Quality Assurance Project Plan

A Long-Term Monitoring Plan to Assess Aquatic Life Uses on Railroad Creek Using Biological Assessment

September 2015

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Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1503116.html

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 SCOL0006.

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Federal Clean Water Act 1996 303(d) Listings Addressed in this Study.
See "Study area" and "Parameters of Interest" sections.

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Cover photo: Tailing piles below Holden Mine near Railroad Creek, U.S. Forest Service.

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EAP: Environmental Assessment Program
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2.0 Abstract

Railroad Creek, located in Chelan County Washington, has been negatively impacted by the effects of historic mining practices at Holden mine. Portions of Railroad Creek are on the Clean Water Act Section 303(d) list of impaired waters for one or more metals. Beginning in 2015, the Washington State Department of Ecology (Ecology) will assess the status of aquatic life uses over time.

This Quality Assurance Monitoring Plan describes a long-term monitoring strategy in which Ecology uses a common set of protocols to assess watershed health in Washington State. Specifically, Ecology will conduct macroinvertebrate, periphyton, habitat, and water quality surveys in Railroad Creek at sites above, below, and within the Holden mine area of effect.

These surveys should be conducted every three years through 2024 or until sufficient evidence demonstrates that water quality has recovered and can support healthy aquatic life in Railroad Creek. The information collected under this plan is meant to supplement other monitoring efforts.

3.0 Background

Holden Mine is an inactive underground mine located 12 miles up Lake Chelan's Railroad Creek, a 303(d) impaired waterway, in the Wenatchee National Forest, near the boundary of Glacier Peak Wilderness (Figure 1). Railroad Creek is located in Chelan County in a remote area of the Cascade Mountain Range in the Wenatchee National Forest and the surrounding area has many important natural resources. The U.S. Department of Agriculture, Forest Service is the lead agency responsible for cleanup efforts in Railroad Creek.

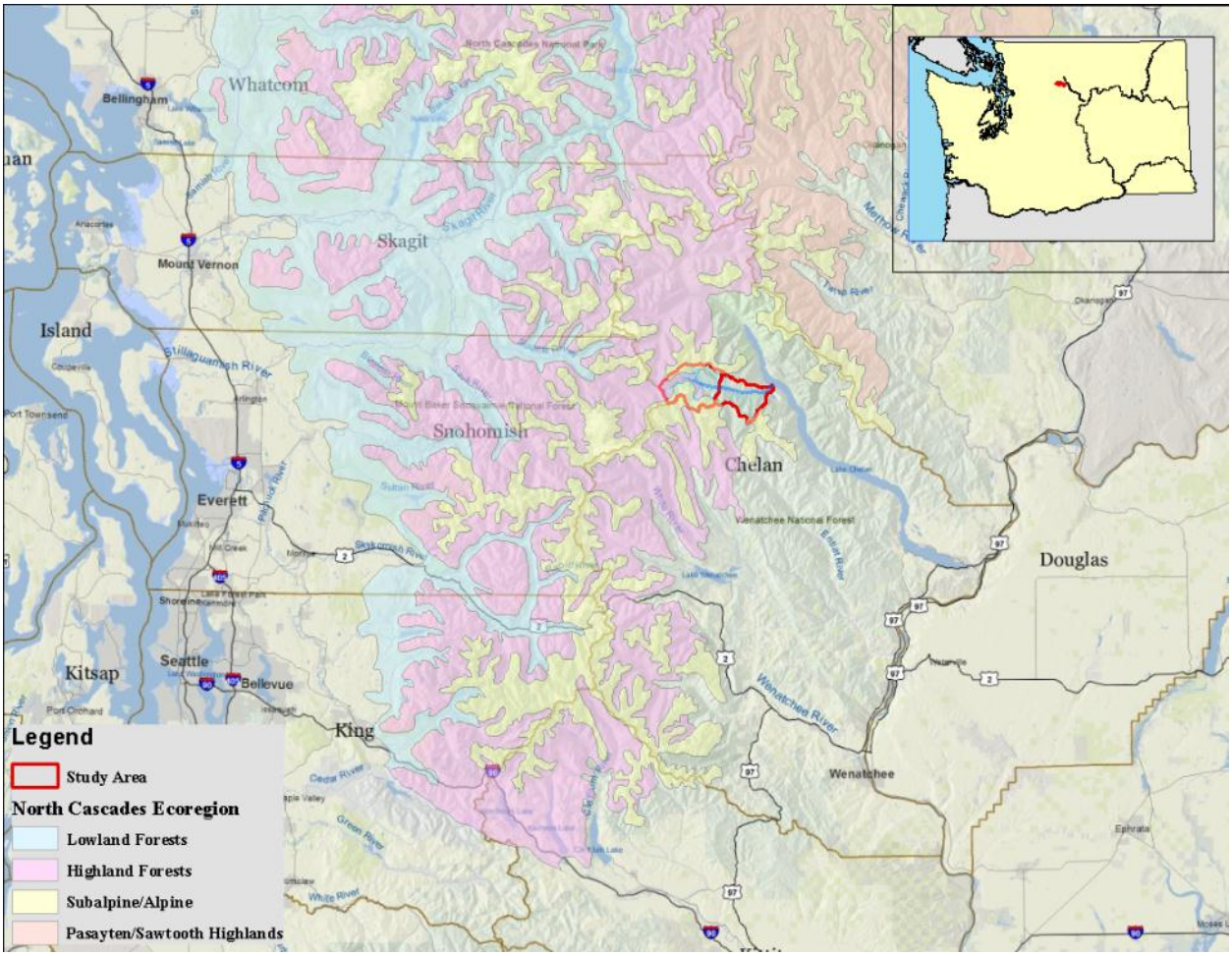

Figure 1. Study area for the Railroad Creek monitoring study.

The impacts from past mining practices to the macroinvertebrate population in Railroad Creek have been well documented (Pine, 1967; Ecology, 1997; Dames and Moore, 1999; MWH, 2010; and others). Figure 2 presents a summary of four studies that assessed the macroinvertebrate community in Railroad Creek along a longitudinal gradient that includes sites above, within, and below the Holden Mine area of effect. Although comparisons cannot be made between studies because of differences in sampling methods, results of these studies demonstrated a consistent pattern in which the number of observed taxa decreased from upstream to downstream of Holden Mine area of effect.

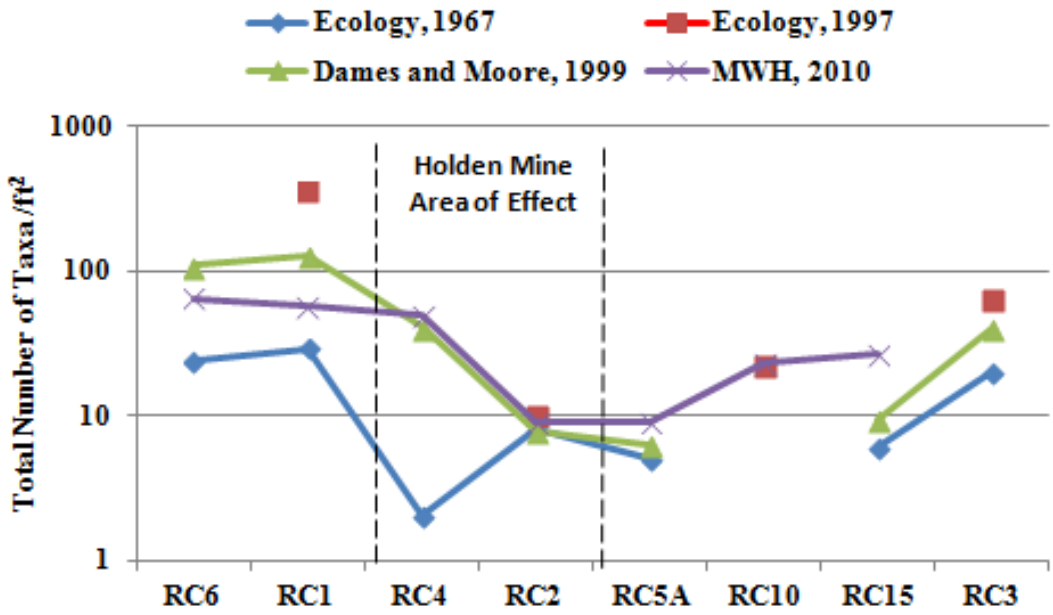

Figure 2. Results of past macroinvertebrate surveys on Railroad Creek.

The Holden Mine area of effect is the monitoring stations within immediate vicinity of known inputs of metals.

3.1 Study area and surroundings

3.1.1 Logistical problems

Because of the study area's remoteness and ongoing cleanup activities, logistical problems may arise when accessing sites. Much of the area has active construction associated with cleanup activities, and this will require close coordination with the USDA Forest Service, the site contractor in charge of construction activities, and residents of Holden Village. Coordination will include obtaining access to field vehicles, adhering to all site safety procedures, and communicating daily planned activities.

3.1.2 History of study area

From 1937 to 1957, the Howe Sound Company conducted mining operations at the Holden Mine site. Their mine and mill facilities produced primarily copper concentrate and lesser quantities of concentrate of zinc and gold. The operation ceased in 1957 when the profitability of copper mining declined. Successors to Howe Sound include Alumet Corporation and, more recently, Intalco Aluminum Corporation (Intalco). After the mining operation closed down, the mining interests were deeded to the Lutheran Bible Institute (currently known as Holden Village). Since 1961, the former mining town site, Holden Village, has served as a non-profit Lutheran ministry and community under a special use permit with the Forest Service. Approximately 5,000 to 6,000 people visit the facility each year and 60 to 70 people reside in Holden Village.

During the mine operation, about 57 miles of underground mine workings were developed. About 8.5 million tons of tailings were placed in piles covering a 90-acre area along Railroad Creek. Several piles of waste rock removed from the mine are located near the mine portals at various locations throughout the site. The site includes the 125-acre mining operation and village footprint, a 10-mile segment of Railroad Creek downstream of the mine, and an approximately 10-acre area of Lake Chelan sediments where Railroad Creek flows into the lake.

3.1.3 Parameters of interest

The intent of this study is to assess the health of aquatic life in Railroad Creek. Aquatic life is expected to recover when reduced concentrations of metals enter the Railroad Creek from the historical Holden mine site.

Given the practical constraints of accurately assessing metal concentrations in surface water and sediment, Ecology staff will use standardized bioassessment methods to assess aquatic life within the study area. This study will also measure other surrogate parameters that will be used to help assess recovery of aquatic life. Currently, Railroad Creek and its tributaries are not listed as impaired for aquatic life use (Table 2).

Table 1 lists the state Water Quality Assessment in the Railroad Creek Watershed, approved by EPA in 2012 (Ecology, 2012). A full list of water quality impairments is available in Washington's Water Quality Assessment 303(d)/305(b) Integrated Report Viewer (https://fortress.wa.gov/ecy/wats/approvedsearch.aspx).

Table 1. Railroad Creek and tributaries on the 2012 303(d) list of impaired water bodies that do not meet water quality standards.

Water Body Name	Category	Parameter	WBID Code	NHD Reach Code	Assessment Listing ID	Township/ Range/Section
Railroad Creek	5	Copper	1205917482070	17020009000202	45367	31N/18E/10
Railroad Creek	5	Lead	1205917482070	17020009000202	45356	31N/18E/10
Railroad Creek	5	Mercury	1205917482070	17020009000202	45383	31N/18E/10
Railroad Creek	5	Copper	1205917482070	17020009000207	45364	31N/17E/15
Railroad Creek	5	Copper	1205917482070	17020009000211	45365	31N/17E/8
Railroad Creek	5	Lead	1205917482070	17020009000211	45355	31N/17E/8
Railroad Creek	5	Mercury	1205917482070	17020009000211	45382	31N/17E/8
Railroad Creek	5	Silver	1205917482070	17020009000211	45388	31N/17E/8
Railroad Creek	1	Arsenic	1205917482070	17020009000212	8968	31N/17E/7
Railroad Creek	5	Copper	1205917482070	17020009000212	45368	31N/17E/7
Railroad Creek	5	Lead	1205917482070	17020009000212	45357	31N/17E/7
Railroad Creek	5	Mercury	1205917482070	17020009000212	45381	31N/17E/7
Railroad Creek	2	Lead	1205917482070	17020009000213	45354	31N/16E/2
Railroad Creek	5	Lead	1205917482070	17020009000213	45358	31N/16E/12
Railroad Creek	5	Mercury	1205917482070	17020009000213	45384	31N/16E/12
Holden Creek	5	Lead	1208140482065	17020009000558	45353	31/N16/E02
Copper Creek	5	Lead	1207715481974	17020009000594	45351	31/N17/E/7

3.1.4 Results of 2013 Periphyton Study

In August 2013, Ecology's Environmental Assessment Program (EAP) collected periphyton samples in Railroad Creek at six locations where biological monitoring has occurred in the past. The purpose of this assessment was to (1) measure the effects of acid mine drainage from Holden Mine on the periphyton communities in Railroad Creek and (2) use data to establish baseline conditions to help assess the effectiveness of cleanup activities over time.

Periphyton sampling locations were chosen based on sites described and sampled by the engineering company MWH Global in 2010 and others (Ecology, 1997; MWH, 2010). Two stations (RC-6, RC-1) were sampled upstream from activities associated with Holden Mine and are intended to serve as controls to compare with downstream conditions. Periphyton was sampled from riffle areas within site reaches, following Ecology protocols (Mathieu et al., 2013).

Samples were analyzed for taxonomic composition and several chemical constituents, including metals. See Appendix A for detailed summary of the data collection and results.

3.1.5.1 Community structure

The periphyton community at Railroad Creek sampling locations was composed of three major divisions of algae: Bacillariophyta (diatoms), Chlorophyta (green algae), and Cyanophyta (cyanobacteria). With the exception of RC-1, cyanobacteria dominated the periphyton community at all sites, as indicated by their relative abundance. Next in abundance were diatoms, followed by green algae (Figure 3a).

The proportional abundance of these divisions was variable between sites with the reference site RC-1 having the greatest abundance of green algae and diatoms. Cyanobacteria made up 75% of the periphyton community at RC-6, and diatoms made up the remaining 25%. Green algae were not identified at RC-6. Dominance by cyanobacteria may be a function of low inorganic nitrogen in Railroad Creek. Cyanobacteria have a competitive advantage over other algae by being able to "fix" atmospheric or molecular nitrogen when bioavailable nitrogen in the ionic form (nitrate and ammonia) is in short supply (Bahls, 2003).

Density of total periphyton, measured as number of cells/cm^2, was greatest at the control sites (RC-6, RC-1) and decreased from RC-4 to RC-10 (Figure 4b). The decrease in density was less pronounced from RC-2 to RC-10. Periphyton taxa and densities are summarized in Table A-4 and A-5. Total organic carbon (TOC) concentrations in periphyton correlated well with total periphyton density, with an R square of 0.77 (Figure 3b, Table A-3). Chlorophyll *a* concentrations were variable and did not correlate (R square 0.33) with total periphyton density (Table A-3).

In total, 99 individual taxa were identified from the study area (Table A-4). The most abundant taxa across sites was the cyanobacteria *Homeothrix* (40.8 %), the diatom *Achnanthidium minutissimum* (22.9%), the cyanobacteria *Phormidium* (13.27%), the cyanobacteria *Lyngbya* (6.9 %), and the green algae *Stigeoclonium* (5.25%). The rest of the taxa made up less than 5% of total relative abundance.

Homeothrix is a genus of cyanobacteria (blue-green algae) that is typically dominant in streams under a broad range of water quality conditions (Lowe and Pan, 1996). *A. minutissimum* was the most abundant diatom, making up 44.3% of the diatom community. *A. minutissimum* is a cosmopolitan diatom with very broad ecological tolerances. It is an attached diatom that is often the first species to pioneer a recently scoured site. This is why it is commonly found in high quantities at recently disturbed sites. It is also frequently dominant in streams subjected to acid mine drainage and to other chemical insults (Stevenson and Bahls, 1999; Cantonati et al., 2013).

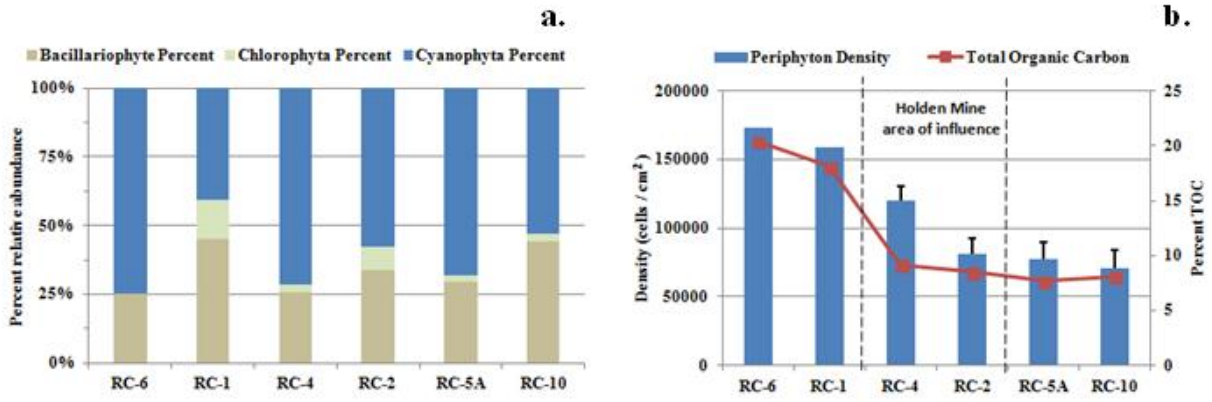

Figure 3. Major classes of algae making up periphyton communities (a), and total periphyton density and percent total organic carbon (TOC) results for Railroad Creek (b).

The Holden Mine area of effect is the monitoring stations within immediate vicinity of known inputs of metals.

3.1.5.2 Periphyton Metals

As part of this assessment, periphyton samples were analyzed for internal concentrations of silver (Ag), aluminum (Al), arsenic (As), cadmium (Cd), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), and zinc (Zn) at all Railroad Creek sampling stations. Ag was the only metal that was below the reporting method detection limit and was not included in this data summary. Replicate periphyton samples for metal analysis were taken at all sites, with the exception of RC-6. Periphyton metal graphs represent replicate means, with standard errors (*n=2*). All metal data are presented in Appendix A.

Figure 4 (total metals) represents the sum of all metals analyzed in periphyton for each site, expressed as total moles (M) of metals per kilogram (kg) periphyton. The lowest concentration of total metals was observed at the control sites, RC-6 and RC-1 in addition to RC-2, which is within the Holden mine area of effect. The next highest concentration of total metals was observed at RC-4, RC-5A and RC-10, respectively (Figure 5).

Results of individual metals are presented in Table 2 and Figures A-2 and A-3. Overall, similar patterns were observed in individual metals concentrations (As, Cd, Cu, Fe and Zn), when compared to total metals. The lowest concentrations of As, Cd, Cu, Fe and Zn were observed at control sites and RC-2, while the highest concentrations of As, Cu and Fe were measured at RC-4. The highest concentrations of Ni, and Zn were observed at RC-10. Concentrations of Al and Cd were highest at RC-5A and RC-10, while concentrations of Pb were highest at RC-6.

A principal component analysis (PCA) on metal concentrations across sites was performed to visualize differences between sampling locations. Results of PCA revealed similarities between sites and showed strong homogeneity within each site (Figure 6). Axes 1 and 2 accounted for 59% and 24% of the total variability, respectively. Axis 1 expressed the gradient of total metal concentrations in periphyton, with sites with low total tissue metals (RC-6, RC-1, and RC-2)

falling on the right side of axis 1 (positive values) and sites with high total tissue metals falling on the left side of axis 1 (RC-4, RC-5 and RC-10).

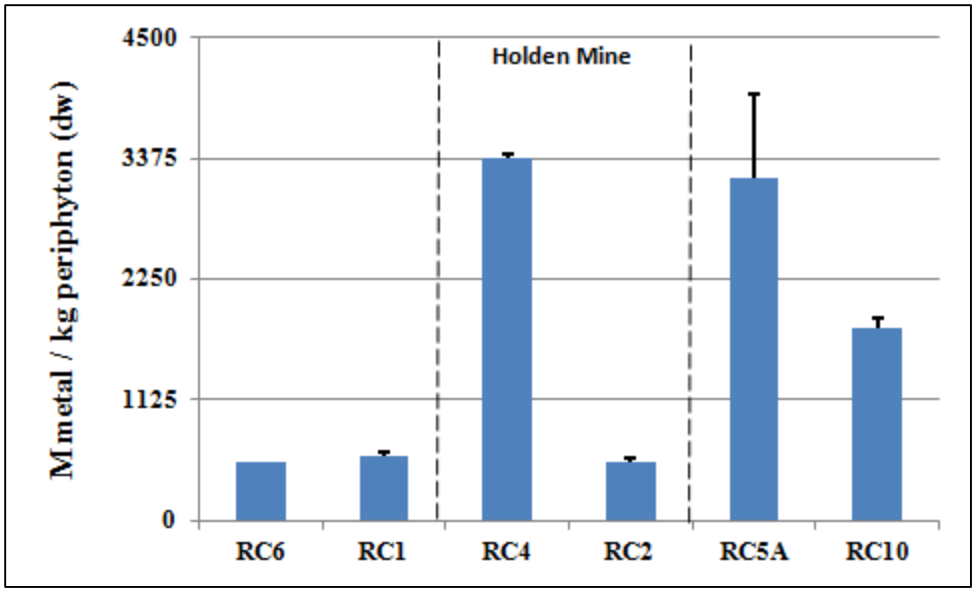

Figure 4. Metals concentrations expressed as total sum moles (M) of metals measured in periphyton.

Table 2. Metals concentrations in periphyton expressed as mg metals/kg periphyton in Railroad Creek.

Station	Total metals (mg/kg dw)								
	Al	As	Cd	Cu	Fe	Mn	Ni	Pb	Zn
RC-6*	16,667	58	4	76	35,327	1,993	105	39	239
RC-1 (A)	18,781	49	4	118	41,200	2,743	141	19	299
RC-1 (B)	18,414	37	3	116	35,903	2,352	133	18	277
RC-4 (A)	21,172	488	9	1,471	342,372	526	48	10	904
RC-4 (B)	20,980	487	10	1,336	349,110	268	51	9	920
RC-2 (A)	19,306	37	2	435	35,463	904	112	29	376
RC-2 (B)	15,259	36	1	320	34,229	541	112	11	272
RC-5A (A)	23,708	259	5	877	231,972	440	95	11	667
RC-5A (B)	39,625	460	9	1,390	385,084	1,142	108	18	1,091
RC-10 (A)	30,625	117	8	603	163,839	1,879	272	13	1,321
RC-10 (B)	26,976	102	7	537	149,573	1,421	264	11	1,116

Sample locations clustered into three distinct groups (Figure 5). Group 1, sites RC-4 (A and B) and RC-5A (A), was characterized by high concentrations of Fe, Cu, and As. Group 2, sites RC-5A (B) and RC-10 (A and B), was characterized by high concentrations of Cd, Zn, and Al. Group 3, with samples from the control sites (RC-6, RC-1) in addition to RC-2, was characterized by high concentrations of Ni, Mn, and Pb.

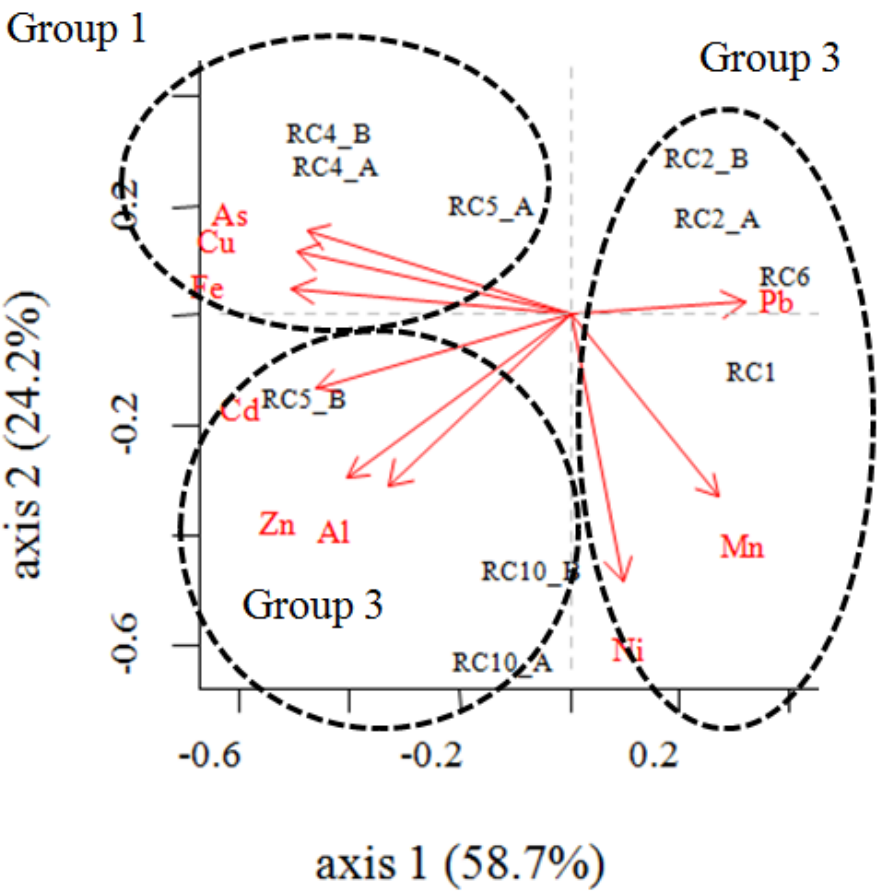

Figure 5. PCA diagram of periphyton metal samples including percent cumulative variance of axis.

Direct ordination of the samples based on site location and concentrations of individual metals in periphyton. The 3 different PCA groups are indicated. Replicates for the sites are represented by _A or _B, with the exception of RC-6 and RC-1.

Figure 6 shows a strong significant ($p \leq 0.05$) correlation between PCA axis 1 and total M of metals in periphyton with R-squared of 0.965.

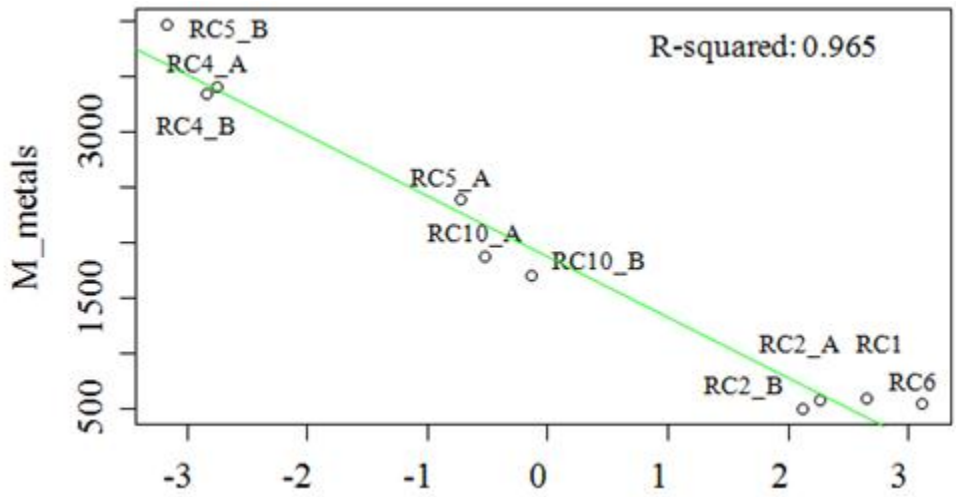

Figure 6. Total moles (M) of metals in periphyton plotted with axis 1 of the PCA.

3.1.5.2 Indicator Metrics

All diatom metrics were plotted against axis 1 of the PCA to identify those most responsive to changes in tissue metal concentrations (Table A-6). The diatom metrics significantly correlated ($p \leq 0.05$) with PCA axis 1 are shown in Table 3. Sampling stations grouped similarly to groupings observed in the PCA ordination (Figures 5 and 6) and correlated well with total periphyton metal concentrations (Table 3, Figure A-4).

Table 3. Results of diatom metrics plotted with axis 1 of the PCA that were significant ($p \leq 0.05$).

Metric	Residual standard error	R^2	F-statistic	p-value
Species Richness	6.26	0.74	22.78	0.001
Shannon H	0.64	0.64	14.48	0.005
Nitrogen Autotroph Taxa Percent	0.06	0.64	14.30	0.005
Eutraphentic Taxa Percent	0.02	0.57	10.66	0.011
Dominant Taxon Percent	0.12	0.59	11.59	0.009
Cosmopolitan Taxa Percent	0.08	0.54	9.45	0.02

The diatom metrics species richness, Shannon H (diversity), and percent nitrogen autotroph taxa all increased with increasing total metals in periphyton. The metrics percent eutraphentic, dominant taxa and cosmopolitan taxa all decreased with increasing total metal in periphyton.

3.1.5.3 Expected Metric Responses

Based on the results of the PCA, six diatom metrics that were strongly correlated to metal concentrations in periphyton have been identified as potential metrics for assessing long- term trends at Railroad Creek. The metric definitions and expected response to decreasing metals concentration over time are described below and shown in Table 4.

Table 4. Select diatom metrics, definitions, and predicted response to decreasing metal inputs to Railroad Creek based on principle components analysis.

Metric	Definition	Response to decreasing metals
Species Richness	Number of algal species in a sample	Decrease
Percent Nitrogen Autotroph Taxa	Taxa that have a low tolerance for organic nitrogen	Increase
Shannon Diversity Index	A function of both the number of species in a sample and the distribution of individuals among those species	Decrease
Percent Eutraphentic Taxa	Taxa with preference for nutrient-enriched waters	Decrease
Percent Dominant Taxa	Percent of dominance of the single most abundant taxon	Increase
Percent Cosmopolitan Taxa	Species of diatoms that are found in all types of water bodies	Increase

Species richness, an estimate of the number of all algal species in a sample−is typically predicted to decrease with increasing pollution. However, in naturally unproductive, nutrient-deficient streams species may be naturally stressed and diversity has been shown to increase with increasing disturbance (Stevenson and Bahls, 1999). In Railroad Creek species richness increased with increasing metal concentrations in periphyton.

Shannon Diversity (Shannon H) is a function of both the number of species in a sample and the distribution of individuals among those species (Klemm et al., 1990). Shannon Diversity scores range from 0, where all individual are the same taxon, to a maximum value that is dependent on the number of taxa in a sample. Patterns of Shannon Diversity are generally dependent on surrounding land use type (Petersen and Remmer, 2010). In Railroad Creek, Shannon Diversity index increased with increasing metal concentration in periphyton.

Eutraphentic diatoms are those taxa with preferences for nutrient-enriched, eutrophic water and are normally used in the identification and assessment of sites impacted by nutrients. The percent of eutraphentic diatoms increased with increasing metal concentrations in periphyton.

Percent nitrogen autotroph diatoms are those taxa using light energy to convert inorganic sources of nitrogen to organic. The percent nitrogen autotroph diatoms in Railroad Creek decreased with increasing metal concentrations in periphyton.

The *percent dominant species* is the single diatom species having the highest percent relative abundance. The greater the percentage contributed by a single dominant species, the greater the degree of impairment (Weber, 1978). The percent dominant taxon decreased with increasing metals concentration in periphyton.

Cosmopolitan taxa are species of diatoms that are found in all types of water bodies and generally are tolerant to a wide range of conditions. The percent cosmopolitan taxa in Railroad Creek decreased with increasing metal concentrations in Railroad Creek.

3.1.5 Regulatory criteria or standards

The Clean Water Act (CWA) established a process to identify and clean up polluted waters. The CWA requires each state to develop and maintain water quality standards that protect, restore, and preserve water quality. Water quality standards consist of (1) a set of designated uses for all water bodies, such as salmon spawning, swimming, and fish and shellfish harvesting; (2) numeric and narrative criteria to achieve those uses; and (3) an antidegradation policy to protect high-quality waters that surpass these conditions.

Ecology has established designated uses for Railroad Creek. These are established to protect aquatic life, recreation, water supply, and other miscellaneous uses (WAC 173-201A-600). Ecology will use bioassessment evaluations to monitor aquatic life uses in Railroad Creek. In addition, periphyton, periphyton metals, sediment metals, water quality, and habitat measures will be collected as supplemental data. This information will be important in determining factors driving or limiting recovery of the biological community in Railroad Creek.

Bioassessment

Water column measurements of chemical and physical components for rivers and streams may not provide sufficient information to detect or resolve all surface water problems. Biological evaluations may detect physical habitat-related or chemical impairments for which there are no criteria. For this reason, bioassessment methods are used to identify the biological health of the water body. Although the state water quality standards do not currently contain numeric biocriteria limits, bioassessment tools are used to determine impairment to designated uses of water bodies. This is an application of the narrative standards in WAC 173-201A-260 and 300.

Ecology currently endorses and uses the River Invertebrate Prediction and Classification System (RIVPACS) multivariate model and a multi-metric index of Biotic Integrity (IBI) to help identify impairments of the biologic community.

Ecology uses RIVPACS and multi-metric index models like the Benthic Index of Biotic Integrity (B-IBI) to assess the biological condition of streams in Western Washington. RIVPACS uses established reference site information to determine a score from the presence of taxa relative to taxa expected to occur. These expectations are based on a set of *predictor variables* that are not affected by human activities. This value identifies, with a specified level-of-confidence, impairment beyond that which can be attributed to natural conditions.

B-IBI is based on the scaled response of community attributes to a range of changes in environmental conditions. The score for each attribute is representative of Good, Fair, or Poor conditions, and is summed to give an overall picture of the biological integrity of the stream. Ecology encourages the collection of supplemental data during biological sampling events, especially conventional and chemical pollutant parameters that may be associated with pollution sources present in the watershed. This information is important in determining what may be causing an impaired biological community.

Ecology is currently developing B-IBI and RIVPACS models for macroinvertebrates in Eastern Washington, which are expected to be completed in 2017. At this time, no regulatory criteria or applicable water quality standards identify impairments of the periphyton community.

Toxic Substances

Toxic pollutants have significant potential to adversely affect designated water uses, aquatic biota, and public health when present at levels above those defined in water quality standards. Therefore, assessment decisions for toxic pollutants are based on detection of these substances above defined safe levels. For the purposes of this study, *toxic substances* refer to metals measured in surface water and freshwater sediment in Railroad Creek.

4.0 Project Description

Ecology will employ a systematic sampling design to evaluate the health of the aquatic biota in Railroad Creek. Macroinvertebrate, periphyton, habitat, and chemical data will be collected at several locations above, within, and below the Holden Mine area of effect on Railroad Creek. Monitoring will occur at locations that have been previously sampled by others (See Section 7.1.2). Also, metals concentrations in periphyton and sediment will be collected and analyzed as an additional line of evidence. To be as comprehensive as possible, monitoring as described in this QAPP is expected to occur every three years through 2024. Aquatic health will be assessed by comparing data collected at locations affected by the mine with stations established upstream of cleanup efforts (control sites). Also, trends in data will be evaluated over the study period to assess progress of implementation activities.

4.1 Project goals

The primary goal of this study is to monitor the aquatic health over time in Railroad Creek.

4.2 Project objectives

Objectives of this proposed study are as follows:

- Conduct biological and habitat assessments at previously established monitoring locations on Railroad Creek following Ecology protocols (Merritt, 2009).
- Analyze periphyton metal concentrations.
- Compare results with data collected previously (MWH, 2010; Collyard and Onwumere, 2013).
- Assess recovery of aquatic biota over time.

4.3 Information needed and sources

Not applicable

4.4 Target population

The target population for this study is macroinvertebrates and periphyton within the Railroad Creek watershed (Figure 5).

4.5 Study boundaries

Water Resource Inventory Area (WRIA) and 12-digit Hydrologic Unit Code (HUC) numbers for the study area:

WRIA
- 47 - Chelan

HUC numbers
- 170200090203 - Upper Railroad Creek
- 170200090204 - Lower Railroad Creek

Figure 7 shows the project study area.

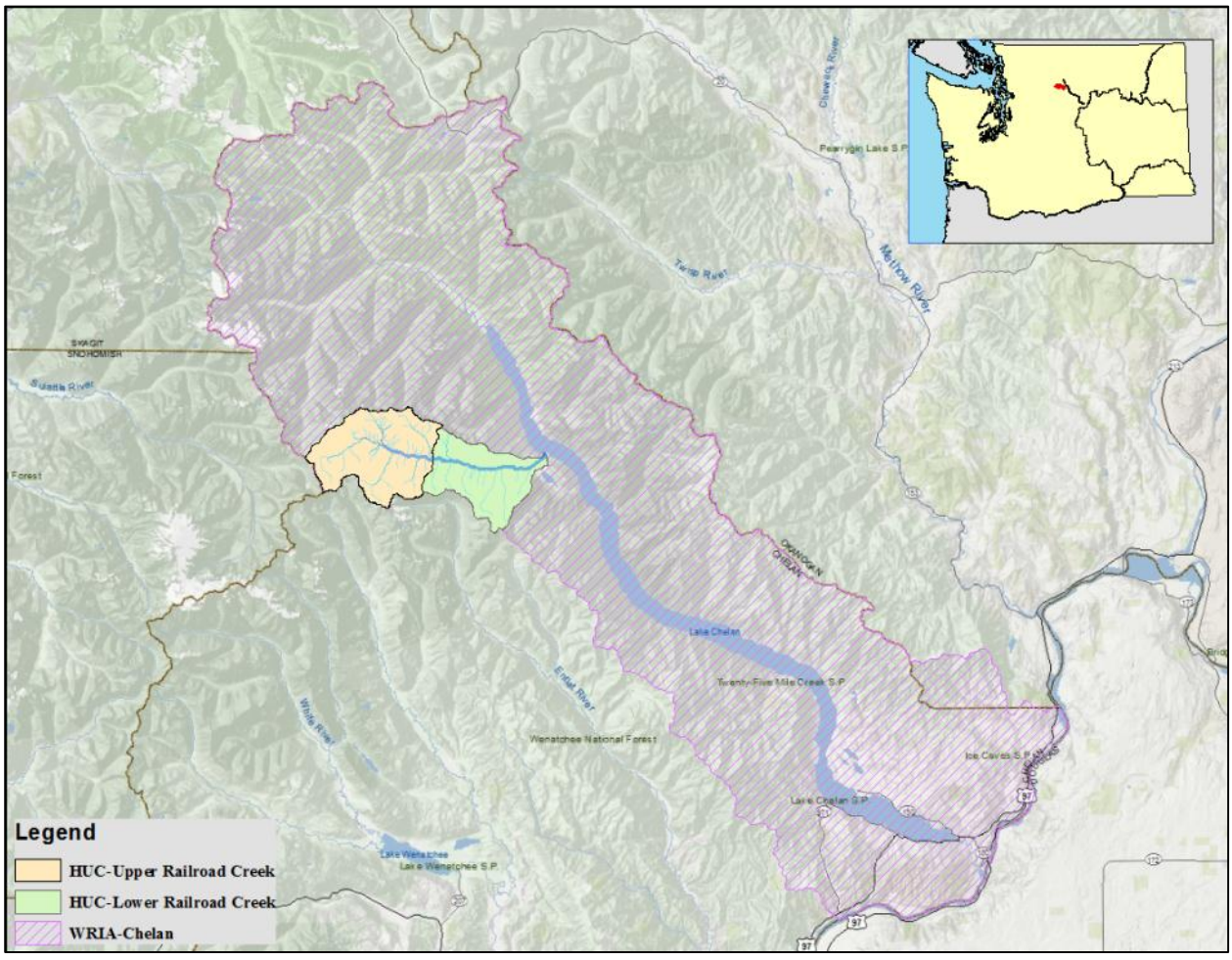

Figure 7. Map showing WRIA and HUC 12 boundaries of project study area.

4.6 Tasks required

The following tasks will be performed to support the goals and objectives of this study:

- Mobilization and demobilization will be necessary for personnel as well as equipment. All personnel and equipment will be mobilized to Lucerne from Chelan by ferry. Vehicles for transporting field staff and equipment will be required to access sampling locations once on location. Site transportation will be arranged with the Forest Service prior to arrival. Personnel and equipment will be demobilized along the same access route used for entry.
- Watershed Health Monitoring (WHM) data will be collected at proposed sampling locations using standard protocols for monitoring river and streams. Monitoring will be conducted by Ecology's WHM staff.
- Metals concentration will be measured in surface water and periphyton samples collected during the WHM assessment.
- Additional morning and afternoon sampling of periphyton and surface water metals will be collected at two locations, to assess potential diurnal cycling of metals.
- Water quality data loggers will be placed in situ to collect continuous (15 min interval) pH, DO, conductivity, turbidity, and temperature data at several sampling locations for a minimum of 72 hours.
- Artificial substrates will be deployed at two sampling locations and retrieved the following spring, to assess metals concentration in periphyton during runoff events.

4.7 Practical constraints

Data collection is not conducted under adverse or unsafe conditions. Staff will consider safety concerns before accessing the sampling locations. Reasons for not collecting data at a location may include; swiftness of stream, depth of sampling location, and other physical barriers preventing wading or accessing sampling locations.

Any circumstance that interferes with data collection and quality will be noted and discussed in reports and data summaries.

4.8 Systematic planning process

4.8.1 Weekly

Weekly workflow plan presented in Table 5 is intended to complete all tasks for this project within 4 days of arrival at locations. If needed, additional time for completing tasks is available in the morning before the planned departure day and time.

Table 5. Workflow for the week of proposed sampling.

Day	Action
1	Arrive in Chelan
2	Ferry from Fields Point to Lucerne (arrive 1145)
	Administrative duties Holden Village and Forest Service
	Deploy available water quality data loggers
3	Site 1 (AM)
	Site 2
	Repeat metals sampling Site 1 (PM)
	Repeat periphyton Site 1 (PM)
	Post processing periphyton
4	Site 3 (AM)
	Site 4
	Repeat metals sampling Site 3 (PM)
	Repeat periphyton Site 3 (PM)
	Post process periphyton
5	Habitat and Bio Site 5
	Habitat and Bio Site 6
	Post process periphyton
	Retrieve water quality data loggers
6	Depart Lucerne (1245)

4.8.2 Daily

The relative timing of daily monitoring activities is variable and should be performed considering efficiency of effort. It depends upon site-specific conditions. However, the crew has specific requirements in organizing their day. These requirements are:

- Water should be sampled prior to in-stream activities upstream.
- Benthos and sediment should be sampled immediately after site layout.

Table 6 provides an example of how a typical data collection event might be accomplished by a 6-person crew.

Table 6. Idealized daily work flow for monitoring.

Activity	Persons	Time Since Arrival On-site (Hrs)			
		1	2	3	4
Verification & Layout	AB				
Water Quality	CD				
Benthos/Sediment	EF				
Habitat	AB+				

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 7 lists the key people involved with this project and their responsibilities.

Table 7. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Valerie Bound Central Regional Office Toxics Cleanup Program Phone: 509-454-7886	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Scott Collyard Directed Studies Unit Western Operation Section Phone: 360-407-6455	Project Manager, Principal Investigator	Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the final report.
Jill Lemmon Directed Studies Unit Western Operation Section Phone: 360-407-7548	Field Lead	Lead for watershed health assessment.
Chad Larson Western Operation Section Phone: 509-454-4183	Assistant Investigator	Assists with data review and analyses. Coauthors data summaries and final report.
Paul Anderson Directed Studies Unit Western Operation Section Phone: 360-407-7548	Field Lead	Lead for water quality sampling.
George Onwumere Directed Studies Unit Western Operation Section Phone: 360-407-6730	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Jessica Archer Western Operation Section Phone: 360-407-6596	Section Manager for the Project Manager	Reviews the draft QAPP, and approves the final QAPP.
Thomas Mackie Eastern Operations Section Phone: 509-454-4244	Section Manager for the Study Area	Reviews the draft QAPP, and approves the final QAPP.
Joel Bird Manchester Environmental Laboratory Phone: 360/871/8801	Director	Reviews and approves the final QAPP.
William R. Kammin Phone: 360/407/6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

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

5.2 Special training and certifications

Key personnel involved in the collection of biological and habitat data and interpretation of results have extensive experience in similar efforts.

5.3 Organization chart

Table 9 lists the individuals involved in this project. All are employees of Ecology unless otherwise noted.

5.4 Project schedule

Table 8 presents the proposed schedule for the 2015 monitoring. The project schedule only includes field work and deliverables for the 2015 study period. Field work and deliverables for the remaining sampling events (2018, 2021, and 2024) are dependent on resources and other considerations. Proposed scheduling for future monitoring related to this QAPP is presented in Table 9.

Scheduling future work will be addressed in addendums to this QAPP prior to each proposed sampling event. Interim results will be reported through development of a project web page and data summary reports within 1 year of the completion of field work. A final report is expected to be produced following completion of the final study in 2025.

Table 8. Proposed schedule for completing the 2015 field and laboratory work, data entry into EIM, and reports.

Field and laboratory work for 2015	Due date	Lead staff
Field work begins	6/2016	Scott Collyard
Field work completed	8/2016	
Post sample processing completed	9/2106	
Laboratory analyses completed	10/2016	
Taxonomic analyses completed	5/2017	
Environmental Information System (EIM) database		
EIM Study ID	SCOL0006	
Product	Due date	Lead staff
EIM data loaded	11/2016	Paul Anderson
EIM data entry review	12/2016	Scott Collyard
EIM complete	12/2016	Scott Collyard
Taxonomic data loaded (EIM)	5/2017	Chad Larson
Taxonomic data entry review (EIM)	6/2017	Scott Collyard
Taxonomic data complete (EIM)	6/2017	Scott Collyard
Data Summary		
Author lead / Support staff	Scott Collyard /Chad Larson	
Schedule Web Reporting		
Summary data uploaded to web	12/2016	
Taxonomic summary uploaded to web	6/2017	
Schedule for Data Summary		
Draft data summary due to supervisor	10/2017	
Draft due to client/peer reviewer(s)	11/2017	
Final (all review done) due to publications coordinator	12/2017	
Final data summary report due on web	1/2018	

Table 9. Proposed long-term monitoring schedule for completing project.

Timeline	Field and laboratory	Expected completion date
2018-2019	Field work	8/2019
	All analyses completed	5/2020
	EIM complete	6/2020
	Web reporting complete	
	Data summary report complete	1/2021
2021-2022	Field work	8/2022
	All analyses completed	5/2023
	EIM complete	6/2023
	Web reporting complete	
	Data summary report complete	1/2024
2024-2025	All analyses completed	8/2025
	EIM complete	5/2026
	Web reporting complete	6/2026
	Data summary report complete	
	Final report	1/2026

5.5 Limitations on schedule

The primary limitations on the sampling schedule include access to sampling locations because of construction activities and access to vehicles for accessing sampling locations. These will be managed through frequent communication and coordination with USDA Forest Service staff.

5.6 Budget and funding

The estimated laboratory budget and number of lab samples shown in Table 10 are based on the proposed schedule in Table 11. Efforts will be made to keep the submitted number of samples within the estimate; however, this is only an estimate.

Table 10. Estimated annual analysis expenses for Railroad Creek field assessment.

Parameter /Analysis	Sampling Events	Field Dupes	Field Blanks	Ms/ Msd	Cost per Sample ($)	Total Samples	MEL Subtotal	Contract Subtotal
Surface Water Metals								
Dissolved Metals	10	1	1	2	190	14	2660	
Hardness	10	1	1	-	23.84	12	286.08	
Persulfate Nitrogen, Total	10	1	1	-	18.43	12	221.16	
Phosphorus, Total	10	1	1	-	19.5	12	234	
Alkalinity	10	1	1	-	18.43	12	221.16	
Sulfate, Total	10	1	1	-	14.09	12	169.08	
Chloride	10	1	1	-	14.09	12	169.08	
Dissolved organic carbon	10	1	1	-	38.98	12	467.76	
Pre-Cleaned Filters for Dissolved Metals	10	1	1	-	35.00	12	420.00	
Periphyton Tissue								
Ash Free Dry Weight	10	10	0	-	24.93	20	498.6	
Chlorophyll *a*	10	10	0	-	46.6	20	932	
Percent Total Solids	10	10	0	-	11.92	20	238.4	
Total Metals	10	10	0	-	217	20	4340	
Percent Total Organic Carbon	10	10	0	-	45.52	20	910.4	
Total Carbon/Nitrogen and Isotopes	10	10	0	-	58.25	20	-	1165
Watershed Health Survey								
Periphyton Identification	10	10	0	-	300	20	-	4800
Macroinvertebrates Identification	7	1	0	-	295	8	-	2065
Metals, Sediment	7	1	0	-	206	8	1800	-
Subtotal							13,567.72	9525.00
Total								**$27,313**

5.6.1 Travel

The estimated travel expense for a field crew of 6 for five days of lodging, ferry passage and per diem expenses is shown in Table 11. This includes 1 overnight stay in Chelan, 4 overnight stays in Holden Village. Overnight stays in Holden Village include meals.

Table 11. Estimated annual travel expenses for Railroad Creek field assessment.

Expense	Cost (6 Staff)	Total Cost
Hotel in Chelan	$83.00 (1 night)	$498
Holden Village Room and Board	$130.00 (4 nights)	$3360
Ferry Travel to and from Lucerne	$60.00	$360
		$4218

6.0 Quality Objectives

6.1 Decision Quality Objectives (DQOs)

This study will measure the health of aquatic life by comparing upstream and downstream results over time. Because of the inherent variability of biological and habitat data, a weight-of-evidence approach will be employed to assess progress, in addition to standard statistical analysis (see section 14.2). Data collected under this QAPP will be compared with water quality standards, as appropriate.

6.2 Measurement Quality Objectives

Field sampling procedures and laboratory analyses inherently have associated uncertainty, which results in data variability. Measurement quality objectives (MQOs) state the acceptable data variability for a project. *Precision* and *bias* are data quality criteria used to indicate conformance with MQOs. The term *accuracy* refers to the combined effects of precision and bias (Lombard and Kirchmer, 2004).

Field sampling precision and bias will be addressed by submitting replicate samples. Ecology's Manchester Environmental Laboratory (MEL) will assess precision and bias in the laboratory through the use of duplicates and blanks.

Table 12 outlines expected precision of sample duplicates, and method reporting limits. The targets for precision of field replicates are based on historical performance by MEL for environmental samples taken around the state by Ecology's Environmental Assessment Program (Mathieu, 2006). The reporting limits of the methods listed in the table are appropriate for the expected range of results and the required level of sensitivity to meet project objectives. The laboratory's MQOs and QC procedures are documented in the MEL *Lab Users Manual* (MEL, 2008).

Table 12. Measurement quality objectives for field and laboratory analyses.

Parameter	Accuracy (deviation or % deviation from true or replicate value)*	Precision (% relative percent difference)	Sensitivity (reporting limit)
In situ parameters			
Dissolved Oxygen	± 0.5 mg/L	10	0 to 50 mg/L
Temperature	± 0.4 º C	10	0 to 30ºC
pH	± 0.3 standard units	10	6 to 14 s.u.
Conductivity	± 5 uS/cm or 10%, whichever is greater	10	0 to 100,000 uS/cm
Turbidity	2% (1-499 NTU), ±4% (500-1600)	15	1 to 1600 NTU
Surface Water			
Dissolved Metals[1]	80-120	10	0.1-50 ug/L
Hardness	80-120	10	0.3 mg/L
Alkalinity	80-120	10	5 mg/L
Persulfate Nitrogen, total	80-120	10	0.025 mg/L
Phosphorus, total	80-120	10	0.005 mg/L
Sulfate, total	80-120	10	0.3 mg/L
Chloride	80-120	10	0.1 mg/L
Periphyton Tissue			
Dissolved organic carbon	80-120	20	0.1 ug/L
Percent Total Solids	80-120	20	0.1%
Percent Total Organic Carbon	80-120	20	0.1%
Metals[1]	80-120	20	0.1-5 mg/Kg
Ash Free Dry Weight	NA	20	0.05 ug/L
Total Carbon	85-115	20	0.01% Total C
Total Nitrogen	85-115	20	0.01% Total N
Total Phosphorus	85-115	20	5.0 mg/kg
Nitrogen and Carbon Isotopes	85-115	20	0.01% Total C and N
Watershed Health Survey			
Periphyton Taxonomy	Stevenson and Bahls, 1999	20 (% RSD)	Lowest Practical Level
Macroinvertebrate Taxonomy	Stevenson and Bahls, 1999	20 (% RSD)	Lowest Practical Level
Persulfate Nitrogen, Total	80-120	10	0.01 mg/L
Phosphorus, Total	80-120	10	0.005 mg/L
Metals[1]	80-120	20	0.1-5 mg/Kg

[1]Al, As, Ca, Cd, Cu, Fe, K, Mn, Mg, Na, Ni, P, Pb, Zn

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. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures). Precision for laboratory duplicate samples will be expressed as relative percent difference (RPD). Precision for field replicate samples will be expressed as the relative standard deviation (RSD) for the group of duplicate pairs (Table 14).

6.2.1.2 Bias

Bias is defined as the difference between the sample value and true value of the parameter being measured. Bias affecting measurement procedures can be inferred from the results of quality control (QC) procedures. Bias in field measurements and samples will be minimized by strictly following Ecology's measurement, sampling, and handling protocols (Table 14).

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as detection limit (Table 14). In a regulatory sense, the method detection limit (MDL) is usually used to describe sensitivity. This should be done in terms of the lowest quantity of a physical or chemical parameter detectable (above background noise) by each field instrument or laboratory method.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Comparability will be achieved by assuring the same methods and SOPs are used in synoptic, ambient, and continuous monitoring efforts.

All data used in statistical comparisons and trend analysis will be assessed for precision before analysis. If data sets do not meet standards for precision and biases, they will not be used in any analysis.

6.2.2.2 Representativeness

The study is designed to have enough sampling sites at sufficient sampling frequency to meet study objectives. Water quality values are known to be highly variable over time and space. Sampling variability can be somewhat controlled by strictly following standard operating procedures and collecting QC samples, but natural spatial and temporal variability can contribute greatly to the overall variability in the results. Resources limit the number of samples that can be taken at one site spatially or over various intervals of time.

In order to account for seasonal variability, limited sampling of periphyton will occur during runoff conditions in the spring using artificial samplers. Additional same-day sampling will also occur at two sampling stations during low-flow assessment to determine if there is any diurnal cycling of periphyton metal concentrations and species. If significant variations are evident, the sampling design may be modified.

6.2.2.3 Completeness

EPA has defined completeness as a measure of the amount of valid data necessary from a measurement system (Lombard and Kirchmer, 2004). The goal for the Railroad Creek study is to correctly collect and analyze 100% of the samples for each of the sites. However, problems occasionally arise during sample collection that cannot be controlled; thus, a completeness of 90% is acceptable. Potential problems include high water levels, site access problems, insufficient samples, and sample container shortages.

7.0 Sampling Process Design (Experimental Design)

7.1 Study Design

Ecology will employ a targeted sampling design to evaluate the health of benthic populations in Railroad Creek. Biological, habitat, and chemical data will be collected at several locations above, below, and within the Holden Mine area of effect in Railroad Creek. Aquatic health will be assessed by comparing data over time as well as comparing results from impacted sites to control sites just upstream of cleanup activities.

Biological and habitat assessments will be conducted once a year and will follow protocols outlined in *Status and Trends Monitoring for Watershed Health & Salmon Recovery: Field Data Collection Protocol Wadeable Streams* (Merritt, 2009). Periphyton sampling will also be conducted at the time of the Watershed Health Assessment and will follow Ecology's Standard Operating Procedures. Additional sampling of periphyton will occur in predawn and dusk hours to assess diel cycling of metal. Artificial substrates will be used to sample periphyton in the spring to assess runoff conditions.

Water quality sampling for nutrients, metals, and hardness will be conducted, following protocols outlined in *Procedures for the Collection, Processing, and Analysis of Stream Samples* (Ward, 2012). Sensor-derived water quality parameters (e.g., oxygen, pH, conductivity, turbidity, and temperature) will also be collected continuously for a minimum of 72 hours at the time, following protocols outlined in *Quality Assurance Monitoring Plan: Continuous Monitoring for Oxygen, Temperature, pH, and Conductivity in Statewide Rivers and Streams* (Hallock, 2009).

7.1.1 Field measurements

7.1.1.1 Watershed Health Assessment

Ecology's WHM program samples streams and rivers across the state to provide a consistent, objective picture of habitat and biological conditions. WHM is designed to answer questions about the overall conditions of watersheds and how conditions change over time (Hartman, 2015). Although the WHM program uses a statistical survey design to answer larger scale (Salmon Recovery Regions) questions of watershed health, the methodologies are applicable to smaller scale, targeted designs. This allows data to be compared and assessed with a larger statewide and national network of similar data collection efforts (Figure 8).

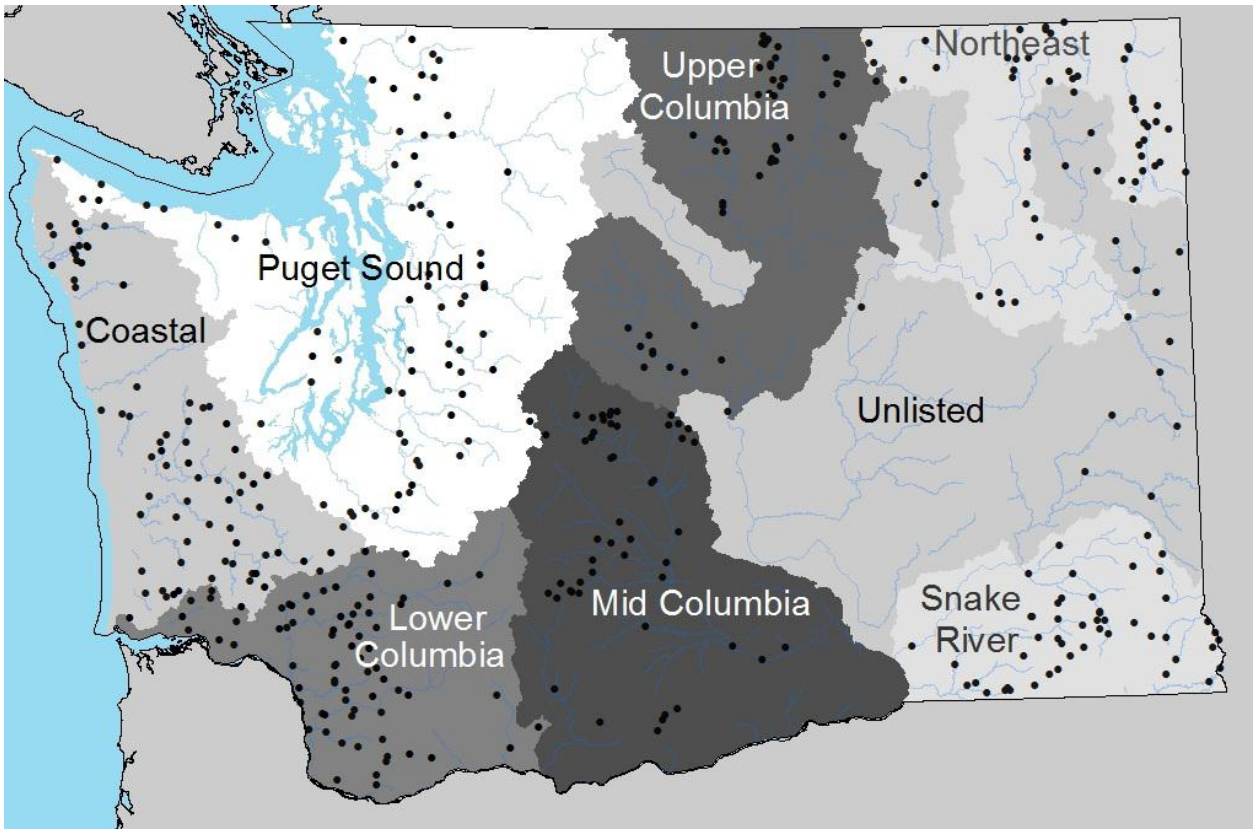

Figure 8. Map of Status and Trends Regions and sampling locations for the Watershed Health Monitoring Program (2009-2014).

The methodologies used in these assessments are from those already broadly applied in the Northwest (Cusimano et al., 2006). All are derivatives or closely related to the EPA's Environmental Monitoring and Assessment Program (EMAP). The source programs include the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), the Aquatic and Riparian Effectiveness Monitoring Program (AREMP), and the Integrated Status and Effectiveness Monitoring Program (ISEMP). Chemical, biological, and habitat assessment protocols for wadeable streams are well-documented.

The data from the WHM assessment are collected at a stream-reach scale. The data will be collected by a crew of at least five persons and can be parsed into tasks to be accomplished by one or more persons at a given time. Sampling in Railroad Creek will be performed along a reach that extends 20 bankfull widths and at least 150 meters. Physical habitat measurements and water and sediment samples will be taken where biological samples are collected, to describe the environment at the time of sampling (Merritt, 2009). This assessment will be conducted by Ecology's staff.

7.1.1.2 Continuous and Ambient Water Quality Monitoring

Monitoring of continuous and ambient water quality parameters will be consistent with methods employed by Ecology River and Freshwater Monitoring Unit (FMU) (Ward, 2012). The FMU has monthly water quality data across WA, spanning a period of more than 50 years and currently including a target network of 62 long-term stations.

Prior to biological and habitat assessments, water quality sensors will be deployed at several of the sampling locations. Sensor-derived water quality measurements (DO, pH, temperature, conductivity, and turbidity) will be recorded continuously every 15 minutes for a minimum period of 72 hours. The number of sensors that will be deployed depends on the availability of sensors at the time of the assessment.

In addition to water quality sampling during the biological assessment, a single discrete sample of metals will be taken at the time of the biological survey.

7.1.1.3 Periphyton

As part of the assessment, periphyton will be sampled to measure the effects of remedial efforts on primary production over time in Railroad Creek. Periphyton are good indicators of pollution in surface water because of their ability to take up materials, their relatively short life cycles (days to months), their sessile nature, and the ease with which they can be sampled (Stevenson and Bahls, 1999; Lowe, 1974; Kelly et al., 1995). The accumulation of metals by natural epilithic periphyton have important implications for organisms feeding upon them, as it is the basis of food webs in many aquatic systems (Besser et al., 2001; De Jonge et al., 2008). Also, periphyton sorption and desorption of metals play an important role in metal distribution in aquatic systems (Xie, 2009). Periphyton are routinely collected as part of Ecology's Ambient Biological and Effectiveness monitoring programs.

Periphyton in Railroad Creek will be sampled in riffle areas at the time of the WHM assessment. Periphyton will be sampled by removing rocks from sampling points. The surfaces of the rocks will be scraped to remove the loosely attached periphyton matrix and samples will be composited. Samples will then be split and prepared for taxonomic identification, chlorophyll *a*, ash free dry weight, percent total solids, total metals, carbon, nitrogen, and percent total organic carbon (%TOC).

7.1.1.4 Diel Metal Sampling

Concentrations of metals cycle daily in the water column in mining-impacted streams (Nimick et al., 2003). This cycling, to an extent, may be driven by metal uptake and release by native periphyton and can play an important role in metal availability and distribution in stream (Morris et al., 2005). To determine if diel cycling of metals is playing a significant role in metal distribution in Railroad Creek, periphyton and surface water metals will be collected at pre-dawn and pre-dusk hours at two locations. If diel cycling of periphyton tissue and water samples is evident, this will be taken into account when interpreting the data.

7.1.1.5 Spring Sampling

To assess effects of spring runoff conditions on the periphyton, artificial substrates will be deployed at two locations, during the fall assessment. Substrates will be removed from the creek the following spring (May, June, or July), frozen with dry ice and returned to the lab for processing. Processing will be identical to procedures described above. Water quality measurements and samples will also be taken during spring sampling.

7.1.2 Sampling location and frequency

Sampling locations are described in Table 13 and Figure 9. Watershed health monitoring will occur once during each proposed sampling year (Table 13). Sampling will occur during Ecology's biological assessment index period (between July and October). If feasible, limited water quality and periphyton sampling may occur outside the index period, in order to assess water quality and the effect of runoff conditions on the periphyton community (See sec. 7.1.1.4).

Table 13. Proposed sampling locations for the 2015 Railroad Creek monitoring study.

Station Name	Description	Latitude	Longitude
RC-6	Railroad Creek sampling station located immediately downstream from the Glacier Peak Wilderness Boundary. This location was established as a control site representing conditions upstream from area of impact.	48.199939	-120.792218
RC-1	Railroad Creek sampling station located approximately 300 yards downstream from the Wilderness Boundary. This location was also established as a control site representing conditions upstream from mine activities.	48.19912	-120.7889
RC-4	Railroad Creek sampling station located next to the footbridge where discharge from waste rock piles may occur and at the upstream edge of Tailings Pile 2. (The upstream boundary of the portion of Railroad Creek was moved.)	48.199171	-120.778451
RC-2	Railroad Creek sampling station located at the downstream edge of Tailings Pile 3.	48.197428	-120.760406
RC-5A	Railroad Creek sampling station located immediately upstream from Tenmile Creek. This location was established to represent conditions downstream from Tailings Pile 2 to Tenmile Creek.	48.195949	-120.749552
RC-10	Railroad Creek sampling station located immediately downstream from Sevenmile Creek.	48.190815	-120.703644
RC-3	Railroad Creek near mouth.	48.198376	-120.594156

7.1.3 Parameters to be determined

Data will be collected for areal biomass, conductivity, dissolved oxygen, and dissolved metals, habitat metrics, discharge, nutrients, sediment metals, periphyton tissue metals, pH, temperature and turbidity. Parameters may be added or removed from the study design as the project advances. Table 14 shows the list of parameters to meet the data needs.

Table 14. Parameters to be collected during the study.

Parameter	Sensor	Discrete Sample	Discrete Observation
Alkalinity		X	
Chloride		X	
Conductivity	X		
Dissolved Organic Carbon		X	
Dissolved Oxygen	X		
Habitat Parameters			X
Hardness		X	
Macroinvertebrates Identification		X	
Dissolved Metals		X	
Discharge	X		
Periphyton Identification		X	
Periphyton Ash Free Dry Weight		X	
Periphyton Chlorophyll a		X	
Periphyton Percent Total Organic Carbon		X	
Periphyton Percent Total Solids		X	
Periphyton Total Carbon/Nitrogen		X	
Periphyton Total Metals		X	
Persulfate Nitrogen, Total			
pH	X		
Phosphorus, Total		X	
Sediment Metals			
Sulfate		X	
Temperature	X		
Turbidity	X		

7.2 Maps or diagram

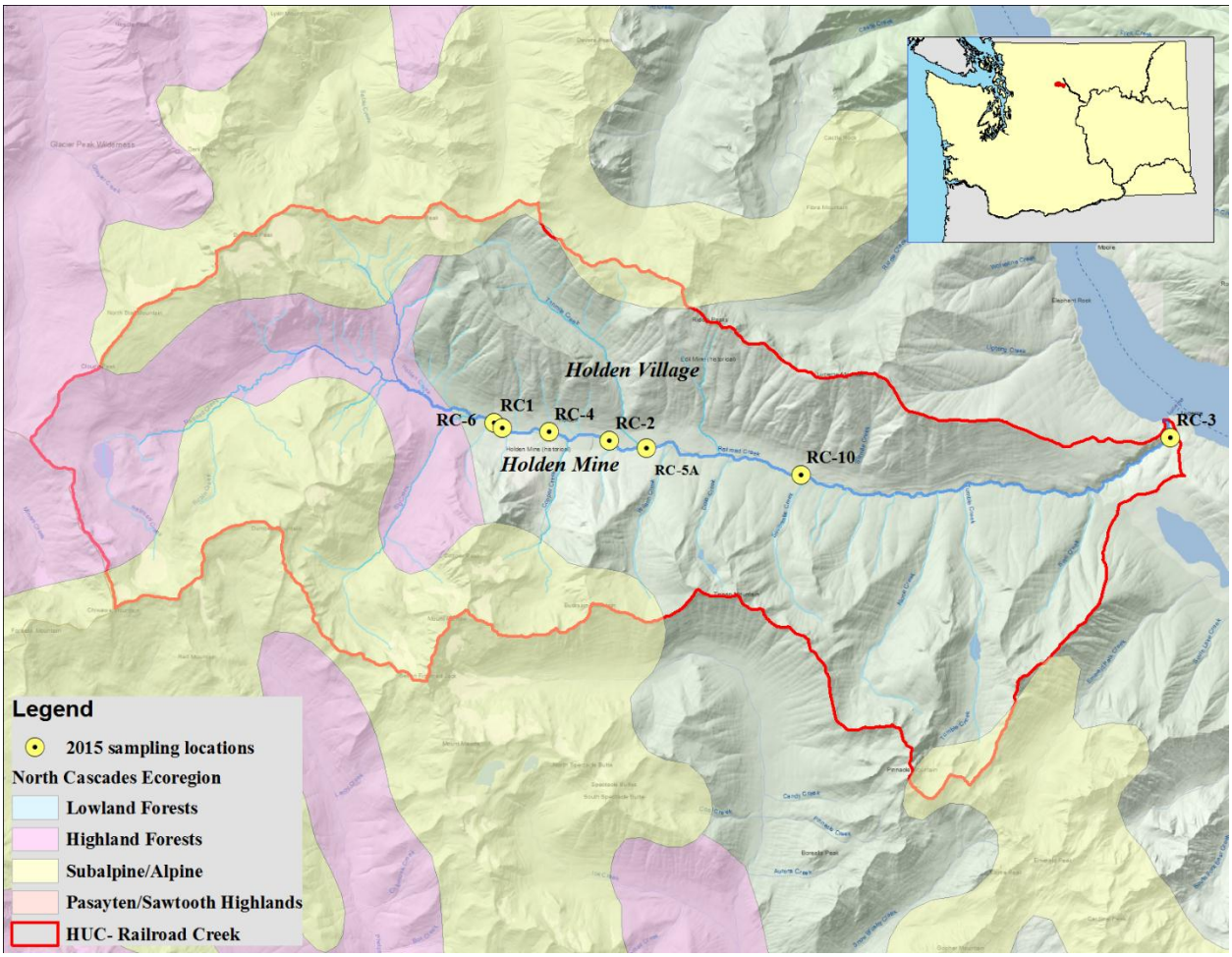

Figure 9. Map of sampling locations for Railroad Creek Study.

7.3 Assumptions underlying design

An inherent assumption of biological sampling is that results are representative of not only current environmental conditions but also the cumulative effects of stressors over time. However, biological assessments may not fully capture the range of conditions or unique events. Also, periphyton have been known to rapidly respond to changes in environmental conditions. Species composition and metal concentrations may be more indicative of conditions at the time of sampling. It is assumed that any improvements in biological and habitat measures will be directly related to actions implemented to reduce metal concentrations.

7.3.1 Changes to the sampling process design

As new information emerge over the study period, sample numbers, timing, frequency, and locations may change. Additional parameters may be sampled as the monitoring priorities and strategy change. Any such changes will be discussed in future addenda to this plan.

7.4 Relation to objectives and site characteristics

Sampling locations were chosen based on proximity to Holden Mine area of effect or locations expected to respond to cleanup activities, past biological sampling efforts, and Washington State's 303 (d) assessment. Sampling at multiple locations above, within, and below the area of effect over time helps assure that spatial and temporal variability are well documented for biological and habitat parameters.

7.5 Characteristics of existing data

Methods described in this QAPP outline the current methodology Ecology employs to assess biological conditions in stream in relation to Clean Water Act guidelines and Washington State's current 303(d) assessment criteria. Past methods for assessing biological conditions are varied, and those earlier data will be of limited use when comparing with current assessment.

8.0 Sampling Procedures

8.1 Field measurement and field sampling SOPs

Field staff will collect grab samples directly into pre-cleaned/sterilized containers supplied by MEL and described in their *Lab Users Manual* (MEL, 2008). Table 15 lists the sample parameters, containers, volumes, preservation requirements, and holding times. Field staff will store samples for laboratory analysis on ice and deliver to MEL within stated holding times via either the Ecology courier or direct drop-off after sampling. MEL follows standard analytical methods outlined in their *Lab Users Manual* (MEL, 2008).

Table 15. Container type, required water volume, methods of preservation, and maximum permissible holding times for synoptic lab-analyzed samples.

Analyte	Container Type	Sample Volume or Weight	Preservation	Holding Time
Water quality				
Metals	Poly	500	Filter and adjust pH to <2 with HNO_3, cool to ≤6°C	6 months
Hardness	Poly	125	$H2SO_4$ to pH<2, cool to ≤6°C	6 months
Alkalinity	Poly	500	Cool to ≤6°C; Fill bottle completely	14 days
Persulfate Nitrogen, Total	Poly	125	Adjust to pH<2 w/ $H2SO_4$ and cool to <4C	28 days
Phosphorus, total	Poly	60	Adjust to pH<2 w/ $H2SO_4$ and cool to <4C	28 days
Sulfate, total	Poly	100	Cool to≤6°C	28 days
Chloride	Poly	100	Cool to≤6°C	28 days
Dissolved organic carbon	Poly	100	Filter in field with 0.45um pore size filter; 1:1 HCl to pH<2; Cool to≤6°C	28 days
Periphyton Tissue				
Chlorophyll *a*	Glass test tube w/acetone	10 mL	Cool to <6C keep in dark	28 days post
Ash Free Dry Weight	Poly	200 mL	Cool to <6C	7 Days
Percent Total Solids	Poly centrifuge tube	1 g ww	Cool to <6C	7 days
Metals[1]	Poly centrifuge tube	1 g ww	Cool to <6C	6 months
Percent Total Organic Carbon	Poly centrifuge tube	1 g ww	Cool to <6C	28 days
Total Carbon & Nitrogen	Poly centrifuge tube	1 g ww	Cool slurry to ≤4°C; keep in dark; dry filter at 103-105°C & store in desiccator	100 days
Phosphorus	Poly centrifuge tube	1 g ww	Cool to <4C keep in dark	14 days pre-acidification; 6 months post
Nitrogen and Carbon Isotopes	Poly centrifuge tube	1 g ww	Cool slurry to ≤4°C; keep in dark; dry filter at 103-105°C & store in desiccator	100 days
Sediment				
Metals[1]	4 oz glass jar	50 g ww	Cool to <4C keep in dark	6 months
Percent Total Organic Carbon	4 oz glass jar	50 g ww	Cool to <4C keep in dark	6 months

[1]Al, As, Ca, Cd, Cu, Fe, K, Mn, Mg, Na, Ni, P, Pb, Zn

Field sampling and measurement protocols will follow standard operating procedures (SOPs) developed by Ecology's EA Program (Table 16). Sampling for procedures for continuous measurements will follow those described in *Standard Operating Procedures for Hydrolab® DataSonde® and MiniSonde® Multiprobes* (Swanson, 2007), 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 Ward (2007). Biological and habitat samples will be collected at selected locations, using Ecology protocols (Merritt, 2009). Biological samples will be collected in riffle areas within stream reaches. The stream reach will be defined as 20 times bankfull width. In addition, periphyton samples will be collected, using Ecology SOP EAP085 (Mathieu et al., 2013). Greater than ten percent of the biological samples will be replicated in the field in a-side-by side manner to assess field and laboratory variability.

Table 16. Field sampling and measurement methods and protocols.

Parameter	Measurement/Sample Type	Lab Method	Field Protocol
Water Quality Samples	Grab samples	See Table 11	Hallock and Ehinger (2003)
Synoptic Continuous DO, pH, Conductivity and Temperature	multi-parameter sonde	n/a	EAP033 (Swanson, 2010)
Flow	Instantaneous	n/a	EAP024 (Kardouni, 2013)
Periphyton	In stream	See Table 19	EAP073 (Mathieu et al., 2013)
Bioassessment and Habitat	In stream	n/a	Merritt (2009)

8.2 Containers, preservation methods, holding times

Information on containers, preservation methods and holding times can be found in Table 17.

8.3 Invasive species evaluation

Field staff will follow EAP's SOP070 on minimizing the spread of invasive species (Parsons et al., 2012). Railroad Creek Watershed is not in an area of extreme concern. Areas of extreme concern have, or may have invasive species like New Zealand mud snails that are particularly hard to clean off equipment and are especially disruptive to native ecological communities. For more information, please see Ecology's website on minimizing the spread of invasive species at www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html.

8.4 Equipment decontamination

Staff will follow all recommended protocols from instrument manufacturers for cleaning and, if needed, re-calibrating sensors. For in situ equipment, staff will follow Ecology's SOP EAP090, *Decontamination of Sampling Equipment for Use in Collecting Toxic Chemical Samples* when cleaning equipment used for in situ sample collection and sample preparation (Friese, 2014).

8.5 Sample ID

All samples will be labeled with station, date, time, parameter and sample identification numbers, and these are recorded in the field log. Each lab sample is automatically given a unique identification number once loaded to the database. This number is transferred to analyses logs (for internal lab samples) or chain-of-custody forms sent to external labs. All sample bottles are reconciled against forms to verify completeness as samples move through the analytical process, described in the Quality Control section of this QAPP.

8.6 Chain/of/custody, if required

During sample collection, a chain of custody form is generated for samples, based on field logs. Chain-of-custody logs are delivered to the lab with the corresponding samples for management of sample counts, scheduling, and tracking analysis. Once the samples are delivered, lab personnel log in each sample and assign a lab number to each, using the sample label number and date. Each laboratory sample number must correspond to a particular date, station, and depth.

When data results are received from labs, chain-of-custody forms are reconciled with data to ensure complete delivery and correct invoicing for all results. If discrepancies exist, research and investigation of the discrepancy is conducted in coordination with the lab(s) until the problem is resolved.

8.7 Field log requirements

In situ measurements made in the surface waters will be either recorded internally within the data logger or collected as water samples and analyzed at the laboratory. Information on samples will be recorded in a digital field log. The field log form also includes data logger information for data processing, such as cast start time, file names, replicate cast number, instrument information, and survey ID. In addition, any changes or deviations from the sampling plan or unusual circumstances that might affect interpretation of results are recorded.

Collection data sheets will also be generated on each survey, to record collected samples to be sent to the lab. A paper log is brought along on every survey to use as a backup if the electronic form or device fails. Digital copies of the field and sample logs are stored for future reference on a shared, secure, frequently backed up network server. Photos will be taken during each survey to record observations and events. These photos are used to document each sampling event and for the creation of reports, procedures and other documents.

8.8 Other activities

All field staff will be required to attend orientation training at the Holden Village when they arrive. Also, because all of the sampling locations falling within active construction areas, field staff may be required to attend morning safety briefings with Rio Tinto before sampling activities begin.

The project manager or field lead for each survey crew is the designated safety officer for that survey. The safety officer will have the following responsibilities:

- Cancelling assessments if conditions warrant.
- Complying with field and safety procedures.
- Knowledge of radio use.
- Knowledge of use and location of the safety equipment.
- Sample handling and processing, including chemical safety protocols.
- Emergency procedures.

Technicians are required to read and follow all appropriate guidelines in the EAP Field Operations Safety Manual and all other applicable sections of this manual (Appendix E).

9.0 Measurement Methods

9.1 Field procedures table/field analysis table

MEL conducts laboratory analyses and laboratory procedures following Standard Operating Procedures and other guidance documents. Analytical methods and lower reporting limits are listed in Table 17.

9.2 Lab procedures table

All lab-analyzed samples will be analyzed at MEL with the exception of periphyton nitrogen and carbon that will be analyzed at University of Washington's Marine Chemistry Laboratory in Seattle, Washington. Periphyton and macroinvertebrate taxonomy will be analyzed by Rhithron Associates, Inc. in Missoula, Montana. Methods for all lab procedures are described in Table 18. QA/QC protocols are discussed in the *Quality Control* section of this plan. More details on laboratory procedures are described in the Manchester Laboratory User's Manual (MEL, 2008).

Table 17. Laboratory analytical methods and reporting limits for lab-analyzed samples.

Analyte	Sample Matrix	Expected Range of Results	Method	Method Detection Limit
Water Quality				
Dissolved Metals	Water	0.05- 2000 ug/L	EPA 200.2 EPA 200.7 EPA 200.8	0.02- 50 ug/L
Hardness	Water	10-300 mg/L	SM2340B	0.1 mg/L
Persulfate Nitrogen, Total	Water	0.005-0.5 mg/L	SM4500NB	0.005 mg/L
Phosphorus, total	Water	0.005-0.2 mg/L	SM4500PH	0.005 mg/L
Alkalinity	Water	20-40 mg/L	SM2320B	5 mg/L
Sulfate, total	Water	0.5-1.0 mg/L	EPA 300.0	0.5 mg.L
Chloride	Water	0.1-1.0 mg/L	EPA 300.0	0.1 mg/L
Dissolved organic carbon	Water	1-2 mg/L	SM5310B	1 mg/L
Periphyton Tissue				
Chlorophyll a	Tissue	0.05 – 100 ug/L	SM10200H3	0.05 ug/L
Ash Free Dry Weight	Tissue	0.05-5 mg	SM10300C	0.05 mg
Percent Total Solids	Tissue	1-20%	EPA2540	1-100%
Metals[1]	Tissue	0.05 – 2000 mg/Kg	EPA 200.2 EPA 200.7 EPA 200.8	0.05 – 5 mg/Kg
Percent Total Organic Carbon	Tissue	1-30 %	SM5310B	0.1% carbon
Total Carbon & Nitrogen	Tissue	0.1-10% of dw	EPA440	0.01% of dw
Total Phosphorus	Tissue	0.01-10% of dw	EPA200.7	0.01% of dw
Nitrogen and Carbon Isotopes	Tissue	0.01-10% of dw	Continuous flow Isotope MS with CHN analyzer	0.01% of dw
Taxonomy				
Periphyton Taxonomy	Stream riffles	Variable	Stevenson and Bahls, 1999	n/a
Macroinvertebrate Taxonomy	Stream riffles	Variable	Barbour, 1999	n/a
Sediment				
Metals[1]	Sediment	0.05 – 2000 mg/kg	EPA 200.2 EPA 200.7 EPA 200.8	0.05 – 5 mg/Kg
Percent Total Organic Carbon	Sediment	0.1 – 20% of DW	SM5310B	0.1% of DW

[1]Al, As, Ca, Cd, Cu, Fe, K, Mn, Mg, Na, Ni, P, Pb, Zn

9.3 Sample preparation method(s)

Sample preparation methods are listed in standard operating procedures for lab analyses or in analytical methods. For analytes and biological samples determine by MEL and others following SOPs or QAPPs are employed:

- EAP029 Standard Operating Procedure for the Collection and Field Processing of Metals Samples (Ward, 2015).
- EAP073 Standard Operating Procedures and Minimum Requirements for the Collection of Freshwater Benthic Macroinvertebrate data in Wadeable Streams and Rivers (Adams, 2010)
- EAP034 Standard Operating Procedures for the Collection, Processing, and Analysis of Stream Samples (Ward, 2012)
- EAP085 Standard Operating Procedures for the Collection of Periphyton Samples for TMDL studies. (Mathieu et al., 2013)

For methods used for sample collecting and preparation of stream sediments, see Merrit (2009).

9.4 Special method requirements

Not Applicable.

9.5 Lab(s) accredited for method(s)

All chemical analysis, except for periphyton nitrogen and carbon, will be performed at MEL, which is accredited for all methods (Table 17). University of Washington's Isotope Laboratory is not accredited by Ecology for periphyton isotopes of nitrogen and carbon. The lab has a rigorous QC program, and analysis of stable isotopes is a routine analysis for this lab. Because this is currently no other lab accredited by Ecology to do this analysis a request to waive required use of accredited lab has be obtained. Rhithron Associates, Inc. in Missoula, Montana will process and analyze macroinvertebrate and periphyton samples.

10.0 Quality Control (QC) Procedures

The ongoing effort to provide high quality data occurs in many steps before, during, and after data collection. QA/QC procedures include the following activities:

- Meeting QA/QC objectives.
- Calibrating equipment and maintaining equipment.
- Conducting sensor performance assessment or verification.
- Evaluating analytical laboratory and field data QA/QC procedures.
- Performing proper sample custody.
- Performing proper data and information management.
- Verifying and validating data through routine data review.
- Assessing data usability (method).
- Conducting audits.

10.1 Table of field and lab QC required

Laboratory analyses and laboratory procedures follow Standard Operating Procedures and other guidance documents (MEL, 2012). Analysis methods and reporting limits are listed in Table 17. Quality control steps for laboratory and field measurements are summarized in Table 18.

Table 18. Laboratory analytical methods and reporting limits for lab-analyzed samples.

Parameter	Field		Laboratory			
	Blanks	Replicates	Check Standards	Method Blanks	Analytical Duplicates	Matrix Spikes
Alkalinity	n/a	10%	n/a	1/batch	1/batch	1/batch
Chloride	n/a	10%	1/batch	1/batch	1/batch	1/batch
Dissolved Organic Carbon	n/a	10%	1/batch	1/batch	1/batch	1/batch
Dissolved Metals	10%	10%	1/batch	1/batch	1/batch	1/batch
Hardness	10%	10%	1/batch	1/batch	1/batch	1/batch
Persulfate Nitrogen, Total	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	n/a	10%	1/batch	1/batch	1/batch	1/batch
Sulfate, Total	10%	10%	1/batch	1/batch	1/batch	1/batch
Periphyton Taxonomy	n/a	10%	n/a	n/a	n/a	n/a
Macroinvertebrate Taxonomy	n/a	10%	n/a	n/a	n/a	n/a
Periphyton Tissue						
Chlorophyll *a*	n/a	10%	n/a	n/a	1/batch	n/a
Ash Free Dry Weight	n/a	10%	n/a	1/batch	1/batch	n/a
Percent Total Solids	n/a	10%	n/a	1/batch	1/batch	n/a
Metals[1]	n/a	10%	1/batch	1/batch	1/batch	1/batch
Percent Total Organic Carbon	n/a	10%	n/a	1/batch	1/batch	n/a
Total Carbon & Nitrogen and Isotopes	n/a	10%	1/batch	1/batch	1/batch	1/batch

10.2 Corrective action processes

QC results may indicate problems with data during the course of the project. The lab will follow prescribed procedures to resolve the problems. Options for corrective actions might include:

- Retrieving missing information.
- Re-calibrating the measurement system.
- Re-analyzing samples within holding time requirements.
- Modifying the analytical procedures.
- Requesting additional sample collection or additional field measurements.
- Qualifying results.

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 returns 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 summaries will be either on Ecology's Effective Monitoring web page (http://www.ecy.wa.gov/programs/eap/tem/index.html), or Ecology's EIM.

11.2 Laboratory data package requirements

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL Users Manual (MEL, 2008). Variability in lab duplicates will be quantified, using the procedures outlined in the MEL Users Manual. Any estimated results will be qualified and their use restricted as appropriate. A standard case narrative of laboratory QA/QC results will be sent to the project manager for each set of samples.

11.3 Electronic transfer requirements

MEL will provide all data electronically to the project manager through the LIMS to EIM data feed. There is already a protocol in place for how and what MEL transfers to EIM through LIMS.

11.4 Acceptance criteria for existing data

No special criteria are necessary to assess the usability of existing data.

11.5 EIM/STORET data upload procedures

All water quality data will be entered into EIM, following all existing Ecology business rules and the EIM User's Manual for loading, data quality checks, and editing.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

There is no need for audits for this study. However, there could be a field consistency review by another experienced EAP field staff during the period of this project. The aim of this review is to improve field work consistency, improve adherence to SOPs, provide a forum for sharing innovations, and strengthen our data QA program.

12.2 Responsible personnel

The project manager conducts audits of all data and works with field and lab technicians to complete audits. The senior field lead participates in checking data before it is finalized and made public.

12.3 Frequency and distribution of report

See section 5.4.

12.4 Responsibility for reports

Given the long-term nature of the study, the data set will be extensive. Analyzing and interpreting data results require an intensive team approach. The project manager leads reporting on status and trends on various products and presentation of results. Members of the WHM team assist in reports and presentations.

13.0 Data Verification

Data verification and review is conducted by the project manager and WHM team by examining all field and laboratory-generated data to ensure:

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

13.1 Field data verification, requirements, and responsibilities

Throughout field sampling, the field lead and all crew members are responsible for carrying out station-positioning, sample-collection, and sensor deployment procedures as specified. Additionally, technicians systematically review all field documents (such as field logs, chain-of-custody sheets, and sample labels) to ensure data entries are consistent, correct, and complete, with no errors or omissions. A second staff person always checks the work of the staff person who primarily collected or generated data results.

13.2 Lab data verification

Lab technicians verify sample and data disposition by conducting continual tracking and reconciliation procedures. A second staff person always checks the work of the staff person who primarily or generated data results.

13.3 Validation requirements, if necessary

All laboratory data that have been verified by MEL staff will be validated by a project staff member. Field measurements data that was verified by a project staff member will be validated by a different staff member.

After data entry and data validation tasks are completed, all field and laboratory data will be entered into the EIM system. EIM data will be independently reviewed by staff for errors at an initial 10% frequency. If significant entry errors are discovered, a more intensive review will be undertaken.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

After all laboratory and field data are verified and validated, the field lead or project manager will thoroughly examine the data package, using statistics and professional judgment, to determine if MQOs have been met. The project manager will examine the entire data package to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. If the criteria have not been met, the field lead and project manager will decide if affected data should be qualified or rejected based upon the decision criteria in the QAPP. The project manager will decide how any qualified data will be used in the technical analysis.

14.2 Data analysis and presentation methods

Data analysis consists of comparing results to water quality standards and detecting changes in monitoring parameters over time. Procedures comparing results to water quality standards are defined in Ecology's Water Quality Program Policy 1-11 (www.ecy.wa.gov/programs/wq/303d/policy1-11Rev.html), and in Ecology's Guidance for Effectiveness Monitoring of Total Maximum Daily Loads in Surface Waters (Collyard and Onwumere, 2013).

The sampling design will be considered successful if project objectives are met.

14.3 Treatment of non/detects

A general practice for data management is that results or concentrations between the method detection limit (MDL) and the reporting limit are reported as detected but not quantified, due to the potential for misuse or misinterpretation of low-level data which has relatively high quantitative uncertainty.

Data results or concentrations of all analytes reported between the MDL and reporting limit are quantified and annotated with a "J" qualifier (estimated concentration); this indicates a higher level of uncertainty in the quantitative value. Statistical evaluations of data whose uncertainties are "high" can lead to erroneous conclusions, especially if the sample populations are limited in size or have high percentages of non-detect data–results where analytes are not present at detectable concentrations.

For lab data, the only sample results considered "detected" are those quantified at concentrations at least three times greater than the corresponding results in the method blank and in the field blank samples. Sample results that are not at least three times greater than the corresponding results in the method blank are qualified with a "U" to indicate "not detected." Sample results that are not at least three times greater than the corresponding results in the field or reagent blank

samples are qualified with a “JB” to indicate “not detected due to contamination of the field or reagent blank”.

14.4 Sampling design evaluation

The project manager will decide whether the data package meets the MQOs, criteria for completeness, representativeness, and comparability, and whether meaningful conclusions (with enough statistical power) can be drawn from the results and analysis. If so, the sampling design will be considered effective.

14.5 Documentation of assessment

In the technical report, the project manager will include a summary of the data quality assessment findings. This summary will be included in the data quality section of the report.

15.0 References

Adams, K. 2012. Standard Operating Procedures and Minimum Requirements for the Collection of Freshwater Benthic Macroinvertebrate data in Wadeable Streams and River. SOP Number EAP073. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_BenthicMacroinvertebrateDataCollection_v1_1EAP073.pdf

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates, and fish. Environmental Protection Agency (EPA 841-B-99-002). 339 pp.

Bahls, L. 2003. Biological Integrity of Streams in the Ruby River TMDL Planning Area Based on the Structure and Composition of Benthic Algae. Prepared for State of Montana, Department of Environmental Quality. Helena, MT.

Besser, J. M., W.G. Brumbaugh, T.W. May, S.E. Church, and B.A. Kimball. 2001. Bioavailability of metals in stream food webs and hazards to brook trout (Salvelinus fontinalis) in the upper Animas River watershed, Colorado. Archives of Environmental Contamination and Toxicology; 40(1):48-59.

Cantonati, Marco, N. Angeli, L. Virtanen, A. Z. Wojtal, J. Gabrieli, E. Falasco, I. Lavoie, S. Morin, A. Marchetto, C. Fortin, S. Smirnova. 2013. Achnanthidium minutissimum (Bacillariophyta) valae deformities as indicators of metal enrichment in diverse widely-distributed freshwater habitats. Science of the Total Environment. Vol 475, 15, pages 201-215.

Collyard, S. and G. Onwumere. 2013. Guidance for Effectiveness Monitoring of Total Maximum Daily Loads in Surface Water. Washington State Department of Ecology, Olympia, WA. Publication No. 13-03-024. https://fortress.wa.gov/ecy/publications/SummaryPages/1303024.html

Cusimano, R., G. Merritt, R. Plotnikoff, C. Wiseman, C. Smith, and WDFW. 2006. Status and Trends Monitoring for Watershed Health and Salmon Recovery: Quality Assurance Monitoring Plan. Washington State Department of Ecology, Olympia, WA. Publication No. 06.03-203 https://fortress.wa.gov/ecy/publications/summarypages/0603203.html

Dames & Moore. 1999. Draft Final Remedial Investigation Report, Holden Mine Site. Prepared for Alumet Inc. by Dames & Moore. Seattle, Washington. July 28, 1999.

De Jonge, M., B.V. Vijver, R. Blust and L. Bervoets. 2008. Responses of aquatic organisms to metal pollution in a lowland river in Flanders: A comparison of diatoms and macroinvertebrates. Science of the Total Environment. Vol 407, pages 615-629.

Ecology. 1997. Effects of Holden Mine on the Water, Sediments and Benthic Invertebrates of Railroad Creek (Lake Chelan). Washington State Department of Ecology, Olympia, WA. Publication No. 97-330. https://fortress.wa.gov/ecy/publications/SummaryPages/97330.html

Ecology. 2012. 2012 Water Washington State Water Quality Assessment. Water Quality Program, Washington State Department of Ecology, Olympia, WA. http://www.ecy.wa.gov/programs/wq/303d/currentassessmt.html

Ecology. 2013. Sediment Management Standards, Chapter 173-204 WAC. Toxic Cleanup Program, Washington State Department of Ecology, Olympia, WA. Publication No. 13-09-055. https://fortress.wa.gov/ecy/publications/SummaryPages/1309055.html

Friese, M. 2014. Standard Operating Procedures for Decontaminating Field Equipment of Sampling Toxics in the Environment. Washington State Department of Ecology, Olympia, WA. SOP Number EAP090. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_EquipmentDeconToxicsSampling_v1_0EAP090.pdf

Hartman, C. 2015. Focus on Environmental Monitoring: 2015 Stream Surveys in the Mid Columbia Region. Washington State Department of Ecology, Olympia, WA. Publication No. 15-03-005. https://fortress.wa.gov/ecy/publications/SummaryPages/1503005.html

Hallock, D. 2009. Quality Assurance Monitoring Plan: Continuous Monitoring for Oxygen, Temperature, pH, and Conductivity in Statewide Rivers and Streams. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-122. https://fortress.wa.gov/ecy/publications/summarypages/0903122.html

Kelly, M.G., C. J. Penny, and B. A. Whitton. 1995. Comparative performance of benthic diatom indices used to assess river water quality. Hydrobiologia 302:179-188.

Klemm, D.J., et al. 1990. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters. U.S. E.P.A., Cincinnati, OH (Pub No. EPA/600/4-90/030)

Lombard, S. and C. Kirchmer. 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. Publication No. 04/03/030. https://fortress.wa.gov/ecy/publications/SummaryPages/0403030.html

Lowe, R. L. 1974. Environmental Requirements and Pollution Tolerance of Freshwater Diatoms. US Environmental Protection Agency, EPA-670/4-74-005. Cincinnati, Ohio, USA.

Lowe, R.L., and Y. Pan. 1996. Benthic algal communities and biological monitors. Pages 705–739 in R. J. Stevenson, M. Bothwell, and R. L. Lowe (editors). Algal ecology: freshwater benthic ecosystems. Academic Press, San Diego, California.

Mathieu, N. 2006. Replicate Precision for Twelve Total Maximum Daily Load (TMDL) Studies and Recommendations for Precision Measurement Quality Objectives for Water Quality Parameters. Washington State Department of Ecology, Olympia, WA. Publication No. 06-03-044. https://fortress.wa.gov/ecy/publications/SummaryPages/0603044.html

Mathieu, N., Collyard, S. and T. Mohamedali. 2013. Standard Operating Procedures for the Collection of Periphyton Samples for TMDL studies. Washington State Department of Ecology, Olympia, WA. EAP085. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_Periphyton_TMDLs_v1.1_0EAP085.pdf

MEL. 2008. Manchester Environmental Laboratory Lab Users Manual, Ninth Edition. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

MEL. 2012. Manchester Environmental Laboratory Quality Assurance Manual. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

Merritt, G., 2009. Draft. Status and Trends Monitoring for Watershed Health and Salmon Recovery: Field Data Collection Protocol. Washington State Department of Ecology, Olympia, WA. Publication No. 09-03-xxx. http://www.ecy.wa.gov/programs/eap/stsmf/docs/01SnTWadeableManA-Vv3bhfl.pdf

Morris, J.M., D.A. Nimick, A.M., Farag, and J.S. Meyer. Does biofilm contribute to diel cycling of Zn in High Ore Creek, Montana? Biogeochemistry (2005) 76: 223-259.

MWH. 2010. Holden Mine Site. Draft Baseline Monitoring Report. Biological Monitoring Resutls for Fall 2010. Prepared for Rio Tinto Inc. by MWH Global. Seattle, Washington. July 28, 1999.

Nimick, D.A., C.H. Gammons, T.E. Cleasby, J.P. Madison, D. Skaar, and C.M. Brick. 2003. Diel cycles in dissolved metal concentrations in streams–Occurrence and possible causes. Water Resources Res. 39(9): citation no. 1247, doi:10.1029/WR001571.

Peterson, J.C. and S.R. Femmer. 2010. Periphyton Communities in Streams of the Ozark Plateaus and Their Relation to Selected Environmental Factors. USGS. Water Resources Investigation Report 02-4210.

Pine, 1967. The Effects of the Holden Mine Tailings upon the Aquatic Insect Fauna of Railroad Creek, A Tributary to Lake Chelan. Environmental Assessment Program, Washington State Department of Ecology, Olympia, WA. Publication No. 67-e00.

Stevenson, R.J., and Bahls, L.L., 1999. Periphyton protocols, in Barbour, M.T., Gerritsen, J., Snyder, B.D., and Stribling, J.B., eds., Rapid bioassessment protocols for use in streams and wadeable rivers—Periphyton, benthic macroinvertebrates, and fish. (2d ed.): Washington, D.C., U.S. Environmental Protection Agency, Office of Water, EPA 841–B–99–002, p. 6–1—6–22.

Swanson, T. 2007. Standard Operating Procedure for Hydrolab® DataSonde® and MiniSonde® Multiprobes, Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP Number EAP033. www.ecy.wa.gov/programs/eap/quality.html

Swanson, T. 2010. Standard Operating Procedure for Hydrolab® DataSonde® and MiniSonde® Multiprobes, Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP Number EAP033. www.ecy.wa.gov/programs/eap/quality.html

USDA Forest Service. 2012. Record of Decision Parts 1 & 2 Holden Mine Site Chelan County, Washington. Prepared by USDA Forest Service, Wenatchee, Washington. Publication No: 4769-16.

WAC 173/201A. Water Quality Standards for Surface Waters in the State of Washington Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/laws/rules/ecywac.html

Ward, W.J. 2012. Standard Operating Procedures for the Collection, Processing, and Analysis of Stream Samples. Washington State Department of Ecology, Olympia, WA. SOP Number EAP034 http://www.ecy.wa.gov/programs/eap/quality.html

Ward, W.J. 2015. Standard Operating Procedure for the Collection and Field Processing of Metals Samples. Washington State Department of Ecology, Olympia, WA. SOP Number EAP029. http://www.ecy.wa.gov/programs/eap/quality.html

Weber, C.I. 1978: Biological field and laboratory methods for measuring the quality of surface waters and effluents. U.S. Environmental Protection Agency Report 670/4/73/001.

Xie, L., D.H. Funk and D.B. Buchwalter. Trophic transfer of Cd from natural periphyton to the grazing mayfly *Centroptilum triangulifer* in a life cycle test. Environmental Pollution. Volume 158, Issue 1, January 2009, Pages 272–277.

18.0 Appendices

Appendix A. Periphyton Sampling Railroad Creek, 2013

Table A-1. Summary of data collection for periphyton 2013 Railroad Creek.

Parameter	Definition	Use	Method
Periphyton	A mixture of algae, bacteria, other associated microorganisms, and non-living organic matter attached to any submerged surface.	Assessment of biological condition of primary producers.	Stevenson and Bahls, 1999
Chlorophyll *a*	Green pigment found in chloroplasts of algae and plants.	To determine the combined biomass of eukaryotic and prokaryotic algae.	SM 10200H3
% Total Organic Carbon	Material derived from decaying vegetation, bacterial growth, and metabolic activities of living organisms or chemicals.	Relative percent of organic material in periphyton samples.	PSEP-TOC
Tissue Metals	The concentration of Ag, Al, As, Cd, Cu, Mn, Ni, Pb, Zn, and Fe in periphyton tissue.	To assess the concentrations of metals in relation to primary productivity.	EPA 1638
Total Solids	The percent of total solids in a tissue sample.	Used to calculate metals concentrations on a dry weight basis.	SM 2540G
Water Chemistry	Discrete measurements of temperature, DO, percent saturation of oxygen, pH, and conductivity using a Hydrolab® Multiprobe.	Assessing general water quality conditions at the time of sampling.	EAP033
Streamflow	Measurement of flow in streams.	Assessing general flow conditions at the time of sampling.	EAP056

Table A-2. In situ water chemistry recorded at the time of periphyton sampling on Railroad Creek in 2013.

Parameter	Station					
	RC-6	RC-1	RC-4	RC-2	RC-5A	RC-10
Date	8/13/2013	8/14/2013	8/15/2013	8/15/2013	8/14/2013	8/14/2013
Time	523	822	1005	843	515	1152
Temp (C°)	14.04	11.2	12	11.32	13.03	11.99
DO (mg/L)	9.02	9.31	9.1	9.31	8.98	9.32
% saturation	87.5	84.1	84.6	84.4	85.2	86.6
pH	6.94	6.97	7.04	6.93	6.8	7.1
Conductivity (uS/cm)	24.6	24.9	26	30.3	33.3	37.6
Discharge (cfs)	116	127	148	151	136	163

Table A-3. Periphyton tissue %TOC and Chl *a* concentrations and area sampled from Railroad Creek in 2013.

Station	% TOC	Chl *a* (ug/cm^2)	Area Sampled (ug/cm^2)
RC-6	1.30	20.40%	1323
RC-1 (A)	3.48	18.10%	1083
RC-1 (B)	2.82	-	1060
RC-4 (A)	0.63	9.14%	715
RC-4 (B)	1.42	7.90%	709
RC-2 (A)	1.35	15.30%	1221
RC-2 (B)	1.71	16.50%	1378
RC-5A (A)	0.70	7.46%	744
RC-5A (B)	0.75	8.73%	792
RC-10 (A)	0.80	9.96%	683
RC-10 (B)	0.55	7.54%	912

-not sampled

Table A-4. Periphyton taxon and density collected from Railroad Creek in 2013.

Taxa	Cell Density (cells/cm^2)									
	RC-6	RC-1	RC- 4 (A)	RC-4 (B)	RC-2 (A)	RC-2 (B)	RC-5A (A)	RC-5A (B)	RC-10 (A)	RC-10 (B)
Cyanophyta (Cyanobacteria)										
Homeothrix	56607	64565	19696	34029	45763	38126	41599	54654	33644	31841
Lyngbya	0	0	54712	17015	0	0	0	0	0	0
Phormidium	73358	0	0	47117	3711	4852	7924	0	0	0
Tolypothrix	0	0	0	0	0	0	0	0	0	8379
Chlorophyta (Green algae)										
Stigeoclonium	0	22227	0	7853	11132	3466	0	4480	0	5028
Bacillariophyta (Diatoms)										
Achnanthes conspicua	0	0	0	83	0	0	0	0	0	0
Achnanthes kriegeri	0	480	5136	1824	1501	534	1651	4265	2639	4368
Achnanthes levanderi	0	0	117	0	0	0	0	0	0	0
Achnanthidium affine	0	0	0	0	0	0	0	152	0	0
Achnanthidium deflexum	0	240	233	0	0	0	0	0	81	0
Achnanthidium gracillimum	289	0	117	0	0	0	110	0	162	514
Achnanthidium minutissimum	38195	66336	20309	15625	23368	18377	6961	15181	11532	21392
Achnanthidium rivulare	0	0	0	0	0	0	165	152	81	0
Achnanthidium thienemannii	0	0	0	0	0	0	0	0	81	0
Adlafia minuscule	0	0	0	0	54	76	0	0	0	0
Amphora copulate	0	0	0	0	0	0	0	102	0	0
Aulacoseira	0	0	0	83	0	0	0	0	41	128
Aulacoseira alpigena	0	0	0	0	0	0	0	0	122	0
Brachysira microcephala	144	0	175	663	107	0	1541	1015	2030	1092
Caloneis	0	0	0	0	0	38	0	0	0	0
Caloneis bacillum	0	0	0	0	0	0	0	0	0	257
Caloneis tenuis	0	0	0	0	0	0	0	51	0	0
Chamaepinnularia soehrensis	0	0	117	0	0	0	0	0	0	0
Cocconeis placentula	0	0	0	83	0	0	0	254	0	193
Cocconeis placentula v. lineata	0	0	58	41	0	0	0	0	0	0
Cymbopleura naviculiformis	0	0	233	0	0	0	0	0	0	0
Diadesmis perpusilla	0	0	58	0	0	0	0	0	0	0
Diatoma anceps	0	0	0	124	0	0	55	51	41	0
Diatoma mesodon	0	120	584	124	214	191	523	711	487	64
Diatoma moniliformis	0	0	0	0	0	0	110	0	0	0
Encyonema minutum	0	0	58	41	0	0	55	102	0	128
Encyonema neogracile	0	0	117	0	0	0	0	0	0	0
Encyonema silesiacum	650	0	467	497	268	0	248	51	406	128
Encyonema ventricosum	0	0	0	0	0	0	110	0	41	0
Encyonopsis cesatii	144	0	233	124	268	0	330	152	0	321
Eolimna minima	0	0	0	83	0	76	55	152	0	0
Eucocconeis laevis	144	0	0	0	0	0	0	0	122	0
Eunotia	0	0	642	373	0	0	413	660	325	578
Eunotia bilunaris v. mucophila	0	0	759	332	0	0	110	254	162	257
Eunotia implicata	0	0	58	0	0	0	55	0	0	0
Eunotia intermedia	0	0	233	0	107	0	55	0	0	385
Eunotia minor	72	0	0	0	0	0	413	355	41	0
Eunotia naegelii	0	0	0	41	0	0	0	0	0	0
Eunotia subarcuatoides	0	0	759	290	161	0	0	457	893	642
Fragilaria capucina	144	120	292	83	0	114	220	558	650	1478
Fragilaria capucina v. gracilis	361	120	175	249	161	76	275	863	731	771
Fragilaria crotonensis	0	0	233	539	0	0	165	203	284	257
Fragilaria vaucheriae	433	120	175	787	375	229	385	914	1299	1606
Frustulia crassinervia	0	0	0	0	0	0	28	0	0	0
Gomphoneis geitleri	0	0	0	0	1286	0	0	0	0	0
Gomphonema	72	1919	700	249	536	381	28	305	325	385
Gomphonema angustatum	0	0	0	83	107	0	28	102	0	0
Gomphonema cymbelliclinum	0	0	0	0	0	0	0	51	0	0
Gomphonema exilissimum	0	0	0	0	0	0	28	0	0	0

Taxa	Cell Density (cells/cm^2)									
	RC-6	RC-1	RC- 4 (A)	RC-4 (B)	RC-2 (A)	RC-2 (B)	RC-5A (A)	RC-5A (B)	RC-10 (A)	RC-10 (B)
Gomphonema kobayasii	433	0	0	0	0	0	220	102	0	0
Gomphonema micropus	0	0	0	41	0	0	0	0	0	0
Gomphonema minutum	0	0	0	41	0	0	0	102	41	0
Gomphonema olivaceoides	0	0	584	497	2680	2097	220	152	0	321
Gomphonema olivaceum	0	0	0	0	0	0	0	51	41	0
Gomphonema parvulum	0	0	233	0	214	38	55	305	203	0
Gomphonema pumilum	0	240	0	0	0	0	0	0	0	0
Gomphonema sarcophagus	0	0	0	0	0	0	0	0	81	0
Gomphosphenia sp. 1 Idaho DW ANSP	0	0	0	0	0	0	0	0	0	128
Hannaea arcus	939	0	525	580	107	153	935	1320	650	964
Mayamaea atomus	0	0	0	83	0	0	0	0	0	0
Meridion circulare	0	0	0	41	0	0	28	0	0	0
Navicula	0	0	0	0	0	0	55	0	0	0

Table A-5. Periphyton taxon and density collected from Railroad Creek in 2013.

Taxa	Cell Density (cells/cm^2)									
	RC-6	RC-1	RC- 4 (A)	RC-4 (B)	RC-2 (A)	RC-2 (B)	RC-5A (A)	RC-5A (B)	RC-10 (A)	RC-10 (B)
Bacillariophyta (Diatoms)										
Navicula angusta	0	0	0	0	0	0	28	0	0	0
Navicula antonii	0	0	0	0	0	0	55	0	0	0
Navicula cryptocephala	0	0	0	0	0	0	55	51	0	0
Navicula cryptotenella	0	0	0	0	107	0	0	0	0	0
Navicula cryptotenelloides	144	0	0	0	0	0	28	0	0	0
Navicula difficillima	0	0	0	41	0	0	0	0	0	0
Navicula lanceolata	0	0	0	0	0	0	28	0	0	0
Navicula recens	72	0	0	83	0	0	0	0	0	128
Navicula seibigiana	0	0	0	0	0	0	28	0	0	0
Navicula ventralis	0	0	58	0	0	0	0	0	0	0
Nitzschia dissipata v. media	72	0	0	0	0	0	0	0	0	0
Nitzschia frustulum	0	0	117	0	0	0	0	0	0	0
Nitzschia liebetruthii	0	0	0	0	0	0	0	0	81	0
Nitzschia microcephala	144	0	0	0	0	0	28	0	0	0
Nitzschia palea	0	0	0	0	0	0	0	102	0	0
Nitzschia perminuta	0	0	117	0	0	76	0	0	0	0
Nitzschia sublinearis	72	0	0	0	0	0	0	0	41	0
Pinnularia	0	0	0	0	0	0	28	51	0	0
Planothidium	0	0	0	0	0	0	0	51	0	128
Planothidium frequentissimum	0	0	0	41	0	0	0	0	81	64
Planothidium lanceolatum	0	0	117	0	0	0	0	0	0	64
Psammothidium daonense	0	0	0	83	0	0	0	0	0	0
Psammothidium subatomoides	0	0	233	83	107	0	55	203	41	321
Reimeria sinuata	794	2039	292	373	0	153	193	203	162	0
Rossithidium nodosum	0	0	642	290	107	76	0	0	244	707
Rossithidium pusillum	0	0	0	0	0	0	28	305	0	0
Stauroneis	0	0	0	0	0	0	0	51	0	0
Staurosira construens v. venter	0	0	0	0	54	0	220	0	0	128
Staurosirella pinnata	0	240	0	83	0	0	28	254	41	0
Synedra rumpens	0	0	0	0	0	0	0	0	0	514
Synedra ulna	0	0	0	0	0	76	0	0	0	0
Tabellaria flocculosa	0	0	58	83	268	114	83	51	81	128
Total density	**173286**	**158766**	**109425**	**130881**	**92763**	**69321**	**66030**	**89597**	**58006**	**83793**

Table A-6. Metrics for periphyton for 2013 Railroad Creek sample sites.

Metric	RC-6	RC-1	RC- 4 (A)	RC-4 (B)	RC-2 (A)	RC-2 (B)	RC-5A (A)	RC-5A (B)	RC-10 (A)	RC-10 (B)
Pollution Index	2.948	2.995	2.94	2.91	2.953	2.965	2.855	2.86	2.838	2.86
Shannon H (log2)	0.957	0.586	2.648	2.581	1.767	1.287	3.509	3.099	3.116	2.806
Species Richness	19	11	36	38	22	18	46	41	36	32
Dominant Taxon Percent	0.8817	0.9217	0.58	0.6283	0.7267	0.8033	0.4217	0.4983	0.4733	0.555
Nitrogen Autotroph Taxa Percent	0.965	0.9583	0.755	0.8683	0.8817	0.945	0.7717	0.7483	0.7933	0.7667
Eutraphentic Taxa Percent	0.015	0.0017	0.0267	0.0533	0.0217	0.015	0.0467	0.0683	0.065	0.0517
Abnormal Cells Percent	0	0	0.0033	0.0033	0.0017	0	0	0.0017	0.01	0.0083
Acidophilous Taxa Percent	0.0017	0	0.0367	0.0217	0.0167	0.005	0.0367	0.035	0.0483	0.0283
Disturbance Taxa Percent	0.0067	0.0033	0.01	0	0	0	0.0067	0	0.01	0.0133
Metals Tolerant Taxa Percent	0.0367	0.005	0.0433	0.0733	0.0333	0.0267	0.0783	0.1	0.135	0.1217
Nitrogen Heterotroph Taxa Percent	0.0033	0	0.01	0.0067	0.0067	0.005	0.0083	0.0183	0.0083	0
Low DO Taxa Percent	0	0	0.0067	0.0033	0.0067	0.005	0.0067	0.0183	0.0083	0
Polysaprobous Taxa Percent	0.03	0.0017	0.03	0.065	0.0267	0.0183	0.0683	0.055	0.0833	0.055
Motile Taxa Percent	0.0333	0.0283	0.0267	0.0533	0.0083	0.0183	0.13	0.0583	0.095	0.0383
Siltation Taxa Percent	0.0117	0	0.0133	0.0117	0.005	0.01	0.0217	0.01	0.005	0.0033
Cosmopolitan Taxa Percent	0.9583	0.96	0.685	0.7833	0.775	0.845	0.6267	0.6817	0.6767	0.705
Native Taxa Percent	0.01	0	0	0	0	0	0.0233	0.0083	0.0033	0
Bacillariophyta Percent	0.25	0.453333	0.32	0.19	0.346667	0.33	0.25	0.34	0.42	0.46
Chlorophyta Percent	0	0.14	0	0.06	0.12	0.05	0	0.05	0	0.06
Cyanophyta Percent	0.75	0.406667	0.68	0.75	0.533333	0.62	0.75	0.61	0.58	0.48

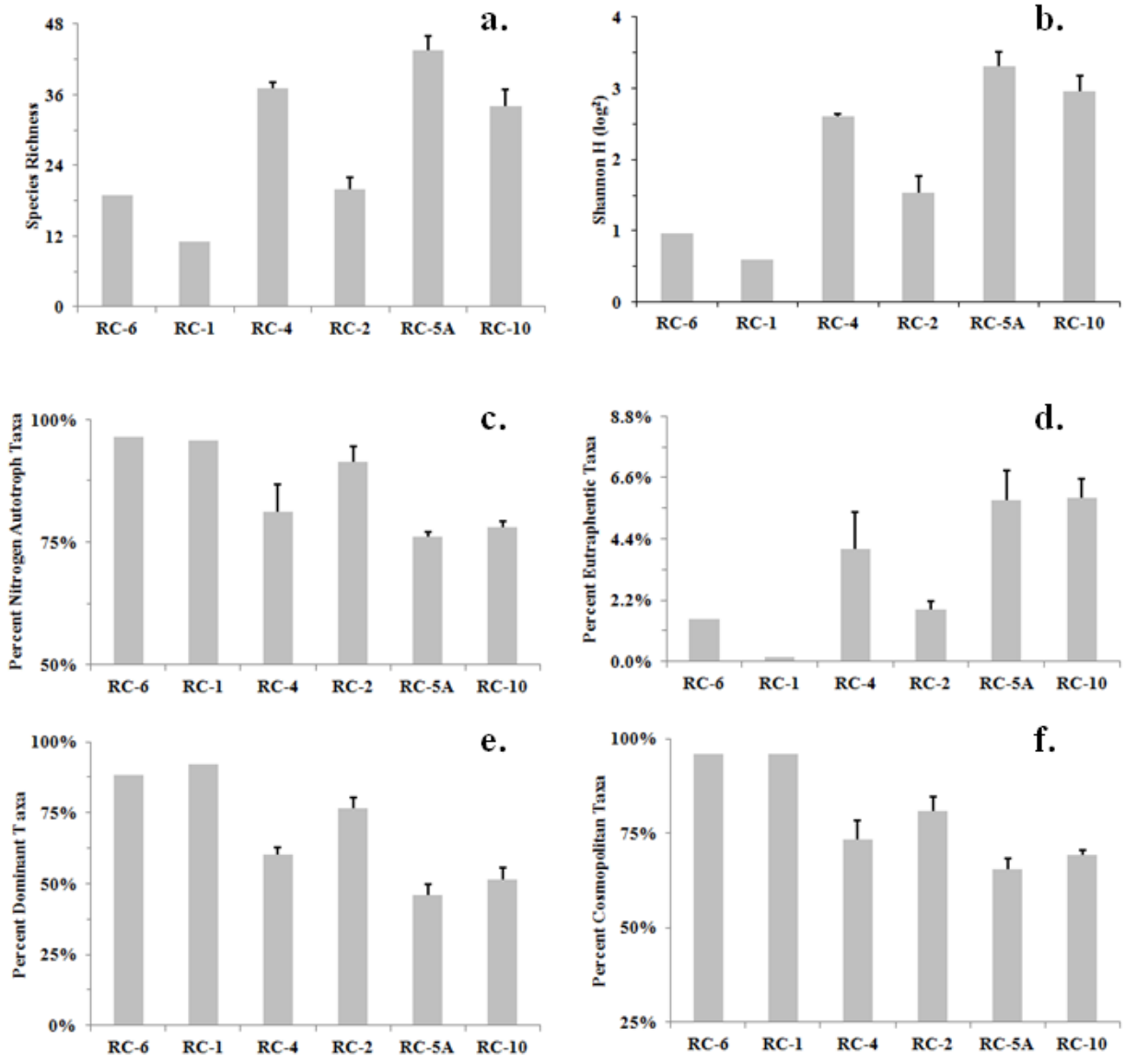

Figure A-1. Results of selected metrics from 2013 periphyton samples collected in Railroad Creek.

Table A-7. Total metal concentrations in periphyton expressed as mg metal/kg periphyton dry weight (dw).

Station	Metal concentration (mg/kg dw)								
	Al	As	Cd	Cu	Fe	Mn	Ni	Pb	Zn
RC- 6*	16667	58	4	76	35327	1993	105	39	239
RC-1 (A)	18781	49	4	118	41200	2743	141	19	299
RC-1 (B)	18414	37	3	116	35903	2352	133	18	277
RC-4 (A)	21172	488	9	1471	342372	526	48	10	904
RC-4 (B)	20980	487	10	1336	349110	268	51	9	920
RC-2 (A)	19306	37	2	435	35463	904	112	29	376
RC-2 (B)	15259	36	1	320	34229	541	112	11	272
RC-5A (A)	23708	259	5	877	231972	440	95	11	667
RC-5A (B)	39625	460	9	1390	385084	1142	108	18	1091
RC-10 (A)	30625	117	8	603	163839	1879	272	13	1321
RC-10 (B)	26976	102	7	537	149573	1421	264	11	1116

Table A-8. Metal concentrations in periphyton collected from Railroad Creek in 2013 expressed as Moles of metals (M)/kg periphyton dry weight (dw).

Station	Total metals (M/kg dw)								
	Al	As	Cd	Cu	Fe	Mn	Ni	Pb	Zn
RC-6*	206	0.78	0.02	0.60	18.14	0.89	0.09	1.83	316
RC-1 (A)	232	0.66	0.02	0.93	24.97	1.20	0.05	2.29	369
RC-1 (B)	227	0.50	0.01	0.91	21.41	1.13	0.04	2.12	321
RC-4 (A)	262	6.51	0.04	11.57	4.79	0.41	0.02	6.91	3065
RC-4 (B)	259	6.50	0.04	10.51	2.44	0.43	0.02	7.03	3126
RC-2 (A)	239	0.50	0.01	3.42	8.22	0.96	0.07	2.87	318
RC-2 (B)	189	0.47	0.01	2.51	4.92	0.96	0.03	2.08	306
RC-5A (A)	293	3.46	0.02	6.90	4.01	0.81	0.03	5.10	2077
RC-5A (B)	490	6.14	0.04	10.94	10.39	0.92	0.04	8.34	3448
RC-10 (A)	378	1.56	0.04	4.74	17.11	2.32	0.03	10.10	1467
RC-10 (B)	333	1.36	0.03	4.22	12.93	2.25	0.03	8.54	1339

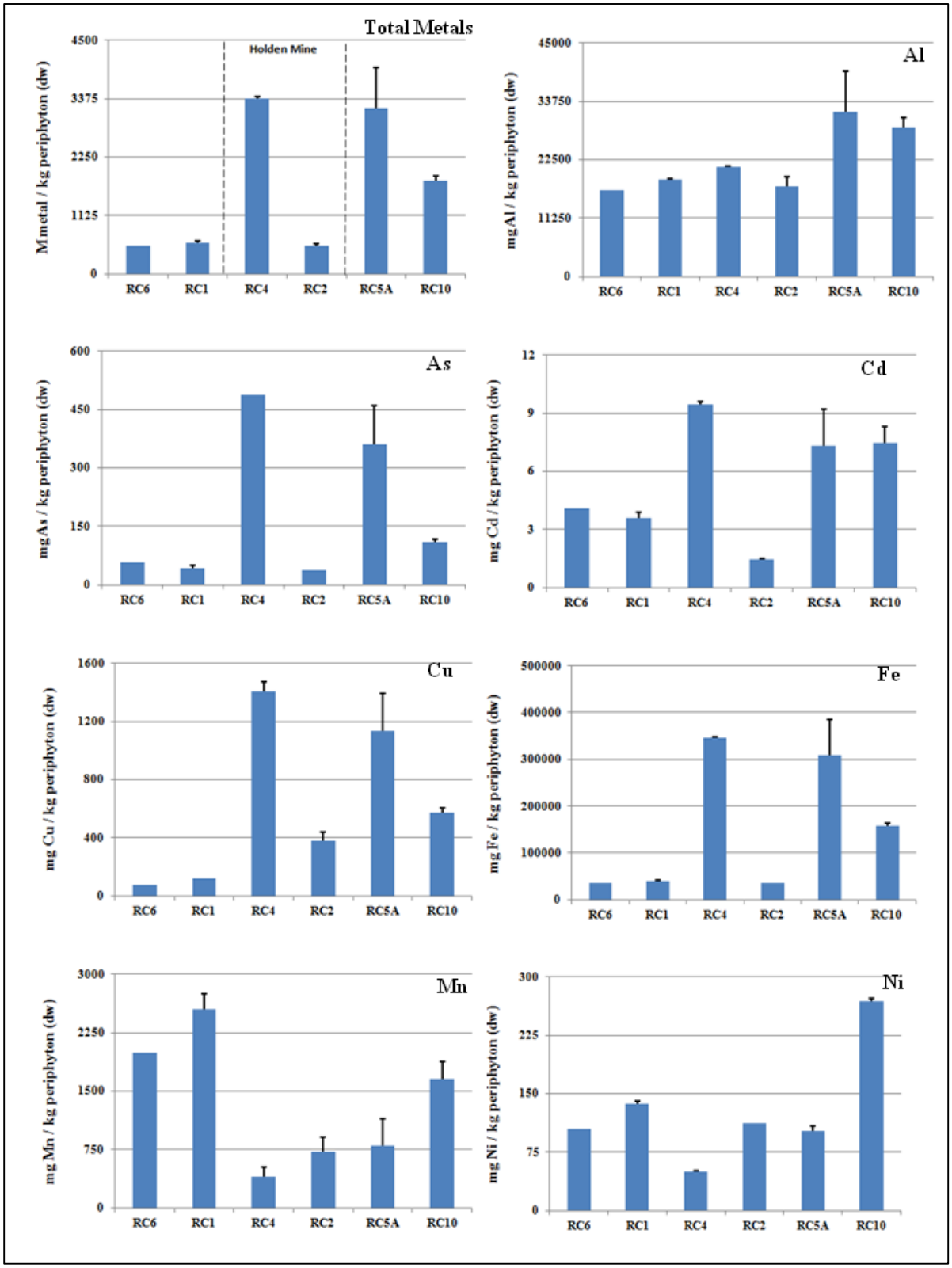

Figure A-2. Concentrations of metals periphyton samples collected from 2013 Railroad Creek sampling.

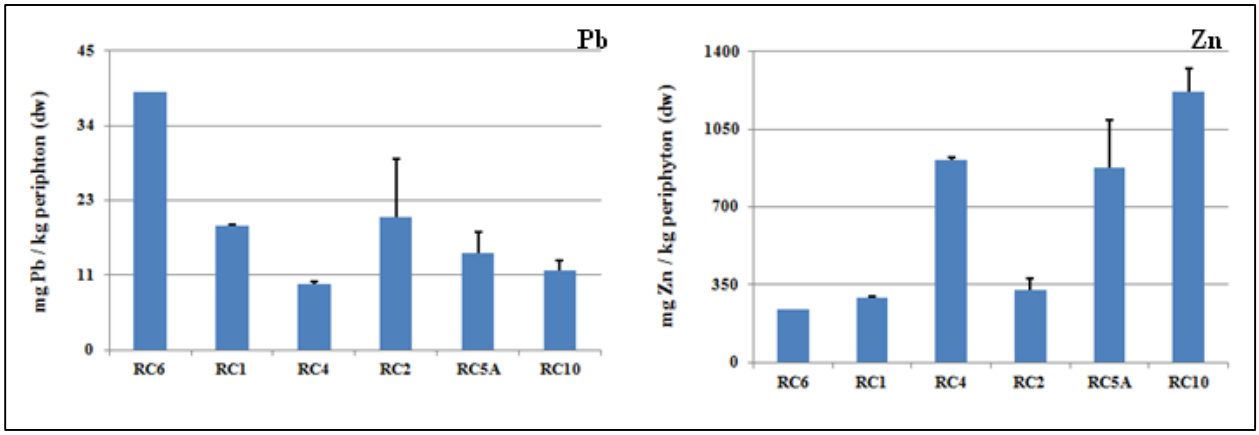

Figure A-3. Concentrations of metals periphyton samples collected from 2013 Railroad Creek sampling.

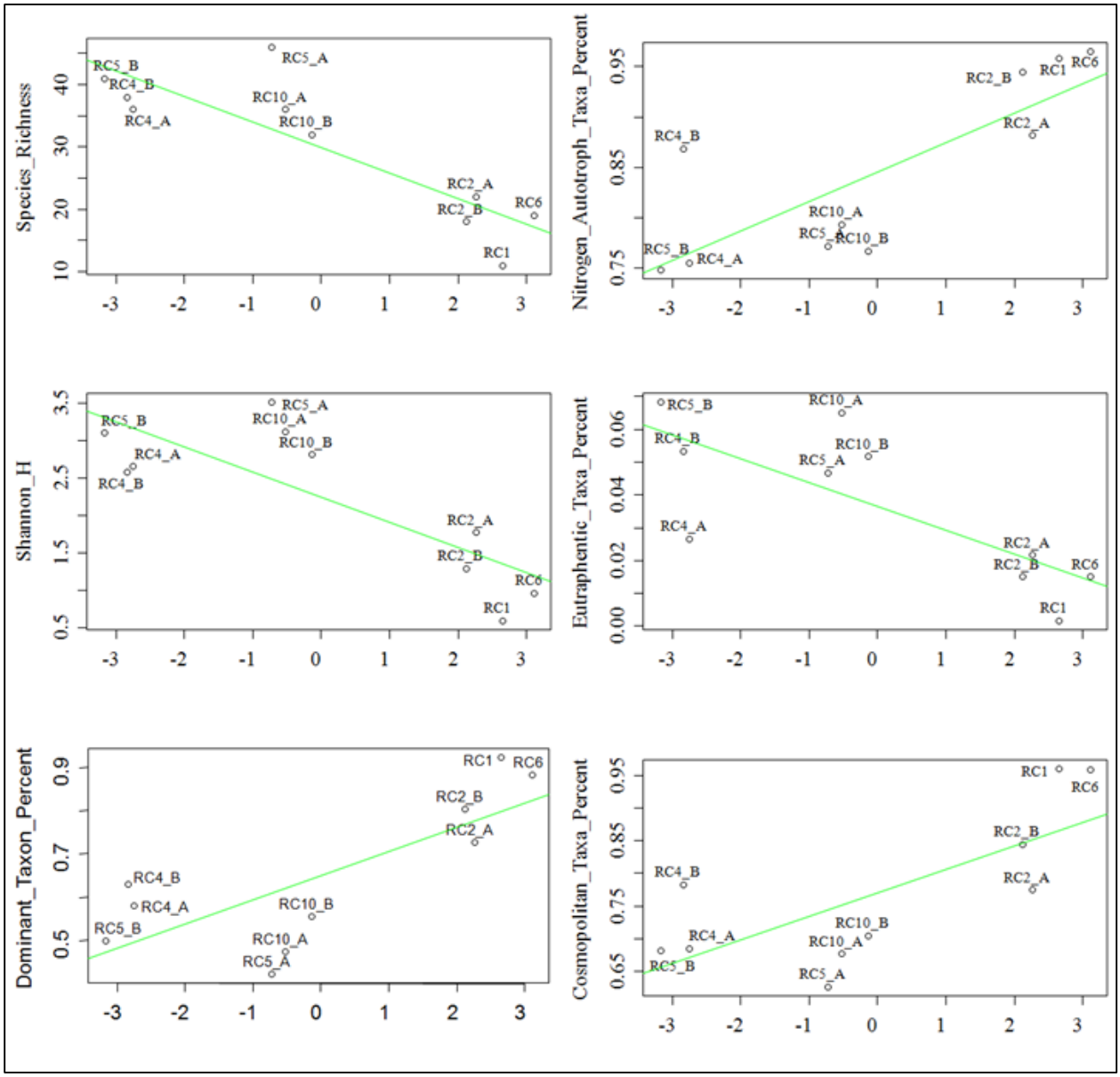

Figure A-4. Results of various diatom metrics regressed with principle components axis 1.

Appendix B. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

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

Bankfull stage: Formally defined as the stream level that "corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne and Leopold, 1978).

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Designated uses: Those uses specified in Chapter 173/201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Diel: Of, or pertaining to, a 24/hour period.

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

Diurnal: Of, or pertaining to, a day or each day; daily. (1) Occurring during the daytime only, as different from nocturnal or crepuscular, or (2) Daily; related to actions which are completed in the course of a calendar day, and which typically recur every calendar day (e.g., diurnal temperature rises during the day, and falls during the night).

Ferricrete: Ferricrete is a hard, erosion-resistant layer of material at the land surface that consists of near surface sediments cemented by iron oxide in to a duricrust. Ferricretes contains sediments and other non-indigenous materials, which have been transported from outside the immediate area in which it occurs. The iron oxide cements are derived from the oxidation of percolating solutions of iron salts. The word is derived from the combination of ferruginous and concrete. Synonyms include ferruginous duricrust, hardpan and ironpan.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Pollution: Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Reach: A specific portion or segment of a stream.

Riparian: Relating to the banks along a natural course of water.

Sediment: Soil and organic matter that is covered with water (for example, river or lake bottom).

Streamflow: Discharge of water in a surface stream (river or creek).

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Synoptic survey: Data collected simultaneously or over a short period of time.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Wasteload allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality/based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act, requiring Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality/limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
e.g.	For example
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
et al.	And others
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
NPDES	(See Glossary above)
QA	Quality assurance
RM	River mile
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
TMDL	(See Glossary above)
TOC	Total organic carbon
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area

Units of Measurement

cfu	colony forming units
g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams
mg	milligram
mg/Kg	milligrams per kilogram (parts per million)
mg/L	milligrams per liter (parts per million)
mL	milliliter
mole	an International System of Units (IS) unit of matter
NTU	nephelometric turbidity units
s.u.	standard units
ug/L	micrograms per liter (parts per billion)
uS/cm	microsiemens per centimeter, a unit of conductivity
ww	wet weight

Quality Assurance Glossary

Accreditation: A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173/50/040] (Kammin, 2010)

Accuracy: The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms precision and bias be used to convey the information associated with the term accuracy. (USGS, 1998)

Analyte: An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella. (Kammin, 2010)

Bias: The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system, and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI). (Kammin, 2010; Ecology, 2004)

Blank: A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process. (USGS, 1998)

Calibration: The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured. (Ecology, 2004)

Check standard: A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards, but should be referred to by their actual designator, e.g., CRM, LCS. (Kammin, 2010; Ecology, 2004)

Comparability: The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator. (USEPA, 1997)

Completeness: The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator. (USEPA, 1997)

Continuing Calibration Verification Standard (CCV): A QC sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re/run at an established frequency during the course of an analytical run. (Kammin, 2010)

Control chart: A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system. (Kammin, 2010; Ecology 2004)

Control limits: Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +// 2 standard deviations from the mean, action limits at +// 3 standard deviations from the mean. (Kammin, 2010)

Data Integrity: A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading. (Kammin, 2010)

Data Quality Indicators (DQI): Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity. (USEPA, 2006)

Data Quality Objectives (DQO): Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.
(USEPA, 2006)

Data set: A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010)

Data validation: An analyte/specific and sample/specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation.
- Use of third/party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography/Mass Spectrometry (GC/MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier, data is usable for intended purposes.
- J (or a J variant), data is estimated, may be usable, may be biased high or low.
- REJ, data is rejected, cannot be used for intended purposes (Kammin, 2010; Ecology, 2004).

Data verification: Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set. (Ecology, 2004)

Detection limit (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero. (Ecology, 2004)

Duplicate samples: Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis. (USEPA, 1997)

Field blank: A blank used to obtain information on contamination introduced during sample collection, storage, and transport. (Ecology, 2004)

Initial Calibration Verification Standard (ICV): A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples. (Kammin, 2010)

Laboratory Control Sample (LCS): A sample of known composition prepared using contaminant/free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. (USEPA, 1997)

Matrix spike: A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects. (Ecology, 2004)

Measurement Quality Objectives (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness. (USEPA, 2006)

Measurement result: A value obtained by performing the procedure described in a method. (Ecology, 2004)

Method: A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed. (EPA, 1997)

Method blank: A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

Method Detection Limit (MDL): This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of

an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)

Percent Relative Standard Deviation (%RSD): A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010)

Parameter: A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all "parameters." (Kammin, 2010; Ecology, 2004)

Population: The hypothetical set of all possible observations of the type being investigated. (Ecology, 2004)

Precision: The extent of random variability among replicate measurements of the same property; a data quality indicator. (USGS, 1998)

Quality Assurance (QA): A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

Quality Assurance Project Plan (QAPP): A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

Quality Control (QC): The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

Relative Percent Difference (RPD): RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a/b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

Replicate samples: Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled. (USGS, 1998)

Representativeness: The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

Sample (field): A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

Sample (statistical): A finite part or subset of a statistical population. (USEPA, 1997)

Sensitivity: In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit. (Ecology, 2004)

Spiked blank: A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method. (USEPA, 1997)

Spiked sample: A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency. (USEPA, 1997)

Split Sample: 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 for QA Glossary

Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. https://fortress.wa.gov/ecy/publications/SummaryPages/0403030.html

Kammin, B., 2010. Definition developed or extensively edited by William Kammin, 2010. Washington State Department of Ecology, Olympia, WA.

USEPA, 1997. Glossary of Quality Assurance Terms and Related Acronyms. U.S. Environmental Protection Agency. http://www.ecy.wa.gov/programs/eap/quality.html

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G/4. U.S. Environmental Protection Agency. http://www.epa.gov/quality/qs/docs/g4/final.pdf

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