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State of Washington

Quality Assurance Project Plan

North River Temperature and Bacteria Verification Study

March 2014

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Publication Information

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

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1403104.html

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search Study ID jkar0005.

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Quality Assurance Project Plan

North River Temperature and Bacteria Verification Study

March 2014

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Signatures are not available on the Internet version.
EAP: Environmental Assessment Program
EIM: Environmental Information Management database

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Abstract

Certain reaches of the North River and contributing tributaries were included on the Washington State 303(d) list of impaired waterbodies because they did not meet surface water quality criteria for fecal coliform bacteria and temperature. The North River watershed is located in rural southwest Washington, flowing through industrial timberland, and empties into the northern area of Willapa Bay.

This technical study will evaluate the relevant water quality parameters during the 2014 - 2015 study period. The goal of this study is to determine whether the existing 303(d) listed stream segments meet Washington State surface water quality criteria. The purpose of the study is to verify temperature and bacteria conditions since the collection of initial data that led to 303(d) listing in 1993. Since initial data collection, action has been taken to reduce water quality impairments.

Each study conducted by Ecology must have an approved Quality Assurance (QA) Project Plan. This plan describes the objectives of the study and the procedures to be followed to achieve those objectives.

Background

Certain reaches of the North River and contributing tributaries were above the acceptable limits of Washington State's water quality criteria for temperature and bacteria (Table 1). Stream reaches that exceed water quality criteria are placed on the 303(d) list, a list of polluted waters that require a cleanup plan. The water quality assessment fulfills one component of the State's obligation to meet the Clean Water Act requirements of section 303(d). The current water quality assessment may be viewed at the following website:
http://www.ecy.wa.gov/programs/wq/303d/currentassessmt.html

Table 1. 303(d) listed stream reaches exceeding water quality criteria

Waterbody	Parameter	Listing ID	NHD reach code	Township Range Section
Joe Creek	Temperature	6906	17100106000434	16N - 8W - 31
Martin Creek	Temperature	35312	17100106000298	15N - 6W - 35
Martin Creek	Temperature	35307	17100106000298	15N - 6W - 28
North River	Bacteria	6691	17100106000243	15N - 10W - 23
North River	Bacteria	6686	17100106000240	15N - 10W - 22
North River	Temperature	6909	17100106000257	16N - 9W - 32
North River	Temperature	6913	17100106000268	16N - 8W - 9
North River	Temperature	6907	17100106000266	16N - 8W - 8
North River, East Fork	Temperature	6905	17100106000348	16N - 9W - 29
Raimie Creek	Temperature	35306	17100106000303	15N - 6W - 16
Redfield Creek	Temperature	35316	17100106000300	15N - 6W - 15
Redfield Creek	Temperature	35314	17100106000300	15N - 6W - 22
Salmon Creek, Upper	Temperature	6911	17100106000411	16N - 8W - 9
Sullivan Creek	Temperature	35320	17100106000501	15N - 6W - 10
Unnamed Creek (trib to N. River)	Temperature	6908	17100106000440	16N - 9W - 33

NHD = National Hydrography Data (stream reach code at the 303(d) listed location)

The two fecal coliform (FC) bacteria listings in Table 1 are from data collected in 1993. The FC bacteria data that exceeded water quality criteria were collected 20 years ago (Seyferlich and Joy, 1993). Since then, cleanup actions near the 303(d) listed reaches include discontinuation of two significant livestock operations and halted discharge of septage from houseboats.

Bacteria sampling conducted by the Shoalwater Bay Tribe during 1999 - 2000 reportedly met water quality criteria (Rountry, 2013). No other recent data are available. As a result, one purpose of this study is to verify the FC bacteria listings at the mouth of the North River.

This study will also verify reaches within the watershed that exceed the temperature criteria (Table 1). The temperature listings of the North River, East Fork North River, Joe Creek, Upper Salmon Creek, and the unnamed tributary represent time-series data collected during 1996 and 1997. The temperature listings of Martin, Raimie, Redfield, and Sullivan Creeks represent time-series data collected during 2002 and earlier.

Temperature data that exceed water quality criteria were collected 10 to 15 years ago. Since then, efforts to restore and maintain natural thermal conditions have been implemented by the Department of Natural Resources (DNR) Forest Practice Rules (Title 222 WAC). The Forest Practices Rules establish standards for forest practices such as timber harvest, pre-commercial thinning, road construction, fertilization, and forest chemical application (DNR, 2013). Forest Practice Rules apply throughout the watershed on all industrial timberlands.

This Quality Assurance (QA) Project Plan describes the approach used to assess the 303(d) listed stream reaches within the North River watershed (Table 1).

Beneficial Uses and Water Quality Criteria

Table 2 shows the designated beneficial uses and water quality criteria for the North River watershed for temperature and FC bacteria. This study will compare collected temperature and bacteria data to water quality criteria (Table 2).

Table 2. Beneficial uses and water quality criteria.

Parameter	Condition
North River, East Fork North River, and Joe Creek Salmonid Spawning, Rearing, and Migration Habitat - Primary Contact Recreation	
Temperature*	Highest 7-DADMAX (7 day average of the daily maximum temperatures) 17.5º C
Bacteria	Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value > 200 colonies/100 mL.
Salmon Creek (upper), Sullivan, Raimie, Martin, and Redfield Creeks Core Summer Salmonid Habitat - Extraordinary Primary Contact Recreation	
Temperature*	Highest 7-DADMAX (7 day average of the daily maximum temperatures) 16.0º C
Bacteria	Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value > 100 colonies/100 mL.

*Supplemental spawning/incubation criteria are 13°C from Feb. 15 to July 1 for the following reaches:

North River upstream of Fall River, Fall River, and the lower reaches of Raimie, Redfield, Sullivan Martin, Pioneer, Salmon and Lower Salmon Creeks (Figure 2)

Temperature

Many types of fish species rely on the watershed for spawning, rearing, migration, and residence. Anadromous fish of the watershed include; chinook, coho, chum, and trout (Herger, 1997). Temperature and supplemental spawning criteria have been established in order to protect aquatic life uses within the watershed.

Temperature affects the physiology and behavior of fish and other aquatic life. Temperature may be the most influential factor limiting the distribution and health of aquatic life and can be greatly influenced by human activities.

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, the criteria are expressed as the highest 7-day average of the daily maximum temperatures (7-DADMax) occurring in a waterbody.

In the water quality standards, aquatic life use categories are described using key species (salmon versus warm water species) and life-stage conditions (spawning versus rearing) [WAC 173-201A-200; 2011 edition].

1. 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.
2. To protect the designated aquatic life uses of "Salmonid Spawning, Rearing, and Migration, and Salmonid Rearing and Migration Only" the highest 7-DADMax temperature must not exceed 17.5°C (63.5°F) more than once every ten years on average.

Washington State uses the criteria described above and in Table 2 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 state provides an allowance for additional warming due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.3°C (0.54°F) increase above the naturally higher (inferior) temperature condition.

In addition to the maximum criteria noted above, compliance must also be assessed against criteria that limit the incremental amount of warming of otherwise cool waters due to human activities. When water is cooler than the criteria noted above, the allowable rate of warming up to, but not exceeding, the numeric criteria from human actions is restricted to:

1. Incremental temperature increases resulting from individual point source activities must not, at any time, exceed 28/T+7 as measured at the edge of a mixing zone boundary (where "T" represents the background temperature as measured at a point or points unaffected by the discharge).
2. Incremental temperature increases resulting from the combined effect of all nonpoint source activities in the waterbody must not at any time exceed 2.8°C (5.04°F).

FC Bacteria

In summary (Table 2), the applicable FC water quality criteria for lower North River and the adjacent marine waters of northern Willapa Bay are as follows:

- Freshwater FC criteria
  - geometric mean < 100 colonies/100mL
  - not more than 10% of all samples > 200 colonies/100mL
- Marine FC criteria
  - geometric mean < 14 colonies/100mL
  - not more than 10% of all samples > 43 colonies/100mL

The Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code (WAC), include designated beneficial uses, waterbody classifications, and numeric and narrative water quality criteria for surface waters of the state (WAC 173-201A, 2011).

The FC criteria have two statistical components: a geometric mean criterion and an upper limit criterion that 10% of the samples cannot exceed. FC samples collected randomly usually follow a log-normal distribution, which will be taken into account in final data analysis.

Freshwater and marine waterbodies are required to meet water quality standards based on beneficial uses. Numeric criteria for specific water quality parameters are intended to protect designated uses. The North River and the nearby brackish estuaries of northern Willapa Bay are classified as *Primary Contact* waters. Potential sources of FC pollution in these areas include but are not limited to: stormwater, failing onsite septic systems, livestock, and wildlife (the latter is considered part of "natural background levels").

The application of freshwater and marine water quality criteria is based on salinity as described in the WAC 173-201A-260:

"*(e) In brackish waters of estuaries, where different criteria for the same use occurs for fresh and marine waters, the decision to use the fresh water or the marine water criteria must be selected and applied on the basis of vertically averaged daily maximum salinity, referred to below as "salinity."*

(i) The fresh water criteria must be applied at any point where ninety-five percent of the salinity values are less than or equal to one part per thousand, except that the fresh water criteria for bacteria applies when the salinity is less than ten parts per thousand; and

(ii) The marine water criteria must apply at all other locations where the salinity values are greater than one part per thousand, except that the marine criteria for bacteria applies when the salinity is ten parts per thousand or greater".

Freshwater criteria for bacteria apply when 95% of salinity values are less than ten parts per thousand (ppt). Marine water criteria apply when salinity is 10 ppt or greater. Similarly, if water quality data show a 95th percentile conductivity of 17,700 micro-ohms (equivalent to salinity greater than 10 ppt), then marine water criteria apply (Swanson, 2008).

For those areas where there is true ambiguity about whether there is marine influence, then the WAC 173-201A-260(c) and -260(d) apply:

"*C. Where multiple criteria for the same water quality parameter are assigned to a waterbody to protect different uses, the most stringent criterion for each parameter is to be applied.*

D. At the boundary between waterbodies protected for different uses, the more stringent criteria apply."

Freshwater Criteria

FC criteria are set to protect people who work and play in and on the water from waterborne illnesses. FC are used as an "indicator bacteria" for the state's freshwaters by assuming that the presence of FC in water indicates the presence of waste from humans or other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. The FC criteria are set at levels that have been shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

The *Primary Contact* use is intended for waters "where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and waterskiing" (WAC 173-201A, 2011). The use is to be designated to any waters where human exposure is likely to include exposure of the eyes, ears, nose, and throat. Since children are also the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection. To protect this use category *"Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200/colonies mL*" (WAC 173-201A, 2011).

Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than ten total samples) limit. These two measures used in combination ensure that bacterial pollution in a waterbody will be maintained at levels that will not cause a greater risk to human health than considered acceptable. While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both monthly (if five or more samples exist) and seasonal (dry season versus wet season) data sets.

The criteria for fecal coliform are based on allowing no more than the pre-determined risk of illness to humans that work or recreate in a waterbody. The criteria used in the state standards are designed to allow seven or fewer illnesses out of every 1,000 people engaged in primary contact activities. Once the concentration of fecal coliform in the water reaches the numeric criterion, human activities that would increase the concentration above the criteria are not allowed. If the criterion is exceeded, the state will require that human activities be conducted in a manner that will bring fecal coliform concentrations back into compliance with the standard.

If natural levels of FC (from wildlife) cause criteria to be exceeded, the standards do not allow human sources to measurably increase bacterial pollution further. Warm-blooded animals,

particularly those managed by humans and thus exposed to human-derived pathogens, are a common source of serious waterborne pathogens for humans.

Marine Water Criteria

In marine (salt) waters, bacteria criteria are set to protect shellfish consumption and people who work and play in and on the water. "[Molluscan shellfish also have a long history as vectors of infectious and sometimes dangerous diseases ranging from typhoid fever and hepatitis to diarrhea and minor intestinal disorders (Rippey, 1994). These agents often originate in discharges of human sewage and indigenous marine bacterial pathogens. The unique biology of shellfish and the way we consume them contribute to our vulnerability to shellfish-borne disease. Shellfish are sedentary filter feeders, pumping large amounts of water through their bodies. This process can concentrate microbial pathogens in their tissues, causing little or no harm to the animal, but posing substantial risks for human consumers, particularly because shellfish are often eaten raw or partially cooked]" (NOAA, 1998). In waters protected for both *Primary Contact Recreation* and *Shellfish Harvesting*, FC bacteria are used as indicator bacteria to gauge the risk of exposure to waterborne pathogens.

To protect *Shellfish Harvesting* and *Primary Contact Recreation* (swimming or water play): "*Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies/100mL*" (WAC 173-201A, 2011).

The *Shellfish Harvesting* and *Primary Contact Recreation* criteria are consistent with National Shellfish Sanitation Program (NSSP) rules. Marine water FC concentrations that meet shellfish protection requirements also meet the federal recommendations for protecting people who engage in primary water contact activities. Thus, the same criteria are used to protect both *Shellfish Harvesting* and *Primary Contact* uses in Washington State standards.

Study Area

The North River generally flows east to west for 60.2 river miles (RM) and empties into the northern region of Willapa Bay (Figure 1). Tidal influence occurs up to RM 7.4 (Phinney and Bucknell, 1975). The watershed area is 252 square miles with a maximum elevation of approximately 1,880 ft. Land use in the watershed predominantly includes industrial timber management/harvest with occasional low-density residential areas (Figure 2).

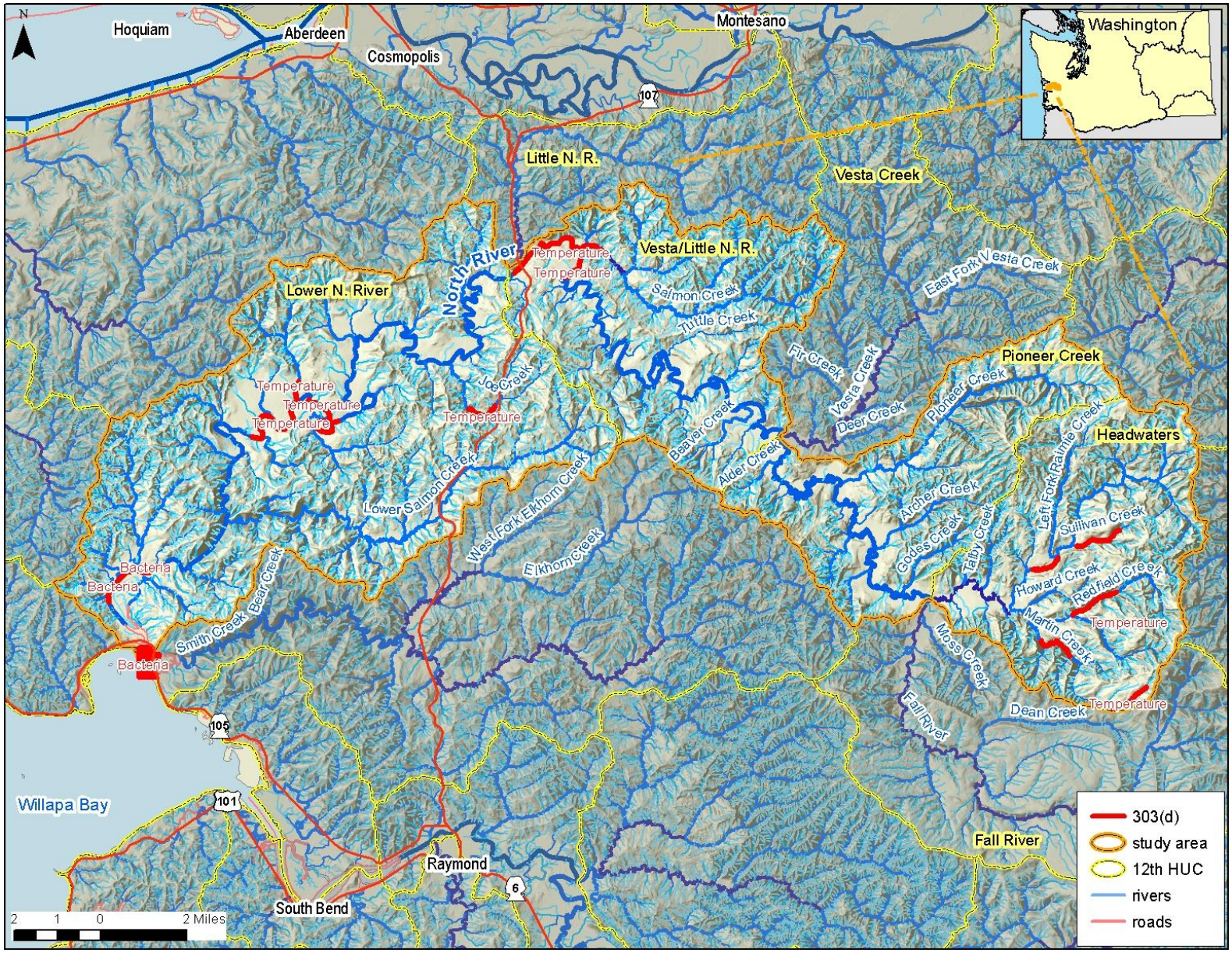

Figure 1. North River study area for 303(d) listed temperature and bacteria.

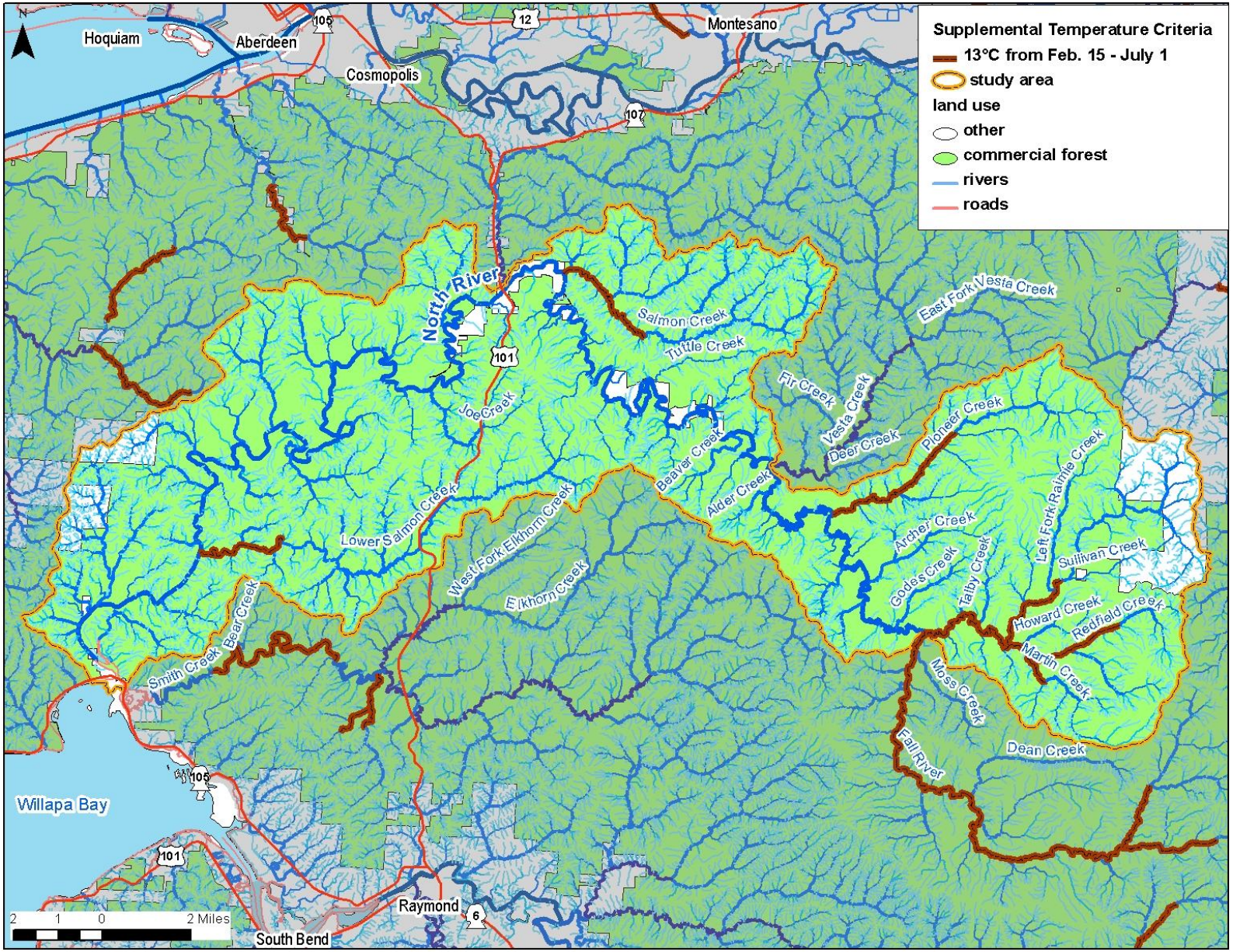

Figure 2. North River supplemental spawning/incubation criteria and land use.

Two reaches that exceed water quality criteria (303(d)) for FC bacteria are located at the mouth of the North River (Table 1 and Figure 1). The remaining indicated reaches that exceed water quality criteria are for temperature.

The third FC bacteria 303(d) listing depicted in Figure 1 is in Willapa Bay at the mouth of Smith Creek. This FC bacteria listing will not be addressed here since it is beyond the scope of this study. Furthermore, the Washington State Department of Health, Office of Shellfish and Water Protection currently samples for FC bacteria in Willapa Bay near the mouth of North River and Smith Creek as part of the NSSP.

The proposed study area comprises the sub-basins (12^{th} HUC) that contain 303(d) listed stream reaches (Figure 1). These sub-basins are: (1) Lower North River, (2) Vesta/Little North River, (3) Pioneer Creek, and (4) the Headwaters. Sub-basins of the North River watershed that do not have known water quality impairments are not included in the study area outlined in Figure 1. Sub-basins not included in the study area are: (1) Little North River, (2) Vesta Creek, and (3) Fall River.

Climate

The North River watershed has a temperate climate with mild wet winters and relatively warmer summers. The majority of precipitation falls from October through April with the remaining months experiencing relatively less precipitation. Western Regional Climate Center data show the basin averages 86.05 inches of precipitation near its mouth in Raymond and 83.09 inches of precipitation slightly downstream of its headwaters in Brooklyn. Meta data for these discontinued meteorological stations are as follows:

Raymond, WA

- Station Name and ID: WILLAPA HARBOR, WASHINGTON (459291)
- Period of Record: 6/1/1948 to 12/31/1979
- Approximate elevation: 10 ft

Brooklyn, WA

- BROOKLYN, WASHINGTON (450917)
- Period of Record : 12/1/1927 to 3/31/1974
- Approximate elevation: 190 ft

Glaciers and snowfields are not present in the basin; therefore, stream discharge is primarily dependent on precipitation and groundwater inputs, with little snowmelt runoff (Smith, 1999).

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

The North River watershed is in WRIA 24 Willapa and HUC number 17100106 (Willapa Bay).

Project Description

Project Goal

The goal of the North River verification study is to determine whether the existing 303(d) listed stream segments meet Washington State surface water quality criteria.

The purpose of the study is to verify temperature and FC conditions since the collection of initial data that led to 303(d) listing. Since initial data collection, action has been taken to reduce water quality impairments including:

- Discontinuation of two significant livestock operations, and halted discharge of septage from houseboats near the mouth of North River (Rountry, 2013).
- Implementation of efforts to restore and maintain natural thermal conditions by the Department of Natural Resources (DNR) Forest Practice Rules (Title 222 WAC). The Forest Practices Rules establish standards for forest practices such as timber harvest, pre-commercial thinning, road construction, fertilization, and forest chemical application (DNR, 2013). This implementation occurs throughout most of the watershed.

Project Objectives

Project objectives are developed in order to achieve project goals. The objectives of this project are as follows:

- Collect FC samples at 303(d) listed segments and compare these data to water quality criteria.
- Collect time-series temperature data at 303(d) listed segments and compare these data to water quality criteria.

To meet its objectives, this project will rely on data collected by Ecology staff during the 2014 - 2015 study period. Data collected by other organizations during this time may also be used. FC and temperature will be monitored at the associated 303(d) listed segments (Figure 1 and Table 1) in the North River watershed for each given parameter. Collected data will be compiled, analyzed, and presented in the final technical report.

Organization and Schedule

Table 3 lists the people involved in this project. All are employees of the Washington State Department of Ecology. Table 4 presents the proposed schedule for this project.

Table 3. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
David Rountry Water Quality Program Southwest Regional Office Phone: 360-407-6276	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP.
James Kardouni Directed Studies Unit Western Operations Section Phone: 360-407-6517	Project Manager / Principal Investigator	Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the draft report and final report.
George Onwumere Directed Studies Unit Western Operations Section Phone: 360-407-6730	Unit Supervisor for the Project Manager	Reviews the project scope and budget, tracks progress, provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Robert F. Cusimano Western Operations Section Phone: 360-407-6596	Section Manager for the Project Manager	Reviews the draft QAPP and approves the final QAPP.
Andrew Kolosseus Southwest Regional Office Phone: 360-407-7543	Unit Supervisor for the Study Area	Reviews the draft QAPP and approves the final QAPP.
Rich Doenges Southwest Region Section Phone: 360-407-6271	Section Manager for the Study Area	Reviews the draft QAPP and approves the final QAPP.
Joel Bird Manchester Environmental Laboratory Phone: 360-871-8801	Director	Approves the final QAPP.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

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

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	April 2015*	James Kardouni
Laboratory analyses completed	May 2015	
Environmental Information System (EIM) database		
EIM Study ID	JKAR0005	
Product	Due date	Lead staff
EIM data loaded	August 2015	James Kardouni
EIM QA	September 2015	To be determined
EIM complete	October 2015	James Kardouni
Final report		
Author lead	James Kardouni	
Schedule		
Draft due to supervisor	August 2015	
Draft due to client/peer reviewer	September 2015	
Draft due to external reviewer(s)	October 2015	
Final (all reviews done) due to publications coordinator	November 2015	
Final report due on web	December 2015	

* Additional time-series temperature data may be collected during the summer of 2015 in order to verify Category 1 conditions as needed

Quality Objectives

To meet the objectives of this study, all field sampling and lab analysis will follow strict protocols outlined in this QA Project Plan. This will ensure data credibility and usability, in compliance with the Water Quality Data Act (RCW 90.48.570-590) and Water Quality Program-Environmental Assessment Program Policy 1-11, Chapter 2: "Ensuring Credible Data for Water Quality Management" (Ecology, 2012). Valid data collected for this project will accurately represent the water quality of the targeted 303(d) listed stream reaches spatially and temporally.

Quality objectives are statements of the precision, bias, and lower reporting limits necessary to address project objectives. Precision and bias together express data accuracy. Other data quality indicators include representativeness and completeness. Quality objectives apply to laboratory and field data collected for this study.

This study is designed to fulfill representativeness and completeness data quality objectives. These quality objectives should be achieved through features of the proposed sampling design, such as selecting appropriate monitoring locations and collecting field data with specific timing and duration.

Representativeness, for example, involves collecting FC samples over the course of one year in order to sufficiently characterize contaminant concentrations annually and temporally. At least ten FC samples will be collected with five samples per climatic regime (wet/dry season). Based on meteorological data collected within the watershed from the Western Regional Climate Center, the wet season will span October through April and the dry season will span May through September. Stream temperatures will be monitored during the warmer months of the year in order to sufficiently characterize the highest potential thermal signal (the thermal critical period, June through September). Stream temperature will also be monitored during the supplemental spawning period (February 15 through July 1) along pertinent waterways including Salmon, Raimie, Redfield, and Martin Creeks.

Completeness is the measure of the necessary amount of valid data from a measurement system. Completeness for this project involves collecting sufficient valid data to adequately characterize true water quality conditions. As a result, completeness ties into the representativeness of this study design. For example, sampling the thermal critical period and FC annually/seasonally will represent true water quality, given the collection of sufficient valid data.

Measurement quality objectives (MQO) state the acceptable accuracy for the data collected for a project. MQOs, sampling methods, protocols, and data analysis are discussed in following sections.

Sampling Process Design (Experimental Design)

Field investigations throughout the North River watershed is designed to address 303(d) listed segments (Figure 1 and Table 1). Temperature data collection will occur during the relatively warmer months of the year (June through September) in order to assess the system's maximum thermal potential for the given sampling year. Temperature data collection will also target pertinent creeks with supplemental spawning criteria from February 15 through July 1. FC data collection will span one year in order to characterize the mouth of the North River and compare seasonal variability. FC data collection will begin April 2014 and end April 2015. Ecology's Water Quality Program Policy 1-11 (Ecology, 2012) requirements will be fulfilled by collecting sufficient data and comparing the results to the water quality criteria.

One purpose of Policy 1-11 is to determine the status of water quality in Washington State based on the review of available monitoring data for compliance with water quality standards (Chapter 173-201A WAC).

Table 5 and Figure 3 show the proposed sampling locations for this study. Access permission from land owners will be necessary in order to establish some of the proposed sampling locations.

Table 5. Proposed sampling locations and parameters in the North River watershed.

Site Name	Parameter	Site Description	Latitude	Longitude
E.F. North River	temperature	East Fork North River upstream of North R	46.83624	-123.81915
Joe Creek	temperature	Joe Creek at Hwy 101	46.83817	-123.71974
Martin Creek	temperature	Martin Creek upstream of Redfield Ck	46.76364	-123.44137
Martin Creek	temperature	Martin Creek near headwaters	46.74356	-123.40687
North River	bacteria	North River near mouth	46.76375	-123.90670
North River	bacteria	North River upstream of mouth	46.77505	-123.88850
North River	temperature	North River at Hwy 101	46.88387	-123.71138
North River	temperature	North River upstream of Salmon Ck	46.88457	-123.68284
North River	temperature	North River downstream of E.F. North R	46.82821	-123.82106
North River	temperature	North River upstream of E.F. North R	46.83593	-123.81311
Raimie Creek	temperature	Raimie Creek upstream of North R	46.79168	-123.44196
Redfield Creek	temperature	Redfield Creek upstream of North R	46.77506	-123.42829
Salmon Creek	temperature	Salmon Creek at mouth	46.89060	-123.68248
Sullivan Creek	temperature	Sullivan Creek upstream of Raimie Ck	46.80241	-123.41266
Unnamed Tributary	temperature	Unnamed tributary to North R	46.83029	-123.80352

Latitude and longitude datum: NAD 83 HARN

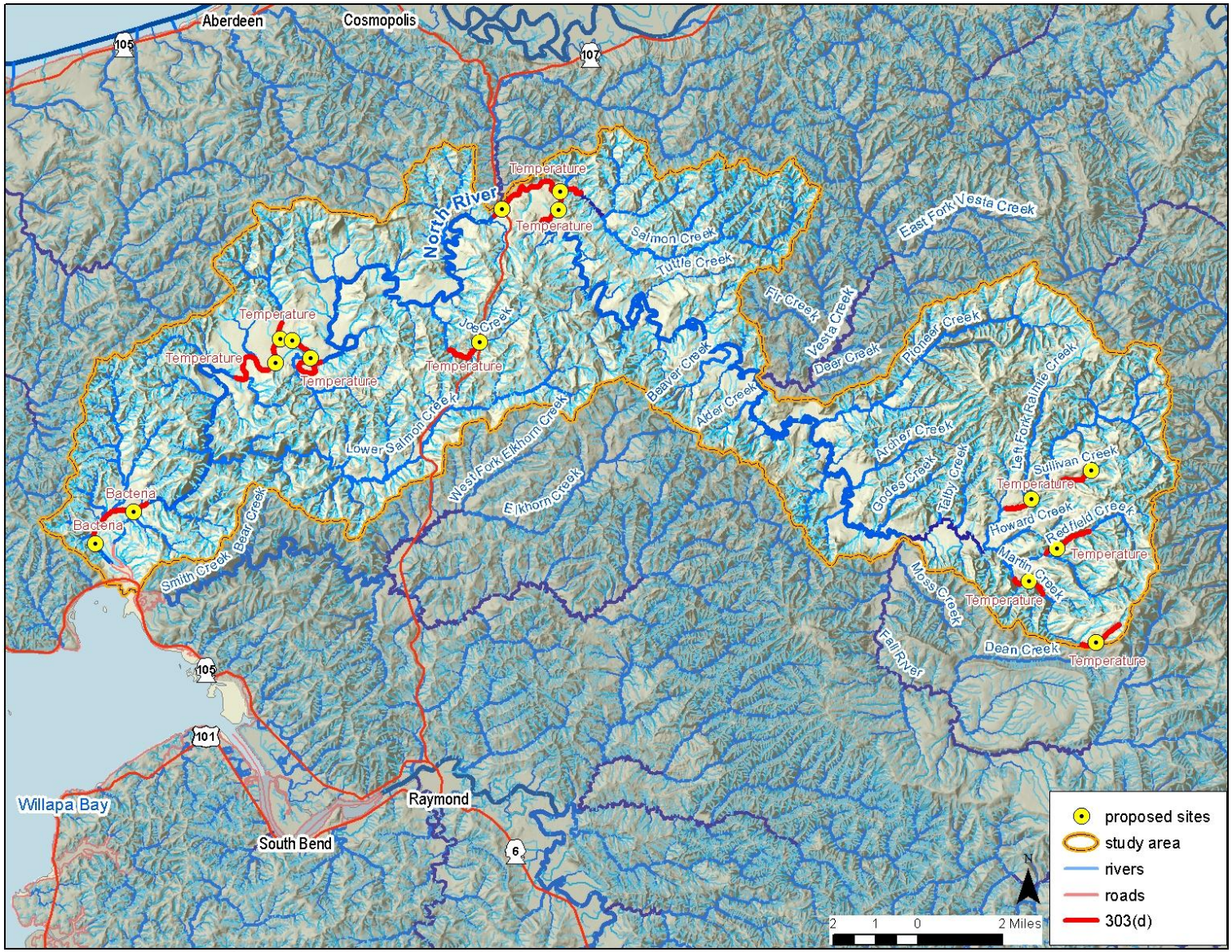

Figure 3. Proposed sampling location in the North River watershed.

Sampling Procedures

Field investigations will follow applicable methods described in the Standard Operating Procedures (SOPs) developed by Ecology's Environmental Assessment Program (EAP) including:

- EAP080 Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams (Ward, 2011)
- EAP030 Standard Operating Procedures for the Collection of Fecal Coliform Bacteria Samples in Surface water (Ward and Mathieu, 2011)
- EAP023 Standard Operating Procedures for the Collection and Analysis of Dissolved Oxygen (Winkler Method) (Ward and Mathieu, 2013)
- EAP033 Hydrolab DataSonde and MiniSonde Multiprobes (Swanson, 2010)
- EAP070 Standard Operating Procedures to Minimize the Spread of Invasive Species (Parsons et al., 2012)
- EAP075 Standard Operating Procedure for Measuring Vertically Averaged Salinity in Brackish Waters (Mathieu, 2013)

SOP documents may be found at the following web address: www.ecy.wa.gov/programs/eap/quality.html.

Fecal Coliform Sampling

FC sampling will commence April 2014 and end April 2015. Sampling will occur approximately once every two weeks, generating a total of 24 sampling events per site. FC sampling will take place at the two 303(d) listed segments of the North River (Figure 3 and Table 5). Water quality parameters such as dissolved oxygen (DO), temperature, pH, conductivity, and salinity will be measured using a multiprobe at the time of FC sampling.

FC samples will be collected from the stream thalweg (center of flow) whenever possible. Since the North River is too deep to wade at the proposed sampling locations, the use of a sample arm may be necessary in order to reach the thalweg or other well-mixed portions of the river. Samples taken will be collected at approximately six inches below the surface of the water, with the sampler standing downstream from the collection point. Samplers will try to avoid stirring up sediment in streams with slow current velocities or shallow channels.

Under high tide conditions of Willapa Bay, the North River may be tidally influenced up to RM 7.4 (Phinney and Bucknell, 1975). The proposed sampling locations are a few river miles upstream of the marine water and are therefore influenced by high tides. We may collect a marine water sample near the high tide.

Vertical salinity profiles will be conducted to determine whether freshwater or marine water conditions were present at the time of FC sampling. Such salinity profile assessments will be conducted by standing near the river's shoreline at the established FC sampling point of access.

Additional salinity surveys may be conducted following EAP075 *Standard Operating Procedure for Measuring Vertically Averaged Salinity in Brackish Waters* (Mathieu, 2013) to determine whether freshwater or marine water criteria apply at the sampling locations. Tide charts provided by the National Oceanic and Atmospheric Association (NOAA) will be reviewed to plan the salinity profile sampling schedules.

Temperature Measurements

Temperature data-loggers (thermistors) will be deployed at approximately 13 locations to monitor and verify thermal conditions at the 303(d) listed segments (Figure 3 and Table 5). The thermistors will be deployed during May and recovered during late September, depending on supplemental spawning criteria and data results. Temperature monitoring will target the thermal critical period (highest temperatures) the watershed may experience during the relatively warmer months of the year. Temperature monitoring will also target the seasonal supplemental spawning criteria (February 15 through July 1) along Salmon, Raimie, Redfield, and Martin Creeks.

If necessary, an additional year of temperature data will be collected starting 2015 to verify sites that met water quality/supplemental spawning criteria in 2014 and 2015. Therefore, the conditions under Policy 1-11 (Ecology, 2012) will be satisfied when determining a Category 1 designation. Category 1 is defined as meeting Washington State water quality criteria with the following evaluation protocols:

"*Continuous monitoring for temperature during the critical season is required to place a waterbody segment in Category 1. Sequential data from at least two years must demonstrate consistent compliance with the numeric criteria or established natural conditions. Single sample event (grab sample) data are not used to place a waterbody segment in Category 1.*"

Each site will have up to two thermistors; one to measure water temperature and another to measure air temperature. The air thermistor serves as a quality assurance (QA) check if the water thermistor becomes dry (out of water). The thermistors will measure and record temperature at 30-minute intervals. Stream thermistors will be deployed in the thalweg of a stream such that they are suspended off the stream bottom and in a well-mixed portion of the stream, typically in riffles or glides.

The thermistor will be carefully concealed to reduce the risk of theft or vandalism. Temperature monitoring stations will be checked monthly to conduct field measurements/observations and to clear accumulated debris away from the instruments. Documentation of the temperature monitoring stations will include:

- GPS coordinates and a sketch of the site, typically conducted during instrument installation
- Depth of the stream thermistor under the water surface and height off the stream bottom
- Stream temperature

- Serial number of each instrument and the action taken with the instrument (e.g., downloaded data, replaced thermistor, or noted movement of the thermistor location to keep it submerged in the stream)
- The date and time before the data-loggers are installed, downloaded, or returned to their logging location

All timepieces and PC clocks will be synchronized to the atomic clock using Pacific Daylight Savings Time. Pacific Standard Time will be reported if instruments are still in place during the time change.

Quality Control Procedures

Total variability for field sampling and laboratory analysis will be assessed by collecting replicate samples. The use of replicate samples provides a type of quality assurance/quality control (QA/QC). Sample precision will be assessed by collecting replicates for at least 50% of samples in each survey. MEL routinely duplicates sample analyses in the laboratory to determine laboratory precision. The difference between field variability and laboratory variability is an estimate of the sample field variability.

Field

The thermistors will be checked for proper function as part of QA/QC. The Onset Hobo Water Temp Pro v2© instruments will have a calibration check both pre- and post-study. This check will be to document instrument bias or performance at representative temperatures. A NIST-certified reference thermometer will be used for the calibration check. The calibration check may show that the thermistor differs from the NIST-certified thermometer by more than the manufacturer-stated accuracy of the instrument (range greater than ±0.21°C).

A thermistor that fails pre-study calibration check will not be used. If the temperature thermistor fails the post-study calibration check, then the actual measured value will be reported along with its degree of accuracy based on the calibration check results. As a result, these data may be rejected or adjusted and qualified.

Variation for field sampling of stream temperatures and potential thermal stratification will be addressed with a field check of stream temperature at all monitoring sites upon thermistor deployment and during instrument retrieval. Additional stream temperature variation checks will be conducted during site visits after initial instrument deployment. Post-processing air temperature and stream temperature data for each site will be compared to determine if the stream thermistor was exposed to the air due to stream stage falling below the installed depth of the stream thermistor.

At each FC sampling site, the *Hydrolab*® DO probe will be checked against Winkler samples (SM4500OC) for QA/QC as described in Ecology's SOP manual (Ward and Mathieu, 2013). The results from the titrations and *Hydrolab*® data will be compared using RSD. RSD values greater than 10% will be assigned a data qualifier fulfilling the precision MQOs for DO. Bias will be evaluated between *Hydrolab*® readings and Winkler titrations by calculating the average residual. *Hydrolab*® DO data will be corrected if significant bias is found.

Table 6 presents the specifications of the field instruments that will be used for this study.

Table 6. Field instrument specifications.

Analysis	Instrument	Method	Range	Accuracy	Resolution
Continuous temperature	Hobo Water Temperature Pro v2	EAP044	-40° to 50°C	± 0.21°C	0.01°C
Instantaneous temperature	Hydrolab Sonde®	SM2550B-F	-5C° to 50°C	± 0.10°C	0.01°C
Specific conductivity	Hydrolab Sonde®	EPA120.1M	1 to 100,000 uS/cm	± (0.5% of reading + 1 uS/cm)	0.1 to 1 uS/cm
Dissolved oxygen	Hydrolab Sonde®	Hach 10360	1 to 60 mg/L	± 0.1 mg/L at ≤ 8 mg/L, ± 0.2 mg/L at > 8 mg/L	0.01 mg/L
pH	Hydrolab Sonde®	EPA150.1M	0 to 14 pH units	± 0.2 units	0.01 units

Laboratory

FC grab samples will be collected directly into pre-cleaned containers supplied by the Manchester Environmental Laboratory (MEL) and described in the MEL *Lab Users Manual* (2008). FC samples for laboratory analysis will be stored on ice and delivered to MEL within 24 hours of collection. Approximately 50% of FC samples will be field duplicates used to assess total (field and lab) variability. Specifications for sample containers, preservations, and holding times are presented in Table 7.

Table 7. Containers, preservation requirements, and holding times for samples collected.

Parameter	Sample matrix	Container	Preservative	Holding time
Fecal Coliform (FC)	Surface water and runoff	250 or 500 mL glass/poly autoclaved	Cool to 4ºC	24 hours
Dissolved Oxygen (DO)	Surface water and runoff	300 mL BOD1 bottle & stopper	2 mL manganous sulfate reagent + 2 mL alkaline-azide reagent	4 days

During each FC site visit, single DO samples will be measured using a *Hydrolab DataSonde®* (Table 6). DO grab samples will be collected using BOD bottles at each FC sampling location for field instrument QA/QC (Table 7). The QA/QC grab samples will be analyzed for DO concentrations using the Winkler method. DO titrations will be conducted at Ecology's wet-lab.

Measurement Quality Objectives

All laboratory measurements will follow the MEL *Lab Users Manual* (2008). Laboratory measurement/analysis procedures are based on "Standard Methods" (APHA et al., 1999). Measurement quality objectives (MQOs) state the level of acceptable error in the measurement process. Precision is a measure of the variability in the results of replicate measurements due to random error (Lombard and Kirchmer, 2004). This random error includes error inherently associated with field sampling and laboratory analysis. Field and laboratory errors are minimized by adhering to strict protocols for sampling and analysis.

Microbiological and analytical methods, expected precision of sample replicates, and method reporting limits and resolution are given in Table 8. The field replicate MQO is expressed as relative standard deviation (RSD) and the laboratory duplicate MQO is expressed as relative percent difference (RPD).

Table 8. Field and laboratory precision measurement quality objectives (MQO) for laboratory samples.

Analysis	Method	Field replicate MQO (RSD)	Lab duplicate MQO (RPD)	Reporting limit
Fecal Coliform (FC) MF	SM 9222D	50% of replicate pairs < 20% RSD 90% of replicate pairs < 50% RSD	40%	1 cfu/100 mL
Dissolved Oxygen (DO)	SM 4500OC	10%	NA	0.1 mg/L

MF = membrane filter, RSD = relative standard deviation, RPD = relative percent difference
SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA et al., 1999)

The targets for analytical precision of laboratory analyses are based on historical performance by MEL for environmental samples taken around the state by Ecology's 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. The laboratory's measurement quality objectives and quality control procedures are documented in the MEL *Lab Users Manual* (MEL, 2008).

Bacteria samples tend to have a higher relative RSD between replicates compared to other water quality parameters. Bacteria sample precision will be assessed by collecting replicates for approximately 50% of samples in each survey. However, the majority of FC sampling conducted by Ecology uses a minimum of 20% total samples having field replicate pairs. Since only two FC sampling locations will be established for this study it is not possible to collect replicate pairs for 20% of the sampling locations each day. Therefore, there will be one replicate per sampling event, establishing 50% of total samples having replicate pairs.

Standard Methods (APHA et al., 1999) recommends a maximum holding time of eight hours for microbiological samples (six hours transit and two hours laboratory processing) for non-potable water tested for compliance purposes. MEL has a maximum holding time of 24 hours for microbiological samples (MEL, 2008). "Standard Methods" (APHA et al., 1999) recommends a holding time of less than 30 hours for drinking water samples and less than 24 hours for other types of water tested when compliance is not an issue. Microbiological samples analyzed beyond the 24-hour holding time are qualified as estimates denoted by a qualifier code. MEL accepts samples Monday through Friday, which means Ecology can sample Sunday through Thursday.

To identify any problems with holding times, two comparison studies were conducted during the Yakima Area Creeks TMDL (Mathieu, 2005). A total of 20 fecal coliform samples were collected in 500-mL bottles and each split into two 250-mL bottles. The samples were driven to MEL within 6 hours. One set of the split samples was analyzed upon delivery. The other set was stored overnight and analyzed the next day. Both sets were analyzed using the membrane filter (MF) method. Replicates were compared to the measurement procedures in Table 8.

The combined precision results between the different holding times yielded a mean RSD of 19%. This is comparable to the 23% mean RSD between field replicates for 12 EAP TMDL studies using the MF method, suggesting that a longer (that is, 24-hour) holding time has little effect on fecal coliform results processed by MEL. Samples with longer holding times did not show a significant tendency towards higher or lower fecal coliform counts compared to the samples analyzed within 6-8 hours.

Chain-of-custody forms and sample tags for each parameter will be prepared before each field study, adhering to MEL (2008) guidelines. Information on the sample tags includes: project name, sample identification number, site identification, date, time, and parameter. Samples will be collected in appropriate containers and delivered to the laboratory along with a chain-of-custody form. Date and time will be recorded on the sample tags at the time of field collection. Information on the sample tags will match with the information on the chain-of-custody form.

Laboratory Budget

Table 9 shows the estimated lab budget for this study based on 2 sampling sites plus one field replicate totaling three samples per survey. The lab budget also includes an additional 10% for unexpected costs. The lab budget is projected to cover expenses to the maximum extent necessary for this study.

Table 9. Estimated laboratory budget.

Parameter	Cost/ sample	Number of surveys	Total number of samples	Total cost
Fecal Coliform (FC)	24.93	24	72	$1,795
Additional samples (e.g., for unknown sources)				$179
			Total:	$1,974

[1]Sample costs include a 50% discount through MEL

Data Management Procedures

Field measurement data will be entered into a notebook of waterproof paper or a field computer and then carefully entered into EXCEL® spreadsheets. Data will be checked to ensure transfer accuracy. This database will be used for preliminary analyses and Quality Assurance/Quality Control (QA/QC). Data will be uploaded by the project manager into Ecology's Environmental Information Management (EIM) System after verification and validation.

Sample results received from MEL by Ecology's Laboratory Information Management System (LIMS) will be loaded into EIM, exported, and added to a cumulative spreadsheet for laboratory results. This spreadsheet will be used to informally review and analyze data during the course of the project.

An EIM user study code (JKAR0005) has been created for this TMDL study and all monitoring data will be available via the internet. The web address for this geospatial database is: www.ecy.wa.gov/eim/. All finalized data will be uploaded to EIM by the EIM data engineer.

All spreadsheet files, photos, paper field notes, and Geographic Information System (GIS) products created as part of the data analysis will be kept with the project data files. Data that do not meet acceptability requirements will be separated from data files and not used for analysis.

Audits and Reports

The project manager is responsible for verifying data completeness before use in the technical report and entry into the EIM. The project manager is also responsible for writing and submitting the final technical report to the Water Quality Program watershed lead. The final technical report will undergo the peer review process by staff with appropriate expertise.

The final report will include analyses of results that form the basis of conclusions and recommendations. Results will include site-specific information for FC, temperature, multi-probe results, QA results, and seasonal summaries.

Data Verification and Validation

Both data verification and validation require adequate documentation.

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL *Lab Users Manual* (MEL, 2008). Lab results will be checked for missing and improbable data. Variability in lab duplicates will be quantified using the procedures developed by MEL (MEL, 2012). Any estimated results will be qualified and their use restricted as appropriate. A standard case narrative of laboratory QA/QC results will be sent to the project manager for each set of samples.

Field notebooks will be checked for missing or improbable measurements before staff leave each site. The EXCEL® Workbook file containing field data will be labeled DRAFT until data verification and validation is complete. Data entry will be checked against the field notebook data for errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation. Valid data will be moved to a separate file labeled FINAL.

As soon as fecal coliform data are verified by MEL, the laboratory microbiologist will notify the project manager about results that exceed water quality criteria. The project manager will then notify the Southwest Regional Office client and Water Quality Program section manager of these elevated counts in accordance with EAP Policy 1-03. The TMDL coordinator will notify local authorities or permit managers as appropriate.

Data received from LIMS will be checked for omissions against the Request for Analysis forms by the project manager. Data can be in EXCEL® spreadsheets (Microsoft, 2007) or downloaded tables from EIM. These tables and spreadsheets will be located in a file labeled DRAFT until data verification and validation is completed. Field replicate sample results will be compared to MQOs in Table 8. Data requiring additional qualifiers will be reviewed by the project manager.

Data for stream temperature monitoring stations will be verified against the corresponding air temperature station to ensure the stream temperature record represents water temperatures and not temperatures recorded during a time the stream thermistor was dewatered. Measurement accuracy of individual thermistors is verified using a NIST-certified reference thermometer and

field measurements of stream temperature at each thermistor location several times during the study period.

Data validation is the next step following verification. Data validation involves a detailed examination of the data package to determine whether the method quality objectives (MQOs) have been met. The project manager examines the complete data package to determine compliance with procedures outlined in the QA Project Plan and SOPs. The project manager is also responsible for data validation by comparing all data to MQOs for precision, bias, and sensitivity to assess data quality.

After data verification and data entry tasks are completed, all field, and laboratory data will be entered into final file and then into EIM. Ten percent of the project data in EIM will be independently reviewed by another EAP employee for errors. If significant entry errors are discovered, a more intensive review will be undertaken.

Data Quality (Usability) Assessment

The project manager will verify that all measurement and data quality objectives have been met for each monitoring station. If the objectives have not been met, consideration will be given to qualify the data, how to use it in analysis, or whether data should be rejected. Documentation of the data quality and decisions on data usability will provide accuracy and transparency of the QA/QC procedures. The data quality assessment methods and results will be documented in individual project data files and summarized in the final technical report.

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Appendix. Glossary, Acronyms, and Abbreviations

Glossary

Ambient: Background or away from point sources of contamination.

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.

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

Fecal coliform: That portion of the coliform group of bacteria that is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10- to 10,000-fold over a given period. The calculation is performed by either (1) taking the nth root of a product of n factors or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

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 neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

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

Reach: A specific portion or segment of a stream.

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

Salmonid: Fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

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.

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

303(d) list: Section 303(d) of the federal Clean Water Act requires 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 standard and are not expected to improve within the next two years.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10% of the data exists and below which 90% of the data exists.

Acronyms and Abbreviations

DO	Dissolved oxygen
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
FC	fecal coliform
GIS	Geographic Information System software
GPS	Global Positioning System
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
NOAA	National Oceanic and Atmospheric Association
NSSP	National Shellfish Sanitation Program
QA	Quality assurance
QC	Quality Control
RM	River mile
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
ft	feet
mL	milliliters
ppt	parts per thousand
uS/cm	microsiemens per centimeter, a unit of conductivity