Quality Assurance Project Plan

Skagit County Pollution Identification and Correction Program – Samish and Padilla Watersheds

November 2017

Prepared by
Skagit County Public Works

Prepared for
Washington State Department of Health

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Each environmental study conducted by or for the EPA must have an approved Quality Assurance Project Plan (QAPP) that describes objectives and the procedures that will be followed to achieve those objectives. This QAPP describes the county's Pollution Identiifcationa and Control (PIC) program for next two years. The QAPP, monitoring results, and any required final project report will be available on Skagit County's website at: https://www.skagitcounty.net/Departments/PublicWorksCleanWater

Data for this project will also be available from DOH and EPA's STOrage and RETrieval (STORET) website: http://www.epa.gov/storet/ ; https://www.epa.gov/waterdata/water-quality-data-wqx

Federal Clean Water Act 1996 303(d) Listings Addressed in this Study. See Section 3.3.

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Cover photo: Samish Bay. Photo by Rick Haley

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Skagit County Pollution Identification and Correction Program – Samish and Padilla Watersheds Water Quality Impairment Project

November 2017

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EAP: Environmental Assessment Program

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2.0 Abstract

The overall purpose of this ongoing monitoring project is to reduce fecal coliform pollution in the Samish and Padilla Bay watersheds and upgrade 4,000 acres of commercial shellfish beds in Samish Bay from "Conditionally Approved" to "Approved". The mechanism to achieve these results are Skagit County's Pollution Identification and Correction (PIC) Program. This Quality Assurance Project Plan (QAPP) will cover the water sampling and analysis aspects of the PIC program during 2017-2019. These include fecal coliform sampling during storm events and investigations, sampling and analysis for Chemicals of Emerging Concern (CECs), and use of a sewage sniffing dog.

Fecal coliform sampling is at the core of the PIC program since the pollution needs to be located and enumerated before we can address the sources. Skagit County has extensive fecal coliform sampling experience and will use standard methods and an Ecology-certified laboratory for analysis.

Skagit County has been collaborating with the University of Washington Center for Urban Waters to develop and implement enhanced methods for detecting CECs. This project will continue the use of CEC markers of human fecal coliform pollution and employ newly-developed techniques for detection of livestock pollution.

Skagit County will contract with Environmental Canine Services for use of a dog trained to detect human sewage in watercourses and water samples. Skagit County has completed three rounds of canine detection work in 2014, 2015, and 2016 and these projects have located many sources of human pollution.

These monitoring projects will support the overall project objective to identify, locate, and remediate sources of fecal coliform pollution.

3.0 Background

3.1 Introduction and problem statement

The Samish Bay Shellfish Growing Area has had problems with excessive fecal coliform bacteria and shellfish-associated sickness since at least the 1990s. In 2008, routine Skagit County water quality monitoring detected high concentrations of fecal coliform in Samish Bay tributaries during rain storms. Subsequent storm event sampling revealed an ongoing problem with high fecal coliform counts during rainstorms. The Clean Samish Initiative (CSI) was formed in 2009 with over 20 Federal, state, and local partner organizations to address fecal coliform pollution in the Samish Basin. One outcome of the CSI is Skagit County's PIC program, which began in 2010. Although much progress has been made in reducing fecal coliform concentration and loading to Samish Bay, the criteria for upgrading the Samish Bay Shellfish Growing Area have not yet been met.

Both Samish and Padilla Bays are the subject of Washington State Department of Ecology Total Maximum Daily Load (TMDL) programs (Ecology 2009a, Ecology 2015).

The PIC program employs many approaches to reduce fecal coliform pollution, including public outreach and education, working with CSI partners to provide technical assistance to residents of the Samish Basin, and enhanced enforcement of septic system rules. The aspects of the PIC program addressed in this QAPP are water quality monitoring for fecal coliform bacteria and Contaminants of Emerging Concern and the use of a sewage-sniffing dog to locates sources of pollution from sewage.

3.2 Study area and surroundings

The study area consists of the Samish and Padilla Bay Watersheds (Figures 1 and 2). These watersheds discharge to important shellfish growing and recreation areas in the bays. The bays are also important estuarine habitat for salmonids and other species. Padilla Bay has regionally important eelgrass habitat. Both watersheds are targeted by Skagit County PIC programs and numerous other local and state pollution abatement efforts.

The two watersheds are adjacent to each other and share a similar Pacific Northwest maritime climate – cool, wet fall through spring rainy seasons and warm, usually dry summers. The Samish River drains mountains up to 4,000 feet in elevation and so has some areas of higher precipitation. The watercourses in the Padilla Bay watershed are all lowland drainages without elevation-enhanced precipitation.

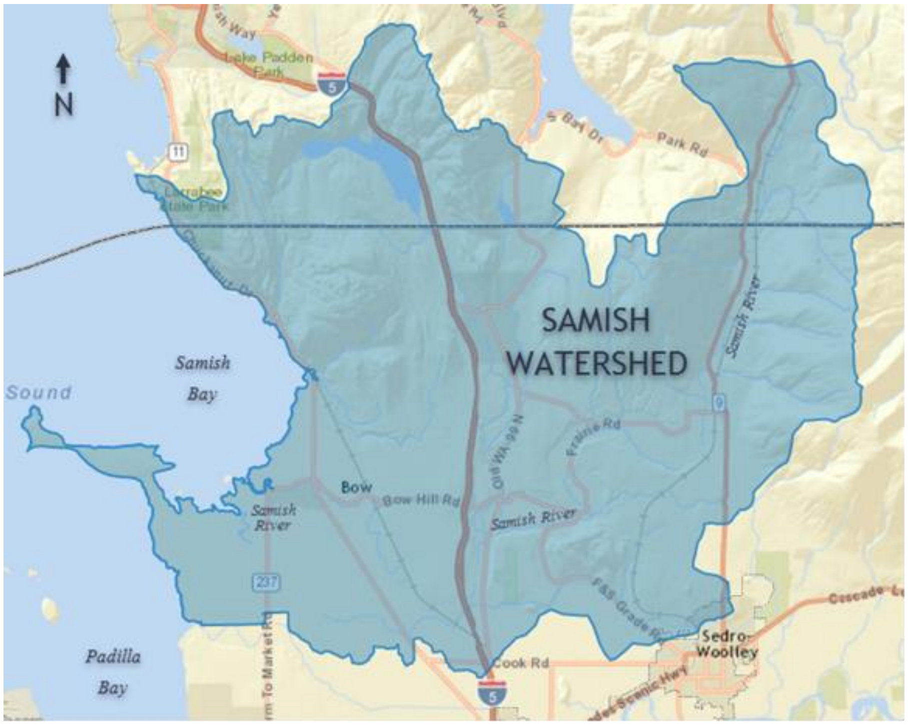

Figure 1. Map of Samish Bay Watershed study area

The Samish Bay Watershed has an area of 140 square miles. The principal freshwater watercourse is the Samish River, which flows out of the valley between Lyman Hill and Anderson Mountain and through an area of mixed livestock pasture and rural residential uses. Further downstream, the river traverses an area of crop farming and rural residences before discharging into Samish Bay near the town of Edison. Other freshwater inputs to Samish Bay include Colony Creek, Edison Slough, and agricultural drainage pump stations. The Washington State Department of Ecology estimated that 70% of the fecal coliform loading to Samish Bay comes from the Samish River (Ecology 2009a).

The Padilla Bay Watershed is 36 square miles. The principal freshwater tributaries to Padilla Bay include Big Indian Slough, Little Indian Slough, No Name Slough, and Joe Leary Slough. Swinomish Channel is a marine channel connecting Padilla Bay with Skagit Bay to the south, and can flow either direction depending on tidal influences and Skagit River discharge. Land uses include livestock pastures, crop farms, and the rural village of Bay View. Bay View State Park includes a swimming beach that is frequently closed by fecal coliform pollution.   Two petroleum refineries occupy March Point on the west side of Padilla Bay.

Figure 2. Map of Padilla Bay Watershed study area

3.2.1 History of study area

Present land uses are described above.. Prior to European settlement, much of the Padilla Bay watershed was lowland marsh area, including much of the Joe Leary Slough watershed identified on old maps as Olympia Marsh. These wetlands were drained by using existing sloughs and adding drainage ditches to produce farmland.

The primary change in the Padilla Bay watershed, other than drainage of wetlands, was the construction in the late 19th century of a sea dike along several miles of the southeast shore of Padilla Bay. This dike cut of hundreds of acres of shallow bay area which was then converted to farmland. This area is now drained by Big Indian, Little Indian, and No Name Sloughs.

3.2.2 Summary of previous studies and existing data

As indicated above, fecal coliform pollution in the Samish Bay watershed has been an ongoing problem since at least the 1990s. Previous efforts at identifying and remediating fecal coliform pollution in the Samish Basin include a local effort in the late 1990s that resulted in improved septic systems in the town of Blanchard and installation of a community waste treatment facility in the town of Edison. Skagit County conducted a Samish-centric ongoing monitoring project from 2000-2003 under a Centennial Grant and continued with some ambient monitoring in the Samish Basin under a subsequent Centennial Grant and Skagit County Clean Water District funding from 2003-present. Ecology conducted a TMDL Water Quality Study in the Samish in 2006 and published the TMDL implementation plan in 2009 (Ecology 2009a).

A central theme to all of those efforts was the scattered and inconsistent nature of the pollution in the Samish Basin. Although these studies did include a minimal effort at storm event sampling, the storm sampling that took place was not focused enough to illuminate the true nature of the fecal coliform pollution in the Samish. The capture of a significant storm event by Skagit County ambient monitoring in 2008 shifted the focus of subsequent Samish Bay Watershed fecal coliform projects and led to the formation of the Clean Samish Initiative. An EPA Puget Sound Watersheds grant (2010-2012) allowed increased monitoring of storm events and revealed both the true scope of fecal coliform pollution in the Samish and also helped CSI partners focus on the locations with the worst pollution problems. Skagit County Clean Water funds are currently being used to continue that monitoring effort. All of the post-2008 monitoring data point to large rainfall events as the key to Samish Bay fecal coliform pollution.

A previous NEP grant (DOH Contract #N20689) awarded to Skagit County was used to pilot the use of Contaminants of Emerging Concern (CECs) for source identification in the Samish Basin. CECs traditionally include compounds that might be found in human sewage, including medicines, food additivies, and metabolites of commonly consumed products like caffeine. In this previous grant, Skagit County cooperated with the University of Washington Center for Urban Waters to develop and test markers for livestock agriculture, including feed additives and veterinary antibiotics, in addition to testing for human CECs.

The same grant was used to bring in a sewage-sniffing dog from Environmental Canine Services, a private firm that trains dogs to detect human sewage. The dog identified several specific locations in Skagit County with human sewage pollution. Follow-up on those locations resulted in repairs to at least 12 failing septic systems.

CSI programs to combat fecal coliform pollution have led to a marked improvement in Samish Bay Watershed water quality, but those improvements do not yet add up to an upgrade in the Samish Bay Shellfish Growing area. The projects outlined in this proposal are intended to take the next step in achieving that upgrade.

Fecal coliform remediation in the Padilla Bay Watershed has a shorter history. Although fecal coliform pollution was identified as a problem in the Padilla Bay Watershed Non-Point Action Plan in the late 1990s, concerted efforts to address the problem were lacking until recently. While Skagit County and Skagit Stream Team volunteers (working in a program coordinated by the Skagit Conservation District and Padilla Bay National Estuarine Research Reserve) conducted ambient monitoring in the watershed since 2000, no focused storm event monitoring occurred until Stream Team volunteers participated in extra storm event monitoring in 2010-2011. Skagit County conducted additional storm event monitoring since then and added Padilla Bay to its PIC program in 2015. Ecology then initiated the Padilla Bay Watershed TMDL in 2016.

Much of the fecal coliform remediation activity in the Padilla Bay Watershed has been in response to closures of the swimming beach at Bay View State Park. A small commercial shellfish growing area is in the northern part of Padilla Bay.

The pattern of Padilla Bay fecal coliform pollution is not as clear-cut as in the Samish basin. Several watercourses in the Padilla Bay watershed show elevated fecal coliform counts independent of storm events. Skagit County will coordinate with Ecology TMDL personnel to continue to expand our knowledge of Padilla Bay fecal coliform pollution.

3.2.3 Parameters of interest and potential sources

This project is primarily concerned with fecal coliform pollution. Projects to remediate fecal coliform pollution will have corollary benefits for other water quality parameters: dissolved oxygen as organic matter is prevented from reaching watercourses, and temperature if riparian plantings are part of the solution.

We will sample for fecal coliform throughout the Samish and Padilla Bay watersheds. This information will help us locate pollution sources and characterize the pollution loads in individual watercourses.

In order to locate and confirm fecal coliform sources, two recently-developed source identification techniques will be used: sampling and analyzing for Contaminants of Emerging Concern (CECs) to look for both human and livestock marker chemicals; and the use of a sewage-sniffing dog to locate sources of human pollution.

3.2.4 Regulatory criteria or standards

Fecal coliform bacteria is regulated under Washington State water pollution laws – 90.48 RCW and 173-201a WAC. The following chart delineates the state standards for marine and freshwater areas.

Table 1. Washington State standards for fecal coliform

Location	Geometric mean exceedance (colonies/100 ml)	10% exceedance (colonies/100 ml)
Marine (Shellfish and primary contact recreation)	14	43
Freshwater (Primary contact recreation)	100	200

There are no established standards or criteria for CECs and for the sewage-sniffing dog.

3.3 Water quality impairment studies

Figures 1 and 2 above illustrate the water quality impairment study areas. There are approximately 40 303(d) listings (Categories 4A and 5) in the project area, including Samish Bay, Padilla Bay, the Samish River and many tributaries and the sloughs draining to Padilla Bay

(Ecology 2012). Both the Samish Bay and Padilla Bay watersheds are currently the subjects of Ecology TMDLs (Ecology 2009a, Ecology 2015).

4.0 Project Description

This project is intended to reduce fecal coliform pollution in the Samish and Padilla Bay watersheds, with the goal of achieving an upgrade to the Conditionally Approved portion of the Samish Bay Shellfish Growing Area and an end to bacteria-based closures of the swimming beach at Padilla Bay's Bay View State Park. This will be accomplished through Skagit County's ongoing Pollution Identification and Correction (PIC) Program. Aspects of the PIC program addressed in this QAPP include water quality sampling for fecal coliform bacteria and Contaminants of Emerging Concern (CECs), and the use of a sewage-sniffing dog. These techniques will be used to locate and identify sources of fecal coliform pollution. This information will then be used in the remainder of the PIC program to reach landowners with pollution sources and find ways to remediate them.

4.1 Project goals

- To identify fecal coliform source organisms
- To locate sources of fecal coliform bacteria
- To eliminate human and agricultural-caused fecal coliform pollution from the Samish and Padilla Bay watersheds
- To achieve an upgrade of the Conditionally Approved portion of the Samish Bay Shellfish Growing Area
- To eliminate closures at the swimming beach at Bay View State Park

4.2 Project objectives

Water quality sampling and fecal coliform identification objectives:

- To collect approximately 500 storm and investigatory fecal coliform samples from Samish and Padilla Bay watersheds
- Conduct apprxomiately 20 hot spot investigations in each watershed – Samish and Padilla Bay.
- To conduct at least 6 CEC sampling events in the Samish and Padilla Bay watersheds
- To employ a sewage sniffing dog for a two-day source identification exercise

4.3 Information needed and sources

Skagit County is in possession of needed existing data, most of which was collected by Clean Samish Initiative partners. This data include previous water quality sampling data (both fecal coliform and CECs) and previous work with a sewage-sniffing dog. Skagit County also has an extensive database of previous PIC actions, including landowner contacts, property visits, and pollution remediation projects.

The new information generated by this project will include ongoing fecal coliform sampling results from new areas, follow-up on areas previously worked on in the PIC program, CEC sampling in new areas, and use of the sewage-sniffing dog in new areas.

4.4 Tasks required

To collect 500 fecal coliform samples in the Samish and Padilla Bay watersheds, Skagit County staff will target rain events for most sampling, including basin-wide sampling and sampling targeted at individual locations suspected of contributing to pollution. Rain events have been shown to have the highest fecal coliform pollution levels. County personnel are able to sample with minimal notice as all necessary equipment and supplies are kept on-hand. Additional non-rain event sampling will also take place, especially in conjunction with CEC and sewage-sniffing dog projects or to characterize suspected septic system runoff.

To conduct at least six CEC sampling events, Skagit County personnel will coordinate with UW Center for Urban Waters staff. We anticipate targeting rain events for most of the six events, but a non-rain event sampling may be justified in order to fully characterize CEC presence in the watersheds. This activity involves specially-cleaned bottles provided by the UW lab and UW personnel will be present for most or all sampling events.

The use of the sewage-sniffing dog involves coordination and scheduling with out-of-state contractors. Since these events need to be scheduled months in advance, selecting weather for the event is not possible. Since the dog is trained to detect human sewage, runoff events that may cause pollution from livestock are not critical to this activity. This activity requires a minimum of equipment. Fecal coliform samples are taken concurrently with the dog activity.

4.5 Systematic planning process used

This document represents the systematic planning for the water quality sampling aspects of this project.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 2. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Michael See Skagit County Public Works 360-416-1400	Water Resources Section Manager	Oversight of PIC program. Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP
Rick Haley Skagit County Public Works, Water Resources Section 360-416-1400	Water Quality Analyst	Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into WQX. Participates in draft and final reporting.
Karen DuBose Skagit County Public Works, Water Resources Section 360-416-1400	PIC Coordinator	Coordinates overall PIC program. Coordinates sewage-sniffing dog activity. Assists in determining sampling locations. Reviews QAPP. Responsible for draft and final reporting.
Dr. Andy James UW Center for Urban Waters 253.254.7030 x 8011	Researcher	Oversees CEC sampling and analysis. Writes draft and final CEC reports.
Heather Bickford Skagit County Public Works, Water Resources Section 360-416-1400	Environmental Technician	Assists with field sampling
Jason Quigley Skagit County Public Works, Water Resources Section 360-416-1400	Environmental Technician	Assists with field sampling
Larry Henderson Edge Analytical, Inc. 800-755-9295	Lab manager	Oversight of fecal coliform sample analysis
Kirsten Weinmeister NEP Grant Coordinator Department of Health 360-236-3307	NEP Grant Coordinator	Oversight of grant and contractual requirements. Coordinates with DOH technical staff.
Tom Gries Ecology (360) 407-6327	Ecology NEP QA Coordinator	Reviews draft and final QAPPs. Comments on any required final project report.
William R. Kammin Ecology Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP: Environmental Assessment Program
EIM: Environmental Information Management database
QAPP: Quality Assurance Project Plan

5.2 Special training and certifications

Skagit County personnel are very experienced in fecal coliform sampling using Skagit County SOPs. Skagit County and UW Center for Urban Waters personnel have developed experience sampling for CECs during our last NEP grant cycle. Skagit County personnel have worked with Environmental Canine Services personnel and dogs three times in the last four years and have developed effective methods for using the dogs.

5.3 Organization chart

Not Applicable - See Table 1

5.4 Proposed project schedule

Table 3. Proposed schedule for completing field and laboratory work, data entry into STORET, and reports.

Field and laboratory work	**Due date**	**Lead staff**
Field work completed (fecal coliform)	03/19	Rick Haley
Laboratory analyses completed (fecal coliform)	03/19	
Field work completed (CECs)	08/18	
Laboratory analyses completed (CECs)	08/18	
Canine services analysis completed	03/19	
EPA WQX (STORET) Database		
WQX ID	ID number:	
WQX data loaded [1]	03/19	Rick Haley
Final report		
Author lead / Support staff		Karen DuBose / Rick Haley
Schedule		
Draft due to supervisor	03/19	
Draft due to WSDOH)	03/19	
Final	03/19	

5.5 Budget and funding

This project is fully funded by EPA Shellfish Strategic Initative Grant, Contract #GVL22580, administered by the Washington State Department of Health. Total funding for the subaward is $386,800. Funding for the CEC work is $37,800. Funding for the sewage-sniffing dog is $26,000. Funding for fecal coliform sampling is not separately listed in the grant document.

6.0 Quality Objectives

6.1 Data quality objectives

DQOs for this project are to obtain FC, CEC, and canine results, of known and acceptable quality, that represent the conditions sampled, and that can be used to meet project objectives, e.g., identify FC hot spots and help determine FC sources."

6.2 Measurement quality objectives

6.2.1 Targets for precision, bias, and sensitivity

MQOs for fecal coliform samples are given in Table 4, and MQOs for CEC samples are given in Tables 4 (human markers) and 5 (agricultural markers). MQOs for canine sampling are given in narrative to follow.

Table 4. Measurement quality objectives for fecal coliform sampling

MQO →	Precision		Bias			Sensitivity
Parameter	Duplicate Samples	Matrix Spike-Duplicates	Verification Standards (LCS,CRM,CCV)	Matrix Spikes	Surrogate Standards*	MDL or Lowest Conc. of Interest
	Relative Percent Difference (% RPD)		Recovery Limits (%)			Concentration Units
Fecal coliform bacteria	40	NA	NA	NA	NA	1.8 mpn/ 100 ml

*Surrogate recoveries are compound specific.

Table 5. Numerical Measurement Quality Objectives (MQOs) for human CECs to be evaluated in this study.

This is the first of two tables describing MQOs for CECs

Compound	CCV (% recovery)	CCV (% RSD)	Ongoing Matrix Spike (% recovery)	Field Duplicates (% RPD)	Instrument Duplicates (% RPD)	Surrogate Recovery (%)	Reporting Limit (ng/L)
Acetaminophen	70-130	<20	50-120	<10	<10		2
Ametryn	70-130	<20	70-125	<10	<10		5
Atrazine	70-130	<20	30-110	<10	<10		0.1
Caffeine	70-130	<20	50-124	<10	<10		4
Carbamazepine	70-130	<20	21-137	<10	<10		0.1
Carbaryl	70-130	<20	55-115	<10	<10		5
Cotinine	70-130	<20	50-124	<10	<10		1
Cyanazine	70-130	<20	55-110	<10	<10		10
Ethyl Paraben	70-130	<20	70-130	<10	<10		1
Ibuprofen	70-130	<20	50-120	<10	<10		0.5
Mecoprop	70-130	<20	45-110	<10	<10		5
Methylparaben	70-130	<20	55-105	<10	<10		3
Paraxanthine	70-130	<20	40-125	<10	<10		2
Ensulizole	70-130	<20	50-120	<10	<10		3
Propylparaben	70-130	<20	30-100	<10	<10		1
Propazine	70-130	<20	55-115	<10	<10		1
Ractopamine	70-130	<20	60-150	<10	<10		0.1
Sulfadimethoxine	70-130	<20	50-120	<10	<10		0.1
Sulfamethoxazole	70-130	<20	35-105	<10	<10		0.1
Sulfamethazine	70-130	<20	65-110	<10	<10		0.1
Sucralose	70-130	<20	70-130	<10	<10		3
Simazine	70-130	<20	55-115	<10	<10		1
Sulfathiazole	70-130	<20	41-120	<10	<10		1
Theobromine	70-130	<20	40-105	<10	<10		10

Compound	CCV (% recovery)	CCV (% RSD)	Ongoing Matrix Spike (% recovery)	Field Duplicates (% RPD)	Instrument Duplicates (% RPD)	Surrogate Recovery (%)	Reporting Limit (ng/L)
Vanillin	70-130	<20	25-110	<10	<10		10
d3 Vanillin						5-150	
d3 Nicotine						5-150	
d3 Triclosan						5-150	
d4 Propylparaben						5-150	
d4 Sulfamethoxazole						5-150	
d5 Atrazine						5-150	
d6 Sucralose						5-150	
d6 Theobromine						5-150	

CCV – Continuing calibration verification standard
RPD – Relative percent difference
RSD – Relative standard deviation

Table 6. Numerical Measurement Quality Objectives (MQOs) for CECs to be evaluated in this study.

This is the second of two tables describing MQOs for CECs

Compound	CCV (% recovery)	CCV (% RSD)	Ongoing Matrix Spike (% recovery)	Lab Duplicates (%RPD)	Instrument Duplicates (%RPD)	Surrogate Recovery (%)	Reporting Limit (ng/L)
Trimethoprim	70-130	<20	50-126	<10	<10		2
Fenbendazole	70-130	<20	40-140	<10	<10		10
Lincomycin	70-130	<20	5-120	<10	<10		1
Clindamycin	70-130	<20	40-140	<10	<10		1
Ceftiofur	70-130	<20	40-140	<10	<10		25
Monensin	70-130	<20	40-140	<10	<10		
Salinomycin	70-130	<20	40-140	<10	<10		
Tylosin	70-130	<20	16-149	<10	<10		2
d6 Erythromycin-H2O						5-150	
d3 Lincomycin						5-150	
d3 Fenbendazole						5-150	
d3 Trimethoprim-2						5-150	
d3 Trimethoprim						5-150	
d10 Carbamazepine						5-150	
d3 Theobromine						5-150	

For canine testing, the dog(s) should provide a positive response (signal dependent on individual dog training) in the presence of human sewage, and provide no response where human contamination is not present, including cases where other fecal sources are present. Minimum detection limits are correlated with fecal coliform levels of 10 colony-forming units (CFU or MPN). MQOs include no false positive responses, no false negative responses, and no response differences between analytical duplicates.

6.2.1.1 Precision

See Tables 4, 5, and 6.

6.2.1.2 Bias

See Tables 5 and 6.

6.2.1.3 Sensitivity

See Tables 4, 5, and 6.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Fecal coliform sampling will follow the Skagit County SOP, which complies with EAO030, Ecology's Fecal Coliform Sampling SOP (Ecology, 2011)

CEC sample collection and processing will be performed according to the UW Tacoma Center for Urban Water Standard Operating Procedures titled, "Sample Preparation for the Extraction and Analysis of Trace Organic Contaminants from Water Samples." Briefly:

Samples will be collected in pre-cleaned, 1L glass amber jars prepared by the UWT Center for Urban Waters personnel prior to sampling. Cleaning includes wash with methanol, ethyl acetate, and DI water. Cleaned containers are sealed with tape until use. Sample collection entails a field-rinse three times before filling them from the thalweg of the watercourse. Clean gloves should be used for each sample collection to avoid cross contamination. Bottles are capped, recorded, and placed under ice for shipment by car to the UW Center for Urban Waters laboratory. Sample maximum holding time is 48 hours.

6.2.2.2 Representativeness

Both fecal coliform and CEC samples will be collected during peak fecal coliform pollution events to maximize their utility for finding and correcting pollution sources. For most locations in the Samish and Padilla Bay watersheds, that means sampling will take place in conjunction with rain events that cause runoff. A small subset of samples will be taken during dry conditions for comparison.

Sample sites will be selected to represent localized pollution sources, upstream/downstream comparisons, and the contribution of tributaries to the mainstem Samish River, Samish Bay, or Padilla Bay.

Samples will be taken from the thalweg of each watercourse sampled. Samples will be collected in a manner that avoids oversampling the surface film or disturbing the substrate.

Any deviations from these conditions will be noted in the field log.

6.2.2.3 Completeness

We are proposing the collection of 500 fecal coliform samples and at least six CEC sampling events (with up to 15 locations each). We are also contracting for the use of a sewage-sniffing dog for a two-day exercise in field operations and neutral-scent area testing. We will consider the project a success if we collect at least 475 fecal coliform samples, conduct six CEC sampling runs, and complete the two-day sewage-sniffing dog exercise.

6.3 Acceptance criteria for quality of existing data

The extensive existing fecal coliform data ranges from data generated by volunteers in an unaccredited laboratory to extensive fecal coliform sampling by Skagit County and CSI partners collected under approved QAPPs and analyzed at a certified laboratory. The existing data are well-catalogued and volunteer data is used only for specific, non-regulatory purposes, although the volunteers involved are highly trained and their data matches County data closely. Where volunteer data suggests pollution sources, County personnel follow up for confirmation of the problem. Volunteer-collected data continues to be part of the CSI effort, but is not part of this project.

We have completed one season of CEC sampling prior to this project. These data were collected under a QAPP and samples were analyzed at the UW Center for Urban Waters laboratory, which is certified for the specific method and most of the compounds tested.

We have also completed three sewage-sniffing dog exercises (2014, 2015, 2016). We anticipate mostly working with the dog in new areas but may include some follow-up samples based on previous data where septic system repairs have occurred.

The main data gaps in the CSI effort are locations where we have detected fecal coliform pollution in the past but have not yet employed the CEC and sewage –sniffing dog in those areas. This project will expand the areas where we have source-tracking information and lead to more pollution remediation.

6.4 Model quality objectives

NA

7.0 Study Design

7.1 Study boundaries

The study boundaries are the entire Samish Bay and Padilla Bay Watersheds. See Figures 1 and 2.

7.2 Field data collection

Tables 7 and 8 show proposed initial sampling locations for the Samish and Padilla Bay Watersheds. Sampling locations are subject to change due to the nature of PIC source tracking.

7.2.1 Sampling locations and frequency

The sampling locations for this project are chose to reflect PIC priorities. They include several locations on the mainstem Samish River, the mouths of major tributaries, and upstream locations on tributaries where possible. These sites are chosen to characterize pollution levels from downstream to upstream in order to locate pollution sources. Repeated sampling is necessary in order to confirm locations with increased pollution, as the time of sampling in relation to the storm event can influence where the pollution is located with sampling efforts.
Samples will generally be collected during or after rain events. Rather than use a standard rainfall amount, Skagit County uses increases in flow in the Samish River as a guide for sampling in the Samish Bay Watershed [1]. Rainfall amounts that cause a river rise vary greatly by season, preceeding conditions, and the path of the rain storm in the basin. River rise is a much more reliable indicator of runoff conditions and has been shown to be strongly correlated with pollution levels. Every effort is made to collect samples during the last half of the rise in the hydrograph on the Samish River. Occasionally sampling may occur before or after that time due to storm event timing.

Padilla Bay Watershed sampling is triggered by rainfall, with 0.25” at the WSU Extension office in Mount Vernon, after an antecedent dry period of at least 24 hours. Not all rain events may be sampled, as staff will make decisions on where to sample for each available rain event.

When sampling sites show consistently low pollution levels, they may be dropped. In watercourses with high levels of pollution, additional sampling sites may be established in order to bracket the pollution sources.

Preliminary sampling locations are listed in Tables 7 and 8. Any given sample run may contain some of these sample sites and may also include sites not on this list, as PIC pollution location needs dictate.

[1] 24-hour increases in flow (cfs) that trigger seasonal shellfish bed closures are provided by the DOH.

Table 7. Samish Bay Watershed sampling locations (NAD 1983)

Site ID	Location	Lat	Long
SCMP03	Thomas Creek at Highway 99	48.525856	-122.340293
SCMP04	Thomas Creek at F&S Grade Rd	48.527867	-122.277866
SCMP06	Friday Creek at Prairie Rd	48.558468	-122.328351
SCMP08	Swede Creek at Grip Rd	48.554611	-122.288750
SCMP11	Samish River at Highway 9	48.601749	-122.232865
SAM3PR	Samish River at 3rd Prairie Rd Crossing	48.586900	-122.234300
PAR	Parsons Creek at Mouth	48.583100	-122.285200
SAMPAR	Samish River at Parsons Creek	48.583000	-122.285200
SAMDCL	Samish River at Double Creek Ln	48.569300	-122.298900
SKAR	Skarrup Creek at Double Creek Ln	48.568800	-122.307300
SAM1PR	Samish River at 1st Prairie Rd Crossing	48.557200	-122.291000
SAMGRIP	Samish River at Grip Rd	48.555100	-122.289600
SAMFS	Samish River at F&S Grade Rd	48.552500	-122.295700
SAM99	Samish River at Highway 99	48.545800	-122.338300
SAMCD	Samish River at Chuckanut Dr	48.516800	-122.378400
SCMP32	Samish River at Thomas Rd	48.521000	-122.411400
SCMP33	Alice Bay Pump Station	48.555100	-122.484600
SCMP36	Edison Slough at School	48.562100	-122.436200
SCMP37	Edison Pump Station	48.560270	-122.445400
SCMP38	North Edison Pump Station	48.571700	-122.441800
SCMP39	Colony Creek at Colony Rd	48.580900	-122.402700
WCPR	Weir Creek at Prairie Rd	48.560100	-122.320100
MOUTH	Samish River at Bay View-Edison Rd (mouth)	48.554700	-122.454000
SAMFM	Samish River at Farm-to-Market Rd	48.531500	-122.444200
SAMJOL	Samish River at end of Jolly Rd	48.540400	-122.343400
BSCREEK	Bob Smith Creek at WDFW	48.547400	-122.339700
BSUP	EF Bob Smith Creek at Bow Hill Rd	48.559000	-122.335500
BSDARK	WF Bob Smith Cr at Bow Hill Rd	48.556100	-122.346900
WILL	Willard Creek at F&S Grade Rd	48.527900	-122.278300
SCGRIP1	Swede Creek at Grip Rd	48.557700	-122.247300
SCHB	Swede Creek at Hoogdal Branch Rd	48.560600	-122.257400
SKAREHR	Skarrup Creek at Echo Hills Rd	48.592300	-122.299200
SKARPCR	Skarrup Creek at Parsons Creek Rd	48.584100	-122.292300
BCCR	Butler Camp Creek at Kelleher Rd	48.528400	-122.319300
THOMOS	Thomas Creek trib at Mosier Rd	48.542800	-122.245300
SAMTHOM	Samish River above Thomas Creek	48.526500	-122.347400
FR3	Friday Creek at Lake Samish Road	48.619320	-122.348080
FR4	Silver Creek at Alger Hall	48.618720	-122.340920
FR5	Silver Cr trib on Alger-Cain Lake Rd near Corbell Ln	48.619940	-122.338060
FR6	Silver Creek at Cain Lake outfall	48.645340	-122.329640
FR7	Friday Creek north of Parsons Creek Road	48.595620	-122.328280
FR8	Butler Creek at Friday Creek Road	48.595240	-122.328370
FR9	Wildes Creek at Friday Creek Road	48.577170	-122.337560
FR10	Friday Creek At Pomona Grange Park	48.563050	-122.330550
Site ID	**Location**	**Lat**	**Long**

FR11	Friday Creek at Prairie Road	48.558460	-122.328340
FR12	Friday Creek on North Green Road at KOA	48.552210	-122.331980
FR13	Friday Creek at first Friday Creek Rd crossing	48.574210	-122.338180
FR14	Friday Creek just above Wildes Creek	48.576260	-122.337720
FR15	Friday Creek at south of Donovan Park	48.587240	-122.329550
FR16	Friday Creek north of Donovan Park (2nd bridge)	48.588330	-122.328680
BUTBCR	Butler Creek at Butler Creek Road	48.604000	-122.320000
WILDES99	Wildes Creek at Old Highway 99	48.588000	-122.323000
WILDESPCR	Wildes Creek at Parsons Creek Road	48.592330	-122.317870
WILDESBCR	Wildes Creek at Butler Creek Road	48.592790	-122.317010
BUT99	Butler Creek at Old Highway 99	48.595000	-122.324000
FCFBL	Friday Creek at Frankie Bob Road	48.604230	-122.335480
FCUPTRIB	Friday Creek trib on Friday Creek Road near Alger	48.612470	-122.336270
FCUP99	Friday Creek trib on Hwy 99 near Alger	48.612520	-122.334730
ALGTRIB	Tributary to Friday Creek just east of FR3	48.619280	-122.347510
SILCORB	Silver Creek above Corbell Lane Trib	48.619867	-122.337918
FRIDP	Friday Creek at Donovan Park	48.595077	-122.329202
I-5 TRIB	accessed from the soundbound rest stop on I-5	48.586820	-122.345730
TRIBBUT	Friday Creek tributary near Butler Creek	48.596720	-122.327640
BC3	Butler Creek tributary north of 3267 BCR	48.598320	-122.317130
BC4	Butler Creek tributary south of 3339 BCR	48.596915	-122.317256
BC7	Butler Creek tributary south of 3149 BCR	48.599610	-122.317200
BC2660	Butler Creek at 2660 Butler Creek Road	48.606350	-122.321690
BUTBCR2	Butler Creek at Butler Creek Road	48.602240	-122.318020
TC1	Thomas Cr at upstr end of SIN property off Kelleher Rd	48.532994	-122.292278
TC2	Thomas Cr at downstr end of SIN property off Kell. Rd	48.532692	-122.299975
TC3	Thomas Creek on Craney property east of Delvan Hill Rd	48.532225	-122.272933
TC4	Thomas Cr trib at RR x-ing - NE of Cougar Peak property	48.546914	-122.268333
TC5	Thomas Creek tributary at Mosier Rd	48.542807	-122.244892
TC6	Thomas Creek at Bridgewater Ln	48.550470	-122.256475
TC7	Thomas Creek at Kelleher Rd	48.528928	-122.305375
TC8	Thomas Cr trib on F&S Grade Rd just E of Valley View Rd	48.534000	-122.302200
TCER	Thomas Creek tributary at Erna Lane	48.541866	-122.259726
TR1	Thomas Creek trib on Cougar Peak prop - northern site	48.550314	-122.273094
TR2	Thomas Creek trib on Cougar Peak prop - middle site	48.549075	-122.270569
TR3	Thomas Creek on Cougar Peak property - southern site	48.547928	-122.269261
TR3BW	Thomas Creek on Thomas Creek Lane	48.549538	-122.260777
WC1	Willard Creek at Garden of Eden Rd	48.519575	-122.250322
WC2	Willard Creek upstr of Thomas Creek on F&S Grade Rd	48.527719	-122.278014
WC3	Willard Creek at Ratchford and Union Roads	48.522220	-122.269430
WILLFSS	Willard Cr at F&S Grade Rd crossing NW of Copper Lane	48.520420	-122.265590

Table 8. Padilla Bay Watershed sampling locations (NAD 1983)

Site ID	Location	Lat	Long
BV1	Susan’s culvert	48.494117	-122.482667
BV2	Luna's field culvert	48.486994	-122.479658
BV3	S Bay View State Park	48.485931	-122.479358
BV4	B Street culvert	48.485133	-122.478878
BV5	B Street #2	48.486494	-122.478086
BV6	Boat launch culvert	48.484400	-122.478778
BV7	Cute beach cottage	48.483511	-122.478225
NN8	Marihugh and Bayview-Edison Road	48.479283	-122.468683
NN9	Bridgeview South	48.476990	-122.464563
NN10	Egbers across footbridge	48.465178	-122.451833
NN11	Egbers field main ditch	48.465101	-122.455330
NN12	No Name Slough tide gate	48.468633	-122.466333
NN13	Bay View Road blue house	48.472600	-122.449017
NN14	Farm to Market Road pallet place	48.458881	-122.444286
NN15	Farm to Market and Bayview Road	48.472283	-122.444006
NN16	Upper Marihugh Road	48.479583	-122.449467
NN17	Wilson Road East Fork	48.486822	-122.448811
NN18	Wilson Road West Fork	48.486514	-122.452267
NN19	Rector Road culvert at green mailbox	48.493933	-122.455383
HS-PR	Higgins Slough at Peterson Road	48.471939	-122.372181
JLS-SSD	South Spur Ditch (JLS) at Josh Wilson Rd	48.486785	-122.400550
LIS-FM	Little Indian Slough at Farm to Market Road	48.455794	-122.444279
SCMP40	Big Indian Slough at Highway 20 truck scales	48.446790	-122.458170
NN11.5	No Name Slough at end of Egbers-Kalso Road	48.465098	-122.455329
BV6	Boat launch culvert on beach in Bayview	48.484440	-122.478754
BV4	B Street culvert on beach in Bayview	48.485154	-122.478814

Each of the listed locations has been sampled at least once in the past. Sampling locations for CECs will likely also come from this list, subject to change as emerging needs dictate. Sample sites for CECs and canine detection will be based on perceived pollution identification needs at the time of sampling. .

7.2.2 Field parameters and laboratory analytes to be measured

Fecal coliform bacteria
Contaminants of Emerging Concern (CECs) are listed in Tables 5 and 6.
Canine detection results

7.3 Modeling and analysis design

NA

7.4 Assumptions in relation to objectives and study area

The main assumption for this project is that fecal coliform pollution in the target areas will continue to be driven to a large extent by rainfall sufficient to produce runoff. We have almost 10 years of data backing up that assumption. However, we will continue to pursue occasional sampling independent of rainfall events, both in this project and our existing ambient sampling program.

7.5 Possible challenges and contingencies

The study design supports the overall objective of the project (fecal coliform pollution reduction) by providing crucial information on fecal coliform pollution levels at specific locations, as well as source identification information from the CEC and canine detection aspects of the sampling plan.

7.5.1 Logistical problems

Basin-wide fecal coliform sampling for PIC projects does involve developing new samples sites. These may include private property access questions and uncertain footing or other access difficulties. Skagit County personnel are experienced in developing new sampling locations and will move upstream or downstream on the watercourse in question.

Tides are a factor in the lower Samish River, which is why there are no sample sites initially designated downstream from SCMP32, which is at RM 4.5. The next available public access is at RM 3.0 and occasionally does have seawater influence. Skagit County has sampled for fecal coliform at RM 3.0 on several occasions when there was not tidal influence and not found substantial differences from sampling at RM 4.5.

7.5.2 Practical constraints

We believe we have all the equipment and staffing necessary for successful completion of this project and that it is adequately funded. Several Skagit County staff are trained in water sampling, and County staff are prepared to assist UW Center for Urban Waters staff with the CEC sampling. County staff also will assist with the canine detection project. Skagit County is already in possession of most of the historic data.

7.5.3 Schedule limitations

The main factor in scheduling is the availability of sampleable rain events, over which we have no control. County staff will be available on call for rain events and reschedule other duties if necessary. CEC and canine detection sampling requires more scheduling and coordination, so capture of rain events for CEC sampling will require communication with UW personnel in order to target rain events. Canine detection requires scheduling months in advance and targeting rain events is not possible, nor is it as crucial when looking for human sources.

8.0 Field Procedures

8.1 Invasive species evaluation

The sampling aspects of this project are not thought to pose significant invasive species risks. The project is confined to two watersheds which are not known to contain New Zealand mud snails, Dreissena mussels, or other easily spreadable invasive species. Much of the sampling can be accomplished from land without entering the water. We do not use felt-soled boots for in-water work. Equipment is left to dry between sampling days.

8.2 Measurement and sampling procedures

Skagit County has their own fecal coliform sampling SOP which is consistent with the Ecology EAP030 Fecal Coliform Sampling SOP (Ecology 2011).

CEC sample collection and processing will be performed according to the UW Tacoma Center for Urban Water Standard Operating Procedures titled, "Sample Preparation for the Extraction and Analysis of Trace Organic Contaminants from Water Samples." Briefly:
Samples will be collected in pre-cleaned, 1L glass amber jars prepared by the UWT Center for Urban Waters personnel prior to sampling. Cleaning includes wash with methanol, ethyl acetate, and DI water. Cleaned containers are sealed with tape until use. Sample collection entails a field-rinse three times before filling them from the thalweg of the watercourse. Clean gloves should be used for each sample collection to avoid cross contamination. Bottles are capped, recorded, and placed under ice for shipment by car to the UW Center for Urban Waters laboratory. Sample maximum holding time is 48 hours.

8.3 Containers, preservation methods, holding times

All water quality samples will be obtained using pre-cleaned bottles from the contract laboratory (fecal coliform) or UW Center for Urban Waters laboratory (CECs). Bottles and exposure trays for canine detection samples will be pre-cleaned at Skagit County offices to specifications from Environmental Canine Services.

Table 9. Sample containers, preservation, and holding times.

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
Fecal coliform	Surface water	120 ml	Lab-supplied pre-cleaned 150-ml plastic bottles	Ice	24-h
CECs	Surface water	1 liter	Lab-supplied pre-cleaned amber glass bottles	Ice	48-h
Canine detection	Surface water	1 liter	Plastic bottles pre-cleaned at County offices	Ice	8-h

8.4 Equipment decontamination

We do not anticipate extensive decontamination requirements for this project. Samples will be obtained (per EAP030) such that any residual bacterial or other contamination on sampling wands will not enter subsequent samples. Sampling equipment will be allowed to dry between sampling days. Pre-cleaned bottles will be used for all samples. Should equipment contamination become an issue, Skagit County will consult Ecology EAP090 for proper decontamination procedures.

8.5 Sample ID

Skagit County has extensive sampling experience in the two watersheds involved with this project, and has existing sample IDs for many locations in those watersheds. Skagit County has also developed a SOP for new sample location IDs and will follow that protocol for this project. All new sample locations are cross-cataloged with GPS coordinates to check for existing IDs and data is transferred to existing ID if necessary.

8.6 Chain-of-custody

Skagit County uses COC forms supplied by the contract laboratory for fecal coliform samples. UW Center for Urban Waters developed their own COCs for CEC sampling. Skagit County will continue to use these forms for this project.

8.7 Field log requirements

Skagit County will use field notebooks for this project to record information not already recorded on COCs and field data sheets.

8.8 Other activities

Skagit County conducts field training for all personnel new to our sampling program. Skagit County maintains active communication with the contract laboratory to facilitate their readiness for extensive sample sets and to discuss unusual sample results.

9.0 Laboratory Procedures

9.1 Lab procedures table

Table 10. Measurement methods (laboratory).

Analyte	Sample Matrix	Samples (Number/ Arrival Date)	Expected Range of Results	Detection or Reporting Limit	Sample Prep Method	Analytical (Instrumental) Method
Fecal coliform	Surface water	Varied	ND – 10,000 mpn	1.8 mpn		SM9221 E/MTF (APHA 1998)
CECs1	Surface water	50-75, dates to be determined	0.1 – 1000 ng/L	See Table 6	UW (2016 a, b)	EPA 1694 (modified) (EPA 2007, UW 2016d)
Canine detection	Surface water	30, dates to be determined	Presence/absence	NA	None	NA

Table 11. Measurement methods (field).

Analyte	Sample Matrix	Samples (Number/ Arrival Date)	Expected Range of Results	Detection or Reporting Limit	Sample Prep Method	Analytical (Instrumental) Method
Canine detection	Surface water	Varied	Presence/absence	Unknown	None	NA

9.2 Sample preparation method(s)

Fecal coliform samples are prepared in the contract laboratory according to the methods outlined in SM9221 E/MTF (APHA 1998).

A detailed description of the sample preparation method for analysis of CECs in water samples is included in the SOPs titled, "Standard Operating Procedure. Agricultural Antibiotics in Water: Extraction and Chemical Analysis" (UW, 2016b), and "Standard Operating Procedure. Sample Preparation for the Extraction and Analysis of Trace Organic Contaminants from Water Samples." (UW, 2016c). The major method steps are summarized below and shown in Figure 3.

- Samples are filtered to remove suspended solids;
- Sample pH is adjusted. Final pH varies according to method and analyte of interest;
- Samples are run through an Oasis HLB solid phase extraction (SPE) cartridge;
- Analytes are eluted from SPE cartridge with methanol and MTBE;
- Eluant is evaporated to near dryness and resuspended in either acetic acid:methanol, or just methanol, depending on method and analyte of interest.
- Sample is analyzed with liquid chromatograph dual mass spectrometer for analyte quantification.

9.3 Special method requirements

Skagit County remains in constant contact with the contract laboratory for fecal coliform determinations. Locations with consistently high fecal coliform counts get a different dilution set designed to better enumerate samples with high numbers. Samples from new areas with suspected high counts are flagged for the lab so the high-count dilution series can be used.

9.4 Laboratories accredited for methods

Both the contract laboratory (Edge Analytical, Burlington, Washington) and the UW Center for Urban Waters (CECs) are accredited by Ecology for the methods we will use in this project. There is no accreditation process for canine detection, but the dogs are highly trained in detecting human sewage.

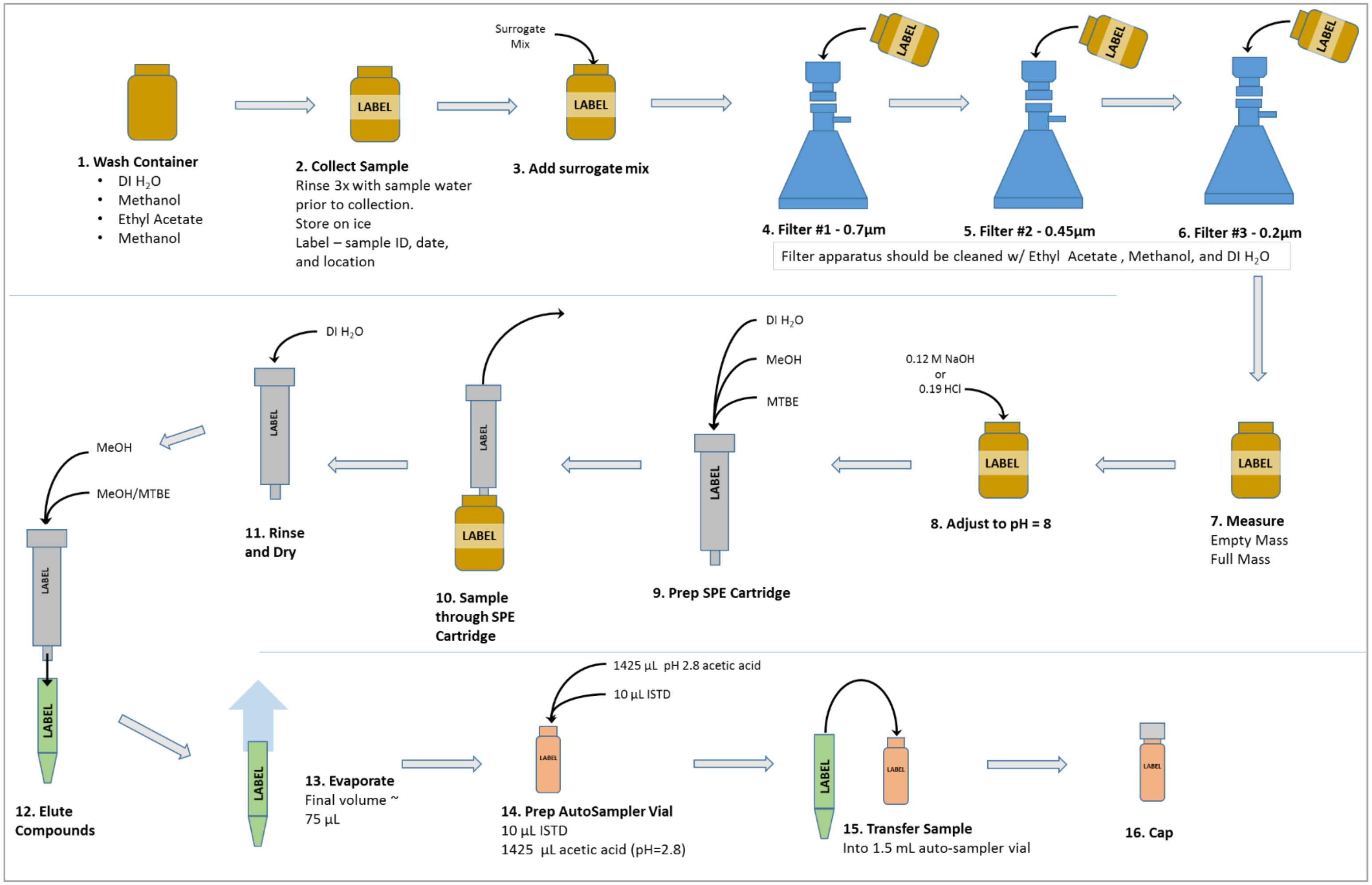

Figure 3. Extraction method for CECs

10.0 Quality Control Procedures

All samples will be obtained by experienced personnel. Data verification will flag inappropriate results. This project has built-in weekly staff meetings where the project is reviewed.

10.1 Table of field and laboratory quality control

Quality control for fecal coliform will include field blanks and replicates, along with the contract laboratory's standard suite of QC procedures.

Table 12. Quality control samples, types, and frequency.

Parameter	Field		Laboratory			
	Blanks	Replicates	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
Fecal coliform	1 per event	10% of samples				
Canine detection	2 per event	Not applicable to field operations	Blind samples with cow, horse, and human waste	NA	Two per event	NA
CECs	1 per event	10% of total samples	Every 8-10 samples	Every 8-10 samples	Two per sample run	Every 20-30 samples

Skagit County will rely on standard procedures of the contract lab for quality control for fecal coliform samples in the laboratory.

10.2 Corrective action processes

In the case of canine detection, questionable sample results in neutral scent area trials can be rechecked immediately. Deviations from expected results (i.e. false positives and false negatives in blind samples and blanks) will be recorded and used to interpret other results. In past experiences with the sewage-sniffing dogs, failed QC samples have not been a problem.

The labs will provide us with QC results for fecal coliform and CECs. Because fecal coliform is such a variable parameter, we generally require repeat sampling before concluding an area is an area of concern for high concentrations. In the case of fecal coliform samples with failed QC results, we will resample the area at the next available occasion.

Skagit County will consult with UW personnel in the case of CEC data not meeting QC standards.

11.0 Data Management Procedures

11.1 Data recording and reporting requirements

The fecal coliform and CEC data will be transferred to EPA's STORET/WQX per the terms of our grant. Lab results will first be entered into the County database, then rechecked against the original lab sheets for data entry errors via the County's standard quality control procedures.

Canine detection data will be housed at Skagit County Public Works in Excel spreadsheets.

All Skagit County data is automatically backed up each evening by Skagit County Information Services.

11.2 Laboratory data package requirements

Skagit County's contract laboratories provide a standard set of documents with each set of sample results. This package includes a cover letter where any unusual conditions are noted, a copy of the COC, the sample results including any data qualifiers, and the laboratory's QC results.

11.3 Electronic transfer requirements

Electronic data transfer is available from Skagit County's contract labs.

11.4 EIM/STORET data upload procedures

Skagit County will submit all data from this project to EPA's STORET/WQX system.

11.5 Model information management

N/A

12.0 Audits and Reports

12.1 Field, laboratory, and other audits

No audits are planned for this project.

12.2 Responsible personnel

NA

12.3 Frequency and distribution of reports

Skagit County routinely distributes weekly fecal coliform sampling results by email to interested parties. Extensive reporting is included in our grant agreement and we will rely on that schedule for more formal reports.

The final report will delineate the methods used, any modifications made to QAPP conditions; the results of fecal coliform, CEC, and canine detection sampling; and interpretation of results with respect to locating pollution sources.

Skagit County will seek review of a draft final report from our partners at WSDOH and NEP QC personnel before report finalization.

12.4 Responsibility for reports

The final report will be the responsibility of Dr. Andy James (UW Center for Urban Waters), Karen DuBose (Skagit County), and Rick Haley (Skagit County).

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

Field data collected by Rick Haley (fecal coliform and CECs) will be verified by Karen DuBose. Field data collected by Karen DuBose (canine detection) will be verified by Rick Haley. CEC data verification will be according to UW Center for Urban Waters procedures (UW Center 2016).

13.2 Laboratory data verification

The contract laboratory for fecal coliform determinations, Edge Analytical (Burlington, WA), completes a rigorous quality control process for every sample set. QC reports are included in the data package the County receives. Skagit County personnel will review field notes, COCs, and data reports for proper sample handling and storage, missing or outlier values, and comparison to DQOs.

For CECs, the QC samples allow for the analyte-specific and sample-specific evaluation of the validity of the results sets. This includes quantifying and accounting for cross contamination, analyte loss during processing (via labeled surrogates), and changes in instrument response (via labelled internal standards).

13.3 Validation requirements, if necessary

NA

13.4 Model quality assessment

NA

13.4.1 Calibration and validation

NA

13.4.2 Analysis of sensitivity and uncertainty

NA

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

Evaluation of whether the project outcomes have met the original objectives will center on whether adequate sampling and analyses occurred according to the original sampling plan. The number of samples planned for this project were thought to be the amount necessary to generate the information needed to locate and remediate pollution sources. Experience in these watersheds has shown that repeated sampling is necessary to confirm and locate pollution sources.

Data will be rejected if the samples were not collected in accordance with SOPs or if the lab QC data indicates the results should be questioned. Data should also meet all applicable MQOs listed in section 6.2. Results should meet the sample adequacy and accuracy criteria. The final determination of project objectives is whether the data collected help identify fecal coliform sources in the Samish and Padilla Bay watersheds.

14.2 Treatment of non-detects

Fecal coliform non-detects (< 1.8 mpn/100 ml) will be listed as <1.8 in data summaries. For statistical purposes they may be substituted with 1 mpn/100 ml.

Non-detects for CECs will be listed as ND or with the Method Detection Limit (MDL) or Method Quantitation Limit (MQL). We do not anticipate using CEC non-detects in statistics, but if so, they will be substituted at one-half the MQL.

14.3 Data analysis and presentation methods

Data collected in this project will be stored in Skagit County's water quality database and/or spreadsheets, and submitted to EPA's STORET system. Microsoft Excel will provide the basic tools necessary for summation and graphical representation of the data.

Since the goal of the project is to detect and remediate fecal coliform pollution sources, the need for statistical analysis for the project is less than for many other studies. There is generally no need to conduct hypothesis testing statistics for fecal coliform and CEC results as they stand alone for use in locating pollution sources. Standard summary statistics will be used to summarize and characterize the data. The study is not long enough for trends analysis, but where possible the data will be used for before/after remediation comparisons.

Fecal coliform data is notorious for high variability. This variability will be characterized through the use of duplicates at a 10% rate.

14.4 Sampling design evaluation

The sampling design is intended to allow us to locate and remediate fecal coliform sources in the Samish and Padilla Bay Watersheds. It will include both basin-wide sampling and focusing on areas with high fecal coliform concentrations detected by previous sampling and the basin-wide sampling in this project. We anticipate this approach will yield the information necessary to reduce fecal coliform pollution in the study areas.

Statistical hypothesis testing is not a major focus of this project. It is immaterial if one location is significantly more polluted than other locations – where pollution is found, it will be addressed. Therefore considerations of statistical power are secondary at most.

Evaluation of the sampling design will center around the central question of whether pollution sources were located that account for the pollution loads detected at the downstream end of the Samish River and in Samish and Padilla Bays. Other parts of this project not delineated in this QAPP are designed to find solutions to pollution sources identified by this sampling. To the extent that those solutions can be implemented during this grant cycle, the ultimate expression of the sampling design will be reduced pollution levels in the Samish and Padilla Bay watersheds.

As CECs are an emerging technology in pollution source identification, it will be important to assess CEC efficacy in locating pollution sources by comparing CEC sampling results with the ability to actually locate activities causing pollution by follow-up inspections.

Skagit County and its partners have extensive experience using fecal coliform sampling and canine detection results to locate pollution sources. A delineation of that success during this grant cycle will be part of the final report for this project.

14.5 Documentation of assessment

Results of the data quality and usability assessment will be documented as part of final project reports.

15.0 References

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16.0 Appendices

Appendix A. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

Ambient: Background or away from point sources of contamination. Surrounding environmental condition.

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).

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

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.

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 waste load 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 waste load determination. A reserve for future growth is also generally provided.

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

CCV	Continuing calibration
CECs	Chemicals of emerging concern
COC	Chain of custody
CRM	Cerified reference material
CSI	Clean Samish Initiative
DQO	Data quality objective
e.g.	For example
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FC	(see Glossary above)
LCS	Laboratory control standard
MDL	Method detection limit
MQL	Method quantitation limit
MQO	Method quality objective
NA	Not applicable
NEP	National Estuary Program (EPA)
ND	Nondetect
PIC	Pollution identification and control
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedure
SPE	Solid phase extraction
STORET	STOrage and RETrieval system for environmental data (EPA)
TMDL	(See Glossary above)
UW	University of Washington
WAC	Washington Administrative Code
WSU	Washington State University

Units of Measurement

cfu	colony forming units
mpn/100 ml	Most probable number per 100 milliliters
ng/L	nanograms per liter (or parts per trillion)

Appendix B. 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 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)

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Appendix C. Sample Preparation for the Extraction and Analysis of Trace Organic Contaminants from Water Samples

Standard Operating Procedure

The University of Washington Tacoma Laboratories at the Center for Urban Waters.

Revision Date: September 2016

Available on request from University of Washington-Tacoma Center for Urban Waters

Appendix D. AGRICULTURAL ANTIBIOTICS IN WATER: EXTRACTION AND CHEMICAL ANALYSIS

Standard Operating Procedure

The University of Washington Tacoma Laboratories at the Center for Urban Waters.

January 2016

Available on request from University of Washington-Tacoma Center for Urban Waters

Appendix E. Triple Quadrupole Liquid Chromatography Dual Mass Spectrometry (LC-MS/MS-QqQ) Setup, Operation, and Data Analysis

Analysis of Trace Organic Contaminants from Water Samples

Standard Operating Procedure

The University of Washington Tacoma Laboratories at the Center for Urban Waters.

Revision Date: August 2016

Available on request from University of Washington-Tacoma Center for Urban Waters

Appendix F. Skagit County Fecal Coliform Sampling Protocol

(Excerpt from Skagit County Water Quality SOPs rev 4-11-13)

Fecal coliform samples

Taken directly into lab-supplied sterile 150-ml bottle

Sample from representative area of watercourse – the thalweg if possible, but if not due to size of watercourse, in an area with current representing the main flow of the watercourse.

With bottle in sampling wand, plunge bottle head first into stream with mouth of bottle facing into current.

Turn right-side up to fill bottle while maintaining mouth of bottle under the surface, but in the top six inches of the water column.

Withdraw wand and bottle from stream.

Make sure there is at least ¼" of head space in bottle.

Cap FC bottle and place under ice

For duplicate fecal coliform samples:

- Locate sterile 500-ml bottle with proper designation for duplicate (FEC1, FEC2, etc). Also locate labeled lab-supplied sterile 150-ml bottles. One bottle should be labeled with the sample site number (e.g. 32), the bottle with the corresponding duplicate label (e.g. FEC1).
- Record sample site where duplicate was taken in proper location on field data sheet.
- Using large sampling wand, rinse bottle twice with water to be sampled (field rinses) and then collect sample using procedures under "Obtaining Water Samples" above.
- Fill first FC bottle half full, rehomogenize, fill second FC bottle half full,
- Then reverse order to finish filling second bottle, then first, rehomogenizing before each pour.
- Leave at least ¼" head space in all fecal coliform bottles
- Cap tightly and place under ice.