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Quality Assurance Project Plan

Tieton River and Lower Naches River Temperature Study

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Quality Assurance Project Plan

Tieton River and Lower Naches River Temperature Study

June 2015

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EAP: Environmental Assessment Program

1.0 Table of Contents

Page

1.0 Table of Contents 2

2.0 Abstract 5

3.0 Background 6
- 3.1 Study area and surroundings 6
  - 3.1.1 Logistical problems 8
  - 3.1.2 History of study area 9
  - 3.1.3 Parameter of concern 9
  - 3.1.4 Results of previous studies 9
  - 3.1.5 Regulatory criteria or standards 10

4.0 Project Description 13
- 4.1 Project goals 13
- 4.2 Project objectives 13
- 4.3 Information needed and sources 13
- 4.4 Target population 14
- 4.5 Study boundaries 14
- 4.6 Tasks required 14
- 4.7 Practical constraints 14
- 4.8 Systematic planning process 14

5.0 Organization and Schedule 15
- 5.1 Key individuals and their responsibilities 15
- 5.2 Special training and certifications 15
- 5.3 Organization chart 15
- 5.4 Project schedule 15
- 5.5 Limitations on schedule 16
- 5.6 Budget and funding 16

6.0 Quality Objectives 17
- 6.1 Decision quality objectives 17
- 6.2 Measurement quality objectives 17
  - 6.2.1 Targets for precision, bias, and sensitivity 18
  - 6.2.2 Targets for comparability, representativeness, and completeness 18

7.0 Sampling Process Design (Experimental Design) 20
- 7.1 Study design 20
  - 7.1.1 Field measurements 20
  - 7.1.2 Sampling location and frequency 20
  - 7.1.3 Parameters to be determined 23
- 7.2 Maps or diagram 23
- 7.3 Assumptions underlying design 23
- 7.4 Relation to objectives and site characteristics 23
- 7.5 Characteristics of existing data 23

8.0 Sampling Procedures 24

8.1 Field measurement and field sampling SOPs 24
8.2 Containers, preservation methods, holding times 24
8.3 Invasive species evaluation 25
8.4 Equipment decontamination 25
8.5 Sample ID 25
8.6 Chain-of-custody, if required 25
8.7 Field log requirements 25
8.8 Other activities 25

9.0 Measurement Methods 26
9.1 Field procedures table/field analysis table 26
9.2 Lab procedures table 26
9.3 Sample preparation method(s) 26
9.4 Special method requirements 26
9.5 Lab(s) accredited method(s) 26

10.0 Quality Control (QC) Procedures 27
10.1 Table of field QC required 27
10.2 Corrective action processes 27

11.0 Data Management Procedures 28
11.1 Data recording/reporting requirements 28
11.2 Laboratory data package requirements 28
11.3 Electronic transfer requirements 28
11.4 Acceptance criteria for existing data 28
11.5 EIM/STORET data upload procedures 28

12.0 Audits and Reports 29
12.1 Number, frequency, type, and schedule of audits 29
12.2 Responsible personnel 29
12.3 Frequency and distribution of report 29
12.4 Responsibility for reports 29

13.0 Data Verification 30
13.1 Field data verification, requirements, and responsibilities 30
13.2 Lab data verification 30
13.3 Validation requirements, if necessary 30

14.0 Data Quality (Usability) Assessment 31
14.1 Process for determining whether project objectives have been met 31
14.2 Data analysis and presentation methods 31
14.3 Treatment of non-detects 31
14.4 Sampling design evaluation 31
14.5 Documentation of assessment 31

15.0 References 32

16.0 Figures 34

17.0 Tables 34

18.0 Appendix. Glossaries, Acronyms, and Abbreviations 35

List of Figures and Tables

Page

Figures

Figure 1. Study area for the Tieton River and Lower Naches River Temperature Study. 7

Figure 2. Proposed locations for the Tieton River and Lower Naches River Temperature Study. 22

Tables

Table 1. Study area temperature listings on the 2012 303(d). 10

Table 2. Organization of project staff and responsibilities. 15

Table 3. Proposed schedule for completing field work, data entry into EIM, and reports. 16

Table 4. Summary of equipment, accuracy, and reporting limits for measuring temperature. 17

Table 5. Summary of equipment, accuracy, and reporting limit for measuring flow. 18

Table 6. Proposed locations for the Tieton River and Lower Naches River Temperature Study. 21

Table 7. Measurement Methods (field) 26

2.0 Abstract

Ecology will conduct an assessment of temperatures in the Tieton River and Lower Naches River within the Naches River Basin during a year with a declared drought.

Temperature loggers will be used to continuously monitor the temperature of the mainstem sites on the Tieton River and Lower Naches River and key water inflows. Also, streamflow will be monitored at selected ungaged locations. Data collection is planned for May-October 2015.

3.0 Background

Certain reaches of the Lower Naches River Basin are included on the Washington State 303(d) list of the federal Clean Water Act of impaired waterbodies, because they did not meet surface water quality criteria for temperature.

Two major streams of the Naches River Basin that flow to the Yakima River are included in this assessment:

- Naches River, below river mile (RM) 17.5.
- Tieton River, from Tieton Dam at Rimrock Lake to confluence with the Naches River.

Both streams contribute to the flows entering the Yakima River. The Tieton River flows into the Naches River at RM 17.5, and the Naches River flows into the Yakima River at approximately RM 116.5 (Selah Gap).

Streamflows during 2015 are expected to be critical low-flow because of a declared drought due to a very low snowpack in the high-altitude portions of the Naches watershed.

3.1 Study area and surroundings

The study area includes the Tieton River, from the confluence with the Naches River up to the Tieton Dam, the Lower Naches River from the confluence with the Yakima River up to the confluence with the Tieton River, and all the major tributaries for both reaches. The study area is located within the Naches River Basin, Water Resource Inventory Area (WRIA 38).

This study will focus only on the lower portion of the Naches River Basin. The upper portion of the Naches River Basin was addressed in the *Upper Naches River Temperature Total Maximum Daily Load: Volume 1, Water Quality Study Findings* (Brock, 2008) and in the *Upper Naches River and Cowiche Creek Temperature Total Maximum Daily Load: Volume 2, Implementation Strategy* (Peterschmidt, 2010). Also, the *Wenatchee National Forest Water Temperature TMDL Technical Report* (Whiley and Cleland, 2003) developed load allocations based on a channel classification system developed for surface waters within the Wenatchee National Forest. See Figure 1 below.

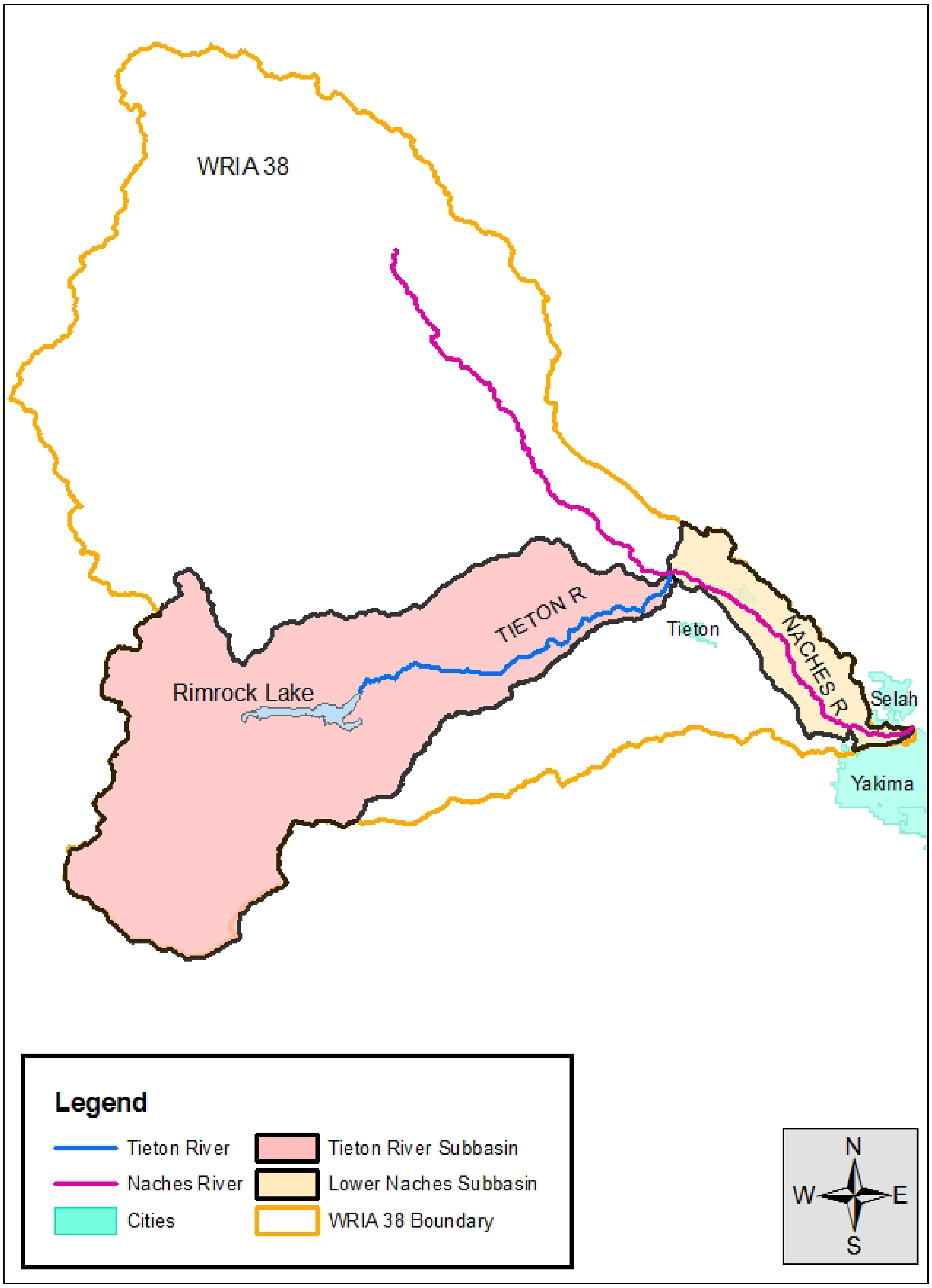

Figure 1. Study area for the Tieton River and Lower Naches River Temperature Study.

The Naches River is a major tributary of the Yakima River. It flows southeast from the Cascade Mountains to the city of Yakima and converges with the Yakima River near Interstate 82. The Tieton River, a major tributary, flows into the Naches River, near the junction of State Highway 410 and U.S. Highway 12.

There are two reservoirs located within the basin: Rimrock Lake (approximately 198,000 acre-feet) is located on the Tieton River and Bumping Lake (approximately 33,700 acre-feet) is located on the Bumping River in the upper Naches River Basin. The US Bureau of Reclamation manages the Yakima reservoirs system, which includes the reservoirs located within the Naches River Basin, using a management strategy descriptively termed "flip-flop."

In practice, flip-flop, which was conceived and initiated in 1981, consists of releasing virtually all water needed by the Wapato Irrigation Project and the Sunnyside Valley Irrigation District from the upper Yakima reservoirs until September. During this time, releases from Rimrock and Bumping Reservoirs are minimized. In early September, the release pattern reverses. The majority of the flow is provided from Rimrock and Bumping Reservoirs, and the upper Yakima releases are curtailed (YSFWPB, 2004).

The purpose of the flip-flop operation is to encourage Chinook salmon, returning to the upper Yakima in the fall, to spawn at lower river stages. This ensures that the flows required to keep the salmon redds watered and protected during the incubation period (November through March) are minimized; it is also consistent with the "normative" flow concept for the upper Yakima arm of the basin (Bureau of Reclamation, 2004).

Land ownership in the Tieton subbasin is predominantly public. The US Forest Service (Wenatchee National Forest) manages most of the land in the basin. The Washington State Department of Natural Resources and Washington Department of Fish and Wildlife manage the next largest proportion of public lands. The private lands consist of small recreational cabins and small resorts.

The valleys of the Lower Naches River subbasin predominantly support irrigated agriculture croplands. The major crops raised in the basin are apples, pears, and cherries. There are three municipalities located within the Lower Naches River Basin: Naches, Tieton, and Yakima.

The climate of the basin ranges from cool and moist in the mountains to warm and dry in the valleys. Most of the precipitation falls during November to February. Annual precipitation in the mountains is from 70 to 140 inches at the Cascade crest and less than 10 inches in the eastern part of the basin. Average summertime temperatures range from 55°F in the mountains to 85°F in the valleys. These conditions are formed by predominately westerly winds coming over the Cascade crest and the rain shadow effect in the valleys below.

3.1.1 Logistical problems

The following logistical issues could occur:

- Inability to measure high flows or access deployed temperature loggers during high flow. At times, some locations might not be wadeable or safe to access at high flows. If flow measurements cannot be taken, it will be noted on our field forms, and if possible, monitoring work may be rescheduled.

- Denial of access to private property. If permission to access is not granted at certain sites, alternate locations will be sought to replace the monitoring site.
- Scheduling conflicts, vehicle or equipment problems, or limited availability of personnel or equipment may interfere with monitoring. These will be dealt with as they occur.

3.1.2 History of study area

Wenatchee National Forest and Washington State public land encompass most of the Tieton subbasin. Timber activities and recreational uses, such as camping, boating, and fishing, are the main uses of the area.

The valleys of the Lower Naches River subbasin are predominantly irrigated agriculture, such as fruit orchards and alfalfa fields, heavily reliant on the Naches River for irrigation water supply. Two municipalities are located within the study area: Naches and Yakima. Naches has a wastewater treatment plant that discharges to the Naches River, while Yakima utilizes the river for municipal water supply.

3.1.3 Parameter of concern

The parameter of interest for this monitoring study is water temperature.

3.1.4 Results of previous studies

There have been numerous studies on the Naches Basin. For a comprehensive list, please consult Appendix A, the Naches Basin Bibliography, found in the Quality Assurance Project Plan for the Naches River Temperature Total Maximum Daily Load (TMDL) study (Brock and LeMoine, 2004).

Data that Ecology collected in 2004, for the Naches River Temperature TMDL (Brock, S.E. and LeMoine, M., 2004), led to the listing of the Tieton River and Lower Naches River reaches. Also, data from the U.S. Geological Survey's NWIS database shows excursions beyond criterion in measurements collected in 1987, 1988, and 1989 for a reach on the Naches River.

The most recent temperature reports for the Naches Basin are the Upper Naches River TMDL: Volume 1, Water Quality Study Findings (Brock, 2008) and the Upper Naches River and Cowiche Creek Temperature TMDL: Volume 2, Implementation Strategy (Peterschmidt, 2010).

Also, the Wenatchee National Forest Water Temperature TMDL Technical Report (Whiley and Cleland, 2003) developed load allocations based on a channel classification system developed for surface waters within the Wenatchee National Forest.

3.1.5 Regulatory criteria or standards

Table 1 lists the study area's temperature listings on the 2012 303(d).

Table 1. Study area temperature listings on the 2012 303(d).

Waterbody Name	Listing ID	Category	NHD Reach Codes
Naches River	8336	5	• 17030002006948
	48443	5	• 17030002000023 • 17030002000024 • 17030002000025
	48444	5	• 17030002002871 • 17030002001305 • 17030002002870 • 17030002002863 • 17030002001307
	48445	5	• 17030002002980 • 17030002001331 • 17030002001320 • 17030002001319 • 17030002001335 • 17030002002837
	48446	5	• 17030002001336 • 17030002002791
Tieton River	48472	5	• 17030002000305 • 17030002000306
	48473	5	• 17030002000306 • 17030002000307
	48474	5	• 17030002000310

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 water temperature. 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 Tieton River and the Lower Naches River, the designated uses of the waters in this specific area are:

- *Aquatic Life Uses (Core Summer Habitat)*: Spring Chinook Salmon (*Oncorhynchus tshawytscha*), Rainbow/Steelhead Trout (*Oncorhynchus mykiss*), and Bull Trout (*Salvelinus confluentus*) are the salmonid species in the Naches Basin. The lower reaches of the basin are mainly used by these species for migration, holding, rearing, and spawning habitat. Pacific lamprey, kokanee salmon, cutthroat trout, and mountain whitefish have also been documented within the basin (YSFWPB, 2004).
- *Recreation*: Fishing, Swimming, and Rafting
- *Water Supply (Industrial, Municipal and Agricultural Water Supply and Stock Watering)*: Agricultural enterprises extract water for irrigation and livestock watering, and the city of Yakima uses the Lower Naches as a drinking water source.
- *Miscellaneous Uses (Wildlife Habitat)*: Riparian areas are used by a variety of wildlife species that are dependent on the habitat.

Temperature criteria

Temperature levels fluctuate over the day and night in response to changes in climatic conditions and river flows. Since the health of aquatic species is tied predominantly to the pattern of maximum temperatures, these criteria are generally expressed as the highest 7-day average of the daily maximum temperatures (7-DADMax) occurring in a waterbody.

In the Washington State water quality standards, aquatic life use categories are described using key species (e.g., salmon, warm-water species) and life-stage conditions (e.g., spawning, rearing, migration) [WAC 173-201A-200].

The beneficial uses designated within the Naches River basin include Char Spawning and Rearing, Core Summer Salmonid Habitat, and Salmonid Spawning, Rearing and Migration. The applicable temperature criteria for the designated uses are contained in 173-201A-200(c) as:

(1) To protect the designated aquatic life uses of “Char Spawning and Rearing,” the highest 7-DADMax temperature must not exceed 12°C (53.6°F) more than once every ten years on average.

(2) To protect the designated aquatic life uses of "Core Summer Salmonid Habitat," the highest 7-DADMax temperature must not exceed 16°C (60.8°F) more than once every ten years on average.

(3) To protect the designated aquatic life uses of "Salmonid Spawning, Rearing, and Migration," the highest 7-DADMax temperature must not exceed 17.5°C (63.5°F) more than once every ten years on average.

Washington uses the criteria described above to ensure that where a waterbody is naturally capable of providing full support for its designated aquatic life uses, that condition will be maintained.

The standards recognize, however, that not all waters are naturally capable of staying below the fully protective temperature criteria. When a waterbody is naturally warmer than the above described criteria, the standards provide an allowance for additional warming due to human activities. In this case, the combined effects of all human activities must also not cause more than a 0.3°C (0.54°F) increase above the naturally higher (inferior) temperature condition.

As part of the Water Quality Standards for Surface Waters of the State of Washington (WAC 173-201A-200), there are also established supplemental protective guidelines for Salmonid spawning and incubation protection (WAC 173-201A-600,-602 and Payne, 2011).

For the Tieton River, Lower Naches River, and the tributaries for each river, there is a 13°C (as a 7-day average of daily maximum temperatures) supplemental temperature requirement from February 15 to June 15 of each year for two reaches:

- The Naches River and its tributaries from latitude 46.7640 longitude -120.8286 (just upstream of Cougar Canyon) to confluence with the Yakima River.
- Oak Creek, a tributary to the Tieton River.

Supplemental temperature requirements are implemented as temperature standards.

4.0 Project Description

4.1 Project goals

This study will help us better understand the seasonal temperature changes and to assess the impact that sources may have on water temperature in the Naches River Basin during a drought year.

The goals of this study are to:

1. Collect temperature data from monitoring sites in the following study waterways:
   - Tieton River, from Rimrock Dam to mouth.
   - Naches River, from confluence with Tieton River to mouth.
   - Tributaries, withdrawals, and key inflows to the above waterways (some flow data will be collected at some of these sites).
2. Provide these data to internal and external users in the online EIM database who may use it to better understand the seasonal temperature changes and to assess the impacts that sources may have on water temperature in the Naches River Basin.

4.2 Project objectives

The objectives of this study are to:

- Establish monitoring sites within the study waterways based on previous study results and the locations of major water sources and withdrawals.
- Monitor established sites for continuous temperature.
- Follow established protocols to ensure that representative stream temperatures and selected flow measurements are obtained throughout the desired monitoring period (May-October) and to prevent equipment loss to vandalism or high streamflow.
- Attempt to maximize the reliability of the data through pre- and post-deployment calibration checks and quality control procedures designed to locate and remove anomalous data.
- Evaluate the quality of the temperature data and publish the data in Ecology’s EIM database.

4.3 Information needed and sources

Not applicable.

4.4 Target population

Monitoring is targeting water temperature in the Tieton River and Lower Naches Basin.

4.5 Study boundaries

The study area is located in WRIA 38 (Tieton River and Lower Naches River subbasins). A map of the study area for the Tieton and Lower Naches Rivers Temperature Study is provided in Figure 1.

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

- WRIA 38
- HUC number 17030002

4.6 Tasks required

Brief summary of tasks required to complete this project:

- Do pre-calibration checks on temperature loggers.
- Deploy loggers at selected monitoring sites.
- Collect temperature data at monitoring sites every 3-4 weeks.
- Collect flow measurements at tributaries, withdrawals, and inputs at selected monitoring sites.
- Collect instantaneous temperature date for deployed loggers every 3-4 weeks.
- Retrieve, download, and do post-calibration checks of all loggers.
- Quality assurance check of the collected temperature and flow data.
- Submit data to Ecology's EIM database.

4.7 Practical constraints

See section 3.1.1.

4.8 Systematic planning process

This QAPP represents the systematic planning process.

5.0 Organization and Schedule

5.1 Key individuals and their responsibilities

Table 2. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Laine Young Water Quality Program Central Regional Office Phone: 509- 731-0911	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Eiko Urmos-Berry Eastern Operations Section Phone: 509-575-2397	Project Manager/ Principal Investigator	Writes the QAPP. Oversees field deployment of temperature loggers and field activities. Conducts QA review of data and enters accepted data into EIM database for publication on the Ecology website. Writes data summary report.
Dan Dugger Eastern Operations Section Phone: 509-454-4183	Field Assistant	Helps collect field information and audits data collection and QA review.
Tom Mackie Eastern Operations Section Phone: 509-454-4244	Section Manager for the Project Manager	Reviews the project scope, tracks progress, reviews the draft QAPP, and approves the final QAPP. Approves the initiation of field work.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP. Approves the initiation of field work.

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

5.2 Special training and certifications

The field lead and assistants for each survey will be trained in and experienced with the SOPs being used.

5.3 Organization chart

See Table 2.

5.4 Project schedule

Field work for data collection is scheduled to start in May 2015 and last through October 15. Table 3 presents the proposed schedule for this project.

Table 3. Proposed schedule for completing field work, data entry into EIM, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	October 2015	Eiko Urmos-Berry
Environmental Information System (EIM) database		
EIM Study ID	EURM0001	
Product	Due date	Lead staff
EIM data loaded	December 2015	Eiko Urmos-Berry
EIM data entry review	January 2016	Dan Dugger
EIM complete	February 2016	Eiko Urmos-Berry
Final technical report		
Author lead	Eiko Urmos-Berry	
Schedule		
Draft due to supervisor	March 2016	
Draft due to client/peer reviewer	April 2016	
Draft due to external reviewer(s)	April 2016	
Final (all reviews done) due to publications coordinator	May 2016	
Final report due on web	June 2016	

5.5 Limitations on schedule

Field-related logistical issues are addressed in section 3.1.1.

Work load of project manager, lead, and assistant will heavily determine if work products can be followed as scheduled.

5.6 Budget and funding

Not Applicable

6.0 Quality Objectives

6.1 Decision quality objectives

Decision quality objectives (DQOs) are not necessary for this project.

6.2 Measurement quality objectives

The accuracy and instrument bias measurement quality objectives (MQOs) of each temperature logger is verified through both pre- and post-deployment calibration checks following the procedures described in the *Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams* (Ward, 2011). The procedures require the temperature loggers be tested in controlled water temperature baths that bracket the expected monitoring range (near 0ºC and near 20ºC). The results are then compared to those obtained with a certified reference thermometer.

If the mean absolute value of the temperature difference for a logger in each water bath, compared against the NIST-certified thermometer, is equal to or less than the manufacturer's stated accuracy, then a second check should be performed. Temperature loggers that fail a second pre-deployment check will not be used.

Table 4. Summary of equipment, accuracy, and reporting limits for measuring temperature.

Equipment	Accuracy	Precision (replicate median RSD)	Reporting Limit
Certified Reference Thermometer # 210-617-C, ICL Calibration Laboratories.	± 0.3 °C	± 0.2 °C	0.1 °C
Thermistor Thermometer #U-08402 Thermistor & #U-93823 Probe, Cole Parmer Co.	± 0.3 °C	± 0.2 °C	0.1 °C
Temperature Logger (Water/Air) #UTBI-001 TidbiT v2, Onset Computer Corp.	± 0.2 °C	± 0.2 °C	0.1 °C

Sampling bias is minimized by following the deployment procedures described in Ward (2011). These procedures specify site selection and deployment methods designed to ensure that the temperature logger results are representative of stream conditions throughout the entire monitoring period and not biased by the effects of solar radiation or low streamflow conditions.

At the beginning of each field week, the Marsh-McBirney FlowMate® will be zeroed out to ensure accurate measurements. The expected accuracy and reporting limits are found on Table 5.

If the SonTek® FlowTracker® Handheld ADV® is used for side-by-side comparisons, the pre-measurement diagnostic will be performed. BeamCheck will be used to test and track the integrity of the ADV probe in a controlled environment. See Table 5.

Table 5. Summary of equipment, accuracy, and reporting limit for measuring flow.

Equipment	Accuracy	Precision (replicate median RSD)	Reporting Limit
Marsh-McBirney FlowMate® 2000	±2%	—	0.01 ft/s
SonTek® FlowTracker® Handheld ADV®	<0.03 ft/s	—	0.01 ft/s

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 for field replicate measurements of temperature will be expressed as the relative standard deviation (RSD) for the group of duplicate pairs (Table 4).

6.2.1.2 Bias

Bias is the difference between the population mean and the true value. Bias is the difference between the population calibration checks used to document logger bias and performance as described in Ward (2011).

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. The detection limit for field measurement of water temperature is 0.1 °C.

6.2.2 Targets for comparability, representativeness, and completeness

6.1.2.1 Comparability

To ensure comparability, field measurements will follow approved Environmental Assessment Program (EAP) SOPs. These are listed in section 8.1.

6.2.2.2 Representativeness

The study is designed to have enough monitoring sites and sufficient monitoring frequency to meet study objectives of characterizing the temperature regime in the target basins.

6.2.2.3 Completeness

Completeness is a measure of the amount of valid data needed to meet the goals defined for the uses of the data. The goals for the collected data will be to:

- Provide water temperature data for future TMDL studies.
- Provide water temperature data for 303(d) assessments of compliance with water quality temperature criteria.

The use of continuous stream temperature data for TMDLs and water quality standards compliance is based on the ability to compare monitoring data to the temperature criteria defined by Washington's Water Quality Standards, found in WAC 173-201A-200(1)(c) (WAC 173-201A-200). The temperature criteria established for protection of aquatic life is measured by the annual 7-day average of the daily maximum temperatures (7-DADMax) or, in some cases, the 1-day daily maximum temperature (1-DMax).

The target for this study is to correctly monitor, record, and analyze 100% of the time intervals pre-set to record by the temperature loggers at all sites. Completeness will be acceptable if water temperatures monitored at each site allows the 7-DADMax and 1-DMax water temperatures to be evaluated for at least 90% of the range of time between May through October 2015.

Potential problems during data collection that need to be avoided if possible include: loss of temperature loggers by flooding or vandalism, loss of valid water temperature recording due to water levels dropping below logger installations, malfunctioning of loggers, and site access problems.

7.0 Sampling Process Design (Experimental Design)

7.1 Study design

The project objectives will be met through characterizing seasonal temperature in the Tieton River and Lower Naches River. Continuous temperature and flow data collection will be required for future analysis to assess temperature dynamics in various reaches of these waterbodies. Monitoring will occur May-October 2015.

7.1.1 Field measurements

The sampling design will use a fixed network of monitoring sites with continuous temperature loggers. Air temperature and relative humidity loggers will also be deployed at select monitoring sites designed to evaluate local meteorological conditions.

Temperature checks will be conducted every 3-4 weeks. Also, instantaneous temperature readings and discharge measurements will be collected at smaller irrigation inflows and outflows during these visits. Flow measurements may be taken during these visits by direct means or by using a staff gage.

7.1.2 Sampling location and frequency

Data collection will occur between May and October of 2015.

Continuous temperature collection:

- Water and air temperature loggers will be deployed to log every 30 minutes in locations where representative temperature data may be obtained throughout the entire monitoring period.
- Relative humidity loggers will be deployed at selected monitoring sites.

At many sites throughout the study area, field measurements will be collected every 3-4 weeks (see Table 6 and Figure 2):

Table 6. Proposed locations for the Tieton River and Lower Naches River Temperature Study.

Site ID	Station Description	Latitude	Longitude	Data-logger
38-NAC-00.5	Naches R at BOR Station near mouth	46.62700	-120.52390	X
38-OLDW	Old Union Diversion	46.62740	-120.56750	
38-FRUW	Fruitvale Diversion - City of Yakima	46.62910	-120.57430	
38-COW-00.5	Cowiche Crk at W. Powerhouse Rd	46.62720	-120.58111	X
38-BINW	Buckskin Slough near Naches River	46.63280	-120.58070	
38-CYIW	City of Yakima Diversion	46.63150	-120.58720	
37-IS-20C	Naches Cowiche Diversion	46.63150	-120.58720	
38-NAC-03.7	Naches R at Powerhouse Rd	46.63185	-120.58547	X
38-CHFW	Chapman Nelson Diversion	46.65070	-120.61720	
38-NAC-08.5	Naches R at Eschbach Park	46.67822	-120.64975	X
37-IS-16C	Yakima Valley Canal -Congdon	46.68340	-120.65390	
38-GLEW	Gleed Diversion	46.69140	-120.65350	
38-WAPW	Wapatox Return	46.69540	-120.65410	X
38-CYIW	City of Yakima Diversion	46.69610	-120.65450	
38-KLYW-R	Kelly Lowry Ditch Return	46.69860	-120.65670	
38-NAC-10.5	Naches R d/s of Naches at Public Fishing	46.70306	-120.66189	X
38-NAC-12.8	Naches R at S. Naches Road	46.72401	-120.69912	X
38-KLYW	Kelly Lowry Diversion	46.73050	-120.71930	
38-SOUW	South Naches Diversion	46.73000	-120.72040	
38-CLCW	Clark Diversion	46.73580	-120.74240	
38-NAC-16.0	Naches R below confluence with Tieton	46.74567	-120.76754	X
38-NACW	Naches R below Y (Naches at Naches)	46.74660	-120.76920	X
38-WOPW	Wapatox Diversion	46.74850	-120.77970	
38-NAC-17.6	Naches R at Y	46.74634	-120.78893	
38-NAC-18.0	Naches R just below Naches Selah Canal	46.74560	-120.79660	
38-NSCW	Naches Selah Canal	46.74810	-120.80600	
38-TIE-00.4	Tieton R near mouth	46.74263	-120.78646	X
38-TIE-01.5	Tieton R at Tom's Pond	46.73256	-120.79507	X
38-OAK-0.05	Oak Creek near mouth	46.72370	-120.81410	X
38-TIE-02.3	Tieton R above Oak Crk	46.72174	-120.81525	X
38-TIE-06.1	Tieton R at 2nd turnout above Mile Marker 180	46.71223	-120.88035	X
38-TIE-09.0	Tieton R near Windy Pt (u/s Hwy 12 bridge)	46.69516	-120.91372	X
38-TICW	Tieton R near USBR flow station	46.67080	-121.00360	X
38-TIEW	Tieton Canal diversion	46.67060	-121.00790	
38-TIE-16.2	Tieton R at Willows campground	46.67311	-121.04144	X
38-PINE-0.05	Pine Creek near mouth, east of FS Work Center	46.67650	-121.07490	
38-HAUS-0.05	Hause Creek near mouth, west of FS Work Center	46.67450	-121.07790	

Site ID	Station Description	Latitude	Longitude	Data-logger
38-MILK-0.05	Milk Creek near mouth, blw Tieton Rd (FS 1200 Rd)	46.67220	-121.08170	
38-SOUP-0.05	Soup Creek near mouth, just west of FS 1500 Rd	46.67260	-121.08390	
38-WILD-0.05	Wildcat Creek near mouth	46.66460	-121.12350	
38-TIE-21.0	Tieton River below Dam	46.65980	-121.12640	X
TIESPILL1	Tieton Canal Release Point, 1 mile blw diversion	46.67000	-120.97870	
TIESPILL2	Tieton Canal Release Point, 2 miles blw diversion	46.67790	-120.96160	
TIESPILL3	Tieton Canal Release Point, 3 miles blw diversion	46.68240	-120.94180	
TIESPILL4	Tieton Canal Release Point, 5.5 miles blw diversion	46.69230	-120.90760	
TIESPILL5	Tieton Canal Release Point, 6.5 miles blw diversion	46.70520	-120.88590	

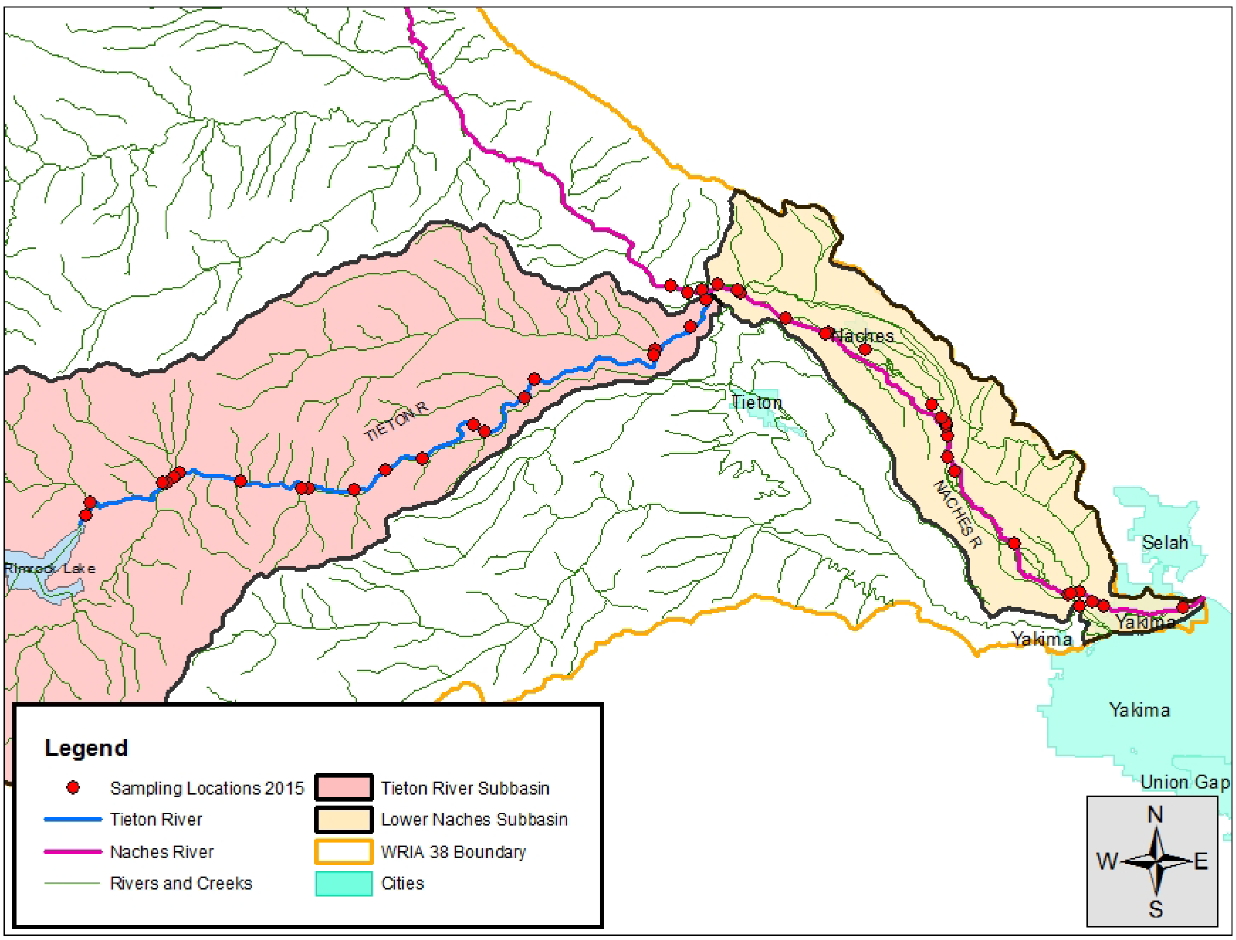

Figure 2. Proposed locations for the Tieton River and Lower Naches River Temperature Study.

Mainstem locations:

- There are 8 sites on the Tieton River and 9 sites on the Naches River.
- Temperature will be monitored.

Tributary locations:

- There are 6 sites on the Tieton River and 2 sites on the Naches River.
- Temperature will be monitored, and, when possible, flow measurements will be collected.

Other smaller inflows and outflows:

- These are mainly irrigation inputs and outputs.
- There are 6 sites off the Tieton River and 15 sites off the Naches River.
- Temperature will be monitored, and, when possible, flow measurements will be collected.
- Some of these sites may not have measureable flow, and temperature and discharge measurements may not be collected.

The location of sites may change, or sites may be added or eliminated. This will depend on access to sites, site conditions, or discovery of additional inflows and outflows to the system.

7.1.3 Parameters to be determined

See section 7.1.2.

7.2 Maps or diagram

See Figure 1 in Section 3.1 for a map of the study area.
See Table 5 and Figure 2 in Section 7.1.2 for a list and a map of the proposed sites for the study.

7.3 Assumptions underlying design

Not applicable.

7.4 Relation to objectives and site characteristics

Not applicable.

7.5 Characteristics of existing data

Not applicable.

8.0 Sampling Procedures

Water and air temperature loggers will be deployed in locations where representative temperature data may be obtained throughout the entire monitoring period.

Each deployment location will be photographed and have site-specific survey information documented on a standardized Continuous Temperature Survey Form (Ward, 2011).

Most loggers will be deployed inside a 2-2½ inch piece of 1½ inch camouflage-painted PVC pipe to shade them from sunlight and to prevent them from being found and vandalized. A few loggers may be installed in culverts without the PVC case (instead using a bolt or anchor weight) when the PVC would interfere with culvert flow and there is no risk of exposure to sunlight.

Further, mid-deployment checks of the water temperature logger locations will be conducted every 3-4 weeks. The periodic checks may result in a temperature logger re-location to a greater depth. All check observations and measurements will be recorded on the survey form.

Where possible, flow measurements in tributaries or other smaller inputs and outputs, occurring every 3-4 weeks, will be conducted using cross-sectional wading or bridge methods. Procedures for streamflow measurements will follow the *Standard Operating Procedures for Estimating Streamflow* (Kardouni, 2013). Flow results will be recorded in cubic feet per second (cfs). At times, a SonTek® FlowTracker® Handheld ADV® may be used to collect flow measurements and the *Standard Operating Procedure for Operation of the SonTek® FlowTracker® Handheld ADV®* will be followed (Burks, 2009).

8.1 Field measurement and field sampling SOPs

To ensure comparability, field measurements will follow approved EAP SOPs (Ecology, 2014):

- EAP080 – Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams.
- EAP011 – Standard Operating Procedure for Instantaneous Measurements of Temperature in Water.
- EAP024 – Standard Operating Procedure for Estimating Streamflow.
- EAP058 – Standard Operating Procedure for Operation of the SonTek® FlowTracker® Handheld ADV®.
- EAP070 – Standard Operating Procedures to Minimize the Spread of Invasive Species.

8.2 Containers, preservation methods, holding times

Not applicable.

8.3 Invasive species evaluation

The study area is not in an area of concern for invasive aquatic species; however, as mentioned in Section 8.1, we will follow SOP EAP070 to minimize any chance of spreading of invasive species.

8.4 Equipment decontamination

Not applicable.

8.5 Sample ID

Not applicable.

8.6 Chain-of-custody, if required

Not applicable.

8.7 Field log requirements

A field log will be maintained by the field lead and used during monitoring. Observations and measurements for water and air temperature logger checks will be recorded on the Continuous Temperature Survey Form.

All observations and measurements will be recorded on forms printed on waterproof paper. They will contain:

- Name of location and site ID
- Date and time
- Field staff
- Field measurement results
- Instrument IDs
- Pertinent observations
- Any temperature logger information
- Comments

8.8 Other activities

Any field staff new to the type of monitoring being conducted for this study will be trained by senior field staff or the project manager, following relevant EAP SOPs. Any maintenance needed for Marsh-McBirney FlowMate® equipment, SonTek® FlowTracker,® Handheld ADV®, or other temperature thermistors will be performed by trained field staff, following the equipment manufacturers' manuals.

9.0 Measurement Methods

9.1 Field procedures table/field analysis table

There will only be field procedures associated with this study. Table 7 shows the field measurement methods required to meet the goals and objectives of this project.

Table 7. Measurement Methods (field)

Analyte	Sample Matrix	Number of Measurements	Expected Range of Results	Method	Method Detection Limit
Water temperature	Water	≤ 500 instantaneous	1.0 - 35° C	Thermistor Thermometer #U-08402 Thermistor & #U-93823 Probe, Cole Parmer Co.	N/A
Velocity	Water	≤ 500 flow measurements	<0.1 – 10 ft/s	Marsh-McBirney FlowMate® SonTek® FlowTracker® Handheld ADV®	0.01 ft/s

9.2 Lab procedures table

Not applicable. See Section 9.1.

9.3 Sample preparation method(s)

Not applicable. See Section 9.1.

9.4 Special method requirements

Not applicable. See Section 9.1.

9.5 Lab(s) accredited method(s)

Not applicable. See Section 9.1.

10.0 Quality Control (QC) Procedures

The accuracy and instrument bias of each temperature logger is verified through both pre- and post-deployment calibration checks, following the procedures described in Ward (2011).

If a recently retrieved temperature logger has a consistent bias of more than ± 0.2ºC, then the raw data may be adjusted or flagged with an appropriate data qualifier. If the pre- and post-deployment biases are not consistent, then the data may be adjusted or rejected.

Marsh-McBirney FlowMate® will be zeroed at the beginning of the field week to ensure accurate measurements. A SonTek® FlowTracker® Handheld ADV® may also be used to take flow measurements. The pre-measurement diagnostic will be performed. BeamCheck will be used to test and track the integrity of the ADV probe in a controlled environment.

We will take duplicate flow measurements to check the accuracy. We may also take side-by-side flow measurements using both flow meters.

10.1 Table of field QC required

See Table 4 and 5 in Section 6.2.

10.2 Corrective action processes

QC results may indicate problems with data during the course of the project. Options for corrective actions might include:

- Recheck pre- and post-calibration checks.
- If possible, retrieve missing information.
- Qualify or reject results.

11.0 Data Management Procedures

11.1 Data recording/reporting requirements

Staff will record all field data in a field notebook or an equivalent electronic collection platform. Before leaving each site, staff will check field notebooks or electronic data forms for missing or improbable measurements. Staff will enter field-generated data into Microsoft (MS) Excel® spreadsheets as soon as practical after they return from the field. The field lead will check data entry against the field notebook data for errors and omissions.

Data from temperature loggers that meet the calibration check accuracy requirement are proofed and QC checked using Ecology's FMU Access® Data Logger Database. All continuous data will also be entered into MS Excel® spreadsheets.

11.2 Laboratory data package requirements

Not applicable.

11.3 Electronic transfer requirements

Not applicable.

11.4 Acceptance criteria for existing data

Not applicable.

11.5 EIM/STORET data upload procedures

All continuous and field data will be entered into Ecology's Environmental Information Management (EIM) Database, following all existing Ecology business rules and the EIM User's Manual for loading, data quality checks, and editing.

12.0 Audits and Reports

12.1 Number, frequency, type, and schedule of audits

Audits are not planned for this project; however, there could be a field consistency review by another experienced EAP field staff during this project. The aim of this review is to improve field work consistency, improve adherence to SOPs, provide a forum for sharing innovations, and strengthen our data QA program.

12.2 Responsible personnel

See Table 2 in Section 5.1.

12.3 Frequency and distribution of report

The data collected under this project will be summarized and published in a formal, peer-reviewed report that includes results, methods, and data quality assessment. The final report will be published according to the project schedule in Section 5.4, Table 3.

12.4 Responsibility for reports

Eiko Urmos-Berry will be the lead on the final report. See Table 2.

13.0 Data Verification

13.1 Field data verification, requirements, and responsibilities

The data will be verified by following the procedures described in the *Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams* (Ward, 2011). These procedures are summarized below:

- Calibration checks and field procedures will be documented on appropriate forms.
- Data will be checked for entry errors and completeness.
- Pre- and post-calibration check results and field measurements will be reviewed to ensure the data quality objectives were met.
- Results will be verified using data plots, field measurements, and stream height/flow information (if available).
- Detected data errors will be corrected, flagged with data qualifiers, or deleted.

For field measurements, the field lead will verify initial field data before leaving each site. This process involves checking the data sheet for omissions or outliers. If measurement data are missing or a measurement is determined to be an outlier, the measurement will be repeated.

13.2 Lab data verification

Not applicable.

13.3 Validation requirements, if necessary

Validation of data is not applicable.

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

14.0 Data Quality (Usability) Assessment

Stream temperature and flow data that have met specified MQOs and passed data verification will be stored in Ecology's EIM database.

14.1 Process for determining whether project objectives have been met

After all field data are verified, the field lead or project manager will thoroughly examine the data to determine if MQOs have been met. The project manager will examine the data 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 decide if affected data should be qualified or rejected.

14.2 Data analysis and presentation methods

No data analysis or methods presentations are currently planned.

14.3 Treatment of non-detects

Not applicable.

14.4 Sampling design evaluation

Not applicable.

14.5 Documentation of assessment

Not applicable.

15.0 References

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16.0 Figures

See Table of Contents for list of figures.

17.0 Tables

See Table of Contents for list of tables.

18.0 Appendix. Glossaries, Acronyms, and Abbreviations

Glossary of General Terms

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

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.

Reach: A specific portion or segment of a stream.

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

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.

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.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such 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.

Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
et al.	And others
MQO	Measurement quality objective
QA	Quality assurance
RM	River mile
SOP	Standard operating procedure
USFS	United States Forest Service
USGS	United States Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
m	meter

Quality Assurance Glossary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Examples of data types commonly validated would be:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Standard Operating Procedure (SOP): A document that 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)

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