Modeling Quality Assurance Project Plan for the Temperature Total Maximum Daily Loads in the Middle-Columbia Hood (Miles Creeks) Subbasin

DEQ25-WQ-0037-QAPP

Version 1.0

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State of Oregon
DEQ Department of Environmental Quality

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Abbreviations

AWQMS	Ambient Water Quality Monitoring System
CTWS	Confederated Tribes of the Warm Springs
DEQ	Oregon Department of Environmental Quality
DMA	Designated Management Agency
DMR	Discharge Monitoring Report
EQC	Oregon Environmental Quality Commission
NCDC	National Climatic Data Center
NPDES	National Pollutant Discharge Elimination System
OAR	Oregon Administrative Rule
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
QAPP	Quality Assurance Project Plan
RAWS	Remote Automatic Weather Stations
STP	Sewage Treatment Plant
SWCD	Soil and Water Conservation District
TIR	Thermal Infrared Radiometry
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
WRIS	Water Rights Information System
WWTP	Wastewater treatment plant

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1 Introduction

This Quality Assurance Project Plan (QAPP) summarizes the modeling approach to be used for the temperature Total Maximum Daily Load, or TMDL, replacement project applicable within the eastern portion of the Middle Columbia-Hood Subbasin (17070105), also sometimes known as the Miles Creeks area. The specific watersheds in the TMDL project area include Eightmile Creek Watershed (1707010502), Fifteenmile Creek Watershed (1707010503), Mill Creek-Columbia River Watershed (1707010504), and four subwatersheds within the Mosier Creek-Columbia River Watershed (1707010511). These subwatersheds include Upper Mosier Creek Subwatershed (170701051102), Lower Mosier Creek Subwatershed (170701051103), Rock Creek Subwatershed (170701051104), and Rowena Creek-Columbia River Subwatershed (170701051105) (Figure 1-1*)*. The Columbia River and waters in the State of Washington are not included in the project area. The TMDL will address all waters in the TMDL project area and replace the Middle Columbia-Hood (Miles Creeks) Subbasin Temperature TMDL (DEQ, 2008) approved by the United States Environmental Protection Agency (USEPA) on February 5, 2009.

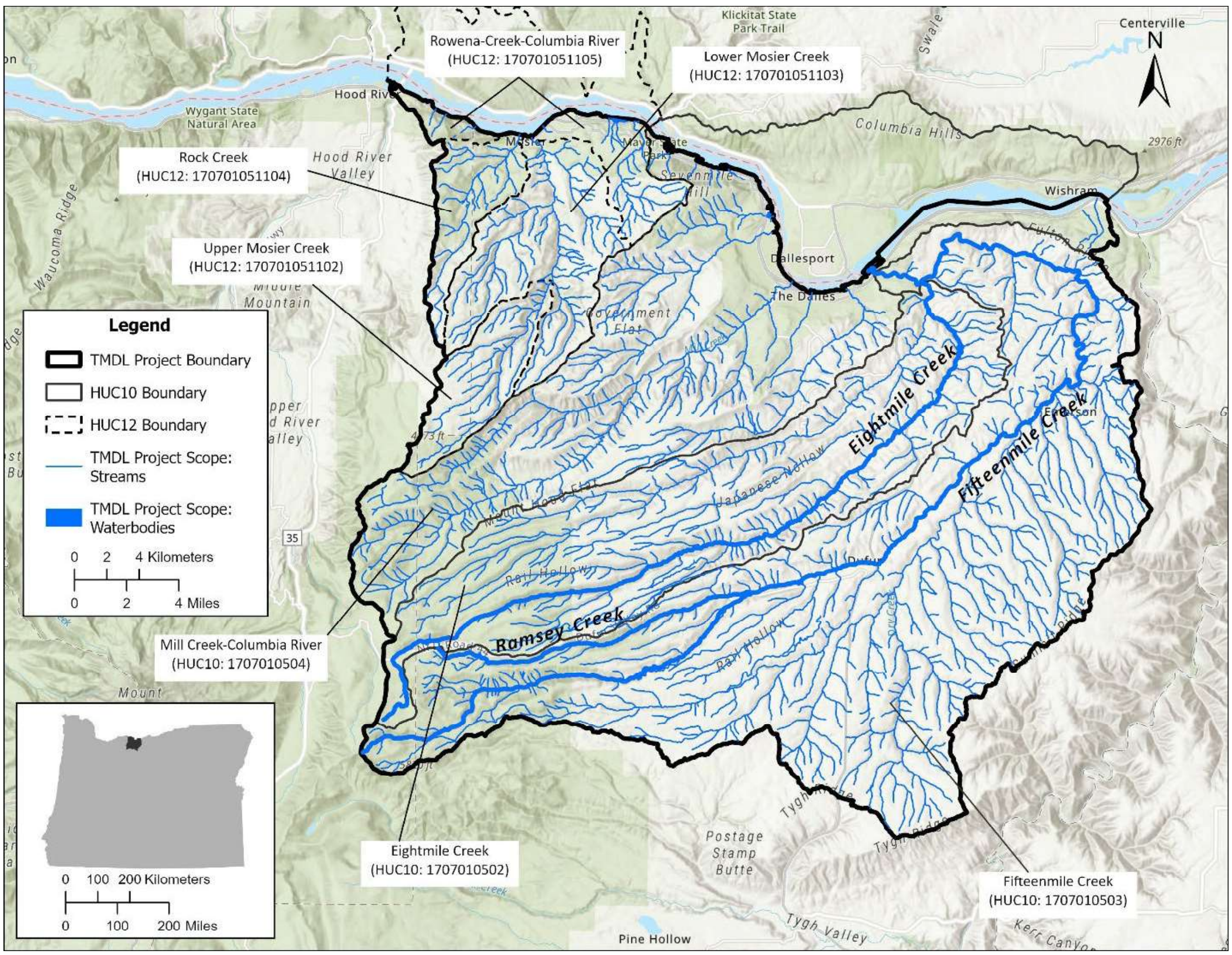

Figure 1-1: Middle Columbia-Hood (Miles Creeks) temperature TMDL project area overview.

A TMDL is a water quality restoration plan and the calculation of the maximum amount of a pollutant that a waterbody can receive while still meeting water quality standards for that particular pollutant. The maximum amount of loading a waterbody can receive is called the loading capacity. Loading from all pollutant sources must not exceed the loading capacity (TMDL) of a waterbody, including an appropriate margin of safety.

Load allocations are portions of the loading capacity that are allocated to background sources or nonpoint sources, such as urban, rural agriculture, or forestry activities. Wasteload allocations are portions of the total load which are allocated to NPDES permitted sources, such as wastewater treatment plants (WWTP) or industries. Wasteload allocations are used to establish effluent limits in NPDES discharge permits. Allocations may also be reserved for future uses, called reserve capacity. Allocations are quantified measures that assure water quality standards will be met and may distribute the pollutant loads between nonpoint and point sources. This general TMDL concept is represented by Equation 1.

$$TMDL = \sum WLA + \sum LA + \textit{Reserve Capacity} + MOS \qquad \text{Equation 1}$$

Where $\sum WLA$ is the sum of wasteload allocations (NPDES permitted sources), $\sum LA$ is the sum of load allocations (nonpoint sources and background), *Reserve Capacity* is allocations reserved for future uses, and *MOS* is a margin of safety to account for uncertainty. For a temperature TMDL, these elements establish the maximum thermal loads that a waterbody may receive without exceeding applicable water quality standards for temperature designed to protect aquatic life and other beneficial uses.

The Clean Water Act requires TMDLs be developed for waterbodies that do not meet water quality standards and are listed as water quality impaired on the State's 303(d) list. The Middle Columbia-Hood (Miles Creeks) Subbasin includes several waterbodies listed on the Oregon 2022 Section 303(d) Category 5 list as water quality limited for temperature (Table 2-1). A TMDL that was previously developed for the Middle Columbia-Hood (Miles Creeks) Subbasin (DEQ, 2008) must be replaced due to litigation.

In 2013, USEPA disapproved the Natural Conditions Criterion contained in Oregon's water quality standard for temperature due to the 2012 U.S. District Court decision for NWEA v. EPA, 855 F. Supp. 2d 1199 (D. Or., 2012). This portion of the temperature water quality standard was used in most temperature TMDLs issued from 2003 through 2012. On October 4, 2019, the U.S. District Court issued a judgment for NWEA v. EPA, No. 3:12-cv-01751-HZ (D. Or., Oct. 4, 2019) and required DEQ and USEPA to replace 15 Oregon temperature TMDLs that were based on the Natural Conditions Criterion and to reissue the temperature TMDLs based on the remaining elements of the temperature water quality standard.

This QAPP is consistent with DEQ's and USEPA's modeling QAPP guidance (DEQ, 2017; EPA, 2016) and documents the analysis and numerical modeling approach that will support the updated Middle Columbia-Hood (Miles Creeks) Subbasin temperature TMDL as well as other project details. In particular, this QAPP details the following:

- Definition of the issue and objectives, including the spatial and temporal extents of the water quality impairments (Section 2);
- A high-level description of the key processes and variables for temperature (Section 3);
- The overarching technical approach, including the appropriate modeling and analytical tools to be used (Section 4);

- The data sources for defining and creating inputs to the model, including data that were used in the modeling for the original TMDL. Examples of these inputs include meteorological data, stream flow and temperature, point sources and vegetation characteristics (Sections 5 and 6);
- How the analysis and modeling will be evaluated for acceptability (Sections 7 and 9);
- Scenarios for evaluating management strategies for reducing anthropogenic thermal loads (Section 10);
- Various aspects for managing the TMDLs development project, including documentation (Section 8), the project team (Section 11), data and records management (Sections 12 and 13); and
- Aspects relating to this QAPP and its role in the project (Sections 14 and 15).

2 Problem definition and management objectives

Multiple waterbodies in the Middle Columbia-Hood (Miles Creeks) Subbasin do not meet the water quality standards for temperature and are listed as Category 5, water quality limited on Oregon's 2022 Section 303(d) list (Table 2-1). The temperature water quality standards are set at a level to protect the most sensitive beneficial uses. The beneficial uses most sensitive to water temperature are fish and aquatic life. The temperature water quality standards in the Middle Columbia-Hood (Miles Creeks) Subbasin include the numeric criteria identified below. The numeric temperature criteria are based on a seven-day average daily maximum continuous measurement of temperature.

- Salmon and Steelhead Spawning: 13.0°C (OAR 340-041-0028(4)(a))
- Core Cold Water Habitat: 16.0°C (OAR 340-041-0028(4)(b))
- Salmon and Trout Rearing and Migration: 18.0°C (OAR 340-041-0028(4)(c))

Where and when the applicable criteria apply are based on the designated fish use maps in OAR 340-041-0160 Figure 160A and Figure 160B. The maps from the rule have been reproduced and are shown in Figure 2-1 and Figure 2-2. Figure 2-1 shows various designated fish uses and applicable criteria, while Figure 2-2 shows salmon and steelhead spawning use designations, based on the NHD.

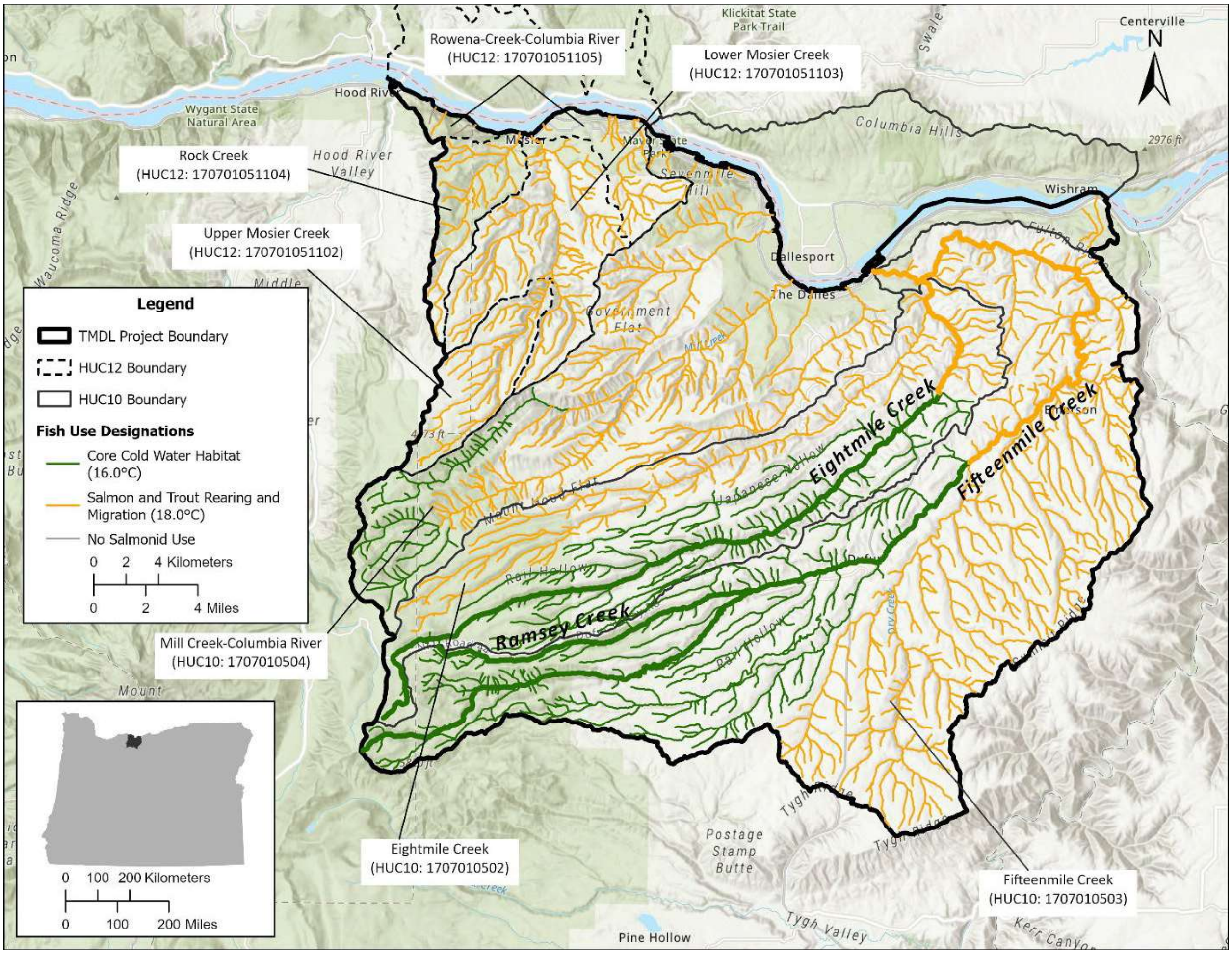

Figure 2-1: Fish use designations and applicable year-round temperature criteria in the Middle Columbia-Hood (Miles Creeks) TMDL project area.

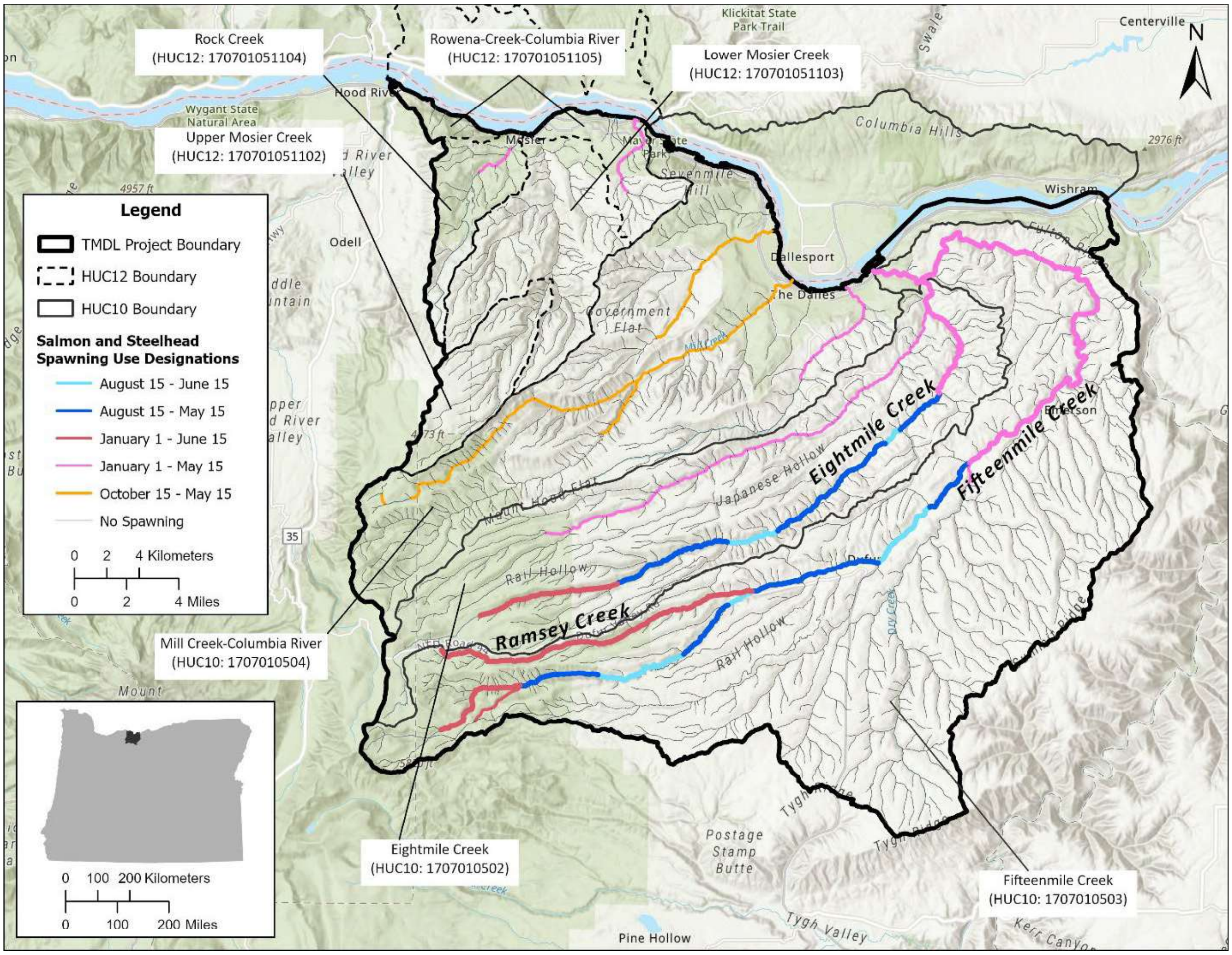

Figure 2-2: Salmon and steelhead spawning use designations in the Middle Columbia-Hood (Miles Creeks) TMDL project area.

The temperature standard authorizes insignificant additions of heat from human sources in waters that exceed the applicable temperature criteria as follows: Following a temperature TMDL or other cumulative effects analysis, the human use allowance (HUA) will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3°C (OAR 340-041-0028(12)(b)).

As described in Section 1, the USEPA and the State of Oregon are required to revise the water temperature TMDL for the Middle Columbia-Hood (Miles Creeks) Subbasin. In revising the TMDL, all of the allocations will be updated to target the applicable biologically based numeric criteria (BBNC) and HUA components of the water quality temperature standards.

Since the issuance of the original TMDL, the extent and number of waterbodies that are identified as water quality limited for temperature have changed. As part of the TMDL update, DEQ will address all current temperature listings based on the most recent integrated report list. The current listings, as they pertain to the Middle Columbia-Hood (Miles Creeks) Subbasin QAPP project area, were obtained from Oregon’s 2022 Integrated Report and are summarized in Table 2-1 and Figure 2-3.

To the extent existing data and information allow, the primary analysis and modeling objectives for this TMDL include:

1) Complete a source assessment and cumulative effects analysis to characterize or identify:
    a. Anthropogenic sources of stream temperature warming;
    b. How much warming comes from background sources;
    c. How much warming comes from each anthropogenic source or source category;
    d. The cumulative warming from all anthropogenic sources combined;
    e. Where along the stream anthropogenic warming occurs;
    f. Where the point of maximum stream warming is located; and
    g. The amount of stream warming that exceeds the HUA and applicable water quality standards.

2) Determine TMDL elements and allocations that attain the applicable temperature criteria by identifying:
    a. The thermal loading capacity for each temperature listed waterbody;
    b. The excess thermal load exceeding the loading capacity for each temperature listed waterbody;
    c. The thermal load and wasteload allocations necessary to meet the applicable water quality standards for each listed waterbody;
    d. Any surrogate measures;
    e. Any reserve capacity;
    f. Any margin of safety; and
    g. The seasonal variation and critical conditions corresponding to the time period when the applicable temperature criteria are exceeded.

3) Support the development of the TMDL Water Quality Management Plan as necessary and as resources allow:
    a. Evaluate existing land management plans, TMDL implementation plans, or rules for sufficiency in minimizing anthropogenic warming to the level established by the TMDL allocations.
    b. Identify additional management strategies or surrogate measures.

Table 2-1: Middle Columbia-Hood (Miles Creeks) assessment units that are classified as water quality limited category 5 for temperature based on the Section 303(d) 2022 Integrated Report.

Assessment Unit Name	Assessment Unit ID	Use Period (Year Listed)
Eightmile Creek	OR_SR_1707010502_02_101504	Year-round (2010)
Dry Creek	OR_SR_1707010503_02_101505	Year-round (2010)
Fifteenmile Creek	OR_SR_1707010503_02_101506	Spawn (2010), Year-round (2010)
Fifteenmile Creek	OR_SR_1707010503_02_101507	Spawn (2010), Year-round (2010)
Mosier Creek	OR_SR_1707010511_02_101513	Year-round (2010)
HUC12 Name: Upper Eightmile Creek	OR_WS_170701050201_02_101980	Spawn (2010)

Assessment Unit Name	Assessment Unit ID	Use Period (Year Listed)
HUC12 Name: Middle Eightmile Creek	OR_WS_170701050202_02_101981	Spawn (2010), Year-round (2010)
HUC12 Name: Lower Eightmile Creek	OR_WS_170701050204_02_101983	Spawn (2010), Year-round (2010)
HUC12 Name: Headwaters Fifteenmile Creek	OR_WS_170701050301_02_101984	Spawn (2010), Year-round (2010)
HUC12 Name: Upper Fifteenmile Creek	OR_WS_170701050302_02_101985	Spawn (2010), Year-round (2010)
HUC12 Name: Upper Dry Creek	OR_WS_170701050303_02_101986	Year-round (2010)
HUC12 Name: Threemile Creek	OR_WS_170701050402_02_101991	Year-round (2010)
HUC12 Name: North Fork Mill Creek-South Fork Mill	OR_WS_170701050403_02_101992	Spawn (2022)
HUC12 Name: Mill Creek	OR_WS_170701050404_02_101993	Spawn (2010), Year-round (2010)
HUC12 Name: Chenoweth Creek	OR_WS_170701050405_02_101994	Spawn (2010), Year-round (2010)
HUC12 Name: Lower Mosier Creek	OR_WS_170701051103_02_102009	Year-round (2010)
HUC12 Name: Rock Creek	OR_WS_170701051104_02_102010	Year-round (2010)

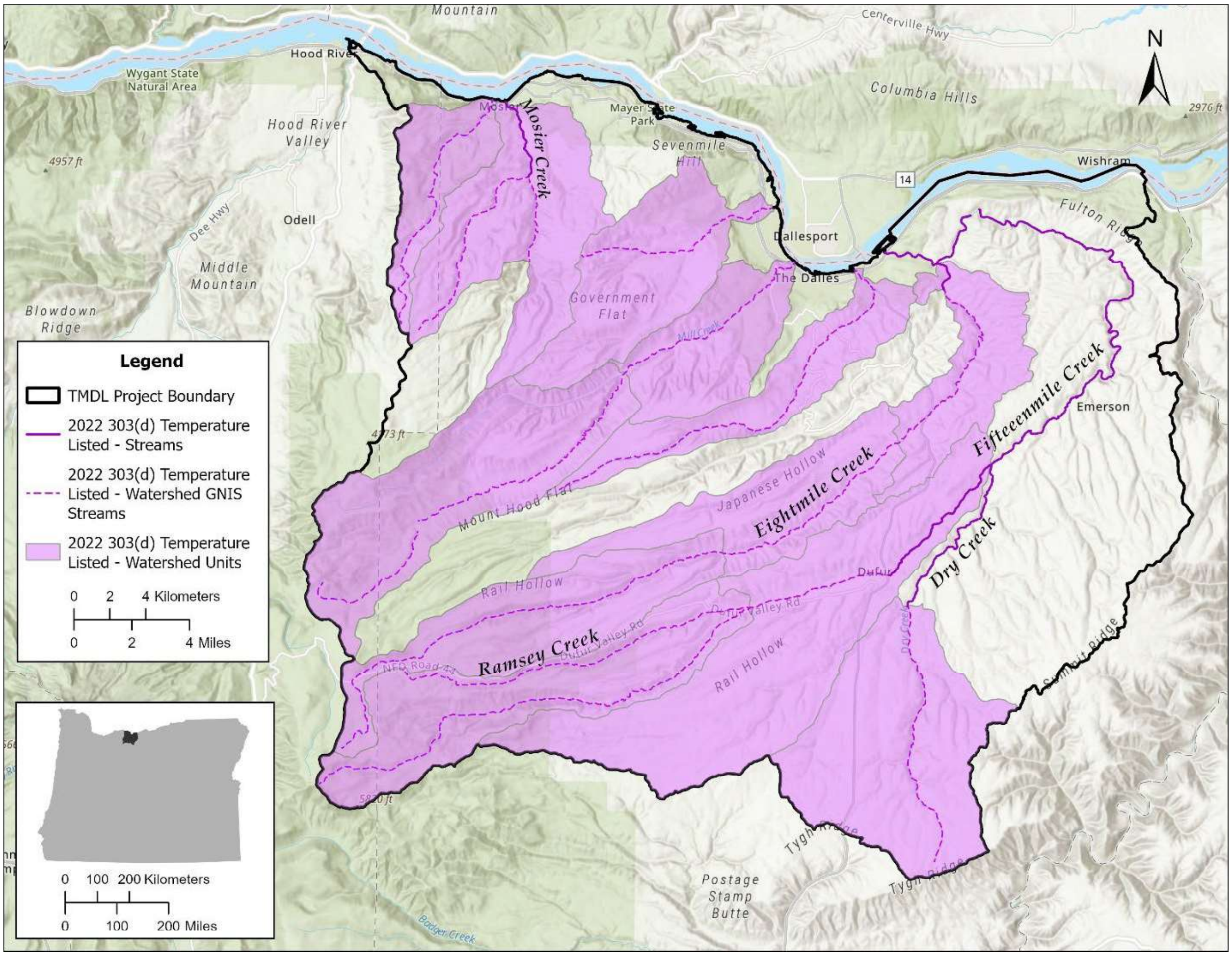

Figure 2-3: Middle Columbia-Hood (Miles Creeks) Category 5 temperature impairments on the 2022 Integrated Report.

3 Conceptual model: key processes and variables

The current theory to explain the nature of heat is called the kinetic-molecular theory. The modern version of this theory was developed in the mid-19th century by Rudolf Clausis, James Clerk Maxwell, and Ludwig Boltzmann. The theory is based on the assumption that all matter is composed of a tiny population of molecules that are always in motion. The molecules in hot objects are moving faster and hence have greater kinetic energy than the molecules in cold objects. Individual molecules have a certain amount of kinetic energy based on their mass and velocity. The thermal energy of an object is determined by adding up the kinetic energy of all the molecules in that object. When a hot and cold object come into contact with each other, the molecules collide and the kinetic energy flows from the molecules with more kinetic energy to molecules with less kinetic energy. This type of flow of kinetic energy is called heat.

Temperature is an intensive property and much like concentration measures the “strength” rather than “quantity” of kinetic energy. The temperature of an object is the measure of the average kinetic energy of all the molecules in that object. Hot water has greater average kinetic energy than cold water but may not have greater total kinetic energy. For example, a small pot of water with a temperature near the boiling point has a higher average kinetic energy than a swimming pool at room temperature. The swimming pool has a much larger quantity of molecules and therefore a higher total kinetic energy than the pot of water.

Temperature is the water quality parameter of concern, but heat, in particular heat from human activities or anthropogenic sources, is the pollutant of concern. Water temperature change (ΔTw) is a function of the heat transfer in a discrete volume and may be described in terms of changes in heat per unit volume. Conversely, a change in volume can result in water temperature change for a defined amount of heat exchange. With this basic conceptual framework of water temperature change, it is possible to discuss stream temperature change as a function of two variables: heat and mass transfer.

Water Temperature Change as a Function of Heat Exchange and Volume,

$$\Delta Tw = \frac{\Delta Heat}{Density \times \textit{Specific Heat} \times \Delta Volume} \qquad \text{Equation 2}$$

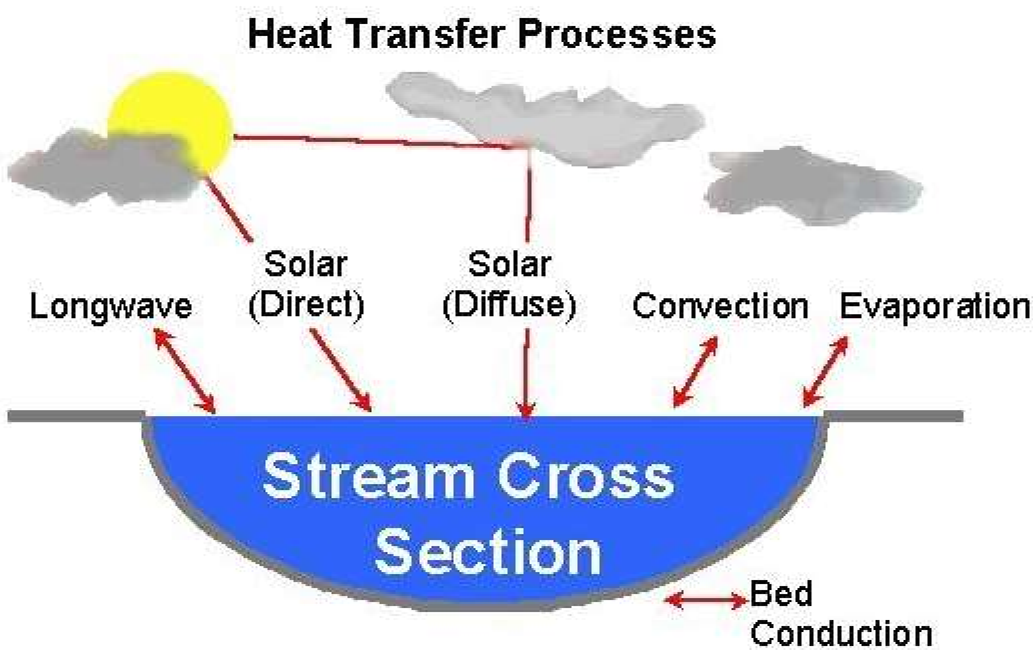

Figure 3-1: Major heat transfer processes.

Heat transfer relates to processes that change heat in a defined water volume. There are several thermodynamic pathways that can introduce or remove heat from a stream. These different processes are shown in Figure 3-1. For any given stream reach heat exchange is closely related to the season, time of day and the surrounding environment and the stream characteristics. Heat transfer can be dynamic and change over relatively small distances and time periods. Equation 3 describes the several heat transfer processes that change stream temperature (Wunderlich, 1972; Jobson and Keefer, 1979; Beschta and Weatherred, 1984;

Sinokrot and Stefan, 1993; Boyd, 1996; Johnson, 2004; Hannah et al., 2008; Benyahya et al., 2012).

$$\Phi_{total} = \Phi_{solar} + \Phi_{longwave} + \Phi_{streambed} + \Phi_{convection} + \Phi_{evaporation} \quad \text{Equation 3}$$

Where,
Φ_{total} = Net heat energy flux (+/-)
Φ_{solar} = Shortwave direct and diffuse solar radiation (+ only)
$\Phi_{longwave}$ = Longwave (thermal) radiation (+/-)
$\Phi_{streambed}$ = Streambed conduction (+/-)
$\Phi_{convection}$ = Stream/air convection[1] (+/-)
$\Phi_{evaporation}$ = Evaporation (+/-)

[1]Air/Water convection includes both turbulent and free surface conduction.

Mass transfer relates to the transport of flow volume downstream, instream mixing, and the introduction or removal of water from a stream. For instance, flow from a tributary will cause a temperature change if the temperature is different from the receiving water. Mass transfer commonly occurs in stream systems as a result of:

- Advection;
- Dispersion;
- Groundwater exchange;
- Hyporheic flows;
- Surface water exchange (e.g., tributary input, precipitation); and
- Other human-related activities that alter stream flow volume.

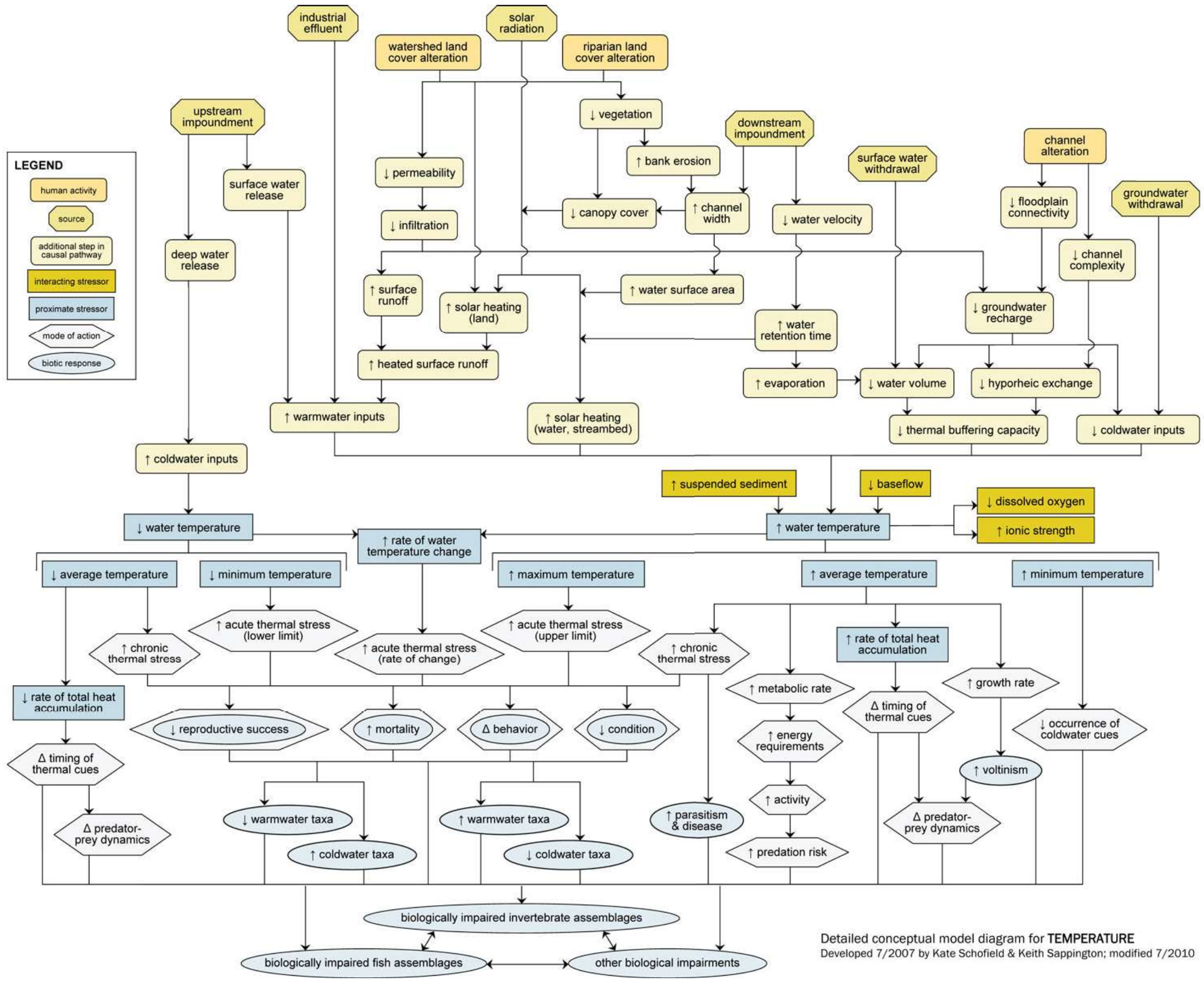

Figure 3-2: Conceptual diagram that identifies the key processes and variables that drive stream temperature changes and the biological responses (Schofield and Sappington, 2010).

Stream temperature is influenced by both human and natural factors. Figure 3-2 is a conceptual diagram that identifies the key process and variables that drive stream temperature. Human sources and natural sources are identified. Near the bottom of the diagram, the biological responses are identified.

Anthropogenic Point Sources: Temperature increases from point sources are those caused by warm water discharges from NPDES permitted facilities, such as industrial outfalls, municipal WWTPs, and other point sources.

Anthropogenic Nonpoint Sources: Temperature increases from human-caused nonpoint sources are caused by increases in solar radiation loading to the stream network from the disturbance or removal of near-stream vegetation, channel modification and widening, hydrologic modification from dams, reductions to the stream flow rate or volume, elevated tributary temperatures, changes in hyporheic flows and channel connectivity, reductions in cold groundwater inflows, and changes to meteorological conditions, such as those caused by climate change.

Background Sources: Background sources include all sources of pollution or pollutants not originating from human activities. In the context of a TMDL, background sources may also include anthropogenic sources of a pollutant that DEQ or another Oregon state agency does not have authority to regulate, such as pollutants emanating from another state, tribal lands, or sources otherwise beyond the jurisdiction of the state (OAR 340-042-0030(1)).

4 Technical approach

4.1 Overview

Stream temperature TMDLs are generally scaled to a subbasin or basin scale since stream temperatures are affected by cumulative interactions between upstream and local sources. For this reason, the TMDL considers all surface waters that affect the temperatures of 303(d) listed waterbodies. For example, Fifteenmile Creek is water quality limited for temperature. To address this listing in the TMDL, all upstream waterbodies are considered in the TMDL analysis and TMDL allocations are applied throughout the entire stream network and include all waters of the state.

An important step in the TMDL is to perform a source assessment which quantifies the background and anthropogenic contributions to stream heating. Models provide a way to evaluate potential sources of stream warming and, to the extent existing data allow, the amount of pollutant loading from these sources. The model that is selected for the TMDL analysis should support the needs of the project. Section 4.2 describes the model framework needs for this project and the models that will be used to support the TMDL.

TMDLs also require the identification of seasonal variations and critical conditions. The TMDL analysis will determine seasonal variation by including a statistical summary and visual plots summarizing the instream temperatures and flow rates observed at various monitoring locations. The time period when the applicable temperature criteria are exceeded will be described in relation to the critical conditions.

The TMDL will establish a loading capacity that specifies the amount of a pollutant or pollutants that a waterbody can receive and still meet water quality standards. The pollutant addressed in the temperature TMDL is heat. The TMDL will divide the loading capacity into thermal wasteload allocations for NPDES permittees and load allocations for background and nonpoint sources of heat to ensure that the applicable temperature standards are achieved. Anthropogenic nonpoint and NPDES permitted point sources are not permitted to heat a waterbody more than 0.3°C above the applicable criteria, cumulatively at the point of maximum impact. The portion of the HUA allocated to each source will be determined in the TMDL with the modeling approach supporting assessment of different allocation options. The modeling approach may also be used to support development of TMDL surrogate measures such as effective shade targets. Nonpoint source allocations can be translated into surrogate measures when a pollutant is difficult to measure, highly variable, or difficult to monitor (OAR 340-042-0040(5)(b)). Thermal load allocations for nonpoint sources can be difficult to measure and monitor. Attainment of the surrogate measures ensures compliance with the nonpoint source allocations.

Stream temperatures for the Middle Columbia-Hood (Miles Creeks) Subbasin TMDL (DEQ, 2008) were simulated using computer models (Heat Source version 7 solar model and Heat

Source version 7 temperature model). The model extents include most of the main rivers and their larger tributaries that contain or influence primary fish habitat. Modeling priority was given to rivers containing point source discharges and listed on the 303(d) list for temperature (i.e., Fifteenmile Creek). Additional priority was placed on rivers with higher nonpoint source activity and greater fish use, which are often larger rivers (i.e., Eightmile Creek and Ramsey Creek). Time and resources did not allow for the modeling of all listed rivers. Current project resources will be dedicated to updating existing models to evaluate new scenarios instead of creating new conditions and recalibrating to a different year.

Site-specific load allocations will be developed for the streams that are simulated. Other streams may be assigned generalized load allocations based on effective shade surrogate measures that target site potential or restored vegetation types. Wasteload allocations will be developed for NPDES permittees.

4.2 Model selection

DEQ developed a Heat Source temperature model (version 7) for Fifteenmile Creek and Heat Source solar models (version 7) for Eightmile Creek and Ramsey Creek for the 2008 temperature TMDL. These models will be carried forward into the revised TMDL scope of work and will define the technical basis of the TMDL and thermal load and wasteload allocations. The modeling framework needs for this project include:

1) Prediction of hourly stream temperatures over a period of days to months and at a no greater than 500 m longitudinal resolution.

2) Prediction of hourly solar radiation flux and daily effective shade at a no greater than 100 m longitudinal resolution.

3) Ability to evaluate hourly stream temperature response from changes in streamside vegetation.

4) Ability to evaluate hourly stream temperature response from changes in water withdrawals and tributary stream flow within the upstream catchment.

5) Ability to evaluate hourly stream temperature response from changes in channel morphology.

6) Ability to evaluate hourly stream temperature response from changes in effluent temperature and flow discharge from NPDES permitted facilities.

The Heat Source stream thermodynamics model (Boyd and Kasper, 2003) was used to model several streams for the development of TMDLs in the Middle Columbia-Hood (Miles Creeks) Subbasin (DEQ, 2008). Because these models already exist and meet all the model framework needs, Heat Source was selected for stream temperature simulation in the project area. The Heat Source model was originally developed at Oregon State University as a master’s thesis, where it was evaluated and approved by an academic committee (Boyd, 1996). Development of the model continued and in 1999 DEQ submitted the model equations and methodology for peer review (DEQ, 1999) and again in 2004 to the Independent Multidisciplinary Science Team (IMST, 2004) where the model was found to be scientifically sound.

The Heat Source model has been used in numerous stream temperature related studies including Loheide and Gorelick (2006), Diabat et al. (2013), Holzapfel et al. (2013), Lawrence et al. (2014), Bond et al. (2015), Woltemade and Hawkins (2016), Justice et al. (2017), and Wondzell et al. (2019). Heat Source has also been used in numerous Oregon TMDLs (DEQ, 2001, 2002, 2003, 2005, 2006, 2007, 2008, 2010, 2018, 2019).

4.3 Software Development Quality Assessment

We do not anticipate any new software development or model code changes as part of this project.

5 Model development and calibration

Waterbodies where model development was initiated for the Middle Columbia-Hood (Miles Creeks) Subbasin TMDL (DEQ, 2008) are listed in Table 5-1. The extent and location of these models is shown in Figure 5-1.

Table 5-1: Waterbodies where a model has already been developed.

Model Version	Model Waterbody
Heat Source version 7 temperature model	Fifteenmile Creek
Heat Source version 7 solar model	Eightmile Creek, Ramsey Creek

The setup and calibration for the models listed in Table 5-1 was completed by DEQ and documented in the Middle Columbia-Hood (Miles Creeks) Subbasin TMDL (DEQ, 2008). Adjustments to the existing calibrated models are unlikely to occur as part of this project. However, if it is determined that the model calibration needs to be updated, the model inputs that are expected to be modified are described in Section 6.1. DEQ will follow the model acceptance criteria and model fit statistics described in Section 7.2.

DEQ will develop effective shade curves for all other waterbodies that were not specifically listed in Table 5-1. Effective shade curves represent the maximum possible effective shade for different vegetation types, stream widths, and stream aspect. Every combination of these conditions is modeled in Heat Source to develop the estimated effective shade. The results are summarized in shade curve plots and/or a lookup table that includes additional combinations of vegetation height, density, and buffer width. Effective shade curves were developed for the original Middle Columbia-Hood (Miles Creeks) Subbasin TMDL (DEQ, 2008). Adjustments to the existing shade curve models are unlikely to occur as part of this project. However, if it is determined that the models need to be updated, DEQ will follow the procedures outlined in this QAPP.

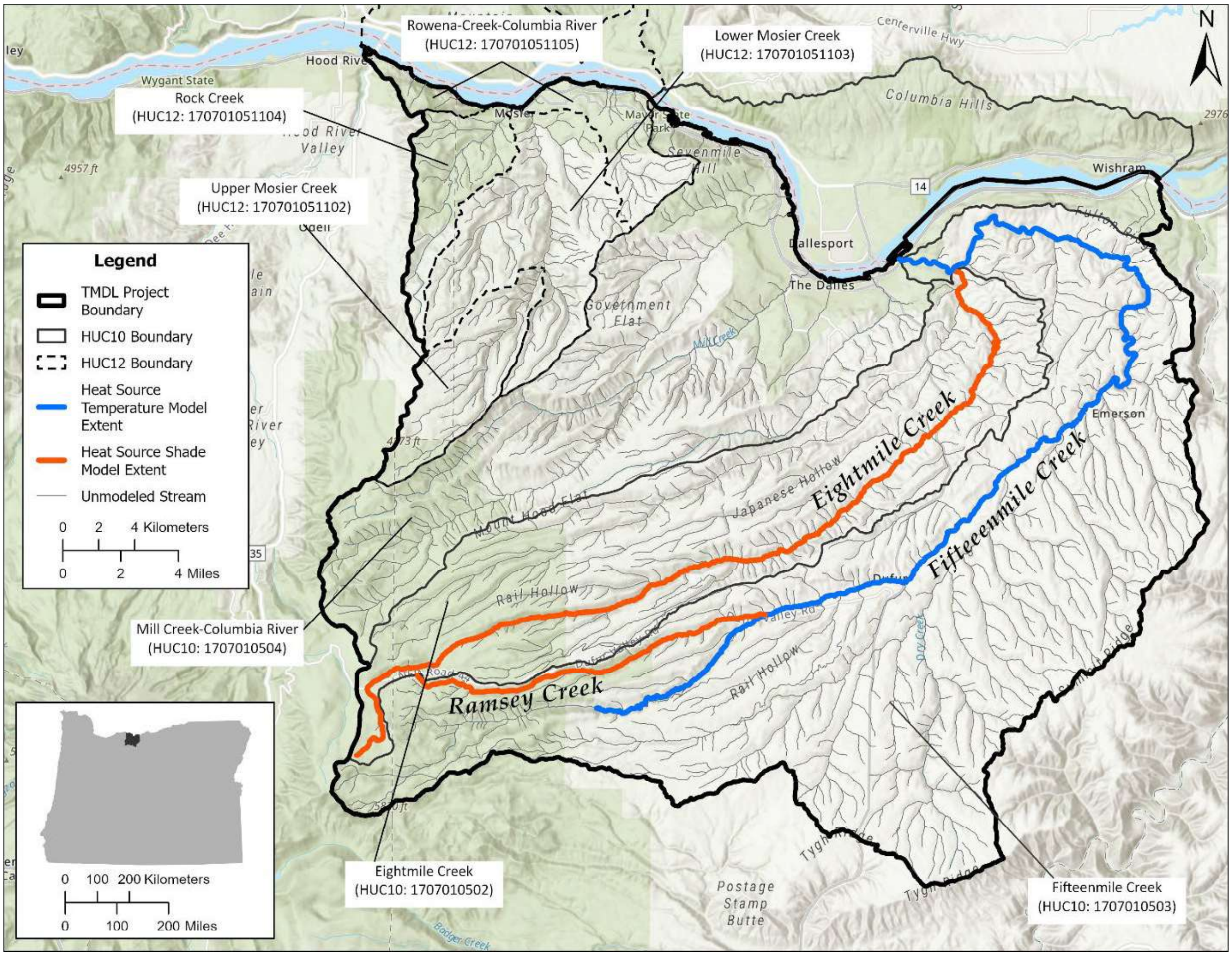

Figure 5-1: Heat Source temperature and shade model extents within the Middle Columbia-Hood (Miles Creeks) TMDL project area.

5.1 Data availability and quality

This section describes the data that are available to support the TMDL project and the quality assurance procedures used when collecting or reviewing the available data.

5.1.1 Meteorological data

Hourly meteorology inputs into the model include air temperature, relative humidity, and wind speed. The data sources for these parameters used to support model development are listed in Table 5-2. Figure 5-2 shows the locations of climate stations used to establish meteorological conditions for model simulations.

Table 5-2: Meteorological monitoring sites supporting model development.

Station	Data Source	Latitude	Longitude	Measurement Parameters
Emerson Bridge	Wasco SWCD	45.5455	-120.98	Air Temperature
Watermaster Larry Toll’s House	Larry Toll (watermaster)	45.5881	-121.181	Air temperature, wind speed/direction, relative humidity

Station	Data Source	Latitude	Longitude	Measurement Parameters
KDLS, The Dalles Municipal Airport	NOAA/NNDC	45.6167	-121.1667	Air temperature, wind speed/direction, relative humidity, cloudiness
Hwy 197 near auction yard	IFPnet	45.59002	-121.12498	Air temperature, wind speed, relative humidity, solar radiation
RAWS (Pollywog Site)	RAWS	45.4586	-121.446	Air temperature, wind speed/direction, relative humidity, solar radiation
Dufur City intake	Wasco SWCD	45.39582049	-121.2786149	Air Temperature
Dufur COOP	COOP	45.4538	-121.13	Air Temperature

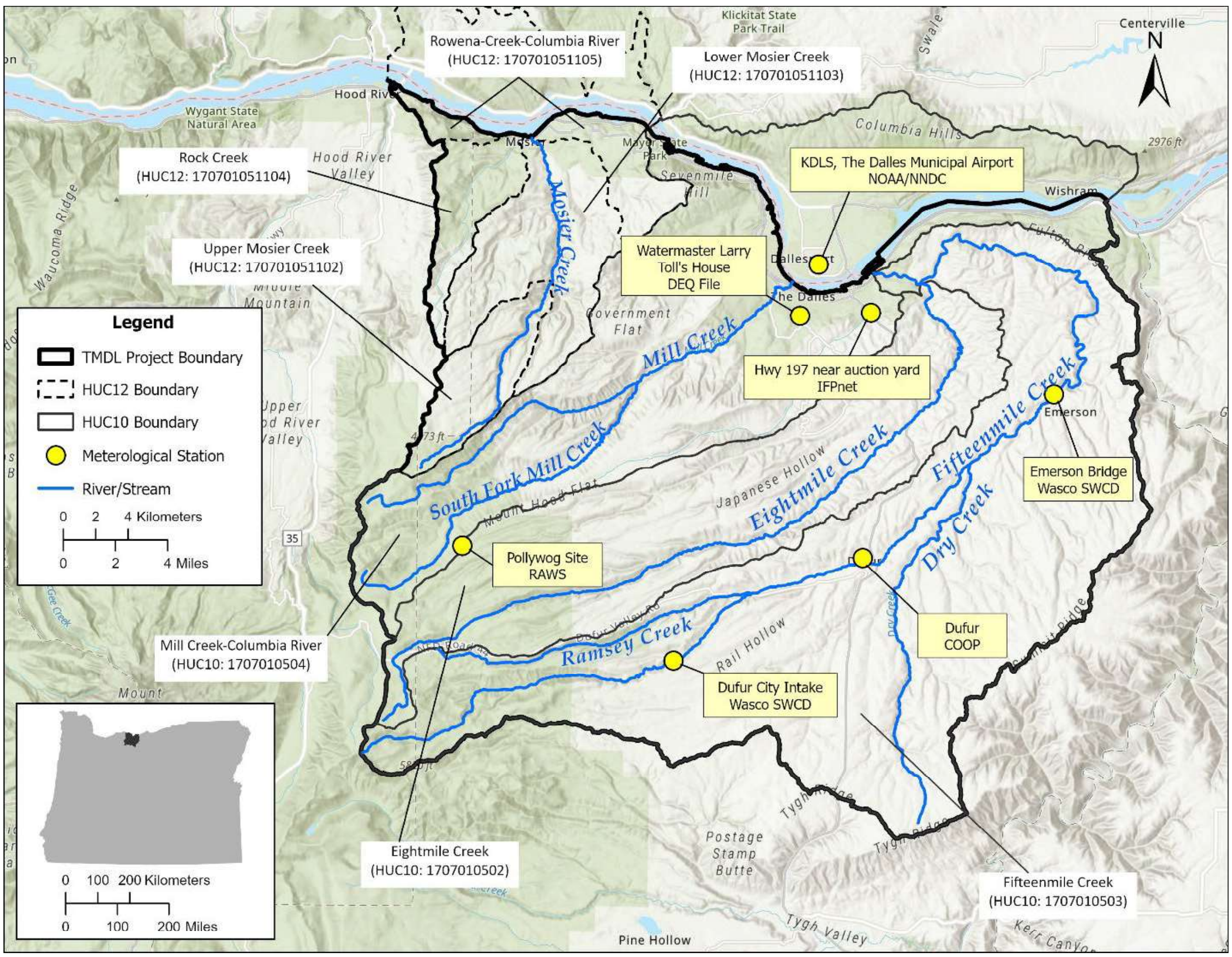

Figure 5-2: Location of climate stations providing meteorological data for model simulations.

Meteorological data includes air temperature, sky conditions, cloudiness, relative humidity, and wind speed.

The meteorological data obtained from the NCDC include the Local Climatological Dataset (NOAA, 2005) and the Global Integrated Surface Dataset (NOAA, 2001). The Local

Climatological Dataset includes quality controlled meteorological data from airports and other prominent weather stations managed by the National Weather Service, Federal Aviation Administration, and the U.S. Department of Defense. The Global Integrated Surface Dataset provides a long-term record of hourly, sub-hourly and synoptic weather observations from a variety of meteorological networks around the world. The dataset includes observations from the World Meteorological Organization, Automated Surface Observing System, Automated Weather Observing Stations, U.S. Climate Reference Network, and others.

5.1.2 Thermal Infrared Radiometry (TIR) data

DEQ contracted with Watershed Sciences, Inc. to provide airborne Thermal Infrared Radiometry (TIR) imagery of spatial temperature patterns within the Middle Columbia-Hood (Miles Creeks) Subbasin (Watershed Sciences, 2003). TIR data are used to support model calibration on model streams and characterize the longitudinal thermal regime and habitat quality. All streams and the TIR collection dates are summarized in Table 5-3.

Table 5-3: Summary of TIR survey collection dates in the Middle Columbia-Hood (Miles Creeks) Subbasin.

Stream	Survey Extent	Date	Time	Survey Distance
Eightmile Creek	Mouth to headwaters	8/3/2002	13:28-14:54	33.5 mi
Fifteenmile Creek	Mouth to headwaters	8/1/2002	13:54-15:33	52.2 mi
Ramsey Creek	Mouth to headwaters	8/2/2002	13:19-13:54	13.1 mi

5.1.3 Continuous stream temperature data

All available continuous stream temperature data were retrieved from DEQ's Ambient Water Quality Monitoring System (AWQMS), USGS's National Water Information System (NWIS), or were obtained during the data solicitation for DEQ's temperature TMDL replacement project. Some temperature data presented in this QAPP were retrieved from DEQ's files and were not available in AWQMS or USGS's database.

The data retrieval period for continuous stream temperature data is from Jan. 1, 1990, to Dec. 31, 2020. Data retrieved from the AWQMS database has a Data Quality Level (DQL) of A, B or E and a result status of "Final" or "Provisional". The data quality level criteria are outlined in DEQ's data validation criteria for water quality parameters measured in the field (DEQ04-LAB-0003-QAG, 2013). The TMDL program uses waterbody results with a data quality level of A, B, or E (DEQ, 2021). Data of unknown quality are used after careful review.

Appendix A summarizes 73 locations where continuous stream temperature data were collected in the Middle Columbia-Hood (Miles Creeks) Subbasin and the organizations that collected those data in Table A-1, and when data were collected at each location in Table A-2. This data will be used to develop temperature models, characterize stream temperature across the TMDL project area, determine seasonal variation, critical conditions, and excess load.

5.1.4 Stream flow data and channel measurements

DEQ retrieved continuous flow rate measurements from various United States Geological Survey (USGS) and Oregon Water Resources Department (OWRD) monitoring sites. DEQ, ODFW, and OWRD measured instantaneous flow rate at multiple stream survey sites during the model period in the summers of 2000 and 2002. In addition to instantaneous flow rate, the surveys included measurements of flow velocity, wetted width, wetted depth, and cross-sectional area. These instream measurements were used to develop flow inputs into the model, support flow mass balance analysis, and calibrate the temperature models. DEQ relies upon the quality control checks implemented by USGS and OWRD. DEQ-collected stream flow measurements utilize field and quality control methods outlined in DEQ's Mode of Operations Manual (DEQ, 2024).

Table B-1 through Table B-3 in Appendix B list the stations where continuous and instantaneous flow volume data were available in the Middle Columbia-Hood (Miles Creeks) Subbasin. Table B-4 lists the years that continuous stream flow data were collected at each location. This data will be used to develop temperature models, calculate 7Q10 low flows statistics, determine seasonal variation, and critical conditions

5.1.5 Point source discharges

Table 5-4 identifies Dufur STP, the only active individual NPDES permittee in the Middle Columbia-Hood (Miles Creeks) Subbasin as of the date of this QAPP. Table 5-5 identifies The City of The Dalles Water Treatment Plant (WTP), the only registrant covered under the general NPDES GEN02 permit in the Middle Columbia-Hood (Miles Creeks) Subbasin. The locations of these point sources are displayed in Figure 5-3.

These permittees submit Discharge Monitoring Reports (DMRs) as a condition of their permit. The frequency and type of reporting varies by permit and permit type. Dufur STP is required to report daily temperature and total flow (MGD) measurements. The City of The Dalles WTP reports flow data as monthly averages and does not report temperature data. The NPDES permits require data to be collected and reported on the DMR using appropriate methods based on a quality assurance and quality control plan. Where possible, DEQ will utilize any continuous effluent data that has been provided to DEQ. When continuous data are not available, DMR data will be utilized to characterize point source discharges. Table 5-6 lists the current number of registrants for all other general NPDES permits in the Middle Columbia-Hood (Miles Creeks) Subbasin that are not listed in Table 5-5.

Table 5-4: Summary of individual NPDES permitted discharges in the Middle Columbia-Hood (Miles Creeks) Subbasin.

Facility Name (Facility Number)	Latitude/Longitude	Permit Type and Description	Stream River Mile
Dufur STP (25491)	45.4508, -121.1231	NPDES-DOM-Db: Sewage - less than 1 MGD with discharging lagoons	Fifteenmile Creek RM 30.3

Table 5-5: Summary of current registrants under the general NPDES 200-J permit in the Middle Columbia-Hood (Miles Creeks) Subbasin.

Facility Name (Facility Number)	Latitude/Longitude	Permit Type and Description	Stream River Mile
City of The Dalles WTP (87831)	45.540, -121.316	200-J: Industrial Wastewater; NPDES filter backwash	South Fork Mill Creek RM 0.87

Table 5-6: Summary of the current number of registrants for all the general NPDES permits in the Middle Columbia-Hood (Miles Creeks) Subbasin that are not listed in Table 5-3.

Permit Type and Description	Current Number of Registrants
GEN12C: Stormwater; NPDES construction more than 1 acre disturbed ground	8
GEN12Z: Stormwater; NPDES specific SIC codes	2

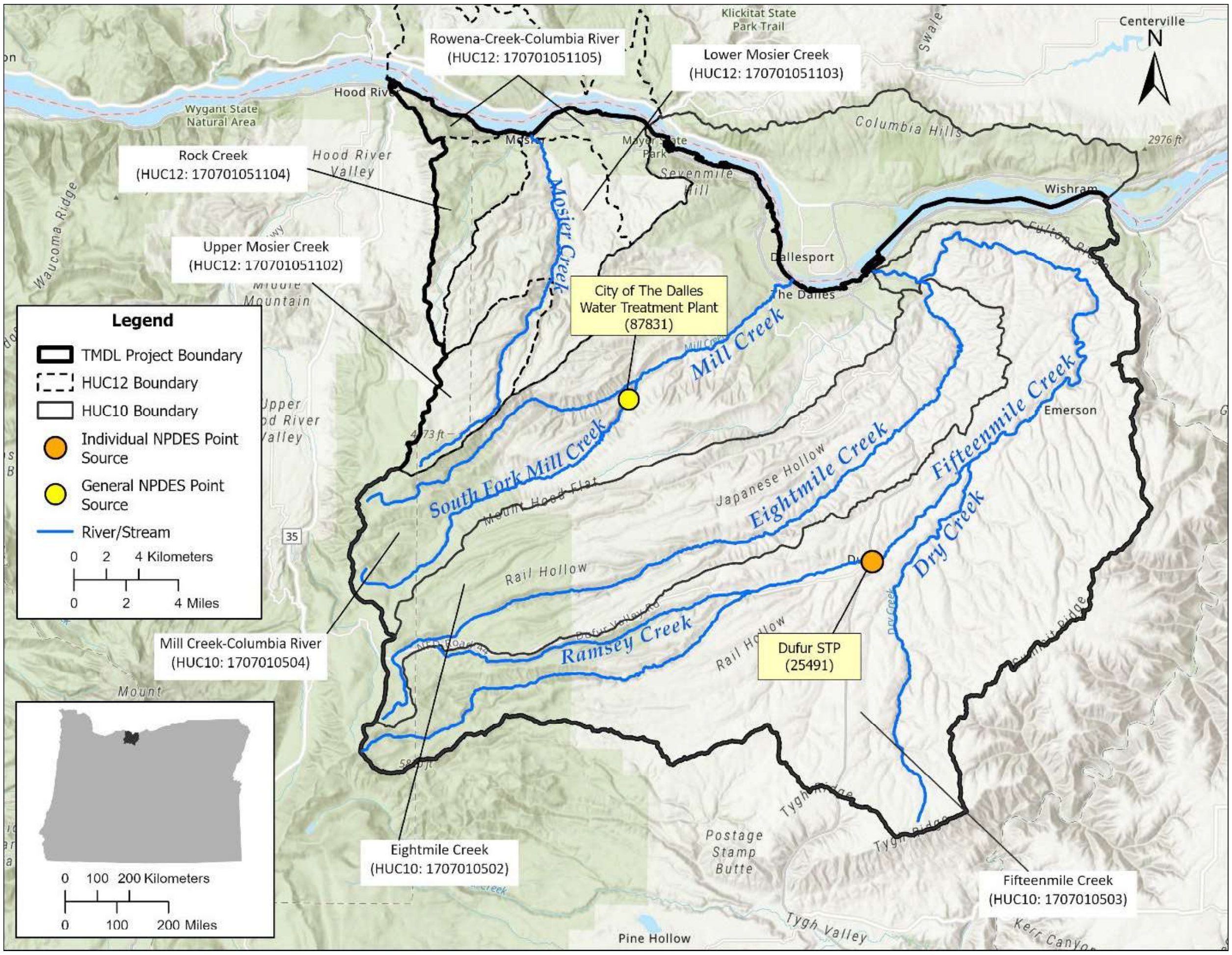

Figure 5-3: Individual and general NPDES permittees located within the Middle Columbia-Hood (Miles Creeks) TMDL project area.

5.1.6 Water rights/surface water diversions

Data on surface water diversion rates (usage) and the points of diversion (location) are available from the Oregon Water Resources Department (OWRD). OWRD regulates all commercial, industrial, domestic, and agricultural water use in the state of Oregon through water rights.

Estimates of water diversion rates and location of points of diversion can be derived from the following OWRD sources:

- Water Rights Information System (WRIS) – the WRIS database contains all permitted or certificated water rights. Data in the WRIS corresponding to quantities of water for use are expressed as maximum use allowable, generally as monthly, seasonal or annual rates or volumes. These maximum values may not correspond to actual usage, which will likely vary based on factors such as irrigation application rate or household consumer demand. DEQ may choose to incorporate the maximum amount allowable, or some lesser quantity provided sufficient information is available to support those rates in the modeling. Water rights information can also be accessed using their online mapping application (https://apps.wrd.state.or.us/apps/gis/wr/Default.aspx).
- Water Use Reports – some, but not all, water rights holders must monitor and report the water they use to the state, typically on a monthly or yearly basis, as a requirement of their water rights. These water use reports will be used to develop withdrawal time series based on available information.

5.1.7 Effective shade measurements

Effective shade is the percent of potential daily solar radiation flux that is blocked by vegetation and topography. DEQ and/or partner agency staff used an instrument called a solar pathfinder to collect effective shade measurements in the field. The effective shade measurement methods and quality control procedures used are outlined in the Water Quality Monitoring Technical Guide Book (OWEB, 1999) and the solar pathfinder manual (Solar Pathfinder, 2016). Table 5-7 lists the locations where effective shade measurements were collected and the effective shade value for August 2002.

Table 5-7: Effective shade data collected in the Middle Columbia-Hood (Miles Creeks) Subbasin.

Station ID	Station	Latitude/Longitude	Effective Shade (%)	Data Source
No Station ID	Fifteenmile at forest boundary	45.3866/-121.34	92	USFS
28973-ORDEQ	Fifteenmile upstream Pine Creek/Hwy 97	45.4506/-121.121	72	DEQ
28975-ORDEQ	Fifteenmile upstream Underhill's diversion near river mile 34	45.4391/-121.186	62	Wasco SWCD
28976-ORDEQ	Fifteenmile upstream Ramsey Creek	45.4331/-121.218	76	DEQ
28977-ORDEQ	Fifteenmile downstream Dufur City intake	45.3957/-121.279	82	Wasco SWCD
FM200	Fifteenmile at Petersburg upstream of Eightmile Creek	45.6113/-121.075	95	ODFW
FM2100	Fifteenmile downstream Lyda Diversion	45.3859/-121.337	51	ODFW
FM900	Fifteenmile at Emerson Loop Rd. (u/s Standard Hollow)	45.5455/-120.98	7	ODFW
No Station ID	Fifteenmile at Dufur City Park	45.4511/-121.126	11	DEQ
No Station ID	Fifteenmile at ISCO site	45.6308/-121.055	5	DEQ
No Station ID	Fifteenmile downstream Underhills diversion near river mile 34	45.4393/-121.185	43	DEQ
No Station ID	Fifteenmile upstream Dry Creek	45.5049/-121.049	7	Wasco SWCD

Station ID	Station	Latitude/Longitude	Effective Shade (%)	Data Source
No Station ID	Fifteenmile upstream mouth	45.6112/-121.119	10	DEQ
No Station ID	Eightmile Creek upstream Fifteenmile Rd	45.6055/-121.084	82	ODFW
No Station ID	Eightmile Creek downstream Fivemile Creek	45.5933/-121.081	81	Wasco SWCD
No Station ID	Eightmile Creek downstream county bridge	45.5603/-121.059	87	Wasco SWCD
No Station ID	Eightmile Creek upstream Endersby bridge	45.4918/-121.152	47	ODFW
No Station ID	Eightmile Creek at River Mile 19	45.4558/-121.272	87	ODFW
No Station ID	Eightmile Creek downstream Road 4430	45.4068/-121.452	74	USFS
No Station ID	Eightmile Creek upstream Road 4430	45.4067/-121.458	100	USFS
No Station ID	Eightmile Creek upstream Road 44	45.3944/-121.499	88	USFS
No Station ID	Ramsey Creek at mouth	45.4337/-121.218	100	ODFW
No Station ID	Ramsey Creek at Ramsey Rd. (new forest boundary)	45.4231/-121.275	55	USFS
No Station ID	Ramsey downstream Road 4450	45.3934/-121.425	89	ODFW

5.2 Data gaps

Non-steady state stream models typically require a significant amount of data because of the large spatial and temporal extents the models typically encompass. As the model size or modeling period increases, the amount of information needed to parameterize it also increases. Often it is not possible to parameterize a model entirely from field data because it can be resource intensive or impractical to collect everything that is needed. In general, these data gaps may be considered and addressed in a number of ways. Table 5-8 summarizes methods that are used to derive the data needed to parameterize the model.

To the greatest extent possible, the method used to derive the model parameters for the existing TMDL models has been summarized in the specific sub-section for each model (sections 5.6 through 5.8).

Table 5-8: Methods to derive model parameters for data gaps.

Method	Possible Parameters	Description
Direct surrogate	Tributary temperatures, meteorological inputs, sediment	Often, neighboring or nearby tributary watersheds share climatological and landscape features. Model parameters with incomplete records or no data may be parameterized using data from a neighboring or nearby location where data are available.

Method	Possible Parameters	Description
Calibration adjustment	All inputs	In some instances, a significant input may be required for appropriate representation in the modeling; however, little may be known about the nature of that input. An example of this is groundwater influx and temperature. Datasets for these inputs can be estimated by adjusting the necessary values within acceptable ranges during the calibration process.
Literature-based values	All inputs	Literature values are often used for model parameters or unquantified model inputs when little is known about the site-specific nature of those inputs. Examples of these types of parameters include stream bed heat transfer properties, hyporheic characteristics, or substrate porosity (Bencala and Walters, 1983; Sinokrot and Stefan, 1993; Hart, 1995; Pelletier et al., 2006).
Mass balance	Tributary temperature and flow	On mainstem-modeled reaches, tributary stream flow or temperature can be estimated using a mass balance approach assuming either flow or temperature data for the tributary are known. If estimating temperature, flow is required, and if estimating flow, temperature is required. Often TIR data are used to estimate tributary flow because upstream, downstream, and tributary temperatures are known, and upstream and tributary flows are known (or estimated).
Simple linear regression	Tributary temperature and flow	Parameters such as flow and temperature in neighboring or nearby tributaries often demonstrate similar diurnal patterns or hydrographs which allow for the development of suitable mathematical relationships (simple linear regression) in order to fill the data gaps for those inputs. This method requires at least some data exist for the incomplete dataset in order to develop the relationship.
Drainage area ratio	Tributary flow	For ungaged tributaries, flows can be estimated using the ratio between the watershed drainage areas of the ungaged location and from a nearby gaged tributary (Risley, 2009; Gianfagna, 2015; Ries et al., 2017). For example, if the watershed area upstream of a gaged tributary is 10 km^2, and the watershed area of an ungaged tributary is 5 km^2, the flows in the ungaged tributary are estimated to be half of those in the gaged tributary. The method is typically used to calculate low flow or flood frequency statistics. In that context, a weighting factor is recommended when the drainage area ratio of the two sites is between 0.5 and 1.5. Weighting factors can be evaluated if instantaneous observed flows are available at the ungaged location.
Flow-probability-probability-flow (QPPQ)	Tributary flow	The flow-probability-probability-flow (QPPQ) method makes use of relating flow duration curves between a gaged tributary and an ungaged tributary (Lorenz and Ziegeweid, 2016). The flow duration curve at ungaged sites is estimated using regression approaches (Risley et al., 2008) and the online USGS tool StreamStats (Ries et al., 2017).

Method	Possible Parameters	Description
Adiabatic adjustment	Air temperature	Air temperature can vary significantly throughout a watershed, particularly with large differences in elevation from headwaters to the mouth of the drainage. To account for these differences, air temperatures can be adjusted using an equation that relates air temperature measured at a meteorological station to a location of a given elevation using the dry adiabatic lapse rate of 9.8 °C/km and the differences in elevation.
GIS Data	Channel position, Channel width, Land cover, Gradient, Elevation, Topographic shade angles	Several landscape-scale GIS data sets can be used to derive a number of model parameters. Digital orthophoto quadrangles (DOQs) are used to classify land cover and estimate vegetation type, height, density, and overhang. DOQs can also be used to determine stream position, stream aspect, and channel width. A digital elevation model (DEM) consists of digital information that provides a uniform matrix of terrain elevation values. It provides basic quantitative data for deriving surface elevation, stream gradient, and maximum topographic shade angles.

5.3 Important assumptions

The effort currently described in the QAPP includes use of existing models developed during the original Middle Columbia-Hood (Miles Creeks) TMDL (DEQ, 2008). Model setup and configuration assumptions used for that effort will be relied upon for new model scenarios included in this QAPP (see section 9). The calibrated models are not expected to be modified; however multiple new scenarios will be developed (section 9) that will utilize many of the parameter and configuration aspects of the calibrated models. It is assumed the parameters used in the calibrations are appropriate for the new model scenarios. The updated TMDL will document model setup assumptions and any changes to the calibrations. Assumptions related to the model theory and underlying model equations can be found in the model user guide (Boyd and Kasper, 2003).

5.4 Model parameters

Table 5-9 summarizes all of the user entered model inputs and parameters required to run Heat Source version 7, and identifies the subset of inputs and parameters that could possibly be modified to improve the calibration of the model. As stated in section 5, adjustments to the existing calibrated models are unlikely to occur as part of this project. However should adjustments be needed, it is unlikely all of the parameters listed in Table 5-9 will be used as calibration parameters; rather this list identifies the candidate model inputs that will be considered for adjustment through the calibration process. The following subsections briefly summarize the model parameter categories and why the parameters are candidates for adjustment during calibration.

5.4.1 Morphology

The morphology inputs that could be used as calibration parameters fall into two categories: channel hydraulics and bed conduction.

5.4.1.1 Channel hydraulics

These inputs include stream gradient, bottom width, side slope angle, and Manning's *n*. Channel hydraulics are important for predicting stream temperatures because they govern the surface area of water that could be exposed to solar radiation, the residence time for exposure, and the degree of light penetration into the water column. An alternative input to channel side slope input in Heat Source version 7 is the input of a width to depth ratio. Field data for these inputs are often difficult to collect over large spatial scales, and values can vary significantly on a small scale. Heat Source is a one-dimensional model and complex channel configurations are represented as a trapezoidal pattern. Adjustments to inputs that affect channel hydraulics are often necessary to calibrate the model.

5.4.1.2 Bed conduction

These inputs include hyporheic zone thickness, percent hyporheic exchange, and porosity. Bottom width and side slope angle also affect these inputs by controlling the wetted perimeter of the channel (i.e., the portion or lateral length of the channel bed in direct contact with the stream). These stream morphological characteristics largely govern heat and mass transfer across the stream bed. Typically, information on the waterbody sediment size class (e.g., bedrock, gravel, sand, silt) is used as the basis for selecting literature values for these inputs.

5.4.2 Meteorology

The two meteorological inputs typically modified in calibration are percent cloudiness and wind speed. Both cloudiness and wind speed can vary significantly on a small geographic scale and the distance to the source of the meteorological data is often much greater than the small-scale localized weather. Hence, adjusting wind and cloudiness is an appropriate calibration method to account for more site-specific weather patterns.

5.4.3 Inflows and Outflows

Mass and thermal inflows and outflows are inputs often adjusted during the calibration process. These inflows of heat and water consist of tributary and groundwater inflows as well as diversions (i.e., water rights withdrawals) and groundwater losses. The temporal and geographic extents of flow gaging and temperature monitoring on tributaries or groundwater are generally sparse. An effective way of improving the calibration is to complete a flow mass balance with available data, and then add, subtract, or adjust flows either globally or in specific locations within the bounds of the flow mass balance and available measurements, and the temperature response predicted by the model.

5.4.4 Vegetation

Vegetation characteristics input into the model are often derived from aerial imagery or LiDAR. The vegetation characteristics determine the degree to which near-stream vegetation has the capacity to block incidental solar radiation on the surface of the modeled waterbody. Three vegetation inputs incorporated into the model calibration process are the vegetation density, overhang, and height. Field measurements offer a general understanding of vegetation characteristics within the watershed; however, variability in these parameters can be significant on smaller geographic scales. To improve the model fit, these model inputs may be modified on a global scale for different vegetation classes within the bounds of available data.

Table 5-9: Summary of model inputs required for Heat Source version 7.

Input Type	Input/Parameter	Units	Calibration Parameter
General	Stream Length	kilometers	NO
General	Modeling Start Date	date (mm/dd/yyyy)	NO
General	Simulation Period	days	NO
General	Flush Initial Condition	days	NO
General	Time Zone	-	NO
General	Model Time Step	minutes	NO
General	Model Distance Step	meters	NO
General	Longitudinal Stream Sample Distance	meters	NO
General	Number Of Tributary Inflow Sites	-	NO
General	Number Of Meteorological Data Sites	-	NO
General	Include Evaporation Losses From Flow (True/False)	-	NO
General	Evaporation Method (Mass Transfer/Penman)	-	NO
General	Wind Function Coefficient a	unitless	NO
General	Wind Function Coefficient b	unitless	NO
General	Include Deep Alluvium Temperature (True/False)	-	NO
General	Deep Alluvium Temperature	degrees Celsius	NO
General	Distance Between Transect Samples	meters	NO
Meteorological Data	Meteorological Data Model Kilometers	kilometers	NO
Meteorological Data	Cloudiness	proportion (0-1)	YES
Meteorological Data	Wind Speed	meters/second	YES
Meteorological Data	Relative Humidity	proportion (0-1)	NO
Meteorological Data	Air Temperature	degrees Celsius	NO
Accretion	Stream Kilometers	kilometers	NO
Accretion	Accretion Inflow Rate	cubic meters/second	YES
Accretion	Water Temperature	degrees Celsius	YES
Accretion	Withdrawal Flow Rate	cubic meters/second	YES
Boundary Condition	Boundary Condition Inflow Rate	cubic meters/second	NO
Boundary Condition	Water Temperature	degrees Celsius	NO
Tributary	Tributary Inflow Model Kilometers	kilometers	NO
Tributary	Tributary Inflow Rate	cubic meters/second	YES
Tributary	Water Temperature	degrees Celsius	YES
Land Cover Data	Node Longitude	decimal degrees	NO
Land Cover Data	Node Latitude	decimal degrees	NO

Input Type	Input/Parameter	Units	Calibration Parameter
Land Cover Data	Topographic Shade Angle - West	degrees	NO
Land Cover Data	Topographic Shade Angle - South	degrees	NO
Land Cover Data	Topographic Shade Angle - East	degrees	NO
Land Cover data	Landcover Ground Elevation	meters	NO
Land Cover Codes	Landcover Code	-	NO
Land Cover Codes	Landcover Height	meters	YES
Land Cover Codes	Canopy Density	proportion (0-1)	YES
Land Cover Codes	Landcover Overhang	meters	YES
Morphology Data	Stream Kilometer	kilometers	NO
Morphology Data	Channel Bed Elevation	meters	NO
Morphology Data	Channel Gradient	meters/meters	YES
Morphology Data	Channel Angle z	meters/meters	YES
Morphology Data	Manning's Roughness Coefficient, n	seconds/meter	YES
Morphology Data	Horizontal Bed Conductivity	Millimeters/second	NO
Morphology Data	Bed Particle Size	millimeters	YES
Morphology Data	Percent Embeddedness	proportion (0-1)	YES
Morphology Data	Rosgen Level I Stream Type	-	NO
Morphology Data	Width to Depth (W:D) Ratio	unitless	YES
Morphology Data	Bankfull Width	meters	NO
Morphology Data	X Factor	unitless	NO
Morphology Data	Stream Aspect	degrees	NO

5.5 Effective shade curves and lookup tables

Heat Source shade models estimate the solar flux and effective shade at any given location using internally calculated solar angles based on inputs of latitude and longitude, vegetation height, vegetation density, vegetation overhang, and vegetation buffer width, elevation, stream aspect, and channel width. The outputs of the shade models are used to produce effective shade curves. Effective shade curves are plots that present the maximum possible effective shade as a function of different types of natural near-stream vegetation, active channel widths, and stream aspects. Channel width is plotted on the x-axis, effective shade is on the y-axis, and a separate symbol and/or line color is used for each stream aspect. Separate plots are produced for each type of natural vegetation that is expected in the TMDL project area. The plots are called effective shade curves because the pattern on the plot resembles a gentle downward sloping curve. As channel width increases, effective shade gets smaller. The plots are produced from the output of Heat Source version 6 shade models that have been parameterized with every combination of the previously mentioned conditions. The effective shade curve approach can be used almost anywhere to quantify the amount of background solar radiation loading and the effective shade necessary to eliminate temperature increases from anthropogenic disturbance or removal of near-stream vegetation.

This model approach can also be used to develop a lookup table to determine the effective shade resulting from other combinations of vegetation height, vegetation density, vegetation overhang, and vegetation buffer widths that are different from background conditions. The lookup table provides a convenient way for readers of the TMDL to estimate the effective shade for current conditions without using the model. The lookup table can also be used as a reverse lookup to determine what vegetation height, buffer width, or vegetation density would achieve a certain effective shade.

5.5.1 Model boundaries

The effective shade models used to develop shade curves are not specific to any single waterbody but will be parameterized using a latitude and longitude located in the TMDL watershed to ensure that the modeled solar altitude and sun angles are appropriate for the area. There is minimal difference in solar altitude and sun angle at any given location within the TMDL project area. The differences are not large enough to affect shade results.

5.5.2 Spatial and temporal resolution

Vegetation in the model is parameterized along a transect perpendicular to the stream aspect on both the right and left sides. The transect includes nine vegetation samples with each sample being 4.6 meters apart. The total transect sample distance is 36.8 meters with the first sample being on the edge of the stream channel. The model time step (*dt*) is 1 minute and outputs are generated every hour.

5.5.3 Source characteristics

The effective shade curve approach can be used almost anywhere in the watershed to quantify the amount of background solar radiation loading and the effective shade necessary to eliminate temperature increases from anthropogenic disturbance or removal of near-stream vegetation.

The lookup tables can be used to estimate existing shade or current solar loading. Other potential sources of thermal loading and the temperature response will not be evaluated by this model.

5.5.4 Time frame of simulation

The model period is a single day in late July or early August. This time frame was chosen to characterize the solar loading when maximum stream temperatures are observed, the sun altitude angle is highest, and the period of solar exposure is longest. This period and set of conditions characterize the TMDL critical condition for effective shade. If shade targets are attained during this period, they will be attained in other times of the year, including the spawning period.

5.5.5 Important assumptions

Models used to develop effective shade curves assume no cloud cover and no topographic shade. The modeled terrain is flat so there is no difference in ground elevation between the stream and the adjacent vegetation buffer area. The vegetation density, vegetation height, vegetation overhang, and vegetation buffer width are assumed to be equal on both sides of the stream. The width of the active channel is assumed to be equal to the distance between near-stream vegetation on either side of the stream. The models also use the same latitude and longitude located in the TMDL project area. There is minimal difference in solar altitude and sun angle at any given location within the TMDL project area. The differences are not large enough to affect shade results.

Effective shade curves were developed for the original Middle Columbia-Hood (Miles Creeks) Subbasin TMDL (DEQ, 2008). Adjustments to the existing shade curve models are unlikely to occur as part of this project. However, if it is determined that the models need to be updated, DEQ will follow the procedures outlined in this QAPP.

5.5.6 Model inputs

There are two categories of models, each with different sets of inputs:

- **Effective shade curves**: Model input values for vegetation height, vegetation density, vegetation overhang, and vegetation buffer width correspond to the restored streamside vegetation types expected in areas that are currently lacking streamside vegetation because of anthropogenic disturbance. The specific values will be determined during the TMDL process and will likely be the same or similar to the values presented in the Middle Columbia-Hood (Miles Creeks) Subbasin TMDL (DEQ, 2008). The other model inputs are the same as what is described in Table 5-10.
- **Effective shade lookup tables**: Model input values to be used for the lookup tables are described in Table 5-10.

Table 5-10: Range of model inputs to be used for effective shade lookup tables.

Model Input	Value Range
Vegetation height (meters)	0 - 90 (or expected maximum)
Vegetation density (percent)	0 -100
Vegetation overhang (meters)	0 - 3 (or expected maximum)
Vegetation buffer width (meters)	0 - 45
Active channel width (meters)	0 - 100 (or expected maximum)
Stream aspect (degrees)	North/South (0/180); Northeast/Southwest (45/225); East/West (90/270); Southeast/Northwest (135/315)
Topographic shade angles (degrees)	0
Cloudiness	0

5.6 Eightmile Creek

The Eightmile Creek model is a shade model developed using Heat Source 7.0. The model was developed by DEQ.

5.6.1 Model boundaries

The extent of the model domain is Eightmile Creek from the headwaters to the confluence with Fifteenmile Creek (Figure 5-4).

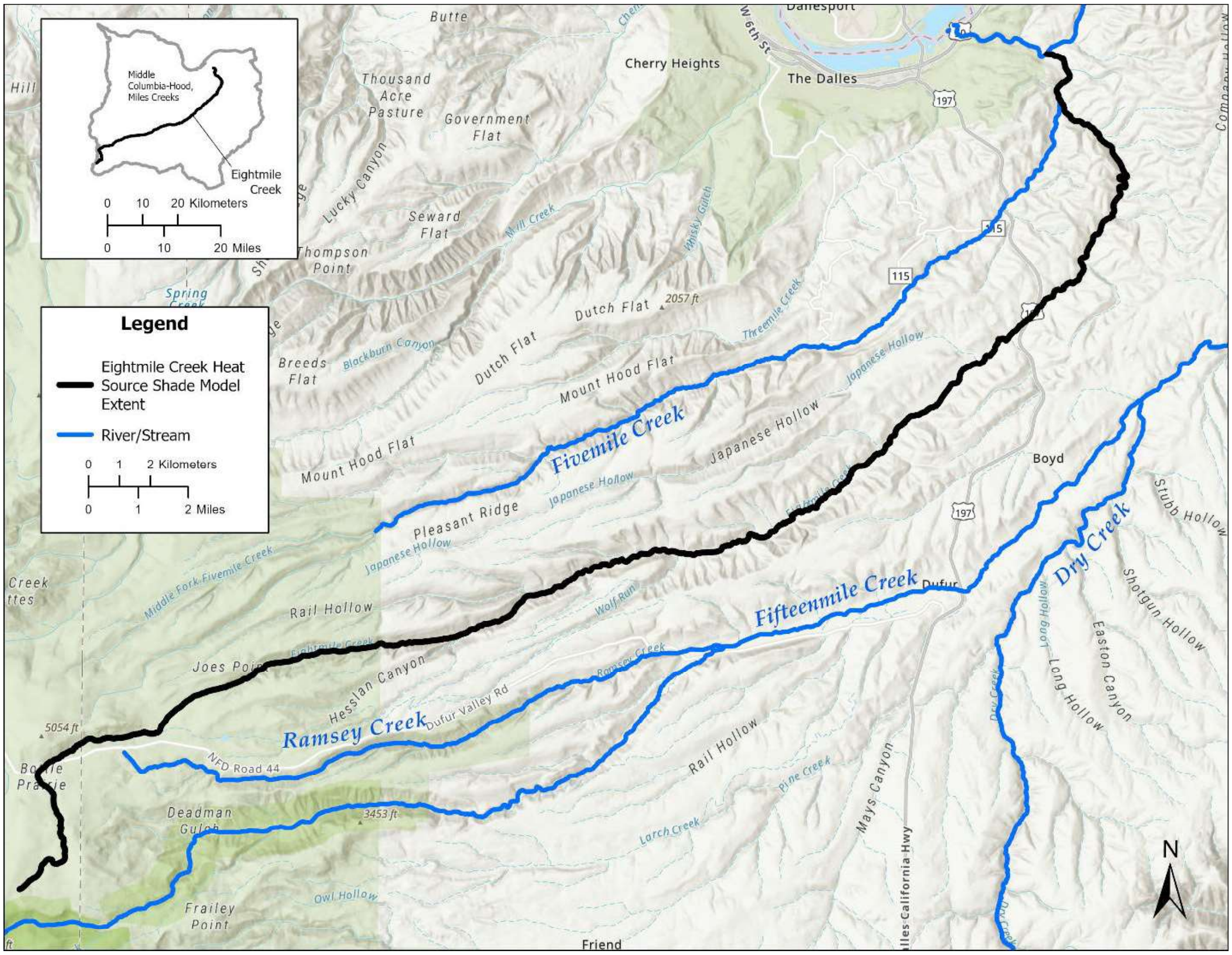

Figure 5-4: Eightmile Creek shade model extent.

5.6.2 Spatial and temporal resolution

The model input spatial resolution (*dx*) is 50 meters. Outputs are generated every 50 meters. The model time step (*dt*) is 1 minute and outputs are generated every hour.

A *dx* of 50 meters was chosen to capture the range of solar flux input caused by the varied vegetation conditions along the length of the stream. The high resolution *dx* will allow evaluation of multiple vegetation management scenarios for each designated management agency (DMA).

5.6.3 Source characteristics

The primary purpose of the Eightmile Creek solar model was to characterize the status of effective shade. Effective shade is a surrogate for solar radiation loading caused by the disturbance or removal of near-stream vegetation. Other potential sources of thermal loading were not evaluated by this model.

The majority land use along Eightmile Creek is forestry, accounting for about 73 percent of the near-stream area. Table 5-11 summarizes all the land uses within 100 meters of the digitized

Eightmile Creek centerline. Land uses were summarized using the 2016 National Land Cover Database (Yang et al., 2018).

Note that the removal of riparian vegetation is a major source of stream temperature warming, and typically occurs in developed or cultivated land uses. In some instances following vegetation removal, the land may cease to be actively managed and may enter the early stages of forest regrowth. For instance, Shrub/Scrub and Herbaceous land uses can be areas where forest clearcuts have occurred and would be classified as forest after regrowth.

Table 5-11: Summary of land uses along the model extent within 100 meters of the digitized Eightmile Creek centerline based on the 2016 National Land Cover Database (Yang et al., 2018).

2016 NLCD Land Cover	Acres	Percent of Total Acres
Evergreen Forest	1112.9	39.7
Shrub/Scrub	660.3	23.5
Cultivated Crops	485.7	17.3
Developed, Open Space	212.2	7.6
Herbaceous	186.1	6.6
Deciduous Forest	65.4	2.3
Developed, Low Intensity	42.7	1.5
Mixed Forest	18.9	0.7
Emergent Herbaceous Wetlands	15.6	0.6
Woody Wetlands	4.2	0.1
Developed, Medium Intensity	1.6	0.1

Anthropogenic-related stream warming caused by the removal of effective shade is closely associated with the uses, the activities, and the condition of vegetation adjacent to the stream. How activities and uses are managed in these areas is partially determined by a variety of different rules and management plans established by the landowner and any agency with land use authority. To better understand the spatial distribution of different agency rules or management plans along the model extent, DEQ mapped known DMAs (Table 5-12).

A DMA is defined in OAR 340-042-0030(2) as a federal, state, or local governmental agency that has legal authority over a sector or source contributing pollutants. Typically, persons or DMAs that are identified in the TMDL Water Quality Management Plan (WQMP) are responsible for developing TMDL implementation plans and implementing management strategies to reduce pollutant loading. Table 5-12 summarizes the potential DMAs and responsible persons along Eightmile Creek model extent.

Table 5-12: Summary of potential designated management agencies (DMAs) or responsible persons along the model extent within 100 meters of the digitized Eightmile Creek centerline.

DMA or Responsible Person	Acres	Percent of Total Acres
Oregon Department of Agriculture	1793.5	61.9
U.S. Forest Service	881.0	30.4
Wasco County	104.0	3.6
Oregon Department of Forestry - Private Forestland	102.5	3.5
U.S. Bureau of Land Management	8.7	0.3
Oregon Department of Transportation	8.4	0.3

5.6.4 Time frame of simulation

The model period is for a single day: July 17, 2002. Shade modeling periods are typically set to a day in July or August, when solar altitudes peak and shade is at a minimum.

5.6.5 Model parameters

The inputs to the model include aerial imagery-derived vegetation heights and stream position. The model was calibrated by comparing the modeled effective shade predictions to the field measured effective shade values summarized in Table 5-13 and displayed in Figure 5-5. The model location in the table below describes the distance of each input from the most downstream model node.

Two or three measurements were taken at each location and averaged for a reach measurement. Adjustments to the calibrated model are not planned or expected but may occur in the event of an error. If it is determined that the model calibration needs to be modified to improve model fit, the three landcover parameters (landcover height, density, and overhang) will be candidates for adjustment. Note that these adjustments would be conducted at a global scale for each land cover class, and would not involve site-specific modifications.

Table 5-13: Calibration sites and parameters used in the Eightmile Creek Heat Source model.

Model Location Name (Station ID)	Model Location (km)	Calibration Parameter	Measurement Date	Data Source
Eightmile Creek upstream Road 44	53.30	Effective Shade	August 2002	USFS
Eightmile Creek upstream Road 4430	49.45	Effective Shade	August 2002	USFS
Eightmile Creek downstream Road 4430	48.95	Effective Shade	August 2002	USFS
Eightmile Creek at River Mile 19	32.65	Effective Shade	August 2002	ODFW
Eightmile Creek upstream Endersby bridge	20.50	Effective Shade	August 2002	ODFW
Eightmile Creek downstream county bridge	7.80	Effective Shade	August 2002	Wasco SWCD
Eightmile Creek downstream Fivemile Creek	2.20	Effective Shade	August 2002	Wasco SWCD
Eightmile Creek upstream Fifteenmile Rd	0.20	Effective Shade	August 2002	ODFW

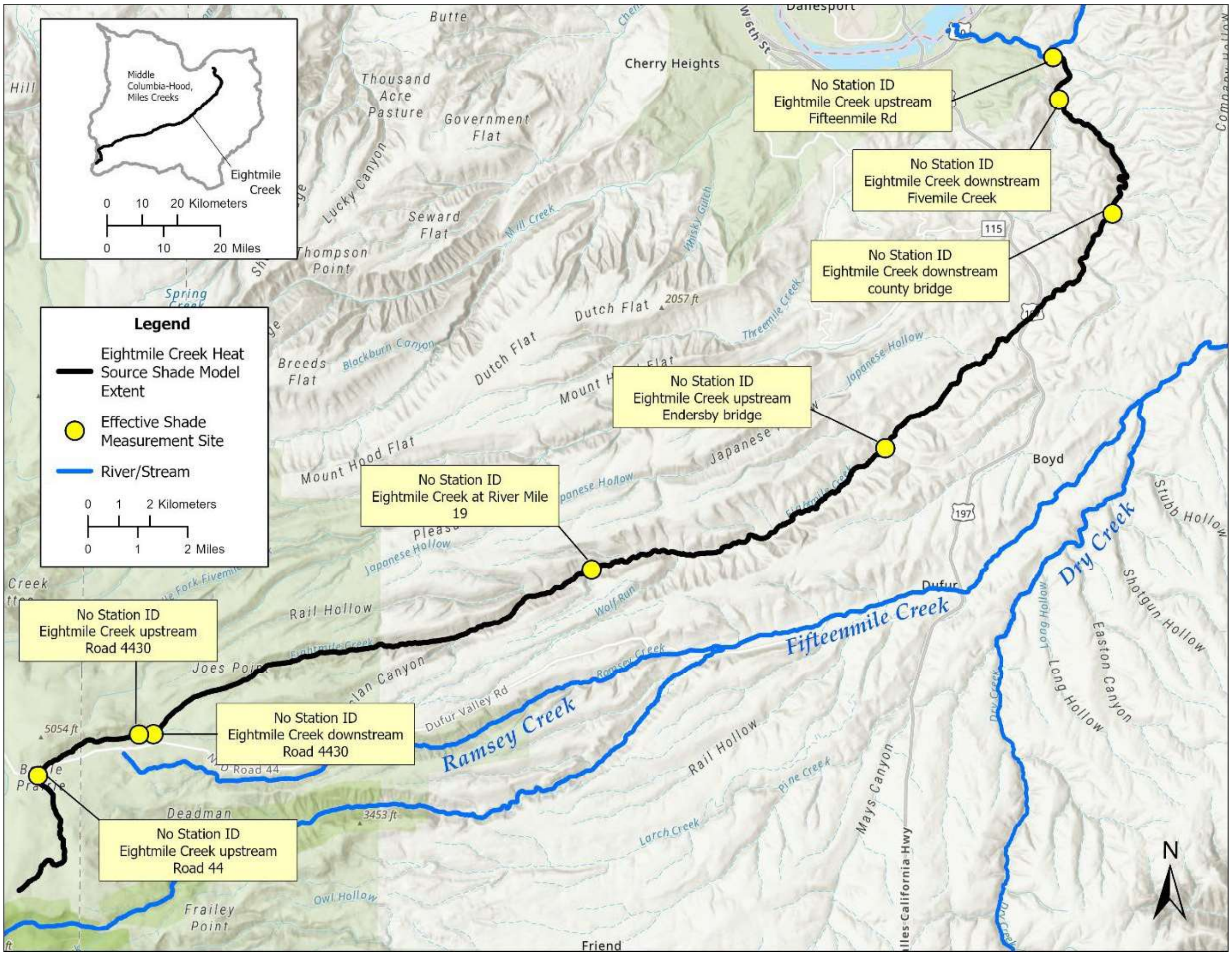

Figure 5-5: Effective shade measurement locations used for the Eightmile Creek model calibration.

5.7 Fifteenmile Creek

The Fifteenmile Creek model is a temperature model developed using Heat Source 7.0. The model was developed by DEQ.

5.7.1 Model boundaries

The extent of the model domain is Fifteenmile Creek from downstream of N South Road to the mouth at the Columbia River (Figure 5-6).

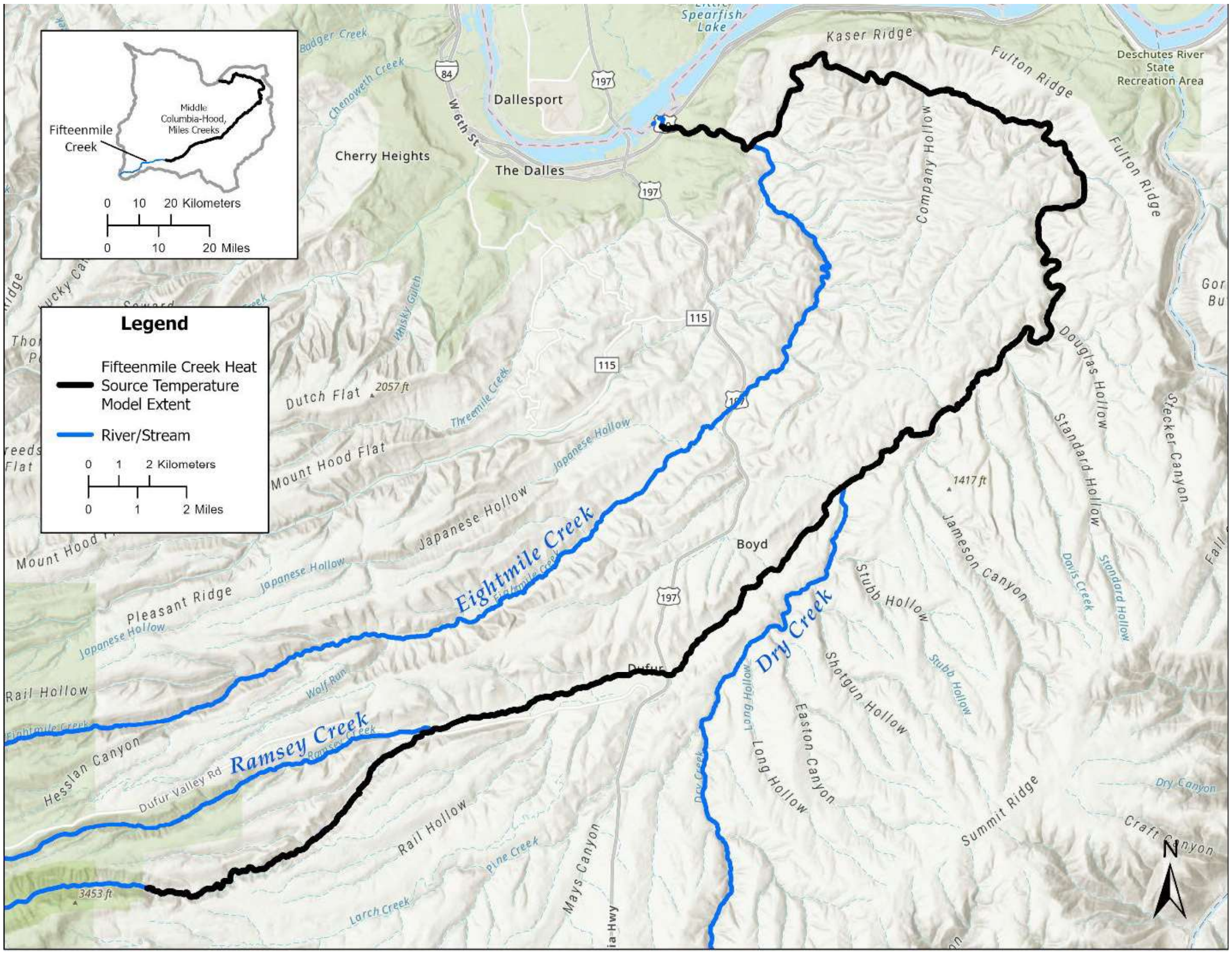

Figure 5-6: Fifteenmile Creek temperature model extent.

5.7.2 Spatial and temporal resolution

The model input spatial resolution (*dx*) is 50 meters. Outputs are generated every 100 meters. The model time step (*dt*) is 1 minute and outputs are generated every hour.

A *dx* of 50 meters was chosen to capture the range of solar flux input caused by the varied vegetation conditions along the length of the stream. The high resolution *dx* will allow evaluation of multiple vegetation management scenarios for each DMA.

5.7.3 Source characteristics

The primary sources of thermal loading contributing to temperature exceedances in Fifteenmile Creek include increases in solar radiation loading from the disturbance or removal of near-stream vegetation, point source discharges, reductions to the stream flow rate or volume, and background sources (DEQ, 2008). Other sources include warming caused by climate change and potential contributions from channel modification and widening. The contribution of these latter potential sources will be investigated as part of a literature review and using results of the original TMDL model analyses. New model scenarios will only be developed if time allows.

There is one permitted individual NPDES point source discharging within the model extent, Dufur STP (Table 5-14). The current NPDES permit (#102478) does not authorize Dufur STP to discharge to Fifteenmile Creek from May 1 – October 31. Discharge is also not allowed from November 1 – April 30 when the temperature in Fifteenmile Creek is greater than 10°C or when creek flow is less than 5 cfs.

Dufur STP is undergoing a project for improvements that will allow for lagoon storage of wastewater in the winter and irrigation of Class D recycled water under a recycled water use plan in the crop growing season to two land application areas. The discharge to Fifteenmile Creek will cease and the NPDES permit will be terminated upon request from the permittee in accordance with Mutual Agreement and Order (MAO) No. WQ/M/ER-2007-0083. Per Justin Sterger of DEQ Permitting, termination of the permit and cessation of discharge to Fifteenmile Creek is expected to occur in May of 2026. The City has historically had issues meeting surface water limits imposed by the NPDES permit and a mutual agreement and order during November 1 – April 30 time period. The cessation of surface water discharge is the City's selected alternative in-lieu of upgrades to meet surface water discharge limits.

Table 5-14: Summary of individual NPDES permitted discharges in Fifteenmile Creek.

Facility Name (Facility Number)	Latitude/Longitude	Permit Type and Description	Stream/River Mile
Dufur STP (25491)	45.4508/-121.1231	NPDES-DOM-Db: Sewage - less than 1 MGD with discharging lagoons	Fifteenmile Creek RM 30.3

The majority land uses along Fifteenmile Creek are forestry and agriculture, accounting for about 91 percent of the near-stream area. Table 5-15 summarizes all the land uses within 100 meters of the digitized Fifteenmile Creek centerline. Land uses were summarized using the 2016 National Land Cover Database (Yang et al., 2018).

Note that the removal of riparian vegetation is a major source of stream temperature warming, and typically occurs in developed or cultivated land uses. In some instances following vegetation removal, the land may cease to be actively managed and may enter the early stages of forest regrowth. For instance, Shrub/Scrub and Herbaceous land uses can be areas where forest clearcuts have occurred and would be classified as forest after regrowth.

Table 5-15: Summary of land uses along the model extent within 100 meters of the digitized Fifteenmile Creek centerline based on the 2016 National Land Cover Database (Yang et al., 2018).

2016 NLCD Land Cover	Acres	Percent of Total Acres
Shrub/Scrub	1319.9	38.7
Cultivated Crops	887.6	26
Herbaceous	363.2	10.7
Evergreen Forest	360.9	10.6
Developed, Open Space	205.5	6
Hay/Pasture	97.6	2.9
Developed, Low Intensity	66.3	1.9
Emergent Herbaceous Wetlands	30.9	0.9
Deciduous Forest	29.8	0.9
Woody Wetlands	25.4	0.7

2016 NLCD Land Cover	Acres	Percent of Total Acres
Developed, Medium Intensity	17.6	0.5
Mixed Forest	4.0	0.1
Developed, High Intensity	0.9	<0.05

Anthropogenic-related stream warming caused by nonpoint sources is closely associated with the uses, the activities, and the condition of vegetation adjacent to the stream. How activities and uses are managed in these areas is partially determined by a variety of different rules and management plans established by the landowner and any agency with land use authority. To better understand the spatial distribution of different agency rules or management plans along the model extent, DEQ mapped known DMAs (Table 5-16).

A DMA is defined in OAR 340-042-0030(2) as a federal, state, or local governmental agency that has legal authority over a sector or source contributing pollutants. Typically, persons or DMAs that are identified in the TMDL WQMP are responsible for developing TMDL implementation plans and implementing management strategies to reduce pollutant loading. Table 5-16 summarizes the potential DMAs and responsible persons along the Fifteenmile Creek model extent.

Table 5-16: Summary of potential designated management agencies (DMAs) or responsible persons along the model extent within 100 meters of the digitized Fifteenmile Creek centerline.

DMA or Responsible Person	Acres	Percent of Total Acres
Oregon Department of Agriculture	2925.0	81.7
Wasco County	362.4	10.1
Oregon Department of Forestry - Private Forestland	92.4	2.6
City of Dufur	65.4	1.8
Confederated Tribes of Warm Springs	58.3	1.6
Union Pacific Railroad	27.6	0.8
U.S. Forest Service	13.8	0.4
U.S. Bureau of Land Management	13.0	0.4
U.S. Government	12.3	0.3
Oregon Department of Transportation	8.9	0.2
Bonneville Power Administration	0.9	<0.05
Oregon Department of State Lands - Waterway	0.7	<0.05

5.7.4 Time frame of simulation

The model period is July 17, 2002 to August 5, 2002. Temperature model periods are typically set in July or August, to coincide with peak stream temperatures.

The TMDL will provide load and wasteload allocations for sources of thermal loads. The existing Heat Source models from the 2008 Middle Columbia-Hood (Miles Creeks) Subbasin TMDL were developed primarily to address summer (non-spawning) periods in 2002 for Eightmile Creek, Fifteenmile Creek, and Ramsey Creek. The Fifteenmile Creek model extent includes the discharge from Dufur STP, the only individual NPDES permittee within the TMDL project boundary. Dufur STP does not discharge during the summer months, and therefore does not affect Fifteenmile Creek stream temperatures during the critical summer conditions. As mentioned above, discharge to Fifteenmile Creek is expected to cease in May of 2026.

Analyses of Fifteenmile Creek stream temperature data collected from 1998-2023 show the temperature criteria are typically exceeded between March 15 through October 31. Within this period, the 13°C numeric spawning criterion applies between March 15 and April 30, which falls within the timeframe that Dufur STP is currently permitted to discharge. The existing model does not cover this particular time period. However, it is not necessary to develop a new calibrated model, as any permitted discharge may only occur when Fifteenmile Creek temperatures are 10 °C and below. In addition, Dufur STP is the only point source discharge to Fifteenmile Creek, eliminating the potential cumulative warming from multiple point source discharges. The point of maximum impact is expected to be at the facility outfall, so a mass balance and mixing equation will be used to determine the appropriate HUA assignment for Dufur STP during the 13°C spawning period.

5.7.5 Model parameters

The model calibration sites and data sources for model inputs are summarized in Table 5-17 through Table 5-19, with locations of temperature and flow monitoring sites shown in Figure 5-7 and Figure 5-8, respectively. Effective shade model calibration sites are summarized in Table 5-20, with locations shown in Figure 5-9. The model inputs and parameters expected to be modified in the event of recalibration are described in Section 6.1.

Hourly meteorology inputs into the model include air temperature, relative humidity, and wind speed. Air temperature data were modified using the dry adiabatic lapse rate to adjust for differences in elevation between the measurement location and the model input location. Wind speeds were adjusted to improve the calibration using a wind-sheltering coefficient to represent difference in wind speed between the measurement location and above the stream within the riparian area.

Table 5-17: Stream temperature monitoring sites supporting Fifteenmile Creek model development.

Monitoring Location ID	Monitoring Location Name	Data Source	Latitude	Longitude	Model Use
28968-ORDEQ	Fifteenmile downstream of Standard Hollow	Wasco County SWCD	45.5453	-120.98	Calibration
28972-ORDEQ	Fifteenmile downstream of Big Spring Gulch	Wasco County SWCD	45.6198	-120.991	Calibration
28973-ORDEQ	Fifteenmile upstream of Pine Creek	Wasco County SWCD	45.4502	-121.119	Calibration
28975-ORDEQ	Fifteenmile upstream of Underhill's Diversion	Wasco County SWCD	45.4391	-121.186	Calibration
28976-ORDEQ	Fifteenmile upstream of Ramsey	Wasco County SWCD	45.4309	-121.225	Calibration
28977-ORDEQ	Fifteenmile at Dufur Reservoir Intake	Wasco County SWCD	45.3958	-121.279	Calibration
FM1200	Fifteenmile at Ashbrook pump	ODFW	45.4499	-121.137	Calibration
FM200	Fifteenmile at Petersburg upstream of Eightmile Creek	ODFW	45.6113	-121.075	Calibration

Monitoring Location ID	Monitoring Location Name	Data Source	Latitude	Longitude	Model Use
FM2100	Fifteenmile downstream of Lyda	DEQ	45.3866	-121.34	Calibration
FM900	Fifteenmile upstream of Standard Hollow	ODFW	45.5455	-120.98	Calibration
No Station ID	Fifteenmile upstream of Dry Creek	Wasco County SWCD	45.5049	-121.049	Calibration
No Station ID	Ramsey Creek	ODFW	45.4337	-121.2180	Tributary
DC1300	Dry Creek	ODFW	45.5052	-121.0464	Tributary
No Station ID	Eightmile Creek	DEQ File	45.6064	-121.0851	Tributary
No Station ID	Fifteenmile Creek	DEQ File	45.3859	-121.3368	Boundary Condition

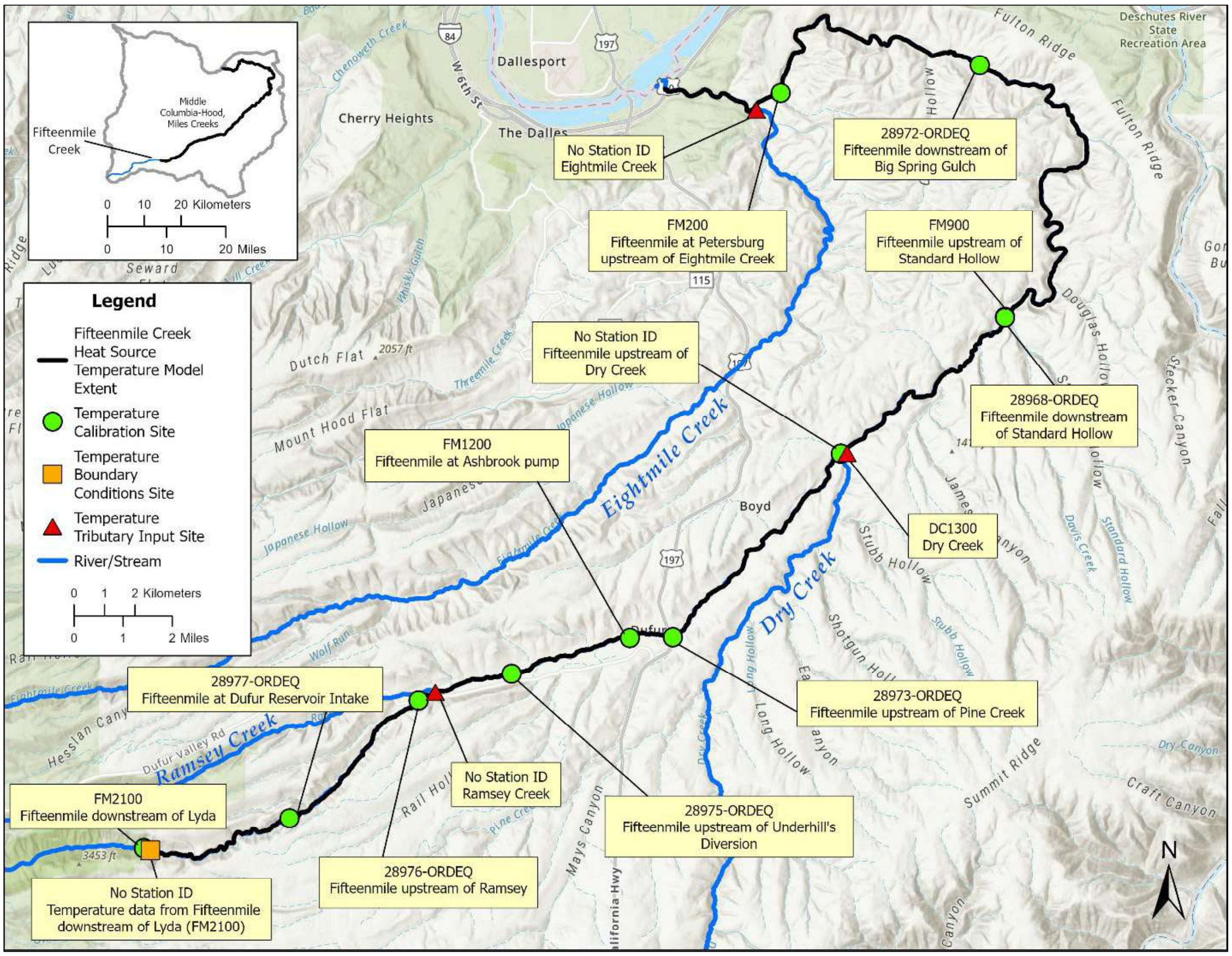

Figure 5-7: Temperature monitoring locations used for Fifteenmile Creek model setup and calibration.

Table 5-18: Continuous flow rate measurement sites supporting Fifteenmile Creek model development.

Monitoring Location ID	Monitoring Location Name	Data Source	Latitude	Longitude	Model Use
28976-ORDEQ	Fifteenmile upstream Ramsey Creek	OWRD	45.4331	-121.218	Calibration
No Station ID	Fifteenmile at ISCO site	OWRD	45.6308	-121.055	Calibration

Table 5-19: Instantaneous flow rate measurement sites supporting Fifteenmile Creek model development.

Monitoring Location ID	Monitoring Location Name	Data Source	Latitude	Longitude	Model Use
28977-ORDEQ	Fifteenmile downstream Dufur City intake	DEQ	45.3957	-121.279	Calibration
FM2100	Fifteenmile downstream Lyda Diversion	DEQ	45.3859	-121.337	Calibration
FM900	Fifteenmile at Emerson Loop Rd. (upstream Standard Hollow)	ODFW	45.5455	-120.98	Calibration
No Station ID	Fifteenmile at Dufur City Park	ODFW	45.4511	-121.126	Calibration
No Station ID	Fifteenmile downstream Underhills diversion	DEQ	45.4393	-121.185	Calibration
No Station ID	Fifteenmile upstream mouth	ODFW	45.6112	-121.119	Calibration
No Station ID	Eightmile Creek	DEQ	45.6064	-121.0851	Tributary
No Station ID	Ramsey Creek	OWRD	45.4337	-121.2180	Tributary
No Station ID	Fifteenmile Creek	DEQ	45.3859	-121.3368	Boundary Condition

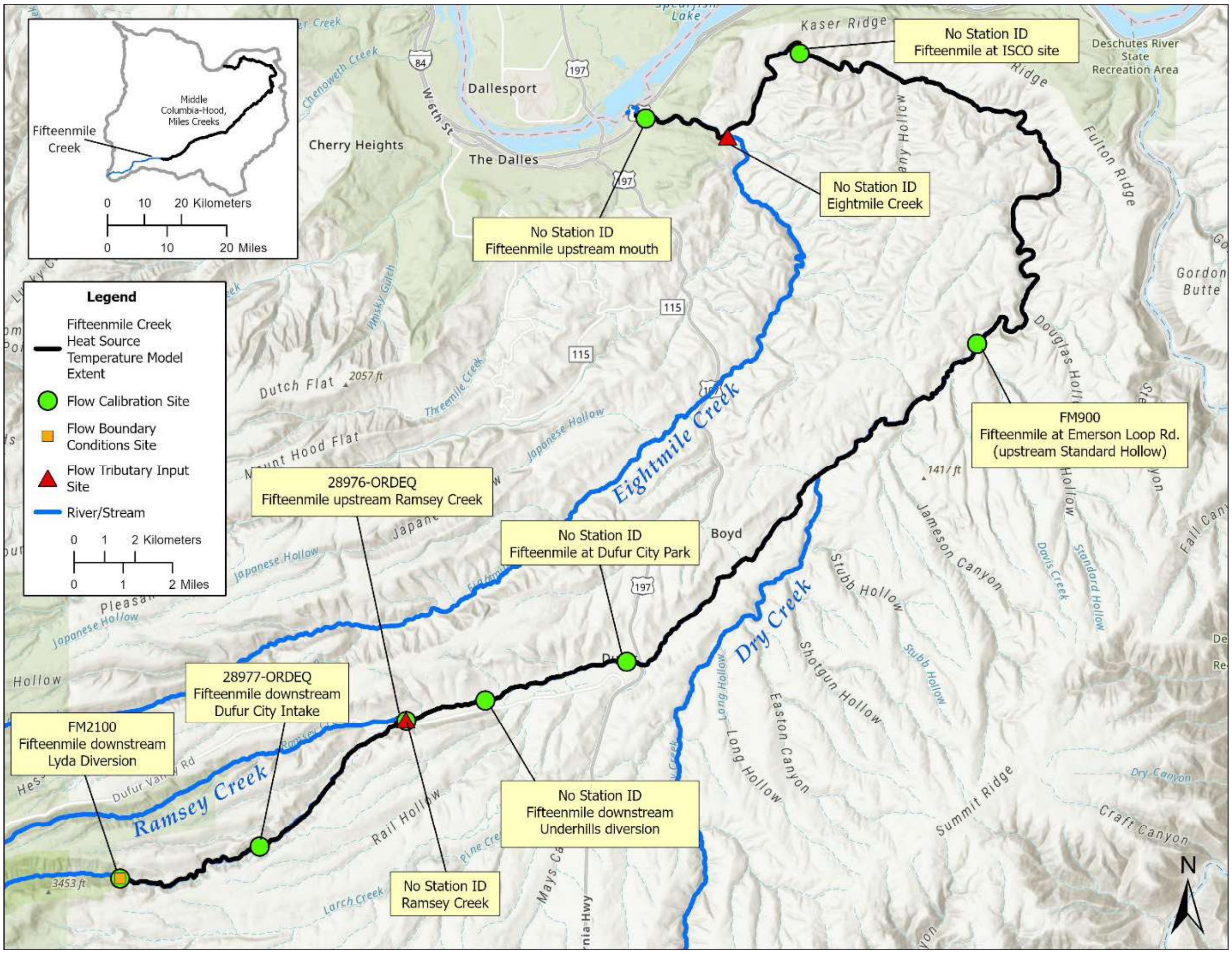

Figure 5-8: Flow monitoring locations used for the Fifteenmile Creek model setup and calibration.

Table 5-20: Effective shade monitoring sites supporting Fifteenmile Creek model development.

Model Location Name (Station ID)	Model Location (km)	Calibration Parameter	Measurement Date	Data Source
Fifteenmile downstream Lyda Diversion	70.5	Effective Shade	August 2002	ODFW
Fifteenmile downstream Dufur City intake	64.65	Effective Shade	August 2002	Wasco SWCD
Fifteenmile upstream Ramsey Creek	57.6	Effective Shade	August 2002	DEQ
Fifteenmile upstream Underhill's diversion near river mile 34	54.9	Effective Shade	August 2002	Wasco SWCD
Fifteenmile downstream Underhills diversion near river mile 34	54.75	Effective Shade	August 2002	DEQ
Fifteenmile at Dufur City Park	49.6	Effective Shade	August 2002	DEQ
Fifteenmile upstream Pine Creek/Hwy 97	49.15	Effective Shade	August 2002	DEQ
Fifteenmile upstream Dry Creek	39.7	Effective Shade	August 2002	Wasco SWCD

Model Location Name (Station ID)	Model Location (km)	Calibration Parameter	Measurement Date	Data Source
Fifteenmile at Emerson Loop Rd. (upstream Standard Hollow)	31.15	Effective Shade	August 2002	ODFW
Fifteenmile at ISCO site	9.1	Effective Shade	August 2002	DEQ
Fifteenmile at Petersburg upstream of Eightmile Creek	5.05	Effective Shade	August 2002	ODFW
Fifteenmile upstream mouth	0.65	Effective Shade	August 2002	DEQ
Fifteenmile at forest boundary		Effective Shade	August 2002	USFS

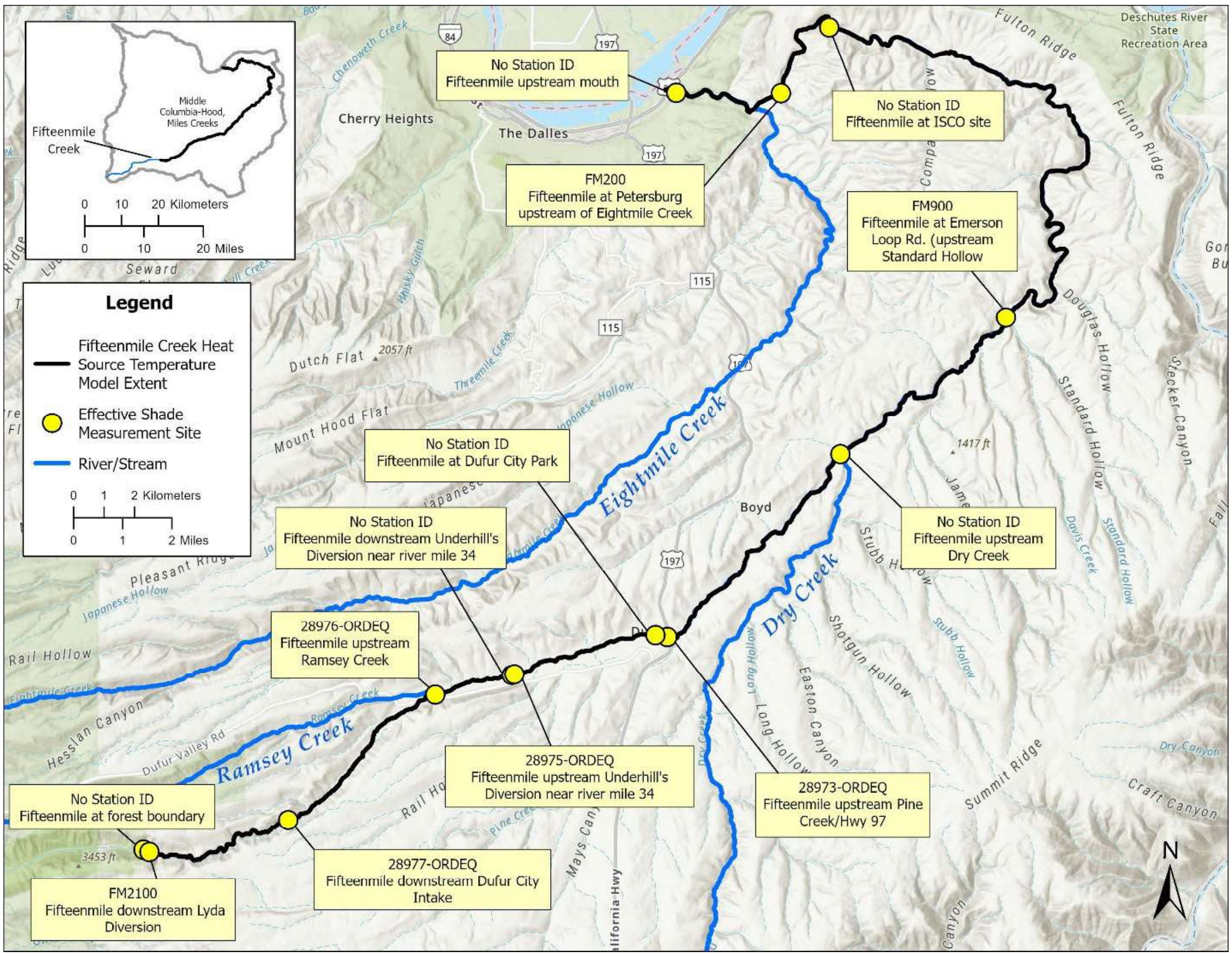

Figure 5-9: Effective shade measurement locations used for the Fifteenmile Creek calibration.

5.8 Ramsey Creek

The Ramsey Creek model is a shade model developed using Heat Source 7.1. The model was developed by DEQ.

5.8.1 Model boundaries

The extent of the model domain is Ramsey Creek from the headwaters to the confluence with Fifteenmile Creek (Figure 5-10).

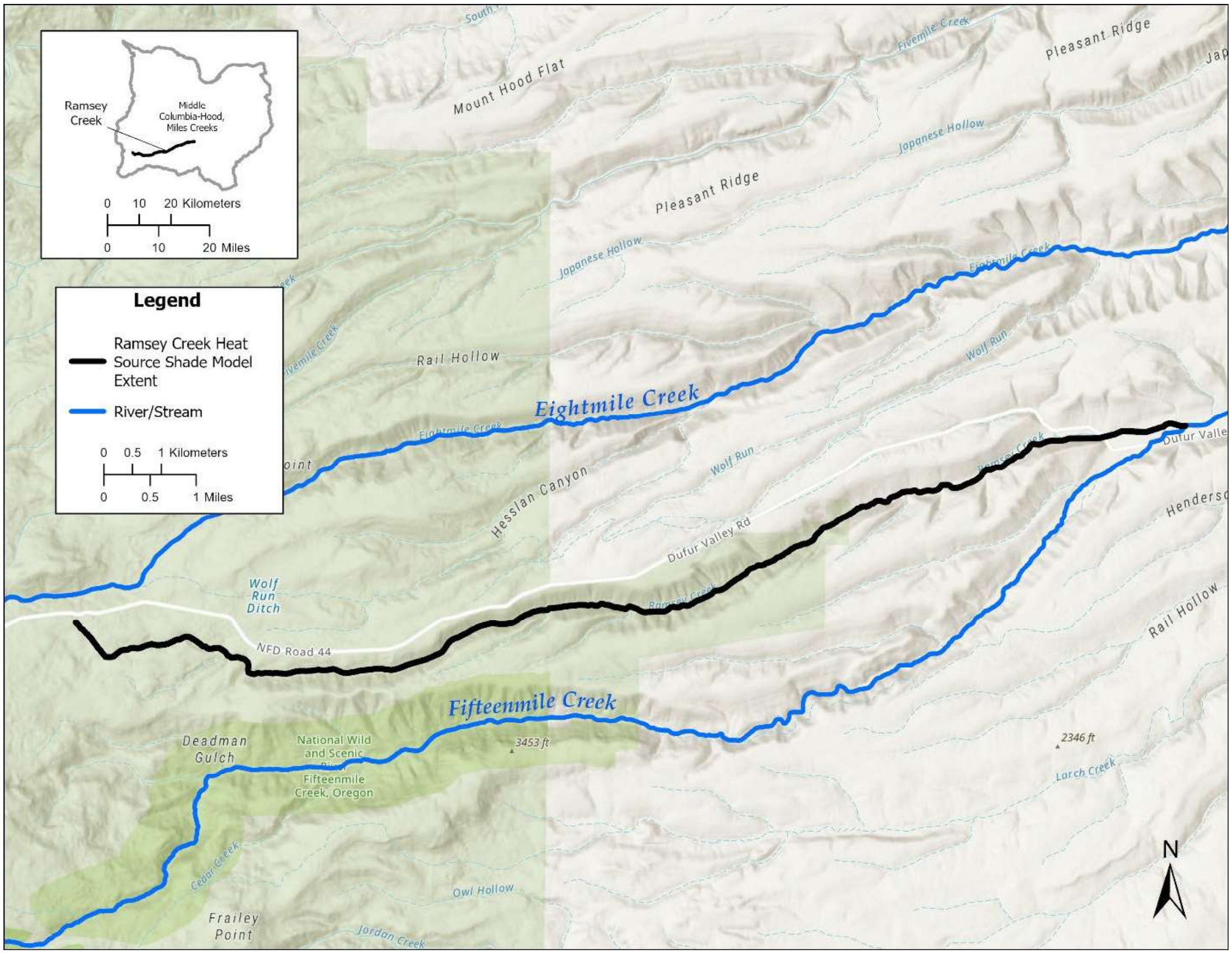

Figure 5-10: Ramsey Creek shade model extent.

5.8.2 Spatial and temporal resolution

The model input spatial resolution (*dx*) is 50 meters. Outputs are generated every 50 meters. The model time step (*dt*) is 1 minute and outputs are generated every hour.

A *dx* of 50 meters was chosen to capture the range of solar flux input caused by the varied vegetation conditions along the length of the stream. The high resolution *dx* will allow evaluation of multiple vegetation management scenarios for each DMA.

5.8.3 Source characteristics

The primary purpose of the Ramsey Creek solar model was to characterize the status of effective shade. Effective shade is a surrogate for solar radiation loading caused by the disturbance or removal of near-stream vegetation. Other potential sources of thermal loading were not evaluated by this model.

The majority land use along Ramsey Creek is forestry, accounting for about 85 percent of the near-stream area. Table 5-21 summarizes all the land uses within 100 meters of the digitized Ramsey Creek centerline. Land uses were summarized using the 2016 National Land Cover Database (Yang et al., 2018).

Note that the removal of riparian vegetation is a major source of stream temperature warming, and typically occurs in developed or cultivated land uses. In some instances following vegetation removal, the land may cease to be actively managed and may enter the early stages of forest regrowth. For instance, Shrub/Scrub and Herbaceous land uses can be areas where forest clearcuts have occurred and would be classified as forest after regrowth.

Table 5-21: Summary of land uses along the model extent within 100 meters of the digitized Ramsey Creek centerline based on the 2016 National Land Cover Database (Yang et al., 2018).

2016 NLCD Land Cover	Acres	Percent of Total Acres
Evergreen Forest	678.5	63.3
Shrub/Scrub	219.7	20.5
Cultivated Crops	132.8	12.4
Developed, Open Space	27.6	2.6
Herbaceous	9.1	0.8
Mixed Forest	3.6	0.3
Developed, Low Intensity	1.3	0.1

Anthropogenic-related stream warming caused by the removal of effective shade is closely associated with the uses, the activities, and the condition of vegetation adjacent to the stream. How activities and uses are managed in these areas is partially determined by a variety of different rules and management plans established by the landowner and any agency with land use authority. To better understand the spatial distribution of different agency rules or management plans along the model extent, DEQ mapped known DMAs (Table 5-22).

A DMA is defined in OAR 340-042-0030(2) as a federal, state, or local governmental agency that has legal authority over a sector or source contributing pollutants. Typically, persons or DMAs that are identified in the TMDL WQMP are responsible for developing TMDL implementation plans and implementing management strategies to reduce pollutant loading. Table 5-22 summarizes the potential DMAs and responsible persons along the Ramsey Creek model extent.

Table 5-22: Summary of potential designated management agencies (DMAs) or responsible persons along the model extent within 100 meters of the digitized Ramsey Creek centerline.

DMA or Responsible Person	Acres	Percent of Total Acres
U.S. Forest Service	715.7	64.2
Oregon Department of Agriculture	336.1	30.1
Oregon Department of Forestry - Private Forestland	44.9	4
Wasco County	13.5	1.2
U.S. Bureau of Land Management	5.1	0.5

5.8.4 Time frame of simulation

The model period is for a single day: July 17, 2002. Shade modeling periods are typically set to a day in July or August, when solar altitudes peak and shade is at a minimum.

5.8.5 Model parameters

The inputs to the model include aerial imagery-derived vegetation heights and stream position. The model was calibrated by comparing the modeled effective shade predictions to the field measured effective shade values summarized in Table 5-23 and isplayed in Figure 5-11. The model location in the table below describes the distance of each input from the most downstream model node.

Two or three measurements were taken at each location and averaged for a reach measurement. Adjustments to the calibrated model are not planned or expected but may occur in the event of an error. If it is determined that the model calibration needs to be modified to improve model fit, the three landcover parameters (landcover height, density, and overhang) will be candidates for adjustment. Note that these adjustments would be conducted at a global scale for each land cover class, and would not involve site-specific modifications.

Table 5-23: Calibration sites and parameters used in the Ramsey Creek Heat Source model.

Model Location Name (Station ID)	Model Location (km)	Calibration Parameter	Measurement Date	Data Source
Ramsey downstream Road 4450	18.70	Effective Shade	August 2002	ODFW
Ramsey Creek at Ramsey Rd. (new forest boundary)	5.10	Effective Shade	August 2002	USFS
Ramsey Creek at the mouth	0.05	Effective Shade	August 2002	ODFW

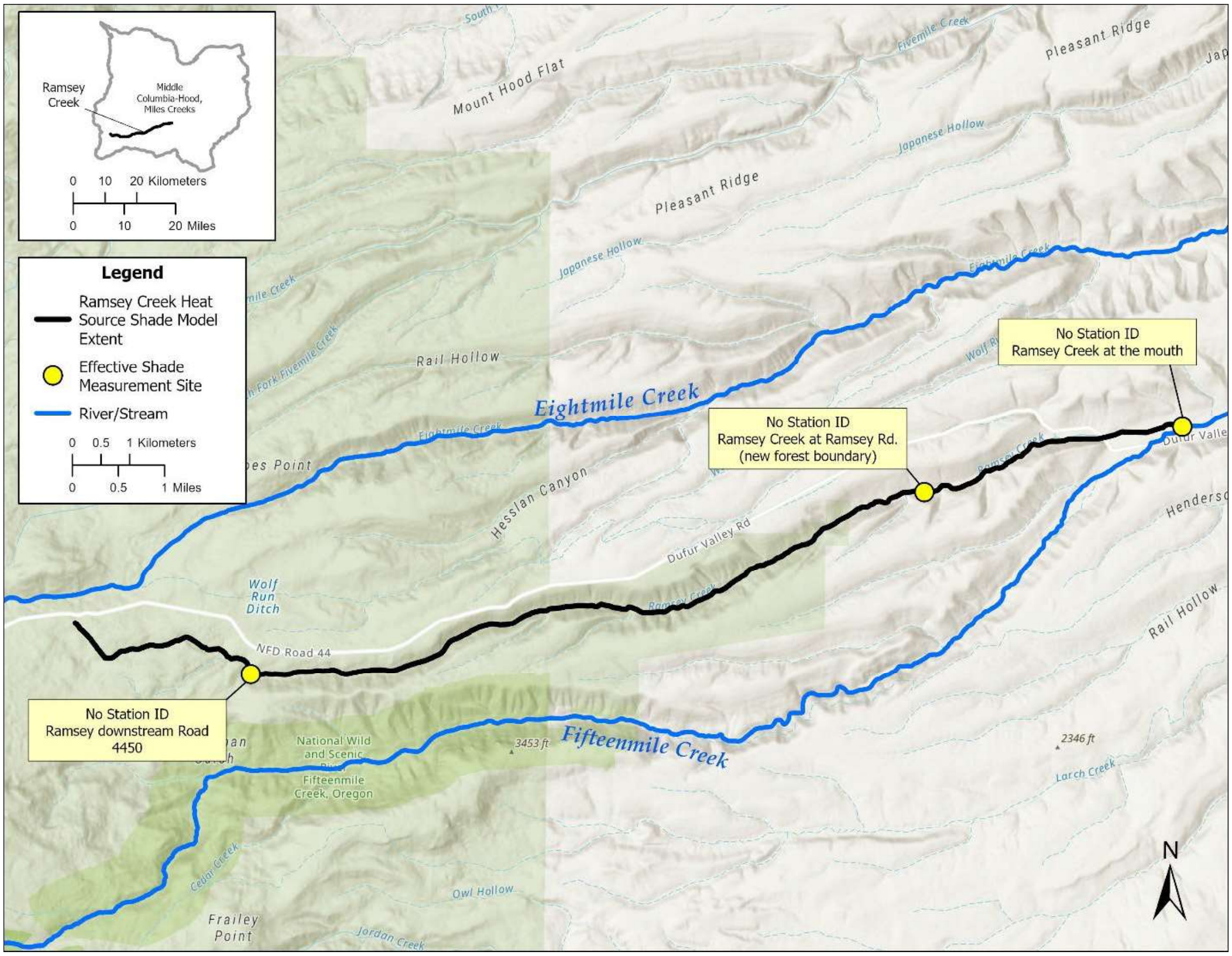

Figure 5-11: Effective shade measurement locations used for the Ramsey Creek model calibration.

6 Model evaluation and acceptance

6.1 Model uncertainty and sensitivity

Model uncertainty can arise from a number of sources, including error associated with measuring field parameters used for model input or calibration, lack of knowledge on the appropriate value to use for model parameters or constants, or an imperfect mathematical formulation in the model of real world physical processes. A model's sensitivity is the degree to which predictions are affected by changes in a single or multiple input parameters.

In many cases, the major source of uncertainty is due to uncertainty in spatial representation of the river channel and adjacent landcover (e.g., bathymetry, vegetation height and density) from lack of data or simplification, configuration of the boundary conditions (e.g., uncertainty in estimation of ungaged tributary flows or temperatures), and uncertainty from limited amount or spatial distribution of observed data used for calibration. These sources of uncertainty are largely unavoidable, but do not invalidate the use of the model for decision purposes.

During the calibration process, it is good practice to evaluate and minimize uncertainty associated with the model parameters to the greatest extent practical (Beck, 1987; EPA, 2009). During the model calibration process, the responsiveness of the model predictions to various assumptions and rate constants should be evaluated. The model setup should include parameters based on literature recommendations and best professional judgment.

Reducing uncertainty in measured field parameters used for model input and calibration is accomplished in the following ways:

- Data used for the TMDL must have been collected based on a project plan with quality assurance and quality control protocols for collecting and analyzing samples.
- The sampling and laboratory analysis must follow widely accepted scientific methods and protocols. These may include DEQ's Mode of Operations Manual (DEQ, 2024), USEPA methods, USGS's published techniques of water resources investigations, the USGS national field manuals, or standard methods for the examination of water and wastewater. All acceptable methods include applicable precision and accuracy checks.
- When possible, accuracy and precision should be evaluated using DEQ's data validation criteria as outlined in DEQ's data validation criteria for water quality parameters measured in the field (DEQ, 2013). The TMDL program uses waterbody results that demonstrate a data quality level of A, B, or E with careful review (DEQ, 2021). For continuous temperature data, a data quality of A or B corresponds to an absolute accuracy of 1.0°C and absolute precision of 2.0°C. Data of unknown quality lacking audit and pre and post accuracy checks may also be used following a careful review, where it is determined the results appear reasonable and free of issues based on professional judgment.

Uncertainties in the mathematical formulation are addressed by using open source models that allow free and transparent inspection of model code, and models that have had their methodologies peer reviewed and evaluated.

It is not anticipated that additional uncertainty or sensitivity analyses will be performed on the existing calibrated models.

6.2 Model acceptance

This section identifies the model acceptance criteria. Model acceptance relies on satisfying seven (7) conditions:

1) Incorporation of all available field observations of the system (e.g., geometry, flow, boundary inputs/withdrawals, and meteorology) for the time period simulated.
2) Model parameters and unmeasured boundary conditions that are within literature-supported and physically defensible ranges.
3) Model predicted results have been compared with the associated observed measurements using graphical presentations. Visual comparisons are useful in evaluating model performance over the appropriate temporal or spatial scales.

4) Goodness of fit statistics have been calculated comparing the model predicted results to the associated observed measurements. The calibration goodness of fit statistics are shown in Equation 4 through Equation 8.

5) Goodness of fit statistics have been used to inform the appropriate use of the model. Where a model achieves an excellent or good fit it can generally assume a strong role in decision making about appropriate management options. Conversely, where a model achieves only a fair or poor fit, it should assume a much less prominent role in decision making about appropriate management options. If a desired level of quality is not achieved on some or all measures, the model might still be useful; however, a detailed description of its potential range of applicability will be provided.

6) Written documentation of all important elements in the model, including model setup, model parameterization, key assumptions, and known areas of uncertainty.

7) Peer review as described in Section 9.

Equation 5 through Equation 8 are the goodness of fit statistics to be calculated for each calibrated temperature model. Equation 4 through Equation 7 are the goodness of fit statistics to be calculated for each calibrated shade model.

Coefficient of Determination – R squared (R^2): A coefficient of determination, or R^2, of one indicates a perfect fit. R^2 is a measure of how well predicted values fit the observed data. It compares the variations in the residuals to the variation of the observed data.

$$R^2 = 1 - \frac{\sum(X_{obs} - X_{mod})^2}{\sum\left(X_{obs} - \overline{X_{obs}}\right)^2} \qquad \text{Equation 4}$$

Mean Error (ME): A mean error of zero indicates a perfect fit. A positive value indicates on average the model predicted values are less than the observed data. A negative value indicates on average the model predicted values are greater than the observed data. The mean error statistic may give a false ideal value of zero (or near zero) if the average of the positive deviations between predictions and observations is about equal to the average of the negative deviations in a data set. Because of this, the mean absolute error (MAE) statistic should be used in conjunction with mean error to evaluate model performance.

$$ME = \frac{1}{n}\sum(X_{mod} - X_{obs}) \qquad \text{Equation 5}$$

Mean Absolute Error (MAE): A mean absolute error of zero indicates a perfect fit. The magnitude of the mean absolute error indicates the average deviation between model predicted values and observed data. The mean absolute error cannot give a false zero.

$$MAE = \frac{1}{n}\sum|X_{mod} - X_{obs}| \qquad \text{Equation 6}$$

Root Mean Square Error (RMSE): A root mean square error of zero indicates a perfect fit. Root mean square error is a measure of the magnitude of the difference between model predicted values and observed data.

$$RMSE = \sqrt{\frac{1}{n}\sum(X_{mod} - X_{obs})^2} \qquad \text{Equation 7}$$

Nash-Sutcliffe efficiency coefficient (NS): Nash-Sutcliffe efficiencies can range from -∞ to 1. An efficiency of 1 corresponds to a perfect match of modeled predicted values to the observed data. An efficiency of 0 indicates that the model predictions are as accurate as the mean of the observed data, whereas an efficiency less than zero occurs when the observed mean is a better predictor than the model.

$$NS = 1 - \frac{\sum(X_{obs} - X_{mod})^2}{\sum\left(X_{obs} - \overline{X_{obs}}\right)^2} \qquad \text{Equation 8}$$

where,
X_{mod} = The model predicted results;
X_{obs} = The observed or measured results;
$\overline{X}_{obs}$ = The mean of the observed or measured temperature;
n = The sample size.

7 Documentation in model reports

Model documentation will consist of a series of TMDL technical appendices describing the model setup, model calibration results, model scenario setup, and model scenario results.

The model setup and calibration documentation will include details on the calibrated model domain and layout; spatial and temporal resolution; timeframe of simulation; summary of data used for model inputs; summary of methods used to fill data gaps; summary of data used for calibration; time series plots comparing observed and model predicted temperatures and other parameters as appropriate; goodness of fit statistics, and plots and tables summarizing temperature and effective shade model results.

The model scenario setup and scenario results documentation will include a description of the scenario, what model elements were modified for the scenario; tables, plots, or narrative summarizing the final values for any modified inputs or parameters; methods or data sources used to set up the scenario; and plots and tables that summarize the scenario results.

When no changes or minor changes are made to the existing TMDL models, the existing TMDL technical appendices will be amended as necessary to document any changes to the existing calibration or management scenarios. For more extensive changes, including extending the model time period or developing entirely new models, new technical appendices may need to be developed to document the models and results.

8 Peer review

Peer review of the models and model results will be conducted in the following ways:

DEQ will conduct internal peer review during the modeling process with input from USEPA Region 10 as needed.

DEQ will consider feedback on model scenarios and results from the TMDL rulemaking advisory committee and make changes as appropriate.

DEQ will review and respond to any public comments received on the model and model results, and make changes as appropriate.

9 Management scenarios

Management scenarios described in this section summarize the means by which sources of stream warming and different management alternatives will be evaluated. Some of these model scenarios may not be developed due to lack of sufficient data and information, because the management scenario is not applicable to the specific waterbody, or because it is determined the scenario will require an effort and timeline that does not align with the project schedule or available resources. In some cases, the management scenario has already been developed as part of the previous TMDL and does not need further adjustment. DEQ will review all available data and information during model development and will document final model scenario decisions, setup, and results in the TMDL technical appendix.

9.1 Current condition

This scenario evaluates the stream temperature or shade response under current existing conditions. This scenario is similar to the calibrated model except that some conditions will be modified, may be removed, or new ones added to reflect the current conditions or discharge loads if they are significantly different from the calibrated model.

This scenario will be developed for Fifteenmile Creek, Eightmile Creek, and Ramsey Creek. Elements of this scenario or scenarios may include:

- Updating the vegetation heights, density, and overhang based on recently collected LiDAR.

9.2 Restored vegetation A

This scenario evaluates the stream temperature response with streamside vegetation at restored conditions. The stream temperature warming or cooling contributed by removal of streamside vegetation is evaluated by comparing this scenario to the current condition model.

This model scenario will be developed for Fifteenmile Creek, Eightmile Creek, and Ramsey Creek. Elements of this scenario or scenarios may include:

- Streamside vegetation will be set to restored conditions in areas along the model extent that are currently characterized as lacking streamside vegetation because of anthropogenic disturbance. The restored vegetation type, height, density, and overhang values will be determined during the TMDL process and will likely be the same or similar to the values presented in the Middle Columbia-Hood (Miles Creeks) Subbasin TMDL (DEQ, 2008).

- Model inputs for land cover height, canopy density, and overhang will be modified to reflect the restored conditions.
- All other model inputs will be the same as the current condition model.

9.3 Restored vegetation B

This scenario evaluates the stream temperature response with streamside vegetation at restored conditions, except in areas with existing infrastructure (i.e., buildings and roads).

Restored vegetation scenario “B” (RV_B) is set up identical to restored vegetation scenario “A” (RV_A) except that areas associated with residential and industrial/commercial development, roads, and bridges are left unchanged and retain the same landcover heights and densities as the current condition model. RV_A and RV_B results are compared to quantify shade and instream temperature effects of existing infrastructure.

This model scenario will be developed for Fifteenmile Creek, Eightmile Creek, and Ramsey Creek.

9.4 Topography

This scenario evaluates the portion of effective shade contributed by topographic features only. The effective shade results of this scenario are compared with the current condition and restored vegetation scenarios to quantify the portion of effective shade associated with current and restored vegetation only.

This model scenario will be developed for Fifteenmile Creek, Eightmile Creek, and Ramsey Creek. Elements of this scenario or scenarios may include:

- Model inputs for land cover height, canopy density, and overhang will be set to zero.
- All other model inputs will be the same as the current condition model.

9.5 Natural stream flow

This scenario evaluates stream temperature response by changing permitted water withdrawals to instream flow. The stream temperature warming or cooling from keeping permitted water withdrawals as instream flow is evaluated by comparing this scenario to the current condition model scenario. Assumptions and methods used to estimate restored stream flow will be documented in the TMDL.

This model scenario will be developed for Fifteenmile Creek only. Elements of this scenario or scenarios may include:

- Maintaining all currently permitted water withdrawals as instream flow in order to increase the thermal loading capacity and reduce stream warming.

- Model boundary and tributary flows will be set to reflect the additional instream flows.
- All other model inputs will be the same as the current condition model.

9.6 Consumptive use stream flow

These scenarios evaluate the stream temperature response to consumptive use water withdrawals. They are identical to the natural stream flow model setup except that all boundary, tributary, and hence instream flows are modified iteratively to reflect various rates of consumptive water withdrawals. The purpose of these scenarios is to determine the maximum consumptive withdrawal rates (as a percentage of natural flow) that will attain both the TMDL load allocation and any HUA assigned for permitted withdrawals. Other scenarios may include the percent consumptive withdrawal rate that attains the overall HUA (0.30°C) or another management-based target consumptive use rate. The percent consumptive withdrawal rate is equal for all tributaries and will be based on the flow rate at a reference gage location, likely at OWRD gage 14105500 (Fifteenmile Cr Nr The Dalles). Results of this scenario will be compared to the natural stream flow scenario to quantify the instream temperature effects of water withdrawals at the reference gage.

This model scenario will be developed for Fifteenmile Creek only. Elements of this scenario or scenarios may include:

- Adjusting all currently permitted water withdrawals to reflect various rates of consumptive use as measured at the reference location.
- Model boundary and tributary flows will be set to reflect the rate of consumptive water use as measured at the reference location.
- All other model inputs will be the same as the current condition model.

9.7 Tributary temperatures A

This scenario evaluates the stream temperature response when the temperature of tributaries that exceed applicable temperature standards are set to temperatures that attain those temperature standards. This scenario will be compared to the current condition model to quantify the stream temperature impact of tributary temperature standard exceedances. Assumptions and methods used to estimate tributary temperatures that attain the applicable temperature standard will be documented in the TMDL.

This model scenario will be developed for Fifteenmile Creek only. Elements of this scenario or scenarios may include:

- Tributary temperature inputs set so they attain the applicable temperature standards.
- All other model inputs, including tributary flow, will be the same as the current condition model.

9.8 Tributary temperatures B

This scenario evaluates stream temperature warming or cooling in Fifteenmile Creek from sources on upstream tributaries attaining their HUA assignment. This scenario will be compared to the background model.

This model scenario will be developed for Fifteenmile Creek only. Elements of this scenario or scenarios may include:

- Tributary temperatures are increased by the portion of the HUA assigned to point or nonpoint sources on that tributary. HUA held as reserve capacity is not included.
- All other model inputs, including tributary flow, will be the same as the current condition model.

9.9 Background

This scenario evaluates the stream temperature response from background sources only. Background sources include all sources of pollution or pollutants not originating from human activities. Background sources may also include anthropogenic sources of a pollutant that DEQ or another Oregon state agency does not have authority to regulate, such as pollutants emanating from another state, tribal lands, or sources otherwise beyond the jurisdiction of the state (OAR 340-042-0030(1)). This scenario essentially combines the following model scenarios: restored vegetation A and natural stream flow. The background scenario will be compared to the current condition model scenario to determine the point of maximum impact, and the amount of cumulative warming originating from human activities. The background scenario will also be used to determine the portion of temperature increases above the temperature criteria that are attributable to background sources. This model scenario will be developed for Fifteenmile Creek only.

9.10 No point sources

This scenario evaluates the stream temperature response from removing point source heat load. The stream temperature warming or cooling from permitted NPDES point sources is evaluated by comparing this scenario to the current condition model scenario.

This model scenario will be developed for Fifteenmile Creek only. Elements of this scenario or scenarios may include:

- Removal of all point sources from the model.
- All other model inputs will be the same as the current condition model.

9.11 TMDL wasteload allocations

This scenario evaluates stream temperature warming or cooling from the TMDL wasteload allocations. This scenario will be compared to the no point source model scenario to evaluate attainment of the HUA allocations. Numeric or narrative wasteload allocations will be developed for all NPDES permittees but some of the permittees may not be included in this model scenario due to availability of effluent data, lack of discharge, or because the discharge is not a significant source of thermal loading.

This model scenario will be developed for Fifteenmile Creek only. Elements of this scenario or scenarios may include:

- Modifying point source discharges to reflect proposed or existing TMDL wasteload allocations.
- All other model inputs will be the same as the current condition model.

9.12 Attainment scenario

The attainment scenario evaluates attainment of the cumulative HUA (0.3°C) based on point and nonpoint sources being set at their respective allocations. This scenario will be compared to the background or similar scenario that excludes the sources receiving a TMDL allocation.

This model scenario will be developed for Fifteenmile Creek only. Elements of this scenario or scenarios may include:

- Point source discharges are set to reflect individual proposed wasteload allocation flows and temperatures.
- Tributary temperatures are increased by the portion of the HUA assigned to point or nonpoint sources on that tributary. HUA held as reserve capacity is not included.
- Model inputs for land cover height, canopy density, and overhang will be modified to reflect the streamside vegetation that achieve TMDL effective shade targets. The vegetation type, height, density, and overhang values will be determined during the TMDL process and will likely be the same or similar to the values presented in the Middle Columbia-Hood (Miles Creeks) Subbasin TMDL (DEQ, 2008).

10 Project organization

10.1 Project team/roles

Project roles and responsibilities are described in Table 10-1.

Table 10-1: The roles and responsibilities of each team member involved in the temperature TMDL replacement project.

Name	Position	Role and Responsibilities
Jennifer Wigal	Water Quality Administrator, Oregon DEQ	**Sponsor** 1. Provide guidance to team and project manager 2. Approve project plan and changes to the project, scope, budget, and

Name	Position	Role and Responsibilities
		schedule (pending manager elevation as necessary) 3. Sustain support of decision makers at their level, all stakeholders 4. Remove roadblocks 5. Communicate progress to other managers and Water Quality Director 6. Review project status 7. Manage resistance 8. Ensure communication with employees affected by changes 9. Provide forum to listen to concerns
Steve Mrazik	Manager, Watershed Management, Oregon DEQ	**Manager** 1. Review and approve teamwork products 2. Communicate progress to other managers 3. Approve project plan, changes to the project, and any changes that affect scope and schedule 4. Approve development and finalization of solutions to issues that occur during the project 5. Decide measures of project success
Michele Martin	Project Manager, Water Quality, Oregon DEQ	**Project Manager** 1. Facilitate meetings, effective meeting management 2. Provide feedback and leadership in the development of meeting agendas, activities during meetings, and tasks 3. Provide feedback on project planning and design 4. Keep sponsor informed 5. Develop project charter 6. Develop project plan (including major tasks, milestones, project schedule, communication plan, risk analysis, etc.) 7. Develop team meeting agendas 8. Keep track of meeting decisions and notes (very brief), and team ideas 9. Ensure team’s work drives towards outcomes and deliverables 10. Sustain engagement of team members and team performance 11. Control project scope (with Technical Lead) 12. Coordinate team communication: emails, SharePoint, shared drives 13. Closeout project and document lessons learned

Name	Position	Role and Responsibilities
Ryan Michie	Senior Water Quality Analyst, Watershed Management, Oregon DEQ	**Project Technical Lead** 1. Lead, oversee, and direct development of the project QAPP 2. Lead, oversee, and direct the public data solicitation process 3. Coordination with EPA and Contractor 4. Lead, oversee, and direct DEQ technical staff 5. Perform model calibration/evaluation 6. Run model scenarios 7. Analyze and interpret model results 8. Lead, oversee, and direct TMDL document writing 9. Participate and present at TMDL public meetings 10. Respond to public comments
Becky Talbot	Water Quality Analyst, Watershed Management, Oregon DEQ	1. Write QAPP 2. Develop and configure models 3. Perform model calibration/evaluation 4. Run model scenarios 5. Analyze and interpret model results 6. Write TMDL 7. Participate and present at TMDL public meetings 8. Respond to public comments
Smita Mehta	Basin Coordinator, Oregon DEQ	1. Review QAPP and TMDL 2. Write WQMP 3. TMDL rulemaking advisory committee coordinator 4. Participate and present at TMDL public meetings 5. Respond to public comments
Benjamin Hamilton	Field QA Officer, Oregon DEQ	Review QAPP
Dianne Lloyd	Oregon Department of Justice	**Legal Counsel**
Rob Burkhardt	Water Quality Specialist, Oregon DEQ	1. Project team point of contact to NPDES permit program and permittees 2. Review wasteload allocations
Rebecca Veiga Nascimento	EPA Region 10 Oregon TMDL Program Manager	**EPA TMDL Lead** 1. Review and direct EPA Contractor work products 2. Technical TMDL reviewer 3. Regulatory/Policy TMDL reviewer

Name	Position	Role and Responsibilities
Ben Cope	EPA Region 10 QAPP Officer for Modeling Projects	**EPA Modeling Lead** 1. Review QAPPs 2. Review EPA Contractor work products
TMDL rulemaking advisory committee	This TMDL will have a rulemaking advisory committee	1. Participate in TMDL rulemaking advisory committee meetings 2. Provide input to DEQ on TMDL and WQMP elements 3. Advise DEQ on economic and fiscal impacts of the proposed rules for entities impacted by the proposed TMDL and potential impacts on small businesses

10.2 Expertise and special training requirements

Additional expertise or special training is not necessary at this time.

DEQ staff involved in developing and configuring models, performing model calibration, running model scenarios, and analyzing and interpreting model results have experience in these tasks from numerous other modeling projects. The Project Manager has extensive experience managing large complex projects and will ensure strict adherence to the project protocols.

10.3 Reports to management

The DEQ Project Manager (or designee) will provide progress reports to DEQ Management and USEPA as needed based on new project information. As appropriate, these reports will provide information on the following:

- Adherence to project schedule and/or budget.
- Deviations from approved QAPP, as determined from project assessment and oversight activities.
- The impact of any deviations on model application quality and uncertainty.
- The need for and results of response actions to correct any deviations.
- Potential uncertainties in decisions based on model predictions and data.
- Data quality assessment findings regarding model input data and model outputs.

10.4 Project schedule

The estimated project schedule for the Middle Columbia-Hood (Miles Creeks) Subbasin TMDL is summarized below. This schedule is subject to change based on TMDL development progress and available resources.

Aug 2025 – Apr 2026: Organization and review of existing models, relevant river temperature, stream flow, habitat, and other data. Completion of TMDL analysis, models, and other technical work described in this modeling QAPP. Early draft TMDL and WQMP documents will be written.

May 2026 – Oct 2026: TMDL rule advisory committee meetings to discuss the draft TMDL, WQMP, and fiscal impacts.

Nov 2026: Draft TMDL and WQMP posted for public comment. DEQ will respond to all public comments received, revise the TMDL and WQMP as necessary.

Dec 4, 2028: Deadline for USEPA's final agency action approving or disapproving of the TMDL.

11 Data management

DEQ does not anticipate collecting additional field samples. Water quality data gathered and used for this project will be managed in DEQ's AWQMS database or the project files.

The modeling software to be used for this project is available on DEQ's TMDL program website.

Model-generated data resulting from testing, calibration, and scenarios will be stored in spreadsheets and text files by DEQ in the TMDL project directory. Metadata describing the content, date, and personnel involved in modeling will be documented alongside raw and summarized data.

Secondary data developed as part of this task will be maintained as hardcopy only, both hardcopy and electronic, or electronic only, depending on their nature.

All electronic data will be maintained on DEQ's computers and servers. DEQ's computers are serviced by in-house specialists. When a problem with DEQ's computers and servers occurs, in-house computer specialists diagnose the problem and correct it if possible. When outside assistance is necessary, the computer specialists call the appropriate vendor. For other computer equipment requiring outside repair and not covered by a service contract, local computer service companies are used on a time-and-materials basis.

Routine maintenance of DEQ's computers and servers is performed by in-house computer specialists. Electric power to each computer flows through a surge suppressor to protect electronic components from potentially damaging voltage spikes. All computer users have been instructed on the importance of routinely archiving work assignment data files from hard drive to server storage. The office network server is backed up on tape nightly during the week. Screening for viruses on electronic files loaded on DEQ's computers or the network is standard policy. Automated screening systems have been placed on all computer systems and are updated regularly to ensure that viruses are identified and destroyed. Annual maintenance of software is performed to keep up with evolutionary changes in computer storage, media, and programs.

12 Recordkeeping and archiving

All data and documents generated during the course of the TMDL project will be archived according to the current Oregon State Archives Division records retention schedules. Generally, TMDL documents will be retained until 15 years after the TMDL is no longer operational.

Records that are stored in electronic format will be located in either the TMDL project folder or Master TMDL folder located on DEQ's TMDL server. The TMDL project folder will contain at minimum the following subfolders: "Project Plans", "Data", "NPDES", and "Models". Alternative names and additional subfolders can be used as appropriate. The Master TMDL folder will contain the written TMDL documents (Word, PDF) along with supporting written documents that support the public comment period and TMDL issuance. The contents and organization of these subfolders is described below.

Project Plans: All documents related to project planning, project proposals, project schedules, and the modeling QAPPs. Each will reside in their relevant subfolders. The final versions of documents will be clearly identified from drafts and ideally located in separate folders.

Data: All field data organized or collected in support of the TMDL project. This may include water quality samples, field sheets, photos, monitoring metadata, third party sampling project plans, or other documentation. The data should be organized by parameter and data source if possible.

NPDES: All available NPDES effluent data, discharge monitoring reports, copies of NPDES permits, and related information. Data and permit information will be organized for each permittee and located in separate subfolders.

Meetings: All documents produced for external meetings including agendas, presentations, and meeting materials. Material for each meeting will be saved in a subfolder organized by meeting type. Draft documents and final documents will be clearly identified.

Models: All models used for the TMDL project including calibration and scenario models. The models should be organized into subfolders for each model domain and model scenario. Draft models and the final TMDL models will be clearly identified and ideally saved in separate folders. The model folders should include:

- The model with all input and output files and any executable code used;
- Copy of all raw and summarized data (including GIS files) used for model input with data source and location metadata included;
- Scripts or spreadsheets used to transform raw data or used to derive model inputs;
- Key assumptions and documentation for the model setup and parameterization;
- Documentation of newly developed model code or modifications to the existing model; and
- Identification of staff that completed the model.

TMDL documents: At each key stage of TMDL and WQMP development, copies of the following documents will be saved in separate subfolders within the project folder on the Master TMDL directory. The final versions of documents will be clearly identified from drafts and ideally saved in separate folders.

- Public Notice Drafts:

- Briefing memo to DEQ Water Quality Division Administrator or Director on public comment draft
- Draft TMDL and WQMP Report (Both Word and PDF)
- Draft TMDL Appendices (Both Word and PDF)
- Public Notice document
- TMDL Summary Fact Sheet
- News release
- GovDelivery Notice and email
- Other public notification emails
- Mailing List (if used)
- Public Comments Errata

- Public Comments Received: Copy of all public comments received

- Final TMDL and WQMP documents:

  - Briefing memo to DEQ Water Quality Division Administrator or Director on final TMDL
  - Final TMDL EQC documents
  - WQMP DMA letters
  - TMDL issuance letter to USEPA (both Word and PDF)
  - USEPA approval letter (USEPA)
  - Response to Comment Document (both Word and PDF)
  - TMDL and WQMP Report (both Word and PDF)
  - TMDL Appendices (both Word and PDF)
  - TMDL Summary Fact Sheet
  - News release
  - GovDelivery Notice and email
  - Other public notification emails
  - Relevant EQC agenda documents
  - Designated Management Agency/Responsible Person notification letters (both Word and PDF)
  - Addendums
  - Errata
  - ATTAINS upload files

13 QAPP review and approval

The DEQ Project Technical Lead will distribute the draft QAPP to the respective DEQ and USEPA project team members for review. Comments will be provided to the Project Technical Lead for further discussion. When possible, revision and submittal of the final plan will be made within 10 business days of receipt of comments. Following approval, the Project Technical Lead will distribute the final, signed copy to the respective DEQ and USEPA project team members.

Official copies of the final, approved QAPP will be retained in DEQ's document control system. If any change(s) to the QAPP are required during the project, they must be described in a memorandum and approved by the signatories to this QAPP and attached to the QAPP.

14 Implementation and adaptive management

DEQ plans to develop a Risk Management Plan to identify project constraints, the risks that may arise during project implementation, and potential solutions. Identified project constraints include the abbreviated project schedule with hard deadlines established via court order, limited resources, uncertain funding from USEPA, and a complex TMDL technical effort which may require additional time and public process. Project risks from these constraints and proposed solutions are described in Table 14-1.

Table 14-1: Project risks and proposed solutions.

Risk Description	Solution
Extended public process for complex TMDLs	Communication to DEQ manager and external contacts as deemed necessary by the manager
Team member availability: Inadequate resources to effectively produce the TMDL	Dedicate additional resources to support the effort from internal staff
Delivery commitment	Designate the projects as priority and dedicate additional resources to support the effort from internal staff or contractor (depending on contractor funding)
Scope creep: Working on the TMDLs could be an opportunity for attempts to add additional technical work that are outside the project scope	Sponsor and Manager to address scope creep with stakeholders as necessary
In scope – no time e.g., technical work may take longer than expected. Prioritizing the in-scope work for only absolute requirements	Request court extensions or allocate more resources to meet deadlines, if more resources are available, or reduce the in-scope requirements to the absolute minimum for a scientifically defensible and EPA approvable TMDL

Should a situation arise that requires a significant change in the technical approach, the project team will update the QAPP as needed through revisions or addenda.

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16 Revision history

Table 16-1: QAPP revision history.

Revision	Date	Changes	Editor
1.0	11/28/2025	New QAPP	R. Michie

A. Appendix A Continuous stream temperature data summary

Table A-1: Continuous temperature monitoring stations in the Middle Columbia-Hood (Miles Creeks) Subbasin currently available in public databases and DEQ files.

Station ID	Station	Latitude/Longitude	Organization
28081-ORDEQ	Ramsey Creek at Old Forest Boundary (RY2800)	45.4042/-121.358	DEQ
28082-ORDEQ	Fifteenmile Creek at Forest Boundary (FI 2330)	45.3858/-121.336	DEQ
28083-ORDEQ	Eight Mile Creek at Forest Boundary (EE2600)	45.4334/-121.358	DEQ
28315-ORDEQ	Fifteenmile CR DS of Cedar CR	45.3798/-121.398	DEQ
28316-ORDEQ	Fifteenmile CR US of Cedar CR	45.3799/-121.401	DEQ
28318-ORDEQ	Eightmile CR DS of RD 4430	45.4071/-121.456	DEQ
28320-ORDEQ	Eightmile CR US of RD 4430	45.4064/-121.46	DEQ
28321-ORDEQ	Mill CR S FK DS of reservoir	45.4758/-121.45	DEQ
28322-ORDEQ	Eightmile CR headwaters at RD 4400	45.3611/-121.506	DEQ
28324-ORDEQ	Cedar Creek headwaters at Road 2730-180	45.3447/-121.465	DEQ
28325-ORDEQ	Cedar CR US of Fifteenmile CR	45.379/-121.399	DEQ
28326-ORDEQ	Alder CR US of reservoir	45.4718/-121.461	DEQ
28328-ORDEQ	Ramsey Creek at new Forest Boundary	45.4186/-121.294	DEQ
28329-ORDEQ	Mill CR S FK US of reservoir	45.469/-121.454	DEQ
28342-ORDEQ	Fifteenmile Creek headwaters upstream of Road 2730	45.3428/-121.522	DEQ
28968-ORDEQ	Fifteenmile Creek downstream of Standard Hollow	45.5453/-120.98	DEQ
28969-ORDEQ	Dry Creek downstream of CREP below Packer Canyon	45.4024/-121.097	DEQ
28970-ORDEQ	Dry Creek upstream of CREP Project Site	45.3468/-121.097	DEQ
28971-ORDEQ	Fifteenmile Creek upstream of Dry Creek	45.5046/-121.049	DEQ
28972-ORDEQ	Fifteenmile Creek downstream of Big Spring Gulch	45.6198/-120.991	DEQ
28973-ORDEQ	Fifteenmile Creek upstream of Pine Creek	45.4502/-121.119	DEQ
28974-ORDEQ	Eightmile Creek downstream of County Bridge	45.5602/-121.059	DEQ
28975-ORDEQ	Fifteenmile Creek upstream of Underhill’s Diversion	45.4391/-121.186	DEQ
28976-ORDEQ	Fifteenmile Creek upstream of Ramsey Creek	45.4309/-121.225	DEQ

Station ID	Station	Latitude/Longitude	Organization
28977-ORDEQ	Fifteenmile Creek at Dufur City Reservoir intake	45.3958/-121.279	DEQ
28978-ORDEQ	Eightmile Creek downstream of Fivemile Creek	45.5933/-121.081	DEQ
28979-ORDEQ	Eightmile Creek upstream of Fivemile Creek	45.5927/-121.08	DEQ
28980-ORDEQ	Eightmile Creek at Highway 197	45.5295/-121.093	DEQ
28981-ORDEQ	Mill Creek at 6th Street Bridge in The Dalles, OR	45.6031/-121.193	DEQ
28982-ORDEQ	Mill Creek at Mill Creek Market Road	45.5744/-121.238	DEQ
29673-ORDEQ	Mill CR N FK at RM 9.66 (ML2900)	45.4928/-121.466	DEQ
31381-ORDEQ	Rock Creek by Hood River	45.6636/-121.438	DEQ
31404-ORDEQ	Mosier Creek	45.5712/-121.408	DEQ
31477-ORDEQ	Harphon Creek, LC reference site	45.6864/-121.766	DEQ
31478-ORDEQ	Mill CR S FK ABV dam, LC reference site	45.4749/-121.455	DEQ
31479-ORDEQ	Mill CR N FK at RM 9.4 (LC reference site)	45.4923/-121.462	DEQ
31482-ORDEQ	Mill CR S FK BLW dam, LC reference site	45.4786/-121.443	DEQ
32982-ORDEQ	South Fork Mill Creek upstream of Wicks Treatment Plant diversion	45.538/-121.317	DEQ
32984-ORDEQ	South Fork Mill Creek 100 feet DS of Wicks Treatment Plant discharge (Mill Creek, Columbia River)	45.5421/-121.313	DEQ
32985-ORDEQ	South Fork Mill Creek upstream of Wicks Treatment Plant discharge (Mill Creek, Columbia River)	45.5418/-121.313	DEQ
32986-ORDEQ	South Fork Mill Creek 50 feet DS of Wicks Treatment Plant Discharge (Mill Creek, Columbia River)	45.542/-121.313	DEQ
32988-ORDEQ	South Fork Mill Creek 10 feet DS of Wicks Treatment Plant discharge (Mill Creek, Columbia River)	45.542/-121.313	DEQ
32994-ORDEQ	Wicks Treatment Plant discharge in pool in South Fork Mill Creek below discharge pipe	45.5419/-121.313	DEQ
33091-ORDEQ	Fifteenmile Creek - 1/3 miles downstream of Standard Hollow	45.5495/-120.974	DEQ
33773-ORDEQ	Fifteenmile Creek downstream of Dry Creek	45.5115/-121.037	DEQ
38611-ORDEQ	Fifteenmile ~300 meters u/s Dry Creek	45.5046/-121.049	DEQ
FM2100	Fifteenmile downstream of Lyda	45.3866/-121.34	DEQ
No Station ID	Boundary Condition	45.3859/-121.337	DEQ
No Station ID	Tributary at model kilometer 63.85	45.3984/ -121.2704	DEQ
No Station ID	Eightmile Creek	45.6064/ -121.0851	DEQ
DC1300	Dry Creek	45.5052/-121.046	ODFW
FM1200	Fifteenmile at Ashbrook pump	45.4499/-121.137	ODFW
FM200	Fifteenmile at Petersburg upstream of Eightmile Creek	45.6113/-121.075	ODFW

Station ID	Station	Latitude/Longitude	Organization
FM900	Fifteenmile upstream of Standard Hollow	45.5455/-120.98	ODFW
No Station ID	Ramsey Creek	45.4337/-121.218	ODFW
14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	45.4589/-121.109	OWRD
14104700	Fifteenmile Cr Nr Moody, OR	45.5955/-120.946	OWRD
14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	45.6304/-121.055	OWRD
14105545	Eightmile Cr At Petersburg, OR	45.6052/-121.08	OWRD
14105550	Fifteenmile Cr Nr The Dalles	45.6061/-121.087	OWRD
CRGNSA-014	Viento Cr. 2013 Water Temp Monitor 1	45.6961/-121.668	USFS
MHNF-035	Eightmile Cr Forest Service Bndry_ee2600_LTWT	45.4334/-121.36	USFS
MHNF-036	Eightmile Creek Bottle Prairie ee4490_LTWT	45.3932/-121.499	USFS
MHNF-037	Eightmile Creek Head ee4490_LTWT	45.4068/-121.457	USFS
MHNF-038	Fifteenmile Creek, Wilderness Bndry fe4600_WT	45.3505/-121.47	USFS
MHNF-040	Fivemile Cr Forest Service Bndry_fe2240_LTWT	45.4662/-121.361	USFS
MHNF-066	North Fork Mill Cr ml2900_LTWT	45.4924/-121.468	USFS
MHNF-082	South Fork Mill Cr ml2500_WT	45.4756/-121.452	USFS
MHNF-112	Fifteenmile Creek fi2330_LTWT	45.3864/-121.338	USFS
MHNF-120	Ramsey Cr ry1880_LTWT	45.4185/-121.294	USFS
14105700	Columbia River At The Dalles, OR	45.6083/-121.19	USGS
No Station ID	Fifteenmile upstream of Dry Creek	45.5049/-121.049	Wasco County SWCD

Table A-2: Summary of existing temperature data in the Middle Columbia-Hood (Miles Creeks) Subbasin. Columns Jan to Dec indicate the number of daily maximum temperature results in each month. Data from the DEQ file that are not in the databases were not summarized in the table.

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996	14105700	Columbia River At The Dalles, OR						1	3	1	1			
1997	14105700	Columbia River At The Dalles, OR			5	29	31	30	28	18	16			
1998	14105700	Columbia River At The Dalles, OR			5	29	30	28	31	31	17			
1999	14105700	Columbia River At The Dalles, OR			7	29	31	30	31	31	20			
1999	28981-ORDEQ	Mill Creek at 6th Street Bridge in The Dalles, OR					12	30	31	31	30	19		
1999	28982-ORDEQ	Mill Creek at Mill Creek Market Road					12	30	31	31	30	19		
2000	14105700	Columbia River At The Dalles, OR			8	29	31	30	31	31	18			
2000	28081-ORDEQ	Ramsey Creek at Old Forest Boundary (RY2800)					15	30	31	31	30	3		
2000	28082-ORDEQ	Fifteenmile Creek at Forest Boundary (FI 2330)						29	31	31	30	16		
2000	28083-ORDEQ	Eight Mile Creek at Forest Boundary (EE2600)					13	30	31	31	30	3		
2000	28315-ORDEQ	Fifteenmile CR DS of Cedar CR						29	31	31	30	16		
2000	28316-ORDEQ	Fifteenmile CR US of Cedar CR						29	31	31	30	16		
2000	28318-ORDEQ	Eightmile CR DS of RD 4430					9	30	31	31	30	10		
2000	28320-ORDEQ	Eightmile CR US of RD 4430					9	30	31	31	30	10		
2000	28321-ORDEQ	Mill CR S FK DS of reservoir						30	31	31	30	10		
2000	28322-ORDEQ	Eightmile CR headwaters at RD 4400					13	30	31	31	30	3		
2000	28324-ORDEQ	Cedar Creek headwaters at Road 2730-180					9	30	31	31	30	10		

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	28325-ORDEQ	Cedar CR US of Fifteenmile CR						29	31	31	30	16		
2000	28326-ORDEQ	Alder CR US of reservoir						30	31	31	30	10		
2000	28328-ORDEQ	Ramsey Creek at new Forest Boundary					15	30	31	31	30	1		
2000	28329-ORDEQ	Mill CR S FK US of reservoir						30	31	31	30	10		
2000	28342-ORDEQ	Fifteenmile Creek headwaters upstream of Road 2730								23	30	10		
2001	14105700	Columbia River At The Dalles, OR			3	29	30	30	30	31	20			
2001	28081-ORDEQ	Ramsey Creek at Old Forest Boundary (RY2800)								22	30	8		
2001	28083-ORDEQ	Eight Mile Creek at Forest Boundary (EE2600)					15	30	31	31	30	23		
2001	28968-ORDEQ	Fifteenmile Creek downstream of Standard Hollow					28	30	31	31	30	29		
2001	28969-ORDEQ	Dry Creek downstream of CREP below Packer Canyon						30	31	31	30	18		
2001	28970-ORDEQ	Dry Creek upstream of CREP Project Site						30	31	31	30	23		
2001	28971-ORDEQ	Fifteenmile Creek upstream of Dry Creek					28	30	31	26	30	29		
2001	28972-ORDEQ	Fifteenmile Creek downstream of Big Spring Gulch					28	30	31	30	30	29		
2001	28973-ORDEQ	Fifteenmile Creek upstream of Pine Creek					28	30	31	31	30	31	7	
2001	28974-ORDEQ	Eightmile Creek downstream of County Bridge					28	30	31	31	30	31	7	
2001	28975-ORDEQ	Fifteenmile Creek upstream of Underhill's Diversion					28	30	31	31	30	31	7	

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	28976-ORDEQ	Fifteenmile Creek upstream of Ramsey Creek					28	30	31	31	30	31	7	
2001	28977-ORDEQ	Fifteenmile Creek at Dufur City Reservoir intake					28	30	31	31	30	31	7	
2001	28978-ORDEQ	Eightmile Creek downstream of Fivemile Creek					28	30	31	31	30	31	8	
2001	28979-ORDEQ	Eightmile Creek upstream of Fivemile Creek					28	30	31	31	30	31	8	
2001	28980-ORDEQ	Eightmile Creek at Highway 197					28	30	31	31	30	31	7	
2001	28981-ORDEQ	Mill Creek at 6th Street Bridge in The Dalles, OR						15	31	31	30	31	18	
2001	28982-ORDEQ	Mill Creek at Mill Creek Market Road						15	31	31	30	31	18	
2001	29673-ORDEQ	Mill CR N FK at RM 9.66 (ML2900)					6	30	31	31	30			
2002	14105700	Columbia River At The Dalles, OR			5	29	28	30	31	31	30	31	5	
2002	28081-ORDEQ	Ramsey Creek at Old Forest Boundary (RY2800)					16	30	31	31	30	7		
2002	28083-ORDEQ	Eight Mile Creek at Forest Boundary (EE2600)					16	30	31	31	30			
2002	28968-ORDEQ	Fifteenmile Creek downstream of Standard Hollow					28	30	31	31	30	30		
2002	28972-ORDEQ	Fifteenmile Creek downstream of Big Spring Gulch					29	30	31	13	30	30		
2002	28973-ORDEQ	Fifteenmile Creek upstream of Pine Creek					29	30	31	31	30	30		
2002	28975-ORDEQ	Fifteenmile Creek upstream of Underhill’s Diversion					29	30	31	31	30	30		
2002	28976-ORDEQ	Fifteenmile Creek upstream of Ramsey Creek					29	30	31	31	30	30		

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	28977-ORDEQ	Fifteenmile Creek at Dufur City Reservoir intake					29	30	31	31	30	28		
2002	28978-ORDEQ	Eightmile Creek downstream of Fivemile Creek					29	30	31	31	30	30		
2002	28979-ORDEQ	Eightmile Creek upstream of Fivemile Creek					29	30	31	31	30	29		
2003	14105700	Columbia River At The Dalles, OR			9	30	31	28	31	31	16			
2003	28968-ORDEQ	Fifteenmile Creek downstream of Standard Hollow					30	30	13	18	30	31	19	
2003	28971-ORDEQ	Fifteenmile Creek upstream of Dry Creek					31	30	13	20	30	31	19	
2003	28972-ORDEQ	Fifteenmile Creek downstream of Big Spring Gulch					31	30	13	18	30	31	19	
2003	28973-ORDEQ	Fifteenmile Creek upstream of Pine Creek					30	30	13	19	30	31	19	
2003	28974-ORDEQ	Eightmile Creek downstream of County Bridge					31	30	13	18	30	31	19	
2003	28975-ORDEQ	Fifteenmile Creek upstream of Underhill’s Diversion					30	30	12	25	30	31	19	
2003	28976-ORDEQ	Fifteenmile Creek upstream of Ramsey Creek					30	30	12	25	30	31	19	
2003	28977-ORDEQ	Fifteenmile Creek at Dufur City Reservoir intake					30	30	13					
2003	28978-ORDEQ	Eightmile Creek downstream of Fivemile Creek					31	30	12	18	30	31	19	
2003	28979-ORDEQ	Eightmile Creek upstream of Fivemile Creek					31	30	12	19	30	31	19	
2003	28980-ORDEQ	Eightmile Creek at Highway 197					31	30	12	20	30	31	19	
2004	14105700	Columbia River At The Dalles, OR			21	30	31	30	31	31	28			
2004	28968-ORDEQ	Fifteenmile Creek downstream of Standard Hollow				21	31	30	31	31	30	27		

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	28971-ORDEQ	Fifteenmile Creek upstream of Dry Creek				21	31	30	31	31	30	27		
2004	28972-ORDEQ	Fifteenmile Creek downstream of Big Spring Gulch				21	31	30	31	31	30	27		
2004	28973-ORDEQ	Fifteenmile Creek upstream of Pine Creek				21	31	30	31	31	30	27		
2004	28974-ORDEQ	Eightmile Creek downstream of County Bridge				21	31	30	31	31	30	27		
2004	28975-ORDEQ	Fifteenmile Creek upstream of Underhill's Diversion				21	31	30	31	31	30	27		
2004	28976-ORDEQ	Fifteenmile Creek upstream of Ramsey Creek				21	31	30	31	31	30	27		
2004	28977-ORDEQ	Fifteenmile Creek at Dufur City Reservoir intake				21	31	30	31	31	30	27		
2004	28978-ORDEQ	Eightmile Creek downstream of Fivemile Creek				21	31	30	12		18	27		
2004	28979-ORDEQ	Eightmile Creek upstream of Fivemile Creek				21	31	30	31	31	30	27		
2004	28980-ORDEQ	Eightmile Creek at Highway 197				21	31	30	31	31	30	27		
2004	31381-ORDEQ	Rock Creek by Hood River						21	3					
2004	31404-ORDEQ	Mosier Creek						22	31	31	27			
2004	31477-ORDEQ	Harphon Creek, LC reference site						24	31	31	20			
2004	31478-ORDEQ	Mill CR S FK ABV dam, LC reference site						24	31	31	21			
2004	31479-ORDEQ	Mill CR N FK at RM 9.4 (LC reference site)						24	31	31	20	17	7	
2004	31482-ORDEQ	Mill CR S FK BLW dam, LC reference site						24	31	31	21			

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	14105700	Columbia River At The Dalles, OR			8	30	31	30	31	31	7			
2005	28971-ORDEQ	Fifteenmile Creek upstream of Dry Creek					20	30	31	31	30	24		
2005	28972-ORDEQ	Fifteenmile Creek downstream of Big Spring Gulch					20	30	31	31	30	24		
2005	28973-ORDEQ	Fifteenmile Creek upstream of Pine Creek					21	30	31	31	30	24		
2005	28974-ORDEQ	Eightmile Creek downstream of County Bridge					21	30	31	31	30	24		
2005	28975-ORDEQ	Fifteenmile Creek upstream of Underhill's Diversion					21	30	31	31	30	24		
2005	28976-ORDEQ	Fifteenmile Creek upstream of Ramsey Creek					21	30	31	31	30	24		
2005	28977-ORDEQ	Fifteenmile Creek at Dufur City Reservoir intake					21	30	31	31	30	24		
2005	28978-ORDEQ	Eightmile Creek downstream of Fivemile Creek					20	30	31	31	30	24		
2005	28979-ORDEQ	Eightmile Creek upstream of Fivemile Creek					20	30	31	24	30	24		
2005	28980-ORDEQ	Eightmile Creek at Highway 197					21	30	8	30	30	24		
2005	32982-ORDEQ	South Fork Mill Creek upstream of Wicks Treatment Plant diversion									3			
2005	32984-ORDEQ	South Fork Mill Creek 100 feet DS of Wicks Treatment Plant discharge (Mill Creek, Columbia River)									30	31	15	
2005	32985-ORDEQ	South Fork Mill Creek upstream of Wicks Treatment Plant discharge (Mill Creek, Columbia River)									30	31	15	
2005	32986-ORDEQ	South Fork Mill Creek 50 feet DS of Wicks Treatment Plant Discharge (Mill Creek, Columbia River)						2	31	31	30	31	15	

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	32988-ORDEQ	South Fork Mill Creek 10 feet DS of Wicks Treatment Plant discharge (Mill Creek, Columbia River)						2	31	31	30	31	15	
2005	32994-ORDEQ	Wicks Treatment Plant discharge in pool in South Fork Mill Creek below discharge pipe						2	21					
2005	33773-ORDEQ	Fifteenmile Creek downstream of Dry Creek					20	30	31	31	30	24		
2006	14105700	Columbia River At The Dalles, OR			23	27	30	30	31	31	30	31	30	31
2006	28971-ORDEQ	Fifteenmile Creek upstream of Dry Creek						23	31	31	30	25		
2006	28972-ORDEQ	Fifteenmile Creek downstream of Big Spring Gulch						23	31	31	30	25		
2006	28973-ORDEQ	Fifteenmile Creek upstream of Pine Creek						24	31	31	30	25		
2006	28974-ORDEQ	Eightmile Creek downstream of County Bridge						23	31	31	30	25		
2006	28975-ORDEQ	Fifteenmile Creek upstream of Underhill’s Diversion						24	31	31	30	25		
2006	28976-ORDEQ	Fifteenmile Creek upstream of Ramsey Creek						24	31	31	30	25		
2006	28977-ORDEQ	Fifteenmile Creek at Dufur City Reservoir intake						24	31	31	30	25		
2006	28978-ORDEQ	Eightmile Creek downstream of Fivemile Creek						23	31	31	30	25		
2006	28979-ORDEQ	Eightmile Creek upstream of Fivemile Creek						23	31	31	30	25		
2006	28980-ORDEQ	Eightmile Creek at Highway 197						23	31	31	30	25		
2006	33773-ORDEQ	Fifteenmile Creek downstream of Dry Creek						23	31	31	30	25		
2006	MHNF-035	Eightmile Cr Forest Service Bndry_ee2600_LTWT					6	30	31	31	30	22		

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	MHNF-037	Eightmile Creek Head ee4490_LTWT					21	30	31	31	30	22		
2006	MHNF-040	Fivemile Cr Forest Service Bndry_fe2240_LTWT				2	31	30	31	31	30	24		
2006	MHNF-112	Fifteenmile Creek fi2330_LTWT					28	30	31	30	30	22		
2006	MHNF-120	Ramsey Cr ry1880_LTWT				3	31	30	31	30	30	25		
2007	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2007	MHNF-035	Eightmile Cr Forest Service Bndry_ee2600_LTWT						3	31	31	30	2		
2007	MHNF-040	Fivemile Cr Forest Service Bndry_fe2240_LTWT						14	31	31	30	3		
2007	MHNF-112	Fifteenmile Creek fi2330_LTWT						15	31	31	30	3		
2007	MHNF-120	Ramsey Cr ry1880_LTWT						15	31	6				
2008	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2008	28972-ORDEQ	Fifteenmile Creek downstream of Big Spring Gulch									15	21		
2008	28975-ORDEQ	Fifteenmile Creek upstream of Underhill's Diversion				30	31	30	31	31	30	21		
2008	28976-ORDEQ	Fifteenmile Creek upstream of Ramsey Creek				30	31	30	31	31	30	21		
2008	28977-ORDEQ	Fifteenmile Creek at Dufur City Reservoir intake				30	31	30	31	31	30	21		
2008	28978-ORDEQ	Eightmile Creek downstream of Fivemile Creek				30	31	30	31	31	30	21		
2008	28979-ORDEQ	Eightmile Creek upstream of Fivemile Creek				29	31	30	31	31	30	21		
2008	28980-ORDEQ	Eightmile Creek at Highway 197				30	31	11						
2008	33773-ORDEQ	Fifteenmile Creek downstream of Dry Creek				30	31	30	31	31	30	21		
2008	38611-ORDEQ	Fifteenmile ~300 meters u/s Dry Creek				30	31	30	31	31	30	21		

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2009	MHNF-035	Eightmile Cr Forest Service Bndry_ee2600_LTWT						26	31	31	30	20		
2009	MHNF-038	Fifteenmile Creek, Wilderness Bndry fe4600_WT						26	31	31	30	20		
2009	MHNF-040	Fivemile Cr Forest Service Bndry_fe2240_LTWT						26	31	31	30	20		
2009	MHNF-066	North Fork Mill Cr ml2900_LTWT						26	31	31	30	20		
2009	MHNF-082	South Fork Mill Cr ml2500_WT						26	31	31	30	20		
2010	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2010	MHNF-036	Eightmile Creek Bottle Prairie ee4490_LTWT					4	43*	49*	38*	30	4		
2010	MHNF-037	Eightmile Creek Head ee4490_LTWT					4	30	31	30	30	4		
2010	MHNF-038	Fifteenmile Creek, Wilderness Bndry fe4600_WT					4	30	31	31	30	4		
2010	MHNF-040	Fivemile Cr Forest Service Bndry_fe2240_LTWT					4	30	31	31	30	4		
2010	MHNF-066	North Fork Mill Cr ml2900_LTWT					4	30	31	31	30	31	2	
2010	MHNF-082	South Fork Mill Cr ml2500_WT						5	31	31	30	6		
2011	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2011	MHNF-037	Eightmile Creek Head ee4490_LTWT							31	31	30	25		
2011	MHNF-038	Fifteenmile Creek, Wilderness Bndry fe4600_WT							31	31	30	25		
2011	MHNF-040	Fivemile Cr Forest Service Bndry_fe2240_LTWT							31	17				
2011	MHNF-066	North Fork Mill Cr ml2900_LTWT						7	31	31	30	25		
2011	MHNF-082	South Fork Mill Cr ml2500_WT						7	31	31	30	25		
2012	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2012	MHNF-037	Eightmile Creek Head ee4490_LTWT							28	31	30	30		
2012	MHNF-038	Fifteenmile Creek, Wilderness Bndry fe4600_WT							28	31	30	30		

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	MHNF-066	North Fork Mill Cr ml2900_LTWT							19	31	30	31		
2012	MHNF-082	South Fork Mill Cr ml2500_WT							19	31	30	31		
2013	14105700	Columbia River At The Dalles, OR	31	26	31	30	31	30	31	31	30	31	30	31
2013	CRGNSA-014	Viento Cr. 2013 Water Temp Monitor 1							30	31	16			
2014	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR								25	30	31	30	31
2014	14105700	Columbia River At The Dalles, OR	31	28	30	30	31	30	31	31	30	31	30	31
2015	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	6	28	31	30	31	30	31	31	30	31	30	31
2015	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	29	31	30	22	7	30	31	30	31
2015	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2015	33091-ORDEQ	Fifteenmile Creek - 1/3 miles downstream of Standard Hollow								18	9			
2016	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	13	31	30	31	30	31	31	30	31	30	25
2016	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	16	31	30	31	30	31	30	30	31	30	31
2016	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2016	MHNF-037	Eightmile Creek Head ee4490_LTWT					20	30	31	29				
2016	MHNF-038	Fifteenmile Creek, Wilderness Bndry fe4600_WT					20	30	31	29				
2016	MHNF-040	Fivemile Cr Forest Service Bndry_fe2240_LTWT					20	30	31	29				
2016	MHNF-066	North Fork Mill Cr ml2900_LTWT					13	30	31	24				
2016	MHNF-082	South Fork Mill Cr ml2500_WT					13	30	31	24				
2017	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	18	28	31	30	31	26	31	31	30	31	30	31
2017	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	29	31	30	31	31	30	31	30	31
2017	14105700	Columbia River At The Dalles, OR	31	27	31	29	30	30	31	31	29	31	30	31
2017	MHNF-038	Fifteenmile Creek, Wilderness Bndry fe4600_WT						4	31	31	30	2		

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	MHNF-066	North Fork Mill Cr ml2900_LTWT						18	31	31	30	2		
2018	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	28	27	30	31	30	31	31	30	31	30	31
2018	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	30	31	30	31	31	29	31	30	31
2018	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2018	MHNF-037	Eightmile Creek Head ee4490_LTWT					20	30	31	31	30	1		
2018	MHNF-038	Fifteenmile Creek, Wilderness Bndry fe4600_WT					20	30	31	31	30	1		
2018	MHNF-040	Fivemile Cr Forest Service Bndry_fe2240_LTWT					20	30	31	31	30	1		
2019	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	28	31	30	31	30	31	31	30	31	30	31
2019	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	30	31	30	31	31	30	31	28	31
2019	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2019	MHNF-037	Eightmile Creek Head ee4490_LTWT					20	29	11	31	18			
2019	MHNF-040	Fivemile Cr Forest Service Bndry_fe2240_LTWT						26	31	31	30	21		
2019	MHNF-112	Fifteenmile Creek fi2330_LTWT					10	30	27					
2019	MHNF-120	Ramsey Cr ry1880_LTWT					10	30	31	31	30	21		
2020	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	29	31	30	31	30	31	31	30	31	30	31
2020	14104700	Fifteenmile Cr Nr Moody, OR			27	30	31	30	31	31	30	31	30	31
2020	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2020	14105545	Eightmile Cr At Petersburg, OR						19	31	31	30	31	30	31
2020	14105550	Fifteenmile Cr Nr The Dalles		2	31	30	31	30	31	31	30	31	30	31
2020	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31

* Some stations have more daily maximum results than the number of days in the month due to multiple probes being deployed at the same location or due to duplicate entries in AWQMS. These data are not proposed to support the modeling, so we did not investigate these specific situations further.

B. Appendix B Stream flow data summary

Table B-1: Continuous flow measurements available from USGS flow gaging stations in the Middle Columbia-Hood (Miles Creeks) Subbasin.

Station ID	Station	Latitude/Longitude
14105700	Columbia River At The Dalles, OR	45.60828/-121.1899
14113200	Mosier Creek Near Mosier, OR	45.64901/-121.3773

Table B-2: Continuous flow measurements available from OWRD flow gaging stations in the Middle Columbia-Hood (Miles Creeks) Subbasin.

Station ID	Station	Latitude/Longitude
14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	45.4589/-121.109
14104700	Fifteenmile Cr Nr Moody, OR	45.5955/-120.946
14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	45.6304/-121.055
14105545	Eightmile Cr At Petersburg, OR	45.6052/-121.08
14105550	Fifteenmile Cr Nr The Dalles	45.6061/-121.087
14113210	Mosier Cr Ab Dry Cr, Nr Mosier	45.6633/-121.381
28976-ORDEQ	Fifteenmile upstream Ramsey Creek	45.4331/-121.218
No Station ID	Fifteenmile at ISCO site	45.6308/-121.055

Table B-3: Instantaneous flow measurements by DEQ and others in the Middle Columbia-Hood (Miles Creeks) Subbasin.

Station ID	Station	Latitude/Longitude	Data Source
28977-ORDEQ	Fifteenmile downstream Dufur City intake	45.3957/-121.279	DEQ
FM2100	Fifteenmile downstream Lyda Diversion	45.3859/-121.337	DEQ
No Station ID	Boundary Condition	45.3859/ -121.3368	DEQ
No Station ID	Eightmile Creek	45.6064/ -121.0851	DEQ
No Station ID	Fifteenmile downstream Underhills diversion	45.4393/-121.185	DEQ
No Station ID	Ramsey Creek at mouth	45.4337/ -121.218	OWRD
FM900	Fifteenmile at Emerson Loop Rd. (upstream Standard Hollow)	45.5455/-120.98	ODFW
No Station ID	Fifteenmile at Dufur City Park	45.4511/-121.126	ODFW
No Station ID	Fifteenmile upstream mouth	45.6112/-121.119	ODFW

Table B-4: Summary of existing flow data in the Middle Columbia-Hood (Miles Creeks) Subbasin. Columns Jan to Dec indicate the number of daily mean flow results in each month.

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
1991	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
1992	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
1993	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
1994	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
1995	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
1996	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
1997	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
1998	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
1999	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2000	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2001	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2002	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2003	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2004	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2005	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2005	14113200	Mosier Creek Near Mosier, OR						23	31	31	30	31	30	31
2006	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2006	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2007	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2007	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2008	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2008	14113200	Mosier Creek Near Mosier, OR	31	29	31	30	31	30	31	31	30	31	30	31
2009	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2009	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR				30	31	30	31	31	30	31	30	31
2010	14105550	Fifteenmile Cr Nr The Dalles					18	30	31	31	30	31	30	31
2010	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2010	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2011	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	30	31	30	31	31	30		1	
2011	14105550	Fifteenmile Cr Nr The Dalles	31	28	31	30	31	30	31	31	30	31	30	31
2011	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2011	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2012	14104700	Fifteenmile Cr Nr Moody, OR										1	3	
2012	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR					1	2	1	3	1	31	30	31
2012	14105550	Fifteenmile Cr Nr The Dalles	31	29	31	30	31	30	31	31	30	31	30	31
2012	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2012	14113200	Mosier Creek Near Mosier, OR	31	29	31	30	31	30	31	31	30	31	30	31
2012	14113210	Mosier Cr Ab Dry Cr, Nr Mosier				14	31	30	31	31	30	31	30	31
2013	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR							23	31	30	31	30	31
2013	14104700	Fifteenmile Cr Nr Moody, OR		2	1		1	2	22	31	30	31	30	31
2013	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2013	14105545	Eightmile Cr At Petersburg, OR									30	31	30	31
2013	14105550	Fifteenmile Cr Nr The Dalles	31	28	31	30	31	30	31	31	30	31	30	31
2013	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2013	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2013	14113210	Mosier Cr Ab Dry Cr, Nr Mosier	31	28	31	30	31	30	31	31	30	31	30	31
2014	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	28	31	30	31	30	31	31	30	31	30	31
2014	14104700	Fifteenmile Cr Nr Moody, OR	31	28	31	30	31	30	31	31	30	31	30	31

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2014	14105545	Eightmile Cr At Petersburg, OR	31	28	31	30	31	30	31	31	30	31	30	31
2014	14105550	Fifteenmile Cr Nr The Dalles	31	28	31	30	31	30	31	31	30	31	30	31
2014	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2014	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2014	14113210	Mosier Cr Ab Dry Cr, Nr Mosier	31	28	31	30	31	30	31	31	30	31	30	31
2015	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	28	31	30	31	30	31	31	30	31	30	31
2015	14104700	Fifteenmile Cr Nr Moody, OR	31	28	31	30	31	30	31	31	30	31	30	31
2015	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2015	14105545	Eightmile Cr At Petersburg, OR	31	28	31	21	10	30	31	31	30	31	30	31
2015	14105550	Fifteenmile Cr Nr The Dalles	31	28	31	30	31	30	31	31	30	31	30	31
2015	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2015	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2015	14113210	Mosier Cr Ab Dry Cr, Nr Mosier	31	28	31	30	31	30	31	31	30	31	30	31
2016	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	29	31	30	31	30	31	31	30	31	30	31
2016	14104700	Fifteenmile Cr Nr Moody, OR	31	29	31	30	31	30	31	31	30	31	30	31
2016	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2016	14105545	Eightmile Cr At Petersburg, OR	31	29	31	30	31	30	31	31	30	31	30	31
2016	14105550	Fifteenmile Cr Nr The Dalles	31	29	31	30	31	30	31	31	30	31	30	31
2016	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2016	14113200	Mosier Creek Near Mosier, OR	31	29	31	30	31	30	31	31	30	31	30	31
2016	14113210	Mosier Cr Ab Dry Cr, Nr Mosier	31	29	31	30	31	30	31	31	30	31	30	31
2017	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	28	31	30	31	30	31	31	30	31	30	31
2017	14104700	Fifteenmile Cr Nr Moody, OR	31	28	31	30	31	30	31	31	30	31	30	31
2017	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	14105545	Eightmile Cr At Petersburg, OR	31	28	31	30	31	30	31	31	30	31	30	31
2017	14105550	Fifteenmile Cr Nr The Dalles	31	28	31	30	31	30	31	31	30	31	30	31
2017	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2017	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2017	14113210	Mosier Cr Ab Dry Cr, Nr Mosier	31	28	31	30	31	30	31	31	30	31	30	31
2018	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	28	31	30	31	30	31	31	30	31	30	31
2018	14104700	Fifteenmile Cr Nr Moody, OR	31	28	31	30	31	30	31	31	30	31	30	31
2018	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	30	31	30	31	31	30	30	30	31
2018	14105545	Eightmile Cr At Petersburg, OR	31	28	31	30	31	30	31	31	30	31	30	31
2018	14105550	Fifteenmile Cr Nr The Dalles	31	28	31	30	31	30	31	31	30	31	30	31
2018	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2018	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2018	14113210	Mosier Cr Ab Dry Cr, Nr Mosier	31	28	31	30	31	30	31	31	30	31	30	31
2019	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	28	31	30	31	30	31	31	30	31	30	31
2019	14104700	Fifteenmile Cr Nr Moody, OR	31	28	31	30	31	30	31	31	30	31	30	31
2019	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2019	14105545	Eightmile Cr At Petersburg, OR	31	28	31	30	31	30	31	31	30	31	30	31
2019	14105550	Fifteenmile Cr Nr The Dalles	31	28	31	30	31	30	31	31	30	31	30	31
2019	14105700	Columbia River At The Dalles, OR	31	28	31	30	31	30	31	31	30	31	30	31
2019	14113200	Mosier Creek Near Mosier, OR	31	28	31	30	31	30	31	31	30	31	30	31
2019	14113210	Mosier Cr Ab Dry Cr, Nr Mosier	31	28	31	30	31	30	31	31	30	31	30	31
2020	14104190	Fifteenmile Cr Bl Pine Cr Nr Dufur, OR	31	29	31	30	31	30	31	31	30	31	30	31
2020	14104700	Fifteenmile Cr Nr Moody, OR	31	29	31	30	31	30	31	31	30	31	30	31
2020	14104800	Fifteenmile Cr At Kaser Ranch Nr The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2020	14105545	Eightmile Cr At Petersburg, OR	31	29	31	30	31	30	31	31	30	31	30	31

Year	Station ID	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	14105550	Fifteenmile Cr Nr The Dalles	31	29	31	30	31	30	31	31	30	31	30	31
2020	14105700	Columbia River At The Dalles, OR	31	29	31	30	31	30	31	31	30	31	30	31
2020	14113200	Mosier Creek Near Mosier, OR	31	29	31	30	31	30	31	31	30	31	30	31
2020	14113210	Mosier Cr Ab Dry Cr, Nr Mosier	31	29	31	30	31	30	31	31	30	31	30	31