DEPARTMENT OF ECOLOGY
State of Washington

# Quality Assurance Project Plan

## Monitoring Metals in Lake Roosevelt Surface Water

June 2025

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**COVER PHOTO**: Lake Roosevelt, April 2023. PHOTO BY WES GLISSON.



[1] https://www.ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database

# Quality Assurance Project Plan

## Monitoring Metals in Lake Roosevelt Surface Water

By Kaitlyn Campbell

Published: June 2025

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EAP: Environmental Assessment Program

# 1.0 Table of Contents

# List of Figures



# List of Tables

# 2.0 Abstract

The Upper Columbia River (UCR) in northeast Washington State (WA) has been contaminated with mining and smelting wastes from a large smelter in Trail, British Columbia, Canada. Studies conducted over the past two decades have demonstrated the presence of toxic concentrations of metals associated with the smelter wastes in sediments, porewater, fish tissue, benthic macroinvertebrates and other media in the UCR and the downstream reservoir portion of the UCR, Lake Roosevelt, which is formed by Grand Coulee Dam. Surface water from Lake Roosevelt is diverted into Banks Lake and used as agricultural water supply throughout Eastern Washington. Previous surface water studies suggest metal concentrations in the water column met drinking water standards; however, these data are over 15 years old and updated baseline information is warranted. To ensure metal concentrations continue to meet Washington State's water quality standards, concentrations of 13 priority metals and other water quality ancillary parameters (total dissolved solids, total suspended solids, alkalinity, hardness) will be measured at three sites over the course of two years. Samples will be collected seasonally to capture differences in flow regime and reservoir height and to provide an accurate estimate of metal concentrations in the water column over time. Results from this study will serve as updated baseline information for this waterbody and inform potential data gap information needs.

# 3.0 Background

## 3.1 Introduction and problem statement

The reservoir portion of the UCR, Lake Roosevelt, was formed by the construction of the Grand Coulee Dam in 1942 and stretches approximately 133 river miles from the dam upstream to within 15 miles from the United States (U.S.) – Canada border. Lake Roosevelt, widely used for recreation, is primarily maintained for power generation, downstream flood control and irrigation purposes. As a result of these operations, the amount of water in Lake Roosevelt fluctuates seasonally with up to 80 feet (ft) in elevation change in reservoir height each year with the full-pool elevation at 1,290 ft above sea-level. Riverine conditions exist in the upper portion of the UCR beginning approximately 15 miles downstream of the U.S.-Canada border.

For nearly a century leading up to 1995, a large smelter facility operated by Teck Cominco Metals (Teck), located approximately 10 miles north of the U.S. - Canada border in Trail, British Columbia, discharged smelter slag and effluent into the UCR. The smelter slag and effluent have been carried downstream to the U.S. portion of the UCR and Lake Roosevelt. As a result, metals, including lead, arsenic, zinc, cadmium and copper have been detected in interstitial water, surficial bed sediments, river sediments, and fish tissue at concentrations that may negatively impact aquatic life and human health (Majewski et al. 2003; Besser et al. 2008; 2018).

Due to this widespread contamination, the U.S. Environmental Protection Agency (EPA) entered into a Settlement Agreement with Teck to conduct a Remedial Investigation and Feasibility Study (RI/FS) in 2006 to evaluate the nature and extent of contamination within the UCR and adjacent upland areas and to develop and evaluate cleanup actions. Previous studies, which are detailed in

Section 3.2.2, indicate elevated metal concentrations in sediment, pore water, and fish tissue. In 2009 and 2010, Teck collected and analyzed three rounds of surface water samples, which showed low concentrations of metals in the water column (Teck American Incorporated 2013). Given the age of existing surface water data, more recent data are needed to ensure compliance with WA State Department of Ecology's water quality standards (Ecology 2023; WAC 173-201A-240).

The present study will analyze surface water samples for metals from three sites within Lake Roosevelt during spring, summer, fall and winter to capture variations in water levels and flow regimes over the course of two years (Figure 1). The resulting data will provide updated baseline water quality information for Lake Roosevelt and inform potential data gap needs of the RI/FS.

## 3.2 Study area and surroundings

Lake Roosevelt is in north-central Washington and extends approximately 133 miles from the Grand Coulee Dam to within 15 miles from the U.S.-Canada border (Figure 1). The lake spans several Water Resource Inventory Areas (WRIAs) including WRIA 42, 53, 58 and 61 and flows through residential, tribal, recreational, and commercial areas. The lake itself is primarily used for public and commercial recreation such as boating, fishing and swimming.

The UCR is divided into six reaches, five of which are located within Lake Roosevelt, starting with Reach 2. Each reach is characterized by distinct geomorphic and hydrodynamic features.

- **Reach 1 (United States Geological Survey [USGS] river mile [RM] 745 to 730):** Reach 1 extends from the U.S.-Canadian border to Northport, WA at USGS RM 730. The first three miles of Reach 1 are shallow (14 ft), narrow and provide a free-running riverine environment. The remaining 12 miles are directly above Lake Roosevelt and influenced by pool levels. This portion changes from free-running riverine to lacustrine (lake-like) conditions based on pool levels and dam operations.
- **Reach 2 (USGS RM 730 to 711):** This is the first reach within Lake Roosevelt, which begins at USGS RM 730 near Onion Creek and extends to the approximate upstream head of Marcus Flats at USGS RM 711. Reach 2 is a relatively narrow channel with a swift current. The riverbed is comprised of larger cobbles and boulders, with finer material along the shoreline, reflecting historical floodplains.
- **Reach 3 (USGS RM 711 to 699):** Reach 3 contains distinct geomorphic features that are believed to favor deposition (and corresponding chemical transport and fate) under historical and contemporary flow regimes. This reach historically contained a series of rapids and cascades known as Kettle Falls, which is now typically inundated by Lake Roosevelt post dam construction. Flow in this reach has decreased since the construction of the dam and water levels have increased, thereby increasing deposition potential for sediment, granulated slag, and contaminants. Subsequently, the fraction of grain-sized particles decreases from upstream to downstream and deposits of granulated slag have been documented. A majority (80–100%) of sediments are coarse particles and the presence of grain-sized particles and granulated slag are thought to be a result of historical flooding of and sediment deposition from upstream reaches.

- **Reach 4 (USGS RM 699 to 640):** This reach is divided into two sub-reaches due to length, differences in sediment and contaminant transport regimes, exposure, and habitat. Reach 4a extends from USGS RM 699 to 676 and borders the Colville Reservation, whereas Reach 4b extends from USGS RM 676 to 640 and borders both the Colville and Spokane Reservations. Together these reaches are referred to as the 'middle reservoir' and end at the confluence with the Spokane River. Water levels in Reach 4a and 4b vary based on water management at the Grand Coulee Dam but typically range from 100 to 300 feet and can become very shallow near the banks.
- **Reach 5 (USGS RM 640 to 617) and Reach 6 (USGS RM 617 to 597):** Reach 5 and 6 represent the 'lower reservoir' and are characterized as a lacustrine environment with slow-moving water. Within Reach 5, the Spokane River joins the Columbia River at USGS RM 639. Within Reach 6, the Sanpoil River joins the Columbia River between USGS RM 615 and 614. Hydraulic resident times are dictated by dam drawdowns and are relatively short, sometimes lasting only 45 days.

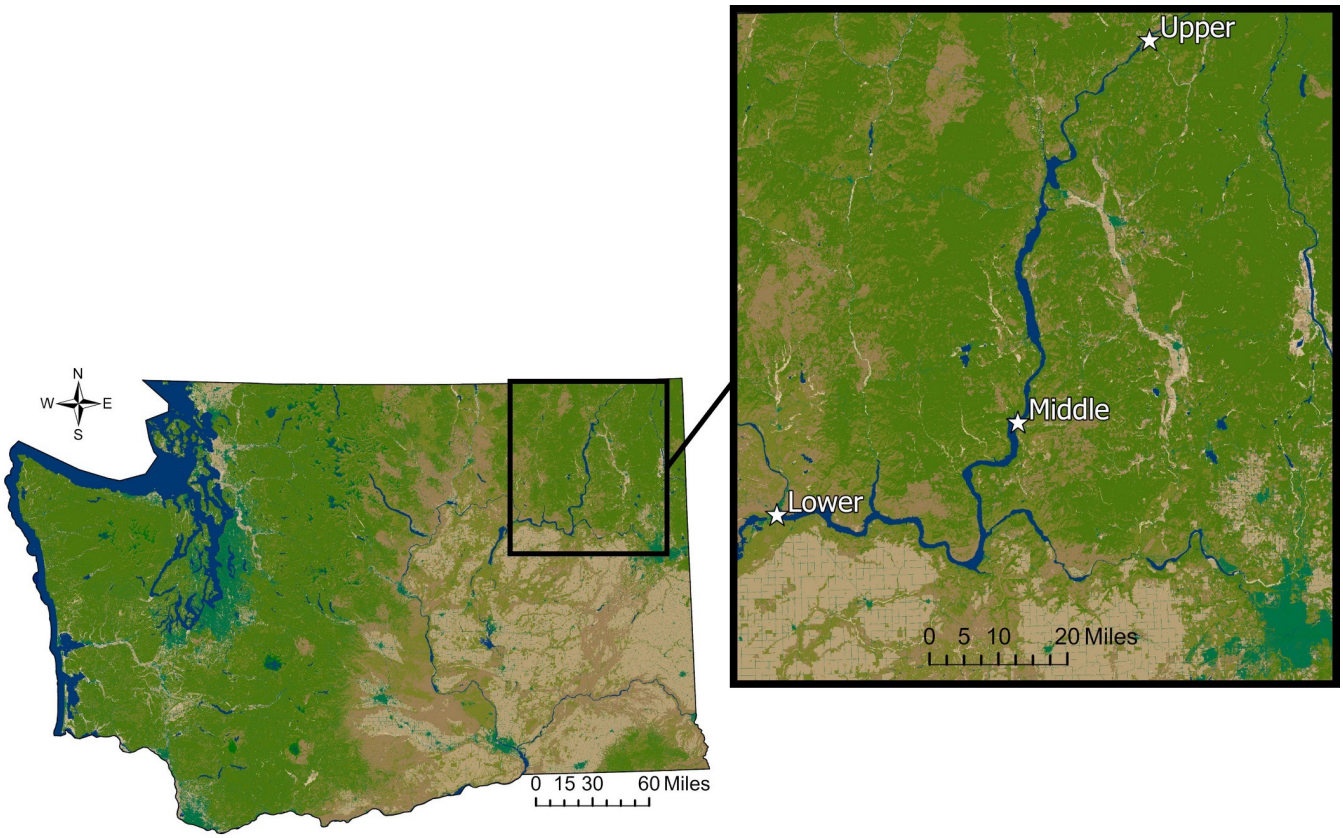


**Figure 1. Map of Washington, USA and the Lake Roosevelt study area.**
White stars mark the upper, middle and lower sampling sites (n=3).

### 3.2.1 History of study area

The UCR was historically occupied by the Confederated Tribes of the Colville Indian Reservation and the Spokane Tribe. By the late 1800s, settlers had arrived to extract resources from the Upper Columbia River and began plans to control the river system for their own benefit. In 1942 the Grand Coulee Dam was completed, creating the reservoir known as Lake Roosevelt, inundating native communities, and destroying salmon fisheries. The dam's original purpose was to provide irrigation water, flood control and to produce hydroelectric power; however, the water and surrounding area quickly became a major recreational and economic resource following the establishment of and inclusion in the Coulee Dam National Recreation Area, now known as the Lake Roosevelt National Recreation Area. The land along both sides of Lake Roosevelt from Northport to 690 RM is largely public with intermediate plots of reservation land along the western bank. At approximately 690 RM, the western side of the river down to the dam is part of the Colville Reservation. The eastern side (from 690 RM to 647 RM) is also public land and then turns into the Spokane Reservation from 646 RM to the outlet of the Spokane River (639 RM). The eastern bank then transitions back to public land from 639 RM to the dam.

### 3.2.2 Summary of previous studies and existing data

Studies on Lake Roosevelt date back to the late 1970s and have historically focused on benthic invertebrate bioassays and the quantitation of metals and non-metals in surface water, pore water, sediments and fish tissue. Elevated metal concentrations have been detected in pore water, sediments, and fish with higher concentrations found closer to the international border and Teck Cominco smelter (Hopkins et al. 1985; Johnson et al. 1989; Bortelson et al. 1994; U.S. EPA 2007). Subsequently, benthic invertebrate bioassays indicated adverse effects on survival, growth, biomass, and reproduction in upper reaches of the UCR, particularly near the border, and in river reaches with slower velocities that encourage deposition of slag material (U.S. EPA 2012). Moreover, fish species that had sustained contact with sediments (i.e., benthic species) tended to have higher tissue concentrations and mirrored patterns observed in previous sediment studies (Serdar et al. 1994). This information led the WA Department of Health (DOH) to create a fish consumption advisory for multiple species and for the WA Department of Ecology to list Lake Roosevelt on the Clean Water Act 303(d) list of impaired water bodies (Munn et al. 1995; Munn 2000; U.S. EPA 2007). Although Lake Roosevelt is listed as an impaired water body due to sediment bioassay and fish tissue data, previous surface water monitoring from 2009 and 2010 showed low concentrations of metals in the water column and all concentrations were met the aquatic life criterion for their respective parameter (Teck American Incorporated 2013).

### 3.2.3 Parameters of interest and potential sources

Contaminants of interest for this study include the following metals and nonmetals that are associated with slag as well as those that have been previously detected in other media (e.g., sediment): antimony (Sb), arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se), thallium (Tl), vanadium (V), and zinc (Zn). Several of these parameters are influenced by characteristics such as pH, the

presence of organic matter, hardness, dissolved organic carbon, temperature, and alkalinity. As a result, additional water quality parameters will be recorded/collected as part of this study including, pH, temperature, conductivity, dissolved oxygen, alkalinity, hardness, and total dissolved/suspended solids.

### 3.2.4 Regulatory criteria or standards

Results from this study will be evaluated against the Washington State Department of Ecology's Water Quality Standards (Ecology 2023; WAC 173-201A-240) as well as other Applicable or Relevant and Appropriate Requirements (ARAR) (Table 1). Compliance will be established if surface water results exceed allowable concentrations of relevant water quality standards.

**Washington's Water Quality Standards**

Washington State's water quality standards consist of criteria and thresholds to protect the health of people, fish, shellfish, and wildlife. Ecology's Water Quality Program Policy 1-11 describes methods to assess surface water health using environmental data by determining whether water quality standards are met (Ecology 2023). Surface waters (freshwater only) are evaluated to support domestic water supply use or aquatic life. For domestic water supply uses, a Drinking Water Exposure Concentration (DWEC) is used to determine if waters meet the criteria. Human health criteria equations are used to develop DWECs, which are then expressed as water ingestion thresholds. DWEC equations are created for carcinogenic (DWECC) and non-carcinogenic health effects (DWECN), with some contaminants having both a DWECC and DWECN. Alternatively, aquatic life criteria are designed to protect freshwater and marine organisms from short-term (acute) and long-term (chronic) exposure to contaminants (WAC 173-201A-240). These criteria typically include a concentration and averaging period. For example, arsenic has a chronic freshwater criterion of 130 µg/L as a 4-day average concentration.

**Table 1. Washington State Department of Ecology Water Quality Standards and Environmental Protection Agency (EPA) Applicable or Relevant and Appropriate Requirements (ARAR).**

| Surface Water Criteria – Dissolved (µg/L) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Parameter | Drinking Water Exposure Concentration (DWEC) | | Aquatic Life Criterion (Freshwater) | | | | Human Health (Freshwater) | | |
| | WA Policy 1-11 ($DWEC_c$[1]) | WA Policy 1-11 ($DWEC_N$[2]) | WAC[3] 173-201A-240 (Acute) | WAC 173-201A-240 (Chronic) | Clean Water Act Section 304A (Acute) | Clean Water Act Section 304A (Chronic) | WAC 173-201A-240 | Clean Water Act Section 304A | National Toxics Rule 40 CFR 131 |
| Antimony | — | 13 | — | — | — | — | 6 | 5.6 | 6 |
| Arsenic | 2,000 | 10 | 300 (a, f) | 130 (b, f) | 340 | 150 | 0.02 (A) | 0.02 | 0.02 |
| Cadmium[4] | — | — | 1.30 | 0.25[6] | 1.8 | — | — | — | — |
| Chromium[4,5] | — | — | 470 (a, f, m) | 61 (b, f, n) | 570 | 74 | — | — | — |
| Copper[4] | — | — | 1.4 | 1.2 | BLM[7] | BLM[7] | 1,300 (B) | 1,300 | — |
| Lead[4] | — | — | 65 | 2.5 | 65 | 2.5 | — | — | — |
| Nickel[4] | — | 670 | 58 | 11 | 470 | 52 | 80 | 610 | 80 |
| Selenium | — | 170 | — | 1.5 | — | — | 60 | 170 | 60 |
| Thallium | — | 2.3 | — | — | — | — | 0.24 | 0.24 | — |
| Zinc[4] | — | 10,000 | 67 | 24 | 120 | 120 | 1,000 | 7,400 | 1,000 |

[1]$DWEC_C$ = Drinking Water Exposure Concentration for carcinogenic effects.
[2]$DWEC_N$ = Drinking Water Exposure Concentration for non-carcinogenic effects.
[3]Washington Administrative Code
[4]Parameters are hardness dependent; values were calculated with a hardness of 100 mg/L.
[5]Chromium is represented as trivalent chromium [Cr (III)].
[6]Based on the Clean Water Act Section 304A 2001 Update of Ambient Water Quality Criteria for Cadmium.
[7]Biotic Ligand Model.
— = Not Applicable.

a. A 1-hour average concentration not to be exceeded more than once every three years on average.
b. A 4-day average concentration not to be exceeded more than once every three years on average.
f. Criteria is for the dissolved fraction.
m. Conversion factor used to calculate the dissolved metal concentration is 0.982.
n. Conversion factor used to calculate the dissolved metal concentration is 0.962.

A. This criterion refers to the inorganic form of arsenic only. These criteria were promulgated for Washington in the National Toxics Rule at 40 CFR 131.36 and are moved to 40 CFR 131.45 to have one comprehensive human health criteria rule for Washington.
B. This criterion is based on a regulatory level developed under the Safe Drinking Water Act.

# 4.0 Project Description

Ecology's Toxics Cleanup Program (TCP) contracted the Environmental Assessment Program (EAP) to conduct surface water sampling at Lake Roosevelt to provide updated baseline water quality information. EAP will collect surface water samples at three sites from the upper, middle, and lower portions of the lake during spring, summer, fall, and winter for two years.

## 4.1 Project goals

The goals of the present study include:

- Quantitate metals associated with mining and smelting activity in the water column.
- Provide updated baseline water quality information (i.e., temperature, hardness, alkalinity, dissolved oxygen, pH, turbidity, conductivity).
- Provide data to support identifying potential data gap needs of the RI/FS.

Results from this study will contribute to:

- Ecology's Water Quality Assessment (WQA).
- Total Daily Maximum Load (TMDL) effectiveness monitoring (Ecology, other groups).
- Data gap evaluation of the RI/FS.

## 4.2 Project objectives

Field work is planned from March 2025 to December 2026. Specific objectives of this study include:

- Collect quarterly surface water samples at three sites from the upper, middle, and lower portions of Lake Roosevelt for analysis of total and dissolved metals.
- Collect surface water samples for hardness, alkalinity, total dissolved solids (TDS), and total suspended solids (TSS) analyses.
- Use a Yellow Spring Instrument (YSI) handheld meter to measure and record pH, turbidity, dissolved oxygen (DO), temperature, and conductivity during surface water collection.
- Obtain flow measurements and reservoir height from existing nearby USGS stream gaging stations during surface water sampling dates.
- Submit monitoring results to Ecology's Environmental Information Management (EIM) database, as appropriate.

## 4.3 Information needed and sources

Previous studies by Ecology, USGS, EPA and other pertinent groups will be reviewed. Historical data from applicable studies will be used to inform site accessibility and selection. During the present study, surface water samples will be collected quarterly (i.e., seasonally) from three sites over two years to assess concentrations of metals associated with mining and smelting activities as discussed in Section 3.2.3.

## 4.4 Tasks required

The tasks required to meet project goals, collect data, and generate summary results are detailed in Section 4.2. Additional information about field and laboratory tasks, and technical approach can be found in Sections 7 and 8.

## 4.5 Systematic planning process

This project-specific QAPP was designed according to Lombard and Kirchmer (2016) and represents the systematic planning process. This QAPP includes the following key elements:

- Description of the project, goals, and objectives (Sections 3 and 4).
- Project organization, responsible personnel, and schedule (Sections 5 and 12).
- Study design to support project goals/objectives and data collection (Sections 7 – 9).
- Specification of quality assurance (QA) and quality control (QC) activities to assess the quality performance criteria (Sections 6, 10 and 11).
- Analysis of acquired data (Sections 13 and 14).

# 5.0 Organization and Schedule

## 5.1 Key individuals and their responsibilities

Table 2 shows the responsibilities of those who will be involved in this project.

**Table 2. Organization of project staff and responsibilities.**

| Staff[1] | Title | Responsibilities |
|---|---|---|
| Brendan Dowling<br>Toxics Cleanup Program<br>ERO<br>Phone: 509-329-3611 | EAP Client | Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP. Manages budget. Analyzes and interprets data. Writes the draft and final report. |
| Kaitlyn Campbell<br>Toxic Studies Unit<br>EAP-SCS<br>Phone: 360-878-4857 | Project Manager; Principal Investigator; Field Lead | Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data and enters data into EIM. Writes the technical memo. |
| Elisa Rauschl<br>Toxic Studies Unit<br>EAP-SCS<br>Phone: 360-764-9249 | Field Assistant | Helps collect samples and records field and processing information. Performs EIM QA. |
| Jim Medlen<br>Toxic Studies Unit<br>EAP-SCS<br>Phone: 360-407-6194 | Unit Supervisor for Project Manager | Provides internal review of the QAPP, approves the budget, and approves the final QAPP. Manages staffing needs. |
| Jessica Archer<br>Toxic Studies Unit<br>EAP-SCS<br>Phone: 360-890-2721 | Section Manager for Project Manager | Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP. Works with management team to help resolve issues affecting the project. |
| Rob Waldrop<br>EAP Manchester Environmental Laboratory<br>Phone: 360-871-8801 | Manchester Lab Director | Reviews and approves the final QAPP. Ensures MEL performs all chemical analyses as requested and ensures results are validated in a timely manner. |
| Christina Frans<br>EAP Manager's Unit<br>Phone: 360-995-2473 | Acting Ecology Quality Assurance Officer | Reviews and approves the draft QAPP and the final QAPP. Ensures EAP adheres to QC-related SOPs and practices. |

EAP: Environmental Assessment Program.
EIM: Environmental Information Management database.
QA: Quality Assurance.
QAPP: Quality Assurance Project Plan.
MEL: Manchester Environmental Laboratory.
SCS: Statewide Coordination Section.
SOP: Standard Operating Procedure.

## 5.2 Special training and certifications

Ecology staff conducting fieldwork have obtained essential training through education and field experience. Field staff are led by a senior staff member who will ensure all procedures are followed. All field staff have received appropriate training based on relevant SOPs, including equipment decontamination, chemical safety, and sample collection, preparation, handling, and storage. Additionally, all staff will adhere to procedures outlined in EAP's Safety Program.

All laboratory personnel have appropriate education and degrees in chemistry with experience in sample preparation, handling, analysis, QA/QC, and chemical safety. These personnel are also expected to meet laboratory accreditation requirements and follow laboratory-specific SOPs for sampling processing, analysis, and data review.

## 5.3 Organization chart

Not Applicable - See Table 2 in Section 5.1.

## 5.4 Proposed project schedule

Tables 3 – 5 list key activities, due dates, and lead staff for this project.

**Table 3. Schedule for completing field and laboratory work.**

| Task | Due Date | Lead Staff |
|---|---|---|
| Field work (varies based on dam drawdowns) | Typically, March-April, June-July, Aug-Sept, and Nov-Dec | Kaitlyn Campbell |
| Laboratory analyses and data validation completed (varies based on time of sample delivery and lab capacity) | Within 7 days to 6 months of sample collection | Rob Waldrop |

**Table 4. Schedule for data entry.**

| Task | Due Date | Lead Staff |
|---|---|---|
| EIM data loaded[a] | Feb 28, 2027 | Kaitlyn Campbell |
| EIM QA | April 30, 2027 | Elisa Rauschl |
| EIM complete | June 30, 2027 | Kaitlyn Campbell |

[a] EIM Project ID: KAIC0001

EIM: Environmental Information Management database.

**Table 5. Schedule for data summary and final report.**

| Task | Due Date | Lead Staff |
|---|---|---|
| Draft technical memo to supervisor | May 31, 2027 | Kaitlyn Campbell |
| Supervisor and peer review | June 15, 2027 | Kaitlyn Campbell |
| TCP client review | June 30, 2027 | Kaitlyn Campbell |
| Final technical memo to client | July 31, 2027 | Kaitlyn Campbell |

## 5.5 Budget and funding

Ecology's TCP is the client for this project. One staff member from EAP is dedicated to this project, however, additional staff will be recruited to assist with field work and sample collection. Tables 6 and 7 show estimated project costs for the duration of the project and a breakdown of the laboratory budget.

**Table 6. Estimated project costs over two years (2025-2026).**

| Item | Cost ($) |
|---|---|
| Salary, benefits, and indirect/overhead | $39,200 |
| Equipment | $1,000 |
| Travel, lodging, and per diem | $11,000 |
| Laboratory (See Table 7 for details.) | $23,315.60 |

**Table 7. Laboratory budget details.**

| Parameter | Number of Samples | Number of Field Replicate Samples | Number of Field Blank Samples | Total Number of Samples | Cost Per Sample ($) | Lab Subtotal ($) |
|---|---|---|---|---|---|---|
| Total Metals | 24 | 8 | 8 | 40 | $216.70 | $8,668.00 |
| Dissolved Metals | 24 | 8 | 8 | 40 | $182.60 | $7,304.00 |
| MS/MSD for Dissolved Metals | 8 | — | — | 8 | $365.20 | $2,921.60 |
| Filters for Dissolved Metals | 24 | 8 | 8 | 50* | $33.00 | $1,650.00 |
| Hardness | 24 | 8 | 0 | 32 | $27.50 | $880.00 |
| Alkalinity | 24 | 8 | 0 | 32 | $22.00 | $704.00 |
| TDS | 24 | 8 | 8 | 40 | $16.50 | $660.00 |
| TSS | 24 | 8 | 0 | 32 | $16.50 | $528.00 |
| | | | | | **Total Cost** | $23,315.60 |

*Additional filters added in case of contamination in the field.
— = Not Applicable

# 6.0 Quality Objectives

## 6.1 Data quality objectives[2]

The data quality objective for this project is to obtain acceptable and defensible data from surface water samples analyzed for metals, hardness, alkalinity, total dissolved solids, and total suspended solids that are representative of current concentrations in Lake Roosevelt over time (i.e., two years) during different flow regimes (i.e., seasons). These data will be used to compare results from previous and future studies. Samples will be analyzed by an accredited laboratory using promulgated methods to obtain data that meet the measurement quality objectives (MQOs).

## 6.2 Measurement quality objectives

MQOs are acceptance criteria for individual data quality indicators and are displayed in Table 8.

### 6.2.1 Targets for precision, bias, and sensitivity

MQOs for the analysis of metals, hardness, alkalinity, total dissolved solids, and total suspended solids are displayed in Table 8. These are expressed in terms of acceptable precision, bias, and sensitivity.

[2] DQO can also refer to ***Decision*** Quality Objectives. The need to identify Decision Quality Objectives during the planning phase of a project is less common. For projects that do lead to important decisions, DQOs are often expressed as tolerable limits on the probability or chance (risk) of the collected data leading to an erroneous decision. And for projects that intend to estimate present or future conditions, DQOs are often expressed in terms of acceptable uncertainty (e.g., width of an uncertainty band or interval) associated with a point estimate at a desired level of statistical confidence.

**Table 8. Measurement quality objectives (e.g., for laboratory analyses of water samples).**

| Parameter | Form | Sensitivity | Bias (% Recovery) | | Precision (% RPD) | |
|---|---|---|---|---|---|---|
| | | MDL / MRL | LCS | Matrix Spike | Lab Duplicate | Matrix Spike Duplicates |
| Antimony | Total | 0.0751 / 0.30 ug/L | 85 – 115 | 75 – 125 | ≤ 20 | ≤ 20 |
| | Dissolved | 0.0039 / 0.20 ug/L | | | | |
| Arsenic | Total | 0.0102 / 0.10 ug/L | | | | |
| | Dissolved | 0.0043 / 0.10 ug/L | | | | |
| Barium | Total | 0.0151 / 0.10 ug/L | | | | |
| | Dissolved | 0.0077 / 0.10 ug/L | | | | |
| Cadmium | Total | 0.0044 / 0.10 ug/L | | | | |
| | Dissolved | 0.0036 / 0.02 ug/L | | | | |
| Chromium | Total | 0.0452 / 0.20 ug/L | | | | |
| | Dissolved | 0.0092 / 0.10 ug/L | | | | |
| Copper | Total | 0.0374 / 0.40 ug/L | | | | |
| | Dissolved | 0.0554 / 0.10 ug/L | | | | |
| Lead | Total | 0.0174 / 0.10 ug/L | | | | |
| | Dissolved | 0.0051 / 0.02 ug/L | | | | |
| Manganese | Total | 0.0031 / 0.1 ug/L | | | | |
| | Dissolved | 0.0031 / 0.01 ug/L | | | | |
| Nickel | Total | 0.0305 / 0.10 ug/L | | | | |
| | Dissolved | 0.006 / 0.01 ug/L | | | | |
| Selenium | Total | 0.0095 / 0.10 ug/L | | | | |
| | Dissolved | 0.0085 / 0.10 ug/L | | | | |
| Thallium | Total | 0.0049 / 0.10 ug/L | | | | |
| | Dissolved | 0.0027 / 0.10 ug/L | | | | |
| Vanadium | Total | 0.0671 / 0.10 ug/L | | | | |
| | Dissolved | 0.0024 / 0.10 ug/L | | | | |
| Zinc | Total | 0.4230 / 5.00 ug/L | | | | |
| | Dissolved | 0.0816 / 1.00 ug/L | | | | |
| Hardness as $CaCO_3$ | NA | 0.067 / 0.30 mg/L | 80 – 120 | NA | | NA |
| Total Dissolved Solids (TDS) | | NA / 0.95 mg/L | | | | |
| Total Suspended Solids (TSS) | | NA / 1.00 mg/L | | | | |
| Alkalinity | Total | 0.570 / 5.00 mg/L | | | | |

RPD = Relative percent difference; MDL = Method detection limit; MRL = Method Reporting limit; LCS = Laboratory Control Samples; NA = Not Applicable.

**Table 9. Measurement quality objectives for Yellow Spring Instrument (YSI) sonde measurements.**

| Parameter | Units | Accept | Qualify | Reject |
|---|---|---|---|---|
| Temperature | ℃ | < or = ± 0.2 | > ± 0.2 and < or = ± 0.8 | > ± 0.8 |
| pH | s.u. | < or = ± 0.2 | > ± 0.2 and < or = ± 0.8 | > ± 0.8 |
| Conductivity | µS/cm | < or = ± 5% | > ± 5% and < or = ± 15% | > ± 15% |
| Dissolved Oxygen | mg/L | < or = ± 0.3 | > ± 0.3 and < or = ± 0.8 | > ± 0.8 |

s.u. = standard units

#### 6.2.1.1 Precision

Precision is a measure of variability among replicate measurements due to random error. Sampling precision will be estimated using results from true field replicates (*n* = 1 field duplicate per sampling event; *n* = 8 total duplicates) and expressed as the Relative Standard Deviation (RSD) (Table 8). Duplicates will be collected using the same field methods to collect true samples.

#### 6.2.1.2 Bias

Bias is the difference between the sample mean and the true value. Laboratory bias will be assessed via laboratory control samples (LCS), matrix spike samples (MS), MS duplicates and field blanks. LCS contain a known amount of analyte and provide a measurement of bias due to sample preparation and/or calibration. MS samples indicate potential interferences due sample matrix and its effect on analyte recovery. MS duplicates provide an estimate of the precision of this bias.

#### 6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as a detection limit. Method detection limits (MDLs) and method reporting limits (MRLs) are displayed in Table 8.

### 6.2.2 Targets for comparability, representativeness, and completeness

#### 6.2.2.1 Comparability

Comparability will be ensured by using consistent and standard field procedures/sample collection methods throughout the duration of the study.

#### 6.2.2.2 Representativeness

Surface water samples will be collected seasonally (spring, summer, fall, and winter) from three sites to account for seasonal variability and fluctuations in the water table/flow regime because of pre-scheduled dam drawdowns. Samples will be collected using standard sampling methods, which will help ensure samples are representative of current site conditions.

#### 6.2.2.3 Completeness

The completeness goal for this project is to collect and analyze 100% of the measurements and samples. However, obstacles may arise that impact the ability to collect or analyze samples, therefore the project will be considered complete if 95% of the measurements and samples are collected and the results meet the project MQOs in Tables 8 and 9.

## 6.3 Acceptance criteria for quality of existing data

Previous surface water data for Lake Roosevelt are extremely limited. Water column results are available from 1986; however, these data will not be used due to age of data and lack of modeling required for this project (Johnson et al. 1989).

## 6.4 Model quality objectives

No modeling will be done for this project. However, summary results including, mean, median, standard deviation, and standard error will be provided.

# 7.0 Study Design

## 7.1 Study boundaries

The study area for this project includes the entire aquatic portion of Lake Roosevelt, starting at USGS RM 730 to the Grand Coulee Dam (Figure 1).

## 7.2 Field data collection

Samples will be collected at three sites from Lake Roosevelt during four sampling events (seasonal) for two years. Surface water sampling sites and alternate locations are provided in Table 10.

### 7.2.1 Sampling locations and frequency

Ecology will conduct quarterly sampling (four times a year) at three sites on Lake Roosevelt (Figure 1). Sample collection will correspond with pre-scheduled drawdowns of the dam and are subject to change based on snowmelt, rainfall, and treaty-based drawdowns. Spring samples will be tentatively collected in late-March to late-April, summer samples will be collected in early-June to early-July, fall samples will be collected in mid-August to mid-September, and winter samples will be collected in mid-November to mid-December.

One site will be in the upper, middle, and lower stretch of Lake Roosevelt (Table 10). These sites were chosen based on site accessibility (i.e., public land; avoidance of unstable banks), presence of boat dock or bridge, presence of free-flowing water (i.e., no stagnant backwater sites), lack of nearby stream or tributary (if present, site will be located above the confluence), and historical monitoring data.

**Table 10. Lake Roosevelt surface water sampling sites for 2025 – 2026.**

| Site | Waterbody | Latitude | Longitude | Description |
|---|---|---|---|---|
| Upper | Lake Roosevelt | 48.921989 | -117.771644 | Near Northport bridge or small dock north of bridge |
| Middle | Lake Roosevelt | 48.129643 | -118.225478 | Hunters Campground Public Boat Launch |
| Lower | Lake Roosevelt | 47.947832 | -118.986762 | Boat ramp above Grand Coulee Dam; near Crescent Bay |

### 7.2.2 Field parameters and laboratory analytes to be measured

In situ field measurements will include water temperature (℃), dissolved oxygen (DO), pH, conductivity (µS/cm), and turbidity (Nephelometric Turbidity Unit; NTU) using a calibrated YSI handheld meter. Reservoir height (ft) and streamflow (cfs) will also be recorded using USGS stream gages at the U.S.-Canadian border (USGS 12399500) and Grand Coulee Dam (USGS 12436000) (U.S. Geological Survey 2024; U.S. Geological Survey 2024b). If data cannot be obtained from these gages, then USGS 12436500 or National Oceanic and Atmospheric Administration (NOAA) gage GCDW1 will be substituted for values at the Grand Coulee Dam and NOAA gage CIBW1 will be used for readings near the international border (U.S. Geological Survey 2024c; NOAA 2024b, NOAA 2024). Water sampling will include the collection of surface water samples for the parameters listed in Table 8. All analyses will be performed by the Manchester Environmental Laboratory (MEL) and all data, including in situ field measurements, will be entered into EIM.

## 7.3 Modeling and analysis design

Not applicable, this project will not involve any modeling.

## 7.4 Assumptions underlying design

The study design assumes the following:

- The sampling of three sites will be representative of current site conditions and will be sufficient to meet the study objectives.
- Sampling once during each season will capture seasonal differences (i.e., flow regime, reservoir height, precipitation, temperature) that may impact results.
- Samples and replicates will characterize the variability in parameter concentrations and will meet the study's measurement quality objectives.

## 7.5 Possible challenges and contingencies

### 7.5.1 Logistical problems

Several logistical issues may interfere with fieldwork and sample collection. These potential challenges and solutions may include:

- Roads to sites may be closed in the fall, winter, and spring due to snow or other unsafe driving conditions.
    - Avoid Stevens Pass along US-2 and instead take I-90. This will require driving through Snoqualmie Pass, which typically has safer driving conditions. The Washington State Department of Transportation (WSDOT) app will be downloaded on all field staff's phones and checked prior to travel. Additionally, an emergency winter car kit will be available along with tire chains in the event of adverse weather.
- Landslides may damage sampling sites/docks, making them inaccessible, and contribute to unstable shorelines and alter water levels.

    - If sampling docks are too damaged to sample from then alternative sampling locations will be used or field staff will seek cooperation from private/public landowners.
- Sample delivery to MEL may be delayed due to unplanned circumstances (i.e., laboratory shutdown, transport delays, etc.), and samples may not be processed within appropriate holding time.
    - Samples may be re-collected in the event they cannot be processed before the holding time expires. This would likely only impact TDS, TSS, and alkalinity samples since their holding times range from 7 to 14 days, whereas metals in surface waters have a holding time of 6 months.
- Sample collection dates may need to be shifted based on reservoir water levels to capture seasonal flow regimes.
    - Adjust as needed and resubmit field sampling plans to the supervisor.

### 7.5.2 Practical constraints

Practical constraints that can interfere with a project may include:

- Scheduling problems with personnel.
    - Postpone work; solicit additional field help from the unit; change schedule to accommodate other staff.
- Availability of adequate resources, both human and budgetary, from EAP and TCP.
    - Postpone or abandon work.
- Assignment of higher priority work.
    - Postpone work and/or alter sampling schedule to accommodate those impacted.
- Short holding time of total suspended solids and total dissolved solid samples (7 days) will require advanced coordination with the laboratory.

Any practical constraints that would affect the ability to meet project goals and objectives will be discussed with the appropriate supervisor as needed and discussed in the final report.

### 7.5.3 Schedule limitations

Changes in project prioritization and workload for both EAP and TCP staff could affect the project schedule. In addition to the logistical and practical constraints that may impact scheduling, other factors that can cause delays to the proposed project schedule include:

- Time required for QAPP review and approval.
- The need for additional sampling or technical analysis work, or the need for policy decisions.

Any unforeseen limitations that would affect the project schedule will be discussed with the appropriate supervisor as needed and discussed in the final report.

# 8.0 Field Procedures

## 8.1 Invasive species evaluation

Lake Roosevelt is not known to contain quagga or zebra mussels or New Zealand mudsnails; however, invasive aquatic plants, such as Eurasian watermilfoil, can be found throughout the lake. To prevent the spread of invasive aquatic plants, all field equipment will be decontaminated according to EAP's SOP *EAP070* prior to each field sampling event (Ecology 2024).

## 8.2 Measurement and sampling procedures

Prior to use in the field, all applicable YSI probes will be checked and recalibrated in the laboratory if needed. pH and conductivity probes will be checked/calibrated against National Institute of Standards and Technology (NIST)-certified pH and conductivity standards, whereas DO probes will be checked against a saturated water bath, the temperature probe will be checked using a NIST-certified thermometer, and the turbidity probe will be checked against NIST-certified turbidity standards. Standard solutions will be on hand while conducting field sampling for potential recalibration due to abnormal readings. All YSI parameters, including pH, conductivity, turbidity, DO, and temperature will be measured using a calibrated handheld YSI meter prior to the collection of any water samples.

Before collecting, all sampling bottles will be rinsed three times with site water according to *EAP015* (Ecology 2021a). Surface waters for metals analysis (total and dissolved) will be collected according to the protocol outlined in *EAP029* (Ecology 2021b). Briefly, total metals samples will be collected via grab samples (with an extension pole) using the pre-cleaned 1 L, high density polyethylene (HDPE) TSS sampling bottle and transferred to a secondary 500 mL HDPE bottle containing 5 mL of 1:1 nitric acid. The total metals samples will be agitated by hand to ensure the preservative mixes with the sample and then stored on ice. The TSS sampling bottle will be used a second time to collect the dissolved metals sample, which will then be filtered in the field within 15 minutes of collection using a site water-rinsed plastic filtering cup and a pre-weighed 0.45 um glass fiber filter (prepped and supplied by MEL). The dissolved metals filtrate will be transferred from the filtration cup to a MEL-supplied 500 mL HDPE bottle containing 5 mL of 1:1 nitric acid, agitated by hand, and immediately stored on ice.

The TSS bottle will be used a third time to collect the actual TSS sample and approximately 100 mL will be subsampled into a 125 mL HDPE bottle containing 1:1 sulfuric acid preservative and serve as the hardness sample. The hardness sample will be inverted to ensure the acid mixes with the sample and stored separately from the metals samples. After subsampling, the remaining portion of the TSS sample will be stored on ice. TDS will be collected via grab sample with an extension pole and stored in a 500 mL HDPE bottle on ice.

Alkalinity samples will be collected via surface water grab sample without any headspace and stored in a 500 mL HDPE bottle. Special care will be given to avoid agitating the sample and it will be stored separately from other samples that require agitation.

Sampling conditions, flow (using USGS stream gages), reservoir height and other technical details will be recorded in a field notebook. All field samples will be immediately stored on ice and

delivered to MEL within the appropriate holding time via an Ecology courier. MEL will process all samples following standard analytical methods outlined in the lab user manual (MEL 2016).

## 8.3 Containers, preservation methods, holding times

Table 11 presents the sample matrix, minimum quantity for analysis, corresponding sample container, preservative requirements and methods, and holding time for each parameter.

**Table 11. Sample containers, preservation, and holding times.**

| Parameter | Matrix | Minimum Quantity Required | Container | Preservative | Holding Time |
|---|---|---|---|---|---|
| Dissolved metals (antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, nickel, selenium, thallium, vanadium, zinc) | Water | 350 mL | 500 mL HDPE bottle | Filter within 15 minutes of collection; then add $HNO_3$ to pH <2, cool to ≤6°C until preservation | 6 months |
| Total metals (antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, nickel, selenium, thallium, vanadium, zinc) | Water | 350 mL | 500 mL HDPE bottle | $HNO_3$ to pH <2 | 6 months |
| Hardness | Water | 100 mL | 125 mL w/m poly bottle | $H_2SO_4$ to pH <2, Cool to ≤6°C until preservation | 6 months |
| Total dissolved solids (TDS) | Water | 250 mL | 500 mL w/m poly bottle | Cool to ≤6°C | 7 days |
| Total suspended solids (TSS) | Water | 1 L | 1 L w/m poly bottle | Cool to ≤6°C | 7 days |
| Alkalinity | Water | 500 mL — NO headspace | 500 mL polyethylene bottle | Cool to ≤6°C; fill bottle completely, DO NOT agitate sample | 14 days |

$HNO_3$ = nitric acid; $H_2SO_4$ = sulfuric acid.
w/m = wide mouth.

## 8.4 Equipment decontamination

Sample bottles will be provided by MEL and will be pre-cleaned. All field supplies are single use, and decontamination will not be necessary. If decontamination is needed, the item will be rinsed with hot tap water in the laboratory and scrubbed using a Liquinox solution, followed by a final tap water rinse. Equipment will then be rinsed three times with deionized (DI) water, followed by a 10% nitric acid rinse, DI rinse, air dried in the hood, and wrapped with the dull side of aluminum foil for transportation into the field. More detailed decontamination methods for inorganics can be found in SOP *EAP090* (Ecology 2021c).

## 8.5 Sample ID

**LR_SP25_DM1.1** will indicate **L**ake **R**oosevelt (LR) surface water samples that were collected in spring 2025 for **d**issolved **m**etals (**DM**) site **1**, sample **1**. The '**1.2**' in LR_SP25_DM**1.2** will denote replicate dissolved metals water samples collected at site 1 in spring 2025. The '**B**' in LR_SP25_DM1.**B** will indicate the dissolved metals bottle blank was performed in spring 2025 at site 1. Bottle blanks will be collected at site 1, as this site is closest to the Teck Cominco smelter in Trail, BC, Canada and has the potential for the highest surface water concentrations. Similarly, the '**F**' in LR_SP25_DM1.**F** will indicate dissolved metals filter blanks. The following abbreviations will be used for other collected parameters: **TM** = **t**otal **m**etals, **TDS** = **t**otal **d**issolved **s**olids, **TSS** = **t**otal **s**uspended **s**olids, **A** = **a**lkalinity, **H** = **h**ardness. The following seasons/years will be denoted as SU25 = Summer 2025, F25 = Fall 2025, W25 = Winter 2025, SP26 = Spring 2026, SU26 = Summer 2026, F26 = Fall 2026, W26 = Winter 2026.

## 8.6 Chain of custody

Chain of custody procedures will be followed according to MEL protocol (MEL 2016). Once collected, samples will be filtered (when applicable), preserved (when applicable), and stored on ice inside the locked sampling vehicle. Samples will be transported to Ecology's Operation Center in Lacey, WA and stored in a secure walk-in cooler until pick up by the lab courier and transported to MEL in Port Orchard, Washington.

## 8.7 Field log requirements

Sampling progress will be recorded in a waterproof field notebook (Rite in the Rain), which will contain the following:

- Name and location of project
- Field personnel
- Sequence of events
- Any changes or deviations from the QAPP
- Environmental conditions
- Date, time (military), location, sample ID, preservation method, and description of each sample
- Field instrument calibration procedures
- Field measurement results
- Identity of QC samples collected
- Unusual circumstances that might affect interpretation of results

## 8.8 Other activities

Field staff unfamiliar with these sampling methods will be trained by senior personnel or project manager according to the relevant Ecology SOPs. The field lead will notify MEL of the sampling events at least three weeks prior to sampling. The field lead will also work with MEL to develop a schedule for sample container delivery.

# 9.0 Laboratory Procedures

## 9.1 Lab procedures table

**Table 12. Measurement methods (laboratory).**

| Analyte | Sample Matrix | Samples (Number / Arrival Date*) | Detection (MDL) / Reporting Limit (MRL) | Sample Prep / Analysis Method |
|---|---|---|---|---|
| Antimony — Dissolved | Water | 24* | 0.0039 / 0.20 µg/L | EPA200.8 |
| Antimony | Water | 24* | 0.0751 / 0.30 µg/L | EPA200.8 |
| Arsenic — Dissolved | Water | 24* | 0.0043 / 0.10 µg/L | EPA200.8 |
| Arsenic | Water | 24* | 0.0102 / 0.10 µg/L | EPA200.8 |
| Barium — Dissolved | Water | 24* | 0.0077 / 0.10 µg/L | EPA200.8 |
| Barium | Water | 24* | 0.0151 / 0.10 µg/L | EPA200.8 |
| Cadmium — Dissolved | Water | 24* | 0.0036 / 0.02 µg/L | EPA200.8 |
| Cadmium | Water | 24* | 0.0044 / 0.10 µg/L | EPA200.8 |
| Chromium — Dissolved | Water | 24* | 0.0092 / 0.10 µg/L | EPA200.8 |
| Chromium | Water | 24* | 0.0452 / 0.20 µg/L | EPA200.8 |
| Copper — Dissolved | Water | 24* | 0.0554 / 0.10 µg/L | EPA200.8 |
| Copper | Water | 24* | 0.0374 / 0.40 µg/L | EPA 200.8 |
| Lead — Dissolved | Water | 24* | 0.0051 / 0.02 µg/L | EPA200.8 |
| Lead | Water | 24* | 0.0174 / 0.10 µg/L | EPA200.8 |
| Manganese — Dissolved | Water | 24* | 0.0038 / 0.010 µg/L | EPA200.8 |
| Manganese | Water | 24* | 0.0038 / 0.10 µg/L | EPA200.8 |
| Nickel — Dissolved | Water | 24* | 0.006 / 0.01 µg/L | EPA200.8 |
| Nickel | Water | 24* | 0.0305 / 0.10 µg/L | EPA200.8 |
| Selenium — Dissolved | Water | 24* | 0.0085 / 0.10 µg/L | EPA200.8 |
| Selenium | Water | 24* | 0.0095 / 0.10 µg/L | EPA200.8 |
| Thallium — Dissolved | Water | 24* | 0.0027 / 0.10 µg/L | EPA200.8 |
| Thallium | Water | 24* | 0.0049 / 0.10 µg/L | EPA200.8 |
| Vanadium — Dissolved | Water | 24* | 0.0024 / 0.10 µg/L | EPA200.8 |
| Vanadium | Water | 24* | 0.0671 / 0.10 µg/L | EPA200.8 |
| Zinc — Dissolved | Water | 24* | 0.0816 / 1.00 µg/L | EPA200.8 |
| Zinc | Water | 24* | 0.423 / 5.00 µg/L | EPA200.8 |
| Hardness (as $CaCO_3$) | Water | 24* | 0.067 / 0.30 mg/L | SM2340B |
| Alkalinity, Total | Water | 24* | 0.570 / 5.00 mg/L | SM2320B |
| Total Dissolved Solids (TDS) | Water | 24* | NA / 0.95 mg/L | SM2540C |
| Total Suspended Solids (TSS) | Water | 24* | NA / 1.00 mg/L | SM2540D |

*Samples will be delivered in late-March to early-April, early-June to early-July, mid-August to mid-September, mid-November to mid-December.
MDL = Method Detection Limit; MRL = Method Reporting Limit; NA = Not Applicable.

## 9.2 Sample preparation method(s)

See Section 8.2 for more details.

## 9.3 Special method requirements

NA.

## 9.4 Laboratories accredited for methods

MEL will analyze all samples for this study and is accredited for the methods listed in Table 12.

# 10.0 Quality Control Procedures

Field quality control procedures include the use of field replicates and field method blanks. Laboratory quality control procedures include matrix spikes, calibration standards, laboratory control samples, and laboratory blanks.

## 10.1 Table of field and laboratory quality control

Field blanks, in the form of transfer and filter blanks (*n* = 1 per sampling event; *n* = 8 total samples), will be used to detect bias resulting from potential contamination from surroundings in the field, sampling and storage containers (i.e., sampling bottles, filter units, filters, blue ice, coolers), or cross-contamination during shipping. For transfer blanks, DI water will be transported in a sample container into the field, transferred into a secondary sample container containing 1:1 nitric acid, and stored with other samples collected during that sampling event. Filter blanks will involve filtering 500 mL of DI water through a MEL provided filtering unit with a 0.45 µm filter and transferring the filtrate to a HDPE bottle containing 1:1 nitric acid. All field blanks will contain 1:1 nitric acid to mimic the preservative used in the primary metals surface water samples and be performed at the most contaminated site to replicate worst case scenario. Acceptable target ranges are provided in Tables 8 and 9.

Field instruments will be calibrated in the laboratory prior to each sampling event using NIST standards. Probe measurements will be checked post-calibration to ensure values are accurate and to assess potential bias from instrument drift, fouling, or interference. Specifically, pH and conductivity probes will be checked against NIST-certified pH and conductivity standards. DO will be checked against 100% saturation with a saturated water bath. Temperature will also be checked using the saturated water bath with an external NIST-certified thermometer. Turbidity will be checked against NIST-certified turbidity standards.

**Table 13. Quality control samples, types, and frequency.**

| Parameter | Field Blanks | Field Replicates | Laboratory Control Samples | Laboratory Method Blanks | Analytical Duplicates | Matrix Spikes / Matrix Spike Duplicates |
|---|---|---|---|---|---|---|
| Total Metals | 1/sampling event | 1/sampling event | 1 pair/batch[1] | 1/batch | NA | 1 pair/batch |
| Dissolved Metals | | | | | | |
| Hardness | NA | | | | | |
| Alkalinity | | | | 2/batch | 2/batch | NA |
| Total dissolved solids (TDS) | 1/sampling event | | | | | |
| Total suspended solids (TSS) | NA | | | | | |

[1]A batch is defined as up to 20 samples analyzed together.
NA = Not Applicable

Each type of QC sample listed in Table 13 will have MQOs associated with it that will be used to evaluate the quality and usability of the results (Section 6.2).

## 10.2 Corrective action processes

In the field, corrective actions will be taken if field instruments (e.g., YSI) yield abnormal results or collection methods are inconsistent with the QAPP. Additional actions will be taken if there are inconsistencies in laboratory analyses, data review processes, MQOs, or if other unforeseen problems arise. Actions may include:

- Collecting new samples using the method described in the approved QAPP.
- Recalibrating field instruments according to SOPs.
- Reanalyzing laboratory samples that do not meet QC criteria.
- Laboratory may request additional samples if holding times are not met.
- Convening project personnel and technical experts to decide on next steps to improve performance of project components.

# 11.0 Data Management Procedures

## 11.1 Data recording and reporting requirements

Field notes and observations will be recorded in waterproof notebooks, prepared field forms, maps, and/or sketches. Data written in field notebooks will be scanned and retained as a digital copy and transferred to an electronic format using Microsoft Office products (Excel/Word) and ArcView GIS. Field data will be quality assured and entered into EIM as soon as practical post-sampling. Missing or abnormal data will be flagged and brought to the attention of the project manager and client for further discussion

Laboratory results will be verified and validated as described in Section 13. Laboratory data generated by MEL will be entered into the Laboratory Information System (LIMS) and an electronic data deliverable (EDD) will be uploaded to EIM by MEL staff. Project staff will access data in EIM after being notified by EIM's automatic notification setting. Procedures for handling qualified values, such as non-detects, will follow Ecology's Toxic Studies Unit (TSU) guidance and/or be documented in subsequent reports.

The Environmental Information System (EIM) Study ID for this project is KAIC0001.

## 11.2 Laboratory data package requirements

Laboratory-generated data will be reviewed and reported according to the MEL User's Manual (MEL 2016). A case narrative will accompany MEL laboratory data and be sent as a pdf (from LIMS) to the project manager. The case narrative will document the verification checks, problems encountered during analyses, corrective actions taken (if any), and a glossary for data flags and qualifiers.

## 11.3 Electronic transfer requirements

MEL staff will enter laboratory data into LIMS and transfer data as an EDD in .csv format to EIM when the work order is complete. EIM has an automatic notification setting that will notify project staff when data are ready for download. Case narratives will be in pdf format and sent to project managers via email.

## 11.4 EIM/STORET data upload procedures

Data (field and laboratory-generated data) will be entered into Ecology's EIM database following EIM guidance. As per EIM Data Review Procedures, approximately 10% of laboratory data will be manually checked by the project manager after entering it into EIM to ensure accuracy.

## 11.5 Model information management

NA. This project will not involve any modeling.

# 12.0 Audits and Reports

## 12.1 Field, laboratory, and other audits

Audits of field procedures, sampling processing, or other components outside of the laboratory environment are not planned and likely not possible due to staffing resources. MEL is an accredited laboratory and is periodically audited by Ecology's Laboratory Accreditation Program.

## 12.2 Responsible personnel

Audits of field procedures, sampling processes, or other components outside of the laboratory environment may occur at the discretion of Ecology's Quality Assurance Officer, supervisors, or the Project Manager. Ecology's Laboratory Accreditation Program conducts audits on laboratory according to their program guidance. See Table 2 in Section 5.1 for more specific information about individual duties and responsible personnel.

## 12.3 Frequency and distribution of reports

A Data Summary Report (DSR) will be generated by the principal investigator for each year of sampling and provided to the client via email. The DSR will include an overview of the study, objectives, summary of laboratory results, and discussion of laboratory results and data quality. The client, at its discretion, will generate a final report, recommendations, website updates, and/or any other follow-up documents.

## 12.4 Responsibility for reports

The principal investigator (EAP's TSU) will be responsible for the DSR/technical memo and the client (TCP) will be responsible for the draft and final report.

# 13.0 Data Verification

EPA defines data verification as "the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements."

## 13.1 Field data verification, requirements, and responsibilities

Initial field data verification will be performed by the project manager immediately after collecting field measurements/sample collection and prior to site departure. This process involves checking the data sheet for missing data or outliers. Measurements will be repeated in the event of missing data or outliers are detected. Post field sampling, the project manager will review and compare field data to determine compliance with MQOs. Any values that are out of compliance will be flagged and their usability will be determined at the end of the project by the project lead.

## 13.2 Laboratory data verification

Laboratory data will be verified and undergo a Stage 2B validation as defined in EPA's Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (U.S. EPA 2009). MEL staff will perform a "same-party validation" according to MEL's internal procedures. MEL's SOP *MEL720017* (MEL 2020) details the peer and final review for inorganics data.

Verification and validation processes and the person(s) that reviewed each dataset will be documented in the Case Narrative and other related documents provided by MEL. The Case Narrative will be provided to the Project Manager, who will review it and address any issues with the data reviewers.

## 13.3 Validation requirements, if necessary

A qualified, independent chemist will validate all data for this project. Raw instrument records and bench sheets will be assessed to determine the quality of project data. This additional layer of validation is warranted since samples will be collected infrequently (months apart) and over the course of two years. It's crucial to confirm instrumental consistency since these data will be used for the EPA's RI/FS and are tied to a newly listed Superfund Site.

## 13.4 Model quality assessment

NA. No modeling will be done for this project.

# 14.0 Data Quality (Usability) Assessment

## 14.1 Process for determining project objectives were met

The project manager will determine the overall quality and usability of data and whether the project objectives were met by assessing all qualified and unqualified data, results from the verification and validation process, and MQO compliance.

## 14.2 Treatment of non-detects

Laboratory data will be reported down to the reporting limit and non-detects will be U- or UJ-qualified (i.e., non-detects will be censored to the laboratory reporting limit). When calculating total metals, non-detects will be substituted for half the detection limit according to the EPA's Regional Guidance on Handling Chemical Concentration Data Near the Detection Limit in Risk Assessments (Smith 1991). Summed values in the summary and final report will only include results that are unqualified and/or J-qualified (indicating that the analyte was positively identified, and the associated numerical value is approximate). Values that have been NJ-qualified (indicating that the analyte has been "tentatively identified" and the associated value represents its approximate concentration) will not be included. If a sample is comprised of all non-detected congener results, then the final value will be assigned "ND" for not detected. Values will be J-qualified if more than 10% of the total result is J-qualified.

## 14.3 Data analysis and presentation methods

Summary results will be calculated using R (R Core Team 2021; version 4.4.0) in RStudio (Posit team 2024; version 2024.4.0.735) with the *dplyr* package (Wickham et al. 2023; version 1.1.4). Data will be grouped by site and contaminant to produce site level summary results. Data will also be grouped by year and contaminant to produce annual contaminant-specific summary results. Raw data and/or summary results will be displayed using the *ggplot2* package (Wickham 2016).

## 14.4 Sampling design evaluation

NA. Statistical analysis will not be performed.

## 14.5 Documentation of assessment

Documents used for the data usability assessment will include a variety of notes and reports as described above, such as:

- Field notes and laboratory Case Narratives.
- Verification and validation reports from laboratories and project staff.
- Worksheets and tables comparing results from field and QC samples to MQOs and other data quality indicators.

A data quality review worksheet may be created to record the overall decision about how to use laboratory results for each analyte and sampling event and may be included in the summary report/technical memo.

# 15.0 References


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# Appendix A. Glossaries, Acronyms, and Abbreviations

## Glossary of General Terms

**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.

**Dissolved oxygen (DO):** Concentration of oxygen gas incorporated in water.

**Drinking Water Equivalent Concentration (DWEC):** The DWEC is a drinking water ingestion exposure threshold used by Ecology to determine whether the designated uses of drinking from surface waters are being met. The DWEC is an interpretation of Washington's water quality criterion for a specific chemical for the protection of human health. Concentrations lower than the DWEC suggest that the uses of drinking from surface waters are being met for that specific contaminant.

**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 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.

**Reach:** A specific portion or segment of a stream.

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

**Total Maximum Daily Load (TMDL):** A distribution of a substance in a water body designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

**Total suspended solids (TSS):** Portion of solids retained by a filter.

**Total dissolved solids (TDS):** Measure of the dissolved combined content of all inorganic and organic substances present in a liquid in molecular, ionized, or microgranular suspended form.

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

**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

| | |
|---|---|
| ARAR | Applicable or Relevant and Appropriate Requirements |
| As | Arsenic |
| Ba | Barium |
| Cd | Cadmium |
| Cr | Chromium |
| Cr (III) | Trivalent chromium |
| Cu | Copper |
| DI | Deionized |
| DM | Dissolved metals |
| DO | Dissolved oxygen (See Glossary above) |
| DOH | Department of Health |
| DQO | Data Quality Objective |
| DSR | Data summary report |
| DWEC | Drinking water equivalent concentration |
| $DWEC_C$ | Drinking water equivalent concentration for carcinogenic effects |
| $DWEC_N$ | Drinking water equivalent concentration for non-carcinogenic effects |
| EAP | Environmental Assessment Program |
| e.g. | For example |
| Ecology | Washington State Department of Ecology |
| EDD | Electronic data deliverable |
| EIM | Environmental Information Management database |
| EPA | U.S. Environmental Protection Agency |
| et al. | And others |
| GIS | Geographic Information System software |
| HDPE | High density polyethylene |
| $HNO_3$ | Nitric acid |
| $H_2SO_4$ | Sulfuric acid |
| ID | Identification |
| i.e. | In other words |
| LCS | Laboratory Control Sample |
| LIMS | Laboratory Information System |
| LR | Lake Roosevelt |
| MDL | Method Detection Limit |
| MEL | Manchester Environmental Laboratory |
| Mn | Manganese |
| MQO | Measurement quality objective |
| MRL | Method Reporting Limit |
| MS | Matrix Spike |
| NA | Not Applicable |
| ND | Not detected |
| Ni | Nickel |
| NIST | National Institute of Standards and Technology |
| NOAA | National Oceanic and Atmospheric Administration |
| Pb | Lead |

| | |
|---|---|
| QA | Quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | Quality control |
| RI/FS | Remedial Investigation and Feasibility Study |
| RM | River mile |
| RPD | Relative percent difference |
| RSD | Relative standard deviation |
| SCS | Statewide Coordination Section |
| SOP | Standard Operating Procedure |
| Se | Selenium |
| Sb | Antimony |
| SOP | Standard operating procedures |
| Teck | Teck Cominco Metals |
| TCP | Toxic Cleanup Program |
| TDS | Total dissolved solids (See Glossary above) |
| Tl | Thallium |
| TM | Total metals |
| TMDL | Total Daily Maximum Loads (See Glossary above) |
| TSS | Total suspended solids (See Glossary above) |
| TSU | Toxic Studies Unit |
| UCR | Upper Columbia River |
| U.S. | United States of America |
| USGS | United States Geological Survey |
| V | Vanadium |
| WA | Washington |
| WAC | Washington Administrative Code |
| w/m | Wide mouth |
| WQA | Water Quality Assessment |
| WRIA | Water Resource Inventory Area |
| WSDOT | Washington State Department of Transportation |
| YSI | Yellow Springs Instruments |
| Z | Zinc |

## Units of Measurement

| | |
|---|---|
| °C | degrees centigrade |
| ft | feet |
| cfs | cubic feet per second |
| L | Liter |
| mg/L | milligrams per liter (parts per million) |
| mL | milliliter |
| NTU | nephelometric turbidity units |
| s.u. | standard units |
| µg/L | micrograms per liter (parts per billion) |
| µm | micron |
| µS/cm | microsiemens per centimeter, a unit of conductivity |
| $ | United States dollar |

## 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 sample 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 quality control (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 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 are usable for intended purposes.
- J (or a J variant) — data are estimated, may be usable, may be biased high or low.
- REJ – data are rejected, cannot be used for intended purposes.
  (Kammin, 2010; Ecology, 2004).

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

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

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

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

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

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

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

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

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

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

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

**Method Detection Limit (MDL):** This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero (Federal Register, October 26, 1984).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**Split sample:** A discrete sample subdivided into portions, usually duplicates (Kammin, 2010).

**Standard Operating Procedure (SOP):** A document which describes in detail a reproducible and repeatable organized activity (Kammin, 2010).

**Surrogate:** For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

**Systematic planning:** A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning (USEPA, 2006).

## References for QA Glossary


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