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State of Washington

Quality Assurance Project Plan

Mid-Yakima River Tributaries Temperature Study

July 2013

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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 data from the study to the Internet.

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1303114.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 User Study ID, DDUG0002.

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Author and Contact Information

Dan Dugger
P.O. Box 47600
Environmental Assessment Program
Washington State Department of Ecology
Olympia, WA 98504-7710

For more information contact: Communications Consultant, phone 360-407-6834.

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Quality Assurance Project Plan

Mid-Yakima River Tributaries Temperature Study

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Approved by:

Signature: Date: July 2013

Laine Young, Client, TMDL Lead, Watershed Unit, Water Quality Program, Central Regional Office

Signature: Date: July 2013

Chris Coffin, Client's Unit Supervisor, Watershed Unit, Water Quality Program, Central Regional Office

Signature: Date: July 2013

Charlie McKinney, Client's Section Manager, Water Quality Program, Central Regional Office

Signature: Date: July 2013

Dan Dugger, Author / Project Manager / Principal Investigator / EIM Data Engineer, Environmental Assessment Program

Signature: Date: July 2013

Thomas L. Mackie, Author's Section Manager, Environmental Assessment Program

Signature: Date: July 2013

Bill Kammin, Ecology Quality Assurance Officer

Signatures are not available on the Internet version.
TMDL: Total Maximum Daily Load
EIM: Environmental Information Management database

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Abstract

Ecology will conduct an assessment of temperatures in three tributaries of the middle Yakima River: North Fork Cowiche Creek, Moxee Drain, and Wide Hollow Creek.

Temperature for these streams is considered to be impacted by agricultural and urban development. All three of the tributaries are located in heavily irrigated watersheds.

Temperature data loggers will be used to continuously monitor the temperature of the streams above and below key water inflows.

The study results will be used to help us better understand the seasonal and annual temperature changes and to also recognize any significant temperature events and sources that may affect aquatic life and other beneficial uses.

Background

Three streams that flow to the Naches and Yakima Rivers were included in this assessment:

- North Fork Cowiche Creek
- Moxee Drain
- Wide Hollow Creek

All contribute to the flows entering the Mid-Yakima River between river miles 106.9 (Union Gap) to 116.5 (Selah Gap). Wide Hollow Creek and Moxee Drain flow directly to the Yakima, while Cowiche Creek is tributary to the Naches River, which is tributary to the Mid-Yakima River.

All three streams have similar environmental impacts for temperature and land use distributions. Because similar analysis and regulatory approaches can be applied to all three streams, they are combined in this assessment.

The water quality characteristics of the streams, canals, and drains are influenced by the various uses of the water along with wastewater additions and runoff from adjacent land. The wastewater and runoff loads can add excessive temperature, bacteria, nutrients, oxygen-demanding substances, pesticides, and suspended sediment. Some reaches of these waterbodies have been monitored and have contaminant concentrations that do not meet state or federal water quality standards. These reaches have been included on the Washington State's 303(d) list.

Study Area

The Yakima urban area is located at the intersection of three Water Resource Inventory Areas (WRIAs) in Yakima County (Figure 1). The city of Yakima forms the urban center, with smaller nearby urban communities at Selah, Union Gap, Naches, Tieton, and Moxee City.

Moxee Drain and Wide Hollow Creek are in the Lower Yakima River Basin (WRIA 37), and Cowiche Creek is in the Naches River Basin (WRIA 38). The study area lies within parts of the Eastern Cascade Slopes and Foothills Ecoregion, and the Columbia Basin Ecoregion.

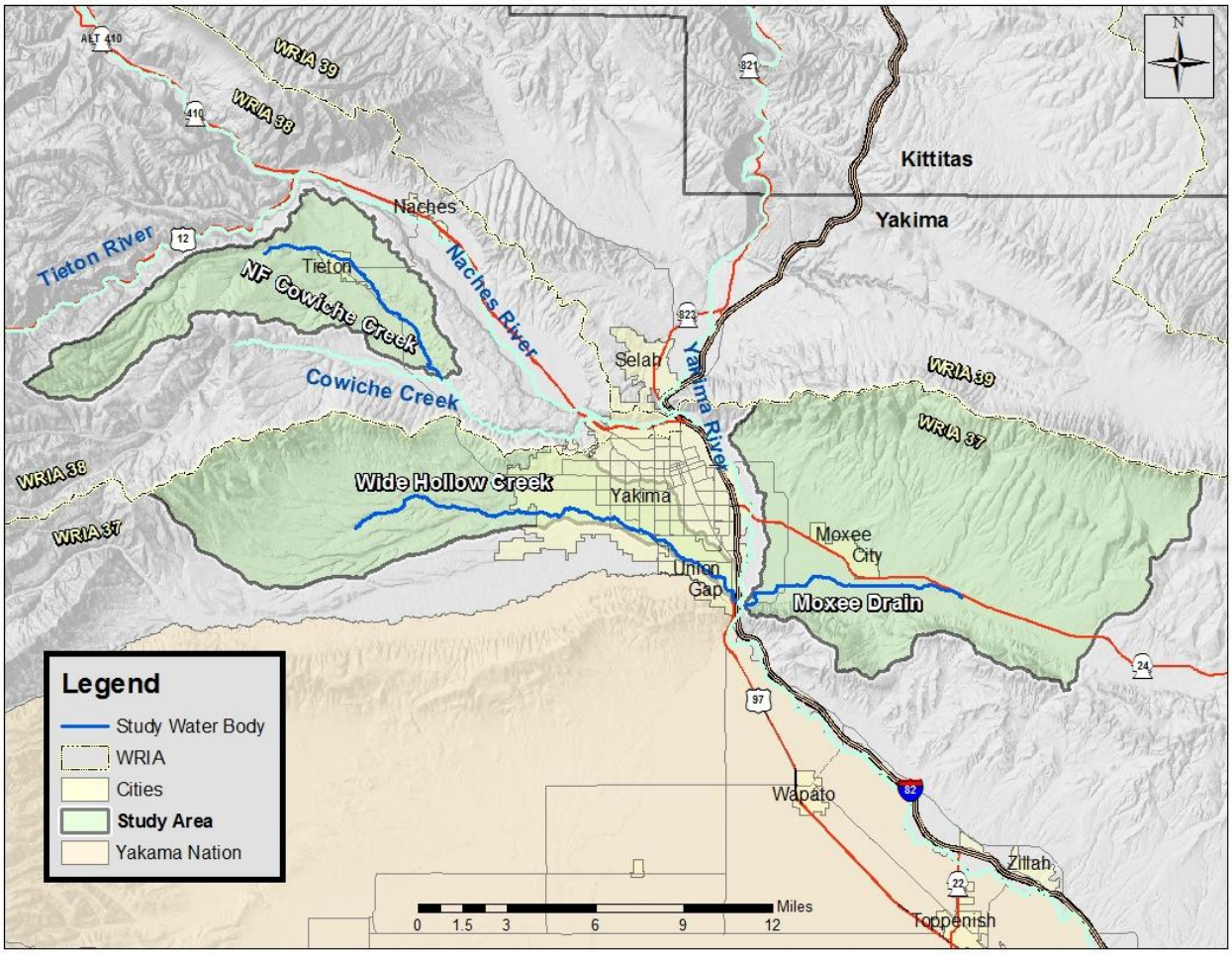

Figure 1. Study watersheds.

Annual precipitation ranges from 35 inches in the upper headwaters of the North Fork Cowiche and Wide Hollow Creeks to 5 inches in the arid lower reaches and Moxee Drain. Temperatures are cooler in the upper reaches of Cowiche and Wide Hollow than in the lower reaches. Winter snow is common and increases with elevation. All three have seasonal hydrologic characteristics and stream networks that are characteristic of agricultural irrigation or drainage operations, for example, high summer irrigation flows and low winter natural base flows.

All three streams flow through:

- Primarily privately owned land.
- One or more urbanized areas as defined by the U.S. Census Bureau (U.S. Census, 2010).
- Ceded lands of the Yakima Treaty of 1855 where usual and accustomed rights of the Yakama Indian Nation are retained.
- One or more irrigation and drainage districts.
- Areas where more than one public agency and industry have NPDES Phase II stormwater permit responsibilities.

These watersheds receive water from irrigation systems fed by the Naches, Tieton, and Yakima Rivers and from creeks emanating from the surrounding foothills. Depending on irrigation efficiency, a certain portion of irrigation water returns to streams by:

- Groundwater seepage
- Overland flow
- Stormwater runoff conveyances
- Discharges from industries holding permits
- Urban drains

The area has been growing rapidly in recent decades and has a unique checkerboard of industrial, urban, transportation, residential, orchard, irrigated agriculture, non-commercial farm, forest, and range land uses.

The population in Yakima County increased by 20,000 people between 2000 and 2010 (U.S. Census, 2013a; 2013b). The population increase has contributed to rapid conversions of farm, orchard, and range land into commercial, industrial, and residential areas. This trend is expected to continue.

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

Water Resource Inventory Areas (WRIAs):

- WRIA 37
- WRIA 38

Eight-digit Hydrologic Unit Code (HUC) numbers:

- 17030002
- 17030003

Water Quality Impairments

Monitoring conducted by Ecology, Confederated Tribes and Bands of the Yakama Nation (Yakama Nation), North Yakima Conservation District (NYCD), U.S. Bureau of Reclamation (USBR), and U.S. Geological Survey (USGS) led to the listing of 15 segments of the North Fork Cowiche Creek, Moxee Drain, and Wide Hollow Creek and their tributaries for temperature on the 303(d) list during the 2008 Water Quality Assessment. Table 1 presents 303(d) listings for temperature in these watersheds.

Within the Moxee Drain watershed, the Roza Canal and Selah-Moxee Canal are 303(d) Category 2 listed for temperature in some reaches that are distant from the Moxee Drain main channel. We will monitor the major effluents of these waterways as they enter Moxee Drain. However, to limit the scope of this project for available resources, we will not monitor listings away from the main channel.

Table 1. Study area temperature listings on the 2008 303(d).

Waterbody Name	Listing ID	Listing Category	NHD Reach Codes	Addressed by this Study
Cowiche Creek, North Fork	8321	5	• 17030002000409	☑
Cowiche Creek, North Fork	8324	5	• 17030002000411 • 17030002000412	☑
Moxee Drain	48208	5	• 17030003000800 • 17030003000799	☑
Moxee (Birchfield) Drain	16091	2	• 17030003000799 • 17030003000775	☑
Moxee (Birchfield) Drain	9614	2	• 17030003000804 • 17030003000822	☑
Moxee Drain	48209	5	• 17030003000822 • 17030003000845	☑
Roza Canal	13925	2	• 17030003003110	☐
Roza Canal	13926	2	• 17030003003105 • 17030003003106 • 17030003003110	☐
Selah-Moxee Canal	8304	2	• 17030003003091	☐
Selah-Moxee Canal Spillway	15023	2	• 17030003003100	☑
Wide Hollow Creek	8307	5	• 17030003000812	☑
Wide Hollow Creek	48211	5	• 17030003000812	☑
Wide Hollow Creek	16095	5	• 17030003000812	☑
Wide Hollow Creek	48213	5	• 17030003000812	☑

NHD: National Hydrography Dataset

Existing and Ongoing Studies

Previous and ongoing studies have analyzed water temperature in Moxee Drain, the North Fork of Cowiche Creek, and Wide Hollow Creek. This study's results may be used to inform both ongoing and future studies.

The North Fork of Cowiche Creek is part of the Upper Naches River and Cowiche Creek Temperature Total Maximum Daily Load. The study used site potential shade to set wasteload allocations, but did not model flow balance to develop temperature recommendations for the Cowiche system (Brock, 2008; Peterschmidt, 2010).

In the North Fork of Cowiche Creek, the Cowiche Regional Publicly-Owned Treatment Plant is the only potential source of temperature that is under an NPDES Permit by the Dept. of Ecology. Any other sources of temperature impacts are from sources that do not currently require a permit.

The Wenatchee National Forest Water Temperature TMDL Technical Report developed load allocations based on a channel classification system developed for surface waters within the Wenatchee National Forest. The study area includes the intermittently flowing headwaters of the North Fork of Cowiche Creek, above French Canyon Dam and Reservoir (Whiley and Cleland, 2003).

Water Quality Standards and Beneficial Uses

Designated and Beneficial Uses

Except for the WRIA 37 special temperature criteria, the study watersheds are surface waters of the state not named in the Washington Administrative Code Table 602 (WAC 173-201A-602) and are to be protected for the designated uses of:

- Salmonid spawning, rearing, and migration
- Primary contact recreation
- Water supply uses:
    - Domestic
    - Industrial
    - Agricultural
    - Stock
- Wildlife habitat
- Commerce and navigation
- Boating
- Aesthetic values

(WAC 173-201A-600)

Temperature Criteria

The highest annual running 7-day average of daily maximum temperatures (7-DADMax) for state waterways to be protected for salmonid spawning, rearing, and migration is 17.5ºC. (WAC 173-201A-200).

Related Temperature Criteria

Special and supplemental criteria were established for protection of salmonids in streams adjacent to the study waterways. None of the reaches in this study are subject to these guidelines[1]. These guidelines are included in this section to provide regional context.

1. For the mainstem Yakima River from mouth to Cle Elum River (river mile 185.6) except where specifically designated otherwise in Table 602 (WAC 173-201A-602):

   Water temperatures shall not exceed a one-day maximum temperature (1-DMax) of 21.0°C due to human activities. When natural conditions exceed a 1-DMax of 21.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9).

2. The Department of Ecology has also established supplemental protective guidelines for salmonid spawning and incubation protection (Payne, 2006). The South Fork and mainstem of Cowiche Creek have a 13°C (7-DADMax) supplemental temperature requirement from February 15 to June 15 of each year. Supplemental temperature requirements are implemented as temperature standards.

Project Description

Goals

This study's goals are to:

1. Collect diel temperature and flow data from stations on study waterways:
   a. North Fork of Cowiche Creek
   b. Moxee Drain
   c. Wide Hollow Creek
2. Provide these data to internal and external users in the online EIM database.

[1] Exception: the South Fork of Cowiche Creek sample site above the confluence with the North Fork of Cowiche Creek is subject to the 13°C (7-DADMax) supplemental temperature requirement from February 15 to June 15 of each year (Payne, 2006).

Objectives

This study's objectives are to:

1. Establish monitoring sites within the study waterways based on previous study results and the locations of major water sources and withdrawals.
2. Monitor established sites for continuous temperature and monthly flow.
    a. Five sites on Wide Hollow Creek will also be monitored for continuous flow as part of a Wide Hollow Creek water quality assessment.
3. Follow established protocols to ensure that representative stream temperatures and flow are obtained throughout the desired monitoring period (July – September) and to prevent equipment loss to vandalism or high streamflow.
4. 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.
5. Evaluate and publish:
    a. Seasonal maximums and maximum 7-day average of daily maximums in Ecology's EIM database.
    b. Continuous data in Ecology's current continuous data storage database.
    c. Wide Hollow Creek results in the report for the Wide Hollow Creek water quality assessment.

Practical Constraints and Logistical Problems

Although rare, logistical problems such as excessive precipitation during typically dry periods, scheduling conflicts, vehicle or equipment problems, or the limited availability of personnel or equipment may interfere with sampling.

Access to some sample sites depends on permission from property owners and managers. If access permission is not granted at potential sample sites, we will not sample at those locations.

When a site is inaccessible for any reason, we will attempt to collect data at suitable substitute locations where access permission is granted.

Any problems that interfere with data collection and quality will be noted and discussed in the EIM submittal or the final report for the concurrent Wide Hollow multi-parameter water quality study.

Organization and Schedule

Table 2 lists the people involved in this project. All are employees of the Washington State Department of Ecology. Table 3 presents the proposed schedule for this project.

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: TMDL Lead	Clarifies scopes of the project. Provides internal review of the QAPP and approves the final QAPP. May provide field support under supervision of project manager.
Dan Dugger Eastern Operations Section Phone: 509-454-4183	Project Manager/ Principal Investigator	Writes the QAPP. Oversees field sampling. Conducts QA review of data, analyzes and interprets data, and enters data into EIM.
Eiko Urmos-Berry Eastern Operations Section Phone: 509-575-2397	Field Assistant	Helps collect samples and records field information.
Tom Mackie Eastern Operations Section Phone: 509-454-4244	Unit and Section Manager for the Project Manager and Study Area.	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and 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
QA: Quality Assurance
QAPP: Quality Assurance Project Plan

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

Field and laboratory work	Due date	Lead staff
Field work completed	June 2014	Dan Dugger
Environmental Information System (EIM) database		
EIM user study ID	DDUG0002	
Product	Due date	Lead staff
EIM data loaded	October 2014	Dan Dugger
EIM quality assurance	November 2014	Eiko Urmos-Berry
EIM complete	December 2014	Dan Dugger

Quality Objectives

Measurement Quality Objectives

The accuracy and instrument bias measurement quality objectives (MQOs) for each temperature logger are 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) and in the Timber, Fish, and Wildlife Agreement (TFW) Stream Temperature Survey Manual (Schuett-Hames et al., 1999). The procedures require that 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 to the NIST-certified thermometer, is equal to or greater 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.

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

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

Assessing compliance with these standards may require that the 7-DADMax be calculated using the applicable 7-day period that contains the maximum annual stream temperature.

The stream water temperature data may have periods of time with data gaps caused by instrument malfunction or from the probe being exposed to air when flows drop below the deployment location. If these data gaps exist, the continuous air temperature data collected from the station or a nearby one will be used to determine if the data gap occurred during the hottest time of the year. If the data gap spans the hottest time period, then that temperature logger data set may not be used for assessing standards compliance. However, if there are other periods of the year that also exceed the 7-DADMax, then the data set may be used for compliance assessment.

The assumption is that the highest annual stream temperature will coincide with the highest air temperature. This situation may also preclude use of the data set to determine that standards were met.

Sampling Process Design (Experimental Design)

The project objectives will be met through characterizing seasonal temperature in the North Fork of Cowiche Creek and Moxee Drain and the annual temperature in Wide Hollow Creek. Continuous temperature and flow data collection will be required to get basic temperature loading data in various reaches of the three waterbodies.

Wide Hollow Creek continuous temperature sampling is extended for a year to supplement a multi-parameter water quality study of Wide Hollow Creek to occur over this same period.

The sampling design will use a fixed network of sites with continuous temperature loggers. The fixed network will emphasize receiving water quality in the three streams and their major tributaries.

Continuous temperature data will be collected between late May or early June and mid-October, 2013 at the North Fork Cowiche Creek, Moxee Drain, and Wide Hollow Creek for at least one year beginning in May or June, 2013. We will conduct temperature checks monthly between May and October because risks of critical temperatures, vandalism, and high flows are all greater during these months. Temperature checks will be conducted once every two months through the winter.

Continuous streamflow data will be obtained from six stream gaging stations:

1. Moxee Drain at Birchfield Road (USBR).
2. Wide Hollow Creek just below Congdon Canal (Ecology).
3. Wide Hollow Creek behind Bergen Screen Print near 40th Ave (Ecology).
4. Wide Hollow Creek behind Texaco Station near 24th Ave. (Ecology)
5. Wide Hollow Creek above Fines Ditch diversion dam near Bay Street (Ecology).
6. Wide Hollow Creek at White Street in Union Gap (Ecology).

Flow monitoring sites will be established by Ecology's Stream Hydrology Unit (SHU). The U.S. Bureau of Reclamation will supply data from their stream gage on Moxee Drain. Monthly flow measurements will be made at all other sites by direct means or by using a staff gage.

Monthly flow measurements will be conducted following the methods and quality assurance protocols outlined in Ecology's SOP (Shedd, 2011) to verify the accuracy of the continuous flow data.

Sample sites and description are listed in Tables 5 to 7 and shown in Figures 2 to 4.

Table 5. Proposed North Fork Cowiche Creek sample locations and parameters.

Site ID	Description	Latitude	Longitude	Temperature		Flow Type
				Air	Water	
38-FC-7	NF Cowiche Creek at French Rd above reservoir	46.7110	-120.8047		☑	M
38-FC-5A	*NF Cowiche Creek at Tieton Rd in Tieton*	*46.7055*	*-120.7525*	☑	☑	M
38-FC-WWA	*NF Cowiche Creek just above wastewater treatment plant*	*46.6748*	*-120.7061*		☑	M
38-FC-WWR	WWTP effluent after wetland treatment.	46.6730	-120.7024		☑	M
38-FC-WWB	*NF Cowiche Creek just below wastewater treatment plant*	*46.6725*	*-120.7021*		☑	M
38-FC-3.5	NF Cowiche Creek at Thompson Road	46.6577	-120.6921		☑	M
38-FC-3	NF Cowiche Creek at Mahoney Road near confluence	46.6475	-120.6822		☑	M
38-FC-2	SF Cowiche Creek near Pioneer Road and confluence	46.6472	-120.6836	☑	☑	M

Italics indicate a new station established for this project. All other stations were established in prior projects.
M: Monthly flow measurement.

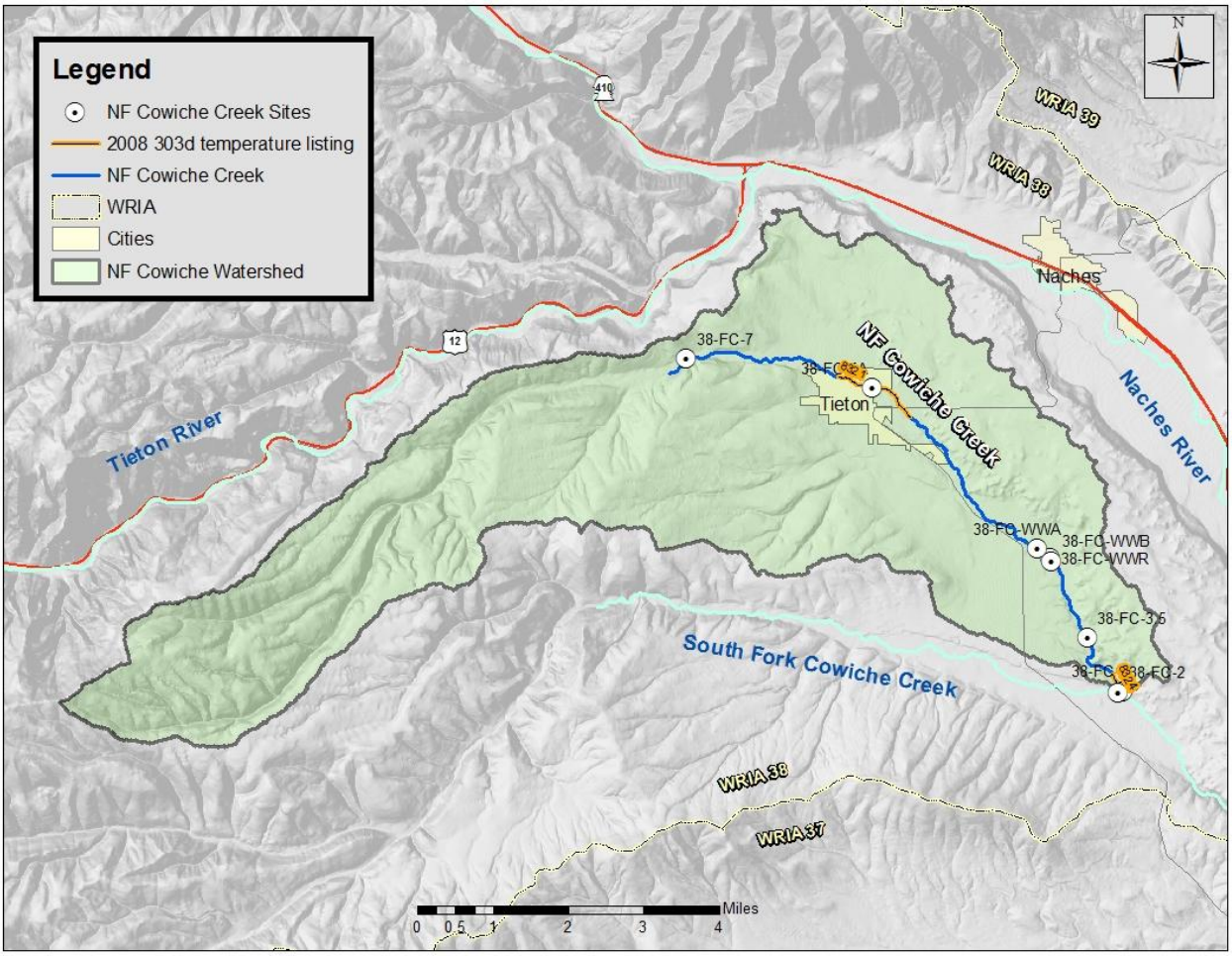

Figure 2. North Fork Cowiche sample sites and 303(d) temperature listings.

Table 6. Proposed Moxee Drain sample locations and parameters.

Site ID	Description	Latitude	Longitude	Temperature		Flow Type
				Air	Water	
37-FM-10	Moxee Drain at Beane Road	46.5408	-120.3134	☑	☑	M
37-FM-9A	*Selah-Moxee Canal at mouth*	*46-5461*	*-120.3509*		☑	M
37-FM-9	Moxee Drain at Walters Road	46.5459	-120.3561		☑	M
37-FM-9.5	Outfall to Moxee Drain at Walters Road	46.5460	-120.3562		☑	M
37-FM-8	Moxee Drain at Beaudry near Beauchene Rd	46.5489	-120.4041		☑	M
37-FM-3.6	DID #11 at mouth	46.5507	-120.4175		☑	M
37-FM-3	Moxee Drain at Birchfield Rd	46.5458	-120.4383		☑	C
37-FM-1	Moxee Drain near mouth off Thorp Rd	46.5378	-120.4587	☑	☑	M
37-IS-0	Irrigation return to Moxee Drain near mouth	46.5380	-120.4561		☑	M

Italics indicate a new station established for this project. All other stations were established in prior projects.
M: Monthly flow measurement.
C: Continuous flow gauge.

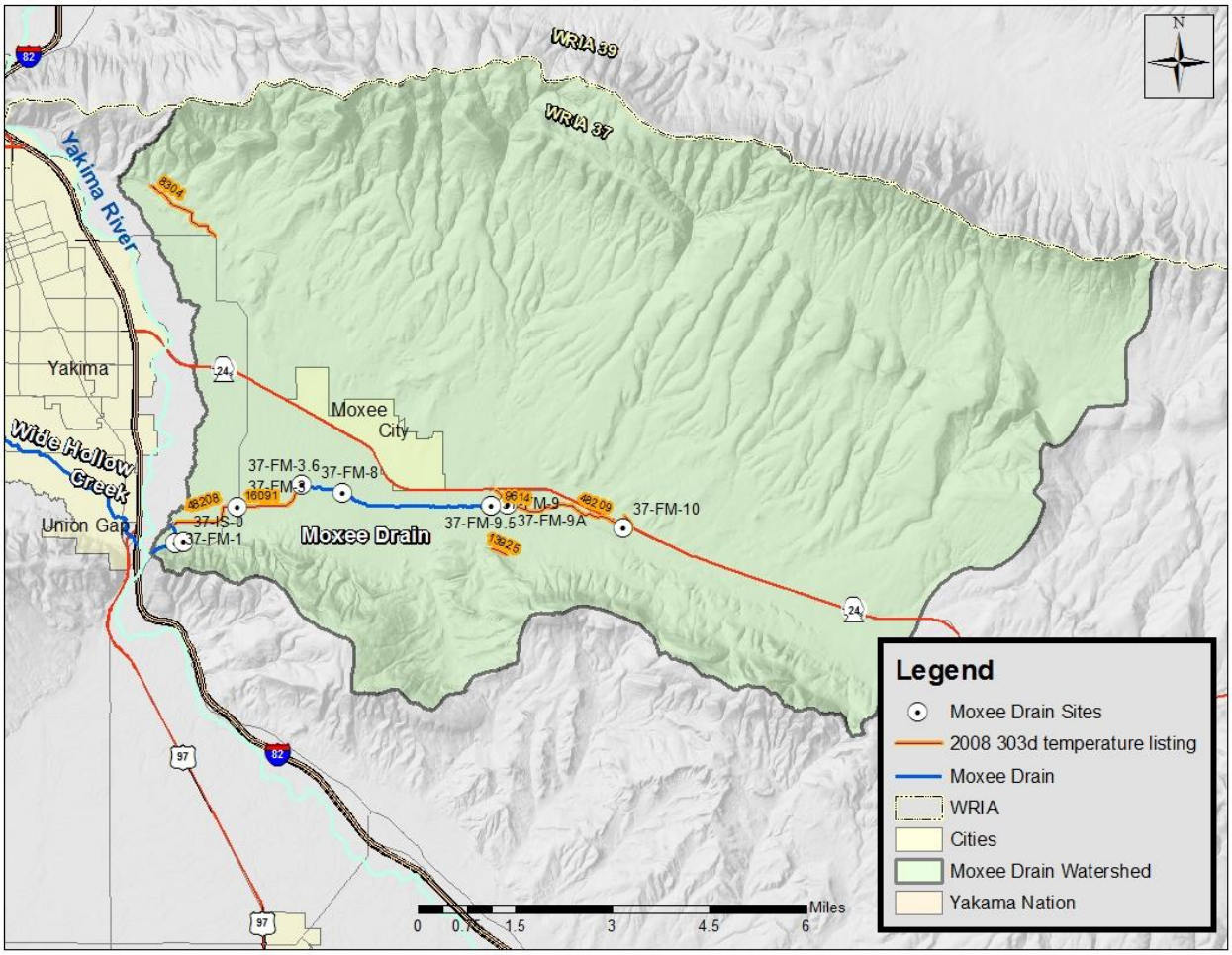

Figure 3. Moxee Drain sample sites and 303(d) temperature listings.

Table 7. Proposed Wide Hollow Creek sample locations and parameters.

Site ID	Description	Latitude	Longitude	Temperature		Flow Type
				Air	Water	
38-IS-16C	*Congdon Canal diversion from the Naches River at Eschbach Park*	*46.6834*	*-120.6539*		☑	M
37-FW-12	Wide Hollow Creek at Dazet Road	46.5798	-120.6464		☑	M
37-FW-13	Cottonwood Creek at Dazet Road	46.5792	-120.6464		☑	M
37-FW-16B	Wide Hollow Creek below Congdon Canal	46.5802	-120.6419	☑	☑	C
37-FW-8	Wide Hollow Creek @ park off 80th Ave.	46.5813	-120.6146		☑	M
37-SS-12	Wide Hollow Creek at 64th Ave.	46.5834	-120.5940		☑	M
37-SS-38	DID outfall #38 at 64th Ave.	46.5833	-120.5939		☑	M
37-SS-48	DID outfall #48 at 64th Ave.	46.5833	-120.5939		☑	M
38-IS-20C	*Naches-Cowiche canal diversion from the Naches River at Powerhouse Road bridge*	*46.6315*	*-120.5873*		☑	M
37-SS-9	Randall Park Pond outlet on 44th Ave.	46.5800	-120.5673		☑	M
37-FW-6B	Wide Hollow Creek behind Bergen Screen Print off 40th Ave.	46.5786	-120.5656	☑	☑	C
37-IS-17	DID #40 outfall @ 38th and Logan	46.5799	-120.5592		☑	M
37-IS-20B	*Naches-Cowiche Canal outflow to Wide Hollow Creek at 32nd Ave near Kissel Park*	*46.5752*	*-120.5510*		☑	M
37-FW-5A	*Wide Hollow Creek behind Texaco Station near 24th Ave.*	*46.5738*	*-120.5477*		☑	C
37-FW-4	Wide Hollow Creek at 16th Ave.	46.5685	-120.5305		☑	M
37-IS-20A	*Naches-Cowiche Canal outflow to Wide Hollow Creek at 12th Ave.*	*46.5684*	*-120.5291*		☑	M
37-IS-14A	*Spring Creek irrigation district outfall at 10th Ave and Pioneer*	*46.5634*	*-120.52016*		☑	M
37-SS-6	City stormwater outfall at 3rd Ave.	46.5589	-120.5097		☑	M
37-IS-12	DID #24 outfall L1 @ 3rd Ave.	46.5588	-120.5096		☑	M
37-FW-3	Wide Hollow Creek upstream of 3rd Ave. bridge	46.5587	-120.5090		☑	M
37-FW-2.5A	*Wide Hollow Creek above Fines Ditch at Bay Street*	*46.5524*	*-120.4909*		☑	C
37-FW-1.5	*Wide Hollow Creek at White Street and 4th in Union Gap*	*46.5496*	*-120.4806*		☑	C
37-FW-2B	*Unnamed Creek at Union Gap Mill*	*46.5636*	*-120.4753*		☑	M
37-FW-2	Spring Cr @ at Union Gap Public Works	46.5427	-120.4715		☑	M
37-FW-0B	*Wide Hollow Creek below Spring Creek*	*46.5399*	*-120.4742*	☑	☑	M

Italics indicate a new station established for this project. All other stations were established in prior projects.
C: Continuous flow gauge.
M: Monthly flow measurement.

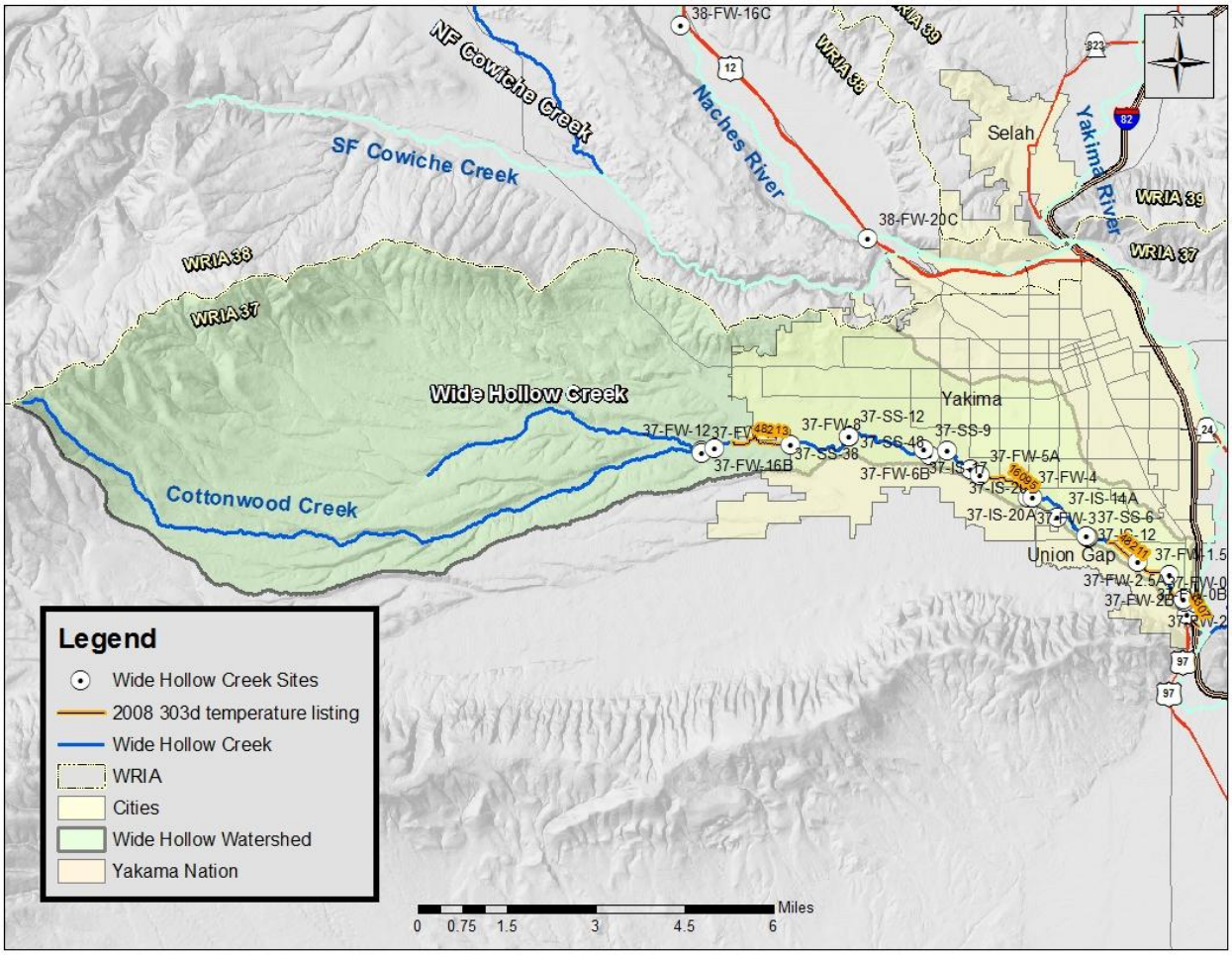

Figure 4. Wide Hollow Creek sample sites and 303(d) temperature listings.

Stations were chosen to characterize water quality and to address specific needs for monitoring data. These stations were selected to:

- Support planned TMDL activities.
- Confirm suspected water quality problems.
- Determine sources of water quality degradation.
- Characterize water quality where not previously monitored.
- Support the waste discharge permitting process.

Stream stations must meet the following criteria before qualifying for temperature monitoring:

- Be located in a well-mixed location, as close to the thalweg as possible, where representative stream temperature data may also be obtained during the late summer low-flow period.
- Be unaffected by groundwater or tributary sources and about six inches off the streambed.
- Be well hidden to prevent loss to vandalism or damage.
- Be safe to access.

Sampling Procedures

The sampling protocols will follow the procedures described in the Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams (Ward, 2011) and in the TFW Stream Temperature Survey Manual (Schuett-Hames et al, 1999).

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 piece of 1½ inch camouflage-painted PVC pipe to shade them from sunlight and to prevent them from being found and vandalized.

Mid-deployment checks of the water temperature logger locations will rely heavily on the temperature results obtained by staff during monthly check runs. The periodic checks may result in a temperature logger re-location to a greater depth. All monthly check run observations and measurements will be recorded on the survey form.

Where possible, monthly flow measurements in streams will be conducted using cross-sectional wading or bridge methods. Low-flow pipe effluents may be measured by timed bucket filling. Flow results will be recorded in cubic feet per second (cfs) on the Discharge Measurement Form Number 040-56. (Shedd, 2011).

On all site visits we will follow Washington State Department of Ecology standard protocols for minimizing the spread of invasive species (Parsons et al., 2012). Example procedures include: (1) beginning sampling upstream and moving downstream to other sites and (2) decontaminating field gear when moving between sample basins.

Quality Control 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) and in the Schuett-Hames et al. (1999).

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.
Finalized station data will be validated by deleting the pre-deployment, post-deployment, and anomalous[2] data from the raw data set.

[2] An example is when dropping water levels expose a temperature logger. This is identified by reviewing a plot of the water and air temperature results. The pattern for an air-exposed water temperature logger will be erratic and will track the air results without a lag time.

Data Management Procedures

Data will be reviewed and entered into Ecology's current continuous data storage database where results may be exported in Excel® files, text (.txt) files, and plots. Annual station daily maximum, minimum, and mean data summaries will be input into Ecology's Environmental Information Management (EIM) Database.

Audits and Reports

Wide Hollow Creek temperature and flow results, methods, and data quality will be published in a water quality assessment report as part of a concurrent study.

Data Verification

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) and in the TFW Stream Temperature Survey Manual (Schuett-Hames et al, 1999). 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.

Data Quality (Usability) Assessment

Stream temperature and flow data that have met specified MQOs and passed data verification will be available to internal and external users. Data for all watersheds will be summarized and stored on Ecology's EIM database, and in Ecology's current continuous data storage database. Wide Hollow Creek data will also be summarized and compared to state water quality standards in a summary report as part of a concurrent multi-parameter water quality study.

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Appendix. Glossary, Acronyms, and Abbreviations

Glossary

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.

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

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

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

Reach: A specific portion or segment of a stream.

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

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

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody 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 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.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

1-DMax	One-day maximum temperature
7-DADMax	The highest annual running 7-day average of daily maximum temperatures
DID	Drainage Improvement District drain.
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
et al.	And others
MQO	Measurement quality objective
NF	North Fork
NPDES	(See Glossary above)
QA	Quality assurance
RM	River mile
SF	South Fork
SOP	Standard operating procedures
TFW	Timber, Fish, and Wildlife Agreement
TMDL	(See Glossary above)
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
WWTP	Wastewater treatment plant

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second