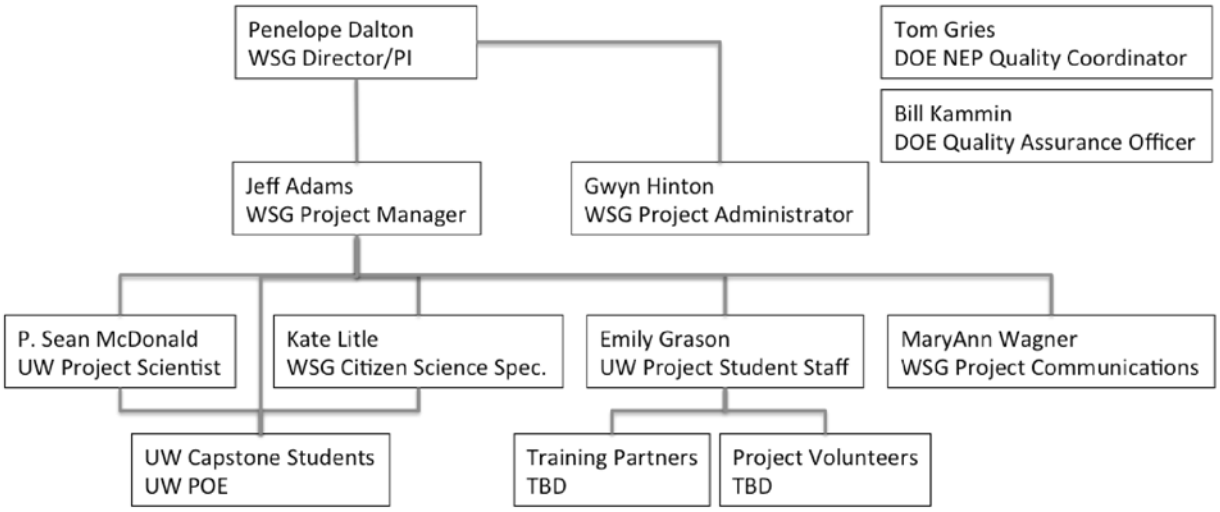
The Washington Sea Grant Project Communications will be responsible for development and implementation of the outreach plan.

The UW Program on the Environment Project Student Interns will be responsible for student-scale evaluation and research studies within the overall project.

The Partners to be determined (TBD) Training Co-coordinators will be responsible for helping recruit volunteers and coordinate the location and timing of training opportunities.

The Volunteers TBD Data Collectors will be responsible for taking training and collecting and submitting data to Project Student Staff in a timely fashion.

Figure 1: Project Organizational Chart



A5. Problem Definition/Background

Rationale for initiating the project

The European green crab (*Carcinus maenas*) is frequently listed among the world's 100 most harmful invaders, having established populations on every continent except Antarctica. Green crabs are efficient and voracious predators that can feed upon a diverse array of marine invertebrates. High-density green crab populations have been associated with impacts to commercial clam fisheries in eastern North America and in California.

European green crab has been observed on the outer coast of Washington and British Columbia since the late 1990's. In 2012, Canadian Department of Fisheries and Oceans scientists first detected the crabs in Sooke Inlet, near Victoria, British Columbia.

The discovery of the Sooke population lead to interest by WDFW and a regional European Green Crab Committee coordinated by the Pacific States Marine Fisheries Commission in reestablishing a monitoring program for Washington's inland waters that would be effective for early detection and efficient for long-term viability under limited budgets. With interest and expertise in citizen science, invasive species and European green crab specifically, Washington Sea Grant and UW research colleagues were very interested in piloting and testing approaches to establish such a program.

Objectives of the project

The primary objective of this project is to establish a long-term, volunteer-based European green crab early detection and monitoring program at a regional scale with a limited post-

establishment budget. To be successful the activities need to be practical, effective, engaging and have clear relevance to management of resources valued by stakeholders and volunteers. Because we hope to never detect European green crab, the secondary objectives are to gain a better understanding of the crabs and other species using the habitat we expect to be most suitable for European green crab establishment. Finally, the project will also provide an opportunity for citizen engagement and involvement that will make them more informed about their marine resources and hopefully better stewards.

Regulatory information, applicable criteria and action limits

We will work with Allen Pleus, Aquatic Nuisance Species Coordinator for WDFW to obtain the necessary collection permits and will report as specified in the permit.

A6. Project/Task Description

Project overview

To detect European green crab at the earliest possible stage of infestation, we will develop early monitoring and detection protocols for volunteers, train volunteers in the use of those protocols and adaptively manage the program using volunteer feedback to ensure the most effective data collection, storage and use. Volunteers will choose from sites identified in a suitable green crab habitat identification and prioritization process.

Project summary and work schedule

The intent of this project is to create an ongoing, self-supporting green crab early detection monitoring program that also information about species living in suitable green crab habitat. The portion of the program supported by this grant and covered in this QAPP ends on November 30, 2016. This project's major tasks and timeline are outlined in the table below.

Table 2: Schedule of Major Project Tasks

2015	
January-June	Prioritize sites, develop protocols, schedule training
June-July	Train volunteers, establish sites
July-October	Volunteers monitoring sites
October-December	Evaluate first season, adaptively manage program
2016	
January-February	Complete adaptation, schedule year 2 trainings and recruit new volunteers
March-April	Volunteer training and establishment of any new sites
April-October	Year 2 sampling
September-November	Prepare final reporting and sustainability plan for monitoring

Geographic focus

Monitoring sites will be based on the prioritization map described above, accessibility, and volunteer interest. To help volunteers precisely and consistently target the best sampling locations within a habitat, WSG will provide volunteers with GPS coordinates of the location

upon which they should base their sampling locations. These will also be marked with semi-permanent markers (rebar with an orange safety cap) to provide a visual aide. Trapping will take place directly waterward of the marker and molt survey transects will take place along the shoreline from the marker.

The WSG team has created, and maintains, a map of shoreline sites in Puget Sound and the Strait of Juan de Fuca categorized by monitoring priority (Figure 1, www.tinyurl.com/wagreencrab). The priority of each site is determined based on the proximity to established populations of green crab and based on habitat characteristics that green crabs are known to prefer.

As of 2014, green crabs have invaded shorelines along the west coast of North America from central California to the west coast of Vancouver Island, and most recently on the southern end of Vancouver Island (Sooke Inlet), within the Salish Sea. Good green crab habitat in the invaded range is:

- protected from high wave action
  - shallow beach slope or extensive tide flat
  - meandering channels or sloughs
  - isolated lagoon
  - artificial impoundment (e.g., culverts)
- in areas with relatively low freshwater input
- replete with marsh vegetation, like pickleweed, which crabs can use for shelter

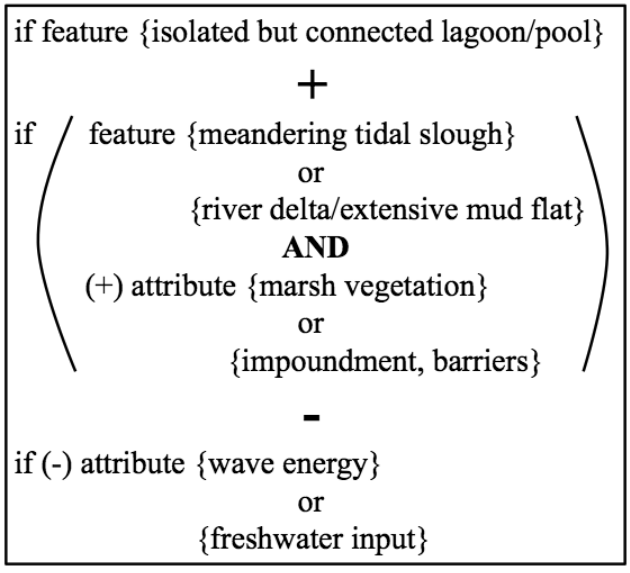
Using satellite imagery in Google Maps and Google Earth, we systematically examined the shoreline for suitable European green crab habitat. The characteristics listed below-left were used to prioritize locations with the formula below-right.

(+) features
- isolated but connected lagoon/pool
- braided and/or highly meandering tidal slough or shallow channel
- river delta or extensive tide flat

(+) attribute
- marsh vegetation
- impoundment/artificial structure

(-) attribute
- high energy
- extensive freshwater input

This list will be refined on an ongoing basis by ground-truthing.



Observations from trap catches and molt surveys will also help us tell if green crabs are likely to be able to live at a site, based on the other species found in that habitat.

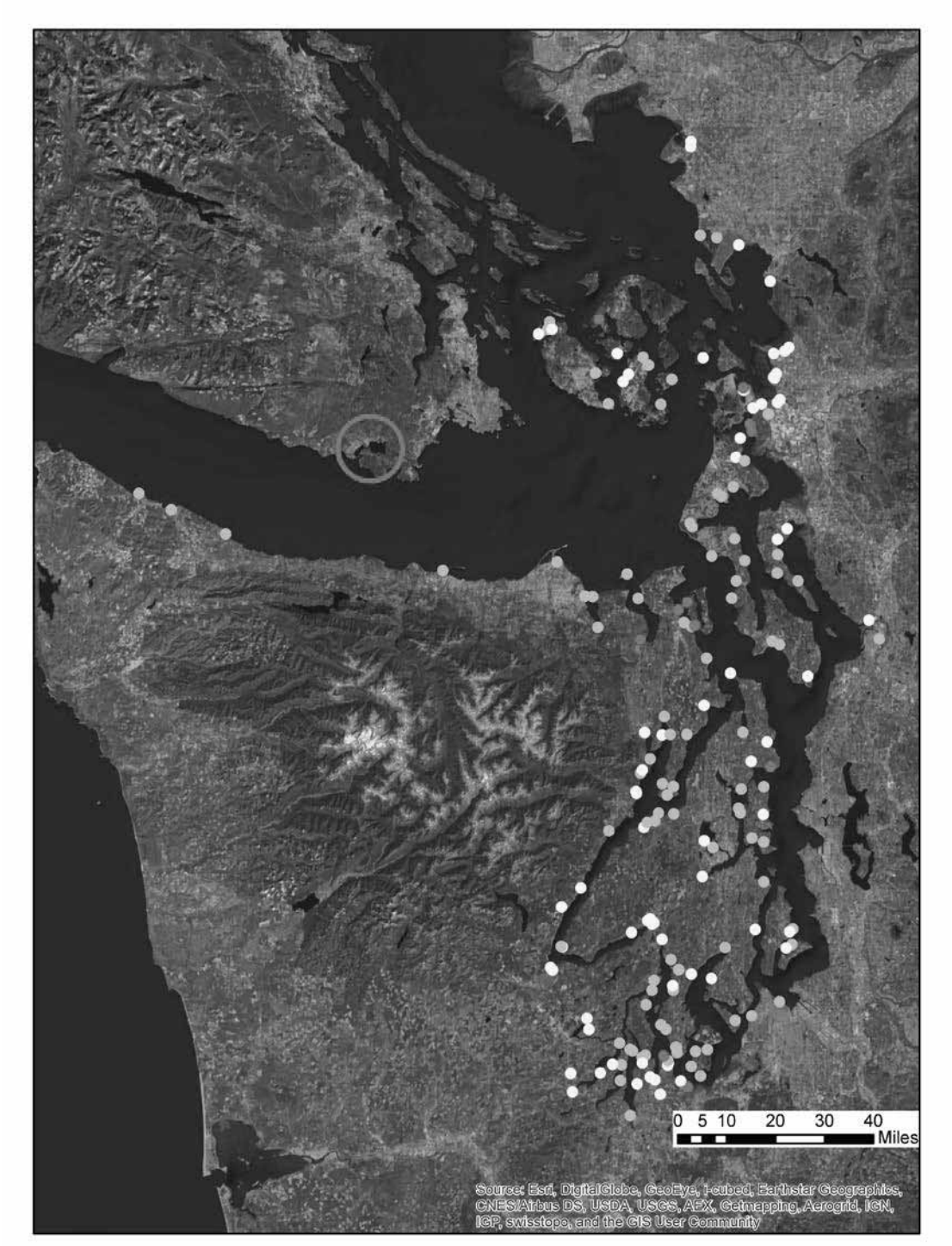


Figure 1. Map of prioritized suitable European green crab habitat. Yellow, orange and red represent moderate, high and highest risk sites respectively, based on prioritization process. The red circle represents Sooke Inlet, site of a recently established green crab population.

Resource and time constraints

The budget for the grant supporting this project (WDFW Grant Agreement#: 14-02055) is included in Appendix A. Staff support for site identification and prioritization, protocol development, volunteer recruitment and training, monitoring, and mid-project evaluation and adaptation is provided through this grant. The grant also supports equipment purchases to support the project and establishment of long-term monitoring for European green crab in Washington's inland waters. Finally, the grant also provides for developing a sustainability plan and an outreach and engagement program beyond the scope of this QAPP. Grant funds leverage volunteer hours and additional inputs from Washington Sea Grant and other program partners.

A7. Special Training/Certification

Volunteers will receive one half-day training on using the methods outlined in the QAPP.

A8. Documents and Records

Report format/information

The format for all data reporting packages will be consistent with the requirements and procedures used for data validation and data assessment described in this QAPP. A final project report will be prepared as described in Section C.

Document/record control

The recording media for the project will be paper and electronic, document and photograph. Field data sheets and images will be archived and managed by the project staff.

Backup of electronic files

Paper files will be converted to electronic documents and cloud backup will be used for electronic files.

B DATA GENERATION AND ACQUISITION

B1. Sampling Methods

Two types of sampling will be conducted. All volunteers who select high-priority sites will be asked to conduct trapping monthly between April and October. These volunteers will also conduct molt surveys. We are limited in the number of traps we can provide during the first year, so volunteers who select lower-priority sites will only be asked to perform molt surveys, also monthly between April and October. Details for each type of survey are outlined below. Field forms are presented in Appendix B.

Site Exploration

Regardless of whether volunteers are trapping, doing molt surveys, or both, they will need to become familiar with the site. Volunteers should first view the location of the coordinates on a Google satellite map (or Website map), to get a sense of where to look for the rebar stake that indicates the monitoring site. Before the targeted monitoring date, volunteers should visit the site on a reasonably low tide (+1 or lower) to locate the stake and walk safely out to the water's edge.

Some sites might require navigating soft sediment or other obstacles, and it is best to be familiar with these ahead of time.

Trapping Crabs

At all high-priority sites, volunteers will deploy a total of 6 baited traps (3 square Fukui fish traps, and 3 minnow traps) for one night-time high tide per month between April and October, following the protocol below:

1. **Timing**. Traps should be deployed ("soaked") for one overnight high tide. This is when crabs are most likely to be foraging in the intertidal zone. Set traps on an afternoon or evening incoming tide, and retrieve them the next day, as the tide is receding. This maximizes the time that the traps will be actively "fishing" and ensures that organisms will not be out of the water for very long.
2. **Preparation.** A few days before setting traps, check that they are in good condition, clean and free of debris, and without large holes in the mesh. Small holes can be repaired using zip ties. Bait boxes need to be checked to ensure that they will close securely, as the plastic can warp over time. Each trap should be individually labeled with permit number and contact information.
3. **Setting traps.** Volunteers will set three Fukui square fish traps and three cylindrical minnow traps at each site.
   a. **Timing.** Set traps in the water as the tide is returning, to ensure they are submerged nearly the entire time they are deployed. Plan to arrive with enough time to set up traps on shore, and to still be able to walk out to the appropriate depth to place the traps
   b. **Baiting traps.** Dump a prepared bag of fish into the bait box, put the lid on and place it loose inside the trap before setting the trap.
   c. **Situating the traps.** Traps should be arrayed in a line parallel to the shore at approximately the same tidal elevation. Alternate the type of trap so that minnow and Fukui traps are interspersed and spaced approximately 10m apart (about 10 long paces).
   d. **Deploying traps.** Set up the Fukui trap by placing the bait box inside, lifting the collapsible sides and clipping them at the top in the middle. The bait need not be secured to the trap. Similarly place the bait box inside the minnow trap and latch the two halves together.
      Sink the pencil rod stake all the way through the trap, from top to bottom, so that the bent portion of the stake is level with the top of the trap, pinning it down. If the substrate is too hard to securely stake the trap, place a rock inside the trap to weight it down. This adds wear-and-tear to the traps, however, so it is preferable to move the trap to a spot where the stake can be used.
   e. **Recording data.** Record the time that the tide returned and submerged the traps to calculate the exact "soak time", or the amount of time that the trap was actually fishing for crabs.
4. **Retrieving traps.** Check the traps on the receding tide before they are exposed, and record the number and species of all organisms in the trap. Organisms will be sorted and data at the same time, so it's easiest to work with a partner: one person can record data, and the other can handle the traps and organisms.
   a. **Timing.** Plan to return to traps as the tide is dropping. This will ensure that any other organisms in the trap will only be out of the water for a very short period of time if at all, and will therefore be in the best condition to survive upon release.

b. Record trap data. Take note of what time traps were removed from the water. Also record the predominant weather condition (select one) that best encompasses the period during which the trap was soaking.

c. **Investigate trap contents.** Pull the stake from the ground and remove any debris that might have covered the trap. Visually inspect the trap before opening it. Many organisms will hide in the corners of the trap or under the bait.

d. **Remove and record organisms in trap.** Place the contents of the trap into the tub provided to make it easier to ID and sort.

i. **Take one photograph of entire trap catch.** Try to get as many of the organisms as possible clearly visible in the photo. Submit this with the trap data for species verification.

ii. **Record trap catch on data sheet. Identify** and record the number of each species present. Measure the size of up to 10 individuals of each species. On the data sheet, fill out a separate row for each species found in each trap. For each species, record the number present in each trap. Then, randomly select individuals of each crab species and measure the carapace width and document the sex until having measured 10 for each sex or until there are no more crabs of that species. If there are fewer than 10 of a species, take size measurements on all individuals present. Fish should be counted and released first because they are the most sensitive to drying out. Handle fish carefully, not only because many species have defensive spines, but also because their skin and protective slime coating can be easily damaged by handling. Use care when handling crabs as well, to avoid getting pinched. Gloves will not protect against large crab claws, but they can help guard against pinches from small shore (Grapsid) crabs.

iii. Release all organisms in the water nearby, *EXCEPT* green crabs (see below).

e. **If a green crab is trapped,** text a photograph to WSG as soon as possible to verify the ID. Photograph the crab with data sheet in the background, identifying site number, trap number, date and time. Record the carapace width in millimeters, and make sure the measurement is visible in the photo. Flip the crab over and photograph the abdomen to allow for verification of sex of the crab as well. Place the crab/s in a sealed ziplock bag, labeled with date, location, and trap number, and store in the freezer until a WSG team member can retrieve it.

f. **If unable to identify an organism,** take a photograph (or a few) using a ruler or some other clear indication of scale in the background. If confident the organism is *not* a green crab, release it into the receding tide with the other organisms. If uncertain, treat it as if it were a green crab, storing it in the freezer, and contact WSG right away. Use a temporary species placeholder on the datasheet, such as "Unknown species A", until the organism can be identified. Provide as much detail as possible in the description to WSG along with the photographs.

5. **Clean and store traps.** Remove bait from the trap (take the bait to discard in home trash or compost), and remove any seaweed or other debris that has collected on or in the traps at the site. Rinse mud off the traps in the water of the receding tide. Cleaning as much material as possible at the site will not only reduce the effort at home, but it will also reduce the possibility of transporting organisms on the traps to a new location. Upon arrival home, rinse the traps well with freshwater. Removing salt and debris will keep the

traps in good condition and make them more pleasant to handle when using them again a month later. Store them in a dry, covered space, out of direct sunlight.

6. **Report data.** Submit all data to WSG within one week of trapping. Submit all data as images via email. Either scan or take a photo of the datasheet (front and back or additional sheets, if necessary) and email to crabteam@uw.edu along with the photos of trap catches. Rename each of the photograph files according to the diagram below. Save hard copies of the data sheets until the end of the trapping season, when they will be collected by WSG. Include photos and/or questions about species that could not be identified in the same email.

Identification level of expected species or species group includes:

Invertebrates

- European green crab (*Carcinus maenas*)
- hairy shore crab (*Hemigrapsus oregonensis*)
- purple shore crab (*Hemigrapsus nudus*)
- helmet crab (*Telmessus cheiragonus*)
- graceful crab (*Cancer (Metacarcinus) gracilis*)
- Dungeness crab (*Cancer (Metacarcinus) magister*)
- red rock crab (*Cancer productus*)
- spider crabs [kelp crab (*Pugettia producta*), graceful kelp crab (*Pugettia gracilis*), graceful decorator crab (*Oregonia gracilis*)]
- sand shrimp (*Crangon* spp.)
- hairy hermit crab (*Pagurus hirsutiusculus*)
- grainy-hand hermit crab (*Pagurus granosimanus*)

Fish

- shiner perch (*Cymatogaster aggregata*)
- staghorn sculpin (*Leptocottus armatus*)
- tidepool sculpin (*Oligocottus maculatus*)
- three-spine stickleback (*Gasterosteus aculeatus*)
- eel-like fishes (gunnels & pricklebacks; *Apodichthys*, *Pholis* & *Xiphister*, *Anoplarchus*)

Molt Surveys

After setting traps, or at sites not identified as high priority, volunteers will look for evidence of green crabs, in the form of molted shells. A systematic molt survey can be extremely informative about green crab presence or absence and about other crab species in the area, and we ask that these volunteers conduct these surveys monthly between April and October.

Crab molts tend to accumulate along the wracklines, the line on the shore where vegetation, trash, and other loose or floating debris is deposited at high tide. However, the wrackline itself can be difficult to observe depending on shoreline morphology. Volunteers will therefore survey transect along the substrate-vegetation (or substrate-riprap) interface, which occurs at a tidal elevation that is relatively stable over time. If a true wrackline is also present and obvious, the volunteers will survey both the fixed and true wracklines as outlined below.

1. **Find survey line.** On a low tide (at least +1 ft), identify the line at which the bare ground interfaces with the lowest observed terrestrial vegetation (i.e. not seagrass or algae). Typically this zone is dominated by pickleweed (*Salicornia* spp.). A vegetation zone may be lacking if the shoreline of the site is armored with rocky riprap or a wall. In this case, survey along the line at which the riprap or wall abuts the bare substrate.

   Ascertain whether the site has a true wrackline left by the most recent high tide. This "dynamic" wrackline changes location with each high tide, and results from the deposition of any light or floating debris left by the receding water. It can be patchy or continuous.
2. **Set transect line.** Stake 50 meter rope along the line formed by the lower (deepest) limit of vegetation, riprap, or wrack. *If trapping as well*, try to capture, as much as possible, the portion of shoreline directly adjacent to the traps. Working around or over natural or manmade barriers may be needed to capture 50m of shoreline. This line is the transect along which crab molts will be sampled.
3. **Molt count sweep survey.** Starting at one end of the line, collect the first 100 crab molts found within a swath 1m of the shoreward side of the rope. Only collect and count molts for which the carapace is sufficient to identify the crab to species (i.e., do not count the molt if only the leg/underside portion of the shell is present). Record the number of each species found, up to 100 crab molts, and indicate the distance along the rope surveyed to find this many crabs (up to the nearest meter marked on the rope). Depending on the site and the time of year, 100 molts may be difficult to find even after surveying the entire transect. In this case, indicate that the entire 50 meter transect was surveyed. This survey will be used to estimate how many molts are present along the entire 50 meter transect.
4. **Survey 5 quadrats.** In addition, volunteers will count all molts and estimate percent cover at a subsample of 5 random sites along the entire transect. Each month, volunteers will be given 5 numbers between 0 and 50 generated by a random number generator. They will conduct sub-surveys at each of the distances along the transect. For instance, if the random numbers are: 7, 13, 27, 40, and 48, for a given month, the volunteers will take subsample observations at the 7th, 13th, 27th, 40th, and 48th, meter marks along measured rope.

   At each subsample point, place a small square quadrat (0.1 m^2 in area) on the shoreward side of the rope. Record the number and species of all identifiable molts in this quadrat. Visually estimate the percent cover (to the nearest 5%) of the top-most layer in each quadrat for the following categories:
   - Percent of wrack and debris (stuff that floated in) of each type:
     - Eelgrass (dead or live)
     - Seaweed (dead or live)
     - Terrestrial vegetation (dead, woody debris)
     - Trash (of human origin, plastic, etc)
   - Percent cover of live vegetation (e.g., *Salicornia*/Pickleweed)
   - Bare substrate/sediment (no wrack or live vegetation)

   The dominant sediment type will also be recorded as either:
   - Mud

- Sand
- Gravel
- Cobble
- Bedrock
- Riprap

5. **Repeat the survey at the true wrackline.** If a true wrackline is evident at the site, repeat the above survey procedure at the lowest (most-recently deposited) clear wrackline. There may be a true wrackline some months but not others.
7. **Keep any molts for uncertain species.** Because molts are only shells of the crabs, it's fine to collect molts for follow up identification. Take a photograph (or a few) with clear indication of scale (e.g., hand, the mesh of the trap, a ruler, or coin) next to the molt. Use a temporary species placeholder on the datasheet, such as "Unknown species A", until the organism can be identified. Provide as much detail in the description to WSG along with the photographs.
8. **If a green crab molt is found,** contact WSG as soon as possible. Text a photo with the survey information (site, wrackline survey number, date), and an indication of scale (e.g., a ruler, or coin) next to the molt. Place the molt a plastic bag, carefully avoiding crushing it, and, if it's very dirty, place it in the freezer to keep the organic material from decaying.
9. **Report data.** Submit all data to WSG within one week of conducting the molt survey. Either scan or take a photo of the datasheet (front and back or additional sheets, if necessary) and email to crabteam@uw.edu. Rename each of the photograph files according to the diagram as for the trapping. Save hard copies of the data sheets until the end of the trapping season, when they will be collected by WSG. Include any photos or questions about unidentified species in this email as well.

More detailed Standard Operating Procedures for trapping crabs and conducting molt surveys, developed for this project and summarized above, will be available at http://wsg.washington.edu/green-crab.

Invasive species transport prevention

No specimens will be removed live from the beach. All sampling equipment will be inspected for any substrate, fauna, or flora. Potentially contaminated equipment will be inspected and cleaned on site, then rinsed in fresh water before visiting any other location. When possible, equipment will be allowed to dry. Training will also include instructions for participants to inspect their clothing for any possible contamination and the need to decontaminate the clothing before returning to any marine area through washing clothing in hot water and thorough drying. No one in the program should wear boots or shoes with felt-covered soles as these can't be properly decontaminated. Details and options for decontamination are given at http://www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html .

Data entry QA procedures

Data entry and interpretation will be completed by project staff or interns and verified by project scientific staff. All electronic records will be compared to the original observations recorded on field data forms to confirm accuracy of data entry.

B2. Analytical Methods

Analysis will include diversity, species richness (number of species), relative abundance, sex ratios, size distributions and species lists. Results will be compared within and between sites over time.

B3. Quality Control

The European green crab monitoring protocols were developed to maximize the likelihood of identifying European green crab at multiple post-settlement sizes. The protocols were also designed to reduce potential for surveyor error and bias, through expert review of data sheets and photo documentation and by random assignment of quadrat locations. The trapping approach uses replication within a site to establish mean response and variability. Because we hope not to detect green crab, the objectives include obtaining useful data from organisms that are captured in traps or identified in molt surveys to better understand what other species are using habitats suitable for green crab establishment and might be at risk.

The monitoring protocols and data management procedures address accuracy and bias concerns by using photos to document trap contents and expert staff to verify sampling results.

The following items will be implemented to provide the best QC throughout the program:

1. Project staff will install permanent markers as starting points from which trap and molt survey locations can be consistently located. Latitude and longitude of the permanent marker will also be with recorded with at least 6 meter accuracy, so the site can be identified in the case of a lost marker.
2. Volunteers will receive training on protocol and species identification.
3. Volunteers knowledge will be surveyed before and after training to evaluate learning and proficiency.
4. Volunteers will be surveyed at the end of the season to evaluate retention.
5. Volunteers will follow the standard procedures as described in the previous section among sites and among monitors.
6. Regular contact through a monthly newsletter will provide volunteers consistent reinforcement of concepts and identification.
7. Monitoring teams will have access to project staff for digital photo identification.

C ASSESSMENT/OVERSIGHT

A final monitoring report will be completed by November 2016. The report will be produced by WSG and UW School of Aquatic and Fishery Sciences colleagues, reviewed by peers within the West Coast Green Crab Group, modified, then reviewed by the NEP Quality Coordinator prior to submission. The report will represent a culmination of the grant-funded portion of the project.

The processes related to the project will be described and results will be interpreted for relationships within and between sites. The reports and data will be made publicly available on the Washington Sea Grant website and through State partners.

The report will include:
• A narrative of processes for site identification, protocol development and volunteer training
• A narrative of processes and results of early project evaluation and adaptation based on the first sampling season
• A narrative of the field research
• A summary of observations
• Analysis of effort
• Analysis of observations
• An assessment of the long-term feasibility of this study

D DATA REVIEW AND EVALUATION

Before leaving the site, field data forms will be reviewed by team leaders to ensure data completeness and thoroughness. Any questions on species identification will be resolved within the week by project staff, using photographs and descriptions. The project staff will review all field data forms (Appendix A) to ensure that questions about missing and unusual data had been addressed and corrected, if needed. Project staff will also randomly select 10% of the sample photographs for identification and measurement verification. Additional verification will be performed and problems addressed if inconsistencies are observed.

Data analysis and interpretation will be reviewed with colleagues in the invasive species management and research community as well as with the volunteers and other partners.

Acknowledgments

We appreciate the groundwork that has been laid for this project from years of research and monitoring by colleagues at many institutions and within our own ranks. We appreciate feedback and expertise from the West Coast Green Crab Group that meets periodically and is coordinated by Pacific States Marine Fisheries Commission. In particular, we are thankful for the efforts of Allen Pleus, WDFW Aquatic Nuisance Species Coordinator, and Stephen Phillips, Pacific States Marine Fisheries Commission, who helped facilitate the support for the project and bring it into being.

We'd also like to give an advanced thank you to the volunteers who will be collecting samples and landowners who will give permission to monitor. It is thanks only to their contributions that the breadth of this program can be fully realized.

Appendix A: Project budget, WDFW Grant #: 14-02055

Green Crab Monitoring Program Budget

Salaries	**Unit Cost**	**Units**	**Total**
Jeff Adams	5094	3.8	19358
Sean McDonald	6580	1.75	11515
Kate Litle	5200	0.9	4680
Hourly Student	16	1560	24960
Benefits			
Jeff Adams	1411	3.8	5362
Sean McDonald	1823	1.75	3190
Kate Litle	1440	0.9	1296
Hourly Student	3	1560	4243
Supplies			
Fukui traps	80	72	5760
Minnow traps	15	132	1980
Bait	2	2160	4320
Substrates	5	210	1050
misc supplies	456	1	456
Travel			
Travel - volunteer training and sampling sites	4258	1	4258
Services			
Publications	2000	1	2000
Mailing	2000	1	2000
Direct Cost Total			96429
Indirect Costs			25072
TOTAL			121501

Appendix B: Data Forms

The following data forms will be used in this project:

Form	Purpose
Trapping field form (one sheet double sided)	Quantify species, sex and size of crabs, fish and other species in traps
Molt survey field form (one sheet double sided)	Quantify density of crab species in wrack or at other lines of deposition

These forms are included below as supplemental documents.

WSG$European$Green$Crab$Monitoring$$$Trapping$Data$Sheet

Date:	Waypoint:	Site-Name:	#-Fukui:	Set-Date:	End-Date:
Surveyor-Name-(Affiliation):		Surveyor-Contact-Info:-	#-Minnow:	Time:	Time:
			Weather: Fog/Mist Heavy-Rain	Clouds Light-Rain	Clear / Total-soak-time:

IFYOUFINDANYGREEN$CRABS,$SAVE$THEM$&$CONTACT$WSG$WITH$PHOTOGRAPHS$ASAP

Trap$Type	Trap$#	Species	Sex$&$Size$(mm)$of$first$10$crabs$(countallother$species)											#$Total	#$Dead	Comments
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													

WSG$European$Green$Crab$Monitoring$$$Trapping$Data$Sheet

IFYOUFINDANYGREEN$CRABS,$SAVE$THEM$&$CONTACT$WSG$WITH$PHOTOGRAPHS$ASAP

Trap$Type	Trap$	Species	Sex$(circle)$&$Size$(mm)offirst10Individuals											#$Total	#$Dead	Comments
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													
			M													
			F													

Please-use-a-second-datasheet-if-you-require-more-space

WSG European Green Crab Monitoring - Molt Survey Data Sheet

Date:	Waypoint #:	Site Name:	**Type of molt surveys (up to 2):**
Surveyor Name (Affiliation):		Contact Info:	Riprap-Substrate Pickleweed-Substrate True wrackline

Transect 1: Fixed Transect Circle one: Riprap-Substrate Pickleweed-Substrate

Molt Sweep Survey *Count first 100 molts observed within 1m on the shoreward side of the transect line*

Species	Number of Molts		Species	Number of Molts	
	Tally	Total		Tally	Total

Total Number of Molts (all species): ____ **Length of transect observed (1-50m):** ____

Quadrat Survey *Set 5 quadrats at randomly assigned distances along transect. Observe molts and cover in each*

	Percent Cover (nearest 5%)						Crab Molts	
							Species	# Molts
Quadrat 1	Random Distance (m):			Wrack (dislodged floating material):				
	Live Veg (attached)			Eelgrass (dead or live)				
	Bare Substrate			Seaweed				
	Sediment type (circle one):			Terrestrial vegetation (dead)				
	Mud	Sand	Cobble	Trash				
	Bedrock	Gravel	Riprap					
Quadrat 2	Random Distance (m):			Wrack (dislodged floating material):				
	Live Veg (attached)			Eelgrass (dead or live)				
	Bare Substrate			Seaweed				
	Mud	Sand	Cobble	Terrestrial vegetation (dead)				
	Bedrock	Gravel	Riprap	Trash				
Quadrat 3	Random Distance (m):			Wrack (dislodged floating material):				
	Live Veg (attached)			Eelgrass (dead or live)				
	Bare Substrate			Seaweed				
	Mud	Sand	Cobble	Terrestrial vegetation (dead)				
	Bedrock	Gravel	Riprap	Trash				
Quadrat 4	Random Distance (m):			Wrack (dislodged floating material):				
	Live Veg (attached)			Eelgrass (dead or live)				
	Bare Substrate			Seaweed				
	Mud	Sand	Cobble	Terrestrial vegetation (dead)				
	Bedrock	Gravel	Riprap	Trash				
Quadrat 5	Random Distance (m):			Wrack (dislodged floating material):				
	Live Veg (attached)			Eelgrass (dead or live)				
	Bare Substrate			Seaweed				
	Mud	Sand	Cobble	Terrestrial vegetation (dead)				
	Bedrock	Gravel	Riprap	Trash				

Notes:

Data emailed to WSG? _____

WSG European Green Crab Monitoring & Molt survey Data sheet

Transect 2: True Wrackline survey

**True wracklines do not occur at all sites, you do not need to complete this side of the form if there is no true wrackline at your site.*

Molt sweep survey — *Count first 100 molts observed within 1 m on the shoreward side of the transect line*

Species	Number of Molts: Tally	Number of Molts: Total	Species	Number of Molts: Tally	Number of Molts: Total

Total Number of Molts all species): ____ **Length of transect observed (1-50m):** ____

Quadrat survey — *Set 5 quadrats at randomly assigned distances along transect. Observe molts and cover in each*

	Percent Cover (nearest 5%)						Crab Molts		
Quadrat 1	Random Distance (m):			Wrack (dislodged floating material):			Species	#Molts	
	Live Veg (attached)			Eelgrass (dead or live)					
	Bare Substrate			Seaweed					
	Sediment type (circle one):			Terrestrial vegetation (dead)					
	Mud	Sand	Cobble	Trash					
	Bedrock	Gravel	Riprap						
Quadrat 2	Random Distance (m):			Wrack (dislodged floating material):					
	Live Veg (attached)			Eelgrass (dead or live)					
	Bare Substrate			Seaweed					
	Mud	Sand	Cobble	Terrestrial vegetation (dead)					
	Bedrock	Gravel	Riprap	Trash					
Quadrat 3	Random Distance (m):			Wrack (dislodged floating material):					
	Live Veg (attached)			Eelgrass (dead or live)					
	Bare Substrate			Seaweed					
	Mud	Sand	Cobble	Terrestrial vegetation (dead)					
	Bedrock	Gravel	Riprap	Trash					
Quadrat 4	Random Distance (m):			Wrack (dislodged floating material):					
	Live Veg (attached)			Eelgrass (dead or live)					
	Bare Substrate			Seaweed					
	Mud	Sand	Cobble	Terrestrial vegetation (dead)					
	Bedrock	Gravel	Riprap	Trash					
Quadrat 5	Random Distance (m):			Wrack (dislodged floating material):					
	Live Veg (attached)			Eelgrass (dead or live)					
	Bare Substrate			Seaweed					
	Mud	Sand	Cobble	Terrestrial vegetation (dead)					
	Bedrock	Gravel	Riprap	Trash					

Notes:

Data emailed to WSG? _____

Technical Memorandum:

Enhanced Monitoring of Fecal Coliform Pollution in Northern Dungeness Bay

15EPA PSP402
Jamestown S'Klallam Tribe
May 30, 2018

Purpose

The purpose of the this memorandum is to report findings of the Jamestown S'Klallam Tribe's (Tribe) *Enhanced Monitoring of Fecal Coliform Pollution in Northern Dungeness Bay* project, a component of the Tribe's "Priority projects for the restoration and protection of Treaty Resources dependent upon Puget Sound" (Sub-task 2.3 of 15EPA PSP402).

Project History/Overview

The Jamestown S'Klallam Tribe has been working with partners for close to two decades to restore the water quality in Dungeness Bay to healthy conditions. Water quality monitoring results in the late 1990s and early 2000s revealed increasingly harmful fecal coliform levels, leading to several closures and downgrades to shellfishing areas of the Bay during 2000-2003 (Figure 1). Consequently, the Tribe also had to suspend operation of its oyster farm business in 2005, which further inhibited the Tribe's ability to exercise its treaty-protected right to harvest and sell shellfish. Committed stakeholders, including the Tribe, formed a Clean Water District (CWD), participated in two fecal coliform studies (for the Dungeness Watershed (Sargeant, 2002) and Dungeness Bay (Sargeant, 2004a), and developed a Clean-Up Plan (Streeter and Hempleman, 2004) to narrow down the problem areas, evaluate likely pollutant sources and establish targets for reducing fecal coliform to safe levels.

Figure 1. Shellfish Area Closure History in Dungeness Bay.

Significant strides have since been made to correct the pollution problems. Collaboration on water quality improvement projects amongst CWD partners and agencies resulted in the 2011 upgrade of approximately 500 acres of Dungeness Bay growing area from *Prohibited* to *Conditionally Approved*. A concerted effort to develop a more thorough and prioritized approach to restoring water quality followed, culminating in a Pollution Identification and Correction Plan in 2014 that is currently being implemented. Further reductions of fecal coliform allowed for the 2015 upgrade of 688 acres in the Bay from *Conditionally Approved* to *Approved*, and an additional 40 acres from *Prohibited* to *Conditionally Approved*.

While this latest reclassification is momentous, the northern part of the Bay remains in *Conditionally Approved* status and is closed for harvest between November 1st and January 31st due to continued elevated fecal coliform levels that fail to meet shellfish growing standards at several sampling stations in the winter. The Jamestown S'Klallam Tribe's long-standing lease on oyster and geoduck growing tidelands in this northern *Conditionally Approved* area is roughly halfway between sampling sites 107 and 109 in the *Conditionally Approved* area (Figure 2). The Tribe desires to exercise its treaty rights in Dungeness Bay by resuming shellfish growing and harvests on its leased areas. To do so, greater precision on boundaries of impacted water (i.e., *Approved* vs *Conditionally Approved*) is needed. This project, therefor, proposed to collaborate with Washington Department of Health (WDOH) by supplementing its regular marine monitoring of Dungeness Bay with additional sampling site(s) in the *Conditionally Approved* Area of northern Dungeness Bay.

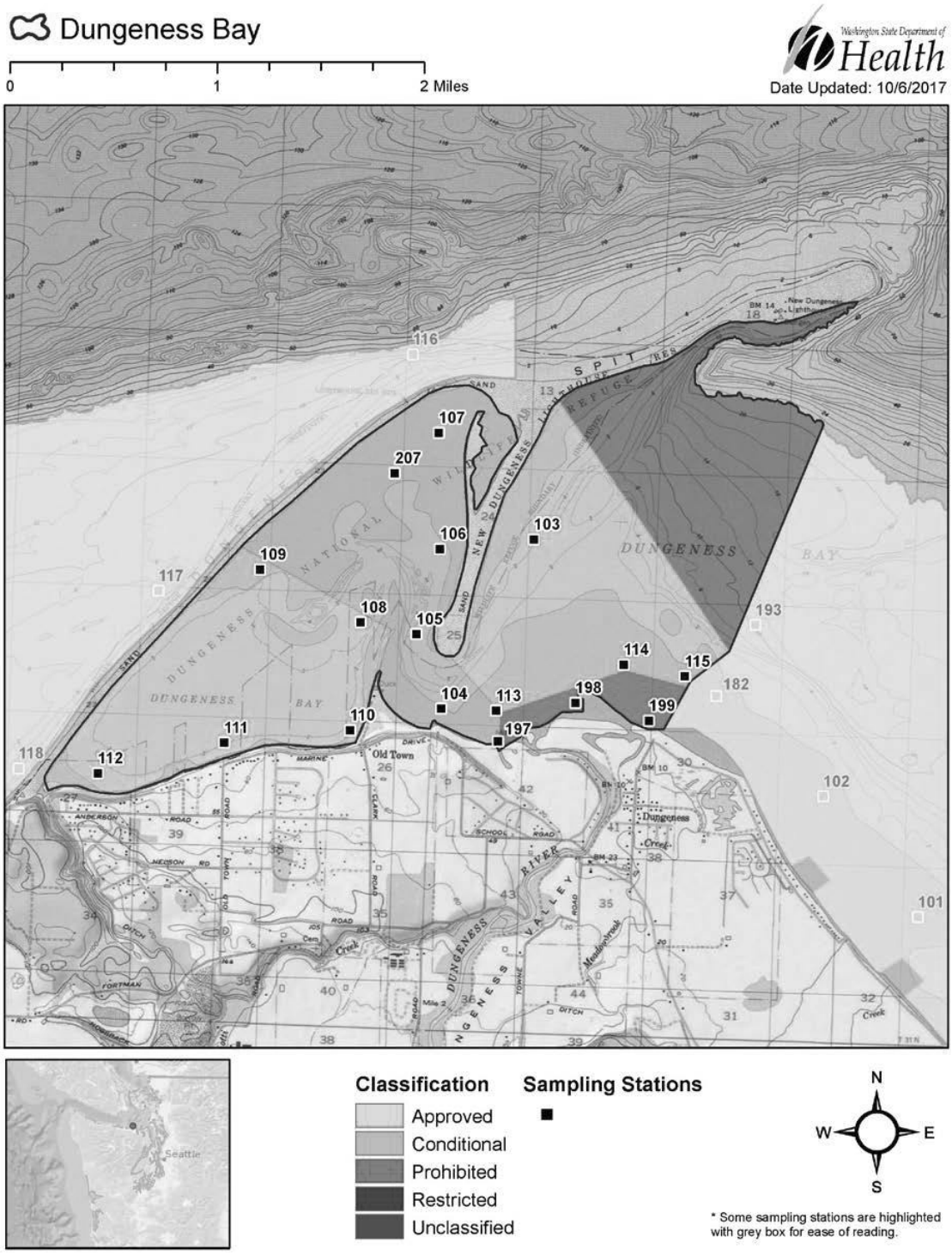
Project Proposal

In collaboration with WDOH, our project proposed to add sampling stations in the northern Dungeness Bay and ultimately obtain enough samples that meet water quality standards in order to reclassify this area as *Approved* and safe for year-round shellfishing. Should sampling indicate that standards are not being met, efforts would continue to characterize and correct any sources of pollution in this area. While the Tribe has a well-established, cooperative relationship with WDOH and already assists with sampling for the Shellfish Growing Area certification program, this enhanced monitoring project is specific to the additional sampling required to further pinpoint the boundary between *Conditionally Approved* and *Approved* areas, especially between sampling stations 107 and 109. This enhanced monitoring would be an extension of existing capabilities within the Tribe.

Sub-tasks included the following:

2.1 Add sampling site(s) in northern Dungeness Bay and develop an associated sampling plan;
2.2 Conduct water sampling at new site(s), in conjunction with regular WDOH marine sampling;
2.3 Analyze, track, and share data results among SWD partners.

Figure 2, Dungeness Bay Shellfish Growing Area Classification Map
(from WDOH 2017 Annual Growing Area Review for Dungeness Bay, December 31, 2017)



The project is also consistent with the following strategies of the 2016 Puget Sound Action Agenda:

C.1 Prevent, reduce, and control the sources of contaminants entering Puget Sound.

C.7 Ensure abundant, healthy shellfish for ecosystem health and for commercial, subsistence, and recreational harvest consistent with ecosystem protection.

C7.1 Improve water quality to prevent downgrades and achieve upgrades of important current tribal, commercial and recreational shellfish harvesting areas.

C9.4 STRT2 Implementation of water quality cleanup plans for Sequim-Dungeness Bays and East Jefferson County Clean Water Districts.

Project Findings/Outcomes

Sub-task 2.1: Add sampling site(s) in northern Dungeness Bay and develop an associated sampling plan

Following deliberations on the most suitable locations for enhanced monitoring, WDOH and Jamestown S'Klallam Tribe settled on the addition of one new site they agreed to be representative of the area. This station, Station 207 (See Figure 2), was added in June 2016 to WDOH's regular, ongoing monthly sampling plan for Dungeness Bay.

Sub-task 2.2: Conduct water sampling at new sites, in conjunction with regular WDOH marine sampling

Enhanced water quality sampling was conducted at Station 207 beginning 06/14/16, in conjunction with WDOH's regular monthly sampling of Dungeness Bay and according to WDOH protocol. The Jamestown S'Klallam Tribe provided staff and boat time, and WDOH processed the samples (for fecal coliform) through the State Health Laboratory. Sampling generally continued monthly, and is currently ongoing.

Sub-task 2.3: Analyze, track, and share data results among CWD partners

WDOH included all enhanced monitoring data in its Annual Growing Area Review for 2017 (See attached, WDOH 2017). WDOH shared updates of all Dungeness marine sampling data, including enhanced sampling at Station 207 with the Jamestown S'Klallam Tribe, and at each of the Sequim-Dungeness Clean Water Work Group's quarterly meetings during the project time period.

This memorandum, along with WDOH's attached Annual Growing Area Review for 2017, satisfies the deliverable for Sub-task 2.3, which is to report findings. Data through 2017 for Station 207 is exerpted from the attached Annual Growing Area Review for Dungeness Bay and summarized in Table 1 below.

Table 1. *Conditionally Approved* **Station 207 FC results for date range 6/14/2016 – 11/15/2017 (the range including the most recent 30 samples for all other regularly monitored stations, as of 12/31/17).**

Date Range	Data Included	Range (FC/100 mL)	GeoMean (FC/100 mL)	E90th (FC/100 mL)	Number of Samples
6/14/2016 – 11/15/2017	All months	1.7 – 17.0	2.9	7.7	18
6/14/2016 – 11/15/2017	Open period data (Feb thru Oct)	1.7 – 6.8	2.0	3.2	13
6/14/2016 – 11/15/2017	Closed period data (Nov thru Jan)	4.5 – 17.0	7.8	16.4	5

Bacteriological results are in relation to NSSP criteria. NSSP standards for approved shellfish growing waters are a fecal coliform geometric mean not greater than 14 organisms/100 mL and an estimated 90th percentile not greater than 43 organisms/100 mL. 30 samples is the minimum SRS criteria.

Station 207 was sampled a total of 18 times during the date range that encompassed the most recent 30 samples collected from each of the regular sampling stations, as of 12/31/17. 30 samples is the minimum required to make a reclassification determination. Since these results were published, Station 207 has been sampled and officially recorded three additional times, making a total of 21 samples (Figure 3). While Station 207 has not reached the 30 minimum, it is notable that, thus far, results have met the standards (FC Geometric mean not greater than 14 FC/100 mL, and an Estimated 90th percentile not greater than 43 FC/100 mL) for each sample during both the Closed and Open periods. WDOH has indicated that once the minimum samples have been reached, WDOH will likely upgrade at least another portion of the *Conditionally Approved* area around that station (personal communication with Trevor Swanson, WDOH, 04/12/18). Completing the process, including acquiring remaining samples needed, deliberating on where the new boundary lines will be, and WDOH's official reclassification could happen by spring/summer of 2019. Until then, the Tribe continues to collaborate on sampling with WDOH, and implementing and tracking progress of the PIC Plan with all CWD partners.

Figure 3. Station 207 monthly data. WDOH.

Station: 207 **Classification: Conditionally Approved** **Method: SRS**

Total Samples: 21
Range (FC/100 mL): 1.7 - 17.0
GeoMean (FC/100 mL): 3

Date Range: 06/14/2016 - 03/07/2018
E90th (FC/100 mL): 8.6
Meets Standard: *N/A

*N/A – SRS criteria require a minimum of 30 samples from each station.

Open Period	Closed Period

Sample	Event Type	Time	Tide	SWT	Salinity	Fecal
06/14/2016	Regulatory	11:26	Flood	13	32	1.7
08/09/2016	Regulatory	10:59	Ebb	14	32	1.7
08/24/2016	Regulatory	09:37	Flood	14	31	1.7
09/13/2016	Regulatory	12:29	Ebb	13	32	1.7
11/07/2016	Regulatory	11:46	Ebb	10	30	4.5
11/15/2016	Regulatory	13:17	Flood	10	31	7.8
12/14/2016	Regulatory	09:33	Flood	7	30	4.5
01/11/2017	Regulatory	09:35	Flood	5	32	11.0
02/14/2017	Regulatory	10:58	Ebb	7	29	2.0
03/22/2017	Regulatory	09:36	Flood	8	25	6.8
04/03/2017	Regulatory	11:42	Ebb	9	29	1.7
05/03/2017	Regulatory	09:13	Flood	10	30	1.7
06/19/2017	Regulatory	12:57	Flood	13	28	1.7
07/19/2017	Regulatory	11:30	Flood	14	30	1.7
08/14/2017	Regulatory	11:13	Ebb	13	29	1.7
09/27/2017	Regulatory	09:25	Flood	12	31	2.0
10/23/2017	Regulatory	11:28	Ebb	10	30	2.0
11/15/2017	Regulatory	09:14	Flood	7	24	17.0
01/22/2018	Regulatory	12:20	Ebb	8	27	2.0
02/28/2018	Regulatory	09:17	Flood	6	31	17.0
03/07/2018	Regulatory	11:25	Ebb	8	29	1.7

References

Sargeant, D., 2002. Dungeness River and Matriotti Creek Fecal Coliform Bacteria Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 02-03-014. www.ecy.wa.gov/biblio/0203014.html.

Sargeant, D., 2004a. Dungeness Bay Fecal Coliform Bacteria Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-012. www.ecy.wa.gov/biblio/0403012.html.

Streeter V. and C. Hempleman, 2004. Clean Water Strategy for Addressing Bacteria Pollution in Dungeness Bay and Watershed and Water Cleanup Detailed Implementation Plan. Southwest Regional Office, Washington State Department of Ecology, Olympia, WA. Publication No. 04-10-059. www.ecy.wa.gov/biblio/0410059.html.

Swanson, T. 2017. Annual Growing Area Review for Dungeness Bay. December 31, 2017. Washington State Department of Health, Office of Environmental Health and Safety. Olympia, WA.

13.4.2 Analysis of sensitivity and uncertainty

Not applicable

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

Sample results from laboratory analyses will be examined for completeness (all samples, all analyses). Processing logs and laboratory reports will be scrutinized for adherence to specified methods and QA/QC requirements so that we know that nutrient samples meet the MQOs. Data will be rejected if it does not meet the MQOs or are for some other reason suspect. For example, a phytoplankton sample could be rejected if the sample is spoiled by not being held in the correct conditions (<4°C and in the dark) before preservation.

After analyses of all the sample data and during the drafting of the technical report we will determine if the project was effective in answering the questions that were po~~i~~sed in ~~Chapter~~ section 3 and if the study design should be modified going forward. This project is a pilot project and will also be evaluated for the efficiency of data collection and the usefulness of data. It will also be evaluated for adding additional data collection i.e. was there any additional information that would be useful yet wasn't collected.

14.2 Treatment of non-detects

Lab QA/QC for the nutrient samples will be sufficient to accept non-detects as legitimate. For example, ammonia concentrations can, at times, be below detection in surface waters where this bioavailable nutrient is rapidly taken up by phytoplankton. For phytoplankton samples it is expected that we would find at least some cells in all our samples but being environmental samples, this can be quite variable (hundreds to millions of cells per liter). If a species of interest is not found it will be presumed to be absent. Non-detects for statistical analyses will be assumed to be zero.

14.3 Data analysis and presentation methods

All data collected during the project will be entered into or copied into an Excel database at the JST Natural Resources office after the data have been reviewed for quality assurance. Regression analyses and other appropriate statistical tests will be conducted to investigate possible correlations between all source data types. Statistical analyses and graphing of results will generally be done in R. JST staff may bring in data specialists from the NWIFC to help with statistical analyses. All analyses will be provided in a final report to Project Managers. Raw data will also be available in the final report or upon request.

14.4 Sampling design evaluation

This study will generate eighteen temporal data points at two depths for two separate sampling stations over a range of sampling conditions through all the seasons where phytoplankton has significant growth in Puget Sound (February through October). It is expected, since we are matching these samples with an existing sampling program for zooplankton, that we will be

able to draw conclusions about the prevalence of HABs and the general conditions that zooplankton are growing under. The frequency of sampling is likely sufficient since the existing sampling program effectively captures the seasonality of the zooplankton community. It may be after full analysis of the results that further studies may want to add or change the depths in which we sample in the future.

14.5 Documentation of assessment

The data usability assessment will be documented in the technical report.

15.0 References

Davis MJ, Chamberlin JW, Gardner JR, Connelly KA, Gamble MM, Beckman BR, Beauchamp DA (2020) Variable prey consumption leads to distinct regional differences in Chinook salmon growth during the early marine critical period. Mar Ecol Prog Ser 640:147-169. https://doi.org/10.3354/meps13279

Esenkulova, Luinenburg, Neville, Trudel, 2014,Observations of Heterosigma akashiwo bloom and associated wild salmon lethargic behavior in Cowichan Bay, Canada, 2014. Harmful Algae News 50, 16-18.

Greene C., L. Kuehne, C Rice, K Fresh, D Pentilla (2015) Forty years of change in forage fish and jellyfish abundance across greater Puget Sound, Washington (USA): anthropogenic and climate associations, Marine Ecological Progress Series Vol 525: 153-170

Keister J, 2017, The Puget Sound Zooplankton Monitoring Program, Technical Report on findings and methods. Appendix 1. marinesurvivalproject.com

Rensel, J.E. (2007) Fish kills from the harmful alga Heterosigma akashiwo in Puget Sound: recent blooms and review. NOAA Technical Report

Sound Toxins manual (2016) Washington Sea Grant, 36 p, available at: https://wsg.washington.edu/wordpress/wp-content/uploads/Sound-Toxins-Manual-2016.pdf

UNESCO. 1994. Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements IOC Manual and Guides 29.

Valderrama. 1981. The simultaneous analysis of total nitrogen and total phosphorus on natural waters. *Mar.Chem*.10: 109-122.

16.0 Appendices

Appendix A. Standard Operating Procedure for EXO2 Sonde Deployment

Sonde Calibration: Calibration of the following sensor types will be conducted within 30 days prior to in situ water quality measurements. Calibrations will follow the methods described in the EXO-User-Manual. In the case that multiple calibrations methods are described in the EXO-User-Manual, the method used is listed alongside the sensor type.

Total Algae BGA-PC (calibration method used: 1-point)

Total Algae BGA-PE (calibration method used: 1-point)

pH (calibration method used: 2-point)

Conductivity/Temperature

Calibration of the following sensor types will be conducted within 24 hours prior to in situ water quality measurements. Calibrations will follow the methods described in the EXO-User-Manual. In the case that multiple calibration methods are described in the EXO-User-Manual the method used is listed alongside the sensor type.

Depth Non-Vented

Optical DO (calibration method used: saturated air)

Post deployment Calibration: All sonde sensor types will be calibrated within 30 days post deployment to asses sensor drift and to ensure that the sensor did not fail the KOR Software QC standards during deployment.

Sonde Maintenance and Storage: The EXO2 Sonde will be stored following the storage methods described in the EXO-User-Manual.

The EXO2 Sonde will be maintained following the sonde maintenance methods described in the EXO-User-Manual including inspection and cleaning which will be conducted within 14 days prior and post to in situ water quality measurements. In addition to conducting routine inspection and cleaning the EXO2 Sonde may be submitted to Xylem for yearly preventative maintenance which includes the following: change of all o-ring seals, firmware updates, and leak test on housing.

Sonde Deployment Methods:

Cast: Cast deployments will be conducted at fixed locations. At sites with water depths 10 meters and under the sonde will be lowered in ~1 meter intervals with 60 second stops at each interval to allow for sensor delay. At sites with water depths over 10 meters the sonde will be lowered in ~10 meter intervals with 60 second stops at each interval to allow for sensor delay.

Alternate method for deep water casts: The sonde will be lowered to depth (typically within 5-10m of the bottom) and held for 60 seconds, then retrieved at a speed approximately equal to

30 meters/minute. When the sonde reaches approximately 1m depth, the instrument will be held again for 60 seconds before completing retrieval.

Towed: Towed deployments will be conducted by towing the sonde at a ~fixed depth, in situ water quality data collected using this method will give a latitude and longitude by matching the date timestamp recorded by the sonde with the date timestamp recorded by a GPS receiver.

Sonde Deployment Period (Timeframe): Continuous EXO2 sonde deployments will not exceed 24hrs.

Data Storage: In situ water quality data will be recorded on to the EXO2 sonde's internal memory. Immediately (maximum of 12hrs) post deployment the data recorded on the sonde's internal memory will be downloaded onto a computer using the KOR software. The data file downloaded to the computer will then be immediately (maximum of 12hrs) copied to a second storage device (thumb drive, external hard drive or second computer).

Many YSI instruments comply with EPA approved test methods for the measurement of several parameters in water. Therefore, these instruments can be used for water analysis and reporting to programs regulated by the EPA such as The Clean Water Act and National Pollutant Discharge Eliminations System (NPDES). The parameters and associated EPA approved test methods to which YSI instruments comply are outlined below. The EPA's approved test methods for water analysis are listed in USA Federal Register 40 CFR Part 136.

YSI instrument measurements comply with the following test methods: **Parameter**	**EPA Approved Method(s) used by YSI**
Dissolved Oxygen with electrochemical DO sensor	Standard Method[2] 4500-O G ASTM Method D888-92,03 (B) USGS Method I–1576–78
Dissolved Oxygen with optical sensor	ASTM Method D888-09 (C) [3]
Specific Conductance	EPA Method 120.1 Standard Method[2] 2510 B
Temperature	Standard Method[2] 2550 B

1. YSI instruments use DO sensors that can measure the initial and final DO readings for a BOD and CBOD test.
2. *Standard Methods for the Examination of Water and Wastewater*, 18th, 19th and 20th edition

Appendix B. Chain of Custody form for nutrient samples

CHAIN OF CUSTODY FORM
Date: _____
Page: _____ of _____

Jamestown S'Klallam Tribe
1033 Old Blyn Highway
Sequim, Washington 98382

Project No.: 2422 HIS
PO #
Project Name: 2021 SSMSP Phytoplankton study

Field Team Leader: Neil Harrington

Phone: (360) 681-4634

Testing Parameters

Laboratory: University of Washington
Address: UW School of Oceanography
Ocean Sci. Bldg. Rm 346
1492 NE Boat St
Seattle, WA 98185
Attention: Aaron Morello
(206) 543-9235

Lab ID	Sample ID	Collection Date	Matrix	Phosphate (PO_4)	Ammonia (NH_4)	Silicate (SiO_4)	Nitrate (NO_2)	Nitrite (NO_3)	Total Phosphorus	Total Nitrogen										No. of containers	Observations, Instructions
																					Total # of Containers =

Relinquished by:
Signature Date Time
Printed Name Company

Received by:
Signature Date Time
Printed Name Company

Shipment Method:
Keep Cool 4 degrees C
Special Requirements or Conditions:
Keep Cool 4 degrees C
Sample Disposition:

Relinquished by:
Signature Date Time
Printed Name Company

Received by:
Signature Date Time
Printed Name Company

Distribution:
1) 1 copy to the Laboratory
2) 1 copy to project manager
3) Return completed original to Jamestown S'Klallam Tribe

Appendix C. Field Sampling Procedures

Jamestown S'Klallam Tribe Phytoplankton Sampling Protocol – updated 1/15/20

Monitoring Sites

Admiralty Inlet (ADI)
Thorndyke Bay (TDB)

Preparation/Equipment

- 20µM Phytoplankton net

- 2.2 L Horizontal Grab (Niskin) Sample Bottle w/weight
- 4x 125mL Nalgene bottles (net tows - 1 per site)
    - Caps and bottles labeled w/site name
- 4x 2L Nalgene bottles (sample bottle)
    - 2 per site (1m/8m)
    - Pre-label w/site names and depth
- 4x 125mL glass jars (phytoplankton)
    - 2 per site (1m/8m)
    - Pre-label w/ site names and depth and 100 ml and 10ml marks
- 8x 60mL Nalgene bottles (nutrients)
    - 2 per site (1m/5m/10m)
    - Pre-labeled
- 4x 60mL Syringes w/ 0.45 µm filter tips
    - 2 per site (1m/8m)
- Cooler w/ice packs
- Bucket for phytoplankton net and Grab sampler
- Datasheets w/ clipboard
- Gloves & Life Jackets

Sampling Overview

- Fill data sheet with weather, sea state, date, time, sample location
- 10 m vertical phytoplankton net tow
- Whole seawater collection (2.2 L Grab Sampler (niskin) Bottle)
    - Collect into 2L bottles @ 1m, 8m depths. Leave at least 1 inch of headspace
- Take subsamples from 2L bottles for nutrients and phytoplankton

Field Sampling Protocol

For each site:

1. Fill data sheet with weather, sea state, date, time, sample location, names of samplers
2. Collect 10m vertical tow
    - Make sure air is purged from the sample bottle/cod-end
    - Sink net to 10m mark on line and retrieve
    - Let sample settle and drain into cod end.
    - Remove cod end and agitate to remove phytoplankton from the inside
    - Pour into 125 ml prelabelled jar, leave headspace and store in a cooler

3. Collect whole water samples at 1 m depth using the 2.2 L Grab Sample (niskin) bottle
    - Rinse the 2L bottles three times with the collected seawater.
    - Fill up a 2L prelabeled (w/ site and depth) sample bottle with the collected seawater leaving at least 1 inch of headspace
    - Within one hour of sampling, sub-sample 60mL out of the 2L bottle for dissolved nutrients using a 60mL syringe w/filter tip and collect the filtrate in the 60 mL Nalgene nutrient bottle. Do not fill more than 2/3 full.
    - After agitation fill a large mouthed prelabeled 60ml Nalgene bottle with the total N and P sample.
    - Secure the lids on all sample bottles and store in cooler.
4. Repeat step 3 for sample collection at 8m.

A. After Returning to Lab

1. Immediately put nutrient samples in the -20°C freezer
2. Put all samples in the fridge or keep in cooler with ice packs
3. See "Lab-based Sample Processing Protocol" for next steps

B. Lab-based Sample Processing Protocol

***Keep all the samples in the cooler (w/ice packs) or fridge until you are ready to process them*

Nutrient Samples:

Put in -20°C freezer immediately

Whole water "plankton" sample:

1. Mark a 'dead' 125 mL glass jar with 10 mL and 100 mL volume markings (use DI water)- numerous jars can be done ahead of time

2. Mix the 2 L whole water sample thoroughly – invert slowly 3+ times

3. Fill the glass jar up to the 100 mL marking

4. Add 7.5 mL of 20% buffered formaldehyde (final conc. 1.5%) to the jar and mix

5. Label jar: site name, depth, date, time, formaldehyde % and prepared initials.

6. Let jar sit overnight (> 8 hours) to allow plankton to settle out (do not disturb).

7. Carefully, remove all water down to the 10 mL marking, making sure not re-suspend or suck up the settled plankton.

8. Use the remaining 10mL (10x concentrated sample) to do quantitative cell counts in the Sedgwick-Rafter (S-R) slide.
    a. Mix the 10mL concentrated sample by swirling the jar several times
    b. Fill the 1 mL S-R counting chamber, making sure there are no bubbles.
    c. If sample is sparse (few phytoplankton cells), then count the entire chamber.
    d. If sample is dense (many phytoplankton cells), then only count 1-4 horizontal scans of the counting chamber (randomly select starting point) until at least 300 cells are counted or you may use a 0.1ml Palmer- Maloney slide and count the entire chamber.
    e. Record your cell count of harmful species/ genera on the phytoplankton data sheet

Plankton net tow sample:

1. Mix the sample thoroughly by inverting the sample at least 3 times.

2. Add 20ml of sample to a 25ml scintillation vial and add 1.5ml of 20% buffered formaldehyde.

3. Add 1 ml of the live sample to a gridded Sedgwick-Rafter slide

4. Count the number of phytoplankton cells (by genera) in each grid and tally up for the entire slide.

5. Record your count data on the plankton monitoring data sheet

Appendix D. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Ambient: Background or away from point sources of contamination. Surrounding environmental condition.

Anthropogenic: Human-caused.

Bankfull stage: Formally defined as the stream level that "corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne and Leopold, 1978).

Baseflow: The component of total streamflow that originates from direct groundwater discharges to a stream.

Char: Fish of genus *Salvelinus* distinguished from trout and salmon by the absence of teeth in the roof of the mouth, presence of light-colored spots on a dark background, absence of spots on the dorsal fin, small scales, and differences in the structure of their skeleton. (Trout and salmon have dark spots on a lighter background.)

Chronic critical effluent concentration: The maximum concentration of effluent during critical conditions at the boundary of the mixing zone assigned in accordance with WAC 173-201A-100. The boundary may be based on distance or a percentage of flow. Where no mixing zone is allowed, the chronic critical effluent concentration shall be 100% effluent.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Critical condition: When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses. For steady-state discharges to riverine systems, the critical condition may be assumed to be equal to the 7Q10 flow event unless determined otherwise by the department.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Diel: Of, or pertaining to, a 24-hour period.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Dilution factor: The relative proportion of effluent to stream (receiving water) flows occurring at the edge of a mixing zone during critical discharge conditions as authorized in accordance with the state's mixing zone regulations at WAC 173-201A-100. http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-020

Diurnal: Of, or pertaining to, a day or each day; daily. (1) Occurring during the daytime only, as different from nocturnal or crepuscular, or (2) Daily; related to actions which are completed in the course of a calendar day, and which typically recur every calendar day (e.g., diurnal temperature rises during the day, and falls during the night).

Effective shade: The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of a stream or other defined area.

Effluent: An outflowing of water from a natural body of water or from a human-made structure. For example, the treated outflow from a wastewater treatment plant.

Enterococci: A subgroup of the fecal streptococci that includes *S. faecalis*, *S. faecium*, *S. gallinarum*, and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5% sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C.

Eutrophic: Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

Existing uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Extraordinary primary contact: Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

Fecal coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Fish Tissue Equivalent Concentration (FTEC): The FTEC is a tissue contaminant concentration used by Ecology to determine whether the designated uses of fishing and drinking from surface waters are being met. The FTEC is an interpretation of Washington's water quality criterion for a specific chemical for the protection of human health: the National Toxics Rule (40 CFR 131.36). Fish tissue sample concentrations that are lower than the FTEC suggest that the uses of fishing and drinking from surface waters are being met for that specific contaminant. Where an FTEC is not met (i.e., concentration of a chemical in fish tissue is greater than the FTEC), that water body is then placed into Category 5 during Washington's periodic Water Quality Assessment (WQA and 303d List). Category 5 listings become part of Washington's 303(d) list

during the assessment process. The FTEC is calculated by multiplying the contaminant-specific Bio-Concentration Factor (BCF) times the contaminant-specific Water Quality Criterion found in the National Toxics Rule.

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Hyporheic: The area beneath and adjacent to a stream where surface water and groundwater intermix.

Load allocation: The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

Municipal separate storm sewer systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (1) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, stormwater, or other wastes and (2) designed or used for collecting or conveying stormwater; (3) which is not a combined sewer; and (4) which is not part of a Publicly Owned Treatment Works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Near-stream disturbance zone (NSDZ): The active channel area without riparian vegetation that includes features such as gravel bars.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water

pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Phase I stormwater permit: The first phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to medium and large municipal separate storm sewer systems (MS4s) and construction sites of five or more acres.

Phase II stormwater permit: The second phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to smaller municipal separate storm sewer systems (MS4s) and construction sites over one acre.

Point source: Source of pollution that discharges at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites where more than 5 acres of land have been cleared.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Primary contact recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Reach: A specific portion or segment of a stream.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Fish that belong to the family *Salmonidae*. Species of salmon, trout, or char.

Sediment: Soil and organic matter that is covered with water (for example, river or lake bottom).

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Synoptic survey: Data collected simultaneously or over a short period of time.

System potential: The design condition used for TMDL analysis.

System-potential channel morphology: The more stable configuration that would occur with less human disturbance.

System-potential mature riparian vegetation: Vegetation which can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes.

System-potential riparian microclimate: The best estimate of air temperature reductions that are expected under mature riparian vegetation. System-potential riparian microclimate can also include expected changes to wind speed and relative humidity.

System-potential temperature: An approximation of the temperatures that would occur under natural conditions. System potential is our best understanding of natural conditions that can be supported by available analytical methods. The simulation of the system-potential condition uses best estimates of *mature riparian vegetation*, *system-potential channel morphology*, *and system-potential riparian microclimate* that would occur absent any human alteration.

Thalweg: The deepest and fastest moving portion of a stream.

Total Maximum Daily Load (TMDL): A distribution of a substance in a water body designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Total suspended solids (TSS): Portion of solids retained by a filter.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Wasteload allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

1-DMax or 1-day maximum temperature: The highest water temperature reached on any given day. This measure can be obtained using calibrated maximum/minimum thermometers or continuous monitoring probes having sampling intervals of thirty minutes or less.

303(d) list: Section 303(d) of the federal Clean Water Act, requiring Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

7-DADMax or 7-day average of the daily maximum temperatures: The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days before and the three days after that date.

7Q2 flow: A typical low-flow condition. The 7Q2 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every other year on average. The 7Q2 flow is commonly used to represent the average low-flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q2 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

7Q10 flow: A critical low-flow condition. The 7Q10 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every ten years on average. The 7Q10 flow is commonly used to represent the critical flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q10 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

90th percentile: An estimated portion of a sample population based on a statistical determination of distribution characteristics. The 90th percentile value is a statistically derived estimate of the division between 90% of samples, which should be less than the value, and 10% of samples, which are expected to exceed the value.

Acronyms and Abbreviations

BMP	Best management practice
DO	Dissolved oxygen
DOC	Dissolved organic carbon
e.g.	For example
Ecology	Washington State Department of Ecology

EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
FC	Fecal coliform
GIS	Geographic Information System software
GPS	Global Positioning System
i.e.	In other words
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
NAF	New Approximation Flow
NPDES	National Pollutant Discharge Elimination System
NSDZ	Near-stream disturbance zones
NTR	National Toxics Rule
PBDE	Polybrominated diphenyl ethers
PBT	Persistent, bioaccumulative, and toxic substance
PCB	Polychlorinated biphenyls
QA	Quality assurance
QC	Quality control
RM	River mile
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
SRM	Standard reference materials
TIR	Thermal infrared radiation
TMDL	Total Maximum Daily Load
TOC	Total organic carbon
TSS	Total suspended solids
USFS	United States Forest Service
USGS	United States Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

WQA	Water Quality Assessment
WRIA	Water Resource Inventory Area
WSTMP	Washington State Toxics Monitoring Program
WWTP	Wastewater treatment plant

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cfu	colony forming units
cms	cubic meters per second, a unit of flow
dw	dry weight
ft	feet
g	gram, a unit of mass
kcfs	1000 cubic feet per second
kg	kilograms, a unit of mass equal to 1,000 grams
kg/d	kilograms per day
km	kilometer, a unit of length equal to 1,000 meters
L/s	liters per second (0.03531 cubic foot per second)
m	meter
mm	millimeter
mg	milligram
mgd	million gallons per day
mg/d	milligrams per day
mg/kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mg/L/hr	milligrams per liter per hour
mL	milliliter
mmol	millimole or one-thousandth of a mole
mole	an International System of Units (IS) unit of matter
ng/g	nanograms per gram (parts per billion)
ng/kg	nanograms per kilogram (parts per trillion)
ng/L	nanograms per liter (parts per trillion)

NTU	nephelometric turbidity units
pg/g	picograms per gram (parts per trillion)
pg/L	picograms per liter (parts per quadrillion)
psu	practical salinity units
s.u.	standard units
µg/g	micrograms per gram (parts per million)
µg/kg	micrograms per kilogram (parts per billion)
µg/L	micrograms per liter (parts per billion)
µm	micrometer
µM	micromolar (a chemistry unit)
µmhos/cm	micromhos per centimeter
µS/cm	microsiemens per centimeter, a unit of conductivity
ww	wet weight

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data (Kammin, 2010). For Ecology, it is defined according to WAC 173-50-040: "Formal recognition by [Ecology] that an environmental laboratory is capable of producing accurate and defensible analytical data."

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms *precision* and *bias* be used to convey the information associated with the term *accuracy* (USEPA, 2014).

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella (Kammin, 2010).

Bias: Discrepancy between the expected value of an estimator and the population parameter being estimated (Gilbert, 1987; USEPA, 2014).

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process (USGS, 1998).

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured (Ecology, 2004).

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards but should be referred to by their actual designator, e.g., CRM, LCS (Kammin, 2010; Ecology, 2004).

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator (USEPA, 2014; USEPA, 2020).

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator (USEPA, 2014; USEPA 2020).

Continuing Calibration Verification Standard (CCV): A quality control (QC) sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run (Kammin, 2010).

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system (Kammin, 2010; Ecology 2004).

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean (Kammin, 2010).

Data integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading (Kammin, 2010).

Data quality indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity (USEPA, 2006).

Data quality objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010).

Data validation: The process of determining that the data satisfy the requirements as defined by the data user (USEPA, 2020). There are various levels of data validation (USEPA, 2009).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set (Ecology, 2004).

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero (Ecology, 2004).

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis (USEPA, 2014).

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport (Ecology, 2004).

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples (Kammin, 2010).

Laboratory Control Sample (LCS)/LCS duplicate: A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. Monitors a lab's performance for bias and precision (USEPA, 2014).

Matrix spike/Matrix spike duplicate: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias and precision errors due to interference or matrix effects (Ecology, 2004).

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness (USEPA, 2006).

Measurement result: A value obtained by performing the procedure described in a method (Ecology, 2004).

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed (USEPA, 2001).

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples (Ecology, 2004; Kammin, 2010).

Method Detection Limit (MDL): The minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results (USEPA, 2016). MDL is a measure of the capability of an analytical method of distinguished samples that do not contain a specific analyte from a sample that contains a low concentration of the analyte (USEPA, 2020).

Minimum level: Either the sample concentration equivalent to the lowest calibration point in a method or a multiple of the method detection limit (MDL), whichever is higher. For the purposes of NPDES compliance monitoring, EPA considers the following terms to be synonymous: "quantitation limit," "reporting limit," and "minimum level" (40 CFR 136).

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all parameters (Kammin, 2010; Ecology, 2004).

Population: The hypothetical set of all possible observations of the type being investigated (Ecology, 2004).

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator (USGS, 1998).

Quality assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data (Kammin, 2010).

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives (Kammin, 2010; Ecology, 2004).

Quality control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data (Ecology, 2004).

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$RPD = [Abs(a-b)/((a + b)/2)] * 100\%$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Relative Standard Deviation (RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$RSD = (100\% * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled (USGS, 1998).

Reporting level: Unless specified otherwise by a regulatory authority or in a discharge permit, results for analytes that meet the identification criteria (i.e., rules for determining qualitative presence/absence of an analyte) are reported down to the concentration of the minimum level

established by the laboratory through calibration of the instrument. EPA considers the terms "reporting limit," "quantitation limit," and "minimum level" to be synonymous (40 CFR 136).

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator (USGS, 1998).

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population (USGS, 1998).

Sample (statistical): A finite part or subset of a statistical population (USEPA, 1992).

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit (Ecology, 2004).

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method (USEPA, 2014).

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency (USEPA, 2014).

Split sample: A discrete sample subdivided into portions, usually duplicates (Kammin, 2010).

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity (Kammin, 2010).

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning (USEPA, 2006).

References for QA Glossary

40 CFR 136. Title 40 Code of Federal Regulations, Part 136: Guidelines Establishing Test Procedures for the Analysis of Pollutants. Available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=3cf9acace214b7af340ea8f6919a7c39&mc=true&node=pt40.25.136&rgn=div5 (accessed 26 Feb. 2020).

Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. Available

at: https://fortress.wa.gov/ecy/publications/SummaryPages/0403030.html (accessed 6 Mar. 2020).

Gilbert, R.O., 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, New York, NY.

Kammin, W., 2010. Definition developed or extensively edited by William Kammin, 2010. Washington State Department of Ecology, Olympia, WA.

USEPA, 1992. Guidelines for exposure assessment. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, D.C. EPA/600/Z-92/001. Available at: https://www.epa.gov/sites/production/files/2014-11/documents/guidelines_exp_assessment.pdf (accessed 26 Feb. 2020).

USEPA, 2001. EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5. U.S. Environmental Protection Agency, Washington, DC. EPA/240/B-01/003. Available at: https://www.epa.gov/quality/epa-qar-5-epa-requirements-quality-assurance-project-plans (accessed 26 Feb. 2020).

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. U.S. Environmental Protection Agency, Washington, DC. Available at: https://www.epa.gov/sites/production/files/2015-06/documents/g4-final.pdf (accessed 26 Feb. 2020).

USEPA, 2009. Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use, OSWER No. 9200.1-85, EPA 540-R-08-005. U.S. Environmental Protection Agency, Washington, DC. Available at: https://www.epa.gov/nscep.

USEPA, 2014. Compendium: Project Quality Assurance and Quality Control: Chapter 1. U.S. Environmental Protection Agency, Washington, DC. SW-846 Update V. Available at: https://www.epa.gov/sites/production/files/2015-10/documents/chap1_1.pdf (accessed 26 Feb. 2020).

USEPA, 2016. Definition and Procedure for the Determination of the Method Detection Limit, Revision 2. EPA 821-R-16-006. U.S. Environmental Protection Agency, Washington, DC. Available at: https://www.epa.gov/sites/production/files/2016-12/documents/mdl-procedure_rev2_12-13-2016.pdf (accessed 6 Mar. 2020).

USEPA, 2020. Glossary: Environmental Sampling and Analytical Methods (ESAM) Program. U.S. Environmental Protection Agency, Washington, DC. Available at: https://www.epa.gov/esam/glossary (accessed 26 Feb. 2020).

USGS, 1998. Principles and Practices for Quality Assurance and Quality Control. Open-File Report 98-636. U.S. Geological Survey, Reston, VA. Available at: https://pubs.usgs.gov/of/1998/ofr98-636/ (accessed 26 Feb. 2020).

WAC 173-50-040. Title 173 Washington Administrative Code. Accreditation of Environmental Laboratories: Definitions. Available at: https://apps.leg.wa.gov/WAC/default.aspx?cite=173-50-040 (accessed 26 Feb. 2020).

Quality Assurance Project Plan

Sequim-Dungeness Clean Water District (CWD) Pollution Identification & Correction (PIC), Trends and Project Monitoring

(Section 319 Match)

Created February 2015

Updated October 2019

Prepared for:
Washington State Department of Ecology

Prepared by:
Clallam County Department of Public Works-Roads
Clallam County Department of Health and Human Services
Clallam Conservation District

Publication Information

The work described herein is supported by a grant from the Washington State Department of Ecology (WQC2020ClCHHS00011). The contents of the QAPP do not necessarily reflect the views and policies of Ecology nor Ecology's mention of trade names or commercial products constitute endorsement or recommendation for use.

This QAPP is available on Clallam Conservation District's website at www.clallamcd.org. Pollution Identification and Correction (PIC) and other water quality monitoring data from this project will be available from Clallam County Health and Human Services, Environmental Health Section (CCEH). Appropriate data will also be uploaded to the Washington State Department of Ecology (Ecology) Environmental Information Management database: www.Ecology.wa.gov/eim/index.htm

Author and Contact Information

Jennifer Bond
Clallam Conservation District
228 W First St., Ste. H
Port Angeles, WA 98362
360.775.3747; jennifer.bond@clallamcd.org

Andrew Perham
223 E 4th St., Ste. 14
Port Angeles, WA 98362
360.417.2350; aperham@co.clallam.wa.us

Heather Watts
Clallam County Environmental Health Services
111 E 3rd Street
Port Angeles, WA 98362
360.417.2415; hwatts@co.clallam.wa.us

Contributors: Ed Chadd, Carol Creasy, and Jacob Melly

Quality Assurance Project Plan

Sequim-Dungeness Clean Water District (CDW) Pollution Identification & Correction (PIC), Trends and Project Monitoring (Section 319 Match)

November 2019

Approved by:

Signature: Heather Watts Heather Watts, Author, PIC Coordinator, CCHHS/EH	Date: 12/9/19
Signature: Jennifer Garcelon Jennifer Garcelon, EH Director, CCHHS	Date: 12/9/19
Signature: Noelle Nordstrom Noelle Nordstrom, Streamkeepers Coordinator, QA Officer, Data Manager, Streamkeepers Program, Clallam County Dept. of Public Works-Roads	Date: 1/6/2020
Signature: Jennifer Bond Jennifer Bond, Author, PIC Plan Development Project Manager, Clallam Conservation District	Date 1-7-20
Signature: Lawrence Sullivan Lawrence Sullivan, Ecology's Unit Supervisor, Water Cleanup and Technical Assistance, Southwest Regional Office	Date: 12/10/19
Signature: Leanne Whitesell, Ecology Project Manager, Water Quality Program, Southwest Regional Office	Date: 12/9/19
Signature: Britta Voss ~~Arati Kaza, Ecology Quality Assurance Team~~ Britta Voss, QA officer (acting), Ecology	Date: 1/6/20
Signature: Katherine Ann Krogslund Katherine Krogslund, Sample Coordinator University of Washington Marine Chemistry Laboratory	Date: 1/8/20
Signature: Sue Waldrip Sue Waldrip, Water Lab Manager, Clallam County Environmental Health Water Lab	Date: 1/6/20

Quality Assurance Project Plan

Sequim-Dungeness Clean Water District (CDW)
Pollution Identification & Correction (PIC),
Trends and Project Monitoring (Section 319 Match)

November 2019

Approved by:

Signature:	Date:
Heather Watts, Author, PIC Coordinator, CCHHS/EH Signature:	Date:
Jennifer Garcelon, EH Director, CCHHS Signature:	Date:
Noelle Nordstrom, Streamkeepers Coordinator, QA Officer, Data Manager, Streamkeepers Program, Clallam County Dept. of Public Works-Roads Signature:	Date:
Jennifer Bond, Author, PIC Plan Development Project Manager, Clallam Conservation District Signature:	Date:
Lawrence Sullivan, Ecology's Unit Supervisor, Water Cleanup and Technical Assistance, Southwest Regional Office Signature:	Date:
Leanne Whitesell, Ecology Project Manager, Water Quality Program, Southwest Regional Office Signature:	Date:
Arati Kaza, Ecology Quality Assurance Team Signature:	Date:
Katherine Krogslund, Sample Coordinator University of Washington Marine Chemistry Laboratory Signature:	Date:
Sue Waldrip, Water Lab Manager, Clallam County Environmental Health Water Lab	

Table of Contents

List of Figures

List of Tables

Distribution List

In addition to the persons identified on the approval page:

Lori DeLorm, Natural Resource Technician
Jamestown S'Klallam Tribe
1033 Old Blyn Highway, Sequim, WA 98382
360.681.4619
ldelorm@jamestowntribe.org

Hansi Hals, Natural Resources Department Director
Jamestown S'Klallam Tribe
1033 Old Blyn Highway, Sequim, WA 98382
360.681.4601
hhals@jamestowntribe.org

Robert Knapp, Environmental Program Manager
Jamestown S'Klallam Tribe
1033 Old Blyn Highway, Sequim, WA 98382
360.681.4666
rknapp@jamestowntribe.org

Shawn Hines
Watershed Planner
Jamestown S'Klallam Tribe
1033 Old Blyn Highway, Sequim, WA 98382
360.681.4624
shines@jamestowntribe.org

Sara Sekerak
NEP Quality Coordinator
Washington State Department of Ecology
Sara.sekerak@Ecology.wa.gov
360.407.6997

Trevor Swanson
Restoration Program
Growing Area Section
Office of Environmental Public Health
Washington State Department of Health
trevor.swanson@doh.wa.gov
360.236.3313

2.0 Abstract

The overall area of focus comprises the boundaries of the Sequim Bay-Dungeness Watershed Clean Water District, a shellfish protection district created by Clallam County in 2001.Work under the Washington State Department of Ecology WQC2020C1CHHS00011 grant will focus investigative work specifically on the upper Matriotti watershed and lower Bell Creek, while pollution correction will continue in the lower Matriotti watershed, Meadowbrook Creek, Meadowbrook Slough, Golden Sands Slough, and Three Crabs Rd. Trends monitoring will continue at existing sites carried over from previous Pollution Identification and Correction Projects Clallam County Environmental Health will be the lead agency, to be assisted by staff and volunteers from Streamkeepers of Clallam County and the Jamestown S'Klallam Tribe.

3.0 Background

This section was adapted from the *Quality Assurance Project Plan for the Clallam Marine Recovery Area (MRA) Septic Solutions Project* (Soule, 2013), and also from *Quality Assurance Project Plan (QAPP) Sequim-Dungeness Clean Water District Pollution Identification & Correction, Trends, and Project Monitoring(PIC) (*Chadd and Bond, 2015).

3.1 Introduction and problem statement

The Clean Water District (CWD) is located in the eastern portion of Clallam County, Washington, on the northeast coast of the Olympic Peninsula, including the City of Sequim (Figure 1). The western edge of the CWD is defined by land draining to Bagley Creek and the eastern edge extends to the area draining to Sequim Bay on the Miller Peninsula. The CWD drains into the marine waters of the Strait of Juan de Fuca, including Dungeness and Sequim bays.

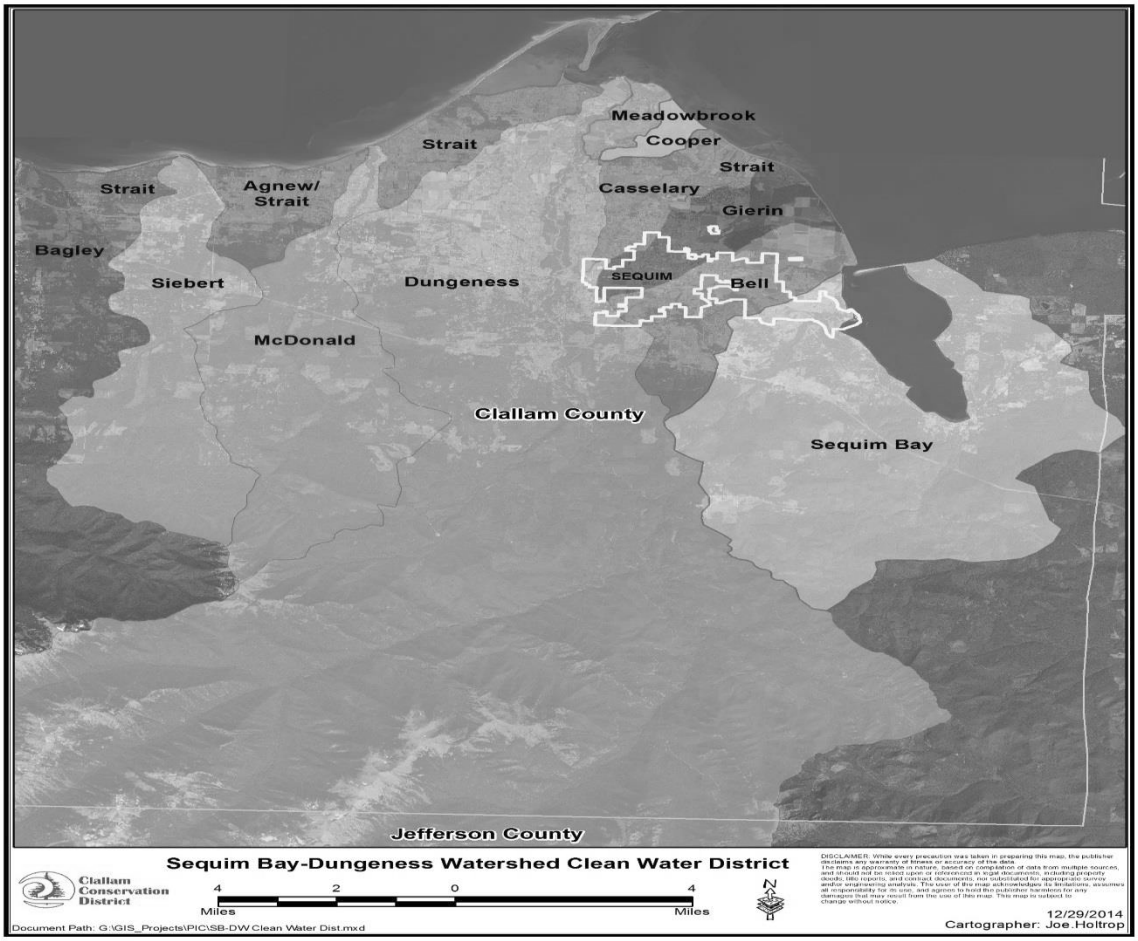


Figure 1: Sequim-Dungeness Clean Water District

Colors denote sub-watersheds within the greater district.

Major Streams within the Clean Water District

Much of the following information was taken from the Elwha-Dungeness Watershed Plan (Elwha-Dungeness Planning Unit 2005).

Tributaries to Sequim Bay:

- Chicken Coop Creek enters the southeast corner of Sequim Bay to the northeast of Jimmycomelately Creek. The mainstem is 3.1 miles in length with an additional 3.1 miles in tributaries.
- No Name Creek, draining to Sequim Bay just south of Chicken Coop Creek, is a generally forested, short, steep creek, relatively undeveloped and minimally impacted by nonpoint sources of pollution.
- Dean Creek is an intermittent stream draining ~3 square miles, flowing ~4 miles from headwaters at an elevation of ~1900' into the southwest corner of Sequim Bay.
- State Park Creek is the largest of several small drainages emptying into the western side of Sequim Bay north of Dean Creek, comprising mixed land uses, including forestry, small farms, and residences.
- Jimmycomelately Creek is the largest stream in the Sequim Bay watershed, draining an extended interior foothill watershed of ~16 square miles, with a vertical drop of 2500' in less than 9 miles, emptying at the south end of Sequim Bay.
- Johnson Creek is the third largest stream within the Sequim Bay watershed (~6.2 square miles), flowing northeast from the foothills of the Olympic Mountains into the west side of Sequim Bay at Pitship Point (near the John Wayne Marina). The total length of Johnson Creek is ~7.4 miles. Five river miles (RM) are attributed to the mainstem, while two miles consist of tributaries. The upper creek flows through a substantial ravine, while the lower two miles are low gradient.
- Bell Creek is a relatively small drainage entering Washington Harbor on the marine shoreline just north of the mouth of Sequim Bay. It is 3.8 miles long and drains a watershed of over 8.9 square miles. Bell Creek has served historically as a conveyance for irrigation water, and much of the creek has been heavily altered by rural and urban development.

Tributaries to Dungeness Bay:

- The Dungeness River flows north into the outer Dungeness Bay just east of the opening between Graveyard and Cline Spits. The river is 32 miles long and drains 172,517 acres. The upper two-thirds of the watershed are within national forest and national park areas. The river contributes the vast majority of freshwater to the Bay (Soule 2013).
- Matriotti Creek is 9.3 miles long and is the largest low-elevation tributary to the Dungeness River, flowing into it on the left bank at RM 1.9.
- Lotzgesell Creek is a tributary to Matriotti Creek that encompasses similar land uses.
- Hurd Creek is a small, low-elevation tributary approximately one mile long that flows into the Dungeness River on the right bank at RM 2.7.
- Meadowbrook Creek flows north toward Dungeness Bay approximately 0.4 miles east of the Dungeness River mouth. Meadowbrook Slough (also referred to as Dungeness Slough,

by neighbors) is approximately 0.5 miles long and parallels a dike along the lower reaches of the Dungeness River. The points of discharge of the Dungeness River, Meadowbrook Slough, and Meadowbrook Creek are dynamic—occasionally the lesser waterways discharge directly into the bay, while other times they first join the Dungeness River which in turn discharges into the bay.

- Golden Sands Slough discharges into outer Dungeness Bay southeast of Meadowbrook Creek. The slough is a series of constructed channels in an estuarine wetland area. Water in the slough tends to be saline and stagnate (Sargeant 2002).
- Cooper Creek discharges into Dungeness Bay just southeast of Golden Sands Slough. The creek is fed by wetlands, and the upland area is undeveloped. The lower portion of the stream channel has been straightened, and the mouth is controlled by a tide gate.
- Cassalery Creek is approximately 4.2 miles long and discharges to Dungeness Bay just southeast of Cooper Creek.
- Gierin Creek discharges into Dungeness Bay just southeast of Cassalery Creek. It is fed by steep-gradient groundwater discharge from the north slopes of the Olympic Mountains. There are 8.3 miles of streams and tributaries in the 3.1 square-mile watershed.
- An un-named intermittent stream periodically discharges to inner Dungeness Bay at the base of Dungeness Spit. Roadside ditches act as stormwater conveyance and may also be used for occasional flushing of irrigation pipelines under the control of the Cline Irrigation District.

<u>Tributaries to the Strait of Juan de Fuca west of Dungeness Bay:</u>

- McDonald Creek is a significant independent drainage, entering the Strait of Juan de Fuca between the western end of Dungeness Spit and Green Point. Its 13.6 miles drain ~23.0 square miles of the northeast flank of Blue Mountain, with headwaters originating at ~4,700'. The creek flows through a deeply incised coastal upland and marine bluff.
- Agnew Ditch is part of Sequim's irrigation ditch system, originating from the Dungeness River. It is conveyed for several miles via McDonald Creek before irrigating the Agnew area—where it is sometimes known as Agnew Creek—and emptying to the Strait.
- Siebert Creek, 12.4 miles long, drains 19.5 square miles of the northwest flank of Blue Mountain and is a significant independent drainage, entering the Strait at Green Point. The watershed includes 31.2 miles of mainstem stream and tributaries, much of which is well incised, with its upper watershed reaching an elevation of 3,800'. It is the westernmost stream influenced directly by Dungeness area irrigation flows.
- Bagley Creek is a medium-sized independent drainage, entering the Strait ~2 miles west of Green Point. It is the westernmost watershed of the CWD. The drainage has approximately 9.5 miles of streams and tributaries.

In 1997, the Washington State Department of Health (WDOH) reported increasing levels of fecal coliform (FC) bacteria in Dungeness Bay near the mouth of the Dungeness River. Bacteria levels continued to increase in later monitoring activities, with higher levels of bacteria occurring in inner Dungeness Bay. As a result, in 2000 WDOH closed 300 acres near the mouth of the Dungeness River to shellfish harvest. In 2001, 100 more acres were added to the closure area.

Then, in 2003, based on a continuing decline in water quality, 1150 acres from the inner portion of Dungeness Bay were reclassified from Approved to Conditionally Approved and an additional 250 acres from the outer bay were reclassified from Approved to Prohibited. Shellfish harvest is allowed in the Conditionally Approved area from February to October.

Since 2003, WDOH has gradually upgraded the classification of several stations in Dungeness Bay from “Prohibited” to "Conditionally Approved", meaning that shellfish harvest is open from February through October but closed in the rainy season—from November through January. In 2011, 500 acres in the bay were upgraded from “Prohibited” to “Conditionally Approved.” Four sites that are near or relatively close to the mouth of the River remain closed year round (WDOH 2012). In 2015, 688 acres in the bay were upgraded from “Conditionally Approved” to “Approved”, and 40 acres were upgraded from “Prohibited” to “Conditionally Approved.” Please refer to Figure 2 for a map of WDOH sampling locations and classifications

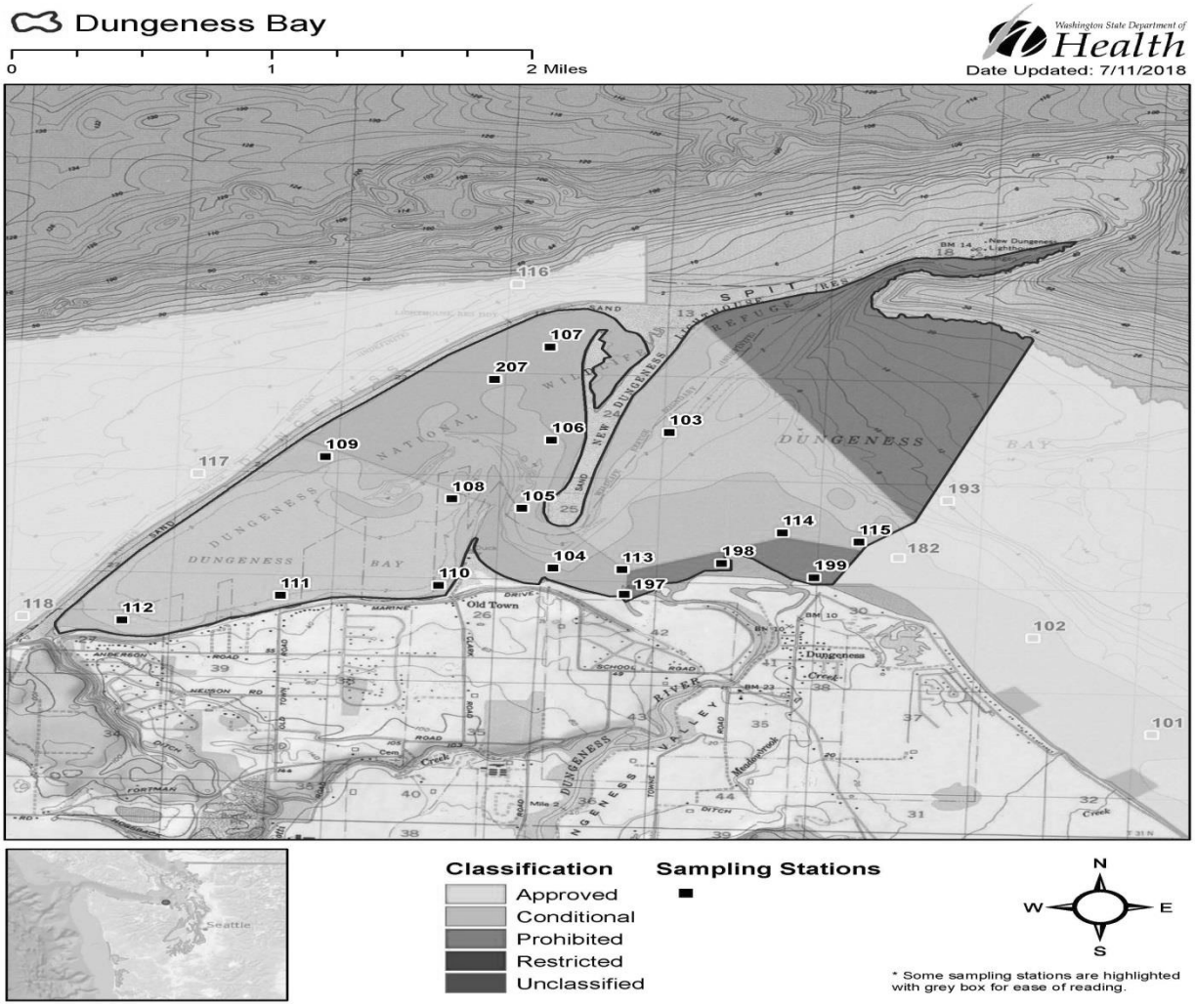


Figure 2: Marine monitoring stations in and around Dungeness Bay with shellfish growing area classification:

(Washington State Department of Health, July 11, 2018).

While water quality improvements have been made within the CWD, areas of Dungeness Bay remain closed to shellfish harvesting because of high fecal coliform bacteria levels. The majority

of water quality monitoring that has occurred to date has been project specific and grant funded. This has made the collection and analysis of long-term water quality data extremely difficult.

This PIC project (Ecology grant WQC2020ClCHHS00011) will continue the Trends Monitoring Program (Figure 3) on approximately 18 CWD streams to collect data on nutrients, fecal indicator bacteria, and other standard physical and chemical parameters at locations just upstream from marine waters. This data helps guide selection of prioritized waterways for targeted/segmented water quality improvement projects, such as this PIC project.

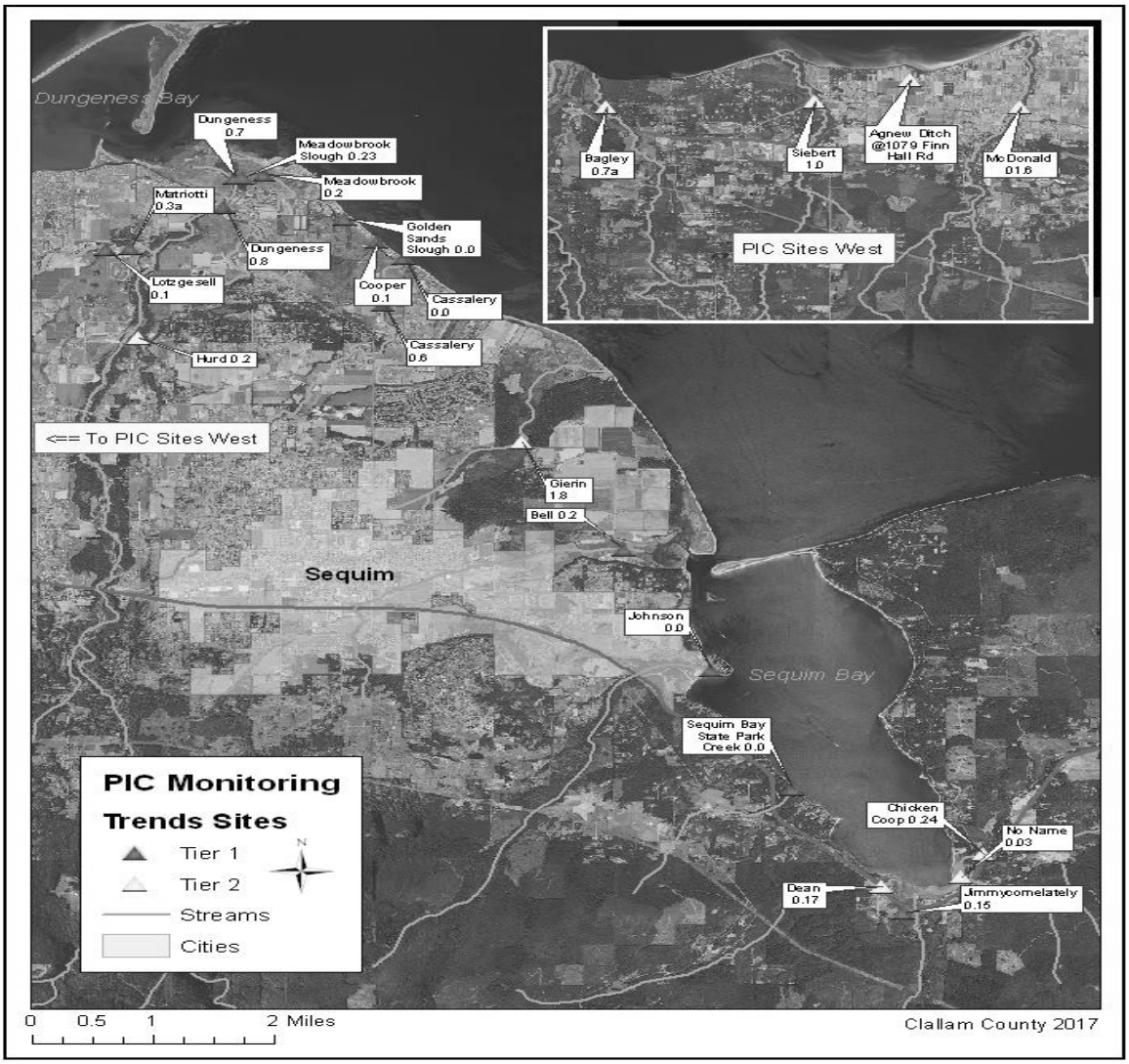


Figure 3: Trends Monitoring Program Sites

Through the planned PIC Project Monitoring Program, segmented sampling will be conducted at 15 sites to identify pollution "hot spots" and sources that can be corrected. Segmented sampling will mainly be conducted in the expanded PIC Project area (upper Matriotti watershed and lower Bell Creek), followed up with correction actions if/when pollution sources are identified. Pollution correction will continue in portions of the Project Area where segmented sampling has generally concluded (Lower Matriotti, Meadowbrook Creek, Meadowbrook Slough, Golden

Sands Slough, and Three Crabs Road). Corrective actions to follow if/when pollution sources are identified.

The goal of these combined tasks is to empower those living within the PIC focus area to make decisions that protect water quality and correct potential pollution sources that increase the quality of the surface water flowing into the bays and ultimately lead to the upgrade of shellfish growing areas.

3.2 Study area and surroundings

3.2.1 History of study area

The study area is the Sequim Bay-Dungeness Watershed CWD, which is bounded on the west by the Bagley Creek drainage area and on the east by the Sequim Bay drainage.

Dungeness Bay and Sequim Bay have traditionally been rich in littleneck clams. Native people have harvested shellfish here throughout tribal memory. In the 1900s, commercially farmed oysters provided local jobs. Recreational harvest has been popular with residents and tourists, and contributes to the image of Sequim as a beautiful and pristine area (Streeter and Hempleman 2004).

The climate in this region of the Olympic Peninsula is considerably drier than elsewhere in western Washington because it lies in the rain shadow of the Olympic Mountains. Precipitation varies from 15 inches near Sequim to 80 inches in the headwaters of the Dungeness River. Due to the low rainfall, the lower Dungeness valley contains about 170 miles of irrigation water conveyance to support approximately 6,000 acres in agricultural production.

Land use within the study area is mostly rural residential and agricultural. Historically, most of the study area outside of the city of Sequim was farmland. A population increase during the past 20 years has resulted in a significant amount of farmland being converted to residential use. Commercial uses are mostly located within the city of Sequim and the Carlsborg urban growth area (UGA). The city of Sequim and the Carlsborg UGA are both served by sewer systems, while residential and commercial businesses in the rural areas use on-site septic systems (OSS).

Existing data are fairly recent and plentiful for core study sites as well as optional sites. This is thanks to the Washington State Department of Ecology (Ecology) Total Maximum Daily Load (TMDL) studies and efforts of CWD members, especially the Jamestown S'Klallam Tribe (JS'KT), Streamkeepers of Clallam County (SK), and Clallam County Environmental Health (CCEH). This project addresses a need to update water quality conditions in the lower Dungeness.

3.2.2 Summary of previous studies and existing data

Numerous studies on surface and ground water quality have been conducted over the past several decades within the Sequim Bay-Dungeness Watershed CWD, particularly the Dungeness Bay drainage. Background information presented in this QAPP is based on the following documents:

1. Dungeness River and Matriotti Creek fecal coliform TMDL (Sargeant 2002) and post-TMDL data review (Sargeant 2004b).
2. Dungeness Bay fecal coliform TMDL (Sargeant 2004a).
3. An initial shellfish closure response plan, a.k.a, Detailed Implementation Plan, was integrated with Water Cleanup Plans associated with both TMDLs into a "Clean Water Strategy" (Streeter and Hempleman 2004). This Strategy has guided the activities of the Dungeness Clean Water Work Group (CWWG) since it was prepared. Status reports on its implementation are submitted annually by Clallam County to the WDOH.
4. Microbial source tracking (MST) found evidence that many animal groups, including humans, contribute to bacterial contamination in Dungeness watershed and Bay (Woodruff et al. 2009a).
5. Effectiveness monitoring, including monthly sampling at dozens of sites over a two-year period for both FC and nutrients (Woodruff et al. 2009b).
6. Ecology conducted a FC TMDL effectiveness monitoring project (Brown 2009, Cadmus Group 2010).

TMDL studies were conducted for both the lower Dungeness River watershed (Sargeant 2002) and Dungeness Bay (Sargeant 2004a). The main objective for both studies was to determine load reductions for FC bacteria. This was done by estimating pollutant loads and concentrations for tributaries to the bay, modeling an acceptable loading capacity, and recommending load allocations.

The *Dungeness River and Matriotti Creek Fecal Coliform Bacteria Total Maximum Daily Load Study* (Sargeant 2002) measured FC concentrations in several freshwater tributaries to Dungeness Bay in 1999 and 2000. The purpose of the study was to determine the freshwater sources of FC that discharge into the bay. The study area included the lower Dungeness River, Hurd Creek, Matriotti Creek, Meadowbrook Creek, and Meadowbrook Slough. The results of the study set target reductions for FC concentrations in these and other tributaries to the Bay.

Rensel Associates conducted bacteria sampling in Dungeness Bay and ditches discharging into the Bay from October 2001 to 2002. A circulation and bathymetry study was also conducted and documented in an April 2003 final technical report (Rensel 2003). The Rensel study was summarized and used as the basis for the *Dungeness Bay Fecal Coliform Bacteria Total Maximum Daily Load Study* (Sargeant 2004a). The TMDL addressed FC bacteria in inner and outer Dungeness Bay, irrigation ditches to the inner Dungeness Bay, and the Dungeness River. Target reductions for FC concentrations were set for the Dungeness River and irrigation ditches discharging to inner Dungeness Bay.

TMDL study findings included:

- *Elevated FC levels are found in several freshwater tributaries flowing into the bay. More stringent load reductions are needed in several upstream tributaries to meet the marine FC criterion in Dungeness Bay, including the Dungeness River (mouth to RM 0.3), Matriotti Creek, Hurd Creek, Meadowbrook Creek, Meadowbrook Slough, Golden Sands Slough, and Cooper Creek.*

- *There are no permitted point source discharges in the study area.*
- *FC pollution is attributed to nonpoint sources, including on-site septic systems, pet and livestock waste, stormwater runoff, and wildlife.*
  The critical period for inner Dungeness Bay is November through February, and the critical period for the outer Dungeness Bay near the mouth of the Dungeness River is March through July.

3.2.3 Parameters of interest and potential sources

The parameters of interest for this project are nutrients, bacteria, temperature, pH, salinity, dissolved oxygen, and conductivity.

OSS failures can contribute to elevated FC levels in freshwater tributaries to the bays. Citizen education about proper OSS operation and maintenance, regular OSS inspections, and system repairs continue to reduce OSS sources of pollution. Within the past decade, the Clallam County Department of Community Development (DCD), CCEH and JSKT decommissioned eight on-site systems from the mouth to RM 1.0 for river restoration purposes. Clallam Conservation District (CCD) offers a cost-sharing program to assist with the repair of failing OSSs that are suspected of impacting water quality.

Other potential sources of FC include livestock, pets, and wildlife.

Projects conducted by the CCD and the Sequim-Dungeness Water Users Association have resulted in the piping of many miles of open irrigation ditches. These projects reduce the amount of water diverted from the Dungeness River, help prevent pollutants from entering the irrigation system, and when totally enclosed, eliminate tail-water discharges to marine and fresh waters.

3.2.4 Regulatory criteria or standards

Chapter 173-201A of the Washington Administrative Code (WAC) establishes water quality standards for surface waters of the state "consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife." These waters are "protected by numeric and narrative criteria, designated uses, and an antidegradation policy."

All tributaries in the project area are identified in Table 602 of this WAC with the varying criterion for the project's parameters of interest.

3.3 Water quality impairment studies

FC concentrations in Matriotti Creek were found to exceed water quality standards in 1991. Matriotti Creek was placed on Washington's 303(d) list of impaired waters in 1996. Dungeness Bay continued to meet water quality standards through 1996.

Like small streams, the network of irrigation ditches was found to be an additional conduit for fecal coliform to enter Dungeness Bay and its tributaries. Agricultural best management practice implementation and the piping of open ditches have reduced FC inputs to the irrigation system.

Please refer to section 3.2 for historical information regarding changes to shellfish bed growing classifications to Dungeness and Sequim Bays.

3.4 Effectiveness monitoring studies

Fecal coliform data collection and analysis

Clallam County and JS'KT conducted FC sampling at many of the freshwater TMDL sites from 2001 to 2004. These data, and data collected by Ecology's ambient monitoring program, were compared to the initial TMDL FC data collected in 1999 and 2000. The results of this analysis were presented in the *Dungeness River and Matriotti Creek Post-Total Maximum Daily Load Data Review* (Sargeant 2004b).

The purpose of the 2004 post-TMDL analysis was to determine whether FC bacteria levels were improving in the tributaries to the bay and if the cleanup actions implemented had been effective. The analysis found significant improvement in some areas and seasons. The 2001-2004 data showed that further reductions are necessary even though the trend during certain critical seasons was showing a decrease in FC concentrations. The Matriotti Creek sites showed the greatest decline and may have contributed to a slight decline in FC concentrations in the Dungeness River. Meadowbrook Creek showed a slight increase in FC concentrations (Sargeant 2004a).

In 2005, Clallam County received a Centennial Clean Water Fund grant from Ecology and JS'KT received an Environmental Protection Agency (EPA) Targeted Watershed Grant. Portions of both grant funds were for FC monitoring in the Dungeness watershed (Streeter 2005).The County and Tribe combined efforts to monitor 58 sites monthly in the Dungeness watershed for FC from September 2005 to August 2008. Some of these sites were selected to fill gaps in ambient water quality information. Twenty-two of the TMDL study sites were included to continue evaluating the effectiveness of TMDL implementation. Irrigation ditches included in the *Dungeness Bay TMDL* study were also sampled when water was flowing at those sites. Seven of the 12 TMDL sites targeted for remediation of FC counts were monitored consistently between 1999 and 2009.

Extensive FC data sets resulting from this monitoring have been analyzed and reported in publications by Battelle (Woodruff et al. 2009b) and Cadmus Group (2010). Both reports present multiple diagrams and illustrations of trends by parameter and sub-area; the reader is referred to the online reports to view specific figures of interest:

- Battelle: "Effectiveness Monitoring of Fecal Coliform Bacteria and Nutrients in the Dungeness Watershed, Washington"
- Ecology: "Dungeness Bay and Dungeness River Watershed Fecal Coliform Bacteria Total Maximum Daily Load Water Quality Effectiveness Monitoring Report" http://www.Ecology.wa.gov/pubs/1003032.pdf

The WDOH continues to conduct monthly sampling in Dungeness Bay to monitor FC pollution in shellfish growing areas as part of the National Shellfish Sanitation Program (WDOH 2009). Analyses of WDOH data found evidence of a reduction in FC pollution from 2003-2011 (DOH 2012). Some areas are "Conditionally Approved" (closed Nov–Jan) rather than "Approved"

because water quality in general is consistently poor in winter months. WDOH shoreline surveys conducted in 2007 and 2008 traced elevated FC levels to both Golden Sands Slough and Cassalery Creek. Further evaluation in Golden Sands Slough found problems with OSS systems and direct sewage discharge to the slough. As a result, WDOH prohibited commercial shellfish harvest within 140-meter and 121-meter radii around the mouths of Golden Sands Slough and Cassalery Creek.

From April 2013 to March 2014, CCEH, in partnership with SK and the JS'KT, conducted a water quality monitoring project under an Ecology grant. This project had two objectives (Soule 2013):

1. Assess the current status of FC bacteria and nutrient concentration in the lower Dungeness River and several area streams through ambient monitoring. Fourteen stations were monitored for the ambient study.
2. Study the potential effectiveness of OSS repair in improving surface water quality in adjacent waterways. Unfortunately, no opportunities for septic system repair occurred during the project period, thus system repair effectiveness could not be evaluated.

Data from this project has been recently analyzed and is expected to help with initial prioritization for targeted PIC monitoring (Clallam County, 2014).From January 2015 to present, CCEH, in partnership with SK and the JS'KT have been conducting a PIC Pilot Project under an EPA National Estuary Project (NEP) grant. This project had multiple objectives (Chadd and Bond, 2015):

1. To conduct monthly trends monitoring at 12 sites within the overall project area (MRA), and quarterly trends monitoring at 9 sites. Results showed a continuation of elevated FC at several sample sites, which guided the current project partners to select the focus areas for the 2017-2019 "Phase 2" project area and the proposed 2019-2022 "Phase 3" project areas for the upcoming Ecology grant.
2. To conduct segmented FC sampling within the selected project area (Meadowbrook Slough and Creek, Golden Sands Slough, Cooper Creek). Meadowbrook Slough and Golden Sands slough were (and still are) the focus of this project due to high targeted sampling results. Meadowbrook Creek and Cooper Creek did not show similar high FC results and were monitored through trends sampling, with the occasional targeted sampling on Meadowbrook Creek.
3. To conduct investigative work within specific Meadowbrook Slough and Golden Sands Slough neighborhoods to identify possible pollution sources, mainly in the form of failing OSS systems. Investigation practices included OSS research for each parcel, on-site inspection of operational OSS, and dye testing of certain OSS located directly adjacent to confirmed "hot spots".
4. To perform corrective actions once potential pollution sources are identified, e.g. requiring OSS repair(s), assist agricultural owners with best management practices (BMP), etc. Neither Meadowbrook Slough nor Golden Sands Slough produced a "smoking gun" regarding a direct pollution source. CCEH required all operating OSS to have systems inspected, and all non-conforming waste disposal methods come into

compliance with WACs and Clallam County Codes (CCC). OSS inspection compliance was largely met, and waste disposal compliance is still ongoing, with two conforming systems in the ground in Golden Sands, and several pending.

Nutrient data collection and analysis

There are no water quality criteria for nutrients in streams; however, when nutrients are found at high levels, they can have a negative impact on aquatic systems. Anthropogenic alterations within a watershed generally lead to higher nutrient concentrations.

The chemical speciation of nutrients becomes an important factor both for evaluation of ecological impacts and as a tracer of source contaminants. For example, ammonium (NH4) is generally found in areas with low oxygen availability (i.e. groundwater) and is rapidly oxidized to nitrate (NO3) in contact with surface waters. Its presence in surface waters, even at low levels, could indicate close proximity to potential sources such as septic systems or agricultural runoff.

Targeted Watershed Initiative funding from EPA obtained by the JS'KT for 2005-08 sampling included collection of nutrient (nitrogen and phosphorus) data from all sites. These data (over 830 nutrient observations), Battelle (Woodruff et al. 2009b) provide a characterization of nutrients in the watershed, including descriptive statistics and general trends.

For a general reference, nutrient data were compared to historic data (nitrate and phosphate [PO4]) collected at another location in the upper Dungeness River between 1959 and 1970. Study findings include:

- For the most part, recent nutrient levels in the lower Dungeness watershed were not very different than historic values, although a direct site comparison could not be made. There were, however, several trends in the data that warrant further investigation.
- NH4 concentrations were slightly higher in all Dungeness River tributaries and Bell Creek compared to those detected in the River or Johnson Creek.
    - In addition, ammonium levels were an order of magnitude higher at Golden Sands Slough, another freshwater station close to the Bay.
    - There were minimal seasonal changes noted in NH4 concentrations, another possible indication of septic system influence since septic system input generally varies less by season than other anthropogenic nutrient sources that get incorporated into seasonal runoff.
- Total inorganic nitrogen (TIN) was higher in Matriotti Creek, Bell Creek, Golden Sands Slough, and the irrigation ditches compared to other water bodies and stations.
    - TIN is an indicator of a number of possible anthropogenic inputs.
    - Overall, the TIN values were higher during the wet season compared to the dry season.
- PO4 and total phosphorus (TP) concentrations showed a similar trend of elevated concentrations in Bell Creek, Golden Sands Slough and the irrigation ditches, with higher concentrations during the wet seasons compared to the dry season.
- There was no significant correlation between nutrients (those mentioned above, plus NO3 and nitrite [NO2]), freshwater FC concentrations, and daily rainfall determined for the days of sample collection. The lack of a statistically significant correlation may be indicative of

varying sources of FC and nutrients; however, analysis of rainfall patterns over a longer duration might demonstrate a correlation.

4.0 Project Description

4.1 Project goals

Three main tasks guide this PIC Project. Work will be focused in the PIC project area highlighted in Figure 4. They include public outreach and education; water quality monitoring and analysis; and technical assistance, correction, and compliance.

The ultimate goal of the project is the upgrade of shellfish growing beds in Dungeness and Sequim Bays. Water quality monitoring and analysis help evaluate this progress and a significant part of the project work is a conducted through a three-pronged approach, each described below.

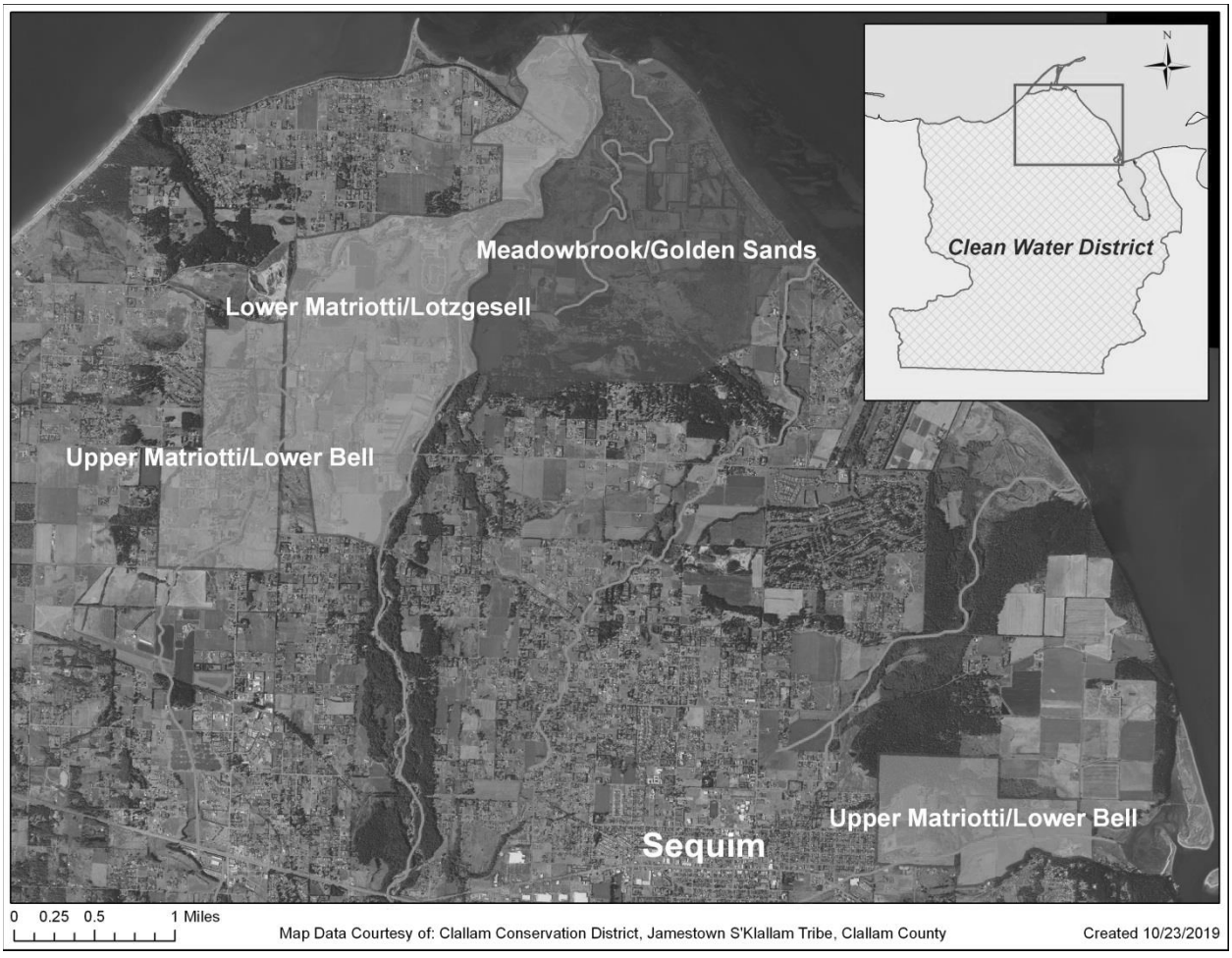


Figure 4: PIC Project Area 2015-2022

Brown: PIC Phase 1/Implementation; Orange: Phase 2; Green: Phase 3

4.2 Project Objectives

This monitoring project has three objectives:

Trends Monitoring Program

A. Identify water quality trends for FC and nutrient pollution within the CWD.
B. Identify waterways that are being impacted by FC and nutrient pollution.
C. Prioritize waterways for PIC Project implementation.

PIC Targeted Monitoring Program

A. Identify sources of bacterial pollution through segmented sampling.
B. Implement correction efforts, e.g. septic system violation abatement, agriculture BMPs, etc.
C. Evaluate effectiveness of pollution correction efforts with follow up water quality sampling.

PIC Project

A. Apply the PIC plan in priority sub-watersheds within the CWD.
B. Identify sources of bacterial pollution through segmented sampling in priority sub-watersheds within the CWD, including Matriotti Creek, Lotzgesell Creek, Meadowbrook Creek, Meadowbrook Slough, and Golden Sands Slough. Other investigative tools include property/OSS evaluation by CCEH field staff, creek "walks", beach "walks", and when practical, dye testing.
C. Use available means to correct suspected sources of pollution within the project area. Examples include public education and outreach, enforcement of State and County Codes, CCEH technical assistance for OSS, and CCD technical assistance for poor agricultural practices.

4.3 Information needed and sources

In addition to the studies reviewed in prior sections, this monitoring plan depends on collaboration between the members of the Sequim Bay-Dungeness CWWG. A subcommittee of CWWG members (consisting of both the signatories and recipients of this plan) has consulted extensively in devising this plan.

4.4 Tasks Required

Trends Monitoring Program Tasks

- Tier 1 waterways (13) will be sampled monthly for FC and bimonthly for nutrients or as funding allows.
- Lower priority Tier 2 waterways (11) will be sampled quarterly for FC, as funding allows.
- Tiers and sampling parameters/periodicity may change in response to data (and available funding). For example, a Tier 1 waterway may drop to Tier 2 if State water quality standards are consistently met, and vice versa, per decision of the CWWG. Upon this occurring, which is not expected to occur during this grant period, reclassification would be reflected in the field logs, databases and an amended QAPP.
- Select polluted waterways for PIC implementation projects.
- Submit data to Ecology's Environmental Information Management (EIM) database (and, in turn, to EPA's STOrage and RETrieval Database [WQX]).

PIC Targeted Monitoring Program Tasks

- Conduct segmented FC sampling on selected waterways to identify sources of bacterial pollution.
- Compile results, assess data, and involve CWWG in preliminary analysis.
- Identify “hot spots” based off of segmented sampling results.
- Implement additional investigative tools such as OSS inspections and dye testing if practical
- Conduct proper corrective actions based on surrounding anthropogenic activity (OSS vs. agriculture).
- Conduct post-remediation activity sampling to evaluate effectiveness.
- Submit all water quality data to Ecology’s EIM (and in turn to EPA’s WQX).

PIC Project Tasks

- Apply PIC Plan to selected project area.
- Compile results, assess data, and involve CWWG in preliminary analysis.
- Use sampling results to direct pollution correction actions within the project area.

4.5 Systematic planning process

The CWWG is tasked with ongoing water quality monitoring and clean-up activities. This group has been meeting regularly to develop the PIC plan, as described above. The PIC plan builds local capacity to adaptively and comprehensively manage pollution by better coordinating water quality monitoring, outreach and clean-up efforts. Figure 5 outlines the PIC Flow Chart.

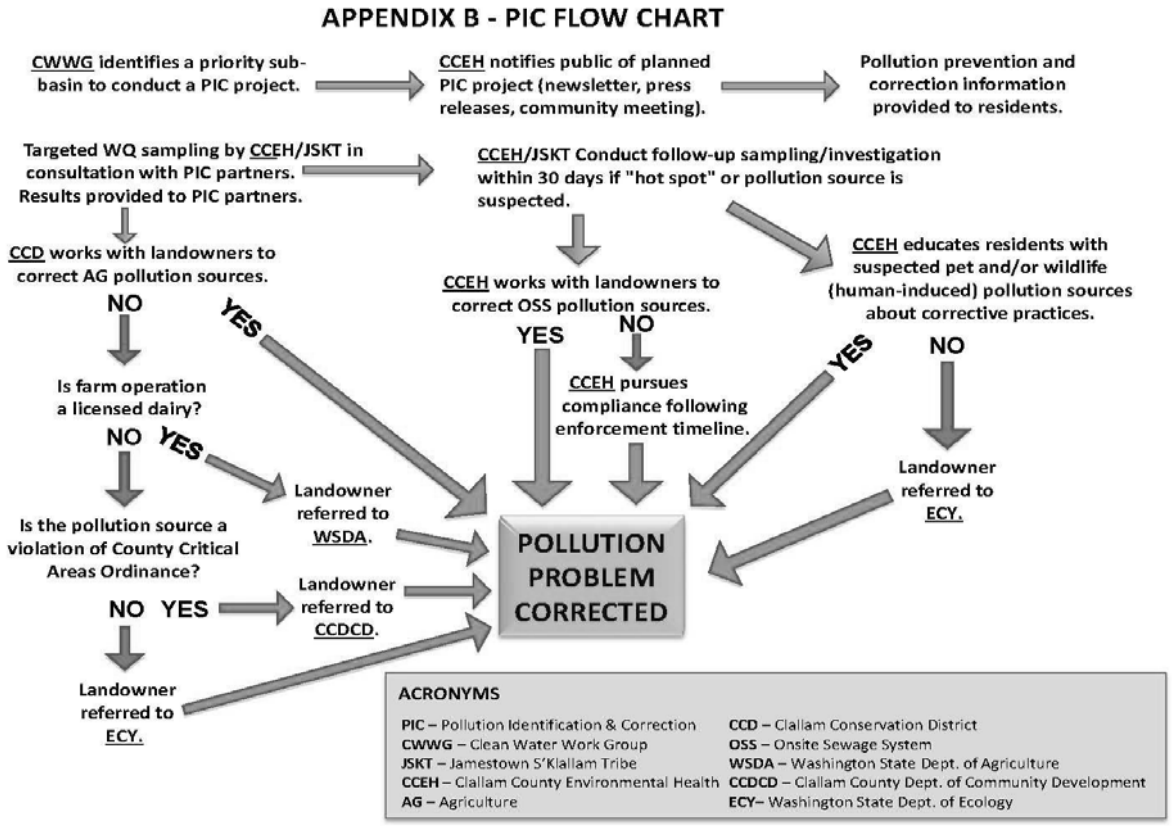


Figure 5: PIC Flow Chart

Trends Monitoring Program – The study design supports project objectives to identify trends for FC and nutrients in the CWD. This data helps project partners gain a broad understanding of the health of District streams and will help prioritize cleanup and protection efforts within the District.

PIC Project Monitoring Program – The selection of PIC Project sampling sites is based on Kitsap County's PIC Manual (Kitsap County 2014). The primary objective of this monitoring program is to identify sources of pollution. This will occur by strategically selecting sampling stations that lead to pollution source identification. Follow-up sampling will sometimes be necessary to evaluate the effectiveness of corrective actions.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Streamkeepers of Clallam County (SK) is the lead agency responsible for QAPP preparation and supervision of all trends monitoring activities, including quality assurance/quality control (QA/QC) and submittal of trends monitoring FC and nutrient data to EIM. The SK program coordinator is the lead staff person for trends monitoring, assisted as needed by staff of CCEH, JS'KT, and CCD.

- Trends Monitoring: SK will lead, with the fieldwork to be performed primarily by SK volunteers. SK staff or volunteers will be responsible for shipment of nutrient samples to University of Washington (UW) Marine Lab and delivery of FC samples to the CCEH lab. SK staff and volunteers will report on trends monitoring data on a quarterly basis, and, in conjunction with CCEH, will compose an annual report analyzing the data.
- PIC Targeted Monitoring: JS'KT will lead sampling efforts and submit data from this sampling to EIM.
- PIC Project: CCEH will serve as project lead, with segmented sampling to be performed primarily by JS'KT staff members.

We intend to use the following laboratories to analyze water samples for all parameters of interest:

- UW Marine Chemistry Laboratory for nutrient samples (Katherine Krogslund, Sample Coordinator)
- CCEH Water Laboratory for fecal coliform (FC) samples (Sue Waldrip, lab manager)

5.2 Special training and certifications

SK volunteers and members of the JS'KT are thoroughly trained per Streamkeepers' QAPP (Chadd 2016a, Chadd 2016b).

5.3 Organization chart

Not applicable (N/A)

5.4 Proposed project schedule

Regular monthly and quarterly schedules have been established for the two tiers of trends sampling (second Tuesday of the month), with a backup day (third Tuesday of the month) in case the regular day is not an option (though any date within the target month will suffice). FC sampling for Tier 1 sites will occur monthly, while nutrient sampling will occur bi-monthly. Targeted sampling will occur regularly as staff availability permits. See Figure 3 for trends monitoring sample sites.

5.5 Budget and funding

Long-term sustainable funding for this sampling plan is not yet secured. The project activities described in this QAPP are being funded under a grant provided by Ecology for three years. This funding will be used as follows:

- QAPP development and submittal
- Long-term water quality trend monitoring to assess the influence of 20 streams in the CWD on marine water quality. This monitoring will collect data for nutrients, bacteria, temperature, pH, salinity, conductivity, dissolved oxygen, and conductivity.
- CCEH will reach out to landowners within the Matriotti Creek and Bell Creek focus areas to request access to stream segments to conduct water quality sampling. CCEH and JS'KT will monitor for bacteria, temperature, and salinity at 15 sites (approximately 360 samples). A segmented sampling site location map will be produced.
- SK, CCEH, and JS'KT will submit all monitoring data into EIM, which will subsequently be submitted to WQX.
- CCEH, with support from SK and JS'KT, will submit an annual water quality monitoring reports for a variety of entities and a final report to be approved by Ecology.
- CCEH will participate in professional development trainings relevant to the project goals.

PIC Ecology 2020	Task 3
Description of Deliverable	**Monitoring/ Investigation**
Personnel	$26,910
Fringe Benefits	$10,764
Contract (UW Lab, Ozark Lab, Mailing Service)	$8,520
Subaward (JSKT, Cons. Dist., SK, WSU)	$18,333
Other (Lincoln Street, Postage, County Water Lab)	$19,870
Indirect/Overhead	$8,073
Total	**$92,470**

6.0 Quality Objectives

6.1 Data quality objectives

The main data quality objective (DQO) for this project is to collect an adequate number of samples to accurately characterize possible sources of bacteria and nutrients in the project area. The samples will be analyzed using EPA methods.

6.2 Measurement quality objectives

Field sampling procedures and laboratory analyses inherently have associated error. Measurement quality objectives (MQOs) establish the allowable error for a project. Precision and bias provide measures of data quality and are used to assess agreement with MQOs. The MQOs for this project are outlined in Table 1 and in further detail below.

Parameter	Bias	Field Precision	Lab Precision	Sensitivity	Expected Range of Results
	Deviation from NIST standard or spiked blank	Field measures = Per-pair variation Lab analyses = Annual median RSD	Relative Standard Deviation (RSD)	Field Measures = Range, Lab Analyses = Method Detection Limit (MDL) [5]	
FIELD MEASUREMENTS—other parameters may be measured following the Streamkeepers QAPP in force at the time (e.g., Chadd 2016a)					
Temperature (thermistor)	0.2 °C (two-point)	0.2 °C	n/a	-5 - 50 °C	0 - 30 °C
Temperature (liquid thermometer)	1 °C (two-point)	0.5 °C			
Salinity	5% RPD	0.02 PSS [6] or 5% RSD		0 - 70 PSS	0 - 35 PSS
LABORATORY ANALYSES					
Fecal coliform	n/a	See footnote [1]	40% [1]	1 cfu/ 100 mL	<MDL - 2000 cfu/ 100 mL
NO_3 - N	15% [2]	10% RSD [3]	20% [4]	0.0134 mg/L	<MDL - 10,000 µg/L
NO_2 - N	20% [2]			0.0010 mg/L	<MDL - 100 µg/L

NH_4 - N		15% RSD [3]		0.0049 mg/L	<MDL - 2000 µg/L
PO_4 - P				0.0005 mg/L	<MDL - 1000 µg/L
SiO_4 - Si [7]	15% [2]	10% RSD [3]		0.0093 mg/L	<MDL - 50,000 µg/L
Total Persulfate N	10% [2]			0.0276 mg/L	<MDL – 15,000 µg/L
Total Persulfate P				0.0011 mg/L	<MDL – 1,500 µg/L

Table 1: MQOs

1. Duplicate pairs with means <20 cfu/100 mL are excluded from these QC tests: 50% of duplicate pairs <20% RSD; 90% of duplicate pairs <50% RSD; all duplicate pairs <85% RSD (Mathieu 2006).
2. University of Washington Marine Chemistry Lab will deal with these tests internally.
3. Duplicate pairs with means less than 5x the reporting limit are excluded. (Mathieu 2006). Nutrient reporting limits are not reported by the lab but are calculated synthetically—see text.
4. Lab duplicates are not required, but they may be requested if field replicates exceed QC limits.
5. Detection limits for nutrients parameters are determined annually by the UW Lab per EPA methods described in 40 CFR 136, Appendix B.
6. Practical Salinity Scale
7. This analyte is not a parameter of interest for this project and is only included because it is batched in the UW lab analyses with parameters of interest.

6.2.1 Targets for Precision, Bias, and Sensitivity

6.2.1.1 Precision

Precision measures the reproducibility of repetitive measurements and is defined as the agreement among independent measurements produced by applying the same process under similar conditions. Precision assessment measures the variability in the results of replicated measurements due to procedural inconsistency, variable environmental conditions, or unknown error. Precision for replicates will be expressed as percent relative standard deviation (%RSD, which for a pair of values equals SQRT (2) * difference/sum * 100%) and assessed following the MQOs outlined in Table 1. Replicate samples will be collected at a minimum 5% of sampling sites, and at least one set of replicate samples will be taken by each field team each day.

6.2.1.2 Bias

Bias is a measure of the systematic error (difference) between the population mean (or an estimated value) and true value of the parameter being measured. Field and laboratory QC procedures, such as blanks, check standards, and spiked samples, provide a measure of any bias affecting measurement procedures. Bias from the true value is very difficult to determine for the set of parameters measured in this project; however, staff will minimize bias in field

measurements and samples by strictly following measurement, sampling, and handling protocols, including:

- Avoidance of skin products; use of gloves.
- Field-grab bottles which contain no potentially-confounding compounds.
- A thorough grab-bottle and syringe acid-wash procedure.
- Regular cleaning and rotation of purified-water bottles taken into the field.
- Bottle transfers made under cover, usually in the cargo area of a vehicle, on a clean surface.
- Avoidance of cleaning products containing quaternary ammonia compounds.

Project staff will assess bias in field samples by submitting field blanks. Field staff will prepare blanks in the field by filling the bottles directly with deionized water, and handling and transporting the samples to the labs in the same manner that the rest of the samples are processed.

For field measurements, project staff will minimize bias by calibrating and/or checking equipment using NIST-traceable standards before and after each run. More detailed information is found in Section 10 on Quality Control Procedures. Staff will assess any potential bias from instrument drift in probe measurements using criteria expressed in Table 7.

6.2.1.3 Sensitivity

Sensitivity is defined as the smallest quantity of an analyte that can be detected by a given method, and an instrument's range represents the span of values that it can measure. Both are presented in Table 1.

6.2.2 Targets for Comparability, Representativeness, and Completeness

6.2.2.1 Comparability

It is important for results from this project to be comparable to results generated by previous projects in the Dungeness watershed. To help ensure comparability, standardized sampling techniques and methods, and analysis and data reduction, are being used. In addition, laboratories for analysis were chosen to be consistent with those used for the EPA Targeted Watershed Grant (Streeter 2005; Woodruff et al. 2009b) and Clallam Marine Recovery Area Septic Solutions (Soule 2013) monitoring plans. The same analytical methods are available and will also be used.

6.2.2.2 Representativeness

This will be addressed by choice of sampling sites and frequency and timing of sampling. Sites will be as close as possible to discharge points of freshwater bodies into marine waters, in order to reflect as accurately as possible the pollutant concentrations upon entry into marine waters. Trends monitoring sampling will be collected monthly for tier 1 sites, and quarterly for tier 2 sites throughout the year, and in general, stream flow status and weather will not deter going into the field. Samples will be collected during low tide periods whenever possible, and samples having appreciable salinity (e.g., > 1 ppt) will be highlighted in field logs. Segmented sampling

will be addressed by selecting a good spatial representation of the stream or creek in question, with one sample site close to the terminus, and one sample site as far upstream as possible within the project area. If/when hotspots are identified, sample sites will be established upstream and downstream of the hotspot. Grab sample protocol follows the *Standard operating procedure for manually obtaining surface water samples* (Joy, 2006).

6.2.2.3 Completeness

The goal set for this project is 90% of planned sampling to be conducted and analyzed. Tier 1 sampling will occur monthly at 13 sites from December 2019 through December 2021. FC is analyzed every month while nutrients are analyzed bi-monthly. Tier 2 sampling will occur on a quarterly basis (January, April, August, and November) at 11 sites during the same timeframe. There are many reasons for missing sampling activities in a monitoring program. These include: (1) inclement weather or flooding, (2) hazardous driving or monitoring conditions, and (3) unavailability of monitoring staff, laboratories, equipment, or supplies.

Routinely missed samples could impart bias in expressions generated from final data. Every effort will be made to sample within each target month. Field monitoring data loss due to equipment failure will be minimized by having backup equipment available. Apart from weather, unforeseen occurrences are random relative to water quality conditions. These occurrences will not affect long-term data analyses, except for effects from potential reduction in sample size.

6.3 Acceptance criteria for quality of existing data

Existing data are covered under other QAPPs and will be submitted to Ecology per these plans if they have not been already.

6.4 Model quality objectives

N/A

7.0 Sampling Process Design

7.1 Study Boundaries

The study area is the Sequim Bay-Dungeness Watershed CWD, which is bounded on the west by the Bagley Creek drainage area and on the east by the Sequim Bay drainage.

7. 2 Field data collection

7.2.1 Sampling location and frequency

Please refer to Figure 3 for sampling locations.

Trends Monitoring

Trends monitoring is currently underway under a previous QAPP iteration (Chadd and Bond, 2017). Sampling will continue once a month on Tier I waterways and quarterly on Tier II waterways from December 2019 through November 2021 (Tables 2 and 3). Tier assignments are subject to change as situations change and data informs adaptation. General criteria for choosing sites and parameters are discussed below. Sampling sites will be located at or near the mouths of waterways, as feasible.

When possible, all monthly or quarterly samples will be collected on the same date. When not practical to do so, sites will be split such that all drainages to specific receiving waters will be sampled on the same day.

Windows for quarterly sampling will be the months of January, April, August, and November. These months correspond to seasonal spikes observed in past sampling.

Stream Name	Receiving Waters	Projected Monitoring Station (CCWR/EIM)	Description
Dungeness River	Dungeness Bay	Dungeness 0.7	0.3 miles downstream of Schoolhouse Bridge, access from Rivers End Rd.
Meadowbrook Creek		Meadowbrook 0.2	Near mouth, upstream of Sequim-Dungeness Way, near Three Crabs Rd.
Meadowbrook Slough		Meadowbrook Slough 0.23	Upstream of the Dungeness Farm Bridge at the end of Abernathy St.
Golden Sands Slough		Golden Sands Slough 0.0	At outlet of south side of Three Crabs Rd.
Cooper Creek		Cooper 0.1	Access from Three Crabs Rd.
Cassalery Creek		Cassalery 0.0 (or 0.6 if tide is too high)	At mouth; private but can be accessed via neighbor & beach
Matriotti Creek	Dungeness	Matriotti 0.3a	Downstream of Ward Rd.

Lotzgesell Creek	River	Lotzgesell 0.1	Upstream of confluence with Matriotti Cr., on Game Farm property
Sequim Bay State Park Creek	Sequim Bay	Sequim Bay State Park Creek 0.0 (or 0.1 if tide is too high)	Sequim Bay State Park, near mouth of creek
Bell Creek		Bell 0.2	About 30' above Schmuck Rd.
Johnson Creek		Johnson Creek 0.0	Downstream of culvert, SE end of Marina parking lot.
Jimmycomelately Cr.		Jimmycomelately 0.15	Upstream of Hwy 101, Ecology gage

Table 2: Tier I Trends sampling sites (FC monthly/ FC + nutrients bi-monthly)

CCWR = Clallam County Water Resources database
EIM = Ecology's Environmental Information Management database

Stream Name	Receiving Waters	Projected Monitoring Station (CCWR/EIM)	Description
Bagley Creek	Strait of Juan de Fuca	Bagley Creek 0.7a	Downstream of Olympic Discovery Trail bridge
Siebert Creek		Siebert Creek 1.0	At Olympic Discovery Trail parking area
Agnew Creek		Agnew Creek/Ditch 0.3	At 1079 Finn Hall Road
McDonald Creek		McDonald Creek 1.6	Downstream of Old Olympic Hwy bridge
Hurd Creek	Dungeness River	Hurd Creek 0.2	At Moore property
Gierin Creek	Dungeness Bay	Gierin 1.8	At upper end of Graysmarsh property, below tributary
Dean Creek	Sequim Bay	Dean Creek 0.17	At Olympic Discovery Bridge
No Name Creek		No Name Creek 0.03	Next to Jamestown Tribe Admin. Bridge
Chicken Coop Creek		Chicken Coop 0.24	About 50 feet upstream of culvert at Old Blyn Hwy.

Table 3: Tier II Trends sampling sites (FC)

PIC Project Monitoring

PIC project areas have been selected from a Priority Work Area List developed biennially by the CWWG after reviewing data and reports produced by the Trends Monitoring Program. The number and location of PIC project targeted sampling sites for Golden Sands Slough, Three Crabs Road, Meadowbrook Slough, and lower Meadowbrook Creek have been established, and the corrective phase of the previous PIC Pilot project will continue in these areas. Segmented sampling sites will be established for the Matriotti watershed, and the upper Meadowbrook Creek using the methods described below. PIC project monitoring will involve segmented

sampling of targeted sub-basins that have been prioritized for cleanup, in this case the lower Matriotti watershed and upper Meadowbrook Creek. The goal of segmented sampling is to locate contamination "hot spots" within a priority sub-basin. "Hot spots" will be defined as locations where the geometric mean of preferably three water quality samples exceeds the "Extraordinary" water quality standards set by Washington State (i.e., 50 fecal coliform colony-forming units per 100 mL for freshwater). Selection of the actual hot-spot sampling sites will be based on a review of available records (e.g., OSSs of concern, poorly drained soils) and visual assessments of potential pollution sources (e.g., poorly managed farms or homes with questionable septic systems).

All samples with FC results exceeding 50 FC/100mL will be re-sampled to confirm that they are indeed hot spots. Re-sampling will occur as soon as possible, ideally within a few days of the initial collection date. When the geometric mean from samples taken exceeds 50 FC/100mL, the hot spot will be designated, warranting further investigation. All hot spots should be investigated. However, when multiple hot spots are identified, additional investigations will be prioritized using the criteria shown in Table 4.

Indicator Organism	**High Priority**	**Medium Priority**	**Low Priority**
Fecal Coliform (FC)	> 400 FC / 100mL	100 to 399 FC / 100mL	50 to 99 FC/100mL

Table 4: Scheme for prioritizing hot spot investigation

Once a hot spot has been identified, additional sampling may occur if needed to further identify the source or sources of pollution. As needed, discharges such as ditches, drainage pipes, irrigation ditches and other drains will be sampled to aid in locating possible pollution sources.

7.2.2 Field parameters and laboratory analytes to be measured

A. Trends Monitoring: Both Tier I & Tier II sampling will include the following parameters:

- Fecal coliform (CFU/100 mL)
- Salinity (ppt or PSS)
- Water temperature (°C)

Tier I sampling will also include the following parameters:

- Dissolved nutrients: NO3, NO2, NH4, PO4, and silicate (Si(OH)4. If funding becomes a problem, we may choose to forego analyses for NO2, PO4, and Si(OH)4 to decrease our costs.
- Total nutrients: N and P. Note, however, that sampling conducted within the CWD in 2013-14 indicated a high correlation between the dissolved and totals nutrients parameters, indicating that it might be possible to forego the Total N and P analyses in consultation with the CWWG.

B. PIC Targeted monitoring – Only samples for analysis of FC will be collected.

C. PIC Project monitoring – Only samples for analysis of FC will be collected.

7.3 Modeling and analysis design

N/A

7.4 Assumptions underlying design

The study area has been the target of several water quality investigations in the past two decades, both of surface and ground water. These prior investigations inform the selection of Tier I & II sites and the parameters to be measured, based on existing data and potential impact to public health and shellfish harvest. Tier II sites are assumed to contribute a smaller load of pollutants to receiving waters based on historic data, land use, or size of discharge. Sampling site selections include the following considerations:

- Attempt to sample all freshwater discharges to marine waters in the study area, plus major tributaries to those discharges.
- Sample each discharge downstream of as many possible point or non-point inputs as possible.
- If possible:
  - Avoid tidal influence so samples will represent freshwater concentrations and sources. Where there is tidal influence, sample from the uppermost, least saline, layer of water.
  - Sample at sites with the greatest ease of access, such as public access.
  - Sample at sites where there is no need to walk into the water body, to avoid invasive species contamination—see section 8.4 below.
  - Sample at sites with a rich historic data set.
  - Sites for field replicate collection should have well-mixed water and typically strong fecal coliform and nutrients signals.

This QAPP identifies analytical methods that will be used to measure nutrients in Trends Monitoring program samples (see Section 8.0). In choosing these methods, we assume that the same laboratory and methods as have been used previously will provide comparable results helpful in identifying water quality trends and pollution sources.

7.5 Possible challenges and contingencies

7.5.1 Logistical problems

Logistical problems should be minimal as the project sampling sites are easily accessed.

7.5.2 Practical constraints

Practical constraints regarding the field aspect of this project are having adequate volunteer support for sampling.

7.5.3 Schedule limitations

Limitations on schedule include the availability of staff coordination, field samplers, calibrated equipment, supplies, laboratories, weather, tides, and, most particularly, funding. Also, field days are limited by the need to submit FC samples to the CCEH Lab by 3:00 pm Thursdays.

8.0 Field Procedures

8.1 Invasive species evaluation

To avoid cross-contamination of invasive species between sites, samplers will follow the Streamkeepers of Clallam County Anti-Contamination Protocol (Chadd 2016b), which is compliant with Ecology Standard Operating Procedures (SOP) EAP070 and EAP071.

8.2 Measurement and sampling procedures

SK maintains rigorous protocols for all steps in the process of monitoring area streams, from documentation to calibration to SOPs to training. Some details from their QAPP may be useful here (Chadd 2016a).

Training:

SK offers training to volunteers, based on the procedures in the Volunteer Handbook (Chadd 2016b). Volunteers see the procedures demonstrated and have the opportunity to practice them, under supervision of staff or experienced volunteers. Training participation is recorded in SK database. New volunteers are then assigned to teams with experienced volunteers guiding them through procedures. Usually several outings are required before new volunteers feel comfortable performing procedures on their own. Only volunteers trained in a given procedure will be allowed to attach their initials to data gathered under that procedure. The SK database connects all data with a sampler, whose training history is recorded in a separate table in that database.

Qualifiers Based on QC Controls:

For each QC control performed, qualifiers indicated by a QC test will be applied to all data governed by that test. In general, instruments will be calibrated (or checked if not able to be calibrated) prior to the sampling session and then checked subsequent to the sampling session. Both pre- and post-sampling checks must meet QC criteria in order for data gathered in between to be considered acceptable.

Post-Period Drift Check Is Sufficient:

Instrument drift away from accuracy is presumed to progress in a single direction, either above or below the accuracy margins. Therefore, in a case where an instrument was checked for accuracy only subsequent to a sampling episode, if the instrument passes its QC post-check, it is presumed that the instrument performed to specifications prior to that check (R Katzneslon, personal communication, October 24, 2011), so long as no substantive maintenance or replacement of instrument parts was performed in between. This situation is to be avoided, because samplers run the risk of downgrading an entire set of data due to not having checked instrument accuracy at the outset.

Accuracy Tests:

Accuracy of water quality measurements is estimated by performance evaluation measurements of the equipment; see Tables 1 and 8 for criteria.

Precision Tests:

Precision of water quality measurements is estimated by analysis of replicate samples taken in the field at one site per team per sampling period. The variation between these sample and replicate values is a measure of variability due to short-term environmental factors, instrument operation, and sampling procedure. See Tables 1 and 8 for acceptance criteria and control limits based on comparing replicates with their paired samples.

QC qualifiers are then applied to all samples in the grouping covered by that replicate/sample pair—for example, the entire group of samples taken by that team during that sampling period. These qualifiers are only applied if they downgrade already-applied QC qualifiers; for example, if program managers have already applied a "REJ" qualifier to a result, a downgrade value of "EST" based on replicate/sample comparison will not change the "REJ" designation for that result.

Special note for QC of fecal coliform samples:

Both field and lab replicates are taken with ≥ 5% of samples. Rather than randomly choosing samples for field and laboratory duplicates, we intend to choose samples likely to have high counts, on the notion that replicated samples with no counts provide little information (S Lombard, personal communication, 2007). The acceptance criteria and control limits in Table 9 are based on comparing field and laboratory replicates with their paired samples.

Side-by-Side Sampling—External:

Separate from Ecology monitoring activities, as possible, SK volunteers or staff will participate in Ecology's Side-by-Side Sampling program (http://www.Ecology.wa.gov/programs/eap/fw_riv/SxSIndex.html), whereby water-quality monitors test water bodies at the same time Ecology tests them as part of their monthly Ambient Monitoring Program. This program affords both parties the opportunity for additional validation of their data.

In-Situ Sampling Procedures: A basic schema of sampling and measurement procedures is presented in Section 8.2 above. The cited method sources, hereby incorporated by reference into this document, give full explanations relating to:

- collection of samples and associated field QC samples
- analytical methods for measurements/analyses done in the field as well as the laboratory
- required equipment and in-situ calibration and maintenance procedures
- required content and format of field log entries
- sampling equipment and methods for its preparation and decontamination

8.3 Containers, preservation, holding times

The field measurement methods and laboratory analytical methods that will be used for trends and PIC monitoring are summarized in Table 5. Sample container, preparation, and holding times are included. The detailed SOPs that will be used are also cited below. See Table 5.

Parameter	Field Method	Field Method Citation	Instrument/ Container type [1]	Sample Preparation	Min. Quantity, Holding time (per lab)
FIELD MEASUREMENTS [2]					
Water Temperature	Electronic meter or thermometer	(Chadd 2016a)	Thermistor or thermometer	In situ	n/a
Salinity	Electronic meter or refractometer	(Chadd 2016a)	Electrode or refractometer	In situ	
LABORATORY ANALYSES					
Fecal coliform [CCEH Lab]	Manual grab	(Chadd 2016a)	Sterilized poly ≥125 mL	10°C, dark	100 mL, 8 hr or 24 hr
Nutrients (dissolved) [UW]	Manual grab	(Joy 2006)	60 mL HDPE narrow mouth acid washed	Field filter with surfactant-free cellulose acetate filter; 6°C, dark	40 mL, 48 hr (unfrozen samples)
Nutrients (total) [UW]	Manual grab	(Joy 2006)	60 mL PP wide-mouth, acid washed	6°C, dark	40 mL, 7 days

Table 5: Field and laboratory methods: sample container, preparation, and holding times

1. Containers will be supplied by the accredited laboratory
2. Additional field measurements may be taken in accordance with Streamkeeper protocols in force at the time (e.g., Chadd 2016 a & b).

8. 4 Equipment decontamination

This project does not expect to be sampling substances with high levels of contaminants. For the routine sampling being performed here, it is sufficient to rinse sampling equipment (but not sample bottles) with sample water between locations (EPA 2015). Samplers will follow the Streamkeepers of Clallam County Safety SOP (Chadd 2016b).

8.5 Sample ID

Bottles will be labeled either with numbers, referenced on the field data sheet, or with the name of the site, date, and QC type (primary sample, field replicate, blank). Bottles intended for different analyses can be distinguished by size and shape, so no further labeling is necessary. Each bottle sent to a lab will be entered into the Clallam County Water Resources (CCWR) database with a unique ID, and each result from each Batch will also have a unique ID.

8.6 Chain-of-custody

Samples will be sent to the appropriate lab accompanied by a copy of the relevant field sampling log and a chain of custody form, likely be obtained from the labs, that has been signed and dated. Please refer to Figure 6 for a sample chain-of-custody form.

PIC Trends Monitoring **Date:** ___/___/___ Clallam County Env. Health Lab / Other: _____ *Tour ID:* _____ ***Rev. 2/8/17***

Tier 1 monthly **Samplers' initials: Stage/Flow: WQ: Bacteria: Nutrients: Turbidity grabs:**

Field ID (fecal bottle #)	Station Name, Code, or Description (Label nutrients bottles with the same number as on the corresponding bacterial sample bottle, and send a copy of this field sheet to the nutrients lab.)	Temperature control at lab, °C	Time (military)	Gage height /Water-level/Top-down (ft)	Samples taken with ProDSS / YSI-85 (circle) #____ Wtr Temp to 0.1 °C	Barometric Pressure to 0.01 in Hg	Dissolved Oxygen to whole % Local	Dissolved Oxygen to 0.1 mg/L	Specific Cond SpC to whole µS/cm	Salinity to 0.1 PSU (ppt)	pH to 0.1	Turbidity to whole FNU	Fecal/ lab rep counts per 100 mL factor	Fecal qualifier (U=<; G=>)	Clallam County lab #	Comments **Stream conditions: -turbid? -smelly? **Ebb or Flood Tide? (Cassalery mouth) **Problems sampling **Unusual situations *(Continue on back if needed; indicate stream & location.)*
	Jimmycomelately 0.15			GH												
	Sequim Bay State Pk 0.0	X		TD -												
	Johnson 0.0	X		GH												
	Bell 0.2	X		GH												
	Cassalery 0.0	X		EST												
	Cassalery 0.6 *(if 0.0 tidal influence; ALWAYS read gage)*	X		GH												
	Meadowbrook Slough .23	X		TD -												
	Cooper 0.1	X		TD -												
	Golden Sands Slough 0.0	X		TD -												
	Meadowbrook 0.2	X		TD -												
	Meadowbrook 0.2 blanks	X		X	X	X	X	X	X	X	X					
	Dungeness 0.7	X		X												*Flow @ECY gage Dung 0.8: ____cfs @ __:__ /____*
	Lotzgesell 0.1	X		TD -												
	Matriotti 0.3a	X		TD -												
	Matriotti 0.3a replicates	X		X												

GH = gage height; TD = measure top-down (record as a negative number); EST=floating-object flow estimate—see other side for calculation

Fecal lab samples submitted by (incl. initials): _____ Date: _____ Time: _____ Rec'd by: _____ Date: _____ Time: _____

Nutrients samples submitted by (incl. initials): _____ Date: _____ Time: _____ Rec'd by: _____ Date: _____ Time: _____

Figure 6: Sample Chain-of-Custody Form

8.7 Field log requirements

The field log for this project will consist of the field sampling log sheet containing the primary data, plus the additional log sheets listed below, describing the overall sampling event and calibration/drift check results. Any corrections will use strikeouts and be initialed and dated.

- Episode/Tour cover sheet—one per sampling team per sampling day
  - http://www.clallam.net/SK/doc/EpisodTourCov.pdf

- Instrument calibration activity & pre/post checks:
  - http://www.clallam.net/SK/QualityAssurance.html

8.8 Other activities

At sites with stream gages, samplers will be asked to record stage height. Sites without gages will be measured for stage from a top-down reference point where possible. Discharge will not be measured simultaneously with sampling, but stage measurements will give a relative idea of stream stage on the day of sampling.

Other General QC Measures:

- Clear, user-friendly, and detailed instructions for all procedures, minimizing judgment calls
- Equipment checked for damage prior to sampling
- Multiple observers when possible
- Each sampling team has an experienced leader
- Staff review of data, including comparing values year-to-year
- Values compared to external data from other agencies, such as stream gage data

9.0 Laboratory Procedures

9.1 Lab procedures table

The matrix for all analyses will be non-potable water. Analytical methods are listed in Table 6. All FC samples will be delivered the same day to the CCEH Water Lab in Port Angeles, WA (accreditation # M421-12) to be analyzed.

Nutrient analyses of water samples will be performed by UW School of Oceanography Marine Chemistry Laboratory in Seattle, WA (accreditation # A521-12). All nutrient samples will be shipped to UW Lab on the day of sampling. UW Lab will batch the dissolved nutrients NO3, NO2, NH4, PO4, and SiOH4 for analysis, and will batch Total N and P for separate analysis. Si data is being collected only because UW Lab batches it in the dissolved nutrients. It is not a parameter of interest for this project.

Analysis	Method Reference	EPA or Standard Method #	NELAC Code	Detection Limits [1] (MDL)
Fecal coliform	APHA 1998	SM 9222 D (m-FC)-97	20210008	1 cfu * 100 mL /volume used in the analysis
UW Marine Chemistry Laboratory				
NO_3 - N	UNESCO 1994	EPA 353.4_2_1997	10068209	0.0134 mg/L
NO_2 - N				0.0010 mg/L
NH_4 - N		EPA 349	10063000	0.0049 mg/L
PO_4 - P		EPA 365.5_1.4_1997	10071406	0.0005 mg/L
SiO_4 - Si		EPA 366	10071600	.0093 mg/L
Total Persulfate N	Valderrama 1981	SM 4500-NH3 B-2011	20106018	.0276 mg/L
Total Persulfate P		SM 4500-P F-2011	SM 4500-P F-2011	0.0011 mg/L

Table 6: Laboratory Analytical Procedures

[1] Detection limits for nutrients parameters are determined annually by the UW Lab per EPA methods described in 40 CFR 136.

9.2 Sample preparation methods

Please refer to Table 6 above.

9.3 Special method requirements

Table 1 outlines field and analytical parameters, expected precision for duplicates (a.k.a. replicates), method detection limits and/or resolution, and the expected range of results. The targets for precision of duplicates are based on historical performance by each laboratory.

For nutrients, field replicates and blanks will be shipped and analyzed in the same batch as regular samples. Lab duplicates (if done) will be charged the same as samples. Bias checks are

run with every run /data set. Please see Table 1 and section for further discussion on bias checks, see Table 1 concerning SRMs and Section 6.2.1.

Field Blanks taken with nutrients samples will be analyzed in the following manner:

- The time period for both analysis and reporting will be the calendar year; the choice of calendar year is based on the annual Method Detection Limit (MDL) reports issued by the University of Washington Marine Chemistry Laboratory.
- Blanks known to be faulty due to procedural irregularities will be qualified as J (estimate) or REJ (rejected).
- Outliers (qualified as OUT per definition of Ecology's Environmental Information Management system) will be determined using Tukey's fences with k = 1.5 (an oft-used benchmark). The Result Comment accompanying such Blanks will be "Exceeds upper Tukey fence with k = 1.5."

The UW lab does not report reporting limits (RLs), but the remaining Blank data (without the above qualifiers) will be used to calculate synthesized RLs for the various parameters, with this procedure developed in consultation with EPA: The synthetic RL will be the larger of 3.18 * MDL or the mean +1 standard deviation of the non-OUT field blanks (D Matheny, personal communication, 2014).

Dissolved nutrient samples will be filtered in situ (see Table 5).

9.4 Laboratories accredited for methods

This PIC project will contract with CCEH Water Lab for monthly trends analysis and segmented analysis of FC samples and UW Marine Chemistry Lab for bi-monthly analysis of nutrient samples.

10.0 Quality Control

10.1 Table of field and lab quality controls

QC procedures for the field and laboratory are summarized in Tables 7, 8 and 9. A "tour" is a round of sampling conducted on a given day by a given field team. A "run" is a batch of samples processed by the lab. Laboratory QC samples will be obtained by SK for documentation purposes.

Parameter	FIELD		LABORATORY			
	Blanks	Replicates	Method Blanks	Spiked Blanks	Analytical Duplicates	Matrix Spikes
Fecal coliform	≥ 1 per tour and 5% of sites		2 per ≤ 10 samples (See Table 8)	None	1 per ≤ 10 samples	n/a
Dissolved Nutrients			2 per run	2 per run	None	None
Total N & P			2 per run	2 per run		
Water temperature	n/a	≥ 1 per tour & 5% of sites	n/a	n/a	n/a	n/a
Salinity						

Table 7: QC Samples, Types, and Frequency

NOTE: NIST SRMs for nutrients will also be run as QC samples to help assess bias (Table 1).

Parameter	Office prep (start of each sampling period)	Maintenance measures (office & field)	Field prep/ checks	Bias checks	Accuracy qualification per bias checks	Replicates for precision control	Precision qualification (per rep/ sample difference)
Temperature	2-pt. (~0° & 20°C) check vs. NIST-traceable thermo-meter	Keep sensor clean		2-pt. calibration check vs. NIST-traceable thermo-meter	"EST" if >±0.2°C; "REJ" if > ± 0.5°C	1 per tour	"EST" if > ±0.2°C; "REJ" if > ± 0.5°C

Parameter	Office prep (start of each sampling period)	Mainten-ance measures (office & field)	Field prep/ checks	Bias checks	Accuracy qualification per bias checks	Replicates for precision control	Precision qualification (per rep/ sample difference)
Salinity	Calibration with NIST-traceable standard	Electrode cleaning solution	Check / rinse electrodes	Post-season check against NIST-traceable standard	"EST" if > ± 10% of standard value; "REJ" if > ± 15% of standard value		"EST" if RSD > 5%; "REJ" if RSD >10%
Fecal Coliform	Verification of colonies once a month; annual proficiency testing with state	Checks of medium, filters, funnels, thermo-meter, rinse & dilution water	Sterilized bottles, 4 oz. (125 mL) minimum; observe holding specs	Pre- and post-sample blanks; control blanks for 1/10 of samples	Adjust/flag data as needed per blank results	Field / lab replicates: ≥ 1 / tour & ≥ 5% of sites	"REJ" if > ± 10 and log-transformed values > ± 0.6 (RSD > 85%) (see text below)

Table 8: Field and Lab Equipment QA/QC Measures

RSD in the table above refers to the relative standard deviation or RSD (also known as the coefficient of variation), which, when n = 2 (as when comparing a sample with a replicate), is defined as:

RSD = abs (difference/sum) x sqrt (2), where abs = absolute value and sqrt = square root

Control measure used: variance between sample and field or lab replicate
If absolute difference ≤ 10 or difference between base-10 logs ≤ 0.6 (RSD ≤ 85%): No qualifier
Otherwise, qualify per the following, using best professional judgment of program manager and laboratory analyst: • Flag sample as "R" (unacceptable); • If other rep/sample pairs from that day's analysis were within tolerance, do not flag the other data, unless there is reason to question the entire batch; • If no other rep/sample pairs in that batch, use best professional judgment of laboratory and monitoring program managers to decide whether to flag other data; • If other rep/sample pairs from that day's analysis exceeded tolerance, consider flagging all the data from that day, or possibly from the team(s) which collected those samples.

Table 9: QC Measures for Bacterial Samples

10.2 Corrective action processes

For CCEH Water Lab FC analyses, QC will be performed using "Standard Methods 9020B Intra-laboratory Quality Control Guidelines" (B Pero, personal communication, 2013).

UW Lab indicated that analytical QC criteria listed for nutrients and Total N and P in Tables 1 and 6 will always be met. Method blank and spiked blank checks are performed at the beginning and end of each run; both must be within the QC range, or the samples are run again (K Krogslund, personal communication, 2019).

Qualifiers will be assigned to data as appropriate, based on qualifier codes developed by the EIM. To be unqualified (i.e., acceptable without qualification for submission for the State Water Quality Report), data must be gathered in accordance with established monitoring procedures, be fully documented, and pass all QC screens. The most common data qualifiers are:

- **J-variants** (laboratory-data estimate): Apply if laboratory identifies sample as an estimate, or if established QC procedures have not been followed or documented (for example, lab duplicates were not run), or one or more QC screens have not passed (for example, lab duplicates were outside precision targets), but the QA officer believes the data to be reasonably trustworthy for general water-quality assessments.
- **J** (Estimated: The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample): Apply if established procedures have not been followed or documented, or one or more QC screens have not passed, but QA officer believes the data to be reasonably trustworthy for general water-quality assessments.
- **OUT** (outlier within dataset): Apply to Field Blanks that fail Tukey fence analysis with k = 1.5. (See Section 6.2.)
- **REJ** (rejected): Apply if established procedures have not been followed and/or documented, or one or more QC screens have not passed, and QA officer believes the data to be untrustworthy for any purpose.

If data are qualified by the laboratory or adjusted due to blanks, replicates, spikes, or blind standards, these adjustments will be documented along with the data and flagged appropriately.

Field blank and sample results for each parameter for each day will be processed using the following steps, developed in consultation with state and federal scientists (N Mathieu, personal communication, 2014; D Matheny, personal communication, 2014; T Gries, personal communication, 2018; APHA, 2012):

- If, after procedural QC and outlier analysis, Field Blank (FB) has not been qualified and FB ≤ Reporting Limit (RL), no qualifier for the field samples.
- If FB has been qualified, qualify all field samples as J or R per judgment of the QA officer, and record a comment alongside the data explaining why that qualifier was applied; for example, "FB is OUT but data deemed reasonable."

- Else, if FB > RL, qualify the FB as J with the comment ">RL". Designate (FB – RL) as the absolute bias for that day, in which case the relative bias for a given measurement would be (absolute bias) / (sample value). Then apply qualifiers per the MQOs for bias in Table 1:
    - If (relative bias) ≤ (target bias) for that parameter, no qualifier for field samples.
    - If (relative bias) > (target bias) but field sample value ≤ RL, qualify it as B, defined by EIM as "Analyte detected in sample and method blank. Reported result is sample concentration without blank correction" (Ecology, 2019); the rationale is that field data with a value < the RL (and also < the FB) is indicative of a truly low value that should not be rejected, regardless of potential contamination issues evidenced by the high FB.
    - Else, qualify all field samples as J or R per judgment of the QA officer, and record a comment alongside the data explaining why that qualifier was applied; for example, "FB > RL and rel bias > target bias, but data deemed reasonable."

For in-situ measurements, see Additional QC notes in section 8.2.

11.0 Data Management Procedures

11.1 Data recording and reporting requirements

Data collection, quality control, management, and reporting will be coordinated by SK. See Section 5.0 for more details.

Recording Field Data

Field data will be collected on custom-designed data sheets. The primary field data sheet, as well as ancillary data sheets (Episode and Tour cover sheets, calibration/check sheets), are on the SK website at http://www.clallam.net/SK/monitoringusables.html. Field samplers will record data and enter their and initials on these sheets. When all data have been collected at a site, the team leader looks over the sheets for completeness, legibility, and obvious errors, and gets further information from team members as appropriate. Any problems with data collection are noted in a "Comments" section of the data sheet. The team leader initials and dates this review, then initials and dates again when turning the sheets in to the office. Then staff initials and dates receipt and QC review of the data. This latter review is a thorough process that includes troubleshooting for decimal and rounding errors, data entered into the wrong field, incomplete data, etc.

Requirements for Laboratory Data Packages

The microbiology and chemical laboratories will report sample results on report forms provided by SK or of their own making. They will indicate their QC review and approval of the data presented. Laboratories will not be required to submit internal QA/QC documentation, such as blanks, spikes, and blind standards, used to determine the adequacy of the analytical procedures, providing their procedures met all internal laboratory QA/QC requirements; but they will be required to keep all such internal records for a minimum of five years.

Transferring Data to Electronic Form

Once field data sheets have been received and reviewed at the Streamkeepers office, volunteers will enter the Trends Monitoring data into the CCWR database. Detailed procedures will be provided to the volunteers, both in written form and in one-on-one training, and staff will be available to volunteers as they perform data entry. Volunteers subsequently will check database entries against field sheets.

Laboratory Data Upload

When laboratories report data in a standard electronic format, SK staff and volunteers will devise database queries to upload the data.

Automated Data Checks

Our intention is to program the CCWR database to automatically perform some of the statistical checks described in the "Quality Control" section above, and in some cases to downgrade data automatically as appropriate (leaving a record of the downgrade). In other cases the database will display a message instructing program managers to examine data and apply downgrades as

appropriate. These automated routines will ensure compliance with QC procedures. In the absence of automation, data qualifiers will be applied manually by the QC officer.

Final Sign-Off of Data

Once all of the above checks have been performed, the QA officer will do a final review of data, including examination of outliers, and sign off that the data are ready for publication.

Management and Storage of Database

The CCWR database is managed by SK It is stored on Clallam County's network drive, which is backed up daily. The database itself is actually two files: CCWR_Data consists exclusively of data tables, while CCWR_User comprises data-entry forms, database queries, reports, lookup tables, metadata, and other database objects. This structure provides stable storage for the data.

Retrieval of Data

Data can be retrieved from the CCWR database in a variety of ways. A number of custom-made reports and queries have been designed to portray the environmental data in the database. Data can also be retrieved via user queries. A variety of CCWR data is also available on the Streamkeepers website: http://www.clallam.net/SK/studies.html.

11.2 Lab data package requirements

Lab documentation should always include all QC results associated with the data, a case narrative discussing any problems with the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers.

The CCEH Water Lab reports results directly on data sheets provided for the project. Outside laboratories will report results and QC information on their standard forms.

11.3 Electronic transfer requirements

Any electronic data transfer will need to be in format readable by SK.

11.4 EIM or WQX data upload procedures

All new data will be uploaded from the CCWR database to Ecology's EIM database for subsequent transfer by Ecology toEPA's WQX database. Upon upload of data to EIM, the data manager will request confirmation that the data have, in turn, been sent to EPA's WQX.

11.5 Model information management

Not applicable.

12.0 Audits and Reports

12.1 Field, laboratory, and other audits

and

12.2 Responsible personnel

Formal program audits are not planned at this time but the need for a program audit may be considered in the future. In lieu of such an audit, the QA officer will be responsible for day-to-day compliance with this document, including assuring that quality of the data is acceptable and that corrective actions are implemented in a timely manner. QC review and signoff will be conducted after each sampling period. In addition, the project manager will review the data and metadata in consultation with the QA officer at some point early in the project and at the end of the project, to assure that procedures have been followed as outlined in this document.

Laboratories participate in performance and system audits of their own procedures; these are available on request.

12.3 Frequency and distribution of report

Data will be submitted annually to Ecology through EIM. Ecology will forward data on to EPA's WQX's database.

12.4 Responsibility for reports

The data manager will summarize data on a quarterly basis at CWWG meetings. An annual data report will be prepared for the CWWG. A draft of this report will also be made available to WDOH staff, Ecology staff, and peers for review and comment.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

Field team leaders will verify data before turning in data sheets. The QA officer will examine the data and metadata for errors or omissions as well as completeness and compliance with QC acceptance criteria, and will apply data qualifiers as needed.

13.2 Laboratory data verification

Laboratory results are reviewed and verified by qualified and experienced lab staff, with findings documented in a case narrative.

13.3 Validation requirements, if necessary

The complete data package, along with the laboratories' written reports, will be assessed by the QA officer and project manager for completeness and reasonableness. There will be no independent data validation.

13.4 Model quality assessment

Not applicable.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

The project manager, in consultation with other staff and laboratories working on this project, will comment in the project final report on whether the data are of sufficient quality and quantity to have achieved the project goals.

14.2 Treatment of non-detects

If the lab does not report a value for analyte concentrations less than the MDL (see Table 6 in Section 9), results will be reported at the MDL.

14.3 Data analysis and presentation methods

All data generated by the activities described in this QAPP, as per the Ecology grant requirements, will be uploaded to Ecology's EIM database. Ecology will forward this data on to EPA's WQX database.

14.4 Sampling design evaluation

The project manager, in consultation with others working on this project, will comment in the project final report on the adequacy of the sampling design and whether changes should be made in further efforts.

14.5 Documentation of assessment

The project manager, in consultation with others working on this project, will comment in the project final report on the adequacy of the sampling design and whether changes should be made in further efforts.

15.0 References

American Public Health Association (APHA). 2012. Standard methods for the examination of water and wastewater. 22nd ed. Washington, DC: American Public Health Association (US).

Brown C. 2009. Quality assurance project plan: Dungeness Bay and lower Dungeness River watershed fecal coliform bacteria total maximum daily load effectiveness monitoring [Internet]. Olympia (WA): Washington State Department of Ecology (US); [cited 2017 Oct 16]. Accessed at https://fortress.wa.gov/Ecology/publications/summarypages/0903104.html

Cadmus Group. 2010. Dungeness Bay and Dungeness River watershed fecal coliform bacterial total maximum daily load water quality effectiveness monitoring report [Internet]. Olympia (WA): Washington State Department of Ecology (US); [cited 2017 Oct 16]. Accessed at https://fortress.wa.gov/Ecology/publications/SummaryPages/1003032.html

Chadd and Bond. 2015. Quality Assurance Project Plan (QAPP) Sequim-Dungeness Clean Water District Pollution Identification & Correction, Trends, and Project Monitoring(PIC) [Internet]. Port Angeles (WA): Clallam County Department of Health and Human Services (US); [cited 2019 Dec 5]. Accessed at http://www.clallam.net/HHS/documents/QAPP2015.pdf

Chadd and Bond. 2017. Quality Assurance Project Plan (QAPP) Sequim-Dungeness Clean Water District Pollution Identification & Correction, Trends, and Project Monitoring(PIC) [Internet]. Port Angeles (WA): Clallam County Department of Health and Human Services (US); [cited 2019 Dec 5]. Accessed at http://www.clallam.net/HHS/documents/QAPP2017.pdf

Chadd EA. 2016a. Quality assurance project plan for Streamkeepers of Clallam County environmental monitoring program [Internet]. Port Angeles (WA): Clallam County Department of Public Works—Roads (US); [cited 2017 Oct 16]. Accessed at http://www.clallam.net/SK/doc/QAPP2016.pdf

Chadd EA. 2016b. Streamkeepers of Clallam County volunteer handbook [Internet]. Port Angeles (WA): Clallam County Department of Public Works—Roads (US); [cited 2017 Oct 16]. Accessed at http://www.clallam.net/SK/volunteerhandbook.html

Clallam County. 2005. Elwha-Dungeness watershed plan, Water Resource Inventory Area (WRIA) 18 and Sequim Bay in west WRIA 17. Port Angeles (WA): Clallam County Elwha-Dungeness Planning Unit (US).

Clallam County. 2019 Sequim-Dungeness Clean Water District stream monitoring results, January 2018 to September 2019. Port Angeles (WA): Clallam County Health and Human Services and Clallam County Department of Public Works—Roads (US).

Ecology, WA Dept. of. 2019. Environmental Information Management system. Valid values – data qualifiers. Accessed at https://apps.ecology.wa.gov/eim/help/ValidValues/DataQualifiers

EPA. 2015. Operating procedure: field equipment cleaning and decontamination [Internet]. Athens (GA): Environmental Protection Agency Region 4 Science and Ecosystem Support Division (US); [cited 2017 Oct 17]. Accessed at https://www.epa.gov/sites/production/files/2016-01/documents/field_equipment_cleaning_and_decontamination205_af.r3.pdf

Joy J. 2006. Standard operating procedure for manually obtaining surface water samples [Internet]. Ver 1.3. Olympia (WA): Washington State Department of Ecology Environmental Assessment Program (US); [cited 2017 Oct 17]. Accessed at http://www.Ecology.wa.gov/programs/eap/qa/docs/ECOLOGY_EAP_SOP_ManuallyObtainingSurfaceWaterSamples_v1_3EAP015.pdf

Kitsap County 2014. Pollution source identification and correction protocol manual [Internet]. Bremerton (WA): Kitsap Public Health District (US); [cited 2017 Oct 17]. Accessed at http://www.kitsapcountyhealth.com/environment/files/2012_PIC_Protocol.pdf

Krogslund, Kathy. 2019. Director, University of Washington Marine Chemistry Lab. Personal communication.

Mathieu N. 2006. Replicate precision for 12 TMDL studies and recommendations for precision measurement quality objectives for water quality parameters [Internet]. Olympia (WA): Washington Department of Ecology Environmental Assessment Program (US); [cited 2017 Oct 17]. Accessed at https://fortress.wa.gov/Ecology/publications/publications/0603044.pdf

Pero B. 2006. Standard operating procedure for fecal coliform membrane filter test, based on SM 9222D. Rev 4. Port Angeles (WA): Clallam County Environmental Health Laboratory (US).

Rensel JE, 2003. Dungeness Bay bathymetry, circulation and fecal coliform studies: phase 2 [Internet]. Arlington (WA): Prepared for Jamestown S'Klallam Tribe and Environmental Protection Agency (US); [cited 2017 Oct 17]. Accessed at https://jamestowntribe.org/wp-content/uploads/2018/08/3-Dungeness-Bay-Study.pdf

Sargeant D. 2002. Dungeness River and Matriotti Creek fecal coliform bacteria total maximum daily load study [Internet]. Olympia (WA): Washington State Department of Ecology (US); [cited 2017 Oct 17]. Accessed at https://fortress.wa.gov/Ecology/publications/summarypages/0203014.html

Sargeant D. 2004a. Dungeness Bay fecal coliform bacteria total maximum daily load study [Internet]. Olympia (WA): Washington State Department of Ecology (US); [cited 2017 Oct 17]. Accessed at https://fortress.wa.gov/Ecology/publications/summarypages/0403012.html

Sargeant D. 2004b. Dungeness River and Matriotti Creek post-TMDL data review [Internet]. Olympia (WA): Washington State Department of Ecology (US); [cited 2017 Oct 17]. Accessed at https://fortress.wa.gov/Ecology/publications/summarypages/0403053.html

Soule A. 2013. Quality assurance project plan, Clallam Marine Recovery Area (MRA) septic solutions. Port Angeles (WA): Clallam County Environmental Health (US).

Streeter V and Hempleman C. 2004. Clean water strategy for addressing bacteria pollution in Dungeness Bay and watershed and water cleanup detailed implementation plan [Internet]. Olympia (WA): Washington State Department of Ecology (US); [cited 2017 Oct 17]. Accessed at https://fortress.wa.gov/Ecology/publications/summarypages/0410059.html

Streeter V. 2005. Quality assurance project plan: bacterial/nutrient/flow effectiveness monitoring in the Clean Water District. Port Angeles (WA): Clallam County Environmental Health (US).

UNESCO. 1994.

Valderrama, 1981.

WDOH. 2009. Fecal coliform pollution in Dungeness Bay through 2008: status and trends summary. Olympia (WA): Washington Department of Health, Office of Shellfish and Water Protection (US).

WDOH. 2018. Annual report: commercial and recreational shellfish in Washington State. Olympia (WA): Washington Department of Health, Office of Shellfish and Water Protection (US).

Woodruff DL, Sather NK, Cullinan VI, Sargeant SL. 2009a. Microbial source tracking in the Dungeness watershed, Washington [Internet]. Richland (WA): Battelle Pacific Northwest Division (US); [cited 2017 Oct 17]. Accessed at https://jamestowntribe.org/wp-content/uploads/2018/09/2-Microbial-Source-Tracking.pdf

Woodruff DL, Cullinan VI, Brandenberger JM. 2009b. Effectiveness monitoring of fecal coliform bacteria and nutrients in the Dungeness watershed, Washington [Internet]. Richland (WA): Battelle Pacific Northwest Division (US); [cited 2017 October 17]. Accessed at https://jamestowntribe.org/wp-content/uploads/2018/09/1-Effectiveness-Monitoring-of-Fecal.pdf

16.0 Appendix A- Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Ambient: Background or away from point sources of contamination. Surrounding environmental condition.

Anthropogenic: Human-caused.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Effluent: An outflowing of water from a natural body of water or from a human-made structure. For example, the treated outflow from a wastewater treatment plant.

Eutrophic: Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

Existing uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Fecal coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2

degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either:
(1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Load allocation: The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

Municipal separate storm sewer systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (1) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, stormwater, or other wastes and (2) designed or used for collecting or conveying stormwater; (3) which is not a combined sewer; and (4) which is not part of a Publicly Owned Treatment Works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any

unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Point source: Source of pollution that discharges at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites where more than 5 acres of land have been cleared.

410

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will,
or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to
(1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Fish that belong to the family *Salmonidae*. Species of salmon, trout, or char.

Sediment: Soil and organic matter that is covered with water (for example, river or lake bottom).

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Total Maximum Daily Load (TMDL): A distribution of a substance in a water body designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

411

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act, requiring Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

90th percentile: An estimated portion of a sample population based on a statistical determination of distribution characteristics. The 90th percentile value is a statistically derived estimate of the division between 90% of samples, which should be less than the value, and 10% of samples, which are expected to exceed the value.

Acronyms and Abbreviations

BMP	Best management practice
CCD	Clallam Conservation District
CCC	Clallam County Code
CCEH	Clallam County Environmental Health
CCWR	Clallam County Water Resources Database
CWD	Sequim-Dungeness Clean Water District
CWWG	Clean Water Work Group
DCD	Clallam County Department of Community Development
DO	(see Glossary above)
DQO	Data quality objective
e.g.	For example
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
FB	Field Blank
FC	(see Glossary above)
GIS	Geographic Information System software

GPS	Global Positioning System
i.e.	In other words
JS'KT	Jamestown S'Klallam Tribe
MDL	Method detection limits
MQOs	Measurement quality objectives
MRA	Marine recovery area
NEP	National Estuary Project
NH3	Ammonia
NH4	Ammonium
NIST	National Institute of Standards and Technology
NO2	Nitrite
NO3	Nitrate
NTA	Near term action
NTR	National Toxics Rule
OSS	Onsite septic system
PIC	Pollution Identification & Correction
PO4	Phosphate
QA	Quality assurance

QAPP	Quality assurance project plan
QC	Quality control
RL	Reporting limit
RM	River mile
RPD	Relative percent difference
RSD	Relative standard deviation
Si	Silicon
Si(OH)4	Silicate
SK	Streamkeepers of Clallam County
SOP	Standard operating procedures
SRM	Standard reference materials
WQX	EPA's storage and retrieval water quality database
SQRT	Square root
TIN	Total inorganic nitrogen
TMDL	(See Glossary above)
TN	Total Nitrogen
TP	Total phosphorus
TSS	(See Glossary above)

UGA	Urban growth area
UW	University of Washington Marine Chemistry Lab
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington Department of Health
WQA	Water Quality Assessment
WRIA	Water Resource Inventory Area
WSU	Washington State University

415

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cfu	colony forming units
cms	cubic meters per second, a unit of flow
ft	feet
g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams
m	meter
mg	milligram
mg/d	milligrams per day
mg/L	milligrams per liter (parts per million)
mg/L/hr	milligrams per liter per hour
mL	milliliter
s.u.	standard unit
µg/kg	micrograms per kilogram (parts per billion)
µg/L	micrograms per liter (parts per billion)

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms *precision* and *bias* be used to convey the information associated with the term *accuracy* (USGS, 1998).

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella (Kammin, 2010).

Bias: The difference between the sample mean and the true value. Bias usually describes a systematic difference reproducible over time and is characteristic of both the measurement system and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI) (Kammin, 2010; Ecology, 2004).

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process (USGS, 1998).

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured (Ecology, 2004).

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards but should be referred to by their actual designator, e.g., CRM, LCS (Kammin, 2010; Ecology, 2004).

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator (USEPA, 1997).

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator (USEPA, 1997).

Continuing Calibration Verification Standard (CCV): A quality control (QC) sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run (Kammin, 2010).

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system (Kammin, 2010; Ecology 2004).

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean (Kammin, 2010).

418

Data integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading (Kammin, 2010).

Data quality indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity (USEPA, 2006).

Data quality objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010).

Data validation: An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment

and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability, and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier – data are usable for intended purposes.
- J (or a J variant) – data are estimated, may be usable, may be biased high or low.
- REJ – data are rejected, cannot be used for intended purposes.
  (Kammin, 2010; Ecology, 2004).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set (Ecology, 2004).

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero (Ecology, 2004).

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis (USEPA, 1997).

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport (Ecology, 2004).

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples (Kammin, 2010).

Laboratory Control Sample (LCS): A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples (USEPA, 1997).

Matrix spike: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects (Ecology, 2004).

420

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness (USEPA, 2006).

Measurement result: A value obtained by performing the procedure described in a method (Ecology, 2004).

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed (EPA, 1997).

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples (Ecology, 2004; Kammin, 2010).

Method Detection Limit (MDL): This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero (Federal Register, October 26, 1984).

Percent Relative Standard Deviation (%RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010).

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all parameters (Kammin, 2010; Ecology, 2004).

Population: The hypothetical set of all possible observations of the type being investigated (Ecology, 2004).

421

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator (USGS, 1998).

Quality assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data (Kammin, 2010).

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives (Kammin, 2010; Ecology, 2004).

Quality control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data (Ecology, 2004).

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

[Abs(a-b)/((a + b)/2)] * 100

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled (USGS, 1998).

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator (USGS, 1998).

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population (USGS, 1998).

Sample (statistical): A finite part or subset of a statistical population (USEPA, 1997).

422

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit (Ecology, 2004).

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method (USEPA, 1997).

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency (USEPA, 1997).

Split sample: A discrete sample subdivided into portions, usually duplicates (Kammin, 2010).

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity (Kammin, 2010).

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning (USEPA, 2006).

References for QA Glossary

Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/Ecology/publications/SummaryPages/0403030.html

Kammin, B., 2010. Definition developed or extensively edited by William Kammin, 2010. Washington State Department of Ecology, Olympia, WA.

USEPA, 1997. Glossary of Quality Assurance Terms and Related Acronyms. U.S. Environmental Protection Agency.

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. http://www.epa.gov/quality/qs-docs/g4-final.pdf

USGS, 1998. Principles and Practices for Quality Assurance and Quality Control. Open-File Report 98-636. U.S. Geological Survey. http://ma.water.usgs.gov/fhwa/products/ofr98-636.pdf

Jamestown S'Klallam Tribe Addendum to:

Quality Assurance Project Plan
Monitoring for Harmful Algal Blooms by SoundToxins Partnership

Grant #G1300035

June 2018

Addendum Prepared by:

Jamestown S'Klallam Tribe

Neil Harrington, Environmental Biologist

Robert Knapp Environmental Program Manager

June 2018

Contact Information

Robert Knapp
Jamestown S'Klallam Tribe
1033 Old Blyn Hwy
Sequim, WA 98382
360.681.4666, Fax: 360.681.4643
rknapp@jamestowntribe.org

Jamestown S'Klallam Tribe (JST) Addendum to QAPP Harmful Algal Bloom Monitoring SoundToxins Partnership.

Approval:

Robert L. Knapp 8/10/18

Robert Knapp, Environmental Program Manager, JST Date

Dani Madrone 8/9/18

Dani Madrone, Grants Project Manager, NWIFC Date

8/21/18

Neil Harrington, Environmental Biologist, JST Date

Preface:

Although the funding for the MERHAB (Monitoring and Event Response for Harmful Algal Blooms) has been exhausted, JST will continue to assist with the project by taking samples for NOAA as outlined in the brief methods section (below).

Methods:

A 1 liter surface sample will be collected weekly in an opaque 1 liter bottle. The bottle will be rinsed 3X with water and then filled just subsurface by hand from the private dock adjacent to Sequim Bay State Park. Bottle will filled to the top, capped tightly and kept in a cooler with blue ice until shipped. The careful collection and handling of this sample will allow it to meet the data quality objectives for the water samples taken under the Soundtoxins QAPP and the manner of collection is identical. The bottle will be labeled with the site, date and time of collection and kept in a cooler with blue ice until shipment to NOAA.

Every two weeks a SPATT (Solid Phase Adsorption Toxin Tracking) disk will be collected and another deployed. This will be tied to the dock with line and the disk will be weighted and left to hang at a depth of 0.5m for two weeks. Once retrieved it will placed in a Ziploc bag, a label on waterproof paper will also be placed in the bag with the site name, deployment and retrieval dates and times. The SPATT disk will be kept in a cooler with blue ice until shipped to NOAA. The bottle and SPATT disks will be shipped overnight in an insulated cooler box with blue ice (separated by paper towels in the box from the samples as to not accidentally freeze them) to NOAA Northwest Fisheries Science Center Biotoxins group in Seattle. Deployment, retrieval and handling of the SPATT disk in a consistent manner should reduce bias, increase sensitivity and precision as well as comparability between dates of SPATT deployment. The bottles, SPATT disks, shipping labels and boxes are all supplied by NOAA.

Samples will be collected May through September 2018 and 2019. Sampling in 2019 will be dependent on funding levels at NOAA.

Quality Assurance Project Plan (QAPP)
for
Streamkeepers of Clallam County
Environmental Monitoring Program

December 2017

Revision of Streamkeepers' prior QAPP (Chadd, 2016)

Prepared by Edward A. Chadd
Clallam County Department of Public Works-Roads
223 E. 4th St., Suite 6, Port Angeles, WA 98362

Available online at http://www.clallam.net/SK/QualityAssurance.html

Quality Assurance Project Plan
for
Streamkeepers of Clallam County
Environmental Monitoring Program

December 2017

Approved by:

Signature: Edward Chadd Date: 12/22/17
Edward Chadd, Associate Planner, Clallam County Department of Public Works-Roads
Program Coordinator, Principal Investigator, Quality Assurance Officer,
Streamkeepers of Clallam County

Signature: Ross Tyler, P.E. Date: 12/22/17
Ross Tyler, County Engineer, Clallam County Department of Public Works-Roads
Supervisor & Manager to Streamkeepers Program Coordinator

Signature: Sue Waldrip Date: 12-26-17
Sue Waldrip, Manager, Clallam County Environmental Health Laboratory

Suggested citation:
Chadd, Edward A. 2017. Quality Assurance Project Plan for Streamkeepers of Clallam County Environmental Monitoring Program. Clallam County Department of Public Works-Roads. Port Angeles, WA.

Cover photo: Streamkeepers volunteers collect a benthic macroinvertebrate sample on Jimmycomelately Creek.

Any use of product or firm names in this publication is for descriptive purposes only and does not imply endorsement by the author or Clallam County.

Table of Contents

List of Figures and Tables

Page

Figures

Tables

2.0 Abstract

In 1999, Clallam County created the Streamkeepers program, an offshoot of a volunteer stream monitoring program, the "Eight Streams Project," operated under WSU Cooperative Extension of Clallam County from 1997-99. Both programs emerged from local watershed management plans which recommended the creation of volunteer "stream teams" to foster watershed stewardship and provide data useful for watershed management and restoration (Sequim Bay Watershed Management Committee, 1991; Dungeness Watershed Management Committee, 1993; Clallam County, 1995). A volunteer watershed-monitoring program gives interested citizens a way of becoming actively and meaningfully involved in a broad-based effort to learn about, protect, and restore watersheds across Clallam County.

Streamkeepers provides a suite of monitoring protocols, a corps of trained data collectors, quality assurance, and data management and reporting, to document the ambient (physical, chemical and biological) conditions of Clallam County waters. We conduct our own quarterly ambient monitoring program and also utilize our monitoring and QA protocols in conducting a variety of special monitoring investigations at clients' requests, in furtherance of those clients' watershed protection and restoration goals. Streamkeepers meets an ongoing need for data for a variety of purposes (Clallam County, 2004).

Per U.S. Environmental Protection Agency guidance in *EPA QA/G-5* (USEPA, 2002), this document describes a "generic QA Project Plan" that covers activities at multiple sites over multiple years, having the same project objectives and sampling and analytical processes. Data collected under this plan meet the requirements of *Washington Department of Ecology Water Quality Program Policy 1-11* (WA Dept. of Ecology, 2006). This plan is to be reviewed annually to determine if any changes are necessary to satisfy all current Ecology and EPA standards and to be supplemented as needed by separate QAPPs for special watershed monitoring projects.

3.0 Background

This document is an update of Streamkeepers' previous Quality Assurance Project Plan (Chadd, 2016). It meets the requirements of the Washington State Department of Ecology for agencies who wish to submit data to be considered for State Water Quality Assessments mandated by the federal Clean Water Act (WA Dept. of Ecology, 2006). There are no significant changes since our prior QAPP.

3.1 Study area and surroundings

The text for this section is based on *State of the Waters* (Clallam County, 2004), a comprehensive report on the watersheds of Clallam County funded by Ecology's State Centennial Clean Water Fund.

Clallam County comprises most of the northern half of the Olympic Peninsula at the northwestern corner of Washington State. It is surrounded by the marine waters of the Pacific Ocean to the west and the Strait of Juan de Fuca to the north. (See Figure 1 below.)

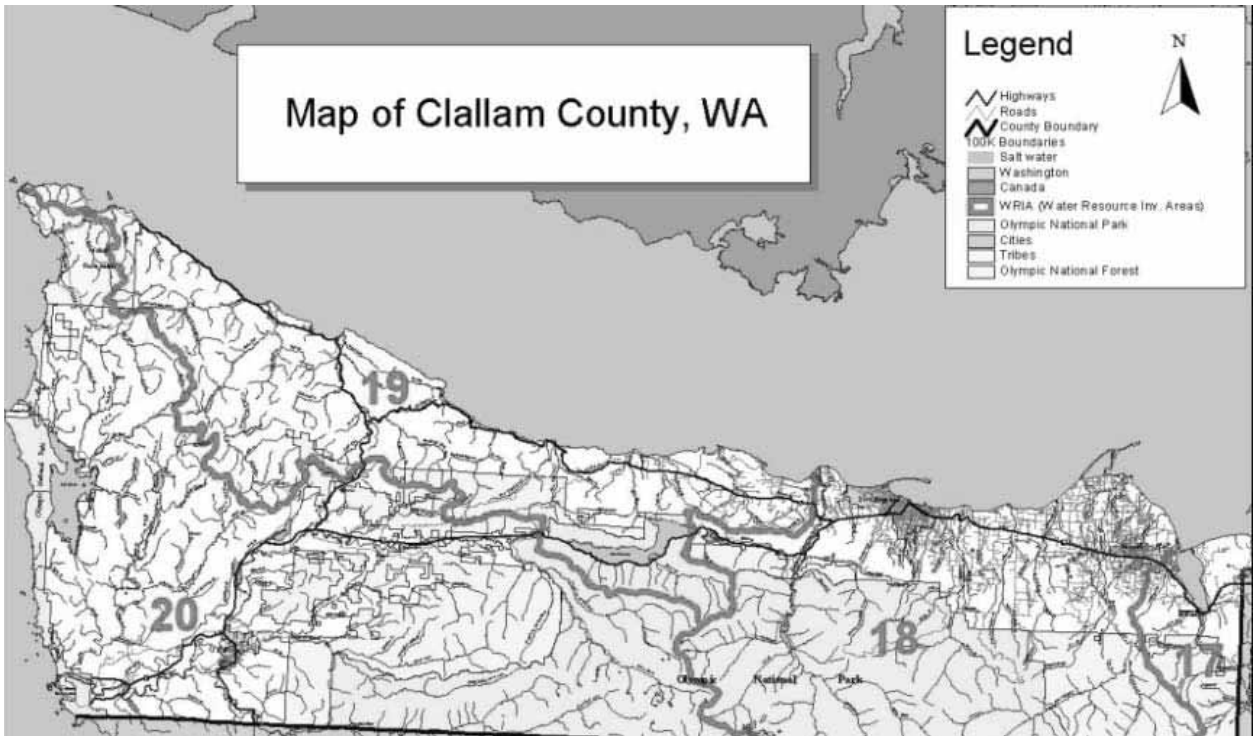


Figure 1. Clallam County, showing Water Resource Inventory Areas (WRIAs).

Clallam County's waters all flow from the Olympic Mountains that form the core of the Olympic Peninsula. The heart of the peninsula has been preserved as Olympic National Park, and has been described as "more than 1,400 square miles of rugged mountains, richly forested river valleys,

and pristine wilderness coast." The waters of Clallam County provide abundant resources for fish, wildlife and humans, including recreational, aesthetic, economic and ecological benefits for citizens and visitors. Important recreational and commercial uses of these waters include boating, fishing, and shellfish harvesting. The County's rivers, creeks, lakes, wetlands and estuaries provide habitat for a diversity of fish and wildlife species, including many different stocks of salmonids. Its groundwater aquifers supply drinking water as well as baseflow to most streams and wetlands.

3.1.1 Logistical problems

We sample at sites on public property or private property where we have secured permission. Sometimes access is not possible due to environmental or property condition, or denial of permission. At some sites, wade-across flow measurements are not possible due to water depth and/or velocity, and at other times, water levels are too low for sampling. Tides sometimes do not allow sampling freshwater input at tidally-influenced sites.

3.1.2 History of study area

For more than a century, the forests of the Olympics were prized by loggers and other residents for their record-size trees. Logging and other development have left a legacy of impacts on both habitat and water quality across the peninsula. While each stream has its own distinctive characteristics, some qualities are common to all of them. Unless in the rainshadow of the Olympics, the watersheds generally have abundant rainfall in the winter that can result in hydrologic stress, especially if the stream is in a disturbed condition. Those streams originating high in the mountains often descend rapidly, then flow across a lower elevation floodplain, before entering salt water in the Pacific Ocean or Strait of Juan de Fuca. Geologic conditions provide for sediment-rich streams, with natural landslides regularly occurring on many peninsula rivers. When such streams were heavily forested, erosion usually proceeded at a more periodic rate. Once logged, especially in the steep upper watersheds, the amount of sediment entering the streams accelerated, often causing severe downcutting, erosion, blockages, and excessive fine sediments in streams, causing problems for aquatic wildlife, including spawning and rearing salmon.

Floodplain functions on peninsula streams have been subject to two major types of human impact. First, many channels have been disconnected from their floodplains. Second, many of the peninsula streams have lost their rich, deep riparian streamside corridors, which in the past provided shading, instream habitat, filtering, and aquatic food resources. Once removed, these benefits were no longer provided for fish, wildlife and water quality; many streams now lack forest cover and have limited large woody debris instream, resulting in poor channel habitat, increased summer water temperatures, low dissolved oxygen, and excessive turbidity. These situations are generally improving with more sensitive forest-practice regulations and numerous restoration projects, but recovery will take decades, and recovery end-states remain to be seen. Other floodplain impacts on some streams include dams, diking, channelization, riparian roads, animal access and other effects of development. While some streams on the peninsula maintain healthy ecosystems, human activities have directly impacted the quality of the water and habitat in the majority, compromising fish and wildlife resources as well as human uses. In an

ecological context, “compromised” means showing signs of ecological degradation, with impacts expected to one or more salmon life-stages, for example (Clallam County, 2005).

3.1.3 Parameters of interest

Sources of ecological degradation

Sources of ecological degradation in the study area are numerous, varied and sometimes difficult to detect. Surface water runoff can contain a mixture of nutrients, bacteria, sediments, petroleum products, metals and other toxic ingredients. The cumulative effect of these “nonpoint source pollutants” on water quality and aquatic life can be significant. Human alterations to water quality and salmonid habitat can be expected to have different consequences for different fish and wildlife species. Across Clallam County, land use activities associated with forest practices, agriculture, rural development, and industry have had negative impacts on water quality and salmonid habitat.

Excessive sediment is one of the most common “pollutants” and a major limiting factor for salmonid production across the peninsula. It can cause channel instability and degrade water quality and salmon habitat. Excess silt in stream gravels can make it difficult for fish to spawn and stream invertebrates to survive. Causes of excessive sediment include increased input from landslides, removal of vegetation and other ground disturbance associated with logging and roads (particularly when built on steep slopes), agricultural practices, and construction activities. On the other hand, decreased amounts of gravels (medium-sized “sediment”) suitable for fish spawning is also sometimes a problem, and has been caused by dams, dikes and other floodplain constrictions.

Excessive nutrients and bacterial contamination are relatively common pollutants in peninsula streams, estuaries and groundwater. Food (e.g., shellfish) gathered where fecal coliform bacteria levels are high can be harmful if eaten by humans. It is not known if fecal coliform bacteria is specifically harmful to salmonids, although its presence may indicate that other pollutants are present that are known to be harmful to fish. Excessive nutrients often result in the rapid growth of algae in streams, causing problems for fish (including declines in dissolved oxygen and increases in temperature), and often aesthetic problems for humans. This contamination can be caused by trampling and unrestricted animal access into riparian corridors or into the stream itself, leaking septic and sewer systems, excessive fertilizers and chemicals applied to the land, and general stormwater runoff.

Low flows cause some salmon to spawn in less stable areas of the stream, possibly increasing the likelihood that fish redds will be washed out during high flow events. Low flows also cause higher water temperatures and lower dissolved oxygen conditions than those needed by many fish and the “high-quality bugs” that salmon need to sustain their populations. Causes of low flows include water withdrawals, the operation of dams and diversions, alteration of floodplains and wetlands, and most particularly changes in vegetation patterns, which accelerate runoff during the rainy season, decrease storage, and therefore reduce summer flows.

Anthropogenic changes can cause or exacerbate flooding, which can seriously degrade stream channel conditions and bring pollutants into the stream, and eventually out into estuaries and bays. These pollutants are harmful to many species, including humans if they eat shellfish or other food gathered from these waters. Flooding is often due to channelization, routing of stormwater through irrigation systems, the presence of roads and impervious surfaces, and increased stormwater from lands where native vegetation has been removed.

Need for Data

Because of these challenges, various parties in Clallam County have focused great attention and effort to restore salmon populations, shellfish beds, and ecological functions. Numerous stream restoration, mitigation, and Best Management Practices projects have been completed, are underway, or are planned; watershed planning councils have devised long-range watershed management plans; and funding is being directed to numerous groups seeking to improve streams and fish habitat. All of these efforts share a need for good, ongoing data on stream health.

3.1.4 Results of previous studies and origin of the current study

While numerous studies have been conducted on various streams, there has been little consistent baseline water quality data available that can be used to identify specific ongoing problems, plan watershed management, or track the effectiveness of restoration projects.

Responding to the above needs, several watershed management plans completed in the 1990s (Sequim Bay Watershed Management Committee, 1991; Dungeness Watershed Management Committee, 1993; Clallam County, 1995) recommended that volunteer "stream adoption" teams be established to help build stewardship of watershed resources by area citizens. The plans also suggested that these teams monitor water quality parameters and become involved in solving problems they identify. A volunteer monitoring program gives interested citizens a way of becoming actively and meaningfully involved in a broad-based effort to learn about, protect, and restore their local watersheds.

In 1996, the Eight Streams Project (a 3-year Washington State Centennial Clean Water Fund grant funded by Ecology and administered by Washington State University Cooperative Extension of Clallam County) initiated a volunteer stream monitoring program on streams in Port Angeles and Sequim, under a Quality Assurance Project Plan approved by Ecology (Washington State University Cooperative Extension, 1997). When the grant expired in 1999, Clallam County established Streamkeepers of Clallam County to continue the stream-monitoring component of the Eight Streams Project. Program staff, in consultation with volunteers and technical advisors, revised the sampling plan and procedures and received Ecology's approval on a new Quality Assurance Project Plan (Baccus and Chadd, 2000). This QAPP has been regularly revised to reflect Credible Data standards adopted by the State of Washington and regulated by Ecology (Washington State Department of Ecology, 2006).

Since its inception, Streamkeepers' volunteer monitoring program has provided a suite of monitoring protocols, a body of trained data collectors, quality assurance, and data management to document the ambient (physical, chemical and biological) conditions of Clallam County waters. We also apply these protocols to help partner agencies and citizens' groups carry out special monitoring investigations connected with watershed protection and restoration. The need for good data has been recognized and is expected to increase over time (Clallam County, 2004).

3.1.5 Regulatory criteria or standards

The data we collect informs decisions under multiple regulatory frameworks such as:

- The federal Clean Water Act and Endangered Species Act
- The state Growth, Shoreline, and Watershed Management Acts, and the local planning/regulatory documents which implement those Acts:
    - The Comprehensive Plans and Shoreline Master Programs for Clallam County and the Cities of Forks, Port Angeles, and Sequim
    - Multi-stakeholder Watershed Management Plans which set broad management strategies for state-designated Water Resource Inventory Areas (WRIAs) 18-20 in Clallam County

    - These plans may incorporate or result in other instruments such as the Elwha-Dungeness Water Management Rule, adopted by the State to help implement the WRIA 18 Watershed Plan by securing water supplies in the Sequim area for the benefit of people, agriculture, fish and wildlife.
- Local plans for stormwater, roads, etc.

An important recipient of Streamkeepers data is the Washington State Department of Ecology (Ecology). We submit all of our quality-controlled data to their Environmental Information Management (EIM) database for broad access and availability to other entities large and small (https://ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database). Ecology is delegated by the federal government to administer the Clean Water Act in the state. Under this Act, Ecology periodically calls for data and publishes a Water Quality Assessment listing all available water quality data and rating the state's water bodies according to state water quality standards (https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d). This Assessment states which water bodies are in need of cleanup or concern and constitutes an important planning tool for the protection and restoration of watersheds.

4.0 Program Description

4.1 Program goals

Streamkeepers was created to involve residents in caring for watersheds, primarily by monitoring them, providing credible and useful data to help guide decision-makers in the protection and restoration of the County's streams.

4.2 Program objectives

In terms of stream monitoring, Streamkeepers' objectives are as follows:

- Define and document baseline physical, chemical and biological conditions of local streams
- Measure spatial and temporal variability of stream attributes
- Look for signs of degraded stream condition in a geographically broad manner
- Help identify sources of degradation
- Assess trends in watershed degradation or restoration
- Provide information to assist in watershed planning, management, restoration and adaptive management

Streamkeepers gathers, manages, analyzes, and reports on data under the direction of and for the use of other entities—those agencies, organizations, and individuals actively working to protect and restore streams. Our data helps advance the missions of a multiplicity of local, state, tribal, and federal agencies, as well as non-governmental groups and individual citizens. In general, these entities use Streamkeeper data to:

- Design, adaptively manage, and evaluate watershed-management plans, restoration projects, ordinances and regulations
- Assure compliance with permitting requirements
- Discover and remediate pollution problems
- Increase knowledge about local watersheds

4.3 Information needed and sources

The Streamkeepers program is designed to gather information, but to the extent that data gathered needs to be compared temporally or spatially, other data sets may need to be accessed. In many cases, Streamkeepers has imported data from other relevant datasets into the Clallam County Water Resources database after performing quality control and describing metadata needed to properly interpret the data. Typically, when Streamkeepers performs such imports, we clean up errors and improve documentation.

4.4 Target population

The Streamkeepers program is primarily designed to assess the chemical, physical, and biological integrity of the County's streams. However, part of that assessment involves gathering data from riparian areas and entire watershed basins, and we are also equipped to apply some of our protocols to lakes, wetlands, and nearshore marine environments.

4.5 Study boundaries

As a program of Clallam County, the Streamkeepers program focuses on Clallam County's streams (see Figure 1 above). However, it can go beyond County boundaries upon request of outside parties, particularly if the study question crosses those boundaries.

Water Resource Inventory Area (WRIA) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area

WRIAs:

- Western portion of WRIA 17
- All of WRIA 18 & 19
- Northern portion of WRIA 20

HUC numbers (8-digit):

- 17100101
- 17110020
- 17110021

4.6 Tasks required

In general, Streamkeeper volunteers use state-of-the-industry, detailed protocols to collect the data. These methods are described in more detail later in this document, and are described in full detail in the Streamkeepers Volunteer Handbook (Chadd, current year's edition). This set of Standard Operating Procedures generally undergoes revision each year, in order to:

- Better explain procedures and make data-collection more efficient
- Account for additional special circumstances
- Improve data quality

Revisions made will not in any case reduce data quality below the stated objectives for a given parameter.

4.7 Practical constraints

In an ideal world, we would gather continuous data on all of Clallam County's streams. However, we are limited by available funding, equipment, staff resources, technical expertise, and volunteer deployment. Hence, we must prioritize our efforts. This prioritization takes place on a continual basis, under the advisement of our Technical and Volunteer Advisory Committees (see next section). In devising our sampling plan, our advisors must balance two primary competing values: the continuity of long data sets, which enable evaluation of long-term trends and provide a stable reference for other data, versus the value of targeted flexibility and breadth of coverage. Another value to consider is volunteers' motivations: sometimes volunteers want to make a commitment to a particular stream, and other times they feel they have gathered enough data from a stream and want to move on. Usually the volunteers accept the recommendations of the technical advisors, but sometimes it works the other way around.

Other practical constraints on data completeness include volunteer availability, access to sites, landowner issues, equipment problems, and high/low flow sampling issues.

4.8 Systematic planning process

As an ongoing program rather than a specific project, Streamkeepers is governed by a systematic planning process which guides the program from year to year.

Streamkeepers is part of the Clallam County Department of Public Works-Roads. Our ultimate accountability is to the County Engineer and the Board of County Commissioners, and through them to the citizens of the County. Program direction is guided by the Streamkeepers Steering Committee, which itself consists of two committees: our Volunteer Advisory Committee and our Technical Advisory Committee.

The VOLUNTEER ADVISORY COMMITTEE is composed of any volunteers who care to participate. It recommends changes to any aspect of the program, including program components, activation or inactivation of sites and streams, and watershed protection and restoration projects. It meets as needed, convened by program managers or at the request of volunteers. It generally meets in the fall to review activities of the past year and make recommendations for the next.

The TECHNICAL ADVISORY COMMITTEE consists of people with technical expertise from local, state, tribal and federal agencies; academia; businesses and consulting firms; and knowledgeable local residents. This group connects the Streamkeepers program to other watershed management efforts and local technical expertise, and recommends priorities for sites, streams, parameters, special investigations, and data reporting, as well as by providing guidance on technical questions. It meets as needed, convened by program managers or at the request of advisors or volunteers. It generally meets in the fall to review activities of the past year and

make recommendations for the next, either in parallel or in conjunction with the Volunteer Advisory Committee.

The STREAMKEEPERS STEERING COMMITTEE consists of the VOLUNTEER ADVISORY and TECHNICAL ADVISORY Committees. It makes final recommendations on program direction and approves Streamkeepers' work plan for the coming year.

STREAMKEEPERS PROGRAM STAFF works with these groups every year to evaluate the prior year's programming and plan the next. Staff often makes recommendations of its own.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 1. Organization of program staff and responsibilities.

Staff	Title	Responsibilities
Ed Chadd Clallam County Road Dept. Phone: 360-417-2281	Program Coordinator, Principal Investigator, Quality Assurance Officer, Data Manager	Clarifies scope of the program in consultation with Steering Committee. Writes the QAPP and field and equipment maintenance/calibration procedures. Recruits, trains, and directs volunteers. Oversees field sampling and transactions with laboratories. Supervises QA review of data, analyzes and interprets data, and oversees entry of data into Clallam County Water Resources database, upload of data to external repositories such as Ecology's EIM database, and reporting of data as requested.
Streamkeepers volunteers	Volunteer	Receive training and execute monitoring activities under this QAPP; assist Program Coordinator.
Streamkeepers volunteers	QC Reviewers	Receive special training from the Principal Investigator to review incoming data sheets for data completeness, cogency, consistency, and legibility.
Streamkeepers Steering Committee (consisting of Volunteer and Technical Advisory Committees)	Steering Committee	Sets direction for the program in consultation with Program Coordinator. See Section 4.8 above.
Ross Tyler Clallam County Road Dept. Phone: 360-417-2448	Manager and Supervisor for Program Coordinator	Provides internal review of the QAPP, reviews and approves the program scope and budget, and approves the final QAPP.
Sue Waldrip Clallam County Environmental Health Laboratory Phone: 360-417-2334	Laboratory Manager	Reviews QAPP, coordinates with Program Coordinator.

5.2 Special training and certifications

The Program Coordinator has experience in all of the procedures described or referred to herein and has received training from multiple organizations, including Ecology, the Adopt-A-Stream Foundation, the Student Watershed Research Project, River Network, Herrera Environmental Consultants, and the National Water Quality Monitoring Council.

5.3 Organization chart – see section 5.1 above

5.4 Program schedule

Streamkeepers is an ongoing program rather than a time-circumscribed project, and thus has no fixed start or end dates for sampling or reports. Our regular ambient sampling schedule is described in Table 2 below. Special-investigation sampling is conducted on a schedule determined by the proponent. Data is QC'd and entered into the Clallam County Water Resources database as soon as possible after field sampling or receipt of lab data, then checked against hard copies as soon as possible thereafter. We submit data to Ecology's Environmental Information Management (EIM) system either when a grant schedule requires it or when Ecology issues a call for data. Other reporting occurs on schedules determined by the end-users of the data. Data is reviewed by Principal Investigator prior to reporting.

Table 2. Streamkeepers' ambient monitoring schedule for parameters submitted to EIM.

Season:	**Water chemistry, flow**	**SxS Water chemistry**	**Benthic macroinvertebrate collection (for Benthic Index of Biotic Integrity)**
Winter	January	Side-by-Side sampling with WA Dept. of Ecology at least 4 times per year.	
Spring	April		
Summer	August		Aug. 1 – Sept. 30
Fall	Sept 15 - Oct 15		

5.5 Limitations on schedule

Scheduling may be impacted by a number of factors, including volunteer team availability, weather, equipment availability and condition. We occasionally sample outside of the sampling window, at the discretion of the Principal Investigator. Database records indicate what the sampling window should have been vs. when the sampling occurred.

5.6 Budget and funding

Budgeting is variable from year to year, but the following table presents a general idea of funding sources.

Table 3. Program budget and funding—typical annual figures.

Component	Typical funder	Approx. cost
Staff 0.5 FTE	Clallam County Road Fund	52,000
Supplies	Clallam County Road Fund	2,000
Fecal lab – Clallam County Environmental Health	Investigation proponent - $26 per sample	?[1]
Benthic macroinvertebrate lab – ES&C	Investigation proponent - ~$350 per sample	?[1]
Analytical lab – Ecology Manchester lab	Investigation proponent – prices vary	?[1]
	Total	54,000+

[1] Funding depends on special investigation proponents and their sampling plans.

6.0 Quality Objectives

6.1 Decision Quality Objectives (DQOs) – n/a

6.2 Measurement Quality Objectives

Although Streamkeepers gathers data on a wide variety of parameters, including fish and wildlife observations, invasive exotic plants, photos, and certain components of physical habitat, the remainder of this QAPP addresses itself to those parameters for which we submit data to Ecology for its Water Quality Assessment or grant fulfillment. These parameters are quantitative and are reported as a number value, with the parameter defined by metadata fields established by Ecology as well as others used by Streamkeepers.

Streamkeepers' measurement quality objectives (MQOs) for these parameters are presented in Table 4 below. Industry standard field methods will be used whenever possible to minimize measurement bias (systematic error) and to improve precision (random error), and all laboratory-bound samples will be collected, preserved, stored, and otherwise managed using accepted procedures for maintaining sample integrity prior to analysis.

In sampling design, methods and MQOs are chosen to fit the particular purpose for which the data will be used. For example, data destined for submittal to Ecology's Water Quality Assessment will be according to Ecology's credible-data requirements.

Stormwater, sediment, and nutrients parameters: In addition to the MQOs below, we have written QAPPs for the sampling of stormwater, stream sediment, and nutrients, each approved by EPA or Ecology; see http://www.clallam.net/SK/stormwatermonitoring.html, http://www.clallam.net/HHS/EnvironmentalHealth/documents/qapp.pdf, and http://www.clallam.net/SK/doc/clnwtrdpolid.pdf. These QAPPs are incorporated by reference into this document (Chadd et al., 2008; Chadd et al., 2009; Knapp et al., 2009; Chadd et al., 2010; Soule and Chadd, 2013; Clallam County Departments et al., 2015).

(This page left blank for two-sided printing.)

Table 4. Measurement Quality Objectives. **(**Frequency of sampling is described in Section 7.1, Study Design.)

* = protocol in Streamkeepers Volunteer Handbook; SM = Standard Methods (APHA); NA = not applicable

% bias = Abs(standard value – measured value) / standard value x 100%, where Abs = absolute value

RSD = relative standard deviation (also known as the coefficient of variation or CV), which, when n = 2 (as when comparing a sample with a replicate), is defined as follows:

RSD = Abs(difference/sum) x Sqrt(2) x 100%, where Abs = absolute value and Sqrt = square root

Parameter (Analyte), matrix	**Method, Source**	**Sample holding time & analyzers**	**Units**	**Expected range of results**	**Resolution**	**Detection limit**	**Reporting limit**	**Bias (vs. standard)**	**Precision (vs. replicates)**
*Barometric pressure, air	Barometer, ASTM D3631	In situ or nearby weather station	in Hg	27 - 31	0.01	20.5, 32.5	20.5, 32.5	0.05 vs. weather station	0.05
*Benthic (invertebrate) Index of Biotic Integrity, tissue	Surber sampler, 500µ mesh, King County 2014	ID & QC by professional taxonomic lab	B-IBI$_{0\text{-}100}$	0 - 100	1	0, 100	0, 100	NA; min. detectable difference = ± 14.11	St. Dev. = 7.2; Signal/ Noise ratio = 10.76
*Dissolved Oxygen, water	Membrane electrode, SM4500 O-G	In situ	mg/L	6 - 15 (70-120% saturation)	0.1 (1% sat.)	0.1	0.3	0.3	0.3
*Dissolved Oxygen, water	Azide Modifi-cation, SM4500 O-C; Ward 2016	4 days in dark after adding flocculants	mg/L	6 - 15 (70-120% saturation)	0.1	0.1	0.2	0.2 (Hallock and Ehinger 2003)	0.2
*Dissolved Oxygen, water	Luminescence sensor, ASTM D888 Test Method C	In situ	mg/L	6 – 15 (70-120% saturation)	0.1 (1% sat.)	0.1	0.2	0.2 or 2%	0.2 or 2% RSD

Parameter (Analyte), matrix	Method, Source	Sample holding time & analyzers	Units	Expected range of results	Resolution	Detection limit	Reporting limit	Bias (vs. standard)	Precision (vs. replicates)
E. coli & Total coliform, water	Colilert© chromogenic substrate test, SM9223	Sterilized poly bottle; analyzed by staff or trained volunteers	MPN CFU/ 100 mL, or presence/ absence	0 - 20,000	1	1	1	See 95% Confidence Limits from SM9221C	10 or 85% RSD
*Enterococcus, water	Enterolert© enzyme substrate; SM9230	Sterilized poly bottle ≥125 mL; accredited laboratory; 8 or 24 hr at <10°C[2]	Most Probable Number (MPN)/ 100 mL	0 - 2000	1; MDL = 100 ÷ volume filtered	1	1	NA	10 or 85% RSD
*Fecal coliform, water	Membrane filtration, SM9222D; USEPA 2005; CCEHL 2006	Sterilized poly bottle ≥125 mL; accredited laboratory; 8 or 24 hr at <10°C[2]	Colony-forming units (CFU)/ 100 mL	0 - 20,000	1; MDL = 100 ÷ volume filtered	1	1	NA	10 or 85% RSD (i.e., Base 10 log-transformed values ± 0.6)
*Flow, water	Wade-across (SWFMC), Schuett-Hames et al. 1994	In situ current & depth measurements	Cubic feet per second (cfs)	0 - 1000	0.1	0.1	0.1	Presumed 10%	10% RSD
*Flow, water	Single-point hydraulic (MID-SECTION), Perry 2003	In situ	Cubic feet per second (cfs)	0 - 1	0.01	0.01	0.01	Presumed 10%	10% RSD
*Flow, water	Bucket (SWFMB), Perry 2003	In situ	Cubic feet per second (cfs)	0 - 1	0.001	0.001	0.001	Presumed 10%	10% RSD

449

[2] Per USEPA 40 CFR, Part 136 (2012), 0-10°C. Samples which have been collected and iced within two hours of lab delivery may be warmer, as long as they show signs of having been chilled down since collection time (Rosenbower, 2016).

Parameter (Analyte), matrix	Method, Source	Sample holding time & analyzers	Units	Expected range of results	Resolution	Detection limit	Reporting limit	Bias (vs. standard)	Precision (vs. replicates)
*Flow, water	Floating object (SWFM FLOAT), Michaud 1994 ; Murdoch et al. 1996	In situ	Cubic feet per second (cfs)	0 - 1000	0.1	0 (if no flow)	0 (if no flow)	Unknown—all data will be qualified as EST	20% RSD
*Flow, water	Wade-across (SWFMC), Schuett-Hames et al. 1994	In situ current & depth measurements	Cubic feet per second (cfs)	0 - 1000	0.1	0.1	0.1	Presumed 10%	10% RSD
*Nitrate-Nitrogen, water	Nitrate ion electrode method, SM4500N03-D; CCEHL 2006	Accredited laboratory; sterilized bottle; 24 hr. at ≤6° C (USEPA, 2012)	mg/L	0 - 5	0.1	0.1	0.1	± 20%	7% RSD
*pH, water	Gel probe or liquid with reference, SM4500-H+	In situ or 2 hr.	pH units	6.5 - 8.5	0.1	0.1, 14	4, 10	0.2	0.2
Precipitation, water (incl. 24 hr.)	Weather station	In situ	in	0 - ?	0.01	0	0	NA	NA
*Salinity, water	Electrode, SM2520B-F	In situ	PSS (ppt)	0 - 32	0.1	0.1	0.1	Calibrated with Specific Conductivity	0.1 or 5% RSD
Settleable solids, water	Volumetric, SM2540F	Grab sample, Imhoff cone	mL/L	0 - 500	1	1	1	NA	1 or 5% RSD

450

Parameter (Analyte), matrix	Method, Source	Sample holding time & analyzers	Units	Expected range of results	Resolution	Detection limit	Reporting limit	Bias (vs. standard)	Precision (vs. replicates)
*Specific Conductivity (at 25 deg C), water	Electrode, SM2510B	In situ	µS/cm	25 – 400 (fresh) - 49,000 (marine)	1	1	1	5%	5% RSD
Stage, water	Staff gage or reference point, Shedd 2008	In situ	ft	NA	0.01	NA	NA	NA	± 0.01
*Temperature (grab), water	Thermistor, SM2550	In situ	°C	0 - 20	0.1	-5	-5	0.2	0.2
*Temperature (grab), water	Thermometer, USGS 1998	In situ	°C	-5 - 35	1	Per instrument	Per instrument	1	1
*Temperature (grab), air	Thermometer, USGS 1998	In situ	°C	-5 - 35	1	Per instrument	Per instrument	1	1
Temperature (continuous), water	Data logger thermistor, Dunham et al. 2005	In situ	°C	0 - 20	0.1	-5	-5	0.2	0.2
*Turbidity, water	Nephelometric, white light spectral, SM2130B	48 hr. in darkness at ≤6°C (USEPA, 2012), bottle >500 mL	NTU	0 - 1000	0.01	0.1	0.5	0.5 or 7%	1 or 7% RSD
*Turbidity, water	Nephelometric, near-infrared, ISO 7027	In situ or 48 hr. in darkness at ≤6°C (USEPA, 2012), bottle >500 mL	FNU	0 - 1000	0.1	0.1	0.5	0.5 or 7%	1 or 7% RSD

451

6.2.1 Targets for Precision, Bias, and Sensitivity

6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error and is usually assessed by analyzing duplicate samples or field measurements. Field measurement precision is estimated by analysis of replicate measurements at one site (randomly selected) per team per sampling season, or at least one replicate per ten measurements. Details on field replicate measurement procedures are described in the "Water Chemistry—General Guidelines" section of the Streamkeepers Volunteer Handbook (Chadd, current year's edition). The variation between these measurement and replicate values is a measure of variability due to short-term environmental factors, instrument operation, and measurement procedure. See Table 4 above for acceptance criteria and control limits based on comparing replicates with paired measurements.

6.2.1.2 Bias

Bias is the difference between the population mean and the true value. Bias is usually addressed by calibrating field and laboratory instruments, and by analyzing lab control samples, matrix spikes, and standard reference materials. For field measurements, bias is assessed by comparing instrument readings with NIST-traceable standard reference materials. See Table 4 above for acceptance criteria and control limits based on bias analysis.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as detection limit, the lowest quantity of a physical or chemical parameter detectable (above background noise) by a field instrument or laboratory method. Furthermore, we set reporting limits at values we feel confident reporting, usually with less sensitivity than detection limits. Detection and reporting limits are presented in Table 4 above.

6.2.2 Targets for Comparability, Representativeness, and Completeness

6.2.2.1 Comparability

Standardized sampling methods are summarized in Table 4 above, and standardized operating procedures (SOPs) for sampling are detailed in Streamkeepers' Volunteer Handbook (Chadd, current year's edition). Data checking procedures are described at http://www.clallam.net/SK/doc/Qrtlydtashtckpl.pdf. Standard data reduction will be by daily average or per client request. Storm-targeted samples will be indicated clearly as such and will not be averaged from different times during a sampling day.

Streamkeepers data is often combined with other data sets for analysis. The following rules will govern such combination:

1. The purpose of the analysis will dictate the stringency of combination rules. For general watershed characterization studies, all data believed to be reasonably accurate might be

accepted, including data not gathered under a Quality Assurance Project Plan (QAPP), or for which the QAPP was not completely followed, or for which QA procedures were not completely documented. This was the case for Clallam County's *State of the Waters* report (Clallam County, 2004). More rigorous standards will be applied for more rigorous purposes: for example, for Ecology's Water Quality Reports, only data gathered to the specifications of Ecology's "credible data" policy (WA Dept. of Ecology, 2006) will be accepted for submission. In the latter case, data submitted is always connected with the particular study under which it was gathered, along with appropriate information about each study.

2. Streamkeepers special investigations in which data is collected under this QAPP will be considered equivalent to Streamkeepers ambient-monitoring data. Some common-sense adjustments may be made to QA procedures in order to assure comparability: for example, if an investigation is not organized according to stream-teams, replicates will be collected at 1/10 of the sampling sites rather than at one of the team's sites for a given sampling season.
3. Data collected under a separate QAPP, but which references the Streamkeepers Handbook for field and QA procedures, will be considered equivalent to Streamkeepers data.
4. Where possible, non-Streamkeepers data sets are analyzed, documented, and incorporated into the Clallam County Water Resources database, with appropriate metadata applied.

6.2.2.2 Representativeness

Sampling is designed to be representative of existing conditions in the following ways:

- Overall site & stream selection: Both streams and monitoring sites are targeted at salient features chosen by our advisory groups (see site selection criteria); because random sampling was not used in their selection, these streams and sites are not chosen to be representative of any larger geographic area.
- Chemical water quality sample representativeness is sought at a given site by taking the sample at or near the point in the channel where water is well mixed and most representative of ambient conditions, and by maintaining probes in the stream until a stable reading is achieved. When sampling in tidally-influenced conditions, if the goal is to sample the freshwater input to the salt water body, the sample may be collected at a point higher in the water column to maximize the freshwater component being sampled.
- Macroinvertebrate sample representativeness: We collect from 8 square-foot areas of substrate per sample, spaced out between multiple riffles, in mid-channel riffle habitat, between August 1 and Sept. 30. If riffles are not available, we use a glide or the fastest part of the stream. Each sample is then sub-sampled to a target of 500 specimens. The purpose of these procedures is to collect a representative sample from a common and easily identified habitat that can be compared to other similar samples across the region and state (King County, 2014). When possible, we sample at least 165 feet upstream or 660 feet downstream of a bridge or other large human-made structure, to minimize the localized effect of that structure (Fore, 1997).

- Assumptions regarding sampling intervals: Streamkeepers' advisors have recommended a basic format of quarterly sampling, based on assumptions of general seasonal variation of data, in order to gather data representative of the different seasons:
  - Winter: January; cold temperatures, high baseflows, storms
  - Spring: April; high baseflows, warmer temperatures, snowmelt, plant budding
  - Summer: August; low flows, high temperatures, full leaf-out
  - Fall: September 15 – October 15; often either lowest flows or first storms of the season; leaf fall and plant die-off
  - B- IBI sampling of benthic macroinvertebrates is Aug. 1 – Sept. 30 (King County, 2014).
- Exceptions to sampling intervals: This quarterly format is amended in individual cases on the recommendations of advisors (the most frequent amendment being to limit sampling to summer and fall, to try to catch the low-flow period). Volunteers can sample at any point within the sampling window, and in some cases may sample a few days outside of the sampling window for a given season, if program managers approve (generally, as long as the weather is not radically different than during the sampling window). Furthermore, special studies will dictate different sampling schedules. For example, a stormwater study will be timed to track a storm event, a summer low-flow study will be timed to catch the lowest flows, and a study of pollutants in recreational areas will focus on times of heaviest use. In all cases, special-purpose sampling will be indicated as such in comments connected with the data in the Clallam County Water Resources database.
- Limitations on representativeness:
  - Intervals: Our seasonal samples are assumed to be adequate for generalized watershed characterization, but they tend to miss extreme events, which are crucial to understanding certain watershed-process phenomena such as flood impacts, "first-flush" effects, and extreme low flows or temperatures. For example, an Ecology study at 42 stations indicated that monthly spot-sampling, on average, underestimated the summer maximum temperature by 3.7°C and the maximum seven-day average of daily maxima by 2.9°C (Hallock and Ehinger, 2003). On request and when possible, we will implement continuous sampling.
  - Timing within sampling window: Most sampling windows are a month long, and samples can be collected any time during that period. Results may need to be normalized per Julian date, and caution must be used in interpretation. However, year-to-year differences in seasonal patterns are probably more significant than the date of sampling within a given month.
  - Time of day: Samples are not collected at a uniform time of day, and therefore diel variations may influence data for certain parameters, particularly temperature, pH, and dissolved oxygen. Data analysis will need to consider such diel effects.
  - Chance events: A summer rainstorm can significantly impact water-quality parameters, so recent higher-flow events may need to be considered when analyzing data.
  - Order of sampling: During ambient monitoring, if there are multiple sampling sites on a given stream, sites are generally visited from upstream to downstream, to minimize the possibility of cross-contamination of exotic organisms from generally-more-impacted downstream sites to generally-less-impacted upstream sites (Washington State Department of Fish & Wildlife, 2012). This is the opposite of the progression that Streamkeepers used to follow, and it presents a number of problems:

- Downstream contamination caused by samplers walking in the stream.
- Possibly biased turbidity data during and after a storm event, because turbidity tends to rise sharply and then decline slowly. Therefore, if a downstream sample has a higher turbidity than an upstream sample taken earlier the same day, the difference may be due to the possibility that turbidity was rising in the entire system due to the rising curve of a storm event.
- A similar reasoning holds for temperature measurements, which tend to rise diurnally; a higher temperature taken at a downstream site later in the day may be the result of timing, not geography.
- In all cases, times are recorded along with measurements to make temporal relationships clear.

6.2.2.3 Completeness

Because Streamkeepers is a volunteer-based program, we cannot guarantee the same level of completeness as a program with a paid staff. (There may be exceptions to this qualification, if a special-investigation client requires a certain completeness standard and funds Streamkeepers staff to guarantee it.) In general, we aim to gather at least 90% of the data outlined in our annual work and sampling plans (http://www.clallam.net/SK/programplanning.html). Occasionally volunteers are unavailable to monitor their assigned streams; whenever possible, staff will assign alternate teams and/or individuals to complete the data collection, or assist with data collection themselves. Custodial sample loss will be minimized with sturdy sample storage vessels and adequate labeling of each vessel. When doing a study based on Streamkeepers data, it is up to the analyst to evaluate the completeness of the data set and qualify conclusions accordingly.

7.0 Sampling Process Design (Experimental Design)

7.1 Study Design

As described in Section 4, "Program Description" (see "Goals," "Objectives," and "Constraints"), the Streamkeepers program is a long-term effort which maximizes available human, capital, and financial resources to facilitate stewardship of Clallam County's watersheds. Because resources and needs change over time, a single sampling design would not be appropriate. However, the basic design of the Streamkeepers monitoring program can be described as follows:

1) *Long-term Ambient Monitoring:* Regularly scheduled field sampling events to collect data on a suite of parameters of watershed health at established sites. Parameters, sites, and scheduling are determined in consultation with Streamkeepers' supervisors and advisory committees, as described in "Organization and Schedule" above.

2) Special Investigations: Special investigations performed at the request of a partner entity, to that entity's specifications. These investigations may be performed under Streamkeepers' QAPP, a separate QAPP, or no QAPP, depending on the requirements of the investigation. Streamkeepers' supervisors and advisory committees are kept apprised of these investigations, and their feedback is invited.

We understand that certain investigations may only meet limited interpretive goals. For instance, an investigation targeting high or low flows will not reflect general ambient conditions, and an investigation collecting data during a brief time window will not in itself allow for analysis of trends. The purpose of any special investigations will be included as a comment alongside the data in the Clallam County Water Resources database. Ecology guidelines particularly specify such a comment to accompany any sampling that targets a storm event.

7.1.1 Field measurements

Field measurements and samples to be collected are described in Section 6.2, "Measurement Quality Objectives."

7.1.2 Sampling location and frequency

1) *Long-term Ambient Monitoring*

Streamkeepers' monitoring focuses on wadeable streams, most of which arise in the foothills of mountains and are of relatively short length—often just a few miles. The choice of which streams to monitor is made by consultation between Streamkeepers staff, supervisors, and advisory groups. These choices are reflected in our annual work plans and sampling plans, available on our website: http://www.clallam.net/SK/programplanning.html.

Targeted sampling locations are a matter of consensus judgment. We generally try to establish three or more monitoring sites on a given stream: ideally, one at or near the mouth, one at a transition point between more- and less-intensively-developed areas, and one above the developed areas. This arrangement allows comparison between stream characteristics at different elevations and levels of human impact. The exact number and location of monitoring sites will depend on characteristics specific to each creek (including access, owner permission, creek geography and history, etc.). Because we are an ongoing program designed to meet the long-term informational needs of local resources managers, the sites change over time. For instance, after several years of monitoring a particular site, we may decide that an adequate baseline of data has been collected and therefore mothball the site; or another entity may decide to take over monitoring in a given area. Specific streams and sites monitored are reviewed annually and may be adjusted each year, according to the recommendations of Streamkeepers' supervisors, technical advisors and volunteers. These changes are reflected in the Streamkeepers workplan devised prior to each calendar year accompanied by individual plans for water quality and benthic macroinvertebrates, and posted on our website: http://www.clallam.net/SK/programplanning.html. All sites are entered as points in Clallam County's Geographic Information System (GIS) and shared with Ecology's EIM database.

Selection criteria for ambient monitoring sites include the considerations presented in Section 6.2.2.2, such as the following:

- Site is typical of its location in the watershed.
- Sites in a stream system collectively present a representative view of the stream as a whole.
- Sites in a stream system collectively help to isolate problem areas in a watershed.
- Reasonable and safe access by volunteers.
- Publicly owned land or permission of landowner to access and mark sites.
- Site contains both pools and riffles, if possible.
- Above saltwater and tidal influence, if possible, unless the tidal location is important.

Any sampling for laboratory analysis (e.g., fecal coliform, nutrients, invertebrates) is constrained by funds available for laboratory fees, and therefore such sampling cannot be guaranteed. Streamkeepers is often able to form partnerships to perform such sampling, but in such a case, the sampling is a special investigation (see below) and sites are determined by the funder.

Micro-location of sampling at a site is generally made by the field team in situ, because certain conditions must prevail for certain types of sampling, e.g., flow, water chemistry, or benthic macroinvertebrate collection. Details of how to determine the best spot for a given procedure are described in Streamkeepers' Volunteer Handbook (Chadd, current year's edition).

2) Special Investigation Work

Special investigation monitoring sites are selected by the proponent to meet their own objectives. Often, the sites chosen are sites already established by Streamkeepers, which offer the advantage of an existing body of data and known access and permission.

7.1.3 Parameters to be determined

The primary parameters investigated by Streamkeepers' ambient monitoring program are described in Table 5 below, including rationale and desired value range. A complete list of parameters to be determined is presented in Section 6.2, "Measurement Quality Objectives."

Table 5. Primary parameters of interest in Streamkeepers' ambient monitoring.
Monitoring Quarters: Winter: January, Spring: April, Summer: August, Fall: Sept. 15 - Oct. 15

Type of Parameter	Parameter	When	Why	Desired Level or Range
Chemical	Dissolved Oxygen	quarterly	Oxygen in water is vital to growth and development of aquatic life.	> 9.5 mg/L for most streams and 8.0 mg/L for the rest*
	pH	quarterly	A healthy stream is neither excessively acid nor alkaline; some aquatic life forms can only live within a narrow pH range, others are more tolerant.	6.5-8.5*
	Salinity	quarterly	In tidally-influenced waters, salinity readings give an idea of the relative degree of freshwater vs. saltwater influence at the sampling point.	Fresh water should generally be 0.1 PSS (Practical Salinity Scale) or less. Open ocean is about 35 PSS.
	Specific Conductivity (at 25°C)	quarterly	A healthy stream has low conductivity. High electrical conductivity indicates various chemical and biological pollution problems.	No standard established for streams, but readings >300 µS/cm may be cause for concern
	Temperature	quarterly	Consistently cool streams provide better habitat for salmonids. Streams that are unusually warm indicate watershed problems.	< 16° C for most streams and < 18° C for the rest*; consistent, cool temperatures
	Turbidity	quarterly	Turbidity (cloudiness in water) results from suspended solids such as mud. High levels of suspended sediment destroy fish habitat.	No more than 5 NTU above "natural" levels (or 10% above if "natural" level is >50).* (An "NTU" is a measure of turbidity.)
Biological	Benthic macroinver-tebrates ($B\text{-}IBI_{100}$)	Annually, Aug 1- Sept 30	Diverse populations of macroinvertebrates signal a healthy stream system capable of supporting fish.	Large diversity of creatures, especially those requiring undisturbed conditions.
	Fecal Coliform and other bacterial concentra-tions	quarterly as funding permits or as requested by other sponsors	Fecal bacteria indicate human and animal waste in runoff water. Fecal matter in streams enriches water with nitrogen, contaminates shellfish, and makes people sick.	Geometric mean of 50 colonies per 100 mL and <10% of readings below 100 colonies for most waters, and geometric mean of 100 & <10% below 200 for the rest*

* Source: State water quality standards, Chapter 173-201A WAC. Clallam County streams for which standards are more lenient are: the Dungeness River and tributaries downstream of Canyon Creek (RM 10.8), Port Angeles Harbor tributaries from Tumwater to Lees Creeks, and the Dickey River. Current state standards for temperature, dissolved oxygen, and fecal coliform are categorized according to designated uses for aquatic life, recreation, etc.

7.2 Maps or diagram

For an overall map of the study area, see Figure 1 in Section 3. For a list of specific locations proposed for sampling, see the current Streamkeepers Work Plan at http://www.clallam.net/SK/programplanning.html.

7.3 Assumptions underlying design

Assumptions underlying design include:

- Representativeness of sites and sampling intervals (see Section 6.2.2.2).
- Appropriateness of parameters selected to describe water quality conditions.
- Efficacy of basing sampling strategy on the stated needs of outside agents.
- The value of long-term data sets.
- The increasing ratio of signal to noise as data sets grow.

7.4 Relation to objectives and site characteristics

The sampling program and field data collection methods are designed to meet program goals and objectives within the limitations of funding, staffing, volunteer effort, and technical limitations. Partner agencies understand that Streamkeeper volunteers are primarily limited to wadeable streams, but "wadeable" is somewhat open to interpretation. We generally follow the "Rule of 10": if velocity (in ft/sec) * depth (in ft) > 10, we stay out. Sometimes the limit is less than 10.

7.5 Characteristics of existing data

Most current water-quality data for wadeable streams that is available in the study area comes from Streamkeepers sampling, and therefore it is a fairly consistent and comparable data set. Ambient monitoring and special investigation sites change over time, but in general, the data available is thought to provide a reasonable representation of water quality in the study area, and therefore it was heavily relied upon for the only comprehensive report on water quality written by Clallam County (Clallam County, 2004).

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

A basic schema of sampling and measurement procedures is presented in Table 4, "Measurement Quality Objectives," in Section 6.2. The Field Procedures section of the Streamkeepers Volunteer Handbook (Chadd, current year's edition), incorporated by reference into this document, gives further details relating to:

- collection of samples and associated field QC samples
- analytical methods for measurements/analyses done in the field as well as the laboratory
- required equipment and in-situ calibration and maintenance procedures
- required content and format of field log entries
- requirements for photographic documentation
- sampling equipment and methods for its preparation and decontamination
- sample containers, sample size, labeling, preservation, holding time requirements, and chain of custody.

The Handbook is revised on a regular basis, so detailed procedures for a given year are given in the Handbook governing that year, and past editions are available from the Streamkeepers office. However, these revisions do not change the Measurement Quality Objectives but rather:

- better explain procedures and make data-collection more efficient
- account for additional special circumstances
- reduce the occurrence of "flagged" data

Revisions to the Handbook and QAPP will not reduce data quality below the stated objectives for a given parameter or compromise comparability with past data for the same parameter.

8.2 Containers, preservation methods, holding times

See Section 6.2 and particularly Table 4.

8.3 Invasive species evaluation

Invasive species, if present at sampling sites, may contaminate sampling equipment, field wear, etc. The Anti-Contamination protocol in the Streamkeepers Volunteer Handbook (Chadd, current year's edition) follows Ecology's SOP EAP070 and addresses invasive species transport and contamination.

8.4 Equipment decontamination

Waters sampled may contain high levels of pathogens or toxins. The Safety protocol in the Streamkeepers Volunteer Handbook (Chadd, current year's edition) addresses procedures to protect samplers and prevent contamination, and Streamkeepers volunteer training includes discussion and demonstration of safety techniques.

8.5 Sample ID

Sample IDs depend on the nature of the sample and laboratory as well as stage in the process:

- Bacterial samples have a random number on the bottle, which is cross-referenced to site/date/time on the data sheet.
- Samples bound for other analytical laboratories will follow conventions established by the lab. In some cases, the other bottles from a site will be marked with the number on the bacterial bottle; in other cases such as Ecology's Manchester Laboratory, there will be a pre-assigned Work Order number, followed by a consecutive number.
- Benthic macroinvertebrate samples are labeled on both the inside and outside with the site, date, samplers, and consecutive jar number.
- Once entered into the Clallam County Water Resources database, each sample container deployed is assigned an automated Batch ID, which is then uploaded to Ecology's EIM database as the Sample ID.

8.6 Chain-of-custody

Sample chain-of-custody procedures are described in the Streamkeepers Volunteer Handbook (Chadd, current year's edition). Besides these procedures, Streamkeepers maintains chain-of-custody records for benthic macroinvertebrate samples, which include the year, site, and # of containers of the sample, and initials and date for receipt in Streamkeepers' office, submission to and return from ID & QC labs, and placement in long-term storage. Streamkeepers and the primary and secondary (quality-control) taxonomy laboratories together arrange for the delivery and return of these samples.

8.7 Field log requirements

Required content and format of field log entries are described in the Streamkeepers Volunteer Handbook (Chadd, current year's edition).

8.8 Other activities

Training: Streamkeepers typically offers annual training to volunteers, based on the procedures in the Volunteer Handbook (Chadd, current year's edition). Volunteers see the procedures demonstrated and have the opportunity to practice them, under supervision of staff or

experienced volunteers. Attendance at all training events is recorded in the Clallam County Water Resources database. New volunteers are then assigned to teams with experienced volunteers guiding them through procedures. Usually several outings are required before new volunteers feel comfortable performing procedures on their own. Only volunteers trained in a given procedure will be allowed to attach their initials to data gathered under that procedure. The database connects all data with a sampler, whose training history is recorded in a separate table in the database.

Maintenance, Calibration, and Quality Control of Test Equipment: Detailed procedures for maintenance and calibration of test equipment prior and subsequent to field sampling are posted on Streamkeepers' website: http://www.clallam.net/SK/QualityAssurance.html. These procedures cover all analytical instruments in use. As with Streamkeepers' field procedures, these procedures get revised on a regular basis to better explain procedures, deal with special situations, or reflect our deeper understanding of maintenance and calibration issues; these revisions will never reduce data quality below the stated objectives for a given parameter or compromise comparability with past data for the same parameter. Maintenance and calibration procedures are summarized in Section 10.1 below.

9.0 Measurement Methods

9.1 Field procedures table/field analysis table

Field procedures are summarized in Table 4 in Section 6.2, and described in detail in the Streamkeepers Volunteer Handbook (Chadd, current year's edition).

9.2 Lab procedures

Lab procedures for bacteria and benthic macroinvertebrates are described in Table 4 in Section 6.2. As explained above, Streamkeepers has no programmatic funding for laboratory samples and therefore conducts such sampling only under special investigations, which are described in the following QAPPs, incorporated by reference in this document, for nutrients, metals, organics, pesticides, and suspended and benthic sediment (Chadd et al., 2008; Chadd et al., 2009; Knapp et al., 2009; Chadd et al., 2010; Soule and Chadd, 2013; Clallam County Departments et al., 2015):
http://www.clallam.net/SK/stormwatermonitoring.html
http://www.clallam.net/HHS/EnvironmentalHealth/documents/qapp.pdf
http://www.clallam.net/SK/doc/clnwtrdpolid.pdf)

9.3 Sample preparation method(s)

Sample preparation methods are described in the documents referenced in Section 9.2.

9.4 Special method requirements

Special method requirements are described in the documents referenced in Section 9.2.

9.5 Lab(s) accredited for method(s)

When lab data is to be uploaded to Ecology's EIM database, accredited labs will be used. Labs that have been used recently include Clallam County Environmental Health Laboratory and Spectra Labs (bacteria), Ecology's Manchester Environmental Laboratory (nutrients, metals, organics, suspended and benthic sediment, pesticides), and Environmental Services and Consulting (benthic macroinvertebrates).

10.0 Quality Control (QC) Procedures

10.1 Table of field and lab QC required

QC procedures for Streamkeepers' regular ambient monitoring parameters are summarized in Table 6 below. QC procedures for additional field and lab procedures are detailed in the documents referenced in Section 9.2.

Table 6. Maintenance, calibration, and QC for Streamkeepers' regular ambient monitoring parameters.

* indicates procedures covered by Streamkeeper SOP's (http://www.clallam.net/SK/QualityAssurance.html)

For definitions of "EST", "REJ", and "J", see Section 10.2 below.

"Session" refers to a month-long quarterly monitoring window during which sampling is performed.

% bias = Abs(standard value – measured value) / standard value x 100%, where Abs = absolute value

RSD in the table below refers to the relative standard deviation (also known as the coefficient of variation or CV), which, when n = 2 (as when comparing a sample with a replicate), is defined as follows:

RSD = Abs(difference/sum) x Sqrt(2) x 100%, where Abs = absolute value and Sqrt = square root

Equip-ment / Procedure/ Standard	**Office prep (beginning of each session or as noted)**	**Main-tenance measures (office & field)**	**Field prep/ checks**	**Quarterly bias post-session checks (plus mid-session as possible)**	**Bias evaluation with standard reference materials**	**Replicates for precision checks**	**Precision evaluation per rep/sample difference**
Tempera-ture logger (contin-uous)	2-point calibration with NIST-traceable thermo-meter (see Dunham et al. 2005)	Periodic station checks (see Dunham et al. 2005)	Side-by-side measure-ment with calibrated thermistor (see Dunham et al. 2005)	Side-by-side measure-ment with NIST-traceable thermometer; 2-point calibration check with NIST-traceable thermometer	"EST" if >±0.2°C "REJ" if >± 0.5°C	NA; side-by-side testing done with NIST-traceable thermo-meter	NA
*Ther-mistor	2-pt. (~0° & 20°C) check vs. NIST-traceable thermo-meter	Keep sensor clean		Post-session 2-pt. calibration check vs. NIST-traceable thermometer	"EST" if >±0.2°C "REJ" if >± 0.5°C	1 replicate per team per session (or minimum 1/10 ratio)	"EST" if >±0.2°C; "REJ" if >± 0.5°C

Equip-ment / Procedure/ Standard	Office prep (beginning of each session or as noted)	Main-tenance measures (office & field)	Field prep/ checks	Quarterly bias post-session checks (plus mid-session as possible)	Bias evaluation with standard reference materials	Replicates for precision checks	Precision evaluation per rep/sample difference
*NIST-traceable thermo-meter	Check/ calibration performed as needed by an ISO-compliant laboratory		Laboratory check will qualify post-checks of thermistors performed with this instrument		"EST" if >±0.05°C or "REJ" if >±0.1°C in range including data		
*Baro-meter	1-point check vs. weather station	Handle with care		1-point check vs. weather station	"EST" if >± 0.05 in.Hg; "REJ" if >± 0.1 in.Hg	1 replicate per team per session (or minimum 1/10 ratio)	"EST" if >± 0.05 in.Hg; "REJ" if >± 0.1 in.Hg
*Dis-solved Oxygen meter (membrane electrode)	Side-by-side testing vs. replicated Winkler titrations (with membrane/ fluid replacement & electrode cleaning)	Membrane & fluid replace-ment & electrode cleaning at least quarterly	Check/rinse probe; in-situ saturated air calibration at stream temper-ature, with pressure adjustment; drift check of meter following measure-ment; recalibrate & resample if check fails	Post-session side-by-side testing vs. replicated Winkler titrations	Meter listed at ±0.3 mg/L & Winkler listed at ±0.2 mg/L (Hallock & Ehinger, 2003); therefore, "EST" if difference >±0.5 mg/L; "REJ" if difference >±1 mg/L	1 replicate per team per session (or minimum 1/10 ratio)	"EST" if >± 0.3 mg/L; "REJ" if >± 0.55 mg/L

Equip-ment / Procedure/ Standard	Office prep (beginning of each session or as noted)	Main-tenance measures (office & field)	Field prep/ checks	Quarterly bias post-session checks (plus mid-session as possible)	Bias evaluation with standard reference materials	Replicates for precision checks	Precision evaluation per rep/sample difference
*Dissolved Oxygen meter (optical lumines-cent)	Two-point calibration with sodium sulfide (zero) and fully-saturated air or water	Keep moist in storage cup when not in use; remove probe for long-term storage	Check probe & rinse as necessary	Post-session recheck vs. theoretical solubility in saturated air or water, and/or side-by-side testing vs. replicated Winkler titrations	No qualifier if ≤ ±0.2 mg/L from theoretical or ≤ ±0.4 from Winkler[3]; "REJ" if ≥ ±0.6 from theoretical and ≥ ±0.8 from Winkler; else EST	1 replicate per team per session (or minimum 1/10 ratio)	"EST" if >± 0.2 mg/L; "REJ" if >± 0.4 mg/L
*Conduc-tivity meter	Calibration with NIST-traceable standard	Electrode cleaning solution	Check /rinse electrodes	Post-session check against NIST-traceable standard	"EST" if >±10% of standard value; "REJ" if >±15% of standard value	1 replicate per team per session (or minimum 1/10 ratio)	"EST" if RSD >5%; "REJ" if RSD >10%
*pH meter	3-point calibration with NIST-traceable standards	Clean/ replace probe as needed if perfor-mance fails	2-point calibration at beginning of each team's session	Post-session 3-point check with NIST-traceable standards	"EST" if post-checks bracketing range of field values are >±0.2 pH unit; "REJ" if >±0.5 pH[4]	1 replicate per team per session (or minimum 1/10 ratio)	"EST" if >±0.2 pH unit; "REJ" if >±0.5 pH unit

[3] Meter accuracy listed at ±0.2 mg/L & Winkler accuracy listed at ±0.2 mg/L (Hallock & Ehinger, 2003).

[4] For pH, if one or more post-checks vs. a buffer is outside the acceptable range, values taken with the meter might still be acceptable. For example, if the field reading was 6.8, and the drift checks showed the meter within specs with the pH 7 standard but deviating by 0.3 with the pH 4 standard, the calibration curve would be such that the 6.8 reading would be well within the meter's accurate range. Curve calculations from drift readings can determine this issue.

Equip-ment / Procedure/ Standard	Office prep (beginning of each session or as noted)	Main-tenance measures (office & field)	Field prep/ checks	Quarterly bias post-session checks (plus mid-session as possible)	Bias evaluation with standard reference materials	Replicates for precision checks	Precision evaluation per rep/sample difference
*Turbidity meter (bench-style)	4-pt. calibration with NIST-traceable standards	Keep sampling well & outsides of vials dry and clean; avoid scratching vials	Poly bottle ≥ 100 mL; observe holding specs. Mix sample well before reading. Zero meter and 1-pt. check with NIST-traceable standards; triplicate samples	Post-session 4-pt. check with NIST-traceable standards prior to next calibration, plus check of field standards	"EST" if post-checks bracketing range of field values show difference > both 0.5 and 7% of standard value; "REJ" if difference > both 1.0 and 10% of standard value	1 replicate set (of 3) per team per session (or minimum 1/10 ratio)	"EST" if difference > 1 NTU (the field MDL) and > 7% RSD; "REJ" if difference > 1 NTU (the field MDL) and >14% RSD
*Turbidity meter (in-situ)	Two-point calibration with DI water and NIST-traceable standard	Keep moist in storage cup when not in use; remove probe for long-term storage	Check probe & rinse as necessary; take average of multiple samples	Two-point check with DI water and NIST-traceable standard	"EST" if post-checks bracketing range of field values show difference > both 0.5 and 7% of standard value; "REJ" if difference > both 1.0 and 10% of standard value	1 replicate set per team per session (or minimum 1/10 ratio)	"EST" if difference > 1 NTU (the field MDL) and > 7% RSD; "REJ" if difference > 1 NTU (the field MDL) and >14% RSD

Equip-ment / Procedure/ Standard	Office prep (beginning of each session or as noted)	Main-tenance measures (office & field)	Field prep/ checks	Quarterly bias post-session checks (plus mid-session as possible)	Bias evaluation with standard reference materials	Replicates for precision checks	Precision evaluation per rep/sample difference
*Pocket thermo-meter (for air temp)	2-pt. (~0° & 20°C) calibration vs. NIST-traceable thermo-meter		Make sure thermo-meter is dry; 2nd reader encouraged	Post-session 2-pt. check vs. NIST-traceable thermometer	"EST" if >±1°C; "REJ" if >±2°C	NA	NA
*Field standards (if used for field calibration)	Tested with freshly-calibrated instruments	Keep well-sealed and within tem-perature specifi-cations	Used to check and/or calibrate instruments in the field	Re-check vs. office standards or freshly-calibrated instruments	At end of sampling period, instruments are re-calibrated with field standards and then tested with office standards; apply control criteria applicable to that instrument		
*Nitrate-Nitrogen (lab)	In-lab calibration per CCEHL 2016		Proper collection technique	Pre- and post-sample blanks; post-sampling meter check	Adjust data per blanks; "J" if post-check >±20% of standard value; "REJ" if post-check >±30% of standard value	Field and lab replicates for 1/10 of samples	"J" if RSD >± 7%; "REJ" if RSD >14%
*Fecal Coliform (lab); (also may test for total coliform/E. coli and entero-coccus)	Verification of colonies once a month; annual proficiency testing with state; see CCEHL 2013	Checks of medium, filters, funnels, thermo-meter, rinse & dilution water;	Sterilized bottles, 4 oz. (125 mL) minimum; observe holding specs	Pre- and post-sample blanks; control blanks for 1/10 of samples	Adjust/flag data as needed per blank results	Field replicates for 1/10 of samples; lab replicates for 1/20 of samples	See Table 7 below

Equip-ment / Procedure/ Standard	Office prep (beginning of each session or as noted)	Main-tenance measures (office & field)	Field prep/ checks	Quarterly bias post-session checks (plus mid-session as possible)	Bias evaluation with standard reference materials	Replicates for precision checks	Precision evaluation per rep/sample difference
Coliscan Easygel (total coli-form & E. coli)		Preserve broth per mfr. instructions	Observe holding times; take post-sample blanks	Replicates of 1/10 of samples for lab fecal coliform counts	NA; flag at staff discretion	Field replicates for 1/10 of samples; lab replicates for 1/20 of samples	"REJ" if RSD > 85%
*Flow meter	Retesting of rotor/ prop units 2x/year	Replace rotor/prop units when <90% of new perfor-mance	Spin, count, and blow tests of rotor/prop units; spares provided	Comparison with stream gage data	NA	Occasional field replicates or side-by-side sampling	NA
Flow—stage gage	Stage/ discharge curve, least-squares method (Bovee and Milhous, 1978)	Choose a stable channel segment; field-reference the gage; check plumb	6-8 wade-across measure-ments to establish the curve	2-3 wade-across measure-ments per year to maintain the curve	"EST" if calculated value <0.4 times the min. or >2.5 times the max. discharge measured	NA	NA
Imhoff Cone (settleable solids)		Keep clean	Proper collection technique		NA	Replicates not normally taken	NA

10.2 Corrective action processes

Data Qualifiers:

Data qualifiers are applied as above. Laboratories will be directed to apply qualifiers per QAPPs written for those analytes. Qualifiers will apply to all samples in the grouping covered by that replicate/sample pair—for example, the entire group of samples taken by a field team during a quarterly session, or the group of samples from which a grab-sample field replicate was taken. These qualifiers are only applied if they downgrade already-applied data qualifiers; for example, if QC reviewers have already applied a "REJ" qualifier to a result,

a downgrade value of "EST" based on replicate/sample comparison will not change the "REJ" designation for that result.

Streamkeepers will use data qualifier codes described in Ecology's EIM database. For non-lab data, possible qualifiers include:

- **No qualifier:** Monitoring procedures have been followed and documented, and all QC screens have passed; the data is acceptable per that parameter's Measurement Quality Objectives (Section 6.2).
- **EST (estimate):** Monitoring procedures have not all been followed and/or documented, or one or more QC screens have not passed; but QC reviewers believe the data to be reasonably trustworthy for non-regulatory purposes.
- **REJ (rejected):** Monitoring procedures have not all been followed and/or documented, or one or more QC screens have not passed; and QC reviewers believe the data to be untrustworthy for any purposes.

After a monitoring event, QC reviewers examine data sheets and communicate with the monitoring team to ascertain if there have been deviations from standard operating procedures; on this basis, reviewers apply data qualifiers as appropriate. Further QC screens and corrective actions are described below.

For lab-generated data, the lab or Streamkeepers will apply qualifiers as appropriate per Ecology's EIM database. In some cases, the lab (e.g., Clallam County's Environmental Health Lab) will report lab replicate data and Streamkeepers' QC reviewer applies the appropriate qualifier, usually either REJ (see above) or J (the equivalent of EST in a lab environment).

Controls for Bias and Precision:

Bracketing qualifiers based on QC controls: For each QC test performed, qualifiers indicated will be applied to all data governed by that test. Such qualifications will occur at a variety of levels, from an individual result up to an entire multiple-visit sampling session. In general, a drift-check of an instrument will apply to all data taken with the instrument since its last substantive maintenance or replacement (e.g., change of a membrane or probe solution), calibration, or equivalent drift check. For example, pH meters are subject to periodic in-field drift checks with field standards as well as periodic drift checks with office standards; in each case, any qualification resulting from these checks would apply to all data taken since the last equivalent check.

Post-period drift check is sufficient: Instrument drift away from accuracy is presumed to progress in a single direction, either above or below the accuracy target. Therefore, in a case where an instrument was checked for accuracy only subsequent to a sampling episode, if the instrument passes its QC post-check, it is presumed that the instrument performed to specifications prior to that check (Katznelson, 2011), so long as no substantive maintenance or replacement of instrument parts was performed in between. This situation is to be avoided, because samplers run the risk of downgrading an entire set of data due to not having checked instrument accuracy at the outset.

Water quality parameters—bias: Bias of water quality measurements is estimated by performance evaluation measurements of the equipment, both in the field and at the office; see Table 6 above and the discussion below for details.

> Office calibration, validation, and drift checks: Instruments are given a complete calibration or validation (depending on whether they can be calibrated) at the office prior to the sampling session and

then drift-checked at the end, using NIST-traceable non-expired "office" standards, certified equipment, and Standard Methods (APHA, 1998). These office checks are the ultimate check of instrument performance. Calibrations and checks may also be performed within sampling sessions.

Field calibration, validation, and drift checks: In certain cases, samplers calibrate, zero, and test instruments prior to sampling with NIST-traceable non-expired "field" standards (see Table 6). Field calibrations minimize instrument drift, and where field calibration is not possible or practical, field calibration tests provide an interim check on instrument performance, to alert samplers to possible problems requiring recalibration or replacement. After sampling, instruments may be checked again for drift; if drift exceeds the target control values, the instrument should be recalibrated or replaced and the field measurements retaken, or the data will be downgraded per Table 6.

Checks of field standards: Field standards are checked for drift against the office standards at the end of their sampling periods.

Detailed equipment calibration, validation, and maintenance procedures are described on Streamkeepers' website at http://www.clallam.net/SK/QualityAssurance.html and are hereby incorporated by reference into this document.

Water quality parameters—precision: Precision of water quality measurements is evaluated by analysis of replicate samples taken in the field at one site (randomly selected) per team per sampling session, or at least one replicate per ten samples. Details on field replicate-sampling procedures are described in the "Water Chemistry—General Guidelines" section of the Streamkeepers Volunteer Handbook (Chadd, current year's edition). The variation between these sample and replicate values is a measure of variability due to short-term environmental factors, instrument operation, and sampling procedure. See Table 6 above for acceptance criteria and control limits based on comparing replicates with their paired samples.

Grab samples for laboratory analysis: When grabbing samples for laboratory analysis, in cases where non-detects are common, we target field and lab replicates at sites likely to have high counts, on the notion that replicated samples with non-detects provide little information (Lombard, 2007). The following QC criteria for bacterial samples are based on comparing field and laboratory replicates with their paired samples, recognizing that there is always the possibility of real environmental variation when grabbing bacterial samples:

Table 7. Analytical laboratory quality control measures for bacterial samples.

Control measure used: variance between sample and field or lab replicate
If absolute difference ≤ 10 or difference between base-10 logs ≤ 0.6 (Relative Standard Deviation ≤ 85%): No qualifier
Otherwise, qualify per best professional judgment of QC and laboratory analysts, including the following options: --If other rep/sample pairs from that Tour were within tolerance, flag only the data from that Visit as "REJ" (unacceptable) or "J" (estimate), and do not flag the other data, unless there is reason to question the entire Tour's batch of samples; --If other rep/sample pairs from that Tour exceeded tolerance, consider flagging all the data from that Tour. --If there are no other rep/sample pairs in that Tour, use best professional judgment of QC and laboratory analysts to decide whether to flag other data.

--It may be useful in some cases to analyze sample-replicate variances for larger data sets for comparison.

Benthic macroinvertebrate samples: Field quality-control measures include checking the sampling net before and after each use to check for tears or organisms left in the net, as well as timing the digging, per the "Benthic Macroinvertebrate Sampling" protocol in the Streamkeepers handbook (Chadd, current year's edition). Field and lab protocols are per King County, 2014. Laboratory quality-control measures are as follows: 10% of the samples from a given year are rechecked by a second, certified taxonomist, for both sorting efficiency and ID accuracy. If the QC taxonomist finds sampling, sorting, or taxonomic identification problems, the data are modified, qualified, re-identified, or discarded, depending on the degree of the problem, following discussion between the taxonomy laboratories and Streamkeepers QC analysts. A taxon found to have been systematically mis-identified will be reclassified for that year's sample batch. In case of dispute, specimens may be sent to additional taxonomists for resolution. If uncertainties in sample interpretation persist, resolution will be sought from a professional bio-statistician familiar with the genesis of the B-IBI. To facilitate consensus identification of taxa, Streamkeepers maintains a synoptic reference collection of best-quality specimens of all taxa found, labeled and confirmed by at least one additional taxonomist. Taxonomists performing ID are instructed to add to this collection when they find new taxa. Furthermore, Streamkeepers maintains a number of more specific documents concerning classification of local fauna, taxonomic procedures, sorting, and subsampling, all of which are incorporated by reference into this document (http://www.clallam.net/SK/QualityAssurance.html); taxonomists are expected to use these documents as guides, revising them in consultation with other professionals as needed. To the extent possible, we engage services of laboratories with knowledge of the local macroinvertebrate fauna. The following control limits apply to the taxonomic laboratory work:

Table 8. Taxonomic laboratory quality control measures for benthic macroinvertebrate samples.

QC activity	**QC target**	**QC actions**
Sorting efficiency and ID accuracy	Sorting and ID errors do not result in a change in the target index score greater than the index's sensitivity (±14.11 for the B-IBI$_{100}$; King County, 2014)	Systematic mis-ID's will be systematically corrected; if target not met for 1 replicate (or <10% of all QC'd replicates), flag data by individual sample; if target not met for >1 or >10% of all replicates, determine whether problem was systematic or specific, and qualify data accordingly. In an extreme case, all data taken in that year will be flagged or samples re-identified.
Synoptic reference collection	Vouchered collection of all taxa identified, confirmed by two taxonomists	If the first two taxonomists disagree on ID, the specimens are sent to additional taxonomists as needed.

Training: Streamkeepers typically offers annual training to volunteers, based on the procedures in the Volunteer Handbook (Chadd, 2015). Volunteers see the procedures demonstrated and have the opportunity to practice them, under supervision of staff or experienced volunteers. Attendance at all training events is recorded in the Clallam County Water Resources database. New volunteers are then assigned to teams with experienced volunteers guiding them through procedures. Usually several outings are required before new volunteers feel comfortable performing procedures on their own. Only volunteers trained in a given procedure

will be allowed to attach their initials to data gathered under that procedure. The database connects all data with a sampler, whose training history is recorded in a separate table in the database.

Side-by-Side Sampling—External: Streamkeepers volunteers or staff participate at least four times per year in Ecology's Side-by-Side Sampling program (http://www.ecy.wa.gov/programs/eap/fw_riv/SxSIndex.html), testing water bodies at the same time Ecology tests them as part of their monthly Ambient Monitoring Program; data is submitted to Ecology in the specified format within 60 days of collection. This program affords both parties the opportunity for additional validation of their data. Every attempt will be made to discuss, understand, and correct any sign of systematic bias that exceeds the QA standards of either party.

Side-by-Side Sampling—Internal: Streamkeepers staff or experienced volunteers may perform split sampling alongside a Streamkeepers volunteer team, per the judgment of the Streamkeepers program manager. Results are compared and actions taken as appropriate, such as qualifiers on past data for that individual or team; additional training for that individual, team, or the entire volunteer corps; or additions/revisions to field procedures. Targets are the same as the precision targets for the parameter as described in Table 5. If targets are not met, corrective actions will include data qualifiers, additional training, and revised instructions, as appropriate.

Other General QC Measures:

- Clear, user-friendly, and detailed instructions for all procedures, minimizing judgment calls
- Equipment calibrated, checked, and maintained prior to sampling
- Multiple observers when possible
- Each sampling team has an experienced leader
- Photo documentation of physical-habitat data
- Questionable noxious weed samples brought in for professional ID
- Staff review of data, including comparing values year-to-year
- Values compared to external data from other agencies, such as stream gage data.

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

Data recording and checking: Streamkeepers' field data are generally collected on custom-designed data sheets, most of which are available on Streamkeepers' website: http://www.clallam.net/SK/monitoringusables.html. Field samplers record and initial data on these sheets. When all data have been collected at a site, the team leader looks over the sheets for completeness, legibility, and obvious errors, and gets further information from team members as appropriate. Any problems with data collection are noted in a "Comments" section of the data sheet. The team leader initials and dates this review, then initials and dates again when turning the sheets in to the office. Then staff initials and dates receipt and QC analysts review the data. The QC review is a thorough process that includes troubleshooting for decimal and rounding errors, data entered into the wrong field, incomplete data, etc.—see http://www.clallam.net/SK/doc/Qrtlydtashtckpl.pdf.

Database entry and checking: Once data sheets have been reviewed, volunteers enter the data into the Clallam County Water Resources (CCWR) database (Microsoft Access software). Detailed procedures are provided to the volunteers, both in written form (see Appendix B) and in one-on-one training, and staff members are available to volunteers as they perform data entry. Volunteers subsequently check the database entries against the field sheets, and then later perform an additional troubleshooting double-check.

Automated data checks: Our intention is to program the CCWR database to automatically perform the statistical checks described in the "Quality Control" section above, and in some cases to downgrade data automatically as appropriate (leaving a record of the downgrade). In other cases the database displays a message instructing QC reviewers to examine data and apply qualifiers as appropriate. These automated routines ensure compliance with QC procedures. In lieu of automation, data qualifiers are assigned manually by QC reviewers.

Final Sign-Off of Data: Once all of the above checks have been performed, the Streamkeepers QA Officer does a final review of data, including examination of outliers, and signs off that the data are ready for publication.

Data reporting: The CCWR database includes a number of custom-made reports, including one for standard water-quality results in tabular format and another for all results, with one record per result. In all cases, daily averages are computed unless the sampling targeted a storm. Numerous other reports have been created at the request of clients.

Benthic macroinvertebrate data: In 2011, a consortium of Puget Sound local governments adopted standard sampling and analytical protocols for the computation of the Benthic Index of Biotic Integrity (B-IBI) and programmed the algorithms into the Puget Sound Benthos website maintained by King County (http://pugetsoundstreambenthos.org/). This database is designed to store and report regional data, and Streamkeepers' intention is to enter the taxonomic sampling data into the CCWR database and then upload the information to the Puget Sound Benthos

database, where anyone will be able to access it. Ecology will use this platform as a data source for its Water Quality Assessments.

11.2 Laboratory data package requirements

Laboratories must provide data in conformance with this QAPP. The data can be in a variety of formats, per arrangement with Streamkeepers staff.

11.3 Electronic transfer requirements

As stated above, arrangements for data transfer will be made between Streamkeepers and the laboratory. Usually data will be transferred in spreadsheet format.

11.4 Acceptance criteria for existing data

The Clallam County Water Resources database contains data sets dating back to 1986. All data is identified by project or program, including appropriate metadata, so data users can evaluate the usability of those data sets.

11.5 EIM/STORET data upload procedures

All qualified water quality data in the Clallam County Water Resources database will be entered into Ecology's EIM database, following all current Ecology business rules and the EIM User's Manual for loading, data quality checks, and editing. The data will be submitted to EIM either when Ecology calls for data or at the close of an Ecology grant involving data collection.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

Streamkeepers program coordinators are responsible for overseeing implementation of this QAPP. Qualitative audits of conformance occur on a continual basis, at a variety of levels:

- Team members check one another's work as they follow procedures in the Volunteer Handbook.
- Experienced field team leaders oversee the work of their teams and review data sheets.
- QA Officer or QC Reviewers review all data sheets prior to database entry (see http://www.clallam.net/SK/doc/Qrtlydtashtckpl.pdf) and communicate with teams about any omissions or problems they find.
- Multiple checks, both human and automated, occur as data is transferred from field sheets to electronic form. At least two people are involved in the data-entry and verification process to avoid errors from fatigue or oversight.
- Procedures described above in "Quality Control" are performed.
- Principal Investigator reviews datasets to troubleshoot outliers.
- Streamkeepers' data reports are shared with Streamkeepers' advisory committees and outside agencies. This audience provides considerable peer review.

In all cases, as problems are found, they are corrected or flagged, and discussed with the relevant personnel. These findings are recorded in a "Comments" field connected to the data in the CCWR database. Streamkeepers staff do not write formal performance reports, but they are intimately involved in both day-to-day operation of the program and implementation of QC procedures, and accordingly are continually making improvements to the overall operation of the program. Improvements to procedures are written into revisions of the documents that govern the program. The Streamkeepers Volunteer Handbook (Chadd, current year's edition) has been revised annually from 1999 to date.

12.2 Responsible personnel – see Section 12.1

12.3 Frequency and distribution of report

Streamkeepers reports on data on occasions such as the following:

- When Ecology calls for data for its Water Quality Assessment.
- When an outside client requests a report.
- When Streamkeepers staff, volunteers, or advisors see a need for a summary report.

Otherwise, as possible, Streamkeepers staff will update data reports available on Streamkeepers' website at http://www.clallam.net/SK/studies.html.

12.4 Responsibility for reports

Streamkeepers program coordinators are responsible for reports.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

As described in Section 12, Streamkeepers data undergoes verification and validation at a number of stages and levels. Performance of these measures is overseen by the Streamkeepers program coordinator, who verifies that QC results have been evaluated and data qualifiers have been applied as necessary.

13.2 Lab data verification

Laboratories will perform laboratory QC per requirements of this QAPP and standard laboratory practices. After the laboratory verification, the Streamkeepers QA Officer or QC Reviewers will perform a secondary verification of each data package, involving detailed review of all parts of the package with special attention to laboratory QC results. They will bring any discovered issues to the laboratory's attention for resolution.

13.3 Validation requirements, if necessary

Independent data validation by an outside party is outside the normal scope of the Streamkeepers program. Special investigations may require and fund such independent audits.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether program objectives have been met

Because the Streamkeepers ambient-monitoring program is an ongoing program rather than a discrete data-gathering project, there is no single set of requirements for representativeness, completeness, and comparability. Those issues depend on the particular use to which the data will be put, and data quality assessment must occur on a case-by-case basis. For example, Clallam County's *State of the Waters* report (Clallam County, 2004) contains extensive evaluation of the quality of the data used for that report, including an appendix devoted to "Uncertainty Analysis for Health Ratings." In general, Streamkeepers' data-quality requirements are determined by the Objectives listed in Section 4.2 above. In this sense, usability of data will be determined as follows:

Table 9. Data-quality requirements for Streamkeepers' ambient monitoring data

Objective	**Data-Quality Requirements**
Define and document baseline physical, chemical and biological conditions of local streams	Determination of whether adequate baseline has been established (e.g., Clallam County, 2004)
Measure spatial and temporal variability of stream attributes	Adequacy of data for statistical analysis of seasonal and geographical differences
Look for signs of degraded stream condition in a geographically broad manner	Adequacy of data to generalize to broader geographic areas
Assess trends in watershed degradation or restoration	Adequacy of data to show statistical proof of trends
Analyze data to understand the relationship between land use and watershed condition	Adequacy of both stream and land-use data
Provide information to assist in watershed planning, management, restoration and adaptive management	Usability of data for planning and management purposes
Submit data to Ecology's Side-by-Side sampling program	Data submitted in Ecology's required format and to Ecology's standards
Submit data to Ecology for Water Quality Assessment	QAPP must be followed and data with certain qualifiers will be excised

These determinations will be carried out by those analyzing the data, who could be Streamkeepers staff, advisors, volunteers, Clallam County officials, or outside clients. To the extent that the data are found inadequate for one or more of the above objectives, Streamkeepers' sampling plan and QAPP may be modified over time to correct those deficiencies.

Special monitoring investigations undertaken by Streamkeepers may have more discrete objectives, and those investigations may specify data quality goals and reporting requirements, at

the discretion of the investigation sponsor. When necessary, those investigations will submit their own QAPPs, or Streamkeepers may submit addenda to this QAPP.

All activities of the Streamkeepers program are evaluated annually by Streamkeepers' advisory groups (Section 4.8), and it is with these groups that the ultimate evaluation of program effectiveness lies. Annual work plans that are vetted by these groups include specific objectives for each year as well as an evaluation of the degree of achievement of those objectives at the end of the year.

14.2 Data analysis and presentation methods

Data analysis and presentation methods will depend on the needs of the user. In general, it is expected that raw data will be reported unless the client asks for a particular type of analysis. At a minimum, data will be reported to Streamkeepers' advisory groups, who will serve as data reviewers. Certain standard reports are built into the Clallam County Water Resources database, including one for conventional water-quality parameters and another for more detailed data in format compatible with Ecology's Environmental Information Management database.

14.3 Treatment of non-detects

Non-detects will be included in data reports. Treatment will depend upon the client but may be one of the following:

- Non-detect may be replaced with the detection limit, half the detection limit, or zero.
- Data reported at values below the determined detection limit may be reported as is, with accompanying information regarding the detection and reporting limits for the parameter/method.

14.4 Sampling design evaluation

The Streamkeepers program was designed to conform to the needs of its data end-users, and annual re-evaluation assures that users' needs are being met. At this point, users' main needs are for a snapshot of watershed health and identification of problems in areas of interest, and the sampling program described here is generally believed to meet those needs.

14.5 Documentation of assessment

Streamkeepers' annual program-evaluation meetings include an assessment of the adequacy of the monitoring program to meet end-users' needs. Those evaluations are summarized in Streamkeepers' annual work plans—see http://www.clallam.net/SK/programplanning.html.

15.0 References

American Public Health Association (APHA). 1998. Standard Methods for Examination of Water & Wastewater (SM), 20th edition. Washington, D.C.

ASTM International (formerly known as American Society for Testing and Materials). Standards accessed at http://www.astm.org/Standard/index.shtml

Baccus, Jessica T., and Edward A. Chadd. 2000. Streamkeepers of Clallam County Quality Assurance Project Plan. Clallam County Department of Community Development. Port Angeles, Washington.

Booth, Derek & Karen Comings. University of Washington, Center for Urban Water Resources Management. Personal communication, March 1998.

Bovee, Ken D., and Robert Milhous. 1978. Hydraulic Simulation in Instream Flow Studies: Theory and Techniques. Fort Collins, CO: Cooperative Instream Flow Service Group (U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency), Aug. 1978. Instream Flow Information Paper No. 5, FWS/OBS-78/33.

Chadd, Edward A. 2016. Quality Assurance Project Plan for Streamkeepers of Clallam County Environmental Monitoring Program. (Revision of *Streamkeepers of Clallam County Quality Assurance Project Plan*, 2015.) Clallam County Department of Public Works-Roads. Port Angeles, WA.

Chadd, Edward A. 2016. Streamkeepers of Clallam County Volunteer Handbook. 16th ed. Clallam County Department of Public Works-Roads. Port Angeles, Washington. http://www.clallam.net/streamkeepers/html/volunteer_handbook.htm *[NOTE: This handbook is updated annually. Revisions do not materially change the measurements themselves, but rather explain the procedures better, deal with additional special circumstances, and make it less likely that data will be rejected by program managers.]*

Chadd, Edward, Robert Knapp, Carol Creasey, and Steven Golding. 2008. Sequim-Dungeness Watershed Water Pollutant Concentration Pilot Sampling Project. Port Angeles, WA: Clallam County Department of Community Development, November 2008. http://www.clallam.net/streamkeepers/assets/applets/QAPP_Approved.pdf.

Chadd, Edward, Robert Knapp, and Carol Creasey. 2009. Addendum to Sequim-Dungeness Watershed Water Pollutant Concentration Pilot Sampling Project. Port Angeles, WA: Clallam County Department of Community Development, September 2009. http://www.clallam.net/streamkeepers/assets/applets/ClallamCo_QAPP_Addendum_9_16_09_approved.pdf.

Chadd, Edward, Robert Knapp, Lara Kawal, Carol Creasey, and Steven Golding. 2010. Sequim-Dungeness Watershed Water Pollutant Concentration Pilot Sampling Project, Phase 2. Port Angeles, WA: Clallam County Department of Community Development, January 2010. http://www.clallam.net/streamkeepers/assets/applets/Phase2_QAPP_Signed.pdf.

City of Bellevue, 1998. Bellevue Stream Team Habitat Assessment Survey.

Clallam County. 1995. Port Angeles Regional Plan. Title 31.04 Clallam County Code. Port Angeles, WA: Board of Clallam County Commissioners. 6/27/95.

Clallam County. 2004. State of the Waters of Clallam County, 2004: A Report on the Health of Our Streams & Watersheds. Clallam County Department of Community Development. Port Angeles, Washington.

Clallam County. 2005. How and Why Streamkeepers of Clallam County Revised the Grading System for the B-IBI for the Puget Sound Lowlands. http://www.clallam.net/streamkeepers/html/revised_b-ibi_grading_system.htm.

Clallam County Departments of Public Works-Roads and Health and Human Services, and Clallam Conservation District. 2015. Sequim-Dungeness Clean Water District Pollution Identification & Correction, Trends, and Project Monitoring. Prepared for Washington State Department of Health. February 2015. http://www.clallam.net/SK/doc/clnwtrdpolid.pdf

Clallam County Environmental Health Laboratory (CCEHL). 2016. Quality Assurance Manual and Standard Operating Procedures for Nitrate Testing. Port Angeles, WA. Rev. 8/1/16.

Clallam County Environmental Health Laboratory (CCEHL). 2013. Quality Assurance Manual and Standard Operating Procedures for Fecal Coliform Testing. Port Angeles, WA. Rev. 3/27/13.

Dunham, Jason, Gwynne Chandler, Bruce Rieman, and Don Martin. 2005. Measuring Stream Temperature with Digital Data Loggers: A User's Guide. Gen. Tech. Rep. RMRSGTR-150WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 15 p.

Dungeness Watershed Management Committee. 1993. Dungeness River Area Watershed Management Plan. Port Angeles, WA: Clallam County Department of Community Development. Oct. 1993.

Elwha-Dungeness Planning Unit. May 2005. Elwha-Dungeness Watershed Plan, Water Resource Inventory Area 18 (WRIA 18) and Sequim Bay in West WRIA 17. Published by Clallam County. Volume 1: Chapters 1-3 and 15 appendices; Volume 2: Appendix 3-E.

Fore, L.S. 1997. Karr's Benthic Macroinvertebrate Stream Sampling Protocol. 2 pp.

Fore, L.S. 1999. Measuring the effects of urbanization on Bellevue streams. Report prepared for Kit Paulsen, Utilities Department, City of Bellevue.

Freudenthal, Joel. Planning Biologist, Clallam County Department of Community Development. Personal communication, June 1999 – June 2000.

Hallock, D. and W. Ehinger. 2003. Quality Assurance Monitoring Plan: Stream Ambient Water Quality Monitoring. Olympia, WA: WA State Dept. of Ecology, Pub. No. 03-03-200, April 2003.

Hallock, Dave. 2011. Personal communication, 10/10/11. Freshwater Monitoring Unit, Environmental Assessment Program, WA Dept. of Ecology.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Henshaw, P. C. and D.B. Booth. 2000. Natural restabilization of stream channels in urban watersheds. Journal of the American Water Resources Association 36: 1219-1236.

ISO. International Organization for Standardization. Standards accessed at http://www.iso.org/iso/home/store/catalogue_ics.htm.

Karr, J.R. and E.W. Chu. 1998. Restoring Life in Running Waters: Better Biological Monitoring. Island Press, Washington D.C.

Katznelson, Revital, Ph.D. 2011. Personal communication, 10/24/11. Contract Lead, Quality Assurance (ACRR) Matrix, Aquatic Sensor Workgroup, Methods and Data Comparability Board, National Water Quality Monitoring Council, Advisory Committee on Water Information (convened by U.S. Geological Survey).

King County. 2014. Recalibration of the Puget Lowland Benthic Index of Biotic Integrity (B-IBI). Prepared by Jo Opdyke Wilhelm, (Water and Land Resources Division [WLRD]); Leska Fore (Statistical Design), Deb Lester (WLRD) and Elene Dorfmeier (WLRD). Seattle, Washington. http://pugetsoundstreambenthos.org/Projects/BIBI-Recalibration-Documentation.aspx.

Knapp, Robert, Edward Chadd, and Carol Creasey. 2009. Sequim-Dungeness Watershed Stormwater Sediment Pollutant Concentration Sampling Project. Port Angeles, WA: Clallam County Department of Community Development, May 2009. http://www.clallam.net/streamkeepers/assets/applets/QAPP_Approved_with-Signatures.pdf.

Kondolf, G.M. 1997. Application of the Pebble Count: notes on purpose, method and variants. Journal of the American Water Resources Association 33(1): 79-87.

Lombard, Stew. 2007. Personal communication, n.d. Quality Assurance Coordinator, Environmental Assessment Program, WA Dept. of Ecology.

Michaud, Joy. 1994. Methods for estimating streamflow, in R.F. Cusimano, Technical Guidance for Assessing the Quality of Aquatic Environments. Olympia, WA: WA State Dept. of Ecology, Pub. No. 91-78, February 1994.

Mitchell, M.K. and W.B. Stapp, 1996. Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools. Tenth ed. Dexter, MI: Thomson-Shore.

Murdoch, T., M. Cheo, and K. O'Laughlin. 1996. The Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods. Everett, WA: Adopt-a-Stream Foundation.

Perry, Thomas, U.S. Bureau of Reclamation hydrologist, Denver, CO. Personal communication, 2003.

Pleus, A.E., and D. Schuett-Hames. 1998. TFW Monitoring Program Method Manual for the Reference Point Survey. Prepared for the Washington State Department of Natural Resources under the Timber, Fish and Wildlife Agreement. TFW-AM9-98-002. DNR #104. May.

Pleus, A.E., D. Schuett-Hames, and L. Bullchild. 1999. TFW Monitoring Program Method Manual for the Habitat Unit Survey. Prepared for the Washington State Department of Natural Resources under the Timber, Fish and Wildlife Agreement. TFW-AM9-99-003. DNR#105. June.

Rosenbower, Nancy. 2016. Sample coordinator, Washington State Department of Ecology Manchester Laboratory. Personal communication, 20 April 2016.

Scholz, J.G. and D.B. Booth. 1999. Stream habitat assessment protocols: an evaluation of urbanizing watersheds in the Puget Sound lowlands. The Washington Water Resource: the quarterly report of the Center for Urban Water Resources Management 10(1). Seattle, WA: University of Washington.

Schuett-Hames, D., A. Pleus and L. Bullchild, 1994. Habitat Unit Survey Module. Timber-Fish-Wildlife Ambient Monitoring Program Manual Northwest Indian Fisheries Commission. (Ed.s D. Schuett-Hames, A. Pleus, L. Bullchild & S. Hall)

Schuett-Hames, D., et al. 1999. TFW Monitoring Program Method Manual for the Large Woody Debris Survey. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-004. DNR #106. June.

Sequim Bay Watershed Management Committee. 1991. Sequim Bay Watershed Management Plan: A Community-Based Resource Management Plan. Port Angeles, WA: Clallam County Department of Community Development. 10/91.

Shedd, James R. 2008. Standard Operating Procedure for Measuring Gage Height of Streams. Version 1.0. Washington State Department of Ecology, Environmental Assessment Program. EAP042. Approved October 7, 2008.

Soule, Ann, and Ed Chadd. 2013. Quality Assurance Project Plan: Clallam Marine Recovery Area Septic Solutions, Task 2, Targeted Survey Septics of Concern, Subtask 2E, Water Quality Monitoring. April 2013.

United States Department of Agriculture (USDA). 1998. Stream Visual Assessment Protocol. Natural Resources Conservation Service, National Water and Climate Center. Technical Note 99-1. March.

United States Environmental Protection Agency (USEPA). 1994. Streamwalk Manual. EPA 910-B-94-002. Region 10, Water Division. Seattle, WA. July.

United States Environmental Protection Agency (USEPA). 1997. Volunteer Stream Monitoring: A Methods Manual. EPA 841-B-97-003. Office of Water. Washington, D.C. November.

United States Environmental Protection Agency (USEPA). 2002. Guidance for Quality Assurance Project Plans. EPA/240/R-02/009, EPA QA/G-5. Office of Environmental Information. Washington, D.C. December. Accessed on 12/22/17 at https://www.epa.gov/sites/production/files/2015-06/documents/g5-final.pdf.

United States Environmental Protection Agency (USEPA). 2005. Manual for the Certification of Laboratories Analyzing Drinking Water. Fifth ed. Office of Water. Office of Ground Water and Drinking Water. Cincinnati, OH. January 2005. EPA 815-R-05-004.

United States Environmental Protection Agency (USEPA). 2012. Required Containers, Preservation Techniques, and Holding Times. 40 CFR, Federal Register, Vol. 77, No. 97, 18 May 2012.

United States Geological Survey (USGS). 1998. Techniques of Water-Resources Investigations. Book 9: Handbooks for Water-Resources Investigations. Section A: National Field Manual for the Collection of Water-Quality Data. Office of Water Quality. Reston, VA. ISBN 0-607-90623-5.

Ward, William J. 2016. Standard Operating Procedures for the Collection and Analysis of Dissolved Oxygen (Winkler Method). EAP 023. Version 2.5, 12/12/2016. Washington State Department of Ecology, Environmental Assessment Program. Accessed on 10/17/17 at http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_CollectionandAnalysisofDOWinklerMethod_v2_5EAP023.pdf.

Washington State Department of Ecology. 2006. Water Quality Program Policy, Chapter 2: Ensuring Credible Data for Water Quality Management. Lacey, Washington. (Accessed on 12/22/17 at http://www.ecy.wa.gov/programs/wq/qa/wqp01-11-ch2_final090506.pdf.)

Washington State Department of Fish & Wildlife, Invasive Species Management Committee. 2012. Invasive Species Management Protocols. Version 2.

Washington State University Cooperative Extension, Clallam County Office. 1997. Eight Streams Project Water Quality Monitoring & Quality Assurance Plan. Port Angeles, Washington.

16.0 Figures

The figures in this QAPP are inserted after first mention in the text.

17.0 Tables

The tables in this QAPP are inserted after first mention in the text.

Appendices—see following pages

Appendix A. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Ambient: Background or away from point sources of contamination. Surrounding environmental condition.

Anthropogenic: Human-caused.

Baseflow: The component of total streamflow that originates from direct groundwater discharges to a stream.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Diel: Of, or pertaining to, a 24-hour period.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Enterococci: A subgroup of the fecal streptococci that includes *S. faecalis*, *S. faecium*, *S. gallinarum,* and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5% sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C.

Fecal coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char.

Sediment: Soil and organic matter that is covered with water (for example, river or lake bottom).

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Streamflow: Discharge of water in a surface stream (river or creek).

Total suspended solids (TSS): Portion of solids retained by a filter.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act, requiring Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

Ecology	Washington State Department of Ecology
e.g.	For example
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
GIS	Geographic Information System software
i.e.	In other words
MQO	Measurement quality objective
QA	Quality assurance
QC	Quality control
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
SRM	Standard reference materials
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
cfu	colony forming units
ft	feet
g	gram, a unit of mass
mg	milligram
mg/L	milligrams per liter (parts per million)
NTU	nephelometric turbidity units
psu	practical salinity units
uS/cm	microsiemens per centimeter, a unit of conductivity

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms precision and bias be used to convey the information associated with the term accuracy. (USGS, 1998)

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella. (Kammin, 2010)

Bias: The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system, and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI). (Kammin, 2010; Ecology, 2004)

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process. (USGS, 1998)

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured. (Ecology, 2004)

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards, but should be referred to by their actual designator, e.g., CRM, LCS. (Kammin, 2010; Ecology, 2004)

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator. (USEPA, 1997)

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator. (USEPA, 1997)

Continuing Calibration Verification Standard (CCV): A QC sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run. (Kammin, 2010)

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system. (Kammin, 2010; Ecology 2004)

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean. (Kammin, 2010)

Data Integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading. (Kammin, 2010)

Data Quality Indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity. (USEPA, 2006)

Data Quality Objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.
(USEPA, 2006)

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010)

Data validation: An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier, data is usable for intended purposes.
- J (or a J variant), data is estimated, may be usable, may be biased high or low.
- REJ, data is rejected, cannot be used for intended purposes (Kammin, 2010; Ecology, 2004).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set. (Ecology, 2004)

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero. (Ecology, 2004)

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis. (USEPA, 1997)

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport. (Ecology, 2004)

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples. (Kammin, 2010)

Laboratory Control Sample (LCS): A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. (USEPA, 1997)

Matrix spike: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects. (Ecology, 2004)

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness. (USEPA, 2006)

Measurement result: A value obtained by performing the procedure described in a method. (Ecology, 2004)

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed. (EPA, 1997)

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

Method Detection Limit (MDL): This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of

an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)

Percent Relative Standard Deviation (%RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010)

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all "parameters." (Kammin, 2010; Ecology, 2004)

Population: The hypothetical set of all possible observations of the type being investigated. (Ecology, 2004)

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator. (USGS, 1998)

Quality Assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

Quality Control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled. (USGS, 1998)

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

Sample (statistical): A finite part or subset of a statistical population. (USEPA, 1997)
Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit. (Ecology, 2004)

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method. (USEPA, 1997)

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency. (USEPA, 1997)

Split sample: A discrete sample that is further subdivided into portions, usually duplicates. (Kammin, 2010)

Standard Operating Procedure (SOP): A document which describes in detail a reproducible and repeatable organized activity. (Kammin, 2010)

Surrogate: For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis. (Kammin, 2010)

Systematic planning: A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning. (USEPA, 2006)

References for QA Glossary

Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. http://www.ecy.wa.gov/biblio/0403030.html

Kammin, B., 2010. Definition developed or extensively edited by William Kammin, 2010. Washington State Department of Ecology, Olympia, WA.

USEPA, 1997. Glossary of Quality Assurance Terms and Related Acronyms. U.S. Environmental Protection Agency. http://www.ecy.wa.gov/programs/eap/quality.html

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. U.S. Environmental Protection Agency. http://www.epa.gov/quality/qs-docs/g4-final.pdf

USGS, 1998. Principles and Practices for Quality Assurance and Quality Control. Open-File Report 98-636. U.S. Geological Survey. http://ma.water.usgs.gov/fhwa/products/ofr98-636.pdf

Appendix B. Clallam County Water Resources Database instructions

General instructions for logging on and opening the data base.

- Turn on computer and monitor.
- After a long start-up, you will be asked to hit "Ctrl,Alt,Delete" which will take you to the log-in window.
- A new password is assigned the first of each month. Ask staff or volunteer for current password.
- On most computers, the desktop has an icon that says, "CCWR_User". Double-click on this. If the icon isn't there, ask for help or if you feel comfortable with the computer browse to the K:\streamkeepers\Data\dataBase folder and select CCWR_User.mdb.
- A screen will ask for a database password: "streams".
- The database switchboard will appear. It has four tabs horizontally across the top of the page:

  Projects/Sites
  People/Teams
  Data Entry/Editing
  Reports

- Click on the Data Entry /Editing for quarterly monitoring, grab tours, and macroinvertebrate collection data entry.

Glossary of terms

- Episode: Either summer, winter, spring or fall quarterly monitoring
- Tour: When a team that is assigned to monitor certain streams, visits the stream/streams to monitor it is a tour. A tour may occur on one day or over a period of weeks during a quarter.
- Visit: A visit is a particular monitoring site on a stream.
- Batch: The data collected from a specific instrument or from the contents of a container during a visit.
- Field Replicate: A duplicate sampling by an instrument during a visit.
- Sub-batch: When multiple readings are taken from a single field sample. Examples: YSI multimeter gives multiple readings [temp, DO, Conductivity, Salinity] from one water sample. The turbidity meter measures the turbidity in three small samples from one bottle of stream water.
- Field Replicate: Field replicate is a duplicate deployment of an instrument to test the accuracy of the first reading, so it's considered a separate batch.
- Run Time Error: If data entry is interrupted by an error message, close the data base and reenter or if necessary, reboot the computer.

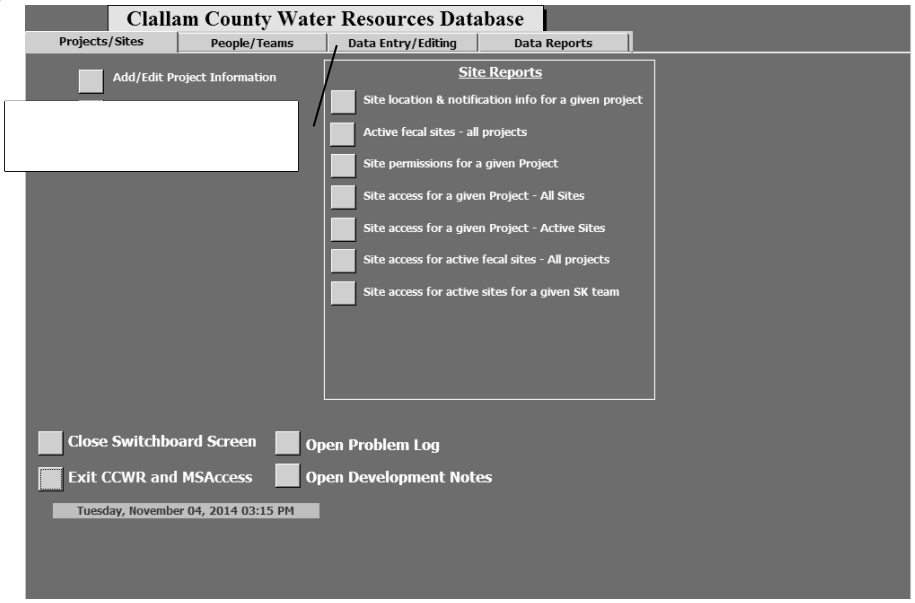
Data sheet filing

- Field data sheets are filed in the file cabinet labeled "Data".
- The oldest data is in the back of the cabinet advancing forward to the most recent data.
- Each file folder contains a quarters worth of data starting with the winter then progressing to Spring, Summer, Fall for each year.
- Each file contains an Episode Cover Sheet, a folder for data "To enter", "To Check", and "To Double Check".
  - The Episode cover sheet is loose and is to remain on top and separate from the Tour data.
  - Each Tour is clipped together with the Tour cover sheet on top.
  - If you are unable to complete entering the tour data, put the sheet being worked on top of the other tour sheets and clip it together.
  - Put a note on the tour containing your name and the date.
  - Generally the same people who started entering/checking a tour should finish it.

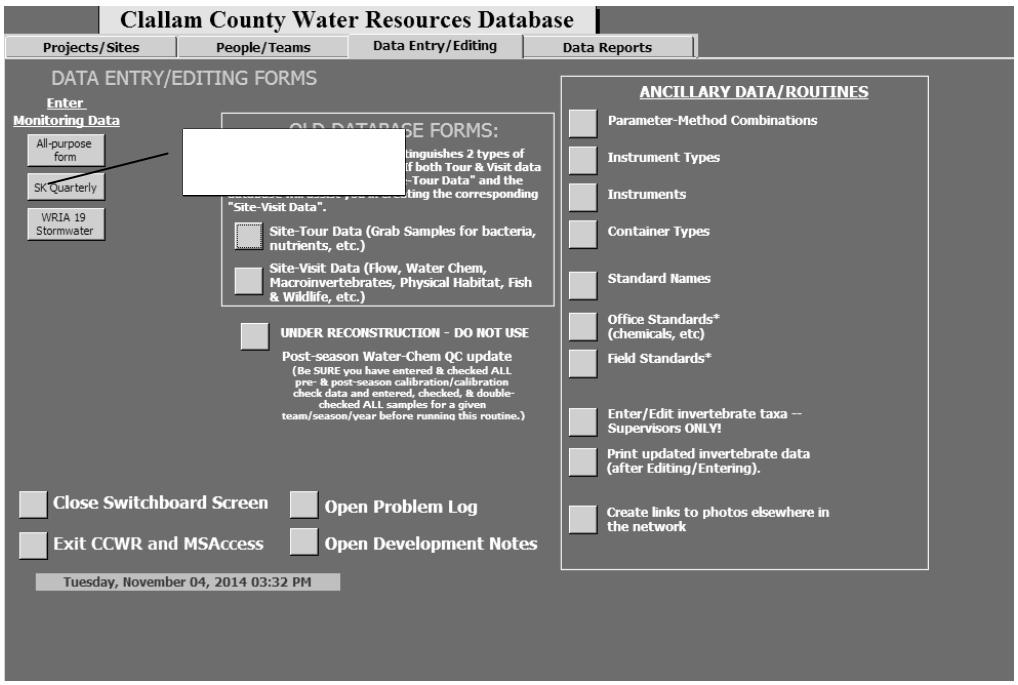
- Once the field sheet data has been entered into the data base the sheets are moved into the "To Check" folder, and once checked, into the "To Double Check" folder after which the field sheets are moved to permanent storage.

Entering Streamkeepers Quarterly Monitoring data.

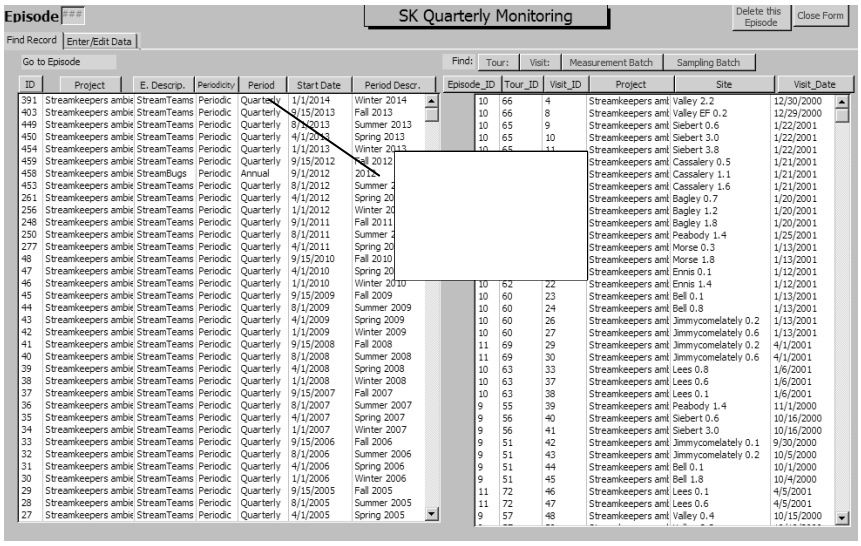
- To enter information from the quarterly monitoring Tour Cover Sheet, click on the "Data Entry/Editing tab of the database switchboard.



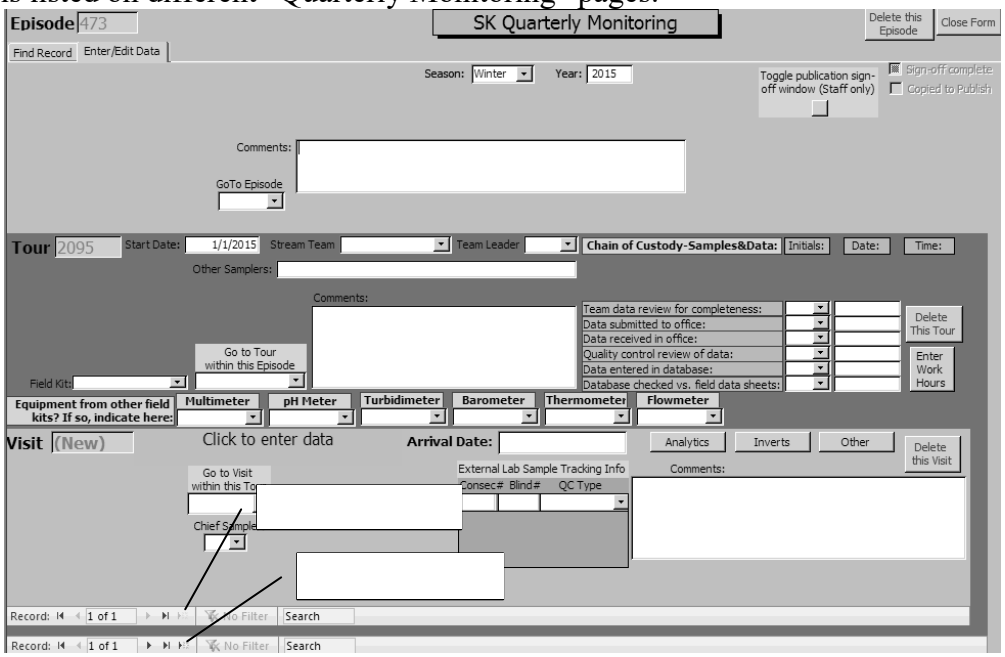
- Next click on the "SK Quarterly" box.



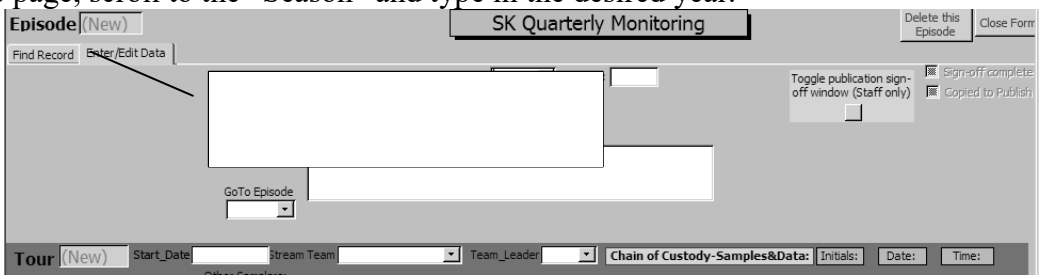
- When the "SK Quarterly Monitoring" page opens, select the desired quarter.



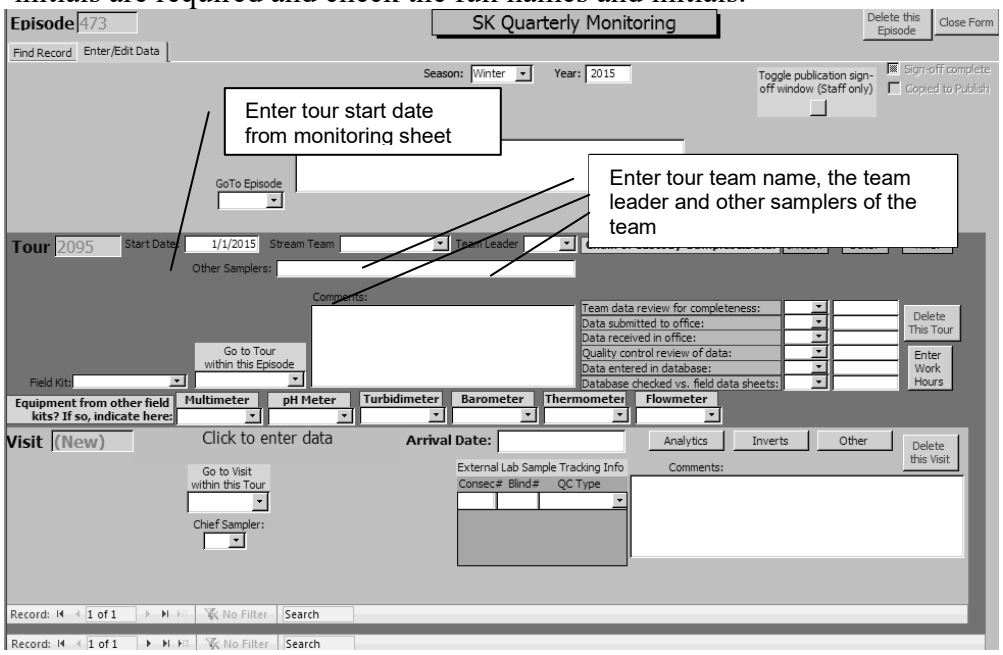
- To navigate the Quarterly Monitoring page look to the bottom left "Record" bars with right and left facing arrows.
  - Use the arrows to find previously entered data, to add data or to check existing data.
  - The top bar is to navigate to different visits within a tour. Example: Salt 1.5 and Salt 6.4.
  - The bottom bar is to navigate to different tours within a quarter. Example: Salt Creek and Peabody Creek. These tours both were monitored in the same quarter but the data is listed on different "Quarterly Monitoring" pages.



- If data has not previously been entered for the quarter, click on "Enter/Edit Data" tab and at the top of the page, scroll to the "Season" and type in the desired year.

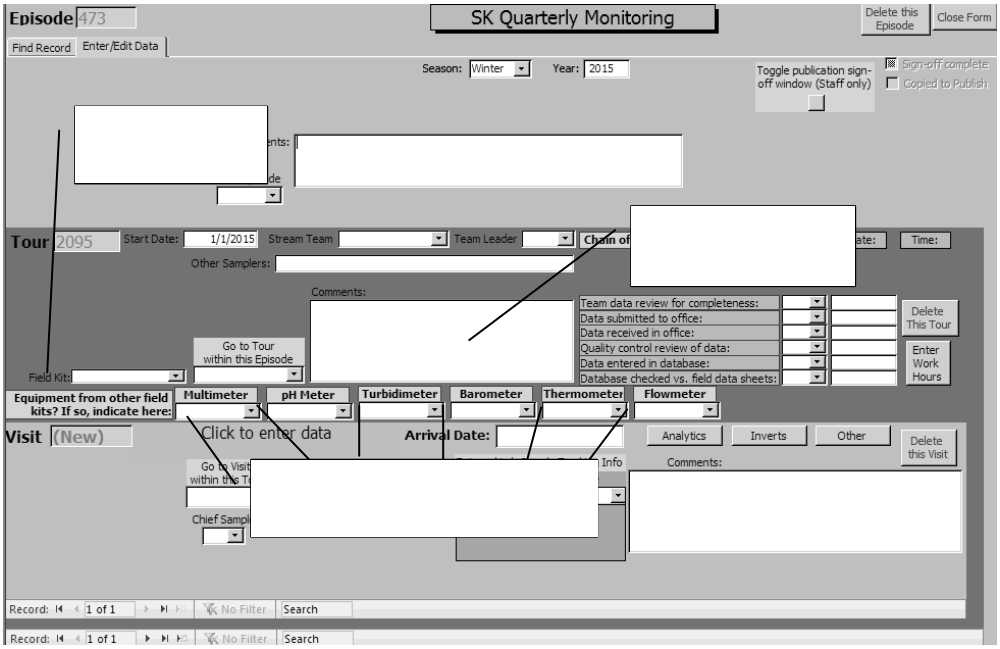


- Enter the tour start date in the "Start Date" box. Using the scroll down menu enter the "Stream Team". The assigned team is given the name of the creeks being monitored. Enter the three initials of the "Team Leader" and the "Other Samplers" (first and second initials and full last name).
  - If unsure of the three initials of a team leader or member use the pull menus where initials are required and check the full names and initials.

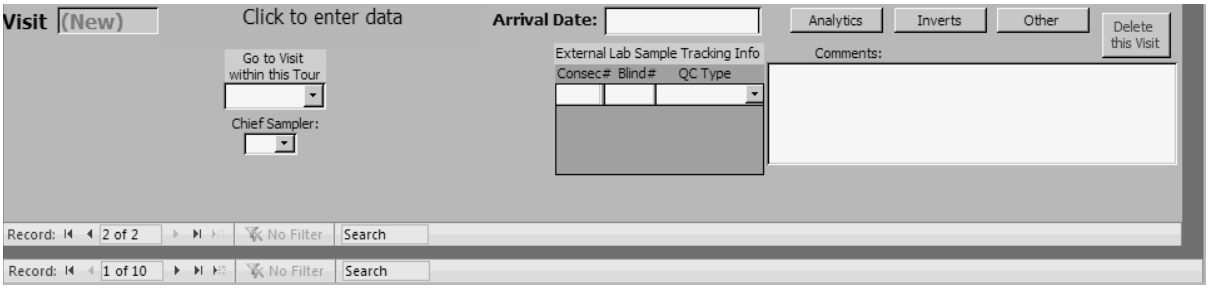


- In the "Field Kit" box use the pull down menu to enter the kit number that can be found in the Field Kit name box on the Tour Cover Sheet. The type of instruments from this kit will automatically populate the data entry sheets. Exceptions are noted in the Field Kit deviations section of the Monitoring Field Data Sheet or in the comments section. If instruments other than those in the field kit are recorded on the field monitoring sheet, use the "Equipment from other field kit? If so indicate here" box and use the pull-down menu to choose the correct instrument.

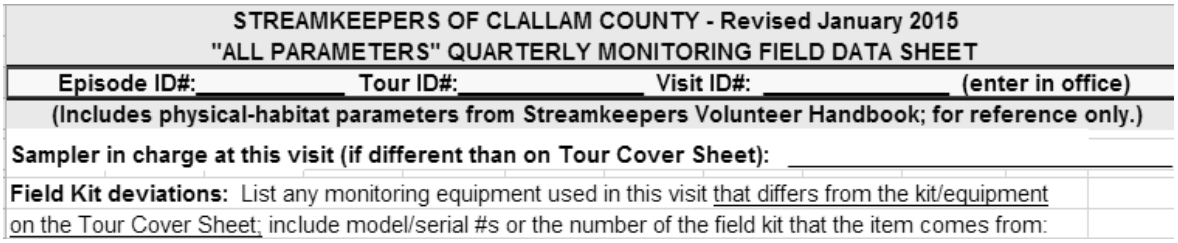
- Enter comments from the Tour Cover Sheet into the tour "Comments" section.

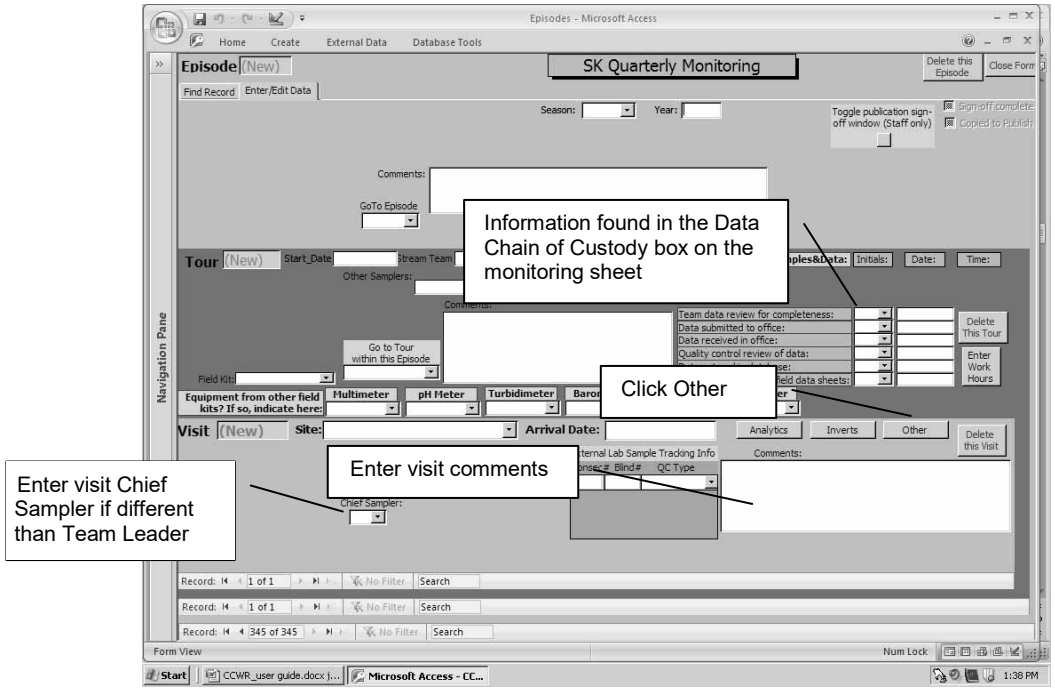


- Information for the blue boxes, "Team data review for completeness:", "Data submitted to office:", "Data received in office:", "Quality control review of data:" can be found on the Tour Cover Sheet.
- After data entry for a tour is complete, enter your three initials and the date in the "Data entered in database:" box .
- Click the pink bar to enter data into the "Visit" section of the "Quarterly Monitoring" sheet.
- After clicking the pink bar the box to enter "Site" will appear. Use the pull-down menu to choose the visit site and enter the date from the Field Data Sheet in the "Arrived Date" box.



- If the "Chief Sampler" for the visit is different than the "Tour" "Team Leader", enter the initials in the box.
- Enter any visit comments from the Field Data Sheet to the "Comments" box.
- At the top of the Field Data Sheet enter the computer assigned "Episode" ID, "Tour" ID and "Visit" ID numbers from the database.





- Click on the "Other" box as shown below to begin entering data from the Monitoring Field Data Sheet.
- Start entering data from the first page of the Monitoring Field Data Sheet (example below).

Noxious weed report for this Visit? *(do every summer or when there are new data)* **Sampler's initials:**

Yes ___ No ___ Didn't check ___

If "yes," complete a separate Noxious Weed report (in your forms folder).

Photos taken? ***(see Handbook for protocol)*** **Yes ___ No ___** **Sampler's initials:**

FOR SUMMER & WINTER PHOTOS: AT SITES WITHOUT ESTABLISHED CROSS-SECTION, USE CENTRAL SAMPLING POINT (A.K.A. "ZERO POINT") AS CENTRAL POINT FOR PHOTOS.

(Cut below after inputting data into database and recording Visit ID# below; then give to photo processor.)

Photo log: *Fill in completely for each picture, including vantage point (where it was taken from)*

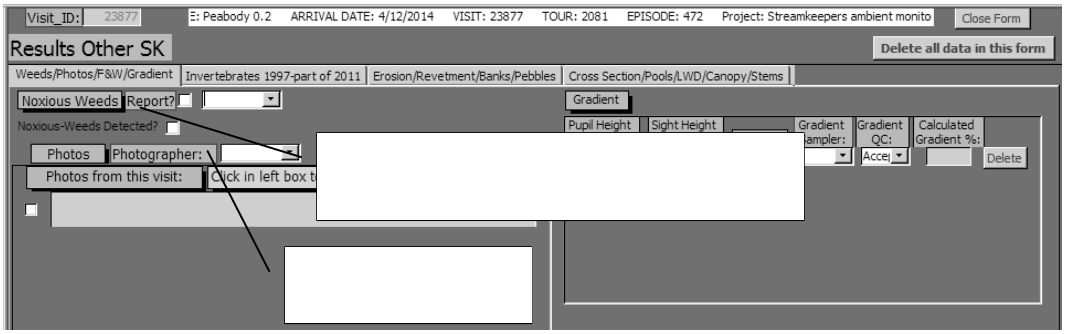
Site Name:_____ Date:____/____/_____ Camera #:_____

Initials	Frame # (*xxx-xxxx*)	Subject	Vantage Point

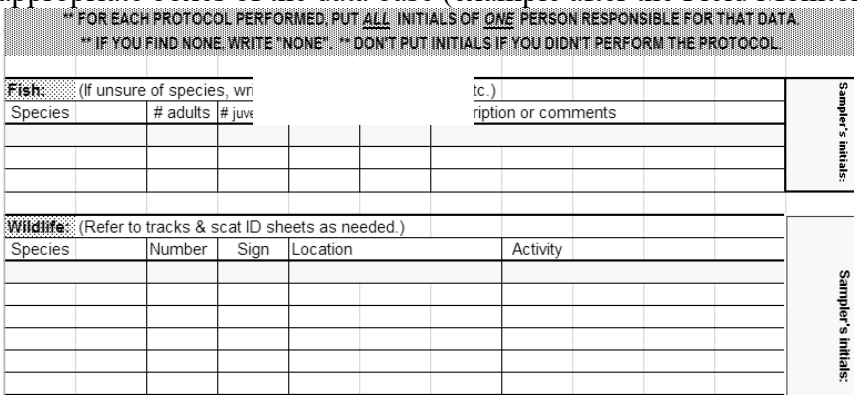
(enter in office) **Visit ID#:**

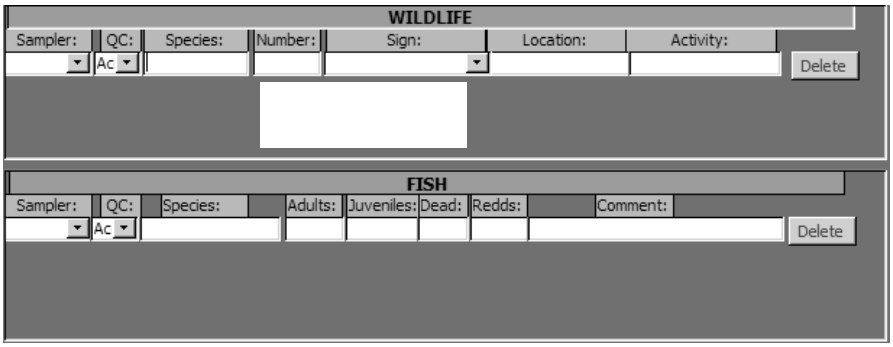
Enter visit ID# on Field Data Sheet if photos were taken

- Enter data from the Field Data Sheet (above) to the page in the data base that opens after clicking "Other" in the database.

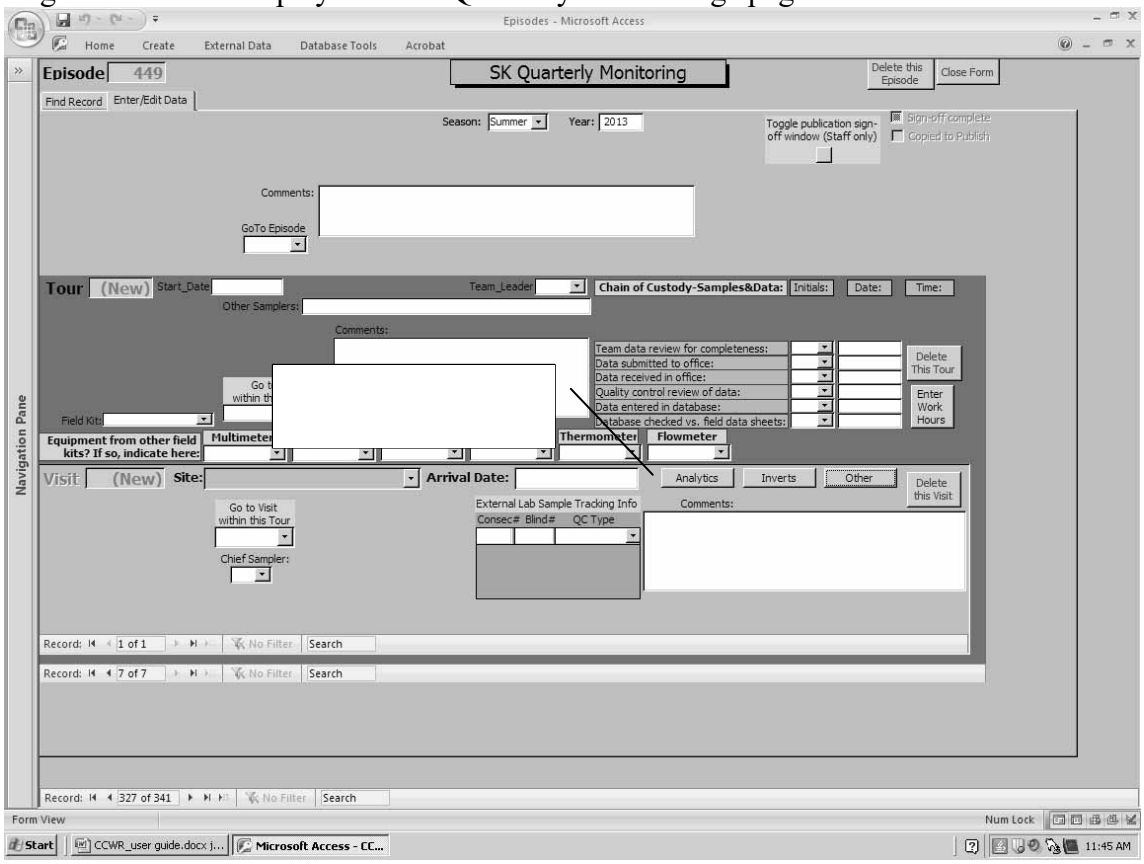


- On the Field Monitoring Data Sheet is a box for Noxious weed report for this visit? If Yes has been checked, look for the Noxious Weed report in the Field Monitoring Data Sheets.
- This report needs to be photocopied (Instructions for photocopying are in the Volunteer Notebook). The photocopy is placed in an interoffice mailing envelop addressed to Kathy Lucero at mail stop WEEDS or ask Staff for help. Indicate on the Noxious Weed report that a copy was sent to WEEDS. Add your initials and date.
- Check the "Noxious Weed Report?" box on the data entry page.
- If photos were taken in the field, the Photo Log at the bottom of the Field Monitoring Data Sheet will have been filled out. Enter the initials of the photographer in the "Photographer" box on the data entry page. Cut off the Photo Log being careful not to cut off pertinent data from the back of the Log or if necessary photocopy the page and cut the Photo Log from the photocopy. At the bottom of the Photo Log is a box to enter Visit ID#. Enter the "Visit ID" found at the top of the data entry page.
- File the log in the pull out bin in the coffee room labeled Photo Log or ask staff.
- Enter Fish and Wildlife information and the sampler's initials from the Field Monitoring Data Sheet (below) into the appropriate boxes of the data base (example after the Field Monitoring Data Sheet).

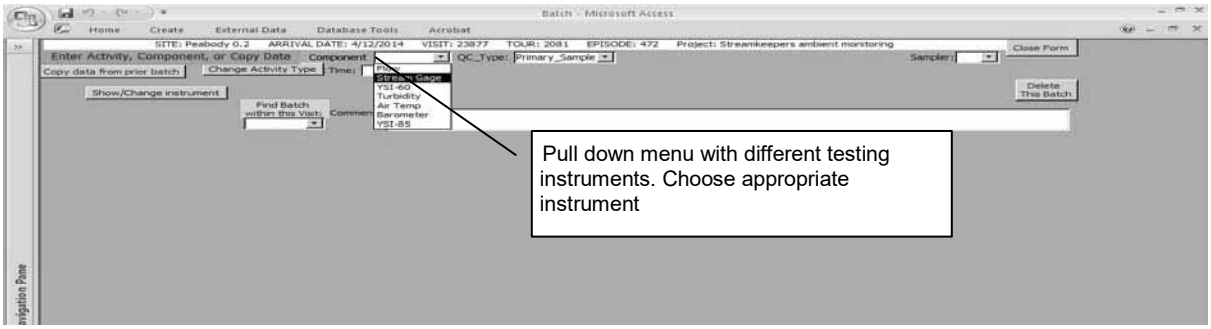




- Click on “Close Form” at top right of page.
- Closing the form will display the “SK Quarterly Monitoring” page.



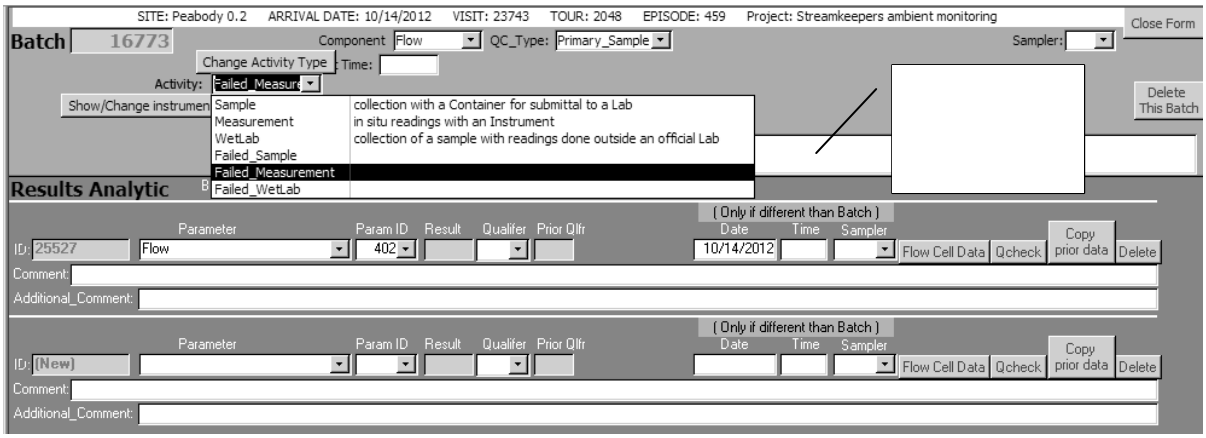
- Click on “Analytics” to enter field data for Flow, YSI 60 Ph, Turbidity, Air temperature, Barometric pressure, YSI-85 multimeter.
- From the pull-down menu choose the instrument that corresponds to the Field Monitoring Data Sheets instrument data.



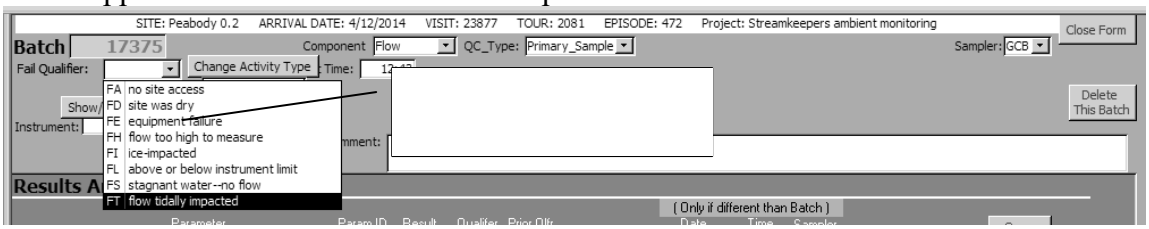
- Choose “Primary Sample” from the pull-down menu.
- Enter the “Sampler” initials and the “Time” the sampling began.

- Click on “Change Activity Type”.

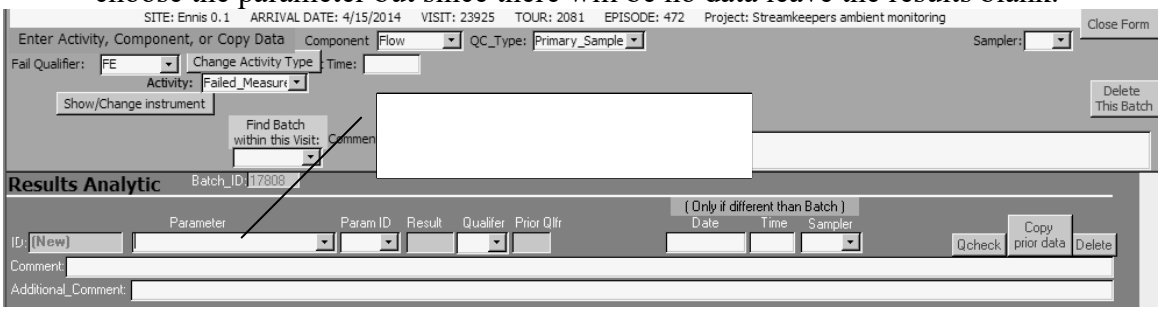
  - The “Change Activity Type” is generally “measurement”, however if the field team was unable to collect data click on the “Change Activity Type” bar and using the pull-down menu choose “Failed_Measurement” or if the component is turbidity, “Failed_WetLab”.
  - Enter any comments made by the field team as to why they were unable to collect data.



  - After the “Change Activity Type” indicates a failure a “Fail Qualifier” box will appear to the left. Choose from the pull-down menu the reason for failure.

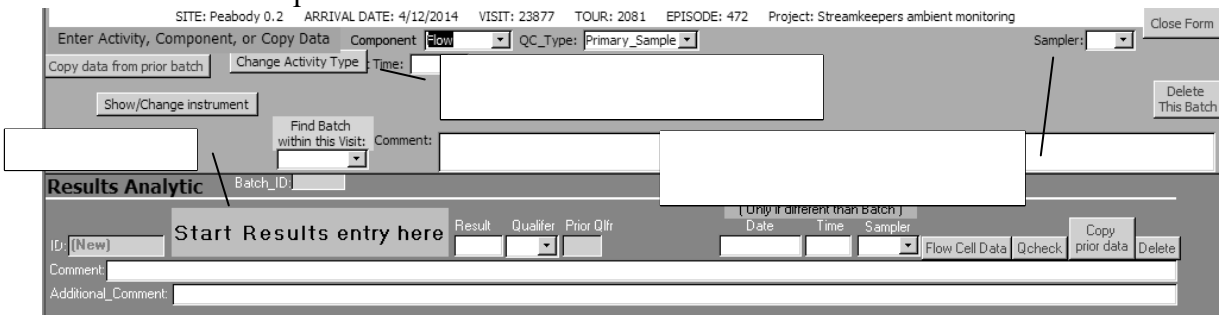


  - In the “Results Analytic” section in the “Parameter” box use the pull-down menu and choose the parameter but since there will be no data leave the results blank.

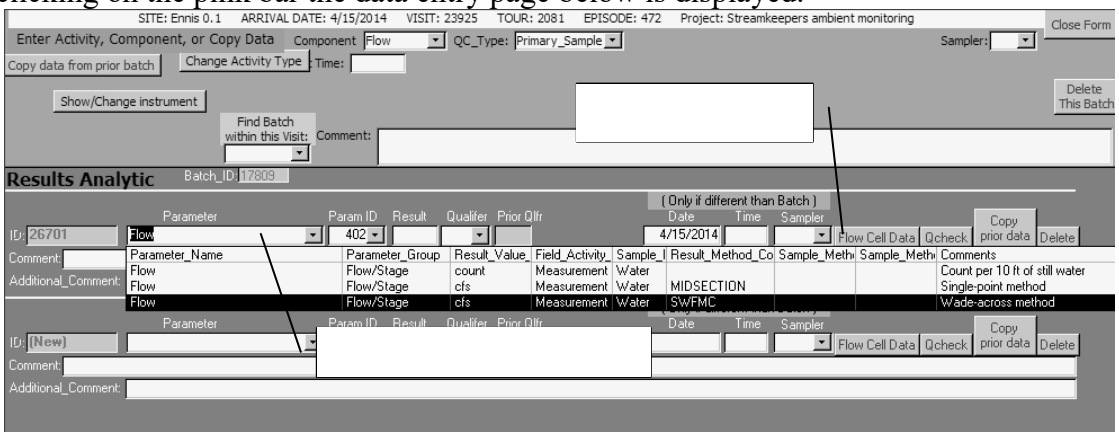


The procedure for any failure to collect data on any instrument is entered the same way for all monitoring equipment.

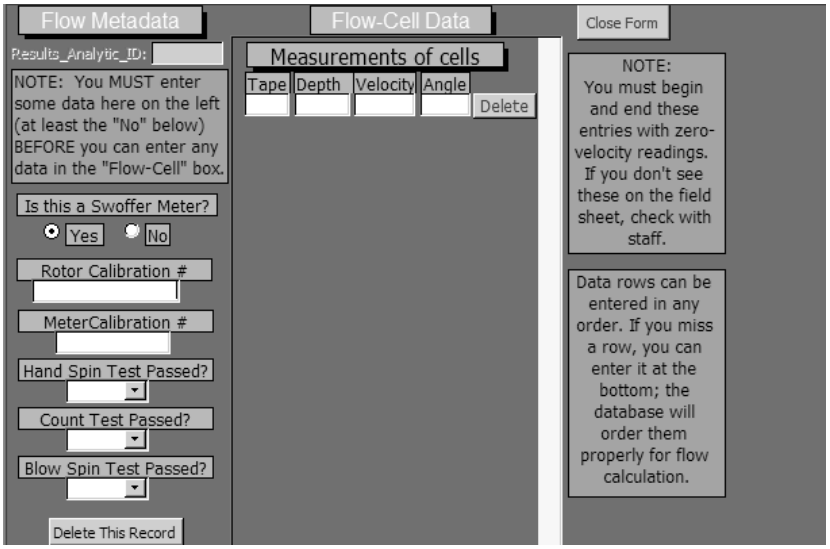
- If measurements were taken and data was entered on the Field Monitoring Sheet, after entering the "Component" (in this case flow) enter the time and the sampler's initials in the appropriate boxes then click on the pink bar.



- After clicking on the pink bar the data entry page below is displayed.



- Click on "Flow Cell Data" after which a page will appear to enter data from the Field Monitoring Data Sheet.



- Answering the question in the box "Is this a Swoffer meter?" depends on what kit the flow meter is from or if there is a comment in the Field Kit deviations on the Field Data Sheet. There are two brands of flowmeter, the Swoffer and the Marsh-McBirney that are used by Streamkeepers. The Swoffer which requires calibration and the Marsh-McBirney which does not. If a Swoffer is being used "Is this a Swoffer meter?" will be checked "Yes" and if the Marsh-McBirney is being used the answer will be "No".
- If the answer is yes and a Swoffer meter was used then enter the calibration information at the top of page on the Field Monitoring Data Sheet under the Flow section (see example below). Enter the Rotor calibration and Meter Calibration on the data entry sheet.

If using a Swoffer meter:	Rotor #:	Rotor calibration # (on bag):	Calibration date:
	Hand-spin test (circle one): **pass / fail**	Meter calibration # (switch on "calibrate"):	
	Count test (circle one): **pass / fail**	Blow-spin test (circle one): **pass / fail**	

- Indicate on the data entry sheet if the Hand Spin Test passed, the Count Test passed and the Blow Spin Test passed.
- If a Marsh-McBirney meter was used the calibration and tests passed boxes will remain bla
- Enter the data from the Field Monitoring Data Sheet (below) into the "Flow-Cell Data" section (Tape, Depth, Velocity).

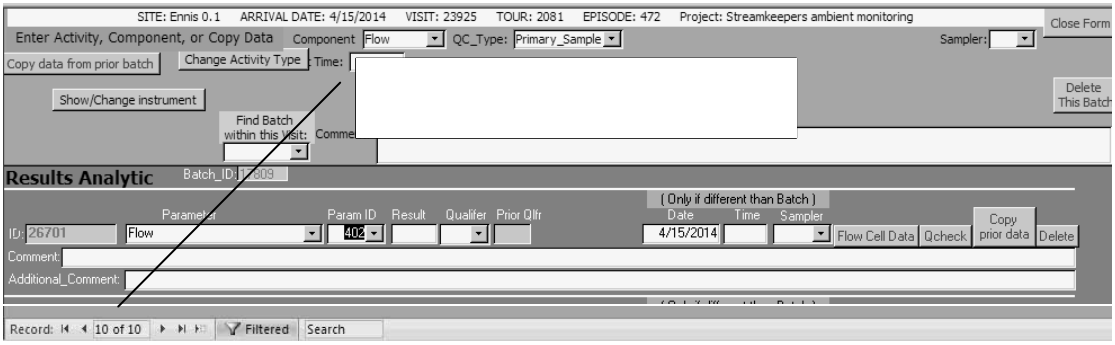
Include zero velocity readings 0.3 ft. to the outside of the first and last "prop-turning" locations where possible.
*When velocity is zero, indicate why: insufficient depth (**insf/d**) insufficient velocity (**insf/v**) or both (**insf/dv**)*

Tape *to nearest 0.1'*	Depth *to 0.01 ft.*	Velocity* *to 0.01 ft. per sec*	Angle** *to nearest 10°*	Tape *to nearest 0.1'*	Depth *to 0.01 ft.*	Velocity* *to 0.01 ft. per sec*	Angle** *to nearest 10°*	
	0	(wetted edge @ dry land)						
					0	(wetted edge @ dry land)		

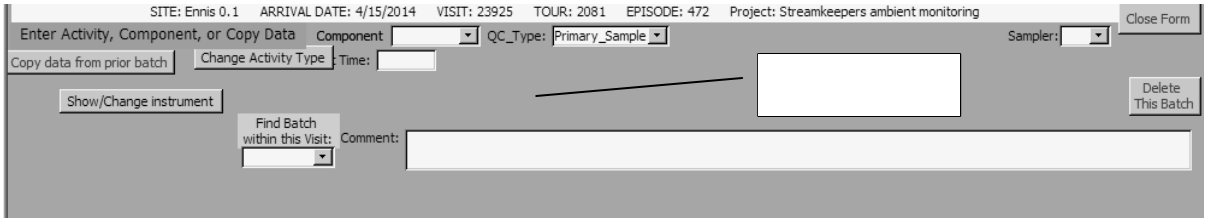
(For depths >2 ft., record velocity readings at both 2/10 and 8/10 depths, and record both to be averaged.)*
*(** Estimate the tell-tail's deviation from straight downstream, then face the prop in the direction of the current.)*

Sampler's initials:

- Click "Close Form" when finished.
- After entering flow data, click on the first arrow of the tool bar for a new batch data entry page.



- New batch page (see below). The remaining data (pH, turbidity, air temperature, barometric pressure, and YSI multimeter) can be entered in the same way as the flow data by adding a new batch data page for each instrument, choosing the instrument, entering the date of collection, the initials of the sampler, and the time of collection.



- The data from the Field Monitoring Data Sheet contains the remaining data to be entered into the data base.
- The yellow bars indicate the information to transfer to the data base.
  - The pH part of the data sheet has two data points to enter into the data base: pH reading and Time.

YSI-60 pH meter calibration *(must do at the beginning of each sampling day)*

Has this already been done today? **Yes / No** If "yes," on what data sheet is the information? _ _ _ _ _ _ _ _ _ _

(If not, you'll need to do it now. Second row					***pH7 pre-cal rdgs***		***pH7 post-cal rd***		
Meter #	*Time (24-hr notation)*	*Sam-pler's Initials*	*pH7 exp date*	*pH10 exp date*	*temp (to 0.1)*	*pH (to .01)*	*temp (to 0.1)*	*pH (to .01)*	*Expected pH, from chart on back, to .01*

pH reading: (to nearest 0.1; expected range 6.5 - 8.5) **Time:**

pH meter post-check with pH 7 buffer (do at every site, after any replicates)	*temp (to 0.1)*	*meter pH (to 0.01)*	*Expected pH (from chart on back, to .01)*	*Difference between meter pH & expected pH (to .01)*
Time: Initials:				

- The Turbidity part of the data sheet has collection time, the sampler's initials and the three turbidity data points (NTU's) to be entered into the data base.
- If the turbidity instrument reading was not taken in the field enter the date and time indicated on the data sheet.
- Included in the picture below are the instrument readings for the Air temperature and the Barometric pressure. Both require an entry for time, initials and the monitored data point.

Turbidity: Last calibration date on turbidimeter: ___ / ___ / ___ *(Only record if not reporting to Streamkeepers.)*

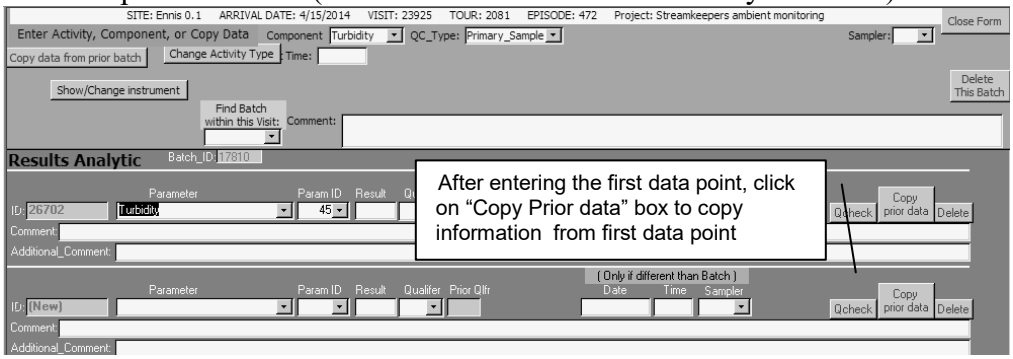
Field calibration check: Perform using sealed "reference standard" vial with a value of about 10.

- # of NTU's listed on this reference vial:_____ Expiration date:___/___/___
- Turbidimeter reading for this reference vial:_____ (to nearest 0.01 NTU)

Rdgs to nearest **whole #** of NTU's: **1**____ **2**____ **3**____ **Avg**____ *(Expected values <5 unless water is high)*

Collection Time:	**Initials:**	**Reading date/time if not done in field:**		**Initials:**
Air temperature/thermometer:		°C (to nearest whole °C)	**Time:**	**Initials:**
Barometric pressure:		Units: **in / mm / mbar** (to nearest 0.01)	**Time:**	**Initials:**

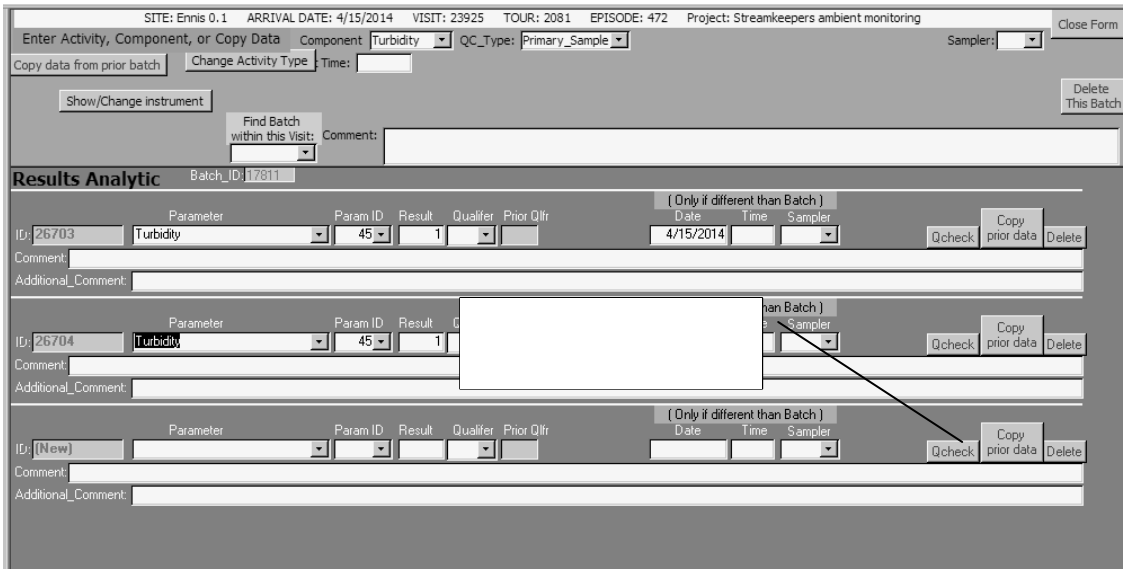
Turbidity has three data points to enter (refer to Sub-Batch under Glossary of Terms).



Enter first data point then click on the "Copy prior data" box which will copy the previous data point into the second "Result" box.

Repeat for the third data point.

- If all three data points are not identical, correct by manually deleting and adding the correct number.

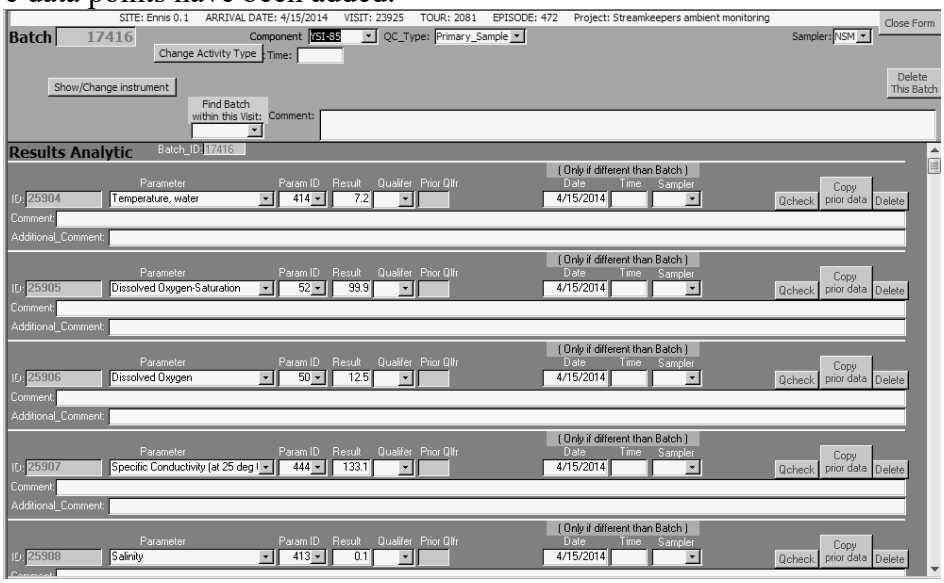


- The YSI-85 part of the Field Monitoring Data sheet contains 5 instrument readings. The five readings plus the time and sampler's initials are entered into the data base.

YSI-85 multimeter	Calibration dates*:	Winkler DO: ___ / ___ / ___	Conductivity: ___ / ___ / ___	Temperature: ___ / ___ / ___
#/name written on meter*:		(*Only record these if you're not reporting to Streamkeepers.)		
Readings:		**Expected ranges:**	If meter results do not fall into the expected ranges or are not close to the replicate, please re-calibrate and	
Water temp:	°C (to nearest 0.1°C)	1-20°C		
DO % Saturation:	% (to nearest 0.1%)	70-120%		
DO Concentration:	mg/L (to nearest 0.1 mg/L)	6-15 mg/L		
Conductivity*:	µS (to nearest whole #)	25-400 µS	**Multimeter Time:**	
Salinity:	PSU (= ppt) (to nearest 0.1)	0-35 PSU	**ultimeter Initials:**	
Dissolved Oxygen drift check	**DO Sat (to nearest 0.1%):**		**Time:**	

- The YSI-85 collects 5 data points: water temperature, % disolved oxygen saturation, dissolved oxygen in mg/L, specific conductivity and salinity.
- Use the pull down menu in the "Parameter" box to enter the parameter.

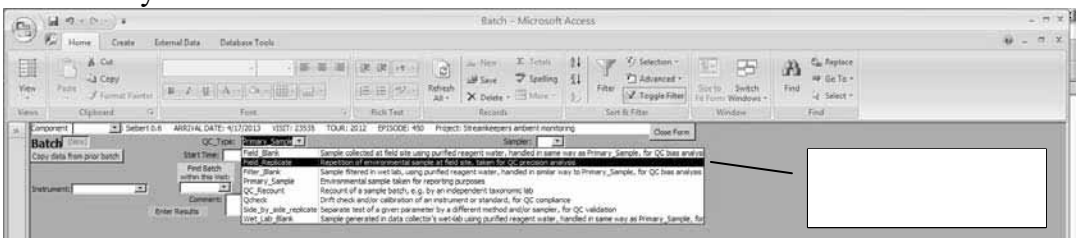
- After entering a data point another blank parameter box will appear for the next data point entry until the five data points have been added.



- If the Field Data Sheets contains data for replicate samples enter the data from each instrument on separate data entry pages.

Field Replicates	*Please check sample/replicate deviations and re-test as necessary; see Handbook*				
YSI-60:	pH:		(to nearest 0.1 pH unit)	**Time:**	**Initials:**
Turbidity readings to nearest **whole #** of NTU's:	**1**____ **2**____ **3**____ **Avg**____			**Time:**	**Initials:**
Pressure:	Barometric pressure:		Units: **in / mm / mbar** (to nearest 0.01)	**Time:**	**Initials:**
YSI-85:	Water temp:		°C (to nearest 0.1°C)	**Time:**	**Initials:**
	DO % Saturation:		% (to nearest 0.1%)		
	DO Concentration:		mg/L (to nearest 0.1 mg/L)		
	Conductivity*:		µS (micro-Siemens--to nearest whole #)		
	Salinity:		PSU (= ppt) (to nearest 0.1)		
Dissolved Oxygen drift check	**DO Sat (to nearest 0.1%):**		**Time:**	**Initials:**	

  - Choose an instrument from the pull down menu in the "component" box of the data entry page (see example below).
  - From "QC Type:" choose "Field Replicate" from the pull down menu.
  - In the "Replicate of:" box choose the batch ID or instrument that this is a replicate of.
  - Enter as before the sampler's initials and the time the field data was collected.
  - Enter the data from the Field Replicate section of the Field Data Sheet just as the Primary Data was entered.

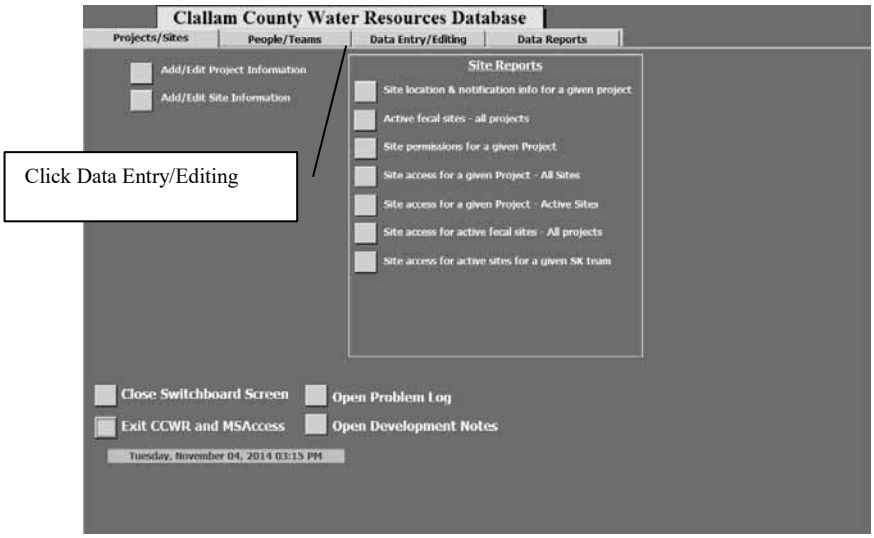


All Purpose Form

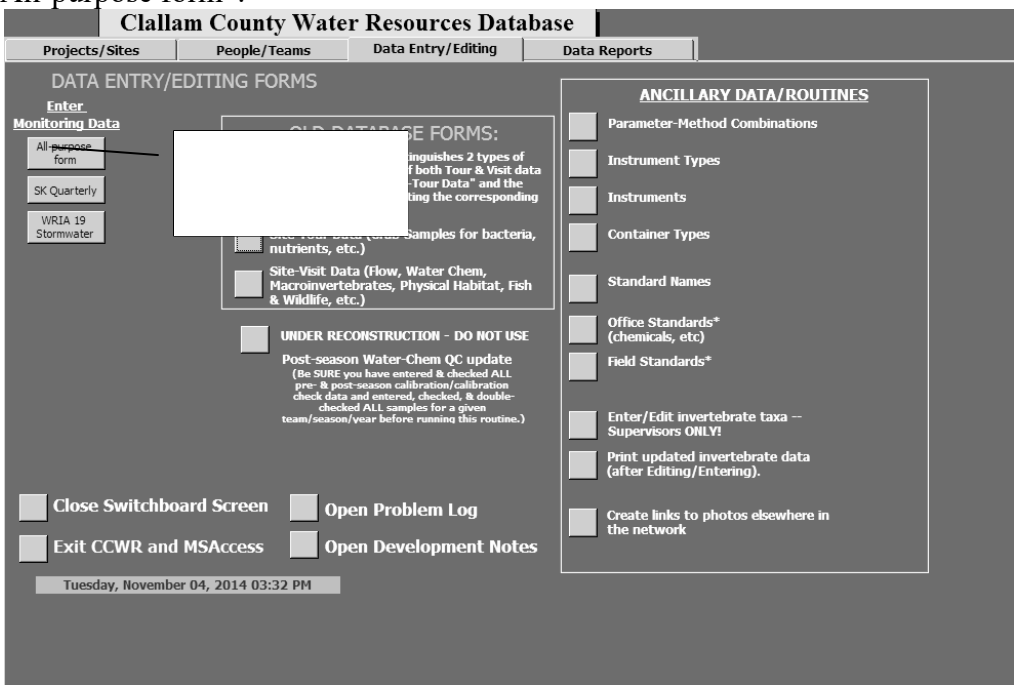
- The All Purpose Form is used to enter grab sample data, bug data and any other data that does not have a customized form for special projects such as Quarterly data.
- Because the field data sheets are generic and used for several field data collecting projects the field data sheets may not fit the database format exactly. Therefore, the data entry person may have to search the field data sheets to find information that is asked for in the data base. For example, the Bug Sampling Tour Cover Sheet has no specific place for field replicate data. The

data collecting team will indicate that the data is a replicate but the database entry person will have to find it. Ask a Streamkeepers person that is in the office if you have questions concerning where to find field data that is required for the database.

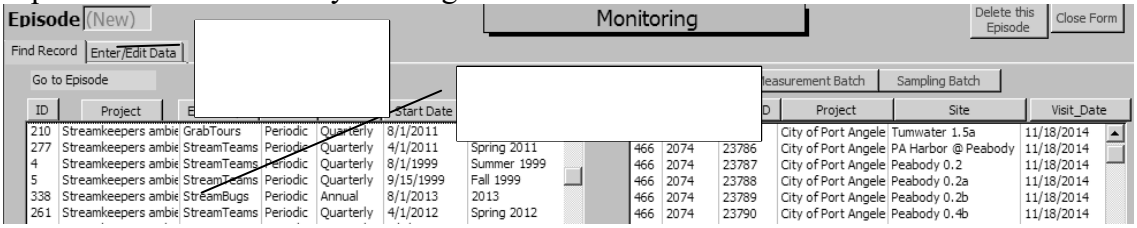
- To enter information from the field monitoring sheets, click on the "Data Entry/Editing tab of the database switchboard.



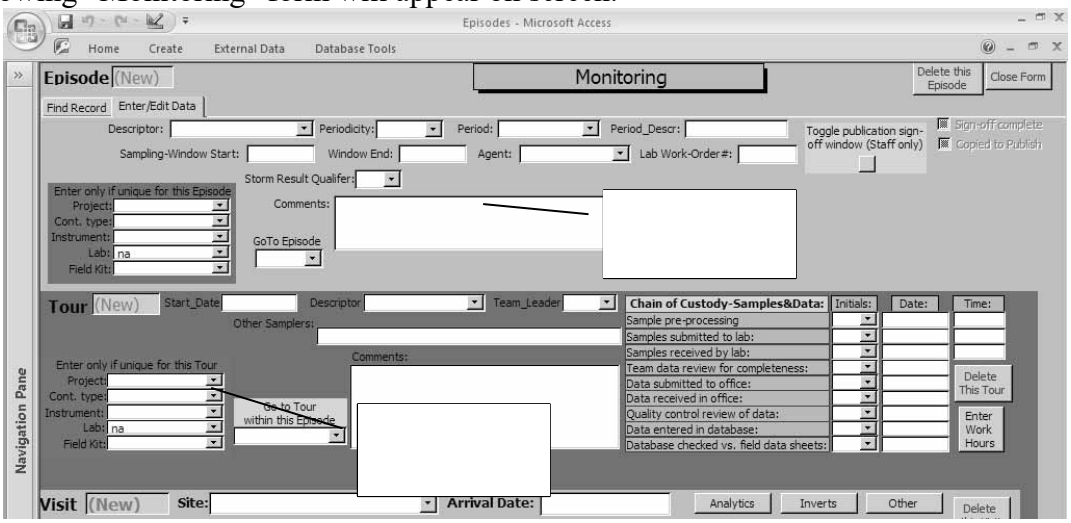
- Click on "All-purpose form".



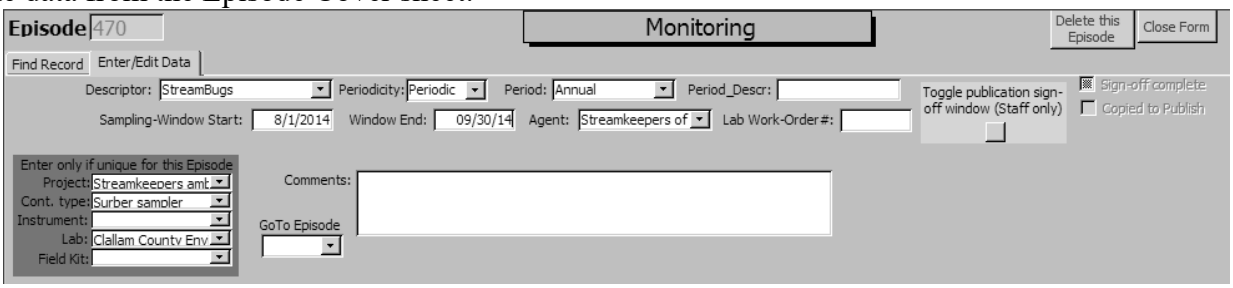
- Choose an Episode using the field Episode Cover Sheet. If there is no data entry for the Episode a new Episode can be created by clicking on "Enter/Edit Data tab".



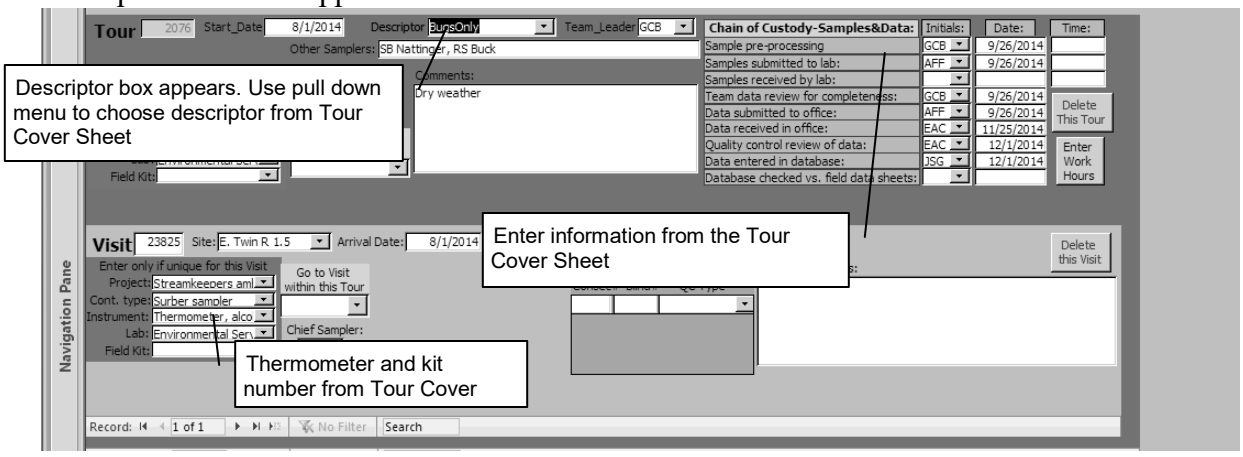
- The following "Monitoring" form will appear on screen.



- If this is a new episode, using the pull-down menus, enter the data from the Episode Cover sheet for "Descriptor:", "Periodicity:", Period:", "Period Descr:", "Sampling-Window Start:", "Window End:", and "Agent:"
- In the blue-green box "Enter only if unique for the Tour" box using the pull-down menus enter the data from the Episode Cover sheet.

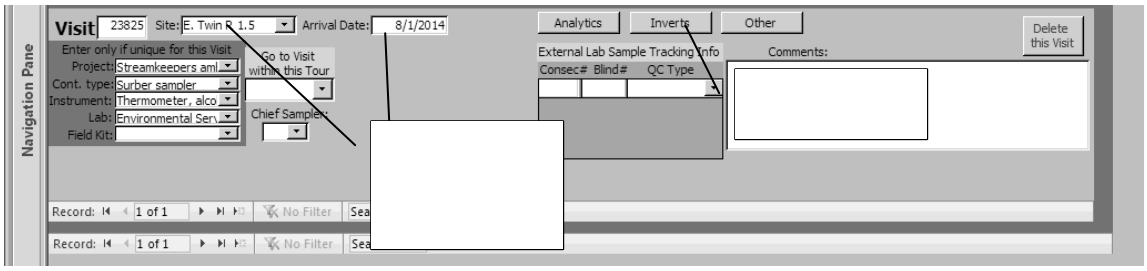


- After completing the Episode information, enter the Tour information (see above).
- Enter the "Start Date" using the Start Date from the Tour Cover Sheet. After the date is entered the "Descriptor" box will appear.

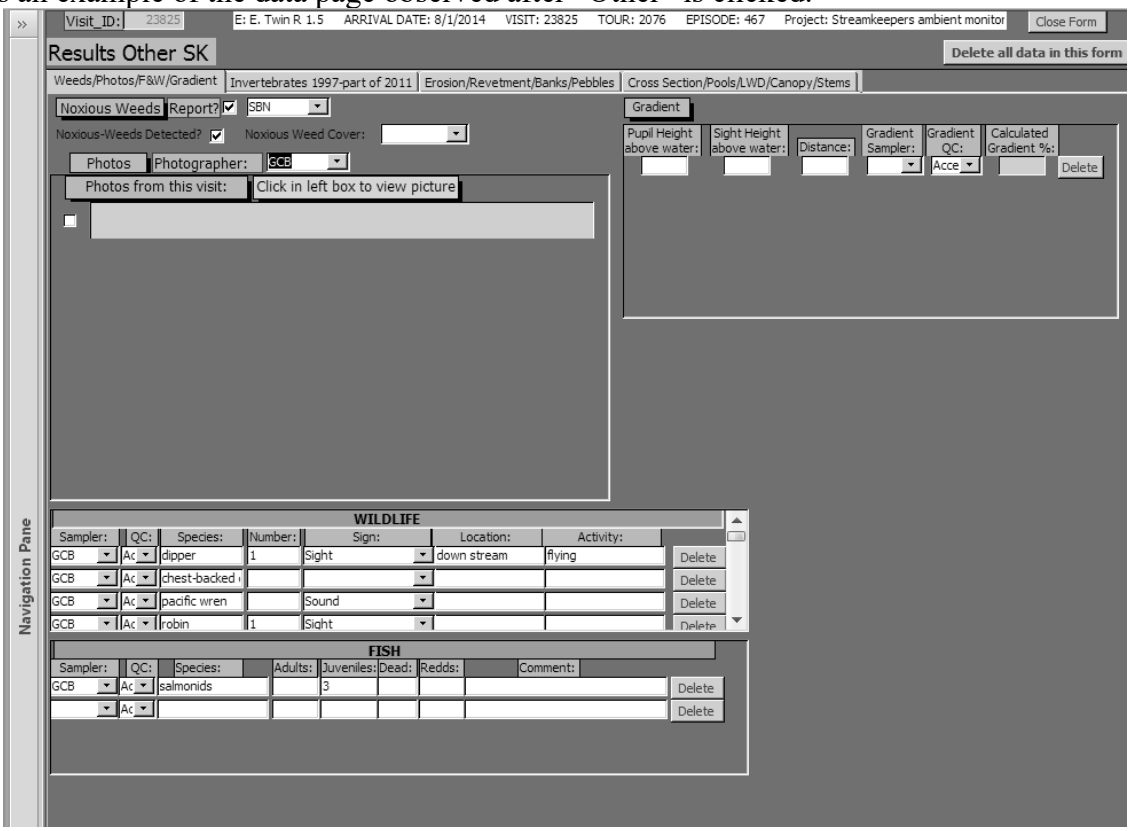


- Enter the team leader's initials from the Tour Cover Sheet into the "Team Leader" box.
- In the "Other Samplers" box enter the first two initials and full last name of the other team members on the Tour Cover Sheet.
- Tour comments can be added to the "Comments" box.

- In the "Chain of Custody-Samplers & Data" box enter the initials and dates from the Tour Cover Sheet. Do not enter data if the Data Sheet QC Review box has no initials. Wait until the review is done before entering the data.
- Add your initials to the Tour Cover Sheet in the Field Data Sheets Entered In Database and the "Data entered into database" box of the "Chain of Custody-Samplers & Data" section.
- Use the pull down menu to complete the "Enter only if unique for the Visit" box.
- Enter the "Site" and the "Arrival Date" for the visit found at the top of the second page of the field data sheet.
- Click on "Other".



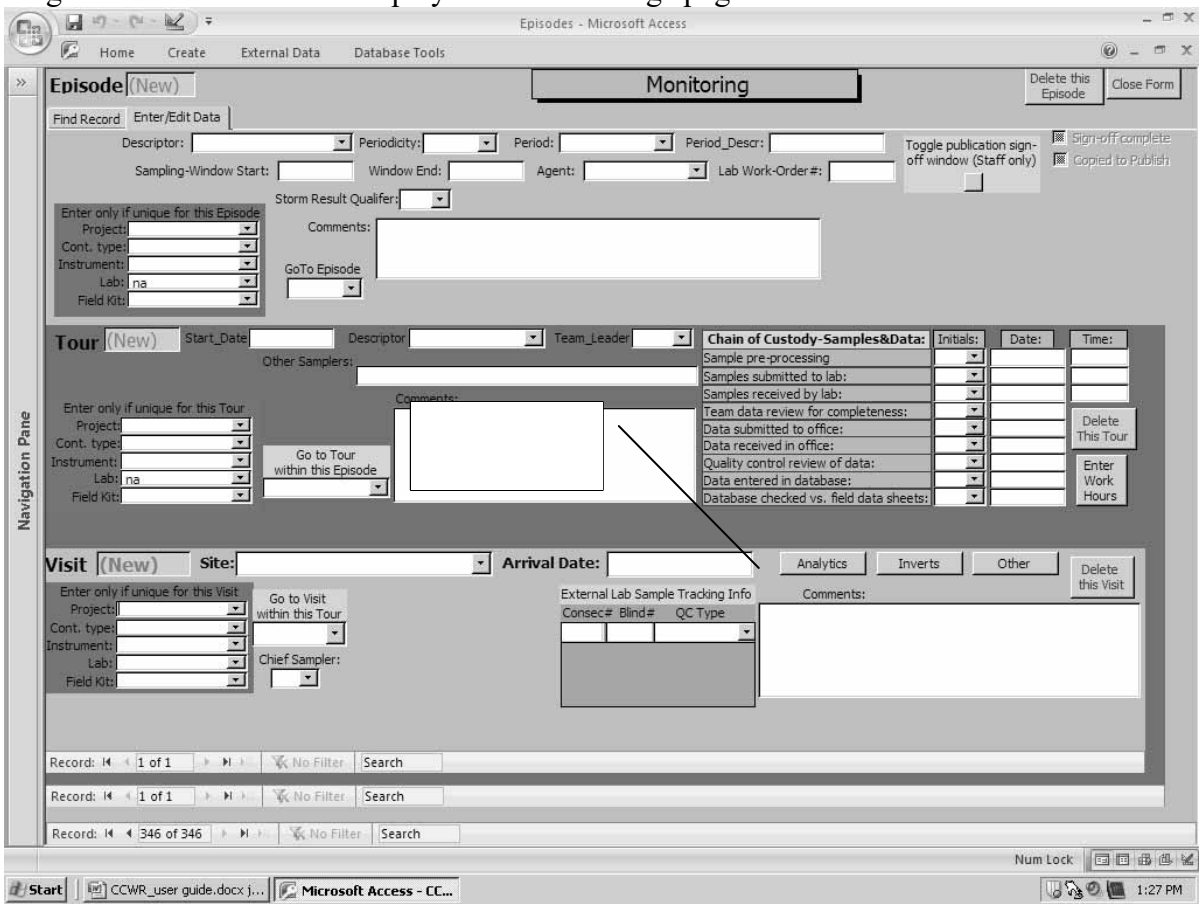
- Below is an example of the data page observed after "Other" is clicked.



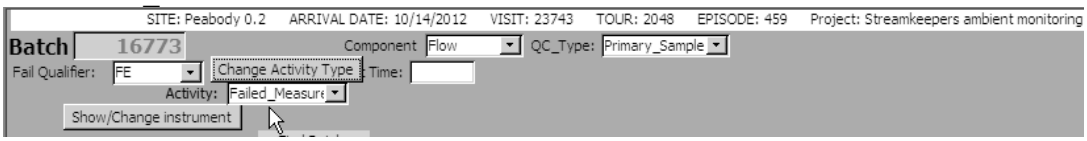
- On the Field Monitoring Data Sheet is a box that can be checked if there is a Noxious weed report for this visit? If Yes has been checked, look for the Noxious Weed report in the Field Monitoring Data Sheets.
- This report needs to be photocopied. The photocopy is placed in an interoffice mailing envelop addressed to Kathy Lucero at mail stop WEEDS or ask Staff for help. Indicate on the Noxious Weed report that a copy was sent to WEEDS. Add your initials and date.
- Check the "Noxious Weed Report?" box on the data entry page.
- If photos were taken in the field, the Photo Log at the bottom of the Field Monitoring Data Sheet will have been filled out. Enter the initials of the photographer in the "Photographer" box

on the database entry page. Cut off the Photo Log being careful not to cut off pertinent data from the back of the Log. At the bottom of the Photo Log is a box to enter Visit ID# generated by the database. Enter the "Visit ID" found at the top of the database entry page.

- File the log in the pull out bin in the coffee room labeled Photo Log or ask staff.
- Complete the "Wildlife" and "Fish" boxes with information from the Field Monitoring Data Sheet. Enter "Sampler" box with sampler's initials. Enter "Species" in the box and the number observed in the "Number:" box. The pull down menus can assist in entering "Sign:", "Location:" and "Activity" with data from the Field Data Sheet.
- Close the form at top right of page.
- Closing the "Other" form will display the "Monitoring" page.



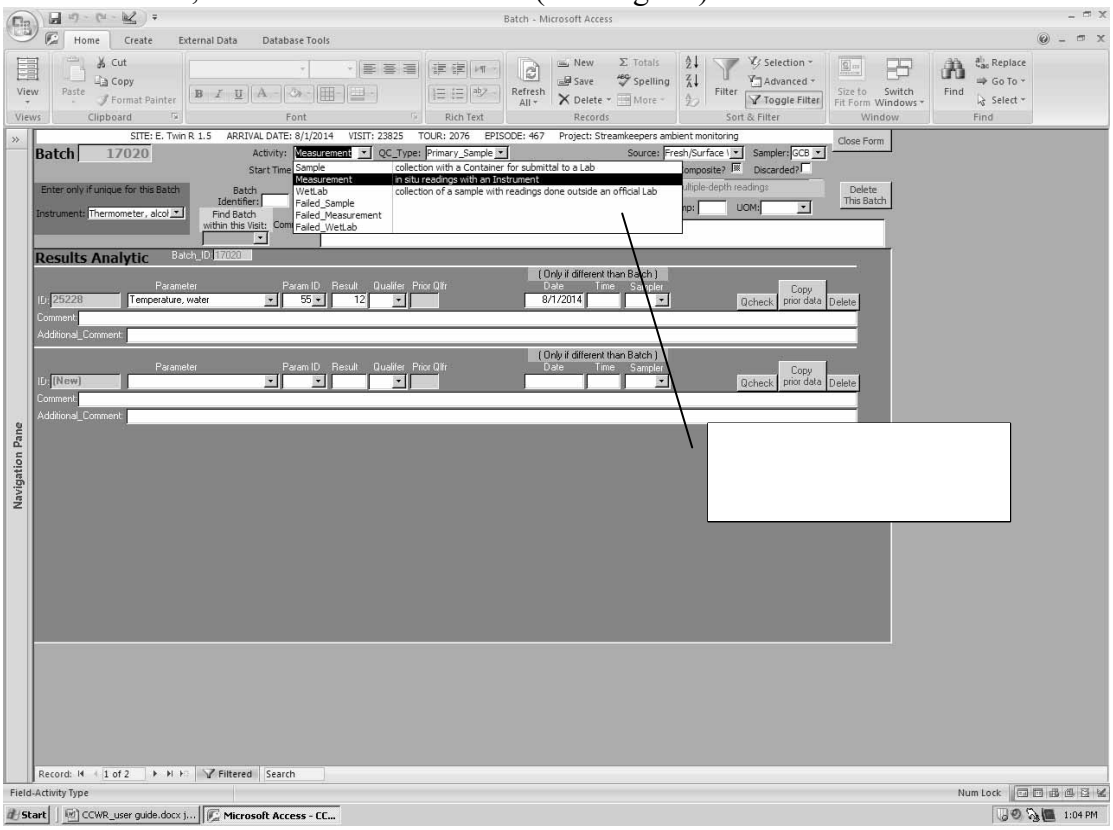
- Click on "Analytics" The page below is an example of the "Analytics" page.
- The "Batch" number is automatically assigned.
- Using the Tour Cover Sheet and the pull-down menus on the Monitoring page, enter information for "Activity", "Source", and "QC Type" box.
    - From the pull-down menu reads the explanation of what each term means and choose the best fit based on the information on the field data sheets.
    - When samplers are unable to gather data and explain why, this needs to be recorded in thedatabase. For SK Quarterly data, you'll need to "Change Activity Type" (see diaghram below) to "Failed_Measurement", or, if the Component is Turbidity, "Failed_WetLab".



- Once you do this, the "Fail Qualifier" field will show up above and to the left. Choose the appropriate reason for the failure. Here are the choices:

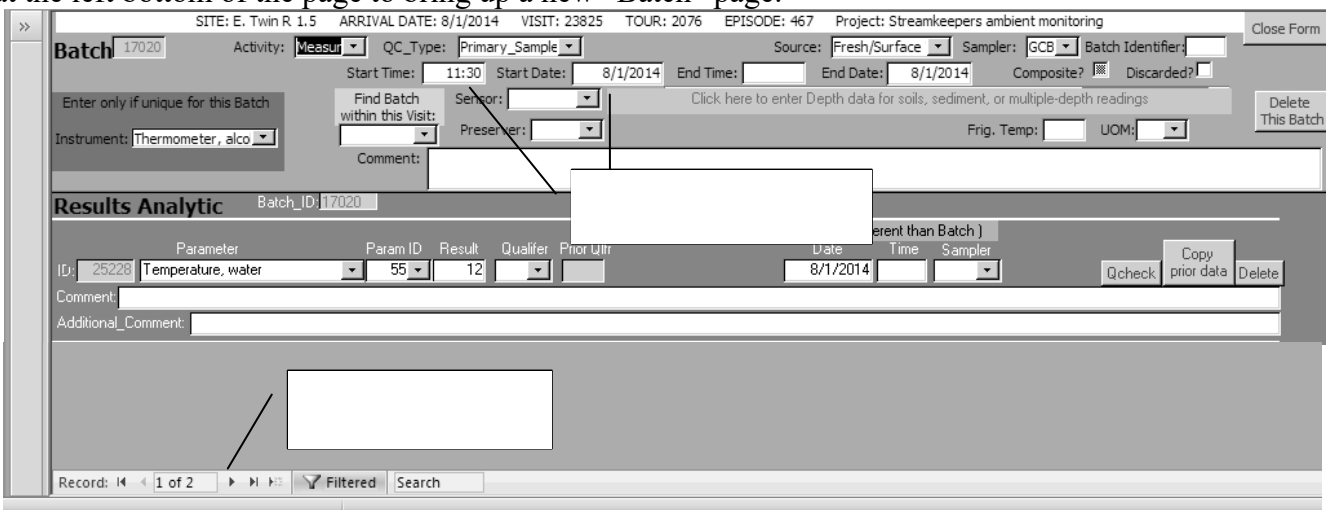
FA	no site access
FD	site was dry
FE	equipment failure
FH	flow too high to measure
FI	ice-impacted
FL	above or below instrument limit
FS	stagnant water--no flow
FT	flow tidally impacted

- If there are additional comments about the failure, put them in the Batch comment field.
- Failed measurements: All-purpose form: When samplers are unable to gather data and explain why, this needs to be recorded in the database. For the All-purpose form, you'll need to "Change Activity Type" (see diagram below) to "Failed_Measurement", "Failed_Sample", or "Failed_WetLab" (see distinctions described above). Once you do this, the "Fail Qualifier" field will show up (see diagram). Choose the appropriate reason for the failure. If there are additional comments about the failure, put them in the Batch comment field. Then go the the Results_Analytic form and enter all Parameters that were unable to be sampled in this Batch, with no Results recorded (see diagram).

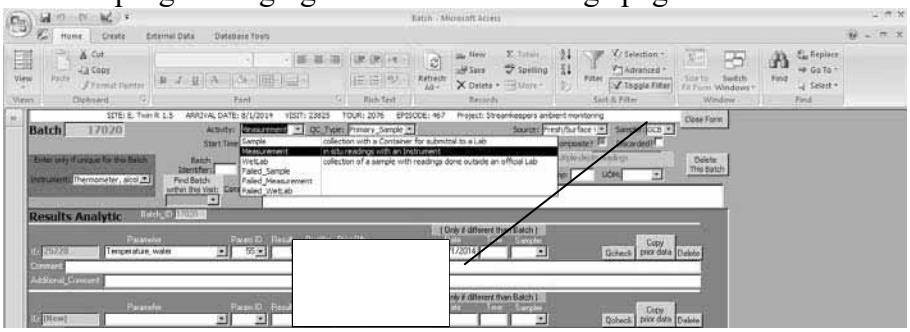


- In the "Sampler" box enter the samplers initials from the field Monitoring Data Sheet.
- Enter the "Start Time" and "Start Date" from the Temperature °C box on the field Monitoring Data Sheet.
- In the "Results Analytic" section, choose the "Parameter" from the pull-down menu then enter the "Results" based on the field Monitoring Data Sheet information.

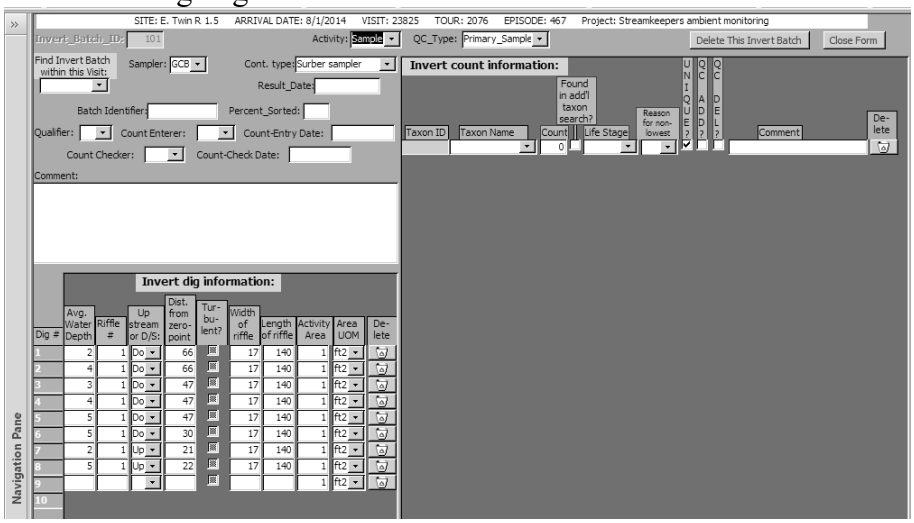
- To enter a different parameter (ex. air temperature) click on the first arrow of the "Records" box at the left bottom of the page to bring up a new "Batch" page.



- Click on "Close Form" top right bringing back the "Monitoring" page.

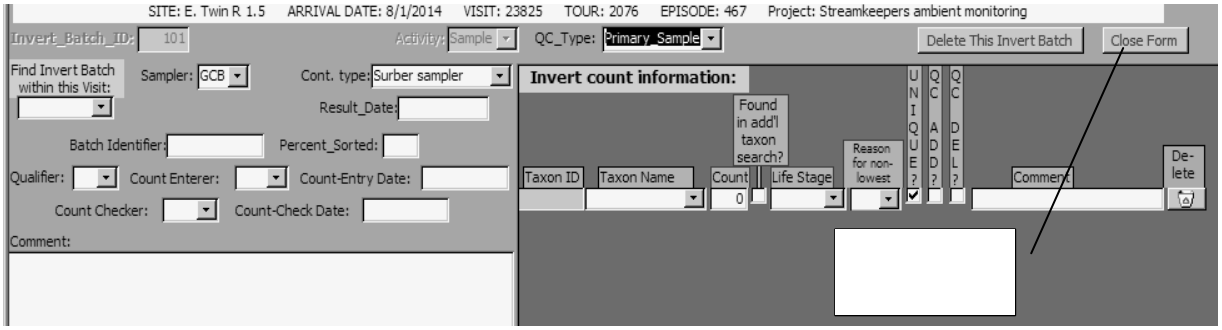


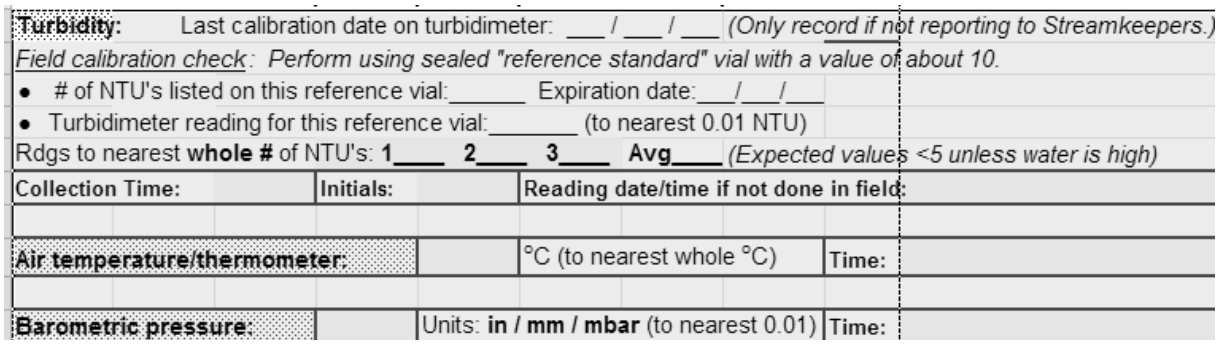
- Click on "Inverts" if entering bug data.



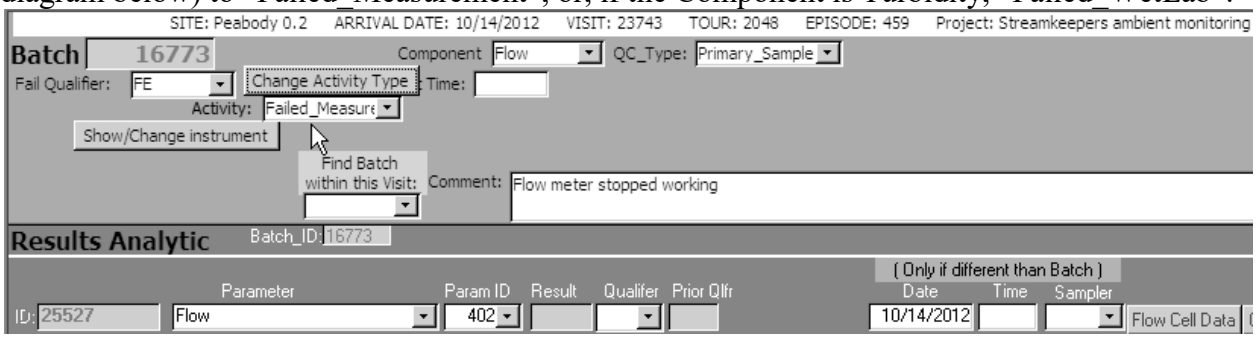
- In the "Activity" box use the pull-down menu to choose "Sample".
- In the "QC Type" box choose "Primary Sample".
- Enter the "Sampler" initials from the Macroinvertebrate Sampling box of the field Monitoring Data Sheet.
- Use the pull-down menu of the "Cont. Type" box to choose "Surber Sampler".

- The data to be entered into the "Invert dig information" is in the vertical direction while the field Monitoring Data Sheet data has been entered horizontally. Keep this in mind when entering the data into the data base.
- The pull-down menu can be used to enter "Up" or "Down" into the "Up stream or D/S" boxes.
- If the Riffle width and Riffle length on the field Monitoring Data Sheets have not all been filled out by the sampler it can be assumed that the widths and length are the same for all of the boxes and should be entered into the "Invert dig information" boxes.
- If replicate samples have been taken in the field click on the first arrow at the "Record" bar to bring up a new batch page. Enter data the same as for the primary samples.
- Click on "Close Form".





Failed measurements: SK Quarterly form: When samplers are unable to gather data and explain why, this needs to be recorded in the database. For SK Quarterly data, you'll need to "Change Activity Type" (see diagram below) to "Failed_Measurement", or, if the Component is Turbidity, "Failed_WetLab".



Once you do this, the "Fail Qualifier" field will show up above and to the left. Choose the appropriate reason for the failure. Here are the choices:

FA	no site access
FD	site was dry
FE	equipment failure
FH	flow too high to measure
FI	ice-impacted
FL	above or below instrument limit
FS	stagnant water--no flow
FT	flow tidally impacted

If there are additional comments about the failure, put them in the Batch comment field.
Then go the the Results_Analytic form and enter all Parameters that were unable to be sampled in this Batch, with no Results recorded. If a multimeter failed, you'd enter all the Parameters that meter would have measured.

Failed measurements: All-purpose form: When samplers are unable to gather data and explain why, this needs to be recorded in the database. For the All-purpose form, you'll need to "Change Activity Type" (see diagram below) to "Failed_Measurement", "Failed_Sample", or "Failed_WetLab" (see distinctions described above). Once you do this, the "Fail Qualifier" field will show up (see diagram). Choose the appropriate reason for the failure. If there are additional comments about the failure, put them in the Batch comment field. Then go the the Results_Analytic form and enter all Parameters that were unable to be sampled in this Batch, with no Results recorded (see diagram).

Appendix C. Links to Streamkeepers documents referenced in this document

Document	Link
Annual work & sampling plans	http://www.clallam.net/SK/programplanning.html
Chemical Hygiene Plan	http://clallam.net/streamkeepers/assets/applets/SKChemicalHygienePlan.pdf
Data checking protocol	http://www.clallam.net/SK/doc/Qrtlydtashtckpl.pdf
Data entry sheets	http://www.clallam.net/SK/monitoringusables.html
Equipment calibration/ maintenance & benthic macroinvertebrate laboratory procedures	http://www.clallam.net/SK/QualityAssurance.html
QAPPs & monitoring plans for stormwater	http://www.clallam.net/SK/stormwatermonitoring.html
QAPP for nutrients 1	http://www.clallam.net/HHS/EnvironmentalHealth/documents/qapp.pdf
QAPP for nutrients 2	http://www.clallam.net/SK/doc/clnwtrdpolid.pdf
Studies and reports	http://www.clallam.net/SK/studies.html
Volunteer handbook, including Field Procedures	http://www.clallam.net/SK/volunteerhandbook.html