State of Oregon
DEQ Department of Environmental Quality

Snake River Temperature Total Maximum Daily Load

Technical Support Document

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Document information

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Front cover: Snake River at mile 220 downstream of Kirkwood Creek. Picture credit: Ryan Michie.

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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	United States Environmental Protection Agency
EQC	Oregon Environmental Quality Commission
ETL	Excess Thermal Load
GIS	Geographic Information System
GNIS	USGS Geographic Names Information System
HUA	Human Use Allowance
HUC	Hydrologic Unit Code
IDEQ	Idaho Department of Environmental Quality
IMD	Internal Management Directive
IPC	Idaho Power Company
LA	Load Allocation
LAC	Local Advisory Committee
LC	Loading Capacity
LiDAR	Light Detection and Ranging
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

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
POD	Points of Diversion
POMI	Point of Maximum Impact
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RC	Reserve Capacity
SCS	Soil Conservation Service
SIA	Strategic Implementation Area
SIC	Standard Industrial Classification
STP	Sewage Treatment Plant
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TSD	Technical Support Document
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 explanations of TMDL concepts and supporting information on decisions and technical analyses included in the Total Maximum Daily Load and Water Quality Management Plan rule addressing temperature impairments in the Snake River and Hells Canyon Complex of reservoirs. The TMDL and WQMP rule have been adopted by Oregon's Environmental Quality Commission, by reference, in Oregon Administrative Rules (OAR) 340-42-0090.

This document is organized into chapters and sections with titles reflective of the same TMDL elements included in the TMDL rule and required by Oregon Administrative Rule OAR 340-042-0040(4). This organization is intended to assist readers in finding and accessing the information relevant to that TMDL rule element. To keep the main sections in this document consistent with all the main sections in the TMDL but not duplicate content unnecessarily, some sections simply refer back to the TMDL.

1.2 Overview of TMDL elements

OAR 340-042-0030(15) defines a Total Maximum Daily Load as a written quantitative plan and analysis for attaining and maintaining water quality standards and must include a number of elements described in OAR 340-042-0040.

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 portion of the pollutant load held in reserve for new sources or expanded growth.

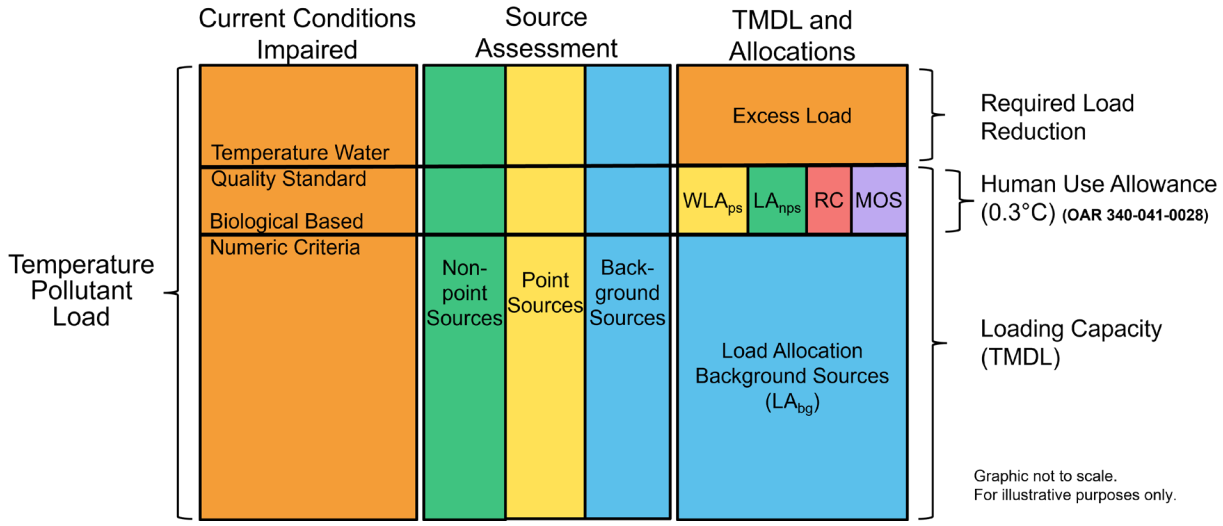


Figure 1-1: Conceptual representation of a TMDL and breakdown of total pollutant loading to a temperature-impaired waterbody into each TMDL element.

Figure 1-1 provides three separate conceptual representations of the TMDL and the pollutant budget. From left to right, the boxes represent steps in the TMDL development process, and the colors of the boxes show which terms are related. The first box on the left shows a temperature impaired water that exceeds the numeric temperature criteria. The current condition water temperature (the top of the box) is higher than the biologically based numeric criteria (which is visualized by the horizontal black line). The federal Clean Water Act requires waters that do not attain water quality standards to have a TMDL developed.

The second box in the middle illustrates the TMDL source assessment step. This is where an analysis is completed to identify the major sources of pollutant loading to the stream and categorize them into source categories or sectors. Nonpoint source related warming is in green, point source warming is in yellow, and background source warming is in blue.

The third box on the right is the last step in the TMDL process. At this step the numeric TMDL pollutant budget is calculated. A key element of a TMDL analysis is the amount of pollutant that a waterbody can receive and still meet the applicable water quality standard. The biologically based numeric criteria plus the human use allowance is the temperature water quality standard for temperature. This is represented by the upper horizontal black line in Figure 1-1. The amount of pollutant loading up to the water quality standard 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 a margin of safety and any 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.

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.

The excess load is the amount of thermal load reduction required to meet the loading capacity and achieve temperature standards.

Wasteload allocations (shown as WLA) are the portion of the TMDL loading capacity allocated to point sources. Load allocations (shown as LAnps and LAbg) are the portion attributed to nonpoint sources, including background sources.

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, new or expanded sources, and sources that were missed or unknown at the time of TMDL development.

The human use allowance or HUA is part of the Oregon temperature standard rule (Oregon Administrative Rule 340-041-0028). This is the condition under which insignificant additions of heat are authorized in waters that exceed the applicable temperature criteria. The rule states that TMDL wasteload allocations and load allocations will restrict all point sources and nonpoint sources to a cumulative water temperature increase of no greater than 0.3 degrees Celsius above the biologically based numeric criteria. As Figure 1-1 shows, the HUA defines the maximum pollutant loading for point source wasteload allocations, nonpoint source load allocations, reserve capacity, and margin of safety.

1.3 Temperature TMDL replacement background

In 2003 and again in 2004 Oregon DEQ and Idaho DEQ issued joint TMDL actions addressing multiple Snake River 303(d) impairments, including temperature (Table 1-1). EPA approved these TMDL actions in March of 2003 and September 2004 respectively. Once approved by EPA, the updated Snake River Temperature TMDL will replace Oregon’s temperature TMDLs listed in Table 1-1. TMDLs for other water quality impaired parameters are still effective.

DEQ is replacing the 2003/2004 temperature TMDL due to a court order. In 2012, in *NWEA v. EPA*, Case No. 3:05-cv-01876-AC, the U.S. District Court found that EPA's approval of an element of Oregon's water quality standard for temperature, the natural conditions criteria, was unlawful. The natural conditions criterion stated that where the natural thermal potential of all or a portion of a water body exceeds the biologically-based numeric temperature criteria in OAR

340-041-0028(4), the natural thermal potential temperatures supersede the biologically-based criteria, and are deemed to be the applicable temperature criteria for that water body. This portion of the temperature water quality standard was effective from 2003 until EPA disapproved it in response to the court decision. Many temperature TMDLs were based on the natural conditions criteria, and this became the subject of a second lawsuit, *NWEA v. EPA*, Case No. 3:12-cv-01751-HZ, asserting the EPA unlawfully approved TMDLs that were based on the now disapproved natural conditions criteria. The court issued a judgment on Oct. 4, 2019, requiring DEQ and EPA to replace 15 Oregon temperature TMDLs that were based on the natural conditions criteria and to reissue the temperature TMDLs to EPA based on the remaining elements of the temperature standard. The 2003/2004 Snake River – Hells Canyon temperature TMDL was included in the list of TMDL requiring replacement.

Table 1-1: Summary of previous TMDLs developed for the Snake River and Hells Canyon Complex.

TMDL Action ID	TMDL Name	EPA Approval Date	Water Quality Impairments Addressed
10007	Snake River - Hells Canyon TMDL	3/1/2003	DDD 4,4', DDE 4,4', DDT 4,4', Dieldrin, Temperature, Total Dissolved Gas
10791	Snake River - Hells Canyon TMDL Revised[1]	9/9/2004	Chlorophyll-a, Dissolved Oxygen, Algae, Sedimentation

1.4 TMDL administrative process and public participation

DEQ convened a rule advisory committee to provide input on drafts of the TMDL, WQMP, and TMDL Technical Support Document (TSD), fiscal and economic impacts, and environmental justice and racial equity statements. The committee met on February 4, 2026, and April 22, 2026. The agency also held an informational webinar about this TMDL on January 14, 2026. A public comment period was held from [date TBA] to [date TBA]. DEQ held a public hearing on [date TBA]. DEQ considered all input received during these public participation opportunities and used input to guide the analyses and preparation of documents. DEQ developed a written response to comments document that is available online. EQC adopted the Snake River Temperature TMDL and WQMP rule on [date TBA]. The TMDL was issued to EPA for action on [date TBA].

[1] During EPA's review of the 2003 TMDL submitted by Oregon and Idaho, a couple of errors were discovered in the TMDLs addressing impairments for chlorophyll-a, dissolved oxygen, algae, and sediment. Both Oregon and Idaho agreed to correct the errors and resubmit those TMDLs to EPA after completion of a second public notice and public comment period. The TMDL issued in 2004 includes all the TMDLs that EPA approved in 2003 and the TMDLs with corrections approved 2004.

2 TMDL name and location

The Snake River Temperature TMDL apples to the entirety of the Snake River, Brownlee Reservoir, Oxbow Reservoir, and Hells Canyon Reservoir within Oregon (Figure 2-1) from approximately river mile 176 at the tri-state border of Oregon, Washington, and Idaho upstream to approximately river mile 409 at the Oregon and Idaho border. This extent sums to a total of 12 assessment units (AUs), all of which are Category 5 listed as impaired for temperature on Oregon's 2024 Section 303(d) list.

Table 2-1: Assessment units included within the scope of the Snake River Temperature TMDL.

Assessment Unit Name	Assessment Unit Description	River Mile	Assessment Unit ID
Snake River	Idaho to Boise River	409 - 392	OR_SR_1705010311_02_102702
Snake River	Boise River to Malheur River	392 - 368	OR_SR_1705011501_02_103231
Snake River	Malheur River to Weiser River	368 - 352	OR_SR_1705011502_02_103230
Snake River	Weiser River to Hog Creek/Brownlee Reservoir	352 - 342	OR_SR_1705020101_02_103229
Brownlee Reservoir	Brownlee Reservoir (Snake River)	342 - 284	OR_LK_1705020103_05_100578
Brownlee Reservoir	Brownlee Reservoir Powder River Arm	9 - 0	OR_LK_1705020311_05_100605
Oxbow Reservoir	Oxbow Reservoir	284 - 272	OR_LK_1705020107_05_100583
Hells Canyon Reservoir	Hells Canyon Reservoir	272 - 247	OR_LK_1705020107_05_100582
Snake River	Hells Canyon Reservoir to Sheep Creek	247 - 229	OR_SR_1706010101_02_103274
Snake River	Sheep Creek to Getta Creek	229 - 206	OR_SR_1706010102_02_103280
Snake River	Getta Creek to Salmon River	206 - 188	OR_SR_1706010103_02_103282
Snake River	Salmon River to Stateline	188 - 176	OR_SR_1706010301_02_103306

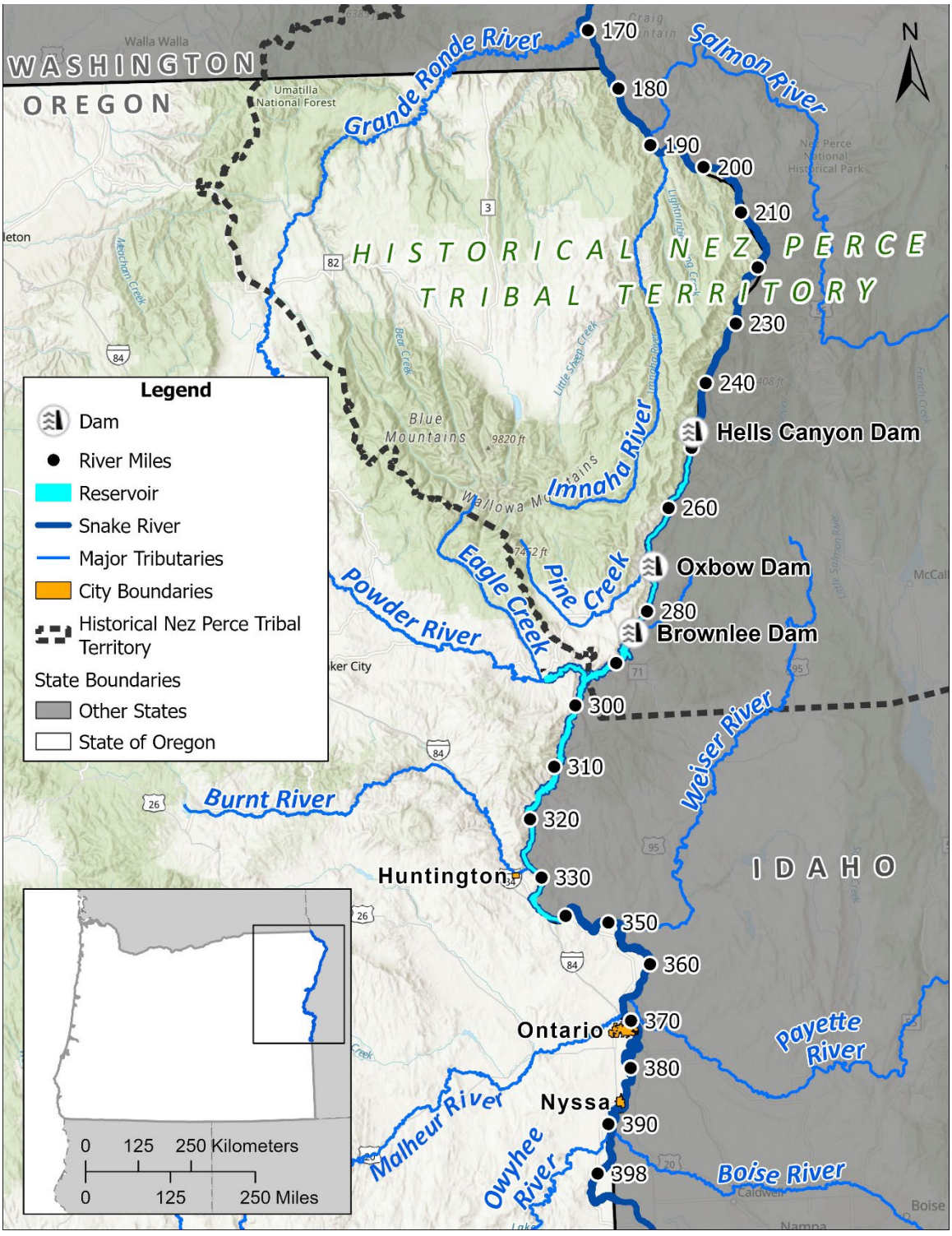


Figure 2-1: Snake River Temperature TMDL project area overview.

2.1 Climate

The climate for most of the Snake River Basin within Oregon is classified as cold semi-arid (BSk), warm-summer mediterranean type (Csb), and warm-summer mediterranean continental (Dsb) in the Köppen-Geiger Climate Classification System (Kottek et al. 2006). Low elevation areas bordering the mainstem Snake River near the confluences of the Burnt and Powder Rivers also fall within the hot-summer mediterranean (Csa) climate type. High elevation areas (above 6,000 feet or 1,828 meters) in the Wallowa and Blue Mountains fall under the dry-summer subarctic (Dsc) climate type while the area north of the Wallowa Mountains fall under warm-summer humid continental (Dfb) and oceanic (Cfb) climate types. Most of these climate types are characterized by dry, cool to warm summers and cool to cold winters with moderate precipitation falling as a mix of rain and snow (mostly as snow at high elevations) (Kottek et al. 2006). However, monsoonal thunderstorms with intense, localized rainfall may occur during the summer months in the area.

The mountain ranges west of the Snake River Basin in Oregon form a barrier against warm, moist weather fronts moving inland from the Pacific Ocean during winter months. Because of this rain shadow effect, annual precipitation is much lower in the Oregon portion of the Snake River Basin than in western portions of the state. From 1991-2020, annual precipitation (Figure 2-2) averaged 18.5 inches (470.5 cm) across the Oregon portion of the Snake River Basin, with an average of 8.6 inches (21.7 cm) in the driest portion of the basin and an average of 148.9 inches (378.2 cm) at the highest elevations (PRISM Climate Group, 2022).

From 1991-2020 (a thirty year “climate normal” period), mean annual temperature in the portion of the Snake River Basin in Oregon was 46.2°F (7.9°C), with a mean annual minimum temperature of 34.0°F (1.1°C) and a mean annual maximum temperature (Figure 2-3) of 68.0°F (20.0°C) (PRISM Climate Group, 2022). However, temperatures vary strongly with elevation in the basin, with high elevations having 12.6-18.0°F (7-10°C) cooler temperatures on average than the basin averages and low elevations having 9.2-9.4°F (7-10°C) warmer temperatures on average than the basin averages.

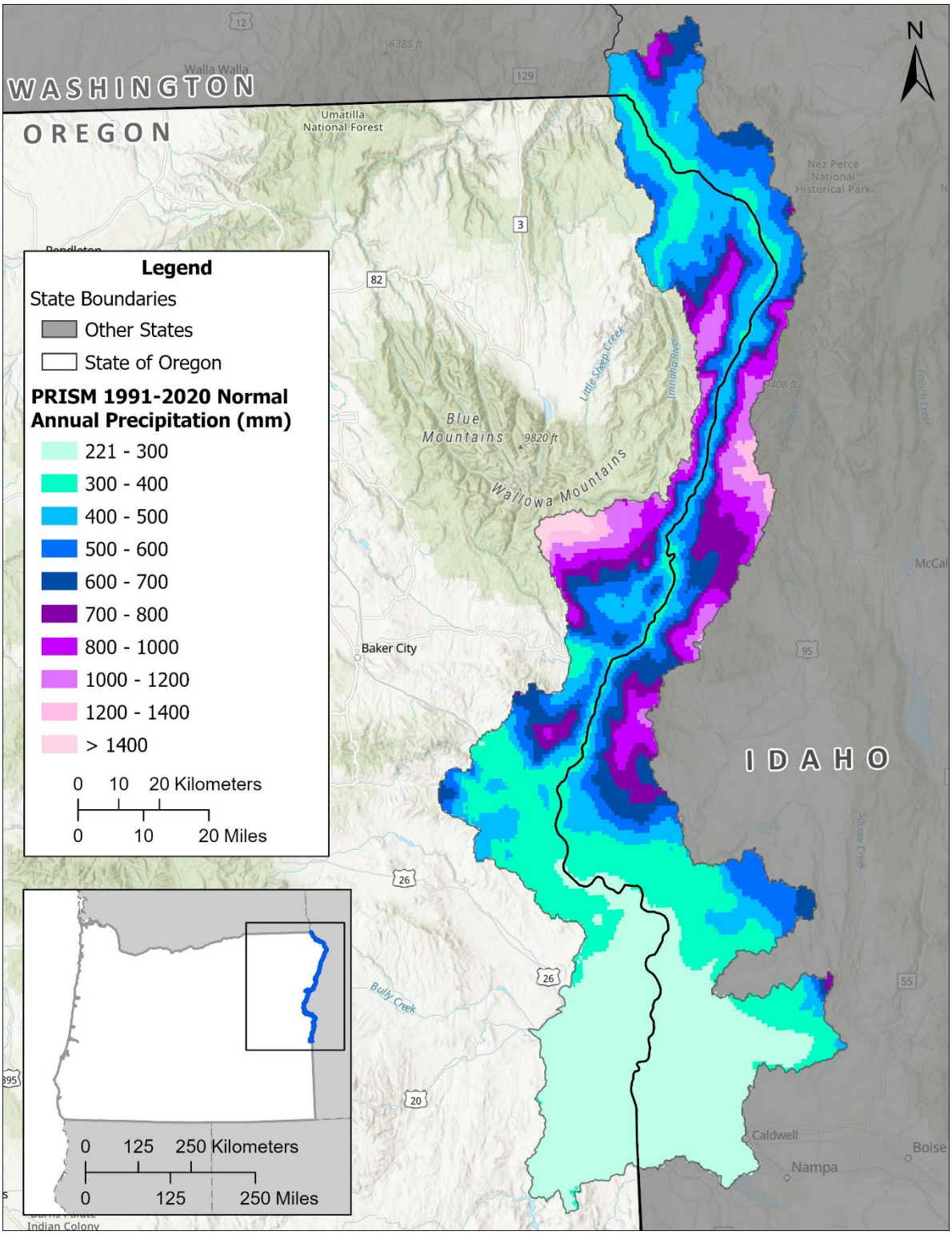


Figure 2-2: PRISM 1991-2020 Normal Annual Precipitation in the Snake River temperature TMDL project area (Data Source: PRISM Climate Group, 2022).

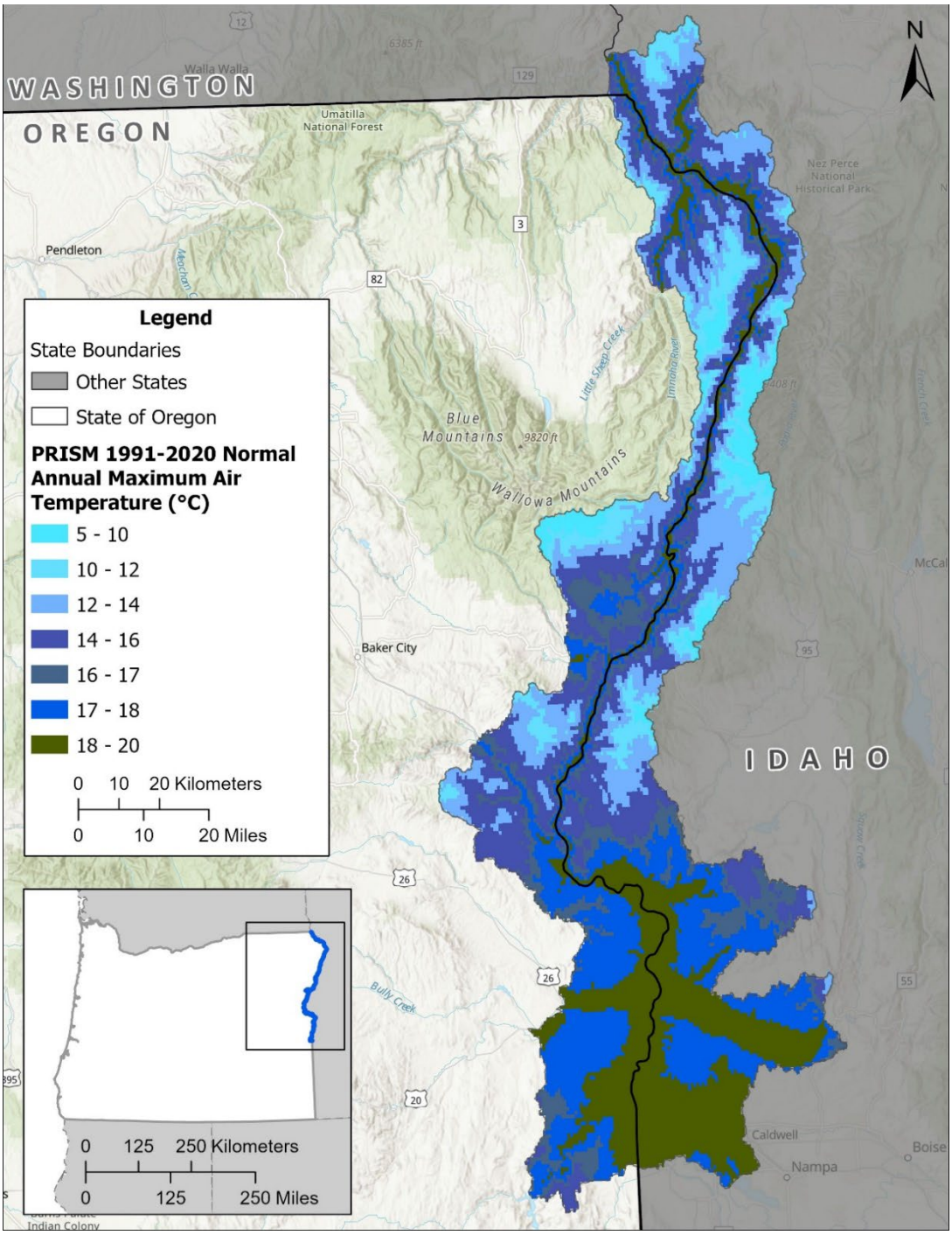


Figure 2-3: PRISM 1991-2020 Normal Annual Maximum Air Temperature in the Snake River temperature TMDL project area (Data Source: PRISM Climate Group, 2022).

2.2 Hydrology

The Snake River Basin drains 107,905 square miles (279,473 km^2) beginning in Yellowstone National Park, WY and entering the Columbia River near Pasco, WA after flowing for 1,080

miles through Wyoming, Idaho, Oregon, and Washington. Numerous major and minor tributaries join the Snake throughout its course. On the shared border between Oregon and Idaho (270 river miles), ten major tributaries enter the Snake, roughly split between Oregon and Idaho (Table 2-2). Dozens of minor tributaries, some of which are intermittent, also enter the Snake directly along the shared border. From the first intersection with the Oregon border downstream to the confluence with the Owyhee River, the Snake River has a Strahler Stream Order of eight according to the USGS National Hydrography Plus High-Resolution dataset. Downstream of the confluence of the Owyhee extending all the way to the triple border of Oregon-Idaho-Wahington, the Snake is classified as a 9th order stream.

Table 2-2: Major tributaries entering directly into the riverine and reservoir assessment units of the Snake River on the Oregon/Idaho border organized from north to south. GNIS_ID refers to the USGS Geographic Name Information System ID.

Snake River Tributary	GNIS ID	Strahler Stream Order	Receiving Assessment Unit	Tributary State
Salmon River	00400069	8	OR_SR_1706010301_02_103306	Idaho
Imnaha River	01144009	7	OR_SR_1706010103_02_103282	Oregon
Pine Creek	01147689	7	OR_LK_1705020107_05_100582	Oregon
Powder River	01164128	7	OR_LK_1705020311_05_100605	Oregon
Burnt River	01139008	6	OR_LK_1705020103_05_100578	Oregon
Weiser River	00392986	7	OR_SR_1705020101_02_103229	Idaho
Payette River	00388284	7	OR_SR_1705011502_02_103230	Idaho
Malheur River	01145769	7	OR_SR_1705011502_02_103230	Oregon
Boise River	00378007	8	OR_SR_1705011501_02_103231	Idaho
Owyhee River	01147319	8	OR_SR_1705011501_02_103231	Oregon

Five major tributaries enter the riverine portion of the Snake River between the Idaho/Oregon border and Brownlee Reservoir near Weiser, ID. These tributaries, in order of upstream to downstream confluences, are the Owyhee, Boise, Malheur, Payette, and Weiser rivers (Table 2-2 and Figure 2-1). Numerous irrigation diversions and return canals on Oregon and Idaho sides of the river are distributed throughout this reach. This area is dominated primarily by agricultural uses (Figure 2-4 and Figure 2-5). USGS estimates that if irrigation and other consumptive water use in the tributary valleys and Snake River plain in Idaho were not occurring, there would be an additional annual flow in the Snake River of about 6 million acre-ft at Weiser (Kjelstrom, 1984).

Downstream of Weiser, ID, the Snake River enters the Hells Canyon Complex (HCC), which consists of a series of three dams and reservoirs owned and operated by Idaho Power Company. The primary purpose for the dam and reservoirs is hydroelectric production. The complex extends approximately 98 miles along the shared Oregon-Idaho border (Figure 2-1). In upstream to downstream sequence, these reservoirs include Brownlee (60 miles), Oxbow (16 miles), and Hells Canyon (22 miles). The drainage area for the entire Hells Canyon Complex is 73,300 square miles (189,846 km^2), or 68% of the entire Snake River Basin drainage area (Baldwin et al. 2020). Two major tributaries enter Brownlee Reservoir, the Burnt and Powder Rivers, while Pine Creek is the only major tributary entering Oxbow Reservoir (Table 2-2 and Figure 2-1).

Below Hells Canyon Dam (River Mile 247), the Snake River remains undammed downstream to the triple border between Oregon-Idaho-Washington (Figure 2-1). Two major tributaries enter in this stretch: the Imnaha and Salmon Rivers (Table 2-2 and Figure 2-1), the latter of which contributes one-third of the average annual flow of the Snake River at the triple border (Statistical graphs - Salmon River at White Bird ID - USGS Water Data for the Nation).

The timing and magnitude of flow in the Snake River depends on seasonal variations in climate and water use for agriculture, municipalities, and generation of electricity. Natural flow regimes in the Snake River Basin generally reflect patterns of accumulating and melting of a seasonal snowpack in high elevation portions of the basin. Except for periodic summertime storms, which may cause localized flooding in tributaries, dry and warm conditions persist from late spring through the middle of fall in the basin (May-November). In large rivers driven by snowmelt regimes, such as the Snake, flows generally peak in spring through early summer and recede to baseflow conditions by late fall. However, water storage and use for electrical generation, irrigation, and municipal purposes have modified the hydrologic regime of the Snake River in ways that influence water temperature.

2.3 Land use

Herbaceous (e.g., grasslands) and shrub/scrub make up 64.4% of the land use/land cover in watersheds (HUC 10) that the Snake River flows through or has tributaries that flow directly to the Snake River in both Oregon and Idaho (Table 2-3). Evergreen forest makes up 14.7% of these watersheds and is concentrated in mountainous terrain in the Hells Canyon reach of the Snake River (Table 2-3; Figure 2-4). Cultivated Crops consist of 13.2% of the land use/land cover and tends to be concentrated near the major tributaries and the mainstem Snake River upstream of Brownlee Reservoir (Table 2-3; Figure 2-4). The remaining land uses make up less than 8% of the area. As of 2024, the population of the six largest incorporated cities in these watersheds include Caldwell, ID (73,177), Ontario, OR (11,999), Payette, ID (8,754), Emmett, ID (8,649), Fruitland, ID (7,095), and Weiser, ID (6,081) (U.S. Census Bureau, 2025).

Table 2-3: Summary of land use and land cover in HUC10 watersheds that flow directly to the Snake River based on the 2024 National Land Cover Database.

2024 NLCD Land use / Land cover class	Acres	Percent of Total Area
Grassland/Herbaceous	1,315,590	47.3
Shrub/Scrub	477,437	17.2
Evergreen Forest	408,393	14.7
Cultivated Crops	366,891	13.2
Developed, Low Intensity	65,096	2.3
Pasture/Hay	56,512	2.0
Open Water	33,959	1.2
Developed, Open Space	29,254	1.1
Developed, Medium Intensity	11,960	0.4
Emergent Herbaceous Wetlands	6,502	0.2
Woody Wetlands	5,439	0.2
Barren Land (Rock/Sand/Clay)	3,246	0.1
Developed High Intensity	1,572	<0.1
Deciduous Forest	469	<0.1
Perennial Ice/Snow	14	<0.1
Mixed Forest	9	<0.1

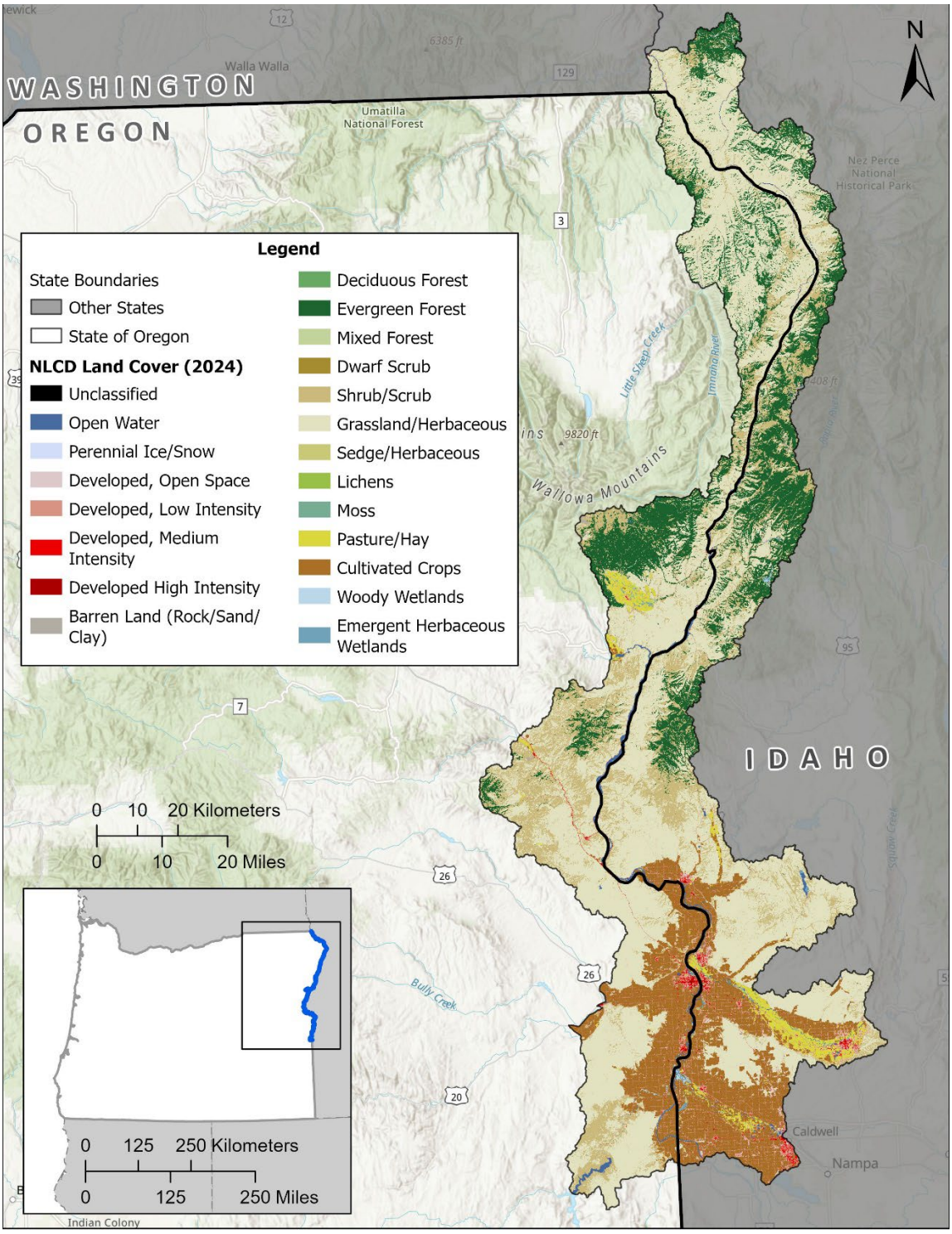


Figure 2-4: Land use and land cover in HUC10 watersheds that flow directly to the Snake River based on the 2024 National Land Cover Database.

2.4 Land ownership and jurisdiction

Land ownership and jurisdiction adjacent to the Snake River and Hells Canyon Complex Reservoirs in Oregon was mapped (Figure 2-5) in order to identify potential Designated Management Agencies (DMAs) and other responsible persons that may have vegetation management or other TMDL implementation responsibilities. A designated management agency (DMA) is defined in OAR 340-042-0030(2) as a federal, state or local governmental agency that has legal authority over a sector or source contributing pollutants.

Land ownership and jurisdiction adjacent to the Snake River and Hells Canyon reservoirs in Oregon include private individuals, federal agencies, and state or local governments. Federal land management agencies, primarily the U.S. Forest Service (USFS) and the Bureau of Land Management (BLM), own and manage the majority of lands, accounting for about 32.5% and 13.5% of area, respectively. Federal land is primarily concentrated in the Hells Canyon reaches. Privately owned range and agriculture lands, where the Oregon Department of Agriculture is the primary DMA, accounts for the next largest portion of area (29.4%). These three DMAs account for just over 75% of the land adjacent to the Snake River and Reservoirs while multiple other DMAs and responsible persons account for the remaining 25%.

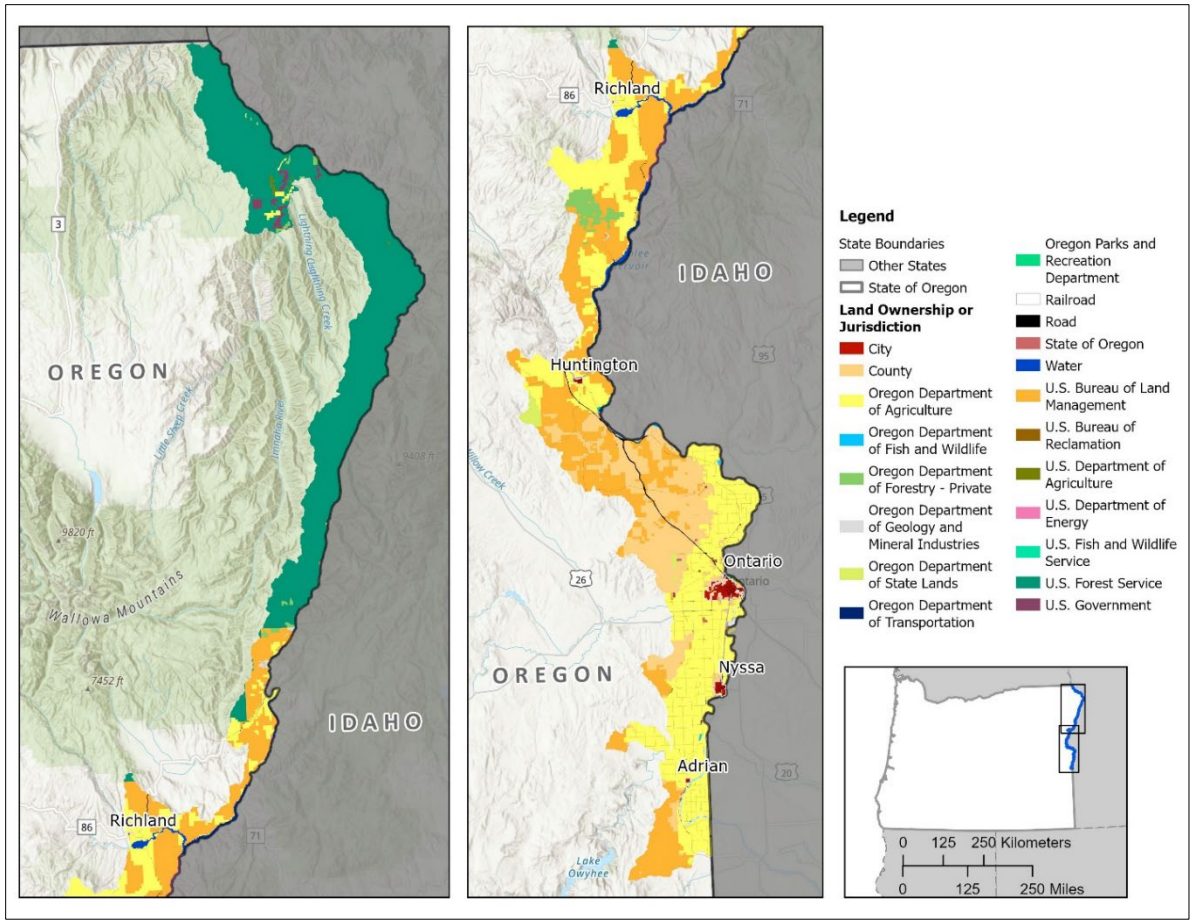


Figure 2-5: Land ownership and jurisdiction in the Snake River temperature TMDL project area.

Table 2-4: Land ownership and jurisdiction summary in Oregon streamside areas adjacent to the Snake River and Hells Canyon Complex reservoirs.

Landowner or Jurisdiction	Classification	Streamside Acres	Percent of Total Streamside Acres
Baker County	County	689.7	4.3
City of Adrian	Municipality	20.1	0.1
City of Nyssa	Municipality	73.4	0.5
City of Ontario	Municipality	127.3	0.8
Malheur County	County	710.2	4.5
Oregon Department of Agriculture	State Agency	4685.7	29.4
Oregon Department of Fish and Wildlife	State Agency	239.3	1.5
Oregon Department of Forestry - Private	State Agency	48.7	0.3
Oregon Department of Geology and Mineral Industries	State Agency	31.1	0.2
Oregon Department of State Lands	State Agency	24.4	0.2
Oregon Department of Transportation	State Agency	469.1	2.9
Oregon Parks and Recreation Department	State Agency	120.6	0.8
State of Oregon	State Agency	92.1	0.6
U.S. Bureau of Land Management	Federal Agency	2145.3	13.5
U.S. Bureau of Reclamation	Federal Agency	3.9	0.0
U.S. Department of Energy	Federal Agency	971.4	6.1
U.S. Fish and Wildlife Service	Federal Agency	100.8	0.6
U.S. Forest Service	Federal Agency	5177.0	32.5
U.S. Government	Federal Agency	46.2	0.3
Union Pacific Railroad	Private	63.5	0.4
Wallowa County	County	81.5	0.5

The land ownership and jurisdiction adjacent to the Snake River and Hells Canyon Complex Reservoirs was determined by reviewing geospatial datasets of ownership, land use, zoning, and jurisdictional boundaries, such as city limits and county boundaries. Cadastral boundaries and ownership information were acquired from Oregon county tax assessors. Cadastral and ownership information provided by a county tax assessor was assumed to be the most accurate information.

The source geospatial features are described in Table 2-5. A twelve-step decision hierarchy was used to identify the potential Designated Management Agency or other responsible person applicable to each tax lot. The decision hierarchy was implemented using an R script with all the geospatial data feeding into the decision tree.

Table 2-5: Geospatial data types and sources used to map land ownership and jurisdiction.

Geospatial data description	Feature name	Data provider
Tax Lot Ownership	Cadastral Survey	Oregon Geospatial Enterprise Office, Baker County, Malheur County, and Wallowa County
County Boundaries	Oregon Counties	Bureau of Land Management
Public Land Management	Oregon Land Management (2015), Oregon Land Management (2019)	Bureau of Land Management
City Limits	Oregon City Limits (2018)	Oregon Department of Transportation
Tribal Governments	Tribal Areas	Oregon Department of Forestry, U.S. Census Bureau (2000 Census)
Roads	Oregon Transportation Network (2017)	Oregon Department of Transportation
Railroads	Oregon Railroads (2017)	Oregon Department of Transportation
Land use/Land cover	2016 NLCD	U.S. Geological Survey, Dewitz (2019)
Zoning	Oregon Zoning (2017)	Oregon Department of Land Conservation and Development

For each mapped landowner or jurisdiction adjacent to the Snake River or reservoirs, the following was summarized:

- Total acres in streamside areas in Oregon
- Total acres in each HUC8 subbasin in streamside areas in Oregon.

Streamside areas are areas directly adjacent to the Snake River or reservoirs. DEQ used Oregon's assessment units to map reservoir edges or river centerline location. The assessment units are based on the national hydrography dataset. A mapping distance of 150 feet from the edge of the reservoir polygon assessment units was used to characterize the streamside area adjacent to the Hells Canyon Complex reservoirs. A distance of 650 feet the centerline of the polyline river assessment units was used on the free flowing (non-reservoir) portions of the Snake River. The mapping distance used on these assessment units is larger because the distance is measured from the center of the river (not the channel edge). Due to the large channel width of the Snake River the larger mapping distance ensures that at least 150 feet of land adjacent to the channel edge is characterized in the streamside area. The specific mapping distance used for each assessment unit is summarized in Table 2-6.

Table 2-6: Mapping distance for each assessment unit used to characterize land ownership and jurisdiction in the streamside areas adjacent to the Snake River and Hells Canyon Complex reservoirs.

AU Name	AU ID	Mapping Distance (feet)
Snake River	OR_SR_1705010311_02_102702 OR_SR_1705011501_02_103231 OR_SR_1705011502_02_103230 OR_SR_1705020101_02_103229 OR_SR_1706010101_02_103274 OR_SR_1706010102_02_103280 OR_SR_1706010103_02_103282 OR_SR_1706010301_02_103306	650 feet from AU river centerline
Brownlee Reservoir, Oxbow Reservoir, and Hells Canyon Reservoir	OR_LK_1705020103_05_100578 OR_LK_1705020311_05_100605 OR_LK_1705020107_05_100583 OR_LK_1705020107_05_100582	150 feet from AU polygon edge

Geospatial data for some entities were not available and thus not included in the summary. For example, irrigation districts, certain special districts, or other organizations that do not have fee-simple land ownership are not included in the mapping. In addition, the area estimates for roads and railroads are approximate. Many of the cadastral features exclude road and railroad right-of-way. Major roads and some railroad corridors are often clipped-out of the cadastral features. Other local roads such as forest roads managed by the federal government are not represented in the larger taxlot parcels. Since road and railroad locations are represented as polylines there is some uncertainty in the mapping of the exact right-of-way boundary location within the clipped-out area of the cadastral features. For landowners listed as “State of Oregon” or “U.S. Government”, the specific state or federal agency that manages those parcels was not available, so the jurisdictional area is summarized separately.

3 Pollutant identification

Temperature is the water quality parameter of concern, but heat or thermal loading is the pollutant of concern causing impairment. Heat caused by human activities are of particular concern.

4 Temperature water quality standards and beneficial uses

Refer to the Snake River Temperature TMDL rule (OAR 340-042-0090(6)(a)) for the applicable temperature criteria and beneficial uses.

The following sections summarizes DEQ evaluation of the most stringent temperature criteria, which formed the basis for the TMDL allocations; and how DEQ translated the cold water refuge narrative criteria, included in the numeric temperature criteria for waters that have been designated for salmon and steelhead migration corridor use in OAR 340-041-0028(4)(d).

4.1 Most stringent temperature criteria

The Snake River and Hells Canyon Complex of reservoirs serve as the shared border between Oregon and Idaho from river miles 176 to 409 (Figure 2-1). The Snake River flows into the states of Washington and Idaho downstream of Oregon at river mile 176. Table 4-1 summarize each state's applicable temperature criteria on the Snake River and reservoirs along the shared border with Oregon. The TMDL rule provides a more detailed summary of applicable criteria in Section 4.1 through Section 4.3.

Table 4-1: Summary of Oregon, Idaho, and Washington numeric temperature criteria on the Snake River and Hells Canyon Complex reservoirs.

Location	Oregon Criteria	Idaho Criteria	Washington Criteria
Snake River RM 409 - 247 Oregon-Idaho Stateline to Hells Canyon Dam,	Redband or Lahontan cutthroat trout use 20.0°C 7DADM	Cold water aquatic life 22.0°C Daily Maximum 19.0°C Daily Average	NA
Brownlee Reservoir (Powder River Arm)	Redband or Lahontan cutthroat trout use 20.0°C 7DADM	NA	NA
Snake River RM 247 - 188 Hells Canyon Dam to Salmon River	Salmon and steelhead migration corridor Apr 16 – Oct 22 20.0°C 7DADM Salmon and steelhead spawning Oct 23 – Apr 15 13.0°C 7DADM	Cold water aquatic life 22.0°C Daily Maximum 19.0°C Daily Average Salmonid spawning Oct 23 – Nov 6 14.5°C 7DADM Nov 7 – Apr 15 13.0°C 7DADM	NA
Snake River RM 188 - 176 Salmon River to the Tri-State border	Salmon and steelhead migration corridor Apr 16 – Oct 22 20.0°C 7DADM Salmon and steelhead spawning Oct 23 – Apr 15 13.0°C 7DADM	Cold water aquatic life 22.0°C Daily Maximum 19.0°C Daily Average	NA
Snake River RM 176 - 139 Tri-State border to Clearwater River	NA	Cold water aquatic life 22.0°C Daily Maximum 19.0°C Daily Average	20.0°C Daily Maximum

40 CFR 131.10(b) and 40 CFR §130.7(c)(1) requires TMDLs to be set at levels that will attain all applicable temperature water quality standards. Therefore, DEQ assessed attainment with criteria in downstream and cross stream waters in the States of Idaho and Washington. This included ensuring that Idaho's existing 2004 Snake River-Hells Canyon TMDL allocations and assumptions were considered and incorporated into Oregon's revised TMDL.

In order to ensure all applicable criteria are attained, DEQ evaluated each state's criteria and determined which was the most stringent. The most stringent criterion was defined as the criterion requiring the largest temperature reductions. If the most stringent criterion is attained, the remaining applicable criteria will also be attained. Therefore, the most stringent criteria form the basis of the TMDL loading capacity and allocations. Modeled temperature data from the five-year calibration period (2014-2018) were used to compare criteria and to determine the largest temperature reduction needed. The model output temperature data were used rather

than monitoring data because they provide a complete and consistent temporal and spatial characterization of temperatures over the 233 mile extent of the Snake River and Hells Canyon Complex of reservoirs.

The first step was to summarize the hourly model temperatures at each location into daily temperature metrics that correspond to the statistical form used for each state's criteria. Specifically, the hourly temperature data were summarized as a daily average, daily maximum, and 7-day average daily maximum. Each daily temperature metric was compared to the applicable criterion and the difference between the daily temperature metric results and each state's applicable criteria were calculated. Only daily temperature metric results at the Oregon/Washington border (river mile 176) were assessed against Washington's criteria. Temperature metrics from all locations were assessed against Oregon and Idaho's criteria.

The calculated temperature reductions required to achieve each state's criteria were standardized into the same statistical unit, the daily maximum reduction, which allows comparison among criteria that use different averaging periods. For Idaho's criteria expressed as a daily average, it was assumed a reduction to the daily maximum temperature would produce an equal reduction to the daily average temperature. **Equation 4-1** was used to estimate the daily maximum reduction needed to attain a criterion expressed as a 7-day average daily maximum. The calculation translates the temperature reduction needed to attain a rolling multi-day averaging period criterion into an equivalent daily maximum temperature reduction, allowing criteria from all three states to be compared using the same statistical basis.

$$DM_{r,i} = \max_{t \in [i, i+6]} \left(\frac{\sum_{k=t-6}^{t} DM_k - (T_C \cdot 7)}{7} \right)$$ **Equation 4-1**

where,

$DM_{r,i} =$ The maximum reduction to the daily maximum temperature on day i required to achieve T_C, the applicable 7-day average of the daily maximum temperature criteria (°C). Note that zero was used for reductions that were negative. A negative reduction means the temperature does not exceed the applicable criteria and no reduction is required.

$DM_i =$ The daily maximum value on day i within the 7-day period (°C).

$T_C =$ The applicable 7-day average daily maximum temperature criteria (°C)

Finally, the count of excursions, percent excursions, and 95th percentile temperature reduction needed to achieve each state's relevant criteria were calculated. The results are presented in Table 4-2 for year round criteria and Table 4-3 for spawning use criteria and include all locations and time periods where and when each criterion applies.

Oregon's temperature criteria require the largest temperature reductions for both year round and spawning use periods and therefore represent the most stringent criteria among the three states. For year round (non-spawning) use periods (Table 4-2), Oregon's 20°C year round

criteria (salmon and steelhead migration corridor and redband or lahontan cutthroat trout uses) require a 6.9°C reduction. Idaho's 19°C cold water aquatic life criterion was the next most stringent criteria with a necessary temperature reduction of 6.8 °C. During periods when spawning uses apply (Table 4-3), Oregon' s 13°C salmon and steelhead spawning use require a 3.3°C reduction, compared to a reduction of 2.2°C and 0.8°C to attain Idaho's 14.5°C and 13°C site specific spawning use criteria, respectively. Based on these results, attainment of Oregon's temperature criteria is expected to result in attainment of Idaho and Washington's criteria as well. Therefore, Oregon's criteria were used as the basis for the TMDL loading capacity and allocations.

Table 4-2: Summary of year round (non-spawning use) temperature criteria excursions, percent excursion, and 95th percentile reduction to daily maximum temperatures to attain each State applicable temperature criteria.

State	Temperature Criteria (ºC)	Temperature Criteria Statistical Base	Count of Excursions	Total Results	Percent Excursion	95th Percentile Temperature Reduction (ºC)
Idaho	19	Daily Average	395,957	1,390,843	28.5	6.8
Idaho	22	Daily Maximum	270,364	1,390,843	19.4	5.0
Oregon	20	7DADM	381,184	1,176,804	32.4	6.9
Washington	20	Daily Maximum	381	1,825	20.9	3.4

Table 4-3: Summary of spawning use period temperature criteria excursions, percent excursion, and 95th percentile reduction to daily maximum temperatures to attain each State applicable temperature criteria. Spawning period criteria apply October 23 – April 15.

State	Temperature Criteria (ºC)	Temperature Criteria Statistical Base	Count of Excursions	Total Results	Percent Excursion	95th Percentile Temperature Reduction (ºC)
Idaho	14.5	7DADM	3,707	8,640	42.9	2.2
Idaho	13	7DADM	3,294	152,448	2.2	0.8
Oregon	13	7DADM	10,351	195,487	5.3	3.3

4.2 Cold water refugia narrative

Waters designated as a salmon and steelhead migration corridor (see TMDL section 4.1.1) 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. 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 narrative provision supplements the numeric criterion of 20°C to protect migrating populations of salmon and steelhead. As the temperature of corridors approach 20°C, the role of cold water refugia is expected to enable fish to migrate to upstream and downstream destinations beyond the Snake River without impairment. Fish may move into cold water refugia if the temperature of the mainstem Snake River corridor becomes too warm.

The cold water refugia narrative is applicable to the Snake River from approximately river mile 176 at the tri-state border of Oregon, Washington, and Idaho upstream to approximately river mile 247.5 at Hells Canyon Dam.

Translation and assessment of the cold water refugia narrative criteria require determination of waters that are at least 2°C colder than the daily maximum temperature of the Snake River and if those cold water refugia are sufficiently distributed. DEQ (2020) and EPA (2021) provide examples of recent translation and assessment of the cold water refugia narrative criteria for the Willamette River and Columbia River migration corridors, respectively.

This TMDL is informed by those frameworks as well as data and information relevant to the Snake River.

4.2.1 Cold water refugia criteria translation framework

Table 4-4 identifies the framework for translation of the cold water refugia narrative in the Snake River. Supporting information and the cold water refugia assessments are summarized in Section 4.2.2 through Section 4.2.5. A summary of the Snake River cold water refugia findings are summarized in Section 4.2.6.

Table 4-4: Cold water refugia narrative criteria translation and assessment framework.

Element	Description
A. Critical period	June 15 through October 22 is the critical temperature period when mainstem temperatures exceed 18°C and salmon and steelhead are actively migrating and may seek cold water refugia.
B. Temperature difference	1. Tributary/groudwater plumes. Difference in daily maximums (mainstem – tributary) >= 2°C when the mainstem exceeds 18°C based on continuous temperature data; difference in NorWeST v2 7DADM (mainstem – tributary) >= 2°C; or documented fish use with supporting temperature measurements or 2. Mainstem diurnal cold water refugia. Mainstem daily diel range (mainstem daily max – mainstem daily minimum) >= 2°C when the mainstem exceeds 18°C
C. High-quality cold water refugia	Tributary 7-day average daily maximum temperatures are consistently 18°C or less during the critical temperature period of migration.
D. Discharge	Adults: Tributaries that are known to be large enough for adults to occupy a tributary plume or the tributary confluence area during the critical temperature period for migration. Juveniles: Tributary flow rate >= 1 cfs during the critical temperature period for migration.
E. Spatial distribution	The distance between cold water refugia along the migration corridor is less than or equal to the mean distance migrating fish travel in one day, approximately 13.2 miles for juveniles and 15.4 miles for adults.

A tributary is determined to be a cold water refuge if it is at least 2°C cooler than the Snake River using the temperature difference framework summarized in Table 4-4 and stream discharge is at least >= one cfs during the critical temperature period. One cfs is assumed to provide a sufficient plume size for juveniles based on discussion with ODFW and findings from the Lower Willamette River cold water refugia study (DEQ, 2020). Mean August tributary flows were obtained from the Enhanced Runoff Method (EROM) model estimates included with the NHDplus version 2 datasets. Specifically, the Q0001E attribute. For adults the exact flow rate producing a plume large enough for adults is difficult to determine without additional data. As summarized in section 4.2.2, habitat and other factors can play an important role. Instead, the tributaries known to be large enough for adults to occupy a tributary plume are identified. Other tributaries will require additional review and data. The tributaries known to have flow rates large

enough for adults include Deep Creek (RM 247), Granite Creek (RM 239), Bernard Creek (RM 235), Sheep Creek (RM 229), Imnaha River (RM 191), and the Salmon River (RM 188).

High quality cold water refugia have temperatures that maintain 18ºC as a 7DADM during the critical period. 18ºC is used because it is the applicable temperature criteria for salmon and trout rearing and migration use and deemed to be fully protective.

As discussed in section 4.2.3, the swim speeds in Table 4-4 (13.2 miles/day for juvenile Chinook salmon and 15.4 miles/day for adult summer Steelhead) represent the slowest overall mean swim speed by species and run. The slowest mean speed was used in order to ensure these slower swimming species could reach cold water refugia within one day. DEQ considers these swim speeds best available estimates.

4.2.2 Types of cold water refugia

There are several types of cold water refugia. Tributary streams that are colder than the mainstem river can provide plumes that serve as cold water refuges for migrating fish in the confluence area of the tributary. Fish can enter these plumes and lower portions of the tributaries to minimize their heat exposure during warm periods. Investigation by Marcoe et al 2018 and others identify the importance of stream discharge, flow velocity, and their interaction with topographic and bathymetric features at the confluence area in forming cold water plumes. Tributaries with a higher discharge relative to the mainstem are more likely to form a well-defined plume. Various flow thresholds for creating cold water plumes have been identified ranging between 1 and 10 cfs (DEQ, 2020, EPA, 2021, Marcoe et al 2018). Tributary discharge alone is not the only factor for plume formation. Even some small tributaries or seeps that flow into a sheltered embayment's, an alcove, or have gravel bars or large woody debris that act as deflectors (Figure 4-1). These habitat features can support formation of cold water plumes if the velocity in the confluence area is slower relative to velocity of the mainstem. Marcoe et al 2018 found slower velocity confluence locations maintained colder water for longer periods as the slower velocities in the sheltered area reduced mixing with the mainstem. Torgersen et al (2012) provide numerous other examples of habitat characteristics and channel complexity that support cold water refugia.

Another source of cold water refuges can be cold inflowing groundwater. Groundwater in this context has a broad definition per Ebersole (2003) and includes any non surface water sources such as deep aquifer groundwater, shallow groundwater, hillslope groundwater, seeps, flow through gravel, or hyporheic flow. Hyporheic flow includes river flow that submerges into the substrate and then re-emerges downstream as colder water (Torgersen. et al. 2012).

Finally, if the diurnal temperature difference between day and nighttime temperatures in the mainstem is great enough, it can provide temporal cold water refuge during those times of the day. In most rivers, temperatures have a daily diurnal pattern, with warmer temperatures occurring during the day usually is the midafternoon. The coolest temperatures occur at night, often right before sun rise, due to the absences of solar radiation flux at night. These cooler nighttime temperatures can serve as diurnal cold water refugia and reduce the number of hours fish are exposed to stressful temperatures throughout the day.

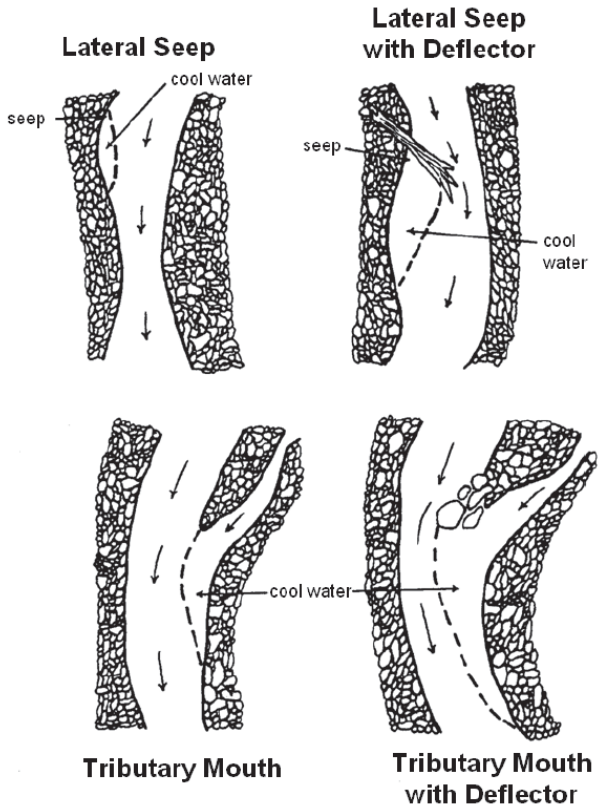


Figure 4-1: Examples of cool water refugia formed by seeps (top), and tributaries (bottom) with wood placement (top right) and a bar (bottom right) reducing mixing and velocity and increasing the size of cold water refugia. Source: Torgersen. et al. 2012; Bilby, 1984.

Based on discussion with ODFW and findings from the Lower Willamette River cold water refugia study (DEQ, 2020), a tributary flow rate of at least one cfs was used as the threshold to identify Snake River tributaries that produce a cold water plume of sufficient size for juvenile salmon and steelhead. The exact flow rate producing a plume large enough for adults is tributary specific and difficult to determine with available data as habitat and other factors can play an important role. Instead, tributaries that are known to be large enough to generate a plume big enough for adults to occupy are identified. Other tributaries will require additional review and data collection. The tributaries assumed to have flow rates large enough for adults include Deep Creek (RM 247), Granite Creek (RM 239), Bernard Creek (RM 235), Sheep Creek (RM 229), Imnaha River (RM 191), and the Salmon River (RM 188).

Flow rate data for Mean August tributary flows were obtained from the Enhanced Runoff Method (EROM) model estimates included with the NHDplus version 2 datasets. Specifically, the Q0001E attribute.

4.2.3 Salmon and steelhead migration corridor use

ODFW timing tables (Figure 4-2) provide a general overview of the periods and relative level of use when salmon and steelhead are actively migrating through the Snake River migration corridor (Hells Canyon Dam to Tri-state border). Periods of peak use on the table represent the times when approximately 90% of an activity, such as migration, occurs. Fish passage counts collected at Lower Granite Dam[2] provides the most comprehensive dataset for evaluating the timing and abundance of adult salmon and steelhead passing upstream, and juvenile salmon and steelhead smolts moving downstream, into and out of the migration corridor of the Snake River.

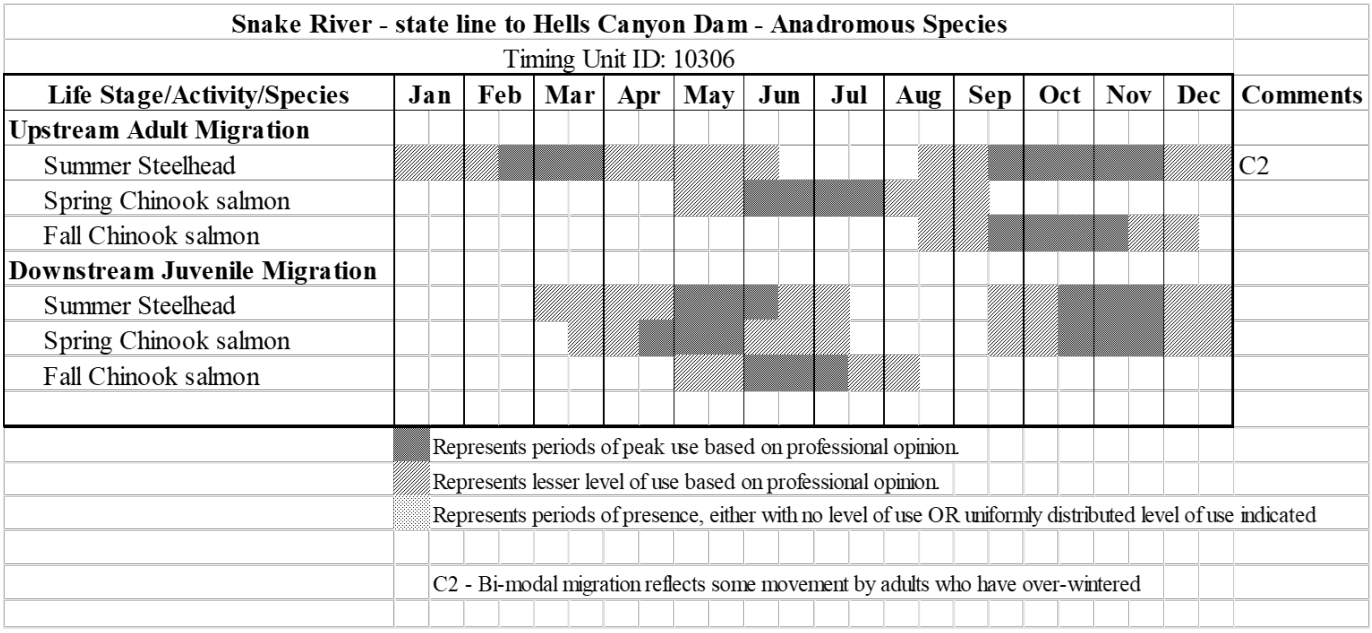


Figure 4-2: ODFW timing table showing periods of salmon and steelhead migration in the Snake River from stateline to Hells Canyon Dam.

Migratory salmon and steelhead use the Snake River designated migration corridor extensively, and at least some runs/life stages are present within the migratory corridor throughout the period of maximum water temperatures. However, the timing and extent of use varies by species, run, and life stage. For example, yearling Spring Chinook salmon smolts have generally outmigrated past Lower Granite Dam by June, prior to exposure to temperatures > 18°C (Figure 4-3). Adult sockeye salmon, in contrast, generally don't arrive at peak numbers until July, as Snake River temperatures are approaching their highest temperatures (Figure 4-4).

[2] Lower Granite Dam is operated by the U.S Army Corps of Engineers and located on the Snake River in southeastern Washington approximately 68 miles (110 km) downstream from the lower end of the Oregon migration corridor.

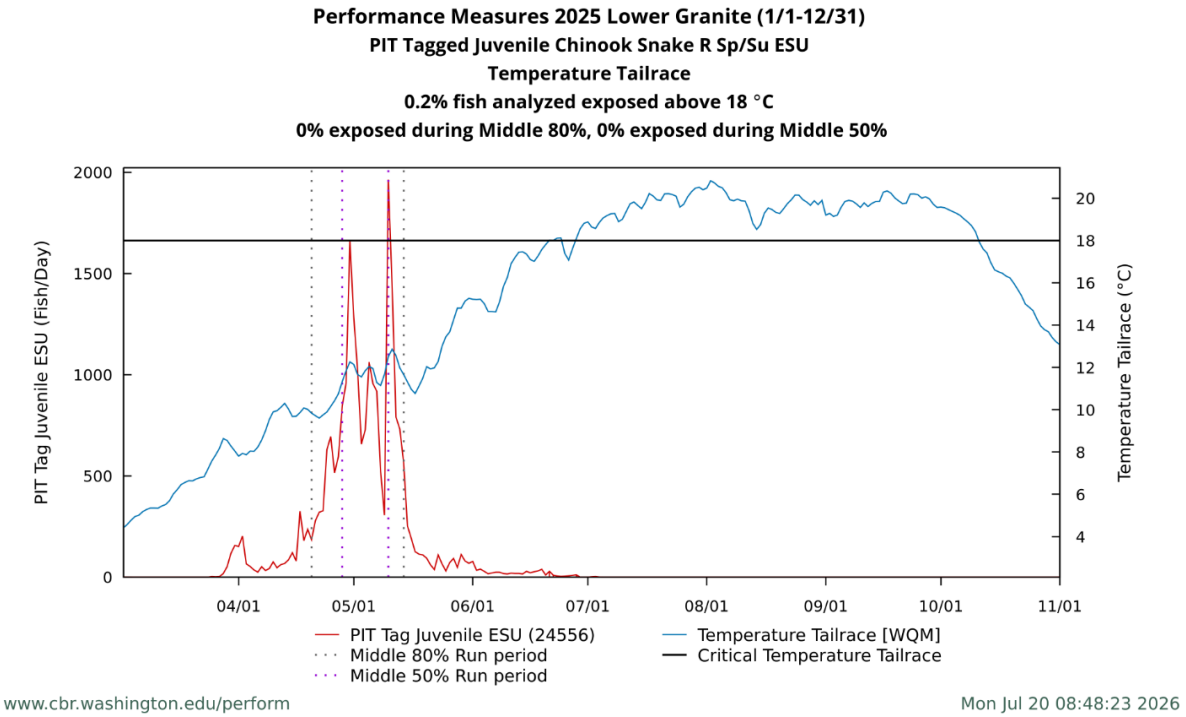


Figure 4-3: Counts of Spring Chinook smolts in relation to water temperature at Lower Granite Dam, 2025. Source: CBR, 2026.

Cold water refugia is intended to support migrating fish as 7DADM temperatures approach or exceed 20 °C. Maximum temperatures exceed 18°C in the Snake River migration corridor approximately mid-June through mid-October (See section 5). This period is considered the critical temperature period for migration and when cold water refugia may be utilized.

Due to variations in migration timing, the extent of exposure to temperatures in excess of 18°C varies by species, run, and life stage. Table 4-5 lists thermal exposure index values (an estimate of the average daily temperature experienced by each run as a whole) at Lower Granite Dam for each species, run, and life stage. The species, runs, and life stages with highest thermal exposures include adult sockeye salmon and adult fall Chinook salmon. Adult sockeye and fall Chinook salmon migration runs experienced the highest average temperatures at Lower Granite Dam over the past 25 years (18.7°C and 17.7°C, with over 80% and 50% of the run exposed to temperatures >18°C, respectively). Outmigrating steelhead, sockeye salmon, and yearling Chinook smolts largely avoided exposure to temperatures >18°C (less than 1% of the run exposed) at Lower Granite Dam due to spring migrations prior to warmest water temperatures. Chinook salmon can be present within the Snake River migration corridor during their first year of life, whether expressing sub-yearling or yearling life histories. For example, sub-yearling Chinook salmon, which are detected at Lower Granite Dam over a broader period (Figure 4-3) had higher exposures (mean temperature exposure index = 15°C), with on average over 22% of the run exposed to temperatures >18°C. Estimates of thermal

exposure obtained by relating water temperatures to passage date at Lower Granite Dam do not account for potential thermal refuge use upstream in the migration corridor, but they do provide an approximate index of the proportion of a run that is exposed to water temperatures where refuge-seeking behavior could be initiated.

Table 4-5: Thermal exposures of migratory salmon and steelhead passing Lower Granite Dam. Temperature exposure index is an abundance-weighted average temperature experienced by a given species/life stage (fish run) from 2001 through 2025. The temperature exposure index are ranked from highest to lowest. All values are 25-year means. Source: CBR, 2026.

Species (ESU)	Life stage	Temperature Exposure Index	Percent of Fish Run Exposed to Temperatures >18ºC	Number of Days During Observed Migration Period that Fish Run Exposed to Temperatures >18ºC
Sockeye	Adult	18.7	80.5	41
Chinook (fall)	Adult	17.7	50.4	34
Steelhead	Adult	16.2	32.5	80
Chinook	Sub-yearling	15.0	22.4	78
Chinook (spring-summer)	Adult	14.8	19.5	39
Sockeye	Smolt	11.5	0.6	14
Steelhead	Smolt	10.6	0.6	35
Chinook	Yearling	10.5	<0.01	16

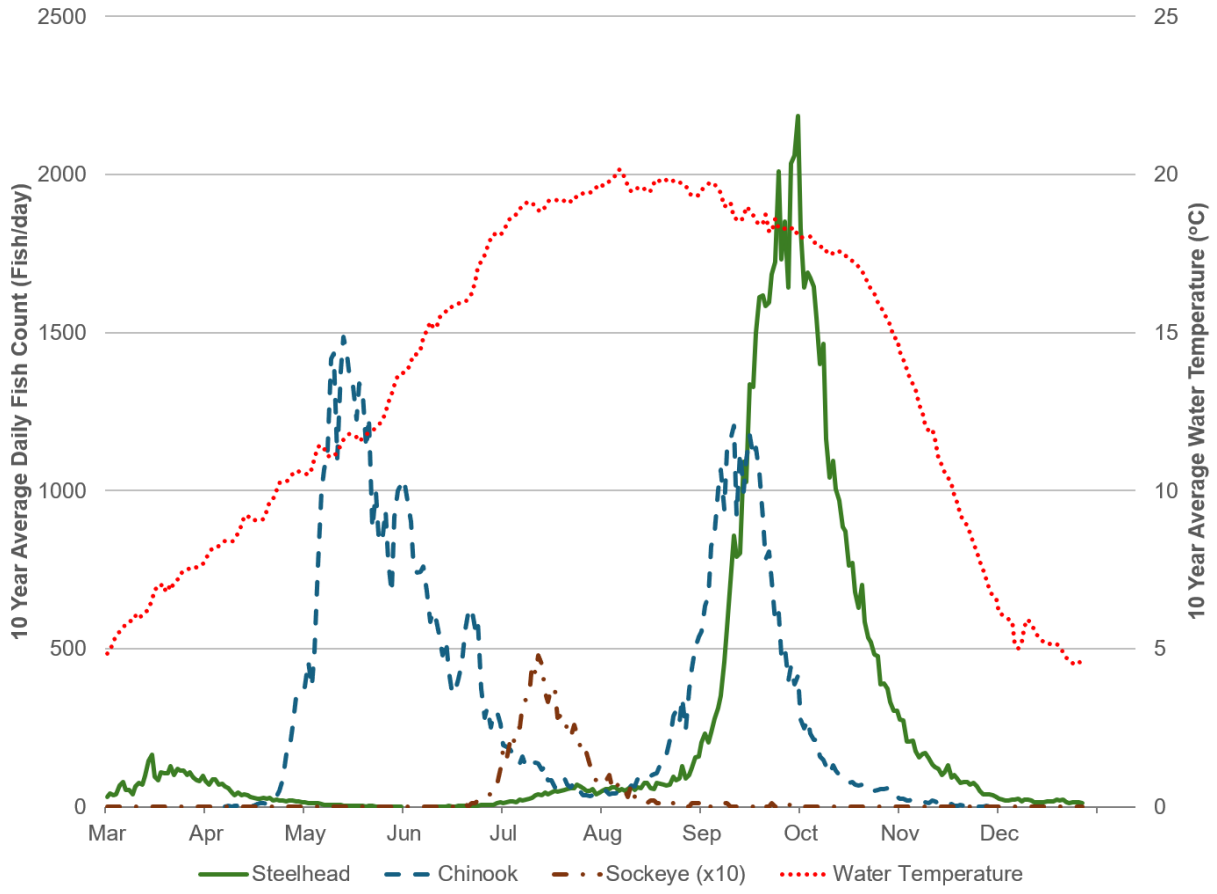


Figure 4-4: Adult Chinook and sockeye salmon (dashed lines) and steelhead (solid line) ten-year average (2015-2024) daily counts in relation to ten-year average water temperature at Lower Granite Dam (red dotted line). Chinook counts include Spring Chinook (first peak in April-May) and Fall Chinook (September peak). Sockeye salmon counts are multiplied by 10 to enhance visibility. Source: CBR, 2026.

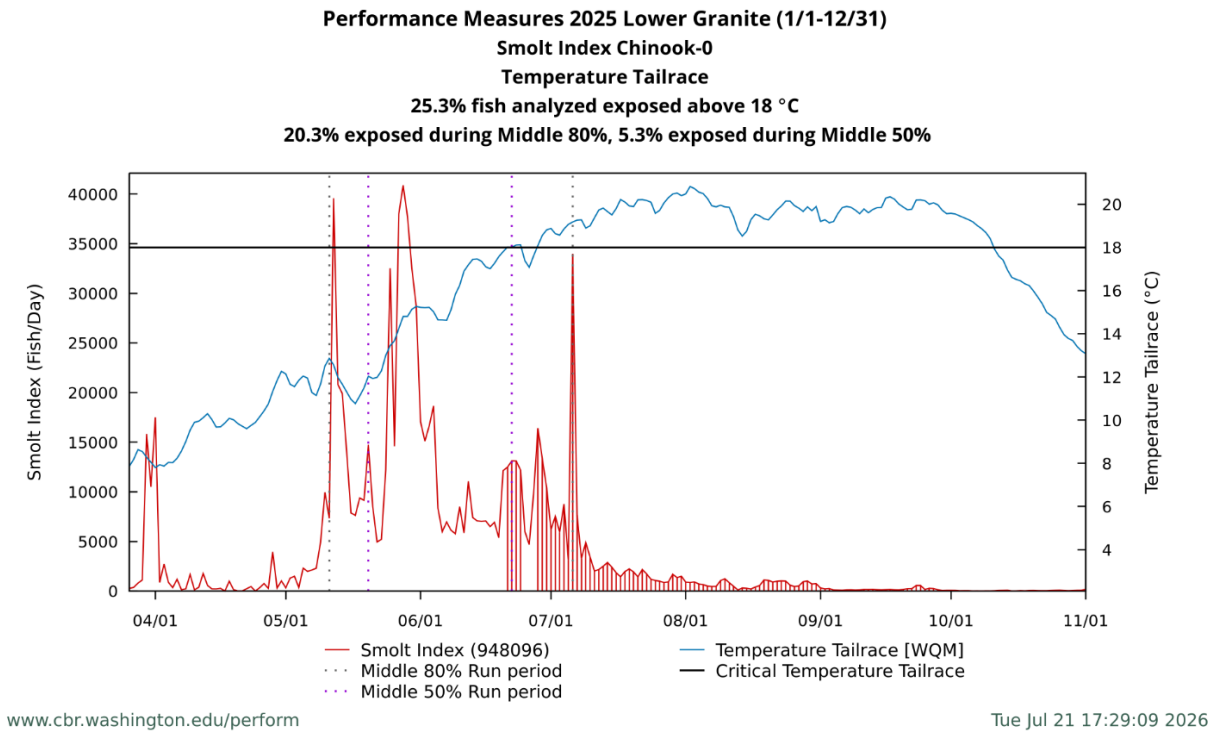


Figure 4-5: Estimates of sub-yearling Chinook salmon passing Lower Granite Dam in relation to daily water temperature during 2025. Vertical hatching under the plot of smolt estimates indicates fish that were exposed to water temperatures >18°C on that date. Source: CBR, 2026.

Direct observation of cold water refuge use by salmon or steelhead has not been documented in the Snake River migratory corridor to our knowledge. The only evidence of cold water refuge use we identified was for bull trout, in a study conducted by Idaho Power (IPC 2025). Body temperatures of tagged fish were recorded, paired with temperatures of the mainstem Snake River and of adjacent tributaries (if present), showing evidence of thermoregulation through cold water refuge use. Bull trout exhibited body temperatures nearly always <16°C (mean = 14.4°C, range = 11-18.2°C), even when Snake River temperatures exceeded 22°C. Mainstem Snake River temperatures recorded at the same time as bull trout temperatures averaged 19.5°C (range = 13.8-22.7°C), with differences between bull trout body temperatures and concurrent Snake River temperatures averaging -5.1°C (range = -8.7-2.2°C). Bull trout were observed using the mainstem Snake River, the plumes of tributaries, and the tributaries themselves. Tributaries and plumes used by bull trout included Granite Creek, Sheep Creek, Deep Creek, Three Creeks, Saddle Creek, and an unnamed creek[3] and associated groundwater fed plume at Snake River mile 237.1.

[3] Unnamed in the federal Geographic Names Information System (GNIS), but the drainage is shown as Dry Gulch and named Blind Creek on the 1995 USGS 7.5 minute topographic map (Old Timer Mountain Quadrangle, ID-OR, NIMA 2674 1 NE – Series V893)

4.2.4 Salmon and steelhead swim speed

Swim speed can be used to estimate the distance and time required for salmon and steelhead to navigate between individual cold water refuges identified along the Snake River migration corridor. Swim speeds are used to inform if there is sufficient spacing of cold water refugia. The spacing between cold water refuges that is necessary to allow salmon and steelhead migration without adverse impacts from maximum daily temperatures likely depends on several factors, including temperature of the intervening river segment, size and thermal history of an individual fish, and the size, temperature, and capacity of the cold water refuges. We currently lack sufficient data to evaluate how these factors interact to determine adequate refuge spacing. For this analysis, we assume that most refuge-seeking fish will move to or between refuges as temperatures approach 20ºC (Goniea et al. 2006). We therefore estimate the minimum acceptable refuge spacing as the mean distance migrating salmon and steelhead can swim in one day. Table 4-6 and Table 4-7 list swim speeds estimated from tagged juvenile and adult salmon and steelhead, respectively.

Swim speed data were provided to DEQ by Oregon Department of Fish and Wildlife and by EPA from published reports and peer-reviewed journal articles. The data compiled by ODFW is based on detections of PIT-tagged juvenile and adult salmon and steelhead at detection facilities at the four lower Snake River dams: Ice Harbor (ICH), Lower Monumental (LMJ), Little Goose (GOJ), and Lower Granite (GRS; GRJ), and at observation points at Snake River at km 225 (SNJ, SNJTRP), Imnaha River at km 7 (IR1), and Grande Ronde River at km 2 (GRNTRP). The abbreviations are the site codes used in the PTAGIS database for each location. Swim speed was computed based on the number of days it took each tagged fish to travel between detection points, divided by the distance in river miles between detection points. Adult data are from detections in years 2014-2025, while juvenile data are from years 2017 and 2024.

Based on these data, juvenile mean swim speed (Table 4-6) ranged from 5.3 to 52.6 miles per day (8.6 to 84.7 km/day) while adult species mean swim speed (Table 4-7) ranged from 14.9 to 40.4 miles per day (24 to 65 km/day). The ranges reflect the mean swim speed for different reaches, species, run, and study. The swim speeds in Table 4-8 represent the overall mean swim speed by species and run for all mainstem reaches from published studies after normalizing by sample size. Juvenile Chinook salmon and adult summer steelhead had the slowest overall mean swim speeds: 13.2 miles/day (21.2 km/day) and 15.4 miles/day (24.8 km/day) respectively. These slowest mean speeds were selected for assessment of sufficient distribution of cold water refugia in order to ensure slower swimming species could reach cold water refugia within one day. DEQ considers these swim speeds best available estimates. They may be revised with new or updated information as appropriate. DEQ is not aware of PIT-tagged data for salmon and steelhead that have been tracked at locations on the Snake migration corridor upstream of the Imnaha River. This data would be beneficial to collect and evaluate.

Table 4-6: Mean swim speed of tagged juvenile salmon and steelhead smolts calculated from receivers and release points in the Snake, Salmon, Grande Ronde, and Imnaha rivers

Species	Mean Swim Speed (km/day)	Sample size	Locations	Source
Chinook	25.0	11100	Little Goose to Lower Monumental	ODFW, 2026
Chinook	15.9	2010	Grande Ronde trap to Lower Granite	ODFW, 2026
Chinook	8.6	84	Imnaha River to Lower Granite	ODFW, 2026
Chinook	18.0	14705	Lower Granite to Little Goose	ODFW, 2026
Chinook	27.0	3352	Lower Monumental to Ice Harbor	ODFW, 2026
Chinook	12.4	441	Snake River at Clarkston to Lower Granite	ODFW, 2026
Summer Steelhead	26.5	11095	Little Goose to Lower Monumental	ODFW, 2026
Summer Steelhead	35.3	1500	Grande Ronde trap to Lower Granite	ODFW, 2026
Summer Steelhead	33.6	276	Imnaha River to Lower Granite	ODFW, 2026
Summer Steelhead	30.4	12690	Lower Granite to Little Goose	ODFW, 2026
Summer Steelhead	33.8	2677	Lower Monumental to Ice Harbor	ODFW, 2026
Summer Steelhead	29.1	366	Snake River at Clarkston to Lower Granite	ODFW, 2026
Sockeye	19.3	41	Little Goose to Lower Monumental	ODFW, 2026
Sockeye	23.4	74	Lower Granite to Little Goose	ODFW, 2026
Sockeye	30.3	10	Lower Monumental to Ice Harbor	ODFW, 2026
Sockeye	84.7	75261	Release sites in the upper Salmon River basin and Lower Granite Dam	Axel et al. 2017 and Griswold et al. 2011

Table 4-7: Mean swim speed of tagged adult salmon and steelhead calculated from receivers and release points in the Snake and Salmon Rivers.

Species	Run	Mean Swim Speed (km/day)	Sample size	Locations	Source
Chinook	Spring	53	727	Lower Granite to Snake River Receiver near Asotin, WA	Keefer et al. 2004
Chinook	Spring	45.5	2434	Little Goose to Lower Granite	ODFW, 2026
Chinook	Spring	36.1	2495	Ice Harbor to Lower Monumental	ODFW, 2026
Chinook	Spring	30.5	2451	Lower Monumental to Little Goose	ODFW, 2026
Chinook	Spring-Summer	55	161	Lower Granite to Snake River Receiver	Bjornn et al. 1992
Chinook	Spring-Summer	25	117	Snake River Receiver to Lower Salmon River	Bjornn et al. 1993
Chinook	Summer	65	192		Keefer et al. 2004
Chinook	Fall	31	33		Keefer et al. 2004
Sockeye		54	27	Lower Granite to Snake River Receiver	Keefer et al. 2008
Sockeye		36	22	Snake River receiver to Lower Salmon River near Little Salmon River confluence	Keefer et al. 2008
Steelhead	Summer	24	722		Keefer et al. 2004
Steelhead	Summer	25.2	2889	Little Goose to Lower Granite	ODFW, 2026
Steelhead	Summer	25.1	2897	Ice Harbor to Lower Monumental	ODFW, 2026
Steelhead	Summer	24.4	2932	Lower Monumental to Little Goose	ODFW, 2026

Table 4-8: Overall mean swim speed of PIT tagged adult and juvenile salmon and steelhead from all reach detection points normalized by sample size.

Life Stage	Species	Run	Overall Mean Swim Speed (km/day)	Sample size
Juvenile	Chinook		21.2	31692
Juvenile	Steelhead	Summer	29.5	28604
Juvenile	Sockeye		84.6	75386
Adult	Chinook	Spring-Summer	42.4	278
Adult	Chinook	Spring	38.7	8107
Adult	Chinook	Summer	65	192
Adult	Chinook	Fall	31	33
Adult	Sockeye		30.9	49
Adult	Steelhead	Summer	24.8	9440

4.2.5 Cold water refugia assessment

The tributary temperature analysis was completed using two types of datasets: continuous river temperature data and the NorWeST version 2 spatial statistical network (SSN) model outputs developed by Issak et al (2022).

4.2.5.1 Tributaries assessed with continuous temperature data

All continuous temperature data used for the tributary analysis was provided by Idaho Power. Idaho Power collected continuous temperature data at the mouths of numerous tributaries to the Snake River (Table 4-9). These data were paired with the nearest Snake River monitoring location. Daily maximums were calculated with the difference representing the Snake River daily maximum minus the tributary daily maximum for each day. Differences were calculated only if both monitoring locations had data on the same day and the Snake River's daily maximum was 18°C or warmer. The count of days with paired daily maximum temperature is shown in Table 4-10. Pittsburg Creek and Eureka Creek were the only tributaries with available temperature data not included in the analysis. Monitoring data were not available on Pittsburg Creek when the Snake River was 20°C or warmer. Eureka Creek had a low number of measurements (20) and the temperatures were unusually warm (maximum of 34.5 °C). The probe may have been out of the water and reading air temperatures, so these data were not used. If a tributary had more than one monitoring location on that tributary the data from each monitoring location were pooled together. A few of these sites had overlapping monitoring periods which resulted in more than one daily maximum per day from the same stream (4,224 total overlapping results. The difference between daily maximums on the same day was small (95th percentile = 0.22°C, mean 0.09°C) so the mean of the duplicate results were used.

The distribution of temperature differences were plotted as boxplots (Figure 4-6) with the 2°C threshold indicated. The boxplots are Tukey style boxplots with the middle line representing the median difference and ends of the box representing the range of differences between the first and third quartiles (25th – 75th percentile). A positive value in Figure 4-6 and means the daily maximum of the tributary is cooler than the Snake River daily maximum. A negative value means the daily maximum of the tributary is warmer than the Snake River daily maximum. Summary statistics were also calculated for each tributary (Table 4-10), showing the percent of days the tributary was 2°C cooler than the Snake River and percent of day the 7DADM was less than 18°C, indicating potential for high-quality cold water refugia.

Table 4-9: Continuous temperature monitoring sites used for cold water refugia analysis. All data provided by Idaho Power.

Tributary Monitoring Location ID	Snake River Mile	State	Latitude	Longitude	Paired Snake River Monitoring Location ID
Salmon_River_1_RB	188	ID	45.8611	-116.7786	Snake_River_189_LB
Knight_Creek_0.1_MC	190	OR	45.8280	-116.7854	Snake_River_189_LB
Knight_Creek_0.12_MC	190	OR	45.8280	-116.7854	Snake_River_189_LB
Imnaha_River_0.1_RB	191	OR	45.8108	-116.7604	Snake_River_192.3_RB
Imnaha_River_0.3_LC	191	OR	45.8145	-116.7632	Snake_River_192.3_RB
Eureka_Creek_0.1_MC	191	OR	45.8230	-116.7755	Snake_River_192.3_RB
Eureka_Creek_0.12_MC	191	OR	45.8230	-116.7756	Snake_River_192.3_RB
Divide_Creek_0.1_MC	193	ID	45.8270	-116.7377	Snake_River_192.3_RB
Divide_Creek_0.12_MC	193	ID	45.8272	-116.7379	Snake_River_192.3_RB
Wolf_Creek_0.1_MC	203	ID	45.7716	-116.5810	Snake_River_202.3_LB
Wolf_Creek_0.12_MC	203	ID	45.7717	-116.5809	Snake_River_202.3_LB
Getta_Creek_0.1_MC	205	ID	45.7474	-116.5417	Snake_River_202.3_LB
Getta_Creek_0.12_MC	205	ID	45.7473	-116.5420	Snake_River_202.3_LB
Tryon_Creek_0.1_MC	209	OR	45.6928	-116.5369	Snake_River_216.3_LB
Tryon_Creek_0.12_MC	209	OR	45.6928	-116.5370	Snake_River_216.3_LB
Somers_Creek_0.1_MC	210	OR	45.6845	-116.5308	Snake_River_216.3_LB
Somers_Creek_0.12_MC	210	OR	45.6844	-116.5309	Snake_River_216.3_LB
Big_Canyon_Creek_0.1_MC	210	ID	45.6781	-116.5215	Snake_River_216.3_LB
Big_Canyon_Creek_0.12_MC	210	ID	45.6779	-116.5217	Snake_River_216.3_LB
Pittsburg_Creek_0.1_MC	215	OR	45.6282	-116.4740	Snake_River_216.3_LB
Pittsburg_Creek_0.12_MC	215	OR	45.6280	-116.4745	Snake_River_216.3_LB
Salt_Creek_0.1_MC	222	OR	45.5533	-116.5275	Snake_River_216.3_LB
Salt_Creek_0.12_MC	222	OR	45.5533	-116.5274	Snake_River_216.3_LB
Temperance_Creek_0.1_MC	223	OR	45.5400	-116.5312	Snake_River_216.3_LB
Temperance_Creek_0.12_MC	223	OR	45.5399	-116.5310	Snake_River_216.3_LB
Sheep_Creek_0.1_LB	229	ID	45.4681	-116.5534	Snake_River_216.3_LB
Sheep_Creek_0.3_LB	229	ID	45.4670	-116.5492	Snake_River_216.3_LB
Rush_Creek_0.1_MC	231	OR	45.4503	-116.5814	Snake_River_216.3_LB
Rush_Creek_0.12_MC	231	OR	45.4503	-116.5814	Snake_River_216.3_LB
Sluice_Creek_0.1_MC	231	OR	45.4452	-116.5858	Snake_River_216.3_LB
Sluice_Creek_0.12_MC	231	OR	45.4452	-116.5858	Snake_River_216.3_LB
Bernard_Creek_0.1_MC	235	ID	45.4010	-116.6124	Snake_River_247.6_PS1
Bernard_Creek_0.12_MC	235	ID	45.4010	-116.6124	Snake_River_247.6_PS1
Hat_Creek_0.1_MC	235	OR	45.3957	-116.6210	Snake_River_247.6_PS1
Hat_Creek_0.12_MC	235	OR	45.3957	-116.6210	Snake_River_247.6_PS1
Saddle_Creek_0.1_MC	236	OR	45.3918	-116.6250	Snake_River_247.6_PS1
Saddle_Creek_0.12_MC	236	OR	45.3918	-116.6251	Snake_River_247.6_PS1
Three_Creek_0.1_MC	238	ID	45.3667	-116.6391	Snake_River_247.6_PS1
Three_Creek_0.12_MC	238	ID	45.3666	-116.6391	Snake_River_247.6_PS1
Granite_Creek_0.2_LB	239	ID	45.3472	-116.6538	Snake_River_247.6_PS1
Battle_Creek_0.1_MC	242	OR	45.3120	-116.6764	Snake_River_247.6_PS1

Tributary Monitoring Location ID	Snake River Mile	State	Latitude	Longitude	Paired Snake River Monitoring Location ID
Battle_Creek_0.12_MC	242	OR	45.3120	-116.6765	Snake_River_247.6_PS1
Brush_Creek_0.1_MC	244	ID	45.2780	-116.6726	Snake_River_247.6_PS1
Deep_Creek_247.5_0.1_MC	247	ID	45.2449	-116.6973	Snake_River_247.6_PS1
Deep_Creek_247.5_0.12_MC	247	ID	45.2449	-116.6973	Snake_River_247.6_PS1

Table 4-10: Summary of the temperature differences (°C) between the Snake River and tributary daily maximums when the Snake River >= 18°C.

Tributary	Snake River Mile	State	Sample Count	Percent of Days Tributary was 2°C Cooler Than the Snake River	Percent of Days Tributary 7DADM was Less Than 18°C
Deep Creek	247	ID	848	100	100
Brush Creek	244	ID	99	100	100
Battle Creek	242	OR	222	92	93
Granite Creek	239	ID	387	100	100
Three Creek	238	ID	222	100	100
Saddle Creek	236	OR	222	56	73
Hat Creek	235.7	OR	127	97	94
Bernard Creek	235	ID	222	100	100
Sluice Creek	231.7	OR	116	97	98
Rush Creek	231	OR	115	92	91
Sheep Creek	229	ID	578	100	100
Temperance Creek	223	OR	116	42	47
Salt Creek	222	OR	116	41	61
Big Canyon	210.6	ID	116	59	65
Somers Creek	210.3	OR	116	46	47
Tryon Creek	209	OR	28	4	0
Getta Creek	205	ID	235	35	41
Wolf Creek	203	ID	235	27	32
Divide Creek	193	ID	238	35	44
Imnaha River	191	OR	898	29	37
Knight Creek	190	OR	154	49	58
Salmon River	188	ID	1875	30	41

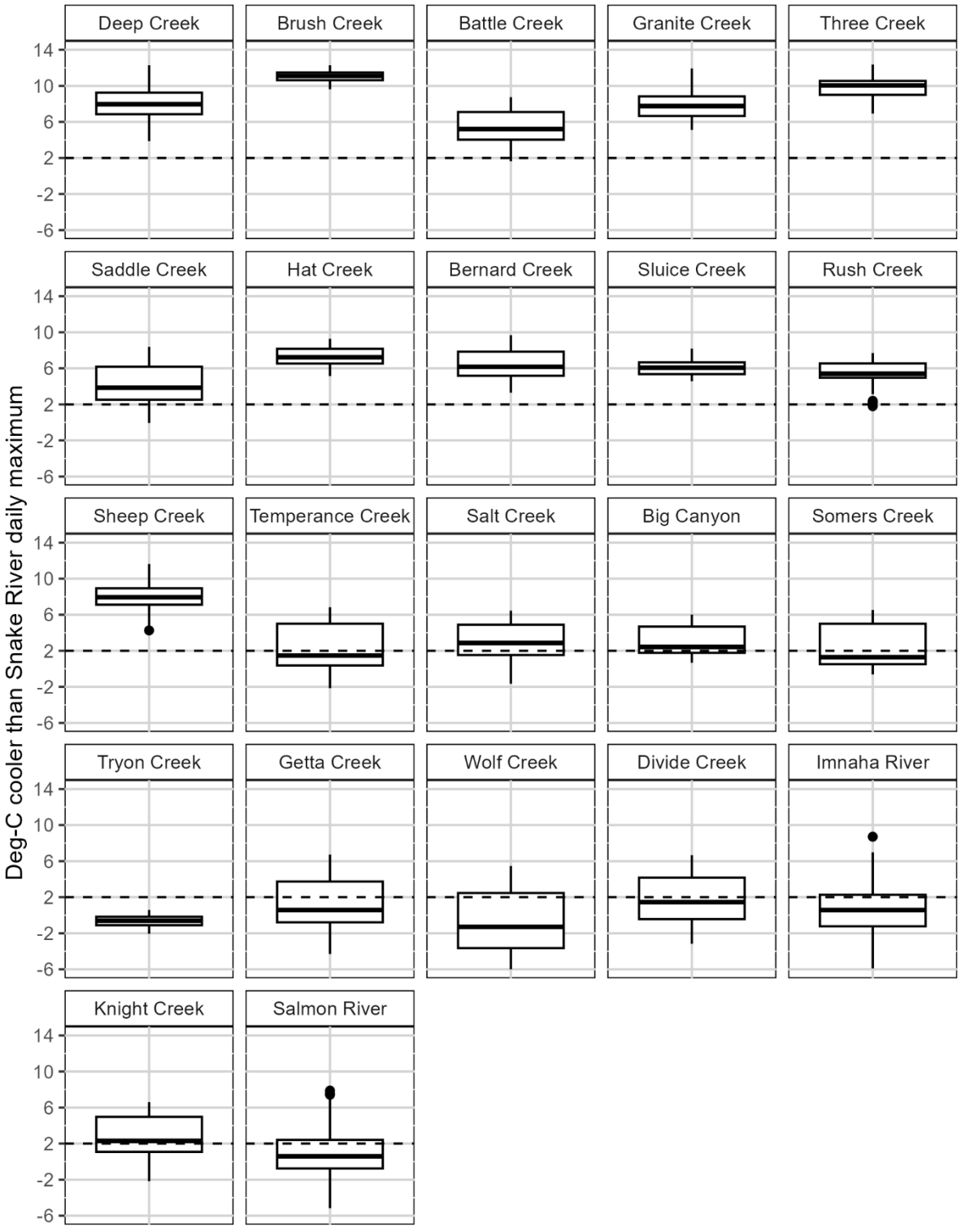


Figure 4-6: Boxplots showing distribution of temperature differences between the Snake River and tributary daily maximums. Cooler temperatures are positive values, and warmer temperatures are negative values. Top of the box is the 75th percentile, middle line is the median, and bottom of the box is the 25th percentile. Cold water refugia occurs at 2^{o}C or higher.

4.2.5.2 Tributaries assessed with NorWeST model outputs

For tributaries without continuous temperature data, the NorWeST version 2 spatial statistical network (SSN) model outputs developed by Issak et al (2022) were used to estimate tributary and Snake River temperatures.

The Middle Columbia East Production Unit, "S2_02_11" MWMaxT model outputs were used which represent the mean maximum of the running 7-day maximum temperature for the months of July and August from 2002-2011. Temperatures from the reach at the tributary mouth and the immediate Snake River reach downstream of the tributary mouth were extracted. In total there were 108 tributaries included in the NorWeST model within the migration corridor, excluding the 22 tributaries evaluated with continuous temperature data in Section 4.2.5.1.

The results show that temperatures at the mouths of most Snake River tributaries evaluated are generally colder than the Snake River (tributary MWMax range = 10.7 °C-24.0 °C). 84 of the 108 tributaries assessed using NorWeST model temperature results have MWMax temperatures at least 2°C colder than the mainstem Snake River MWMax (difference range = -2.1°C to 11.5°C with positive values being coolder than the Snake River). Almost half of those 84 colder tributaries (41 out of 84) have July and August MWMax temperatures less than or equal to 18°C. Many of these colder temperature however have very small flow rates at their mouths based on the EROM data. The summary of NorWeST model temperature results for tributaries with a mean August flow >= 1 cfs are presented in Table 4-11. Tributaries with a flow >= 1 cfs are likely to generate a cold water plume of sufficient size for juveniles.

Table 4-11: Summary of the temperature differences (°C) between the Snake River and tributaries with EROM mean August flow >= 1 cfs using the outputs of the NorWeST version 2, S2_02_11" MWMaxT model (Issak et al 2022).

Tributary	Snake River Mile	State	EROM Mean Aug Flow (cfs)	Snake River S2_02_11 MWMax Temperature (°C)	Tributary S2_02_11 MWMax Temperature (°C)	Difference (°C)
Hells Canyon Creek	246.9	OR	2.0	21.7	17.0	4.7
Stud Creek	245.7	OR	1.7	21.6	15.8	5.9
Wild Sheep Creek	241.5	OR	1.2	21.7	12.6	9.2
Bull Creek	241.4	OR	1.1	21.7	13.9	7.8
Kirkwood Creek	220.6	ID	3.0	22.1	18.6	3.5
Deep Creek	199.2	OR	2.7	21.9	24.0	-2.1
Cherry Creek	185.4	OR	1.4	22.0	20.5	1.4
Cook Creek	183.6	OR	1.9	22.0	21.8	0.2

4.2.5.3 Mainstem Snake River diurnal cool water refugia assessment

The approach used to evaluate availability of Snake River diurnal cool water refugia is similar to the tributary analysis. The Snake River daily maximum and daily minimums were compared for each day when the Snake River daily maximum temperature is 18ºC or warmer. The model calibration temperatures were used for this analysis as it provides a complete temporal and spatial characterization of temperatures in the Snake River downstream of Hells Canyon Dam. The differences between Snake River daily maximums and daily minimums is generally less than 2°C except for a few days in the reaches between river miles 220 and 230. The full distribution of temperatures is shown in the boxplots in Figure 4-7. Based on these results nighttime temperatures in the Snake River do not provide diurnal cold water refuge.

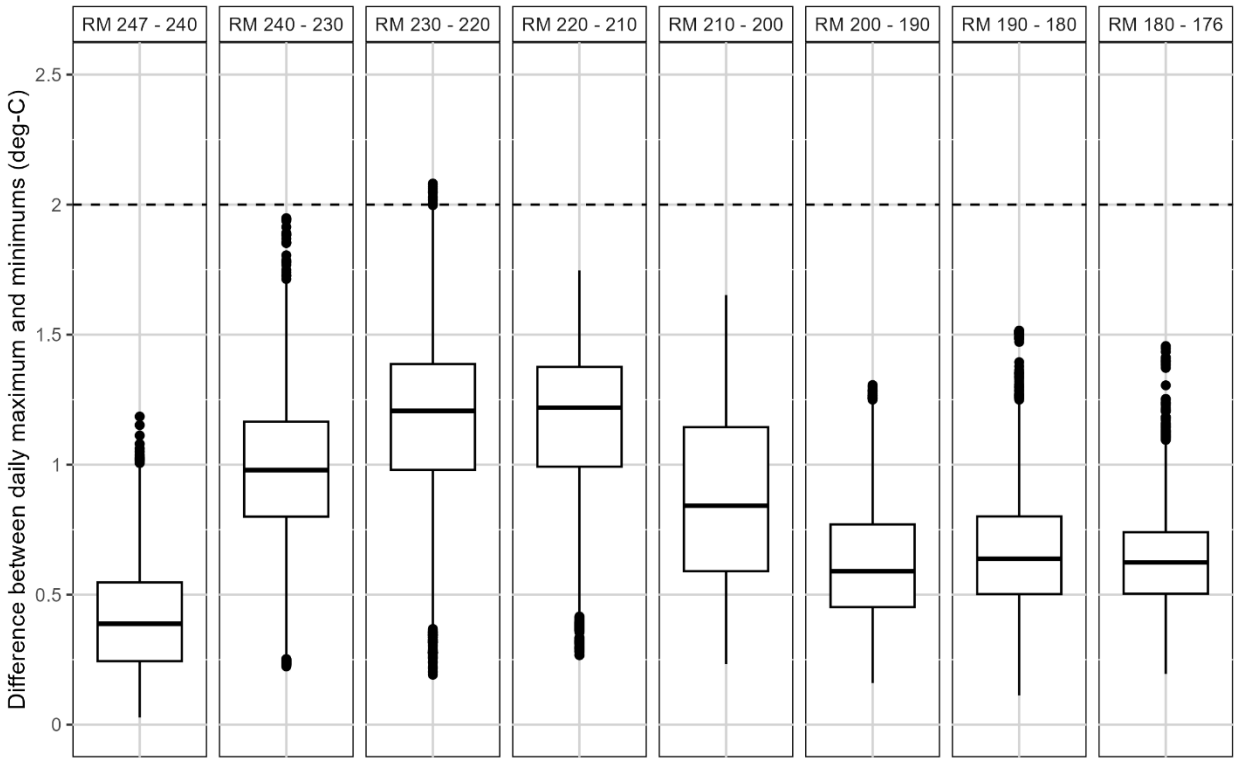


Figure 4-7: Boxplots showing distribution of temperature differences between the Snake River daily maximum and daily minimum during periods when the daily maximum >= 20 ºC.

4.2.6 Cold water refugia findings

Applying the translation framework approach to tributaries or groundwater with available temperature data, the 21 Snake River tributaries listed in Table 4-12 and mapped in Figure 4-8, provide cold water refugia at their mouths. High-quality cold water refugia appear readily available at Sheep Creek and tributaries upstream of river mile 229. There are no known high-quality cold water refugia tributaries downstream of river mile 229.

The distances between all 21 tributary cold-water refugia locations with flow estimated to be greater than one cfs in August are all located less than the mean distance that juvenile salmon and steelhead swim in one day. For the six tributaries known to be large enough for adults, the distance between the Imnaha River and Sheep Creek cold water refugia is about 38 miles, a little over twice the mean swim distance that adult summer steelhead swim in one day. The distances between the other five cold water refugia tributaries are within one day's mean swim speed for adult salmon and steelhead.

Cold water refugia use is generally not a concern for out-migrating juvenile Sockeye, steelhead, and Chinook based on fish passage data available at Lower Granite Dam. For example, yearling Spring Chinook salmon smolts have generally outmigrated past Lower Granite Dam by June, prior to exposure to temperatures > 18^{o}C. However, for adults, approximately 50% of adult Chinook, 80% of adult sockeye and 32% of adult steelhead fish runs are exposed to temperatures exceeding 18^{o}C when cold water refuge seeking behavior may be occurring (Table 4-5).

Based on the available data, cold water refugia are available and sufficiently distributed for juvenile salmon and steelhead. For adult salmon and steelhead, cold water refugia are available and sufficiently distributed throughout most of the migration corridor with the exception of the 38 mile reach between the Imnaha River and Sheep Creek. In this reach, the available data show there are many tributaries with cold water, however, it is unknown if these tributaries generate cold water plumes of sufficient size that could be used by adults. Additional temperature, flow, and fish monitoring is recommended.

Table 4-12: Tributary or groundwater cold water refugia in the Snake River migration corridor.

Cold Water Refugia Tributary	River Mile	State	EROM Mean Aug Flow (cfs)	High Quality Cold Water Refugia	Tributary Plume Large Enough for Adults	Temperature Data Source
Deep Creek	247	ID	42.3	Yes	Yes	IPC data
Hells Canyon Creek	246.9	OR	2.0	Yes		Issak et al 2022
Stud Creek	245.7	OR	1.7	Yes		Issak et al 2022
Battle Creek	242	OR	3.3	Yes		IPC data
Wild Sheep Creek	241.5	OR	1.2	Yes		Issak et al 2022
Bull Creek	241.4	OR	1.1	Yes		Issak et al 2022
Granite Creek	239	ID	46.9	Yes	Yes	IPC data
Three Creek	238	ID	2.4	Yes		IPC data
Unnamed stream[4] and groundwater springs	237.1	ID	-	Yes		IPC 2025
Saddle Creek	236	OR	6.1			IPC data
Bernard Creek	235	ID	8.1	Yes	Yes	IPC data
Sluice Creek	231.7	OR	1.9	Yes		IPC data
Sheep Creek	229	ID	30.1	Yes	Yes	IPC data
Temperance Creek	223	OR	2.7			IPC data
Kirkwood Creek	220.6	ID	3.0			Issak et al 2022
Somers Creek	210.3	OR	1.1			IPC data
Getta Creek	205	ID	1.7			IPC data
Wolf Creek	203	ID	4.0			IPC data
Divide Creek	193	ID	2.8			IPC data
Imnaha River	191	OR	247.2		Yes	IPC data
Salmon River	188	ID	5832.6		Yes	IPC data

[4] Unnamed in the federal Geographic Names Information System (GNIS), but the drainage is shown as Dry Gulch and named Blind Creek on the 1995 USGS 7.5 minute topographic map (Old Timer Mountain Quadrangle, ID-OR, NIMA 2674 1 NE – Series V893.

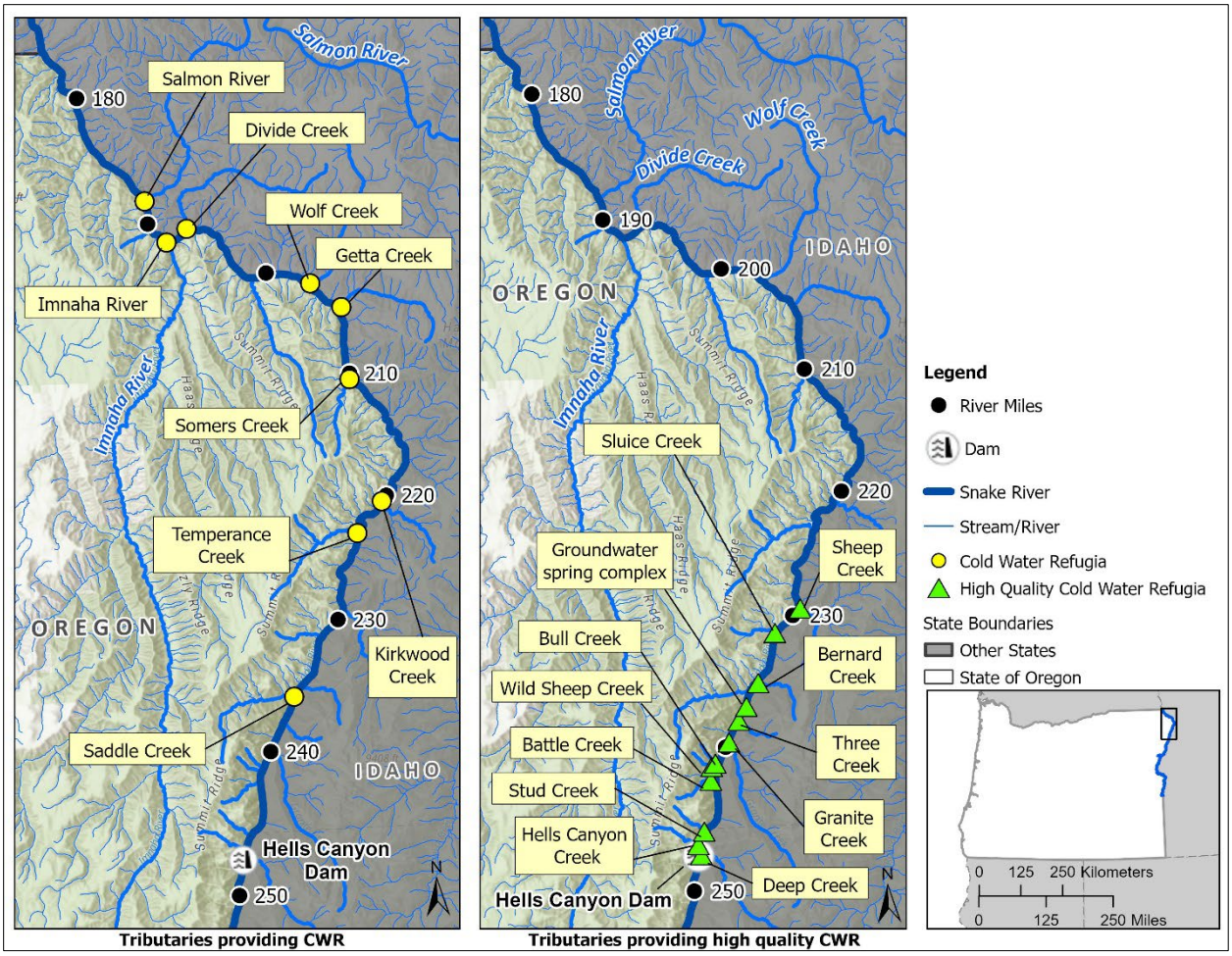


Figure 4-8: Locations of known tributary or groundwater cold water refugia in the Snake River migration corridor.

5 Seasonal variation and critical period for temperature

Per OAR 340-042-0040(4)(j) and 40 CFR 130.7(c)(1), TMDLs must identify any seasonal variation and the critical condition or period of each pollutant.

DEQ reviewed available temperature data to determine seasonal temperature variation and the critical condition and period. The critical period is based on the frequency and period when 7DADM stream temperatures exceed Oregon's applicable temperature criteria or contribute to exceedances downstream. Table 5-1 summarizes the water temperature monitoring data used to evaluate seasonal variation and designate critical periods.

In setting the critical period, DEQ relied upon monitoring sites with the longest periods of exceedance as well as results of the modeling analysis which provide estimates of temperatures at locations without monitoring data. When downstream locations have longer exceedance periods relative to upstream waters, the longer period is used as the critical period for upstream

waterbodies. 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.

Table 5-1: Water temperature monitoring locations and periods used to determine seasonal temperature variation and critical periods.

Monitoring Location ID	Monitoring Location	Snake River Mile	Data Date Range	Count of 7DADM Results
USGS 13173600	Snake River near Adrian OR	396.8	11/04/08 - 11/27/10	727
USGS 13213100	Snake River at Nyssa OR	382.4	08/30/04 - 10/18/15	3611
Snake_River_383_MC	Snake River at river mile 383, mid channel	380.5	10/01/02 - 05/14/19	4659
Snake_River_354.3_LB	Snake River at river mile 354.3, left bank	350.2	01/30/03 - 07/16/18	4495
USGS 13269000	Snake River at Weiser ID	346.7	01/01/02 - 12/31/24	4323
Snake_River_345.6_MC	Snake River at river mile 345.6, mid channel	341.4	02/08/02 - 09/01/20	4540
Snake_River_345.2_LB	Snake River at river mile 345.2, left bank	340.9	04/28/04 - 07/17/19	5105
Snake_River_283.9_LC	Snake River at river mile 283.9, left half channel	280.5	01/17/02 - 09/02/20	6105
Snake_River_283.9_RC	Snake River at river mile 283.9, right half channel	280.5	01/17/02 - 06/22/19	5554
Snake_River_269.8_LC	Snake River at river mile 269.8, left half channel	266.6	02/28/02 - 09/01/20	3167
Snake_River_247.6_PS1	Snake River at river mile 247.6, in penstock #1 of Hells Canyon Dam powerhouse	244.7	01/01/02 - 04/12/19	5559
Snake_River_229.8_LB	Snake River at river mile 229.8, left bank	227.2	01/01/02 - 05/07/19	5573
Snake_River_216.3_LB	Snake River at river mile 216.3, left bank	213.7	01/01/02 - 02/12/20	5827
Snake_River_202.3_LB	Snake River at river mile 202.3, left bank	199.7	01/01/02 - 03/09/19	5892
Snake_River_189_LB	Snake River at river mile 189, left bank	186.9	01/01/02 - 09/17/19	6185
USGS 13317660	Snake River at McDuff Rapids at China Garden ID	172.4	10/27/05 - 12/31/24	6967

Figure 5-1 through Figure 5-17 show boxplots of the seasonal variation of 7DADM temperatures and the period of exceedance at temperature monitoring locations on the Snake River. 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 magnitude and period of exceedance varies based on monitoring location and which criterion apply. The plots show that maximum stream temperatures typically occur in July or August. This period coincides with the lowest annual stream flows (Figure 6-4), maximum solar radiation fluxes, and warmest ambient air temperature. Conversely the coolest stream temperatures occur in December and January coinciding with the lowest solar radiation fluxes and coolest ambient air temperatures. The warmest 7DADM temperatures were observed at monitoring stations in the Snake River between the Weiser River and the upstream end of Brownlee Reservoir (RM 340 – RM 346). Monitoring data at USGS 13269000, Snake River at Weiser, ID (Figure 5-5) show median 7DADM temperatures from years 2002 through 2024 were between 25ºC and 27ºC July 1 through August 15. 7DADM temperatures at other monitoring stations upstream of Brownlee regularly exceed Oregon's 20ºC Redband or Lahontan cutthroat trout criterion approximately May 1 through September 30 (Figure 5-1 through Figure 5-7).

The calibrated model predicts laterally averaged surface 7DADM temperatures in Brownlee, Oxbow, and Hells Canyon Reservoirs exceed Oregon's 20ºC Redband or Lahontan cutthroat trout criterion approximately May 15 through October 15 (Figure 5-8 through Figure 5-10).

7DADM temperatures in the reaches downstream of Hells Canyon Dam exceed the 20ºC salmon and steelhead migration corridor and 13ºC salmon and steelhead spawning use criteria approximately June 15 through November 15. The warmest 7DADM temperatures during spawning use period occur at the end of October when the spawning use period begins on October 23.

Relative to patterns upstream of Brownlee Reservoir, the temperature data show a shift in the seasonal thermal pattern and period of criteria exceedance in the Hells Canyon Complex reservoirs and downstream of the dams. Upstream of Brownlee Reservoir the peak maximum temperatures occur in early July (Figure 5-6). Downstream of the dams the peak maximum temperatures shift to late-August (Figure 5-11 through Figure 5-17). The calibrated model predicts laterally averaged surface 7DADM temperatures in the reservoirs exceed the 20ºC Redband or Lahontan cutthroat trout criterion May 15 through October 15 (Figure 5-8 through Figure 5-10) - approximately two weeks later than the exceedance period upstream of Brownlee. The 7DADM temperatures downstream of the reservoirs are also cooler in the spring and early summer; and warmer later in the summer and fall relative to 7DADM temperatures upstream of the reservoirs. As summarized in Section 7.2.1, this seasonal pattern shift is

caused by the dam and reservoir operations and the effect each impoundment has on residence time and the thermocline.

Based on review of the temperature data, the critical period for the Snake River upstream of Brownlee Reservoir (approximately RM 340 - 409) is May 1 through October 31. The critical period from the tri-state border and within the reservoirs (approximately RM 176 - 340) is May 15 through November 15. The critical periods and relevant locations are presented in Table 5-2.

Table 5-2: Critical periods for the Snake River and Hells Canyon Complex.

Location	AU IDs	Critical Period
Snake River from ID/OR Stateline to Brownlee Reservoir (approximately RM 409 - 340)	OR_SR_1705010311_02_102702 OR_SR_1705011501_02_103231 OR_SR_1705011502_02_103230 OR_SR_1705020101_02_103229	May 1 - October 31
Brownlee Reservoir, Oxbow Reservoir, Hells Canyon Reservoir and Snake River from Hells Canyon Dam to the tri-state border (approximately RM 340 - 176)	OR_LK_1705020103_05_100578 OR_LK_1705020311_05_100605 OR_LK_1705020107_05_100583 OR_LK_1705020107_05_100582 OR_SR_1706010101_02_103274 OR_SR_1706010102_02_103280 OR_SR_1706010103_02_103282 OR_SR_1706010301_02_103306	May 15 – November 15

Waters upstream of Brownlee Reservoir do not exceed the 20°C Redband or Lahontan cutthroat trout criterion past September, however the critical period extends to October 31 to recognize the influence the reservoirs have on critical temperatures downstream of Hells Canyon where the 13°C salmon and steelhead spawning use criterion apply. 7DADM temperatures upstream of Brownlee Reservoir regularly exceed 13°C through the end of October.

As mentioned in the paragraphs above, dam and reservoir operations cause a seasonal shift in 7DADM temperatures. The temperature modeling results predict that once the natural seasonal thermal pattern is restored the critical period will shift accordingly. The No Dam model scenario was used to evaluate 7DADM temperatures with a restored natural seasonal thermal pattern. In this scenario, 7DADM temperatures downstream of Hells Canyon Dam will exceed criteria approximately April 1 through October 31, a shift of about 1.5 months earlier from the existing temperatures. This critical period shift is shown in Figure 5-18 and Figure 5-19.

If temperature monitoring data consistently show the period of temperature criteria exceedances in the reservoirs and downstream of Hells Canyon Dam have shifted from the periods in Table 5-2, DEQ may adjust the period when TMDL allocations apply consistent with the shift. This provision is provided in the TMDL rule. The surrogate measure temperature target will continue to apply April 1 – November 15 to ensure the natural seasonal thermal pattern narrative criterion is attained.

The seasonal variation in mean daily flow at Weiser, downstream of Hells Canyon Dam, and at McDuff Rapids at the tri-state border are presented in Section 6.3, Figure 6-4 , Figure 6-5, and

Figure 6-6, respectively. The lowest minimum flow rates typically occur July through September. Downstream Hells Canyon Dam and at the tri-state border, the monthly median flows have a different pattern relative to the monthly median flows at Weiser. The lowest median flows at Weiser occur July through September while downstream of Hells Canyon Dam the lowest median flows occur October through November.

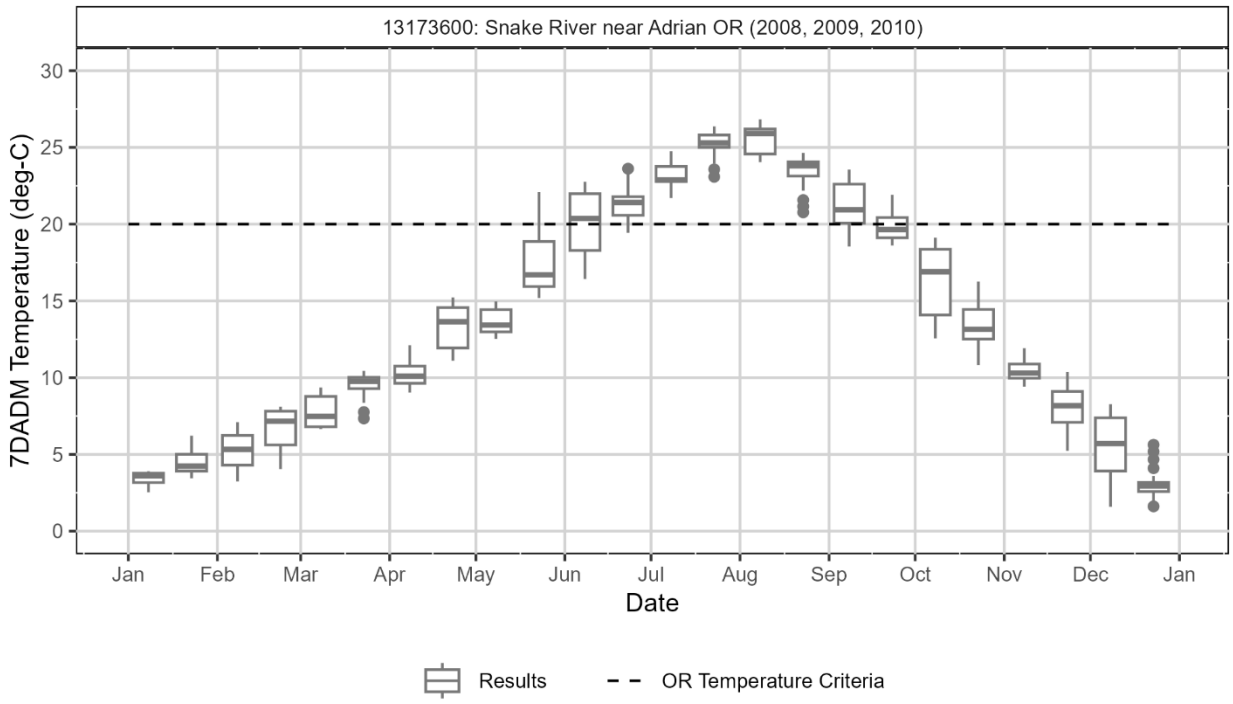


Figure 5-1: Seasonal variation of 7DADM temperatures near Snake River mile 396 near Adrian, Oregon.

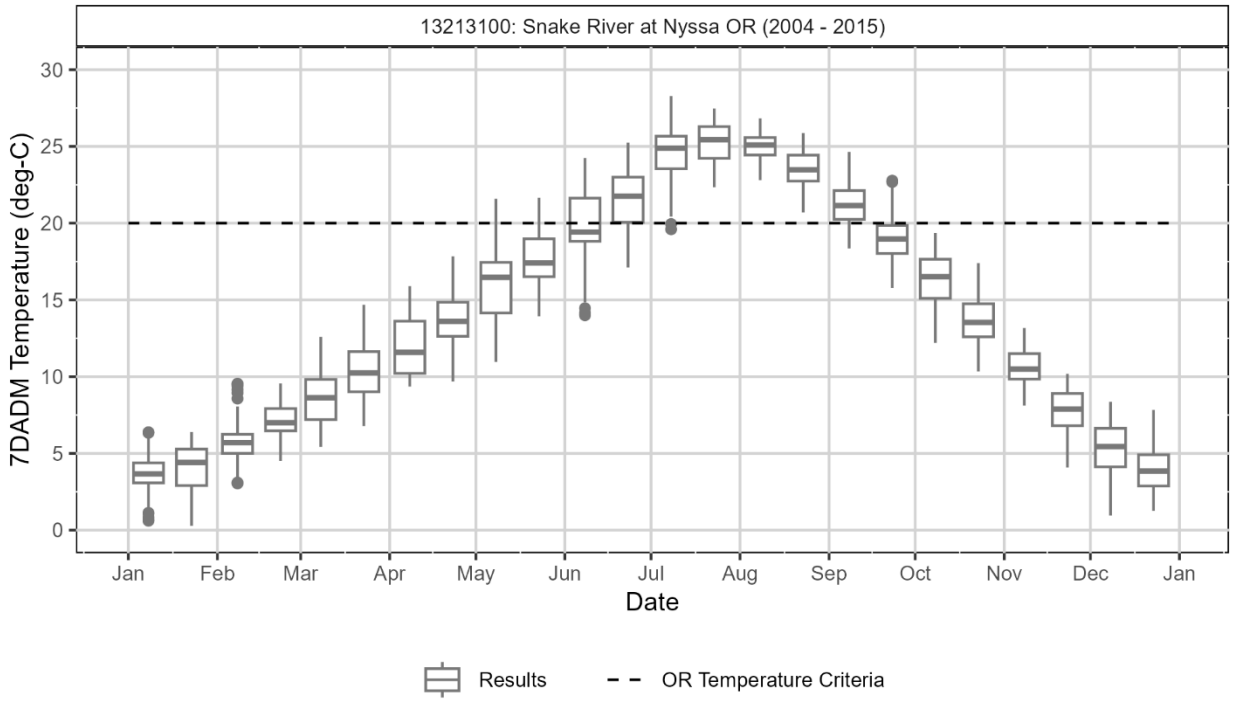


Figure 5-2: Seasonal variation of 7DADM temperatures near Snake River mile 382 at Nyssa, Oregon.

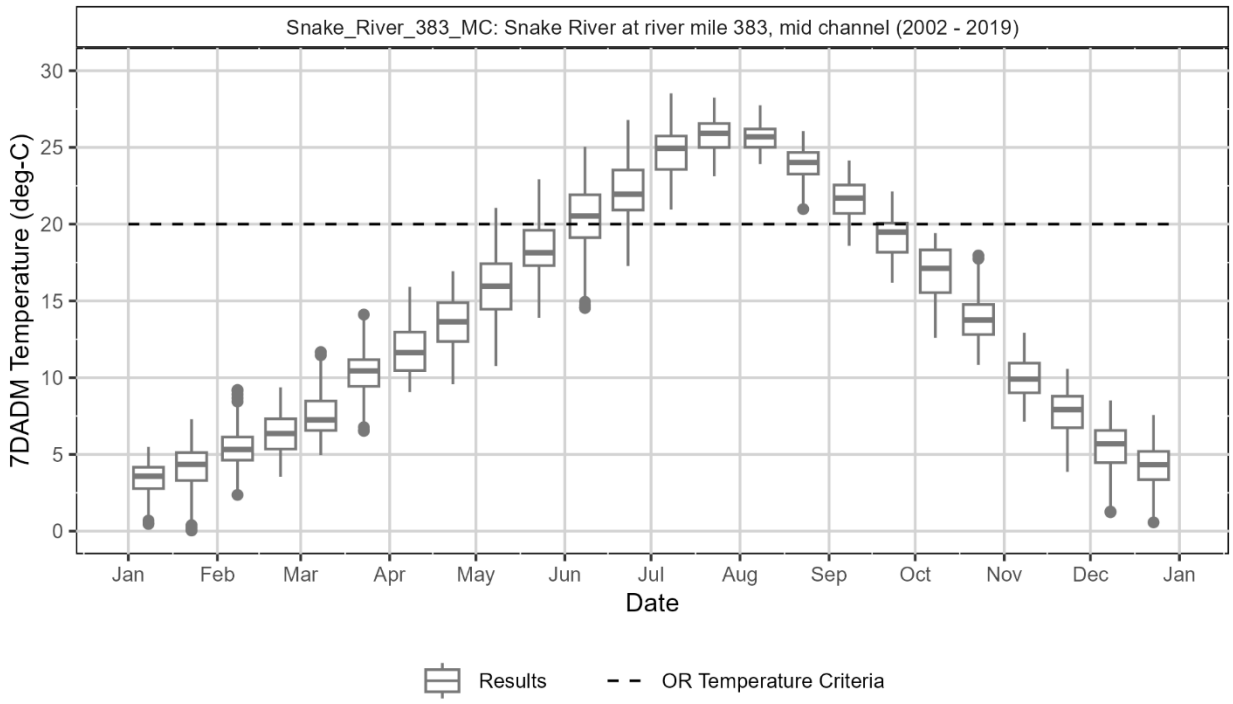


Figure 5-3: Seasonal variation of 7DADM temperatures at Snake River mile 383.

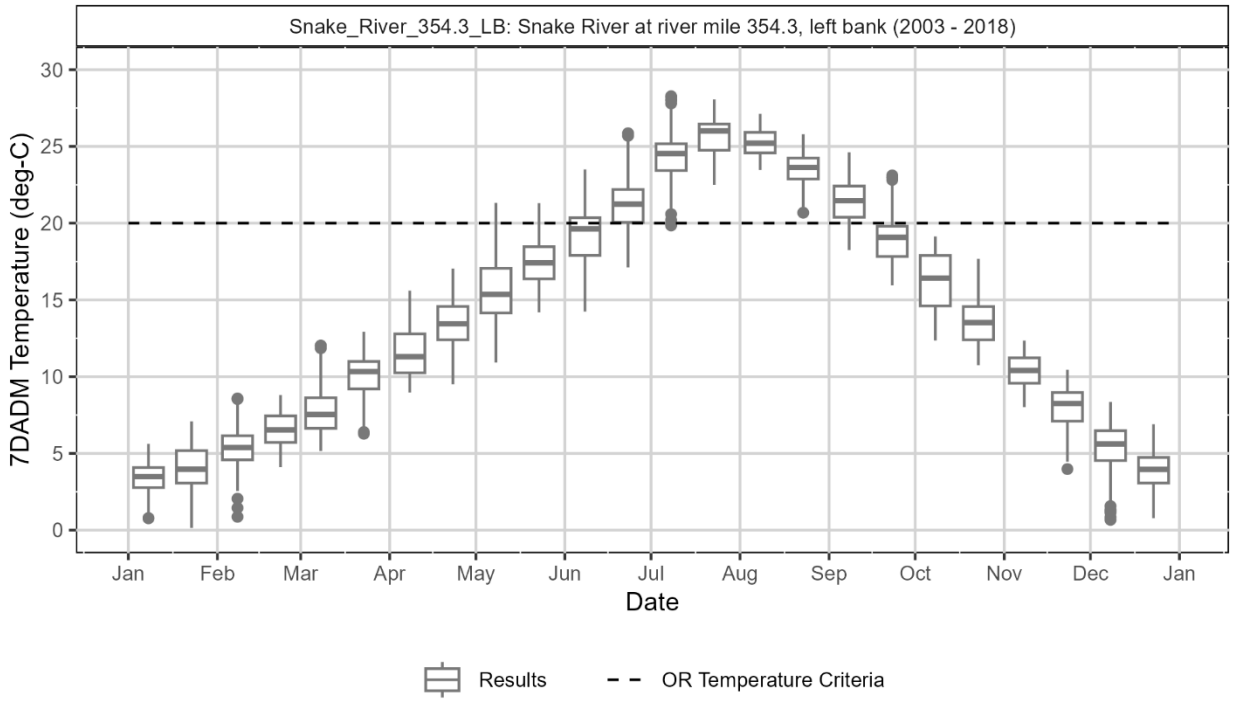


Figure 5-4: Seasonal variation of 7DADM temperatures at Snake River mile 354.

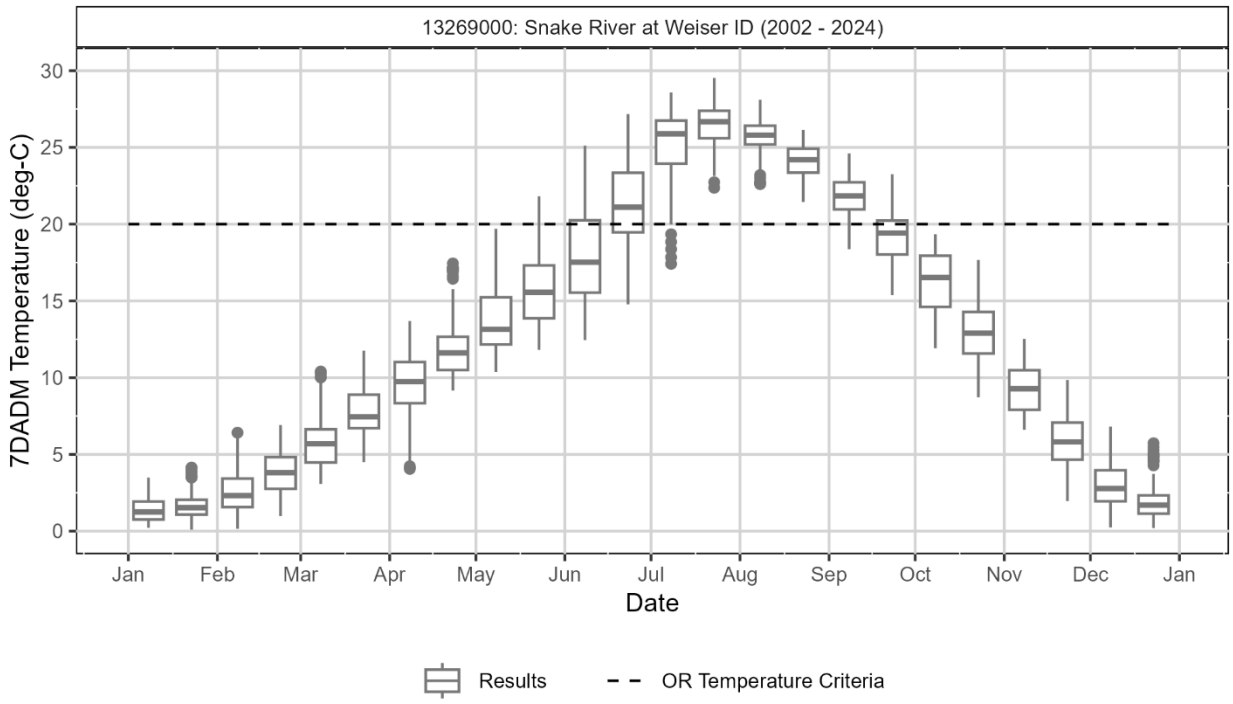


Figure 5-5: Seasonal variation of 7DADM temperatures at Snake River mile 346 at Weiser, Idaho.

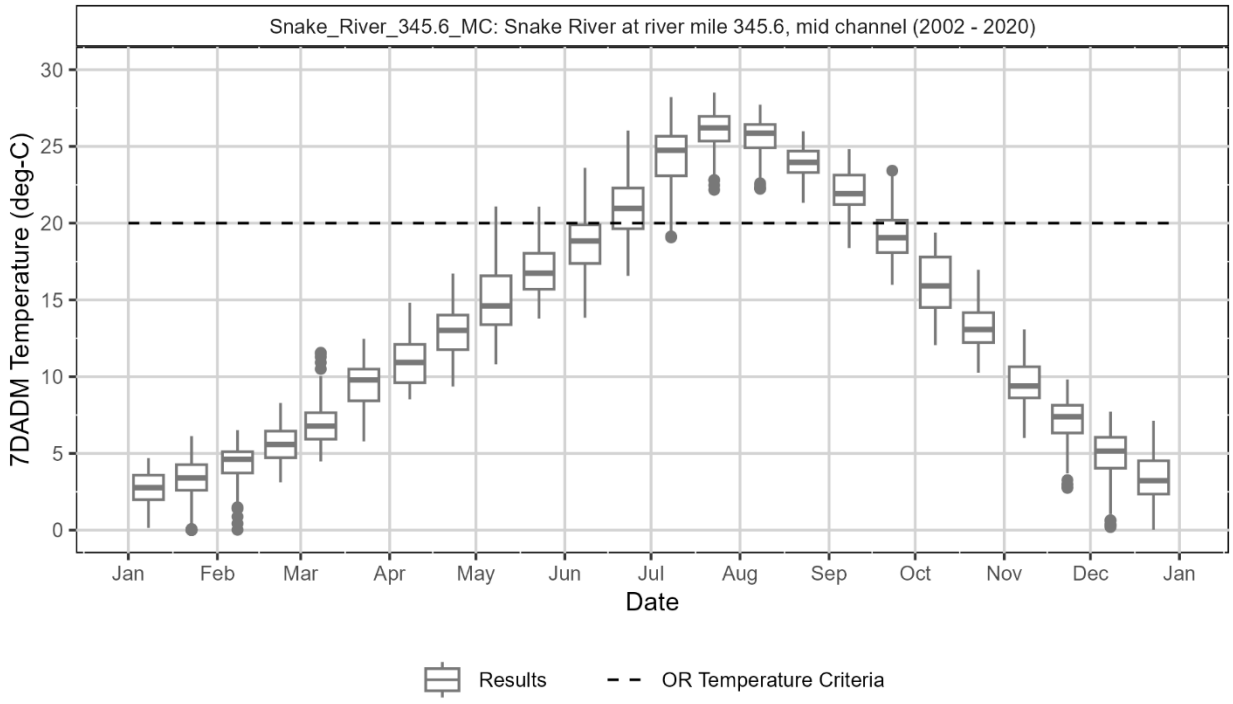


Figure 5-6: Seasonal variation of 7DADM temperatures at Snake River mile 345.6, mid channel.

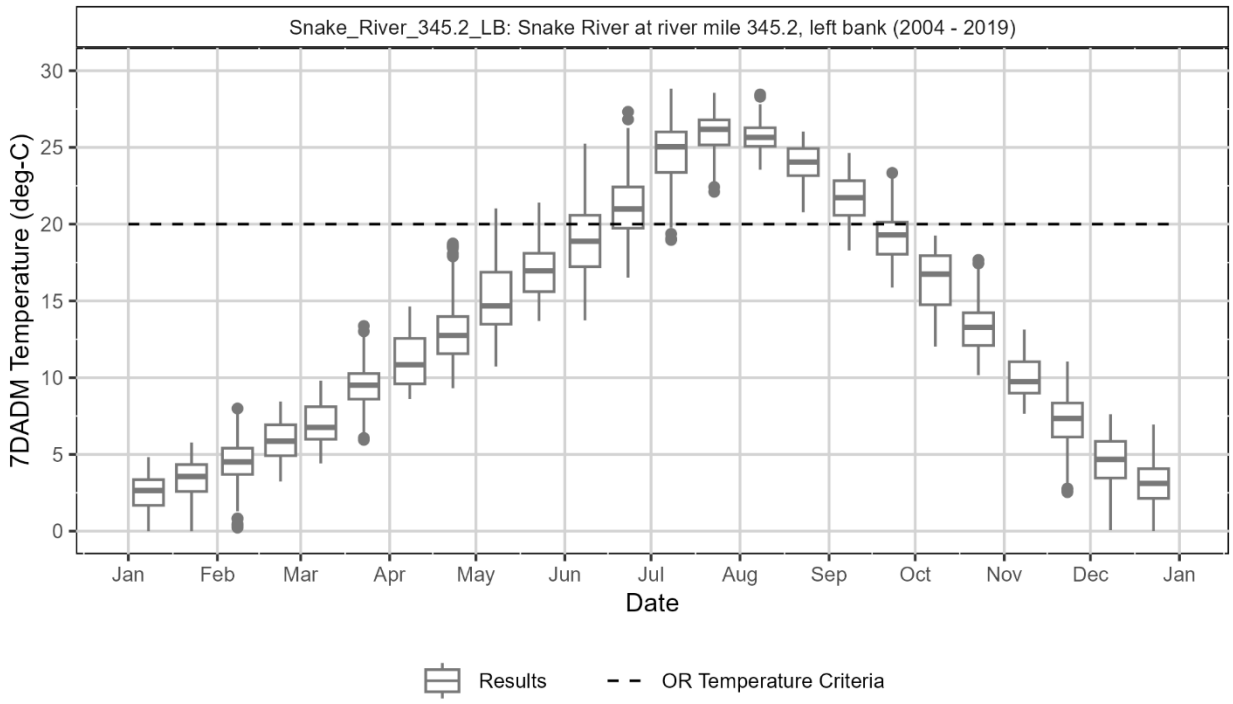


Figure 5-7: Seasonal variation of 7DADM temperatures at Snake River mile 345, left bank channel.

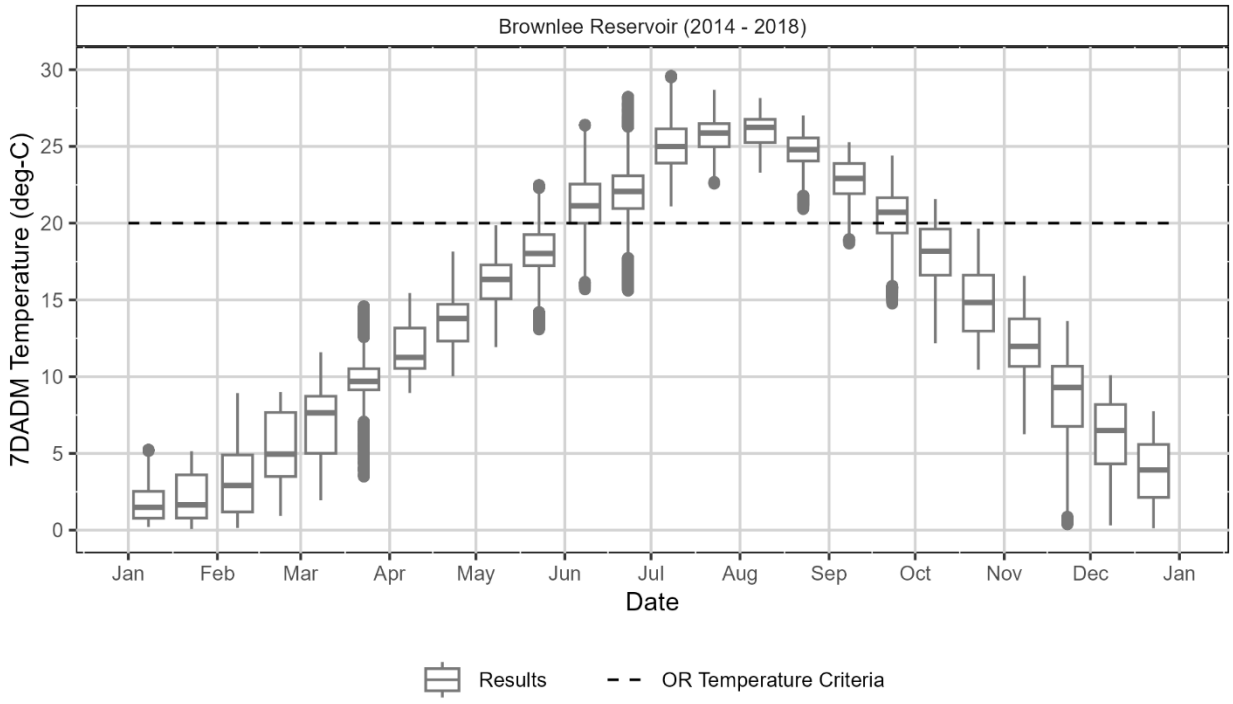


Figure 5-8: Seasonal variation of laterally averaged surface 7DADM temperatures from all Brownlee Reservoir segments in the calibrated model.

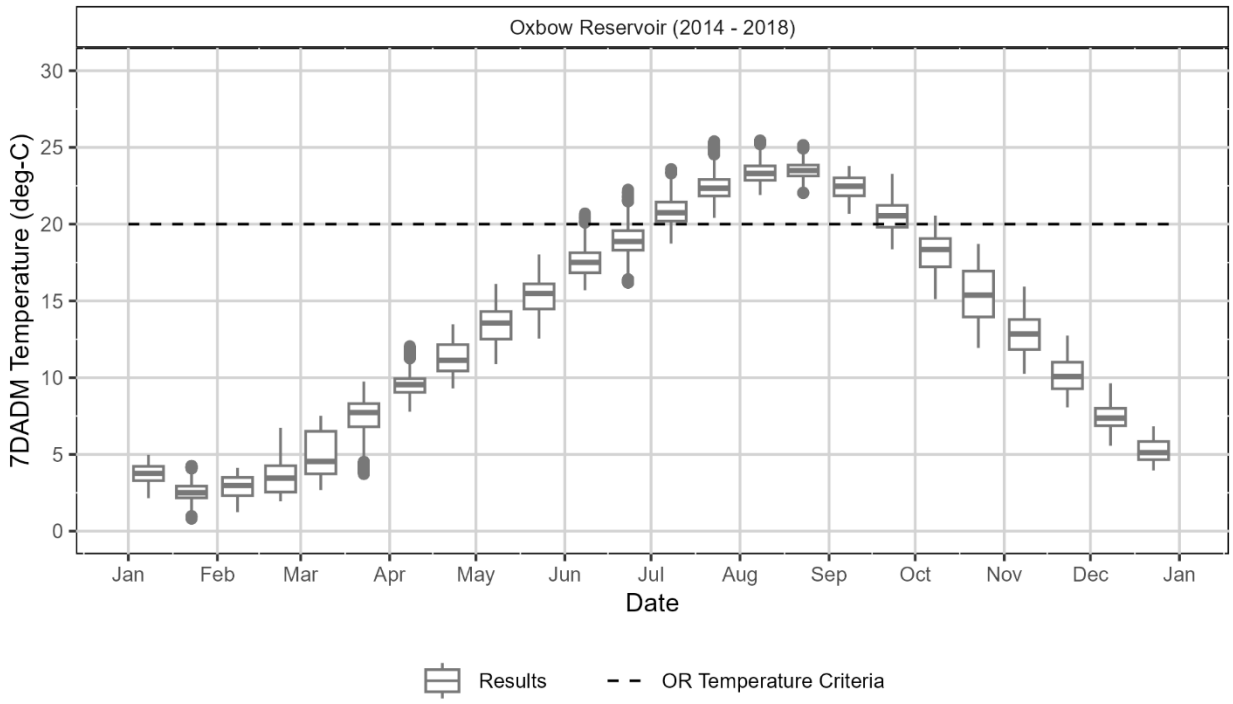


Figure 5-9: Seasonal variation of laterally averaged surface 7DADM temperatures from all Oxbow Reservoir segments in the calibrated model.

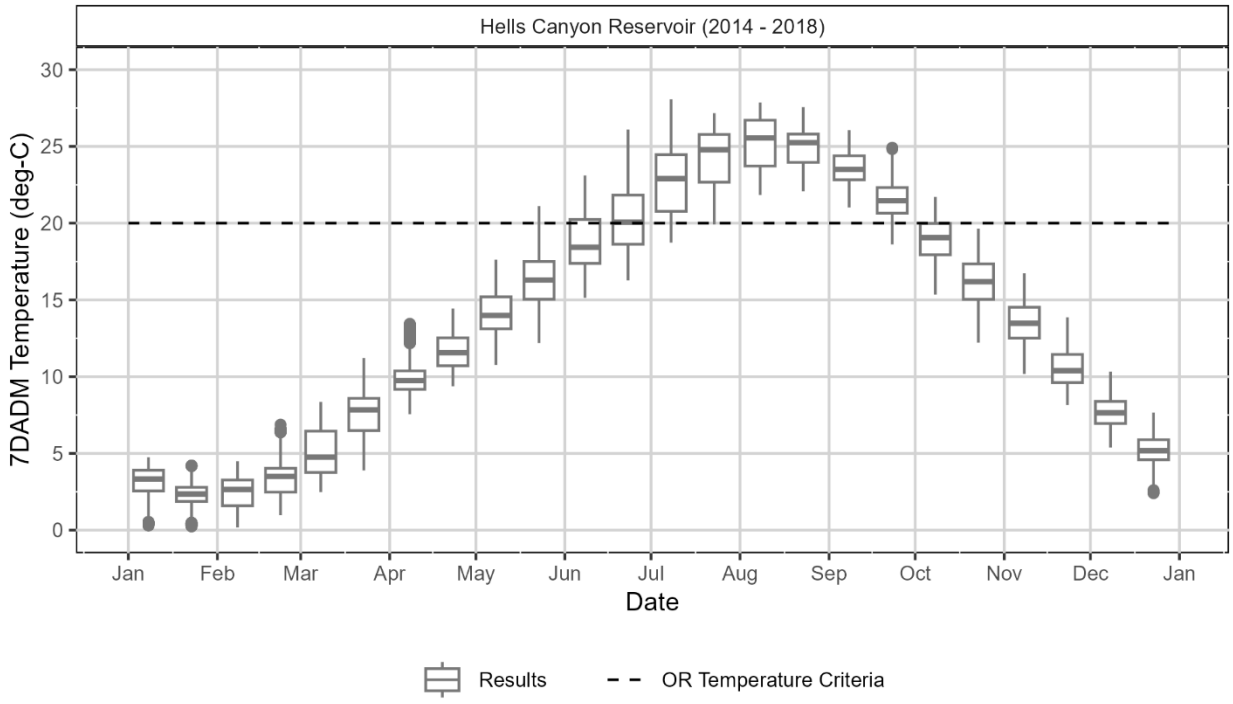


Figure 5-10: Seasonal variation of laterally averaged surface 7DADM temperatures from all Hells Canyon Reservoir segments in the calibrated model.

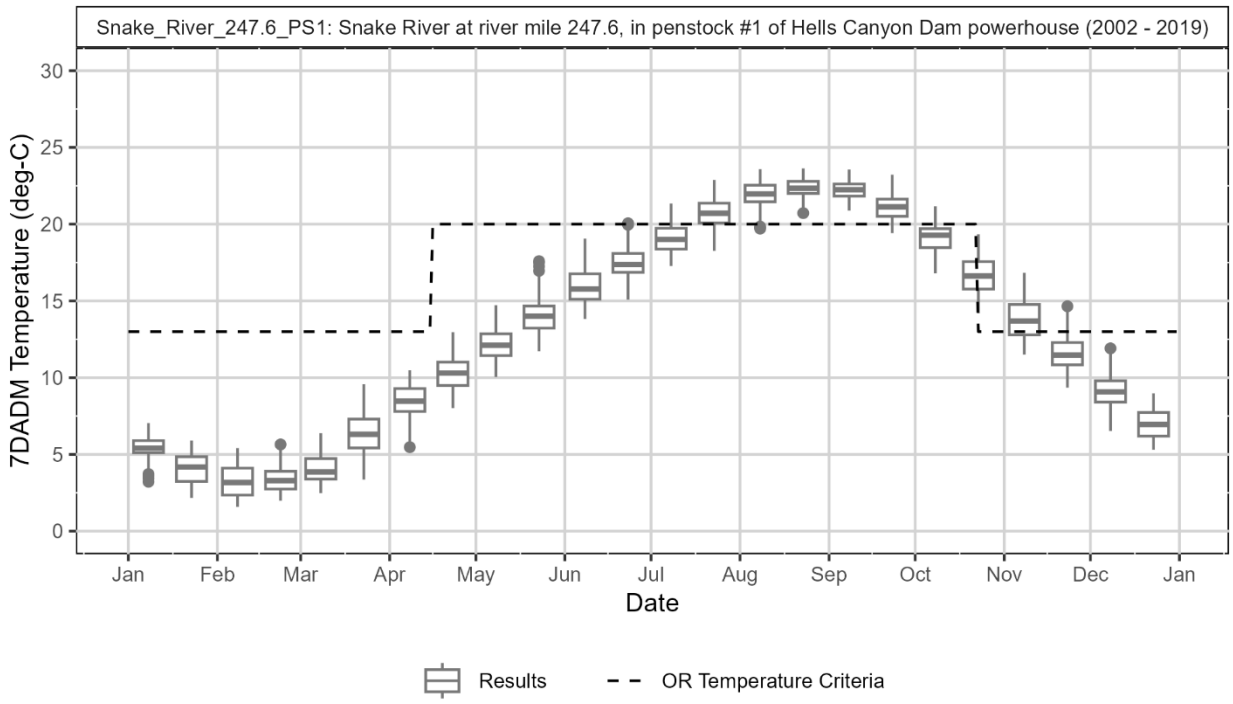


Figure 5-11: Seasonal variation of 7DADM release temperatures from Hells Canyon Dam Penstock #1 at Snake River mile 247.

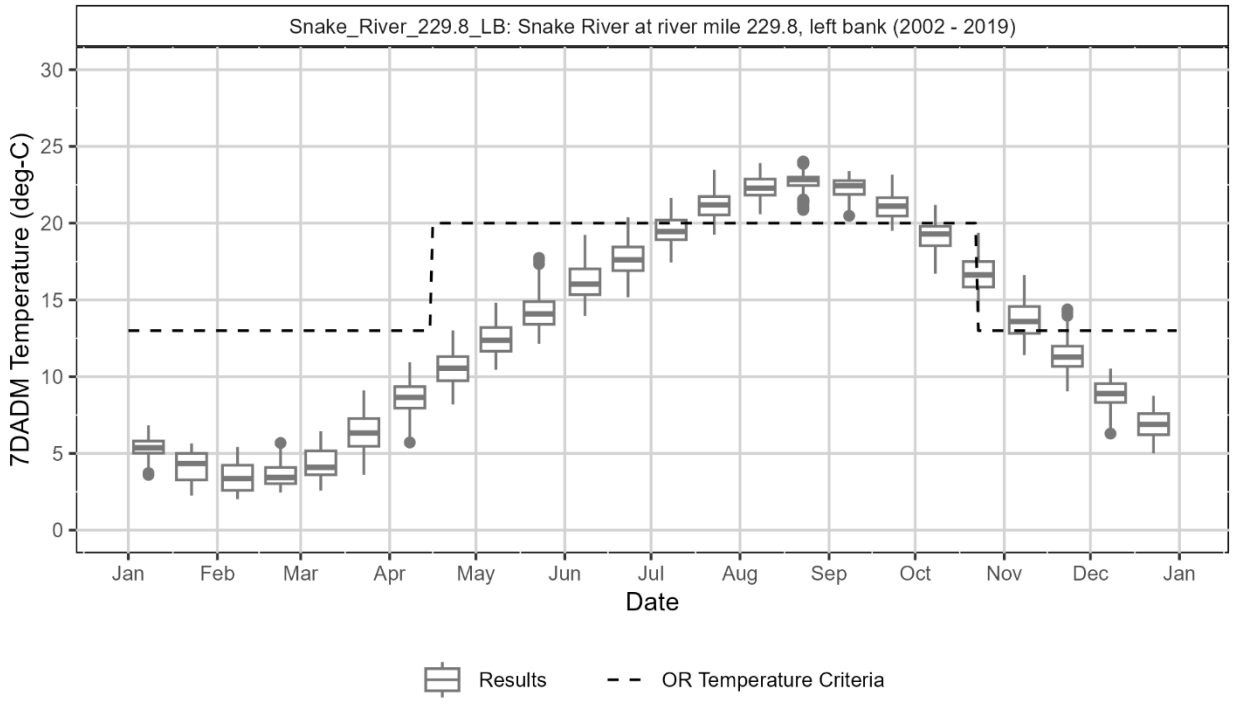


Figure 5-12: Seasonal variation of 7DADM temperatures at Snake River mile 229.

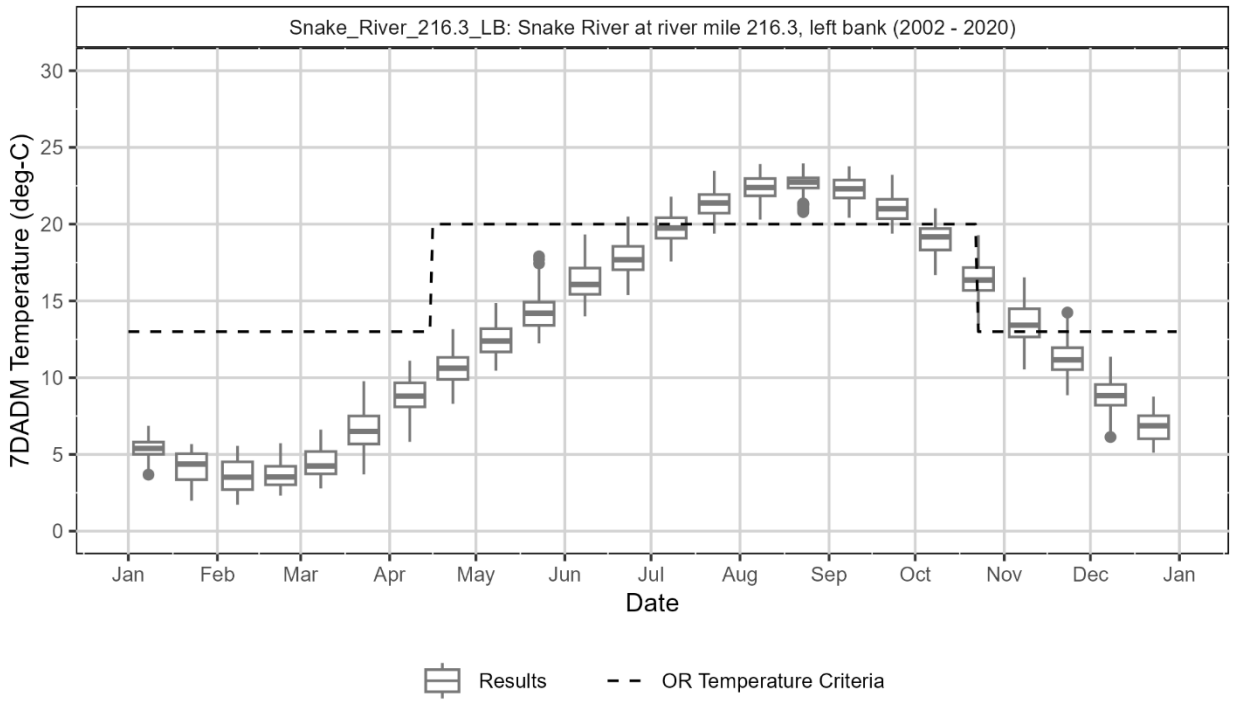


Figure 5-13: Seasonal variation of 7DADM temperatures at Snake River mile 216.

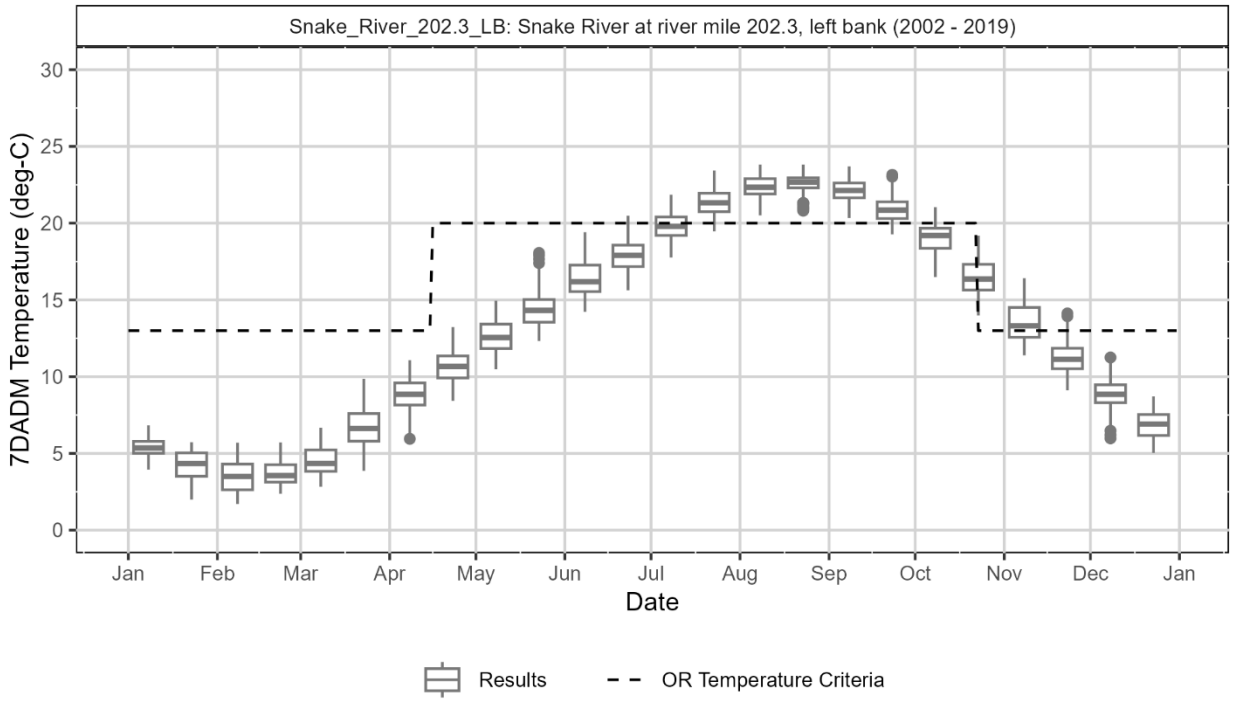


Figure 5-14: Seasonal variation of 7DADM temperatures at Snake River mile 202.

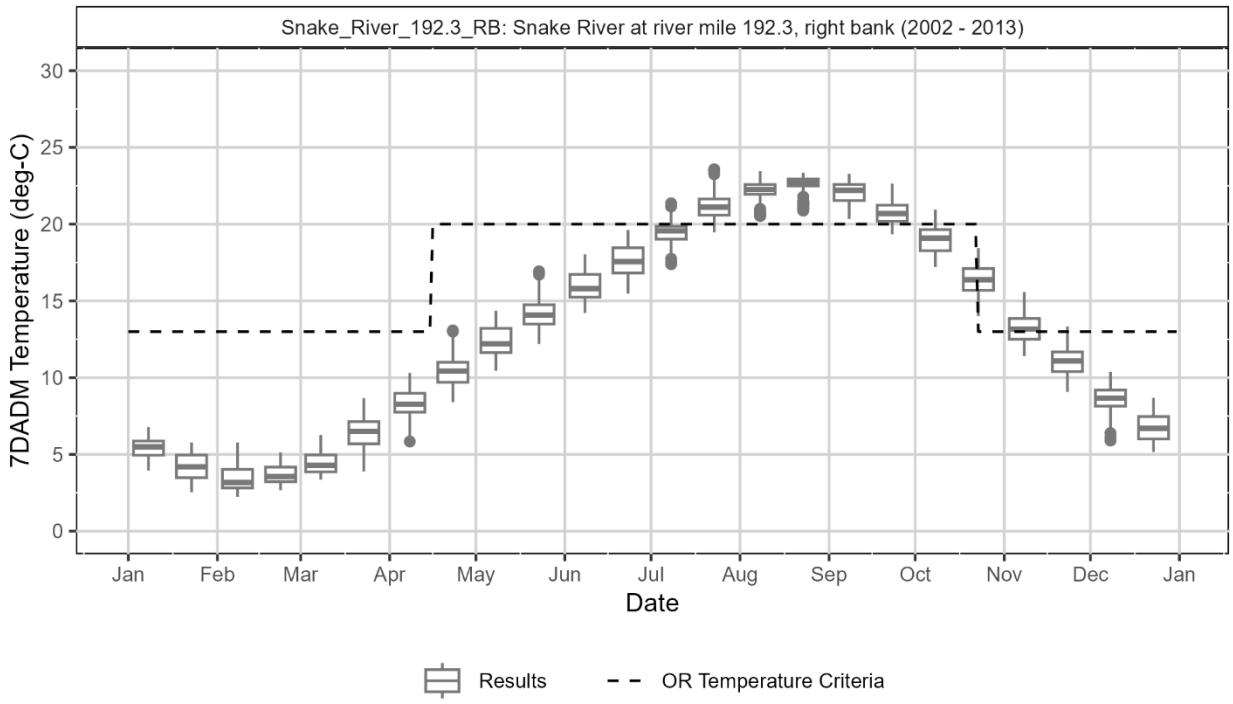


Figure 5-15: Seasonal variation of 7DADM temperatures at Snake River mile 192.

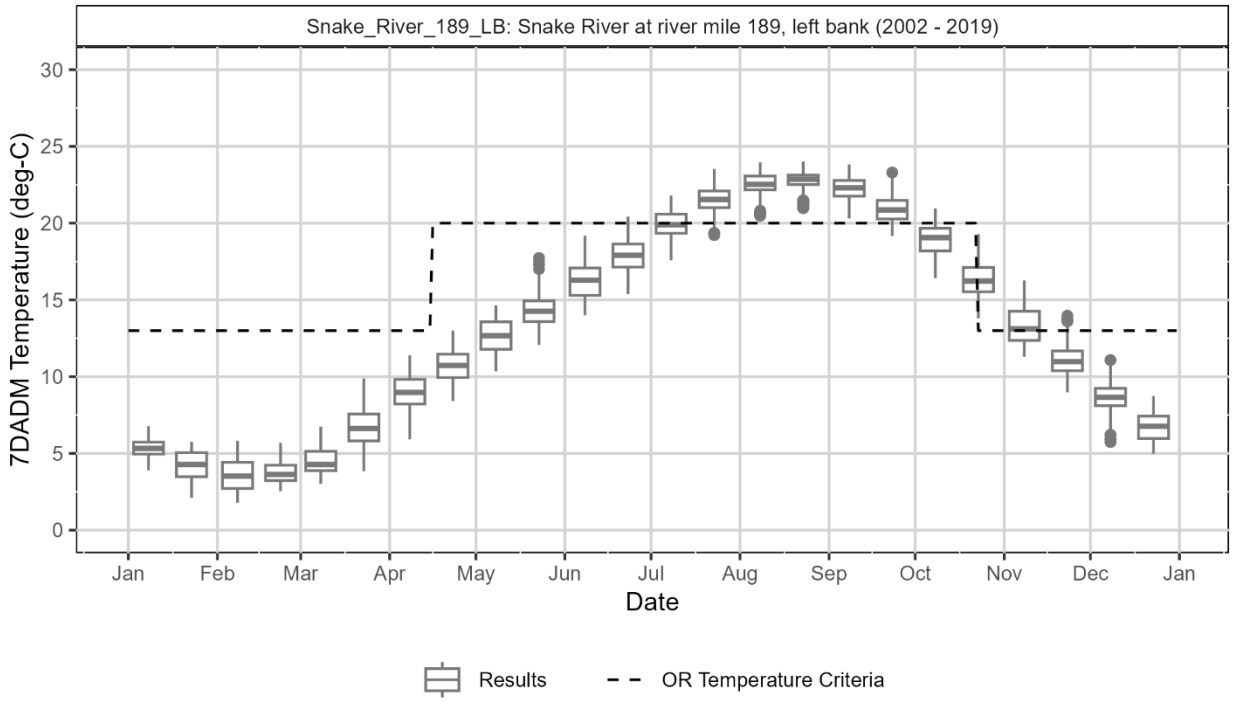


Figure 5-16: Seasonal variation of 7DADM temperatures at Snake River mile 189.

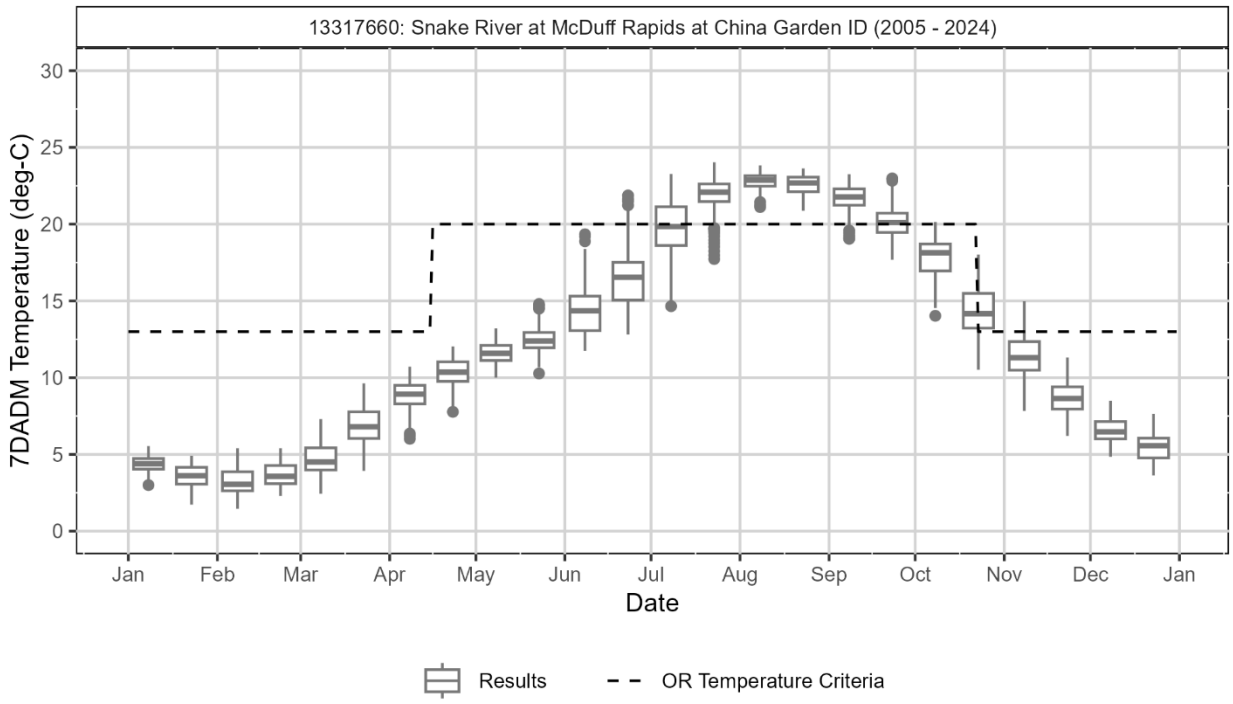


Figure 5-17: Seasonal variation of 7DADM temperatures at Snake River mile 172 at McDuff Rapids/China Garden, ID.

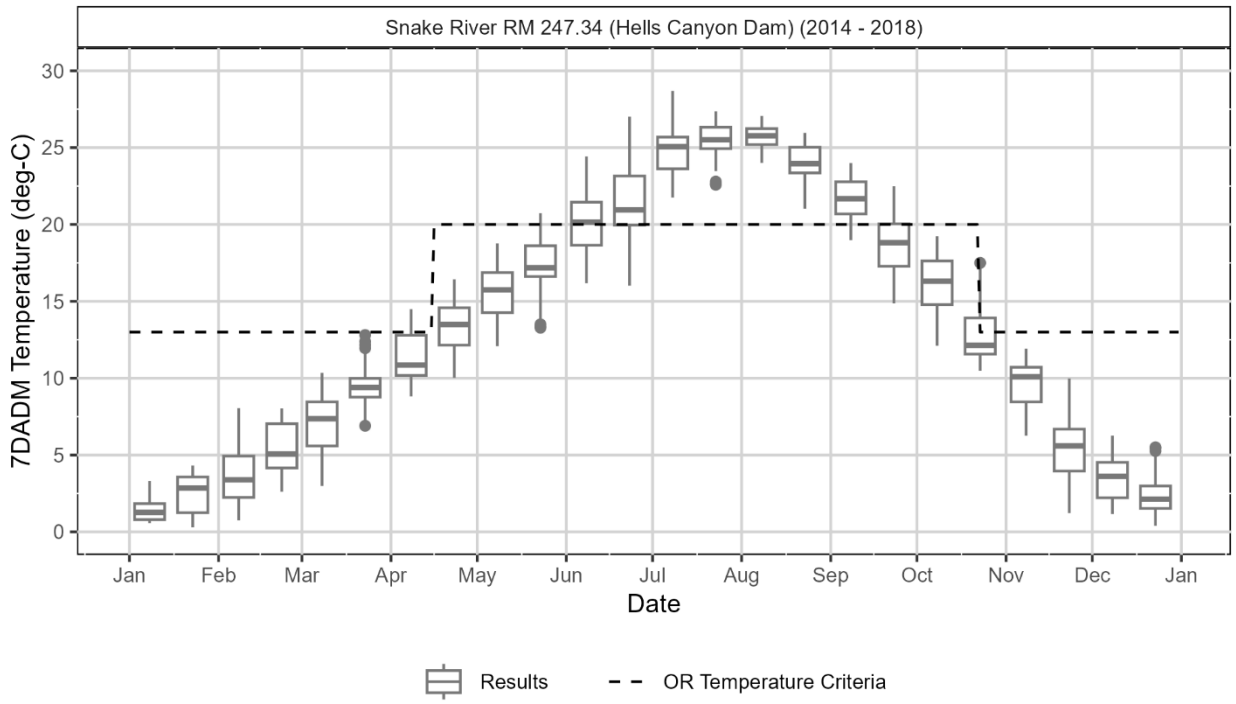


Figure 5-18: Seasonal variation at Snake River mile 247.34 without the seasonal pattern shift currently observed within the reservoirs and downstream of Hells Canyon Dam. 7DADM temperature data is from the No Dam model scenario.

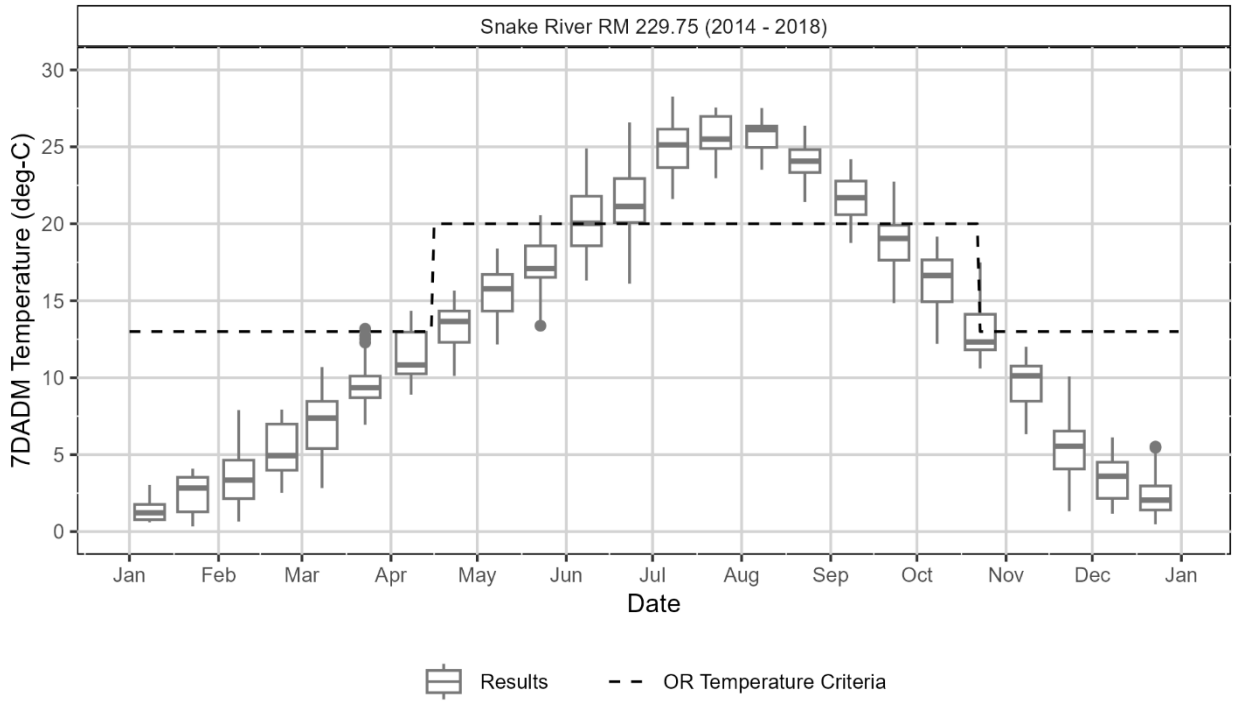


Figure 5-19: Seasonal variation at Snake River mile 229.75 without the seasonal pattern shift currently observed within the reservoirs and downstream of Hells Canyon Dam. 7DADM temperature data is from the No Dam model scenario.

6 Temperature water quality data evaluation and analyses

A critical component to TMDL development is water quality data evaluation and analysis. To the extent that existing data allow, the data and analysis are used to understand and characterize the temperature water quality impairment, assess potential pollutant sources, calculate necessary pollutant reductions, and evaluate various management scenarios and thermal loading levels for sufficiency of attaining the applicable temperature water quality standards. DEQ uses both field measured data and models to complete the TMDL analysis.

6.1 Analysis and data overview

The TMDL development process requires use of numerous temperature, hydrologic, meteorologic, and landscape data sets to characterize temperature conditions and complete a thermal pollutant source assessment. The purpose of the source assessment is to identify the sources of stream temperature warming and quantify the impact and contributions each source

contributes to the temperature criteria exceedances. Data analysis and models provide the means to evaluate potential sources of stream warming and, to the extent existing data allow, the amount of pollutant loading from these sources. The results from this analysis are then used to evaluate the maximum amount of thermal load the waterbody can receive from each source category and still meet temperature criteria. This latter step informs the assignment of allocations to each pollutant source category.

Figure 6-1 summarizes the different data types used to support the TMDL analysis and TMDL model. Data from approximately 77 temperature monitoring sites (Table 6-2) , 29 flow rate or water level monitoring sites (Table 6-3), and 7 meteorological monitoring stations in and around the Snake River were used to support the TMDL analysis. DEQ reviewed multiple years of point source discharge monitoring reports and other relevant information from the NPDES permits to characterize point source discharges (summarized in Section 9.2).

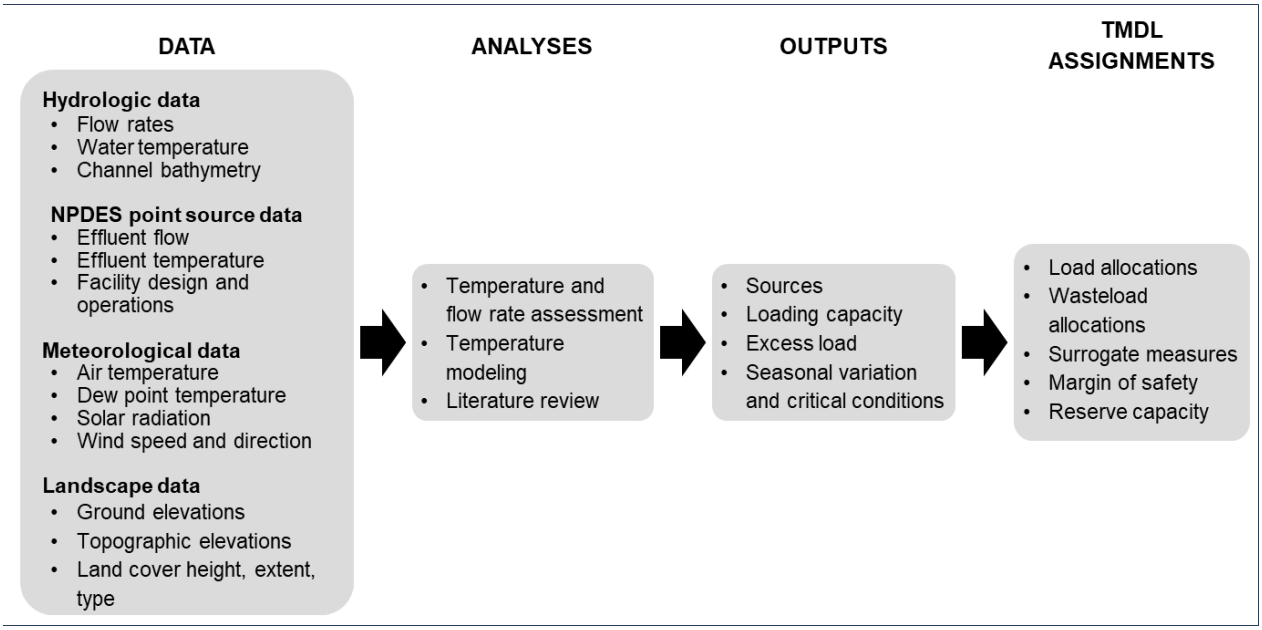


Figure 6-1: Diagram summarizing types of data used for the Snake River temperature TMDL analysis, analysis outputs, and resulting TMDL assignments.

Table 6-1 summarizes how these data were used for the TMDL. Table 6-2 and Table 6-3 identify the specific monitoring sites where temperature and flow related field measured data were used for TMDL development. Appendix A through Appendix C to this document describes the specific applications of these data and data sources. All data are public and available upon request.

Table 6-1: Summary of data types, sources, and how they were used for TMDL development.

Data Type	TMDL Data Uses	Data Sources
Continuous stream temperature	Stream temperature characterization Temperature criteria attainment analysis Seasonal variation and critical period analyses Excess load calculation Loading capacity calculation Allocation calculation Model tributary input and model calibration	Idaho Power Company, United States Geological Survey, Oregon DEQ, Washington Department of Ecology, Untied States Bureau of Reclamation
Stream flow rates and water level (reservoirs)	Stream flow rate characterization Seasonal variation and critical period analyses 7Q10 low flow calculation Excess load calculation Loading capacity calculation Allocation calculation Model tributary input and model calibration	Idaho Power Company, United States Geological Survey, Untied States Bureau of Reclamation
Point source discharge temperatures and flow rates	Effluent discharge and thermal load characterization Allocation calculation Model input	Oregon DEQ, Idaho DEQ, Idaho Power Company, City of Fruitland, City of Ontario, City of Weiser, City of Asotin, Simplot – Ontario
Meteorological data: air temperature, dew point temperature, wind speed, wind direction, and shortwave solar radiation.	Model input	United States Bureau of Reclamation Agrimet, Idaho Power Company, United States Geological Survey
River channel and reservoir bathymetry	Derive channel elevation, shape, and location for model setup.	Idaho Power Company and U.S. Army Corps of Engineers
USGS 30m and LiDAR 1m bare earth digital elevation models (DEM). LiDAR 1m digital surface model (DSM)	Derive land surface elevation and river gradients Derive vegetation elevation and height Derive topographic shade	United States Geological Survey, Oregon Department of Geology and Mineral Industries

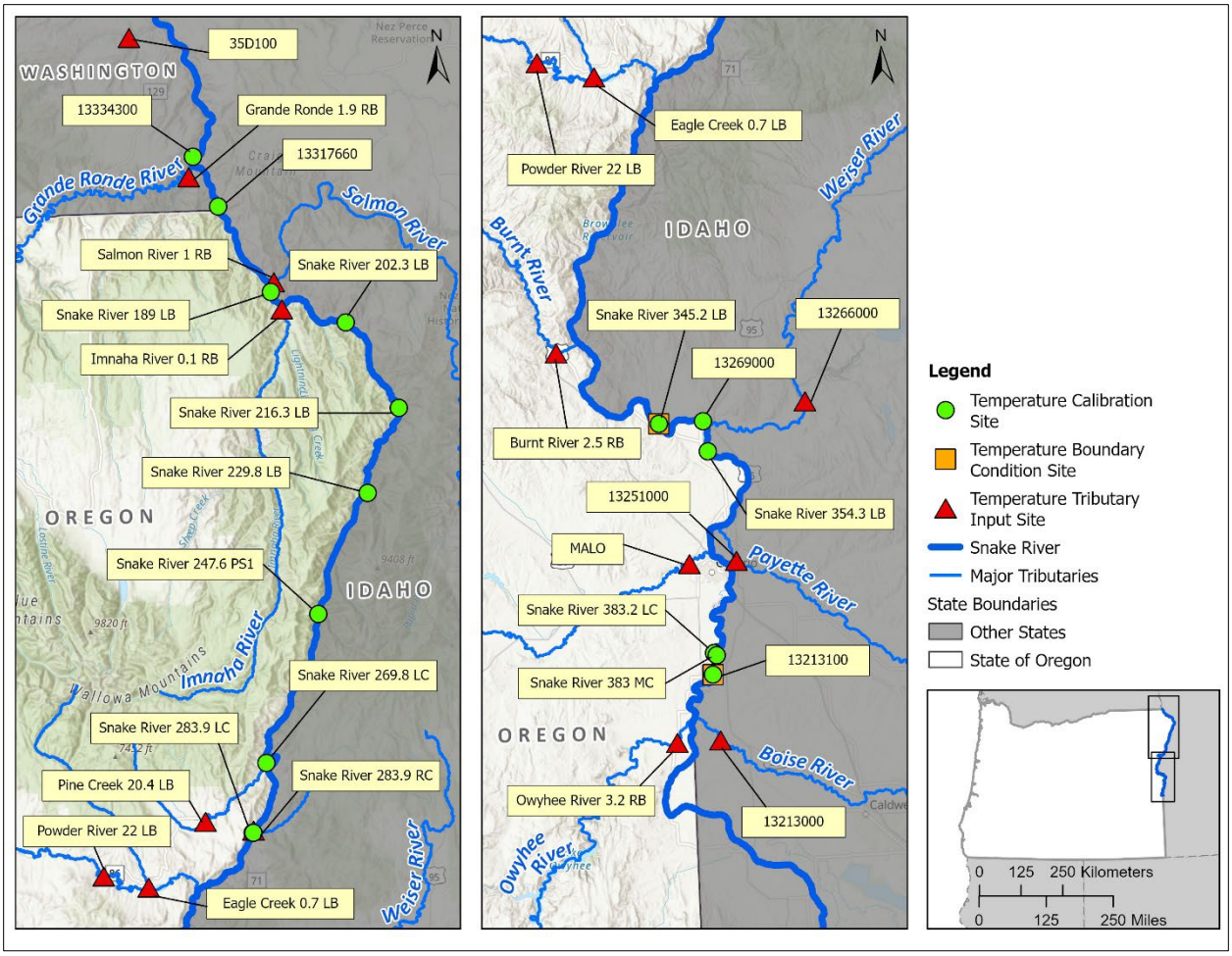


Figure 6-2: Locations of temperature monitoring sites used for Snake River TMDL development.

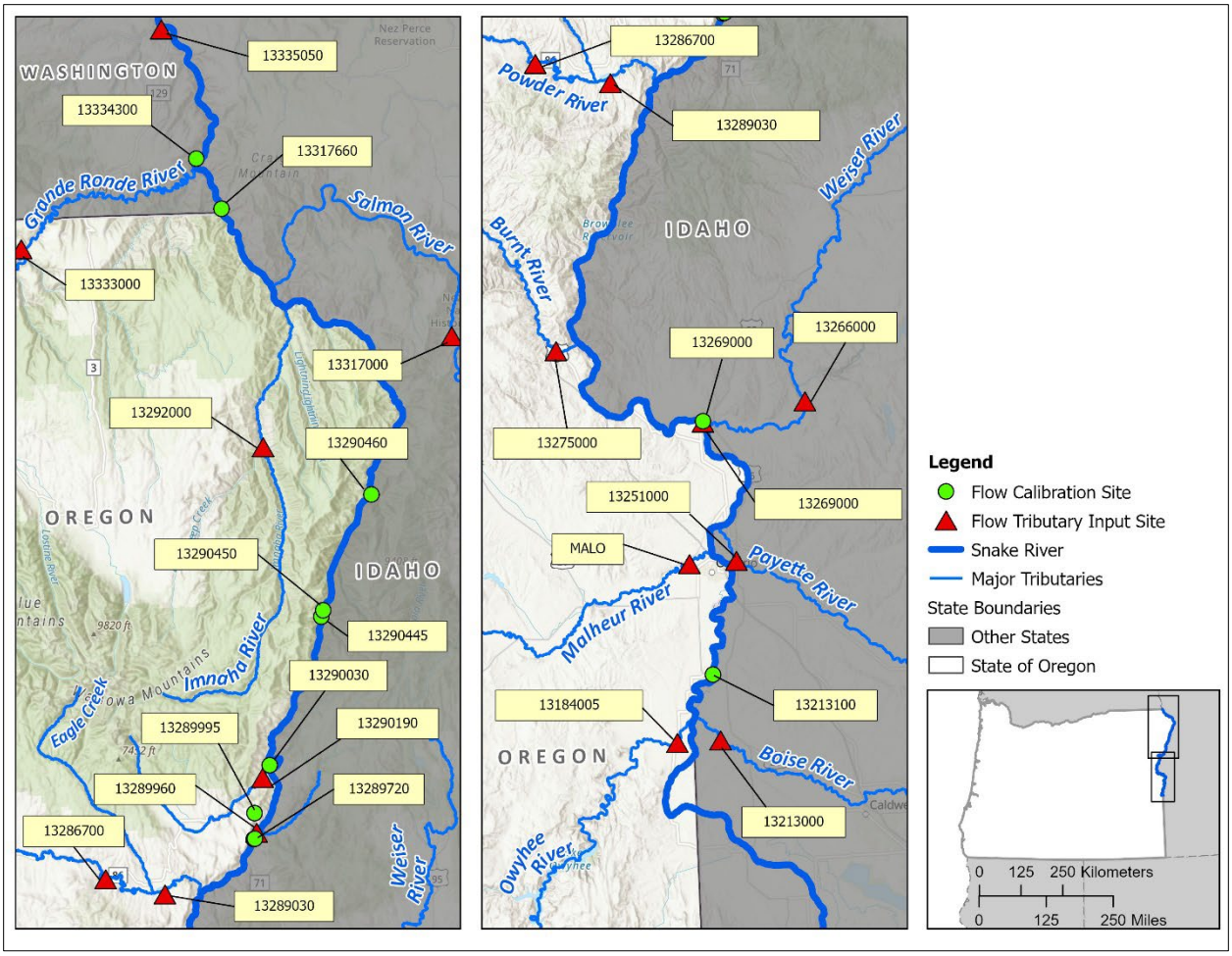


Figure 6-3: Locations of flow and water level monitoring sites used for Snake River TMDL development.

Table 6-2: Summary of all temperature monitoring sites used for Snake River TMDL development.

Monitoring Location ID	Monitoring Location	Latitude	Longitude	Data Source
13173600	Snake River near Adrian OR	43.7310	-117.0718	USGS
13213000	Boise River Near Parma, ID	43.7817	-116.9728	USGS
13213100	Snake River at Nyssa OR	43.8761	-116.9825	USGS
13251000	Payette River Near Payette, ID	44.0422	-116.9253	USGS
13266000	Weiser River Near Weiser, ID	44.2700	-116.7722	USGS
13269000	Snake River at Weiser ID	44.2456	-116.9808	USGS
13317660	Snake River at McDuff Rapids at China Garden ID	46.0031	-116.9169	USGS
13334300	Snake River Near Anatone, WA	46.0971	-116.9777	USGS
35D100	Asotin Cr. abv George Creek	46.3231	-117.1349	WAECY
Battle_Creek_0.1_MC	Battle Creek at river mile 0.1, mid channel	45.3120	-116.6764	IPC

Monitoring Location ID	Monitoring Location	Latitude	Longitude	Data Source
Battle_Creek_0.12_MC	Battle Creek at river mile 0.12, mid channel	45.3120	-116.6765	IPC
Bernard_Creek_0.1_MC	Bernard Creek at river mile 0.1, mid channel	45.4010	-116.6124	IPC
Bernard_Creek_0.12_MC	Bernard Creek at river mile 0.12, mid channel	45.4010	-116.6124	IPC
Big_Canyon_Creek_0.1_MC	Big Canyon Creek at river mile 0.1, mid channel	45.6781	-116.5215	IPC
Big_Canyon_Creek_0.12_MC	Big Canyon Creek at river mile 0.12, mid channel	45.6779	-116.5217	IPC
Brush_Creek_0.1_MC	Brush Creek at river mile 0.1, mid channel	45.2780	-116.6726	IPC
Burnt_River_2.5_RB	Burnt River at river mile 2.5, right bank	44.3551	-117.2732	IPC
Deep_Creek_247.5_0.1_MC	Deep Creek at river mile 0.1, mid channel	45.2449	-116.6973	IPC
Deep_Creek_247.5_0.12_MC	Deep Creek at river mile 0.12, mid channel	45.2448	-116.6969	IPC
Divide_Creek_0.1_MC	Divide Creek at river mile 0.1, mid channel	45.8270	-116.7377	IPC
Divide_Creek_0.12_MC	Divide Creek at river mile 0.12, mid channel	45.8272	-116.7379	IPC
Deep_Creek_247.5_0.1_MC	Deep Creek at river mile 0.1, mid channel	45.2449	-116.6973	IPC
Eagle_Creek_0.7_LB	Eagle Creek at river mile 0.7, left bank	44.7548	-117.1738	IPC
Eureka_Creek_0.1_MC	Eureka Creek at river mile 0.1, mid channel	45.8230	-116.7755	IPC
Eureka_Creek_0.12_MC	Eureka Creek at river mile 0.12, mid channel	45.8230	-116.7756	IPC
Getta_Creek_0.1_MC	Getta Creek at river mile 0.1, mid channel	45.7474	-116.5417	IPC
Getta_Creek_0.12_MC	Getta Creek at river mile 0.12, mid channel	45.7473	-116.5420	IPC
Grande_Ronde_1.9_RB	Grande Ronde at river mile 1.9, right bank	46.0620	-116.9917	IPC
Granite_Creek_0.2_LB	Granite Creek at river mile 0.2, left bank	45.3472	-116.6538	IPC
Hat_Creek_0.1_MC	Hat Creek at river mile 0.1, mid channel	45.3957	-116.6210	IPC
Hat_Creek_0.12_MC	Hat Creek at river mile 0.12, mid channel	45.3957	-116.6210	IPC
Imnaha_River_0.1_RB	Imnaha River at river mile 0.1, right bank	45.8108	-116.7604	IPC

Monitoring Location ID	Monitoring Location	Latitude	Longitude	Data Source
Imnaha_River_0.3_LC	Imnaha River at river mile 0.3, left half channel	45.8145	-116.7632	IPC
Knight_Creek_0.1_MC	Knight Creek at river mile 0.1, mid channel	45.8280	-116.7854	IPC
Knight_Creek_0.12_MC	Knight Creek at river mile 0.12, mid channel	45.8280	-116.7854	IPC
MALO	Malheur River at 36th St. Bridge near Ontario, OR	44.0403	-117.0204	BOR
Owyhee_River_3.2_RB	Owyhee River at river mile 3.2, right bank	43.7807	-117.0600	IPC
Pine_Creek_20.4_LB	Pine Creek at river mile 20.4, left bank	44.8718	-117.0195	IPC
Pittsburg_Creek_0.1_MC	Pittsburg Creek at river mile 0.1, mid channel	45.6282	-116.4740	IPC
Pittsburg_Creek_0.12_MC	Pittsburg Creek at river mile 0.12, mid channel	45.6280	-116.4745	IPC
Powder_River_22_LB	Powder River at river mile 22, left bank	44.7787	-117.2893	IPC
Rush_Creek_0.1_MC	Rush Creek at river mile 0.1, mid channel	45.4503	-116.5814	IPC
Rush_Creek_0.12_MC	Rush Creek at river mile 0.12, mid channel	45.4503	-116.5814	IPC
Saddle_Creek_0.1_MC	Saddle Creek at river mile 0.1, mid channel	45.3918	-116.6250	IPC
Saddle_Creek_0.12_MC	Saddle Creek at river mile 0.12, mid channel	45.3918	-116.6251	IPC
Salmon_River_1_RB	Salmon River at river mile 1, right bank	45.8611	-116.7786	IPC
Salt_Creek_0.1_MC	Salt Creek at river mile 0.1, mid channel	45.5533	-116.5275	IPC
Salt_Creek_0.12_MC	Salt Creek at river mile 0.12, mid channel	45.5533	-116.5274	IPC
Sheep_Creek_0.1_LB	Sheep Creek at river mile 0.1, left bank	45.4681	-116.5534	IPC
Sheep_Creek_0.3_LB	Sheep Creek at river mile 0.3, left bank	45.4670	-116.5492	IPC
Sluice_Creek_0.1_MC	Sluice Creek at river mile 0.1, mid channel	45.4452	-116.5858	IPC
Sluice_Creek_0.12_MC	Sluice Creek at river mile 0.12, mid channel	45.4452	-116.5858	IPC
Snake_River_189_LB	Snake River at river mile 189, left bank	45.8416	-116.7879	IPC
Snake_River_192.3_RB	Snake River at river mile 192.3, right bank	45.8164	-116.7583	IPC

Monitoring Location ID	Monitoring Location	Latitude	Longitude	Data Source
Snake_River_202.3_LB	Snake River at river mile 202.3, left bank	45.7786	-116.5938	IPC
Snake_River_216.3_LB	Snake River at river mile 216.3, left bank	45.6164	-116.4643	IPC
Snake_River_229.8_LB	Snake River at river mile 229.8, left bank	45.4626	-116.5573	IPC
Snake_River_247.6_PS1	Snake River at river mile 247.6, in penstock #1 of Hells Canyon Dam powerhouse	45.2438	-116.7015	IPC
Snake_River_269.8_LC	Snake River at river mile 269.8, left half channel	44.9729	-116.8542	IPC
Snake_River_283.9_LC	Snake River at river mile 283.9, left half channel	44.8454	-116.8978	IPC
Snake_River_283.9_RC	Snake River at river mile 283.9, right half channel	44.8451	-116.8967	IPC
Snake_River_345.2_LB	Snake River at river mile 345.2, left bank	44.2444	-117.0708	IPC
Snake_River_345.6_LC	Snake River at river mile 345.6, left half channel	44.2397	-117.0664	IPC
Snake_River_345.6_MC	Snake River at river mile 345.6, mid channel	44.2398	-117.0664	IPC
Snake_River_354.3_LB	Snake River at river mile 354.3, left bank	44.2013	-116.9735	IPC
Snake_River_383.2_LC	Snake River at river mile 383.2, left half channel	43.9074	-116.9780	IPC
Snake_River_383_MC	Snake River at river mile 383, mid channel	43.9041	-116.9736	IPC
Somers_Creek_0.1_MC	Somers Creek at river mile 0.1, mid channel	45.6845	-116.5308	IPC
Somers_Creek_0.12_MC	Somers Creek at river mile 0.12, mid channel	45.6844	-116.5309	IPC
Temperance_Creek_0.1_MC	Temperance Creek at river mile 0.1, mid channel	45.5400	-116.5312	IPC
Temperance_Creek_0.12_MC	Temperance Creek at river mile 0.12, mid channel	45.5399	-116.5310	IPC
Three_Creek_0.1_MC	Three Creek at river mile 0.1, mid channel	45.3667	-116.6391	IPC
Three_Creek_0.12_MC	Three Creek at river mile 0.12, mid channel	45.3666	-116.6391	IPC
Tryon_Creek_0.1_MC	Tryon Creek at river mile 0.1, mid channel	45.6928	-116.5369	IPC
Wildhorse_0.1_LB	Wildhorse River at river mile 0.1, left bank	44.8518	-116.8955	IPC
Wolf_Creek_0.1_MC	Wolf Creek at river mile 0.1, mid channel	45.7716	-116.5810	IPC

Monitoring Location ID	Monitoring Location	Latitude	Longitude	Data Source
Wolf_Creek_0.12_MC	Wolf Creek at river mile 0.12, mid channel	45.7717	-116.5809	IPC

Table 6-3: Flow and water level monitoring sites used for Snake River TMDL development.

Monitoring Location ID	Monitoring Location	Latitude	Longitude	Data Source
13173600	Snake River near Adrian, OR	43.7310	-117.0718	USGS
13184005	Owyhee River Near Adrian, OR	43.7808	-117.0600	IPC
13213000	Boise River Near Parma, ID	43.7817	-116.9728	USGS
13213100	Snake River at Nyssa, OR	43.8761	-116.9825	USGS
13251000	Payette River near Payette, ID	44.0422	-116.9253	USGS
13266000	Weiser River Near Weiser, ID	44.2700	-116.7722	USGS
13269000	Snake River at Weiser, ID	44.2456	-116.9808	USGS
13275000	Burnt River at Huntington, OR	44.3582	-117.2732	USGS
13286700	Powder River near Richland	44.7777	-117.2927	IPC
13288300	Eagle Creek at Richland	44.7546	-117.1739	IPC
13289030	Daly Creek below Diversion near Richland, OR	44.7452	-117.1405	IPC
13289702	Brownlee Reservoir	44.8379	-116.9039	IPC
13289720	Snake River below Brownlee Dam	44.8388	-116.9010	IPC
13289960	Wildhorse River at Brownlee Dam, ID	44.8519	-116.8958	USGS
13289995	Oxbow Reservoir	44.8856	-116.8994	IPC
13290030	Snake River below Oxbow Dam	44.9728	-116.8540	IPC
13290190	Pine Creek near Oxbow	44.9525	-116.8742	IPC
13290445	Hells Canyon Reservoir	45.2428	-116.7021	IPC
13290450	Snake River below Hells Canyon Dam	45.2544	-116.6969	IPC
13290460	Snake River at Johnson Bar ID-OR State Line	45.4633	-116.5564	USGS
13290460	Snake River at Johnson Bar	45.4633	-116.5564	IPC
13292000	Imnaha River at Imnaha	45.5624	-116.8343	IPC
13292000	Imnaha River at Imnaha, OR	45.5624	-116.8343	IPC
13317000	Salmon River at White Bird, ID	45.7503	-116.3239	USGS
13317660	Snake River at McDuff Rapids at China Garden, ID	46.0031	-116.9169	USGS
13333000	Grande Ronde River at Troy, OR	45.9457	-117.4510	USGS
13334300	Snake River Near Anatone, WA	46.0971	-116.9777	USGS
13335050	Asotin Creek at Asotin, WA	46.3407	-117.0560	USGS
MALO	Malheur River at 36th St Bridge Ontario, OR	44.0403	-117.0204	BOR

6.2 Model setup and application overview

The CE-QUAL-W2 model, version 4.5 was used to support the TMDL analyses. CE-QUAL-W2 is a laterally averaged, two-dimensional hydrodynamic and temperature model developed by the U.S. Army Corps of Engineers and Portland State University (Wells, 2021).

The calibrated model for Brownlee, Oxbow, and Hells Canyon was developed by Portland State University and Idaho Power (Appendix A). EPA and their contractor Tetra Tech, and Oregon DEQ led the development of Snake River calibrated model which includes the riverine sections upstream and downstream of the reservoirs (Appendix B). The models for the riverine sections of the Snake River are new and were not available for the 2004 TMDL. There are also several model scenarios developed evaluating different management options and the TMDL allocations (Appendix C). These new and updated models were used to understand how current conditions and source activity contribute to loading and temperature dynamics.

The model covers a five-year period from the beginning of 2014 to the end of 2018.

There are six linked models stretching from mile 398 river near the town of Adrian, Oregon, through the reservoirs, downstream to the Clearwater River at Lewiston, Idaho. The extent of the six linked models is as follows:

- Adrian to Brownlee (RM 398 – 345)
- Brownlee Reservoir (RM 345 – 285)
- Oxbow Reservoir (RM 258 – 272)
- Hells Canyon Reservoir (RM 272 – 247)
- Hells Canyon Dam to OR-ID-WA border (RM 247 – 176)
- OR-ID-WA border to Clearwater River, ID (RM 176 - 139)

The model extent downstream in Washington and Idaho was not used for the TMDL, however it was included as part of the broader model development effort in order to fill the last remaining model gap in the Lower Snake and Columbia River system. There is now a model for the entire extent of the Snake River starting at the upstream Oregon/Idaho border downstream through the Columbia River to the Pacific Ocean.

Within the model domain, there are 14 major tributary inflows, seven point sources, and the three Hells Canyon Complex dams.

To understand the influence of different sources, as well as how temperatures change under different management scenarios, a number of model scenarios were developed. These include:

- **No Point sources**. The No Point Source scenario is the same as the calibration except there are no point source discharges.
- **Restored Vegetation**. Restored Vegetation is a scenario that has restored vegetation conditions.
- **No Dams**. The No Dams scenario has the dam and reservoirs removed. The main changes are to the model bathymetry and the vegetation within the reservoir footprints. The bathymetry for the reservoir models is configured based on our best estimate of the historic river channel. Restored vegetation was also included along the historic channel and where there is dam infrastructure. The purpose of this scenario is to estimate the temperature response without the influence of the dam and reservoirs.
- **Background.** Background is a combination of No point sources, Restored Vegetation, and No Dams scenarios.

- **Wasteload Allocations**. The wasteload allocation scenario has the point source discharges modified to reflect the proposed TMDL wasteload allocations.
- **Tributary A**. Tributary A scenario is the same as the Background model but with Oregon tributary temperatures increased by the 0.3ºC Human Use Allowance. Idaho tributaries were increased by the amounts identified in the 2004 TMDL or by amount authorized by existing NPDES permits (e.g. Weiser River).
- **Tributary B.** Tributary B is also the same as the background model, but the tributary temperatures were reduced so they attain the applicable temperature criteria.
- **HCC Surrogate Target**. This scenario has Hells Canyon Dam releases set at the TMDL surrogate target temperatures. The surrogate target attains the assigned load allocation and implements the natural seasonal thermal pattern narrative.
- **Human Use Allowance Attainment**. The HUA attainment scenario evaluates attainment of the cumulative human use allowance assignments based on point and nonpoint sources being set at their proposed allocations. In this scenario, point sources are set to their proposed wasteload allocations, tributary temperatures are increased by the portion of their respective human use allowances, and vegetation is set to restored conditions.
- **Reserve Capacity.** There were two reserve capacity model scenarios used to evaluate if there is sufficient capacity to hold some of the human use allowance as reserve capacity. Both are the same as the HUA Attainment scenario, but with a hypothetical allocation of +0.10ºC and +0.15 ºC temperature increase at the upstream model boundary near the ID/OR border.

The details on model setup and calibration are discussed in Appendix A and B. The setup and results of the model scenarios is discussed in Appendix C.

Evaluating the temperature response or temperature change from a particular source category was accomplished primarily by comparing two different model scenarios. Table 6-4, also included in TSD Appendix C, summarizes what questions or topics are answered through the comparison of different model scenarios. The results of these comparisons were used to determine the effect of allocations and the effect of different source category activity on stream temperatures.

Table 6-4: Summary of question or topic addressed by Snake River model scenario comparisons.

Scenario Baseline	Scenario Comparison	Question/topic addressed
No Point Source	Calibration	Effect of NPDES-permitted point source discharges.
No Dams	Calibration	Effect of existing dams and reservoir operations.
Restored Vegetation	Calibration	Effect of fully restored vegetation along the Snake River mainstem.
Background	Calibration	Effect of anthropogenic sources that were quantified and represented in the model.
Background	Tributary A	Effect of Snake River tributary temperatures set at their respective TMDL HUA allocations.
Background	Tributary B	Effect of elevated temperatures in Snake River tributaries that exceed applicable temperature criteria.
Background	TMDL Wasteload Allocations	Effect of point source discharge at WLAs levels.
Background	HUA Attainment	Effect of point and nonpoint sources set at their respective TMDL allocations. Evaluates attainment of the Human Use Allowance
Background	Surrogate	Effect of Hells Canyon Dam releases set at the TMDL surrogate measure temperature target.
Background	Applicable temperature criteria	Temperature criteria exceedances contributed by background sources.
Background	Reserve Capacity +0.1 °C	Effect of point and nonpoint sources set at their respective TMDL allocations plus a hypothetical allocation of reserve capacity equal to 0.1°C increase at the upstream Snake River model boundary (RM 398) near Adrian, Oregon.
Background	Reserve Capacity +0.15 °C	Effect of point and nonpoint sources set at their respective TMDL allocations plus a hypothetical allocation of reserve capacity equal to 0.15 °C increase at the upstream Snake River model boundary (RM 398) near Adrian, Oregon.

6.3 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). 7Q10s is considered the critical low flow and used to calculate numeric loading capacities and allocations. DEQ calculated annual 7Q10s for each assessment unit (Table 6-5) and upstream of each NPDES permitted point source discharge (Table 6-6).

The 7Q10s were calculated from available daily mean flow rate data measured at USGS or IPC gaging stations between January 1, 1990 and December 31, 2024 (up to 35 years). DEQ relied

on the quality control protocols implemented by USGS and IPC. Only data with a result status of "Approved" or "Published" were included in 7Q10 calculations. Annual 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. At least 10 years of flow data were used with some exceptions. The water year (Oct 1 – Sept 30) was used to define the annual period. For ungaged assessment units, it was possible to estimate the daily mean flow using gages located upstream, downstream, or on tributaries. The daily mean flows at the ungaged reach were estimated by summing or subtracting the daily mean flow from the gaged locations as appropriate. For example, the flow on the Snake River upstream of the Weiser River is not gaged but can be estimated by subtracting flow recorded on the Weiser River (USGS-13266000) from the flows recorded on the Snake River downstream of the Weiser River (IPC-13269000). 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 location were calculated first, prior to the 7Q10 calculation. The annual 7Q10 and the seasonal variation in mean daily flow at Weiser, downstream of Hells Canyon Dam, and at McDuff Rapids at the tri-state border are presented in Figure 6-4 , Figure 6-5, and Figure 6-6, respectively.

Table 6-5: The annual 7Q10 low flow for each assessment unit and the data sources used.

AU ID	Data Sources	Annual 7Q10 (cfs)	Data Period	Count of Daily Mean Flow Results
OR_SR_1705010311_02_102702	USGS 13213100 – USGS 13213000 – IPC 13184005	4256	10/1/2002 - 12/31/2024	7969
OR_SR_1705011501_02_103231	USGS 13213100	4755	01/1/1990 - 12/31/2024	12784
OR_SR_1705011502_02_103230	IPC 13269000 – USGS 13266000	5831	01/1/1990 - 12/31/2024	12784
OR_SR_1705020101_02_103229	IPC 13269000	6092	01/1/1990 - 12/31/2024	12784
OR_LK_1705020103_05_100578	IPC 13289720 (Brownlee Dam outflow)	7251	01/1/2014 - 12/31/2021	2922
OR_LK_1705020311_05_100605	IPC 13286700 + IPC 13288300	8	04/16/1999 - 12/31/2024	8205
OR_LK_1705020107_05_100583	IPC 13290030 (Oxbow Dam outflow)	6854	01/1/2014 - 12/31/2021	2922
OR_LK_1705020107_05_100582	IPC 13290450 (Hells Canyon Dam outflow)	6884	01/1/1990 - 12/31/2024	12748
OR_SR_1706010101_02_103274	USGS/IPC 13290450	6884	01/1/1990 - 12/31/2024	12748

AU ID	Data Sources	Annual 7Q10 (cfs)	Data Period	Count of Daily Mean Flow Results
OR_SR_1706010102_02_103280	USGS/IPC 13290460	7654	10/1/1992 - 12/31/2024	11508
OR_SR_1706010103_02_103282	IPC 13290460	7654	10/1/1992 - 12/31/2024	11508
OR_SR_1706010301_02_103306	USGS 13317660	11369	10/1/2003 - 12/31/2024	7763

Table 6-6: The annual 7Q10 low flow for each NPDES point source and data sources.

NPDES Permittee WQ File Number: EPA Number	Data Source	Annual 7Q10 (cfs)	Data Period	Count of Daily Mean Flow Results
Idaho Power – Hells Canyon Power Plant 41297 : OR0027278	IPC 13290450 (Hells Canyon Dam outflow)	6884	01/1/1990 - 12/31/2024	12748
Idaho Power - Oxbow Power Plant 41299 : OR0027286	IPC 13290030 (Oxbow Dam outflow)	6854	01/1/2014 - 12/31/2021	2922
Ontario STP 63631 : OR0020621	USGS/IPC 13290450	6884	01/1/1990 - 12/31/2024	12748
Simplot – Ontario 63810 : OR0002402	USGS/IPC 13290450	6884	01/1/1990 - 12/31/2024	12748

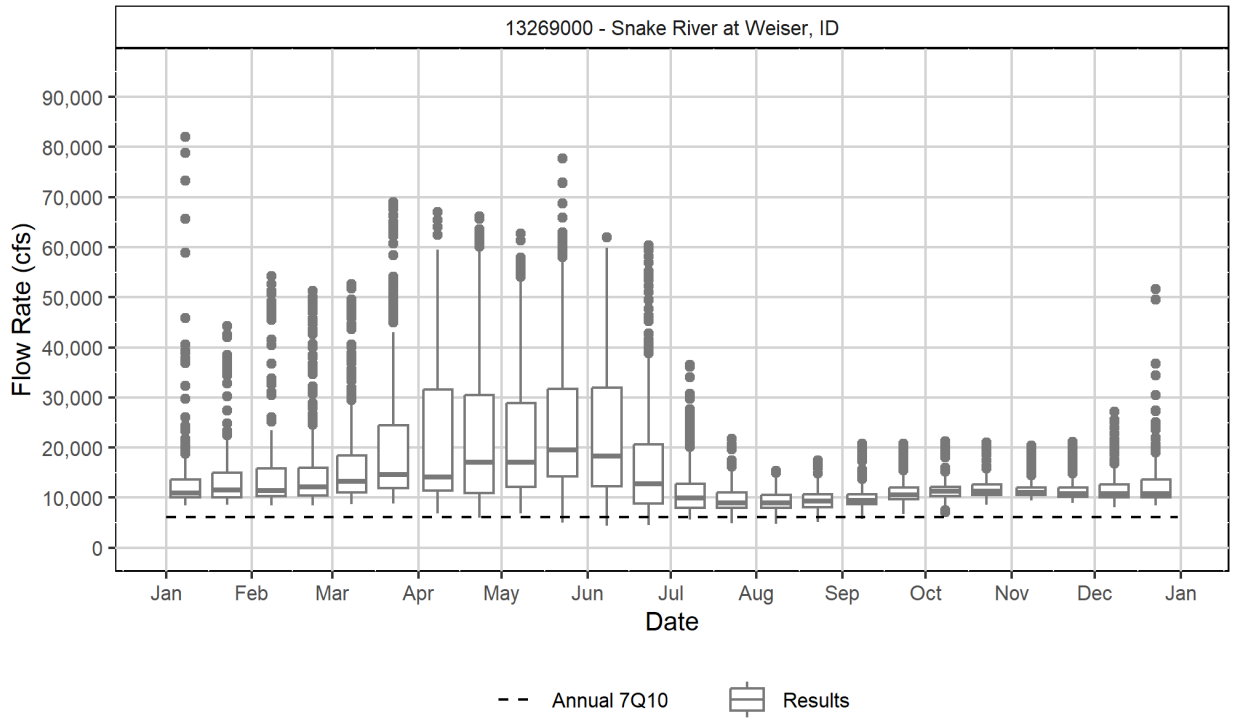


Figure 6-4: Annual 7Q10 and seasonal variation in daily mean flow rates at Snake River mile 346 at Weiser, Idaho.

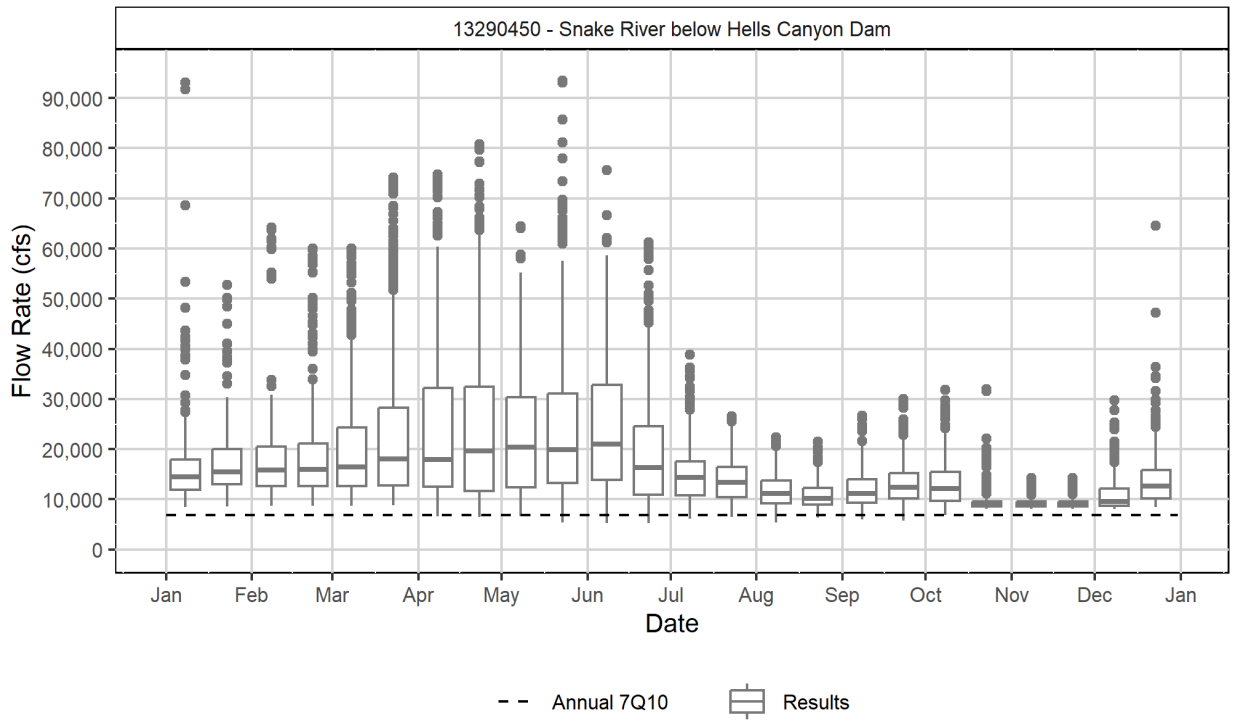


Figure 6-5: Annual 7Q10 and seasonal variation in daily mean flow rates at Snake River mile 247 downstream of Hells Canyon Dam.

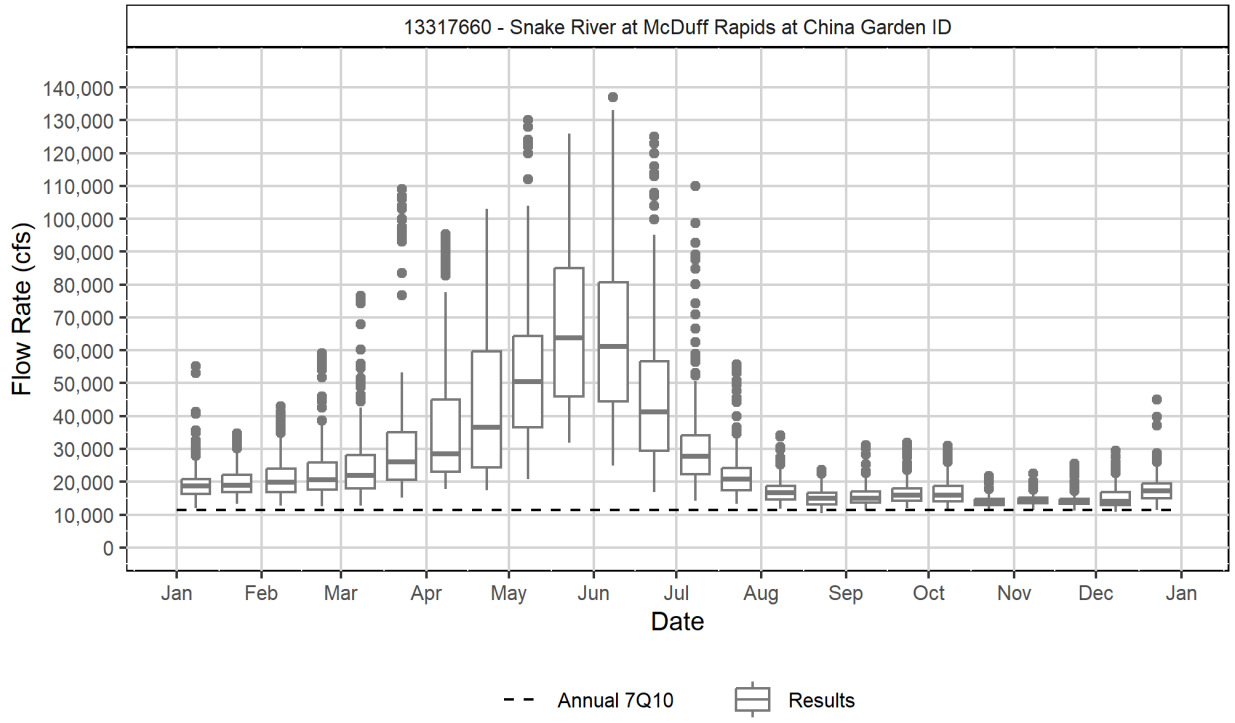


Figure 6-6: Annual 7Q10 and seasonal variation in daily mean flow rates at Snake River mile 176 (tri-state border) at McDuff Rapids at China Garden ID.

7 Pollutant sources and source categories

7.1 Point sources

All non-stormwater individual NPDES permittees with an active permit discharging to the Snake River were identified as sources of thermal loading (Table 7-1). Four of these permittees are located in Oregon and two in Idaho. Only Oregon permittees were assigned thermal wasteload allocations in the TMDL. Individual NPDES permittees located in Idaho were assigned a wasteload allocation in the 2004 TMDL (ODEQ and IDEQ, 2004).

NPDES permitted point source discharges covered by ODOT's Phase I individual MS4 stormwater permit and registrants under the general stormwater permits (MS4 phase II, 1200-A, 1200-C, and 1200-Z) and other Oregon general NPDES permits with discharges to the Snake River (200-J, CAFO NPDES) are not consequential sources of thermal loading and do not impact aquatic life beneficial uses based on DEQ evaluation of the permit requirements, available dilution, or frequency and magnitude of discharges.

7.1.1 Individual NPDES permitted point sources

Non-stormwater Individual NPDES permittees identified in Table 7-1 were identified as a source of thermal loading, The thermal loading from the individual facilities evaluated have a relatively small temperature increase that does not exceed the 0.30°C human use allowance.

Current discharges from Oregon and Idaho NPDES permitted point sources evaluated with the model have a 95th percentile 7DADM cumulative temperature increase by as much as 0.08°C during the summer and 0.06°C during the spawning period. The point of maximum impact is located downstream of Hells Canyon Dam. The thermal loading and temperature increase at each facility's outfall was also evaluated and is discussed in section 9.2.

Table 7-1: Individual NPDES permittees discharging to the Snake River.

NPDES Permittee WQ File Number: EPA Number	Oregon WQ File Number	EPA Number	Applicable Oregon Temperature Criteria (°C)	Receiving Stream (Oregon AU ID)
Idaho Power – Hells Canyon Power Plant	41297	OR0027278	20.0 13.0	Snake River RM 247 (OR_SR_1706010101_02_103274)
Idaho Power - Oxbow Power Plant	41299	OR0027286	20.0	Hells Canyon Reservoir RM 272.5 (OR_LK_1705020107_05_100582)
Idaho Power - Brownlee Power Plant	-	ID0020907	20.0	Oxbow Reservoir RM 284 (OR_LK_1705020107_05_100583)
Ontario STP	63631	OR0020621	20.0	Snake River RM 369 (OR_SR_1705011501_02_103231)
Simplot - Ontario	63810	OR0002402	20.0	Snake River RM 370 (OR_SR_1705011501_02_103231)
Weiser WWTP	-	ID0020290	20.0	Snake River RM 351 (OR_SR_1705011502_02_103230)

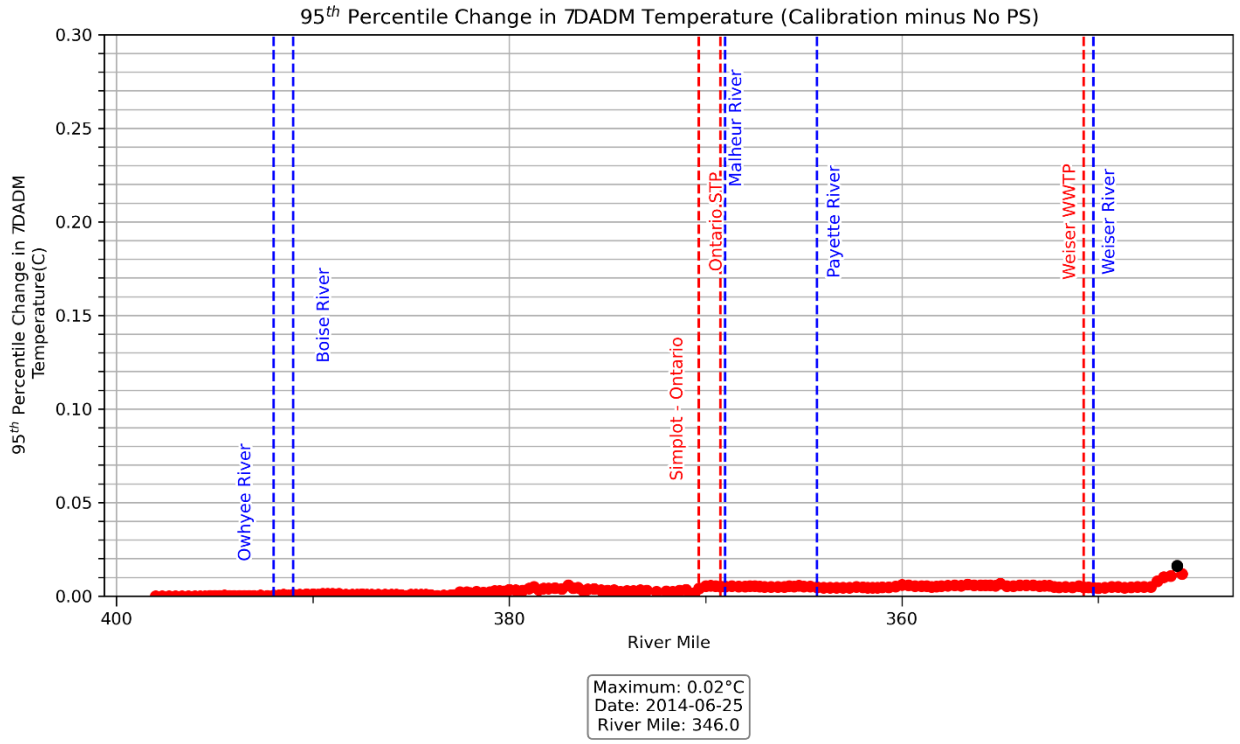


Figure 7-1: 95th percentile 7DADM cumulative temperature increase above applicable criteria from point source discharges in the Snake River from Adrian, OR to Brownlee Reservoir during the summer period.

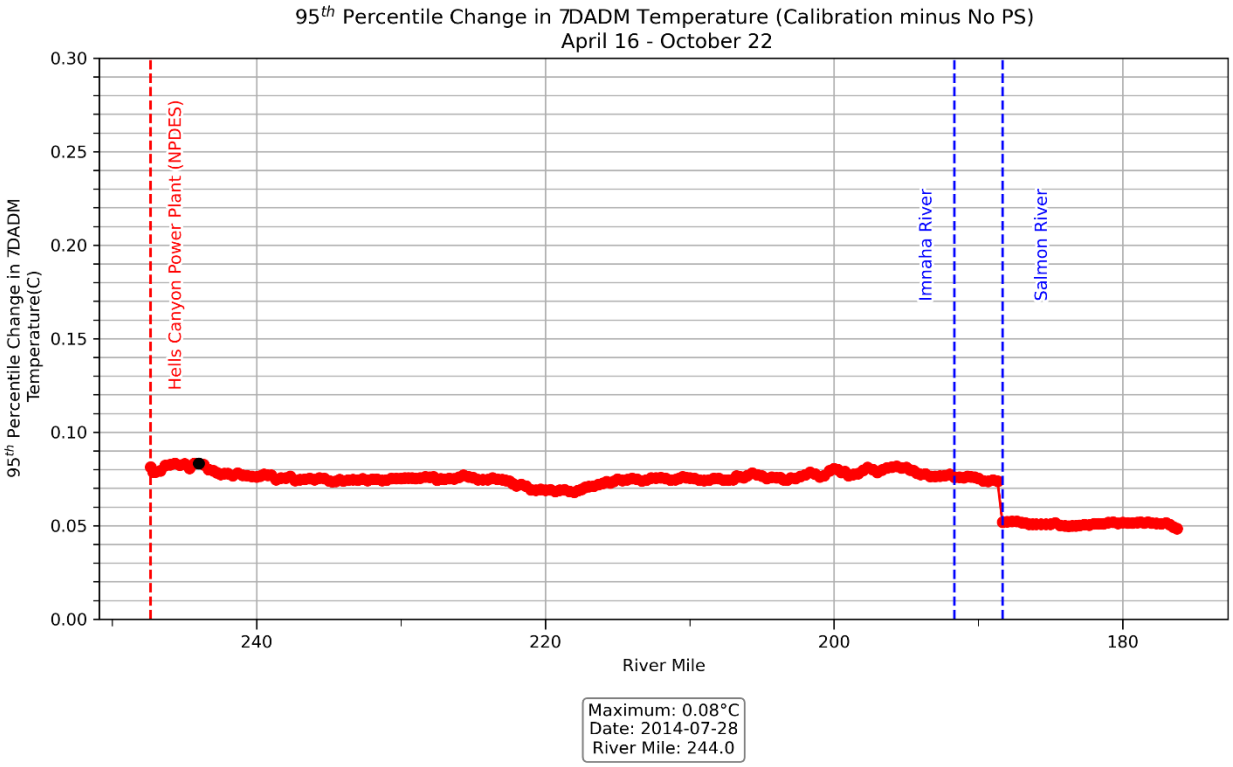


Figure 7-2: 95th percentile 7DADM cumulative temperature increase above applicable criteria from point source discharges in the Snake River downstream of Hells Canyon Dam during the summer period.

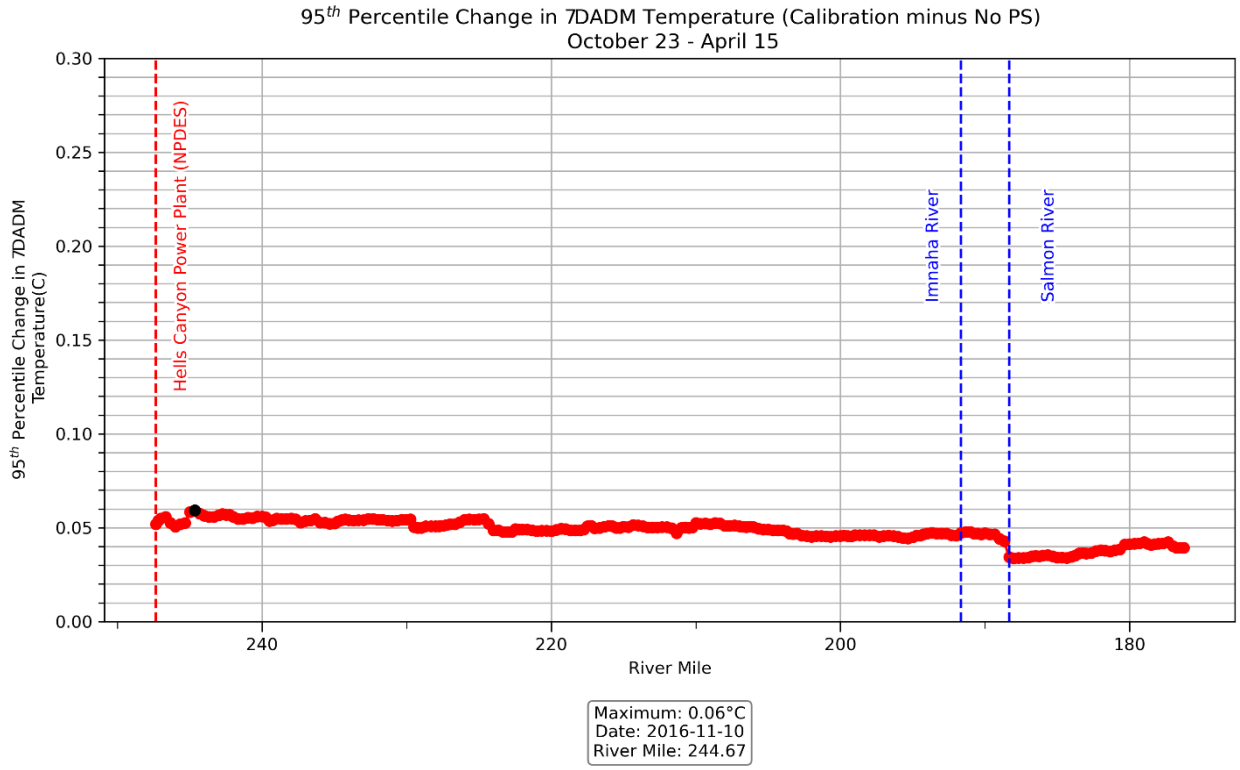


Figure 7-3: 95th percentile change in 7DADM cumulative temperature increases above applicable criteria from point source discharges in the Snake River downstream of Hells Canyon Dam during the spawning period (October 23- April 15).

7.1.2 General NPDES permitted point sources

Currently, there are four categories of general NPDES permit types with registrants authorized to discharge to the Snake River including:

- 200-J Industrial Wastewater: NPDES filter backwash
- 1200-A Stormwater: NPDES sand & gravel mining
- 1200-C Stormwater: NPDES construction more than 1-acre disturbed ground
- 1200-Z Stormwater: NPDES specific SIC codes

The single 200-J registrant (City of Ontario WTP, WQ File # 63632) does not discharge to the Snake River based on the past five years (2020 – 2025) of DMRs reviewed by DEQ, and therefore is not considered a source of thermal load.

The remaining registrants have coverage under the construction (1200-C), and industrial (1200-A and 1200-Z) general stormwater permits. DEQ determined that these stormwater discharges are unlikely to contribute to exceedances of the Snake River temperature criteria due to the frequency of precipitation and stormwater discharge during the critical period, and the available dilution in the Snake River. Therefore, no additional TMDL requirements are needed for stormwater sources to control temperature, other than those included in the NPDES permit.

7.2 Nonpoint and background sources

Nonpoint source categories or activities identified as sources of thermal loading that increase 7DADM stream temperatures above the applicable criteria include:

- Dam and reservoir operation;
- Elevated temperatures from inflowing tributaries to the Snake River.
- Increases in solar radiation loading from the disturbance or removal of near-stream vegetation.
- Background sources, including natural sources and anthropogenic sources defined as backgrounds sources

7.2.1 Dam and reservoir operations

The operations of the Hells Canyon Complex of dams influence the natural seasonal thermal pattern and period of criteria exceedance within the Hells Canyon Complex reservoirs and downstream of the dams. The temperature data and TMDL model results show upstream of Brownlee Reservoir the peak maximum temperatures occur in early July (Figure 5-6). Downstream of the dams the peak maximum temperatures shift to late-August (Figure 5-11 through Figure 5-17). The 7DADM temperatures downstream of the reservoirs are therefore cooler in the spring and early summer, and warmer later in the summer and fall relative to 7DADM temperatures upstream of the reservoirs.

This shift results in a maximum cumulative temperature increase of 3.0 degrees in the late summer (Figure 7-4, Table 7-2) and about 6.4 degrees Celsius during the fall spawning period (Figure 7-5, Table 7-2). The temperature profile shift and temperature changes caused by the Hells Canyon Complex occur in the reservoirs and also downstream of Hells Canyon Dam. The seasonal pattern shift, illustrated in Figure 7-10 through Figure 7-10 for the years 2014 -2018, is caused by the dam and reservoir operations and the effect each impoundment has on residence time and the thermocline. The seasonal pattern shift continues downstream of Hells Canyon Dam all the way to triple-state border at river mile 176, although it is moderated at greater distance downstream from Hells Canyon Dam (Figure 7-11).

DEQ evaluated the shift and determined it is caused by the dam and reservoir operation by comparing the seasonal thermal profile of calibrated model to the profile of the Snake River without the influence of the Hells Canyon Complex dam and reservoirs (No Dam scenario). The no dam scenario has a similar seasonal thermal profile as the background model scenario, which also excludes the dams as well as other anthropogenic sources. The background scenario reflects a more natural seasonal thermal profile. The seasonal shift downstream of Hells Canyon is a concern because it can affect the timing of fish migration and influences the viability of spawning and the growth of newly emerged fry.

Table 7-2: 7DADM increases above Oregon's 20°C year-round and 13°C spawning use period temperature criteria on each AU from HCC dam and reservoir operations.

Assessment Unit	Year Round Use Period Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)	Spawning Use Period Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)
Snake River Hells Canyon Reservoir to Sheep Creek OR_SR_1706010101_02_103274	2.99	6.36
Snake River Sheep Creek to Getta Creek OR_SR_1706010102_02_103280	3.00	6.10
Snake River Getta Creek to Salmon River OR_SR_1706010103_02_103282	2.61	5.44
Snake River Salmon River to Stateline OR_SR_1706010301_02_103306	1.61	2.74

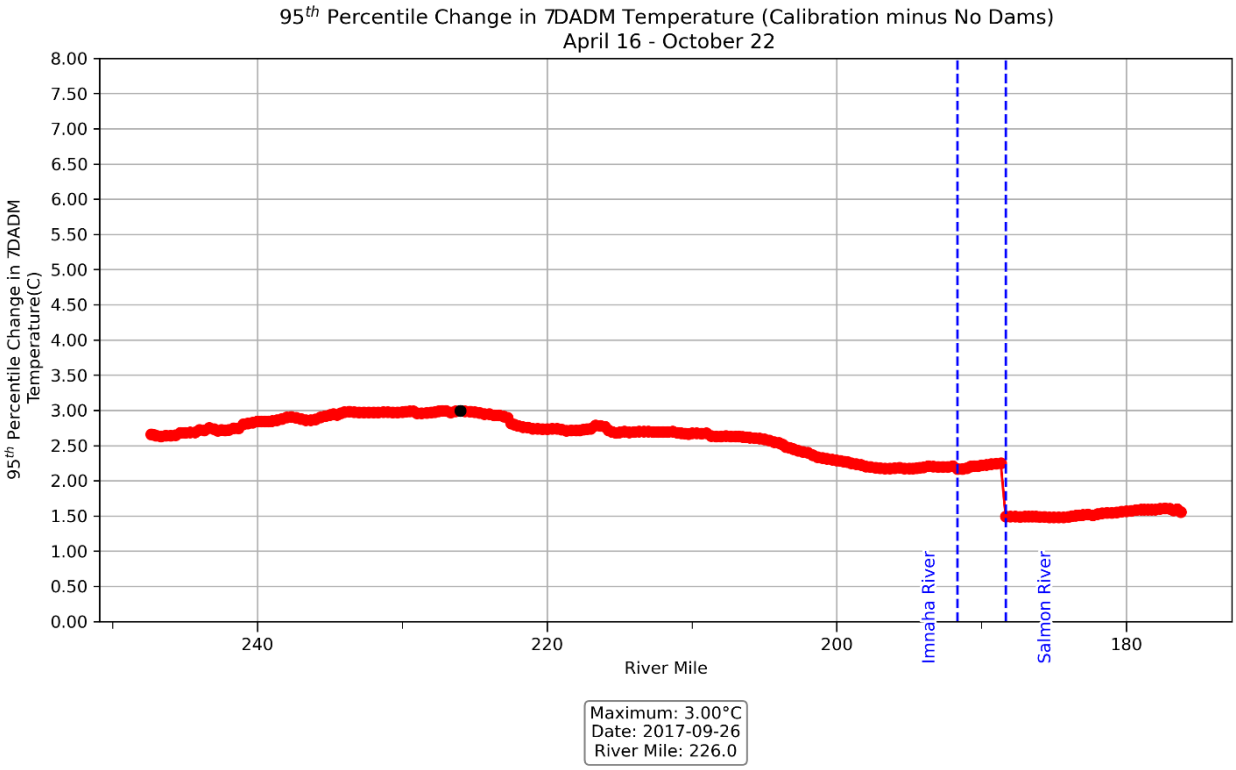


Figure 7-4: 95th percentile 7DADM cumulative temperature increase above applicable criteria during the summer season (April 16- October 22) downstream of Hells Canyon Dam due to HCC dam and reservoir operation.

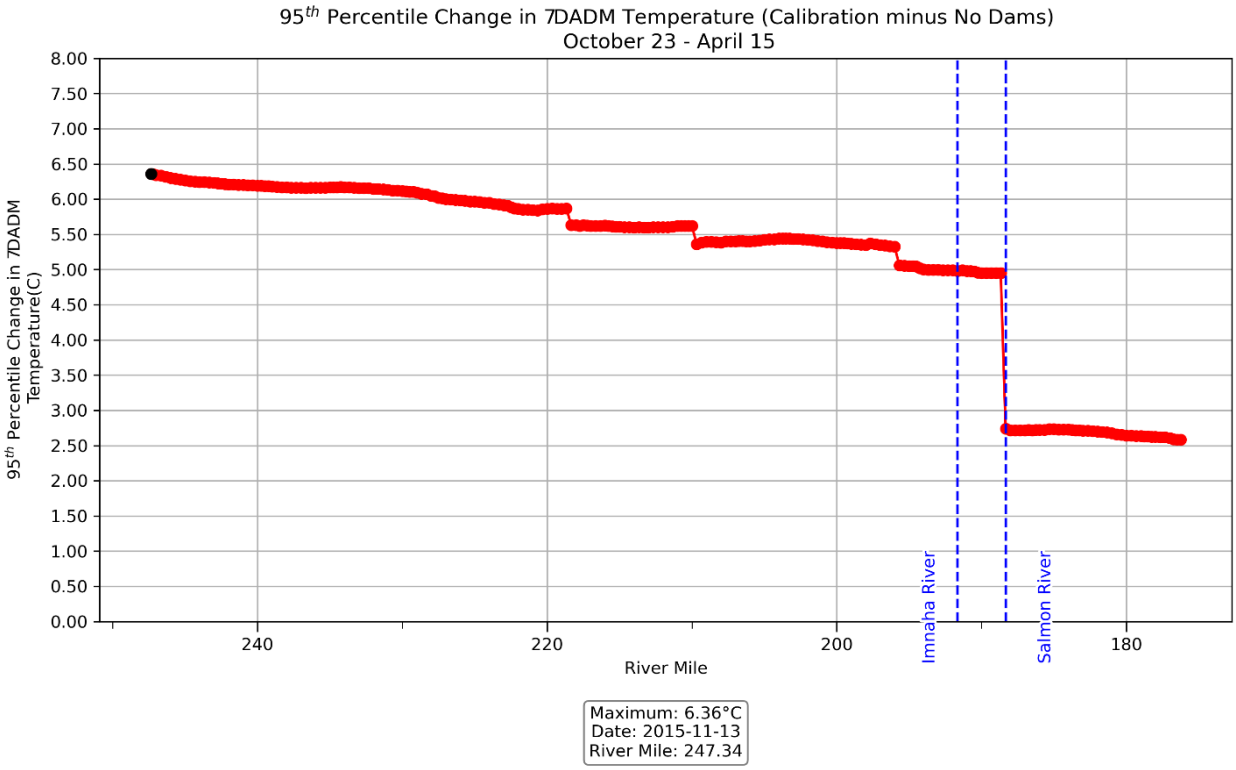


Figure 7-5: 95th percentile 7DADM cumulative temperature increase above applicable criteria during the spawning season (October 23- April 15) downstream of Hells Canyon Dam due to HCC dam and reservoir operation.

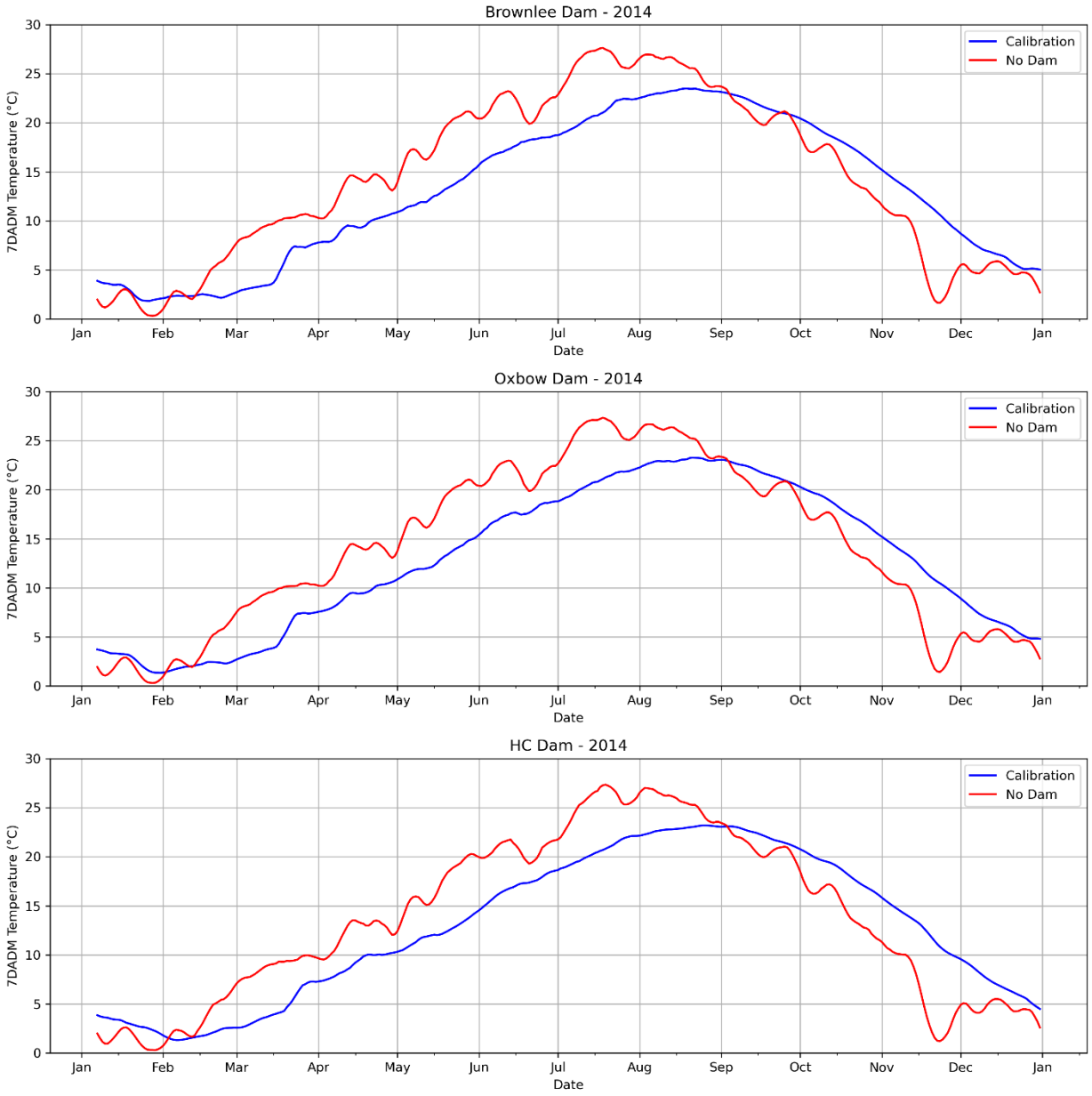


Figure 7-6: Modeled daily 7DADM temperature in 2014 for the Snake River segment at Brownlee Dam, Oxbow Dam, Hells Canyon Dam comparing calibration and no dams scenarios and the seasonal thermal pattern shift.

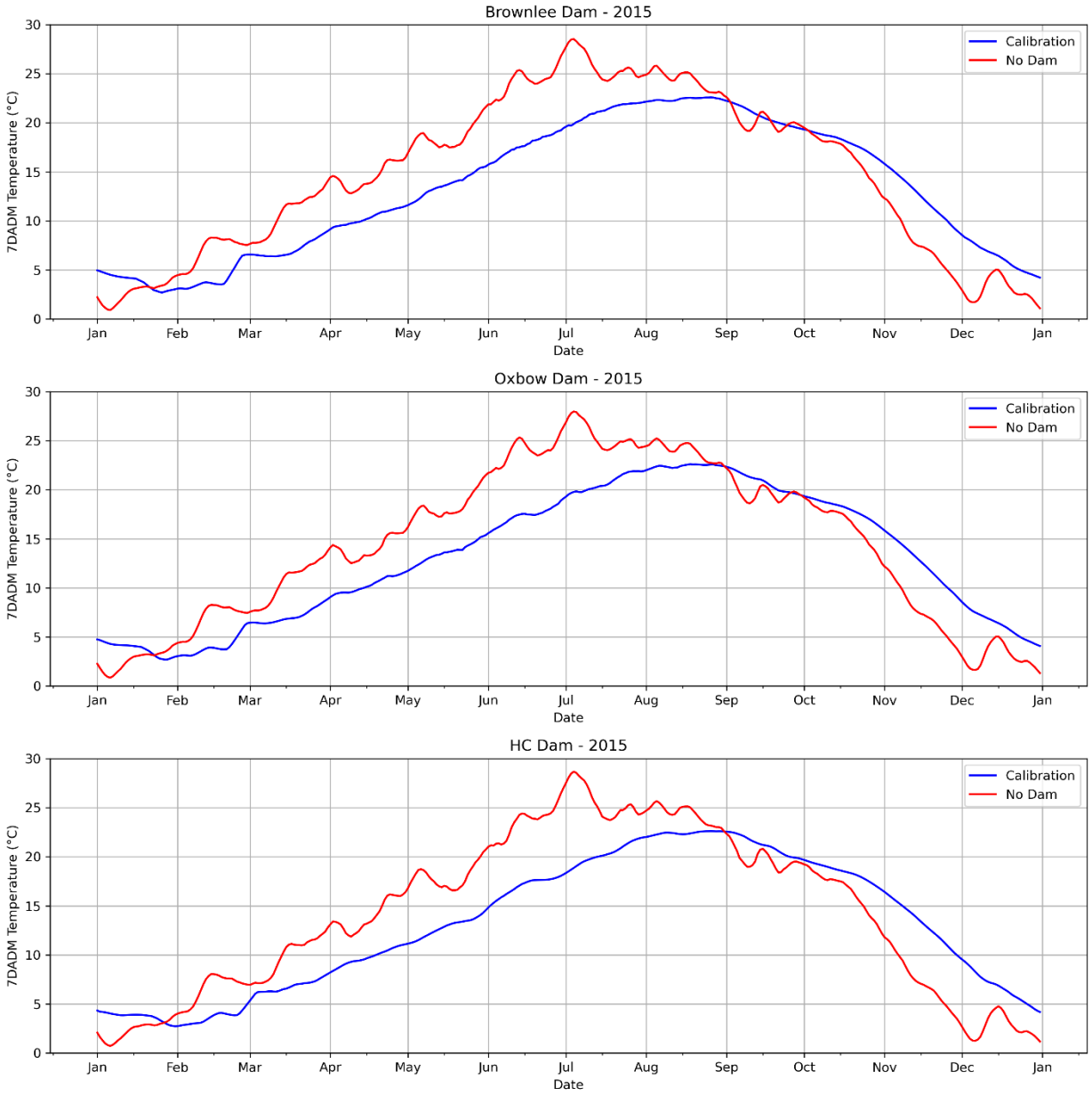


Figure 7-7: Modeled daily 7DADM temperature in 2015 for the Snake River segment at Brownlee Dam, Oxbow Dam, Hells Canyon Dam comparing calibration and no dams scenarios and the seasonal thermal pattern shift.

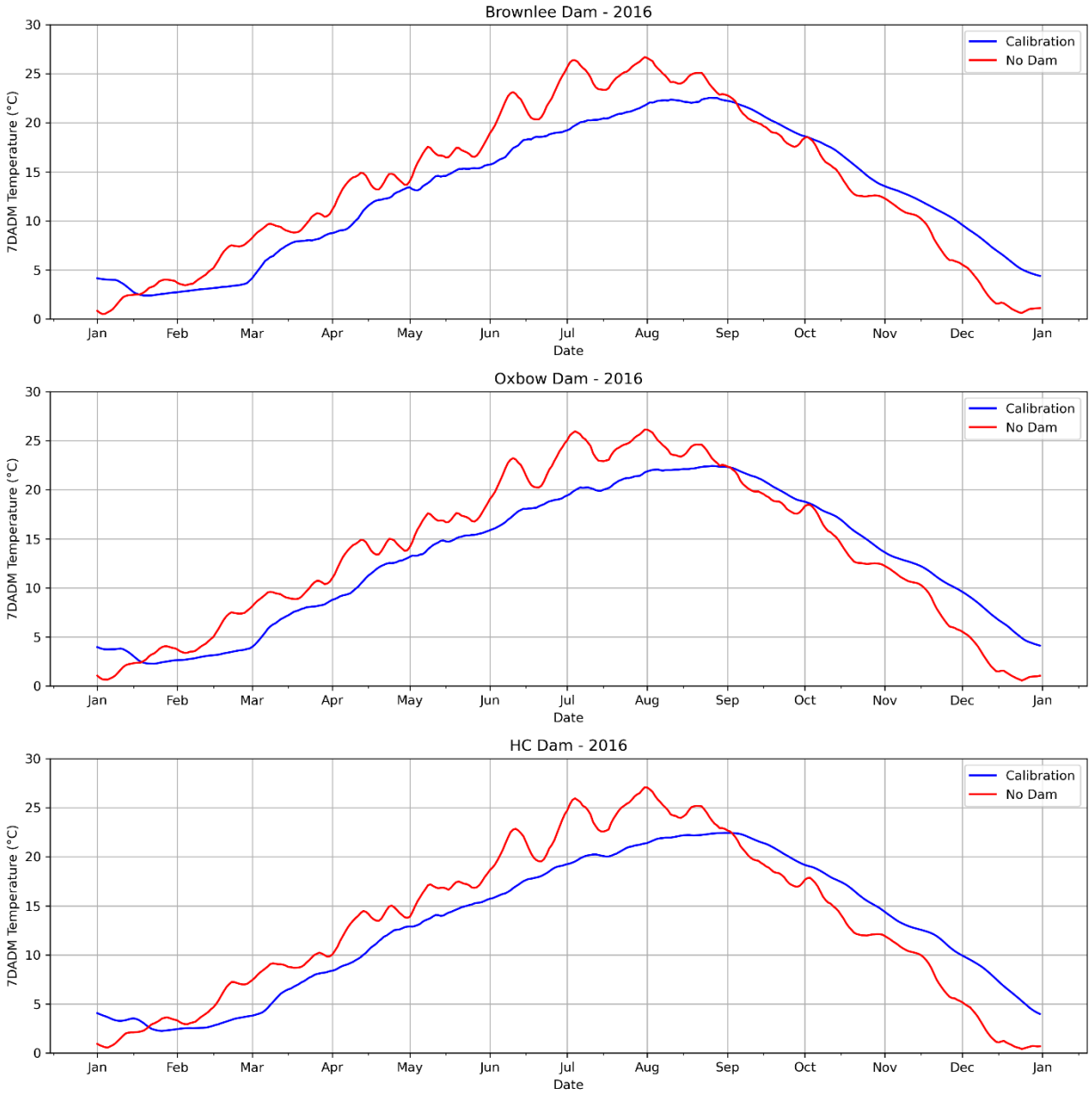


Figure 7-8: Modeled daily 7DADM temperature in 2016 for the Snake River segment at Brownlee Dam, Oxbow Dam, Hells Canyon Dam comparing calibration and no dams scenarios and the seasonal thermal pattern shift.

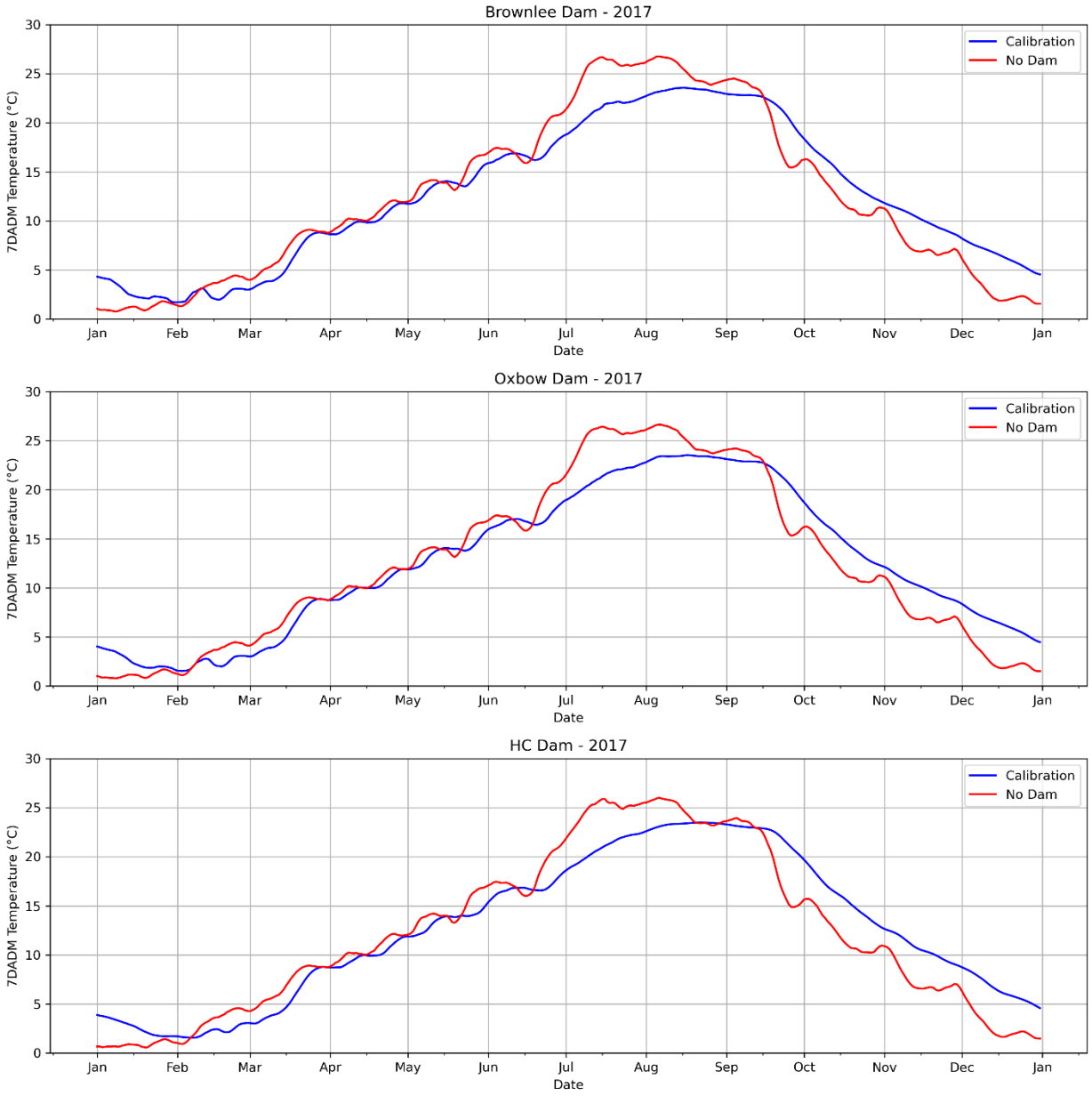


Figure 7-9: Modeled daily 7DADM temperature in 2017 for the Snake River segment at Brownlee Dam, Oxbow Dam, Hells Canyon Dam comparing calibration and no dams scenarios and the seasonal thermal pattern shift.

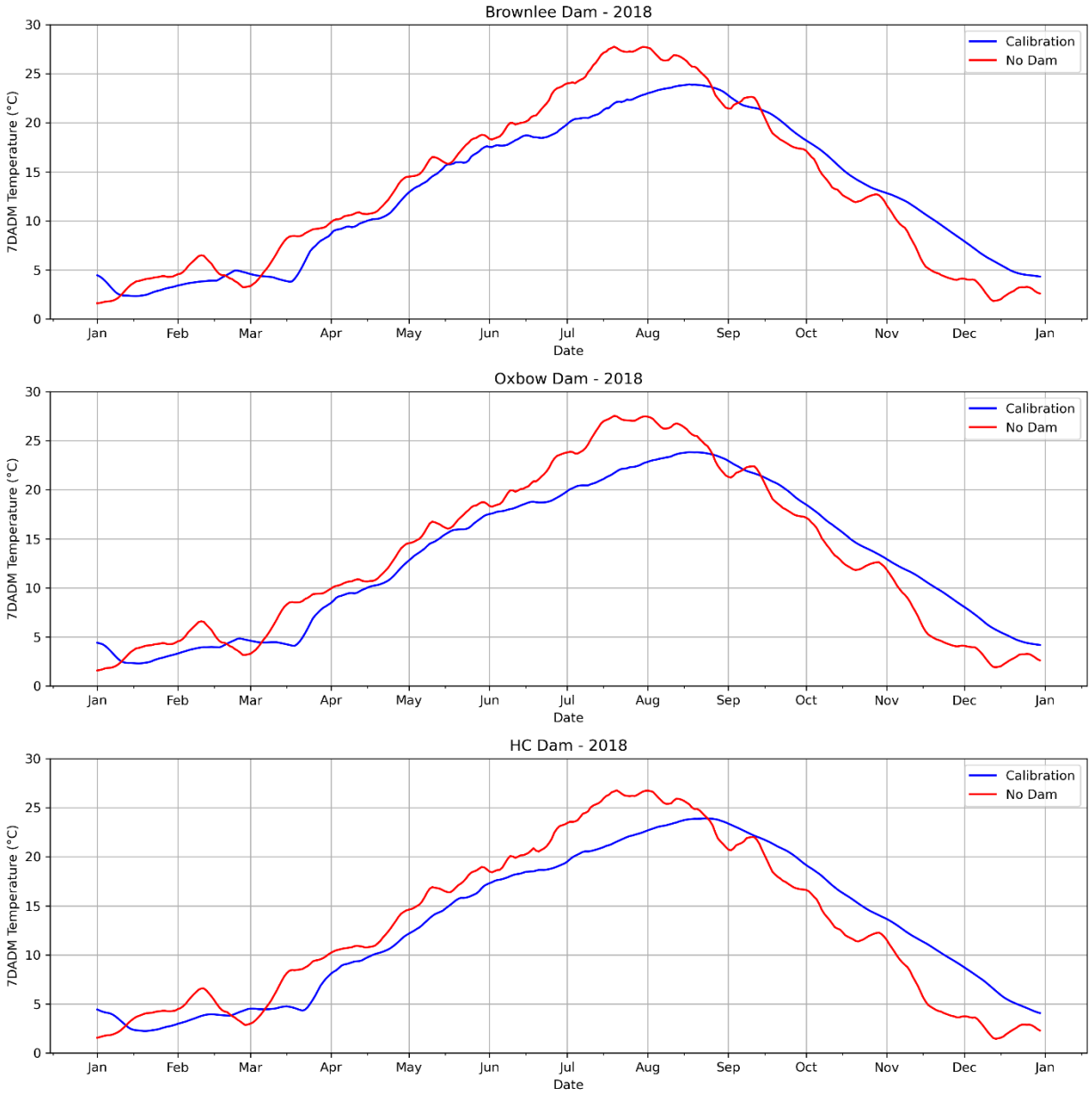


Figure 7-10: Modeled daily 7DADM temperature in 2018 for the Snake River segment at Brownlee Dam, Oxbow Dam, Hells Canyon Dam comparing calibration and no dams scenarios and the seasonal thermal pattern shift.

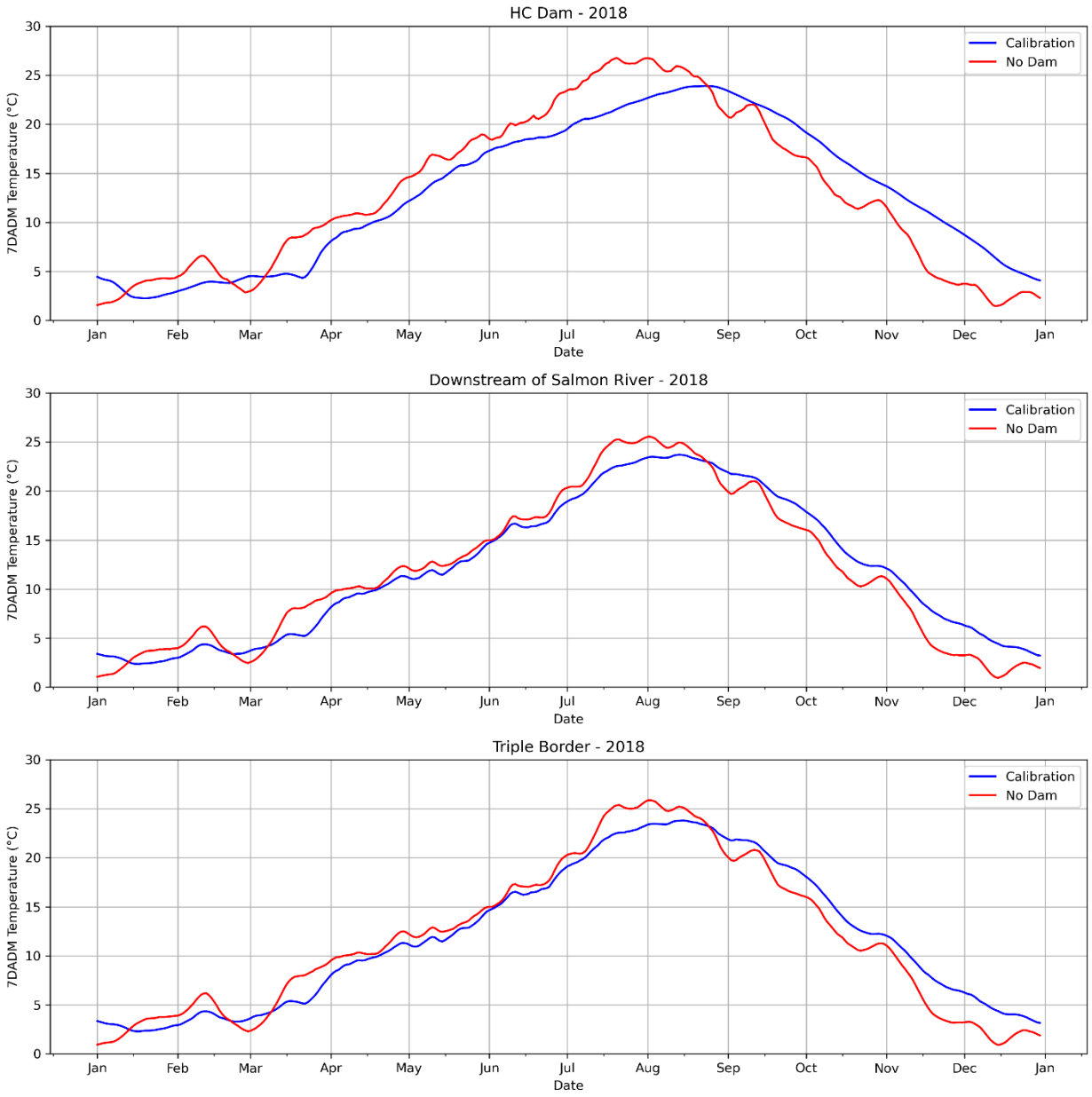


Figure 7-11: Modeled daily 7DADM temperature in 2018 for the Snake River segment at Hells Canyon Dam, downstream of the Salmon River, and at the triple border at river mile 176, comparing calibration and no dams scenarios and the seasonal thermal pattern shift.

7.2.2 Tributary warming

Temperature criteria exceedances on tributaries flowing into the Snake River; and criteria exceedances in the Snake River upstream of the model boundary in Idaho increase temperatures in the TMDL project area cumulatively by as much as 6.95°C in the summer when the 20°C criteria apply (Figure 7-12) and 0.28°C during the 13°C spawning period (Figure 7-13).

Temperature criteria exceedances on Oregon tributaries increase Snake River temperatures cumulatively by as much as 0.49°C in the summer when the 20°C criteria apply (Figure 7-14) and 0.06°C during the 13°C spawning period (Figure 7-15). Downstream of the Salmon River, the model predicts background sources do not contribute to exceedances of the 13°C spawning use criterion in that reach. During this period, the Salmon River provides cold inflowing water to the Snake River that is at or below the 13°C spawning use criterion. Therefore, the spawning criterion in the Snake River below the confluence of the Salmon River will be attained once TMDL allocations assigned to upstream anthropogenic point and nonpoint source are achieved.

The Snake River upstream of the model boundary, followed by the summer period inflow from the Salmon and Payette Rivers have the largest influence on Snake River temperatures (Figure 7-12).

Table 7-3: 7DADM increases above Oregon's 20°C year-round and 13°C spawning use period temperature criteria on each AU from elevated temperatures in Snake River tributaries flowing from Oregon or Idaho.

Assessment Unit	Year Round Use Period Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)	Spawning Use Period Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)
Snake River Stateline to Boise River OR_SR_1705010311_02_102702	6.95	NA
Snake River Boise River to Malheur River OR_SR_1705011501_02_103231	6.23	NA
Snake River Malheur River to Weiser River OR_SR_1705011502_02_103230	4.91	NA
Snake River Weiser River to Hog Creek/Brownlee Reservoir OR_SR_1705020101_02_103229	4.40	NA
Brownlee Reservoir OR_LK_1705020103_05_100578	3.88	NA
Oxbow Reservoir OR_LK_1705020107_05_100583	2.67	NA
Hells Canyon Reservoir OR_LK_1705020107_05_100582	2.64	NA

Assessment Unit	Year Round Use Period Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)	Spawning Use Period Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)
Snake River Hells Canyon Reservoir to Sheep Creek OR_SR_1706010101_02_103274	2.43	0.27
Snake River Sheep Creek to Getta Creek OR_SR_1706010102_02_103280	2.35	0.26
Snake River Getta Creek to Salmon River OR_SR_1706010103_02_103282	2.38	0.28
Snake River Salmon River to Stateline OR_SR_1706010301_02_103306	3.85	0.00

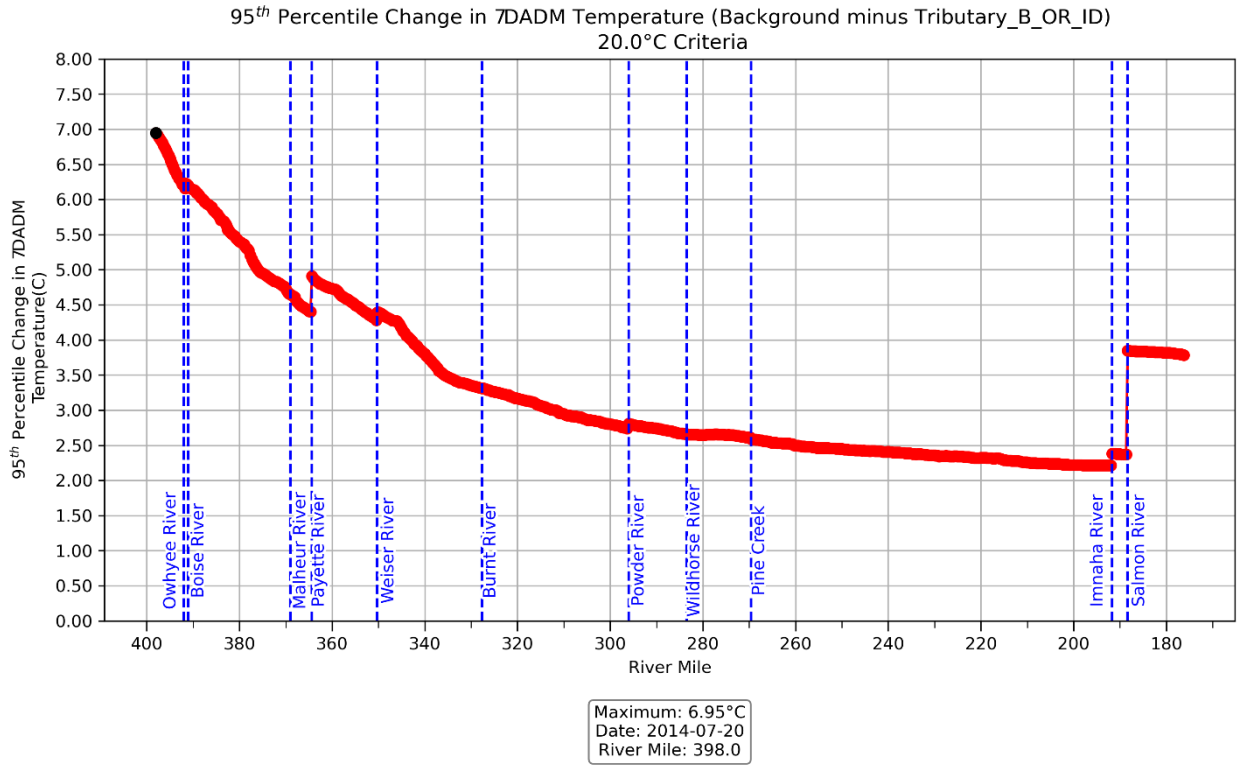


Figure 7-12: 95th percentile 7DADM cumulative temperature increase due to temperature criteria exceedances on Oregon and Idaho tributaries, from Adrian to Washington State line, during the 2014-2018 modeling period when the 20ºC applicable criteria apply.

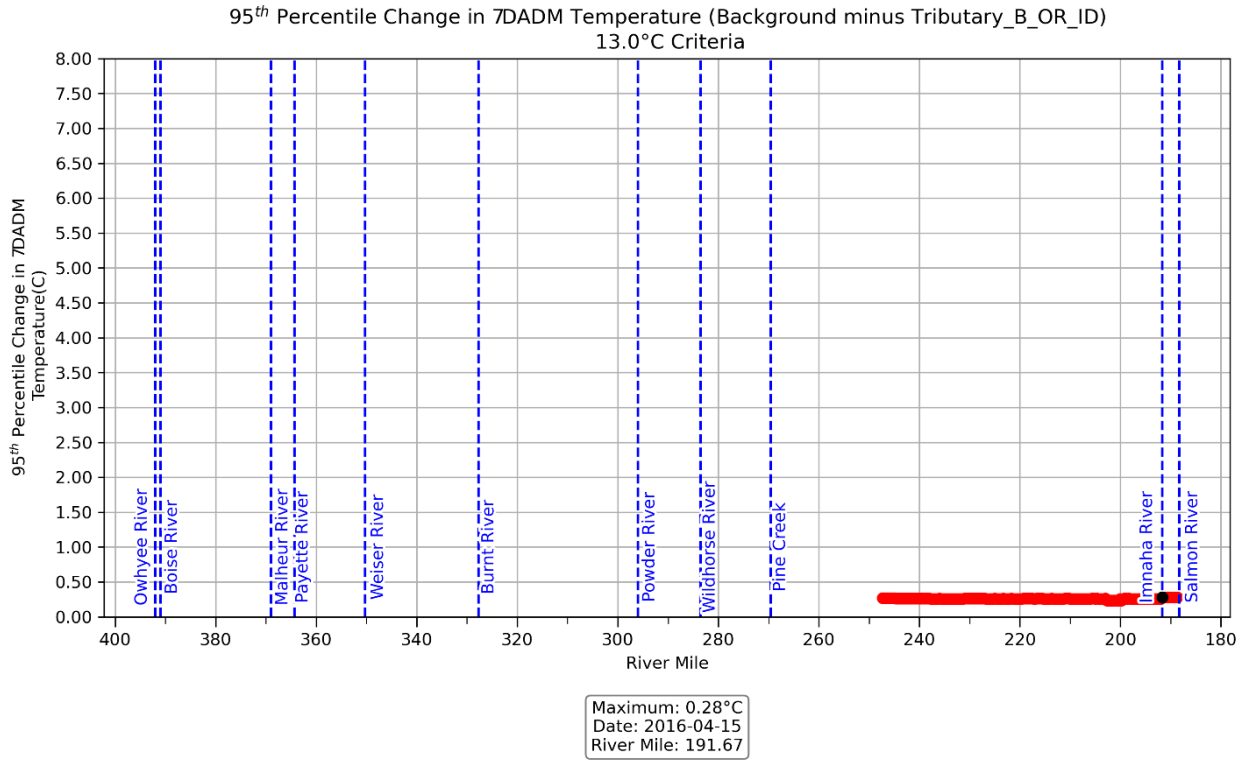


Figure 7-13: 95th percentile 7DADM cumulative temperature increase due to temperature criteria exceedances on Oregon and Idaho tributaries, from Adrian to Washington State line when the 13ºC spawning criterion applies (October 23- April 15).

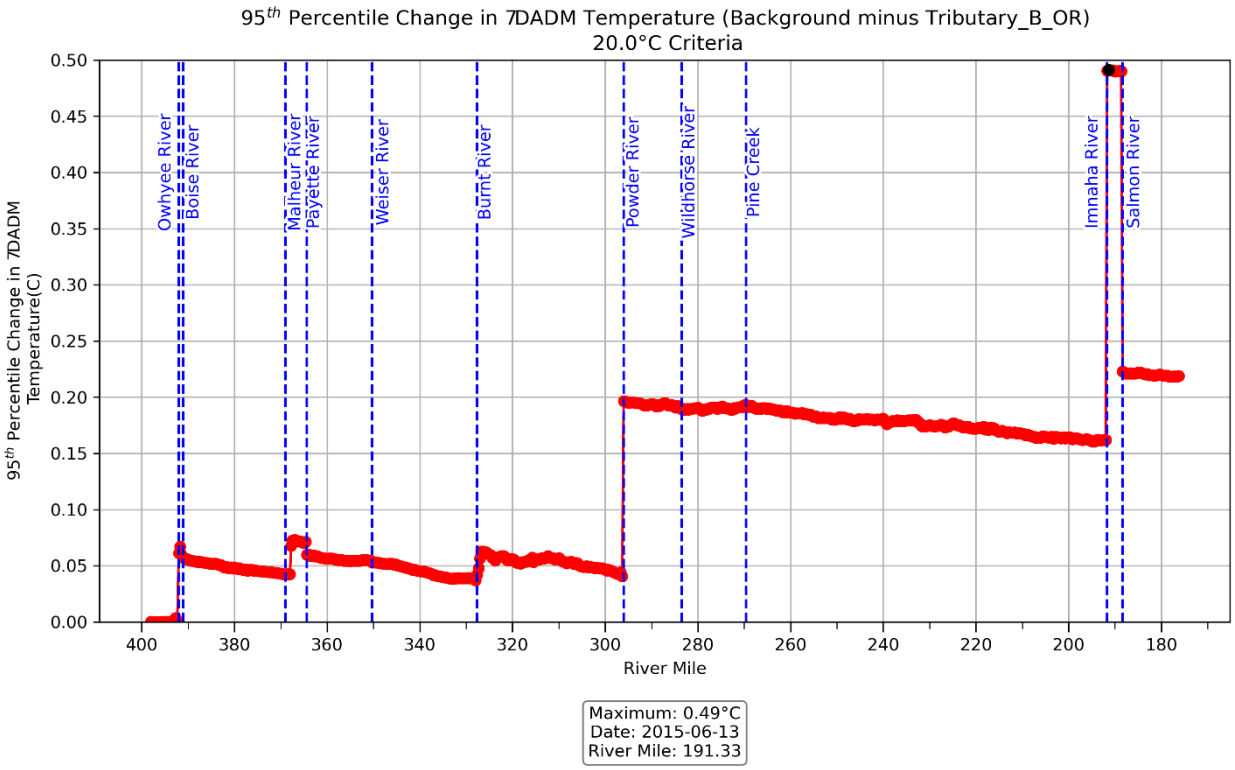


Figure 7-14: 95th percentile 7DADM cumulative temperature increase due to temperature criteria exceedances on Oregon tributaries, from Adrian to Washington State line, during the 2014-2018 modeling period when the 20°C applicable criteria apply.

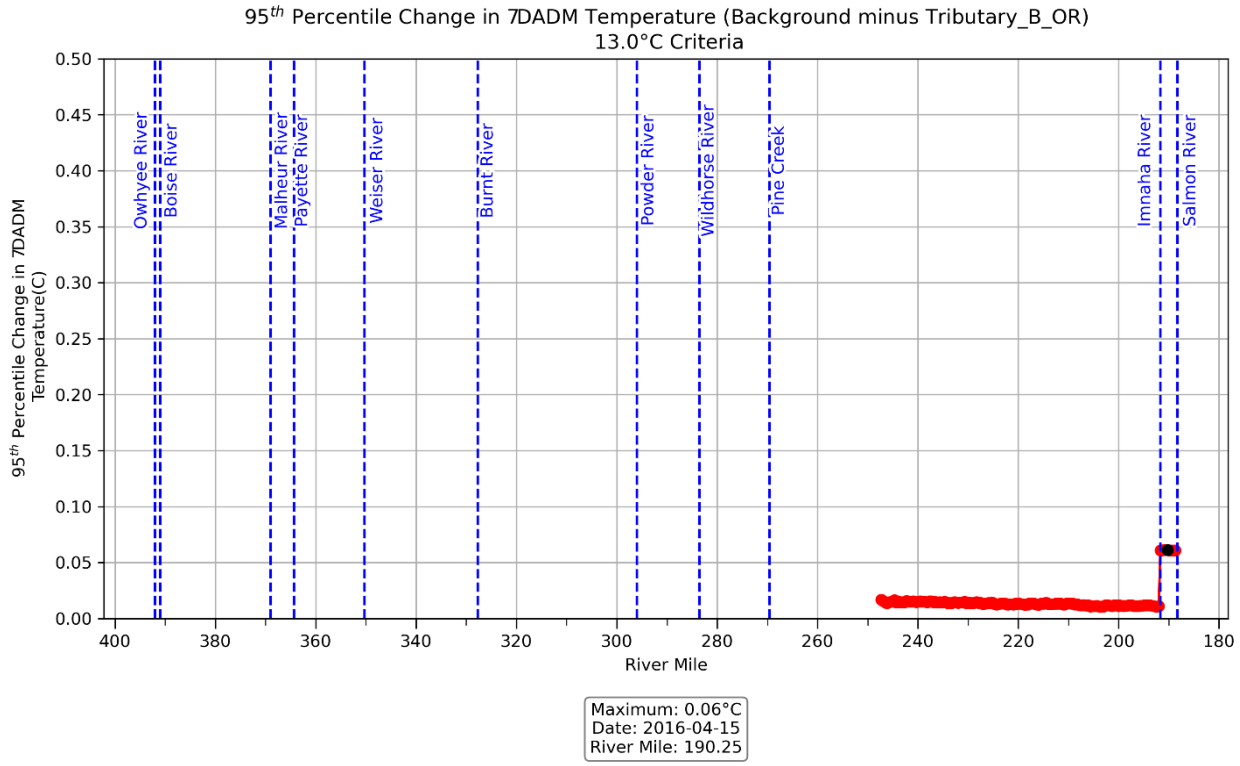


Figure 7-15: 95th percentile 7DADM cumulative temperature increase due to temperature criteria exceedances on Oregon tributaries, from Adrian to Washington State line when the 13ºC spawning criterion applies (October 23- April 15).

7.2.3 Disturbance or removal of near stream vegetation

Vegetation removal or disturbance on the Snake River increases 7DADM temperatures cumulatively by as much as 0.14°C upstream of Brownlee Reservoir (Figure 7-16), 0.15°C during the summer downstream of Hells Canyon Dam (Figure 7-17) and 0.04°C C during the spawning period (Figure 7-18). The influence of vegetation removal on Snake River tributaries is not included in these results. Warming from tributary sources is discussed in section 7.2.2.

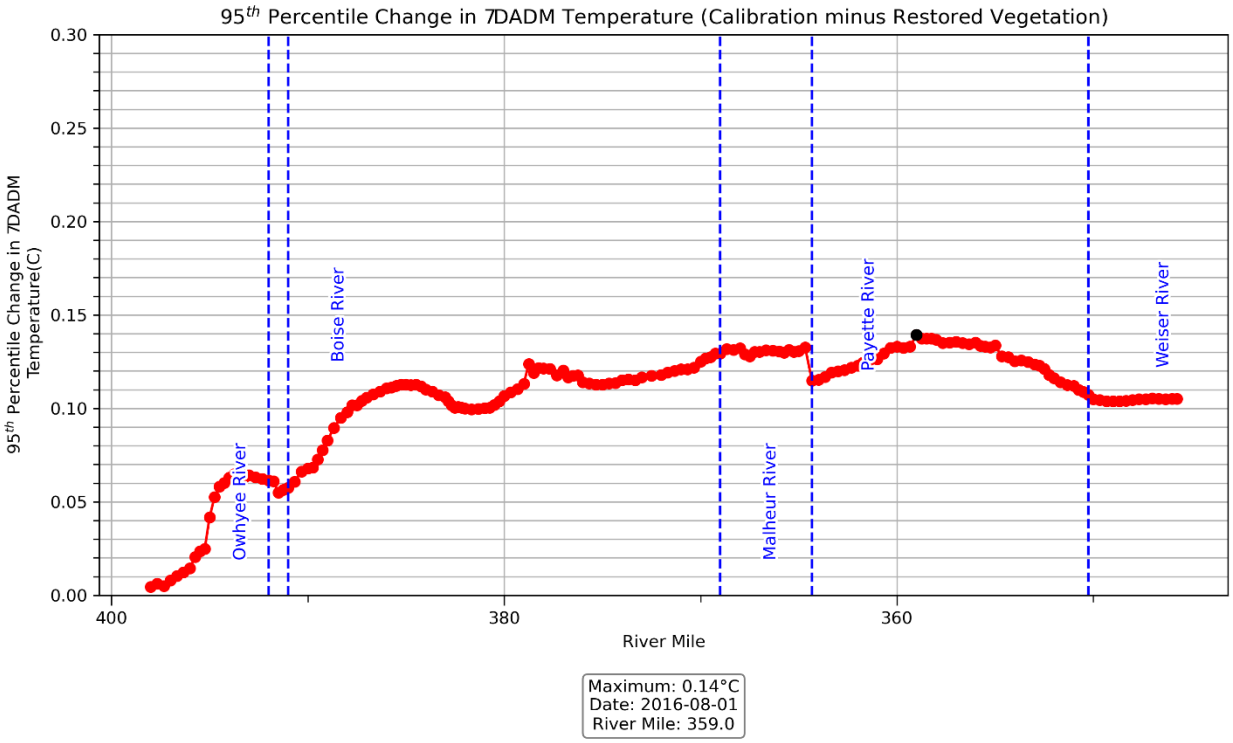


Figure 7-16: 95th percentile 7DADM cumulative temperature increase from disturbance or removal of vegetation adjacent to the Snake River from Adrian, OR to Brownlee Reservoir.

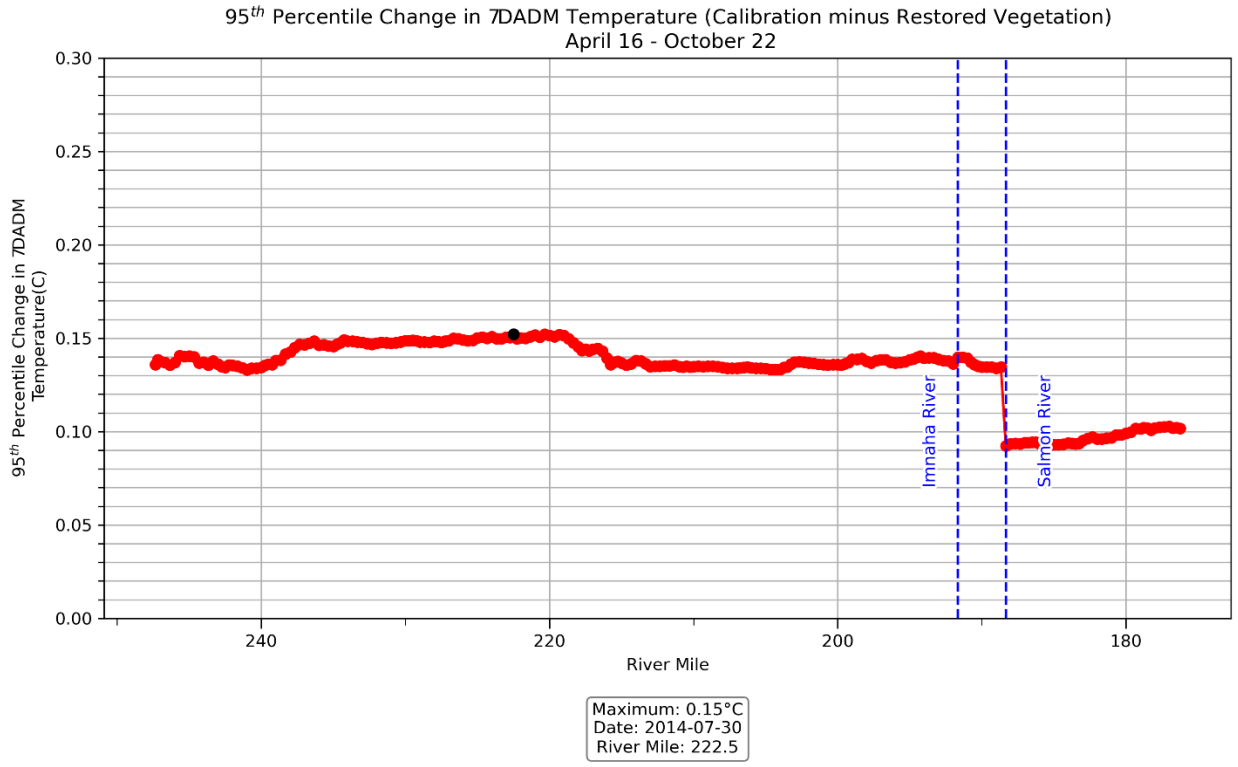


Figure 7-17: 95th percentile 7DADM cumulative temperature increase from disturbance or removal of vegetation adjacent to the Snake River downstream of Hells Canyon Dam during the summer period.

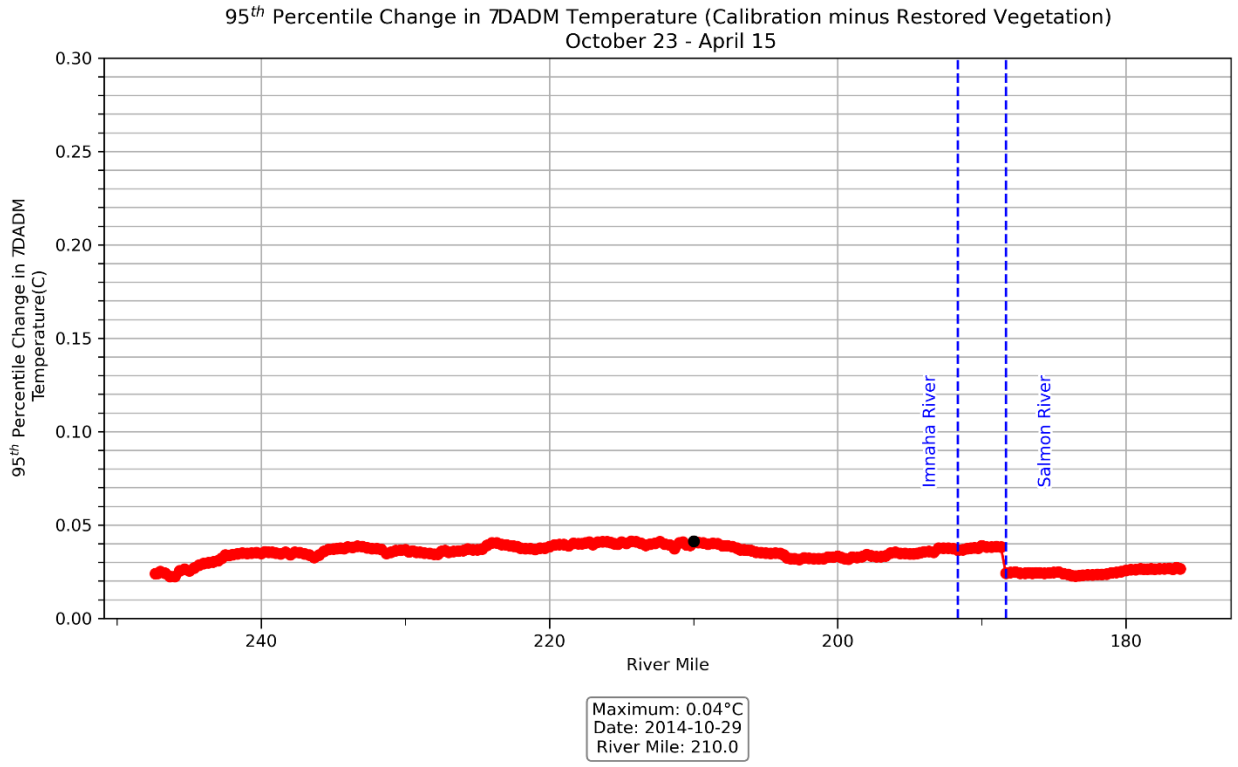


Figure 7-18: 95th percentile 7DADM cumulative temperature increase from disturbance or removal of vegetation adjacent to the Snake River downstream of Hells Canyon Dam during the spawning period.

Table 7-4: 7DADM increases above Oregon's 20°C year-round and 13°C spawning use period temperature criteria on each AU from disturbance or removal of near stream vegetation.

Assessment Unit	Year Round Use Period Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)	Spawning Use Period Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)
Snake River Stateline to Boise River OR_SR_1705010311_02_102702	0.07	NA
Snake River Boise River to Malheur River OR_SR_1705011501_02_103231	0.13	NA
Snake River Malheur River to Weiser River OR_SR_1705011502_02_103230	0.14	NA
Snake River Weiser River to Hog Creek/Brownlee Reservoir OR_SR_1705020101_02_103229	0.11	NA
Snake River Hells Canyon Reservoir to Sheep Creek OR_SR_1706010101_02_103274	0.15	0.04
Snake River Sheep Creek to Getta Creek OR_SR_1706010102_02_103280	0.15	0.04
Snake River Getta Creek to Salmon River OR_SR_1706010103_02_103282	0.14	0.04
Snake River Salmon River to Stateline OR_SR_1706010301_02_103306	0.10	0.03

7.2.4 Background sources

Background sources as defined in OAR 340-042-0030(1) 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. In this TMDL thermal loading from sources in Idaho and stream temperature warming caused by climate change are background sources.

Stream temperature warming from climate change is a background source because the majority of the climate change causing pollutants emanate from outside of Oregon.

DEQ completed a literature review to assess climate change-driven stream temperature impacts. Based on that review (DEQ, 2025), 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. Because the Snake River is a regulated system influenced by multiple dam and reservoir operations and other flow modification activities, it is unclear if climate change is a significant contributor to river temperature increases.

Non-human caused background thermal loading 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, tributary inflows; precipitation; cloudiness; air temperature; relative humidity and other factors. Many of these factors can be influenced by anthropogenic impacts, particularly on Snake River tributaries.

It was not possible to develop a model in which all human or background influences were controlled or accounted for. As a best estimate, background thermal sources were quantified using the Snake River model by removing the thermal loading from point sources, removing the dam and reservoirs, and restoring streamside vegetation to the estimated site potential conditions. The setup and configuration details of this model, called the background scenario, is further described in Appendix C. Estimates of background temperatures for major Snake River tributaries are not available, so tributary temperatures were not adjusted for the background scenario. And as discussed in the previous paragraphs, both anthropogenic and background warming contributed by Idaho tributaries are considered background sources under Oregon rules. Therefore, current Idaho tributary temperatures represent the background condition.

In a separate model scenario, called Tributary scenario B, the influence of elevated Snake River tributary temperatures was evaluated (see section 7.2.2 and Appendix C). The 7DADM background temperatures of the background scenario were compared to the applicable temperature criteria to determine if background sources contribute to exceedances of the criteria and the magnitude of those exceedances.

The contribution from background sources in each AU for each applicable criteria is summarized in and Table 7-6. The largest 95th percentile cumulative temperature increase above the 20°C year-round criteria from all background sources are 7.8°C and occurs in the reach between the Boise River and the Malheur River at approximately Snake River mile 370 (Table 7-5). During the 13°C spawning use period, background sources have a 1.6°C cumulative temperature increase above the spawning criteria with the largest increase occurring at Snake River mile 199.75 (Table 7-6). Downstream of the Salmon River, the model predicts background sources do not contribute to exceedances of the 13°C spawning use criterion. The spawning criterion in that reach will be attained once TMDL allocations assigned to anthropogenic point and nonpoint source are achieved.

Based on the results, DEQ concludes that thermal loading from background sources in the Snake River contribute to exceedances of the applicable temperature criteria and therefore were assigned a bulk load allocation. Reductions from background sources will be required to attain the applicable temperature criteria.

Table 7-5: Background nonpoint source 7DADM increases above Oregon's 20°C year-round use period temperature criteria on each AU.

Assessment Unit	Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)	Point of Maximum Increase (River Mile)
Snake River Stateline to Boise River OR_SR_1705010311_02_102702	7.01	391.75
Snake River Boise River to Malheur River OR_SR_1705011501_02_103231	7.77	370.33
Snake River Malheur River to Weiser River OR_SR_1705011502_02_103230	7.59	368.33
Snake River Weiser River to Hog Creek/Brownlee Reservoir OR_SR_1705020101_02_103229	7.72	341.67
Brownlee Reservoir OR_LK_1705020103_05_100578	7.70	341.33
Oxbow Reservoir OR_LK_1705020107_05_100583	7.29	284.5
Hells Canyon Reservoir OR_LK_1705020107_05_100582	7.08	272.6
Snake River Hells Canyon Reservoir to Sheep Creek OR_SR_1706010101_02_103274	7.11	230.67
Snake River Sheep Creek to Getta Creek OR_SR_1706010102_02_103280	7.09	229.25

Assessment Unit	Maximum AU 95th Percentile 7DADM Temperature Increase (ºC)	Point of Maximum Increase (River Mile)
Snake River Getta Creek to Salmon River OR_SR_1706010103_02_103282	6.71	205.67
Snake River Salmon River to Stateline OR_SR_1706010301_02_103306	5.49	176.25

Table 7-6: Background nonpoint 7DADM increases above Oregon's 13°C spawning use temperature criteria on each AU.

Assessment Unit	Maximum AU 95th Percentile 7DADM Temperature Increase (°C)	Point of Maximum Increase (River Mile)
Snake River Hells Canyon Reservoir to Sheep Creek OR_SR_1706010101_02_103274	1.36	247.34
Snake River Sheep Creek to Getta Creek OR_SR_1706010102_02_103280	1.56	206
Snake River Getta Creek to Salmon River OR_SR_1706010103_02_103282	1.61	199.75
Snake River Salmon River to Stateline OR_SR_1706010301_02_103306	0	-

8 Loading capacity and excess loads

Refer to the [final date] Snake River Temperature TMDL rule (OAR340-042-0090(6)(a)) for the loading capacity and excess loads.

9 Allocations, reserve capacity, and margin of safety

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 point of maximum impact. DEQ allocated a thermal load equivalent to a 0.30°C increase to current and future loading from human sources and the remainder of the loading capacity to background sources. Distribution of the human use allowance is discussed in section 9.1, 9.2 (point sources), and 9.3 (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, the assumptions and requirements Idaho's existing 2004 temperature TMDL, 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 [final date] Snake River Temperature TMDL rule (OAR 340-042-0090(6)(a)) for the human use allowance assignments.

This table summarizes all the human use allowance assignments to each source category on each assessment unit. The values assigned to each source reflect the model based maximum cumulative warming for that source category on each AU.

At some locations the sum of the Human Use allowance assignments from each individual source category is a more than the cumulative warming from all sources combined as shown in Figure 10-1 and Figure 10-2. This occurs because the peak warming from different source categories occurs at different times. The portion of the HUA assigned to each source categories is intended to capture all the potential warming from that source category during the TMDL critical period, even if it might happen at different times. The net effect is that there is less human use allowance available as reserve capacity.

Some source categories were assigned a 0.0ºC human use allowance or no increase in temperature above the applicable criteria. 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.

9.2 Wasteload allocations for point sources

Refer to the [final date] Snake River Temperature TMDL rule (OAR 340-042-0090(6)(a)) 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 wasteload allocations. The model was then used to determine if this amount of warming provided capacity for other source categories and reserve capacity. For all point sources, it was determined that thermal WLAs could be set equal to or slightly greater than current maximum effluent discharge. Maximum effluent discharge is based on the paired average dry weather

design flow (ADWDF) or a maximum flow allowed by the NPDES permit and maximum effluent temperature. These data were obtained from discharge monitoring reports and the NPDES permits. 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. **Equation 9-3** was used to calculate the change in temperature. The temperature increase was rounded up to the nearest thousands place for the HUA assigned to each facility. The following sections briefly summarize each point source and the data used to calculate the assigned HUA and wasteload allocations.

9.2.1 Idaho Power - Hells Canyon Power Plant

The Hells Canyon Power Plant operated by Idaho Power (WQ File #41297, EPA Number OR0027278), holds an individual NPDES permit for discharge of non-contact cooling water into the Snake River at approximately river mile 247. The Hells Canyon Power Plant consists of five outfalls. Outfalls 1-3 discharge non-contact cooling with a maximum permitted discharge of 9 MGD. Additionally, wastewater is collected in the powerhouse sump and discharged via outfall 4 into the Snake River, with a permitted maximum discharge of 1.5 MGD. Outfall 5 discharges sanitary wastewater into a holding tank, which is then pumped and transported off-site every two weeks. The current NPDES permit (# 101287) restricts discharge temperatures to be no more than background temperature (ambient temperature) plus 5.5°C when background temperature is higher than 7.2°C (NPDES, 2004).

The maximum effluent discharge used for the WLA is based on the NPDES permitted maximum effluent discharge of 10.5 MGD. DMRs from 2014 to 2018 were reviewed to determine the maximum effluent temperature. Temperature observations in the DMRs were reported as a temperature change (ΔT), or the difference between the outfall temperature and ambient background water temperature. Ambient background temperature is not reported on the DMRs so the absolute effluent temperature was calculated by adding the reported ΔT to the calibrated model simulated temperature outflow from Hells Canyon Dam. The resulting maximum temperature (27.8 °C) was used as the maximum effluent temperature. The annual 7Q10 of 6884 cfs was calculated from discharge measured at the IPC/USGS gage 13290450 Snake River below Hells Canyon Dam. See Section 6.3 for additional 7Q10 details. The final calculated HUA assigned to the Hells Canyon Power Plant is 0.019°C and 0.035°C during the 20°C salmon and steelhead migration corridor use period and 13°C salmon and steelhead spawning use period, respectively.

9.2.2 Idaho Power - Oxbow Power Plant

The Oxbow Power Plant operated by Idaho Power (WQ File #41299, EPA Number OR0027286), holds an individual NPDES permit for discharge of non-contact cooling water and sump wastewater into Hells Canyon Reservoir at approximately river mile 273. The Oxbow Power Plant has five outfalls. Outfalls 1-4 discharge non-contact cooling water with a maximum permitted discharge of 12 MGD. Outfall 5 discharges powerhouse sump wastewater, with a maximum permitted discharge of 0.15 MGD. The current NPDES permit (#101275) restricts

discharge temperatures to be no more than background temperature (ambient temperature) plus 5.5°C when background temperature is higher than 14.4°C (NPDES, 2004).

The maximum effluent discharge used for the WLA is based on the NPDES permitted maximum effluent discharge of 12.15 MGD. DMRs from 2014 to 2018 were reviewed to determine the maximum effluent temperature. Temperature observations in the DMRs were reported as a temperature change (ΔT), or the difference between the outfall temperature and ambient background water temperature. The ΔT was reported for most of the modeling period. The actual maximum temperatures were reported for winter and fall of 2014 and winter of 2015. Temperature for the power plant outfalls was calculated by adding the reported ΔT to the calibrated model simulated temperature outflow from Oxbow Dam. The resulting maximum temperature (27.6 °C) was used as the maximum effluent temperature. The annual 7Q10 of 6854 cfs was calculated from the derived discharge below Oxbow Dam. The data were provided by Idaho Power (IPC 13290030). See Section 6.3 for additional 7Q10 details. The final calculated HUA assigned to the Oxbow Power Plant is 0.021°C.

9.2.3 Ontario STP

The City of Ontario STP (WQ File #63631, EPA Number OR0020621) holds an individual NPDES permit for discharge of domestic treated wastewater to the Snake River at approximately river mile 369. The current NPDES permit (#101633) prohibits the facility from discharging water to the Snake River from May 1 to October 31. The maximum effluent discharge (3.06 MGD) is the Average Dry Weather Design Flow reported in the 2019 NPDES permit evaluation report. The maximum effluent temperature (20.3°C) is the maximum effluent temperature reported on DMRs from 2014-2018 during the discharge period from November 1 – April 30. Even though the facility is prohibited from discharge May 1 to October 31, the assigned WLA is applicable for the entire TMDL allocation period, including the summer period. The WLA will be incorporated into the NPDES permit should the discharge prohibition change in the future. The annual 7Q10 of 4755 cfs was calculated from discharge measured at USGS gage 13213100 Snake River at Nyssa. See Section 6.3 for additional 7Q10 details. The final HUA assigned to Ontario STP is 0.001°C (rounded up from the calculated value of 0.0004°C).

9.2.4 Simplot – Ontario

Simplot Ontario (WQ File #63810, EPA Number OR0002402) holds an individual NPDES permit for discharge of processed wastewater and stormwater to the Snake River at approximately river mile 370. The facility was formally operated by Kraft Heinz Foods Company. The maximum effluent discharge used for the WLA is based on the Average Dry Weather Design Flow (4.3 MGD) reported in the 2021 NPDES permit evaluation fact sheet. The maximum effluent temperature reported on DMRs reviewed from 2014-2018 was 35.6°C. However, for consistency with Oregon's thermal plume limitations in OAR 340-041-0053(2)(d)(B) a maximum temperature of 32°C was used for calculating the WLA. The annual 7Q10 of 4755 cfs was calculated from discharge measured at USGS gage 13213100 Snake River at Nyssa. See Section 6.3 for additional 7Q10 details. The final HUA assigned to Simplot Ontario is 0.017°C.

9.2.5 WLA equations

9.2.5.1 Wasteload allocation equation

Equation 9-1 was used to calculate the thermal wasteload allocations in the Snake River Temperature TMDL rule.

$$WLA = \Delta T \cdot (Q_E + Q_R) \cdot C_F \qquad \textbf{Equation 9-1a}$$

$$WLA = \Delta T \cdot Q_E \cdot D_F \cdot C_F \qquad \textbf{Equation 9-1b}$$

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 (ºC) above the applicable temperature criterion using 100% of river flow not to be exceeded by each individual source from all outfalls combined.

$Q_E =$ 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

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

9.2.5.2 Wasteload allocation attainment equation

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

$$ETL = (T_E - T_C) \cdot Q_E \cdot C_F$$ **Equation 9-2**

where,

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

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

$T_E =$ 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

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

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

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

9.2.5.3 Calculating change in temperature

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

$$\Delta T_{ps} = \left(\frac{Q_E}{Q_E + Q_R}\right) \cdot (T_E - T_C) \qquad \textbf{Equation 9-3a}$$

$$\Delta T_{ps} = \left(\frac{T_E - T_C}{D_F}\right) \qquad \textbf{Equation 9-3b}$$

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)

$T_C =$ The point of discharge applicable river temperature criterion (°C)

9.2.5.4 Calculating acceptable effluent temperatures

Equation 9-4 was used to calculate the daily maximum effluent temperatures (°C) acceptable under the assigned portion of the HUA (ΔT) and the wasteload allocation (WLA).

$$T_{E_WLA} = \frac{(Q_E + Q_R) \cdot (T_C + \Delta T) - (Q_R \cdot T_C)}{Q_E}$$ **Equation 9-4a** (using ΔT)

$$T_{E_WLA} = \frac{(WLA)}{Q_E \cdot C_F} + T_C$$ **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.

$Q_E =$ 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.

$T_C =$ The point of discharge applicable river temperature criterion (°C)

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

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

9.2.5.5 Calculating acceptable effluent flows

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

$$Q_{E_WLA} = \frac{(Q_R \cdot T_C) - ((T_C + \Delta T) * Q_R)}{T_C + \Delta T - T_E}$$ **Equation 9-5a** (using ΔT)

$$Q_{E_WLA} = \frac{(WLA)}{(T_E - T_C) * C_F}$$ **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.

$T_E =$ 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.

$T_C =$ The point of discharge applicable river temperature criterion (°C)

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

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

9.3 Load allocations for nonpoint sources

Refer to the [final date] Snake River Temperature TMDL rule (OAR 340-042-0090(6)(a)) 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 above applicable criteria) to the Hells Canyon Complex dam and reservoir operations to address warming from dam impoundment, the release of impounded water back to the natural channel, and the resulting shift in the natural seasonal thermal pattern. In addition, a surrogate measure temperature target was developed to implement the dam and reservoir HUA and corresponding load allocation, (see TMDL Section 9.1, 9.3, and 9.4). Note the 0.14°C included with the surrogate measure temperature target is not warming assigned to the complex but rather pass through warming from upstream sources (e.g. tributaries and point sources). The modeling analysis summarized in Appendix C, found the temperature impacts from dam and reservoir operations shift temperatures patterns causing cooler 7DADM temperatures in the summer relative to no

dam temperatures, and warmer 7DADM temperatures in the fall and early spring. Based on this analysis, DEQ concludes that the existing operations will attain the HUA and equivalent LA assignment in the early spring through mid-summer, but not in the late summer and fall.

The load allocations assigned to tributaries account for temperature increases in the Snake River caused by point or nonpoint source anthropogenic warming in tributaries to the Snake River. 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 in the Snake River are based on all tributaries in Oregon attaining the entire 0.3°C HUA at their mouths. For Idaho tributaries, it was assumed the Payette River has no more than a 0.3°C at the mouth. This is based on Idaho NPDES permit requirements for Fruitland WWTP. Other Idaho tributaries are assumed to have no more than a 0.14°C increase at the mouth consistent with Idaho's Snake River Temperature TMDL (IDEQ, 2004). Snake River anthropogenic warming entering Oregon at river mile 409 was assumed to be zero and considered a background source under OAR 340-042-0030(1). Warming from background sources is addressed under the background load allocation.

Temperature increases caused by solar loading and lack of streamside vegetation has a relatively small temperature impact. The no warming requirement (zero HUA) is consistent with site potential vegetation conditions and allocations for nonpoint sources identified in Idaho's Snake River Temperature TMDL (IDEQ, 2004) and other temperature TMDLs in Oregon. DEQ did not develop an effective shade surrogate measure for the Snake River as the warming from lack of vegetation is relatively small.

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 a load that will attain the applicable biologically based numeric temperature criteria, and wasteload allocations and nonpoint source load allocations consistent with the attainment of the 0.3°C human use allowance above the numeric criteria.

As summarized in the allocations summary tables in TMDL section 9.7, the sum of the wasteload allocations, load allocations, and reserve capacity on each assessment unit do not exceed that AUs thermal TMDL loading capacity. As discussed in Section 6.2, DEQ used the CE-QUAL-W2 model to evaluate attainment of the assigned allocations. For point and nonpoint sources, attainment is defined based on the human use allowance rule where the cumulative warming from all wasteload and load allocations must not be greater than 0.3°C (0.5°F) above the applicable biological criterion after complete mixing in the waterbody, and at the point of maximum impact (POMI). Point source and nonpoint source thermal loading that maintains temperatures below the applicable temperature criteria are included as part of the background allocation.

As shown in Figure 10-1 and Figure 10-2, the 95th percentile 7DADM cumulative temperature increases above applicable criteria from the combined effects of point sources and nonpoint sources set at their respective TMDL allocations is 0.15°C during the summer and 0.17°C during the spawning period. The maximum cumulative warming from TMDL assigned loads is less than the 0.3°C HUA demonstrating attainment. The remainder of the HUA up to 0.3°C on each AU has been set aside as reserve capacity.

Similarly, Figure 10-3 and Figure 10-4 show that the point source wasteload allocations attain the cumulative HUA assigned to the point source sector on each AU. The maximum warming is 0.06°C during the summer and 0.11°C during the spawning period.

The dam and reservoir surrogate measure temperature target described in TMDL Section 9.4 results in attainment of the load allocation and no warming HUA assignment by the Hells Canyon Complex downstream of Hells Canyon Dam (Figure 10-5). The surrogate is also the numeric temperature target implementing the natural seasonal thermal pattern narrative. Attainment of the surrogate measure temperature target ensures attainment of the natural seasonal thermal pattern downstream of Hells Canyon Dam. The background and no dam model scenarios were used to estimate temperatures with a restored natural seasonal thermal pattern. As summarized in Section 7.2.1, this seasonal pattern shift is caused by the Hells Canyon Complex dam and reservoir operations and the effect each impoundment has on residence time and the thermocline. Because the surrogate measure temperature target will lead to no increase in temperatures at Hells Canyon Dam relative to inflowing temperatures above Brownlee (replicating a free flowing no dam temperature pattern) the resulting seasonal thermal profile will also reflect the natural seasonal thermal profile, and therefore attain the natural seasonal thermal pattern temperature criteria.

The surrogate measure also implements the minimum duties provision in rule at OAR 340-041-0028(12)(a). This provision states that anthropogenic sources are only responsible for controlling the thermal effects of their own discharge or activity in accordance with their overall heat contribution. For dam and reservoir operations, the surrogate measure reflects inflowing temperatures upstream of the reservoirs (or no dam temperatures), thus ensuring dam operators are only responsible for temperature increases caused by the dam and reservoir operations.

The Snake River AU from the Salmon River to Stateline (OR_SR_1706010301_02_103306) has an unassessed temperature status on the 2024 Integrated Report for the spawning use period but is likely temperature impaired based on data assessed during the TMDL process (See TMDL section 2.2). The TMDL model predicts the spawning criterion in the Snake River below the confluence of the Salmon River will be attained once TMDL allocations assigned to upstream anthropogenic point and nonpoint source are achieved.

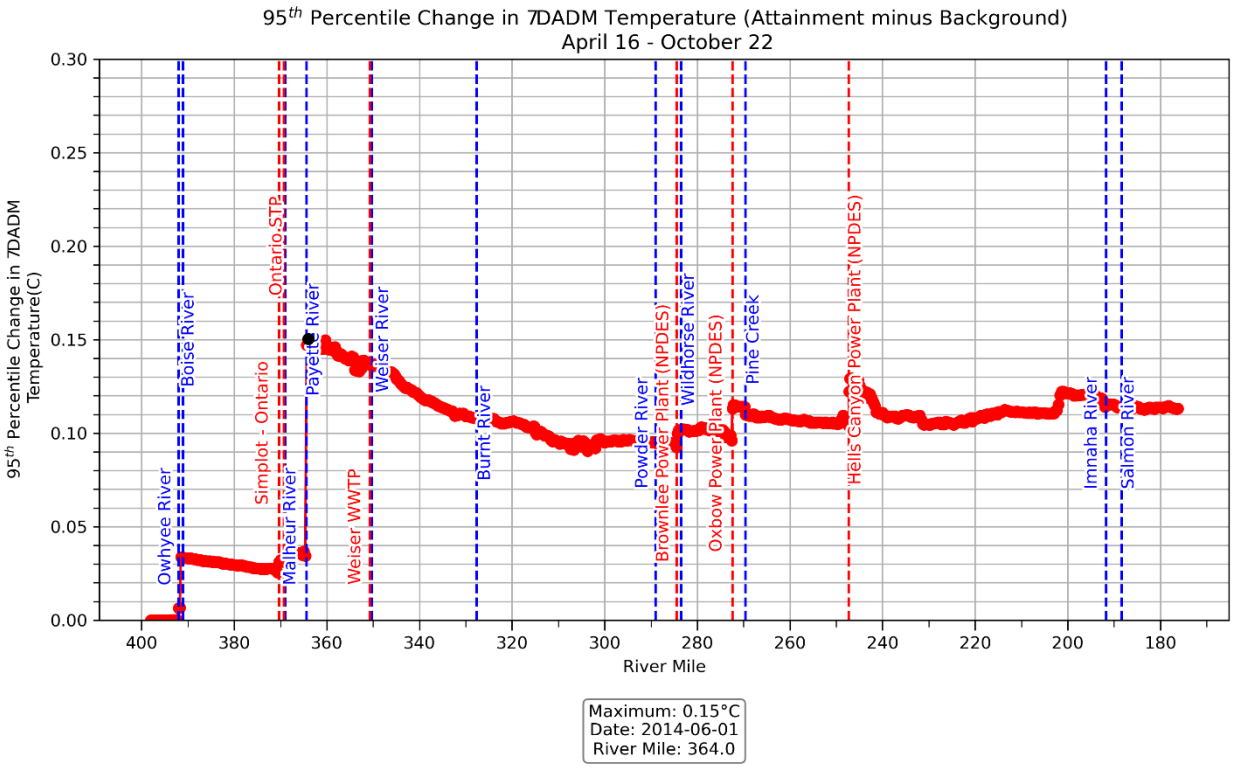


Figure 10-1: 95th percentile 7DADM cumulative temperature increase above applicable criteria during the summer season (April 16- October 22) due to combined effects of point sources and nonpoint sources set at their respective TMDL allocations.

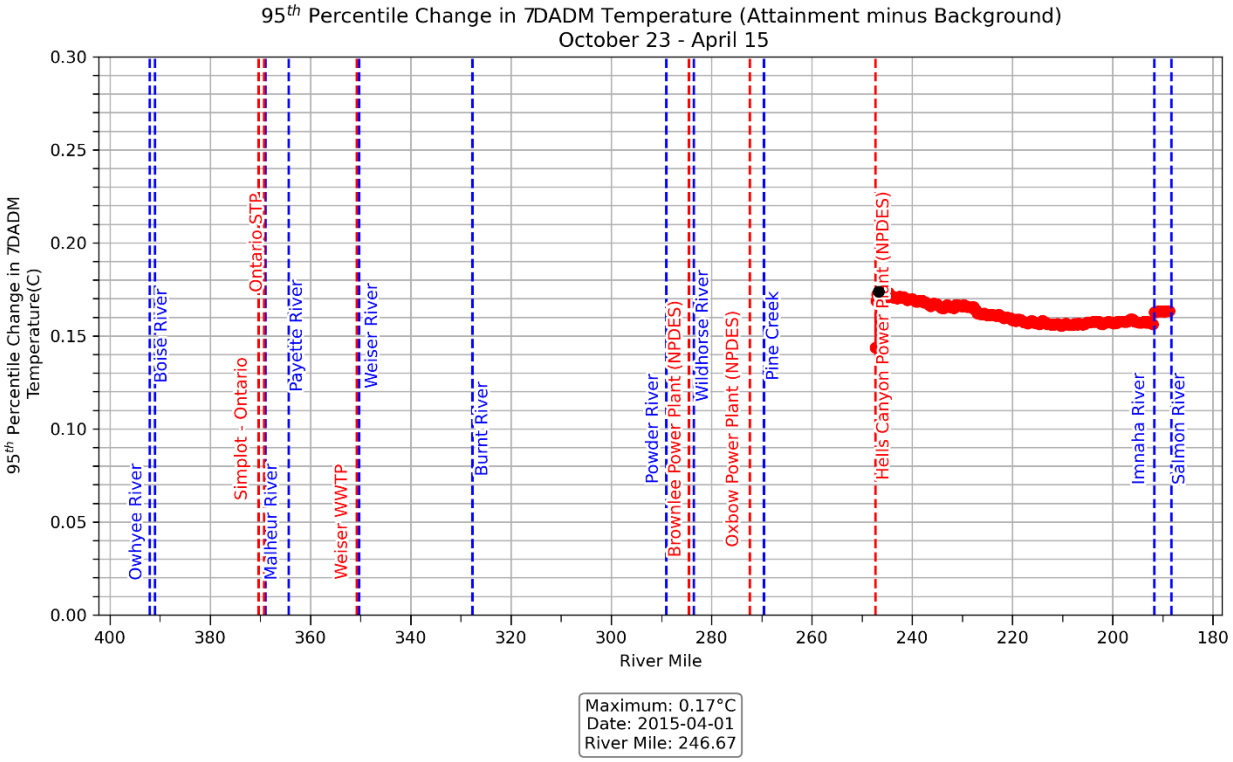


Figure 10-2: 95th percentile 7DADM cumulative temperature increase above applicable criteria during the spawning season (October 23- April 15) due to combined effects of point sources and nonpoint sources set at their respective TMDL allocations.

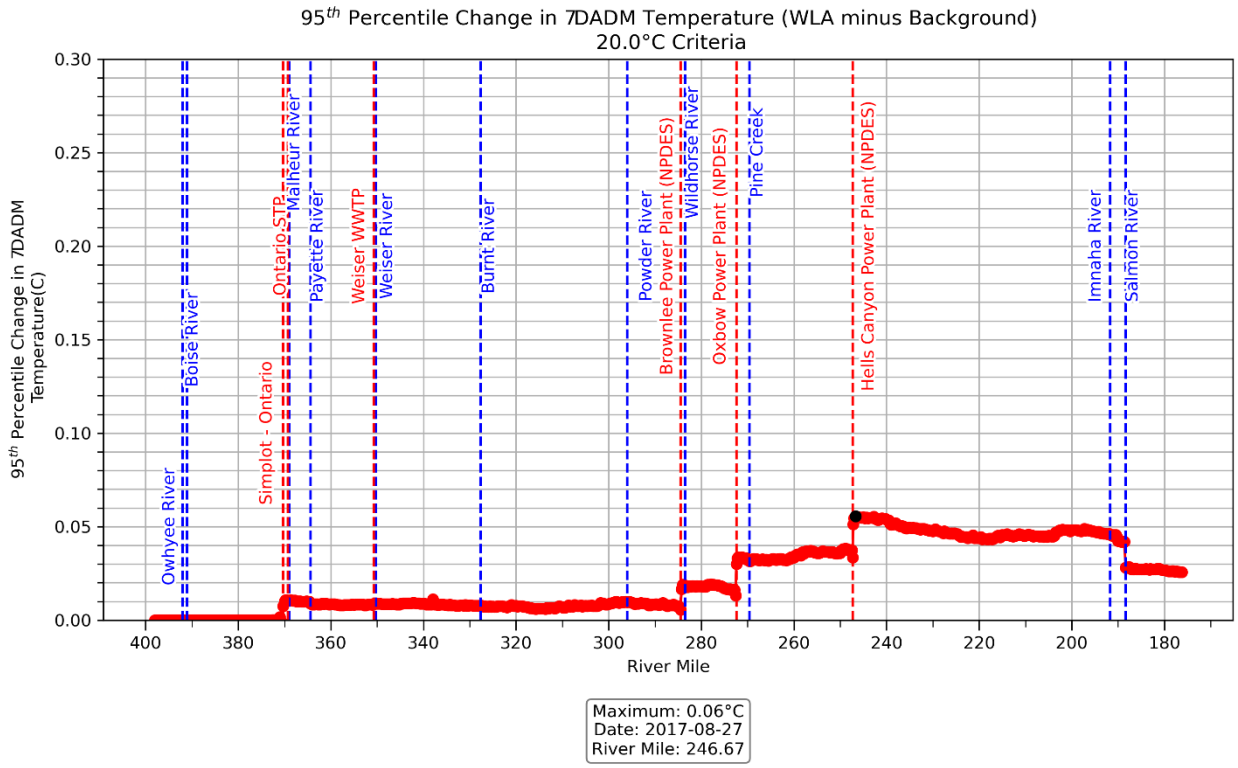


Figure 10-3: 95th percentile 7DADM cumulative temperature increase above the 20ºC applicable criteria due to combined effects of point sources discharging at their respective TMDL wasteload allocations.

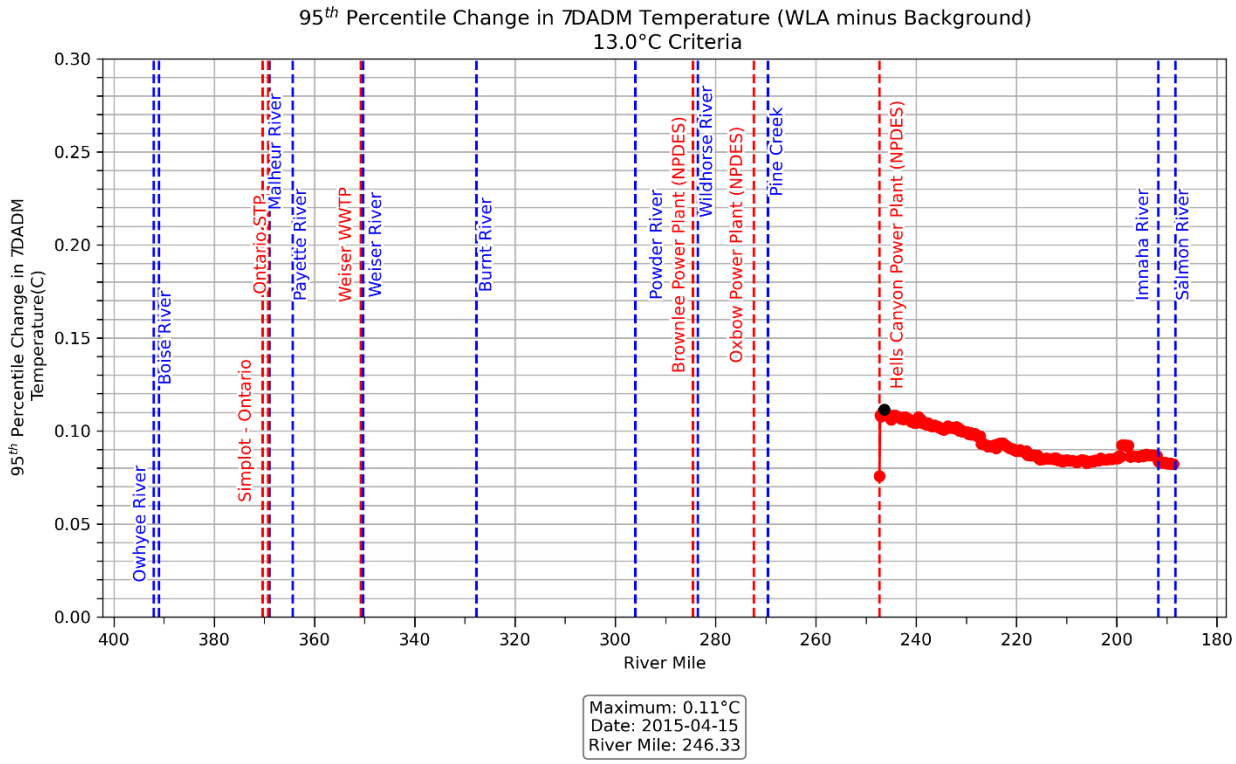


Figure 10-4: 95th percentile 7DADM cumulative temperature increase above the 13ºC spawning criteria (October 23- April 15) with point sources discharging at their respective TMDL wasteload allocations.

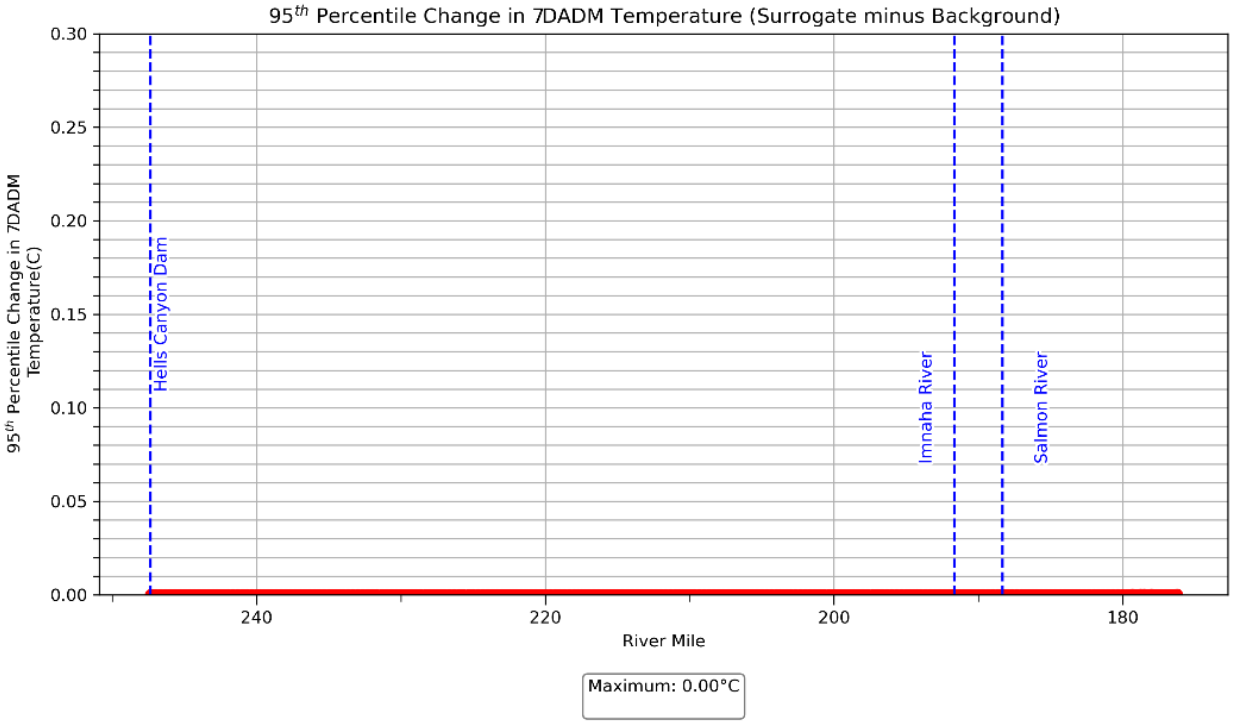


Figure 10-5: 95th percentile 7DADM cumulative temperature increase above applicable criteria due to the Hells Canyon Dam set at the surrogate measure temperature target.

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Appendices

This report includes the following appendices.

Appendix A: Hells Canyon Complex CE-QUAL-W2 water quality model development and calibration

Appendix B: Snake River CE-QUAL-W2 temperature TMDL model development and calibration

Appendix C: Snake River temperature TMDL model scenarios

Appendix D: Snake River surrogate measure regression