Total Maximum Daily Loads for the John Day River Basin

Technical Support Document

Temperature

DRAFT, May 2026

State of Oregon
DEQ Department of Environmental Quality

This document was prepared by:
Victoria Avalos

Oregon Department of Environmental Quality
Water Quality Division
700 NE Multnomah Street, Suite 600
Portland Oregon, 97232
Contact: Steve Mrazik
Phone: 503-229-5983 x267
www.oregon.gov/deq

State of Oregon
DEQ Department of Environmental Quality

Translation or other formats

Español | 한국어 | **繁體中文** | **Русский** | **Tiếng Việt** | **العربية**

800-452-4011 | TTY: 711 | deqinfo@deq.oregon.gov

Non-discrimination statement

DEQ does not discriminate on the basis of race, color, national origin, disability, age, sex, religion, sexual orientation, gender identity, or marital status in the administration of its programs and activities. Visit DEQ's Civil Rights and Environmental Justice page.

Table of Contents

Non-discrimination statement ii

Table of Contents iii

List of figures vi

List of tables ix

List of equations x

Acronyms xi

1 Introduction 1

1.1 Document purpose and organization 1

1.2 Overview of TMDL elements 1

1.3 TMDL administrative process and public participation 2

2 TMDL name and location 2

2.1 Climate 3

2.2 Hydrology 5

2.3 Intermittent streams 6

2.4 Land Use 8

2.5 Land Ownership and Jurisdiction 9

3 Pollutant identification 11

4 Temperature water quality standards and beneficial uses 11

4.1 Natural lakes 11

4.2 Cold water refugia narrative 12

5 Seasonal variation and critical period for temperature 16

5.1 Lower John Day Subbasin seasonal variation 20

5.2 Middle Fork John Day Subbasin seasonal variation 21

5.3 North Fork John Day Subbasin seasonal variation 23

5.4 Upper John Day Subbasin seasonal variation 34

6 Temperature water quality data evaluation and analyses 38

6.1 The 7Q10 low-flow statistic 39

7 Sources or source categories 53

7.1 Point sources 53

7.1.1 Individual NPDES permitted point sources 54

7.1.2 General NPDES permitted point sources 54
7.2 Nonpoint and background sources 55
7.2.1 Background sources 55
7.2.2 Water management and consumptive use water withdrawals 56
7.2.3 Channel modification and simplification 57
7.2.4 Solar loading from disturbance or removal of near stream vegetation 58
7.2.5 Climate change 58
7.2.6 John Day River 58
7.2.7 North Fork John Day River 59
7.2.8 Middle Fork John Day River 60
8 Loading capacity and excess loads 60
9 Allocations, reserve capacity, and margin of safety 62
9.1 Human use allowance assignments 63
9.2 Wasteload allocations for point sources 64
9.2.1 City of Dayville (23560) 64
9.2.2 John Day WWTF (127619) 64
9.2.3 Long Creek STP (51180) 64
9.2.4 Mt. Vernon STP (59065) 65
9.2.5 WLA equations 65
9.3 Load allocations for nonpoint sources 69
9.3.1 Load allocation equations 70
10 Water quality standards attainment 71
10.1 Point sources 71
10.1.1 John Day River point source impacts 72
10.2 Nonpoint sources 73
10.2.1 Tributary temperature assessment 74
10.3 John Day River assessment for Columbia River Temperature TMDL 74
10.3.1 Background 74
10.3.2 Methods and assumptions 75
10.3.3 Results 75
11 Water quality management plan support 76
11.1 Adequacy of Agricultural Water Quality Management programs in attaining TMDL load allocations and effective shade surrogate measures 76

12 References 78
Appendices 85
Appendix A: Heat Source Model Report 86
Appendix B: Model Calibration 86
Appendix C: Potential Near-Stream Land Cover 86
Appendix D: Assessment Units addressed by Temperature TMDLs for the John Day Basin 86
Appendix E: Upper John Day Subbasin Effective Shade Results 86
Appendix F: North Fork John Day Subbasin Effective Shade Results 86
Appendix G: Middle Fork John Day Subbasin Effective Shade Results 86
Appendix H: Lower John Day Subbasin Effective Shade Results 86
Appendix I: John Day Basin Interactive TMDL Map 86
Appendix J: Climate Change and Stream Temperature in Oregon: A Literature Synthesis 86
Appendix K: Stream Buffer Width Literature Review 87

List of figures

Figure 2-1: PRISM 1991-2020 Normal Annual Precipitation in the John Day Basin temperature TMDL project area (Data Source: PRISM Climate Group, 2022). 4
Figure 2-2: PRISM 1991-2020 Normal Annual Maximum Air Temperature in the John Day Basin temperature TMDL project area (Data Source: PRISM Climate Group, 2022). 5
Figure 2-3: Land uses in the John Day River Basin TMDL project area based on the 2024 National Land Cover Database. 9
Figure 2-4: Land ownership and jurisdiction in the John Day River Basin temperature TMDL project area. 10
Figure 4-1: Boxplots showing distribution of temperature differences between the John Day River daily maximum and daily minimum during periods when the daily maximum >= 20°C. 14
Figure 5-1: Seasonal variation at the Pine Creek near Clarno temperature monitoring site in the Lower John Day Subbasin. 20
Figure 5-2: Seasonal variation at the Bridge Creek above Coyote Canyon near Mitchell temperature monitoring site in the Lower John Day Subbasin. 20
Figure 5-3: Seasonal variation at the Big Creek temperature monitoring site in the Middle Fork John Day Subbasin. 21
Figure 5-4: Seasonal variation at the Camp Creek at its mouth temperature monitoring site in the Middle Fork John Day Subbasin. 21
Figure 5-5: Seasonal variation at the Middle Fork John Day River above Camp Creek near Galena temperature monitoring site in the Middle Fork John Day Subbasin. 22
Figure 5-6: Seasonal variation at the Lower Vinegar Creek temperature monitoring site in the Middle Fork John Day Subbasin. 22
Figure 5-7: Seasonal variation at the Indian Creek temperature monitoring site in the North Fork John Day Subbasin. 23
Figure 5-8: Seasonal variation at the Big Wall Creek temperature monitoring site in the North Fork John Day Subbasin. 24
Figure 5-9: Seasonal variation at the Wilson Creek temperature monitoring site in the North Fork John Day Subbasin. 24
Figure 5-10: Seasonal variation at the Little Wall Creek near Skookum Creek temperature monitoring site in the North Fork John Day Subbasin. 25
Figure 5-11: Seasonal variation at the Little Wall Creek near Bacon Creek temperature monitoring site in the North Fork John Day Subbasin. 25
Figure 5-12: Seasonal variation at the Skookum Creek temperature monitoring site in the North Fork John Day Subbasin 26
Figure 5-13: Seasonal variation at the Swale Creek temperature monitoring site in the North Fork John Day Subbasin. 26
Figure 5-14: Seasonal variation at the Ditch Creek temperature monitoring site in the North Fork John Day Subbasin. 27
Figure 5-15: Seasonal variation at the Cable Creek at mouth temperature monitoring site in the North Fork John Day Subbasin. 27

Figure 5-16: Seasonal variation at the Camas Creek at mouth temperature monitoring site in the North Fork John Day Subbasin. 28
Figure 5-17: Seasonal variation at the Camas Creek upstream of its confluence with Lane Creek temperature monitoring site in the North Fork John Day Subbasin. 28
Figure 5-18: Seasonal variation at the Hidaway Creek temperature monitoring site in the North Fork John Day Subbasin. 29
Figure 5-19: Seasonal variation at the Lane Creek temperature monitoring site in the North Fork John Day Subbasin. 29
Figure 5-20: Seasonal variation at the West Fork Meadow Brook temperature monitoring site in the North Fork John Day Subbasin. 30
Figure 5-21: Seasonal variation at the Texas Bar Creek temperature monitoring site in the North Fork John Day Subbasin. 30
Figure 5-22: Seasonal variation at the Big Creek at mouth temperature monitoring site in the North Fork John Day Subbasin. 31
Figure 5-23: Seasonal variation at the Meadow Creek temperature monitoring site in the North Fork John Day Subbasin. 31
Figure 5-24: Seasonal variation at the North Fork John Day River upstream of Big Creek temperature monitoring site in the North Fork John Day Subbasin. 32
Figure 5-25: Seasonal variation at the Clear Creek temperature monitoring site in the North Fork John Day Subbasin. 32
Figure 5-26: Seasonal variation at the Lake Creek temperature monitoring site in the North Fork John Day Subbasin. 33
Figure 5-27: Seasonal variation at the North Fork John Day River at it confluence with Lake Creek/Granite Creek temperature monitoring site in the North Fork John Day Subbasin. 33
Figure 5-28: Seasonal variation at the North Fork John Day River upstream of Onion Creek temperature monitoring site in the North Fork John Day Subbasin. 34
Figure 5-29: Seasonal variation at the John Day River upstream of Goose Rock temperature monitoring site in the Upper John Day Subbasin. 34
Figure 5-30: Seasonal variation at the Rock Creek at mouth temperature monitoring site in the Upper John Day Subbasin. 35
Figure 5-31: Seasonal variation at the Murderers Creek temperature monitoring site in the Upper John Day Subbasin. 35
Figure 5-32: Seasonal variation at the Fields Creek temperature monitoring site in the Upper John Day Subbasin. 36
Figure 5-33: Seasonal variation at the Canyon Creek temperature monitoring site in the Upper John Day Subbasin. 36
Figure 5-34: Seasonal variation at the East Fork Canyon Creek temperature monitoring site in the Upper John Day Subbasin. 37
Figure 5-35: Seasonal variation at the John Day River upstream of Rail Creek and Roberts Creek temperature monitoring site in the Upper John Day Subbasin. 37
Figure 6-1: Overview of TMDL project area and temperature model extents. 39
Figure 9-1: Conceptual representation and breakdown of total pollutant loading to a temperature-impaired waterbody. 62

Figure 10-1: Change in maximum 7DADM stream temperatures between the Wasteload Allocations and No Point Sources scenarios for the John Day River over all time periods. 73
Figure 10-2: Change in maximum 7DADM stream temperatures between the Tributary Temperature Scenario (0.30 HUA includes reserve capacity) and Current Condition Calibration scenarios for the John Day River over all time periods. 74

List of tables

Table 2-1: Summary of land uses in the John Day River Basin TMDL project area based on the 2016 National Land Cover Database. 8
Table 5-1: Water temperature monitoring locations and periods used to determine seasonal temperature variation and critical periods for the John Day River Basin. 18
Table 5-2: Designated critical periods for waters in the Upper John Day Subbasin (17070201). 19
Table 5-3: Designated critical periods for waters in the North Fork John Day Subbasin (17070202). 19
Table 5-4: Designated critical periods for waters in the Middle Fork John Day Subbasin (17070203). 19
Table 5-5: Designated critical periods for waters in the Lower John Day Subbasin (17070204). 19
Table 6-1: The 7Q10 low-flow estimates for modeled temperature-impaired rivers in the John Day Basin. 42
Table 6-2: The 7Q10 low-flow estimates for NPDES permitted discharges assessed in this TMDL. 53
Table 7-1: Individual NPDES permitted point source discharges that have the potential to contribute thermal loads to John Day River Basin streams at a frequency and magnitude to cause exceedances to the temperature standard. 54
Table 7-2: Maximum 7DADM increases above the applicable temperature criteria associated with background nonpoint sources. 56
Table 10-1: Maximum difference between daily mean temperature under various scenarios at the John Day River mouth. 76
Table 10-2: John Day River human use allowance assignments and the equivalent maximum increase measured above the daily mean temperature. 76
Table 11-1: Summary of OAR 603-095 for streamside management in seven management areas within the John Day River Basin Temperature TMDL project area. 77
Table 11-2: Summary of the most recent updates to Area Plans, which occur during ODA's full biennial review process. 78

List of equations

Equation 8-1 60
Equation 8-2 61
Equation 9-1 65
Equation 9-2 65
Equation 9-3 66
Equation 9-4 67
Equation 9-5 68
Equation 9-6 68
Equation 9-7 70
Equation 9-8 71

Acronyms

Listed acronyms apply to this document and its appendices.

7DADM	7-Day Average Daily Maximum
7Q10	7-Day, 10-Year Low Flow
ADWDF	Average Dry Weather Design Flow
AU	Assessment Unit
AWQMS	Ambient Water Quality Monitoring System
BG	Background Source
BLM	U.S. Bureau of Land Management
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
DEM	Digital Elevation Model
DEQ	Oregon Department of Environmental Quality
DMA	Designated Management Agency
DMR	Discharge Monitoring Report
DOGAMI	Oregon Department of Geology and Mineral Industries
DOQ	Digital Orthophoto Quad
DQL	Data Quality Level
DSM	Digital Surface Model
EPA	Environmental Protection Agency
EQC	Oregon Environmental Quality Commission
ETL	Excess Thermal Load
EWEB	Eugene Water and Electric Board
GIS	Geographic Information System
GLO	General Land Office
GNIS	USGS Geographic Names Information System
HTML	Hyper Text Markup Language
HUA	Human Use Allowance
HUC	Hydrologic Unit Code
IMD	Internal Management Directive
LA	Load Allocation
LAC	Local Advisory Committee
LC	Loading Capacity
LiDAR	Light Detection and Ranging
LT50	Lethal Time 50

MF	Middle Fork
MGD	Millions of Gallons per Day
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
MWMT	Maximum Weekly Maximum Temperature
NA	Not Applicable
NHD	National Hydrography Dataset
NID	National Inventory of Dams
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NWI	National Wetland Inventory
OAR	Oregon Administrative Rules
ODA	Oregon Department of Agriculture
ODC	Oregon Department of Corrections
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish & Wildlife
ORS	Oregon Revised Statutes
OWRD	Oregon Water Resources Department
PCW	Protecting Cold Water
PER	Permit Evaluation Report
PGE	Portland General Electric
POD	Points of Diversion
POMI	Point of Maximum Impact
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RC	Reserve Capacity
SCS	Soil Conservation Service
SF	South Fork
SIA	Strategic Implementation Area
SIC	Standard Industrial Classification
STP	Sewage Treatment Plant
SWCD	Soil and Water Conservation District
TIR	Thermal Infrared Radiometry
TMDL	Total Maximum Daily Load
TSD	Technical Support Document
USACE	U.S. Army Corps of Engineers

USFS	U.S. Department of Agriculture Forest Service
USGS	United States Geological Survey
WDOE	Washington Department of Ecology
WLA	Wasteload Allocation
WQMP	Water Quality Management Plan
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Document purpose and organization

This document provides comprehensive supporting information on technical analyses completed for the Total Maximum Daily Load (TMDL) and Water Quality Management Plan (WQMP) for addressing temperature impairments in the waters of the John Day River Basin. This document provides explanations of TMDL concepts and analysis and support for conclusions and requirements included in the John Day River Basin TMDL and WQMP, which have been adopted by Oregon's Environmental Quality Commission (EQC), by reference, in Oregon Administrative Rules (OAR) 340-42-XXXX.

This document is organized into sections with titles reflective of the TMDL elements required by Oregon Administrative Rule OAR 340-042-0040(4). This organization is intended to assist readers in readily accessing the information relied on for TMDL element-specific determinations.

1.2 Overview of TMDL elements

According to OAR 340-042-0030(15) Definitions: Total Maximum Daily Load means a written quantitative plan and analysis for attaining and maintaining water quality standards and includes the elements described in OAR 340-042-0040. Determinations on each element are presented in the John Day River Basin TMDL for temperature. Technical and policy information supporting those determinations are presented in this report at the section headings that correspond to the TMDL elements for which complex analysis was undertaken.

In plain language, a TMDL is a pollutant budget plan to ensure that the receiving waterbody can attain water quality standards that protect beneficial uses of the water. This budget calculates and assigns pollutant loads for discharges of point (end of pipe) and nonpoint (landscape) sources, in consideration of natural background levels, along with determination of a margin of safety and reserve capacity.

A margin of safety (MOS) accounts for the uncertainty in predicting how well pollutant reductions will result in meeting water quality standards and can be expressed either explicitly, as a portion of the allocations, or implicitly, by incorporating conservative assumptions into the analyses.

Reserve capacity (RC) sets aside some portion of the loading capacity for pollutant discharges that may result from future growth and new or expanded sources.

A key element of analysis is the amount of pollutant that a waterbody can receive and still meet the applicable water quality standard and is referred to as the "loading capacity" (LC) of a waterbody. Because the loading capacity must not be exceeded by pollutant loads from all existing sources, plus the margin of safety and reserve capacity, it can be considered the maximum load. Hence, the loading capacity is often referred to as the Total Maximum Daily Load, or TMDL. A loading capacity, or TMDL, is calculated on each assessment unit (AU) for each applicable temperature criteria in the TMDL project area. An AU is a partition (segment) of the state's waterbodies (streams, river, lakes, estuaries, etc.) into manageable units. The Integrated Report makes assessment conclusions for each AU.

Another key element of analysis is allocating portions of the loading capacity or TMDL to known sources. Allocations are quantified measures that assure water quality standards will be met and may distribute the pollutant loads between nonpoint and point sources. "Load allocations" are portions of the loading capacity that are attributed to: 1) nonpoint sources such as urban, agriculture, rural residential or forestry activities; and 2) natural background sources such as soils or wildlife. "Wasteload allocations" (WLAs) are portions of the total load that are allotted to point sources of pollution, such as permitted discharges from sewage treatment plants, industrial wastewater or stormwater. As noted above, allocations can also be reserved for future uses, termed "reserve capacity."

This general TMDL concept is represented by the following equation:

TMDL = ∑Wasteload Allocations + ∑Load Allocations + Reserve Capacity + Margin of Safety

Together, these elements establish the pollutant loads necessary to meet the applicable water quality standards for impaired pollutants and protect beneficial uses.

1.3 TMDL administrative process and public participation

Following completion of DEQ's drafting process, including engagement of a rule advisory committee on the fiscal impact statement and aspects of the rule, this revised temperature TMDL for the John Day River Basin was adopted by EQC, by reference, into rule section OAR 340-042-XXXX. Any subsequently amended or renumbered rules cited in this document are intended to apply.

DEQ convened a rule advisory committee to provide input on drafts of the TMDL, WQMP, Technical Support Document (TSD) (DEQ, XXXXa and XXXXb), fiscal and economic impacts, and Environmental Justice and Racial Equity. The committee met on January 28, 2026, and May 20, 2026. The agency held one informational webinar about this TMDL. A public comment period was held from August XX through October XX, 2026. DEQ held a public hearing on MONTH DD, YEAR. DEQ considered all input received during these public participation opportunities and used input to guide the analyses and preparation of documents. DEQ developed a response to comments that is available online. EQC adopted the John Day River Basin TMDL and WQMP rule on MONTH DAY, YEAR. EPA approved the TMDL on MONTH DAY, YEAR.

2 TMDL name and location

Refer to [DATE] John Day River Basin TMDL rule (OAR …) for the location and impaired waters addressed by this TMDL.

2.1 Climate

The John Day River Basin has a continental climate characterized by low winter and high summer temperatures, low average annual precipitation and dry summers. Rain, snowfall, and temperature regimes vary substantially across the Basin. Climate in the Basin ranges from sub-humid in the upper Basin to semi-arid in the lower subbasin. The John Day River Basin portion of the Deschutes Umatilla Plateau experiences cold winters and hot summers, with moderate night temperatures. Most precipitation is discharged over the Coast Range and Cascade Mountains before reaching the Plateau. Physical features of the area create microclimates that deviate from the general pattern of warmer lower elevations and colder higher elevations. Eastern Oregon's precipitation is highly influenced by elevation.

According to PRISM normals of annual conditions over the past 30 years (1991-2020), the average annual precipitation in the John Day River Basin ranges from around 225 mm (9") in the lower elevations of the basin to over 1,140 mm (45") in the higher elevations of the Cascade Range (PRISM Climate Group, 2022) (**Figure 2-1**). The highest precipitation levels are typically seen during the winter months, between November and March. Several feet of snow accumulate in the mountains bordering the Basin to the east and south. In contrast, the summer months are generally drier, with July and August being the driest months of the year. Less than 10% of the annual precipitation falls as rain during July and August, usually from sporadic thunderstorms.

In terms of temperature, the PRISM normals show that the average annual maximum temperature in the John Day River Basin is around 14.7°C (58.5°F). However, temperatures can vary depending on elevation and the time of year. The average annual maximum temperatures in the John Day River Basin range from 6.57°C (43.8°F) to about 19.78°C (67.6°F) (Error! Reference source not found.). The summer months are typically warm, with average temperatures of up to 26°C (78.8°F) in July. The coolest winter months are December and January, with average temperatures of 3°C (37.4°F) in December.

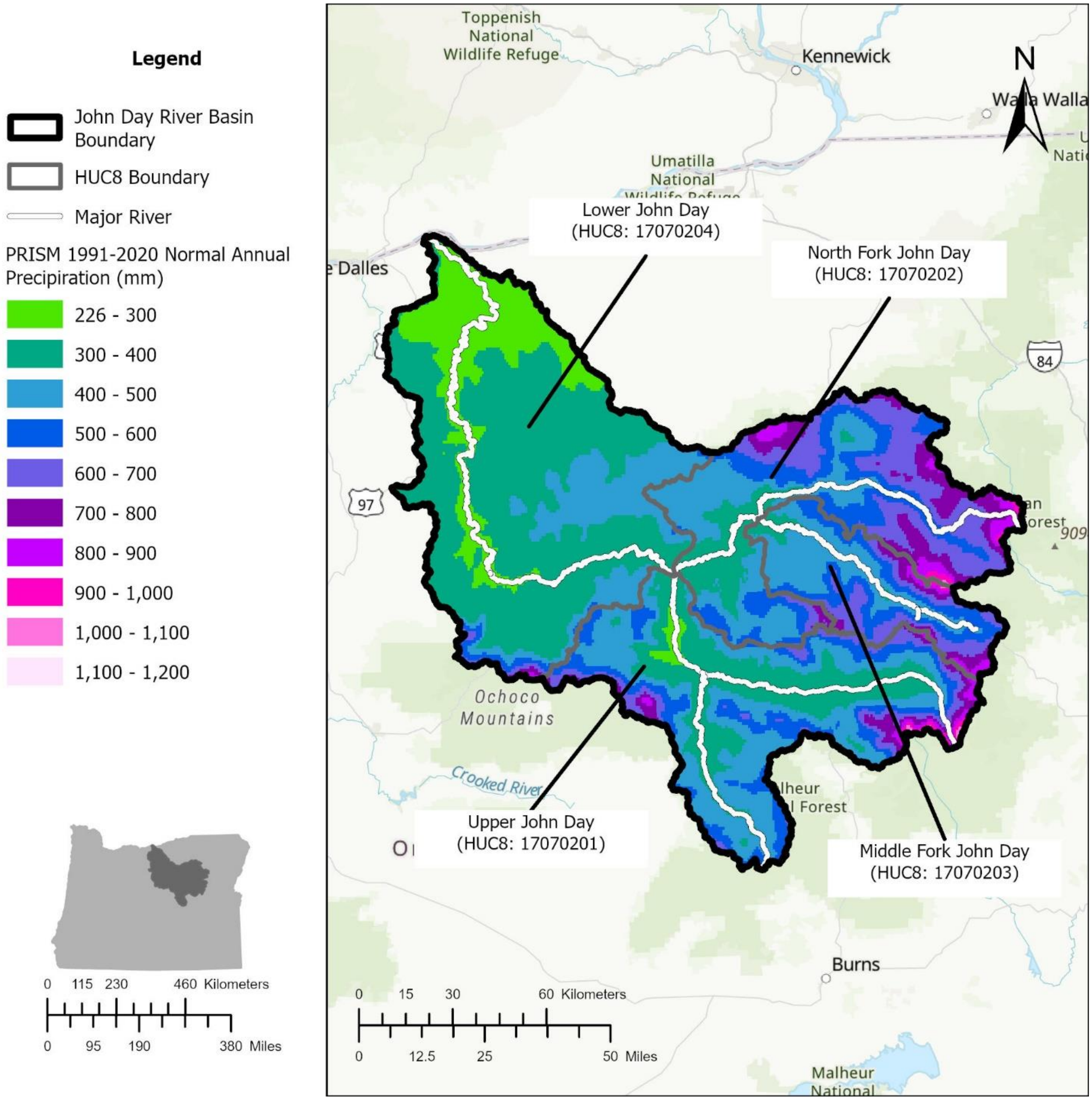

Figure 2-1: PRISM 1991-2020 Normal Annual Precipitation in the John Day River Basin temperature TMDL project area (Data Source: PRISM Climate Group, 2022).

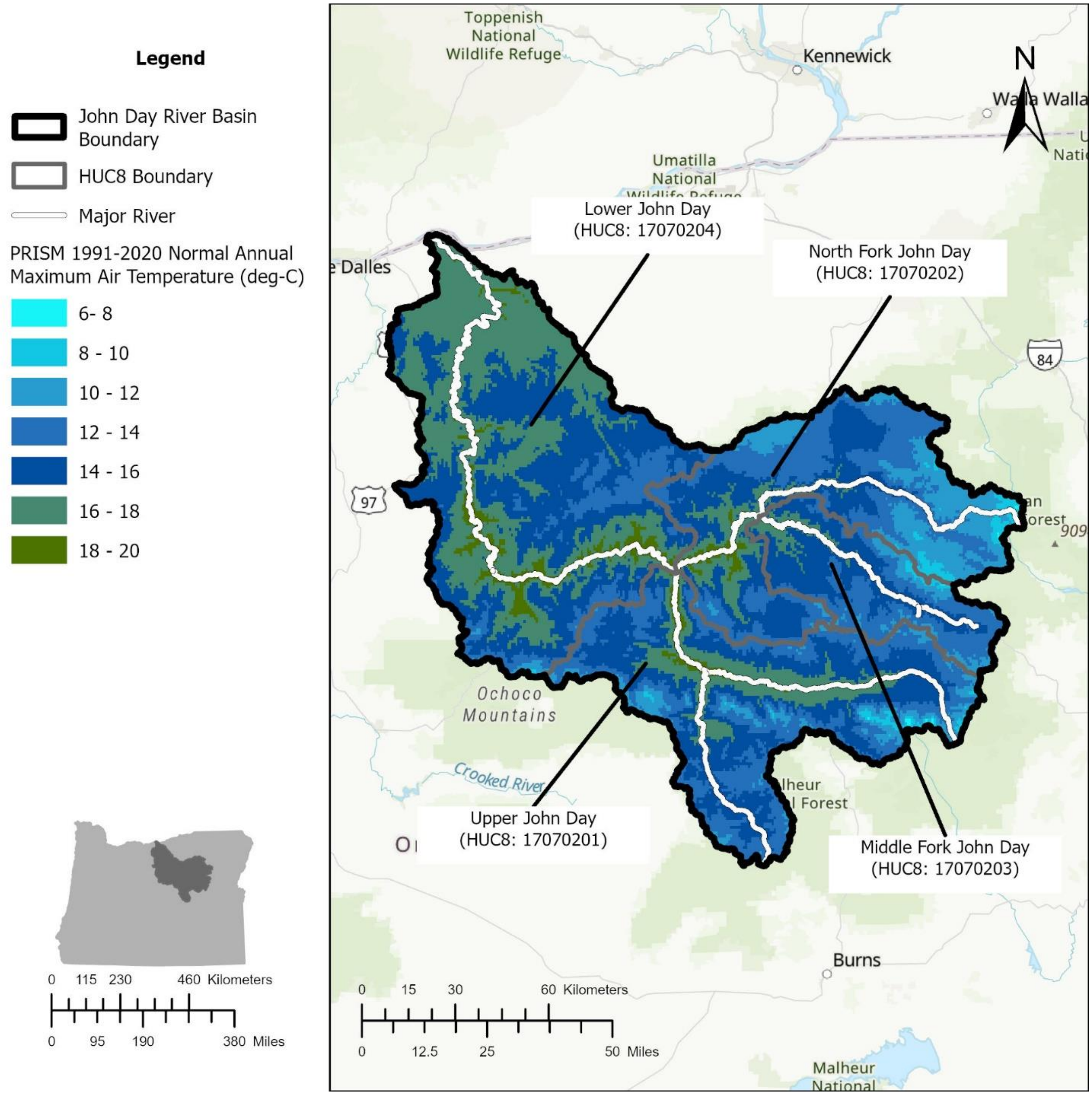

Figure 2-2: PRISM 1991-2020 Normal Annual Maximum Air Temperature in the John Day River Basin temperature TMDL project area (Data Source: PRISM Climate Group, 2022).

2.2 Hydrology

Most water in the John Day River Basin is derived from the upper watershed, primarily in the form of melting snow. Discharge from the free-flowing (no large-scale dams) John Day River is highly variable from peak to low flows. An unusually large stage-range is discussed in hydrological memos relating to mainstem morphologic and vegetation assessment (Fogg, 2007; Smith, 2006).

Flow data in the John Day River Basin is currently being collected from 18 stations located on the river and various tributaries. These and historic gages were used in calibrating the hydrology Basin-wide for TMDL development. However, the bulk of the TMDL analysis relied on the currently active gaging.

These gages are at McDonald Ferry (mainstem river mile 21), Service Creek (mainstem river mile 157), Picture Gorge (mainstem river mile 205), City of John Day (mainstem river mile 253), Blue Mountain Hot Springs (mainstem river mile 275), City of Monument (North Fork river mile 16), above Dayville (South Fork river mile 5), Ritter Hot Springs (Middle Fork river mile 15), and near Izee (South Fork river mile (river mile 34). Other streams currently being monitored include: Mountain Creek, Lone Rock Creek, Butte Creek, Murderer's Creek, Deer Creek, Canyon Creek, Strawberry Creek, Camas Creek and Bridge Creek.

The USGS-maintained gage at McDonald Ferry, Oregon (gage # 14048000), the oldest gage in the Basin, has been in operation since December 1904. The discharge measured at this station represents 7580 square miles, or approximately 96% of the entire Basin, providing Basin-scale hydrologic patterns. Long-term month-averages are plotted in Figure X. John Day River mean annual discharge ranges from a high of 4818 CFS-cubic feet per second (136 CMS-cubic meters per second) in 1984 to the low of 603 CFS (17 CMS) in 1934, as portrayed in Figure X. The River's long-term mean annual discharge into the Columbia River is slightly more than 2000 CFS (56.6 CMS). This information is from the Northwest Power and Conservation Council (NWPC, 2001) Subbasin Plan for the John Day River Basin.

Peak stream flows in the John Day River usually occur from March through May while the seasonal low flows typically occur from August through October. The highest recorded discharge of the John Day River was 42,800 CFS (1210 CMS) on December 24, 1964, caused by warm rain melting large amounts of snow. The lowest recorded discharge from the McDonald Ferry station was zero for part of September 2, 1966, August 15 to September 16, 1973, and August 13, 14 and 19 to 25, 1977. Peak flow at the McDonald Ferry gaging station is typically over 100 times greater than the lowest flows of the same year. From year to year, peak flows can vary as much as 300 to 700% (CBRCD, 2005). This unusual stage range has implications for rates and pattern of riparian vegetation growth and recovery.

Insert figure of mean monthly discharge from 1904 to 2002 at McDonald Ferry gage #14048000 (see 2010 TMDL Figure 1.4-5)

Insert figure of Mean annual flows in the John Day River Basin, McDonald Ferry gage #14048000 (see 2010 TMDL Figure 1.4-6.)

2.3 Intermittent streams

An intermittent stream as defined by Nadeau (2015) is a channel that contains water for only part of the year, typically during winter and spring when the streambed may be below the water table or when snowmelt from surrounding uplands provides sustained flow. The channel may or may not be well defined. The flow may vary greatly with stormwater runoff. An intermittent stream may lack the biological and hydrological characteristics commonly associated with the continuous conveyance of water. Intermittent streams contribute to maintenance of cold water in downstream tributaries, even during periods when there is no surface flow (Ebersole et al., 2015).

The TMDL applies to intermittent streams for three primary reasons:

1) To protect aquatic life that may reside in intermittent streams. Intermittent streams can be “dry” but continue to support aquatic life in residual pools that remain during the dry periods. Residuals pools are often fed by subsurface flow. There is at least one published study in Oregon documenting the presence of juvenile salmonids in these residual pools over the summer (May and Lee, 2004). The temperature water quality standards apply to residual pools and the aquatic life that use them.

2) To protect downstream temperatures. Stream warming is cumulative and not contained to just human activities within the reaches that are impaired. Activities in upstream tributaries, including intermittent streams, can influence stream temperatures downstream. For this reason, the EQC has developed standards protecting cold water (PCW) that already meets the biological based criteria and may not be currently listed as impaired (see OAR 340-041-0028 (11)). In particular, intermittent streams are important for downstream temperatures because they can:

    a. Be flowing when temperature TMDLs apply. Streams classified as intermittent may only be “dry” in the summer or during low precipitation years. Temperature TMDLs apply to periods when downstream tributary temperatures exceed the applicable temperature standard. In the John Day River Basin the TMDL allocations apply May 1 – Oct 31 in most watersheds. Some watersheds require longer allocation periods (see Section 5). The TMDL allocation period includes months when intermittent streams may be flowing, such as in the spring or early fall when the spawning criterion apply.

    b. Become perennial or have longer periods of surface flow following timber harvest. Multiple studies have documented the increase to summer flow and annual water yield following a timber harvest (Hibbert, 1967; Rothacher, 1970; Harr et al., 1982; Keppeler and Ziemer, 1990; Bowling et al., 2000; Surfleet and Skaugset, 2013; Segura et al., 2020). Insufficient shade over these streams contributes to excessive solar loading, temperature increases, and may contribute to downstream warming.

    c. Be flowing subsurface because they are currently degraded. In Eastern Oregon there are examples of degraded intermittent streams becoming perennial after riparian restoration. Restoring the riparian vegetation will allow the system to aggrade, raising the water table and returning flow to the surface (Elmore and Beschta, 1987).

3) As an implicit margin of safety to address the current inaccuracies associated with classification and mapping of intermittent streams, and their period of flow in relation to the period when TMDL allocations apply. There are multiple approaches used to identify and map stream flow permanence and duration. Some of the more recent methods used in Oregon (Nadeau, 2015; Jaeger et al., 2019) are improvements over previous methods; and the classifications included in past versions of the NHD. Fritz et al. (2013)

demonstrated that the flow permanence classifications included in the NHD only had about a 50% agreement with field-based observations. DEQ believes the current classifications are not accurate enough for reliable application and use for the TMDL.

For these reasons the TMDL allocations apply to intermittent streams unless field-based data is assembled to document a stream does not contain residual pools and does not have surface flow during the entire period the TMDL applies.

2.4 Land Use

Evergreen forests, grassland/ herbaceous, and shrub/ scrub uses dominate land use in the John Day River Basin TMDL project area, which is summarized in **Table 2-1** and **Figure 2-4** based on the 2016 National Land Cover Database (Dewitz and USGS, 2021).

The largest land use category in the basin is Evergreen forest, accounting for 35.00% of the land and are mainly located toward the higher elevations. Grassland/ herbaceous accounts for about 32% of the land in the basin. Lastly, shrub/ scrub land accounts for just under 25% of the basin. Together these three land uses account for over 90% of the total basin area. Urban areas are not prominent, with less than 2% of the total area designated as developed (including low, medium and high intensity). There are seventeen incorporated cities in the basin, all with populations under 2000, making for a basin population estimate of 6,522 people (Population Research Center, 2025).

Table 2-1: Summary of land uses in the John Day River Basin TMDL project area based on the 2024 National Land Cover Database.

2016 NLCD Land Cover	Acres	Percent of Total Area
Evergreen Forest	1773027.642	35.00%
Grassland/ Herbaceous	1629411.624	32.17%
Shrub/ Scrub	1237101.438	24.42%
Cultivated Crops	270611.562	5.34%
Developed, Open Space	56771.172	1.12%
Emergent Herbaceous Wetlands	41600.358	0.82%
Developed, Low Intensity	32094.318	0.63%
Pasture/ Hay	11201.454	0.22%
Woody Wetlands	5891.658	0.12%
Open Water	5323.782	0.11%
Developed, Medium Intensity	1626.594	0.03%
Barren Land (Rock/Sand/Clay)	504.162	0.01%
Developed, High Intensity	115.662	<0.01%
Mixed Forest	2.886	<0.01%
Perennial Ice/Snow	1.776	<0.01%

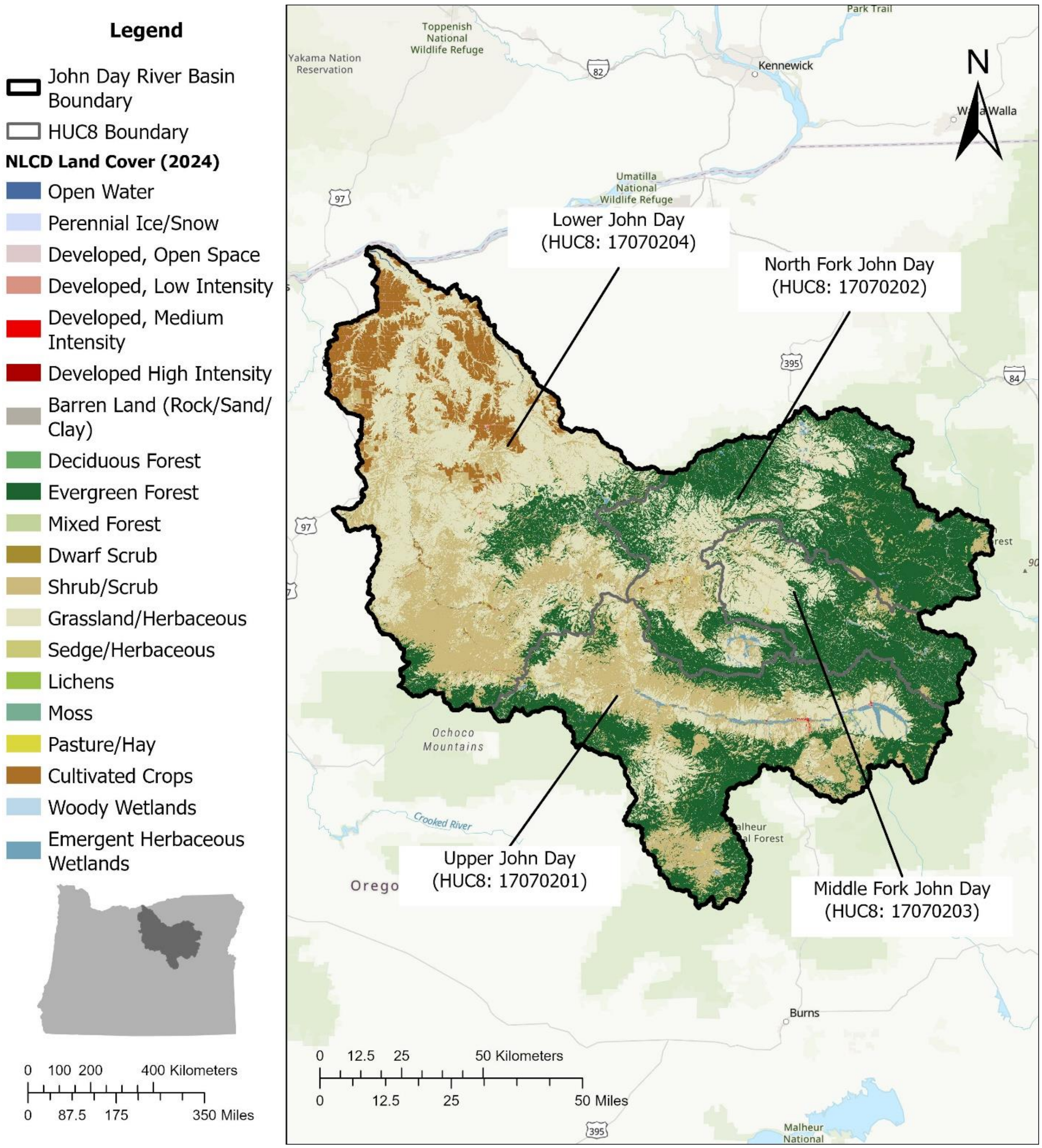

Figure 2-3: Land uses in the John Day River Basin TMDL project area based on the 2024 National Land Cover Database.

2.5 Land Ownership and Jurisdiction

The John Day River Basin TMDL project area is a complex landscape with a variety of landowners and jurisdictions (**Figure 2-4**). Land ownership and jurisdiction was determined using the Designated Management Agency (DMA) Geographic Information System (GIS) data described in Section 2.2 of the calibration report (TSD Appendix A). Land ownership within the subbasins includes state and federal agencies, as well as counties and municipalities. Oregon

State and federal agencies own the majority of land in the basin, accounting for about 88% of the total basin. The agencies with the largest ownership are Department of Agriculture (ODA), which owns and manages about 46%, followed closely behind by the US Forest Service owns and manages about 32% of the land in the John Day River Basin.

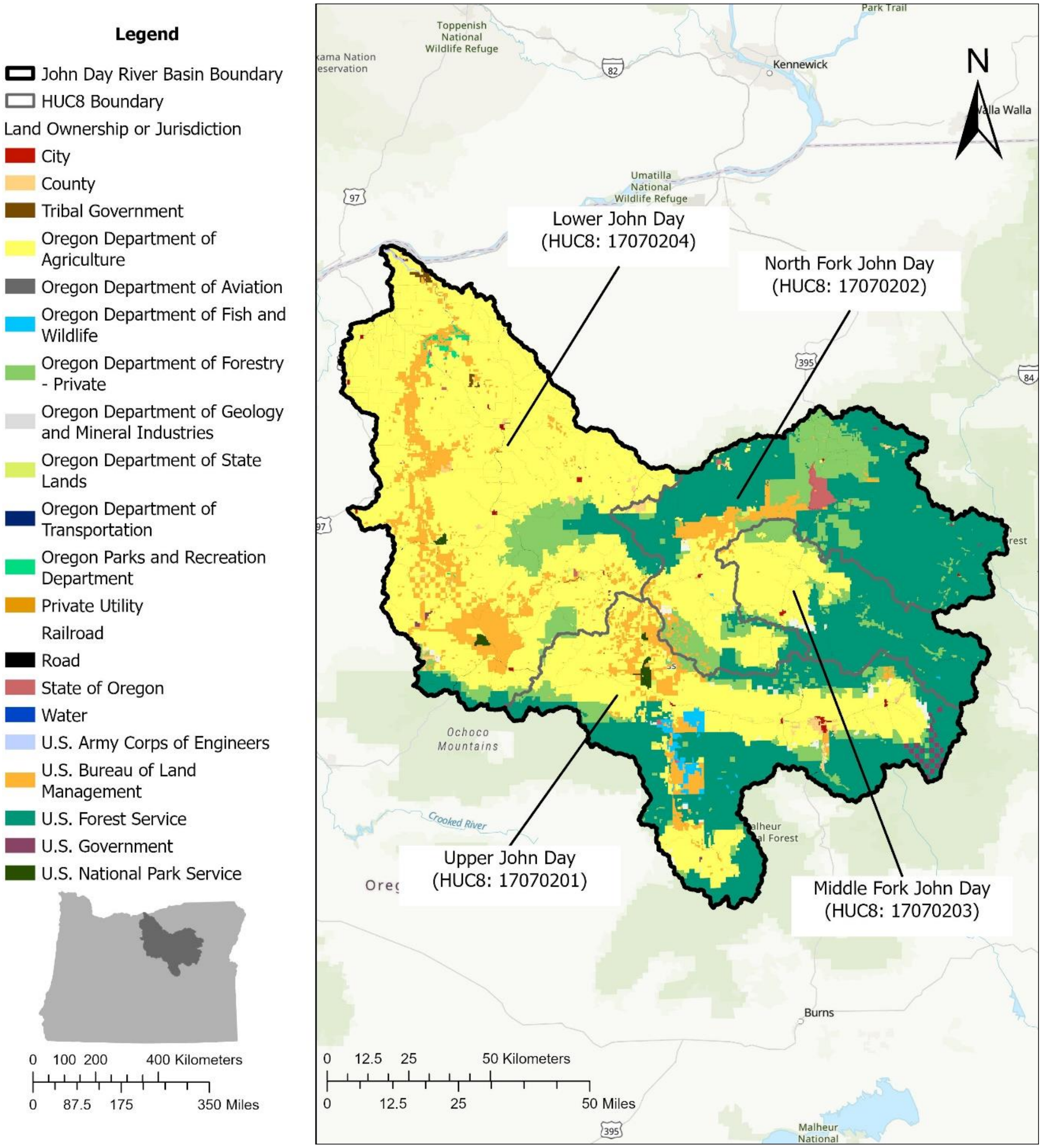

Figure 2-4: Land ownership and jurisdiction in the John Day River Basin temperature TMDL project area.

3 Pollutant identification

Refer to DATE John Day River Basin TMDL rule (OAR ….) for the pollutants addressed by this TMDL.

4 Temperature water quality standards and beneficial uses

Refer to DATE John Day River Basin TMDL rule (OAR ….) for the applicable temperature criteria in the John Day River Basin.

[Insert narrative to summarize how DEQ interpreted the narrative criteria into a numeric target.]

4.1 Natural lakes

The narrative natural lakes criterion at OAR 340-041-0028(6) states that natural lakes may not be warmed by more than 0.3°C (0.5°F) above the natural condition unless a greater increase would not reasonably be expected to adversely affect fish or other aquatic life. Absent a discharge or human modification that would reasonably be expected to increase temperature, DEQ will presume that the ambient temperature of a natural lake is the same as its natural thermal condition. Any lake that is not a reservoir (i.e. formed by the damming or diversion of rivers) is considered a natural lake and subject to the narrative criterion for natural lakes. This includes lakes that have been modified or enlarged and are now managed, as long as they were originally a natural lake. TSD Appendix [D] identifies the known lake AUs where the natural lakes criterion applies.

For the purpose of applying the natural lakes criterion, ambient temperatures have the same meaning as defined in OAR 340-041-0002(2) where ambient means the temperature measured at a specific time and place. The selected location for measuring ambient temperature must be representative of the lake in the vicinity of the point being measured.

This criterion specifies a total allowable warming of lake waters of 0.3°C from all anthropogenic sources, point and nonpoint, not an increase for each source independently. The amount of warming each source category is allowed is based on the assigned human use allowance in this TMDL.

The Temperature IMD (DEQ, 2008a) outlines procedures to implement the narrative. DEQ incorporated the IMD recommendations with additional information to translate the natural lakes narrative into a numeric temperature target. The procedures summarized below will be used by DEQ to implement the natural lakes narrative criterion in the John Day River Basin temperature TMDL project area.

1) DEQ will determine if ambient temperatures reflect the natural thermal condition. DEQ may require modeling or other analysis to estimate the natural condition lake

temperatures if human modifications have impacted or have potential to impact lake temperatures. DEQ will make this determination based on the best available information and professional judgment. Conclusions must be documented with the rationale explained.

2) If ambient temperatures are determined to be the same as the natural thermal condition, the TMDL target temperatures will represent the 7DADM calculated from continuous temperature monitoring at one or more representative locations in the lake. The sampling approach and number of monitoring locations may vary depending on the lake size, temperature variability, and stratification regime. Continuous temperature data should be collected for a minimum of one year during the critical period but may be extended for additional years depending on climatic conditions or other factors affecting lake temperatures during the monitoring period. For stratified lakes, monitoring is focused to the epilimnion. DEQ may require monitoring in deeper waters if appropriate. For example, if a point source discharges to waters below the epilimnion, or there is information showing the most temperature sensitive fish or other aquatic life reside in deeper waters. After continuous temperature monitoring is complete, ambient 7DADM temperatures may be characterized into monthly target values using the minimum ambient 7DADM measured for that month. These monthly 7DADM temperatures can be used in lieu of additional continuous temperature monitoring. The ambient 7DADM temperatures (based on continuous monitoring or monthly values), plus 0.3°C HUA represent the lake temperature targets to be used for calculation of the TMDL loading capacity and allocations.

3) If modeling or other analysis is used to estimate the natural thermal condition, the natural condition temperatures will be characterized into monthly 7DADM temperature targets as described in item 2.

4) Per OAR 340-041-0028(6), DEQ may allow an increase greater than 0.3°C above the natural condition if that increase is not expected to adversely affect fish or other aquatic life. The HUA assigned to anthropogenic sources in this TMDL do not exceed 0.3°C. Therefore, any increase above the natural condition temperatures shall be implemented so the target temperature plus 0.3°C HUA, is protective of fish or other aquatic life. The source requesting an increase must demonstrate to DEQ's satisfaction that the greater increase would not reasonably be expected to adversely affect fish or other aquatic life. DEQ will base its determination on the best available information and professional judgment. DEQ will consult a biologist or other expert(s) on the lake in question from other agencies or academic institutions, if available. Pertinent information may include the current ambient lake temperature, the resident species of the lake and their thermal requirements, lake characteristics (i.e. size, productivity, stratification, etc.) and whether the lake has been altered or impacted by human activity in the past, and the magnitude, duration and frequency of the proposed temperature increase.

4.2 Cold water refugia narrative

Waters designated as a salmon and steelhead migration corridor (see TMDL Section 4.4) must have cold water refugia that are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body. The narrative provision supplements the numeric criterion of 20°C to protect migrating populations of salmon and steelhead.

Migration corridors are often river channels that are too wide for effective vegetation shading and groundwater inflow to maintain cooler temperatures, although these factors can be important to maintaining cold refuges in these rivers. The narrative criteria directs that sufficient cold-water refuge be available within the warmer waters of migration corridors. As the temperature of corridors approach 20°C, the role of cold ware refugia is expected to enable fish to migrate upstream and downstream without impairment.

Cold water refugia is defined in OAR 340-041-0002(10) to mean those portions of a water body where or times during the diel temperature cycle when the water temperature is at least 2°C colder than the daily maximum temperature of the adjacent well-mixed flow of the water body.

The cold water refugia narrative is applicable to the John Day River from the mouth of the John Day River, upstream to river mile 185, at the confluence of the North Fork John Day River and John Day River.

There are several types of cold water refugia. Tributary streams that are colder than the river they flow into provide cold water refuges for migrating fish in the confluence area of the tributary. These areas are called plume cold water refuges. Fish can enter these plumes and the lower portions of colder tributaries to minimize their heat exposure during warm periods. Cold water refuges can also be formed by cold inflowing groundwater. This type of cold water refugia includes river flow that submerges into the substrate and then re-emerges as colder water, often termed hyporheic flow (Torgersen. et al. 2012). Another type is the temperature difference between day and nighttime temperatures in the mainstem John Day River. River temperatures have a daily diurnal pattern, with warmer temperatures occurring during the day usually around midafternoon. The coolest temperatures occur at night, often right before sun rise. The cooler nighttime temperatures are due to the absences of solar radiation flux at night. These cooler nighttime temperatures can serve as diurnal cold water refugia.

DEQ evaluated the potential for tributaries of the John Day River to serve as cold plume water refugia as well as diurnal cold water refugia.

To evaluate diurnal cold water refugia, John Day River daily maximum and daily minimums were compared for each day when the daily maximum temperature is 20ºC or warmer. The model calibration temperatures were used for this analysis as it provides a complete temporal and spatial characterization of temperatures in the Lower John Day. The river was divided into 10-kilometer segments to show sufficient distribution in the John Day River. Across all segments, the median difference between John Day River daily maximums and daily minimums are greater than 2°C. In many reaches, the 2°C minimum fell below the lower quartile, which indicates that at least 75% of observations exceeded this value. The median temperature differences generally ranged from approximately 3 to 5°C, with the largest values occurring between model kilometers 140–130. The full distribution of temperatures is shown in the boxplots in **Figure 4-1**. Based on these results the nighttime temperatures (greater than or equal to 2°C difference) are sufficiently distributed (10km) in the John Day River and therefore serves as diurnal cool water refuge.

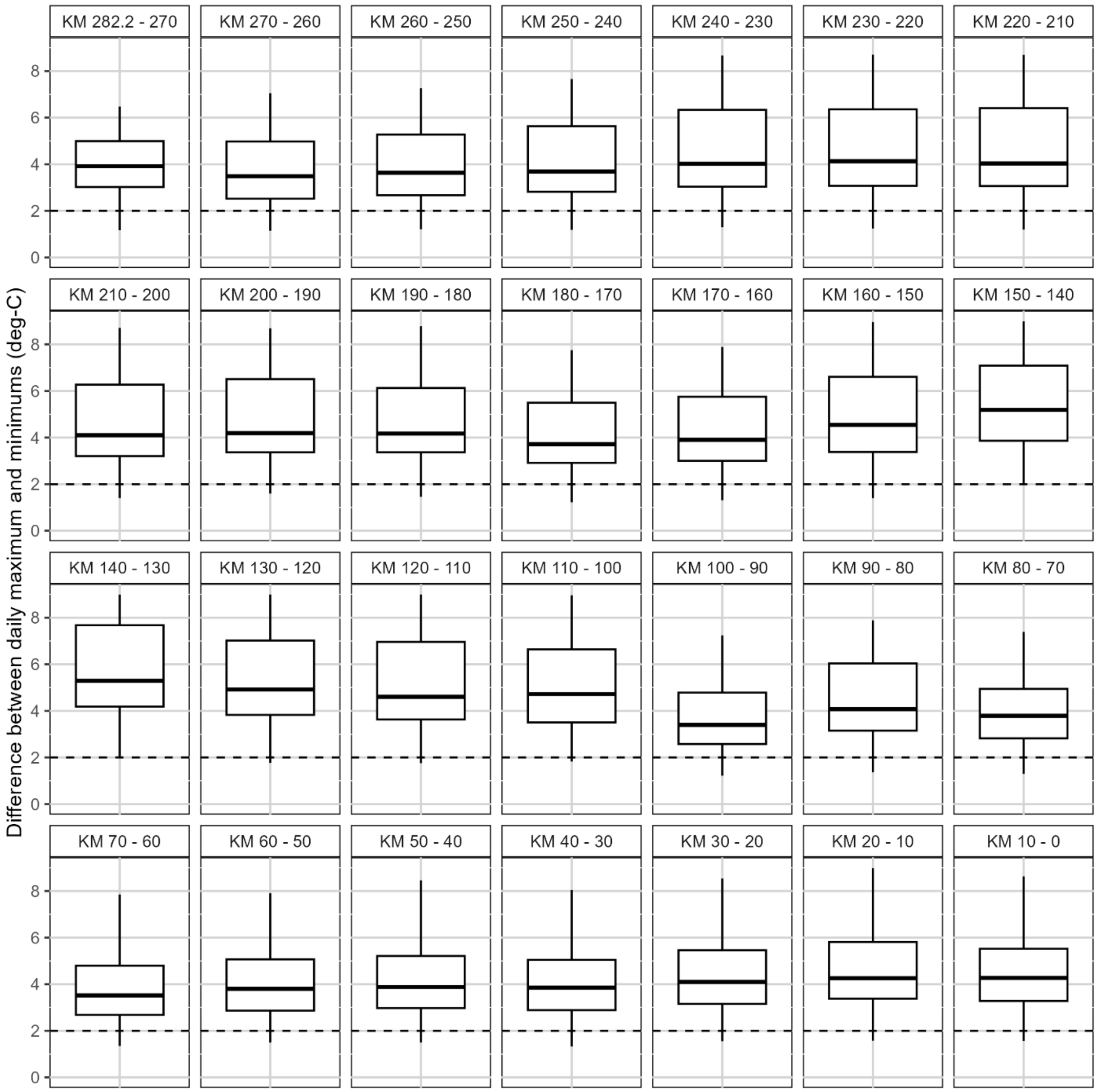

Figure 4-1: Boxplots showing distribution of temperature differences between the John Day River daily maximum and daily minimum during periods when the daily maximum >= 20°C.

A tributary analysis was also performed to evaluate tributaries as cold plume water refugia. A tributary was determined to be a cold water refuge if the August mean temperature of the tributary inflow is at least 2°C cooler than the August mean of the John Day River.

DEQ determined two tiers of cold plume water refugia, which have been summarized in **Table 4-1**. Tier 2 cold plume water refugia applies when tributary temperatures are greater than or equal to 2°C colder than John Day River. For tier 1, the 2°C threshold applies, and August mean flow for the tributary is greater than or equal to 7 cfs. The flow threshold is consistent with the approach used in the Columbia River where EPA used 7-10 cfs as the minimum August mean tributary flow needed to form a cold water plume (EPA, 2021). Based on the criteria, 150 of 153 of the tributaries identified in the NorWeST database meet the tier 2 cold plume water refugia criterion, and 2 of 153 tributaries meet the tier 1 cold plume water refugia criterion (**Figure 4-2**). The two tributaries that meet the Tier 1 criterion are Bridge Creek and Thirtymile Creek.

Table 4-1: Screening criteria for cold plume water refugia.

Tier	Cold plume water refugia screening criteria	Tributaries Meeting Screen / Total Tributaries
Tier 2	Tributary temperature >= 2°C colder than John Day River	150/153
Tier 1	Tier 2 and tributary mean August flow >= 7 cfs	2/153

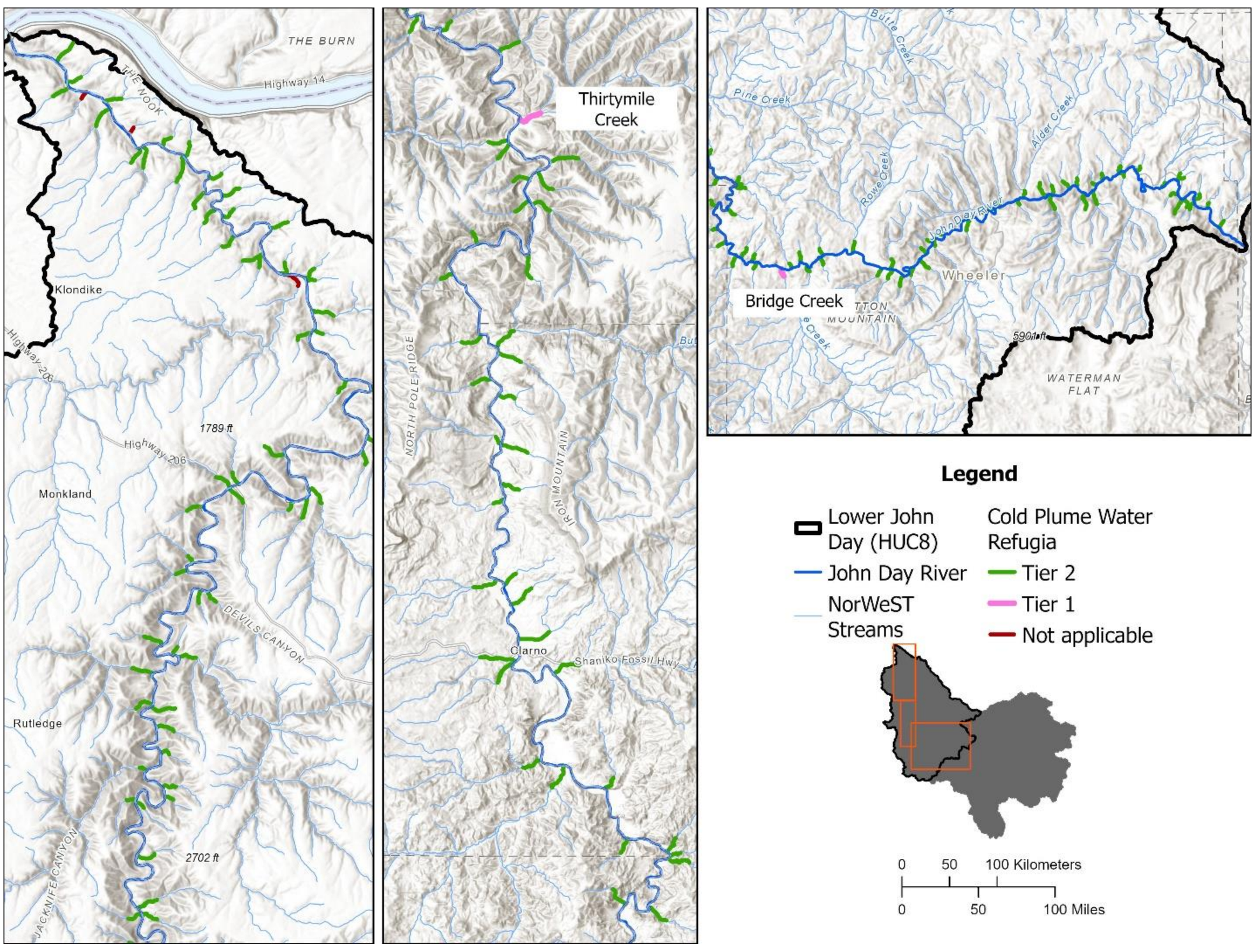

Figure 4-2: Map of NorWeST streams and identified cold plume water refugia.

5 Seasonal variation and critical period for temperature

DEQ reviewed available temperature data to determine seasonal temperature variation and the critical period. The critical period is based on the frequency and period when 7DADM stream temperatures exceed the applicable temperature criteria. **Table 5-1** summarizes the water temperature monitoring data used to designate critical periods.

Figure 5-1 through **Figure 5-35** show boxplots of the seasonal variation of 7DADM temperatures and the period of exceedance at select monitoring locations identified as having Category 5 temperature impairments on the 2022 Integrated Report. When multiple monitoring sites were available, the sites with multiple years of data were selected. Temperature data were grouped by the first and second half of each month. The month was split on the 15th with the first group including all results measured on the 1st through the 14th day and the second group including all results measured on the 15th through the end of the month. The boxplots are Tukey style boxplots with the middle line representing the median and ends of the box representing the temperature range between the first and third quartiles (25th – 75th percentile). The whiskers extend to values no further than 1.5 times the interquartile 7DADM temperature range (i.e., 1.5 times the difference between 25th and 75th percentiles). The points represent individual 7DADM temperature values beyond 1.5 times the interquartile range. The dashed line corresponds to the applicable temperature criteria. The shaded yellow area identifies the period when any 7DADM temperature exceeded the applicable temperature criteria.

The plots show that maximum stream temperatures typically occur in July or August. This period usually coincides with the lowest annual stream flows, maximum solar radiation fluxes, and warmest ambient air temperature conditions. The warmest median 7DADM temperatures were observed in...

The period and frequency of temperature criteria exceedance varies based on monitoring location. Monitoring locations in the Lower John Day Subbasin had the longest periods of exceedance. At Pine Creek near Clarno, 7DADM temperatures exceeded the applicable criteria approximately February 15 through August 31 (**Figure 5-1**). Exceedances occurred approximately March 15 through October 15 in Bridge Creek above Coyote Canyon near Mitchell, Oregon (**Figure 5-2**).

DEQ uses the critical period to determine when allocations apply. In setting the allocation period, DEQ relied upon monitoring sites with the longest period of exceedance. When downstream monitoring sites have longer exceedance periods relative to upstream waters, the longer period is used as the critical period for upstream waterbodies when the downstream waterbodies were not modeled; or if the model shows thermal loads to upstream waterbodies contribute to temperature criteria exceedances in downstream waterbodies. For example, INSERT EXAMPLE. This ensures warming of upstream waters does not contribute to downstream exceedances.

The frequency of exceedance was also considered. If any individual 7DADM temperature values within 1.5 times the interquartile range exceeded the criterion (shown as the upper whisker on the boxplots), that period was included in the critical period. These 7DADM values represent approximately 98% or more of all observations in that 15-day period.

The critical periods for waterbodies in the John Day River Subbasins are presented in **Table 5-2** to **Table 5-5**. Allocations presented in the TMDL apply during these periods.

Table 5-1: Water temperature monitoring locations and periods used to determine seasonal temperature variation and critical periods for the John Day River Basin.

Monitoring Location ID	Monitoring Location	Monitoring Period	Number of 7DADM values
14046890	Pine Creek near Clarno, OR	01/22/04 - 06/27/22	6562
14046778	Bridge Creek above Coyote Canyon near Mitchell, OR	08/24/06 - 12/07/22	4752
MNF-096	Big Creek 1_WT	07/15/13 - 09/28/15	163
MNF-017	Camp Creek at mouth 112819a_LTWT	06/16/04 - 06/22/20	807
14043840	MF John Day River above Camp Creek, near Galena, OR	10/06/16 - 12/05/22	2226
MNF-251	Vinegar Creek Lower 113520a_LTWT	06/16/04 - 10/26/05	269
UmatNF-022	IndianFB_LTWT	04/18/04 - 11/02/19	3676
UmatNF-068	Wall2AtFB_LTWT	05/13/04 - 09/15/10	1314
UmatNF-070	Wlsn4AWL_LTWT	05/13/04 - 10/09/18	2506
UmatNF-035	LWall2Sk_LTWT	05/20/04 - 10/06/14	1889
UmatNF-036	LWallBac_LTWT	06/10/14 - 11/02/19	1199
UmatNF-062	Skookum2_LTWT	05/20/04 - 10/06/14	1480
UmatNF-064	Swale3Sk_LTWT	06/24/04 - 07/17/18	2337
UmatNF-014	Ditch2Cr_LTWT	06/25/04 - 09/25/18	2532
UmatNF-082	Cable@MT_LTWT	05/12/04 - 10/17/06	360
UmatNF-008	CamasAtMT_LTWT	06/23/04 - 10/17/19	2606
UmatNF-083	CamsALan_LTWT	05/12/04 - 10/02/06	345
UmatNF-020	HidaSpgs_LTWT	06/23/04 - 10/24/19	2875
UmatNF-089	Lane@MT_LTWT	06/10/05 - 10/02/06	210
UmatNF-040	MdwbrAtMT_LTWT	05/20/04 - 10/22/19	2772
UmatNF-066	TXBarAtMT_LTWT	05/21/04 - 10/21/10	1115
UmatNF-074	BigCr@MT_LTWT	07/02/04 - 10/11/06	277
UmatNF-039	MdwbFkgs_LTWT	06/29/05 - 10/22/19	2091
UmatNF-095	NFJDaBig_LTWT	07/02/04 - 09/18/06	254
UmatNF-009	ClearFB_LTWT	08/03/04 - 10/26/10	701
UmatNF-086	GrnitAtMT_LTWT	07/07/04 - 09/25/06	294
UmatNF-096	NFJDaGrn_LTWT	07/07/04 - 09/25/06	294
WWNF-143	NFJD.94G.1_LTWT	07/02/03 - 10/16/16	435
28453-ORDEQ	John Day River - Goose Rock	07/30/99 - 09/26/00	170
24479-ORDEQ	Rock Creek at mouth (tributary to John Day River)	05/30/00 - 09/19/04	159
MNF-054	Murderers Creek 152811a_LTWT	06/05/04 - 10/14/10	483
26556-ORDEQ	Fields Creek	06/22/00 - 10/01/01	210

Monitoring Location ID	Monitoring Location	Monitoring Period	Number of 7DADM values
MNF-018	Canyon Creek boundary BMRD 153234a_LTWT	06/05/04 - 11/06/08	459
MNF-032	East Fork Canyon Creek 153216a_LTWT	07/01/07 - 11/06/08	241
MNF-040	John Day River_LTWT	07/03/04 - 09/29/19	1825

Table 5-2: Designated critical periods for waters in the Upper John Day Subbasin (17070201).

Subbasin	Watershed or Waterbody Name	Critical Period
Upper John Day Subbasin 17070201	All waters	May 1 – October 31

Table 5-3: Designated critical periods for waters in the North Fork John Day Subbasin (17070202).

Subbasin	Watershed or Waterbody Name	Critical Period
North Fork John Day Subbasin	All waters, except those noted	May 1 – October 31
North Fork John Day Subbasin	Wall Creek Watershed (1707020208)	April 15 - October 31

Table 5-4: Designated critical periods for waters in the Middle Fork John Day Subbasin (17070203).

Subbasin	Watershed or Waterbody Name	Critical Period
Middle Fork John Day Subbasin	All waters, except those noted	July 1 - October 31
Middle Fork John Day Subbasin	Camp Creek-Middle Fork John Day River Watershed (1707020302) Bridge Creek-Middle Fork John Day River watershed (1707020301)	March 1 - October 31

Table 5-5: Designated critical periods for waters in the Lower John Day Subbasin (17070204).

Subbasin	Watershed or Waterbody Name	Critical Period
Lower John Day Subbasin	All waters, except those noted	March 15 – October 15
Lower John Day Subbasin	Lower Pine Creek Subwatersheds (170702040408) Upper Pine Creek Subwatersheds (170702040407)	February 1 - October 31

5.1 Lower John Day Subbasin seasonal variation

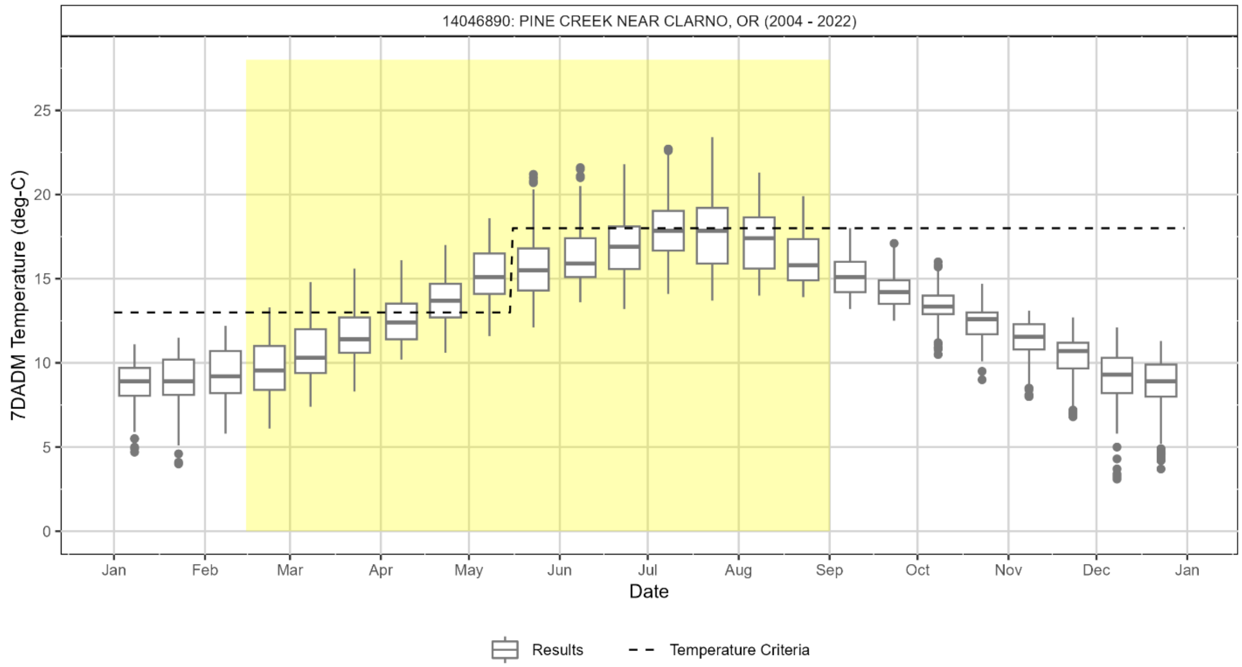

Figure 5-1: Seasonal variation at the Pine Creek near Clarno temperature monitoring site in the Lower John Day Subbasin.

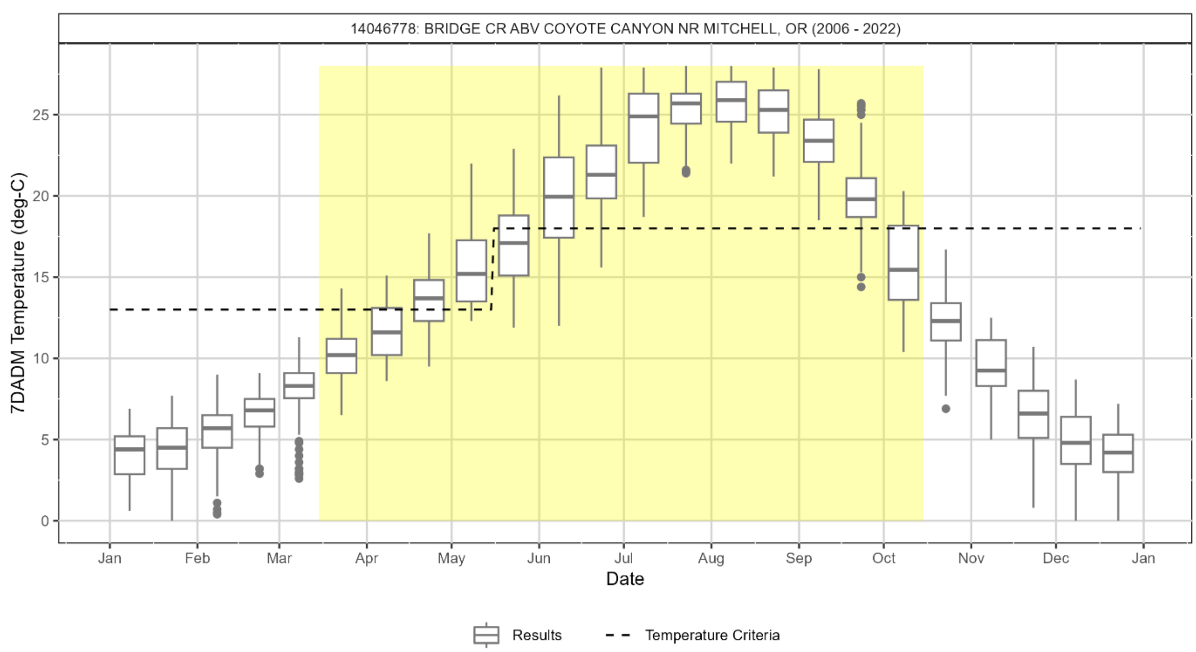

Figure 5-2: Seasonal variation at the Bridge Creek above Coyote Canyon near Mitchell temperature monitoring site in the Lower John Day Subbasin.

5.2 Middle Fork John Day Subbasin seasonal variation

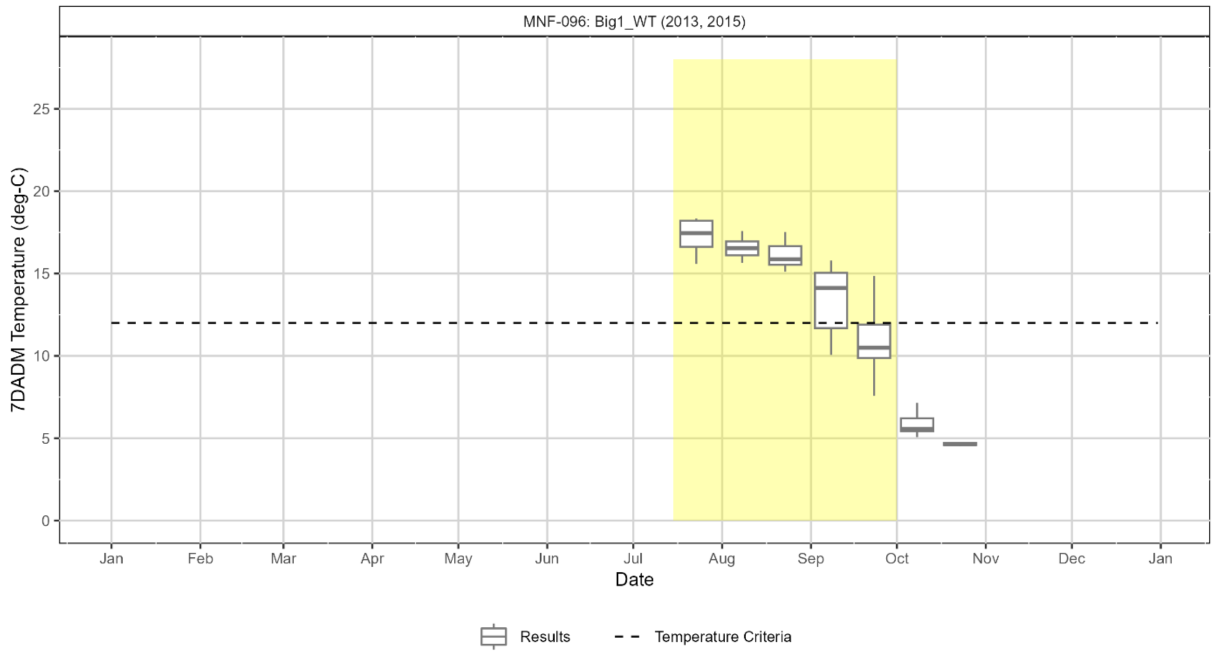

Figure 5-3: Seasonal variation at the Big Creek temperature monitoring site in the Middle Fork John Day Subbasin.

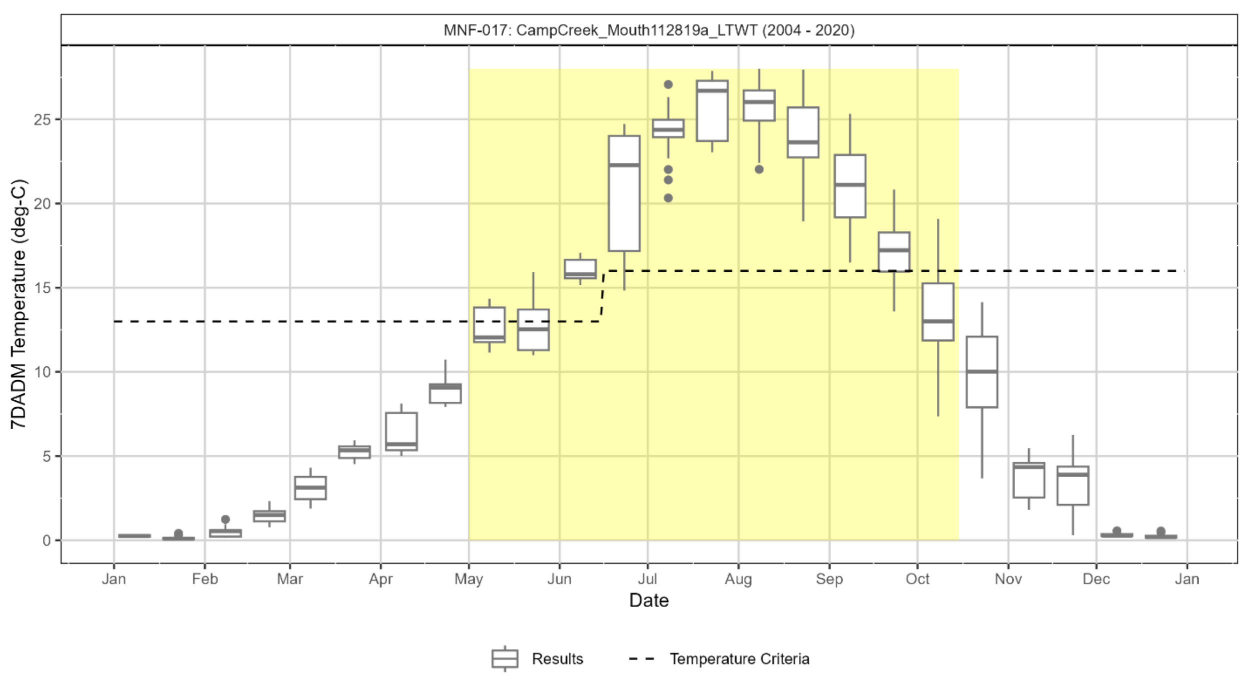

Figure 5-4: Seasonal variation at the Camp Creek at its mouth temperature monitoring site in the Middle Fork John Day Subbasin.

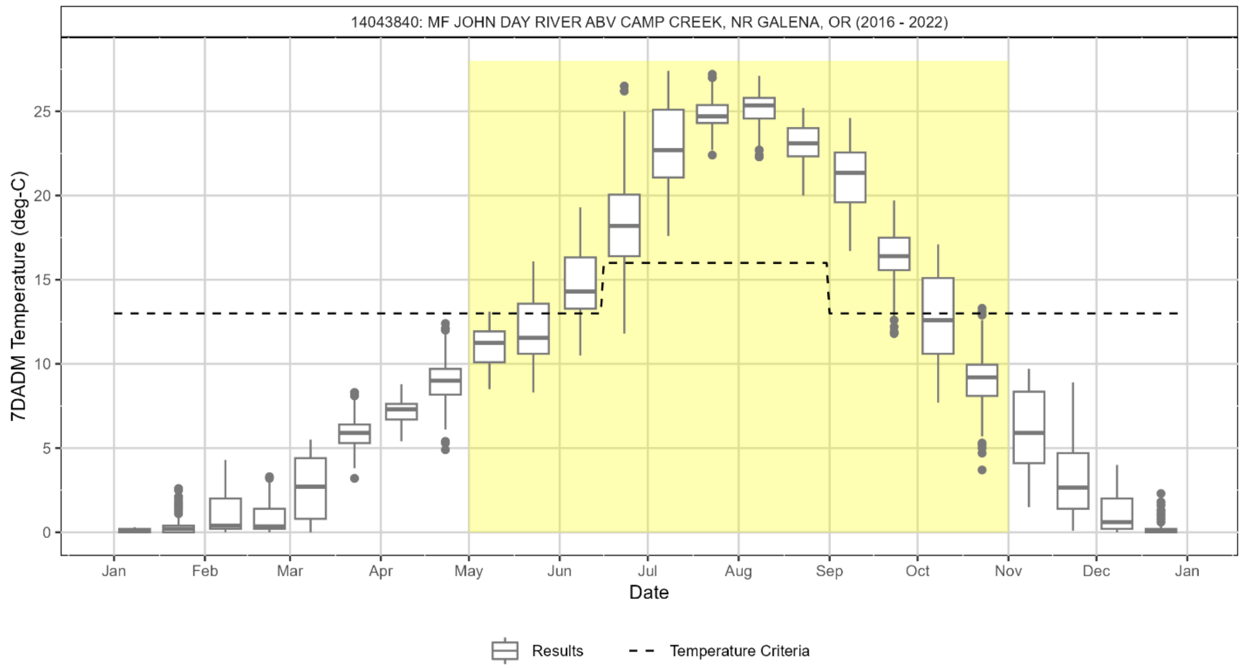

Figure 5-5: Seasonal variation at the Middle Fork John Day River above Camp Creek near Galena temperature monitoring site in the Middle Fork John Day Subbasin.

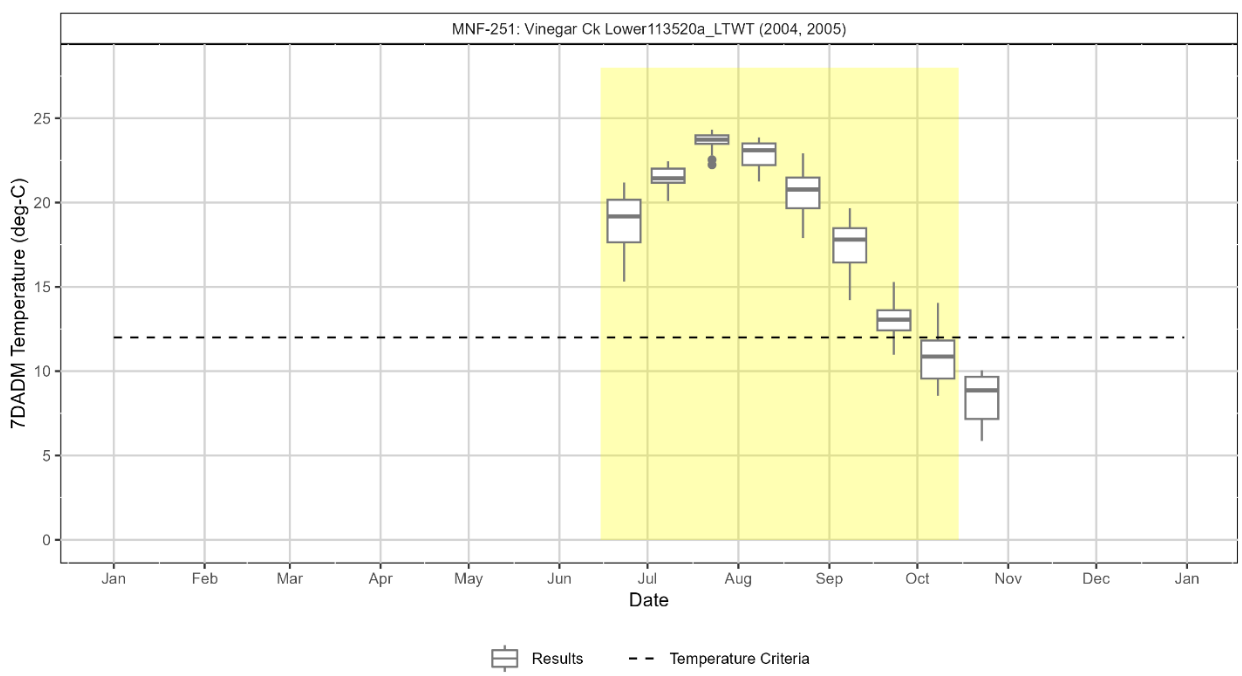

Figure 5-6: Seasonal variation at the Lower Vinegar Creek temperature monitoring site in the Middle Fork John Day Subbasin.

5.3 North Fork John Day Subbasin seasonal variation

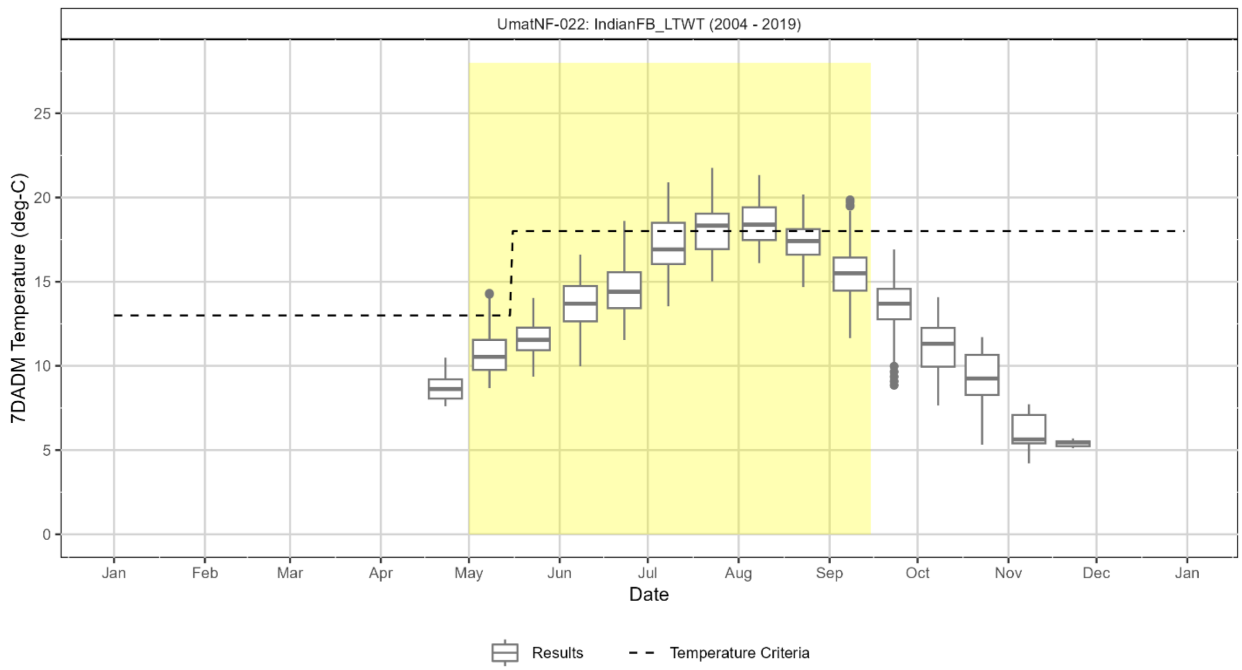

Figure 5-7: Seasonal variation at the Indian Creek temperature monitoring site in the North Fork John Day Subbasin.

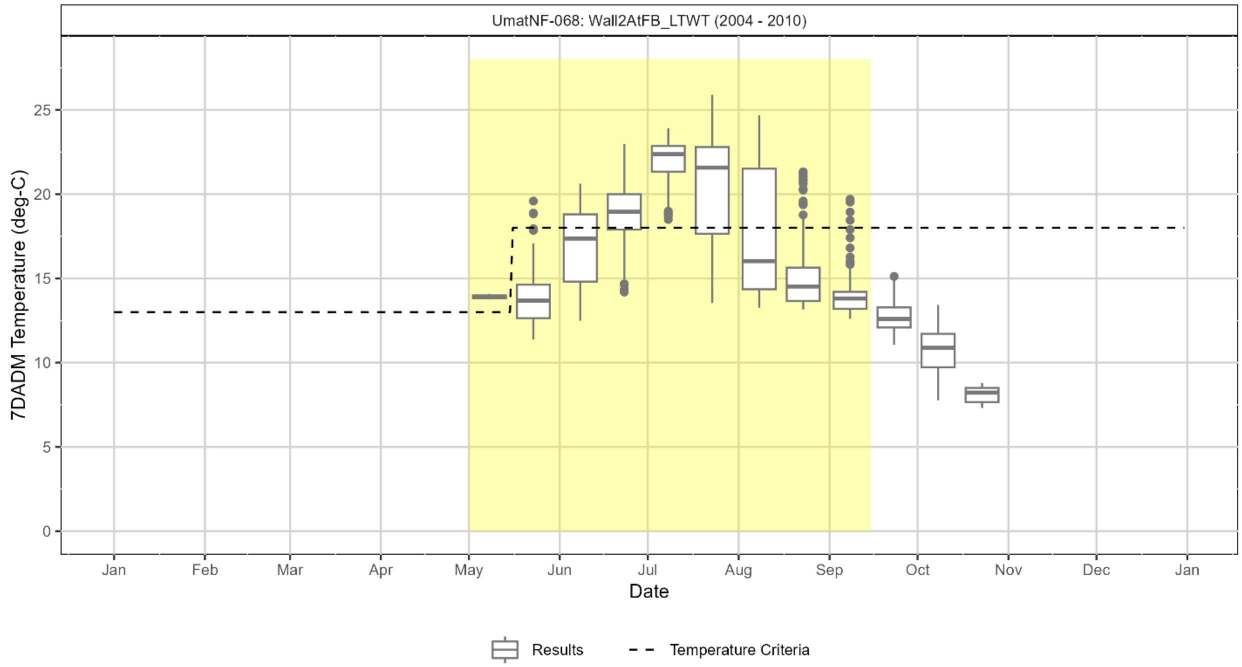

Figure 5-8: Seasonal variation at the Big Wall Creek temperature monitoring site in the North Fork John Day Subbasin.

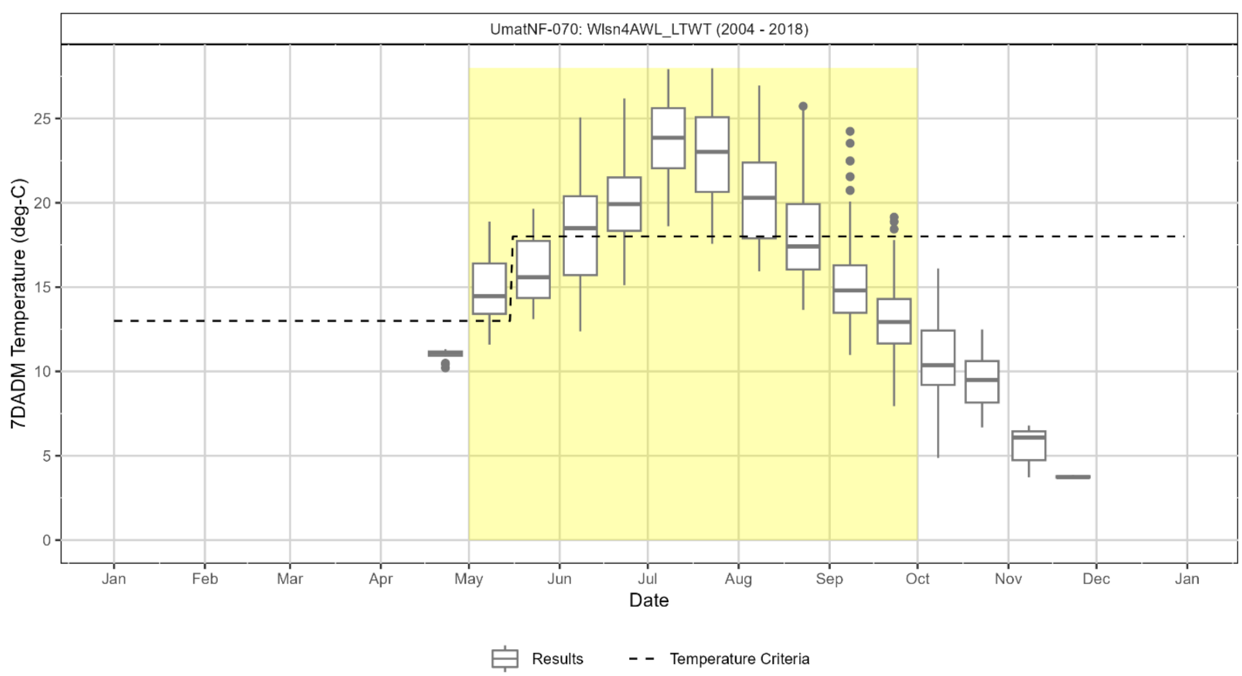

Figure 5-9: Seasonal variation at the Wilson Creek temperature monitoring site in the North Fork John Day Subbasin.

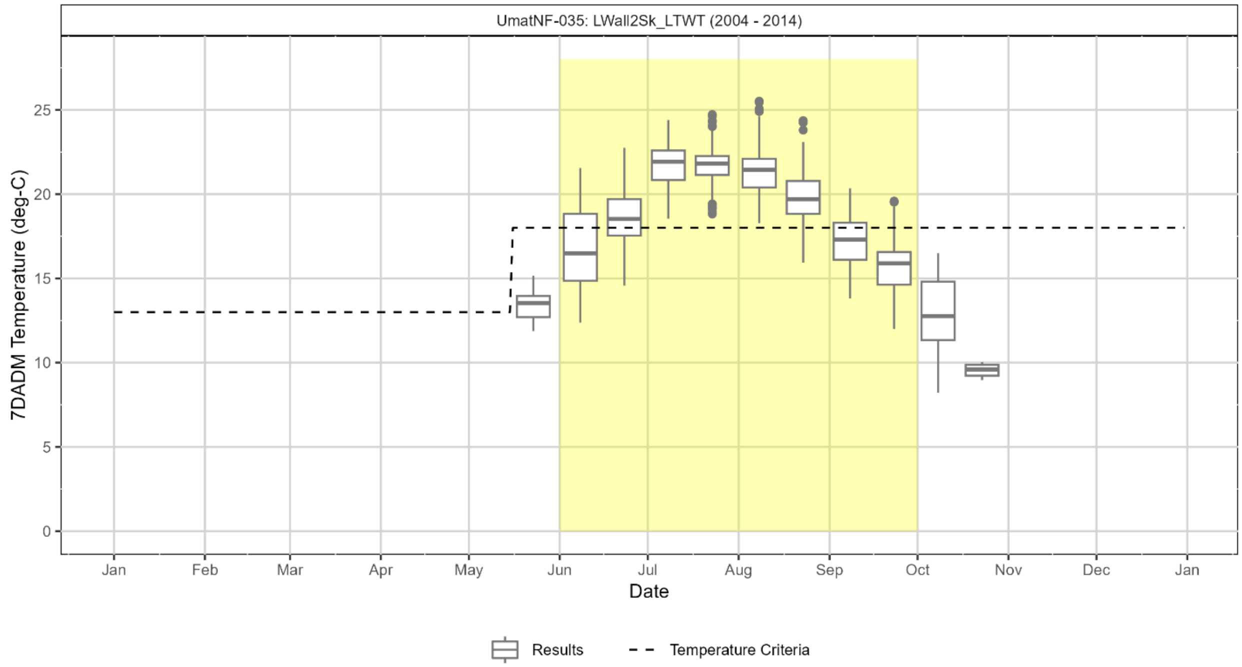

Figure 5-10: Seasonal variation at the Little Wall Creek near Skookum Creek temperature monitoring site in the North Fork John Day Subbasin.

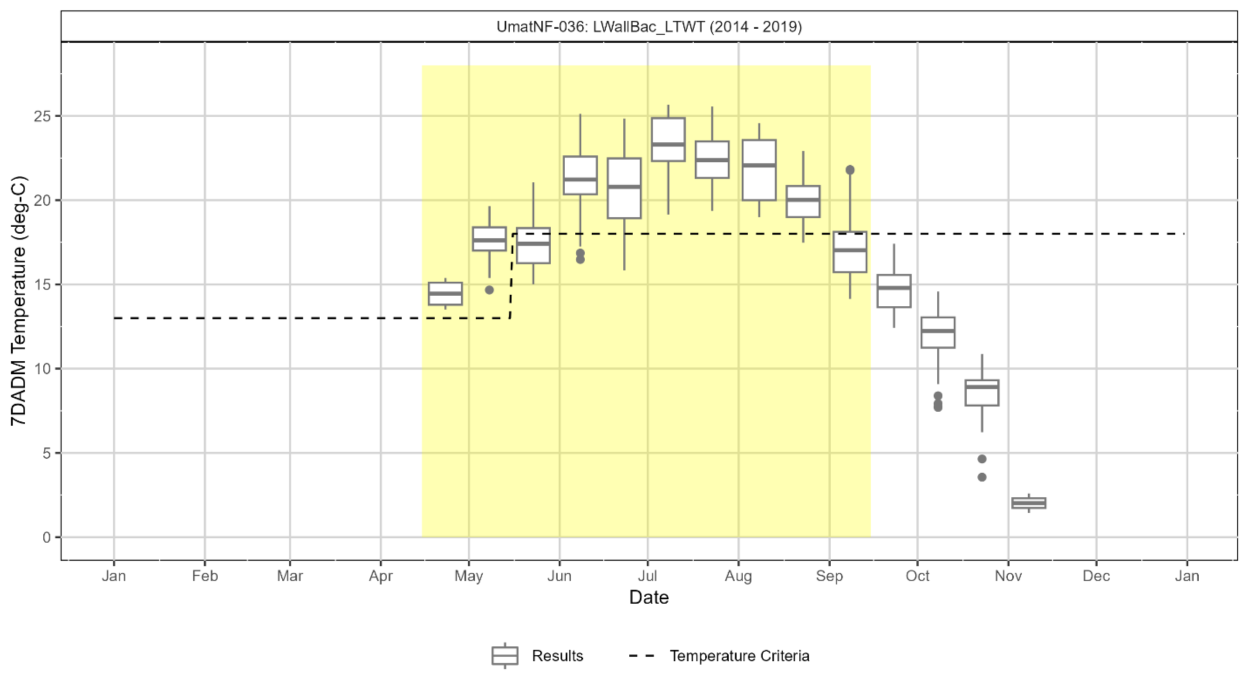

Figure 5-11: Seasonal variation at the Little Wall Creek near Bacon Creek temperature monitoring site in the North Fork John Day Subbasin.

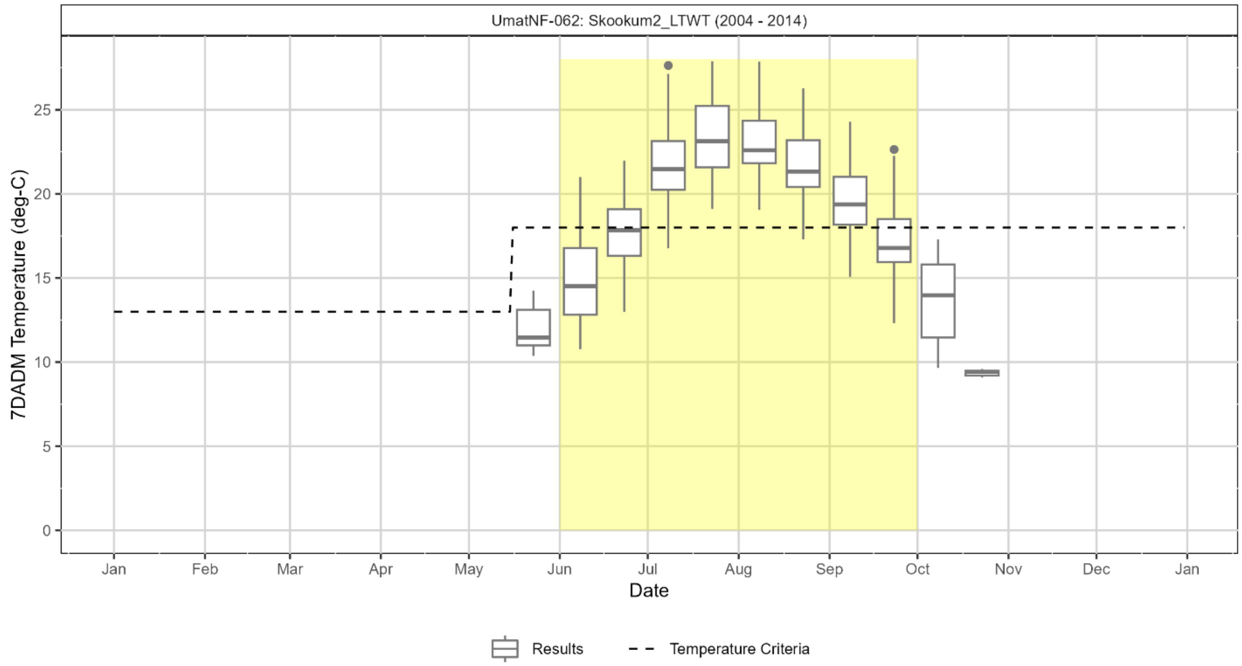

Figure 5-12: Seasonal variation at the Skookum Creek temperature monitoring site in the North Fork John Day Subbasin

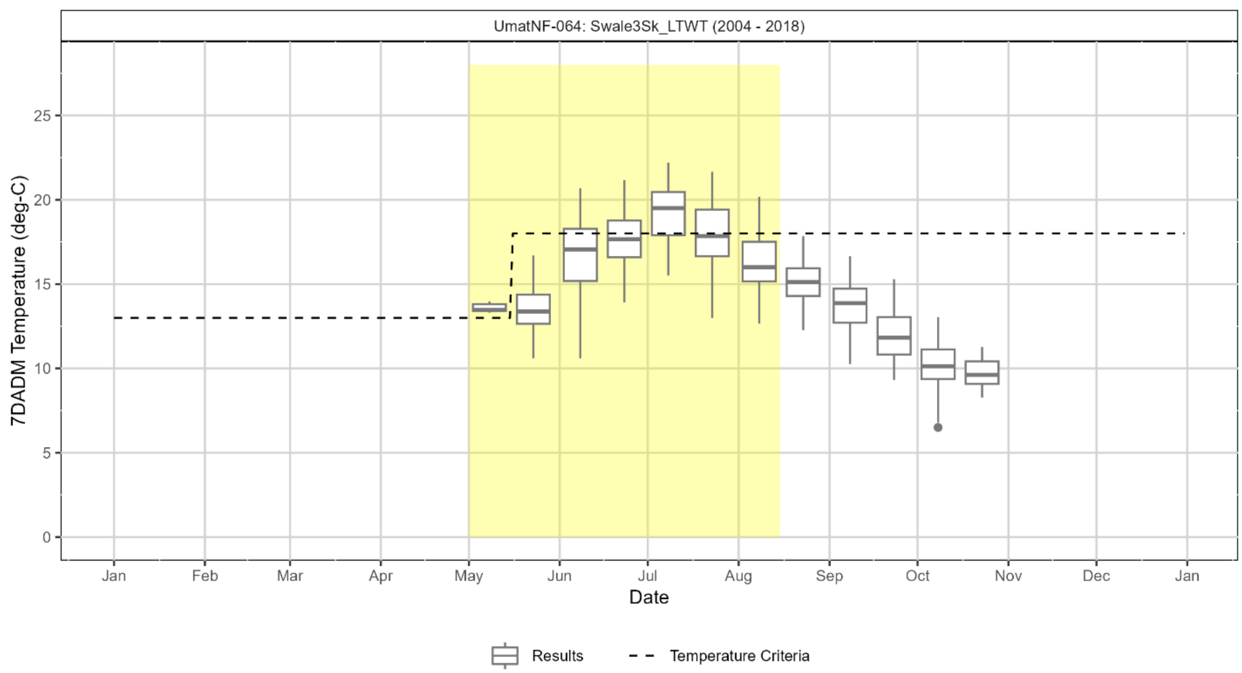

Figure 5-13: Seasonal variation at the Swale Creek temperature monitoring site in the North Fork John Day Subbasin.

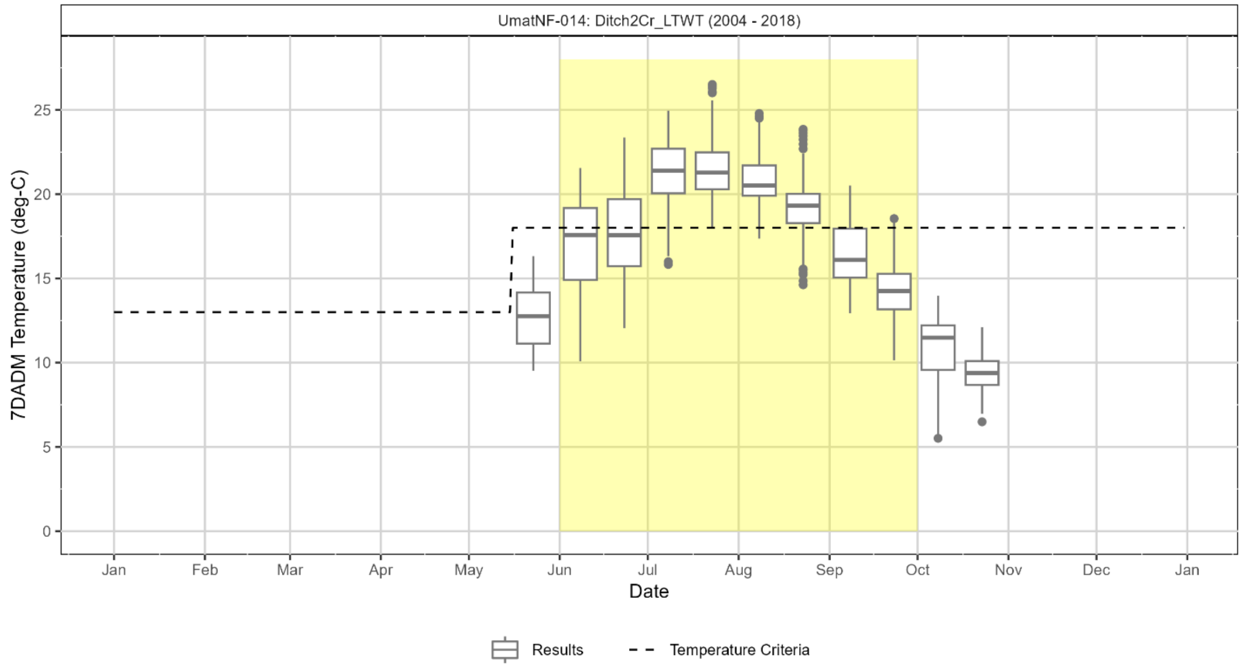

Figure 5-14: Seasonal variation at the Ditch Creek temperature monitoring site in the North Fork John Day Subbasin.

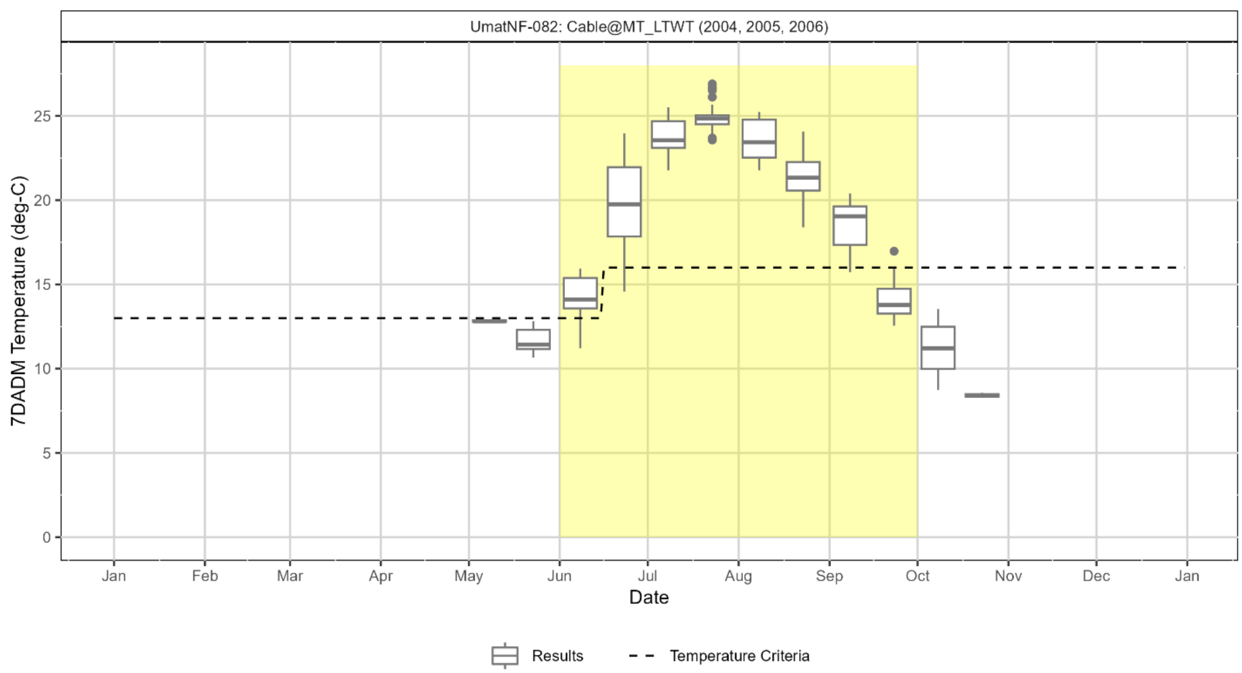

Figure 5-15: Seasonal variation at the Cable Creek at mouth temperature monitoring site in the North Fork John Day Subbasin.

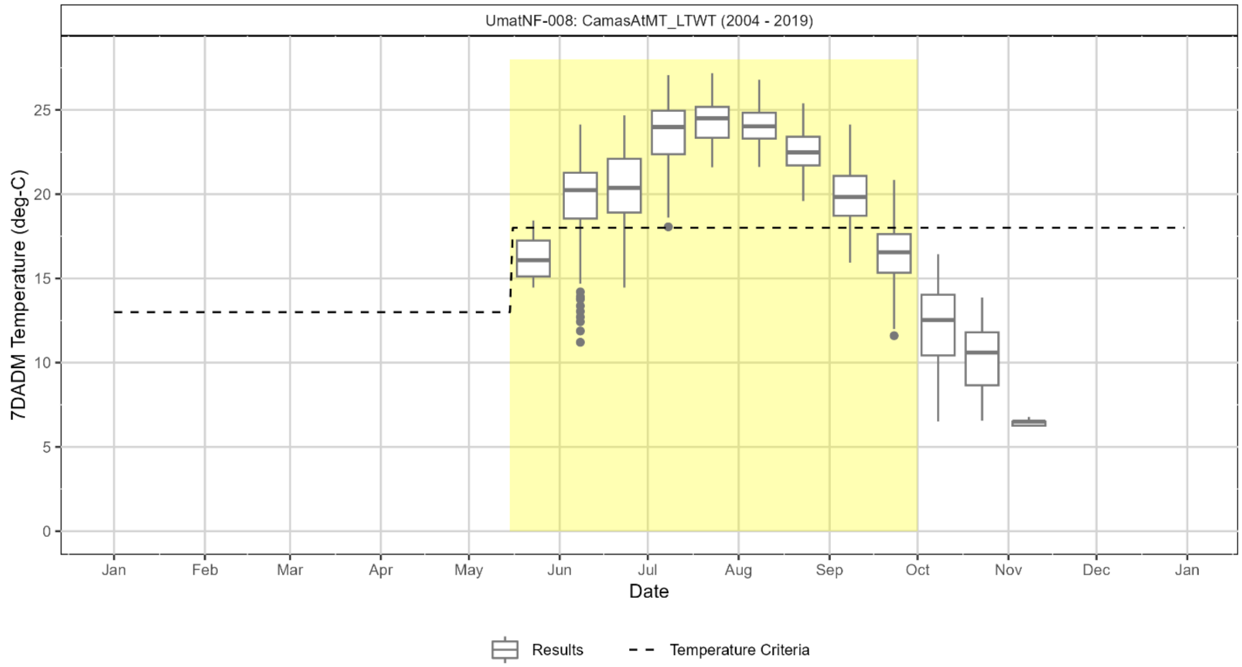

Figure 5-16: Seasonal variation at the Camas Creek at mouth temperature monitoring site in the North Fork John Day Subbasin.

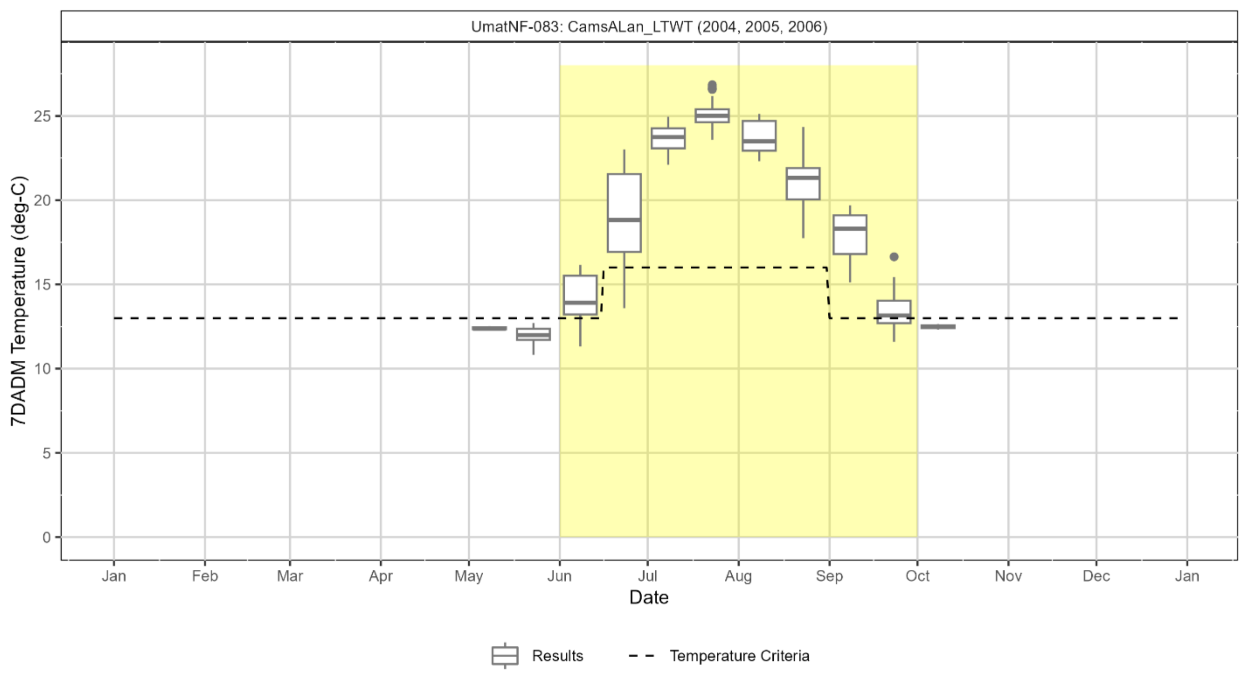

Figure 5-17: Seasonal variation at the Camas Creek upstream of its confluence with Lane Creek temperature monitoring site in the North Fork John Day Subbasin.

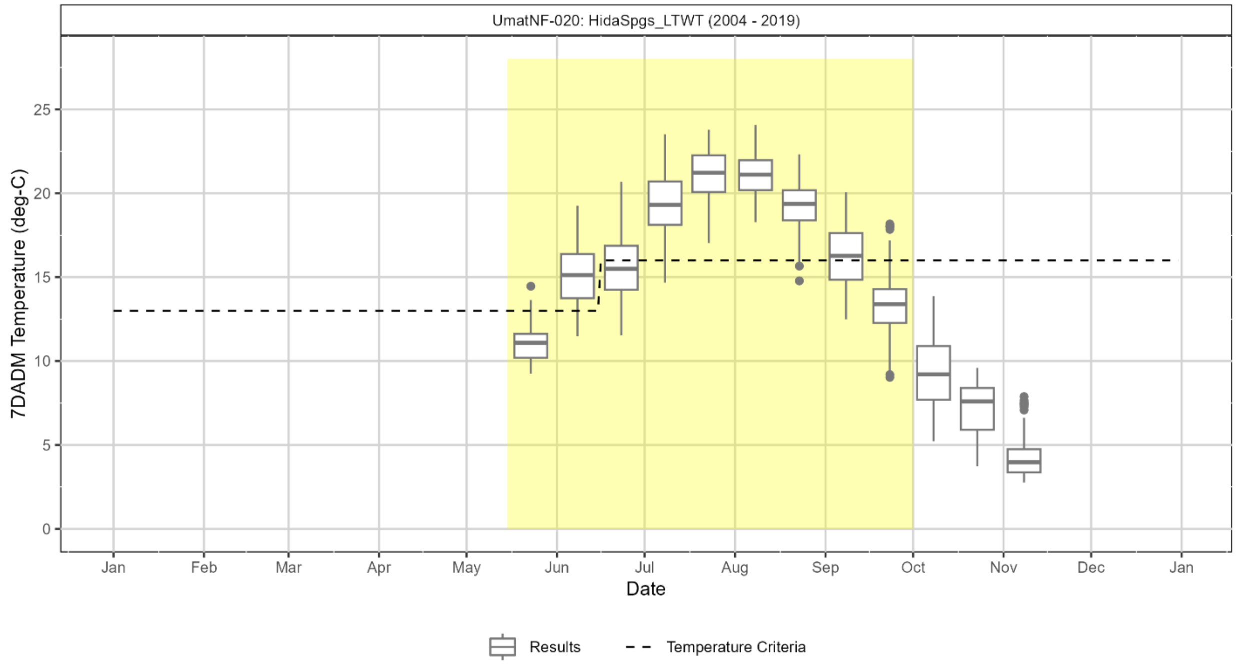

Figure 5-18: Seasonal variation at the Hidaway Creek temperature monitoring site in the North Fork John Day Subbasin.

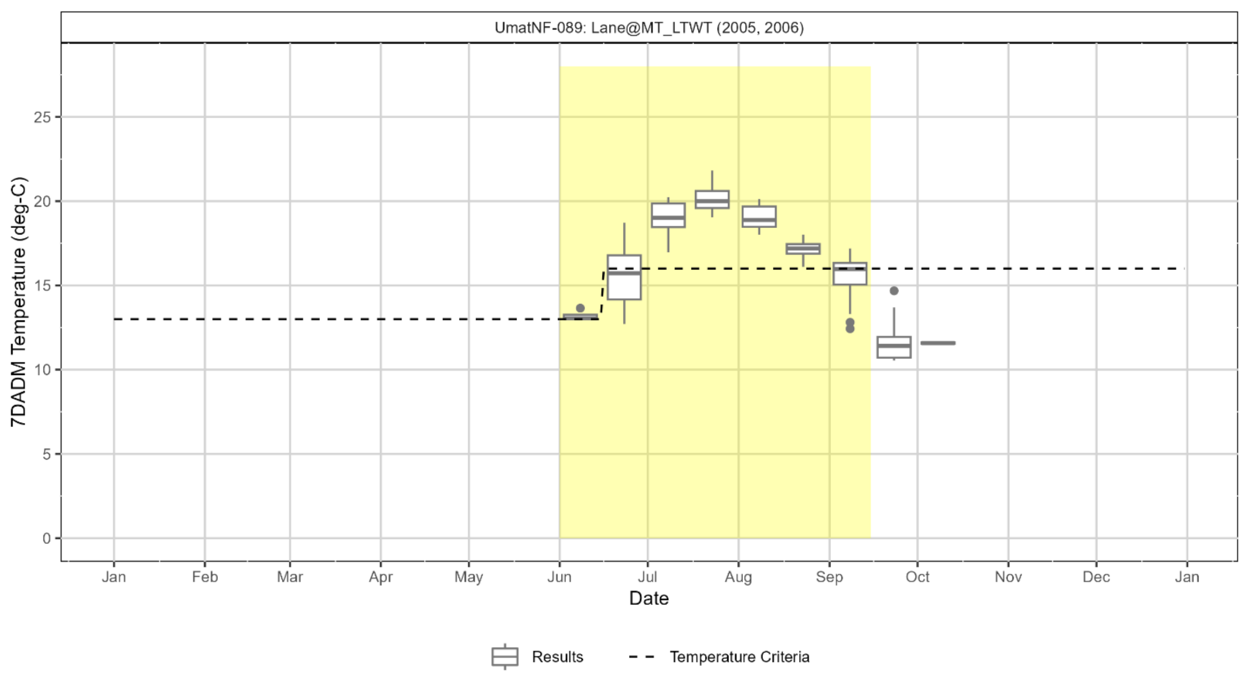

Figure 5-19: Seasonal variation at the Lane Creek temperature monitoring site in the North Fork John Day Subbasin.

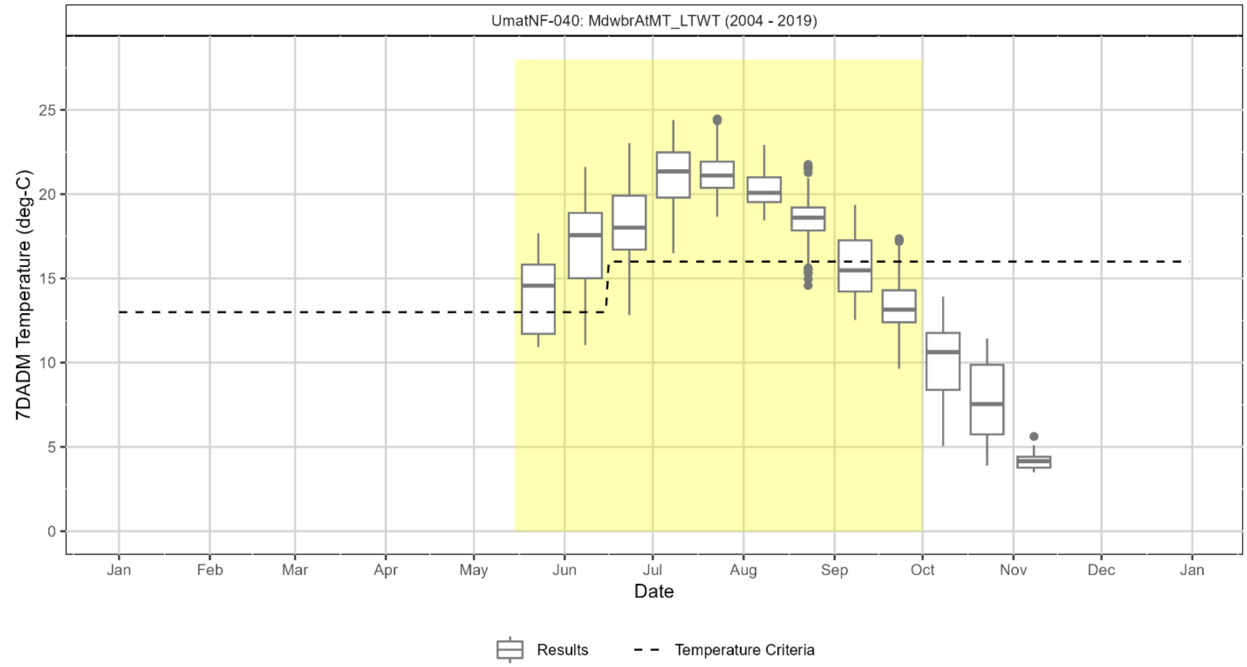

Figure 5-20: Seasonal variation at the West Fork Meadow Brook temperature monitoring site in the North Fork John Day Subbasin.

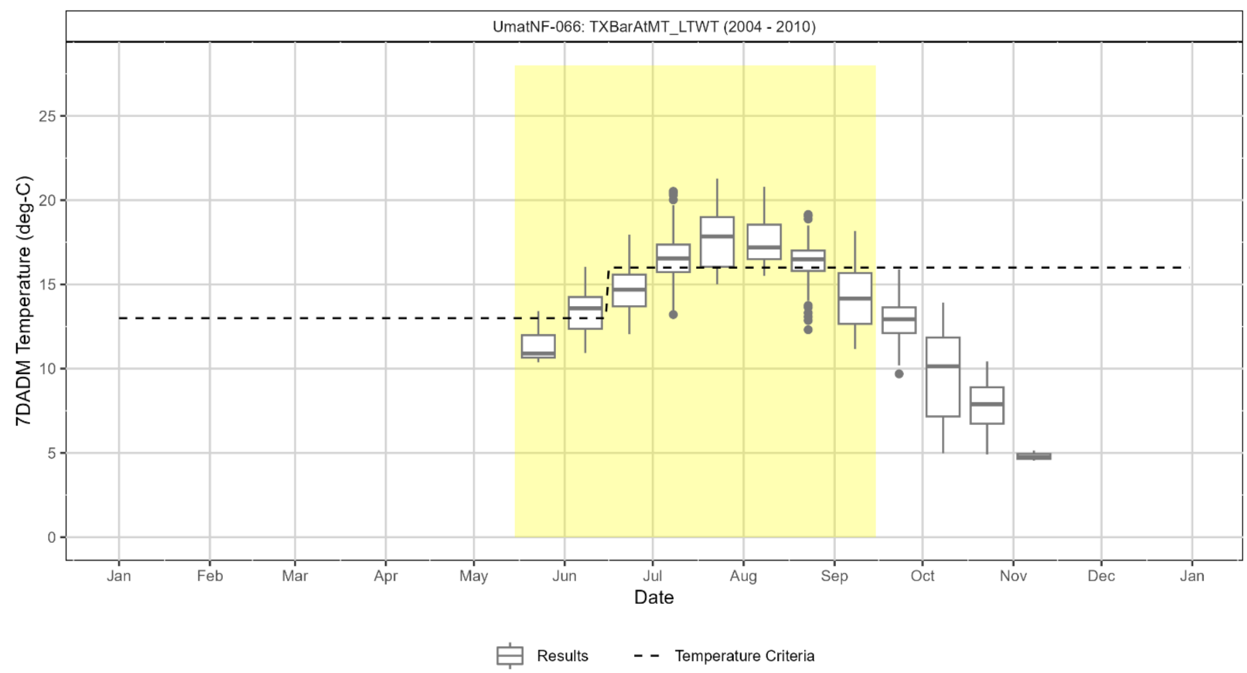

Figure 5-21: Seasonal variation at the Texas Bar Creek temperature monitoring site in the North Fork John Day Subbasin.

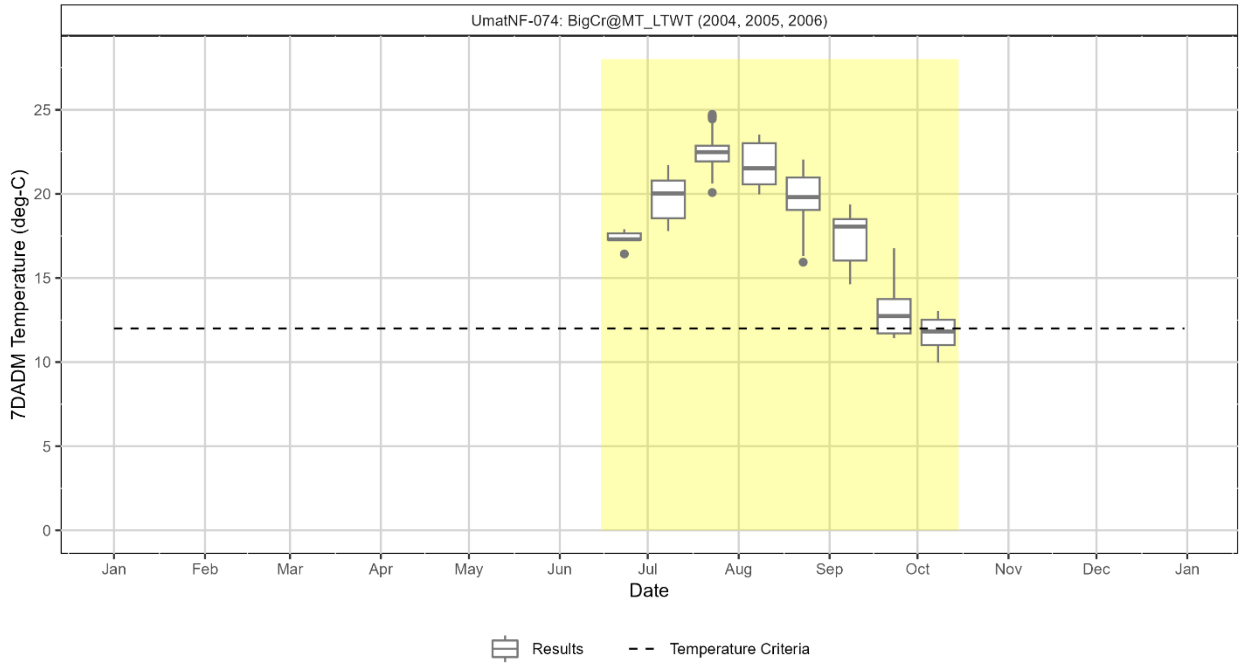

Figure 5-22: Seasonal variation at the Big Creek at mouth temperature monitoring site in the North Fork John Day Subbasin.

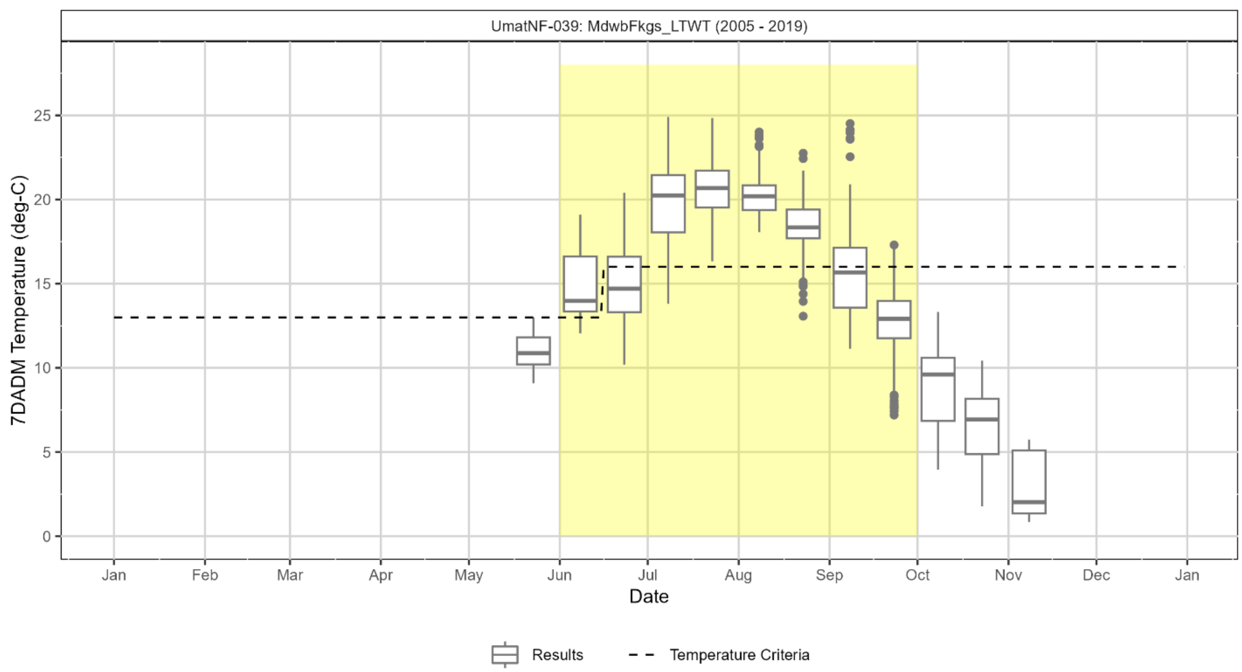

Figure 5-23: Seasonal variation at the Meadow Creek temperature monitoring site in the North Fork John Day Subbasin.

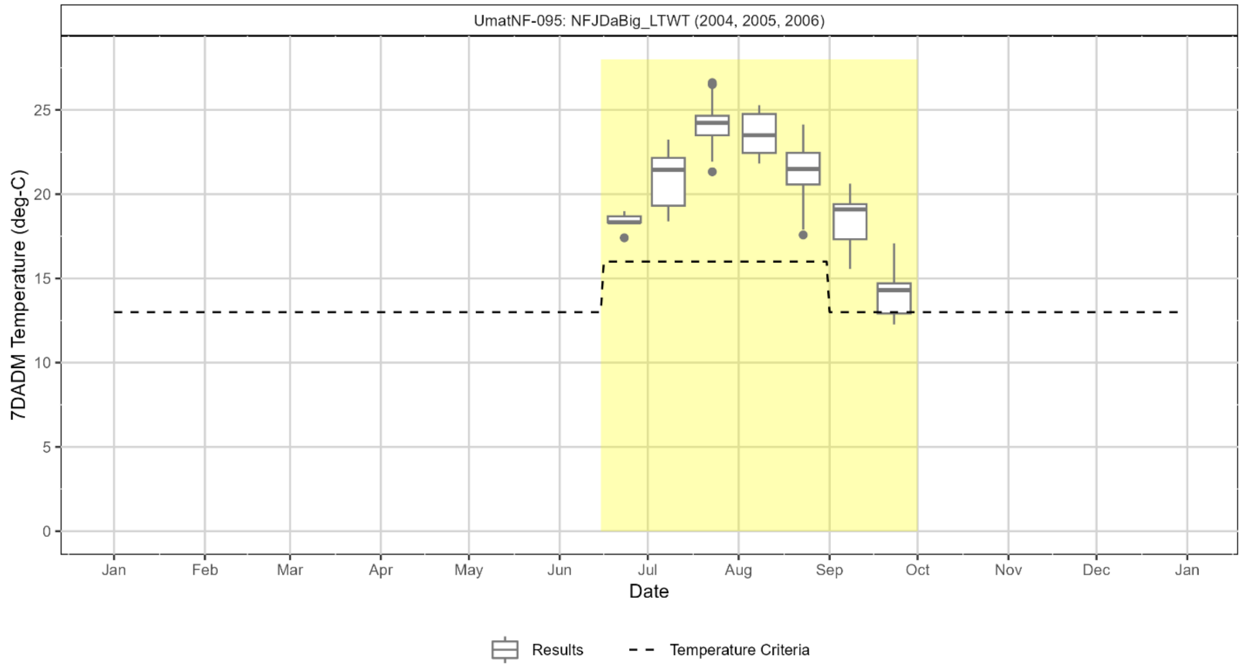

Figure 5-24: Seasonal variation at the North Fork John Day River upstream of Big Creek temperature monitoring site in the North Fork John Day Subbasin.

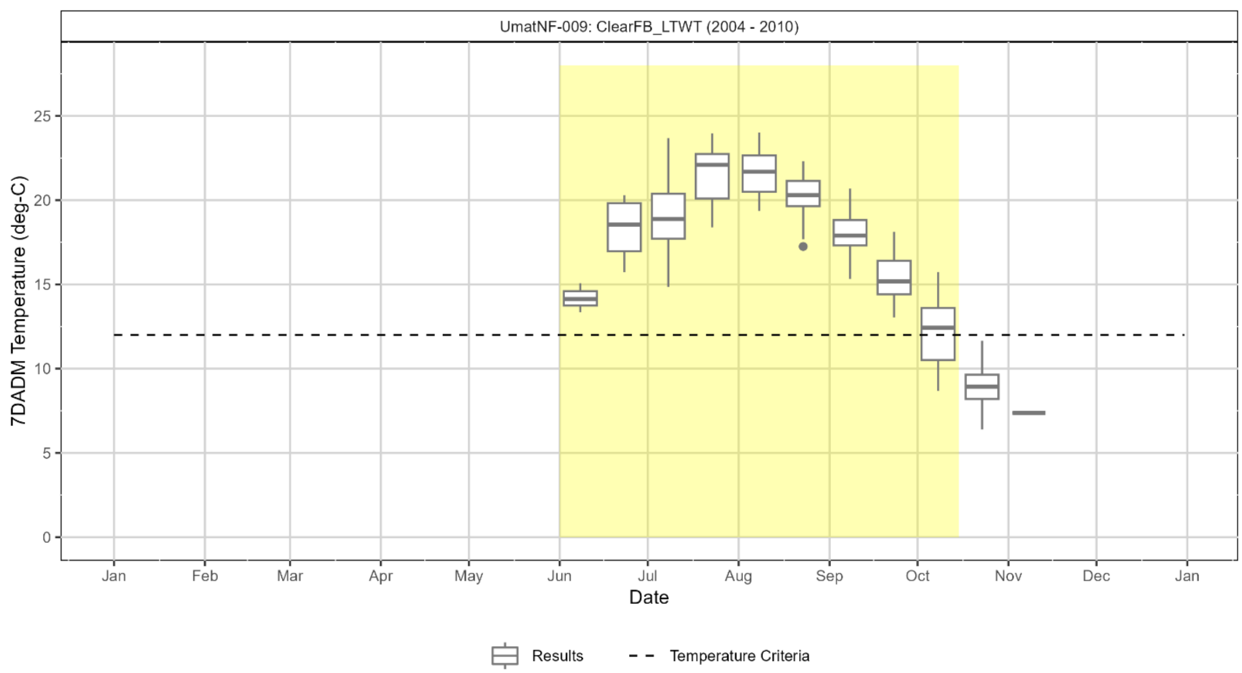

Figure 5-25: Seasonal variation at the Clear Creek temperature monitoring site in the North Fork John Day Subbasin.

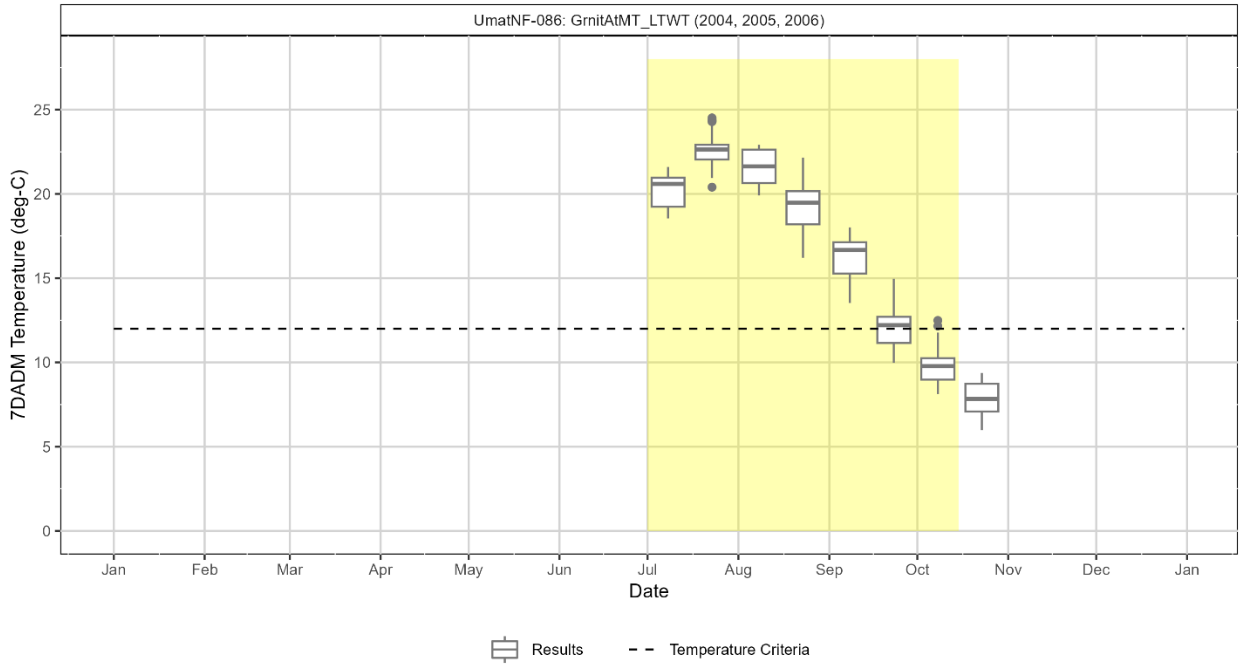

Figure 5-26: Seasonal variation at the Lake Creek temperature monitoring site in the North Fork John Day Subbasin.

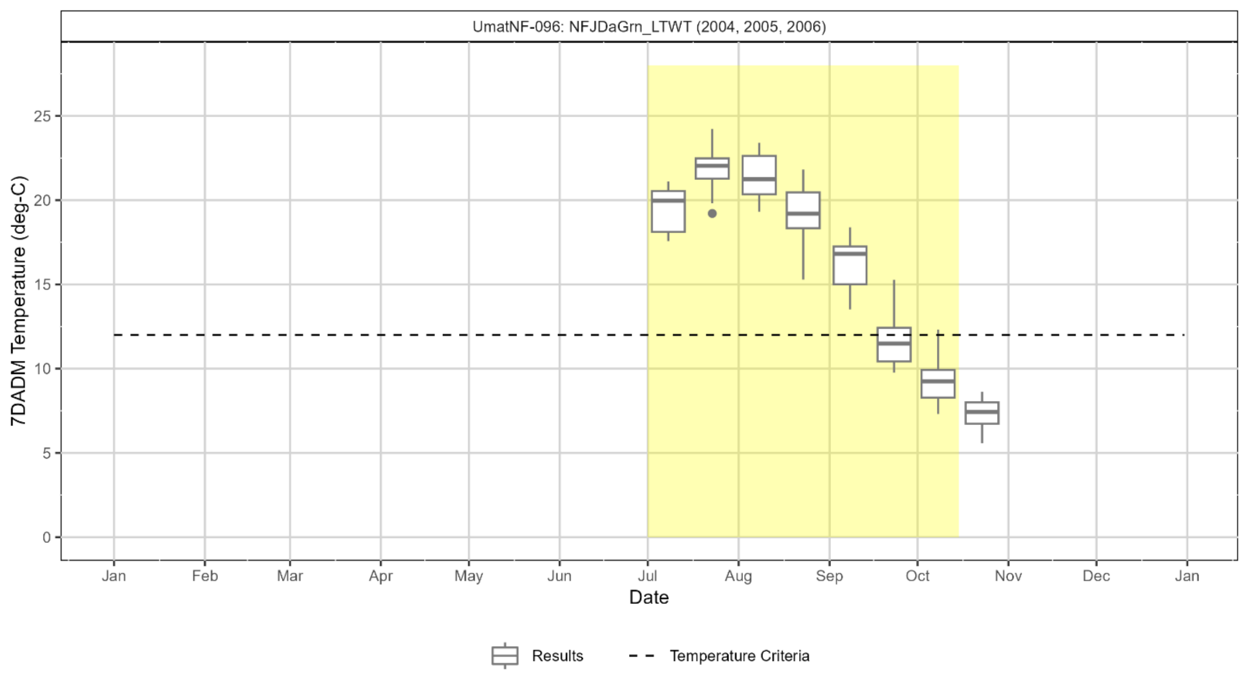

Figure 5-27: Seasonal variation at the North Fork John Day River at it confluence with Lake Creek/Granite Creek temperature monitoring site in the North Fork John Day Subbasin.

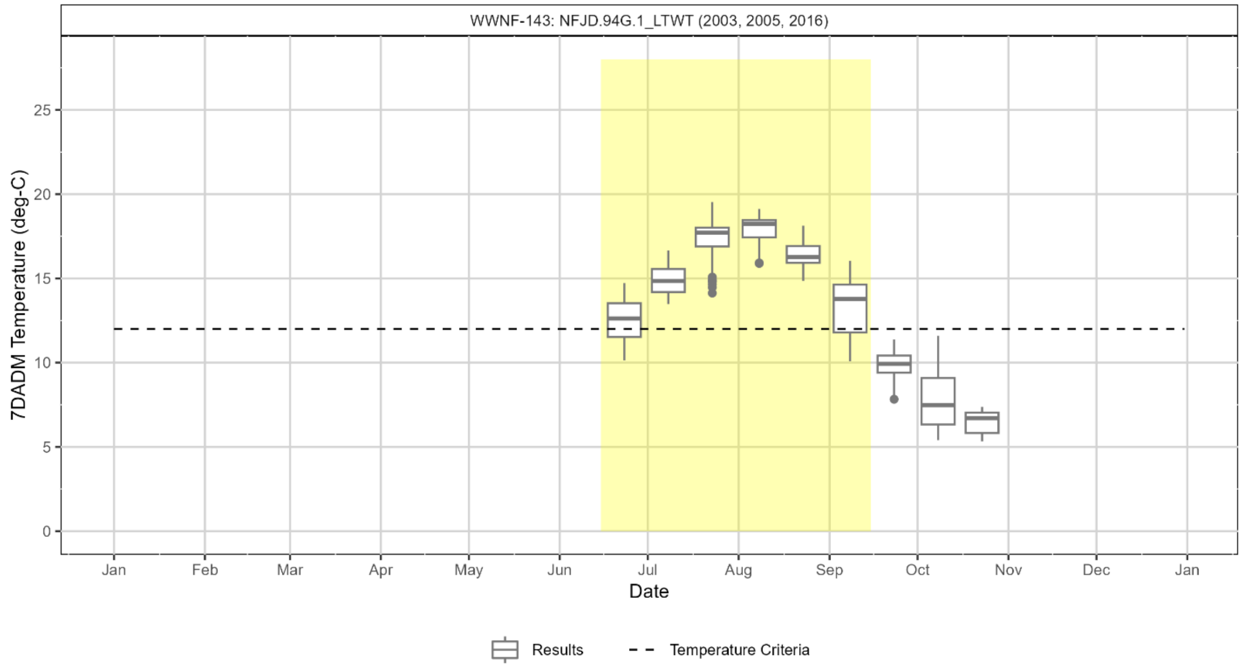

Figure 5-28: Seasonal variation at the North Fork John Day River upstream of Onion Creek temperature monitoring site in the North Fork John Day Subbasin.

5.4 Upper John Day Subbasin seasonal variation

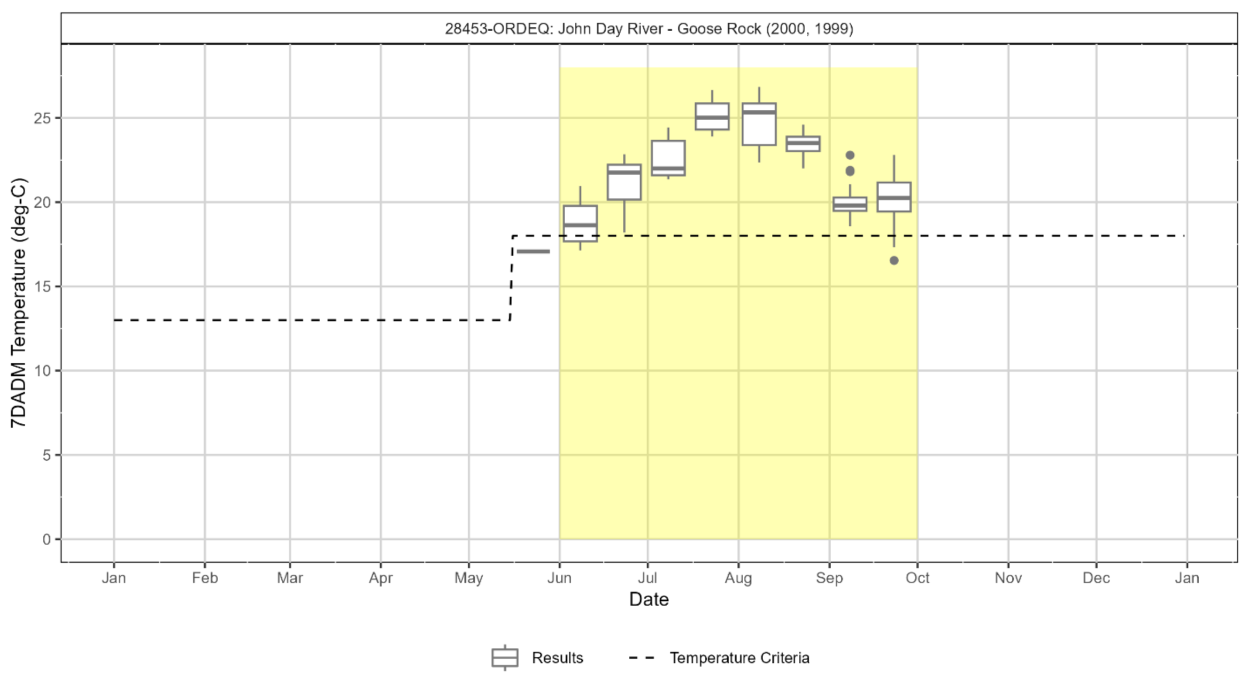

Figure 5-29: Seasonal variation at the John Day River upstream of Goose Rock temperature monitoring site in the Upper John Day Subbasin.

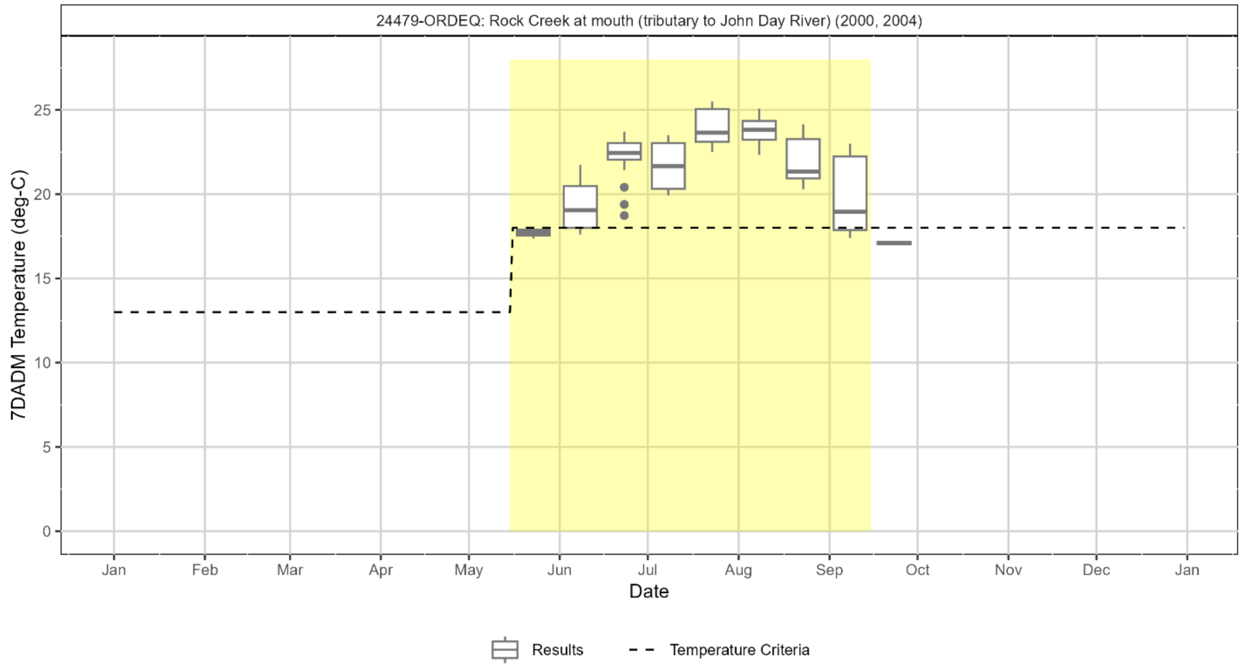

Figure 5-30: Seasonal variation at the Rock Creek at mouth temperature monitoring site in the Upper John Day Subbasin.

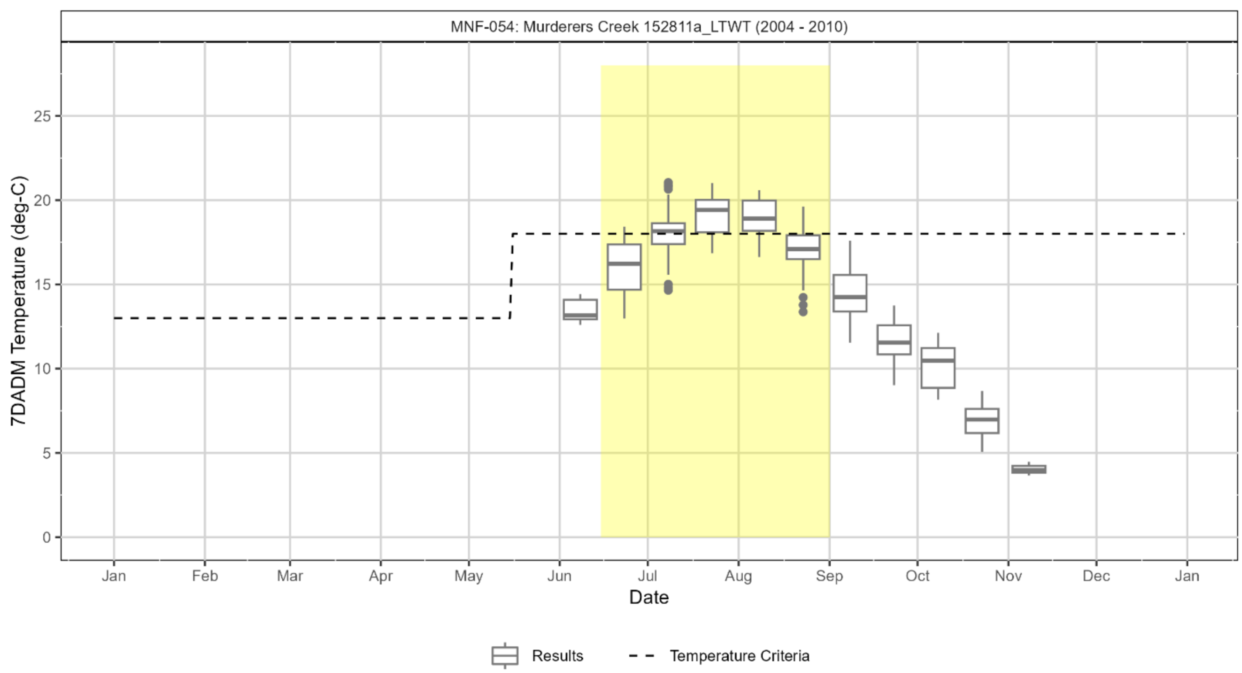

Figure 5-31: Seasonal variation at the Murderers Creek temperature monitoring site in the Upper John Day Subbasin.

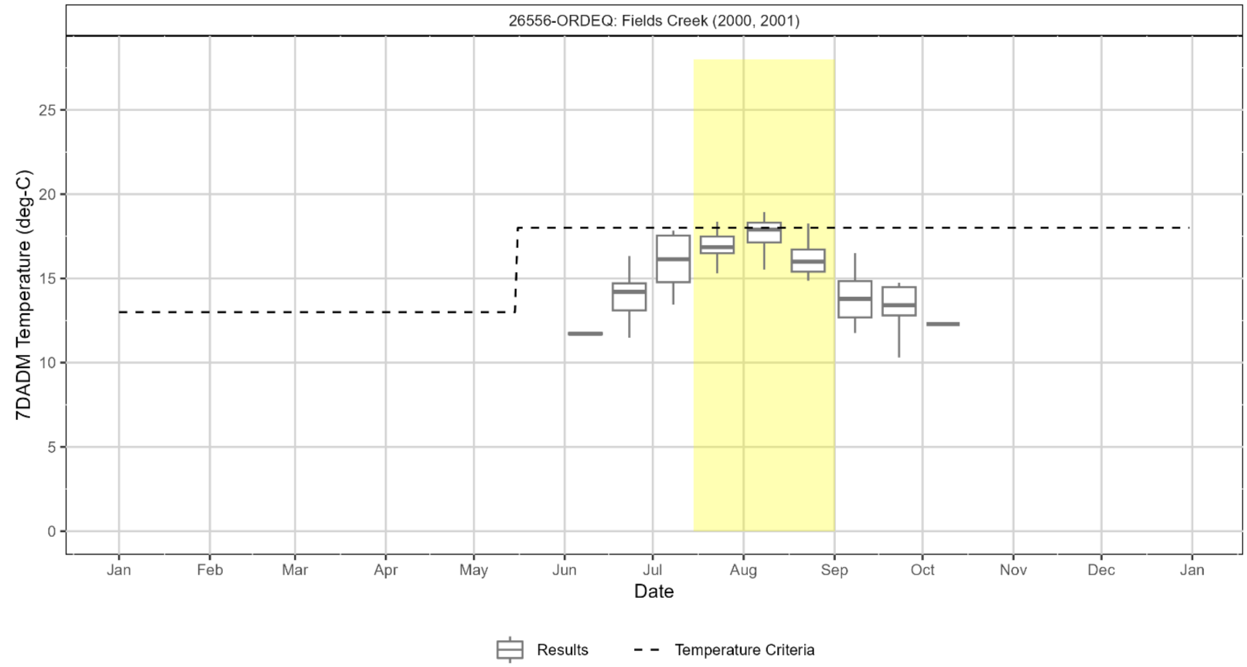

Figure 5-32: Seasonal variation at the Fields Creek temperature monitoring site in the Upper John Day Subbasin.

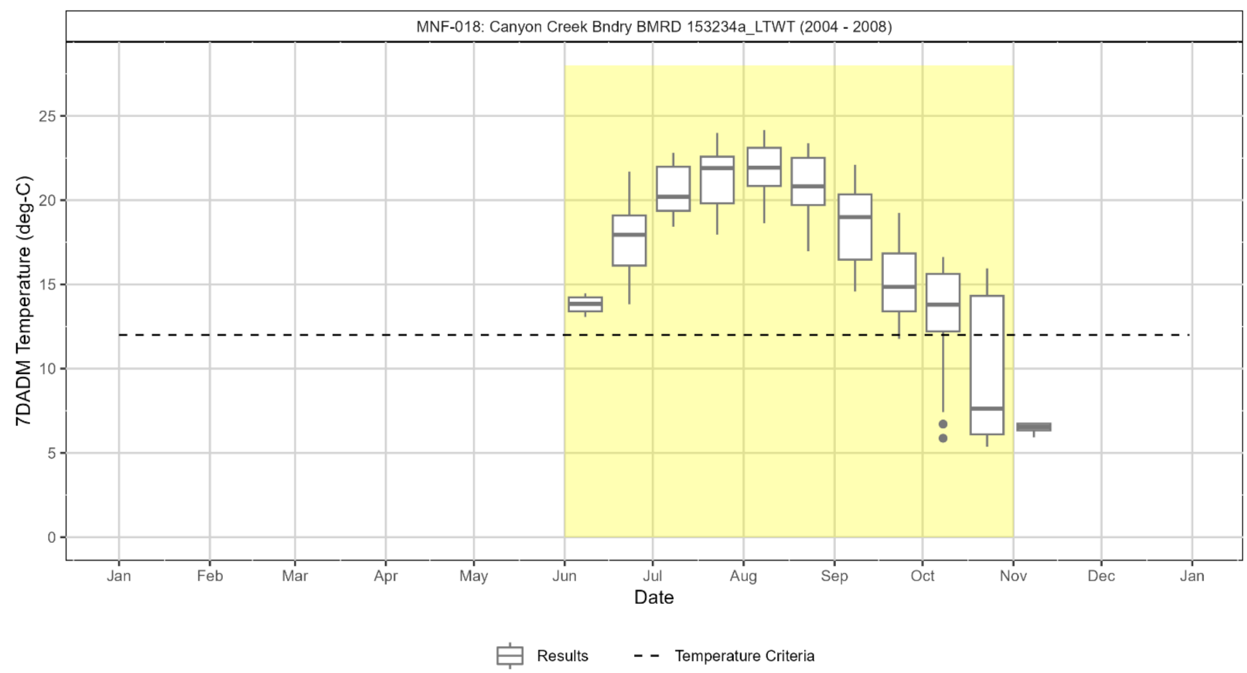

Figure 5-33: Seasonal variation at the Canyon Creek temperature monitoring site in the Upper John Day Subbasin.

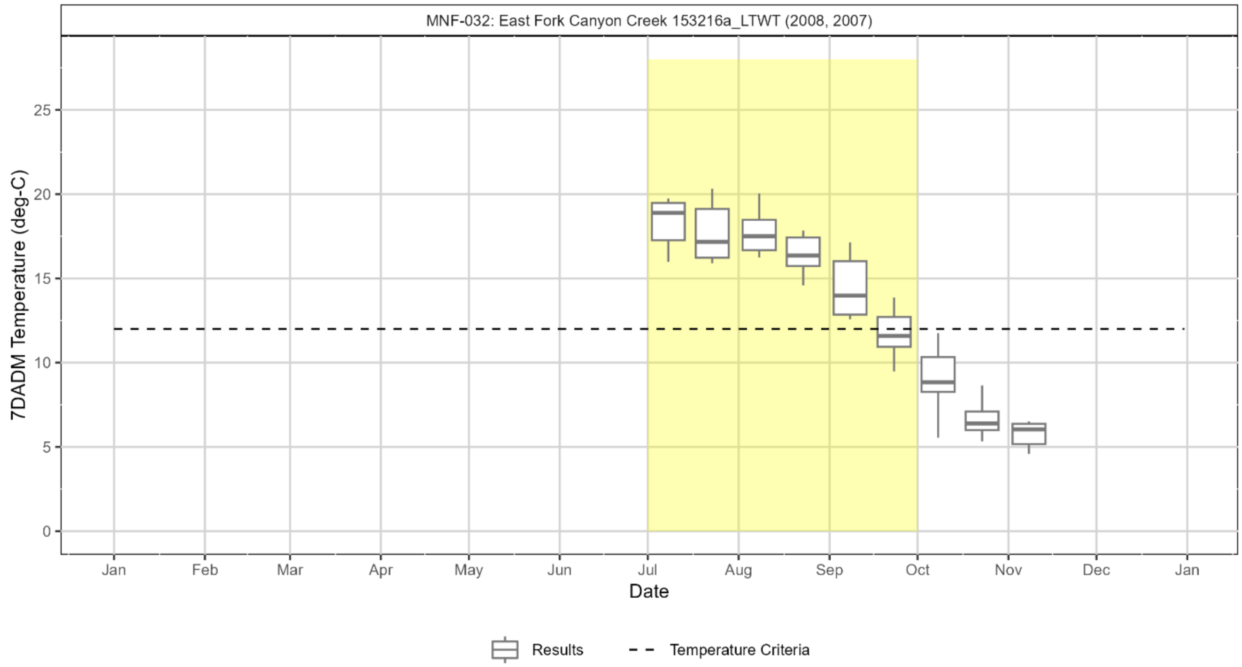

Figure 5-34: Seasonal variation at the East Fork Canyon Creek temperature monitoring site in the Upper John Day Subbasin.

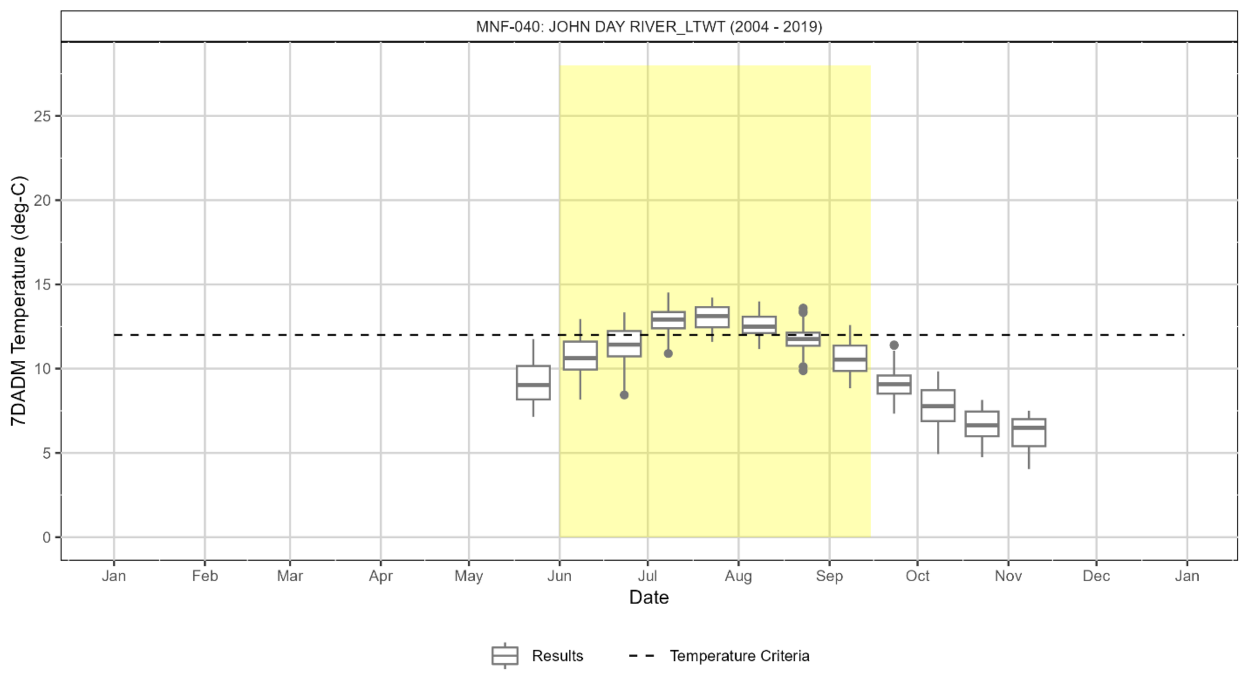

Figure 5-35: Seasonal variation at the John Day River upstream of Rail Creek and Roberts Creek temperature monitoring site in the Upper John Day Subbasin.

6 Temperature water quality data evaluation and analyses

A critical TMDL element is water quality data evaluation and analysis to the extent that existing data allow. To understand the water quality impairment, assess potential pollutant sources, and evaluate the ability of various management scenarios in achieving the TMDL and applicable temperature water quality standards, the analysis requires a predictive component. DEQ uses models to evaluate potential stream warming sources and, to the extent existing data allow, their current and TMDL allocation pollutant loads (**Figure 6-1**). Heat Source was used in this effort and is described in Appendices A and B of this document.

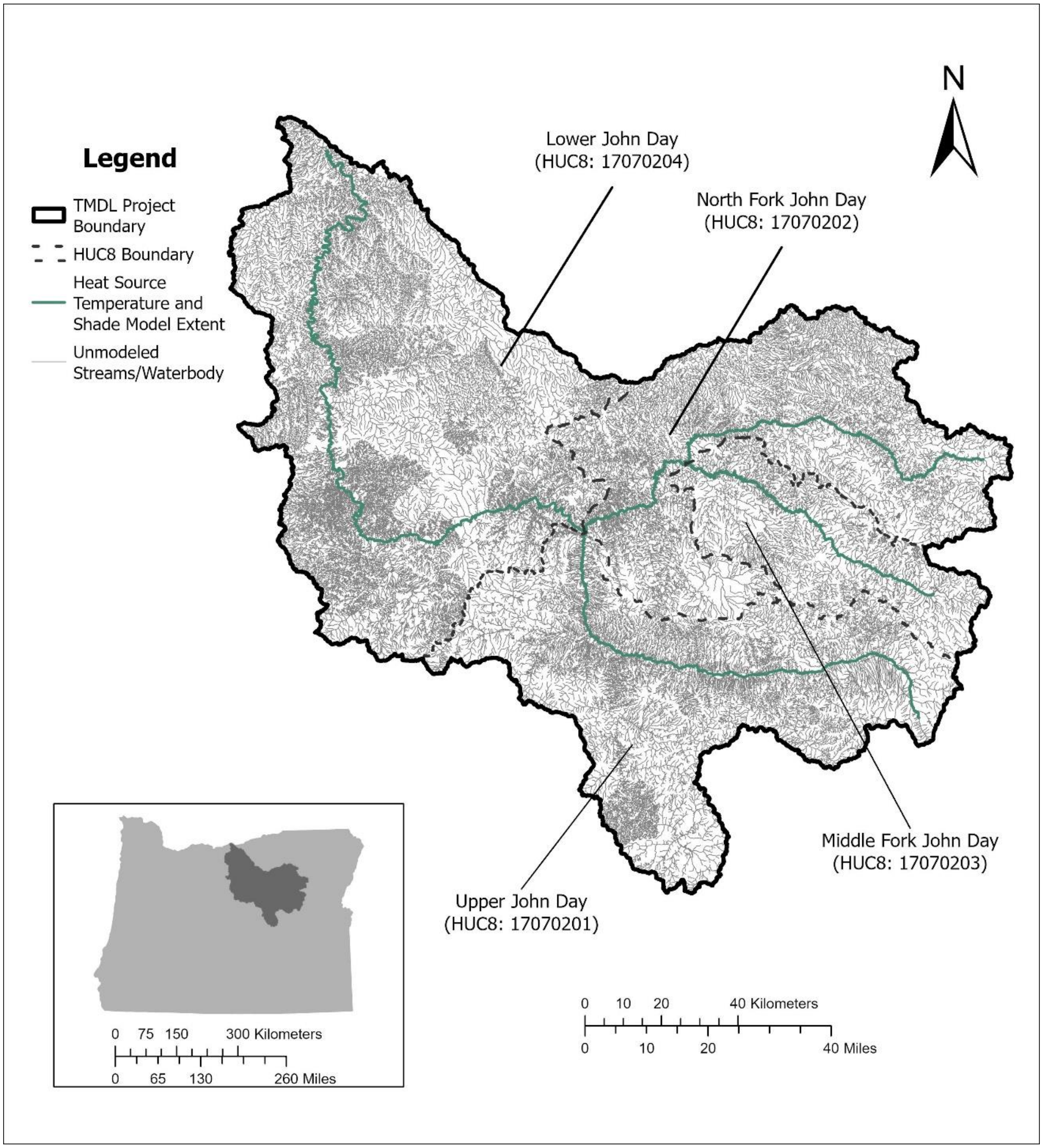

Figure 6-1: Overview of TMDL project area and temperature model extents.

6.1 The 7Q10 low-flow statistic

The "7Q10" is a summary low-flow statistic equal to the lowest seven-day average flow that occurs once every ten years (on average). For the John Day River Basin temperature TMDL, estimated 7Q10s were used to calculate numeric loading capacities and allocations. DEQ calculated annual 7Q10s for temperature-impaired assessment units (AUs) in the John Day River Basin, and for the receiving waterbodies that have NPDES permitted discharges with a WLA.

The 7Q10 estimates were based on the following approaches:

1) If sufficient daily mean flow data from USGS or OWRD gaging stations were available for a given waterbody, 7Q10 estimates were calculated using these data. Available flow data were retrieved for up to a 30-year period (typically January 1, 1991 to December 31, 2023). DEQ relied on quality control protocols implemented by USGS and OWRD. Only data with a result status of “Approved” (USGS) or “Published” (OWRD) were included in 7Q10 calculations. 7Q10s were calculated by the method of EPA’s DFLOW program (Rossman, 1990), which computes extreme design flows using the log-Pearson Type III probability distribution. A minimum of 10 years of flow data were used with some exceptions. For some ungaged reaches, it was possible to estimate the daily mean flow using nearby gages located upstream, downstream, or on tributaries. The daily mean flows at the ungaged reach were estimated by summing or subtracting the daily mean flows from the gaged locations as appropriate. For example, the daily mean flow on a mainstem river downstream of a major tributary is not gaged but can be estimated by summing the daily mean flow from a gage on the tributary and a gage on the mainstem river upstream of the major tributary. Flow records needed to be available from all gages on the same day, otherwise the flow rate on that day was recorded as missing. Daily mean flows for the ungaged reach were calculated first, prior to the 7Q10 calculation using DFLOW.

2) If insufficient daily mean flow data from USGS and OWRD stream flow gaging stations were available, the web-based tool StreamStats (USGS, 2019) was used to estimate 7Q10s. The 7Q10s are reported with the same level of significant figures as the values calculated using the gage method, except for values equal to or greater than 1000 cfs, which are reported to three significant figures. Details of StreamStats are described below.

StreamStats version 4 is a web-based GIS application developed by the USGS. StreamStats has a map-based interface that allows the user to determine drainage area delineations, basin characteristics, and estimates of stream flow statistics for user-selected locations along available streams. The program also provides users with access to stream monitoring data by selecting USGS data-collection stations in the map application and providing access to flow statistics and other information for the stations. StreamStats provides estimates of various stream flow statistics for user-selected sites by solving site-specific regression equations. The regression equations were developed through a process, known as regionalization, which involves use of regression analysis to relate stream flow statistics computed for a group of selected stream gages (usually within a state) to basin characteristics measured for the stream gages. Basin characteristics are used to obtain estimates of the stream flow statistics for ungaged sites.

StreamStats regression equations for Oregon were developed by Cooper (2005) and Risley et al. (2008). These equations were based on basin characteristics and flow statistics (e.g., historical percentile flow-exceedance values and annual and monthly 7Q10). Flow statistics were computed at 466 gaging stations across Oregon and proximal out-of-state areas. This study area was divided into 10 regions based on ecological, topographic, geologic, hydrologic, and climatic criteria. StreamStats includes 910 annual and monthly regression equations to estimate 7Q10s for ungaged stream sites in the 10 aforementioned regions. These equations were developed for unregulated streams (without major dams, constructed reservoirs, catchment development, or significant diversions/withdrawals). If the equations are applied to ungaged streams subject to such influences, the resultant estimates may require adjustment to approximate actual flows.

The StreamStats user selects a stream location of interest and the program estimates the associated drainage area and summary flow statistics. For this TMDL, DEQ's procedure specified that selected stream locations should be the most downstream location on each stream for which DEQ required flow estimates; the exception was if DEQ required 7Q10 estimates for NPDES permitted point source receiving waters, in which case the selected stream location was immediately upstream of the point source outfall. StreamStats also estimates basin characteristics for the selected catchment, including drainage area, mean annual precipitation, mean slope, and climatic characteristics (Cooper, 2005; Risley et al., 2008). If estimates are outside suggested parameter ranges, the warning message "extrapolated with uncertainty" appears in the StreamStats report.

Table 6-1: The 7Q10 low-flow estimates for modeled temperature-impaired rivers in the John Day River Basin.

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
Battle Creek	OR_SR_1707020111_05_101556	0	StreamStats	44.491, -119.579	
Bear Creek	OR_SR_1707020106_05_101534	0.595	StreamStats	44.442, -118.777	
HUC12 Name: Upper Beech Creek	OR_WS_170702010801_05_102055	0	StreamStats	44.533, -119.040	
HUC12 Name: Upper Beech Creek	OR_WS_170702010801_05_102055	0	StreamStats	44.537, -119.044	
Beech Creek	OR_SR_1707020108_05_101540	1.31	StreamStats	44.412, -119.116	
HUC12 Name: Upper Canyon Creek	OR_WS_170702010701_05_102051	1.14	StreamStats	44.212, -118.846	
Canyon Meadows Lake	OR_LK_1707020107_05_100025	0.677	StreamStats	44.237, -118.779	
East Fork Canyon Creek	OR_SR_1707020107_05_101539	2.06	StreamStats	44.246; -118.912	
Canyon Creek	OR_SR_1707020107_05_101538	3.03	StreamStats	44.245, -118.912	
Canyon Creek	OR_SR_1707020107_05_101537	5.87	StreamStats	44.422, -118.959	
HUC12 Name: Cottonwood Creek	OR_WS_170702011102_05_102072	0.886	StreamStats	44.447; -119.643	
Cottonwood Creek	OR_SR_1707020111_05_101558	0.313	StreamStats	44.507, -119.609	
HUC12 Name: Dads Creek-John Day River	OR_WS_170702010505_05_102042	0	StreamStats	44.454, -118.672	
HUC12 Name: Dads Creek-John Day River	OR_WS_170702010505_05_102042	0	StreamStats	44.446, -118.634	
HUC12 Name: Upper Deer Creek	OR_WS_170702010205_05_102025	0.869	StreamStats	44.206, -119.380	
HUC12 Name: Upper Deer Creek	OR_WS_170702010205_05_102025	0	StreamStats	44.184, -119.334	
HUC12 Name: Lower Deer Creek	OR_WS_170702010206_05_102026	3.37	StreamStats	44.192, -119.526	
HUC12 Name: Dog Creek-John Day River	OR_WS_170702010608_05_102050	0	StreamStats	44.418, -118.902	1993-10-01 ~ 2023-09-30
HUC12 Name: East Fork Beech Creek	OR_WS_170702010802_05_102056	0	StreamStats	44.528, -118.909	

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
HUC12 Name: East Fork Beech Creek	OR_WS_170702010802_05_102056	0	StreamStats	44.515, -118.975	
Fields Creek	OR_SR_1707020110_05_101550	1.15	StreamStats	44.436, -119.293	
HUC12 Name: Utley Creek	OR_WS_170702010104_05_102018	0	StreamStats	44.018, -119.371	
HUC12 Name: Lonesome Creek	OR_WS_170702010101_05_102015	0	StreamStats	44.032, -119.266	
HUC12 Name: Grub Creek	OR_WS_170702010607_05_102049	0	StreamStats	44.468, -118.890	
Grub Creek	OR_SR_1707020106_05_101531	0	StreamStats	44.430, -118.858	
Indian Creek	OR_SR_1707020106_05_101532	1.94	StreamStats	44.442, -118.799	
HUC12 Name: Headwaters John Day River	OR_WS_170702010501_05_102038	16.8	USGS/OWRD: 14036860	44.348, -118.575	1996-10-01 ~ 2023-09-30
HUC12 Name: Headwaters John Day River	OR_WS_170702010501_05_102038	6.2	USGS/OWRD: 14036860 x StreamStats drainage ratio	44.349, -118.574	1996-10-01 ~ 2023-09-30
John Day River	OR_SR_1707020111_05_102568	25.9	StreamStats	44.528, -119.632	1993-10-01 ~ 2014-09-30
John Day River	OR_SR_1707020114_05_102609	23.4	StreamStats	44.754, -119.639	1993-10-01 ~ 2023-09-30
HUC12 Name: Dog Creek-John Day River	OR_WS_170702010608_05_102050	0	StreamStats	44.417, -118.916	
HUC12 Name: Headwaters Murderers Creek	OR_WS_170702010301_05_102028	0.575	StreamStats	44.266, -119.288	
HUC12 Name: Headwaters Murderers Creek	OR_WS_170702010301_05_102028	1.53	StreamStats	44.267, -119.288	
Murderers Creek	OR_SR_1707020103_05_101525	4.06	StreamStats	44.278, -119.424	
Murderers Creek	OR_SR_1707020103_05_101526	3.2	StreamStats	44.315, -119.539	1994-01-12 ~ 2012-09-30
Pine Creek	OR_SR_1707020102_05_101521	0	StreamStats	44.097, -119.500	
HUC12 Name: Castle Creek-John Day River	OR_WS_170702010606_05_102048	0.823	StreamStats	44.402, -118.815	
HUC12 Name: Reynolds Creek	OR_WS_170702010503_05_102040	4.71	StreamStats	44.414, -118.595	

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
Rock Creek	OR_SR_1707020113_05_101564	1.67	StreamStats	44.528, -119.634	
Lower Mountain Creek	OR_SR_1707020112_05_101560	0.526	StreamStats	44.522, -119.716	
Mountain Creek	OR_SR_1707020112_05_101561	0.03	USGS/OWRD: 14040600	44.557, -119.863	1993-10-01 ~ 2011-09-30
HUC12 Name: Upper Mountain Creek	OR_WS_170702011201_05_102074	0.0117	StreamStats	44.522, -120.054	
HUC12 Name: Headwaters South Fork John Day River	OR_WS_170702010102_05_102016	0	StreamStats	44.001, -119.305	
South Fork John Day River	OR_SR_1707020101_05_101516	2	StreamStats	44.032, -119.348	
South Fork John Day River	OR_SR_1707020102_05_101519	5.59	StreamStats	44.191, -119.527	1993-10-15 ~ 2015-09-30
HUC12 Name: Strawberry Creek-John Day River	OR_WS_170702010601_05_102043	1.2	USGS/OWRD: 14037500	44.342, -118.657	1993-10-01 ~ 2015-09-30
HUC12 Name: Strawberry Creek-John Day River	OR_WS_170702010601_05_102043	0	StreamStats		
HUC12 Name: Sunflower Creek	OR_WS_170702010204_05_102024	0.758	StreamStats	44.177, -119.523	
HUC12 Name: Sunflower Creek	OR_WS_170702010204_05_102024	0	StreamStats	44.182, -119.582	
HUC12 Name: Sunflower Creek	OR_WS_170702010204_05_102024	0	StreamStats	44.171, -119.548	
HUC12 Name: Strawberry Creek-John Day River	OR_WS_170702010601_05_102043	1.16	StreamStats		
HUC12 Name: Beaver Creek	OR_WS_170702020203_05_102094	3.03	StreamStats	44.780, -118.456	
HUC12 Name: Beaver Creek	OR_WS_170702020203_05_102094	0.22	StreamStats	44.764, -118.426	
HUC12 Name: Beaver Creek	OR_WS_170702020203_05_102094	1.69	StreamStats	44.774, -118.451	
HUC12 Name: Big Creek	OR_WS_170702020303_05_102099	0.652	StreamStats	45.012, -118.605	
Big Creek	OR_SR_1707020203_05_101577	3.1	StreamStats	44.981, -118.641	
Meadow Creek	OR_SR_1707020203_05_101578	5.77	StreamStats	44.980, -118.639	
Big Creek	OR_SR_1707020203_05_101573	10.2	StreamStats	44.961, -118.682	
HUC12 Name: Bull Run Creek	OR_WS_170702020202_05_102093	2.57	StreamStats	44.808, -118.425	
HUC12 Name: Bull Run Creek	OR_WS_170702020202_05_102093	0	StreamStats	44.788, -118.375	
HUC12 Name: Bull Run Creek	OR_WS_170702020202_05_102093	0.372	StreamStats	44.780, -118.347	

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
HUC12 Name: Dry Camas Creek-Camas Creek	OR_WS_170702020501_05_102107	0	StreamStats	45.164, -118.643	
HUC12 Name: Dry Camas Creek-Camas Creek	OR_WS_170702020501_05_102107	0	StreamStats	45.177, -118.626	
Camas Creek	OR_SR_1707020205_05_101584	1.73	StreamStats	45.189, -118.764	
HUC12 Name: Bowman Creek-Camas Creek	OR_WS_170702020502_05_102108	0.0705	StreamStats	45.163, -118.644	
HUC12 Name: Bowman Creek-Camas Creek	OR_WS_170702020502_05_102108	0	StreamStats	45.170, -118.696	
HUC12 Name: Bowman Creek-Camas Creek	OR_WS_170702020502_05_102108	0	StreamStats	45.184, -118.754	
Camas Creek	OR_SR_1707020205_05_101581	1.5	USGS/OWRD: 14042500	45.158, -118.841	1993-10-01 ~ 2014-09-30
HUC12 Name: Cable Creek	OR_WS_170702020504_05_102110	1.46	StreamStats	45.082, -118.758	
HUC12 Name: Cable Creek	OR_WS_170702020504_05_102110	0.993	StreamStats	45.082, -118.759	
Cable Creek	OR_SR_1707020205_05_101582	1.86	StreamStats	45.157, -118.842	
Hidaway Creek	OR_SR_1707020205_05_101583	1.62	StreamStats	45.166, -118.791	
HUC12 Name: Lane Creek-Camas Creek	OR_WS_170702020505_05_102111	0	StreamStats	45.204, -118.762	
Lane Creek	OR_SR_1707020205_05_101580	0.282	StreamStats	45.190, -118.765	
Camas Creek	OR_SR_1707020206_05_101587	4.24	StreamStats	45.132, -118.960	
HUC12 Name: Upper Owens Creek	OR_WS_170702020602_05_102113	0	StreamStats	45.204, -118.841	
Owens Creek	OR_SR_1707020206_05_101591	0	StreamStats	45.170, -118.936	
Owens Creek	OR_SR_1707020206_05_101586	0.166	StreamStats	45.133, -118.960	
Camas Creek	OR_SR_1707020206_05_101588	7.25	StreamStats	45.011, -118.995	
HUC12 Name: Bridge Creek	OR_WS_170702020608_05_102119	0	StreamStats	45.057, -118.968	
HUC12 Name: Upper Fivemile Creek	OR_WS_170702020604_05_102115	0	StreamStats	45.131, -119.107	
Fivemile Creek	OR_SR_1707020206_05_101590	2.94	StreamStats	45.073, -118.987	

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
HUC12 Name: Clear Creek	OR_WS_170702020204_05_102095	6.5	StreamStats	44.779, -118.456	
HUC12 Name: Clear Creek	OR_WS_170702020204_05_102095	0.841	StreamStats	44.763, -118.497	
HUC12 Name: Clear Creek	OR_WS_170702020204_05_102095	0.265	StreamStats	44.774, -118.491	
Clear Creek	OR_SR_1707020202_05_101571	11.2	StreamStats	44.821, -118.451	
HUC12 Name: Crane Creek-North Fork John Day River	OR_WS_170702020105_05_102091	1.12	StreamStats	44.893, -118.477	
HUC12 Name: Headwaters Desolation Creek	OR_WS_170702020401_05_102103	1.84	StreamStats	44.820, -118.688	
HUC12 Name: Headwaters Desolation Creek	OR_WS_170702020401_05_102103	2.18	StreamStats	44.819, -118.688	
HUC12 Name: Upper Desolation Creek	OR_WS_170702020402_05_102104	0	StreamStats	44.838, -118.723	
HUC12 Name: Upper Desolation Creek	OR_WS_170702020402_05_102104	0	StreamStats	44.846, -118.735	
HUC12 Name: Upper Desolation Creek	OR_WS_170702020402_05_102104	0	StreamStats	44.857, -118.761	
HUC12 Name: Upper Desolation Creek	OR_WS_170702020402_05_102104	0	StreamStats	44.864, -118.772	
HUC12 Name: Upper Desolation Creek	OR_WS_170702020402_05_102104	0	StreamStats	44.878, -118.782	
HUC12 Name: Middle Desolation Creek	OR_WS_170702020403_05_102105	0.719	StreamStats	44.928, -118.831	
HUC12 Name: Middle Desolation Creek	OR_WS_170702020403_05_102105	0	StreamStats	44.934, -118.769	
Desolation Creek	OR_SR_1707020204_05_101579	8.09	StreamStats	44.997, -118.936	
Ditch Creek	OR_SR_1707020207_05_101592	0.704	StreamStats	44.952; -119.296	
East Fork Cottonwood Creek	OR_SR_1707020209_05_101609	0	StreamStats	44.776, -119.404	
HUC12 Name: Upper Granite Creek	OR_WS_170702020201_05_102092	0.957	StreamStats	44.808, -118.425	
HUC12 Name: Upper Granite Creek	OR_WS_170702020201_05_102092	0	StreamStats	44.820, -118.415	

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
Granite Creek	OR_SR_1707020202_05_101572	3.58	StreamStats	44.821, -118.450	
Granite Creek	OR_SR_1707020202_05_101570	18.3	StreamStats	44.865, -118.562	
HUC12 Name: Lower Granite Creek	OR_WS_170702020206_05_102096	0	StreamStats	44.842, -118.495	
Lake Penland	OR_LK_1707020207_05_100032	0	StreamStats	45.117, -119.316	
HUC12 Name: Mallory Creek	OR_WS_170702020708_05_102128	1.01	StreamStats	44.976; -119.287	
HUC12 Name: Mallory Creek	OR_WS_170702020708_05_102128	0	StreamStats	45.043, -119.306	
Mallory Creek	OR_SR_1707020207_05_101594	0.592	StreamStats	44.973, -119.284	
North Fork John Day River	OR_SR_1707020201_05_101569	11.5	StreamStats	44.866, -118.561	
HUC12 Name: Baldy Creek-North Fork John Day River	OR_WS_170702020101_05_102087	1.46	StreamStats	44.910, -118.317	
HUC12 Name: Baldy Creek-North Fork John Day River	OR_WS_170702020101_05_102087	0.491	StreamStats	44.909, -118.317	
HUC12 Name: Baldy Creek-North Fork John Day River	OR_WS_170702020101_05_102087	0	StreamStats	44.915, -118.298	
North Fork John Day River	OR_SR_1707020203_05_101575	28.1	StreamStats	44.960, -118.682	
North Fork John Day River	OR_SR_1707020203_05_101574	33.9	StreamStats	44.998, -118.935	1929 ~ 1958
North Fork John Day River	OR_SR_1707020207_05_101596	37.6	StreamStats	45.009, -118.995	1929 ~ 1958
North Fork John Day River	OR_SR_1707020207_05_101595	36.6	StreamStats	44.884, -119.409	
North Fork John Day River	OR_SR_1707020210_05_101613	44	USGS: 14046000	44.814, -119.432	1993-10-01 ~ 2023-09-30
HUC12 Name: Onion Creek-North Fork John Day River	OR_WS_170702020103_05_102089	0	StreamStats	44.912, -118.400	
HUC12 Name: Ellis Creek-Potamus Creek	OR_WS_170702020706_05_102126	1.69	StreamStats	45.067, -119.213	
Rudio Creek	OR_SR_1707020210_05_101616	0.335	StreamStats	44.785, -119.582	
HUC12 Name: Texas Bar Creek-North Fork John Day River	OR_WS_170702020306_05_102102	0	StreamStats	45.025, -118.827	
Texas Bar Creek	OR_SR_1707020203_05_101576	0.498	StreamStats	45.016, -118.849	

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
HUC12 Name: Trail Creek	OR_WS_170702020102_05_102088	1.63	StreamStats	44.916, -118.406	
HUC12 Name: Trail Creek	OR_WS_170702020102_05_102088	0.699	StreamStats	44.938, -118.389	
HUC12 Name: Trail Creek	OR_WS_170702020102_05_102088	0.203	StreamStats	44.937, -118.389	
Wall Creek	OR_SR_1707020208_05_101606	3.68	StreamStats	44.883, -119.411	
Big Wall Creek	OR_SR_1707020208_05_101605	1.98	StreamStats	44.925, -119.420	
Indian Creek	OR_SR_1707020208_05_101607	0	StreamStats	44.929, -119.498	
Wilson Creek	OR_SR_1707020208_05_101601	0.67	StreamStats	44.925, -119.570	
HUC12 Name: Little Wall Creek	OR_WS_170702020802_05_102133	0	StreamStats	44.981, -119.504	
Little Wall Creek	OR_SR_1707020208_05_101603	0.0394	StreamStats	44.969, -119.432	
Skookum Creek	OR_SR_1707020208_05_101600	0.834	StreamStats	44.999, -119.409	
Skookum Creek	OR_SR_1707020208_05_102569	1.46	StreamStats	44.971, -119.431	
HUC12 Name: Swale Creek	OR_WS_170702020801_05_102132	0	StreamStats	45.009, -119.399	
Swale Creek	OR_SR_1707020208_05_101608	0.113	StreamStats	44.998, -119.408	
West Fork Meadow Brook	OR_SR_1707020207_05_101599	1.04	StreamStats	44.997, -118.945	
HUC12 Name: Wilson Creek	OR_WS_170702020804_05_102135	0	StreamStats	44.993, -119.628	
HUC12 Name: Wilson Creek	OR_WS_170702020804_05_102135	0	StreamStats	44.999, -119.668	
HUC12 Name: Bear Creek-Middle Fork John Day River	OR_WS_170702030301_05_102164	0	StreamStats	44.722, -118.824	
HUC12 Name: Big Creek	OR_WS_170702030302_05_102165	0.966	StreamStats	44.768, -118.791	
HUC12 Name: Big Creek	OR_WS_170702030302_05_102165	0	StreamStats	44.771, -118.812	
HUC12 Name: Big Creek	OR_WS_170702030302_05_102165	0	StreamStats	44.775, -118.821	
HUC12 Name: Big Creek	OR_WS_170702030302_05_102165	0	StreamStats	44.780, -118.810	
Big Creek	OR_SR_1707020303_05_101626	1.43	StreamStats	44.766, -118.874	
HUC12 Name: Bridge Creek	OR_WS_170702030105_05_102155	1.75	StreamStats	44.588, -118.509	
HUC12 Name: Bridge Creek	OR_WS_170702030105_05_102155	0.86	StreamStats	44.542, -118.536	
HUC12 Name: Bridge Creek	OR_WS_170702030105_05_102155	0	StreamStats	44.536, -118.535	
HUC12 Name: Upper Camp Creek	OR_WS_170702030205_05_102160	0.121	StreamStats	44.565, -118.841	
HUC12 Name: Upper Camp Creek	OR_WS_170702030205_05_102160	0	StreamStats	44.565, -118.843	

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
HUC12 Name: Upper Camp Creek	OR_WS_170702030205_05_102160	0	StreamStats	44.627, -118.859	
HUC12 Name: Upper Camp Creek	OR_WS_170702030205_05_102160	0	StreamStats	44.630, -118.850	
Camp Creek	OR_SR_1707020302_05_101618	3.29	StreamStats	44.663, -118.811	
HUC12 Name: Lower Camp Creek	OR_WS_170702030207_05_102162	0	StreamStats	44.653, -118.828	
Camp Creek	OR_SR_1707020302_05_101623	5.37	StreamStats	44.693, -118.796	
HUC12 Name: Clear Creek	OR_WS_170702030104_05_102154	5.2	StreamStats	44.592, -118.508	
HUC12 Name: Dry Fork Clear Creek	OR_WS_170702030103_05_102153	1.07	StreamStats	44.576, -118.491	
HUC12 Name: Balance Creek-Middle Fork John Day River	OR_WS_170702030208_05_102163	0	StreamStats	44.675, -118.750	
HUC12 Name: Indian Creek-Middle Fork John Day River	OR_WS_170702030303_05_102166	0.13	StreamStats	44.798, -118.911	
HUC12 Name: Lick Creek	OR_WS_170702030206_05_102161	1.01	StreamStats	44.635, -118.783	
HUC12 Name: Lick Creek	OR_WS_170702030206_05_102161	0.817	StreamStats	44.635, -118.784	
Lick Creek	OR_SR_1707020302_05_101622	2.17	StreamStats	44.663, -118.810	
HUC12 Name: Headwaters Long Creek	OR_WS_170702030401_05_102169	1.33	StreamStats	44.693, -119.016	
HUC12 Name: Mill Creek-Middle Fork John Day River	OR_WS_170702030106_05_102156	2.24	StreamStats	44.601, -118.492	
HUC12 Name: Mill Creek-Middle Fork John Day River	OR_WS_170702030106_05_102156	0	StreamStats	44.587, -118.447	
HUC12 Name: Mill Creek-Middle Fork John Day River	OR_WS_170702030106_05_102156	0	StreamStats	44.601, -118.493	
Middle Fork John Day River	OR_SR_1707020301_05_101617	7.22	StreamStats	44.594, -118.517	
HUC12 Name: Little Boulder Creek-Middle Fork John Day River	OR_WS_170702030202_05_102158	0	StreamStats	44.621, -118.571	

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
HUC12 Name: Little Boulder Creek-Middle Fork John Day River	OR_WS_170702030202_05_102158	0	StreamStats	44.628, -118.590	
HUC12 Name: Little Boulder Creek-Middle Fork John Day River	OR_WS_170702030202_05_102158	0	StreamStats	44.632, -118.611	
HUC12 Name: Little Boulder Creek-Middle Fork John Day River	OR_WS_170702030202_05_102158	0	StreamStats	44.626, -118.613	
Middle Fork John Day River	OR_SR_1707020302_05_101619	7.43	StreamStats	44.601, -118.534	
Middle Fork John Day River	OR_SR_1707020302_05_102577	7.4	USGS: 14043840	44.693, -118.794	2011-10-01 ~ 2023-09-30
HUC12 Name: Granite Boulder Creek-Middle Fork John Day River	OR_WS_170702030203_05_102571	0.577	StreamStats	44.644, -118.658	
HUC12 Name: Granite Boulder Creek-Middle Fork John Day River	OR_WS_170702030203_05_102571	0.051	StreamStats	44.657, -118.682	
Middle Fork John Day River	OR_SR_1707020303_05_101624	14.8	StreamStats	44.836, -119.031	
Middle Fork John Day River	OR_SR_1707020305_05_101597	15	USGS: 14044000	44.889, -119.141	1993-10-01 ~ 2023-09-30
HUC12 Name: Summit Creek	OR_WS_170702030102_05_102152	0.462	StreamStats	44.585, -118.429	
HUC12 Name: Vinegar Creek-Middle Fork John Day River	OR_WS_170702030201_05_102157	0	StreamStats	44.687, -118.541	
Vinegar Creek	OR_SR_1707020302_05_101620	0.156	StreamStats	44.602, -118.534	
HUC12 Name: Squaw Creek	OR_WS_170702030101_05_102151	0.655	StreamStats	44.585, -118.428	
HUC12 Name: Alder Creek	OR_WS_170702040108_05_102187	0.21	StreamStats	44.809, -119.959	
Bear Creek	OR_SR_1707020403_05_101648	0	StreamStats	44.677, -120.279	
Bridge Creek	OR_SR_1707020403_05_101651	0	StreamStats	44.564, -120.145	
Bridge Creek	OR_SR_1707020403_05_101650	0	StreamStats	44.677, -120.278	

AU Name	AU ID	Annual 7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/ Longitude	Gage Period
HUC12 Name: Upper Bridge Creek	OR_WS_170702040303_05_102198	0	StreamStats	44.571, -120.170	
HUC12 Name: Upper Bridge Creek	OR_WS_170702040303_05_102198	0	StreamStats	44.583, -120.211	
Bridge Creek	OR_SR_1707020403_05_101647	0.5	USGS/OWRD: 14046778	44.727, -120.302	2006-03-15 ~ 2023-09-30
HUC12 Name: Brown Creek	OR_WS_170702041106_05_102250	0	StreamStats	45.067, -119.867	
Rosebush Creek	OR_SR_1707020413_05_101709	0	StreamStats	45.519, -120.670	
HUC12 Name: Upper Grass Valley Canyon	OR_WS_170702041304_05_102261	0	StreamStats	45.407, -120.724	
Grass Valley Canyon	OR_SR_1707020413_05_101708	0	StreamStats	45.597, -120.424	
Hay Creek	OR_SR_1707020410_05_101697	0	StreamStats	45.505, -120.360	
HUC12 Name: Upper Kahler Creek	OR_WS_170702040103_05_102182	0	StreamStats	44.901, -119.751	
Pine Creek	OR_SR_1707020404_05_101664	0	StreamStats	44.910, -120.396	
Pine Creek	OR_SR_1707020404_05_101662	0.1	USGS: 14046890	44.907, -120.446	2003-10-01 ~ 2022-06-28
Rock Creek	OR_SR_1707020411_05_101705	0.18	StreamStats	45.104, -119.623	
Rock Creek	OR_SR_1707020412_05_101701	1.09	StreamStats	45.577, -120.404	
HUC12 Name: Service Creek-John Day River	OR_WS_170702040201_05_102189	0.372	StreamStats	44.797, -120.003	1993-10-01 ~ 2023-09-30
HUC12 Name: Sorefoot Creek-John Day River	OR_WS_170702040701_05_102222	0	StreamStats	44.946, -120.500	
Sorefoot Creek	OR_SR_1707020407_05_101677	0	StreamStats	44.949, -120.485	
HUC12 Name: Cottonwood Creek-Butte Creek	OR_WS_170702040501_05_102213	0	StreamStats	44.960, -120.139	
Thirtymile Creek	OR_SR_1707020408_05_101684	0	StreamStats	45.167, -120.164	
Thirtymile Creek	OR_SR_1707020408_05_101685	0	StreamStats	45.162, -120.468	
Dry Fork Thirtymile Creek	OR_SR_1707020408_05_101680	0	StreamStats	45.170, -120.157	
HUC12 Name: Buckhorn Creek	OR_WS_170702041105_05_102249	0	StreamStats	45.013, -119.899	

Table 6-2: The 7Q10 low-flow estimates for NPDES permitted discharges assessed in this TMDL.

Facility Name (Facility Number)	Stream	7Q10 (cfs)	Flow Estimation Method	Flow Estimation Latitude/Longitude	Gage Period
City of Dayville	John Day River	4	USGS: 14040500 - 14039500	44.464, -119.511	1993-10-15 ~ 2014-09-30
Mt Vernon STP	John Day River	12	USGS: 14038530	44.411, -119.117	1993-10-01 ~ 2023-09-30
Long Creek STP	Long Creek	0.863	StreamStats	44.728, -119.104	
John Day STP	John Day River	12	USGS: 14038530	44.422, -118.965	1993-10-01 ~ 2023-09-30
John Day WWTF	John Day River	12	USGS: 14038530	44.422, -118.965	1993-10-01 ~ 2023-09-30

7 Sources or source categories

A key element of TMDL development is a complete, comprehensive source assessment for the relevant water quality pollutant(s). This includes identification of all relevant point and nonpoint sources to the impaired waterbody, characterization/quantification of their pollutant load contributions, determination of seasonal variation, and delineation of periods when applicable temperature criteria are exceeded at various locations, to the extent that existing data allow. The TMDL report and its appendices describe the significant thermal pollutant sources identified within the John Day River Basin temperature TMDL area and the data sources that DEQ utilized for TMDL modeling.

The current thermal loading from most point sources evaluated for the TMDL analysis do not exceed the 0.3°C human use allowance, the portion of human caused warming allowed by the temperature standard when waters exceed the applicable temperature criteria. Nonpoint sources, on the other hand, have temperature impacts with temperature increases well above the 0.3°C human use allowance in nearly all impaired waters evaluated. Therefore, nonpoint sources will require the largest temperature reductions for waters to attain the applicable temperature criteria.

7.1 Point sources

Individual and some general NPDES permittees were identified as sources of thermal loading to waters in the John Day River Basin and assigned thermal waste load allocations. While individual and some general NPDES permittees identified in this TMDL discharge or have potential to discharge thermal loads that increase stream temperature, the loading from the majority of the individual facilities evaluated do not result in temperature increases that exceed the 0.30°C human use allowance. DEQ's individual facility specific thermal load assessment is documented in Section 9.2 of this document and Section 9.1.2 of the John Day River Basin temperature TMDL.

7.1.1 Individual NPDES permitted point sources

There are three domestic facilities with an individual NPDES permit within the John Day River Basin. There is also one domestic WPCF permit within the John Day River Basin. All four of the facilities were identified as potential sources of thermal load and were assigned WLAs in this TMDL (**Table 7-1**). The specific AUs where these NPDES permitted point source discharge is summarized in Appendix [D].

Table 7-1: Individual NPDES permitted point source discharges that have the potential to contribute thermal loads to John Day River Basin streams at a frequency and magnitude to cause exceedances to the temperature standard.

Permittee	Permit type	DEQ WQ File Number	Permit Number	Receiving water name (AU ID)	River mile
City of Dayville	NPDES-DOM-Db	23560	101794	OR_SR_1707020110_05_101552	209.9
Mt Vernon STP	NPDES-DOM-Db	59065	101316	OR_SR_1707020109_05_101547	239
Long Creek STP	NPDES-DOM-Da	51180	101751	OR_SR_1707020304_05_101629	20
John Day WWTF*	WPCF-DOM-C2a	43569	103281	OR_SR_1707020109_05_101547	248

*Previously John Day STP WQ File number 43569, Permit Number 102481

7.1.2 General NPDES permitted point sources

There are two categories of general NPDES permit types with registrants in the John Day River Basin including:

- 400-J Industrial Wastewater: NPDES log ponds
- 1300-J General Industrial: NPDES oily stormwater, oil and water separators

Discharges covered by industrial wastewater (400-J), stormwater, or other general NPDES permits (1300-J) will not contribute to exceedances of applicable temperature criteria and impact beneficial uses based on the permit requirements, available dilution, or frequency and magnitude of discharge. Therefore, no additional TMDL requirements are needed for these sources to control temperature, other than those included in the NPDES permits. More specific wasteload allocations can be considered if subsequent data and evaluation demonstrate a need and if reserve capacity is available. Temperature impacts from these sources are limited, as follows:

- The 400-J permit applies to log ponds. 400-J permit specifies that log ponds, during the critical May 1 through October 31 period, may only discharge during unseasonably wet weather or other reasons beyond the control of the permittee.

- The 1300-J permit applies to facilities with oily stormwater runoff. A review of monitoring data for facilities with 1300-J permits shows that discharges are related to precipitation events which predominantly occur during the winter season.

7.2 Nonpoint and background sources

OAR 340-41-0002 (42) defines nonpoint sources as “diffuse or unconfined sources of pollution where wastes can either enter, or be conveyed by the movement of water, into waters of the state.” Generally, nonpoint thermal sources in the John Day River Basin include activities associated with agriculture, forestry, dam and reservoir management, and development. Example sources and/or activities that contribute nonpoint thermal loads that increase stream temperature include:

- Human-caused increases in solar radiation loading to streams from stream-side vegetation disturbance or removal;
- Channel modification and widening;
- Dam and reservoir operation;
- Activities that modify flow rate or volume; and,
- Background sources, including natural sources and anthropogenic sources of warming through climate change and other factors.

Anthropogenically influenced thermal loads are targeted for reduction to attain the applicable temperature water quality criteria. The following actions are needed to attain the TMDL allocations:

- Restoration of stream-side vegetation to reduce thermal loading from exposure to solar radiation,
- Restoration of complex channel morphology and hyporheic or groundwater connection;
- Management and operation of dams and reservoirs to minimize temperature warming, and,
- Maintenance of minimum instream flows.

7.2.1 Background sources

By definition (OAR 340-042-0030(1)), 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. Stream temperature warming from climate change is a background source as the majority of the climate change causing pollutants emanate from outside of Oregon.

The background thermal loading a stream receives is influenced by a number of landscape and meteorological characteristics, such as: substrate and channel morphology conditions; streambank and channel elevations; near-stream vegetation; groundwater; hyporheic flow; tributary inflows; precipitation; cloudiness; air temperature; relative humidity and others. Many of these factors, however, are influenced by anthropogenic impacts, including climate change. As such, it was not possible to develop a model in which all human influences were controlled or accounted for. As a best estimate, background thermal sources were quantified for the modeled rivers with delineable anthropogenic influences (i.e., vegetation alterations, water withdrawals, point source discharges) accounted for, thus isolating the remaining background sources.

In some of the rivers modeled, thermal loading from background sources contributed to exceedances of the applicable temperature criteria and therefore were identified as significant source of thermal loading. Reductions from background sources will be required to attain the applicable temperature criteria. The contribution from background sources for each model stream is summarized in **Table 7-2** and in each model river sections below.

Table 7-2: Maximum 7DADM increases above the applicable temperature criteria associated with background nonpoint sources.

River	Maximum 7DADM Temperature Increase (°C)	Point of Maximum Impact (model km)
John Day River	10.9	338.0
North Fork John Day River	6.11	164.5
Middle Fork John Day River	7.34	35.15

7.2.2 Water management and consumptive use water withdrawals

Water management activities and water withdrawals is a source category that accounts for nonpoint source temperature impacts associated with the withdrawal of water that is intended for consumptive uses (such as irrigation or domestic use) and the warming that might occur as that water moves through a canal or ditch before being returned to the natural river.

Water withdrawals decrease the capacity of streams to assimilate thermal loads and result in warmer stream temperatures. In waterbodies where temperatures are already known to exceed standards, further withdrawals from the stream will reduce the stream's assimilative capacity and cause greater fluctuation in daytime and nighttime stream temperatures.

DEQ assessed the impact of consumptive use water withdrawals on stream temperature for all of the modeled streams.

- In the John Day River (Upper John Day and Lower John Day Subbasins) we evaluated stream temperature response to water withdrawals and found that a 1% reduction of natural streamflow resulted in a stream temperature increase equal to the portion of the HUA allocated to water withdrawals (0.10°C).
- In the John Day River (Upper John Day and Lower John Day Subbasins) we evaluated stream temperature response to removing water withdrawals entirely and found that withdrawals were responsible for a 6.26°C increase at the POMI.

- In the North Fork John Day River (North Fork John Day Subbasin) we evaluated stream temperature response to water withdrawals and found that a 1% reduction of natural streamflow resulted in a stream temperature increase of 1.14°C, and 0.33°C at the outlet
- In the North Fork John Day River (North Fork John Day Subbasin) we evaluated stream temperature response to removing water withdrawals entirely and found that withdrawals were responsible for a 2.34°C increase at the POMI.
- In the Middle Fork John Day River (Middle Fork John Day Subbasin) we evaluated stream temperature response to water withdrawals and found that a 10% reduction of natural streamflow resulted in a stream temperature increase equal to the portion of the HUA allocated to water withdrawals (0.04°C)
- In the Middle Fork John Day River (Middle Fork John Day Subbasin) we evaluated stream temperature response to removing water withdrawals entirely and found that withdrawals were responsible for a 2.97°C increase at the POMI.

7.2.3 Channel modification and simplification

Stream channel modification and simplification for flood control or navigation and watershed development also influences stream temperature. Historically, floodplains have not been treated as an integral part of the stream channel and this has lead to development in areas prone to channel migration and flooding (Kondolf and Keller, 1991). Channelization and bank armoring to protect these areas exacerbates erosion and flooding elsewhere in the basin unless much of the channel is armored (Sear 1994). Bank armoring and the loss of floodplain connectivity diminish over-bank flows that create and maintain channel complexity. Without access to floodplains high stream flows can cause channel down cutting and lower seasonal water tables. Riparian vegetation, off channel habitats and cold water refugia may all be negatively affected by such actions.

The morphology of the streams and rivers in the John Day River Basin has been altered significantly from historic and natural conditions. As channels and uplands are modified through land use, instream and bedload sediment loads generally increase, which generally results in widening the downstream channel. Through restoration, though channel widths will not always decrease, we generally expect potential decreases of 25-50% (Anderson et al. 2004, Beechie et al. 2007, Castro & Jackson 2001, Grande Ronde Model Watershed 2002, Hey, R. 2006, Li et al. 1994, McDowell, P. 2000, ODSL 2005, River Design Group 2007, Rosgen 1996, Smith & Smith 1984, USBLM 1998, USFS 1995, USFS 2007). Alternatively, one example of channel widening via restoration is found in the USFS restoration of nine miles of upper-middle part of the North Fork of the John Day, where channel and vegetation restoration through and area of dredge mine tailings resulted in a slight widening of the channel. There are other areas in the John Day River Basin, including the Granite Creek watershed, where in-channel dredging occurred and similar results might be expected, where tailing piles have artificially narrowed channels. This underscores the difficulty in pre-determining channel potential. As described in TMDL Section 9.1.4.1, the temperature surrogate measure for channel morphology is narrative rather than quantitative.

7.2.4 Solar loading from disturbance or removal of near stream vegetation

Solar radiation is the energy source driving daily stream heating. Solar radiation is directly influenced by channel and vegetation conditions as stated previously. In addition, streams manifest indirect causes of solar heating. Stream straightening can be an indirect cause of solar heating. Straightening increases gradient, in turn increasing velocity and associated erosivity. This typically enlarges the channel, resulting in a wide and shallow stream, particularly during the low flow season. Bank weakening, by vegetation disturbance and associated loss of soil/root strength, similarly results in wide and shallow channels. Bank disturbance by livestock, vehicles and development generally leads to increases in stream width. A wide shallow stream is readily heated by the sun if not shaded. These situations are common in the John Day River Basin, as elsewhere.

In the John Day River Basin, thermal loading from nonpoint sources contributed to exceedances of the applicable temperature criteria and therefore were identified as significant source of thermal loading. The vegetation model scenario examines the impact of near stream vegetation removal and is summarized in **Table 7-3** and in each model river sections below.

Table 7-3: Maximum 7DADM increases above the applicable temperature criteria associated with background nonpoint sources.

River	Maximum 7DADM Temperature Increase (°C)	Point of Maximum Impact (model km)
John Day River	8.40	410
North Fork John Day River	7.68	152.2
Middle Fork John Day River	6.62	107.95

7.2.5 Climate change

DEQ completed a literature review to assess climate change-driven stream temperature impacts. Based on that review (Appendix J), since the late 1970s, stream temperature impacts from climate change ranged from +0.05°C to +0.27°C per decade on unregulated streams and -0.48°C to +0.52°C per decade on regulated streams. Stream temperature trends in regulated systems are more variable, as upstream flow and temperature management can confound natural long-term warming trends in the data (Isaak et al., 2012). The temperature impact in the summer months (June, July, and August) is greater relative to the annual average impact.

7.2.6 John Day River

Thermal pollutant sources identified for the John Day River include lack of sufficient shade-producing streamside vegetation, consumptive use water withdrawals, tributaries to the John Day River with waters exceeding the temperature criteria, and background sources. See TSD Appendix B for details. Briefly, along the John Day River model extent:

- Lack of sufficient streamside vegetation was associated with a mean effective shade gap of 11.21 percentage points, corresponding to daily maximum water temperature increases of 8.40°C at the POMI at model km 410, and 0.06°C at the mouth.
- Warming from tributary waters that exceeded water quality criteria was associated with daily maximum water temperature increases of 7.80°C at the POMI at model km 282, and 0.43°C at the mouth.
- Surface water withdrawals were associated with a 7DADM increase of 6.26°C at the POMI at model km 290, and 0.28°C at the mouth. When modeled consumptive use is reduced to 1% of natural streamflow, the resulting stream temperature increase was equal to the portion of the HUA allocated to water withdrawals (0.10°C).
- Channel modifications, such as decreases in channel width by 30%, were associated with 7DADM water temperature increase of 6.83°C at the POMI at model km 393, and 0.63°C at the mouth.
- Background sources were associated with a water temperature standard exceedance of 7.65°C above the applicable numeric criteria at model km 27. This means that to attain the temperature criteria, background sources need to have a temperature reduction of 7.65°C.

7.2.7 North Fork John Day River

Thermal pollutant sources identified for the John Day River include lack of sufficient shade-producing streamside vegetation, consumptive use water withdrawals, tributaries to the John Day River with waters exceeding the temperature criteria, and background sources. See TSD Appendix B for details. Briefly, along the North Fork John Day River model extent:

- Lack of sufficient streamside vegetation was associated with a mean effective shade gap of 19.69 percentage points, corresponding to daily maximum water temperature increases of 7.68°C at the POMI at model km 152.2, and 0.43°C at the mouth.
- Warming from tributary waters that exceeded water quality criteria was associated with daily maximum water temperature increases of 5.65°C at the POMI at model km 51, and 1.73°C at the mouth.
- Surface water withdrawals were associated with a 7DADM increase of 2.34°C at the POMI at model km 132.7, and 1.61°C at the mouth. When modeled consumptive use is reduced to 1% of natural streamflow resulted in a 7DADM temperature increase of 1.14°C at the POMI at model km 154.8, and 0.33°C at the mouth.
- Channel modifications, such as decreases in channel width by 30%, were associated with 7DADM water temperature increase of 2.81°C at the POMI at model km 72.3, and 1.71°C at the mouth.
- Background sources were associated with a water temperature standard exceedance of 12.89°C above the applicable numeric criteria at model km 152.3. This means that to

attain the temperature criteria, background sources need to have a temperature reduction of 12.89°C.

7.2.8 Middle Fork John Day River

Thermal pollutant sources identified for the John Day River include lack of sufficient shade-producing streamside vegetation, consumptive use water withdrawals, tributaries to the John Day River with waters exceeding the temperature criteria, and background sources. See TSD Appendix A for details. Briefly, along the Middle Fork John Day River model extent:

- Lack of sufficient streamside vegetation was associated with a mean effective shade gap of 26.45 percentage points, corresponding to daily maximum water temperature increases of 6.62°C at the POMI at model km 107.95, and 3.98°C at the mouth.
- Warming from tributary waters that exceeded water quality criteria was associated with daily maximum water temperature increases of X.XX°C at the POMI at model km XXX, and 0.XX°C at the mouth.
- Surface water withdrawals were associated with a 7DADM increase of 2.97°C at the POMI at model km 2.55, and 2.75°C at the mouth. When consumptive use is reduced to 10% of natural streamflow resulted in a 7DADM temperature increase of 0.04°C at the POMI at model km 2.55, and 0.03°C at the mouth, which is less than the portion of the HUA allotted to this source category.
- Channel modifications, such as decreases in channel width by 30%, were associated with 7DADM water temperature increase of 4.08°C at the POMI at model km 52.95, and 3.35°C at the mouth.
- Background sources were associated with a water temperature standard exceedance of XX°C above the applicable numeric criteria at model km 152.3. This means that to attain the temperature criteria, background sources need to have a temperature reduction of XX°C.

8 Loading capacity and excess loads

Refer to DATE John Day River Basin TMDL rule (OAR ….) for the loading capacity and excess load.

As described in the TMDL report, the pollutant load that a waterbody can receive and still meet water quality standards is called the loading capacity (LC). For temperature, a thermal loading capacity is assigned to all AUs in the John Day River Basin. The thermal loading capacity was calculated using **Equation 8-1**.

$$LC = (T_C + \mathrm{HUA}) \cdot Q_R \cdot C_F \qquad \textbf{Equation 8-1}$$

where,

$LC =$ Loading Capacity (kcal/day).

$T_C =$ The applicable river temperature criterion (°C).

$\text{HUA} =$ The 0.3°C human use allowance assigned to point sources, nonpoint sources, margin of safety, or reserve capacity.

$Q_R =$ The daily mean river flow rate in cubic feet per second (cfs). For a lake, a dilution factor of 1 may be used for Q_R unless determined using another method.

$C_F =$ Conversion factor using flow in cfs: 2,446,665

$$\left(\frac{1\,m}{3.2808\,ft}\right)^3 \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\,\cdot 1°\text{C}} = 2{,}446{,}665$$

The TMDL presents the loading capacity for select temperature impaired Category 5 AUs modeled for the TMDL analysis at the critical 7Q10 low flow. It is intended that **Equation 8-1** be used to calculate the loading capacity for any AU or stream location in the John Day River Basin not identified in the John Day River Basin Temperature TMDL or when river flows are greater than 7Q10. In cases when there are two year-round applicable temperature criteria that apply to the same AU, the more stringent criteria shall be used for the loading capacity.

Because flow monitoring data were not available at most temperature monitoring locations, it was not possible to calculate the excess thermal load. Instead, the excess temperature and percent load reduction were calculated for each AU where temperature data were available. The extensive monitoring across the John Day River Basin represents a wide range of waterbodies; however not all streams in the John Day River Basin have monitoring data. **Equation 8-2** can be used to determine excess temperature and percent reduction for additional streams if data becomes available in the future. Temperature data collected in John Day River Basin between 1/1/1991 and 12/31/2023 were downloaded from DEQ's AWQMS database. Following data review and filtering for acceptable data quality there were 452 temperature monitoring stations available where excess temperature could be calculated. The maximum excess temperature and corresponding percent reduction were summarized in the temperature TMDL for each AU and each temperature criteria applicable on that AU.

The excess temperature is the maximum difference between the monitored 7DADM river temperature and the applicable numeric criterion including the HUA. The percent load reduction (**Equation 8-2**) represents the maximum portion of the actual thermal loading that must be reduced to attain the TMDL loading capacity.

The percent load reduction is mathematically equal to the percent temperature reduction calculated from the monitoring data. This is because the river flow rate used to calculate a thermal load is the same number in the numerator and denominator and is cancelled out when calculating the percent reduction. The percent load reductions shown in Table 8-2 of the John Day River Basin TMDL were calculated from temperatures in degrees Celsius.

$$\text{PR} = \frac{(T_R - T_C - \text{HUA})}{T_R} \cdot 100$$

Equation 8-2

where,

$\text{PR} =$ Percent load reduction (%). If PR < 0, PR = 0

$T_R =$ The maximum 7DADM ambient river temperature (°C).

$T_C =$ The applicable river temperature criterion (°C).

$\text{HUA} =$ The 0.3°C human use allowance assigned to point sources, nonpoint sources, margin of safety, or reserve capacity.

9 Allocations, reserve capacity, and margin of safety

Figure 9-1 provides three separate conceptual representations of the total load to a temperature-impaired water. The left (completely orange) block shows the total load, with the bisecting lines representing the load that would meet the biologically-based numeric criteria plus the HUA (the temperature standard). The middle block represents the portions of the total load contributed by the different source categories (point, nonpoint, and background). The right block illustrates how the loading capacity element of the TMDL defines the various allocations.

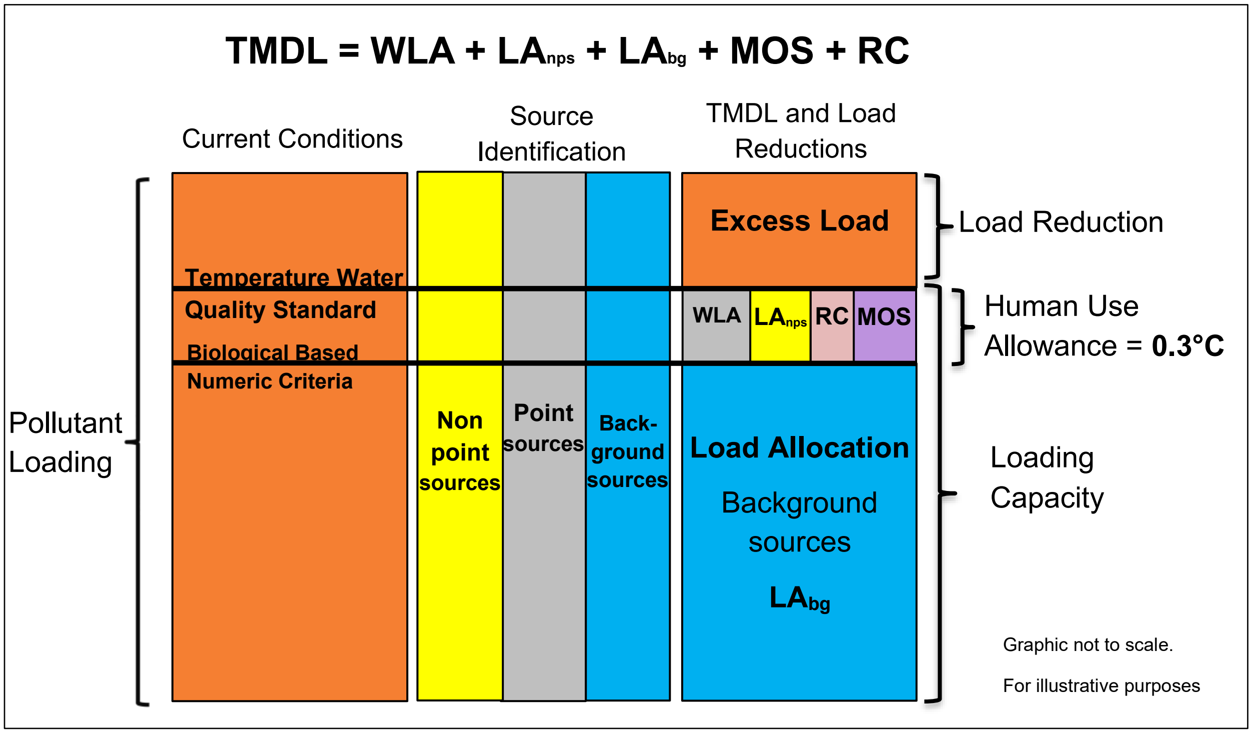

Figure 9-1: Conceptual representation and breakdown of total pollutant loading to a temperature-impaired waterbody.

Wasteload allocations (shown as WLA) are the portion of the TMDL loading capacity allocated to point sources and load allocations (shown as LA_{nps} and LA_{bg}) are the portion attributed to nonpoint sources, including background sources. OAR 340-042-0040(6) identifies the factors that DEQ or EQC may consider when distributing wasteload and load allocations.

The factors include:

a) Contributions from sources;

b) Costs of implementing measures;
c) Ease of implementation;
d) Timelines for attainment of water quality standards;
e) Environmental impacts of allocations;
f) Unintended consequences;
g) Reasonable assurances of implementation;
h) Any other relevant factor.

Oregon's temperature standard provides a framework for how the loading capacity is distributed between human sources of warming and background sources. The HUA at OAR 340-041-0028(12)(b)(B) identifies the portion of the loading capacity reserved for human uses. The rule requires that wasteload and load allocations restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.30°C (0.5°F) above the applicable criteria after complete mixing in the waterbody, and at the POMI. DEQ allocated a thermal load equivalent to a 0.30°C increase to human sources and the remainder of the loading capacity to background sources. Distribution of the human use allowance is discussed in section 9.1, **Error! Reference source not found.** (point sources), and **Error! Reference source not found.** (nonpoint sources). Factors used when assigning allocations included the relative contribution from existing sources, the environmental impact of the allocations and the regulatory requirement to attain water quality standards, and the policy goal to retain some of the loading capacity for future use as reserve capacity.

9.1 Human use allowance assignments

Refer to the [DATE] John Day River Basin Temperature TMDL rule (OAR ….) for the human use allowance assignments.

DEQ's approach to point sources was to assign a cumulative warming HUA on AUs with point sources up to a maximum of 0.10°C. A HUA of 0.10°C was determined to be the maximum HUA that would allow most point sources to maintain current thermal loads without immediate noncompliance. DEQ did not assign more than 0.0°C to any AU without point sources in order to have capacity available for nonpoint sources and reserve capacity. The approach for HUA assignment for any single point source and for unmodeled AUs (**Figure 6-1**) is described further in Section 9.2

DEQ's approach to nonpoint sources was to assign values to each source category that reflect the model based maximum cumulative warming for that source category for each AU. When the model results indicated that warming would not be reduced to a cumulative warming of 0.30°C, DEQ considered the magnitude of the thermal load contributed from known sources, the allocation assigned in the older TMDL being replaced, ease of implementing the allocations, the environmental impact of those contributions including where the impact occurs, and how the source contribution impacts cumulative warming.

Some source categories were assigned a 0.0°C human use allowance or no increase in temperature. A zero human use allowance should not be interpreted as zero total thermal loading or zero discharge. Thermal loads from source categories assigned a zero human use allowance may still have a discharge but cannot contribute to temperature increases above the applicable criteria when 7DADM temperature exceed the criteria.

The current thermal loading from most point sources evaluated by DEQ do not exceed the human use allowance. Nonpoint sources, on the other hand, have temperature impacts with temperature increases well above the assigned human use allowance in nearly all impaired waters evaluated. Nonpoint sources will require the largest temperature reductions for waters to attain the applicable temperature criteria.

9.2 Wasteload allocations for point sources

Refer to the [DATE] John Day River Basin Temperature TMDL rule (OAR ….) for the wasteload allocations assigned to point sources.

The allocation approach for point sources in Oregon was to use the current maximum thermal loads at critical 7Q10 low flow conditions as the starting point to calculate HUA assignments and waste load allocations. The model was then used to determine if this amount of warming provided capacity for other source categories and reserve capacity. The HUA assigned to each facility at the point of discharge is therefore based on the temperature increase above the applicable criteria using the maximum effluent discharge at 7Q10 river flows, assuming 100% mix. **Error! Reference source not found.** was used to calculate the change in temperature. The temperature increase was rounded up to the nearest thousands place for the HUA. The following sections briefly summarize each point source and the data used to calculate the assigned HUA and wasteload allocations.

9.2.1 City of Dayville (23560)

City of Dayville (WQ File# 23560, EPA Number OR0041505) discharges to John Day River RM 209.9. Basis for maximum effluent temperature and flow rate from DMRs from April to November from 2016 to 2023. City of Dayville was assigned an HUA of 0.10°C, and based on the Average Dry Weather Design Flow (ADWDF) of 0.048 MGD, DEQ does not anticipate the facility to be out of compliance.

9.2.2 John Day WWTF (127619)

John Day STP (WQ File# 43569, EPA Number 127619) discharges to John Day River RM 248. Basis for maximum effluent temperature and flow from Average Dry Weather Design Flow of 0.600 MGD. DEQ does not anticipate the facility to be out of compliance.

9.2.3 Long Creek STP (51180)

Long Creek STP (WQ File #51180, EPA Number OR0034070) discharges to Long Creek RM 20. Basis for maximum effluent flow from Average Dry Weather Design Flow of 0.030 MGD. Discharge is prohibited, unless by written DEQ approval, until receipt of the Mixing Zone/Water Quality Criteria Analysis report required by Schedule B of the permit.

9.2.4 Mt. Vernon STP (59065)

Mt. Vernon STP (WQ File #59065, EPA Number OR0030694) discharges to John Day River RM 239. Basis for maximum effluent flow from Average Dry Weather Design Flow of 0.100 MGD. Discharge is prohibited, unless by written DEQ approval, until receipt of the Mixing Zone/Water Quality Criteria Analysis report required by Schedule B of the permit.

9.2.5 WLA equations

9.2.5.1 Wasteload allocation equation

Equation 9-1 is used to calculate the thermal wasteload allocations in Error! Reference source not found..

$WLA = \Delta T \cdot (Q_E + Q_R) \cdot C_F$ **Equation 9-1a**

$WLA = \Delta T \cdot Q_E \cdot D_F \cdot C_F$ **Equation 9-1b**

where,

$WLA =$ Wasteload allocation (kilocalories/day), expressed as a rolling seven-day average.

$\Delta T =$ The assigned portion of the HUA at the point of discharge. Represents the maximum temperature increase (°C) above the applicable temperature criterion using 100% of river flow not to be exceeded by each individual source from all outfalls combined. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ΔT = 0.0.**Error! Reference source not found.** is used to determine if the minimum duties provision applies.

$Q_E =$ The daily mean effluent flow (cfs).

When effluent flow is in million gallons per day (MGD) convert to cfs:

$$\frac{1{,}000{,}000\ gallons}{1\ day} \cdot \frac{0.13368 ft^3}{1\ \text{gallon}} \cdot \frac{1\ day}{86{,}400\ sec} = 1.5472\ ft^3/sec$$

$Q_R =$ The daily mean river flow rate, upstream (cfs).

When flow is <= 7Q10, Q_R = 7Q10. When flow is > 7Q10, Q_R equals the daily mean river flow, upstream.

$D_F =$ Dilution factor $(Q_E + Q_R)/Q_E$ For lakes, the dilution factor is 1 unless determined using another method.

$C_F =$ Conversion factor using flow in cfs: 2,446,665

$$\left(\frac{1\ m}{3.2808\ ft}\right)^3 \cdot \frac{1000\ kg}{1\ m^3} \cdot \frac{86400\ sec}{1\ day} \cdot \frac{1\ kcal}{1\ kg\ \cdot 1°\text{C}} = 2{,}446{,}665$$

9.2.5.2 Wasteload allocation attainment equation

DEQ evaluated attainment of a wasteload allocation (WLA) using **Equation 9-2**. **Equation 9-2** calculates the excess thermal loading (ETL). The ETL is compared against the wasteload allocation (WLA) to assess attainment.

$ETL = (T_E - T_{C,i}) \cdot Q_E \cdot C_F$ **Equation 9-2**

where,

$ETL =$ The daily excess thermal load (kilocalories/day), expressed as a rolling seven-day average.

$T_{C,i} =$ The point of discharge applicable river temperature criterion (°C) (T_c); or when the minimum duties provision at OAR 340-041-0028(12)(a) applies $T_{C,i}$ = the daily maximum temperature measured at the facility intake (T_i). **Error! Reference source not found.** is used to determine if the minimum duties provision applies.

$T_E =$ The daily maximum effluent temperature (°C)

$Q_E =$ The daily mean effluent flow (cfs or MGD)

$C_F =$ Conversion factor for flow in cfs: 2,446,665

$$\left(\frac{1\text{ m}}{3.2808\text{ ft}}\right)^3 \cdot \frac{1000\ kg}{1\ m^3} \cdot \frac{86400\ sec}{1\ day} \cdot \frac{1\ kcal}{1\ kg\ \cdot 1°\text{C}} = 2{,}446{,}665$$

Conversion factor for flow in millions of gallons per day (MGD): 3,785,411

$$\frac{1\ m^3}{264.17\ gal} \cdot \frac{1000\ kg}{1\ m^3} \cdot \frac{1000000\ gal}{1\ million\ gal} \cdot \frac{1\ kcal}{1\ kg\ \cdot 1°\text{C}} = 3{,}785{,}441$$

9.2.5.3 Calculating change in temperature

Equation 9-3 is used to assess the change in temperature based on point source effluent discharge, river flow, and the applicable temperature criteria.

$$\Delta T_{ps} = \left(\frac{Q_E}{Q_E + Q_R}\right) \cdot \left(T_E - T_{C,i}\right)$$ **Equation 9-3a**

$$\Delta T_{ps} = \left(\frac{T_E - T_{C,i}}{D_F}\right)$$ **Equation 9-3b**

where,

$\Delta T_{ps} =$ The river temperature increase (°C) above the applicable river temperature criterion using 100% of river flow.

$Q_E =$ The daily mean effluent flow (cfs).

When effluent flow is in million gallons per day (MGD) convert to cfs:

$$\frac{1{,}000{,}000\ gallons}{1\ day} \cdot \frac{0.13368 ft^3}{1\text{ gallon}} \cdot \frac{1\ day}{86{,}400\ sec} = 1.5472\ ft^3/sec$$

$Q_R =$ The daily mean river flow rate, upstream (cfs).

When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the daily mean river flow, upstream.

$D_F =$ Dilution factor $(Q_E + Q_R)/Q_E$ For lakes, the dilution factor is 1 unless determined using another method.

$T_E =$ The daily maximum effluent temperature (°C)

$T_{C,i} =$ The point of discharge applicable river temperature criterion (°C) (T_c); or when the minimum duties provision at OAR 340-041-0028(12)(a) applies $T_{C,i}$ = the daily maximum temperature measured at the facility intake (T_i). **Error! Reference source not found.** is used to determine if the minimum duties provision applies.

9.2.5.4 Calculating wasteload allocation effluent temperatures

Equation 9-4 is used to calculate the daily maximum effluent temperatures (°C) acceptable under the allocated portion of the HUA (Δ*T*) and the wasteload allocation (WLA).

$$T_{E\_WLA} = \frac{(Q_E + Q_R) \cdot (T_{C,i} + \Delta T) - (Q_R \cdot T_{C,i})}{Q_E}$$ **Equation 9-4a** (using ΔT)

$$T_{E\_WLA} = \frac{(WLA)}{Q_E \cdot C_F} + T_{C,i}$$ **Equation 9-4b** (using WLA)

where,

$T_{E\_WLA} =$ Daily maximum effluent temperature (°C) allowed under the wasteload allocation.
When T_{E_WLA} is > 32°C, T_{E_WLA} = 32°C as required by the thermal plume limitations in OAR 340-041-0053(2)(d)(B).

$WLA =$ Wasteload allocation (kilocalories/day) from **Equation 9-1**.

$\Delta T =$ The assigned portion of the HUA at the point of discharge. Represents the maximum temperature increase (°C) above the applicable river temperature criterion using 100% of river flow not to be exceeded by each individual source from all outfalls combined. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, Δ*T* = 0.0.

$Q_E =$ The daily mean effluent flow (cfs).
When effluent flow is in million gallons per day (MGD) convert to cfs:

$$\frac{1{,}000{,}000\ gallons}{1\ day} \cdot \frac{0.13368 ft^3}{1\ \text{gallon}} \cdot \frac{1\ day}{86{,}400\ sec} = 1.5472\ ft^3/sec$$

$Q_R =$ The daily mean river flow rate, upstream (cfs).
When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the daily mean river flow, upstream.

$T_{C,i} =$ The point of discharge applicable river temperature criterion (°C) (T_c); or when the minimum duties provision at OAR 340-041-0028(12)(a) applies $T_{C,i}$ = the daily maximum temperature measured at the facility intake (T_i). **Error! Reference source not found.** is used to determine if the minimum duties provision applies.

$C_F =$ Conversion factor for flow in cfs: 2,446,665

$$\left(\frac{1\ m}{3.2808\ ft}\right)^3 \cdot \frac{1000\ kg}{1\ m^3} \cdot \frac{86400\ sec}{1\ day} \cdot \frac{1\ kcal}{1\ kg\ \cdot 1°\text{C}} = 2{,}446{,}665$$

9.2.5.5 Calculating wasteload allocation effluent flows

Equation 9-5 is used to calculate the daily mean effluent flow (cfs) acceptable under the allocated portion of the HUA (ΔT) and the wasteload allocation (WLA).

$$Q_{E\_WLA} = \frac{(Q_R \cdot T_{C,i}) - ((T_{C,i} + \Delta T) * Q_R)}{T_{C,i} + \Delta T - T_E}$$ **Equation 9-5a** (using ΔT)

$$Q_{E\_WLA} = \frac{(WLA)}{(T_E - T_{C,i}) * C_F}$$ **Equation 9-5b** (using WLA)

where,

$Q_{E\_WLA} =$ Daily mean effluent flow (cfs) allowed under the wasteload allocation.

$WLA =$ Wasteload allocation (kilocalories/day) from **Equation 9-1**.

$\Delta T =$ The assigned portion of the HUA at the point of discharge. Represents maximum temperature increase (°C) above the applicable river temperature criterion using 100% of river flow not to be exceeded by each individual source from all outfalls combined. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ΔT = 0.0.

$T_E =$ The daily maximum effluent temperature (°C).

$Q_R =$ The daily mean river flow rate, upstream (cfs).
When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the daily mean river flow, upstream.

$T_{C,i} =$ The point of discharge applicable river temperature criterion (°C) (T_c); or when the minimum duties provision at OAR 340-041-0028(12)(a) applies $T_{C,i}$ = the daily maximum temperature measured at the facility intake (T_i). **Error! Reference source not found.** is used to determine if the minimum duties provision applies.

$C_F =$ Conversion factor for flow in cfs: 2,446,665

$$\left(\frac{1\,m}{3.2808\,ft}\right)^3 \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\ \cdot 1^\circ C} = 2{,}446{,}665$$

9.2.5.6 Minimum duties equation

When assessing the wasteload allocation for attainment, DEQ used the approach described in **Equation 9-6** to implement the minimum duties provision.

$$T_{E\_WLA} < T_i$$ **Equation 9-6**

When minimum durites applies, there may be no increase in temperature above the intake temperature (T_i) and the assigned portion of the HUA is zero (ΔT= 0).

where,

$T_{E\_WLA} =$ Daily maximum effluent temperature (°C) allowed dunder the wasteload allocation as calculated using **Equation 9-4** where $T_{C,i}$ equals the applicable temperature criteria

$T_i =$ The daily maximum influent temperature (°C) measured at the facility intake.

9.3 Load allocations for nonpoint sources

Refer to the [DATE] John Day River Temperature TMDL rule (OAR ….) for the load allocations assigned to nonpoint sources.

Background sources were assigned a thermal load equivalent to the applicable numeric criteria where and when it applies (e.g. 20°C, 13°C). The loads assigned are the maximum possible amount of loading that will attain the temperature criteria.

DEQ assigned a load allocation and HUA of 0.00°C (no warming) to dam and reservoir operations. Small reservoirs in the basin are used for irrigation, recreation, and livestock and based on their small fraction of basin area and low volume, reservoirs are a relatively small source of heating. A surrogate measure was developed to implement the dam and reservoir HUA and corresponding load allocation (See TMDL Section 9.1.4).

The load allocations assigned to tributaries account for temperature increases in the modeled streams caused by point or nonpoint source anthropogenic warming in tributaries of John Day, North Fork John Day, and Middle Fork John Day Rivers. Inflow from canals or drains are also included in this category as they are considered waters of the state. The tributary HUA assignments for each AU are based on all tributaries in Oregon attaining the entire 0.3°C HUA at their mouths.

Lack of streamside vegetation is one of the largest sources of stream warming contributing to multiple degrees of warming where it was assessed (Section **Error! Reference source not found.**). Except for streamside vegetation reduction caused by existing infrastructure (roads, railroads, buildings, and utility corridors), all other nonpoint sources of solar loading were assigned a zero human use allowance, meaning a reduction in streamside vegetation may not cause an increase in temperature above the applicable criterion.

The solar loading allocation is implemented through an effective shade target. Effective shade can be easily measured in the field and is simpler to monitor relative to a thermal load. Based on an extensive literature review, DEQ determined that a vegetation buffer width based on a slope distance of 120 ft would be sufficient in most cases to have no warming and attain the shade targets (TSD Appendix K). This assumes the site potential trees are at least 100-120 feet tall and will grow within 120 feet slope distance from the stream bank, they can cast a shadow at least 120 feet and shade the stream. Therefore, the 120 feet is applicable. For other eastside streams, the site potential tree/shrub heights are shorter (e.g. willows), and in some locations will not grow 120 feet from the stream because the floodplain is much narrower, upland locations may have different soils and may require deeper roots to reach groundwater. Instead, the main shade producing vegetation will occupy a dense stripe in the floodplain near the stream with grass in the upland. In these cases, the sufficient shading distance will be less than 120 feet and will be a function of the site potential tree/shurb heights, and the distance these plants can naturally grow as you move away from the stream and floodplain. Effective shade surrogate measure targets represent a surrogate for the amount of solar loading that will attain the HUA and load allocations for nonpoint sources managing streamside vegetation.

DEQ chose to assign a portion of the human use allowance to existing infrastructure (roads, railroads, buildings, and utility corridors) over other land uses because moving, rebuilding, or modifying this infrastructure in addition to restoring streamside vegetation is a much more complex and potentially costly endeavor compared to restoring or protecting existing streamside vegetation in areas without infrastructure constraints.

DEQ assigned a load allocation and HUA of up to 0.15°C for temperature impacts associated with surface water withdrawals. This nonpoint source category accounts for warming from the withdrawal of water that is intended for consumptive uses (such as irrigation), and the warming that might occur as that water moves through a canal or ditch before being returned to the natural river.

9.3.1 Load allocation equations

9.3.1.1 Load allocation equation for background sources

Load allocations are assigned to background sources and anthropogenic nonpoint sources on all waters in the John Day River Basin. Load allocations for background sources are calculated using **Equation 9-7**.

$$LA_{BG} = (T_C) \cdot (Q_R) \cdot C_F \qquad \textbf{Equation 9-7}$$

where,

$LA_{BG} =$ Load allocation to background sources (kilocalories/day).

$T_C =$ The applicable temperature criteria, not including the HUA. When there are two year-round applicable temperature criteria that apply to the same AU, the more stringent criteria shall be used.

$Q_R =$ The daily average river flow rate (cfs). For a lake, a dilution factor of 1 may be used for Q_R unless determined using another method.

$C_F =$ Conversion factor using flow in cfs: 2,446,665

$$\left(\frac{1\ \text{m}}{3.2808\ \text{ft}}\right)^3 \cdot \frac{1\ m^3}{35.31\ ft^3} \cdot \frac{1000\ kg}{1\ m^3} \cdot \frac{86400\ sec}{1\ day} \cdot \frac{1\ kcal}{1\ kg\ \cdot 1℃} = 2{,}446{,}665$$

Section 9.1.3 of the John Day River Basin TMDL presents the load allocation assigned to background sources for temperature impaired Category 5 AUs that were modeled for the TMDL analysis. The load allocation presented is based on the critical 7Q10 low flow. **Equation 9-7** shall be used to calculate the load allocation to background sources for any AU or stream location in the John Day River Basin not identified in the TMDL or when river flows are greater than 7Q10.

Equation 9-7 may also be used to calculate the load allocations for background nonpoint sources if in the future the applicable temperature criteria are updated and approved by EPA.

9.3.1.2 Load allocation equation for nonpoint sources

Load allocations assigned to anthropogenic nonpoint sources on any AU or stream location in the John Day River Basin are calculated using **Equation 9-8.** The portions of the HUA (ΔT) assigned to nonpoint sources or source categories are presented in Section 9.1 of the John Day River Basin TMDL.

$$LA_{NPS} = (\Delta T) \cdot (Q_R) \cdot C_F$$ **Equation 9-8**

where,

$LA_{NPS} =$ Load allocation to anthropogenic nonpoint sources (kilocalories/day).

$\Delta T =$ The portion of the HUA assigned to each nonpoint source or source category representing the maximum cumulative temperature increase (^{o}C) from the nonpoint source or source category. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ΔT = 0.0.

$Q_R =$ The daily average river flow rate (cfs). For a lake, a dilution factor of 1 may be used for Q_R unless determined using another method.

$C_F =$ Conversion factor using flow in cfs: 2,446,665

$$\left(\frac{1\text{ m}}{3.2808\text{ ft}}\right)^3 \cdot \frac{1\,m^3}{35.31\,ft^3} \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg \cdot 1°\text{C}} = 2{,}446{,}665$$

10 Water quality standards attainment

TMDLs are a science-based approach to restoring water quality and eventually attaining and maintaining water quality standards in impaired waters. The Clean Water Act instructs that a TMDL "be established at a level necessary to implement applicable water quality standards." This TMDL assigns background sources load allocations consistent with applicable biologically based numeric temperature criteria, and wasteload allocations and nonpoint source load allocations consistent with the attainment of the 0.3^{o}C human use allowance. As summarized in the allocations summary tables in TMDL section 9.3, the sum of the wasteload allocations, load allocations, and reserve capacity on each assessment unit do not exceed that AUs thermal TMDL loading capacity. The following subsections, Sections 10.1 and 10.2, discuss the approach used to evaluate attainment of the assigned allocations.

10.1 Point sources

DEQ's approach to point source allocations is summarized in TSD sections 9.1 and 9.2 with facility specific assessment summaries described in Section 9.2.

For point sources, attainment of the temperature criteria is demonstrated by attaining the assigned HUA and equivalent WLA at the point of discharge and cumulatively at the point of maximum impact.

On unmodeled streams and where a model based cumulative effects analysis was not completed (**Figure 6-1**), it was assumed that warming impacts from individual point sources did not dissipate with distance from the outfall. This approach is protective based on model results from other streams that show temperature impacts from point sources dissipating moving downstream from the outfall. DEQ also mapped the outfall locations to AUs and adjusted the HUA assignments on AUs that did not have point sources, but that were downstream of AUs with dischargers, to ensure that there would be no warming above the HUA assigned to point sources. This ensures cumulative warming from all point sources will not exceed the portion of the HUA assigned to the point source sector.

On temperature modeled streams (**Figure 6-1**), DEQ evaluated attainment with a cumulative effects analyses. The model analysis consisted of setting point source effluent discharges at their respective WLAs. The stream temperature from this model scenario were then compared to stream temperatures from a model scenario without point sources. The difference is the change in temperature caused by point sources discharging at their WLAs. This analysis allow DEQ to assess how warming from point sources occurred over space and time, and to confirm that the assigned human use allowance and applicable temperature criteria would be attained.

Cumulative effects model analyses were completed for the John Day River. The point source sector was assigned 0.1 on three AUs on the John Day River where the modeling shows they have a downstream cumulative warming. The wasteload allocation increases John Day River temperature no more than 0.1°C (**Figure 10-1**). Model results confirm that cumulative warming from point sources will not exceed the portion of the HUA assigned to point sources on John Day River.

10.1.1 John Day River point source impacts

Figure 10-1 shows the impact of WLAs for the John Day River modeled. The Mt. Vernon STP is the location of the point of maximum impact (POMI) of point sources for the John Day River. The POMI is located downstream of the confluence of Beech Creek and the John Day River at RM 239. Major point sources which impact river temperature include Mt. Vernon STP and the City of Dayville which discharge to the John Day River. The maximum impact in the Upper John Day Subbasin is 0.10ºC, for a total HUA assignment to point sources of 0.10ºC for AUs with individual and general NPDES permits (OR_SR_1707020106_05_101533, OR_SR_1707020109_05_101547, and OR_SR_1707020110_05_101552) in the Upper John Day Subbasin, with a reserve capacity of 0.025ºC for future use or growth.

Due to the absence of point sources in the Lower John Day Subbasin, a total HUA assignment to point sources was 0.0ºC with a reserve capacity of 0.05ºC for future use or growth.

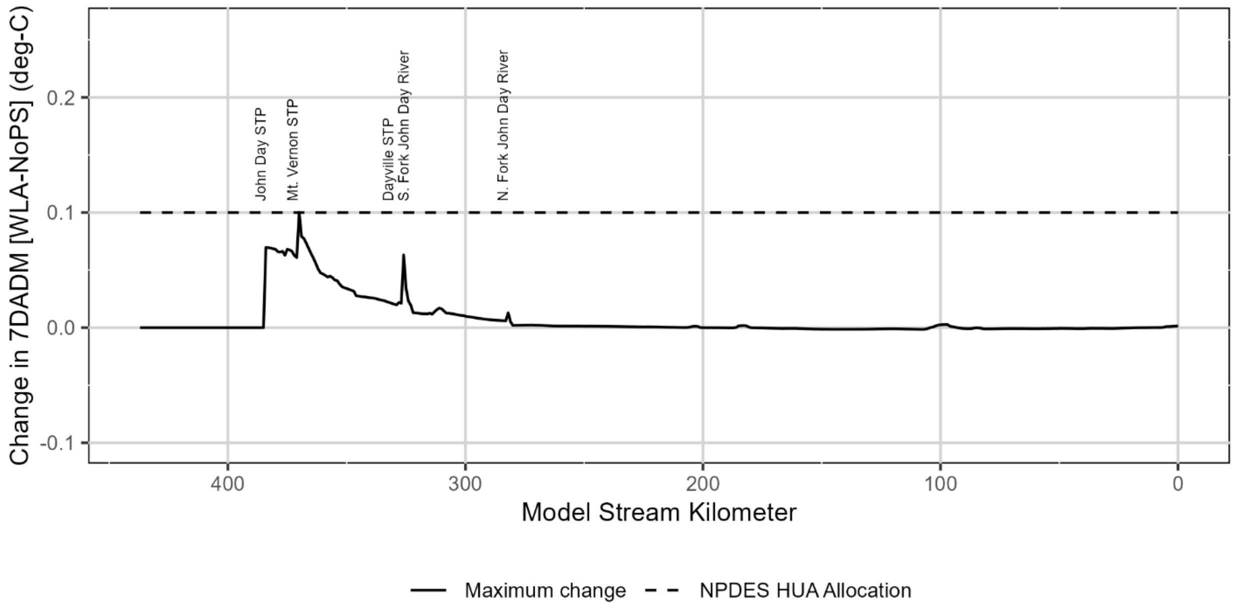

Figure 10-1: Change in maximum 7DADM stream temperatures between the Wasteload Allocations and No Point Sources scenarios for the John Day River over all time periods.

10.2 Nonpoint sources

DEQ's approach to nonpoint source allocations is to distribute portions of the HUA to the nonpoint source categories. Water management activities and water withdrawals, solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure, dam and reservoir operations, and solar loading from all other nonpoint source sectors.

The portion of the HUA allocated to nonpoint source categories was set to ensure no more than 0.3°C of cumulative warming from all NPDES point sources and nonpoint sources on a given waterbody. The nonpoint source HUA allocation will be implemented by assessing the cumulative warming of a waterbody by all nonpoint sources. This ensures cumulative warming from all nonpoint sources will not exceed the portion of the HUA allocated to nonpoint sources.

DMAs responsible for nonpoint source categories are expected to meet their HUA assignments, which were calculated to attain water quality standards. The HUA allocations for nonpoint source categories are achieved through the implementation of load allocations and surrogate measures. DMAs are responsible for implementing management activities that achieve the surrogate measure targets appropriate to their source category and location. A DMA has achieved their load allocation when surrogate measure targets are met. When all DMAs within a nonpoint source category have met their surrogate measure targets and achieved their load allocations, the HUA allocation to that nonpoint source category is achieved.

Effective shade surrogate measure targets are set at levels that assume no anthropogenic warming of the stream. When effective shade targets are met, the HUA assignments and load allocations to solar loading from nonpoint sources are achieved.

10.2.1 Tributary temperature assessment

DEQ modeled a "Tributary Temperatures" scenario that represented background conditions except that most tributaries' temperatures were set to CCC + 0.30°C throughout the modeling period. This Tributary Temperatures scenario was compared to the CCC scenario (see Section 9.3) to model the effects of tributaries discharging at their assigned HUAs on the John Day River temperatures, which excludes any reserve capacity.

Comparison of the Tributary Temperatures Attainment scenario to the CCC scenario (Figure 10-2) indicated a maximum 7DADM temperature change of 0.26°C at the POMI (river km 282) and 0.02°C at the mouth (river km 0.00).

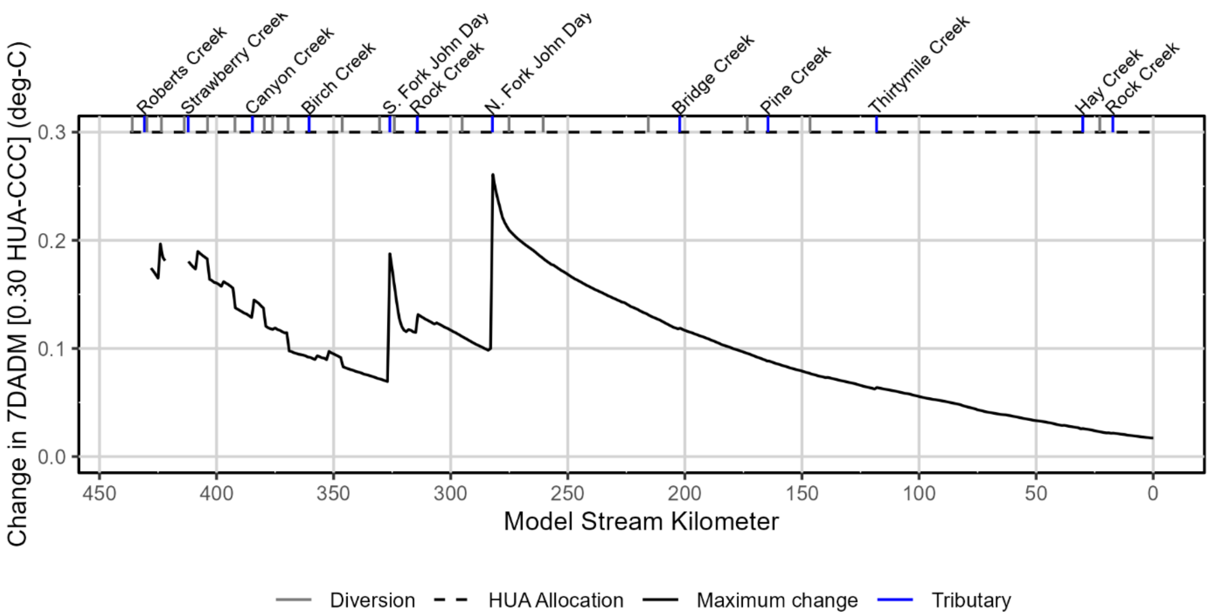

Figure 10-2: Change in maximum 7DADM stream temperatures between the Tributary Temperature Scenario (0.30 HUA includes reserve capacity) and Current Condition Calibration scenarios for the John Day River over all time periods.

10.3 John Day River assessment for Columbia River Temperature TMDL

10.3.1 Background

EPA's Columbia and Lower Snake Rivers temperature TMDL (EPA, 2021) allocated 0.1°C of warming in the Columbia River to anthropogenic sources in Columbia River tributaries. EPA determined that to achieve this allocation, tributary temperatures must be ≤0.5°C above the natural condition at their mouths. Per consultation with EPA, the 0.5°C increase is measured above the daily mean. This is due to the daily timestep of the model simulation. DEQ evaluated John Day River Temperatures for this purpose via comparisons of various model scenarios to determine if temperature changes associated with allocations to anthropogenic sources attain the Columbia River allocation.

10.3.2 Methods and assumptions

DEQ provided allocations that are greater than zero to multiple anthropogenic source categories including point sources, dam and reservoir operations, consumptive uses (water withdrawals), solar loading from existing infrastructure, existing buildings, and existing utility infrastructure, and reserve capacity. Except for point sources, consumptive uses, and existing infrastructure, DEQ did not develop model scenarios that represent model scenarios that represent ground conditions, operations, or other management strategies that attain the other nonpoint source TMDL allocations. The models were focused on assessing current loading only.

To estimate the impact of the other nonpoint source categories, a conversion factor was developed to convert increases above the 7DADM to increases above the daily mean temperatures. This provided an estimate using the allocated portion of the HUA. The sum of each sector's increase was evaluated against the Columbia River TMDL allocation of 0.5°C.

For point sources and consumptive use sectors, the model was used to assess the John Day River's attainment of its Columbia River TMDL allocation. No single model scenario was developed that reflected both point sources, consumptive use withdrawals, and existing infrastructure attaining their allocations. Thus, DEQ evaluated the results from each source category and assumed that the sum of the results equals the total change above natural conditions. DEQ completed the following scenario comparisons using the model:

1. Consumptive use water withdrawal vs natural flow
2. TMDL WLA vs no (NPDES-permitted) point sources

The TSD Appendices A and B provide detailed information on the model scenarios setup and results. The change above the daily mean was computed as follows:

1. Calculate scenario 1 (i.e., natural conditions) daily mean temperatures at each km and day in the model extent.
2. Calculate scenario 2 (i.e. anthropogenically altered conditions) daily mean temperatures at each km and day in the model extent.
3. For each day and model km, subtract step 1 result from step 2 result.
4. From the time-series longitudinal results of step 3, find the maximum difference at the John Day River mouth (km: 0.00)

10.3.3 Results

Table 10-1 provides the results of these model scenario comparisons at the John Day River mouth. The maximum cumulative temperature change from the daily mean is 0.005°C.

For the source categories listed in **Table 10-1**, the maximum model-calculated increases above the daily means are about 0.967 times the equivalent allocated portions of the HUA measured above the 7DADM. The factor (0.967) was then applied to estimate the maximum increases above the daily means for the remaining source categories (**Table 10-2**).

After summing the results (**Table 10-2**), the total estimated increase is 0.29°C and is thus likely to attain the 0.5°C tributary temperature allocation for the John Day River in the Columbia and Lower Snake Rivers temperature TMDL.

Table 10-1: Maximum difference between daily mean temperature under various scenarios at the John Day River mouth.

Scenario 1	Scenario 2	Maximum difference in daily mean (°C)	Maximum difference in 7DADM (°C)	Conversion factor (Max daily mean at mouth/ Max 7DADM at mouth)
Background	Attainment	0. 00528	0. 00546	0.967

Table 10-2: John Day River human use allowance assignments and the equivalent maximum increase measured above the daily mean temperature.

Source or source categories	Allocated portion of human use allowance (°C)	Max increase above the daily mean (°C)
NPDES point sources	0.00	0.00
Dam and reservoir operations	0.00	0.00
Anthropogenic warming from tributaries	0.05	0.048
Solar loading from existing transportation corridors, existing utility infrastructure	0.10	0.097
Consumptive use water management and water withdrawals	0.10	0.097
Solar loading from nonpoint sectors	0.00	0.00
Reserve capacity	0.05	0.048
Total	0.30	0.29

11 Water quality management plan support

11.1 Adequacy of Agricultural Water Quality Management programs in attaining TMDL load allocations and effective shade surrogate measures

The Oregon Legislature passed the Agricultural Water Quality Management Act in 1993, which directed ODA to adopt rules as necessary and to develop plans to prevent water pollution from agricultural activities (ORS 568.900 to 568.933 and ORS 561.191 and OAR chapter 603, divisions 90 and 95). Subsequently, ODA worked with Local Advisory Committees (LACs) and

Soil and Water Conservation Districts (SWCDs) to develop Agricultural Water Quality Area Rules and Area Plans for 38 watershed-based management areas across the state.

The John Day River Basin TMDL includes four management areas: North and Middle Forks John Day River, Upper Mainstem and South Fork John Day River, Middle John Day, and Lower John Day. Each management area has agricultural water quality regulatory requirements, called Area Rules. Each management area also has an Agricultural Water Quality Management Area Plan, which is not regulatory but guides landowners in how to protect water quality from agricultural activities.

OAR 603-095 requires agricultural activities to allow streamside vegetation to establish and grow to provide shade on perennial and some intermittent streams. **Table 11-1** summarizes the streamside management measures required by state law for the four management areas included in this TMDL. Specific requirements differ depending on the management area; however, most management areas identify vegetation goals based on site capability, which is not clearly defined. However, in OAR 603-095 there are no requirements for streamside vegetation to be established on agricultural lands when streamside vegetation deficiency is not caused by an agricultural activity. The rule does not apply to conditions resulting from unusual weather events or other circumstances not within the reasonable control of the landowner or operator, which is defined in the OAR.

Table 11-1: Summary of OAR 603-095 for streamside management in seven management areas within the John Day River Basin Temperature TMDL project area.

Agricultural Water Quality Management Area	Prevention and Control Measures*
North and Middle Forks John Day River	Cropland, rangeland and pasture condition must allow, within the capability of the site, vegetation sufficient to protect water quality. Riparian area condition must allow the establishment, growth and active recruitment of riparian vegetation, consistent with the vegetative capability of the site. Irrigation must be done in a manner that limits the amount of pollutants in the runoff from the irrigated area.
Upper Mainstem and South Fork John Day River	Landowners or occupiers shall manage streamside areas to allow the establishment, growth, and/or maintenance of riparian vegetation appropriate to the site. Vegetation must be sufficient to provide shade and to protect the streamside area such that it maintains its integrity during high stream flow events such as those events which are reasonably expected to occur following a 25-year, 24-hour storm event. If any agricultural activity degrades riparian vegetation, the landowner or occupier shall replant or restore the disturbed area to an adequate cover as soon as practical.
Middle John Day	Streamside management must allow the establishment, growth, and active recruitment of vegetation, consistent with the vegetative capability of the site, for protection of water quality by filtering sediment, stabilizing streambanks and providing shade.
Lower John Day	Management must allow the establishment and improvement, over time, of riparian vegetation for streambank stability, filtering sediment and shading, consistent with site capability.

*Prevention and Control Measures are identified in OAR for each management area for various agricultural activities. The ones summarized in this table are specific to streamside management.

Each management area has an Area Plan, which is not regulatory and does not establish prohibitions on agricultural activities that may impact water quality or require active restoration on agricultural lands. Instead, Area Plans rely on outreach and education, and voluntary landowner actions to implement conservation and management activities that protect water quality. ODA continues to work with LACs, SWCDs, DEQ and other watershed partners to implement, evaluate, and update Area Plans through their Biennial Review process for each of the management areas included in this TMDL.

As part of the biennial review process, DEQ prepares and submits to ODA specific feedback about water quality in the management areas. DEQ's assessments also address land conditions, agricultural activities, and implementation gaps that likely contribute to water quality impairments. DEQ has identified that a high priority for many management areas is to protect and reestablish riparian vegetation. The Area Plans for the four management areas included in this TMDL have all been reviewed by DEQ within the last year. Some of these reviews were completed as part of ODA's light biennial review process; during light reviews ODA convenes members of the LAC to report out on restoration and land management accomplishments and water quality status and trends within the management area, but ODA does not change or update plans during a light review. **Table 11-2** is a summary of the most recent updates for these Area Plans.

Table 11-2: Summary of the most recent updates to Area Plans, which occur during ODA's full biennial review process.

Agricultural Water Quality Management Area	Date of most recent Area Plan update
North and Middle Forks John Day River	2025
Upper Mainstem and South Fork John Day River	2025
Middle John Day	2025
Lower John Day	2023

12 References

Bartoo, N.W. 1972. The vertical and horizontal distribution of northern squawfish, peamouth, yellow perch, and adult sockeye salmon in Lake Washington. M.S. Thesis. University of Washington, Seattle, WA.

Beitinger, T.L., Bennett, W.A. & McCauley, R.W. 2000. “Temperature tolerances of North American freshwater fishes exposed to dynamic changes in temperature”. Environmental Biology of Fishes. 58: 237–275.

Blevins, E., L. McMullen, S. Jepsen, M. Blackburn, A. Code, and S.H. Black. 2019. Mussel-Friendly Restoration: A guide to the essential steps for protecting freshwater mussels in aquatic and riparian restoration, construction, and land management projects and activities. The Xerces Society for Invertebrate Conservation.

Black, E.C. 1953. “Upper lethal temperature of some British Columbia freshwater fishes”. Journal of the Fisheries Board of Canada. 10(4):196-210.

Black, B. A., J. B. Dunham, B. W. Blundon, M. F. Raggon, and D. Zima. 2010. “Spatial Variability in Growth-Increment Chronologies of Long-Lived Freshwater Mussels: Implications for Climate Impacts and Reconstructions”. Ecoscience 17:240–250.

Bowling, L.C., Storck, P., Lettenmaier, D.P., 2000. Hydrologic effects of logging in western Washington, United States. Water Resources Research 36(11): 3223-3240.Carveth, C.J, Widmer, A.M., Bonar, S.A. 2006. ”Comparison of upper thermal tolerances of native and nonnative fish species in Arizona”. Transactions of the American Fisheries Society, 135(6): 1433-1440.

Castleberry, D.T., Cech, J.J., 1993. “Critical thermal maxima and oxygen minima of five fishes from the Upper Klamath Basin.” California Fish and Game 78(4):145-152.

Chapman, R., Drake, F., Hawkins, B., Woods, S., & Wyatt, G. Not dated, circa 2003. The Effects of Villwok’s Ford on Native and Exotic Fishes of Rickreall Creek. Prepared In fulfillment of Requirements for FW 441, 442, & 443 For Department of Fisheries and Wildlife, Oregon State University & The Rickreall Watershed Council.

Chastain, J., Feldhaus, J., Heck, M., Ogawa, G., Osborne-Gowey, J., Rombough, C., and Schwab, A. 2002. The Fishes of Rickreall Creek. Prepared In Fulfillment of Requirements for FW 441, 442 & 443 for Department of Fisheries and Wildlife, Oregon State University & The Rickreall Watershed Council. Department of Fisheries and Wildlife, Oregon State University. May 30, 2002.

Cooper, R. M., 2005, Estimation of Peak Discharges for Rural, Unregulated Streams in Western Oregon: U. S. Geological Survey Scientific Investigations Report 2005-5116, 134 p.

Dewitz, J. (2021). *National Land Cover Database (NLCD) 2019 Products* [Data set]. U.S. Geological Survey.

DEQ (Oregon Department of Environmental Quality). 2003. Staff report to the Environmental Quality Commission from Stephanie Hallock, Director. “Agenda Item D, Rule Adoption: Water Quality Standards, Including Temperature Criteria, OAR Chapter 340, Division 41, December 4, 2003, EQC Meeting.”

DEQ (Oregon Department of Environmental Quality). 2006. Willamette Basin TMDL. Portland, OR.

DEQ (Oregon Department of Environmental Quality). 2008a. Temperature Water Quality Standard Implementation – A DEQ Internal Management Directive.

DEQ (Department of Environmental Quality). 2008b. Middle Columbia-Hood (Miles Creeks) Subbasin TMDL. Portland, OR.

DEQ (Department of Environmental Quality). 2008c. Molalla-Pudding Subbasin TMDL. Portland, OR.

DEQ (Oregon Department of Environmental Quality). 2011. "Protecting Cold Water Criterion IMD, Internal Management Directive, Nonpoint Source Compliance with the Protecting Cold Water Criterion of the Temperature Standard."

DEQ (Oregon Department of Environmental Quality). 2020. "Lower Willamette River Cold-Water Refuge Narrative Criterion Interpretation Study."

DEQ (Oregon Department of Environmental Quality). 2022. "Methodology for Oregon's 2022 Water Quality Report and List of Water Quality Limited Waters".

DEQ (Oregon Department of Environmental Quality). 2024. "Total Maximum Daily Loads for the Lower Columbia-Sandy Subbasin".

Ebersole, JL, Wiginton PJ, Jr. Leibowitz SG, Comeleo, RL. Van Sickle, J. 2015. Predicting the occurrence of cold-water patches at intermittent and ephemeral tributary confluences with warm rivers. *Freshwater Science* 34(1): 111-124.

Elmore W and Beschta RL. 1987. Riparian Areas: Perceptions in Management. *Rangelands* 9(6): 260-265.

EPA (U.S. Environmental Protection Agency). 2003. "EPA Region 10 guidance for pacific northwest state and tribal temperature water quality standards". EPA 910-B-03-002.

Fairbairn, D. 2022. *Water Temperature Impacts From In-Channel Ponds in Portland Metro and Northwest Region*. Oregon Department of Environmental Quality (DEQ) Report.

Fogelman, K.J., Archambault, J.M., Irwin, E., Walsh, M., Brewer, S. and Stoeckel, J.A. 2023. "A review of lethal thermal tolerance among freshwater mussels (Bivalvia: Unionida) within the North American faunal region." Environmental Reviews, vol. 31, no. 2, p. 278

Fritz, K.M., Hagenbuch, E., D'Amico, E., Reif, M., Wigington, P.J., Leibowitz, S.G., Comeleo, R.L., Ebersole, J.L., and Nadeau, T.L. 2013. Comparing the extent and permanence of headwater streams from two field surveys to values from hydrographic databases and maps. *Journal of the American Water Resources Association* 49(4): 867-882.

Gadomski, D.M., Barfoot, C.A., Bayer, J.M., and Poe, T.P. 2001. "Early life history of the northern pikeminnow in the lower Columbia River Basin." Transactions of the American Fisheries Society. 130:250-262.

Gray, R. H. and Dauble, D. D. 1979.Biology of the sand roller in the central Columbia River. Transactions of the American Fisheries Society 108:646 Issue 6, Volume 19.

Gray, R.H. and Dauble, D.D. 2001. Some life history characteristics of cyprinids in the Hanford Reach, mid-Columbia River. Northwest Science 75(2): 122-136.

Harr, R.D., Levno, A., Mersereau, R., 1982. "Streamflow changes after logging 130-year old Douglas fir in two small watersheds". Water Resources Research 18(3): 637–644.

Herb, W.R., Janke B., Mohseni, O., and Stefan, H. 2008. Thermal pollution of streams by runoff from paved surfaces. Hydrological Processes. 22: 987-999.

Hester, E.T. Bauman K.S. 2013. “Stream and retention pond thermal response to heated summer runoff from urban impervious surfaces.” Journal of the American Water Resources Association. 49(2): 328-342.

Hibbert, A.R. 1967. Forest treatment effects on water yield. Forest treatment effects on water yield. In: Sopper, William E.; Lull, Howard W., eds. Forest hydrology. Proceedings of a National Science Foundation advanced science seminar; 1965 August 29 - September 10; University Park, PA. New York: Pergamon Press; 527-543.

Holzer, K. 2020, *Effects of Inline Ponds on Stream Temperatures in the Johnson Creek Watershed*.

Hutchison, J.M., Thompson, K.E., Fortune, J.D. Jr.. 1966. The Fish and Wildlife Resources of the Upper Willamette Basin, Oregon, and Their Water Requirements. A Report with Recommendations to the Oregon State Water Resources Board. Basin Investigations Section, Oregon State Game Commission. Federal Aid to Fish Restoration Progress Report. June 1966, Portland, Oregon.

Isaak, D. J., Wollrab, S., Horan, D., & Chandler, G. 2012. “Climate change effects on stream and river temperatures across the northwest US from 1980–2009 and implications for salmonid fishes”. Climatic change, *113*(2): 499-524.

Jaeger, K.L., Sando, R., McShane, R.R., Dunham, J.B., Hockman-Wert, D.P., Kaiser, K.E., Hafen, K., Risley, J.C., Blasch, K.W. 2019. Probability of Streamflow Permanence Model (PROSPER): A spatially continuous model of annual streamflow permanence throughout the Pacific Northwest. Journal of Hydrology X, (2):1

John, K.R. 1964. “Survival of fish in intermittent streams of the Chiricahua Mountains, Arizona”. Ecology. 45(1): 112-119.

Jones, M.P., Hunt, W.F. 2009. Bioretention impact on runoff temperature in trout sensitive waters. Journal of Environmental. Engineering. 135(8):577-585.

Jones, M.P., Hunt, W.F., and Winston, R.J. 2012. Effect of Urban Catchment Composition on Runoff Temperature. Journal of Environmental. Engineering. 138(12):1231-1236.

Keppeler, E.T., Ziemer, R.R., 1990. Logging effects on streamflow: Water yield and summer low flows at Caspar Creek in northwestern California. *Water Resources Research* 26(7): 1669–1679.

LTWC and ODFW. (Long Tom Watershed Council and Oregon Department of Fish and Wildlife). Unpublished data. Long Tom River Cutthroat Trout Migration Study 2010-2015. ODFW Salmon Trout Enhancement (STEP) Program

May C.L., and Lee D.C. 2004. The relationships among in-channel sediment storage, pool depth, and summer survival of juvenile salmonids in Oregon Coast Range streams. *North American Journal of Fisheries Management* 24: 761–74.

Meeuwig, M., J. M. Bayer, and R. A. Reiche. 2003. Identification of Larval Pacific Lampreys (Lampetra tridentata), River Lampreys (L. ayresi), and Western Brook Lampreys (L. richardsoni) and Thermal Requirements of Early Life History Stages of Lampreys, Annual Report 2002-2003. Bonneville Power Administration (BPA), Portland, OR (United States).

MFWP (Montana Fish and Wildlife Program). 2023. Peamouth - Mylocheilus caurinus. Montana Field Guide. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Retrieved on November 28, 2023.

Moodie, G. E. E. (1966). Some factors affecting the distribution and abundance of the chiselmouth (Acrocheilus alutaceus) (T). Retrospective Theses and Dissertations, 1919-2007. University of British Columbia. Retrieved November 28, 2023.

Nadeau, TL. 2015. Streamflow duration assessment method for the Pacific Northwest, U.S. Environmental Protection Agency, Region 10, Document No. EPA 910-K-14-001.

Nelson, K.C. and Palmer, M.A. 2007. Stream temperature surges under urbanization and climate change: data, models, and responses. Journal of the American Water Resources Association. 43(2): 440-452.

NVDEP 2016. (Nevada Department of Environmental Protection). DRAFT Mountain Sucker (Catostomus platyrhynchus) Thermal Tolerance Analyses – Juvenile and Adult, Summer.

OAR (Oregon Administrative Rule) 340-041. Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon.

OAR (Oregon Administrative Rule) 340-042. Total Maximum Daily Loads (TMDLs).

ODFW 1992. (Oregon Department of Fish and Wildlife). Long Tom Subbasin Fish Management Plan, March, 1992, page 17.

ODFW (Oregon Department of Fish and Wildlife). 2023. Fish Life Stage Timing Tables, June 2023, Middle Willamette, Rickreall Creek.

Pandolfo, T.J., Cope, W.G., Arellano, C., Bringolf, R.B., Barnhart, M.C., and Hammer, E. 2010. Upper thermal tolerances of early life stages of freshwater mussels. Journal of the North American Benthological Society 29: 959–969.

Parsley M.J., Palmer D.E., and Burkhardt, R.W. 1989. Variation in Capture Efficiency of a Beach Seine for Small Fishes. North American Journal of Fisheries Management 9(2):239-244

Population Research Center, 2025. Portland State University, data created in April 15, 2026, accessed April 25, 2026.

PRISM Climate Group, 2022. Oregon State University, data created in December 2022, accessed March 25, 2025.

Risley, John, Stonewall, Adam, and Haluska, Tana. 2008. Estimating flow-duration and low-flow frequency statistics for unregulated streams in Oregon: U.S. Geological Survey Scientific Investigations Report 2008-5126. 22 p.

Roberge, M., and T. Slaney. 2001. Life History Characteristics of Freshwater Fishes Occurring in British Columbia, With Major Emphasis on Lake Habitat Characteristics. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 2574: 189 pp.

Roberge, M., Hume, J.M.B., Minns, C.K., and Slaney, T. 2002. Life history characteristics of freshwater fishes occurring in British Columbia and the Yukon, with major emphasis on stream habitat characteristics. Canadian Manuscript Report of Fisheries and Aquatic Sciences. 2611

Rosenfeld, Jordan. 2003. Update COSEWIC status report on the chiselmouth, Acrocheilus alutaceus, in Canada. Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Ottawa. 1-22 pp

Rossman, L A. 1990. “DFLOW User’s Manual.” U.S. Environmental Protection Agency, Washington, DC, EPA/600/8-90/051 (NTIS 90-225616)

Rothacher, J., 1970. Increases in water yield following clear-cut logging in Pacific Northwest. Water Resources Research 6(2), 653–658.

Rounds, S.A., 2010. Thermal effects of dams in the Willamette River basin, Oregon: U.S. Geological Survey Scientific Investigations Report 2010-5153, 64 p.

Sabouri, F., Gharabaghi, B., Mahboubi, A.A., McBean, E.A. 2013. Impervious surfaces and sewer pipe effects on stormwater runoff temperature. *Journal of Hydrology*. 502:10-17.

Schultz, L.D. and K.N. Bertrand. 2011. An assessment of the lethal thermal maxima for mountain sucker. Western North American Naturalist. 71(3), 404-411.

SECOR (SECOR International Incorporated). 2002. Mixing Zone Modeling Study, Dynea Overlays Inc., SECOR PN: 150T.09382.02

Segura, C., Bladon, K.D., Hatten, J.A., Jones, J.A., Hale, V.C., Ice, Ice, G.G. 2020. Long-term effects of forest harvesting on summer low flow deficits in the Coast Range of Oregon. Journal of Hydrology. 585.

Smith, G.R. 1966. Distribution and evolution of the North American catostomid fishes of the subgenus Pantosteus, genus Catostomus. Miscellaneous Publications, Museum of Zoology, University of Michigan, No. 129. Ann Arbor, MI

Snyder, D.E. 1983. Identification of catostomid larvae in Pyramid Lake and the Truckee River, Nevada. Transactions of the American Fisheries Society 112:333-348.

Surfleet, C.G., Skaugset, A.E., 2013. The Effect of timber harvest on summer low flows, hinkle creek, Oregon. Western Journal of Applied Forestry. 28(1): 13–21.

Stratton Garvin, L.E., Rounds, S.A., and Buccola, N.L. 2022. Updates to models of streamflow and water temperature for 2011, 2015, and 2016 in rivers of the Willamette River Basin, Oregon: U.S. Geological Survey Open-File Report 2022–1017.

Thompson, A., T. Wilson, J. Norman, A.L. Gemechu, and A. Roa-Espinosa. 2008. Modeling the effect of summertime heating on urban runoff temperature. *Journal of the American Water Resources Association*. 44:1548-1563.

Tiffan K.F., Erhardt, J.M., Rhodes, T.N., and Hemingway, R.J. 2017. Ecology of the Sand Roller (Percopsis Transmontana) in a lower Snake River reservoir, Washington. Northwestern Naturalist. 98: 203-214.

UNH (University of New Hampshire) Stormwater Center. 2011. Examination of thermal impacts from stormwater best management practices. The University of New Hampshire, Durham, NH.

USACE (US Army Corps of Engineers Portland District). 2019. “Willamette Basin Review Feasibility Study Final Integrated Feasibility Report and Environmental Assessment”.

USGS (U.S. Geological Survey). 2019. The StreamStats program, online.

Wardynski, B.J., Winston, R.J., Line, D.E., Hunt, W.F. 2014. Metrics for assessing thermal performance of stormwater control measures. *Ecological Engineering*. 71:551-562.

WDOE (Washington Department of Ecology). 2011a. Snoqualmie River Basin Temperature Total Maximum Daily Load: Water Quality Improvement Report and Implementation Plan.

WDOE (Washington Department of Ecology). 2011b. Salmon Creek Temperature Total Maximum Daily Load: Water Quality Improvement Report and Implementation Plan.

Whitesel, T.A., Uh, C.T. 2023. “Upper temperature limit of larval Pacific lamprey Entosphenus tridentatus: implications for conservation in a warming climate”. *Environmental Biology of Fishes*. 106: 837–852.

Winston, R. J., Hunt, W. F., and Lord, W. G. 2011. Thermal mitigation of urban stormwater by level spreader-vegetative filter strips. *Journal of Environmental. Engineering*. 137(8): 707–716.

Zeiger, S.J., and Hubbert J.A. 2015. Urban stormwater temperature surges: A central US watershed Study. Hydrology. 2:193-209.

Appendices

The TSD includes the following appendices:

Appendix A: Heat Source Model Calibration and Setup

Appendix B: Heat Source Model Scenario Report

Appendix C: Potential Near-Stream Land Cover

Appendix D: Assessment Units addressed by Temperature TMDLs for the John Day River Basin

Appendix E: Upper John Day Subbasin Effective Shade Results

Appendix F: North Fork John Day Subbasin Effective Shade Results

Appendix G: Middle Fork John Day Subbasin Effective Shade Results

Appendix H: Lower John Day Subbasin Effective Shade Results

Appendix I: John Day River Basin Interactive TMDL Map

Appendix J: Climate Change and Stream Temperature in Oregon: A Literature Synthesis

Appendix K: Stream Buffer Width Literature Review

Appendix A: Heat Source Model Calibration and Setup

Appendix B: Heat Source Model Scenario Report

Appendix C: Potential Near-Stream Land Cover

Appendix D: Assessment Units addressed by Temperature TMDLs for the John Day River Basin

Appendix E: Upper John Day Subbasin Effective Shade Results

Appendix F: North Fork John Day Subbasin Effective Shade Results

Appendix G: Middle Fork John Day Subbasin Effective Shade Results

Appendix H: Lower John Day Subbasin Effective Shade Results

Appendix I: John River Basin Interactive TMDL Map

Appendix J: Climate Change and Stream Temperature in Oregon: A Literature Synthesis

Appendix K: Stream Buffer Width Literature Review