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State of Washington

Quality Assurance Project Plan

Lower Yakima River Monitoring for Aquatic Life Parameters to Support Water Quality Gaging

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Quality Assurance Project Plan

Lower Yakima River Monitoring for Aquatic Life Parameters to Support Water Quality Gaging

by Jim Carroll

August 2022

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CRO: Central Regional Office, Department of Ecology
EAP: Environmental Assessment Program, Department of Ecology
EOS: Eastern Operations Section, Department of Ecology

1.0 Table of Contents

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2.0 Abstract

Previous monitoring within the Yakima River boundary waters of the Yakama Nation Reservation (city of Union Gap to city of Mabton) has shown that the Yakima River can have high water temperatures and low dissolved oxygen (DO) levels that do not protect fish and other aquatic life that depend on cool, oxygenated water.

This project coordinates the collection of water quality data in support of U.S. Geological Survey continuous water quality monitoring that is being conducted at several Lower Yakima River locations during 2022. The U.S. Bureau of Reclamation, along with the Yakima Basin Integrated Plan and the Benton Conservation District, is sponsoring water quality monitoring gages to provide calibration data in order to construct a water quality model that simulates water temperature and DO. The model will be used to assess different water management strategies to improve fish migration in the Yakima River corridor.

Sampling will occur from June through November 2022, capturing data for critical periods during the irrigation season, as well as some post-irrigation periods. Sampling will take place twice a month at 11 locations within the Lower Yakima River basin.

3.0 Background

3.1 Introduction

The U.S. Bureau of Reclamation (USBR), in coordination with the Yakima Basin Integrated Plan (YBIP) and the Benton Conservation District (BCD), is trying to understand the dynamics that cause high water temperature and low dissolved oxygen (DO) in the Lower Yakima River. The goal is to improve the water quality in the river in order to improve fish spawning, rearing, and migration throughout the Yakima River corridor.

In order to better understand the temperature and DO levels in the Lower Yakima River, several continuous water quality monitoring gages are being sponsored by the USBR, YBIP, and BCD in 2022. The continuous water quality monitoring will support the development of a Washington State Department of Ecology (Ecology) water quality model (Pickett, 2017) that can simulate water temperature and DO levels in the Yakima basin. The calibrated Ecology model will be used by USBR as a tool to simulate different water management scenarios, such as pulse releases of water from reservoirs. The model will predict what changes in temperature and DO levels are expected from the different management action scenarios.

The USGS is contracted to install and conduct continuous water quality monitoring for parameters such as temperature, turbidity, specific conductivity, DO, pH, and nitrate at five Lower Yakima River sites for the 2022 irrigation season (shown in Figure 2):

- Yakima River at the city of Union Gap above Ahtanum Creek
- Yakima River below the city of Granger (Emerald)
- Yakima River below the city of Prosser
- Yakima River at the city of Kiona
- Yakima River at Van Giesen Bridge (West Richland)

This project is a complementary monitoring study that will support the USGS gaging on the Yakima River in 2022. The USBR is contracting with Ecology to sample water chemistry and conduct additional water quality monitoring in the Lower Yakima River mainstem. The additional monitoring will provide a more complete data set that can be used to calibrate a water quality model for temperature and primary productivity (which causes DO levels to change), in order to understand important dynamics which affect aquatic life use throughout the basin.

3.2 Study area and surroundings

The study area is located within Water Resource Inventory Area (WRIA) 37, the Lower Yakima River basin. It consists of the mainstem Yakima River and the mouths of its major tributaries from river mile (RM) 121.7 upstream of the city of Yakima to RM 8.4 at the Van Giesen Bridge in West Richland (Figure 1). The Lower Yakima River basin lies in Yakima County and Benton County. Yakima and Richland are the largest municipalities in the basin, and there are many other smaller cities.

The Reservation of the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation, or YN) lies on the west bank of the Yakima River from Ahtanum Creek near the city of Union Gap to the city of Mabton. The river in this reach flows mostly within the boundaries of the Yakama Nation Reservation (Figure 1).

The Yakima River runs through a valley of highly productive agricultural lands, renowned in particular for fruit tree crops, wine grapes, and hops, while the surrounding hills are shrub steppe grasslands. The Yakima River agricultural lands are a highly managed irrigated system. The U.S. Bureau of Reclamation (USBR) owns and operates five major reservoirs in the system: Keechelus, Kachess, and Cle Elum reservoirs at the upstream end of the upper Yakima Valley; Bumping Lake and Rimrock Lake in the Naches River basin. Although these five reservoirs are all outside the study area, the managed releases of flow from the reservoirs are the dominant drivers of flow entering the Lower Yakima River.

Flows in the Lower Yakima River are also significantly affected by the operations of many irrigation districts. The largest of these are:

- Roza Irrigation District
- Selah-Moxee Irrigation District
- Sunnyside Valley Irrigation District
- Wapato Irrigation Project
- Kennewick Irrigation District
- Columbia Irrigation District

3.2.1 History of study area

Land use in the Lower Yakima valley is predominantly irrigated agriculture that is heavily reliant on the Yakima River for irrigation water supply. The Yakima River basin is one of the most irrigated areas in Washington State. As mentioned, USBR operates the Yakima Project, which greatly influences stream discharge volumes in the Yakima River and some of its tributaries. The USBR delivers water to meet downstream demands, such as irrigation, power production, and instream flow for fish protection. To meet these demands, the USBR releases water from storage reservoirs in the upper basins of the Yakima River.

Management of water volumes for human uses has changed the distribution of water throughout the year in the Yakima River from natural and historical conditions. Original conditions flowed highest during the spring snowmelt and lowest during summer. Because irrigation water delivery has been mandated by Congress and court adjudications, water volumes now flow high during summer in the Yakima.

For decades, high temperatures and suspended solids, turbidity, DDT, and other pesticides have been documented in the Lower Yakima. As a result, several reaches of the Lower Yakima and several of its tributaries do not meet Washington State water quality criteria.

Water quality issues of concern in the Lower Yakima River basin include high water temperature, low DO, high pH, as well as high levels of suspended sediments and turbidity, toxics, and nutrients. These water quality issues in the basin impact the beneficial uses of the water, threatening the health of aquatic animals and fish living in it.

In the latter decades of the century, Congress and the courts have mandated that fishery concerns be addressed, including defining minimum flows levels in the Lower Yakima River. Driven by these fishery mandates and agricultural losses during drought years, more than 35 government and stakeholder groups met for 12 years, culminating in 2010 with the YBIP. The YBIP plans for large-scale projects designed to ensure additional flow volumes to support fish and increase supply during drought years. It also has a component for restoration of the watershed, riparian areas, and fish habitat.

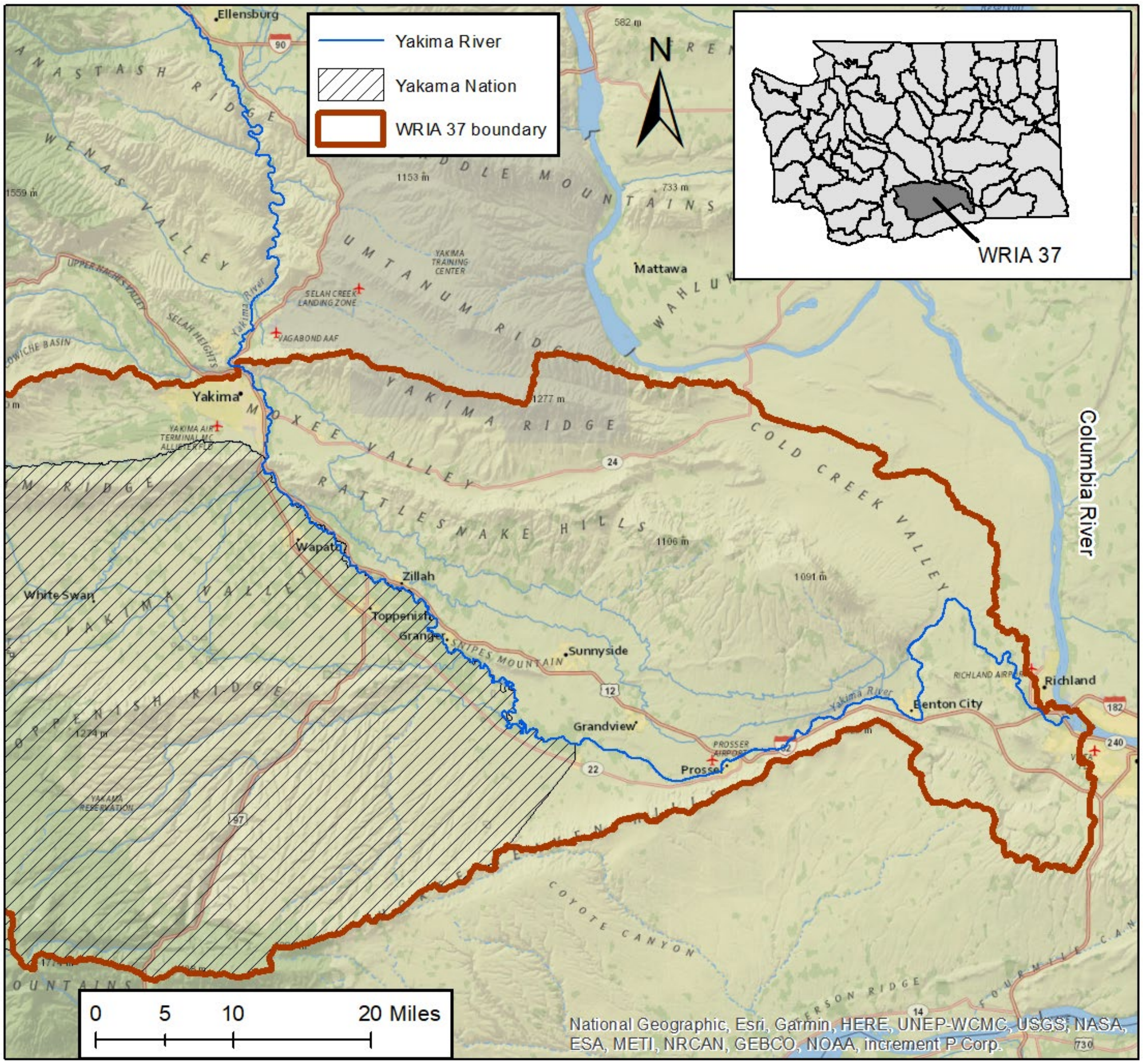


Figure 1. Study area for Lower Yakima River water quality monitoring for aquatic life parameters.

3.2.2 Parameters of interest and potential sources

This monitoring study focuses on temperature and DO, as well as parameters that interplay with river metabolism. These parameters play an important role in providing healthy habitat for salmonids and other aquatic life.

Water temperature has received the most attention from fishery restoration efforts in the Yakima River basin. High temperatures in the Lower Yakima River are known to reach levels in the summer (nearing 30°C) that create a barrier to migration for salmonids (Gendaszek, A.S., and Appel, M., 2021).

Pickett (2016) and USGS (2009) have shown that some of the primary causes of high water temperatures in the Lower Yakima include:

- Summer days in the Yakama River basin are hot, dry, and clear, providing maximum solar radiation to the water.
- The Yakima River width of the surface water does not allow riparian vegetation shade to block the solar radiation.
- The Yakima River has lost floodplain and riparian functions due to channelization; development on the flood plains; disconnection of the floodplain by levees and other structures; as well as reductions in spring flood flows due to reservoir management.
- The Yakima River has low flow in parts of the river due to water diversions. Lower flow and shallow depths allow the water to heat up faster than deeper water.

However, compared to pre-development hydrology, flow is now likely higher in other parts of the river during the summer due to reservoir releases. Fishery needs are being addressed by current water management by requiring minimum instream flow in critical locations, such as below Parker. As part of Yakima River water management, a volume of reservoir water has been set aside to be released at the call of fishery managers to create a cold water pulse during periods of cool summer weather. The sudden and rapid migration of salmon during this pulse is well documented.

Low DO is primarily driven by productivity in the river, as noted in previous studies by the USGS (2009), summarized below. Primary productivity from algal and plant growth requires warm temperature, light and food (nutrients) to proliferate. The warm temperature of the Yakima River provides ideal water temperature for growth. Clear water provides ample light through the water column for primary productivity. The Yakima River turbidity may create limiting light conditions in some parts of the river where the light is blocked from reaching the river bottom where attached algae and plants grow on the substrate. The most limiting nutrients in freshwater rivers like the Yakima River are usually phosphorus and nitrogen. The most likely sources of nutrient loading to the Yakima River are from agriculture return flows and wastewater discharges.

There are many facilities in the Lower Yakima River basin that are covered by a National Pollutant Discharge Elimination System (NPDES) or State Waste Discharge permit. These include individual permits and several general permits. NPDES municipal wastewater treatment plants that discharge into (or near) the Yakima River include:

- Yakima Publicly Owned Treatment Works (POTW)
- Buena (unnamed tributary)
- Zillah POTW
- Toppenish (E. Toppenish Cr.)
- Granger POTW
- Sunnyside POTW (Joint Drain 334, Sulfur Cr.)
- Wapato (Marion Drain)
- Harrah (Marion Drain)
- Mabton POTW
- Grandview POTW
- Prosser POTW
- Benton City POTW
- West Richland POTW

3.2.3 Summary of previous studies and existing data

Pickett (2016) provides a detailed summary of past studies and data. Relevant past studies have included modeling of Yakima River temperatures; modeling of DO and pH in the Lower Yakima River below Prosser; numerous studies of hydrogeology, groundwater, flood plain morphology, and thermal regimes; routine ambient monitoring; and a reconnaissance survey during the summer of 2015. The most relevant studies are described below. Past studies and data described in that memorandum represent supporting information to meet the goals of this Quality Assurance Project Plan (QAPP).

Of particular interest to this study is the United States Geological Survey (USGS) study of eutrophication in the Lower Yakima River (USGS, 2009). Given the central role of the USGS study in identifying eutrophication issues in the Lower Yakima, its abstract is provided here:

> In response to concerns that excessive plant growth in the Lower Yakima River in south-central Washington was degrading water quality and affecting recreational use, the U.S. Geological Survey and the South Yakima Conservation District conducted an assessment of eutrophication in the lower 116 miles of the river during the 2004–07 irrigation seasons (March–October). The Lower Yakima River was divided into three distinct reaches based on geomorphology, habitat, aquatic plant and water-quality conditions. The Zillah reach extended from the upstream edge of the study area at RM 116 to RM 72, and had abundant periphyton growth and sparse macrophyte growth, the lowest nutrient concentrations, and moderately severe summer DO and pH conditions in 2005. The Mabton reach extended from RM 72 to RM 47, and had sparse periphyton and macrophyte growth, the highest nutrient conditions, but the least severe summer DO and pH conditions in 2005. The Kiona reach extended from RM 47 to RM 4, and had abundant macrophyte and epiphytic algae growth, relatively high nutrient concentrations, and the most severe summer DO and pH conditions in 2005.
>
> Nutrient concentrations in the Lower Yakima River were high enough at certain times and locations during the irrigation seasons during 2004–07 to support the abundant growth of periphytic algae and macrophytes. The metabolism associated with this aquatic plant growth caused large daily fluctuations in DO concentrations and pH levels that exceeded the Washington State water-quality standards for these parameters between July and September during all 4 years, but also during other months when streamflow was unusually low. The daily minimum DO concentration was strongly and negatively related to the preceding day's maximum water temperature—information that could prove useful if a DO predictive model is developed for the Lower Yakima River.
>
> Periphytic algal growth generally was not nutrient-limited and frequently reached nuisance levels in the Zillah reach, where some surface-water nutrient concentrations were below the reference concentrations suggested by the U.S. Environmental Protection Agency. Although lowering nutrient concentrations in this reach might limit periphytic algal growth enough to improve DO and pH conditions, groundwater inflow at some locations might still provide an adequate supply of nutrients for periphytic algal growth.
>
> Macrophyte growth in the Kiona reach was dominated by water stargrass (Heteranthera dubia), was far greater compared to the other two reaches, varied greatly between years, and was negatively related to greater spring runoff due to lower light availability. Lowering nutrient concentrations in the Kiona reach might not impact the level of macrophyte growth because macrophytes with extensive root systems such as water stargrass can get nutrients from river sediment. In addition, the results from this study did not indicate any nutrient uptake by the macrophytes from the water column (nutrient uptake from the sediment was not examined).

> Creating the prolonged turbid and deep conditions during spring necessary to suppress macrophyte growth in this reach would not be possible in years with low streamflow. In addition, because of the relatively stable substrate present in much of this reach, the macrophyte root systems would likely not be disturbed under all but the most extremely high streamflows that occur in the Lower Yakima River.

Other studies provide useful information that could support model development and quality assessment:

- Ecology is currently conducting a project to build and calibrate a water quality model for temperature and DO in the Lower Yakima River based on available data (Pickett, 2017). This model will be updated with the calibration data collected in 2022.
- Longitudinal thermal profiles of nine reaches in the Lower Yakima River were surveyed at ambient river velocity during summer 2018 when surface-water temperatures were near their annual maximum (Gendaszek and Appel, 2021)

3.2.4 Regulatory criteria or standards

Washington State designated and beneficial uses

Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A-200) establish beneficial uses of waters and incorporate specific numeric and narrative criteria for parameters such as turbidity. The criteria are intended to define the level of protection necessary to support the beneficial uses. Washington Administrative Code (WAC) 173-201A-600 and WAC 173-201A 602 list the use designations for specific areas (WAC 173-201A-600 and WAC 173-201A-602).

For the Lower Yakima River, the designated uses of the waters in this specific area are:

Aquatic Life Uses

- *Salmonid Spawning, Rearing, and Migration*: Yakima River and its tributaries, downstream from the Cle Elum River, except for Ahtanum Creek (*Core and Char Spawning/Rearing*) and Sulphur Creek (*Rearing and Migration only*).

Recreation (Primary Contact)

- Fishing
- Swimming

Water Supply (Municipal, Industrial, and Agricultural Water Supply and Stock Watering)

- Agricultural enterprises extract water for irrigation and livestock watering.
- Other industries use Yakima River water for their operations.

Miscellaneous Uses (Wildlife Habitat, Harvesting, Commerce, Boating, and Aesthetics)

- Riparian areas are used by a variety of wildlife species that are dependent on the habitat.

Criteria for designated aquatic life uses

The criteria used to protect the aquatic life uses are outlined in Table 1. The water quality standards have a special water temperature criteria for WRIA 37 (see Table 1). In addition, a complete list of additional supplemental criteria can be found in the Water Quality Standards for Surface Waters of the State of Washington (Ecology, 2019).

Table 1. Washington State water quality criteria for temperature and DO in the Lower Yakima River and tributaries (WRIA 37), except Ahtanum Creek.

Parameter	Criteria
Water Temperature	Water temperature shall not exceed a 1-DMax (1-day daily maximum) 21.0°C (69.8°F) due to human activities. When natural conditions exceed 21.0°C (69.8°F), no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C (0.54°F); nor shall such temperature increases, at any time, exceed t=34/(T + 9).
Dissolved Oxygen	To protect the designated aquatic life use of "Salmonid Spawning, Rearing, and Migration," the lowest 1-day minimum oxygen level must not fall below 8.0 mg/L more than once every ten years on average.

Current impairments for temperature, DO, and pH

Table 2 lists the current listings on the 303(d) list (category 5 listings) for water temperature, DO, and pH in the Lower Yakima River (WRIA 37).

Table 2. Current category 5 listings for temperature, DO, and pH on the Lower Yakima River.

Listing ID	Assessment Unit ID	Parameter	Location description
11199	17030003000240	pH	Yakima River at Terrace Heights
11195	17030003000236	pH	Yakima River at Nob Hill Blvd.
8309	17030003000143	Dissolved Oxygen	Yakima River below Prosser
11177	17030003000102	Dissolved Oxygen	Yakima River at Kiona
6734	17030003000102	pH	Yakima River at Kiona
8311	17030003000102	Temperature	Yakima River at Kiona
15008	17030003000038	Dissolved Oxygen	Yakima River at Van Giesen St.
15018	17030003000038	pH	Yakima River at Van Giesen St.

4.0 Project Description

4.1 Project goals

The goal of this study is to collect water quality data, field measurements and water samples, from the mainstem Lower Yakima River. Ecology will collect this data in contract with the USBR to support the continuous water quality monitoring in the Lower Yakima River by the USGS in 2022. The data will be part of a larger data set used to model and simulate water temperature and DO levels in the Lower Yakima River basin.

4.2 Project objectives

Fieldwork will occur from spring 2022 through November 2022.

Specific objectives of the study are to:

- Collect biweekly (twice a month) samples of suspended solids, turbidity, nutrients, organic carbon, and alkalinity in the Lower Yakima River mainstem and major tributaries.
- Monitor continuous (diel) temperature, turbidity, chlorophyll a, and DO at several stations, as shown in Table 8 (section 7.2.2 below).
- Submit results of monitoring into Ecology's Environmental Information Management database, as appropriate.

4.3 External information needed and sources

Streamflow data may be needed for the Lower Yakima River and its tributaries from within the study area. It will be downloaded from various online streamflow databases from USBR, USGS, Ecology, and other sources.

4.4 Tasks required

The tasks required to meet project goals are discussed in Section 4.2. More details on field and lab tasks are described in Section 7.

4.5 Systematic planning process

This project-specific QAPP and the Programmatic QAPP (McCarthy and Mathieu, 2017) represent the systematic planning process and include the key elements:

- Description of the project, goals, and objectives (Section 3 and 4).
- Project organization, responsible personnel, and schedule (Sections 5 and 12).
- Study design to support the project goals/objectives and procurement of data (Sections 7, 8, and 9).
- Specification of quality assurance/quality control (QA/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

Key responsibilities of individuals are listed in Table 3.

Table 3. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Jim Carroll CRO, EOS, EAP 509-406-2459	Project Manager	Writes the QAPP. Conducts QA review of data and analyzes and interprets data. Tracks schedule. Reviews and approves draft and final data summary report.
Teo Fisher CRO, EOS, EAP 509-406-5944	Field Lead and Data Manager	Manages time-series sample collection, monitoring, and field records information. Conducts QA review of time-series data, analyzes and interprets data.
Rachel Caron CRO, EOS, EAP 509-454-4244	Unit Manager	Reviews the project scope and budget, tracks budget and progress, reviews the draft QAPP, and approves the final QAPP.
George Onwumere EOS, EAP 509-454-4244	Section Manager	Reviews the project scope and budget, tracks budget and progress, reviews the draft QAPP, and approves the final QAPP.
Alan Rue MEL, EAP Phone: 360-871-8801	Laboratory Director	Reviews and approves the final QAPP.
Arati Kaza Phone: 360-407-6964	Ecology QA Officer	Reviews and approves the final QAPP.

CRO: Central Regional Office, Department of Ecology
EAP: Environmental Assessment Program, Department of Ecology
EIM: Environmental Information Management database
EOS: Eastern Operations Section, Department of Ecology
MEL: Manchester Environmental Laboratory
QA: Quality Assurance
QAPP: Quality Assurance Project Plan

5.2 Special training and certifications

All field staff involved in this project either already have the relevant experience in the following standard operating procedures (SOPs) or will be trained by more senior field staff who do. Any staff helping in the field who lack sufficient experience will always be paired with someone who does have the necessary training and experience and who will then lead the field data collection and oversee/mentor less experienced staff.

5.3 Organization chart

See Table 3, Section 5.1.

5.4 Project schedule

See Table 4 below for project schedule.

Table 4. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	November 2022	Teo Fisher / Eiko Urmos-Berry
Lab analyses completed	December 2022	
Environmental Information System (EIM) database		
EIM Study ID	JICA0006	
Product	**Due date**	**Lead staff**
EIM data loaded	February 2023	Teo Fisher
EIM data entry review	March 2023	Eiko Urmos-Berry
EIM complete	December 2023	Teo Fisher
Final data summary report		
Author lead / Support staff	Ecology	
Schedule		
Final data summary report due on web	December 2023	

5.5 Limitations on schedule

Potential field-related constraints are addressed in Section 7.5. Any unforeseen limitations that would affect the project schedule will be discussed with the appropriate supervisor as needed.

5.6 Budget and funding

The budget in Table 5 assumes 13 sampling events.

Table 5. Tentative project budget.

Parameter	Total # of Samples	MEL Cost Per Sample	Subtotal
Alkalinity (carbonate & bicarbonate)	156	$20.00	$3,120.00
Dissolved organic carbon - DOC	156	$45.00	$7,020.00
Total organic carbon - TOC	156	$35.00	$5,460.00
Ammonia - NH3	156	$15.00	$2,340.00
Orthophosphate - OP	156	$20.00	$3,120.00
Total Phosphorus - TP colorimetric	156	$20.00	$3,120.00
Nitrate/Nitrite - NO2/NO3	156	$15.00	$2,340.00
Total Persulfate Nitrogen	156	$20.00	$3,120.00
TSS/TNVSS	156	$30.00	$4,680.00
Chlorophyll a	130	$60.00	$7,800.00
		Grand Total =	$43K

6.0 Quality Objectives

Quality objectives are statements of the precision, bias, and lower reporting limits necessary to meet project objectives. Precision and bias together express data accuracy. Other considerations of quality objectives include representativeness and completeness. In 2017, Ecology published a Programmatic Quality Assurance Project Plan (QAPP; McCarthy and Mathieu, 2017) that has standard and approved requirements for project quality objectives. This 2022 QAPP will refer to the 2017 Ecology publication for these statements.

6.1 Decision quality objectives

All of the data collected for this project should meet the measurement quality objectives (MQO) to be used for the project goals. Decisions can be made on a case-by-case basis for data that do not meet the MQO as to whether the data can be used for project purposes (e.g., informational, estimated values).

6.2 Measurement quality objectives

Field sampling procedures and lab analysis inherently have associated error. MQOs state the allowable error for a project. Precision and bias provide measures of data quality and are used to assess agreement with MQOs.

6.2.1 Targets for precision, bias, and sensitivity

6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error. Precision is usually assessed by analyzing duplicate field measurements or lab 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 laboratory procedures). Table 5 of the Programmatic QAPP (McCarthy and Mathieu, 2017) presents field measurement MQOs for precision and bias, as well as the manufacturer's stated accuracy, resolution, and range for the field equipment that will be used in this study. Table 6 below presents the MQOs for additional equipment being used in the project that are not included in the Programmatic QAPP.

Table 6. Manufacturers' specifications for equipment being used in project.

Parameter	Equipment	Precision Field dupes (median)	Accuracy	Resolution	Range	Expected Range
Dissolved Oxygen	miniDOT	5% RSD	± 5% of measurement or ± 0.3 mg/L, whichever is larger	0.01 mg/L	0 to 150% saturation	1 - 15 mg/L
Turbidity	Manta Trimeter	15% RSD	± 2% of reading or ± 0.3 NTU, whichever is larger	0.01 NTU	0 - 1000 NTU	0 - 500 NTU

6.2.1.2 Bias

Bias is the difference between the population mean and the true value of the parameter measured. Bias is usually addressed by calibrating field and laboratory instruments, and by analyzing lab control samples, matrix spikes, and standard reference materials. Laboratory quality control (QC) procedures such as blanks, check standards, and spiked samples will provide a measure of any bias affecting sampling and analytical procedures for this project.

The MQOs for water samples taken in the field and associated lab analyses are shown in Table 6 of the Programmatic QAPP (McCarthy and Mathieu, 2017). Table 6 in the Programmatic QAPP outlines analytical parameters, expected precision of sample duplicates, and method reporting limits. Table 7 below shows the method reporting limits for analyses that differ from the Programmatic QAPP. The target expectations for precision of field duplicates are based on historical performance by Ecology's Manchester Environmental Laboratory (MEL) for environmental samples taken around the state by EAP (Mathieu, 2006). The reporting limits of the methods listed in the table are appropriate for the expected range of results and the required level of sensitivity to meet project objectives.

6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as detection limit. In a regulatory sense, the method detection limit (MDL) is usually used to describe sensitivity. The method reporting limit and the reporting limits are the same for the parameters of interest for this project. See Table 6 in the Programmatic QAPP (McCarthy and Mathieu, 2017) for MDLs for this project, as well as Table 7 below for MDLs that differ from the Programmatic QAPP.

Table 7. Measurement reporting limits for analyses.

Analysis	Method	Method Lower Reporting and (Detection) Limit
Alkalinity	SM2320B	2.0 mg/L
Nitrate/Nitrite	EPA 353.3	0.10 (0.05) mg/L
Ammonia	SM4500NH3D	0.10 (0.05) mg/L
Dissolved Organic Carbon	SM5310B	0.50 (0.237) mg/L
Total Organic Carbon	SM5310B	0.50 (0.237) mg/L
Total Persulfate Nitrogen	SM4500NC	0.10 (0.05) mg/L
Total Phosphorus	SM4500PH	0.010 (0.0063) mg/L

6.2.2 Targets for comparability, representativeness, and completeness

6.2.2.1 Comparability

See Section 6.2.2.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

6.2.2.2 Representativeness

See Section 6.2.2.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

6.2.2.3 Completeness

See Section 6.2.2.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

7.0 Study Design

7.1 Study boundaries

The Water Resource Inventory Area (WRIA) and 8-digit Hydrologic Unit Code (HUC) numbers for the study area are:

- WRIA: 37, Lower Yakima River basin
- HUC number: 17030003

Figure 1 shows the boundary of WRIA 37 and highlights the section of the Yakima River that pertains to the project study area.

7.2 Field data collection

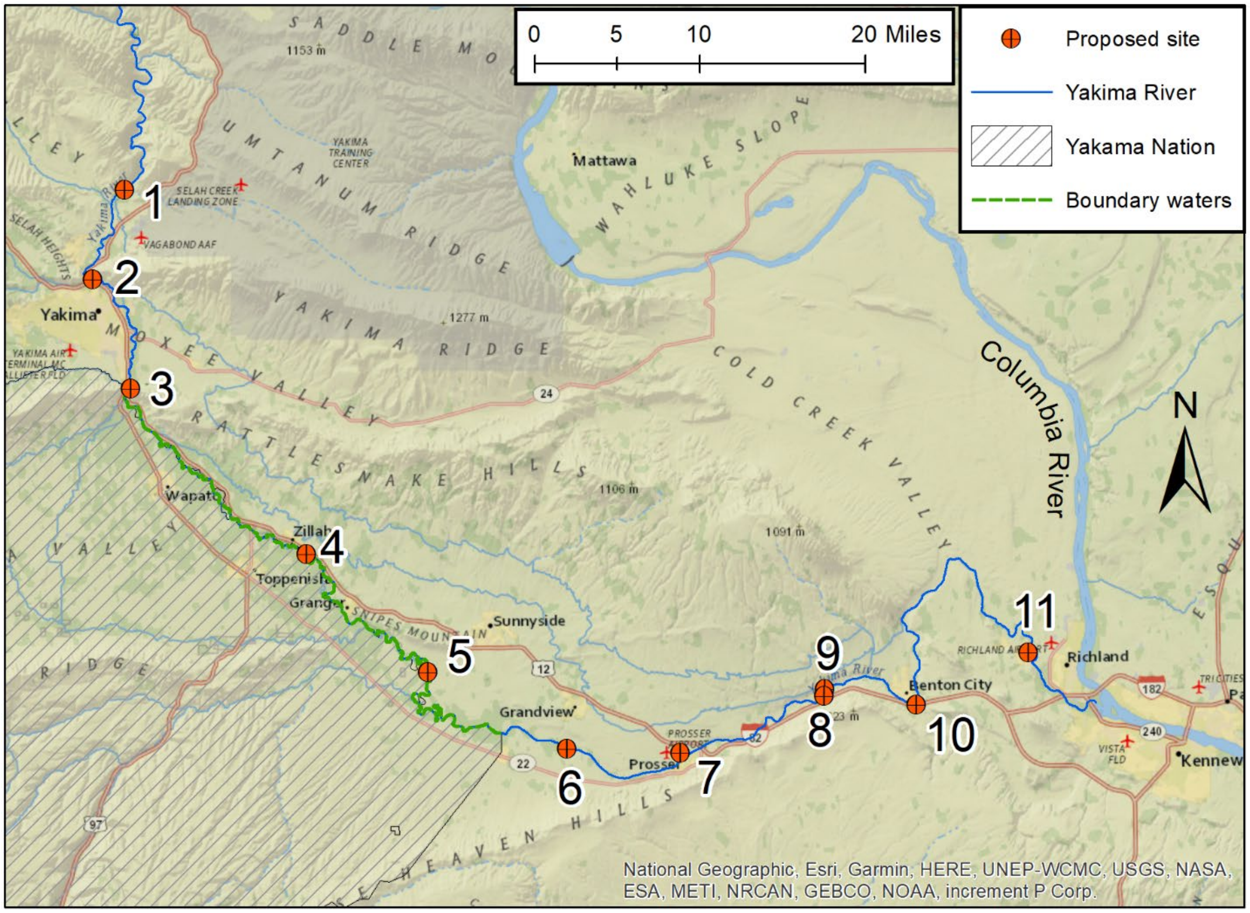
7.2.1 Sampling location and frequency

If possible, water sample collection will be conducted twice a month from June 2022–November 2022. In that way the first sampling will occur during the irrigation season and conclude with samplings after the end of the irrigation season. This will capture conditions as they change and transition out of the irrigation season in the Lower Yakima River basin.

Figure 2 shows a general map of site locations and shows a list of proposed site locations.

7.2.2 Field measurements and sample parameters (lab analyses)

The parameters to be determined via field data collection are discussed below and shown in Table 8.



Location Number	Location Name	Latitude	Longitude
1	Yakima River at Selah Moxee Diversion	46.708060	-120.474455
2	Naches River near mouth	46.630095	-120.514969
3	Yakima River at Union Gap	46.534240	-120.467121
4	Yakima River above E. Toppenish Drain	46.389565	-120.244967
5	Yakima River below Granger	46.285465	-120.092219
6	Yakima River at Euclid	46.217204	-119.916962
7	Chandler Canal Diversion	46.212811	-119.774205
8	Yakima River above Chandler Return	46.264509	-119.590797
9	Chandler Canal Return	46.267586	-119.590937
10	Yakima River at Kiona	46.252902	-119.475403
11	Yakima River at Van Giesen	46.297412	-119.333529

Figure 2. Map and table of proposed monitoring sites.

Table 8. List of measurements and parameters to be determined at each site location.

Site ID	Monitoring sites	Cont. flow	Sample type	Cont. Turb/ HL	DO meter	Field measurements (temp, DO, pH, cond, turbidity)	Sample (TSS, nutrients, TOC, DOC, alkalinity)	Chlorophyll a sample	Turb check/ Light meter	Temp tidbit logger
YKSM	Yakima River at Selah Moxee Diversion	USBR	LB grab	ECY Turb/HL		X	X		Turb / Light	X
NACM	Naches River near mouth	USBR	RB grab		X	X	X			X
YKUG	Yakima River @ Union Gap	USGS	LB grab	USGS		X	X	X		
YKET	Yakima River above East Toppenish Drain		LB grab		X	X	X	X		X
YKEM	Yakima River below Granger (Emerald)	USGS	LB grab	USGS		X	X	X		
YKEU	Yakima River at Euclid Bridge	USBR	LB grab	ECY Turb	X	X	X	X		X
YKPR	Chandler Diversion	USBR	LB grab	ECY CHLa/HL		X	X	X	Light	X
YKAC	Yakima River above Chandler Return		LB grab		X	X	X			X
CHAN	Chandler Return	USBR	RB grab		X	X	X	X		X
YKKO	Yakima River @ Kiona	USGS	LB grab	USGS		X	X	X		
YKVG	Yakima River @ Van Giesen	USGS	RB grab	USGS		X	X	X		

Abbreviations:
comp. = composite sample
cond. = specific conductivity
Cont. = continuous
DO = dissolved oxygen datalogger
DOC = dissolved organic carbon
grab = grab sample
HL = Hydrolab multi-meter datalogger
Inst. = instantaneous
Temp. = temperature.
TOC = total organic carbon
TSS = total suspended solids
Turb = turbidity

Streamflow measurements

Ecology will not be taking streamflow measurements as part of the synoptic sampling and monitoring. Streamflow data for the Lower Yakima River and its tributaries will be acquired from USBR, USGS, and others, who already measure continuous streamflow at many locations on the Yakima River as well as some tributaries. Table 9 shows the location and station names of the gages that this project will use to determine streamflow for the project. Ecology's Stream Hydrology Unit may take periodic streamflow measurements at locations measured by other agencies to conduct QC checks.

Table 9. List of continuous streamflow gages.

Agency	Agency Site ID	Gage Site Location
USGS	12484500	Yakima River @ Umtanum
USBR	RBDW	Yakima River below Roza Dam
USBR	TEAW	Naches River near 16th Ave
USGS	12500450	Yakima River at Union Gap above Ahtanum Creek
USBR	RSCW	New Reservation Canal
USBR	SNCW	Sunnyside Canal
USBR	PARW	Yakima River below Parker (doesn't catch fish screen return)
USGS	12505450	Granger Drain
USGS	12507573 (new)	Yakima River below Granger (new Emerald gage)
USBR	SUCW	Sulphur Creek Wasteway
USGS	12508990	Yakima River near Mabton
USBR	CHCW	Chandler Canal diversion
USBR	YRPW	Yakima River below Prosser
USGS	12510500	Yakima River at Kiona

Continuous water quality monitoring

USGS is conducting continuous water quality monitoring for parameters such as temperature, turbidity, specific conductivity, DO, pH, and nitrate at several Yakima River sites for the 2022 irrigation season (Table 10).

Ecology will install continuous water quality monitoring sensors at several locations to fill in gaps of data collection and improve the understanding of data variability. (Table 11). Meters will be installed and maintained following Ecology's protocols (McCarthy and Mathieu, 2017) and other more current SOPs:

- https://apps.ecology.wa.gov/publications/documents/1703207.pdf
- https://apps.ecology.wa.gov/publications/SummaryPages/2003201.html
- https://apps.ecology.wa.gov/publications/SummaryPages/2203216.html
- https://apps.ecology.wa.gov/publications/SummaryPages/1903229.html
- https://apps.ecology.wa.gov/publications/SummaryPages/1903230.html

Table 10. List of USGS continuous water quality gages.

Agency	Agency Site ID	Gage Site Location	Parameters
USGS	12500450	Yakima River at Union Gap above Ahtanum Creek	DO, Temp, SpCond, Turb, Nitrate
USGS	12507573	Yakima River below Granger (new Emerald gage)	DO, Temp, SpCond, Turb, Nitrate
USGS	12509489	Yakima River below Prosser (above WWTP)	DO, Temp, SpCond, pH, Turb, Nitrate
USGS	12510500	Yakima River at Kiona	DO, Temp, SpCond, pH
USGS	12511800	Yakima River at Van Giesen Bridge	DO, Temp, SpCond, pH

Table 11. List of proposed Ecology continuous water quality monitoring gages.

Site ID	Continuous Monitoring Sites	Parameters
YKSM	Yakima River at Selah Moxee	DO, Temp, SpCond, pH, Turbidity
YKPR	Yakima River above Prosser Dam	DO, Temp, pH, SpCond, Chlorophyll a

Special studies

Measurements of light extinction, time-of-travel, channel geometry, and other parameters that fill data gaps needed to complete model set up and calibration will be collected throughout the study period.

7.3 Maps or diagram

A map of proposed monitoring locations can be found in Figure 2.

7.4 Assumptions underlying design

In conjunction with the USGS and USBR continuous water quality gages, this field data collection is specifically designed to generate a data set that will allow calibration of a water quality model that can simulate water temperature and DO in the Lower Yakima River. The calibration data collection will also rely on the successful field data collection from tributaries and drains to the mainstem river, concurrently being done with the Yakama Nation (Carroll, 2022).

7.5 Possible challenges and contingencies

See Section 7.5 in the Programmatic QAPP (McCarthy and Mathieu, 2017) for a list of potential logistical problems, practical constraints, and schedule limitations.

8.0 Field Sampling Procedures

8.1 Invasive species evaluation

See Section 8.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.2 Measurement and sampling procedures

See Section 8.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017). Table 9 in the Programmatic QAPP (McCarthy and Mathieu, 2017) lists the field activities and their associated SOPs used to collect different types of data.

Other Ecology SOPs can be found on Ecology's website[1].

8.3 Containers, preservation methods, holding times

See Section 8.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.4 Equipment decontamination

See Section 8.4 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.5 Sample ID

See Section 8.5 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.6 Chain of custody, if required

See Section 8.6 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.7 Field log requirements

See Section 8.7 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

8.8 Other activities

See Section 8.8 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

[1] https://www.ecology.wa.gov/quality

9.0 Laboratory Procedures

9.1 Lab procedures table

See Table 11 in the Programmatic QAPP (McCarthy and Mathieu, 2017) for lab methods, including sample matrix, expected range of results, and method detection limit.

9.2 Sample preparation method(s)

See Section 9.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

9.3 Special method requirements

No special methods will be used for this study.

9.4 Lab accredited for methods

All chemical analysis will be performed at MEL, which is accredited for all methods.

10.0 Quality Control Procedures

See Section 10.0 in the Programmatic QAPP (McCarthy and Mathieu, 2017) for a list of field and laboratory quality control (QC) procedures.

10.1 Table of field and laboratory quality control

See Section 10.1 (Table 13) in the Programmatic QAPP (McCarthy and Mathieu, 2017) for list of the types and frequency of QC samples needed for lab and field samples.

10.2 Corrective action processes

See Section 10.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

See Section 11.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

11.2 Laboratory data package requirements

See Section 11.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

11.3 Electronic transfer requirements

See Section 11.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

11.4 EIM data upload procedures

See Section 11.4 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

No audits are planned for this study. However, there could be a field consistency review by another experienced field staff member during this project. The aim of this type of review is to improve fieldwork consistency, improve adherence to SOPs, provide a forum for sharing innovations, and strengthen the data QA/QC.

12.2 Responsible personnel

See Table 3 found in Section 5.1.

12.3 Frequency and distribution of report

A summary of the data collected under this project will be published in a formal, peer-reviewed report that includes results, methods, and data quality assessment. The final data summary report will be published according to the project schedule in Table 4, Section 5.4.

12.4 Responsibility for reports

The project manager and principal investigators will co-author the final data summary report.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

See Section 13.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

13.2 Verification of laboratory data

See Section 13.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

13.3 Validation requirements, if necessary

See Section 13.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.0 Data Quality (Usability) Assessment

14.1 Process for determining whether project objectives have been met

See Section 14.1 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.2 Treatment of non-detects

See Section 14.2 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.3 Data analysis and presentation methods

See Section 14.3 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.4 Sampling design evaluation

See Section 14.4 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

14.5 Documentation of assessment

See Section 14.5 in the Programmatic QAPP (McCarthy and Mathieu, 2017).

15.0 References

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16.0 Appendix. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

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

Baseflow: The component of total streamflow that originates from direct groundwater discharges to a stream.

Char: Fish of genus *Salvelinus* distinguished from trout and salmon by the absence of teeth in the roof of the mouth, presence of light-colored spots on a dark background, absence of spots on the dorsal fin, small scales, and differences in the structure of their skeleton. (Trout and salmon have dark spots on a lighter background.)

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.

Critical condition: When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses. For steady-state discharges to riverine systems, the critical condition may be assumed to be equal to the 7Q10 flow event unless determined otherwise by the department.

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

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

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

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

Effluent: An outflowing of water from a natural body of water or from a human-made structure. For example, the treated outflow from a wastewater treatment plant.

Eutrophication: Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

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

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

Point source: Source of pollution that discharges at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites where more than 5 acres of land have been cleared.

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

Primary contact recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Reach: A specific portion or segment of a stream.

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

Salmonid: Fish that belong to the family *Salmonidae*. Species of salmon, trout, or char.

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.

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

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

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

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.

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

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

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

1-DMax or 1-day maximum temperature: The highest water temperature reached on any given day. This measure can be obtained using calibrated maximum/minimum thermometers or continuous monitoring probes having sampling intervals of thirty minutes or less.

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.

7-DADMax or 7-day average of the daily maximum temperatures: The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days before and the three days after that date.

7Q10 flow: A critical low-flow condition. The 7Q10 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every ten years on average. The 7Q10 flow is commonly used to represent the critical flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q10 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

90th percentile: An estimated portion of a sample population based on a statistical determination of distribution characteristics. The 90th percentile value is a statistically derived estimate of the division between 90% of samples, which should be less than the value, and 10% of samples, which are expected to exceed the value.

Acronyms and Abbreviations

DO	(see Glossary above)
DOC	Dissolved organic carbon
e.g.	For example
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency

et al.	And others
i.e.	In other words
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
NPDES	(See Glossary above)
NSDZ	Near-stream disturbance zones
QA	Quality assurance
QC	Quality control
RM	River mile
SOP	Standard operating procedure
TNVSS	Total non-volatile suspended solids
TOC	Total organic carbon
TSS	(see Glossary above)
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
WWTP	Wastewater treatment plant
YBIP	Yakima Basin Integrated Plan

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
ft	feet
g	gram, a unit of mass
kg	kilograms, a unit of mass equal to 1,000 grams
kg/d	kilograms per day
km	kilometer, a unit of length equal to 1,000 meters
m	meter
mm	millimeter
mg	milligram
mgd	million gallons per day
mg/d	milligrams per day
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)
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, 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 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 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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