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Addendum 2 to Quality Assurance Project Plan

French Creek and Pilchuck River Temperature, Dissolved Oxygen, and pH Total Maximum Daily Load

August 2016

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Publication Information

Addendum

This addendum is on the Department of Ecology's website at
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This addendum is an addition to an original Quality Assurance Project Plan. It is not a correction (errata) to the original plan.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search Study ID TSWA0004.

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Author and Contact Information

Nuri Mathieu
Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

For more information contact: Communications Consultant, phone 360-407-6834.

Addendum 2 to
Quality Assurance Project Plan

French Creek and Pilchuck River Temperature, Dissolved Oxygen, and pH Total Maximum Daily Load

August 2016

Approved by:

Signature:	Date: August 2016
Ralph Svrjcek, Client, WQP, Northwest Regional Office	
Signature:	Date: August 2016
Kevin Fitzpatrick, Client's Section Manager, WQP, Northwest Regional Office	
Signature:	Date: August 2016
Nuri Mathieu, Author / Project Manager and Principal Investigator, EAP	
Signature:	Date: August 2016
Cristiana Figueroa-Kaminsky, Author's Unit Supervisor, EAP	
Signature:	Date: August 2016
Dale Norton, Author's Section Manager, EAP	
Signature:	Date: August 2016
Bill Kammin, Ecology Quality Assurance Officer	

Signatures are not available on the Internet version.
EAP: Environmental Assessment Program
WQP: Water Quality Program

Table of Contents

Note: All required sections not included in this addendum are discussed in the original QAPP (Swanson et al., 2012).

3.0 Background

Tetra Tech, a consulting and engineering firm, was contracted by EPA to develop the initial Quality Assurance Project Plan (QAPP) for the French Creek and Pilchuck River Temperature, Dissolved Oxygen, and pH TMDL Study (Swanson et al., 2012). At Tetra Tech and EPA's request, Ecology helped develop the QAPP. In addition, they were to perform the analysis and modeling for the study. Ecology was tasked with collecting the data outlined in a QAPP (Swanson et al., 2012). Ecology collected the field data in the summer of 2012. Tetra Tech was unable to perform the analysis due to a lack of continued funding, and the modeling/analysis work was transferred to Ecology's Environmental Assessment Program in 2013.

Upon initial data review, Ecology determined that the level of channel geometry data for Pilchuck River, as well as flow data and groundwater information, was insufficient to set up a QUAL2Kw model of acceptable quality to meet the project goals. Ecology led 3 weeks of sampling efforts in the summer of 2014 to meet this need (Mathieu, 2014). Ecology used the new and original data to develop and calibrate a temperature model for the Pilchuck River.

Ecology began calibrating the model for DO, pH, and nutrients in 2016. These initial calibration attempts yielded a couple of important findings including:

- The model is sensitive to several variables (groundwater nutrients and pH, Granite Falls WWTP nutrients).
- The model predicts pH above water quality criteria and rapid uptake of nutrients downstream of the Granite Falls WWTP (Figure 3).

The original 2012 QAPP inadequately addressed the influence of groundwater and the Granite Falls WWTP on the Pilchuck River. This QAPP addendum describes supplemental sampling activities to be conducted in 2016 that are necessary to meet the original project objectives.

4.0 Project Description

Management actions in response to this TMDL study may include efforts to reduce nutrient loading in the Pilchuck River watershed. As such, nutrient loading must be adequately characterized to support these actions.

In addition, diel fluctuations in DO and pH must be adequately characterized spatially along the length of the river, in order to provide a meaningful representation of the physical and biological processes affecting these parameters.

This project is designed to address these two needs.

4.1 2012 project goal

The goal of the TMDL study is to evaluate compliance with state water quality standards for temperature, DO, and pH in the French Creek and Pilchuck River watersheds and to support development of a Water Quality Improvement Report and Implementation Plan.

4.2 Project objectives

New 2016 objective

1. Characterize the influence of significant point sources on processes governing DO and pH in the Pilchuck River.

Relevant 2012 project objectives

2. Characterize processes governing DO and pH in French Creek and the Pilchuck River and major tributaries, including the influence of tributaries, nonpoint sources, and **groundwater**.
3. Develop a model to simulate watershed processes, instream biochemical processes and productivity, dissolved oxygen, and pH in French Creek and the Pilchuck River and major tributaries. Using critical conditions in the model, determine the capacity to assimilate **biochemical oxygen demand** and nutrients.

4.3 Information needed and sources

Sufficient information is needed about the influence of groundwater and the Granite Falls WWTP on DO and pH in the Pilchuck River. As an example, figures 1 and 2 depict the resolution of the 2012 data collection for pH and inorganic phosphorus. New data generated by this project will greatly increase the resolution of these and other parameters, as well as add groundwater sampling.

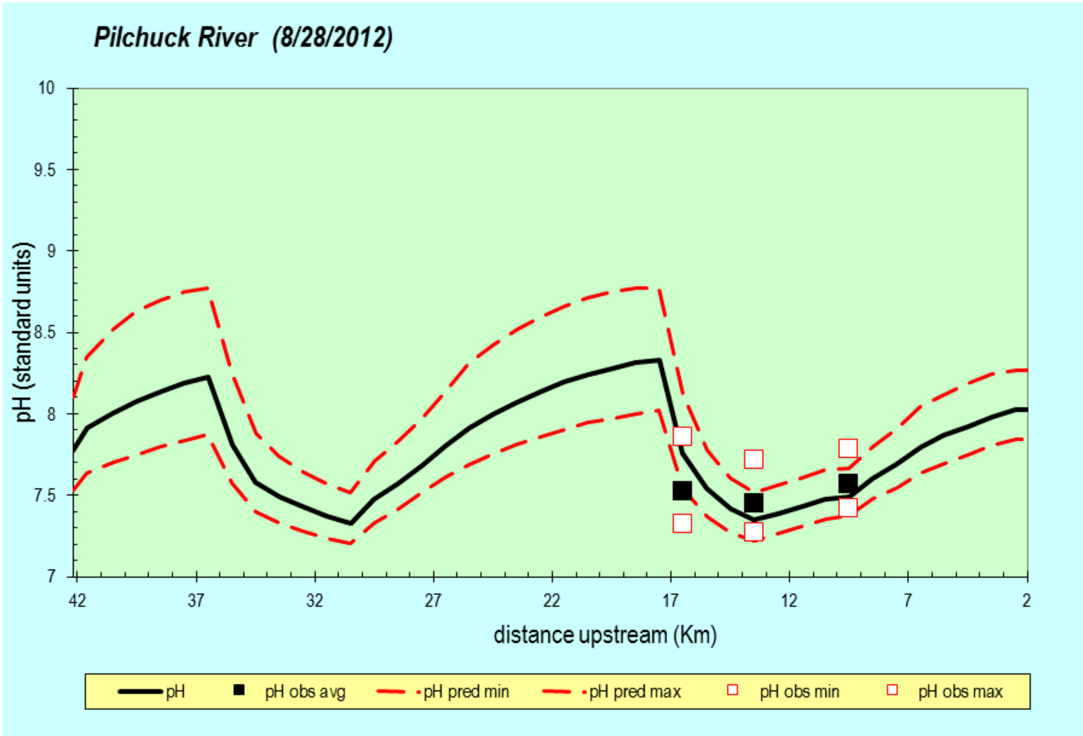

Figure 1. Exploratory model predicted pH vs observed 2012 data. Depicts lack of data in areas of potentially high pH. NOTE: final model calibration results may vary significantly.

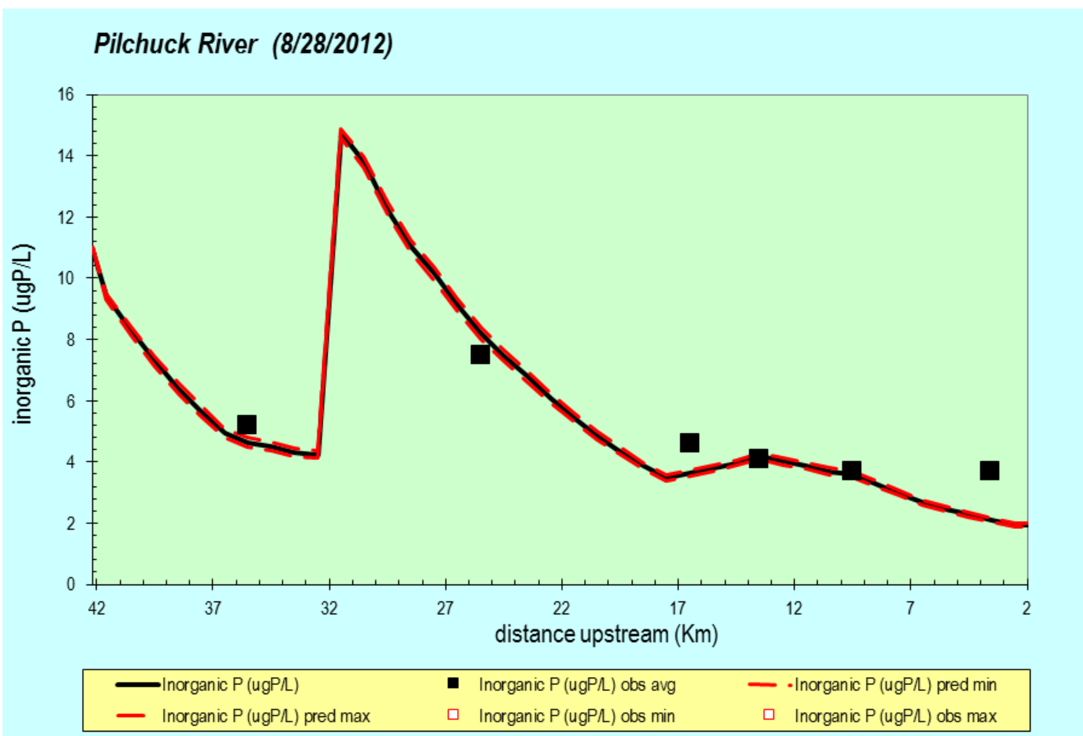

Figure 2. Exploratory model predicted inorganic phosphorus vs observed data. Depicts lack of phosphorus data downstream of Granite Falls WWTP at ~KM 32. NOTE: final model calibration results may vary significantly.

4.4 Tasks required

In order to meet the project goals and objectives listed above, the following data collection and analysis activities will be performed in 2016.

1. **Tasks required to accomplish Objective #1 (characterize influence of point sources on DO and pH)**
   a) Obtain aliquots of routine composite samples collected at the Granite Falls WWTP and send to Manchester Environmental Laboratory (MEL) for nutrient and alkalinity analysis.
   b) Measure/sample above and below Granite Falls WWTP (see task 2f).
   c) Deploy sondes above and below Granite Falls WWTP (see task 2d).

2. **Tasks required to accomplish Objective #2 (characterize processes governing DO and pH; influence of groundwater)**
   a) Install piezometers at approximately 12 locations on the mainstem Pilchuck River.
   b) Measure water levels and water quality in piezometers.
   c) Sample alkalinity and nutrients in piezometers. *Note: No groundwater data were collected in the 2012 study*.
   d) Deploy multi-probe sondes to collect continuous diel data (15 minute intervals) for temperature, pH, DO, rhodamine WT, and specific conductance at ~2 mile intervals along the river.
   e) Release and measure rhodamine WT dye to accurately estimate time of travel and pollutant dispersion in the river.
   f) Measure water quality parameters and sample for alkalinity, biochemical oxygen demand - 5-day test (BOD5), and nutrients at ~2 mile intervals along the river.

3. **Tasks required to accomplish Objective #3 (model biochemical processes, productivity, DO, and pH; determine capacity to assimilate BOD and nutrients)**
   a) Confirm channel geometry and pollutant dispersion in model using time of travel data (task 2e).
   b) Use groundwater and treatment plant data collected in 2016 (tasks 1a, 1b, 2b, and 2c) to refine input data to the existing QUAL2Kw model.
   c) Use diel DO and pH data to refine calibration of existing model (task 2d).
   d) Use BOD5 data (task 2f) to determine the capacity to assimilate BOD. *Note: BOD data not collected in the 2012 study.*

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 1 lists the Ecology staff involved in this project, as well as corresponding titles and responsibilities.

Table 1. Organization of project staff and responsibilities.

Staff (All EAP except client)	Title	Responsibilities
Ralph Svrjcek Water Quality Program Northwest Regional Office Phone: 425-649-7165	EAP Client	Clarifies scope of the additional work. Provides internal review and final approval of the addendum.
Christopher Martin Water Quality Program Northwest Regional Office Phone: 425-649-7110	Licensed Hydrogeologist	Provides oversight for installation, development, and sampling of shallow in-stream piezometers.
Nuri Mathieu Modeling and TMDL Unit Western Operations Section Phone: 360-407-7359	Project Manager and Principal Investigator	Writes the addendum. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the draft and final reports.
Cristiana Figueroa-Kaminsky Modeling and TMDL Unit Western Operations Section Phone: 360-407-7392	Unit Supervisor for the Project Manager	Provides internal review and final approval of the addendum and approves the budget.
Dale Norton Western Operations Section Phone: 360-407-6596	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, and provides internal review and final approval of the addendum.
Joel Bird Manchester Environmental Laboratory Phone: 360-871-8801	Director	Reviews and approves the final addendum.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Provides review and final approval of the addendum.

5.4 Proposed project schedule

Table 2 contains the proposed project schedule.

Table 2. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	September 2016	Nuri Mathieu
Environmental Information System (EIM) database		
EIM Study ID	TSWA0004	
Product	Due date	Lead staff
EIM data loaded	April 2017	Nuri Mathieu
EIM quality assurance	May 2017	TBD
EIM complete	June 2017	Nuri Mathieu
Final report		
Author lead / support staff	Nuri Mathieu	
Schedule[1]		
Draft due to supervisor	February 2017	
Draft due to client/peer reviewer	March 2017	
Draft due to external reviewer(s)	April 2017	
Final (all reviews done) due to EAP publications coordinator	May 2017	
Final report due to WQP publications coordinator	June 2017	

[1] Represents the schedule for the final TMDL technical report. The 2016 results will be incorporated into the originally planned TMDL report.

5.5 Budget and funding

Table 3 contains the proposed lab budget for the 2016 sampling effort.

Table 3. Proposed lab budget for 2016 sampling.

Parameter/analysis	Sites	Replicates	Field Blanks	Total Samples	$/ sample	Sub-total
Surface water						
Alkalinity	6	1	1	8	$ 18	$147
BOD5	8	1	1	10	$ 60	$596
Total Persulfate Nitrogen	12	2	1	15	$ 18	$276
Ammonia	12	2	1	15	$ 14	$211
Nitrite/Nitrate	12	2	1	15	$ 14	$211
Orthophosphate	12	2	1	15	$ 16	$244
Total Phosphorus	12	2	1	15	$ 20	$293
					Surface water Sub-total =	$1,979
Groundwater						
Alkalinity	16	2	2	20	$ 18	$369
Total Persulfate Nitrogen	16	2	2	20	$ 18	$369
Ammonia	16	2	2	20	$ 14	$282
Nitrite/Nitrate	16	2	2	20	$ 14	$282
Orthophosphate	16	2	2	20	$ 16	$325
Total Phosphorus	16	2	2	20	$ 20	$390
					Groundwater Sub-total =	$2,016
					Total =	**$3,995**

6.0 Measurement Quality Objectives

Measurement quality objectives (MQOs) are described for the majority of parameters in the original QAPP with the exception of BOD5, which was not sampled in the original study, and water level, and Rhodamine WT. MQOs for BOD5 are included in Table 4 and for groundwater level and Rhodamine WT in Table 5.

Table 4. Measurement quality objectives for Biochemical Oxygen Demand - 5-day test (BOD5).

Analysis	Method	Lab Blank Limit	Check Standard (% recovery limits)	Matrix Spikes (% recovery limits)	Precision – Lab Duplicates (RPD)	Precision – Field Duplicates (median)[1]
BOD5	SM5210B	<0.2 mg/L	85-115%	n/a	20%	25% RSD

[1] Reporting limit may vary depending on dilution.

Table 5. Measurement Quality Objectives for groundwater level and Rhodamine WT.

Parameter	Equipment/ method	Precision-Field duplicates (median)	Equipment Accuracy	Equipment Resolution
Groundwater Level	Electric/ Steel Tape	± 0.01 ft	± 0.01 ft	0.01 ft
Rhodamine WT	Fluorometer	n/a	± 3%[1]	0.01 ppb

[1] For signal level equivalents of 1 ppb rhodamine WT dye or higher using a rhodamine sensor.

7.0 Study Design

In general, the 2016 data collection will involve:

- One synoptic survey to characterize nutrients and diel water quality on the mainstem Pilchuck River at a better spatial resolution (compared to the 2012 study).
- Composite samples from the Granite Falls WWTP during the synoptic survey.
- Groundwater nutrient sampling and water quality measurements.
- Time of travel studies to determine reach-specific velocities and pollutant dispersion.

Ecology plans to accomplish this field work with the following sampling events:

- Late July – Piezometer installation (One ~12 hour field day).
- Mid-August – Synoptic survey and piezometer sampling (One ~50 hour field week).
- Early to Mid-September – Piezometer removal/sampling (One ~12 hour field day).

7.2 Field data collection

7.2.1 Sampling location and frequency

Figure 3 depicts proposed sampling locations within the TMDL study area. Table 6 includes location names, descriptions, and frequency of samples. Locations may change based on accessibility and channel conditions in 2016. Piezometer locations are subject to change based on water levels at the time of installation and suitability of substrates. Sampled locations will be documented in the final report.

7.2.2 Field parameters and laboratory analytes to be measured

Parameters to be measured and analyzed during the 2016 sampling effort include:

- For groundwater
  - Samples analyzed for alkalinity, ammonia, nitrite-nitrate, total persulfate nitrogen, orthophosphate, and total phosphorus.
  - Measurements of water level, temperature, DO, pH, and specific conductance.
  - Continuous temperature measurements at the bottom of each piezometer.
- For surface water
  - Samples analyzed for alkalinity, ammonia, BOD5, nitrite-nitrate, total persulfate nitrogen, orthophosphate, and total phosphorus.
  - Continuous and discrete measurements of temperature, DO, pH, specific conductance, and rhodamine WT.

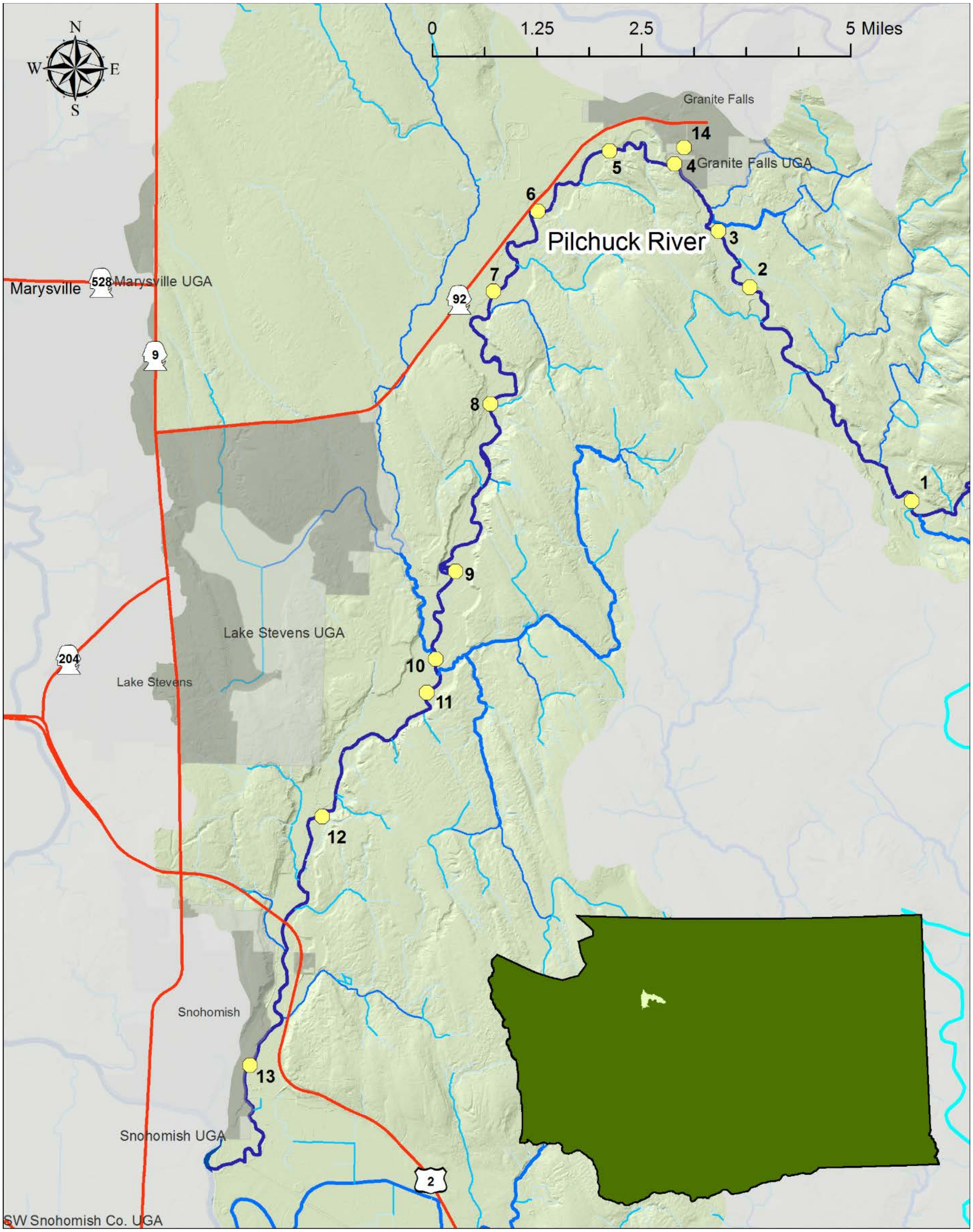

Figure 3. Proposed sampling locations for the 2016 study.

Table 6. Sampling locations and frequency for the 2016 study.

Station ID	Map #	Continuous Sonde Deployment	Surface water-Nutrients	Surface water-Alkalinity	BOD5	Piezometer – Water level	Piezo - Nutrients	Piezo - Continuous Temperature	Piezo - One Day	Time of Travel (Rhodamine WT)	Description
Mainstem Sites											
07-PIL-25.5	1	3d	1X	1X	1X						Pilchuck River at Menzel Lake Rd
07-PIL-21.5	2	3d				3X	1X	8wk		3d	Pilchuck River at Robe-Menzel Rd
*RM 21 to 19	3		1X						1X		TBD on Pilchuck River between RM 21 and 19 during August float
~RM 19	4	3d	1X	1X	1X	3X	2X	8wk		3d	Pilchuck River immediately upstream of Granite Falls WWTP outfall
~RM 18	5		1X		1X				1X		Pilchuck River ~1 mile below Granite Falls WWTP outfall
*RM 18 to 15	6		1X						1X		TBD on Pilchuck River between RM 18 and 15 during August float
10-PIL-15.1	7	3d	1X	1X	1X	3X	2X	8wk		3d	Pilchuck River at 64th St NE
~RM 13 to 12	8		1X						1X		TBD on Pilchuck River between RM 13 and 12 during August float
10-PIL-10.4	9	3d	1X	1X	1X	3X	1X	8wk		3d	Pilchuck River at Russel Rd
10-PIL-8.6	10	3d	1X			3X	2X	8wk			Pilchuck River upstream of Little Pilchuck
10-PIL-8.3	11	3d	1X		1X	3X	1X	8wk		3d	Pilchuck River downstream of OK Mill Rd
10-PIL-5.7	12	3d	1X	1X	1X	3X	2X	8wk			Pilchuck River at Dubuque Rd
10-PIL-2.0	13	3d	1X	1X	1X	3X	1X	8wk		3d	Pilchuck R at 86th / 6th St
Point source sites											
10-GRA-WWTP	13	72hr	2C	2C	2C*						Granite Falls WWTP effluent immediately after treatment at plant

d: days of continuous sonde measurements
wk: weeks of continuous temperature measurements
#X: the number of discrete samples
#C: the number of composite samples
* denotes parameter analyzed by WWTP

7.2.3 Groundwater data

Where site conditions allow[1], instream piezometers will be installed at 8 car-accessible sites in July and 4 float-accessible sites in August to monitor surface-water and groundwater head relationships, water quality, and streambed water temperatures (Figure 4). For float-accessible sites, piezometers will be installed, developed, sampled, and removed within the same site visit.

In general, Ecology will install piezometers that are 5-foot by 1.5-inch galvanized pipes that are crimped and perforated at the bottom. At float-accessible locations, 0.5" or 1" diameter pipes may be installed, as these will not need to be instrumented for temperature. Following installation, the piezometers will be developed using standard surge and pump techniques to assure a good hydraulic connection with the streambed sediments.

Each piezometer will be instrumented with up to three thermistors for continuous monitoring of streambed water temperatures (Figure 4). In a typical installation, one thermistor will be located near the bottom of the piezometer, one at a depth of approximately 0.5 feet below the streambed, and one will be located roughly equidistant between the upper and lower thermistors.

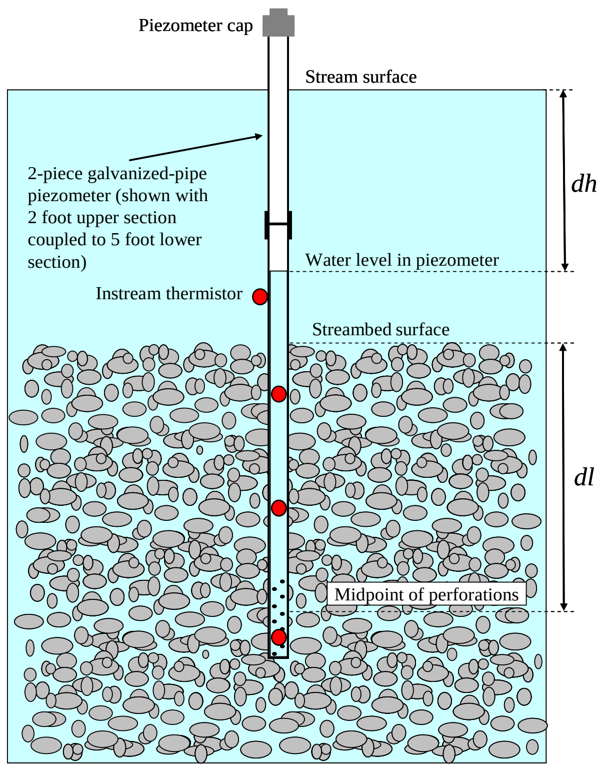

Figure 4. Instream piezometer conceptual diagram (diagram not to scale).

[1] Piezometer installation may not be possible at some sites due to the presence of near-surface bedrock or consolidated streambed sediments.

Surface-water stage and instream piezometer water levels will be measured using a calibrated electric well probe, steel tape, or a manometer board (as appropriate). The water level (head) difference between the piezometer and the river provides an indication of the vertical hydraulic gradient (VHG) and the direction of flow between the river and groundwater. When the piezometer head exceeds the river stage, groundwater discharge into the river can be inferred. Similarly, when the river stage exceeds the head in the piezometer, loss of water from the river to groundwater storage can be inferred.

Field staff will conduct two groundwater survey events, one in August and one in September, which will include samples for alkalinity and nutrients (gaining only), water level/VHG measurements, and water quality sonde measurements. All 12 piezometers will be sampled in August and 4 piezometers (to be determined) will be re-sampled in September. All piezometers will be removed after final measurements and/or samples are collected in September.

7.2.4 Time of travel to determine average stream velocities

Travel times will be estimated along the Pilchuck River to further understand how water and pollutants move through the system and to calibrate the model. Time-of-travel studies will use fluorescent dye (20% Rhodamine WT) to trace the movement of a dye cloud from an upstream point to a downstream point and calculate the average velocity of that body of water. Rhodamine WT dye is used by Ecology, the USGS, and others to provide safe and effective time-of-travel measurements. The methods and protocols used in this survey will follow those prescribed by Carroll (2012) and Kilpatrick and Wilson (1982).

Field measurements of dye concentration in the stream will be made using a Hydrolab DataSonde® equipped with a rhodamine fluorometer, recording measurements every 5-10 minutes at key locations downstream from the initial point of dye release. Over a period of time in the stream, the dye will dissipate, becoming visually undetectable.

Ecology will notify the appropriate officials and local emergency contacts before injecting the dye. Announcing the dye studies will prevent unnecessary emergency actions in the event a spills complaint is submitted (i.e., someone calls the sheriff or Ecology spills hotline because the river just turned red/pink).

8.0 Field Procedures

8.2 Measurement and sampling procedures

The measurement and sampling procedures will follow those outlined in the 2012 QAPP with the addition of the following procedures relevant to groundwater and time of travel data collection:

- EAP061 - Installing, Monitoring, and Decommissioning Hand-driven In-water Piezometers (Sinclair and Pitz, 2016).
- EAP037 - Time of Travel Studies in Freshwater using a Dye Tracer (Carroll, 2012).
- Aliquots of routine composite samples will be collected at the Granite Falls WWTP by treatment plant operations staff following standard internal procedures and requirements outlined in their NPDES permit.

Table 7. Measurement procedures and equipment specifications.

Parameter	Matrix	Equipment Range[1]	Expected Range of Results	Method	Method Detection Limit
Water level	Water	0 to 300 ft	0-5 feet	E-tape, steel tape, or transducer	0.01 feet
Rhodamine WT	Water	**Low sensitivity:** 0.04 - 1000 ppb **Med. sensitivity:** 0.04 to 100 ppb **High sensitivity:** 0.04 to 10 ppb	0-50 ppb	SOP EAP037	0.04 ppb

[1] Rhodamine WT sensors will be set at medium sensitivity.

8.3 Containers, preservation methods, holding times

Field staff will collect BOD5 grab samples directly into new 1-gallon cubitainers supplied by MEL. Table 8 lists the containers, volumes, preservation requirements, and holding times. Field staff will store samples for laboratory analysis on ice and deliver to MEL within 24 hours of collection via either the Ecology courier, overnight shipping, or direct drop-off after sampling. WWTP composite samples will be picked up from treatment plant by Ecology staff and delivered to MEL within 24 hours of end of the compositing period.

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

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
Biochemical Oxygen Demand- 5-day test (BOD5)	Water	2,000 mL	1 gallon cubitainer	Cool to ≤6°C; keep in dark.	48 hours

9.0 Laboratory Procedures

9.1 Lab procedures table

Table 9 contains details for the selected BOD5 analytical method.

Table 9. Laboratory measurement/analytical methods.

Analyte	Sample Matrix	Number of Samples	Expected Range of Results	Reporting Limit	Sample Prep Method	Analytical (Instrumental) Method
BOD5	Water	10	2-200 mg/L	2 mg/L[1]	n/a	SM5210B

[1] May vary depending on dilution.

10.0 Quality Control Procedures

Ecology will adhere to all quality control procedures outlined in the original QAPP (Swanson et. al., 2012). Likewise, Ecology will use the measurement quality objectives defined in the original QAPP to assess quality/usability of the collected data.

The original QAPP discusses quality procedures for all parameters that will be collected during the 2016 study, with the exception of BOD5, water level, and Rhodamine WT. Table 8 contains the types and frequency of quality control samples for these parameters.

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

Parameter	Field		Laboratory			
	Blanks	Replicates	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
BOD5	10%	10%	1/batch	1/batch	1/batch	1/batch
Water level	n/a	10%	n/a	n/a	n/a	n/a
Rhodamine WT	100%[1]	n/a	n/a	n/a	n/a	n/a

[1] Each Rhodamine WT sensor will be placed in DI water upon retrieval in the field and the value recorded.

Rhodamine WT sensors are tested and factory-calibrated by the manufacturer at least once every two years. In addition sensors will be calibrated to a prepared Rhodamine WT standard of 50 ppb. All sensors will be calibrated with the same batch of standard to improve consistency in results between sites.

15.0 References

Carroll, J., 2012. Standard Operating Procedures for Time-of-Travel Studies in Freshwater using a Dye Tracer, Version 2.0. Washington State Department of Ecology, Olympia, WA. SOP Number EAP037. www.ecy.wa.gov/programs/eap/quality.html

Kilpatrick, F.A. and J.F. Wilson Jr., 1982. Measurement of Time-Of-Travel in Streams by Dye Tracing. U.S. Geological Survey. Techniques of Water-Resources Investigations, Book 3, Chapter A9.

Mathieu, N., 2014. Addendum to Quality Assurance Project Plan: French Creek and Pilchuck River Temperature, Dissolved Oxygen, and pH Total Maximum Daily Load. Washington State Department of Ecology, Olympia, WA. Publication No. 14-03-112. https://fortress.wa.gov/ecy/publications/SummaryPages/1403112.html

Sinclair, K. and C. Pitz, 2016. Standard Operating Procedures for Installing, Monitoring, and Decommissioning Hand-driven In-water Piezometers, Version 2.1. Washington State Department of Ecology, Olympia, WA. SOP Number EAP061. www.ecy.wa.gov/programs/eap/quality.html

Swanson, T., A. King, N. Gurdian, and J. Zhen, 2012. French Creek and Pilchuck River Temperature, Dissolved Oxygen, and pH Total Maximum Daily Load Water Quality Study Design (Quality Assurance Project Plan). Washington State Department of Ecology, Olympia, WA. Publication No. 12-03-114. https://fortress.wa.gov/ecy/publications/SummaryPages/1203114.html