Quality Assurance Project Plan

Concrete Manufacturing and/or Recycling: Statewide Effluent Characterization

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Each study conducted by the Washington State Department of Ecology must have an approved Quality Assurance Project Plan (QAPP). 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.

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This plan was prepared by a licensed geologist. A signed and stamped copy is available upon request.

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COVER PHOTO: Photograph of a stockpile of concrete rubble taken by Jay Fennell (Ecology) during an announced inspection.

Quality Assurance Project Plan

Concrete Manufacturing and/or Recycling: Statewide Effluent Characterization

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NWRO: Ecology's Northwest Regional Office
PTS: Permit and Technical Services
WQP: Water Quality Program

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2.0 Abstract

The State of Washington's (State) Department of Ecology (Ecology) Water Quality Program (WQP) Sand & Gravel General Permit provides Ecology with the regulatory mechanism to control the discharge of pollutants to waters of the State. The general permit conditionally authorizes stormwater and wastewater discharges from 19 categories of industrial activities, including five concrete manufacturing and/or concrete recycling activities.

Concrete is a vital material to the construction industry. Potential environmental concerns due to the alkaline nature of leachate from recycled concrete aggregate stockpiles prompted Ecology to conduct a literature review to identify potential pollutants of concern for water quality. This 2022 literature review identified potential pollutants of concern released from recycled concrete aggregates. They include: antimony, arsenic, barium, total chromium, copper, nickel, lead, manganese, mercury, selenium, sulfur (as sulfate) and zinc.

This characterization study will focus on permitted concrete manufacturing and/or concrete recycling facilities that discharge stormwater and/or manufacturing process wastewaters to groundwater or surface waters. These discharges[1] occur on the facility property to ground using an unlined pond, lagoon, or other impoundment that allows water to infiltrate or to a surface water via a ditch or piped outfall. Ecology will collect water quality samples during a wet and dry season (i.e., March and August, respectively) from eighty of the 229 facilities meeting these selection criteria for the pollutants of concern identified in the literature review.

Upon completion of the sample collection field work, Ecology will perform data analysis on lab results and prepare a final technical memorandum and will include summary statistical information useful to the general permit's 2026 reissuance.

[1] Although infrequent, there are concrete manufacturers and/or recyclers that have a monitoring point, but not a discharge point, located on the facility's property.

3.0 Background

3.1 Introduction and problem statement

The Washington State Department of Ecology (Ecology) first issued the National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge Sand and Gravel General Permit (general permit) on April 1, 1994. The permit has undergone several revisions and reissuances to include emerging operations discharging wastewater to waters of the State of Washington (state).

The general permit provides Ecology with the regulatory mechanism to control the discharge of pollutants to waters of the State (33 U.S Code 1251; Chapter 90.48 RCW). Ecology uses the general permit to regulate the discharge of process water, stormwater, and mine dewatering water associated with sand and gravel operations, rock quarries, and similar mining facilities, including aggregate recycling, concrete batch operations, and hot mix asphalt operations[2]

Facilities conducting concrete manufacturing or concrete recycling activities are permitted with at least one of the following North American Industry Classification System (NAICS) or Ecology codes (which are prefaced with ECY):

- 327320: Ready-Mix Concrete Manufacturing
- 327331: Concrete Block and Brick Manufacturing
- 327332: Concrete Pipe Manufacturing
- 327390: Other Concrete Product Manufacturing
- 327999: All other Miscellaneous Nonmetallic Mineral Product Manufacturing
- ECY002: Concrete Recycling

There are 229 permitted facilities conducting concrete manufacturing and/or recycling (CMR) in the state. Several of these facilities utilize a pond, lagoon, or other types of unlined impoundments on the facility property for infiltration. Wastewater that is allowed to infiltrate and percolate, or potentially percolate, is considered a discharge to groundwater. Some facilities may also discharge wastewaters to a surface water outfall. The character and quality of discharges from these facilities have not been closely examined in Washington State.

Ecology's Recycled Concrete Aggregate Literature Review identified several soluble, diffusible, and available pollutants of concern (POC) that are released specifically from recycled concrete aggregate (Ecology 2022). The availability of the pollutants of concern is highly variable due to the wide degree of inherent physical and chemical differences in both newly manufactured and recycled concrete materials.

[2] For this document, we will collectively term the types of waters discharged as "wastewater."

Ecology is concerned that the concentrations of POC in some discharges may cause or contribute to exceedances of the state's surface water and/or groundwater quality standards (i.e., measuring high concentrations of POC at the point of discharge may result in the discharge causing/contributing to a violation in the receiving water). The published technical memorandum on the characterization study will help inform the development of the 2026 general permit.

3.2 Study area and surroundings

The 229 permitted candidate facilities are shown in Figure 1 and listed in Appendix A. A general overview of the state's range of environmental settings, geography, topography, and geology is discussed in this section.

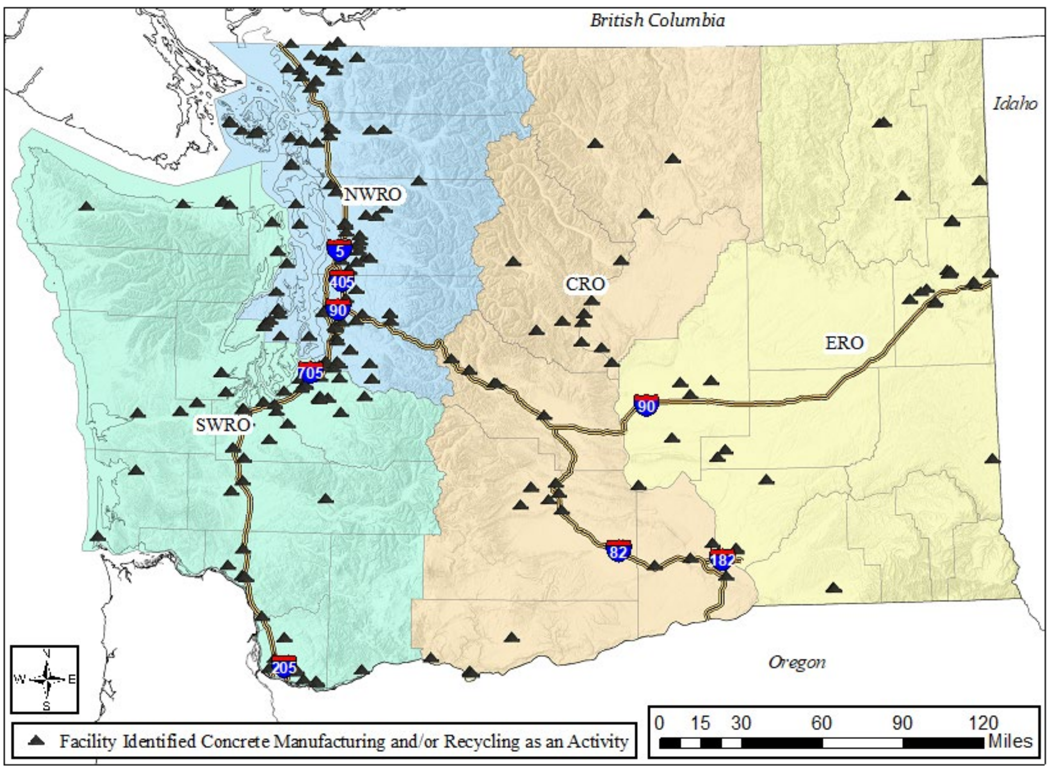

Figure 1: Figure showing the facilities identifying concrete manufacturing and/or recycling as an activity, the Southwest (SWRO), Northwest (NWRO), Central (CRO), and Eastern (ERO) regional offices are also shown.

We can divide the state into two main climatic regions: the areas west and east of the Cascade Range. In the western part of the state, winters are mild and wet, with temperature lows rarely dropping below freezing at elevations below the Cascade foothills (ranging from a few hundred to a couple thousand feet above sea level). Summers are relatively dry and warm, with temperatures usually ranging from the 60s to the 70s Fahrenheit. The western region receives a significant amount of precipitation during the fall and winter months, ranging between 20 inches in areas within the rain shadow of the Olympic Mountains, the east of the range, and to 150 inches on the western side of the Olympics annually.

By contrast, eastern Washington experiences colder winters with occasional snowfall, and summers that are warmer and drier (commonly less than 10 inches of precipitation annually) than in western Washington. Temperatures in eastern Washington range seasonally from below freezing to the mid-40s Fahrenheit in winter with summer daytime temperatures exceeding 90 degrees Fahrenheit.

The environmental settings of the facilities are expected to vary from heavily industrialized, semi-urban, to rural. Of the 229 facilities, over two-thirds of the facilities are within 2 miles of a major road or interstate. Over half of the 229 facilities are within 1,000 feet of a surface water body.

The 229 candidate facilities are located across the state and exhibit a diverse geologic history and complex profile. On the eastern edge of the state, the Paleozoic North America rocks is the oldest surface exposure in the state. The Intermontane Superterrane, Insular Superterrane, Siletz-Cresent Terrane all accreted to the North American continent during the subduction of the oceanic plate. Modern Cascade Range volcanics, Missoula glacier floods, and the Columbia River basalts have shaped Washington’s geologic setting.

The state’s highest elevation is Mount Rainer at 14,411 feet above sea level. The lowest elevation in the state is along the coastline of the Pacific Ocean. Generally, the elevation increases from coast to the Cascade Range and the Columbia River Plateau. The wide range of elevations contributes to Washington’s regional climatic settings.

Limestone (i.e., calcium carbonate) is a calcareous raw material used in the production of cement. Washington’s coastal presence has allowed for the sedimentary deposition of limestone across the state. The presence of limestone reflects the dynamic geological history of Washington, showcasing periods of marine sedimentation and exotic terrains. Danner, 1966 reports on the quantity and quality of stone available in the largest and most accessible deposits in western Washington.

3.2.1 History of study area

Ecology first issued the Sand & Gravel General Permit in 1994, establishing a framework for regulating discharges from the industrial and construction aggregate mining industry. Permit documents including site maps are available for the facilities in Ecology's Permitting and Reporting Information System (PARIS)[3] database. Ecology's PARIS database contains site-specific information about water quality permits, inspection records, enforcement actions, and discharge monitoring reports (DMRs).

Concrete manufacturing and/or recycling (CMR) activities eligible for coverage under the general permit included those classified under the North American Industrial Code System (NAICS) as 3273XX, except for cement manufacturing. Concrete recycling was nested under 3273XX industrial activities prior to Ecology's establishing ECY002 (concrete recycling) industrial code during the 2015 permit reissuance. Doing so enabled Ecology to establish permit conditions only applicable to the industry segment conducting concrete aggregate recycling activities. This included focusing best management practices (BMPs) and technical assistance on activities that potentially present an environmental concern (Ecology, 2015a).

As the body of research around the environmental impacts of concrete run-off and leachate continues to evolve over the years, it is important to ensure the general permit remains current in its protection of state water quality. Over the lifespan of the general permit, Ecology has adjusted the list of pollutants to be monitored in the general permit based on a reasonable potential analysis of the effluent. This maintains an accurate representation of the effluent characteristics for the industries covered by the permit. Most notably, Ecology included requirements for routine nitrate + nitrite sampling in the initial 1994 permit. Ecology removed, re-integrated, and subsequently removed this parameter during the 1999, 2010, and 2015 reissuances, respectively.

Ecology also periodically reviews and updates BMPs in the general permit. For example, Ecology has required concrete specific BMPs within the general permit to manage alkaline pH run-off generated at concrete recycling facilities.

3.2.2 Summary of previous studies and existing data

Ecology's Recycled Concrete Aggregate Leachate: A Literature Review, summarizes previous studies and existing data related to this study (Ecology, 2022). This section will provide a summary of the literature review studies and findings.

[3] https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Water-quality-permits-database

There are a few studies that have assessed the pollutants released from concrete stockpiles or an analog of a concrete stockpile (Engelsen 2012, 2017; Sadecki et al. 1996; Walker & Associates, Inc. 2006). Countless other studies have evaluated the concrete material using laboratory leaching tests. The laboratory leaching test methods used in the studies include, but are not limited to: EPA Methods 1311, 1312, 1313, 1315, and 1316, U.S. Geological Survey, American Society of Testing Materials, European, Dutch, German, and other non-standard leaching methods.

The literature review identified POC that may leach from cement-based materials at concentrations exceeding state water quality standards, for both surface water and groundwater, in both the field and laboratory studies.

The RCA leachate POC identified for surface water in the literature review are antimony, arsenic, chloride, hexavalent chromium, copper, lead, mercury, nickel, pH, polycyclic aromatic hydrocarbons, selenium, total suspended solids, turbidity, and zinc. Table 1 provides the summary statistics of POC exceeding a surface water criterion in the literature review.

Table 1: The number of studies with concrete leachate results and the number of studies exceeding a state surface water criterion for the metal pollutants of concern, according to the literature review (Ecology, 2022).

Pollutant of Concern	Number of Studies with Leachate Results	Number of Studies Exceeding a Surface Water Criterion (Chapter 173-201A WAC)
Antimony	8	4
Arsenic	15	5 (2 field)
(Hexavalent) Chromium	19	17 (2 field)
Copper	17	15 (1 field)
Nickel	15	8
Lead	17	3
Mercury	6	1
Selenium	12	7
Zinc	18	4

Of the metal POC, antimony, arsenic, hexavalent chromium, copper, and nickel were observed to exceed the surface water quality criteria repeatedly (Chapter 173-201A WAC). Lead, mercury, selenium, and zinc exceedances of the surface water criteria were seldom. Chloride and polycyclic aromatic hydrocarbons are not commonly observed to exceed surface water quality criteria and thus are not a concern for permit development. Total suspended solids, turbidity, and pH already have effluent limits in the general permit.

Leachate entering an unlined detention pond or basin must comply with groundwater quality standards (Chapter 173-200 WAC). The RCA leachate POC identified in Ecology, 2022 with potential to exceed the state groundwater quality criteria are arsenic, barium, chloride, total chromium, iron, lead, manganese, pH, polycyclic aromatic hydrocarbons, selenium, sulfur (as sulfate), and total dissolved solids. Table 2 provides the summary statistics of POC exceeding the groundwater criteria in the literature review.

Table 2: The number of studies with concrete leachate results and the number of studies exceeding a state surface water criterion for the metal pollutants of concern, according to the literature review (Ecology, 2022).

Pollutant of Concern	Number of Studies with Leachate Results	Number of Studies Exceeding the Groundwater Criteria (Chapter 173-200 WAC)
Arsenic	15	15 (3 field)
(Total) Chromium	19	10 (3 field)
Sulfur (as sulfate)	13	4
Barium	13	2
Manganese	6	1
Iron	6	2 (1 field)
Lead	17	1

Of the metal and nutrient POC, arsenic, total chromium, selenium, and sulfur (as sulfate) repeatedly exceeded the groundwater quality criteria and barium, chloride, manganese, iron, and lead exceedances were seldom. Chloride, iron, and polycyclic aromatic hydrocarbons are not commonly observed to exceed groundwater quality criteria and thus are not a concern for permit development. Total dissolved solids and pH already have effluent limits in the general permit.

3.2.3 Parameters of interest and potential sources

The groundwater and surface water discharge monitoring point locations will be analyzed for the same pollutants. The parameters of interest include:

- Field parameters
  - pH, conductivity, temperature, turbidity, oxidation/reduction potential (ORP), and dissolved oxygen (DO).
- Lab parameters
  - General chemistry: total dissolved solids (TDS), total suspended solids (TSS)
  - Nutrients: sulfate
  - Metals: total and dissolved trace and heavy metals (As, Ba, Cr, Cu, Hg, Mn, Ni, Pb, Se, Zn).

The sample locations will be one of the facility's existing monitoring points, which will be a pond, lagoon, or other unlined impoundment for infiltration to groundwater or a discharge outfall to a surface water body. These locations are also representative of discharges related to a CMR industrial activity. CMR permitted facilities with concrete manufacturing and/or recycling as a listed activity (Figure 1) will be chosen at random proportional to the total number of facilities within each of Ecology's administrative regions. Ecology will use Microsoft Excel's random number generator to generate the list of candidates.

3.2.4 Regulatory criteria or standards

The general permit is a combined NPDES and State Waste Discharge permit authorizing permitted facilities to discharge effluent to the waters of the State, which includes both surface waters and groundwaters. Permitted discharges must not cause or contribute to a violation of: Groundwater Quality Standards (Chapter 173-200 WAC), Surface Water Quality Standards (Chapter 173-201A WAC), or Sediment Management Standards (Chapter 173-204 WAC) of the State of Washington; and 40 CFR 131.

The permitted facilities may have other state, county, or local permits in addition to the general permit.

4.0 Project Description

Ecology's Water Quality Program will conduct a statewide study of 80 of the permitted facilities with a concrete manufacturing and/or recycling (CMR) related NAICS or Ecology code. Ecology will collect samples from the monitoring point identified by the CMR facility as either a representative sampling location or effluent discharge location (i.e., pond, lagoon, or other unlined impoundment and/or surface water discharge outfall) for CMR activities on the property.

The results will fill a data gap into Washington State's effluent from concrete manufacturers and/or recyclers. This information will assist Ecology in determining if additional sampling or pollution prevention measures may be proposed in the next reissuance of the general permit.

4.1 Project goals

The project goal is to obtain water quality samples from 80 permitted facilities and analyze those samples for POC that are identified in the literature review (Ecology, 2022). The data set produced from this project will aid in the development and reissuance of the general permit.

4.2 Project objectives

The project objective is to collect two seasonal discharge samples from 80 of the permitted CMR facilities within an annual wet and dry season cycle and analyze them for the POCs identified in the literature review (Ecology, 2022). Ecology will present results for each industry code and collectively in a technical memorandum. This project will enable Ecology to characterize the effluent from CMR facilities.

4.3 Information needed and sources

Water quality data is needed from the CMR facilities to assess if discharges from these activities have the potential to cause or contribute to a violation of applicable water quality standards. Collecting the effluent samples from CMR facilities and analyzing for the POC will provide data that can be used to compile summary statistical information on the POC detected in the discharge samples.

4.4 Tasks required

- Scoping, Site Selection, Communication
    - Coordination with Ecology's Manchester Environmental Laboratory.
    - Scoping of locations
        - Select 80 of the 229 permitted facilities with a CMR effluent discharge monitoring point.
    - Draft letters to Permittees
        - Early: Letter informing the Permittee of the intent to sample 80 of the 229 facilities.
        - Prior to sampling: Letter informing the Permittee their facility has been selected for sampling.

- Preparation, Logistics, Sampling
    - Order consumables (e.g., tubing, filters, batteries), coolers, 2 peristaltic pumps, and sample pole.
    - Prepare bottles, forms, coolers.
    - Make travel arrangements including vehicle reservations and lodging for sampling events.
    - Coordinate two sampling events, wet season 2024 and dry season 2024, with the permitted facilities, permit inspector, permit administrators, and Eric Daiber or Jay Fennell.

- Results and Report
    - Prepare a final technical memorandum upon the completion of all sampling and analysis.
    - Evaluate the results and display statistics, i.e., mean, standard deviation, median, and ranges.

4.5 Systematic planning process

This quality assurance project plan (QAPP) serves as the planning document for the project.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 3 shows the responsibilities of those who will be involved in this project.

Table 3. Organization of project staff and responsibilities.

Staff[1]	Title	Responsibilities
Eric Daiber GPU, PTS, WQP	Project Manager/ Principal Investigator/ LG	Writes the QAPP. Clarifies scope of the project. Conducts field sampling and transportation of samples to the lab. Conducts QA review of data, analyzes and interprets data. Writes the draft technical memorandum and final technical memorandum.
Jay Fennell WPU, WQP, NWRO	Assistant Project Manager/Co-Investigator/Data Manager	Assists with project development, internal review of the QAPP, field sampling, data interpretation, and technical memorandum preparation.
Lucienne Banning GPU, PTS, WQP	WQP Supervisor for the Project Manger	Provides internal review of the QAPP. Provides technical project review.
Jeff Killelea PTS, WQP	Section Manager for the Project Manager	Reviews and approves the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP. Provides technical project review.
Dean Momohara Manchester Environmental Lab (MEL)	MEL Director	Reviews and approves the final QAPP.
Chris Dudenhoeffer Quality Assurance, WQP	Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

WQP: Water Quality Program
NWRO: Northwest Regional Office
QAPP: Quality Assurance Project Plan
GPU: General Permit Unit
LG: Licensed Geologist
PTS: Permitting and Technical Section
MEL: Manchester Environmental Laboratory
WPU: Watershed Protection Unit

5.2 Special training and certifications

This project is overseen by Eric Daiber, who is a Washington State licensed geologist.

Field staff are also highly recommended to maintain First Aid/CPR certification and Defensive Driving training. Field staff are required to wear steel toe boots, safety vest, hard hat, safety glasses, and may be required to wear hearing protection while on the facility. Staff may be required to receive site specific training and should expect to be escorted by plant personnel while on the facility.

All field staff should have a detailed working knowledge of this QAPP and any applicable standard operating procedures (SOPs) to ensure the collection of credible and useable data. This includes familiarity with the sampling equipment and instruments being used. Section 8.0 details equipment and SOPs. Also, it is recommended that field staff familiarize themselves with Ecology, 2015a.

5.3 Organization chart

See Table 3.

5.4 Proposed project schedule

Tables 4 and 5 list key activities, due dates, and lead staff for this project.

Table 4. Schedule for completing field and laboratory work

Task	Due date	Lead staff
Field work	March 2024 and August/September 2024	Eric Daiber, Jay Fennell
Lab analyses	May 2024 and August/September 2024	MEL Staff

Table 5. Schedule for final report

Task	Due date	Lead staff
Draft to supervisor	December 2024	Eric Daiber
Draft to client/peer reviewer	January 2025	Eric Daiber
Draft to external reviewers	January 2025	Eric Daiber
Final draft to publications team	March 2025	Eric Daiber
Final report due on web	March 2025	Publications Team

5.5 Budget and funding

Table 6 shows the total analytical costs associated with both rounds of sampling of 80 facilities at Ecology's Manchester Environmental Laboratory (MEL).

Table 6. Laboratory budget details for both sampling events

Parameter	Estimated Total Number of Permittees Samples	Total Number of MS/MSD[1]	Total Number of Samples	Cost Per Sample	Lab Total Cost for Samples (not including MS/MSD)
Determination of Trace Elements (Total)	192	17	209	$180.00	$34,560.00
Determination of Trace Elements (Dissolved)	192	17	209	$160.00	$30,720.00
Total Mercury	192	17	209	$42.00	$8,064.00
Dissolved Mercury	192	17	209	$42.00	$8,064.00
Sulfate	192	17	209	$16.00	$3,072.00
Total Dissolved Solids	192	17	209	$16.00	$3,072.00
Total Suspended Solids	192	17	209	$16.00	$3,072.00
				Total (rounded)	$90,700
				Total Cost for 17 MS/MSD (1/13 samples)	$7,600
				Total Estimated Projected Laboratory Costs for the Project	$98,300

[1]MS/MSD: Matrix Spike/Matrix Spike Duplicate

Table 7 shows the estimated budget details for both rounds of sampling.

Table 7. Estimated total project budget and funding

Item	Cost
Equipment	$20,000
Travel and Per Diem	$25,000
Laboratory (See Table 6 for details.)	$100,000
Unexpected Expenses	$10,000
Total	$155,000

6.0 Quality Objectives

The quality objective for this project is to collect CMR facility discharge data of known, acceptable, and documentable quality, achieved by establishing measurement quality objectives (MQOs) for precision and bias (accuracy), sensitivity, completeness, comparability, and representativeness, and by testing data against these criteria.

6.1 Data quality objectives[4]

Data quality objectives (DQOs) establish acceptable quantitative criteria for the quality and quantity of collected data, relative to the ultimate use of the data. DQOs serve as performance or acceptance criteria and represent the overarching quality objectives of the study. The main DQO for this project is to collect known, acceptable, and defensible effluent samples for the POC that are representative of current concentrations at the monitoring point for the permitted facilities.

Fieldwork to collect samples will be conducted following EAP015 and WQP001 for manually obtaining 'grab' surface water samples (Ecology, 2019; Ecology, 2018). Additionally, field staff are also recommended to read Ecology, (2015b), A guide for Industrial Stormwater General Permit.

Sample analysis will occur using accredited methods (see Table 11) to obtain data that meet the measurement quality objectives (MQOs) that are described below and that are comparable to previous results.

6.2 Measurement quality objectives

MQOs are performance or acceptance criteria for individual data quality indicators, including quantitative factors (precision, bias, sensitivity, and completeness) and qualitative factors (comparability and representativeness).

6.2.1 Targets for precision, bias, and sensitivity

The multiparameter instrument has the below reported range, resolution and accuracy shown in Table 8. The MQOs for project results, expressed in terms of acceptable precision, bias, and sensitivity, are described in this section and summarized Table 9.

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[4] 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. Instrument range, resolution, and accuracy for field measurements

Parameter	Instrument Range	Instrument Resolution	Instrument Accuracy
Temperature	-5 to 70°C	0.1 °F or 0.1 °C	+/- 0.2 °C
pH	0 to 14 standard units	0.01 standard units	+/- 0.2 standard units
Specific Conductivity	0 to 200 mS[1]/cm	0.001 mS/cm	Greater than 0.001 mS/cm
Dissolved Oxygen	0 to 50 mg/L	0.01 mg/L	At least +/- 0.1 mg/L
Oxidation Reduction Potential	-1999 to 1999 mV[2]	0.1 mV	+/- 20 mV
Turbidity	0 to 4000 NTU[3]	0.1 NTU	Less than +/- 5% NTU

[1]mS: millisiemens
[2]mV: millivolt
[3]NTU: Nephelometric Turbidity Unit

Table 9: Measurement quality objectives for laboratory analyses of water samples

Parameter	Lab Duplicate (RPD)	Matrix Spike Duplicate (RPD)	Lab Control Standard (% Recovery)	Matrix Spike (% Recovery)	Surrogate Standards (% Recovery)	MRL or Lowest Concentrations of Interest
Metals	≤ 20	≤ 20	85 – 115	75 – 125	N/A	0.01 – 250 ug/L
Mercury	≤ 20	≤ 20	80 – 120	75 – 125	N/A	0.05 ug/L
Sulfate	≤ 20	≤ 20	90 – 110	75 – 125	N/A	0.300 mg/L
Total Dissolved Solids	≤ 20	N/A	80 – 120	N/A	N/A	0.950 mg/L
Total Suspended Solids	≤ 20	N/A	80 – 120	N/A	N/A	1.00 mg/L

RPD Relative percent difference
MRL Method reporting limit

6.2.1.1 Precision

Precision is a measure of the variability between results of replicate measurements that is due to random error. It is usually assessed using duplicate field measurements or lab analysis of duplicate samples. 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 lab procedures).

Collection of one duplicate sample will occur at a minimum of every 10 samples. Duplicate sample collection will occur by filling two sets of bottles at the same time from a pre-selected facility. Precision for field and lab duplicate samples will be expressed as relative percent difference (RPD) as shown in Table 9. The smaller the RPD, the more precise the measurement process.

Good precision is indicative of relative consistency and comparability between different samples. The targets for precision are based on past performance characteristics of measurements performed by MEL.

6.2.1.2 Bias

Bias is defined as the difference between the sample value and true value of the parameter being measured. Bias is usually addressed by calibrating field and lab instruments, and by analyzing lab control samples, matrix spikes, and standard reference materials (see Table 9). Bias in field measurements and samples will be minimized by strictly following Ecology's measurement, sampling, and handling protocols.

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. For this project, two measures of sensitivity are considered: the method reporting limit (MRL) and the lower limit of quantitation (LLOQ). The MRL and LLOQ not only consider whether a compound is present, but also the accuracy and precision of the measured value.

The analytical methods for the metals to be assessed (EPA methods 200.7, 200.8, and 245.1) employ MRLs, and an associated method detection limit (MDL), which is the lowest concentration of a compound that can be positively identified. The analytical methods used for total dissolved solids (SM2540C), total suspended solids (SM2540D), and sulfate (EPA300.0) also have MRLs and MDLs. Targets for lab measurement sensitivity required for the project are listed in Table 9.

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

Comparability expresses the confidence with which one set of data can be compared to another. The study will ensure comparability to the extent possible by implementing standardized procedures for sampling and analysis. SOPs for this project are listed in Section 8.2.

Laboratory analyses will follow the methods described in Section 9.1 (Lab procedures) for each suite of analytes. Laboratory-specific SOPs for the preparation and analysis of samples, data reduction, and data review for each analysis will be followed.

6.2.2.2 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent the actual water quality of the effluent from CMR activities being discharged to waters of the state. The study will collect samples twice, once in the fall and once in the spring, to account for seasonal variability from the CMR facilities. Samples are assumed representative of site conditions and the water quality of the effluent at the time they are collected. The study will employ industry standard sampling methods to ensure collection of representative effluent discharge samples.

6.2.2.3 Completeness

Completeness establishes whether a sufficient number of valid measurements were obtained to meet project objectives. The number of samples and results expected establishes the comparative basis for completeness.

The completeness goal for this project is to collect and analyze 100% of the samples. However, problems and situations arise attempting sample collection that are outside of our control, thus the study will accept a completeness of 60% (48 facilities) sampled both sampling events. Examples of potential problems the study team may encounter are adverse conditions (i.e., dry season, frozen ponds, lagoons, unlined impoundment or outfall), equipment failure, or other unanticipated situations.

6.3 Acceptance criteria for quality of existing data

Discharge Monitoring Reports (DMRs) are reports containing results of each facilities self-monitoring for process water, stormwater, and mine dewatering water discharges authorized by the general permit. Since the effective date of the general permit, April 1st, 2021, all permitted facilities are required to submit quarterly DMRs to Ecology.

The merging of DMR data with the data collected in this study will not be performed. Joining these data sets may introduce inconsistencies into the study’s analysis, undermining its reliability and validity.

DMRs employ various qualifiers to characterize the data. These qualifiers include but are not limited to: no discharge, below detection limit/no detection, monitoring is conditional/not required at this monitoring point, incorrect sampling frequency, failed to sample/required analysis not conducted, frozen conditions/unsafe conditions, greater than, or estimated values/below quantitation limits.

6.4 Model quality objectives

Not applicable. This project will not involve any modeling.

7.0 Study Design

This study is designed to collect representative samples from the facilities monitoring point to assess effluent concentrations for POCs from permitted CMR facilities. This information will inform Ecology's decision-making on the proposed draft general permit and final 2026 reissuance of the permit.

7.1 Study boundaries

The study boundaries are CMR facilities within Washington State. Figure 1 shows the 229 candidate facility locations.

7.2 Field data collection

7.2.1 Sampling locations and frequency

We will collect samples from one representative monitoring point location identified in each facility's permit. Using best professional judgment, we will assess which monitoring point will provide the most representative sample of discharges from CMR activities. The following criteria will be considered while identifying a sample collection location, including but not limited to:

- Facility site map,
- Facility coverage letter identifying the locations of monitoring points,
- Comingling discharges,
- Contributing industrial activities, and
- Stormwater discharges.

Sampling will occur twice, once during the wet season (e.g., March) and again during the dry season (e.g., August, September). Of the 229 CMR facilities, the 80 randomly selected candidate facilities will be proportional to the regional percentage of facilities. Table 10 shows the total number of CMR facilities in each region and the number of facilities the study plans to sample in each region. Collection of samples will occur at the same monitoring point the facility collects their sample of groundwater or surface water discharge. Appendix A lists the 229 CMR facilities' latitude and longitude in decimal degrees.

Table 10: The total number of facilities with concrete manufacturing and/or recycling split by containing Ecology Regional Office.

Regional Office	Total Number of Facilities with Concrete Manufacturing/Recycling Identified as an Activity	Percentage of Total Facilities in Each Region	Number of Facilities to be Sampled in Each Region
Southwest Regional Office	71	31%	25
Northwest Regional Office	91	40%	32
Central Regional Office	35	15%	12
Eastern Regional Office	32	14%	11
Totals	**229**	**100%**	**80**

7.2.2 Field parameters and laboratory analytes to be measured

The parameters to be measured and sampled include:

- Temperature (Field)
- pH (Field)
- Specific conductivity (Field)
- Dissolved oxygen (DO) (Field)
- Oxidation/reduction potential (ORP) (Field)
- Turbidity (Field)
- Requested Metals [As, Ba, Cr, Cu, Hg, Mn, Ni, Pb, Se, and Zn] (Laboratory)
- Sulfate (Laboratory)
- Total dissolved solids (Laboratory)
- Total suspended solids (Laboratory)

The requested metals are a list of inorganic analytes (As, Ba, Cr, Cu, Hg, Mn, Ni, Pb, Se, and Zn) using specified EPA analytical methods in Table 11. Assessment of sulfate will use EPA analytical method in Table 11.

7.3 Modeling and analysis design

Not applicable.

7.4 Assumptions underlying design

The study design is based on the following assumptions:

- A sample size of 80 randomly selected facilities sufficiently represents all 229 facilities.
- Regardless of site-specific facility factors (i.e., activities conducted on-site, size of the facility, regional climatic setting), the study should provide similar effluent characteristics for facilities conducting similar activities.
- The data collected from the facilities pond, lagoon, or other type of unlined impoundment will represent the effluent discharging from the facility and runoff generated from concrete stockpiles.
- The study design assumes the contaminant list includes all current POC for CMR facilities. Scientific advancements or future research may result in the addition of pollutants to this list. There may be other pollutants released from the facility that are not included on this list.
- This study assumes Ecology will have access to 80 of the 229 facilities.
- Sampling each selected facility twice, once during a wet season and once during a dry season is sufficient to observe a potential seasonal variation (i.e., temperature, precipitation).
- POC concentrations detected at effluent discharge monitoring are a conservative estimate of the effluent POC concentration.

7.5 Possible challenges and contingencies

7.5.1 Logistical problems

A primary challenge is accessing the facilities to sample their monitoring point. Communication with the permittee is critical to coordinating access to their monitoring point to maintain a smooth sampling event. For facilities with more than one monitoring point location, Ecology will use best professional judgement and sample the most representative location on-site.

In instances where no discharge is occurring to surface waters and surface waters are the sole discharge point, such that there is no discharge to ground using an unlined pond, lagoon, or other impoundment, no sample will be collected from this facility.

Logistics with shipping could become an issue. Since the facilities are statewide and over two-thirds are located nearby a major roadway, shipping issues are not generally expected as FedEx and UPS carriers should operate in these areas. The WQP project manager/field staff will coordinate with Ecology's regional offices personnel prior to the sampling events.

The final technical memorandum will note and discuss any circumstance that interferes with data collection and quality.

7.5.2 Practical constraints

Practical constraints to grab sampling are typically determined by characteristics of the site's topography (such as steep, unstable hillsides) and/or unclear path to the point of discharge of the facility's pond, lagoon, or other type of unlined impoundment.

During the dry season, insufficient water in the facility's pond, lagoon, or other type of unlined impoundment may make collecting water quality parameters and/or water samples challenging. With the winter season temperature in eastern Washington may drop below freezing; ice water that is frozen may inhibit the collection of samples and/or water quality parameters.

The short holding time from time of sampling for the total suspended solids and total dissolved solids of 7 days, requires planning and advance arrangement with the analytical laboratory. The project manager will work closely with MEL to ensure lab capacity.

The final technical memorandum will discuss any practical constraints that impact the ability to collect samples.

7.5.3 Schedule limitations

Changes in project prioritization and workload for WQP staff could affect the project schedule. Factors that can cause delays to the proposed project schedule include:

- Time required for QAPP review and approval.
- Changes to project scope and/or budget.
- Unforeseen field or laboratory complications (e.g., inability to collect samples from selected facility, problems with lab analytical equipment).

Any unforeseen limitations which affect the project schedule will be discussed with the principal investigator and appropriate supervisor as needed and discussed in the final technical memorandum.

8.0 Field Procedures

8.1 Invasive species evaluation

Does not apply to this type of study. Receiving surface waters will not be sampled.

8.2 Measurement and sampling procedures

Surface water sampling activities for this study will follow standard operating procedures (SOPs) developed by Ecology's Environmental Assessment Program and WQP. This includes EAP015 and WQP001 for manually obtaining 'grab' surface water samples (Ecology, 2019; Ecology, 2018). Additionally, field staff should also read Ecology, (2015b), A guide for Industrial Stormwater General Permit.

Field measurements will occur at all sampling locations and recorded on waterproof field datasheets. Use of new gloves, new silicone tubing, filter, and pre-cleaned, pre-preserved sample bottles will help prevent potential cross-contamination of the sample equipment. Collection of the sample water will occur at the facility monitoring point where effluent discharge occurs using an adjustable swing sampler or telescopic pole with a new sample collection bottle or manually. Water grab samples will be collected at about 15–30 cm below the water surface when possible, ensuring the preservation for the samples does not diminish.

For the dissolved metals, the sample water is collected using an unpreserved, precleaned empty transport containers and then pumped with new silastic tubing through a peristaltic pump with an instream filter media (0.45 um disposable in-line filter) and into a new, empty, preserved, precleaned container for dissolved metals and sulfate samples. A new 2-foot section of silicone tubing will be used for the pumping mechanism. Each facility and sampling event will use new silicone tubing. Capping of all sample bottles will occur as soon as possible after receiving the water sample.

Equipment blanks will be used to detect for sample contamination from the equipment or procedure. An addendum to this QAPP will address any changes in sampling equipment. Field parameters (pH, temperature, specific conductance, dissolved oxygen, oxidation reduction potential (ORP), and turbidity) will be collected using a YSI ProDSS multiparameter sonde. A YSI ProDSS multiparameter sonde will be used to measure the field parameters.

If there is not enough water for the water quality analyses requested, the study will apply the following priority. The first analyte to be collected will be the total metals then the dissolved metal samples, then the same sequence for the sulfate sample, finally total dissolved solids followed by total suspended solids, in this specified order.

Using the YSI ProDSS, field measurements of water temperature, dissolved oxygen, pH, ORP, conductivity, and turbidity will be collected at the same depth of sample collection (~15–30 cm below the water surface).

Samples will be stored on ice while being transferred to Ecology's Manchester Environmental Laboratory (MEL) using standard chain-of-custody procedures. MEL will analyze effluent samples for the laboratory parameters of interest (Table 11).

The final technical memorandum will document and discuss and deviations from the sample plan.

8.3 Containers, preservation methods, holding times

Table 11 presents the parameter, sample containers, preservation, and holding time required to meet project goals and objectives. Samples will be shipped in ice-filled coolers to MEL to ensure holding times are met.

Table 11. Sample containers, preservation, and holding times

Parameter	Matrix	Minimum Quantity Required	Container	Preservative	Holding Time
Metals (total)[1]	Water	350 mL	500 mL HDPE bottle	Pre-acidified to pH 2 with 1:1 HNO3; Cool to ≤ 6°C	6 months
Metals (dissolved)[1,2]	Water	350 mL	500 mL HDPE bottle	Pre-acidified to pH 2 with 1:1 HNO3; Cool to ≤ 6°C	6 months
Mercury (total)	Water	350 mL	500 mL HDPE bottle	Pre-acidified to pH 2 with 1:1 HNO3; Cool to ≤ 6°C	6 months
Mercury (dissolved)	Water	350 mL	500 mL HDPE bottle	Pre-acidified to pH 2 with 1:1 HNO3; Cool to ≤ 6°C	6 months
Sulfate	Water	100 mL	500 mL w/m poly bottle	Cool to ≤ 6°C	28 days
Total Dissolved Solids	Water	500 mL	500 mL w/m poly bottle	Cool to ≤ 6°C	7 days
Total Suspended Solids	Water	1000 mL	1000 mL w/m poly	Cool to ≤ 6 °C	7 days

[1] Metals include: As, Ba, Cr, Cu, Mn, Ni, Pb, Se, and Zn.
[2] Dissolved Metals will be filtered through 0.45 um filter media prior to preservation in nitric acid.

8.4 Equipment decontamination

New, clean sample tubing and filters will be used to gather and prepare any water quality samples that are collected for this project. Pump tubing and filters will not be reused.

8.5 Sample ID

MEL will provide the field lead with work order numbers for all scheduled sampling dates. The work order number will be combined with a regional identifier and field ID number that is generated by the field lead. This combination of work order number, regional office, and field ID number constitutes the sample ID (e.g., 2403022-NWRO-08). All sample IDs will be unique and be recorded in field logs and in will be recorded in an electronic spreadsheet for tracking purposes.

8.6 Chain of custody

Chain-of-custody procedures will be followed according to MEL protocol (Ecology, 2016).

Once collected, samples will be properly labeled and stored in an ice-filled cooler inside the sampling vehicle. If the sample vehicle is left unattended, it will be locked to maintain chain-of-custody.

Samples may be transported to Ecology's Operation Center in Lacey, Washington. Samples may be kept in a secure walk-in cooler until picked up by the lab courier and transported to MEL in Port Orchard, Washington. Alternatively, samples may be brought to a secure holding area in Tukwila, Washington to be picked up and transported to MEL by the lab. If the samples must be shipped to MEL, UPS or FedEx can be used and the appropriate chain of custody measures taken.

8.7 Field log requirements

A field log will be maintained by the field lead and used during each sampling event. The following information will be recorded:

- Name of facility site
- Name(s) of facility site personnel/facility representative(s)present
- Name of operations occurring on-site
- Name of field staff
- Environmental conditions
- Field measurement results
- Date, time, sample ID, description of samples collected
- Identity of QC samples (if appropriate)
- Pertinent observations and/or any problems with sampling, including deviations from the QAPP
- Unusual circumstances that might affect interpretation of results
- Any conflict in sample point selection will be noted.

Field logs will consist of waterproof 8.5 x 11-inch field sheets pre-printed for ease of recording and kept in an enclosed metal clipboard. Permanent, waterproof ink or pencil will be used for all entries. Corrections will be made with single line strikethroughs, initialed, and dated.

8.8 Other activities

Field staff new to the type of sampling conducted for this study will be trained by senior field staff or the project manager following relevant Ecology SOPs and the site safety worksheet.

The field lead will notify MEL of the schedule for sampling events at least three weeks before sampling. Samples collection will occur between Monday and Friday. Study field staff will notify the lab immediately of any deviations from the scheduled date of sampling. The field lead will work with the lab to develop a schedule for delivery of sampling containers to ensure that the appropriate number and type of required sample containers are available.

If a sample is damaged during transit or testing, a new sample may be collected and submitted for analysis. The lab should notify the project lead as soon as possible when a sample is unsuitable.

9.0 Laboratory Procedures

9.1 Lab procedures table

Analytes for this project, along with the expected number of samples and an expected range of results, are listed in Table 12.

Table 12. Expected range of results, detection reporting limit, and laboratory measurement methods.

Analyte	Sample Matrix	Samples (Number/ Arrival Date)	Expected Range of Results	Detection or Reporting Limit	Analytical (Instrumental) Method
Total Metals[1]	Water	110/Wet Season 110/Dry Season	<1 – 50,000 µg/L	0.1 – 250 µg/L	EPA 200.7 (Martin et al, 1994)/ EPA 200.8 (Creed et al., 1994)
Dissolved Metals[1]	Water	110/Wet Season 110/Dry Season	<1 – 50,000 µg/L	0.01 – 250 µg/L	EPA 200.7 (Martin et al, 1994)/ EPA 200.8 (Creed et al., 1994)
Sulfate	Water	110/Wet Season 110/Dry Season	<0.300 – 350 mg/L	0.300 mg/L	EPA300.0 (USEPA, 1993)
Mercury	Water	110/Wet Season 110/Dry Season	<0.00001 – 50 ug/L	0.05 ug/L	EPA245.1 (USEPA, 1994)
Dissolved Mercury	Water	110/Wet Season 110/Dry Season	<0.00001 – 50 ug/L	0.05 ug/L	EPA245.1 (USEPA, 1994)
Total Dissolved Solids	Water	110/Wet Season 110/Dry Season	<0.950 – 1,200 mg/L	0.950 mg/L	SM2540C (APHA, 1998)
Total Suspended Solids	Water	110/Wet Season 110/Dry Season	<1.00 – 50.0 mg/L	1.00 mg/L	SM2540D (APHA, 1998)

[1] Metals include: As, Ba, Cr, Cu, Hg, Mn, Ni, Pb, Se, and Zn.

9.2 Sample preparation method(s)

Samples that require filtering will be field-filtered using a new in-line 0.45 µm capsule filter.

The laboratory will follow sample preparation procedures described in the analytical methods listed in Table 12.

9.3 Special method requirements

There are no special method requirements for this project.

9.4 Laboratories accredited for methods

Ecology's Manchester Environmental Laboratory (MEL) will perform all analyses for the analytes listed in Table 12.

10.0 Quality Control Procedures

Quality control (QC) procedures provide the information needed to assess the quality of the collected data. The QC procedures can also help identify problems or issues associated with data collection and analysis while the project is underway.

The study will assess total precision for field sampling and laboratory analysis by collecting replicate samples. MEL routinely duplicates sample analyses in the laboratory to determine laboratory precision. The difference between the variability in field duplicates and the variability in laboratory duplicates is an estimate of the field variability. Field blanks, such as an equipment and trip blanks, will be used to check for sample contamination.

The primary types of QC samples used to evaluate and control the accuracy of lab analyses are check standards, duplicates, spikes, and blanks (Ecology, 2016). Check standards serve as an independent check on the calibration of the analytical system and can be used to evaluate bias. Duplicates are used to evaluate laboratory precision. Matrix spikes are used to check for matrix interference with detection of the analyte, and are used to evaluate bias as it relates to matrix effects. Blanks are used to check for sample contamination in the laboratory process.

10.1 Table of field and laboratory quality control

Table 13 contains the number of field blanks, field replicate samples, verification standards, method blanks, and matrix spikes/matrix duplicates performed for this study. A minimum of 10% of the samples collected will be a duplicate measurement.

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

Parameter	All Field Blanks	Field Replicate Sample	Verification Standards (LCS, CRM, CCV)	Method Blanks	Matrix Spikes/Matrix Spike Duplicate
Metals (total)[2]	16	1/10 of samples	1/batch[1]	1/batch	1 pair/batch
Metals (dissolved)[2]	16	1/10 of samples	1/batch	1/batch	N/A
Mercury (total)	16	1/10 of samples	1/batch	1/batch	1 pair/batch
Mercury (dissolved)	16	1/10 of samples	1/batch	1/batch	N/A
Sulfate	16	1/10 of samples	1/batch	1/batch	1 pair/batch
Total Dissolved Solids	16	1/10 of samples	1/batch	1/batch	N/A
Total Suspended Solids	16	1/10 of samples	1/batch	1/batch	N/A

[1] A batch is defined as up to 20 samples analyzed together.
[2] Metals include: As, Ba, Cr, Cu, Hg, Mn, Ni, Pb, Se, and Zn.

CCV Continuing calibration verification
CRM Certified reference material
LCS Laboratory control sample

Each type of QC sample listed above 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

Corrective actions will be taken if activities are inconsistent with the QAPP, field procedures, laboratory analyses, data review processes, MQOs or performance expectations, or if some other unforeseen problem arises. Such actions may include:

- Re-calibrating the analytical instrument.
- Collecting new samples using the method described in the approved QAPP.
- Accepting and qualifying lab results that do not meet all QC criteria.
- Reanalyzing lab samples that do not meet QC criteria.
- Convening project personnel and technical experts to improve performance of project components by discussing and deciding on options and next steps.

11.0 Data Management Procedures

As field and lab data are completed, the study will organize data using various tabular and graphical formats for additional review, calculations, characterization, and reporting.

11.1 Data recording and reporting requirements

Field staff will record all field data in a field notebook/data sheets. Before leaving each site, field staff will check field notes for missing or improbable measurements. Field staff should consult the project manager or supervisor on missing or unusual data.

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

11.2 Laboratory data package requirements

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL *Users Manual* (Ecology, 2016). 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. MEL will send a standard case narrative of laboratory QA/QC results to the project manager for each set of samples.

The project manager will receive laboratory results from MEL analyses will be sent to the Project Manager in .pdf format (from LIMS), along with a Case Narrative. The Case Narrative will address various data verification checks described in Section 13 below.

11.3 Electronic transfer requirements

MEL will enter laboratory data generated by MEL into the Laboratory Information Management System (LIMS).

11.4 Model information management

Not applicable, this project will not involve any modeling.

12.0 Audits and Reports

12.1 Field, laboratory, and other audits

Field audits are always appropriate for a project involving either field measurements or sampling. It is likely that insufficient QA resources are currently available for auditing activities; however, another experienced WQP staff member could conduct a field consistency review. The aim of such reviews 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

See Section 12.1.

12.3 Frequency and distribution of reports

Publication of a final technical memorandum will occur according to the project schedule shown in Section 5.4.

Communication to the Water Quality Program supervisors of validated interim results will occur when they are available.

12.4 Responsibility for reports

The WQP project manager will lead the publication of the final technical memorandum.

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

The project manager will perform initial field data verification immediately after completing field measurements/sample collection and prior to departing the site. This process involves checking the data sheet for omissions or outliers. If field data are missing or a measurement is an outlier, field staff will repeat the measurement.

After the sampling event, the project manager will compare all field data to determine compliance with MQOs. Values that are out of compliance with the MQOs will be noted. At the conclusion of the study, the project lead will compile and assess all out-of-compliance values (if any) for usability.

13.2 Laboratory data verification

MEL staff will perform the lab verification following standard laboratory practices. After the lab verification, the project manager will perform a secondary verification of each data package. This secondary verification will entail a detailed review of all parts of the lab data package with special attention being paid to lab QC results. If any issues are discovered, the project manager will resolve them.

13.3 Validation requirements, if necessary

The results from MEL will not need to be validated. Not applicable.

13.4 Model quality assessment

Not applicable.

14.0 Data Quality (Usability) Assessment

14.1 Process for determining project objectives were met

After all lab and field data are verified, a detailed examination of the data package using statistics and professional judgment to 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 project manager will qualify or reject affected data based upon the decision criteria from the QAPP. The project manager will decide how any qualified data will be used in the technical analysis.

14.2 Treatment of non-detects

For summary statistics and analysis, non-detects will be described in the technical memorandum. Non-detects will be considered any analyte that was not detected at or above the reported sample quantitation limit. Any non-detects will be included in the study results in a separate summary statistical analysis.

14.3 Data analysis and presentation methods

Once the data have been reviewed, verified, and validated, the project manager will determine if the data can be used toward the project goals and objectives. A technical memorandum will include verified analytical data

The final technical memorandum will be prepared at the completion of the second sampling and will include the following:

- Map of the state showing locations of sampled facilities
- Description of field and lab methods
- Discussion of data quality and the significance of any problems encountered
- Summary tables of field and analytical data
- Discussion of water quality results and comparison of results to water quality criteria
- Conclusions and recommendations, limitations and future work
- As appendices: chain of custody forms, laboratory narratives, and field sheets.

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 can be drawn from the data. If so, the sampling design will be considered effective.

14.5 Documentation of assessment

The project manager will include a section in the final technical memorandum summarizing the findings of the data quality assessment. This assessment will contain an evaluation of the analytical results with respect to region as well as North American Industry Classification System (NAICS) or Ecology codes.

15.0 References

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Appendix A. Facility Latitude and Longitude

Facility Number	Latitude (DD)	Longitude (DD)	Facility Number	Latitude (DD)	Longitude (DD)
1	47.51025391	-120.2930450	116	48.06697083	-121.9392090
2	47.62670135	-120.2180023	117	48.47792435	-122.6421661
3	47.37316132	-120.1401978	118	47.54365158	-122.0334473
4	47.51636505	-120.4516754	119	48.01737976	-122.5487823
5	47.46789551	-120.6543961	120	48.97344971	-122.3403015
6	48.46736526	-120.1853638	121	48.23643112	-122.3064957
7	46.59769058	-120.4789734	122	47.25910568	-122.3226547
8	46.31689835	-119.9810028	123	48.51169968	-122.9000015
9	47.55572891	-120.2782211	124	48.49415588	-122.9362793
10	46.24361038	-119.4613876	125	48.51031113	-123.0374069
11	47.84214020	-119.9837036	126	47.46788025	-122.2430344
12	47.29238129	-120.0609436	127	48.46268845	-122.5504303
13	46.62921143	-120.6950073	128	47.56074905	-122.6991806
14	47.25109863	-121.1839981	129	48.53799820	-122.3369980
15	47.01390076	-120.5950012	130	48.52939987	-122.3040009
16	47.18190002	-120.9670029	131	47.41701508	-122.6770020
17	47.18270111	-120.9869003	132	48.02930832	-122.1865616
18	48.09013748	-119.7829895	133	48.07279968	-122.0210037
19	45.63272858	-121.1572037	134	48.91493225	-122.1192856
20	46.64962769	-120.5017700	135	47.39719009	-122.2318954
21	46.53206635	-120.7750778	136	48.54594040	-122.3346024
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32	47.30998993	-121.3246002	147	47.47793198	-122.2495422
33	47.83731079	-120.8424149	148	48.54905701	-123.1264954
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36	47.18263626	-119.5228119	151	47.54858780	-121.8158493
37	46.77950287	-119.2415695	152	47.50881958	-122.0852890
38	46.81833267	-119.1772156	153	48.20059967	-122.2639999

39	47.65439987	-117.5599976	154	48.26420593	-121.6030121
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41	47.67416763	-117.1944427	156	48.99925232	-122.2755814
42	47.68222046	-117.1837616	157	47.42020798	-122.4522934
43	47.11890030	-119.4469986	158	48.55956268	-123.1338272
44	47.75125122	-117.3888092	159	46.30964279	-124.0483627
45	48.54698181	-117.8881683	160	46.58189392	-123.0278778
46	46.65674591	-118.8604813	161	45.56506729	-122.3271103
47	46.28387833	-119.1057663	162	46.97891235	-123.7789612
48	47.73529816	-117.3719864	163	46.99665070	-123.4458923
49	48.15850449	-117.7235718	164	46.67222214	-123.7736130
50	46.29246140	-119.1076813	165	46.95887756	-122.9850693
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55	47.63890076	-117.6060028	170	46.13000870	-122.9236450
56	48.01330185	-117.3359985	171	45.63750458	-122.6952515
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58	46.07170105	-118.3629990	173	47.19490051	-122.4860382
59	47.59865570	-117.6949997	174	46.63694382	-122.9399109
60	48.22179031	-117.1006012	175	45.57333374	-122.3320618
61	47.73242188	-117.3783493	176	47.02151489	-122.9573059
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72	48.84058762	-122.5758514	187	46.92409134	-122.9487305
73	48.53338242	-121.8898239	188	47.23950958	-122.4196014
74	48.89081192	-122.3883133	189	47.01967239	-122.9487534
75	47.62482071	-122.1679001	190	47.19083786	-122.4881973
76	48.78248215	-122.4470901	191	47.13952637	-122.5016937
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81	47.84621048	-121.9851227	196	47.09099197	-122.3642883
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84	47.41704559	-122.2384262	199	46.18249130	-123.0348892
85	48.88029861	-122.2919998	200	46.85881424	-122.7446976
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91	48.20679092	-122.1486053	206	47.16327286	-122.4754181
92	48.17360306	-122.1415939	207	47.20058441	-122.3576813
93	47.88429642	-122.0738831	208	47.06227112	-122.7971802
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95	47.80898285	-122.6429291	210	47.08295822	-122.3570328
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99	47.35200119	-122.1243210	214	47.87201691	-122.7173462
100	47.54751205	-122.3361282	215	46.55471420	-122.2921600
101	47.54894638	-122.3442841	216	45.69411087	-122.6546097
102	48.89302063	-122.3668213	217	47.46638870	-122.8104935
103	48.78807449	-122.4458313	218	47.08218002	-122.3575363
104	47.91370010	-122.0798874	219	48.11091232	-123.1116638
105	47.27796936	-121.9684982	220	46.27170181	-122.9229965
106	48.12820053	-122.5836029	221	46.12551880	-122.9080276
107	48.52964401	-121.9966736	222	46.75708771	-122.9371948
108	48.84920120	-122.6760025	223	47.10443878	-122.0040817
109	47.27193451	-122.2064209	224	47.26109314	-122.3638840
110	47.98117065	-122.1771469	225	45.80379486	-122.5851898
111	48.33593369	-122.6296158	226	47.15706253	-122.4692764
112	47.77863312	-122.1453247	227	47.02039337	-122.9488602
113	47.55532837	-122.7089233	228	47.01612091	-122.1893997
114	48.34000015	-122.6283340	229	46.94853973	-122.6020508
115	47.53327560	-122.6912384			

Appendix B. Glossaries, acronyms, and abbreviations

Glossary of General Terms

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

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

Groundwater: Water in the subsurface that saturates the rocks and sediment in which it occurs. The upper surface of groundwater saturation is commonly termed the water table.

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.

Oxidation Reduction Potential: A measure of the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species affinity for electrons and tendency to be reduced.

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.

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

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Total Dissolved Solids (TDS): The solids that are capable of passing through a glass fiber filter (1.0 – 1.5 µm) and dried to a constant weight at 180 degrees centigrade.

Total suspended solids (TSS): The particulate material in a sample that does not pass through a glass fiber filter.

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

Acronyms and Abbreviations

BOD	Biochemical oxygen demand
DO	Dissolved Oxygen (see Glossary above)
e.g.	For example
Ecology	Washington State Department of Ecology
EAP	Environmental Assessment Program
EPA	U.S. Environmental Protection Agency
et al.	And others
i.e.	In other words
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
MTCA	Model Toxic Control Act
ORP	Oxidation-reduction potential
PAHs	Polycyclic aromatic hydrocarbons
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RCW	Revised Code of Washington
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedure
SWM	Solid Waste Management Program
TOC	Total organic carbon
TSS	Total suspended solids (see Glossary above)
TDS	Total dissolved solids (see Glossary above)
WAC	Washington Administrative Code
WQP	Water Quality Program
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
ft	feet
mg/L	milligrams per liter (parts per million)
mL	milliliter
mS/cm	millisiemens per centimeter, a unit of conductivity
mV	millivolt, units of oxidation-reduction potential
ng/L	nanograms per liter (parts per trillion)
NTU	nephelometric turbidity units
pg/L	picograms per liter (parts per quadrillion)
s.u.	standard units
µg/L	micrograms per liter (parts per billion)
µmhos/cm	micromhos per centimeter
µS/cm	microsiemens per centimeter, a unit of conductivity

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, deionized 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 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 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 the 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 40 CFR 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 two values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than two 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 stepwise 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).

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