Quality Assurance Project Plan

On-site Sewage System (OSS)
Ultraviolet Disinfection Unit Study

Contact Numbers C17128 and C17129

June 2017

Prepared by:
Washington State Department of Health
Wastewater Management Section

Prepared for:
Washington State Department of Health

Publication Information

The purpose of this Quality Assurance Project Plan (QAPP) is to describe on-site sewage system UV disinfection unit evaluation work carried out by the Washington State Department of Health in partnership with Tacoma-Pierce County Health Department, Thurston County Public Health and Social Services Department, and University of Washington. This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement PC-00J88801 to the Washington State Department of Health. 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.

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This QAPP, sampling results, and the final project report will be available on the Washington State Department of Health's website at
http://www.doh.wa.gov/CommunityandEnvironment/Shellfish/EPAGrants

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1.0 Title Page, Table of Contents, and Distribution List

Quality Assurance Project Plan

On-site Sewage System (OSS)

Ultraviolet Disinfection Unit Study

June 2017

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Table of Contents

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2.0 Abstract

To gain clarity regarding trends in installation and function of ultraviolet disinfection (UVD) units in Washington, the Department of Health (DOH) will conduct a cross-sectional observational study of a certain population of on-site sewage systems (OSS) with permitted UVD units. We will investigate the correctness of installation, present functioning, and efficacy of treatment provided by UVD units used in OSSs.

Approximately two hundred OSSs with permitted UVD units will be field evaluated in Pierce County and Thurston County, Washington. Each OSS will be evaluated to determine: if the UVD unit was installed correctly, if the unit is currently functioning as it is meant to, and, where possible in Thurston County, what the quality of the effluent is, including fecal coliform concentration. We expect to identify relationships between proper installation, functioning of UVD units, and microbial load. We may also identify other relationships or trends related to installation or operation and maintenance. Results will inform future consideration of UVD units in the regulatory framework, including during regulation revisions.

3.0 Background

The state on-site sewage system (OSS) rule (chapter 246-272A WAC) lays out design requirements for OSSs, matching treatment components with soil type, vertical separation, treatment level, and distribution method. In meeting these design requirements, the state rule allows use of UVD units for disinfection or bacterial reduction under limited circumstances.

For new construction (WAC 246-272A-0230(2)(g)), the rule prohibits use of disinfection to meet treatment levels A or B in Type 1 soils and to meet treatment level C. For repairs (WAC 246-272A-280(7)), the rule again prohibits use of disinfection to meet treatment levels A or B in Type 1 soils and to meet Treatment level C, and to meet treatment levels A or B on sites with less than 18 inches vertical separation. Due to these restrictions and the number of sites where UV is allowed, use of UV disinfection for bacterial reduction is most closely associated with systems on sites meeting treatment level B.

The department's 2004 On-Site Rule Development Committee Report noted that disinfection units were "considered by many in industry and local health jurisdictions to be unreliable and ineffective," and recommended product testing to help verify performance. Since the state OSS rule's adoption in 2005, DOH registered UVD units have been used to meet the higher treatment levels, particularly in lowland areas of Puget Sound characterized by shallow, medium- to course-textured soils as describe above. Prior to 2005, UV units were used on a limited basis under DOH guidance.

Recent estimates from local health jurisdictions (LHJs) suggest there are more than 6,500 UV units in use in the state. Roughly 90 percent of the units are located in Puget Sound counties; more than 75% in three South Sound counties (Pierce, Mason, and Kitsap); and fully a third are found in Pierce County (2,200 units). The high concentration of UV units in Pierce County is a key reason we selected it as a study site.

DOH maintains a list of registered on-site treatment products meeting the different treatment levels of the rule. This includes proprietary treatment products using UVD units to meet treatment levels A and B where manufacturers have verified product performance at an accredited testing facility. The most commonly used UVD unit on the state's list of registered treatment products is the Salcor 3G UV. Recognizing the technical challenges associated with UVD units, DOH has worked with Salcor to address operational needs and concerns. This includes technical training workshops organized by DOH for industry members and LHJs, and feedback to the manufacturer by the department, LHJs, and the department's technical advisory group (TAG) on various operational issues.

In December 2012, Kitsap County completed a study documenting widespread operational problems with UVD units in use in its jurisdiction (The Disinfector® and Salcor 3G®). Since 2010 the Salcor unit has been the disinfection unit of choice in new OSSs. The study reported an UVD unit operational failure rate of 44% (437 failures out of 994 inspected OSSs with UVD units). Reported commonly observed problems that rendered UVD units non-operational included shorted-out electrical supply, melted electrical connectors or panels, burned-out bulbs, broken ballasts, broken quartz containers, torn Teflon barriers, flooded UVD units, and whole

UV unit fires/melt downs. These reported problems raise questions about the technology's reliability in line with concerns expressed during the 2005 rule-making process. The reported problems coincided with improvements in Kitsap County's online OSS inspection reporting system. DOH informally canvassed LHJs for feedback on UVD problems and formally surveyed the same group during the state OSS rule evaluation in 2014. Counties expressed anecdotal concerns regarding the use, reliability, and performance of UVD units, but no other county has provided documentation of UVD issues comparable to Kitsap County's experience and investigations.

4.0 Project Description

To gain clarity regarding trends in installation and function of UVD units in Washington, Department of Health (DOH) will conduct a cross-sectional observational study of a certain population of OSSs with permitted UVD units. The correctness of installation, present functioning, and the level of treatment provided by UVD units used in OSSs will be investigated.

DOH will contract with Tacoma Pierce County Health Department (TPCHD) and Thurston County Public Health and Social Services (TCPHSS) to host the study within Pierce County and Thurston counties, respectively. Approximately 100 hundred OSSs with UVD units will be selected from the total number population of OSSs with permitted UVD units in the two counties, and subsequently field evaluated to answer the objective questions. Because OSSs are designed to obtain representative effluent samples in Thurston County, wastewater samples additionally will be collected from the evaluated OSSs in Thurston County for the laboratory analysis of fecal coliform and for conducting field parameters measurements of UVD unit treated effluent.

DOH will solicit voluntary participation in the study via mailed invitation to the owners of these OSSs. A reimbursement of the fee that OSS owners paid to the local health department for maintenance inspection will be offered to each participant as incentive/compensation for participation. DOH will collect information from the invited population that volunteer to participate (volunteers) and will create a list of these (with system information and owner contact information). TPCHD and TCPHSS will serve as the point of the contact for inquiries within their respective county and will answer related questions and comments from those invited or the interested public.

DOH will conduct the site visits, collect the information needed for the study, and collect samples. TPCHD and TCPHSS will provide DOH with the list of participants, including contact information for the owner and system and permit information necessary to be adequately prepared/equipped for each site visit. DOH will develop field logs to be completed for each site. DOH will collaborate with Thurston County Health Laboratory for the analyses of fecal coliform samples.

In addition to NEP funds, DOH will conduct all field activities through use of their own personnel and supply resources. This will include contacting owners and arranging site visits, conducting the site visit, accessing the system, completing the checklists, collecting grab samples, conducting field measurements, returning the system to pre-visit status, and submitting samples to the laboratory.
The laboratory will provide analyses results directly to DOH. DOH will compile and summarize the results of all completed checklists (and laboratory analysis results) in a spreadsheet format to facilitate investigation of trends and correlations. This summarized data will feed the development of a final report on the results of the study. These data and the accompanying final report are the primary products of the study.

4.1 Project goals

Department of Health (DOH) will conduct a cross-sectional observational study of a population of OSSs with permitted UVD units to gain clarity in the functioning of currently installed UVD units. The uncertainty around the reliability and safety of UVD function has created a regulatory environment with radically different approaches between counties (jurisdictions) and uncertainty of the technology's standing in regulations, current and future, among many designers and contractors. The uncertainty over the technology's effectiveness and reliability must be addressed. Likewise the disparate and incompatible perception and resultant regulatory approaches between jurisdictions must be addressed.

The goal of this study is to determine the effectiveness of UVD units in the field. This will inform consideration of UVD systems in future revisions of DOH regulations as well as DOH's position regarding management requirements for currently installed UVD systems. At polar extremes of possibilities, the project may provide information that UVD unit installations in Washington are unsafe and/or unreliable and need further regulatory safeguards, or conversely it may indicate that UVD systems have negligible risk and regulatory safeguards are unmerited. More likely, specific trends will emerge associated with installation or maintenance operations potential issues around which more regulatory clarity is merited.

4.2 Project objectives

The objectives of this study are to field evaluate approximately 100 OSSs with UVD units to describe our findings quantitatively/statistically, and to use these results to make assumptions about of the larger populations of OSSs with UVD units.

Systems field evaluation objectives include characterizing specific aspects of component installation, operational maintenance that the system has received, such as UV lamp replacements, as well as general condition of critical components. UVD unit treated effluent will be evaluated in Thurston County using a combination of laboratory analyses for fecal coliform and field measurements of wastewater quality parameters.

The results of the field evaluations and the laboratory analyses will be used to investigate correlations between the following variables: proper installation, operational maintenance, current functioning of UVD units, measured wastewater quality parameters and effluent fecal coliform levels. This will be done using statistical methods aided by statistical analysis software.

4.3 Information needed and sources

Most data for this project will be generated during the project itself. TPCHD and TCPHSS will provide information about the location of installed UVD systems and the contact information for the owners of these systems. With this information, only those systems that are eligible for the study will be recruited. Additionally, TPCHD and TCPHSS will provide information about system design and installation, as well as most recent maintenance procedures. Most of these data is publicly available via an online maintenance tracking system used by both counties (OnlineRME). Any data not available through this system will be provided by the county environmental health department staff.

4.4 Target population

The target populations for this project are the OSS with UV disinfection units in Pierce and Thurston County. Pierce and Thurston County have approximately 2,000 and 140 OSSs with UVD units, respectively.

4.5 Study boundaries

The geographical boundaries for the project will be Pierce County and Thurston County.

4.6 Tasks required

This project will involve the following related tasks.

Task 1. Develop plans, agreements, and administrative documents.
- a. Develop the QAPP, related SOPs and other related supportive documents
- b. Develop agreements with Tacoma-Pierce County Health Department and Thurston Health Department
- c. Develop lists of potential participants from lists of UVD permits
- d. Develop participant invitation letter
- e. Develop equipment/supplies list

Task 2. Hire Project Research Assistant

Task 3. Secure OSS Owner Participation
- a. Contract Department of Enterprise Services to send participant invitation letter
- b. Schedule site visits

Task 4. Procure Field Equipment/Supplies[1]

Task 5. Train all field personnel in the use of the equipment/supplies

Task 6. Data collection
- a. Perform site evaluations
- b. Collect wastewater samples for lab analysis
- c. Conduct field measurements
- d. Complete field logs

Task 7. Conduct QA/QC review of data

Task 8. Perform statistical analyses

Task 9. Complete Final Report

4.7 Practical constraints

The primary practical constraints associated with this project relate to the accessibility of the target UVD unit populations on privately owned property and to the accessibility of OSS that are designed with sampling locations for obtaining representative UVD unit effluent samples.

[1] Equipment/supplies purchased includes a Realtech P200 Analyzer, YSI Pro Series 1011 pH sensor, ODO senor cap kit, UVC blocking goggles, 18V cordless drill driver kit, NIST traceable thermometer, 3ml plastic transfer pipettes, deionized water, nitrile gloves, voltage tester, turbidity 0 and 50 NTU calibration standards, YSI pH 4 and 7 buffer solutions, and conductivity 1000 uS/cm calibration solution.

To address these concerns, project staff has worked to obtain permission from system owners in advance to access properties with UVD units to conduct the field evaluations and sampling. The project also targets sampling systems with UVD units in Thurston County. Thurston County is one of the few Puget Sound Counties requiring OSS designs with free-falling sampling locations to obtain representative UVD unit effluent samples.

4.8 Systematic planning process

The systematic planning process used was the development of the Scope of Work (SOW) in the NEP contracts for the project and the Quality Assurance Project Plan (QAPP).

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 1 lists the people involved in this project. Figure 1 displays the organizational structure. The schedule may be limited by staff workload priorities or dates that all lab data is received.

Table 1. Project Staff and Responsibilities

Jeremy Simmons Washington State Department of Health (WDOH) Wastewater Management Section 360-236-3346 jeremy.simmons@doh.wa.gov	Project Manager	Responsible for project design, preparation of QAPP, and overall project coordination. Responsible for adherence to procedures in the QAPP. Reviews and approves the draft and final report.
Randy Freeby WDOH Wastewater Management Section 360-236-3379 randal.freeby@doh.wa.gov	Field Lead	Coordinates field work scheduling with TPCHD, TCPHSS, and UW research assistants. Oversees system evaluations, field measures, sampling, and transport of samples to the laboratory in project area. Conducts QA review of data, analyzes and interprets data. Reviews and edits draft QAPP and final report.
John Eliasson WDOH Wastewater Management Section 360-236-3041 john.eliasson@doh.wa.gov	QA/QC Lead	Writes the QAPP. Oversees the technical direction and quality control of the project. Conducts QA review of data, analyses and interprets data.
Gary Porter Tacoma-Pierce County Health Department 253-798-6569 GPorter@tpchd.org	Local Health Department Project Coordinators	Provides field team with list of selected sites, on-site sewage system records, and property owner contact information in the project area. Reviews QAPP and project's SOPs.
Steve Petersen Thurston County Public Health and Social Services 360-867-2627 peterss@co.thurston.wa.us		Provides field team with list of selected sites, on-site sewage system records, and property owner contact information in the project area. Reviews QAPP and project's SOPs.
Meagan Jackson University of Washington – Environmental and Occupational Health Sciences 360-949-2843 meaganja@uw.edu	Research Assistant – Field Staff	Conducts system evaluations, field measurements and sampling, and data entry. Transports samples to laboratory in the project area. Conducts QA review of data, analyzes and interprets data. Drafts final report.
Leslie Turner WDOH Wastewater Management Section 360-236-3379 leslie.turner@doh.wa.gov	Field Assistant	Coordinates field work scheduling with TPCHD TCPHSS and UW research assistants. Oversees system evaluations, field measures, sampling, and transportation of samples to the laboratory in the project area. Conducts QA review of data, analyzes and interprets data. Reviews and edits the draft QAPP and final report.

Erik Iverson Thurston County Public Health and Social Services 360-867-2631 iversoe@co.thurston.wa.us	Laboratory Manager	Provides analytical results, laboratory contract services, and oversees quality assurance/quality control of the laboratory.
Tom Gries Department of Ecology Environmental Assessment Program 360-407-6327 tgri461@ecy.wa.gov	NEP Quality Coordinator	Reviews draft QAPP and recommends approval (approves in absence of QA Officer). Comments on draft of final project report.
Bill Kammin Department of Ecology Environmental Assessment Program 360-407-6946 Bkam461@ecy.wa.gov	Quality Assurance Officer	Reviews and approves QAPP.
Megan Schell Department of Health National Estuary Program (NEP) 360-236-3307 megan.schell@doh.wa.gov	NEP Grant Coordinator	Reviews and approves QAPP for alignment with agreed upon grant funded scopes of work.

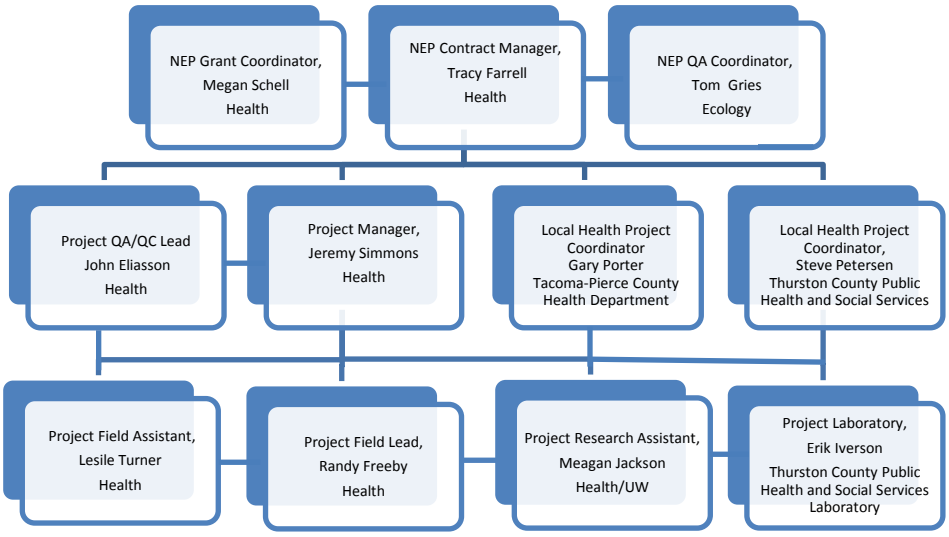
5.2 Special training and certifications

Field staff will be trained as required to complete the technical aspects of this QAPP. As appropriate to their responsibilities, project personnel will be proficient in relevant aspects of sample collection, shipping, handling, and analysis; data reporting and management; and the related QC requirements and practices. Each member of the field staff must demonstrate proficiency with their assigned duties. Training for provided for field staff will be documented in their individual training plans.

Laboratory personnel designated to analyze the samples will have successfully completed required demonstrations of capability for the methods used. The laboratory must be an environmental laboratory accredited by Washington State Department of Ecology for the analysis and reporting of fecal coliform Standard Methods which are listed in Section 8.

5.3 Organization chart

Figure 1. UV Disinfection Unit Study - Project Team Organization



5.4 Project schedule

January—May 2017:

- QAPP and related SOPs developed
- Agreements with TPCHD and TCPHSS developed
- Lists of potential participants from lists of UVD permits developed
- Participant invitation letter written
- Equipment/supplies list developed
- Project research assistant hired

April 2017:

- Department of Enterprise Services contracted to send participant invitation letters

May 2017:

- Recruitment letters sent to OSS homeowners
- Site evaluations scheduled
- Supplies and equipment procured

June—September 2017:

- Calibration and field measurement training completed,
- Site evaluations and field measurements performed,
- Laboratory testing performed,
- Ongoing quality control and preliminary data analysis

September—December 2017:

- Analysis and interpretation of data
- Draft final report written
- Final report completed and posted on DOH website

5.5 Limitations on schedule

The schedule for this project may be influenced by the response of OSS owners volunteering to participate in the project.

Laboratory acceptance of samples is limited to Monday through Wednesday. Samples must be delivered to the laboratory by 3:00 pm to allow time to process the samples on the same day.

The project schedule is subject to the Project Research Assistant's employment period.

5.6 Budget and funding

Funding for this project is provided through an EPA National Estuary Program Pathogens grant to DOH. Funds support DOH internal project costs and Local Health Jurisdiction Contract Numbers C17128 and C17129. The project budget is $75,000.

6.0 Quality Objectives

This section contains the measurement quality objectives of this study and includes analyses both in the field and in the laboratory. The overall quality assurance (QA) objective is to ensure that the field data collected are of known and acceptable quality. Consistency in methods of sampling, analysis, data interpretation, and reporting will be a high priority to meet these objectives.

6.1 Decision Quality Objectives (DQOs)

Not applicable.

6.2 Measurement Quality Objectives

Measurement Quality Objectives (MQOs) are statements about how good the measurements need to be in order to be useful as inputs to the decision process. MQOs are often reduced to statements about the acceptable values of Data Quality Indicators (DQIs).

There are three quantitative DQIs: precision, sensitivity, and completeness. Precision is monitored by the use of Quality Control (QC) samples. Sensitivity is monitored through instrument calibration and the determination of method detection limits (MDLs) and reporting limits. Completeness is a calculated value. The three qualitative DQIs, bias, representativeness and comparability, are assessed through the sample design process and selection of methods. The DQIs are defined in Table 2.

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. Precision will be evaluated by collecting and analyzing field replicates (not splits) for fecal coliform for a minimum of 10% of the samples collected for each sampling event and a minimum of one replicate per sampling day.

Laboratory duplicate analyses will indicate the degree of imprecision due to the combined effects of sample splitting in the laboratory, and imprecision of analytical methods. The laboratory will run split samples taken from the same collection bottle at a minimum of 10% of samples analyzed (at least once per sample batch). Measurement precision for lab sample analysis will be determined by calculating the RPD expressed as a percent.

$$RPD = [(S - D) / (S+D)/2] \times 100\%$$

Where:

RPD = relative percent difference
S = Analytical result of sample of origin
D = Analytical result of the duplicate sample

Table 2. Measurement Quality Objectives (MQOs)

Parameter	Verification Standards (LCS,CRM,CCV)	Duplicate Samples	Matrix Spikes	Matrix Spike-Duplicates	Surrogate Standards	Lowest Concentrations of Interest
	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Relative Percent Difference (RPD)	% Recovery Limits	Units of Concentration
FIELD MEASUREMENTS						
UV % Transmittance	N/A	0.5%	N/A	N/A	N/A	1%/cm @ 254 nm
Turbidity	N/A	≤ 10%	N/A	N/A	N/A	0.1 NTU
Dissolve Oxygen	N/A	≤ 10%	N/A	N/A	N/A	0.1 mg-DO/L
pH	N/A	≤ 10%	N/A	N/A	N/A	0.1 s.u.
Conductivity	N/A	≤ 10%	N/A	N/A	N/A	0.1 µS/cm
Temperature	N/A	≤ 10%	N/A	N/A	N/A	0°C.
LABORATORY ANALYSES						
Fecal Coliform (MF)[1]	N/A	≤ 35%	N/A	N/A	N/A	1CFU/100mL

[1] Using Standard Method 9222D

Acceptable RPD values for each parameter are given in Table 2. The RPD of laboratory duplicates will be less than or equal to 35 percent for fecal coliform bacteria for values that are greater than 5 times the reporting limit, and ±2 times the reporting limit for values less than or equal to 5 times the reporting limit. Results that do not meet the labs internal RPD's will be qualified as an estimate, consistent with DOH procedures.

6.2.1.2 Bias

Bias is defined as the difference between the population mean and true value of the parameter being measured. Most sources of bias are minimized by strict adherence to established protocols for the collection, preservation, transportation, storage, and analysis of samples.

For field measurements, staff will minimize bias by the following:

- Pre-calibrating meters according to manufacturer recommendations before each day of usage.
- Assess any potential bias from instrument drift in probe measurements:
  - For pH, conductivity, and turbidity pre-checking the probes against NIST certified pH and conductivity standards.
  - For dissolved oxygen pre-checking the probe against 100% water-saturated air.
  - For temperature, checking the probe's temperature reading before and after each run using a NIST certified thermometer.
- Adhere to the sampling and handling procedures in project work SOPs.
- Provide complete data collection and organization.

- Conduct periodic reviews and evaluations of field sampling procedures.
- Analyze data in an appropriate manner based upon essential considerations, such as temporal variations.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. Sensitivity is assured primarily through the selection of appropriate analytical methods, equipment and instrumentation, and is expressed in terms of method detection limits (MDL) and reporting limiting. This is assessed through instrument calibrations, calibration verification samples and the analysis of procedural blanks with every analytical batch. Microbiological analytical and field measurement methods reporting limits are listed in Table 5.

6.2.2 Targets for Comparability, Representativeness, and Completeness

6.2.2.1 Comparability

Comparability is a data quality measure expressing the confidence with which one data set can be compared to another. In the field, this is addressed primarily through the use of standardized sampling and analytical methods, units of measurement, and reporting limits procedures. SOP review, projection specific training, and strict adherence to DOH protocols will ensure comparability between samples collected at different sites, or by different staff. To ensure the comparability of field measurements made throughout the duration of the project, all field samples will be measured immediately, and the same field instruments and measurement techniques will be used consistently. Calibrations will be performed according with the manufacturer's specifications and/or SOPs.

To ensure the comparability of fecal coliform lab results, all samples will be transported to the lab promptly to ensure the holding time is met, and the instruments and techniques used for sample collection will be used consistently. In the lab, comparability is ensured through the use of comparable analytical procedures and ensuring that lab personnel are trained in the proper application of the procedures. Within-study comparability is assessed through analytical performance (QC sample analyses).

6.2.2.2 Representativeness

Representativeness refers to degree to which a sample reflects the population from which it is taken. Representativeness will be ensured by executing consistent sample collection protocols, including timing of sampling collection, sampling location, sampling procedures, and sample preservation. The representativeness of all field data will be qualitatively assessed by determining if the data are consistent with known or anticipated wastewater quality in the OSS samples and accepted scientific and engineering principles. Field measurements will also be checked for completeness of procedures and documentation of procedures and results. Representativeness will also be ensured by using each analytical method at its optimum capability to provide the most accurate and precise measurements possible.

6.2.2.3 Completeness

Completeness is the measure of the amount of valid data needed to be obtained from a measurement. Completeness will be measured by tracking the number of valid data results against the specified requirements this study.

Completeness will be calculated by the following equation:

Percent completeness = (V/T) x 100%

Where:

V = number of measurements that are valid

T = total number of measurements planned in the study

The goal for this data quality objective is to correctly collect and analyze 100% of the samples scheduled for each of the sites. However, problems occasionally arise during sample collection that cannot be controlled; thus, a completeness of 95% is acceptable.

The following are examples of instances that might cause a sample analyses to be incomplete:

- Instrument failure
- Calibration requirement not being met
- OSS access problems
- Grab sample minimum required quantity not available at sampling location, or
- Inclement weather delaying sampling or field measurements.

7.0 Sampling Process Design (Experimental Design)

7.1 Study Design

The study design for this project includes collecting wastewater samples from a minimum of 27 different OSSs with UVD units in Thurston County for the laboratory analysis of fecal coliform and conducting field parameters measurements where representative UVD unit treated effluent samples can be obtained.

Sixty-five OSSs with UVD units will be evaluated in Pierce County. Because OSSs are not typically designed for obtaining representative UVD unit effluent samples in Pierce County, the field evaluations will be limited to documenting the installation and operational maintenance that each OSS has received by completing the UVD unit operational checklist. Appendix B includes an example of the project's operational checklist.

The sampling process design in Thurston County is based on the objectives of characterizing the wastewater quality of OSSs with UVD units. In addition to completing the operational checklist for each OSS evaluated, wastewater samples will be collected from UVD units for the laboratory analysis of fecal coliform and for conducting field parameter measurements. Direct free-flowing grab samples of the UVD unit effluent will be collected into sterile sampling bottles for fecal coliform analysis. The sampling matrix in Thurston County is provided in Table 3. For the SOPs for collection of fecal coliform samples and the field measurements in OSSs, see Appendix C.

Table 3. Thurston County Sampling Matrix

Parameter	Sample Type	Sample Location UVD Unit Effluent	Testing Location	Number of Samples Collected on Each Site (27 sites)	Field Duplicates
UV % Transmittance	Grab	√	On-site	1	1/day
Turbidity	Grab	√	On-site	1	1/day
Conductivity	Grab	√	On-site	1	1/day
Dissolved Oxygen	Grab	√	On-site	1	1/day
pH	Grab	√	On-site	1	1/day
Temperature	Grab	√	On-site	1	1/day
Fecal Coliform	Grab	√	Laboratory	1	1/day

7.1.1 Field measurements

In addition to fecal coliform bacteria sampling, field staff will collect field measurements including UV transmittance, turbidity, dissolved oxygen, pH, conductivity, temperature, and data on the condition and operation of on-site sewage systems in Thurston County. Appendix B includes an example of the project's field data form (Field Checklist).

7.1.2 Sampling location and frequency

Wastewater measurements and sampling from the outlet of UVD units will be conducted on properties in Thurston County. The samples will be taken once for each site during June—September, 2017.

7.1.3 Parameters to be determined

Parameters to be sampled are provided in Table 4.

Turbidity will be measured with a Global Water WQ770-B turbidity meter and sensor, specific conductivity and pH will be measured using a ProPlus Handheld Multiparameter Instrument, dissolved oxygen will be measured using a LDO probe (ProODO Handheld Optical Dissolved Oxygen Meter), and % transmittance will be analyzed using a Real UV254 P200 meter.

7.2 Maps or diagrams

Figure 2. Map of the Project Area – Pierce County Study Area

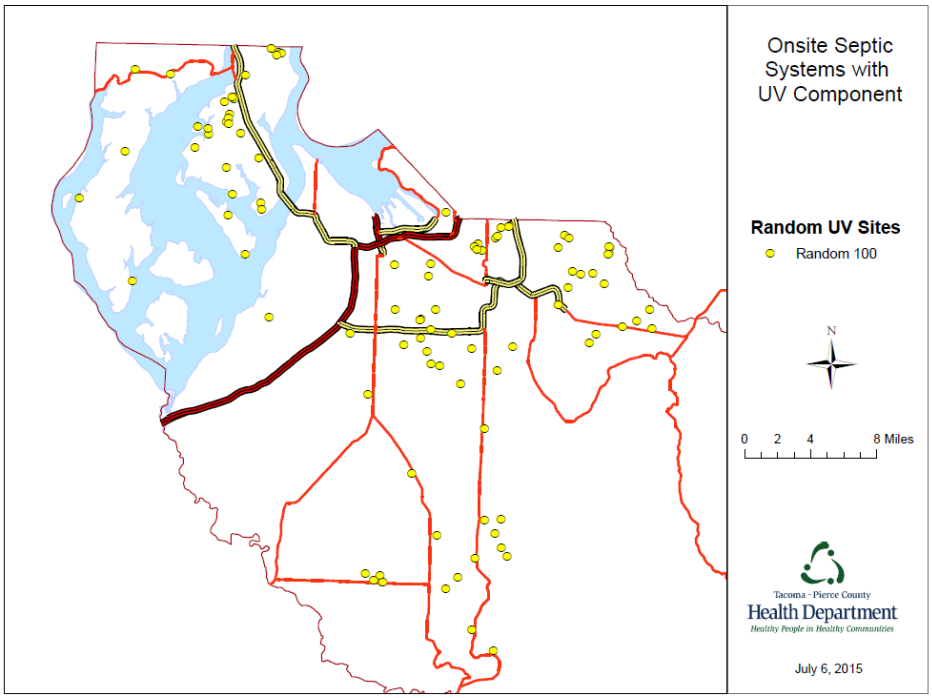
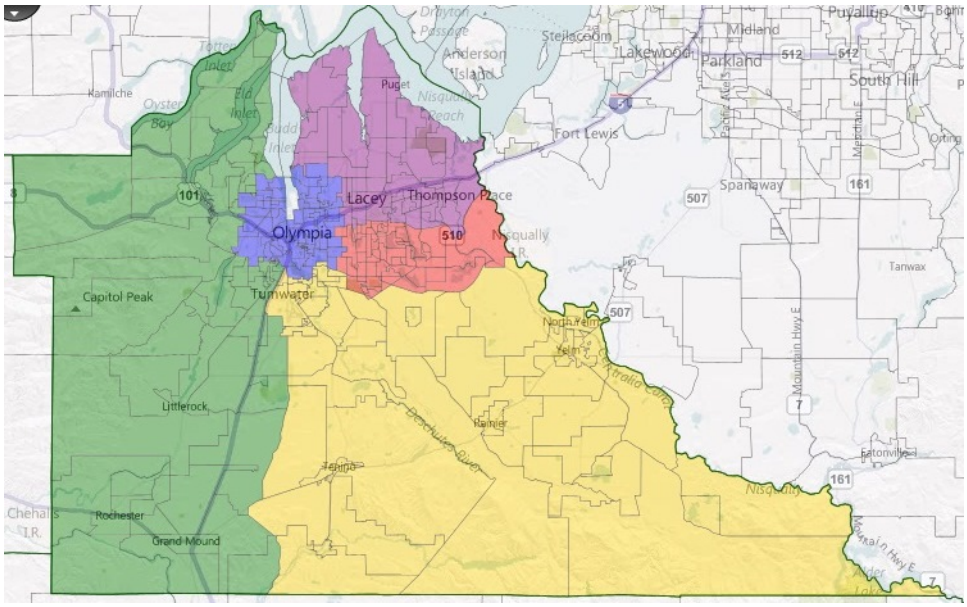


Figure 3. Map of the Project Area – Thurston County Study Area



7.3 Assumptions underlying design

We assume data gathered are representative for that particular UV disinfection unit at that particular time. We also assume any trends or patterns detected in analysis for these data represent real world patterns in Pierce and Thurston County. Percent transmittance, turbidity, conductivity, pH, dissolved oxygen, and temperature measurements can be used as wastewater quality indicators of the UV disinfection unit effluent.

7.4 Relation to objectives and site characteristics

OSSs in Pierce County are not normally designed to provide access for obtaining representative UVD unit effluent samples. Thus, wastewater samples will not be collected in Pierce County. By including OSS in Thurston County, where sampling ports are required for monitoring, we are ensuring that samples can be collected from most all of the examined OSSs in Thurston County.

By measuring fecal coliform concentrations in a representative sample of UVD units in Thurston County, our study will gather data to determine what level of treatment is reached at the effluent of OSS with UVD units. These data will provide insight into the treatment effectiveness under well-enforced maintenance standards. By additionally measuring other water quality parameters and visually assessing the installation and functionality of UVD units, our study will be able to identify the relationships between water quality measures and between proper installation, functioning on UVD units, and microbial load. By evaluating systems in both Thurston and Pierce County, we will be able to compare the prevalence of UVD unit malfunctions under different maintenance programs.

7.5 Characteristics of existing data

No systematic assessment of the status of OSSs with UVD units has been completed in Thurston and Pierce Counties. In Thurston County, some information about effluent quality is available from past sampling results. However, these results have been collected by several different certified monitoring specialists and some variation is likely due to differences in sampling procedures. Additionally, this data is not in an easily accessible format and has not been examined systematically to provide a complete picture of the county as a whole. No data exists about the status of the UVD units themselves. The data gathered in this study will allow for comparisons between installation and maintenance characteristics of the UVD unit and water quality measurements. The study will also collect currently nonexistent data about the status of UVD units in Pierce County. This will allow for conclusions to be made about the reliability of OSSs with ultraviolet disinfection in both counties.

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

Standard Operating Procedures (SOPs) are developed for the field collected parameters and will be used by personnel performing field work for the project (SOPs provided in Appendix C).

Fecal coliform sample collection will be performed according to the procedures specified in the *Standard Operating Procedures for the Collection of Fecal Coliform Bacteria Samples in On-Site Sewage Systems* (Health, 2016). Bacteria grab samples will be collected directly into containers supplied by TCPHSS staff. Samples will be collected from the wastewater stream center of flow whenever possible. Samples will be labeled, transferred to a cooler, placed in crushed or cube ice, and kept between 0°C and 4°C. All samples will be delivered to the TCPHSS Laboratory no later than 6 hours after collection. Analysis will be performed within 8 hours of collection.

8.2 Containers, preservation methods, holding times

An accredited laboratory TCPHSS will provide sterile sample containers. Sample containers, preservations methods, and holding are shown in Table 4.

Table 4. Sample Containers, Preservation and Holding Times

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
Fecal Coliform	Wastewater	100 ml	Sterile, Plastic	Cool, 4^{o} C	$\leq$ 8 hr.
UV % Transmittance	Wastewater	3.5 ml	Sterile, Plastic	None	Immediate
Turbidity	Wastewater	50 ml	Pre-cleaned, Plastic	None	Immediate
pH	Wastewater	20 ml	Pre-cleaned, Plastic	None	Immediate
Dissolved Oxygen	Wastewater	20 ml	Pre-cleaned, Plastic	None	Immediate
Conductivity	Wastewater	20 ml	Pre-cleaned, Plastic	None	Immediate
Water Temperature	Wastewater	20 ml	Pre-cleaned plastic	None	Immediate

8.3 Equipment decontamination

Water sample bottles are sterile per laboratory quality assurance program. They are reusable bottles. When field meters are used, the probe will be rinsed three times with distilled water prior to taking the measurement.

8.4 Sample ID

Specific blind sample IDs are provided for each site. Sample IDs are stored in the REDCap database and noted on the field logs provided to the field staff by the Project Research Assistant. Each sample is tagged with a label that provides the sample ID.

All fecal coliform samples will be identified with a unique number and samples labeled with the following information.

- Sample ID:
- Date: (1/1/17)
- Time of Collection: (09:15)
- Initials of sample collector
- Sample type: (Normal or QC)
- Preservative Method: (Ice)

8.5 Chain-of-custody, if required

Chain of custody will be maintained for all fecal coliform samples collected during the study. The field staff responsible for sample collection will fill out a chain of custody form for each set of samples. If the person transporting the samples is not the field sampler, the chain of custody form will indicate the transfer of samples. The form will be signed and dated for each set of samples delivered to TCPHSS Laboratory. The receiving technician will acknowledge receipt of the samples by signing the chain of custody form and providing a copy of the form to the sample delivery person. Copies of the completed chain of custody forms will be included with all laboratory reports transmitting final analytical results.

8.6 Field log requirements

The field log for this project will consist of an observational checklist containing the primary field data on the condition of each observed UV unit in the field plus the field data log containing the field measurements results.

The pre-specified checklist and field data log will be completed with the REDCap Mobile data collection tool on a Samsung Tab4 tablet. The logs will be filled out for each site visit and stored on the tablet's hard-drive memory. Upon connection with wireless internet, the data logs will be backed up to a secure online server. REDCap is an electronic data collection tool that is provided by the Institute of Translational Health Sciences (ITHS), University of Washington. Backup data sheets will be kept available for cases of technical malfunctions. Examples of the field log sheets are provided in Appendix B.

8.7 Other activities

8.7.1 Health and Safety

Persons involved with OSS monitoring could potentially be subjected to unsafe environments. Hazards include, but are not limited to traffic, slips, trips, falls, heat and cold stress, exposure to chemicals, exposure to UVC light and biological pathogens. Project safety procedures are described in the DOH Wastewater Management Section, Field Safety Manual, and (DOH 337-120) January 2013. This document is available on file and can be made available upon request.

9.0 Measurement Methods

9.1 Field procedures table/field analysis table

Table 5 shows the field and laboratory measurements methods required to meet the goals and objectives of this project. SOPs for the measurement of the field parameters are provided in Appendix C and include calibration procedures.

Table 5. Measurement Methods (field and laboratory)

Analyte	Sample Matrix	Sample Number	Expected Range of Results	Reporting Limit	Sample Prep Method	Analytical (Instrumental Method)
FIELD ANALYSES						
UV % Transmittance	Waste-water	1/site, 27 sites	50 to 80% per cm	0.1 %/cm	None	Real UVT meter
Turbidity	Waste-water	1/site, 27 sites	0 to 50 NTUs	0.1 NTU	None	Nephelometric sensor method EPA 180.1
pH	Waste-water	1/site, 27 sites	5-8 s.u.	0.01 s.u.	None	Glass electrode Method 4500 H B
Dissolved Oxygen (DO)	Waste-water	1/site, 27 sites	0.05-20 mg-DO/L	0.1 mg-DO/L	None	Luminescent Method ASTM D888-09
Conductivity	Waste-water	1/site, 27 sites	20-200 µS/cm	1 µS/cm	None	Conductivity cell Method #2510B
Temperature	Waste-water	1/site, 27 sites	5 - 30º C.	0.1° C.	None	Method 2550B
LABORATORY ANALYSES						
Fecal Coliform [1]	Waste-water	1/site, 27 sites	After UVD unit 1-10^5 cfu/100 ml	1 cfu/100ml	None	APHA Method 9222D

[1] Contract laboratory: TCPHSS Laboratory, 2000 Lakeridge Drive SW, Olympia WA 98502, (360) 867-2631 accredited by Ecology for FC, SM9222 D (m-FC) – 97.

9.2 Lab Procedures Table

DOH will use the services of the TCPHSS Laboratory, a Washington State accredited laboratory. DOH will emphasize quality control and require any internal laboratory problems related to sample analysis of this project to be documented and communicated to the DOH.
DOH may receive testing results from the laboratory via e-mail, or regular mail. The fecal coliform sample method is displayed in Table 5

10.0 Quality Control (QC) Procedures

10.1 Field and lab QC required

Laboratory and field QC procedures are described in Table 6.

Routine laboratory QC procedures will be followed. Total variation of field sampling and laboratory analysis will be assessed by collecting replicate wastewater samples. Fecal coliform samples tend to have a high RPD between replicates compared to other water quality parameters. Bacteria sample precision will be assessed by collecting replicates for 10% of samples in each sampling day. TCPHSS Laboratory routinely duplicates samples analysis in the laboratory to determine laboratory precision. A sterility test will be run on the culture media for positive and negative control cultures each time a new batch is made.

Field sampling and measurements will follow quality control procedures described in DOH SOPs. Sampling will be done in a manner to prevent cross-contamination of samples, especially with respect to fecal coliform. Sampling equipment will be cleaned prior to use. Problems with field quality control will be reported immediately to the Project QA/QC Lead who will determine and implement the proper corrective action.

We will use fresh pH and conductivity standards for field meter calibrations and checks. Luminescent dissolved oxygen calibrations and checks are conducted using DO% water-saturated air. The data received from this quality control sample will be recorded, but not reported with the final assembled data. The results from these special analyses will be used to help ensure proper equipment function.

Accuracy of field measurements is ensured by proper equipment calibration per the SOPs indicated for the project. Equipment manuals and SOPs for field instruments will be followed closely regarding suggested routine and preventive maintenance, and will be checked upon return to office after every sampling period and stored in such a way as to minimize damage between sampling periods. Refer to the SOPs in Appendix A.

Table 6. QC Samples, Types and Frequency

Parameter	Field		Laboratory			
	Blanks	Replicates	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
Fecal Coliform bacteria	N/A	1/10 samples	N/A	N/A	1/10 or 1/batch	N/A
% UV Transmittance	N/A	1/10	N/A	N/A	N/A	N/A
pH	N/A	1/10	N/A	N/A	N/A	N/A
Turbidity	N/A	1/10	N/A	N/A	N/A	N/A
Dissolved Oxygen	N/A	1/10	N/A	N/A	N/A	N/A
Conductivity	N/A	1/10	N/A	N/A	N/A	N/A
Temperature	N/A	1/10	N/A	N/A	N/A	N/A

10.2 Corrective action processes

Field-related activities that could require corrective action include problems with sample collection, field measurements, labeling, and improper entries or missed entries in logbooks. If a problem occurs, the problem will be noted in the field log book. The problem, once identified, will be corrected. If a change in a SOP related to sample collection or handling of a field measurement is needed, the change will be approved by the QA/QC Lead and Project Manager. All corrective actions will be thoroughly documented and discussed in the final report.

Laboratory corrective actions will be taken whenever:

- There is a non-conformance with sample receiving or handling procedures;
- The QA/QC data indicates any analysis is out of the established control limits;
- Audit findings indicate a problem has occurred, and
- Data reporting or calculations are determined to be incorrect.

TCPHSS Laboratory has a corrective action plan as part of the laboratory QA/QC Manual. These procedures will be followed. All corrective actions will be thoroughly documented and reported to the QA/QC Lead. All data impacted by a correction will be so noted and a discussion of the problem and corrective action will be included with the data reported. Options for corrective actions might include:

- Rejecting the results
- Resampling at the UVD unit sites
- Qualifying the results

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

The data being collected during this verification will include both manual and electronic data collection and storage methods. Electronic field notebooks will be maintained to document all activities related to the sampling, field measurements, field observations, and equipment calibrations.

All samples collected in the field will be assigned a specific random sample identification number (ID) that will be used to track and record the data throughout the collection, analysis, and data reported steps. The electronic field data sheets, Chain of Custody forms, and laboratory reports will include the random sample ID, sample date and time, and sampler's name. Laboratory results will be reported in electronic reports showing all results and QA findings for each set of data.

Field data will be compiled within the online REDCap database. On a weekly basis, all data will be downloaded in an EXCEL workbook format, and the laboratory results will be added to the database. Field sheets or field notebooks, Chain of Custody forms, QC sample records, and laboratory reports will be stored on site at DOH.

The field data logs will be checked in the field by the Project Field Lead. The Project Field Lead and Research Assistant will ensure the data sheets are filled in accurately and completely. They will identify and correct any sample identification or field entry errors. The Field Lead will also ensure that holding times have not been exceeded and that the samples were appropriately handled. Any data that has not met these requirements will be removed from the database, and samples will not be submitted to the lab for analysis.

11.2 Lab data package requirements

TCPHSS Laboratory will provide analytical results for all fecal coliform primary and QC samples. The hard-copy data package will be signed by the laboratory manager. The laboratory will also provide the completed chain-of-custody forms and a narrative or cover letter that describes any problems with the analyses, corrective actions, an explanation of any data qualifiers, and all applicable QA/QC documentation. The hard copy and electronic versions of the data package will be archived in the DOH's archives at the close of the project.

11.3 Electronic transfer requirements

As soon as is practical after returning from the field, the Project Research Assistant will check the electronic field data sheets for missing or improbable measurements. The de-identified field-generated data will then be downloaded from the online REDCap database. A complete database that connects the random sample IDs with identifying information (site address, homeowner name, homeowner phone number, and homeowner email address) will be kept under password protection. All electronic data transfers within the REDCap system are compliant with UW's Institutional Review Board requirements for protection of identifying information. For additional

information about the data security ensured by REDCap, see the ITHS REDCap Security Statement and REDCap General Security Overview.

When reviewing the data, data may only be excluded from the final database with the approval of the QA/QC Lead or Project Manager. The EXCEL Workbook file will be labeled "DRAFT" until data verification are competed. The laboratory will provide the analytical results in electronic reports. After receipt of the analytical results, these will be added to the database in EXCEL. Data entry will be checked by the QA/QC Lead against the field notebook data for errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation. Verified data will be moved to a separate file labeled "FINAL".

11.4 Acceptance criteria for existing data

No existing data will be used for this project.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

In lieu of formal project audits, the Project QA/QC Lead will be responsible for day-to-day compliance with this document, including that quality of the data is acceptable and that corrective actions are completed in a timely manner. In addition, the project manager will review the data and metadata in consultation with the Project QA/QC Lead 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. The Project QA/QC Lead and Project research assistant will also review the data and data qualifiers monthly to ensure that obvious analytical problems are addressed.
If the QC objectives for a measurement are not met, an investigation of the difficulties will be conducted, and if necessary, corrective action taken. Data failing to meet any QC objective will be flagged in the final report. As long as the completeness objectives are met with unflagged data, the QC objectives will have been met.

12.2 Responsible personnel

The Project QA/QC Lead will be responsible for ensuring that the quality of the data is acceptable. The Project manager and research assistant will work with the QA/QC Lead to review data throughout the study period.

12.3 Frequency and distribution of report

The final project report will be a document explaining the study design, all types of data collected, and a detailed description of the evaluation procedures and methods, including data analysis. A descriptive and analytical summary of the data will be provided, as well as an explanation of the study findings. No individual data will be provided in this report to protect the identity of study participants. The report will contain a discussion of out-of-control events and any corrective actions taken. De-identified raw data, all QA/QC data sheets, and QA/QC results will be available upon request.

A copy of the draft project report will be sent to the NEP QC for review and comment before finalization.

The final report will be posted on the DOH website at http://www.doh.wa.gov/CommunityandEnvironment/Shellfish/EPAGrants. An electronic version of the report will also be sent directly to study participants who indicate interest in the study findings.

12.4 Responsibility for reports

The Project Research Assistant will be responsible for preparing a final report. The report will be reviewed by TPCHD, TCPHSS, DOH, and NEP QC.

13.0 Data Verification

Data verification is defined as a detailed examination of results, to ensure that quality assurance criteria have been met. This section defines data review, and verification and then presents the methods to be used to verify the data, including the procedures that will be followed if DQOs are not met.

13.1 Field data verification, requirements, and responsibilities

Data verification requires documentation of the data creation and recording process.
All data will be verified to ensure they are representative of the samples analyzed and locations where measurements were made, and that the data and associated quality control (QC) data conform to project specifications. The Project Research Assistant will calibrate equipment and review field data during collection to ensure that all required data has been collected and that parameters measured are characteristic of expected results. Field meter calibration results are done daily by reading the calibration standard and comparing to the calibrated value. If verification is out of the acceptable range, the test cell may need to be cleaned or the instrument recalibrated.

The Project Field Lead will verify initial field data before leaving each sampling site. This process involves checking the electronic field data sheet for errors and omissions. The Project Field Lead will also ensure that sampling and field measurements match QC acceptance criteria and that Standards Operating Procedures (SOPs) are followed. If field measurement data are missing or a measurement is determined to be an outlier, the measurement will be repeated.

The Project QA/QC Lead will review 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. This process includes examining the data and metadata for transcription errors, adherence to specified methods and calibration requirements, proper laboratory documentation, complete chain of custody, and proper formatting and completeness. If the QC objectives for a measurement are not met, an investigation of the difficulties will be conducted, and if necessary, corrective action taken. Data failing to meet any QC objective will be flagged in the final technical report. As long as the completeness objectives are met with unflagged data (completeness $\geq$ 95% unflagged results), the QC objectives will have been met.

13.2 Lab data verification

Laboratory staff will perform the laboratory verification following the lab's standard operating procedures. The laboratory will verify that holding conditions and times are met, and the chain of custody is intact for the samples received. After the laboratory verification, DOH staff will perform a secondary verification of each data package. This secondary verification will entail a review of all parts of the laboratory data package with special attention to laboratory QC results. Lab results will be checked for missing or improbable data. DOH staff will review data to ensure that laboratory analyses fit within the defined MQOs for this project. Staff will bring any discovered issues to the laboratory manager for resolution.

The Project QA/QC Lead will review the laboratory results and determine any limitations on the use of the data and include these limitations in the Final Project Report.

13.3 Validation requirements, if necessary

Not applicable.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

If MQOs have been met, the quality of the data should be useable for meeting project objectives. We will assess the data to determine if they are the right quality and quantity to support the project objectives. This will include an assessment of whether the requirements for representativeness and comparability have been met. The number of valid measurements completed will be compared with those established.

After all laboratory and field data are checked, project staff will examine the entire data package to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. Data that does not meet MQOs will be further evaluated by the Project Manager and QA/QC Lead to determine whether it is still usable by the project. For the purposes of the observational studies, data that are qualified may still be useable for project objectives. If sufficient evidence is found supporting data quality for use in this project, the data will be flagged as appropriate to indicate the cause of the concern it will not be rejected. If data is seriously suspect as to its validity (for example, if the field instrument was malfunctioning), it will be flagged with as "R" meaning "rejected."

14.2 Data analysis and presentation methods

All results, including statistical analysis, will be provided in the final report. Any data that were excluded in statistical analysis will be reported with an explanation as to why they were not included in the analysis. All raw data will be included as an appendix to the final report. The data obtained during the site evaluations will be statistically analyzed, reduced, and presented in tables, graphs and charts. We expect to use statistical analyses to determine correlations between proper installation, operational maintenance, current functioning of UVD units, measured wastewater quality parameters and effluent fecal coliform levels. The statistical methods and any statistical programs used will be described in the final report. A detailed discussion of the results will accompany the tables, graphs and/or charts and will be presented in the final report. Conclusions drawn from the analysis of the test results will be presented in the final report.

14.3 Treatment of non-detects

For data analysis purposes, any non-detect result for a diluted sample (reported as "<" or "less-than" qualifier) will be assigned a FC value of one whole unit less than the reported maximum potential value. For example, if the result is <10 CFU/100 mL, we would use 9 for all calculations. However, if the result is <1 CFU/100 mL, a value of 1 will be used for any calculation.

14.4 Sampling design evaluation

The Project QA/QC Lead will decide whether the data package meets the MQOs, criteria for completeness, representativeness, and comparability, and whether meaningful conclusions can be drawn from the data.

The data also will be evaluated to determine if the sampling design has been adequate and if it needs modification for future use. The sampling design is established in Section 7.0. The aspects to be evaluated include:

- Sampling locations
- The number of samples collected
- Parameters to be determined
- Field measurements collected.

The evaluations will be based on whether or not the study questions were addressed with the data collected using the established sampling design.

14.5 Documentation of assessment

Project assessments will be documented in the final report. The final report will be reviewed by the Project Team, the NEP QC, and then posted on the DOH website at http://www.doh.wa.gov/CommunityandEnvironment/Shellfish/EPAGrants upon completion.

15.0 References

American Public Health Association (APHA) (2012). Standard Methods for the Examination of Water and Wastewater. 22nd ed. E.W. Rice. R.B. Baird, A.D. Eaton, and L.S. Clesceri, eds. APHA-AWWA-WEF, Washington D.C.

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Health, 2016. Standard Operating Procedures for Collection of Fecal Coliform Bacteria Samples in On-Site Sewage Systems.

Health, 2012. Standard Operating Procedures for Measuring Turbidity. A Guide to Field Measurements Using a Handheld Turbidity Meter.

16.0 Figures

17.0 Tables

18.0 Appendices

Appendix A. Glossary, Acronyms, and Abbreviations

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, etc. (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. (i. e. CRM, LCS, etc.) (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 dataset contains data that is misrepresented, falsified, or deliberately misleading. (Kammin, 2010)

Data Quality Indicators (DQI) - Data Quality Indicators (DQIs) are 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) - Data Quality Objectives are 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)

Dataset - 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 dataset. 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
- Dataset 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 dataset for errors or omissions, and assessment of the Data Quality Indicators related to that dataset for compliance with acceptance criteria (MQO's). Verification is a detailed quality review of a dataset. (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)

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 – The term split sample denotes when a discrete sample 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

Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. http://www.ecy.wa.gov/biblio/0403030.html

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Kammin, 2010. Definition developed or extensively edited by William Kammin, 2010.

USGS, 1998. Principles and Practices for Quality Assurance and Quality Control. Open-File Report 98-636. http://ma.water.usgs.gov/fhwa/products/ofr98-636.pdf

Glossary – General Terms

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.

Disinfection, ultraviolet (UV): a process used to inactivate microorganisms in wastewater by irradiating them with ultraviolet light to disrupt their metabolic activity, thus rendering them incapable of reproduction.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Effluent*:* Liquid discharged from an on-site sewage system treatment component.

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 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.

Nephelometric turbidity unit (NTU): Turbidity (or clarity) of water assessed by passing a beam of light through the sample and measuring the scatter of that light.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

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: Such 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 is 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.

Treatment component: A technology that treats sewage in preparation for further treatment and/or dispersal into the soil environment.

Treatment level: One of six levels (A, B, C, D, E, & N) used in these rules to:
(a) Identify treatment component performance demonstrated through requirements specified in WAC 246-272A-0110; and
(b) Match site conditions of vertical separation and soil type with treatment components. Treatment levels used in these rules are not intended to be applied as field compliance standards. Their intended use is for establishing treatment product performance in a product testing setting under established protocols by qualified testing entities.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on effectiveness of UV light for disinfection.

UV disinfection unit: A chamber where exposure to UV light takes place, consisting of an UV lamp, quartz sleeve, and related components of the UV disinfection process including (but not limited to) UV reactor appurtenances, ballast, and control panel. The unit is used to irradiate secondary treated wastewater with UV light for sufficient exposure time and with sufficient intensity to inactivate microorganisms.

UV light: Electromagnetic radiation with wavelength form 20-0 to 400 nm.

UV transmittance (UVT): A measurement of the amount of ultraviolet light (commonly at 254 nm due to its germicidal effect) that passes through a water sample compared to the amount of light that passes through a pure water sample. The measurement is expressed as a percentage, % UVT. As the UV absorbance increases, the UV transmittance decreases.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10% of the data exists and below which 90% of the data exists.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

APHA	American Public Health Association
CFU	Colony Forming Unit
DOH	Washington State Department of Health
DQI	Data quality indicator
DQO	Decision quality objective
e.g.	For example
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
et al.	And others
FC	Fecal coliform
ITHS	Institute of Translational Health Sciences, University of Washington
LHJ	Local health jurisdiction
MDL	Maximum detection limit
MF	Membrane filter
MQO	Measurement quality objective
NEP	National Estuary Program
NIST	National Institute of Standards and Technology
OSS	On-site sewage system
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality Control
RPD	Relative percent difference
SOP	Standard operating procedures
TCPHSS	Thurston County Public Health and Social Services
TPCHD	Tacoma Pierce County Health Department
UV	Ultraviolet
UVD	Ultraviolet disinfection
UVT	UV Transmittance
DEOHS	University of Washington Department of Environmental & Occupational Health Sciences
WAC	Washington Administrative Code

Units of Measurement

°C	degrees centigrade
CFU/100 ml	colony forming units per 100 ml of sample
cm	centimeter
ft	feet
gpm	gallons per minute
mg	milligram
ml	milliliter
mg/L	milligrams per liter (parts per million)
nm	nanometer
NTU	nephelometric turbidity units
s.u.	standard units
uS/cm	microsiemens per centimeter
%/cm	Percent per centimeter @ 254 nm

Appendix B – Field Logs

Operational Checklist: UVD UNIT

OSS Owner's name: _____ Parcel #:_____
Site address: _____
Evaluation completed by: _____
Evaluation completed on: Date: ____ / ____ / ___ Time:_____

1. Control panel: N.A._____
   a. Power On/Off Switch Accessible Yes____No_____
   b. Is enclosure watertight. Yes____No_____
   c. Alarm present Yes____No_____
      If present, operating properly. Yes____No_____
   d. UV unit on an independent circuit breaker Yes____No_____

2. Power supply to UV unit
   a. Protected from electrical power disconnection Yes____No_____
   b. UV lamp 'ON'. Yes____No_____
   c. LED indictor present and easily visible when UV unit on Yes____No_____ N/A___
   d. Splice box lid and cord grips are tight. Yes____No_____
   e. Power cord length from ballast in panel to UV lamp ≤50 ft Yes____No_____ N/A___
   f. Adequate cable slack present to UV lamp Yes____No_____
   g. Electrical system is free of corrosion/damage. Yes____No_____

3. UV housing unit:
   a. Location □ Buried □ Within a tank □ Other: _____
   b. Protected from freezing flooding, debris, damage Yes____No_____
   c. Unit accessible for cleaning and maintenance Yes____No_____
   d. Appears in good condition. Yes____No_____
   e. Leaks/Cracks present. Yes____No_____

4. UV Contact chamber, lamp, and sleeve conditions
   a. Evidence of damage or leakage. Yes____No_____
   b. UV lamp completely enclosed in the protective sleeve Yes____No_____
   c. Sludge buildup at bottom of contact chamber. Yes____No_____
   d. Type of protective sleeve: □ Quartz □ Teflon □ Other: _____
   e. Biofilm and mineral deposit buildup on protective sleeve. None___ Low ___ Medium___ High___

5. Accessibility for field monitoring and sampling
   a. Accessible location to obtain representative effluent sample. Yes____No_____
   b. Fecal coliform samples collected for analyses. Yes____No_____
   c. Flow measurement taken. Yes_____No____ milliliters___/ seconds _____
      converted to _____ gpm (1mL/sec. = 0.0159 gpm)

6. Visual observations of wastewater characteristics at sampling point
   a. Determine wastewater characteristics using the following color rating scale:
      □ Black □ Brown □ Mustard □ Gray □ White □ Other____ □ None
   b. Determine wastewater characteristics using the following turbidity rating scale:
      □ Clear □ Cloudy □ Muddy □ Grainy □ Milky

NOTES

_____
_____
_____
_____

FIELD DATA LOG
UV Disinfection Unit

Site address: _____

Evaluation completed by: _____

Evaluation completed on: Date: ____ / _____ / _____ Time: _____

Ambient Temperature: _____ ºC Barometric Pressure: _____ in Hg

Parameter	Value	Unit	Comments
UV Transmittance		%	
Turbidity		NTU	Calibration Verification
Dissolved Oxygen		mg/L	
pH		units	
Conductivity		µS/cm	
Temperature		ºC	

Other notes (weather conditions, wastewater characteristics that may compromise treatment):

_____
_____
_____
_____
_____
_____
_____

Appendix C – SOPs

www.doh.wa.gov/CommunityandEnvironment/Shellfish/EPAGrants/UltravioletDisinfection