DEPARTMENT OF ECOLOGY
State of Washington

Addendum 1 to Quality Assurance Project Plan

Deep Lake (Stevens County) Monitoring

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Addendum

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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 JROS0024.

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Addendum 1 to
Quality Assurance Project Plan

Deep Lake (Stevens County) Monitoring

August 2016

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EAP: Environmental Assessment Program
ERO: Eastern Regional Office

1.0 Table of Contents

List of Figures and Tables

Page

Figures

Tables

2.0 Abstract

This addendum to the 2014 Deep Lake (Stevens County) Monitoring Quality Assurance Project Plan provides details about sampling locations, parameters, and sampling/ analysis schedules for the 2017-2018 extended monitoring of Deep Lake. Substantial changes from the original sampling plan will be changing the focus from being lake-centered to moving into the upstream creeks that supply water to the lake. Five new locations will be sampled, along with one site from the original study to be revisited at the lake's inlet.

A two-year study will assess water quality as well as pollutant loading to the lake. Parameters to be monitored will include zinc, fecal coliform, chloride, total suspended solids, ammonia, nitrite-nitrate nitrogen, total persulfate nitrogen, ortho-phosphorus, total phosphorus, pH, dissolved oxygen, conductivity, temperature, and streamflow.

3.0 Background

Deep Lake is located approximately 10 miles southeast of Northport, Washington, in Stevens County (Figure 1). The lake is located in Water Resource Inventory Area (WRIA) 61 (Upper Lake Roosevelt), and level 8 HUC 17020001 (Franklin D. Roosevelt Lake). It has a surface area of 0.32 square miles and a maximum depth of about 45 feet.

The lake is located along North Fork Deep Creek, which drains a mostly forested area along the western slope of a north-south range of the western Rocky Mountains. North Fork Deep Creek flows into Deep Lake at the north end of the lake, and flows out at the south end. From the outlet of Deep Lake, the creek flows southwest to join with South Fork Deep Creek, forming Deep Creek, which empties to Lake Roosevelt near Northport.

Much of Deep Lake is surrounded by residential development including vacation homes. The surrounding landscape is primarily forestland. For about four miles upstream of Deep Lake, North Fork Deep Creek flows along a fairly level valley bottom, which is dominated by livestock grazing for a part of the year. The Anderson-Calhoun Mine, an open pit mine which formerly produced lead and zinc, is located along North Fork Deep Creek, about four miles upstream of Deep Lake.

Local residents have expressed a desire for monitoring of the lake. Potential sources of nutrients, fecal coliform, and sediment include upstream livestock activities as well as possible residential sources adjacent to the lake. The focus of this study will be to expand on the previous lake study and help to clarify the source of some issues found in the Deep Lake study. The list below is of the water quality issues found from the lake study that will be addressed by this additional study.

- Elevated fecal coliform and total suspended solids in the inlet stream to lake.
- Significant sediment trapping from the lake.
- Anoxia in the hypolimnion during summer months.
- Increased frequency of algal blooms in lake.

During the 4/22/16 Eastern Operations Program Management team meeting, the conditions and past results for Deep Lake studies were discussed. In this meeting management determined that further investigation should be performed to better understand the source of the issues found during the Deep Lake Study. They then decided that the following items were to be considered as options for further study:

1. Add an additional ambient station higher up in the watershed on North Fork Deep Creek to determine fecal, nutrient, and sediment contribution of livestock grazing.
    - Limitations: access, increased lab budget, increased personnel time.
2. Add additional monitoring sites on tributaries such as Silver Creek, Republican Creek, McKinnon Creek, Sherlock Creek, and O'Hare Creek to better bracket pollutant contributions from livestock and wildlife. This may identify major sources and impacted areas.
    - Limitations: access, lab budget, increased personnel time.

3. Take flow data at all monitoring sites to complete a loading analysis (minus groundwater input) for the watershed below the upper ambient station.
    - Limitations: increased personnel time.

4. Sample for zinc to assess if levels in North Fork Deep Creek could affect algal blooms.

From these options Ecology has decided to go forward with addressing three of the four items that were listed. It was found that the practicality and funding for adding an additional ambient site was not feasible. The sample sites chosen in this plan will give us the necessary information we need to understand the loading that is occurring in the inlet creek without our placing an additional ambient sample site.

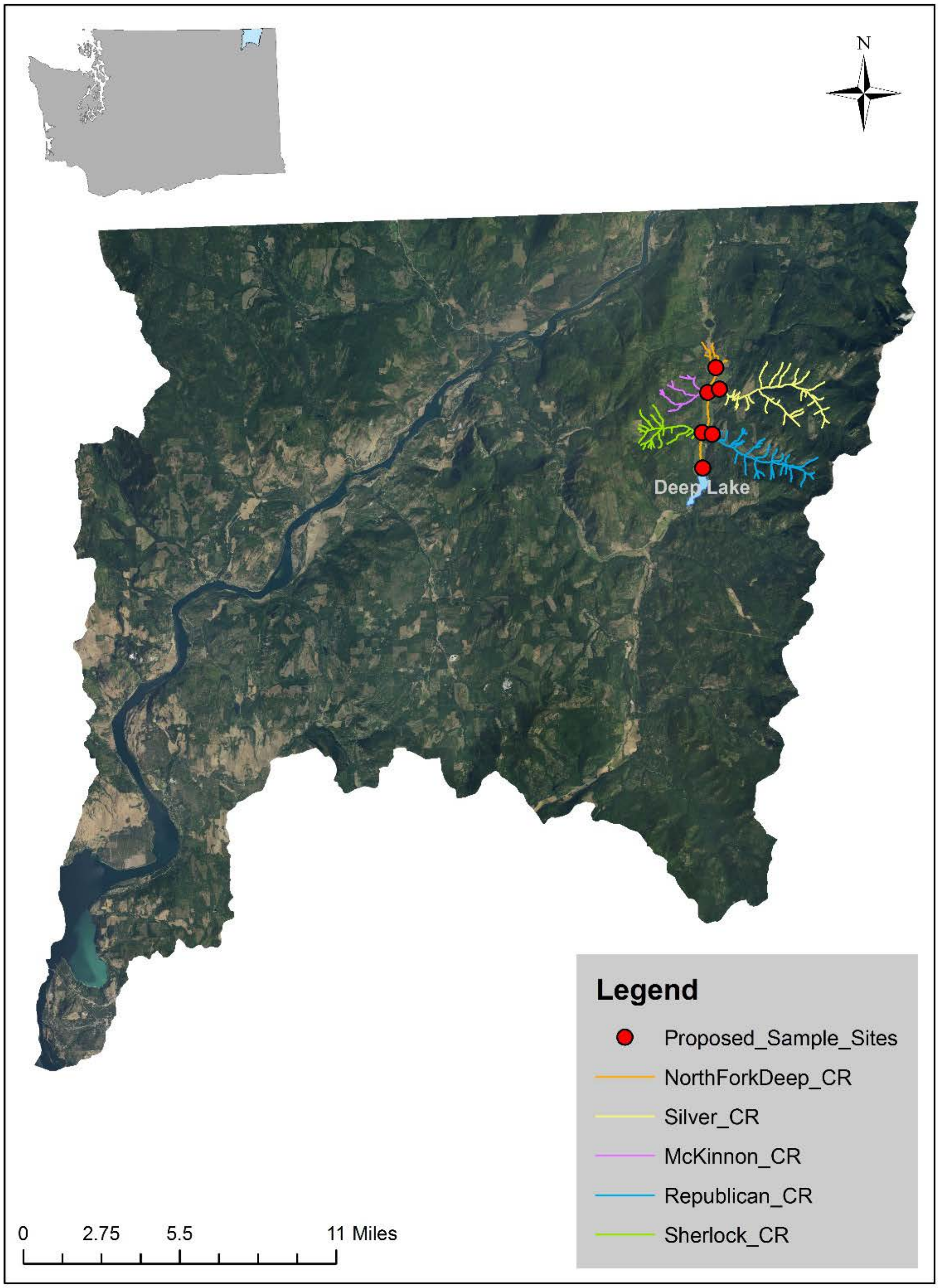

Figure 1: Water Resource Inventory Area 61. Stevens County, WA.

4.0 Project Description

The original Deep Lake study resulted from a desire for lake monitoring by local residents at Deep Lake. This follow-up study will help to address more completely the issues facing Deep Lake. Due to the local interest from landowners, we will continue to work closely with interested parties. We will continue to strive for a transparency when dealing with this study and its stakeholders. Throughout this study we will continue to communicate our findings to interested parties and encourage community involvement. Local residents will be given the opportunity to:

- Accompany Ecology field crews during monitoring events, allowing them to learn and practice monitoring techniques.
- Visually check for signs of blue-green algae blooms, and if a bloom appears to be occurring, take a sample for algal toxin analysis. This can be accomplished through Ecology's Freshwater Algae Control Program: http://www.ecy.wa.gov/programs/wq/plants/algae/monitoring/index.html with project staff helping to make sure that residents have the necessary sampling kits/containers on hand.
- Conduct independent monitoring studies in 2014 and/or thereafter. Such monitoring would be the responsibility of the involved residents and would be outside of Ecology's purview. However, Ecology staff would be available to advise and review data if residents so desire.

4.1 Goals and Objectives

The goals of this project are to:

- Provide water quality data for water entering Deep Lake to help support findings from the previous lake study.
- Assess zinc, fecal coliform, suspended solids, and pollutants entering Deep Lake and identify its source.

These goals will be served by meeting the following objectives:

- Monthly water quality sampling May through October of 2017 and 2018.
- Addition of five new sampling sites to target source of water quality issues found from previous lake study.
- Compare data from input streams to data collected in the previous lake study.

The overall objectives of understanding the water quality issues in Deep Lake have not changed. The concerns raised by local citizens over Deep Lake were mostly addressed with the original lake study. With the addition of five new sample sites, we will be better informed in assessing the issues uncovered in the original lake study and the possible source of the issues. We will be expanding our study into the upper watershed in an attempt to identify the source of the lake issues of elevated fecal coliform, total suspended solids, and eutrophication of the lake.

4.4 Target Population and Sampling Locations

The target population of the 2017-2018 expanded study will be the surface waters flowing into Deep Lake.

4.7 Practical Constraints

Although rare, logistical problems such as excessive precipitation during typically dry periods, scheduling conflicts, sample bottle delivery errors, vehicle or equipment problems, site accessibility, or the limited availability of personnel or equipment may interfere with sampling. Any circumstance that interferes with data collection and quality will be noted and discussed in the final report. Three of the six proposed sample sites are on private property. Landowners' permission to access these sites will be necessary to perform a complete study of the waters entering Deep Lake.

5.0 Organization and Schedule

5.4 Project Schedule

Key activities for the 2017-2018 expanded Deep Lake monitoring work are listed in Table 1.

Table 1: Proposed schedule for completing the field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	10/2018	Andrew Albrecht
Laboratory analyses completed	11/2018	
Environmental Information System (EIM) database		
EIM user study ID	JROS0024	
Product	Due date	Lead staff
EIM data loaded	1/2019	TBD
EIM quality assurance	2/2019	TBD
EIM complete	3/2019	Andrew Albrecht
Final technical memo to client		
Author lead	Andrew Albrecht	
Due Date	6/2019	

5.6 Budget

The proposed lab budget for the 2017-2018 extended Deep Lake monitoring is provided in Table 2. This budget does not include the full cost of the monitoring program. It is limited to direct expenses for the specific elements below.

Table 2: Project budget.

Parameter	Cost / Parameter	2016	2017	Total
Total Zn	$41.19	$411.90	$411.90	$823.80
Dissolved Zn	$51.19	$511.90	$511.90	$1,023.80
Ammonia-N	$26.02	$1,092.84	$1,092.84	$2,185.68
Chloride	$14.09	$591.80	$591.80	$1,183.60
Nitrate + nitrite-N	$14.09	$591.78	$591.78	$1,183.56
Persulfate nitrogen, total	$14.09	$591.78	$591.78	$1,183.56
Phosphorus, soluble reactive	$14.09	$591.78	$591.78	$1,183.56
Phosphorus, total	$16.26	$682.92	$682.92	$1,365.84
Solids, total suspended	$19.50	$819.00	$819.00	$1,638.00
Fecal coliform - FCMF	$24.93	$1,047.06	$1,047.06	$2,094.12
Total		$6,932.76	$6,932.76	$13,865.52

7.0 Sampling Process Design

7.1 Study Design

A field crew of at least two people will collect samples monthly from May through October in 2017 and 2018. All six sites will be sampled monthly for nutrients, fecal coliform, chloride, total suspended solids, ammonia, nitrite-nitrate nitrogen, total persulfate nitrogen, ortho-phosphorus, total phosphorus, pH, dissolved oxygen, conductivity, temperature, and streamflow. The two sample sites on North Fork Deep Creek will be sampled monthly for zinc levels entering the lake. The proposed sample sites can be found in Figure 2 and Table 3.

7.1.2 Station Locations and Frequency

Six stations will be sampled monthly from May through October in 2017 and 2018. (See Figure 2 and Table 3). Sample locations and quantity may change if access issues change or if the collected data necessitate a different or expanded approach.

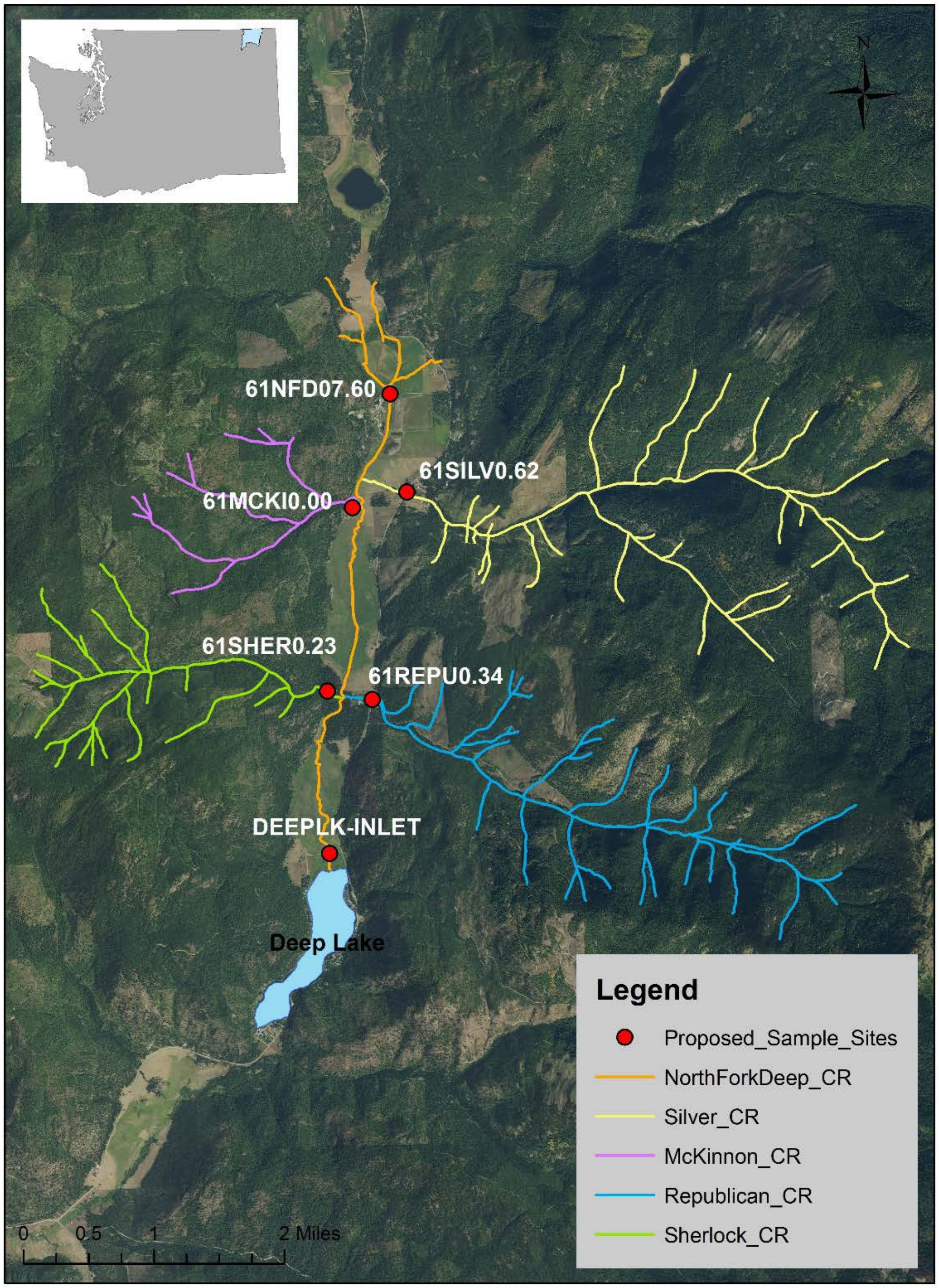

Figure 2: Proposed sampling locations for extended Deep Lake monitoring in 2017 and 2018.

Table 3: Proposed sampling locations for extended Deep Lake monitoring in 2017 and 2018, including site name, site description, and location.

Site Name	Site Description	Latitude	Longitude
61NFD7.60	Calhoun Mine Road	48.919717	-117.589996
61MCKI0.00	McKinnon Creek near mouth	48.90729	-117.597022
61SILV0.62	Deep Lake Boundary Rd crossing	48.908785	-117.587803
61SHER0.23	Sherlock Creek near mouth	48.887069	-117.602342
61REPU0.34	Deep Lake Boundary Rd crossing	48.885969	-117.594857
DEEPLK-INLET	Inlet of Deep Lake at North Shore Way	48.869136	-117.602952

7.1.3 Parameters to be Determined

See sections 7.1 and 7.12.

8.0 Sampling Procedures

8.1 Field Measurement and Field Sampling SOPs

Field sampling and measurement protocols will follow Ecology's SOPs below (Table 4). The sampling procedures for field water quality will follow those described in *Standard Operating Procedures for Hydrolab® DataSonde® and MiniSonde® Multiprobes* (SOP EAP033), modified as necessary in accordance with users manuals to account for luminescent-type oxygen probes.

Sampling procedures for lab-analyzed samples will follow procedures in SOP EAP015.

Table 4: Field sampling and measurement methods and protocols.

Parameter	Measurement/ Sample Type	Lab Method	Standard Operating Procedure
Water quality samples (see Table 8 for list)	Grab samples	See Table 5	EAP015 (Swanson, 2013)
Dissolved oxygen	Displacement sample	SM 4500 OC	EAP023 (Ward and Mathieu, 2011)
Dissolved oxygen, pH, conductivity, ORP, Chl a, and temperature	Hydrolab® multi-parameter data logger	n/a	EAP033 (Swanson, 2010)
Flow	Instantaneous	n/a	EAP024 (Sullivan, 2007) EAP055 (Shedd et al., 2008)

To ensure comparability, field measurements will follow approved Environmental Assessment Program SOPs:

- EAP011 - Instantaneous Measurement of Temperature in Water
- EAP015 - Manually Obtaining Surface Water Samples
- EAP023 - Collection and Analysis of Dissolved Oxygen (Winkler Method)
- EAP024 - Estimating Streamflow
- EAP029 - Collection and Field Processing of Metals Samples
- EAP030 - Fecal Coliform Sampling
- EAP033 - Hydrolab®, DataSonde®, and MiniSonde® Multiprobes
- EAP042 - Measuring Gage Height of Streams
- EAP055 - Operation of Teledyne Instruments Stream-Pro Acoustic Doppler Current Profiler
- EAP056 - Measuring and Calculating Stream Discharge

8.2 Containers, Preservation methods, Holding Times

Standard Ecology protocols will be used for sample collection, preservation, and shipping to MEL. Sample containers, sample volume requirements, sample preservation, and holding times are described in Table 5.

Table 5: Container type, required water volume, method of preservation, and maximum permissible holding times for synoptic lab-analyzed samples.

Analysis	Matrix	Recommended quantity	Container	Container index no.	Holding time	Preservative
General Chemistry						
Ammonia-N	Water	125 mL	125 mL clear w/m poly bottle	#19	28 days	H^2SO4 to pH < 2; Cool to < 6°C
Chloride	Water	100 mL	500 mL w/m poly bottle	#22	28 days	Cool to < 6°C
Nitrate + nitrite-N	Water	125 mL	125 mL clear w/m poly bottle	#19	28 days	H^2SO4 to pH < 2; Cool to < 6°C
Persulfate Nitrogen, total	Water	125 mL	125 mL clear w/m poly bottle 0.45 um pore size filters for dissolved TPN	#19	28 days	H^2SO4 to pH < 2; Cool to < 6°C
Phosphorus, soluble reactive	Water	125 mL	125 mL amber w/m poly bottle 0.45 um pore size filters for dissolved TPN	#20	48 hrs	Filter in field with 0.45 um pore size filter; Cool to < 6°C
Phosphorus, total	Water	50 mL	60 mL clear n/m poly bottle	#26	28 days	1:1 HCl to pH < 2; Cool to < 6°C
Solids, total suspended	Water	1000 mL	1000 mL w/m poly bottle	#23	7 days	Cool to < 6°C
Metals						
Total recoverable zinc	Water	350 mL	500 mL HDPE bottle	#16	24 hrs	Cool to < 6°C
Dissolved zinc	Water	350 mL	500 mL HDPE bottle	#16	24 hrs	Cool to < 6°C
Microbiology						
Fecal coliform	Water	250 mL, 500 for QC	250 mL glass/ poly autoclaved bottle	#27 or #29	24 hrs	Fill the bottle to the shoulder; Cool to ≤ 10°

9.0 Measurement Methods

9.2 Lab Procedures Tables

Ecology will use MEL for all laboratory analysis. Samples will be collected for nutrient analysis, total suspended solids and turbidity, chlorides and fecal coliform bacteria. Table 6 describes sampling collection details for laboratory analysis.

Table 6: Measurement quality objectives for lab-analyzed samples.

Analyte	Sample Matrix	Expected Range of Results	Method	Method Detection Limit
Ammonia-N	Water	0.01-0.25 mg/L	SM4500NH3H	0.01 mg/L
Nitrate + nitrite -N	Water	0.01-6 mg/L	SM4500NO3I	0.01 mg/L
Persulfate nitrogen, total	Water	0.005-0.5 mg/L	SM2540D	0.005 mg/L
Phosphorus, soluble reactive	Water	0.003-0.15 mg/L	SM4500PG	0.003 mg/L
Phosphorus, total	Water	0.005-0.2 mg/L	SM4500PF	0.005 mg/L
Solids, total suspended	Water	1 – 20 mg/L	SM2540D	1 mg/L
Turbidity	Water	1-50 NTU	EPA 180.1	1 NTU
Fecal Coliform bacteria	Water	1-2500 cfu/100 mL	MF 9222D	1 cfu/100 mL
Chloride	Water	.01-10 mg/L	EPA 300.0	0.1 mg/L
Total recoverable zinc	Water	.01 - 2 mg/L	EPA 200.8	10 µg/L
Dissolved zinc	Water	.01 - 2 mg/L	EPA 200.8	0.5 µg/L

10.0 Quality Control Procedures

10.1 Laboratory and Field Quality Control

The table below contains details of quality controls used for field and laboratory samples.

Table 7: Laboratory analytical methods and reporting limits for lab-analyzed synoptic samples.

Analysis	Field Blanks	Field Replicates	Lab Check Standard	Lab Method Blank	Lab Replicate	Lab Matrix Spikes
Field Analysis						
Velocity/discharge	N/A	1/run	N/A	N/A	N/A	N/A
pH	N/A	1/run	N/A	N/A	N/A	N/A
Temperature	N/A	1/run	N/A	N/A	N/A	N/A
Dissolved oxygen	N/A	1/run	N/A	N/A	N/A	N/A
Conductivity	N/A	1/run	N/A	N/A	N/A	N/A
Laboratory Analysis						
Ammonia-N	10%	10%	1/batch	1/batch	1/batch	1/batch
Nitrate + nitrite -N	10%	10%	1/batch	1/batch	1/batch	1/batch
Persulfate nitrogen, total	10%	10%	1/batch	1/batch	1/batch	1/batch
Phosphorus, soluble reactive	10%	10%	1/batch	1/batch	1/batch	1/batch
Phosphorus, total	10%	10%	1/batch	1/batch	1/batch	1/batch
Solids, total suspended	10%	10%	1/batch	1/batch	1/batch	1/batch
Fecal coliform	N/A	10%	N/A	1/ batch	1/ batch	N/A
Chloride	10%	10%	1/batch	1/batch	1/batch	1/batch
Metals						
Total recoverable zinc	10%	10%	1/batch	1/batch	1/batch	1/batch
Dissolved zinc	10%	10%	1/batch	1/batch	1/batch	1/batch

11.0 Data Management Procedures

11.1 Data recording/Reporting requirements

Staff will record all field data in a field notebook or an equivalent electronic collection platform. Before leaving each site, staff will check field notebooks or electronic data forms for missing or improbable measurements. Staff will enter field-generated data into Microsoft (MS) Excel® spreadsheets as soon as practical after they return from the field. If data were collected electronically, data will be backed up on Ecology servers when staff return from the field. The field assistant will check data entry against the field notebook data for errors and omissions. The field assistant will notify the field lead or project manager of missing or unusual data.

Lab results will be checked for missing and/or improbable data. MEL will send data through Ecology's Laboratory Information Management System (LIMS). The field lead will check MEL's data for omissions against the "Request for Analysis" forms. The project manager will review data requiring additional qualifiers.

In addition, data will be provided either on Ecology's Effective Monitoring web page (http://www.ecy.wa.gov/programs/eap/tem/index.html), Ecology's Stream Monitoring web page (www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html) or on Ecology's Flow Monitoring web page (www.ecy.wa.gov/programs/eap/flow/shu_main.html).

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18.0 Appendix. Quality Control for Procedures for Ambient Monitoring Lab-analyzed Parameters

Field

The accuracy and instrument bias of each sensor will be verified through independent field meter measurements (except nitrate-N) made before and after monthly servicing. Furthermore, accuracy and instrument bias will also be evaluated in the field (e.g., conductivity, pH, and dissolved oxygen). Post-deployment calibration checks will be conducted, following the procedures described in Swanson (2010). Deployment, retrieval, and monthly grab check samples will be collected as described in Ward (2007). Quality control associated with grab samples is described in Hallock and Ehinger and evaluated annually (Hallock, 2009).

Discrete Grab Sample Collection

The QA program for discrete grab sample collection will consist of three parts:

- Adherence to standard operating procedures for sample/data collection and periodic evaluation of sampling personnel.
- Consistent instrument calibration methods and schedules.
- Collection of field QC samples according to set times defined by the monitoring schedules.

Field QA protocols are described in detail in Hallock and Ehinger.

Three types of field QC samples will be collected once annually for each station:

- *Duplicate (Sequential) Field Samples.* These will consist of an additional sample collection made approximately 15-20 minutes after the initial collection at a station. These samples will represent the total variability due to short-term, instream dynamics; sample collection and processing; and laboratory analysis.
- *Duplicate (Split) Field Samples.* These will consist of one sample (usually the duplicate sequential sample) split into two containers that are processed as individual samples. We will do this to eliminate instream and sample collection variability so we can assess the remaining variability attributable to field processing and laboratory analysis.
- *Field Blank Samples.* These will consist of the submission and analysis of de-ionized water and are true field process blanks. The blank de-ionized water will be poured into cleaned sample collection equipment, and the sampler will simulate collecting a water sample, including lowering the sampling device to the water surface. The expected value for each analysis will be the reporting limit for that analysis. Significantly higher results will indicate that sample contamination occurred during field processing or during laboratory analysis.

Semi-blind QC samples will be submitted to the laboratory. Samples will be identified as QC samples, but sample type (duplicate, split, or blank) and station will not be identified. Pre-deployment, post-deployment, and anomalous data will be deleted from the raw data set.

Laboratory

MEL will analyze all ambient water quality samples for this study. The MEL Quality Assurance Manual (MEL, 2012) documents the laboratory's quality control procedures in detail. If any of these quality control procedures are not met, the associated results will be qualified and used with caution, or not used at all. Table 19 outlines the quality objectives associated with MEL's quality control procedures. If check samples and post-deployment calibrations indicate an offset or a linear drift, continuous data may be adjusted as necessary prior to evaluating against data quality objectives. If check samples and the post-deployment calibration are not consistent, or if data do not meet quality objectives after adjustments, then the data will be qualified or rejected.

Pre-deployment, post-deployment, and anomalous data will be qualified as "REJ" from the raw data set and not used.

Table 8: Measurement quality objectives for lab-analyzed samples.

Parameter	Accuracy/Bias % known value	Precision (% relative standard deviation)	Sensitivity (detection limits)
Ammonia-N	80-120%	10%	0.01 mg/L
Fecal coliform (>20 cfu/100 mL)	N/A	50% of pairs <20%; 90%	1 colony per 100 mg/L
Nitrate + nitrite-N	80-120%	10%	0.01 mg/L
Nitrogen, total	80-120%	10%	0.003 mg/L
Persulfate nitrogen, total	80-120%	10%	0.01 mg/L
Phosphorus, soluble reactive	80-120	10%	1 ug/L
Phosphorus, total	80-120%	10%	0.005 mg/L
Solids, total suspended	80-120%	10%	0.5 mg/L
Hardness	80-120%	10%	0.3 mg/L
Metals, Total	80-120%	10%	0.05 – 5 ug/L
Metals, Dissolved	80-120%	10%	0.05 – 1 ug/L