Upper Klamath and Lost Subbasins Temperature TMDL and Water Quality Management Plan

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State of Oregon
Department of Environmental Quality

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1. Introduction

The Klamath River basin (Figure 1-1) is 12,680 square miles originating in southern Oregon extending through northern California to the Pacific Ocean at Requa in Del Norte County, CA. Forty-four percent of the watershed lies within Oregon while the remaining 56 percent lies within California. This document presents Total Maximum Daily Loads (TMDLs) for temperature in the Oregon portion of the Upper Klamath (Hydrologic Unit Code 18010206) and the Lost subbasins (Hydrologic Unit Code 18010204).

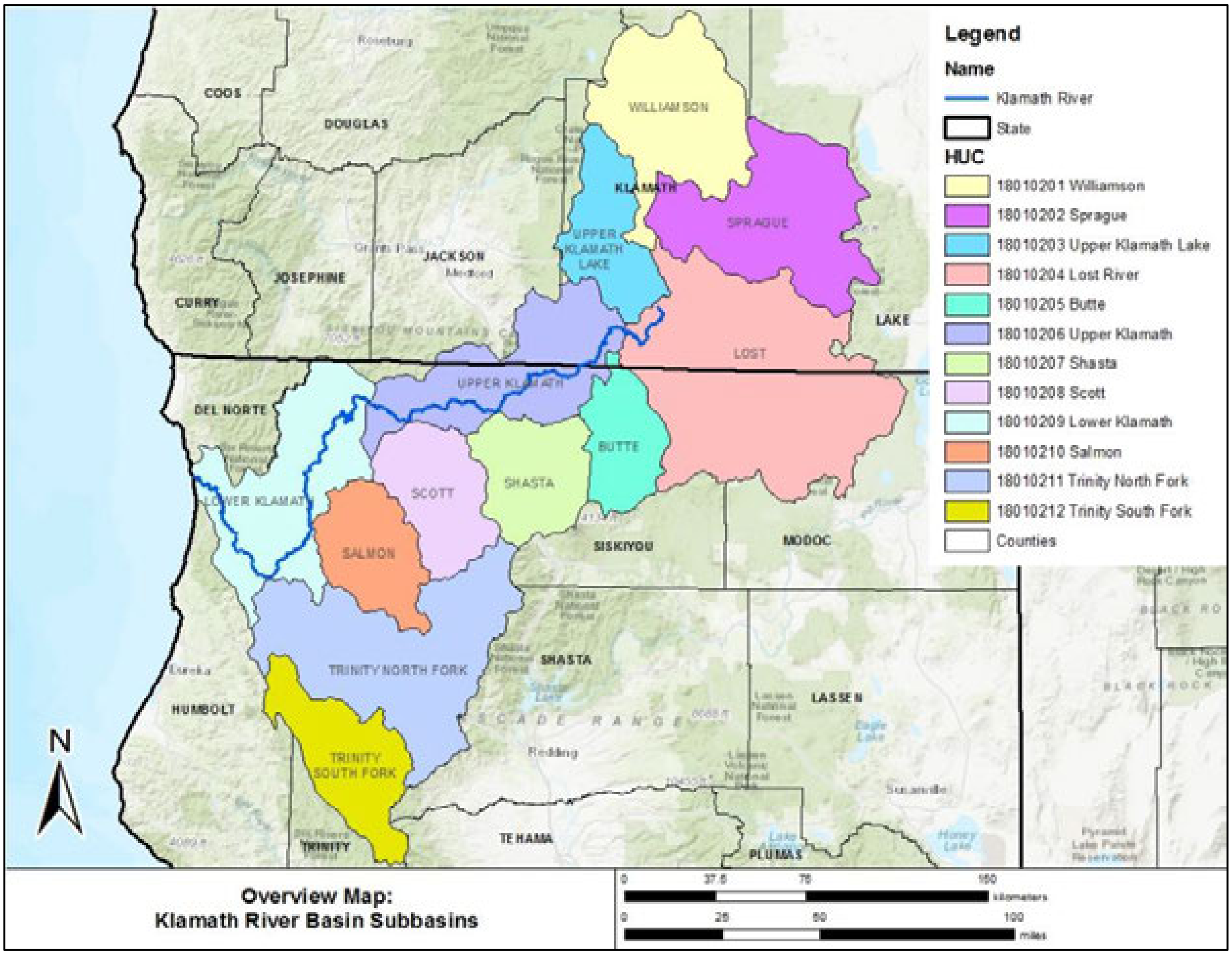


Figure 1-1. Klamath River basin.

In 2010 TMDLs for the Klamath River basin were developed for dissolved oxygen, chlorophyll *a*, pH, ammonia toxicity and temperature (DEQ 2010). All of the 2010 TMDLs were approved, except those for temperature, but were subsequently revised and were issued by the Oregon Department of Environmental Quality (DEQ) and approved by the U.S. Environmental Protection Agency (EPA) in 2019 (DEQ 2019). However, two petitioners filed for judicial review of the 2019 TMDL in Marion County Circuit Court for the State of Oregon. The temperature TMDL was not part of this judicial review. As required by federal court order, the U.S. Environmental Protection Agency and state of Oregon must revise the water temperature TMDLs for the Upper Klamath River and Lost subbasins.

1.1 TMDL Definition and Regulatory Context

A TMDL, or total pollutant load to a waterbody, is the sum of individual wasteloads allocated to point sources, load allocations assigned to non-point sources and loads assigned to background. The amount of pollutant that a waterbody can receive and meet the applicable water quality standard is the loading or assimilative capacity of the waterbody, and it is calculated as the TMDL. Loading from all pollutant sources must not exceed the loading or assimilative capacity (TMDL) of a waterbody, including an appropriate margin of safety.

Load allocations are portions of the loading capacity that are attributed to either natural background sources, such as soils, or from non-point sources, such as urban, rural agriculture, or forestry activities. Wasteload allocations are portions of the total load that are allotted to point sources of pollution, such as sewage treatment plants or industries. The wasteload allocations are used to establish effluent limits in discharge permits. Allocations can also be reserved for future uses. Allocations are quantified measures that assure water quality standard will be met and may distribute the pollutant loads between nonpoint and point sources. This general TMDL concept is represented by the following equation:

$$\text{TMDL} = \text{Wasteload Allocation} + \text{Load Allocation} + \text{Reserve Capacity} + \text{Margin of Safety}$$

Together, these elements establish the heat loads necessary to meet the applicable water quality standards for temperature and protect aquatic life and other beneficial uses. This TMDL also contains analyses and policy considerations that are unique to the challenges posed by temperature impairments in the Pacific Northwest.

TMDL Approach

The DEQ is the Oregon state agency responsible for implementing the Clean Water Act in the Klamath River basin. The EPA delegates many Clean Water Act authorities to the State of Oregon which is administered by the Environmental Quality Commission (EQC) through Oregon Revised Statute. The EQC has granted DEQ authority to develop TMDLs and issue them as orders (Oregon Administrative Rule (OAR) 340-042) or adopted by rule by the EQC. DEQ was granted authority by the EQC to implement TMDLs through Oregon Administrative Rule (OAR) 340-042 with special circumstances agricultural lands and nonfederal forestland as governed by the Agriculture Water Quality Management Act and the Forest Practices Act, respectively. The EPA has the authority under the Clean Water Act to approve or disapprove TMDLs that states submit. When a TMDL is officially submitted by a state to EPA, EPA has 30 days to take action on the TMDL. In the case where EPA disapproves a TMDL, EPA would need to establish the TMDL within 30 days.

To establish the TMDL, DEQ quantifies the amount of heat that exceeds the criteria (excess loading) and identifies the known anthropogenic sources. The TMDL sets a loading capacity that limits the amount of heat that can be discharged to achieve the biologically-based numeric criteria and human use allowance. The TMDL then distributes the loading capacity among background, unidentified sources of heat, known anthropogenic sources, margin of safety, and reserve capacity.

Figure 1-2 illustrates how the TMDL is established to meet water quality standards. The TMDL establishes a loading capacity equivalent to the biologically-based numeric criteria plus the human use allowance[1] (see purple arrow and solid green line, respectively). This loading capacity, expressed as a heat load, represents the amount of heat that can be added to the river and still meet water quality standards. The 0.3ºC human use allowance (expressed as a heat load) is divided among known anthropogenic sources, margin of safety, and reserve capacity (see green arrow). The biologically-based numeric criteria (expressed as a heat load) is allocated to background and unidentified sources, with the majority of heat coming from background sources (see blue arrow).

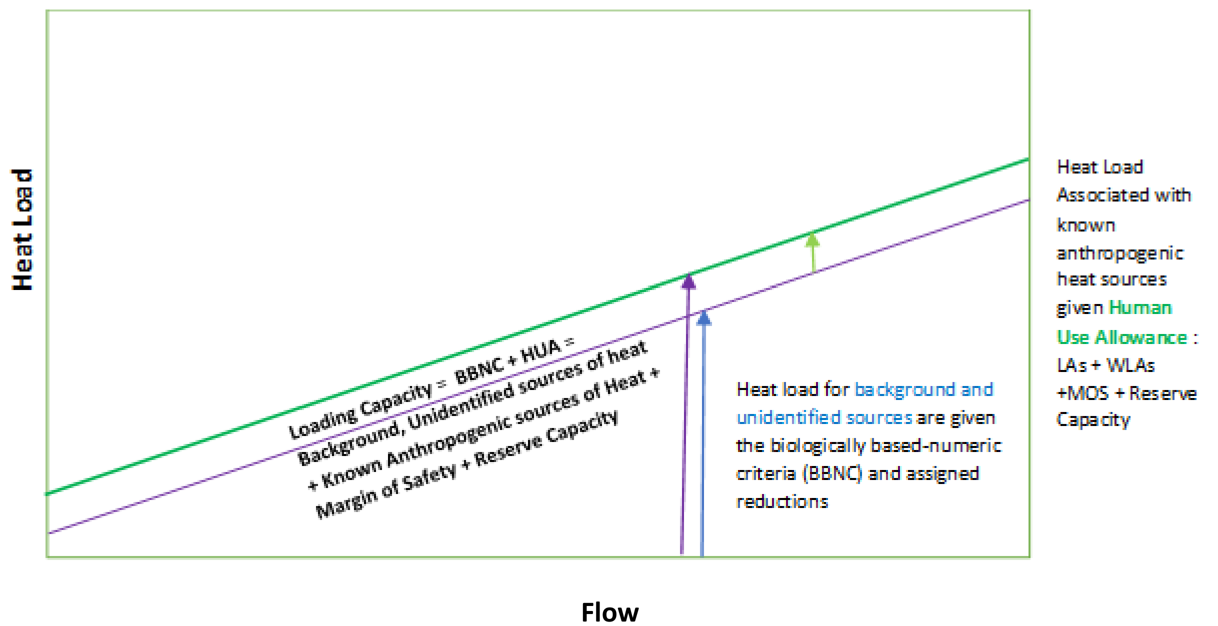


Figure 1-2. Elements of a TMDL.

Attainment Approach

In some cases, modeling indicates that even with the removal of known, quantifiable sources, the water quality criteria will not be attained. In these cases, DEQ assigns a heat load reduction to background and unidentified sources in order to meet the criteria.

Figure 1-3 illustrates how attainment of the water quality standard is addressed. The red line illustrates the current temperatures. The red arrow illustrates the reductions to existing heat loads from anthropogenic, background, and unidentified sources needed to *attain* the water quality standard. In cases where modeling has shown that even with the removal of known, quantifiable sources, the water quality criteria cannot be met, DEQ assigns a heat load reduction to background and unidentified sources (see yellow arrow) to ensure that the total allocated heat load attains the TMDL loading capacity. To be conservative, DEQ assigns the highest heat load reduction needed to attain the TMDL loading capacity at any given point. The TMDL is established at a level that represents a significant heat load reduction from current temperature, after it is implemented (see red arrow).

[1] This applies to all situations except the narrative cooling water criterion. In this case, the human use allowance does not apply.

Since some sources requiring reduction may be unknown, the TMDL requires an ongoing assessment and restoration program using adaptive management to meet the TMDL targets. The Water Quality Management Plan describes the adaptive management that is needed.

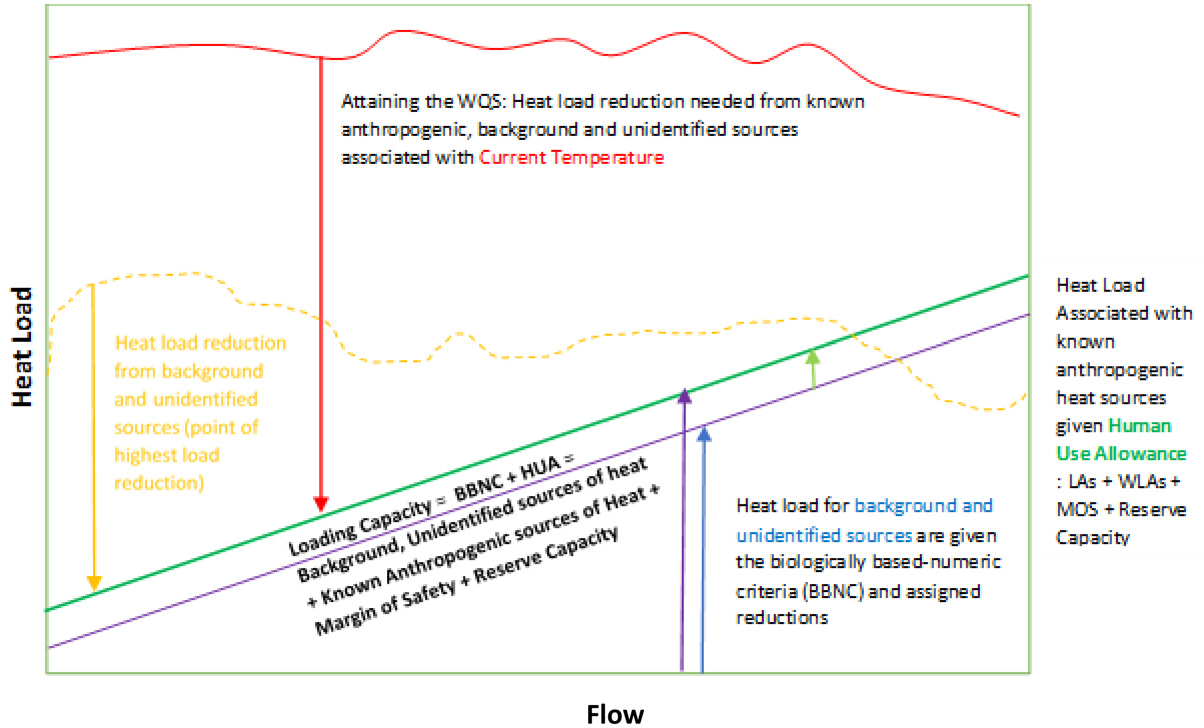


Figure 1-3. Temperature TMDL Attainment Approach.

Critical Conditions

After discussing the loading capacity, allocations, margin of safety, reserve capacity, and attainment elements, the TMDL further discusses the excess loading and allocations for critical conditions in the context of overall natural variability in river temperatures in this watershed. The TMDL analysis conservatively identifies critical conditions, i.e., the greatest exceedance of the criteria, and sets the loading capacity and heat load reductions to address these conditions. Because the allocations address the critical exceedance, the waterbody is expected to achieve the criteria over the vast majority of conditions. It is important to acknowledge that these critical conditions and the resulting maximum high temperatures occur on rare occasions.

Natural Variability in Temperature

Temperatures in streams naturally fluctuate over the day and year in response to changes in solar energy, air temperature, wind, river flows, groundwater flows, and other factors. This natural variability in river temperatures is always an important factor in the water quality status of the waterbody. In some cases, waters may meet temperature criteria in cold and/or high flow periods but exceed the criteria in hot weather and/or low flow periods. Figure 1-3 (yellow dotted line) shows this situation where a heat load reduction is needed for low flow periods, but not for high flows.

1.1.1 Permitting and Enforcement Tools

DEQ administers two different types of wastewater permits to protect surface waters from point source discharges: National Pollutant Discharge Elimination System (NPDES) and Water Pollution Control Facilities (WPCF) permits (Oregon Revised Statute [ORS] 468B.050). The statute requires that no person shall discharge waste into waters of the state or operate a waste disposal system without obtaining a permit from DEQ. DEQ has been given authority from the EPA to issue NPDES permits.

Waste discharge pertains to releasing waste to surface waters from any operation that has a water discharge including but not limited to wastewater, sewage, processing water, wash water, cooling water, etc. These discharges to surface water may occur directly through a pipe or ditch or indirectly through a storm sewer system. Certain industries and activities may also be required to obtain permits for stormwater runoff from their properties. NPDES permits fall into two categories: individual and general. Disposal pertains to getting rid of the waste by means other than discharge, such as evaporation, seepage, or land application. Disposal activities require a WPCF permit issued by DEQ. WPCF permitted operations do not allow for any discharge to surface waters, therefore they are not addressed in this TMDL.

TMDL allocations for nonpoint sources in Oregon will be implemented through TMDL Implementation Plans developed by Designated Management Agencies or other responsible person or sources. For facilities in Oregon covered by a permit or license issued by the federal government, the TMDLs will likely be implemented through a Water Quality Standards Certification issued by DEQ pursuant to Section 401 of the federal Clean Water Act.

If a source that is covered by the TMDLs complies with its NPDES permit, DEQ-approved TMDL Implementation Plan, applicable forest practice rules, agricultural management rules and plan, or Section 401 certification, it will be considered in compliance with the TMDLs. DEQ has the regulatory authority to take enforcement action to compel a Designated Management Agency to develop and implement a TMDL implementation plan. DEQ, however, will first attempt to work collaboratively with the entity to achieve compliance.

1.1.2 Tribal Trust Responsibilities

The United States has a trust responsibility to protect and maintain rights reserved by, or granted to, federally recognized tribes and individual Native Americans, by treaties, statutes, and executive orders. The trust responsibility requires that federal agencies take all actions reasonably necessary to protect trust assets, including fishery resources of the Native American tribes in the Klamath River basin. The DEQ must consider federal tribal trust responsibilities in the Klamath River basin since TMDLs are subject to the approval of the EPA. TMDLs will be implemented in Oregon in accordance with permitting and Section 401 certification programs and with the Water Quality Management Plan, thus protecting the tribal trust.

1.1.3 Dam Decommissioning

These TMDLs were developed with the expectation that PacifiCorp’s J.C. Boyle hydropower project on the Klamath River in Oregon will be decommissioned in the near term. This expectation is dependent on full implementation of an agreement between the U.S. Department of the Interior, PacifiCorp, the states of Oregon and California, tribes, and many other parties. The 2016 Amended Klamath Hydroelectric Settlement Agreement (Amended KHSA) establishes a process for the orderly removal of the J.C. Boyle dam in Oregon and three other hydroelectric facilities on the Klamath mainstem in California. PacifiCorp has applied to the Federal Energy Regulatory Commission for a license for transfer of these facilities to a dam removal entity (DRE) that will be responsible for the ultimate removal of those four hydroelectric dams on the Klamath River. The Klamath River Renewal Corporation (KRRC) was established as the DRE. In addition to being a co-applicant to FERC for license transfer for the purposes of facilities removal, the KRRC has applied for and been granted a Section 401 Water Quality Certification from Oregon for the removal of the dams.

The removal of J.C. Boyle Dam in Oregon will remove the heat impacts of that dam's operations, including the impacts of reservoir storage. Under the Amended KHSA, Keno dam will be retained, but transferred to the Bureau of Reclamation. To the extent that the cessation of hydroelectric generation is likely to affect the operation of Keno dam (as it will no longer be operated in conjunction with J.C. Boyle), the removal of J.C. Boyle is also expected to affect heat loading in the Keno reach of the Klamath River. Under the Amended KHSA, PacifiCorp is responsible for implementation of interim water quality and fishery measures until the time that removal of J.C. Boyle occurs. Under the Amended KHSA, and this TMDL, PacifiCorp is also required to submit to DEQ a proposed TMDL implementation plan. Under the Amended KHSA, that plan must incorporate the water quality-related interim measures, and be submitted within 60 days of DEQ's approval of this TMDL.

1.1.4 TMDL Implementation via the Water Quality Management Plan

DEQ has completed TMDLs and associated Water Quality Management Plans for the Upper Klamath Lake Drainage (DEQ 2002) including the Sprague, Williamson, and Upper Klamath Lake subbasins. In addition, in 2019 DEQ completed TMDLs and Water Quality Management Plans for the Upper Klamath and Lost subbasins for nutrient-related impairments with subsequent revisions that were most recently completed in 2019 (DEQ 2019). This TMDL and Water Quality Management Plan document completes the remaining TMDLs for temperature in the Upper Klamath River and Lost subbasins within Oregon.

The WQMP is the section of the TMDL that provides the framework for TMDL implementation and is used to help inform the more detailed information in the TMDL Implementation Plans that will be written by the Designated Management Agencies (DMAs) and responsible persons. The WQMP sets goals and milestones to be incorporated in the TMDL Implementation Plans to achieve the allocations in the TMDL document.

Oregon's approach to TMDL implementation includes designating responsible management agencies, as well as responsible persons or sources. A Designated Management Agency is a federal, state, or local governmental agency that has legal authority over a sector or source contributing pollutants and is identified as such by DEQ in a TMDL. The Designated Management Agencies in the Upper Klamath and Lost subbasins include: U.S. Forest Service, U.S. Bureau of Reclamation, U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, Oregon Department of Agriculture, Klamath County, Jackson County, Oregon Department of Forestry, the City of Klamath Falls, and the municipalities Merill, Malin, and Bonanza.

Designated Management Agencies and responsible persons are responsible for preparation of TMDL implementation plans include Water Management Districts, Klamath River Renewal Company (KRRC), and PacifiCorp. These entities must develop individual TMDL Implementation Plans or participate in development of a unified implementation plan to address load allocations identified in the TMDLs. Each source specific TMDL Implementation Plan must indicate how the entity will reduce pollution to address load allocations. Entities required to submit a TMDL Implementation Plan are not responsible for pollution arising from land management activities that occur outside of their jurisdictional authority.

The following are elements of the Water Quality Management Plan required under OAR 340-042-0040(4)(I), and will serve as a framework when developing the Water Quality Management Plan for the Upper Klamath River and Lost subbasins:

- Condition assessment and problem description.
- Goals and objectives.
- Proposed management strategies designed to meet the wasteload allocations and load allocations in the TMDL. This will include a categorization of sources and a description of the management strategies proposed for each source category.
- Timeline for implementing management strategies including:
    - Schedule for revising permits,
    - Schedule for achieving appropriate incremental and measurable water quality targets,
    - Schedule for implementing control actions, and
    - Schedule for completing other measurable milestones.
- Explanation of how implementing the management strategies will result in attainment of water quality standards.
- Timeline for attainment of water quality standards
- Identification of persons, including Designated Management Agencies, responsible for implementing the management strategies and developing and revising sector-specific or source-specific implementation plans.
- Identification of sector-specific or source-specific implementation plans that are available at the time the TMDL is issued.
- Schedule of preparation and submission sector-specific or source-specific implementation plans by responsible persons, including Designated Management Agencies, and processes that trigger revisions to these implementation plans.
- Description of reasonable assurance that management strategies and sector-specific or source-specific implementation plans will be carried out through regulatory or voluntary actions.
- Plan to monitor and evaluate progress towards achieving TMDL allocations and water quality standards including:
    - Identification of persons responsible for monitoring, and
    - Plan and schedule for reviewing monitoring information and revising the TMDL.
- Plan for public involvement in implementing management strategies.
- Description of planned efforts to maintain management strategies over time.

- General discussion of costs and funding for implementing management strategies. Sector-specific or source-specific implementation plans may provide more detailed analyses of costs and funding for specific management strategies.
- Citation of legal authorities relating to implementation of management strategies.

1.1.5 Adaptive Management Process

DEQ intends to review TMDL implementation, the TMDLs and the Water Quality Management Plan for the Klamath River basin in Oregon on a five year cycle. In conducting this review DEQ will evaluate the progress towards achieving the TMDL allocations, water quality standards, and implementation of the Water Quality Management Plan. DEQ expects that each Designated Management Agency, responsible persons, and designated source will also monitor and document its progress in implementing provisions of its TMDL Implementation Plan. This information will be provided to DEQ for its use while reviewing the TMDLs.

As implementation of the Water Quality Management Plan and the associated TMDL Implementation Plan proceeds, DEQ expects that Designated Management Agencies, responsible persons, and designated sources will develop benchmarks for attaining water quality improvement, which will measure progress. Where effectiveness of management techniques laid out in the TMDL Implementation Plans or implementation of these plans is not adequate, DEQ expects the Designated Management Agencies, responsible persons, and designated sources to revise the components of their plans to address these deficiencies. If DEQ determines that all appropriate measures are being taken by the Designated Management Agencies, responsible persons and designated sources, and water quality criteria are still not being met, DEQ may reopen and revise the TMDL. DEQ will also consider reopening the TMDL, subject to available resources, should new information become available indicating that the TMDL or its associated water quality targets need to be modified.

The implementation of TMDLs and the associated TMDL Implementation Plans are generally enforceable by DEQ, other state agencies, and local government. However, sufficient initiative likely exists to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, DEQ will expect that the responsible agency will work with land managers to overcome impediments to progress through education, technical support, or enforcement. Enforcement may be necessary in instances of insufficient action towards progress, such as failure to meet implementation milestones established in the TMDL Water Quality Management Plan (DEQ 2019). This could occur first through direct intervention from land management agencies (e.g. Oregon Department of Forestry, Oregon Department of Agriculture, counties, and cities), and secondarily through DEQ, with a departmental order to implement water quality management goals.

DEQ recognizes a time period from several years to several decades will be necessary after full implementation before management practices identified in a TMDL implementation plan become fully effective in reducing and controlling certain forms of pollution, especially heat loads from lack of riparian vegetation. Much of this is due to the lag between planting vegetation and growth for providing shade. In addition, DEQ recognizes that technology for controlling some pollution sources such as nonpoint sources is, in many cases, in the development stages and will likely take one or more iterations to develop effective techniques. It is possible that after application of all reasonable best management practices, some TMDLs or their associated surrogates may not be achievable as originally established and may require adaptation and alteration.

DEQ also recognizes that despite the best and most sincere efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDLs and/or their associated surrogates. Such events could be, but are not limited to, floods, fire, insect infestations, and drought.

1.2 Pollutant Identification

Pollutant Identification OAR 340-042-0040(4)(b): This section identifies the pollutant causing the impairment.

Temperature is the water quality parameter of concern, but heat, in particular heat from human activities or anthropogenic sources, is the pollutant of concern in this TMDL. Specifically, water temperature change is an expression of heat flux to waterbody:

$$\Delta\, Temperature = \frac{\Delta\, Heat}{density\ \cdot specific\ heat \cdot \Delta\, Volume}$$

Stream temperature is influenced by natural factors such as climate, geomorphology, hydrology, and vegetation (Figure 1-4). Human or anthropogenic heat sources may include discharges of heated water to surface waters, increases in sunlight reaching the water's surface due to the removal of near-stream vegetation and reductions in stream shading, changes to stream channel form, and reductions in natural stream flows and the reduction of coldwater inputs from groundwater. The pollutant targeted in this TMDL is heat from the following sources: (1) heat from warm water discharges from various point sources, (2) heat from human caused increases in solar radiation loading to the stream network from the disturbance or removal of near-stream vegetation, (3) heat from channel modification and widening, (4) heat from modification to flow rate or volume (5) heat from reservoirs and irrigation ditches which, through their operations, increase water temperatures or modify thermal regimes in downstream river reaches, and (6) background sources of heat which includes anthropogenic sources of warming through climate change and other factors.

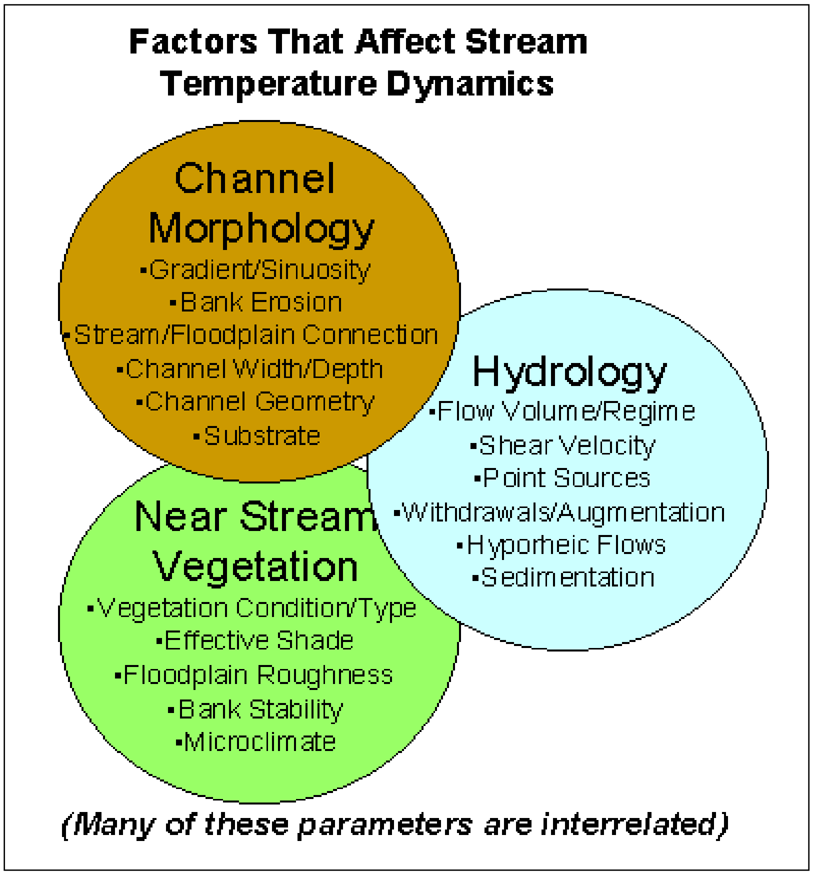


Figure 1-4. Factors affecting stream temperature.

2. Mainstem Klamath River Temperature TMDLS

These Klamath River Temperature TMDLs were developed as part of a comprehensive multistate analysis and also achieve California water quality standards at the Stateline (North Coast Regional Water Quality Control Board [NCRWQCB], 2010).

For this document, “Keno impoundment” refers to the portion of the Klamath River upstream of Keno dam to the mouth of Link River (a segment of the Klamath River), including Lake Ewauna, approximately river miles 231 to 252. This portion of the river is also commonly known as the Keno Reservoir. The components of the Klamath River TMDL are summarized in Table 2-1 and Figure 2-1. RM stands for river mile and is based on the Water Resources Map series from 1978 and is consistent with river mile metrics in the 2004-2006 DEQ 303(d) list, presented on the following pages.

Table 2-1. Summary of Klamath River temperature TMDL components.

Waterbodies OAR 340-042-0040(4)(a)	Temperature impairments in the impoundments and riverine sections of the Klamath River from the outlet of Upper Klamath Lake to the State border with California, including Link River and Lake Ewauna.
Designated Beneficial Uses OAR 340-041-0271, Table 180A	The most sensitive designated beneficial uses are fish and aquatic life, and fishing.
Pollutant Identification OAR 340-042-0040(4)(b)	Heat.
Target Identification and Applicable Water Quality Standards OAR 340-042-0040(4)(c) *CWA §303(d)(1)* OAR 340-041-0028(4)(e) OAR 340-041-0028 (9)(a) OAR 340-041-0028 (11) OAR 340-041-0028 (12)(b) OAR 340-041-0185(2) California’s downstream water quality standards	OAR 340-041-0028(4)(e): (e) **Redband or Lahontan Cutthroat Trout Use**. The seven-day-average maximum temperature of a stream identified as having Lahontan cutthroat trout or redband trout use may not exceed 20.0 degrees Celsius (68.0 degrees Fahrenheit). OAR 340-041-0028 (12)(b)(B) **Human Use Allowance**. Following a temperature TMDL or other cumulative effects analysis, wasteload and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5 Fahrenheit) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact. OAR 340-041-0028 (9) (a) **Cool Water Species**. No increase in temperature is allowed that would reasonably be expected to impair cool water species. The numeric benchmark in this TMDL implementing the cool water species narrative is an instream daily maximum temperature target of 28^{o}C. OAR 340-041-0028 (11) (a) **Protecting Cold Water**: Except as described in subsection (c) of this rule, waters of the State that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria in section (4) of this rule, may not be warmed by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This provision applies to all sources taken together at the point of maximum impact where salmon, steelhead, or bull trout are present. OAR 340-041-0185(2) **Point Source Site Specific Criteria**. From June 1 to September 30, no NPDES point source that discharges to

	the portion of the Klamath River designated for cool water species may cause the temperature of the water body to increase more than 0.3°C above the natural background after mixing with 25% of the stream flow. Natural background for the Klamath River means the temperature of the Klamath River at the outflow from Upper Klamath Lake plus any natural warming or cooling that occurs downstream. This criterion supersedes OAR 340-041-0028(9)(a) during the specified time period for NPDES permitted point sources. California Water Quality Standards: It is the policy of Oregon DEQ to achieve water quality standards established by neighboring states in interstate waters.
Existing Sources *CWA §303(d)(1)* OAR 340-042-0040(4)(f)	**Nonpoint sources** include warming and heat input from natural sources; human land management practices, water management district operations; dam and reservoir operations, and hydromodification. These nonpoint sources influence the quantity and timing of heat delivery to downstream river reaches. **Point Sources** Discharge from waste water treatment plants.
Seasonal Variation *40 CFR 130.7(c)(2)* OAR 340-042-0040(4)(j)	Peak temperatures typically occur in mid-July through mid-August. On the Klamath River, the period of exceedance of Oregon's temperature criteria is from June 1- September 30. Warming from anthropogenic sources at the Oregon/California border occur year round. The critical period in this TMDL on the Klamath River is year-round.
Excess Load OAR 340-042-0040(4)(e)	See Section 2.6.
TMDL Loading Capacity and Allocations *40 CFR 130.2(f)* *40 CFR 130.2(g)* *40 CFR 130.2(h)* OAR 340-042-0040(4)(d), (g), (h), (k)	**Loading Capacity:** See Section 2.5. **Human Use Allowance (All Sources)** – See Section 2.7.1. **Wasteload Allocations (Point Sources)** - See Section 0 **Load Allocations (Non-Point Sources)** – See Section 2.7.3 **Reserve Capacity** – See Section 2.8.
Margins of Safety *40 CFR 130.7(c)(2)* OAR 340-042-0040(4)(i)	The margin of safety is implicit using conservative assumptions.
WQ Standard Attainment Analysis OAR 340-042-040(4)(l)(E) *CWA §303(d)(1)*	See Section 2.7.4. Analytical modeling of TMDL loading capacities demonstrates attainment of water quality standards. The Water Quality Management Plan (WQMP) will consist of Implementation Plans and other strategies that contain measures to attain allocations. The TMDL and WQMP will incorporate multiple elements that together will provide reasonable assurance that the TMDL will be implemented. This reasonable assurance and accountability framework is discussed in Chapter 5.
Water Quality Management Plan OAR 340-042-0040(4)(l)	Provided in Chapter 6.

2.1 Designated Beneficial Uses and Water Quality Standards

Beneficial uses are those uses of water that the state has identified for waters of the state. The beneficial uses of waters of the state are identified in state statute with the EQC adopting by rule beneficial uses by basin. Water quality standards are adopted by the EQC to protect the most sensitive beneficial uses.

2.1.1 Beneficial Uses

Beneficial Uses: OAR 340-042-0040(4)(c): This TMDL identifies the beneficial uses in the TMDL geographic area and is intended to protect the most sensitive beneficial uses.

Oregon Administrative Rules 340- 41-0180(1), Table 180A lists the “Designated Beneficial Uses” occurring within the Klamath River (Table 2-2). Numeric and narrative water quality standards are designed to protect the most sensitive beneficial uses. The most sensitive beneficial uses relevant to the Klamath River are salmonid fish spawning and rearing and resident fish and aquatic life.

Table 2-2. Designated Beneficial Uses in the Klamath River.

Beneficial Use	Occurring	Beneficial Use	Occurring
Public Domestic Water Supply	✓	Boating	✓
Private Domestic Water Supply	✓	Water Contact Recreation	✓
Industrial Water Supply	✓	Aesthetic Quality	✓
Irrigation	✓	Hydro Power	✓
Livestock Watering	✓	Commercial Navigation and Transportation	✓
Fish and Aquatic Life	✓		
Wildlife and Hunting	✓		
Fishing	✓		

Source: Oregon Administrative Rules 340- 41-0180(1), Table 180A

Water quality problems are of great concern because of their potential impact on native fish in the Klamath River basin including the shortnose sucker (*Chasmistes brevirostris*), Lost River sucker (*Deltistes luxatus*), and interior redband trout (*Oncorhynchus mykiss* ssp.). Both sucker species were listed as endangered under the federal Endangered Species Act in 1988 (Williams 1988).

There are many beneficial uses in the Klamath River basin[1]; however, only a subset apply to temperature impairments in the Klamath River. The beneficial uses affected by excessive temperatures include Fish and Aquatic Life and Fishing (DEQ 2005).

2.1.2 Applicable Water Quality Standards

Water Quality Standards: OAR 340-042-0040(4)(c): This TMDL is developed to meet the relevant water quality standards for protection of the most sensitive beneficial uses.

EQC issued, and EPA approved, numeric and narrative water quality standards to protect designated *beneficial use*s in the Klamath River basin (Administrative Rules OAR 340–041–0180 - 0185, Table 180A, November 2003), and antidegradation policies to protect overall water quality. In practice, water quality criteria have been set at a level to protect the most sensitive beneficial uses and seasonal criteria may be applied for uses that do not occur year-round.

In order to protect the salmonid, water quality criteria have been developed in Oregon *(OAR 340-041-0028)*. Oregon's water temperature criteria use salmonids' life cycles as indicators. If temperatures are protective of these indicator species, other species will share in this protection. Numeric stream temperature criteria are expressed as a seven-day average of daily maximum temperature (7DADM). They specify where and when the fish use occurs, and, therefore, where and when numeric criteria apply. The fish use designation map provided in OAR 340-041-0180 Figure 180A is shown in Figure 2-1.

2.1.2.1 Redband or Lahontan Cutthroat Trout Use

Waters that have been designated for redband or Lahontan cutthroat trout use are identified in OAR 340-041-0180 Figure 180A and shown in Figure 2-1. The mainstem of the Klamath River is designated as redband or Lahontan cutthroat trout use from Keno Dam to the Oregon/California Stateline. OAR 340-041-0028(4) (e) states that the seven-day-average maximum temperature of a stream identified as having redband or Lahontan cutthroat trout use may not exceed 20.0 degrees Celsius (68.0 degrees Fahrenheit).

2.1.2.2 Human Use Allowance

Oregon water quality standards also have provisions for human use (OAR 340-041-0028(12)(b)). The human use allowance is an insignificant addition of heat (0.3° C) authorized in waters that exceed the applicable temperature criteria. The applicable temperature criteria are defined in OAR 340-041-0002(4) to mean "the biologically based temperature criteria in OAR 340-041-0028(4), or the superseding cold water protection criteria in 340-041-0028(11)". Following a temperature TMDL, or other cumulative effects analysis, waste load and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5 Fahrenheit) above the applicable biological criterion after complete mixing in the waterbody, and at the point of maximum impact. The rationale behind selection of 0.3 deg-C for the human use allowance and how DEQ implements this portion of the standard can be found in DEQ (2003) and the Temperature IMD (DEQ 2008).

Note that the cool water species criterion is not considered a biologically based numeric criterion so the human use allowance provision does not apply to waters designated for this

[1] https://www.oregon.gov/deq/Rulemaking%20Docs/table180a.pdf

use. Warming from human sources is limited where needed to achieve the temperature target implementing the cool water species narrative criterion. See Section 2.1.2.3 for additional details.

2.1.2.3 Cool Water Species

The Klamath River upstream of Keno Dam has been designated for cool water species use. The Cool Water Species criteria rule in OAR 340-041-0028(9)(a) states that “No increase in temperature is allowed that would reasonably be expected to impair cool water species.” The criteria apply to all sources except for point sources discharging to the Klamath River upstream of Keno Dam from June 1 – September 30. The criteria for point sources discharging between June 1 and September 30 are discussed in Section 2.1.2.3.1.

The department has determined that Lost River and shortnose suckers are the most sensitive cool water species that may be present in reaches designated for cool water species. A review of available studies evaluating the temperature tolerance of Lost River and shortnose suckers was completed in order to identify a numeric TMDL temperature target to implement the cool water species narrative rule. A summary of the studies reviewed follows.

Castleberry and Cech (1993) reported a critical thermal maximum of 32.7°C for juvenile shortnose suckers. The critical thermal maximum was determined by gradually increasing temperature over a period of several minutes to a few hours until loss of equilibrium or death occurred.

Bellerud and Saiki (1995) found that in 96 hour exposure tests complete survival of Lost River juveniles, shortnose juveniles, and shortnose larvae occurred at temperatures below 28.1°C, 30.7°C, and 30.8 °C respectively. The full results for this study were also summarized by Saiki et al. (1999) in a per reviewed journal article (next paragraph).

Saiki et al. (1999) calculated the upper median lethal tolerance limit (LC_{50}) from exposures lasting 24 hours, 48 hours, 72 hours, and 96 hours. Their results are reproduced in Table 2-3. Generally speaking the minimum reported LC_{50} lethal temperature within the confidence interval was 29.4°C for shortnose juveniles. Saiki et al. (1999) also reported that fish exposed to the highest temperature treatments (32.5°C – 33.8°C) all died within one hour.

Table 2-3. Upper median lethal temperature tolerance limits for Lost River and shortnose suckers as reported by Saiki et al. (1999).

Species and Life Stage	Mean LC_{50} (95% confidence intervals) after each exposure time (Celsius)			
	24 hours	48 hours	72 hours	96 hours
Lost River Larvae	31.9 (31.8-32.0)	31.8 (31.7-32.0)	31.8 (31.6-32.0)	31.7 (31.5-31.9)
Lost River Juveniles	30.8 (30.0-31.5)	30.8 (30.0-31.5)	30.6 (30.0-31.3)	30.5 (30.0-31.0)
Shortnose Larvae	31.8 (31.7-32.0)	31.8 (31.7-32.0)	31.8 (31.7-32.0)	31.8 (31.7-31.9)
Shortnose Juveniles	31.1 (29.4-32.8)	30.3 (29.4-31.3)	30.3 (29.4-31.3)	30.3 (29.4-31.3)

Loftus (2001) concluded that 28°C is a high stress threshold for the Lost River sucker and shortnose sucker.

The U.S. Fish and Wildlife Service recommended 28°C as a primary constituent element temperature threshold for Lost River sucker and shortnose suckers in their final critical habitat designation (USFWS, 2012). The U.S. Fish and Wildlife Service also found temperatures above 28°C are likely to adversely affect Lost River sucker and shortnose sucker in their biological opinion evaluating EPA's approval of Oregon's Temperature Standards (USFWS, 2015).

Based on review of available tolerance information and recommendations from U.S. Fish and Wildlife Service, DEQ believes that water temperatures greater than 28°C results in impairment to Lost River and shortnose suckers. In 2017 DEQ, outlined how the agency would implement the cool water species narrative for the five mile section of the Link River and Klamath River associated with the urban area for Klamath Falls (Wigal 2017). This memo also identified 28°C as a critical threshold. The memo suggested that 28°C calculated as a 7–day average daily maximum (7DADM) be used as the numeric target implementing the narrative criterion in this portion of the Klamath River. An analysis of temperature data shows that for periods in the summer, the daily maximum river temperatures within a rolling 7-day period can be upwards of four degrees Celsius warmer than the 7-day average daily maximum for the same period. The data that are available in the five mile section of the Klamath River show temperatures have never exceeded 28°C as a daily maximum, however, temperatures recorded by USGS downstream at Miller Island (station ID 420853121505500) do occasionally exceed 28 °C as a daily maximum but do not exceed 28 °C when averaged over a seven day rolling period. For example on July 18, 2003 the daily maximum was 29.5 °C and the 7DADM was 25.5 °C. To be protective, the TMDL target will be expressed as a daily maximum instead of the 7-day average of the daily maximums. This ensures river temperatures do not reach levels that would adversely affect and impair Lost River sucker and shortnose sucker.

Therefore, the numeric benchmark in this TMDL implementing the cool water species narrative criterion designated on the Klamath River is an instream daily maximum temperature target of 28°C. Where the cool water species criterion applies, warming from anthropogenic sources shall be limited in order to attain and maintain temperatures no greater than 28°C.

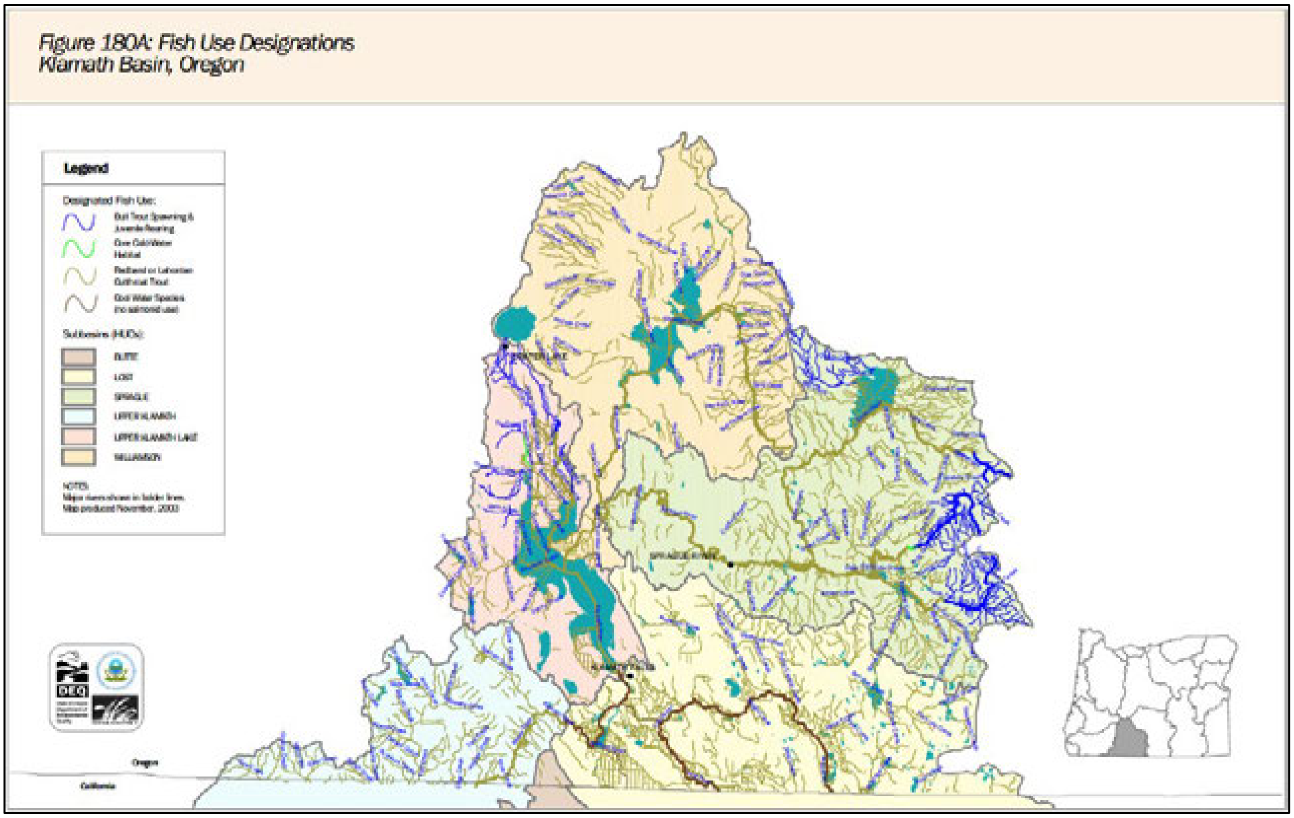


Figure 2-1. Oregon fish use designations for the Klamath basin[2].

2.1.2.3.1 Point Sources on the Klamath River

The cool water species provisions in OAR 340-041-0028(9)(a) are superseded by basin-specific criteria in OAR 340-041-0185(2) for point sources on the Klamath River. This basin-specific rule states that “from June 1 to September 30, no NPDES point source that discharges to the portion of the Klamath River designated for cool water species may cause the temperature of the water body to increase more than 0.3°C above the natural background after mixing with 25% of the stream flow. Natural background for the Klamath River means the temperature of the Klamath River at the outflow from Upper Klamath Lake plus any natural warming or cooling that occurs downstream”.

For point sources discharging upstream of Keno Dam on the Klamath River from October 1 – May 31, the wasteload allocations and allowed warming shall be limited in order to attain and maintain temperatures at the edge of the mixing zone no greater than the cool water species instream temperature target of 28°C, or downstream criteria. As discussed in Section 2.1.2.3, temperatures that exceed 32°C over a short exposure time (≤1 hour) can be lethal to suckers.

In order to minimize short term lethal exposure in the mixing zone, effluent temperatures shall not exceed 32°C at the end of the outfall pipe.

[2] http://www.oregon.gov/deq/Rulemaking%20Docs/figure180a.pdf

2.1.2.4 State of California Water Quality Standards

The Klamath River flows from Oregon into California. Therefore, allocations established in Oregon's TMDL must also achieve the water quality standards and numeric targets established in California.

The North Coast Regional Water Quality Control Board has established a temperature TMDL on the Klamath River (NCRWQCB 2010) with monthly average temperature targets (Table 2-4). The temperature targets reflect a natural condition and protects salmonids. Per communication with NCWQCB, Chinook salmon are present in the Klamath River from about August to when temperatures start to drop (approximately November). Coho salmon are present from December to January and sometimes February for spawning. Steelhead are present December through February, with spawning and eggs in the gravel through April. The TMDL also requires no warming from anthropogenic sources at the Stateline as the Klamath River enters California. In this TMDL, no warming is implemented as a modeled temperature increase no greater than 0.04°C - a temperature considered not measurable with most field instrumentation.

See Appendix D for additional background on the North Coast Regional Water Quality Control Board's temperature water quality standards and targets.

Table 2-4. Temperature numeric targets (°C) at the California/Oregon Stateline expressed as monthly averages (NCRWQCB, 2010).

May	June	July	August	September	October
14.4 °C	18.2 °C	19.1 °C	18.9 °C	15.1 °C	10.4 °C
58 °F	64.8 °F	66.5 °F	66 °F	59.2 °F	50.7 °F
November	**December**	**January**	**February**	**March**	**April**
3.6 °C	2.3 °C	3 °C	6 °C	9.4 °C	12 °C
38.4 °F	36.1 °F	37.4 °F	42.8 °F	48.9 °F	53.5 °F

2.1.3 Impaired Waterbodies and 303(d) Listings

DEQ is one of several entities that monitors the water quality of streams, lakes, estuaries, and groundwater in Oregon. This information is used to determine whether water quality standards are not being met, and consequently, whether the beneficial uses of the waters are impaired. Specific State and Federal plans and regulations are used to determine if water quality standards are not being met. These regulations include the Federal Clean Water Act of 1972 and its amendments Title 40 Code of Federal Regulations 131, Oregon's Administrative Rules (OAR Chapter 340), and Oregon's Revised Statutes (ORS Chapter 468).

Section 303(d) of the Federal Clean Water Act (1972) requires that waterbodies that exceed water quality criteria, thereby failing to fully protect beneficial uses, be identified and placed on a 303(d) list[3]. Monitoring has indicated that water temperatures in the Klamath River exceed the State of Oregon temperature criteria with 2 individual temperature listings equaling 47.9 miles. These water quality limited segments are addressed in this Chapter. Table 2-5 and Figure 2-2

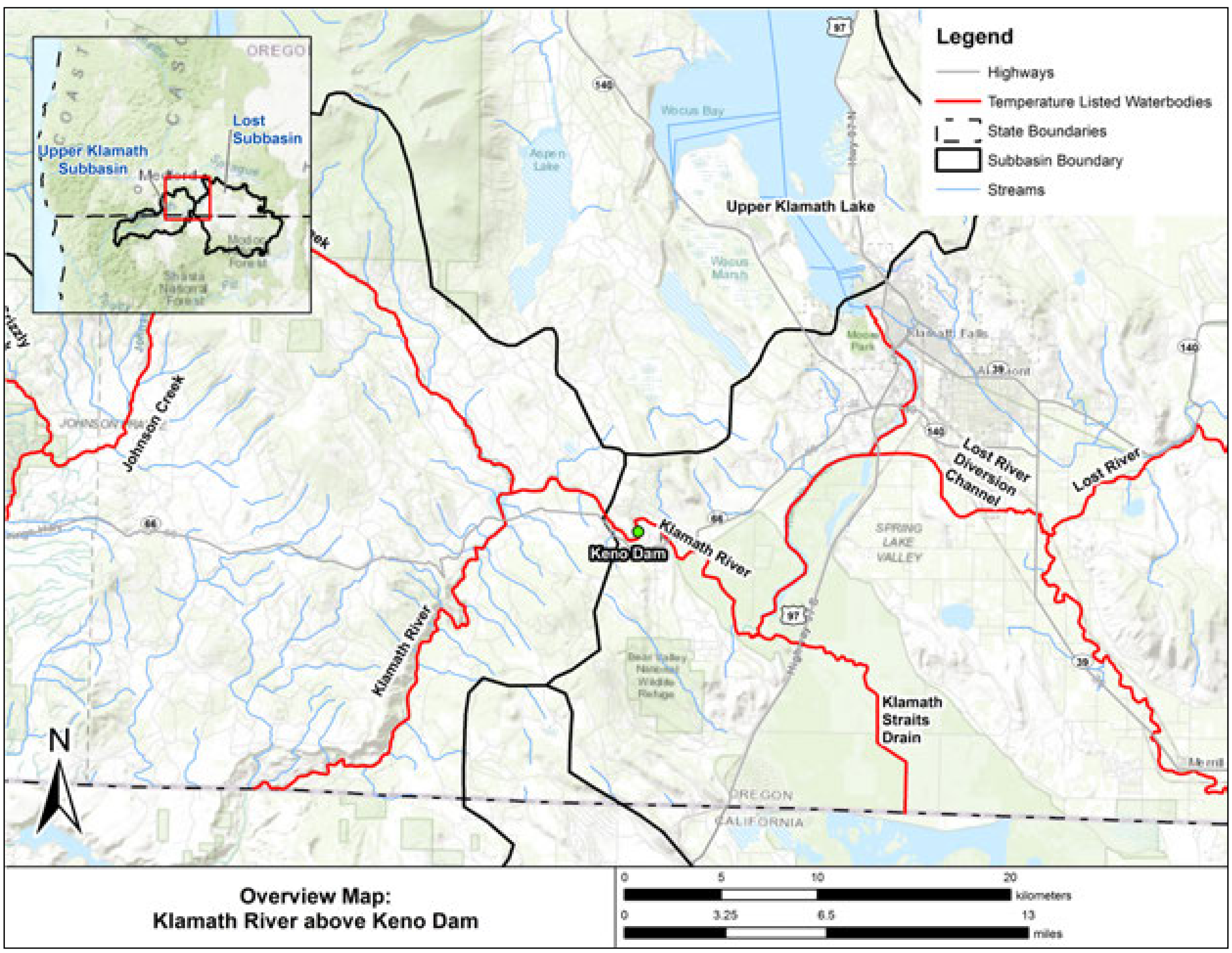
[3] For specific information regarding Oregon's 303(d) listing procedures, and to obtain more information regarding the Klamath River basin 303(d) listed streams, visit the Oregon Department of Environmental Quality's web page at https://www.oregon.gov/deq/wq/Pages/WQ-Assessment.aspx.

present the segments of the Klamath River that have been included in Oregon's 2012 section 303(d) list of impaired waters for temperature. The tributaries to the Klamath River in the Upper Klamath subbasin are addressed in Chapter 3. Klamath Straits Drain, Lost River Diversion Channel, and other water quality limited segments in the Lost subbasin are addressed in Chapter 4.

Table 2-5. Water quality limited segments for temperature in this TMDL and their water quality criteria.

303(d) ID	Waterbody Name	LLID	River Mile	Use: Applicable Criterion (°C)
12840	Klamath River	1221913420005	207 to 231.1	Redband trout: 20.0 7DADM (OR/CA Stateline to Keno Dam)
NA	Klamath River	1221913420005	231.1 to 254.9	Cool Water Species: 28.0 Daily Maximum (Keno Dam to Upper Klamath Lake)

Figure 2-2. Oregon water quality limited segments on the Klamath River included on the 2012 303(d) list. Keno Dam is located at river mile 231.1 at the most upstream end of impairment 12840.



2.2 Seasonal Variation and Critical Period

OAR 340-042-0040(4)(j), 40 CFR 130.7(c)(2)

TMDLs must also identify seasonal variation and the critical condition.

Seasonal variation in stream temperature typically follows a pattern where the peak stream temperatures occur in late July or early August when stream flows are low, radiant heating rates are high, and ambient conditions are warm. The coolest temperatures occur during the winter.

The critical condition is determined as the period when the available data show temperatures exceed the applicable criterion. The critical period also defines the time period when the TMDL allocations, reserve capacity, and margin of safety apply. As illustrated by tables in Section 2.6, downstream of Keno Dam the 20°C redband and Lahonton trout use criteria is exceeded 23% of time based on available data (Table 2-12) typically June through September in Oregon and year round at the Stateline (Table 2-13 through Table 2-15).

Based on these data, the critical condition is June 1 – September 30 to achieve Oregon's criteria and year-round for California's targets. Allocations, reserve capacity, and margin of safety developed for the Klamath River shall apply year-round.

2.3 Water Quality Modeling Overview

In order to support TMDL development for the Klamath River, the need for an integrated hydrodynamic and water quality modeling system was identified. The following model capabilities were identified:

- Capable of simulating the complex hydrodynamics of Keno impoundment.
- Capable of predicting nutrient cycles, dissolved oxygen, pH, and temperature.
- Dynamic (time-variable) and thus capable of representing the highly variable flow and water quality conditions within and between years.

Following a review of potential modeling approaches, DEQ, NCRWQCB, and U.S. EPA selected the water quality models developed by Watercourse Engineering for PacifiCorp (Watercourse Engineering, 2004), hereafter referred to as the *PacificCorp Model*. DEQ, NCRWQCB, and U.S. EPA determined that with some enhancements, the PacifiCorp model would provide the optimal basis for developing the Klamath River TMDLs. Complete documentation of modeling configuration, model input, and calibration is presented in Appendix B (*Model Configuration and Results - Klamath River Model for TMDL Development*, Tetra Tech 2009).

The original PacifiCorp model used Resource Management Associates (RMA) RMA-2 and RMA-11 models and the CE-QUAL-W2 (W2) model. The modeling domain for the Klamath River was divided into nine model segments as depicted in Table 2-6**.** The river and reservoirs within each model segment were further divided into higher resolution elements for greater detail in modeling. The five segments located in Oregon and applicable to this TMDL effort include the Klamath River from the Link River to the Oregon/California state line. The W2 model was used to simulate stream temperature and flow in the reservoir portions of the Klamath River (Lake Ewauna portion above Keno Dam and the JC Boyle Reservoir). The remainder of the river was modeled using RMA-2 and RMA-11. RMA-2 simulates hydrodynamics, while RMA-11 represents water quality processes. CE-QUAL-W2 is a hydrodynamic and water quality model

Both the W2 and RMA models require key data for model setup including bathymetry that defines the geometry of the system, time-variable flow and temperature boundaries, and meteorological data defining atmospheric conditions governing heat exchange at the air-water interface. The W2 model also requires dam configuration and operational information. The modeling framework adopted for developing the Klamath River TMDLs is consistent with available models appropriate for application to riverine/reservoir systems and is based on the PacifiCorp modeling approach to this unique river system.

Table 2-6. Model components applied to each Klamath River modeling segment.

Modeling Segment	Segment Type	State	Model(s)	Dimension
Klamath River (Link River)	River	OR	RMA-2/RMA-11	1-D
Klamath River (Lake Ewauna-Keno Dam)	Reservoir	OR	CE-QUAL-W2	2-D
Klamath River (Keno Dam to J.C Boyle Reservoir)	River	OR	RMA-2/RMA-11	1-D
Klamath River (J.C Boyle Reservoir)	Reservoir	OR	CE-QUAL-W2	2-D
Klamath River (Full Flow Reach to OR/CA state line)	River	OR	RMA-2/RMA-11	1-D
Copco Reservoir	Reservoir	CA	CE-QUAL-W2	2-D
Iron Gate Reservoir	Reservoir	CA	CE-QUAL-W2	2-D
Iron Gate Dam to Turwar	River	CA	RMA-2/RMA-11	1-D
Turwar to Pacific Ocean	Estuary	CA	EFDC	3-D

The model was set up to reproduce conditions observed in 2000 from Upper Klamath Lake to the Pacific Ocean and in 2002 from Upper Klamath Lake to the Stateline. Given the range of controls on water flow in the Upper Klamath subbasin, it is difficult to compare the model years to a 'typical' year; however, the two model years do appear to capture a variety of flows that are commonly observed (Figure 2-3). The model was calibrated by attempting to find the best fit between computed and observed data by adjusting model parameters, while keeping the parameters within the range of literature values. The model was validated with 2002 water quality data using 'replicative model validation' that tests goodness-of-fit during and after model calibration through graphical and statistical comparison of model results and field measurements (definition from Arhonditsis and Brett 2004). The model was generally able to reproduce observed water quality in the Klamath River (see graphs in Appendix B).

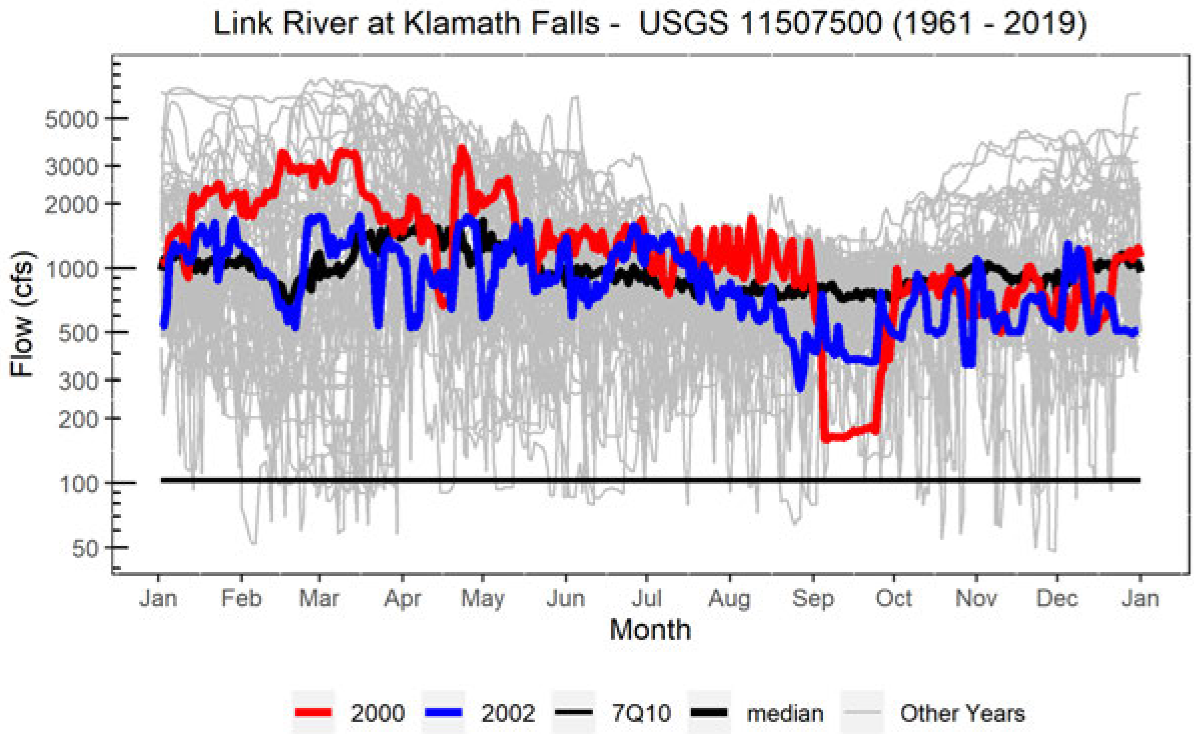


Figure 2-3. Flow measurements at Link River. The hydrographs of every year except those being modeled are in gray. Note y-axis is on a log scale.

Like any dynamic water quality model, the Klamath River TMDL models were developed based on assumptions, and therefore have inherent limitations and uncertainty. Development and application of the Klamath River TMDL model have focused on key best practices identified in EPA's March 2009 "Guidance on the Development, Evaluation, and Application of Environmental Models," including peer review of models; QA project planning, including data quality assessment; and model corroboration (qualitative and/or quantitative evaluation of a model's accuracy and predictive capabilities). The entire TMDL modeling process has been a case study for collaboration at both technical and policy levels, with participation of two federal agencies, two state agencies, and private consultants over a seven year period. In addition to the key practices noted above, model sensitivity and uncertainty analysis have also been considered. The model sensitivity was performed as needed throughout model calibration and source assessment phases of model scenarios to better understand model predictions and limitations. Since it was not a formal process with defined output and metrics, it is not presented in this document. Discussion of uncertainty as it relates to the TMDL is discussed in the the Margin of Safety section (Section 2.8).

This analytical tool went through multiple rounds of peer review. Staff with modeling expertise from DEQ, NCRWQCB, and EPA worked as a team with Tetra Tech reviewing and advising on model development and application. In 2005, the calibrated model was also reviewed by Merlynn Bender of U.S. Bureau of Reclamation (BOR), Dr. Scott Wells of Portland State University, and Brown and Caldwell under contract with the City of Klamath Falls. The NCRWQCB also had their TMDL go through an external scientific peer review in 2009 (NCRWQCB 2010). Lastly, BOR contracted the USGS to review the Keno impoundment portion of the model (Rounds and Sullivan 2009 and Rounds and Sullivan 2010). DEQ, along with EPA and NCRWQCB, considered all peer review comments and made changes to the model and documentation when appropriate.

After testing the Klamath River model through hydrodynamic and water quality calibration and corroboration, a series of scenarios were developed to support TMDL determination. The scenarios followed a logical progression that enabled numeric criteria and natural conditions for relevant parameters to be fully evaluated and used as the driver for allocation of the loading capacity. They can be grouped into the following broad categories: existing conditions, natural conditions, and TMDL compliance. The temperature and flow output from the Klamath River models were used to develop a load capacity curve at Keno Dam and at the state line. The loading capacity curve characterizes the allowable thermal load capacity for a range of expected flows throughout the year. The following sections provide a brief description of the scenarios, associated assumptions, and results. Detailed descriptions of modeled scenarios used to develop the allocations are provided in Appendix C.

2.4 Existing Pollution Sources

OAR 340-042-0040(4)(f), OAR 340-042-030(12)

A source is any process, practice, activity, or resulting condition that causes or may cause pollution or the introduction of pollutants to a waterbody. This section identifies the pollutant sources and estimates, to the extent existing data allow, and the amount of actual pollutant loading from existing sources. Sources of heat to streams include point and nonpoint sources. Specific sources are described below and are subsequently allocated a portion of the Loading Capacity (Section 2.5). The thermal load in the Upper Klamath subbasin is a mixture of natural background loads and loads from anthropogenic sources.

2.4.1 Point Sources

Point source means a discernible, confined, and discrete conveyance including, but not limited to, a pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel or other floating craft, or leachate collection system from which pollutants are or may be discharged but does not include agricultural storm water discharges and return flows from irrigated agriculture (OAR 340-041-0002(46)). DEQ issues NPDES permits for sources that discharge to surface waters according to OAR 340-045-0015. NPDES permits fall into two categories: general and individual. Existing permit information was obtained for the Klamath River.

There are no communities that require a MS4 stormwater permit along the Klamath River. Municipalities that need to obtain an MS4 permit are classified as either "Phase I" or "Phase II". Phase I MS4s cover areas with populations greater than 100,000 while regulated Phase II (or "small") MS4s serve populations less than 100,000 that are located fully, or partially, within an Urbanized Area in the State of Oregon as defined by a Decennial Census conducted by the U.S. Bureau of Census. The largest municipality along the Klamath River is Klamath Falls with a population of approximately 20,000 (see Lost Subbasin Temperature TMDL Chapter 3 Section 3.2.1), which does not meet the population threshold of 100,000 to be considered for a MS4 permit. Klamath Falls is also not identified as an Urbanized Area. Therefore, there are no MS4 permits along the Klamath River.

As of September 2018 there are four individually permitted facilities that discharge to the Klamath River above Keno Dam (Figure 2-4 and Table 2-7) and five facilities that are covered under the 1200-Z industrial stormwater permit (Table 2-8), and one entity under the 1200-A stormwater permit for sand and gravel mining activities (Table 2-8). There are also ten entities that have coverage under the 1200-C construction stormwater general permit. Registrants that have coverage under the 1200-C construction stormwater general permit are not listed in this TMDL because they are ephemeral in nature and the number and location of registrants will vary year-to-year. Refer to DEQ's permits database for current permit information: http://www.deq.state.or.us/wq/sisdata/sisdata.asp

Table 2-7. Individual NPDES permits discharging to the Klamath River.

File Number	Facility Name	Facility Type	River Mile
46763	Klamath Falls Wastewater Treatment Plant	Domestic Wastewater	251
83316	South Suburban Wastewater Treatment Plant	Domestic Wastewater	250
18677	Columbia Forest Products	Industrial	248
96207	Collins Products	Industrial	246.5

Table 2-8. 1200-Z General industrial stormwater NPDES permits discharging to the Klamath River.

File Number	Facility Name	Permit Type
96207	Collins Products	General 1200-Z
18677	Columbia Forest Products	General 1200-Z
115951	Panel Processing of Oregon	General 1200-Z
112793	Reach, Inc.	General 1200-Z
119345	Rocky Mountain Construction, LLC	General 1200-A
112918	Waste Management of Oregon, Klamath Falls Division	General 1200-Z

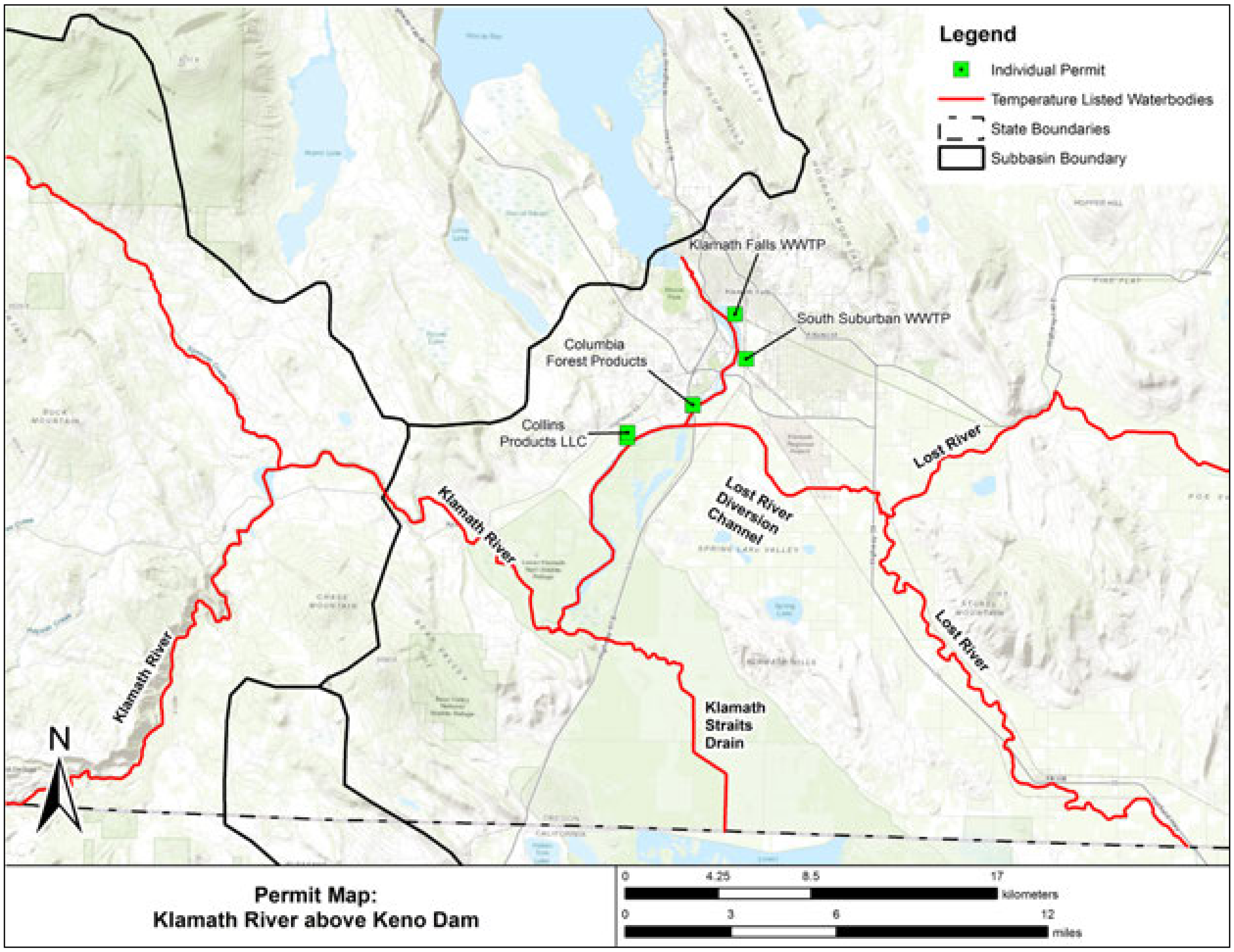


Figure 2-4. Location of individual NPDES permits discharging to the Klamath River.

Data were not available in sufficient quantity to characterize the temperature impact from most of the stormwater dischargers identified in Table 2-8. Instead DEQ reviewed literature from studies in the mid-west and east coast of the United States on stormwater and stream temperature impacts. This review provides evidence that, under certain conditions, runoff from impervious pavement or runoff that is retained in uncovered open ponds can produce short duration warm discharges (Herb et al. 2008, Jones and Hunt 2009, UNH Stormwater Center 2011, Winston et al. 2011, Hester and Bauman 2013). Increases in runoff temperature are highly dependent on many factors including air temperature, dewpoint, pavement type, percent impervious, and the amount of impervious surface blocked from solar radiation (Nelson and Palmer 2007, Herb et al. 2008, Thompson et al. 2008, Winston et al. 2011, Jones et al. 2012, Sabouri et al. 2013, and Zeiger and Hubbert 2015). These warm runoff discharges can create “surges” that produce increases in stream temperature typically for short durations (Hester and Bauman 2013, Wardynski et al. 2014, Zeiger and Hubbert 2015). However, studies that evaluated stormwater discharges over weekly averaging periods did not indicate exceedances above biologically based critical thresholds (Wardynski et al. 2014, Washington Department of Ecology 2011a and 2011b). Stormwater permit registrants are also not expected to be a significant source of flow during the summer critical period as the average monthly rainfall is less than one inch (see Section 3.2.4). The flow rate in the Klamath River is large enough that stormwater discharges will have no potential to increase temperature. Based on a flow mass balance using discharge information submitted by Collins Products (which is covered under the 1200-Z general permit) it is estimated that a stormwater discharge will result in a change in temperature of 0.0001°C or less.

Therefore, industrial stormwater general permit registrants are not likely to contribute significant thermal loading to the Klamath River and will receive wasteload allocations equal to their current thermal load (see Section 0 for more detail).

2.4.2 Nonpoint Sources

Nonpoint sources are diffuse or unconfined sources of pollution where wastes can either enter, or be conveyed by the movement of water, into waters of the state (OAR 340-41-0002 (42)). Historically, human activities have altered the stream morphology and hydrology and decreased the amount of riparian vegetation in the subbasin. The subbasin includes urban, agricultural, and forested lands. Additionally, hydroelectric projects and multiple points of diversion in the Upper Klamath subbasin have altered stream flow levels. Low summertime flows decrease the thermal assimilative capacity of streams. Pollutant (solar radiation) loading causes larger temperature increases in stream segments where flows are reduced by human uses. Details on the nonpoint sources of thermal loading due to hydromodification from dams, diversions, and water management districts in the Upper Klamath subbasin are provided in the following sections.

2.4.2.1 Near Stream Vegetation Disturbance/Removal

Vegetation removal on the Klamath River does result in some warming in the Klamath River but based on DEQ's review of available data and information does not appear to be a major source of stream warming for the following reasons: (1) Following DEQ's review of aerial imagery and LiDAR upstream of Keno Dam we conclude there appear to be areas with opportunity for vegetation restoration but the effectiveness of riparian shading on maintaining cooler stream temperatures is decreased because of the width and volume of the river. Sullivan et al. (2013) conducted shading scenarios on the reaches upstream of Keno Dam and found that the daily average decrease in temperature from the current condition baseline was nearly zero near the Link River to 0.6 degrees Celsius at Keno Dam. The shading scenario assumed a continuous block of 20 meter (65.6 ft) tree heights on both banks with transmission of solar radiation through the canopy assumed to be zero (100 percent solar blockage). DEQ does not consider these assumptions to be realistic estimates of restored vegetation and it's extent upstream of Keno so the true reduction in temperature will likely be smaller; (2) the riverine portions from Keno Dam to the state line do not appear to be significantly degraded by human activity based on our review of aerial imagery and LiDAR data, and (3) since the river is constrained by steep canyon walls downstream of Keno Dam, the potential for restoring extensive riparian vegetation is limited.

Because warming from vegetation removal is not a significant source, DEQ has provided a human use allowance to land management DMAs of zero (Table 2-16). This means there can be no excess loading from land management activities such as vegetation removal.

2.4.2.2 Hydromodification: Dams, Diversions, and Water Management Districts

There are several dams, diversions, and water management districts (irrigation and drainage districts) operating in the Upper Klamath and Lost subbasins that influence temperature in the Klamath River. Some of the hydromodification activities that could lead to warmer stream temperatures are listed below:

- Diversion dams are used to divert water from a stream to an irrigation ditch or canal. Diversion dams affect stream temperature by reducing discharge in the downstream reach of the river. Reductions in stream flow in a natural channel slow the movement of water and generally increase the amount of time the water is exposed to solar radiation. Stream temperatures downstream of diversion dams can be substantially warmer than those above.
- Diversion of water from the Klamath River and tributaries of the Klamath River decrease the ability of streams to assimilate heat load and result in warmer stream temperatures.
- Canals and other unpiped water conveyance systems generally are open ditches. These ditches are usually unshaded and increase the surface area of water exposed to solar radiation. Where canal waters are allowed to mix with natural stream flows, such as at diversion dams and at places where natural stream channels (or modified stream channels) are used to convey irrigation water to downstream users, stream temperatures can increase.
- Irrigation return flows come off fields or pastures after irrigation. These excess waters may end up in a stream or the irrigation ditch to be used by the next water right holder. These waters are generally warm and may be nutrient-rich as well.
- Operational spills are places in the irrigation delivery system where excess unused irrigation water in the canals is discharged back into either a downslope canal or lateral or a natural stream channel without being delivered to or used on an individual field. These waters may be picked up by the next water right holder. These waters can also increase stream temperatures.

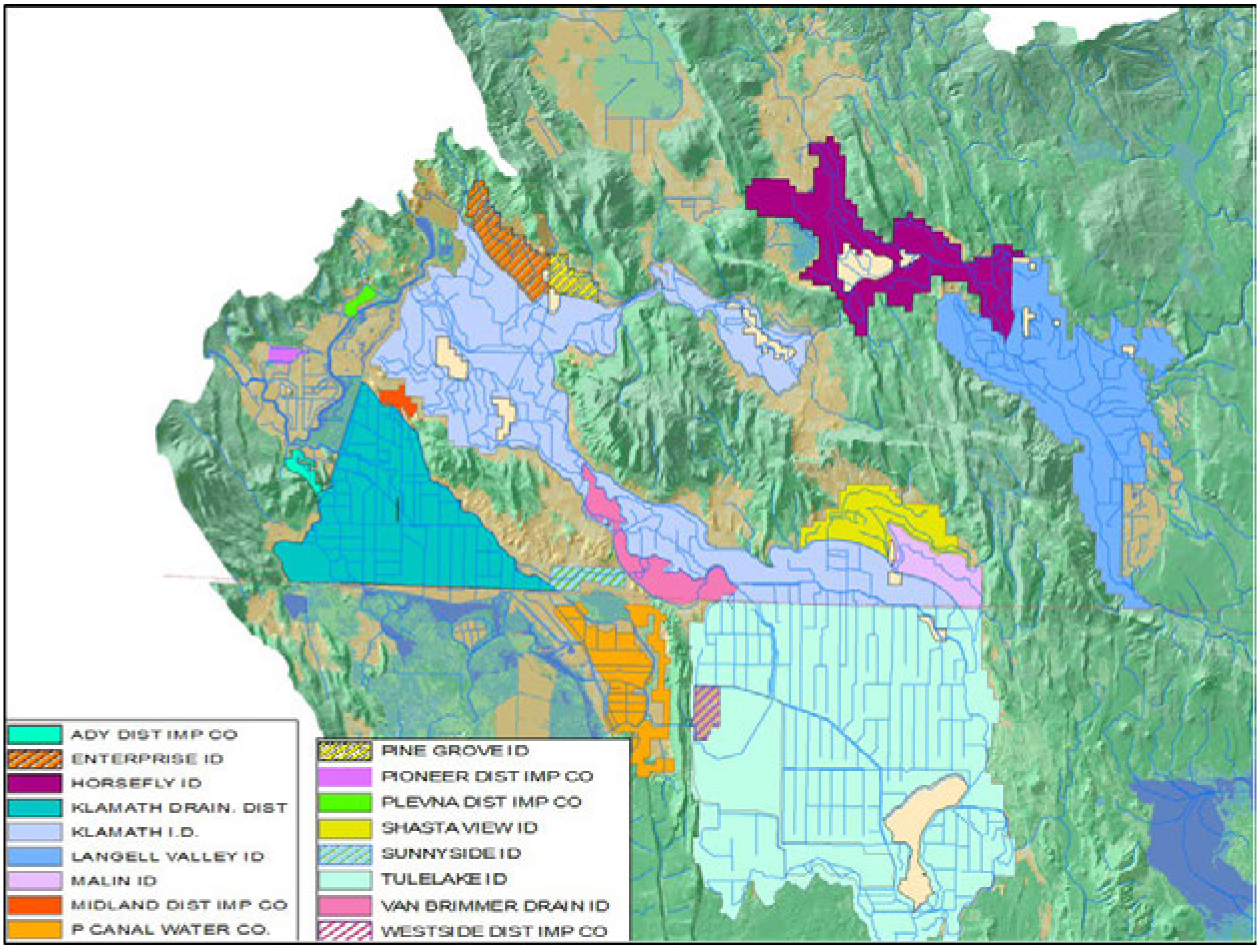


Figure 2-5. Map of Water Management Districts in the Klamath River Basin

2.4.2.2.1 Klamath Project

The Lost River Diversion Channel and Klamath Straits Drain are part of United States Bureau of Reclamation's (BOR) Klamath Project. It is DEQ's understanding that operation and maintenance of BOR owned Klamath Project facilities and waterways are delegated to various Water Management Districts. The Lost River Diversion Channel and Klamath Straits Drain are used to divert and discharge water into the Klamath River in the impounded reach upstream of Keno Dam (Figure 2-1). For this document the "Lost River system" refers to the hydrologically connected natural and constructed conveyances of the Lost River, Tule Lake, Lower Klamath Lake, Klamath Straits Drain, and other associated canals and drains. TMDLs to address temperature impairments within the Lost River system in the Lost subbasin of Oregon are in Chapter 4. EPA has promulgated a TMDL for the Lost River system in California (U.S. EPA, 2008). The Klamath River temperature TMDL (this chapter) investigates the impact of elevated temperatures in the Lost River Diversion Channel and Klamath Straits Drain, and by extension the canals and other water conveyance facilities that are hydrologically connect the Klamath River to the Lost River system. The Lost subbasin TMDL investigates impacts of elevated water temperatures from operation of the Klamath Project on the Lost River.

BOR's Klamath Project supplies water to approximately 240,000 acres of cropland (38% of it in California and 62% of it in Oregon) (BOR2009). Water is supplied from Upper Klamath Lake and Klamath River along with reservoirs and tributaries within the Lost River system. Included in the project are reclaimed lands of Tule Lake, Lower Klamath Lake, and facilities related to flood control. In terms of its relationship with the Klamath River, the Klamath Project withdraws water from Upper Klamath Lake via A-canal and from Keno impoundment via Ady Canal and North Canal, which are owned by the Klamath Drainage District. The Lost River Diversion Channel can transfer water to or from the Klamath River. The Lost River Diversion Channel typically discharges to the Klamath River September to April and is diverting Klamath River water from May to August. Pump stations at the western end of Klamath Straits Drain transfer water to the Klamath River. Water flows to the Klamath River from Klamath Straits Drain year round. Except during high water, there was no surface water connection between the Klamath River and the ancestral Lost River drainage prior to construction of the Klamath Project (BOR 2005).

Warming in the Klamath River from anthropogenic warming in the Lost River Diversion Channel and Klamath Straits Drain was evaluated in this TMDL using the Klamath River model. Depending on time of year, the Lost River Diversion Channel and Klamath Straits Drain can both cool or warm the Klamath River. The background temperatures in Lost River Diversion Channel and Klamath Straits Drain were set equal to the Klamath River temperatures directly upstream from where these tributaries flow into the Klamath River.

During the discharge period in the model year (year 2000) the Lost River Diversion Channel warmed the Klamath River at the point of discharge by a maximum of 5.5ºC (Figure 2-4). Periods with no line in Figure 2-4 indicate times when water was flowing into the Lost River Diversion Channel from the Klamath River. During the same year the Klamath Straits Drain warmed the Klamath River at the point of discharge by a maximum of about 1.0ºC.

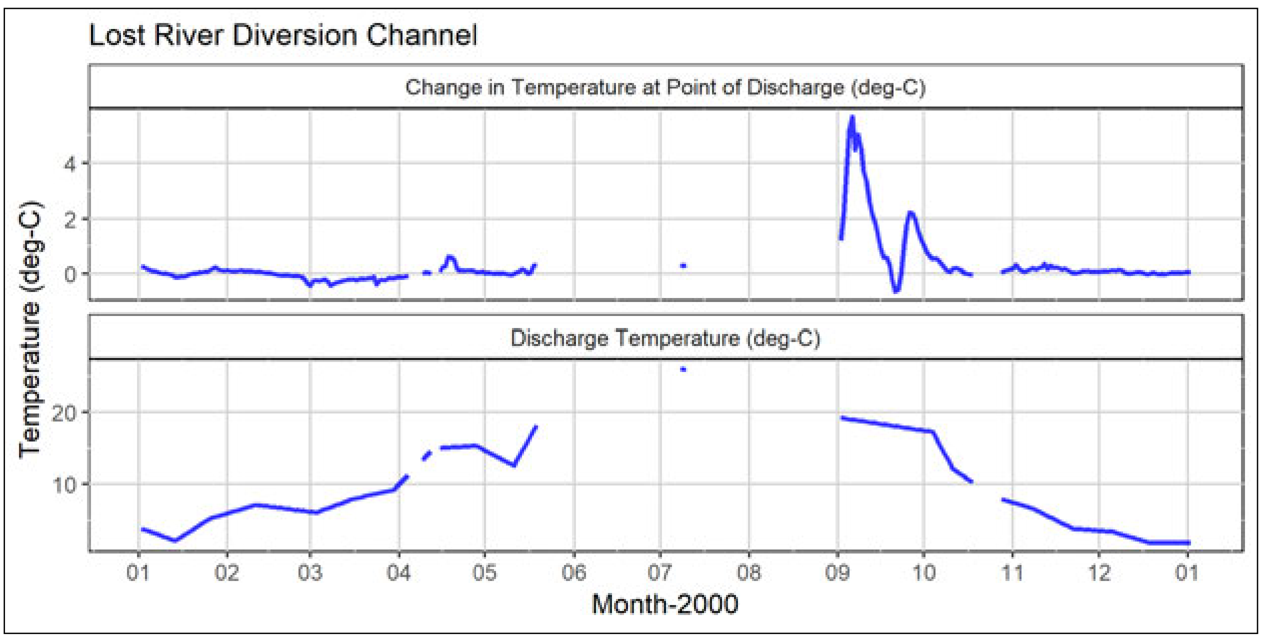


Figure 2-6. Discharge temperatures and change in daily maximum Klamath River temperatures from the Lost River Diversion Channel.

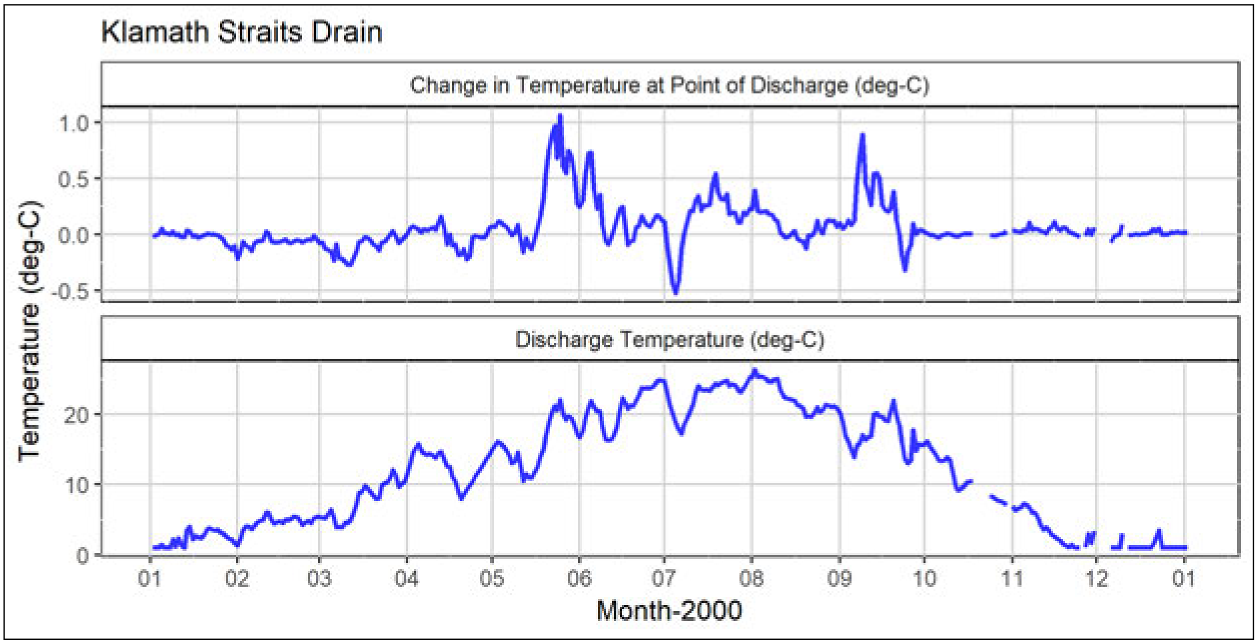


Figure 2-7. Discharge temperatures and change in daily maximum Klamath River temperatures from the Klamath Straits Drain.

2.3.2.3.1 PacifiCorp's Klamath River Hydroelectric Projects

The reservoirs and conveyances associated with, owned by and operated by PacifiCorp, differ from other sources. The storage of water in reservoirs and the removal of water from the river for power generation can degrade or improve water quality depending on the parameter, the time of year and the location. Regardless of any improvement, it is the responsibility of PacifiCorp to ensure that only minor degradation of water quality occurs at other times and places. For this TMDL, PacifiCorp's Klamath River Hydroelectric Project developments include East Side and West Side on Link River, Keno, and JC Boyle. These developments include dams, reservoirs, water conveyances, and powerhouses. Much of the information in this section comes from documents produced by PacifiCorp for the relicensing of the project which provide a much more detailed description of the facilities and their impact on water resources and water quality (PacifiCorp 2004a and 2004b).

East Side and West Side Development

The East Side and West Side powerhouses receive water from diversions at the Link River Dam, which is owned by BOR and operated by PacifiCorp (see Section 2.7.4) (PacifiCorp 2004a). The lengths of these diversions are 0.6 miles and 1.1 miles, respectively. PacifiCorp is proposing the decommissioning of this development. Therefore, these facilities are not considered further in the source assessment and do not receive an allocation.

Keno Development

The Keno Dam is owned by PacifiCorp and operated by PacifiCorp under a contract with BOR. There is no power generation associated with this dam. PacifiCorp operates the dam to maintain reservoir elevations to meet the diversion needs of BOR and others while providing enough water to meet downstream flow requirements. The reservoir behind Keno Dam stretches for 22.5 miles with a maximum depth of 19.5 feet and an average width of 910 feet. At an approximate average flow of 1,500 cfs, retention time in Keno impoundment is six days while at 710 cfs, retention time is 13 days. Keno impoundment does not appear to thermally stratify. A natural, bedrock reef upstream of the current Keno Dam historically used to constrict flow and maintain water surface elevation in the present day Keno impoundment. The reef elevation was lowered with dynamite in 1908 prior to construction of Keno Dam to manage high flows, reduce the risk of flooding, and make lands in the Lower Klamath Lake area more suitable for agriculture (Carlson et al. 2001).

J.C. Boyle Development

The J.C. Boyle development is located 5.6 miles downstream of Keno Dam and consists of a dam, reservoir, water conveyance system, and powerhouse. The water conveyance system transfers water from the reservoir at river mile 223 to the powerhouse at river mile 219. The reservoir is 3.6 miles long with a maximum depth of 42 feet. The retention time at approximately average flows (1,500 cfs) is 1.2 days while the retention at 710 cfs is 2.5 days. A minimum flow of 100 cfs is required below the dam. A series of springs discharges into the river between the withdrawal and return (see Section 2.7 for discussion). To meet power demands, discharge from the powerhouse varies throughout the day when river flows are less than 3,000 cfs. The typical maximum powerhouse flow is 2,500 cfs. Therefore, during the low flow period of the year, daily flows below the powerhouse can range from 500 to 3,000 cfs.

Temperature Impacts

The quantitative source assessment for Keno and JC Boyle developments is also the analysis used to determine load allocations in Section 2.7.3.3. The operation of Keno Dam increases 7-day average daily maximum temperature by a maximum of 0.66 °C at the outlet (Figure 2-10, Table 2-19). The impact of JC Boyle development is more complex because it includes the impacts from Keno Dam and because of the removal and return of water from the river. The impacts have been quantified monthly in Section 2.7.3.3.

Water temperature in Keno impoundment is largely controlled by the natural temperature regime of water discharging from Upper Klamath Lake. Seasonal temperatures entering Keno impoundment through Link River typically exceed 25ºC during summer months. Water is cooled somewhat after flowing through the riverine reach between Keno and JC Boyle Reservoirs (Figure 2-12). The JC Boyle Reservoir primarily serves to regulate peaking flows for the J.C. Boyle Powerhouse. The variability in the recorded outflows (total flows) due to the four primary outlets is shown in Figure 2-8. The extreme variability in the outflow is primarily due to the hourly releases to the powerhouse canal. The fish ladder and fish bypass release contribute a constant 100 cfs (80 and 20 cfs respectively) and some occasional release from the spillway which occurred mostly during February and March. The portion of Klamath River that remains (100 cfs minimum flow) in the mainstem Klamath River downstream of the JC Boyle diversion is similar to temperatures in the JC Boyle Reservoir. However, at river mile 221 water from springs discharges at approximately 225 cfs at a relatively constant 11 to 12ºC (Figure 2-9), lowering maximum 7DADM river temperature by as much as 6-7 degrees Celsius. Maximum 7DADM otherwise exceeds 24ºC in summer months (Figure 2-10).

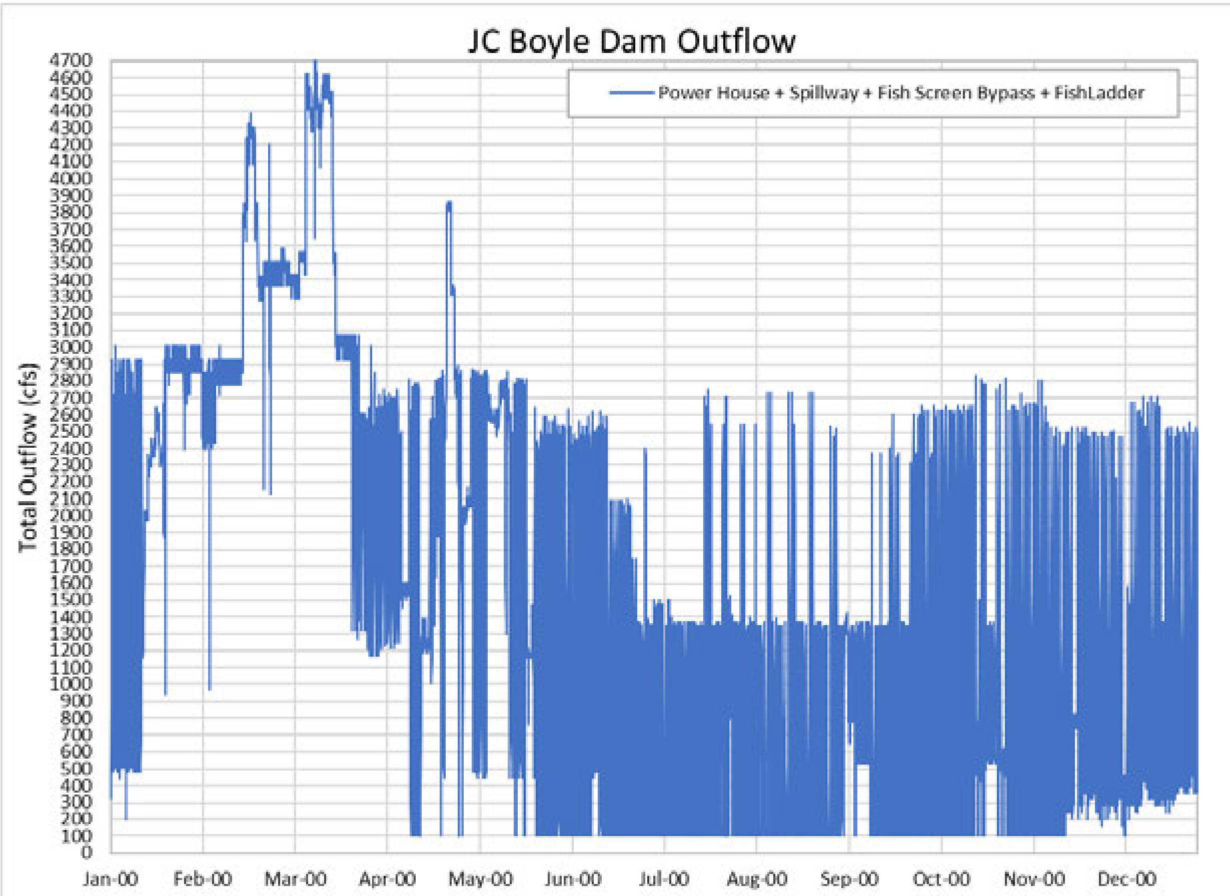


Figure 2-8. Total outflow from JC Boyle

The cooler, spring influenced river mixes rapidly with the warmer water discharged from the JC Boyle Powerhouse and results in temperature increases (Figure 2-10). Peaking operations at the JC Boyle Power house combined with the constant temperature spring inputs to the Klamath River impose unique temperature signals on the river downstream of the Powerhouse with non-peaking flows dominated by cooler spring water and peaking flows dominated by warmer water from JC Boyle reservoir. See Appendix C, temperature calibration graphs for the Bypass/Full Flow Reach (Modeling Segment 5) Figure H-7, Figure H-10, and Figure H-12.

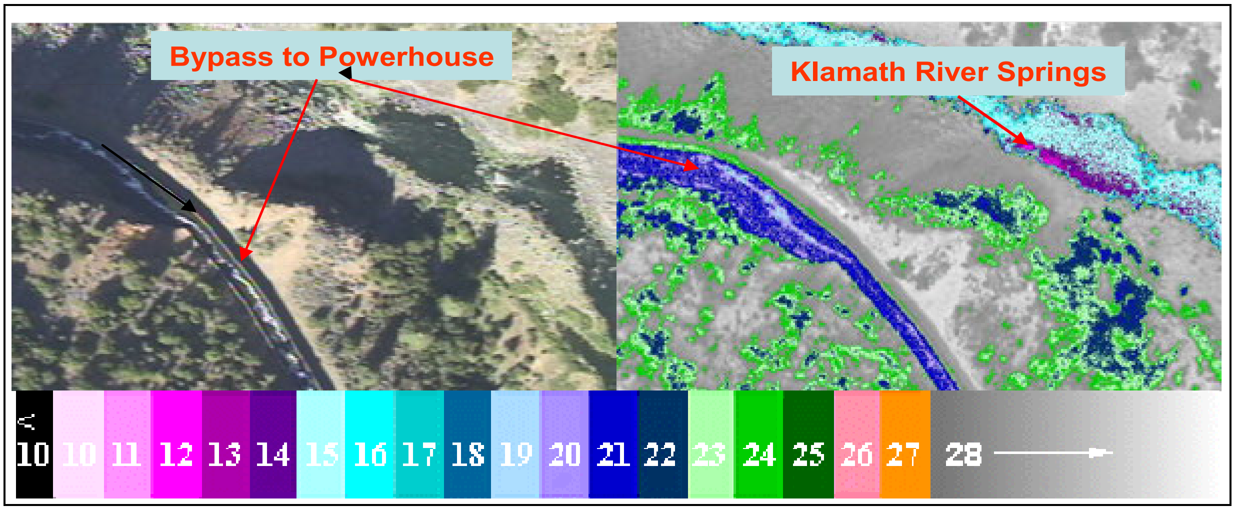


Figure 2-9. True color image (left) and thermal infrared image (right) of the bypass reach showing indirect discharge of 12º C groundwater. The 'Bypass to Powerhouse' is the water which is diverted from the Klamath River and transferred via a canal to the JC Boyle powerhouse (data from Watershed Sciences 2002).

JC Boyle and Keno Dam appear to cause 7-day average daily maximum temperatures to increase by a maximum of 1.73°C and a maximum of 0.1 °C, respectively, above the monthly mean temperature at the Stateline (Figure 2-13, Figure 2-14 and Table 2-23). It is common for temperature impacts from reservoirs to be greatest downstream of the outlet because of the decreased daily temperature range and consequent increase to daily minimum temperatures (see Khangaonkar and Yang 2008 and DEQ 2006b for discussion).

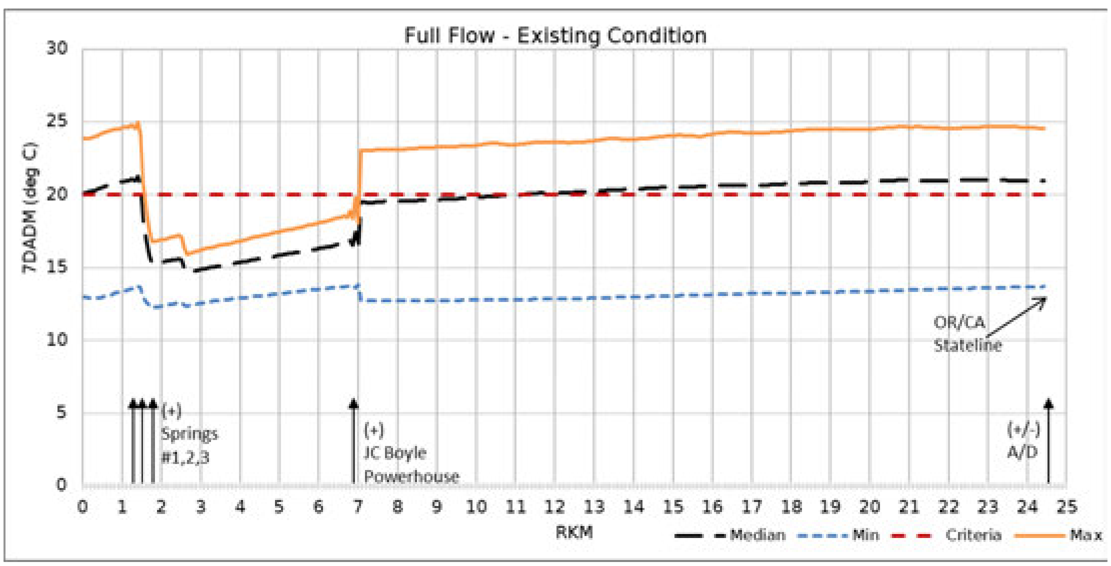


Figure 2-10. Modeled minimum, median, and maximum 2001 existing condition 7-day average daily maximum temperatures downstream of JC Boyle Reservoir (shown as RKM zero) to the Oregon/California Stateline.

2.4.2.3 Unquantified Anthropogenic Sources

Unidentified or unquantified anthropogenic sources are other sources of warming (not mentioned in the sections above) that may contribute to exceedances to the applicable criteria but were not explicitly quantified in the TMDL modeling. Some examples may include warming attributed to climate change, illicit discharges, unquantified surface or ground water withdrawals, warm groundwater seepage from nearby irrigation ponds, or other unidentified anthropogenic sources. Because these sources are unquantified, it is not possible to separate their loading from background loading. The warming and loading from both unidentified anthropogenic sources and background sources are presented together in Figure 2-11. This is important because the TMDL analysis indicates that background and unidentified anthropogenic sources contribute excess warming above the applicable criteria on the Klamath River. Excess warming from these sources are targeted for reduction under this TMDL.

2.4.3 Background Sources

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

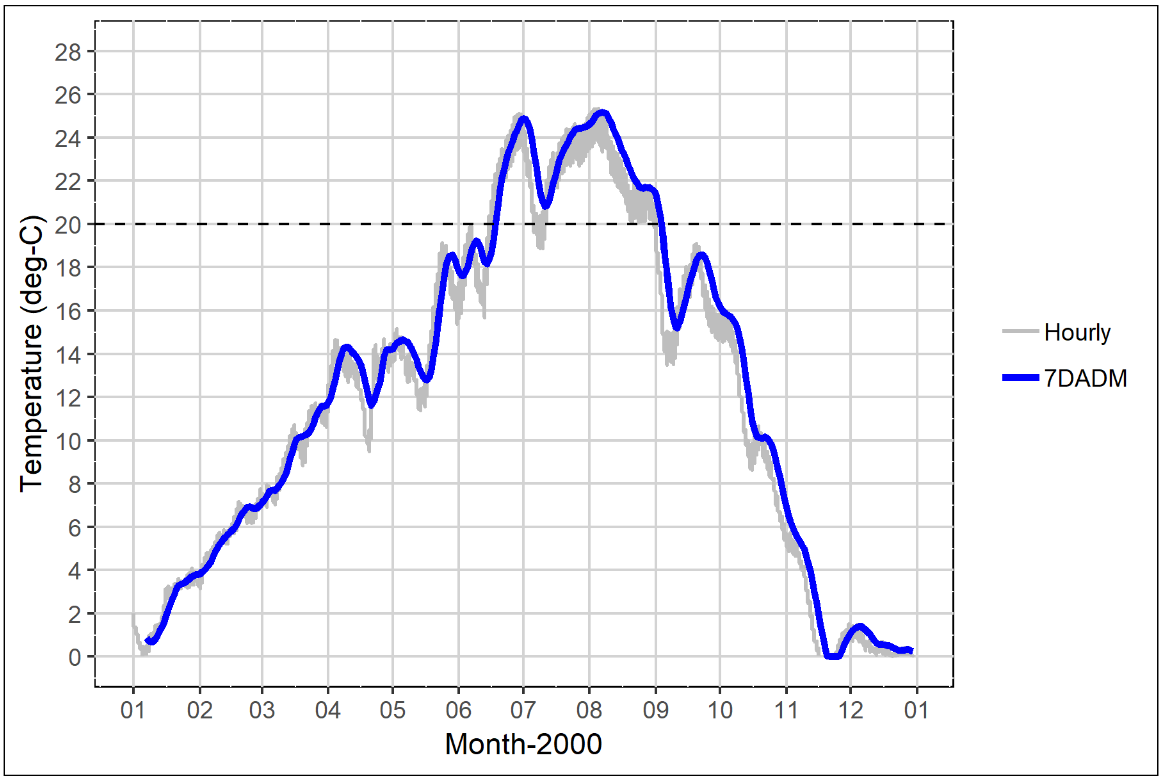
Background sources account for non-anthropogenic sources of warming. Background sources account for non-anthropogenic sources of warming. The amount of background loading a stream receives is influenced by a number of landscape and meteorological characteristics. Those characteristics include but are not limited to substrate and channel morphology conditions, streambank and channel elevations, near stream vegetation, groundwater, hyporheic, or tributary surface flows, and climate related factors including precipitation, cloudiness, air temperature, relative humidity, and others. When these features exist in a condition DEQ determines to be natural, reference, or restored the loading received on the stream is background loading as defined under OAR 340-042-0030(1). When stream conditions are in a natural, reference, or restored condition, examples of loading from background sources include, but are not limited to, direct and diffuse solar and longwave radiation; mass transfer of thermal load as a result of advection, dispersion, and exchange from mixing with groundwater, hyporheic flows, or tributary surface flows; heat exchange between the water column and the substrate through conduction; and between the water column and the atmosphere through evaporation and convection.

When landscape conditions are not in a natural, reference, or restored condition due to current or legacy human practices; AND the loading from processes identified in the paragraph above result in stream temperature warming above and beyond that of background loading, DEQ considers the excess loading to be anthropogenic loading. Only in cases where DEQ or another Oregon state agency does not have the authority to regulate the loading (as defined in OAR 340-042-0030(1)) does DEQ consider it background loading.

Background including natural inputs of solar radiation are one of the largest heat sources in the Upper Klamath subbasin. Streams in Oregon are generally warmest in summer when solar radiation inputs are greatest and stream flows are low. The amount of solar energy that reaches the surface of a stream is determined by many factors, including the position of the sun in the sky, cloud cover, local topography, stream aspect, stream width, and near-stream vegetation. Streams generally warm in a downstream direction as they become wider and near-stream vegetation is less effective at shading the surface of the water. Also, the cooling influences of ground water inflow and the impact of smaller tributaries have less of an impact downstream as a stream becomes larger. Greater reach volumes are associated with a reduction in stream sensitivity to natural and human sources of heat.

Background sources of warming were explicitly quantified on Klamath River through modeling (Figure 2-11). As discussed in Section 2.4.2.3 (Unidentified Anthropogenic Sources) estimates of background loading however may include some portion of unquantified anthropogenic sources. During the model year background sources warmed the river to a maximum 7-day average daily maximum of 25.2ºC at Keno Dam outlet (Figure 2-11). The portion of background warming up to the applicable criteria has been provided a load allocation. The portion that exceeds the applicable 20 ºC criteria (maximum of 5.2 ºC) is considered excess warming and targeted for reduction. Additional excess warming plots are shown in Appendix C.

Figure 2-11. Hourly and 7-day average daily maximum background temperatures at Keno Dam outlet based



on the T1BSR2 model scenario. The dashed line is the 20 degrees C redband or Lahontan cutthroat trout use criterion and target for background sources.

2.5 Loading Capacity

OAR 340-042-0040(4)(d), 40 CFR 130.2(f)

Loading capacity is the amount of a pollutant or pollutants that a waterbody can receive and still meet water quality standards (OAR 340-042-0040(4)(d)).

Except where the cool water species narrative applies on the Klamath River upstream of Keno dam, the loading capacity for this temperature TMDL is based on the applicable temperature criterion plus the human use allowance (HUA). The HUA is used in temperature TMDLs to restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3°C (0.5 °F) above the applicable criterion at the point of maximum impact (OAR 340-041-0028(12)(b)(B)). The loading capacity is calculated using the river flow, numeric temperature criteria, and the HUA, to develop the heat load that can be allocated to meet the temperature water quality standard. The HUA is allocated to identify nonpoint sources as Load Allocations, NPDES point sources as Wasteload Allocations, the margin of safety, and reserve capacity for future sources. Background sources and unidentified nonpoint sources are not allocated any of the HUA but are assigned a Load Allocation.

The approaches used to calculate the thermal loading capacities for these TMDL segments are documented in Appendix H. This appendix describes the use of the United States Geological Survey (USGS) StreamStats[4] program to estimate river flow for ungaged waterbodies as well as available data and information to supplement other calculations.

For all waterbodies, the thermal loading capacity was calculated using Equation 2-1 below. The loading capacity values for each TMDL waterbody are provided as examples in the tables below, while specific loading capacities can be calculated for any given flow measurement using Equation 2-1.

Loading Capacity Equation

$$\boldsymbol{LC} = (\boldsymbol{T_C} + \boldsymbol{HUA}) \times \boldsymbol{Q_R} \times \boldsymbol{C_F} \qquad \textbf{Equation 2-1}$$

where,

LC = Loading Capacity (kilocalories per day).

T_C = The applicable temperature criteria (°C).

HUA = The 0.3°C human use allowance allocated to point sources, nonpoint sources, margin of safety, or reserve capacity. The HUA provision does not apply for waters designated for cool water species criterion. On these waters this portion of the equation is removed.

Q_R = The daily average river flow rate, upstream (cubic feet per second [cfs]).

C_F= Conversion factor using cubic feet per second: (2,446,622 kcal-s/°C-ft^3-day)

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[4] https://streamstats.usgs.gov/ss/

$$\frac{1\,m^3}{35.314\,ft^3} \times \frac{1000\,kg}{1\,m^3} \times \frac{86{,}400\,sec}{1\,day} \times \frac{1\,kcal}{1\,kg \times 1°C} = 2{,}446{,}622$$

Loading capacities were calculated for each of the TMDL waterbodies using flow estimates described in Appendix H. Flow values were incorporated into Equation 2-1 to calculate the allowable thermal load at that flow. Estimated flows are presented for a variety of flow conditions, representing the full suite of expected flows in the watershed and capturing the seasonal variation required in a TMDL. The flow conditions are defined in Table 2-8 and loosely correspond to flow intervals described by EPA (2007). The lower flow values are exceeded a majority of the time, while the floods are exceeded infrequently (USEPA 2007). The loading capacity for each flow condition is calculated using the lowest flow estimate for that flow condition; however, the loading capacity applies to the entire range of flows within that condition. For example, the "dry" condition loading capacity is calculated using the 95th percentile flow duration. This loading capacity applies to all flows up to the 50th percentile flow duration, which is then used to calculate the "mild" condition loading capacity (Table 2-8).

Table 2-9. Flow conditions used in thermal loading capacity calculations.

Flow Condition	StreamStats Representation	Applicable Flow Duration Range*	Description
Low	7Q10	Q_R < 95th percentile	Lowest 7-day average flow that occurs (on average) once every 10 years (7Q10)
Dry	95th percentile	95th percentile ≤ Q_R < 50th percentile	Flow that is exceeded approximately 95%, or the vast majority, of the time
Mild	50th percentile	50th percentile ≤ Q_R < 25th percentile	Flow that is considered within the typical or normal range; includes the median flow for a stream
Moderate	25th percentile	25th percentile ≤ Q_R < 10th percentile	Flow that is exceeded only 25% of the time, considered to be above the normal range
High	10th percentile	10th percentile ≤ Q_R < 5th percentile	Flow that is exceeded only 10% of the time, considered to be far above the normal range; often associated with the rainy season and higher storm flows
Very High	5th percentile	Q_R ≥ 5th percentile	Flow that is infrequently exceeded; represents very high flows that do not occur often

*Q_R = river flow

Table 2-9 through Table 2-10 present the thermal loading capacities for each TMDL waterbody including the flow estimate used to represent each flow condition.

Table 2-10. Thermal loading capacity by flow condition for the Klamath River upstream of Keno Dam.

Flow Condition	T_C (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	28.0	422	2.89E+10	<520 cfs
Dry	28.0	520	3.56E+10	520 cfs to <1,036 cfs

Flow Condition	T_C (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Mild	28.0	1,036	7.10E+10	1,036 cfs to <2,133 cfs
Moderate	28.0	2,133	1.46E+11	2,133 cfs to <2,849 cfs
High	28.0	2,849	1.95E+11	2,849 cfs to <3,236 cfs
Very High	28.0	3,236	2.22E+11	≥3,236 cfs

[1]Calculated using the Existing Condition Klamath River Model for the year 2000.
[2] Loading capacity calculated using Equation 2-1, the representative flow estimate from the fourth column, and the applicable criterion. This loading capacity applies to the flow range in the last column of the table.

Table 2-11. Thermal loading capacity by flow condition for the Klamath River (at the Oregon/California Stateline).

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	548	2.68E+10	<735 cfs
Dry	20.0	0.3	735	3.60E+10	735 cfs to <1,290 cfs
Mild	20.0	0.3	1,290	6.31E+10	1,290 cfs to <2,457 cfs
Moderate	20.0	0.3	2,457	1.20E+11	2,457 cfs to <3,272 cfs
High	20.0	0.3	3,272	1.60E+11	3,272 cfs to <3,738 cfs
Very High	20.0	0.3	3,738	1.83E+11	≥3,738 cfs

[1]Calculated using the Existing Condition Klamath River Model for the year 2000.
[2] Loading capacity calculated using Equation 2-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. The HUA is not applicable to interstate waters. This loading capacity applies to the flow range in the last column of the table.

A load capacity curve was developed using different flow conditions for each TMDL waterbody, which characterizes the allowable thermal load capacity for a range of expected flows throughout the year (see Appendix H). Allocations divide the loading capacity between individual point sources and nonpoint sources of heat and set the thermal load targets which will result in achieving the water quality standards. In addition to individual point sources and nonpoint sources, a portion of the thermal loading capacity was set aside as a reserve capacity.

2.6 Excess Load

OAR 340-042-0040(4)(e)

Excess thermal loads are used to evaluate, to the extent existing data allow, the difference between the actual pollutant load in a waterbody and the loading capacity of that waterbody. Equation 2-2 is used to calculate the excess thermal load, if observed temperature and flow data are available.

Excess Load Equation

$$\boldsymbol{EL} = (\boldsymbol{T_R} - \boldsymbol{T_C} + \boldsymbol{HUA}) \times \boldsymbol{Q_R} \times \boldsymbol{C_F}$$ **Equation 2-2**

where,

EL = Excess thermal load above the applicable temperature criteria (kilocalories per day).

T_R = The current stream temperatures (°C), expressed as a 7-day average daily maximum or daily maximum depending on the applicable criteria.

T_C = The applicable temperature criteria (°C).

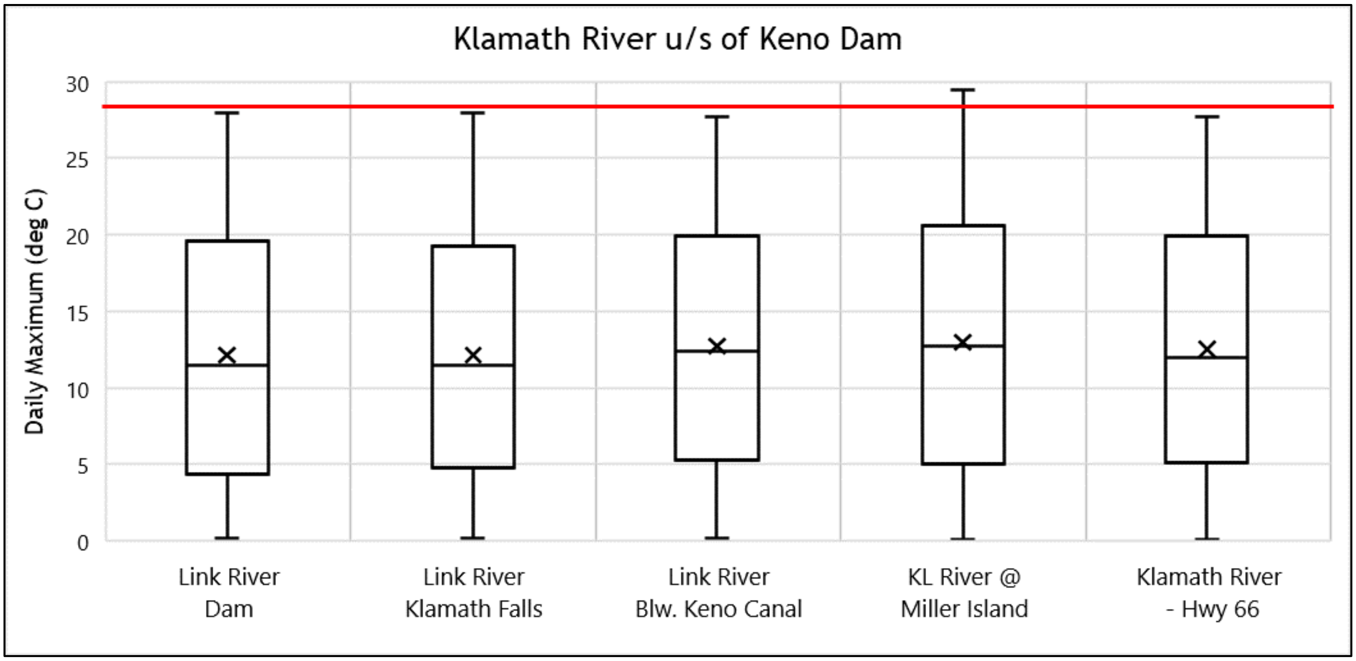
HUA = The 0.3°C human use allowance allocated to point sources, nonpoint sources, margin of safety, or reserve capacity. The HUA provision does not apply for waters designated for cool water species criterion. On these waters this portion of the equation can removed.

Q_R = The daily average river flow rate, upstream (cubic feet per second [cfs]).

C_F = Conversion factor using cubic feet per second: (2,446,622 kcal-s/°C-ft^3-day)

$$\frac{1\ \mathrm{m}^3}{35.314\ \mathrm{ft}^3} \times \frac{1000\ \mathrm{kg}}{1\ \mathrm{m}^3} \times \frac{86{,}400\ \mathrm{sec}}{1\ \mathrm{day}} \times \frac{1\ \mathrm{kcal}}{1\ \mathrm{kg} \times 1°\mathrm{C}} = 2{,}446{,}622$$

Temperature data from various monitoring stations in the Klamath River were plotted and compared to the applicable temperature criteria (Figure 2-12 and Table 2-12). All of the available data were obtained from the U.S. Geological Survey (USGS). These data included observed daily stream temperatures for six stations in the Klamath River.



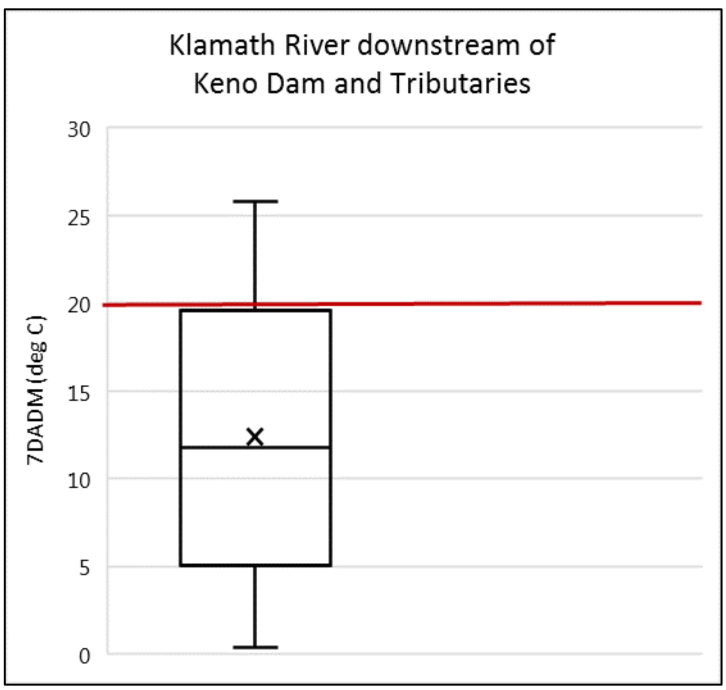


Figure 2-12. Box plot of all available daily maximum stream temperatures for various locations upstream and downstream of Keno Dam. The red line represents the maximum cool water species target of 28°C in the upper figure and the maximum cold water species target of 20°C in the lower figure. (Station IDs for each of these locations are listed in Table 2-12).

Table 2-12. Maximum temperature and percent exceedance of temperature criteria on the Klamath River.

Data Source and Station ID	Station Description	Period of Record	Number of Observations	Applicable Criterion (°C)	Maximum Temperature	Percent Exceedance *
USGS 11509370	Klamath River Above Keno Dam, At Keno, OR (Hwy66)	5/24/1991 – present	8,107	28 (Daily Max)	27.7	0%
USGS 11509500	Klamath River At Keno, OR	12/21/2005 – present	4,664	20 (7DADM)	25.8	23%
USGS 420853121505500	Klamath River At Miller Island Boat Ramp, OR	2/6/1999 – present	6,541	28 (Daily Max)	29.5	0.09%
USGS 11507500	Link River At Klamath Falls, OR	9/30/2003 – present	5,497	28 (Daily Max)	28	0%
USGS 11507501	Link River Below Keno Canal, Near Klamath Falls,OR	6/16/2001 – present	5,809	28 (Daily Max)	27.7	0%
USGS 421401121480900	Link River Dam	6/16/2001 – present	6,215	28 (Daily Max)	28	0%

*portion of available continuous daily data that exceed the applicable criteria

As shown in Table 2-11 the cool water species criteria is rarely exceeded upstream of Keno Dam and resulted in no excess temperature or excess load for the model year (Table 2-12). Downstream of Keno Dam, the 20ºC redband and Lahonton cutthroat trout use criteria is exceeded 23% of time (Table 2-12) during the period data is available. During the model year, the maximum excess temperature was 4.6ºC downstream of Keno Dam and 4.5 ºC at the Stateline (Table 2-12 through Table 2-15). Maximum temperature and percent exceedance of temperature criteria on the Klamath River.

Table 2-13. Modeled monthly Klamath River excess temperature (°C) and excess load (kcal/day) statistics Upstream of Keno Dam during the model year (2000).

Keno Outflow	Excess 7DADM Temperature			Excess Load		
Month	Min	Median	Max	Min	Median	Max
January	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
February	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
March	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
April	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
May	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
June	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
July	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
August	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
September	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
October	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
November	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
December	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00

Table 2-14. Modeled monthly Klamath River excess temperature (°C) and excess load (kcal/day) statistics at Keno Outflow during the model year (2000).

Keno Outflow	Excess 7DADM Temperature			Excess Load		
Month	Min	Median	Max	Min	Median	Max
January	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
February	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
March	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
April	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
May	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
June	0.00	0.00	4.30	0.00E+00	0.00E+00	9.14E+09
July	0.44	3.22	4.56	7.88E+08	6.55E+09	9.80E+09
August	1.04	2.67	4.34	1.91E+09	5.30E+09	9.25E+09
September	0.00	0.00	0.83	0.00E+00	0.00E+00	1.51E+09
October	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
November	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00
December	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00

Table 2-15. Modeled monthly Klamath River excess temperature (°C) and excess load (kcal/day) at OR/CA Stateline during the model year (2000)

Stateline	Excess 7DADM Temperature			Excess Load			Excess above CA Mean monthly Target
Month	Min	Median	Max	Min	Median	Max	
January	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00
February	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00
March	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00
April	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.15
May	0.18	0.20	0.27	6.23E+08	7.86E+08	1.01E+09	0.11
June	0.22	3.16	4.10	6.29E+08	6.87E+09	1.12E+10	0.00
July	0.67	2.98	4.15	1.43E+09	5.92E+09	1.15E+10	0.00
August	0.49	2.25	4.29	9.32E+08	5.45E+09	1.18E+10	0.00
September	0.46	0.46	0.46	9.29E+08	9.29E+08	9.29E+08	0.26
October	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.07
November	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.19
December	0.00	0.00	0.00	0.00E+00	0.00E+00	0.00E+00	0.00

2.7 Allocations

Loading capacity in this TMDL is expressed as a thermal load in kilocalories per day; however, in order for the TMDL to be more meaningful to the public and guide implementation efforts, allocations have also been expressed in thermal loads for each source, as a change in temperature or ΔT (delta T). The loading capacity was separated into load allocations for background sources and identified nonpoint sources, wasteload allocations for point sources, a margin of safety, and a reserve capacity. In this TMDL an implicit margin of safety was allocated (Section 2.9). The allocations for the nonpoint sources, point sources, and reserve capacity were calculated from the human use allowance (Section 2.7.1). Allocations are calculated using Equation 2-3 or Equation 2-4 and apply year round. Background sources were not allocated any of the HUA but were assigned a Load Allocation (Section 2.7.3).

2.7.1 Human Use Allowance

OAR340-041-0028(12)(b)

The human use allowance is defined as insignificant additions of heat that are authorized in waters that exceed the applicable biologically based numeric temperature criteria.

Where the 20°C redband or Lahontan cutthroat trout uses are identified, the loading capacity available for human use is based on an allowable 0.3°C temperature increase at the point of maximum impact. For example, the total load from anthropogenic sources, considering both point and nonpoint sources, cannot exceed the HUA of 0.3°C. This includes any permits, dams/reservoirs, identified nonpoint sources, margin of safety, and a reserve capacity for future growth. Designated management agencies[5], permittees, or other responsible persons are responsible for implementing the TMDL and achieving their allocations.

On the Klamath River, where the cool water species use criteria applies, the loading capacity available for nonpoint sources is based on the sum of background warming and anthropogenic warming that does not exceed the instream TMDL target of 28°C. To achieve the human use allowance allocations downstream of Keno Dam and the targets at California's Stateline, DEQ is limiting warming from anthropogenic sources such that all sources are limited to a cumulative thermal load equal to an increase of 0.3°C above the upstream mean ambient river temperatures when the daily maximum river temperatures are ≤27.7 °C. A temperature increase and thermal load of zero is allocated to anthropogenic nonpoint sources when the daily maximum river temperature are ≥28.0 C. A zero load is allocated when temperatures exceed 28°C in order to implement Oregon's rule provision in OAR 340-041-0028(9)(a) stating "no increase in temperature is allowed that would reasonably be expected to impair cool water species". Unlike the human use allowance provision for the applicable biologically based numeric criteria, the cool water species rule does not authorize warming when temperatures exceed a level that would impair cool water species. As discussed in Section 2.1.2.3 that level for this TMDL is 28°C.

Loading capacities for the TMDL waterbodies were allocated between the various known sources. Anthropogenic sources were assigned a portion of the HUA (equivalent to 0.3°C), as identified in Table 2-16.

The analysis DEQ used to arrive at the allocated portion of cumulative warming at Keno Dam outlet is described in Appendix C.4.1. Briefly, the allocated portion of warming assigned to sources upstream of Keno Dam were determined though iterative modeling using the difference between model scenarios TOD2RN3 and T1BSR2. We started with allocations to each point source and various water management districts managing LRDC and KSD equal to 0.075 deg-C. DEQ found these allocations did not meet all criteria including the CA targets established at Stateline. DEQ reduced the portion assigned to each source and remodeled until the model results demonstrated achievement of all criteria. The cumulative impact at Keno outlet June 1-Sept 30 is 0.06 deg-C from point sources and 0.08 deg-C from LRDC and KSD (assigned to water management districts). 0.02 deg-C is allocated to two other water management districts.

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[5] As per OAR 340-042-0030(2), designated management agency means a "federal, state or local governmental agency that has legal authority over a sector or source contributing pollutants, and is identified as such by the Department of Environmental Quality in a TMDL".

Zero is allocated to land management DMAs (see Section 2.4.2 for rationale). The remainder is allocated to reserve capacity and other sources.

Table 2-16. HUA allocations to anthropogenic sources in the Klamath River.

Sources	Warming at point of heat loading[1] (ºC)	Cumulative warming at Keno Dam outlet[2] (ºC)	Cumulative warming at Oregon/California Stateline (ºC)
Point Sources	See Table 2-17 and Table 2-18	0.06	0.0
Bureau of Reclamation and Water Management Districts	See Table 2-20 and Table 2-21	0.10	0.0
Keno Dam and Reservoir	0.08	0.08	0.0
Eastside hydroelectric project	0.0	0.0	0.0
Westside hydroelectric project	0.0	0.0	0.0
J.C. Boyle Dam and Reservoir	0.0	0.0	0.0
ODA and agricultural practices	0.0	0.0	0.0
ODF and private forest practices	0.0	0.0	0.0
USFS	0.0	0.0	0.0
BLM	0.0	0.0	0.0
Kamath County	0.0	0.0	0.0
Water withdrawals (from sources not already identified in this table), existing transportation infrastructure, buildings, and utility corridors.	0.01	0.01	0.0
All other anthropogenic sources	0.0	0.0	0.0
Reserve Capacity	Varies based on location	0.05	0.3

1. Warming at point of heat loading refers to the maximum warming allowed at the location where the source's loading occurs in the Klamath River. For point sources the point of heat loading is at the edge of the mixing zone. For dams and reservoirs the point of heat loading is within the reservoir impoundment and where water is returned to the natural river channel downstream of the dam. For diversions and water withdrawals the point of heat loading is at the point of diversion. For transportation infrastructure, buildings, utility corridors, and for land management DMAs including USFS, BLM, ODF, or ODA where hydromodification or vegetation removal activities occur, the point of heat loading refers to the cumulative warming at all locations along the waterbody where these sources exist.
2. The cumulative warming at Keno Dam outlet is where the Klamath River water is released from Keno Dam into the natural river channel at the most upstream point where redband or Lahontan cutthroat trout designated uses begin.

2.7.2 Wasteload Allocations

OAR 340-042-0040(4)(g), 40 CFR 130.2(g)

This section describes the portions of the receiving water's loading capacity that are allocated to existing point sources of pollution, including all point source discharges regulated under the Federal Water Pollution Control Act Section 402 (33 USC Section 1342).

Wasteload allocations for point sources are presented in Table 2-17 and Table 2-18 with a description of assumptions and requirements summarized in Section 2.7.2.1.

The basin-specific rule OAR 340-041-0185(2) states “from June 1 to September 30, no NPDES point source that discharges to the portion of the Klamath River designated for cool water species may cause the temperature of the water body to increase more than 0.3°C above the natural background after mixing with 25% of the stream flow. Natural background for the Klamath River means the temperature of the Klamath River at the outflow from Upper Klamath Lake plus any natural warming or cooling that occurs downstream”. Point source wasteload allocations must also achieve a cumulative warming of no more than 0.06°C when temperatures exceed the 20ºC redband or Lahontan cutthroat trout use portion of the human use allowance established downstream of Keno Dam and no warming above monthly average temperature targets established by the State of California North Coast Water Quality Control Board at the Oregon/California Stateline.

Discharges from the years 2000 and 2013-2018 for the City of Klamath Falls WWTP and South Suburban WWTP exceeded these allocations typically in the winter months. See Appendix I for additional details.

Table 2-17. Wasteload allocations for NPDES point sources on the Klamath River from June 1 - Sept 30.

Point Source	DEQ WQ File #	ΔT (deg-C)	Effluent Flow - QE (cfs)	Annual River Flow 7Q10 (cfs)	7Q10 WLA (kcal/day)	Maximum Effluent Temperature (deg-C)
Klamath Falls WWTP (Spring Street STP)	46763	0.05	11.7	104	1.42E+07	32
South Suburban WWTP	83316	0.05	5.1	104	1.33E+07	32
Columbia Forest Products	18677	0.005	0.01	61	7.46E+05	32
Collins Products outfall #1 and #2 combined	96207	0.005	0.1	61	7.47E+05	32

Table 2-18. Wasteload allocations for NPDES point sources on the Klamath River from Oct 1 - May 31.

Point Source	DEQ WQ File #	ΔT (deg-C)	Effluent Flow - QE (cfs)	Annual River Flow 7Q10 (cfs)	7Q10 WLA (kcal/day)	Maximum Effluent Temperature[6] (deg-C)
Klamath Falls WWTP (Spring Street STP)	46763	0.03	11.7	104	8.49E+06	See Footnote 6
South Suburban WWTP	83316	0.03	5.1	104	8.01E+06	See Footnote 6
Columbia Forest Products	18677	0.005	0.01	61	7.46E+05	See Footnote 6
Collins Products outfall #1 and #2 combined	96207	0.005	0.1	61	7.47E+05	See Footnote 6

2.7.2.1 Assumptions and Requirements of Wasteload Allocations

The following are TMDL assumptions and requirements that together reflect how the wasteload allocations were developed and should be implemented to be consistent with this TMDL.

- Wasteload allocations presented in Table 2-17 and Table 2-18 in conjunction with requirements established in this TMDL demonstrate achievement of all Oregon temperature criteria in the Klamath River and targets established at the Oregon/California border by the North Coast Water Quality Control Board.
- Wasteload allocations apply year round.
- Equation 2-3 was used to calculate the flow-based wasteload allocations (WLAs).
- Equation 2 4 shall be used to determine compliance with the WLA and represents the daily excess thermal load discharged by a facility given their actual effluent flow and effluent temperature.
- Wasteload allocations in Table 2-17 and Table 2-18 may be implemented in NPDES permits in any of the following ways: 1) incorporating the numeric 7Q10 wasteload allocation as a single numeric value, 2) incorporating numeric values calculated using Equation 2-3 for different river flow ranges and/or facility effluent flow rates, or 3) incorporating Equation 2-3 directly into the permit with the wasteload allocation calculated on a daily basis.
- The 7Q10 wasteload allocations presented in Table 2-17 and Table 2-18 were calculated using Equation 2-3 where Q_R is equal to the 7Q10 river flow and Q_E is equal to the effluent flow rates presented in the tables.
- All point sources shall have a maximum effluent temperature of 32 deg-C at the end of the outfall pipe. This temperature limit is intended to limit short term exposure of Lost River sucker and shortnose suckers to lethal temperatures above 28 deg-C at the edge of the mixing zone.

[6] From October 1 – May 31, when daily maximum river temperatures >= 28 deg-C, the allowed change in temperature (ΔT) is zero, and the daily maximum effluent temperature shall be 28 deg-C

- From October 1 – May 31, when daily maximum river temperatures >= 28 deg-C, the allowed change in temperature (ΔT) is zero, the WLA is zero, and the daily maximum effluent temperature shall be <= 28 deg-C.
- Effluent flow rates in Table 2-17 and Table 2-18 represents the maximum effluent flow rate discharged in the allocation model scenario. Discharge data was characterized using available information contained in discharge monitoring reports (DMRs) or data that were provided by the point source.
- The daily mean river temperature at Link River (USGS 11507500) is an appropriate estimate for natural background per OAR 340-041-0185(2). Daily mean river temperatures immediately upstream of the outfall may also be used as long as adjustments are made to eliminate any anthropogenic warming or cooling between the outflow from Upper Klamath Lake and that location.
- 7Q10 river flows in Table 2-17 and Table 2-18 were calculated using flows from USGS station 11507500 Link River at Klamath Falls. For sources located downstream of the Lost River Diversion Channel, the estimated 7Q10 is based on the 7Q10 at USGS station 11507500 plus or minus the monthly average daily flow from or into the Lost River Diversion Channel calculated from discharge data available from the U.S. Bureau of Reclamation's gage on the Lost River Diversion Channel at Tingley (LRVO). The U.S. Bureau of Reclamation believes that wind and other factors can make flow measurements at the LRVO gage noisy. 7Q10 calculated at USGS station 11507500 may also change based on changes in Upper Klamath Lake and management of Link River Dam. Therefore, with DEQ approval, 7Q10 in the Klamath River may be calculated using alternative flow data sources, time periods, or methods as appropriate. 7Q10 is the lowest 7-day average flow that occurs on average once every 10 years.
- When river flow is equal to or less than the 7Q10, the river flow used in Equation 2-3 shall be equal to 7Q10.

Any new or existing point sources not explicitly given a wasteload allocation in Table 2-17 and Table 2-18 may apply to DEQ for use of reserve capacity. See conditions and procedures outlined in the reserve capacity Section 2.8.

Wasteload Allocation Equation

The following equation was used to calculate the thermal wasteload allocations.

$$WLA = (\Delta T) \cdot (Q_E + Q_R) \cdot C_F \qquad \textbf{Equation 2-3}$$

where,

$WLA =$ Wasteload allocation (kilocalories/day).

$\Delta T =$ The maximum temperature increase (°C) 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). If using MGD convert to cfs using $Q_{E\_MGD} \cdot 1.5472$.

$Q_R =$ 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 mean daily river flow, upstream.

$C_F =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

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

WLA Permit Compliance Equation

The following equation shall be used to determine compliance with the wasteload allocation (WLA).

$$ETL = (T_E - T_R)\cdot Q_E \cdot C_F$$ **Equation 2-4**

where,

$ETL =$ The daily excess thermal load (kilocalories/day) used to evaluate compliance with the wasteload allocation (WLA) calculated from Equation 2-3.

$T_R =$ The applicable river temperature criteria (°C). For point sources upstream of Keno Dam the temperature criteria from June 1 – September 30 is defined in OAR 340-041-0185(2) as the temperature of the Klamath River at the outflow from Upper Klamath Lake plus any natural warming or cooling that occurs downstream. The daily mean river temperature at Link River (USGS 11507500) is an appropriate estimate for T_R. Daily mean river temperatures immediately upstream of the outfall may also be used for T_R as long as adjustments are made to eliminate any anthropogenic warming or cooling between the outflow from Upper Klamath Lake and that location.

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

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

$C_F =$ Conversion factor for flow in cubic feet per second (cfs): 2,446,665

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

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

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

2.7.2.2 Point Source Stormwater Discharges on the Klamath River

NPDES related industrial and construction stormwater sources have been determined to not have a reasonable potential to increase Klamath River stream temperatures and are assigned a wasteload allocation equal to their current thermal load (zero). Based on a flow mass balance using discharge information submitted by Collins Products (which has coverage under the1200-Z general permit) it is estimated that a stormwater discharge will result in a change in temperature of 0.0001°C or less.

If data collected after the TMDL has been issued indicates that stormwater in the Klamath River is a source of thermal loading that is causing an increase in stream temperature, then stormwater facilities may access a portion of the reserve capacity. At that time, the use of additional BMPs to reduce thermal loading shall also be evaluated. Effective BMPs include: reducing the amount of solar exposure on the runoff by directing it through covered or underground storage detention facilities; reducing the volume of runoff using bioretention or other filtration methods; and providing thermal protection through the use of vegetated buffers (Jones and Hunt 2009; Natarajan and Davis 2010; UNH Stormwater Center 2011; Winston et al. 2011, Wardynski et al. 2013, Long and Dymond 2014).

2.7.3 Load Allocations

Load Allocations OAR 340-042-0040(4)(h), 40 CFR 130.2(h): This element determines the portions of the receiving water's loading capacity that are allocated to existing nonpoint sources including background sources. The thermal load allocations in the Upper Klamath subbasin is a mixture of background loads and anthropogenic nonpoint sources. Load allocations for each TMDL waterbody are presented in in this section and descriptions of the source categories are provided below.

The analyses presented in this TMDL concludes that allocations applying from June 1 – September 30 will address the impairment on Klamath River tributaries in Oregon, but year-round allocations are needed on the Klamath River to achieve TMDL targets established by California's North Coast Water Quality Control Board at the Oregon/California border.

2.7.3.1 Background Sources

Background sources are defined in Section 2.4.3.

The background load allocation is calculated using Equation 2-5**.**

On the Klamath River upstream from Keno Dam, where the cool water species criteria apply, background vary from year to year and is equivalent to the allowed temperature increase from background sources up to 28 deg-C as a daily maximum. Background temperatures and the load allocation into the Klamath River from Upper Klamath Lake can be estimated year round using USGS station 11507500 Link River at Klamath Falls.

On the Klamath River downstream of Keno Dam, where the biologically based redband or Lahontan cutthroat trout use and human use allowance criteria apply, the background load allocation (shown in Table 2-19) is equivalent to the allowed temperature increase from background sources. The background load allocation is a portion of the loading capacity equal to the product of the allowed increase (the applicable criterion of 20°C), the stream flow, and a conversion factor.

Table 2-19. Load allocations for background sources on the Klamath River downstream of Keno Dam.

		River Flow Condition (Q_R) (cfs)					
		Low	Dry	Mild	Moderate	High	Very High
		422	520	1036	2133	2849	3236
	ΔT (°C)	Load Allocation (LA) (kilocalories/day)					
Background Klamath River downstream Keno Dam Outlet to OR/CA Stateline	20.0	2.06E+10	2.54E+10	5.07E+10	1.04E+11	1.39E+11	1.58E+11

$$\boldsymbol{Allocation = \Delta T \times Q_R \times C_F}$$ **Equation 2-5**

where,

$Allocation$ = Allocation of the thermal loading capacity to a source (kilocalories per day).

ΔT = Allowable temperature increase (°C).

Q_R = The daily average river flow rate, upstream (cubic feet per second [cfs]).

C_F = Conversion factor using cubic feet per second: (2,446,622 kcal-s/°C-ft^3-day)

$$\frac{1\ m^3}{35.314\ ft^3} \times \frac{1000\ kg}{1\ m^3} \times \frac{86{,}400\ sec}{1\ day} \times \frac{1\ kcal}{1\ kg \times 1°C} = 2{,}446{,}622$$

2.7.3.2 Water Management Districts

The load allocations for water management districts are presented in Table 2-20. Load allocations are calculated using Equation 2-6 and represent the equivalent thermal load resulting in the allowed temperature increase (ΔT) allocated to each source in Table 2-16 (HUA allocation table). Compliance with the load allocations may be determined using Equation 2-7. Other methods, including modeling, may be used if approved by DEQ.

Table 2-20. Load allocations for nonpoint sources on the Klamath River from June 1 - Sept 30.

Source	ΔT[1] (°C)	Source Discharge Q_D (cfs)	River Flow 7Q10 (cfs)	7Q10 LA[4] (kcal/day)	Maximum Temperature (°C)
Klamath Drainage District Bureau of Reclamation for warming in Lost River Diversion Channel	0.05	1066.0	104	1.27E+07	27.9
Klamath Drainage District Bureau of Reclamation for warming in Klamath Straits Drain	0.05	344.1	61	1.27E+07	27.9
Plevena Irrigation District	0.01	20	61	9.91E+05	27.9
Keno Irrigation District	0.01	20	61	9.91E+05	27.9

Table 2-21. Load allocations for nonpoint sources on the Klamath River from Oct 1 - May 31.

Source	ΔT (°C)	Source Discharge Q_D (cfs)	River Flow 7Q10 (cfs)	7Q10 LA[4] (kcal/day)	Maximum Temperature (°C)
Klamath Drainage District Bureau of Reclamation for Lost River Diversion Channel	0.03	1066.0	104	7.63E+06	27.9
Klamath Drainage District Bureau of Reclamation for Klamath Straits Drain	0.03	344.1	61	7.63E+06	27.9
Plevena Irrigation District	0.01	20	61	1.98E+06	27.9
Keno Irrigation District	0.01	20	61	1.98E+06	27.9

Load Allocation Equation

The following equation is used to calculate thermal load allocations for water management districts.

$$\boldsymbol{LA} = (\Delta\boldsymbol{T}) \cdot (\boldsymbol{Q_D} + \boldsymbol{Q_R}) \cdot \boldsymbol{C_F} \quad \textbf{Equation 2-6}$$

where,

$LA =$ Load allocation (kilocalories/day).

$\Delta T =$ The maximum allowed temperature increase (°C) in the Klamath River.

$Q_D =$ The daily mean flow of the Klamath Straits Drain, Lost River Diversion Channel or tributary/canal into the Klamath River (cfs).

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

$C_F =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

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

LA Compliance Equation

The following equation may be used to determine compliance with the load allocation (LA) from Equation 2-6. Other methods including modeling may be used if approved by DEQ.

$$ETL = (T_E - T_R) \cdot Q_E \cdot C_F \quad \textbf{Equation 2-7}$$

where,

$ETL =$ The daily excess thermal load (kilocalories/day) used to evaluate compliance with the load allocation (LA) from Equation 2-6.

$T_R =$ The daily mean river temperatures (°C) immediately upstream of incoming tributaries or the closest upstream monitoring site if data is not available immediately upstream.

$T_E =$ The daily mean of the Klamath Straits Drain, Lost River Diversion Channel or tributary/canal temperature (°C).

$Q_E =$ The daily mean flow of the Klamath Straits Drain, Lost River Diversion Channel or tributary/canal into the Klamath River (cfs).

$C_F =$ Conversion factor for flow in cubic feet per second (cfs): 2,446,665

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

2.7.3.3 Dams and Reservoirs

The load allocations for dam and reservoir operations are presented in Table 2-18. Load allocations were calculated using Equation 2-8 and represent the equivalent thermal load resulting in the allowed temperature increase (ΔT) allocated to each dam and reservoir in Table 2-16.

Table 2-22. Load Allocations for dam and reservoirs operations on the Klamath River.

		River Flow Condition (Q_R) (cfs)					
		Low	Dry	Mild	Moderate	High	Very High
		422	520	1036	2133	2849	3236
Dam	ΔT (°C)	Load Allocation (LA) (kilocalories/day)					
Keno Dam and Reservoir	0.08	8.26E+07	1.02E+08	2.03E+08	4.17E+08	5.58E+08	6.33E+08
J.C. Boyle and Keno Dam at Stateline	0.0	0.00	0.00	0.00	0.00	0.00	0.00
Westside Project	0.0	0.00	0.00	0.00	0.00	0.00	0.00
Eastside Project	0.0	0.00	0.00	0.00	0.00	0.00	0.00

Dams and Reservoir Load Allocation Equation

The following equation was used to calculate thermal load allocations for dams and reservoirs.

$$LA = (\Delta T) \cdot (Q_R) \cdot C_F$$ **Equation 2-8**

where,

$LA =$ Load allocation (kilocalories/day).

$\Delta T =$ The maximum allowed temperature increase (°C).

$Q_R =$ The daily average river flow rate (cfs).

Conversion factor using flow in cubic feet per second (cfs): 2,446,665

$$C_F = \frac{1\,ft^3}{1\,sec} \cdot \frac{1\,m^3}{35.31\,ft^3} \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\ \cdot 1°C} = 2{,}446{,}665$$

Evaluating compliance using the change in temperature, rather than a thermal load, is often a more useful approach for reservoir management because it relates directly to the temperature standard and is easier to evaluate and understand.

Model results show both Keno Dam and JC Boyle Dam increase Klamath River temperatures for certain months (Figure 2-13, Figure 2-14, Figure 2-15, Table 2-23, and Table 2-24). The calculated point of maximum impact for Keno Dam is located at the dam outlet. The point of maximum impact for JC Boyle is at the border with California.

To guide implementation for these dams, a temperature reduction was calculated. The temperature reduction (ΔTreduction, °C) is derived from the dam's predicted warming (ΔTcurrent, °C) at their respective points of maximum impact with all other source allocations in place, minus the dam's allowed warming (ΔT°C) from Table 2-16. The reduction is calculated using Equation 2-8 as:

$$\Delta T\text{reduction} = \Delta T\text{current}, - \Delta T \qquad \textbf{Equation 2-9}$$

The reduction (ΔTreduction) to meet California's temperature targets at the Stateline are based on reductions to the monthly average temperature. The reduction (ΔTreduction) to meet Oregon's allocated portion of the humans use allowance is based on a reduction from the maximum 7DADM.

The reductions calculated for the model year are shown in Table 2-23, Table 2-24, and Table 2-25. Table 2-25 shows the reductions for Keno Dam at the Stateline assuming J.C. Boyle is removed. The reductions shown represent the maximum reduction for each month the allocations apply. The model used for TMDL development predicts that the maximum 7DADM temperature reductions are 0.59°C and 2.57°C at Keno Dam and at the California border, respectively (Table 2-19). The maximum temperature reduction at the Stateline using California's monthly average targets is 0.24°C (Table 2-20).

DEQ also calculated reductions at Stateline from warming by Keno Dam assuming J.C. Boyle Dam is removed. These reductions are presented in Table 2-25.

The reduction calculations were based on flow and climate conditions in the year 2000. DEQ expects the Klamath River models to be refined and improved upon, particularly to guide TMDL implementation. After DEQ review and acceptance, a different temperature model using different assumptions may be used to calculate the required reductions for implementation, including reduction in other years.

The department may, on a case-by-case basis, require the Klamath River dams to develop and implement a temperature management plan. (OAR 340-041-0028 (12)(e)).

Table 2-23. Current maximum monthly 7DADM warming and reductions for Keno Dam and J.C. Boyle Dam to achieve Oregon and California temperature targets.

Month	Keno Outlet Maximum 7DADM Warming (°C) (ΔTcurrent)	Keno Outlet Maximum 7DADM Reduction (°C) (ΔTreduction)
June	0.15	0.07
July	0.67	0.59
August	0.24	0.16
September	0.47	0.39

Table 2-24. Maximum current monthly average warming and reductions for Keno Dam and J.C. Boyle Dam to achieve California's water quality targets at OR/CA Stateline.

Month	J.C Boyle and Keno Maximum 7DADM Warming at Stateline (°C) (ΔTcurrent)	J.C. Boyle and Keno Maximum 7DADM Reduction at Stateline (°C) (ΔTreduction)	J.C Boyle and Keno Dam Warming at Stateline above California Monthly Average Target (°C) (ΔTcurrent)	J.C. Boyle and Keno Dam monthly Average Reduction at Stateline (°C) (ΔTreduction)
January	0.38	0.38	-0.22	0
February	-0.26	0.00	-0.12	0
March	-0.23	0.00	-0.04	0
April	0.68	0.68	0.10	0.1
May	0.88	0.88	-0.10	0
June	1.95	1.95	-0.34	0
July	2.57	2.57	0.15	0.15
August	2.03	2.03	0.24	0.24
September	1.54	1.54	0.12	0.12
October	1.21	1.21	-0.03	0
November	2.50	2.50	0.12	0
December	1.40	1.40	-0.22	0

Table 2-25. Maximum monthly average warming and reductions for Keno Dam assuming J.C Boyle is removed in order to achieve California's water quality targets at OR/CA Stateline.

Month	Keno Dam Maximum 7DADM Warming at Stateline (°C) (ΔTcurrent)	Keno Dam Maximum 7DADM Reduction at Stateline (°C) (ΔTreduction)	Keno Dam Monthly Average Warming at Stateline (°C) (ΔTcurrent)	Keno Dam monthly Average Reduction at Stateline (°C) (ΔTreduction)
January	0.01	0.01	-0.02	0
February	0.03	0.03	0.01	0.01
March	0.15	0.15	-0.01	0
April	0.21	0.21	0.00	0
May	0.26	0.26	0.01	0.01
June	0.14	0.14	-0.06	0
July	0.35	0.35	0.10	0.10
August	0.12	0.12	-0.03	0

Month	Keno Dam Maximum 7DADM Warming at Stateline (°C) (ΔTcurrent)	Keno Dam Maximum 7DADM Reduction at Stateline (°C) (ΔTreduction)	Keno Dam Monthly Average Warming at Stateline (°C) (ΔTcurrent)	Keno Dam monthly Average Reduction at Stateline (°C) (ΔTreduction)
September	0.30	0.30	0.07	0.07
October	0.18	0.18	0.08	0.08
November	0.19	0.19	0.06	0.06
December	0.18	0.18	0.08	0.08

2.7.4 Allocation Attainment

Dams at current the condition and allocation achieving reductions are shown in Figure 2-13, Figure 2-14, and Figure 2-15. Cumulative warming and attainment of the allocated portions of the human use allowance to point sources, water management districts, Keno Dam, and J.C Boyle dam are shown in Figure 2-16 (Keno Dam outlet) and Figure 2-17 (OR/CA Stateline). The plots represent the modeled allocations with the dams achieving their reductions. Figure 2-18 shows the cumulative warming from the same sources at the OR/CA Stateline but based on warming above California's monthly average temperature targets. The warming above the monthly average does not exceed 0.04 C - a temperature considered not measureable with field instrumentation that attains California's requirements.

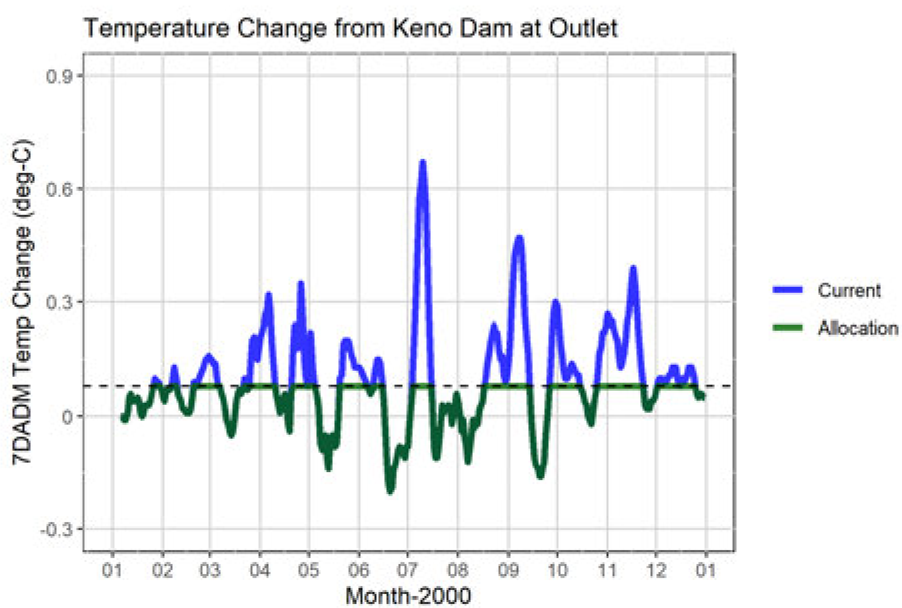

Figure 2-13. Warming of 7DADM temperature at Keno Dam outlet from Keno Dam current conditions and at allocations with Keno dam achieving required reductions. The allocated portion of the human use allowance for Keno Dam at this location is 0.08 C (dashed line).

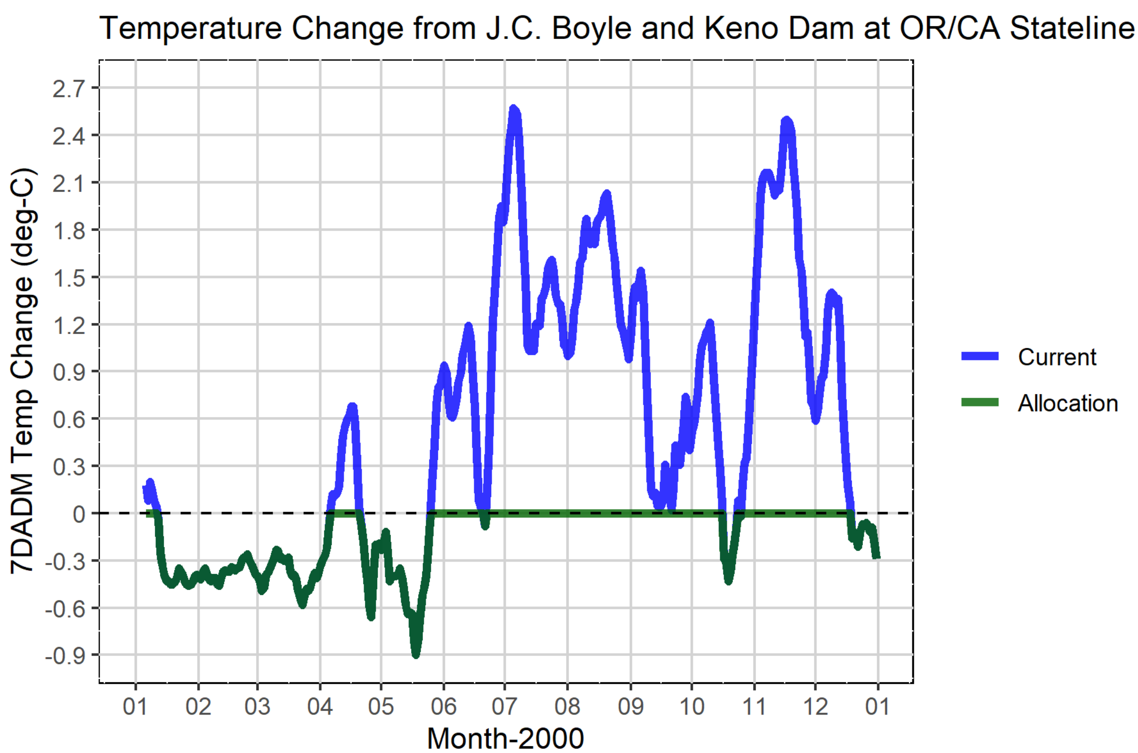

Figure 2-14. Warming of 7DADM temperature at OR/CA Stateline from J.C Boyle and Keno Dam under current conditions and at allocations with the dams achieving required reductions. The allocated portion of the human use allowance at this location is zero deg-C (dashed line).

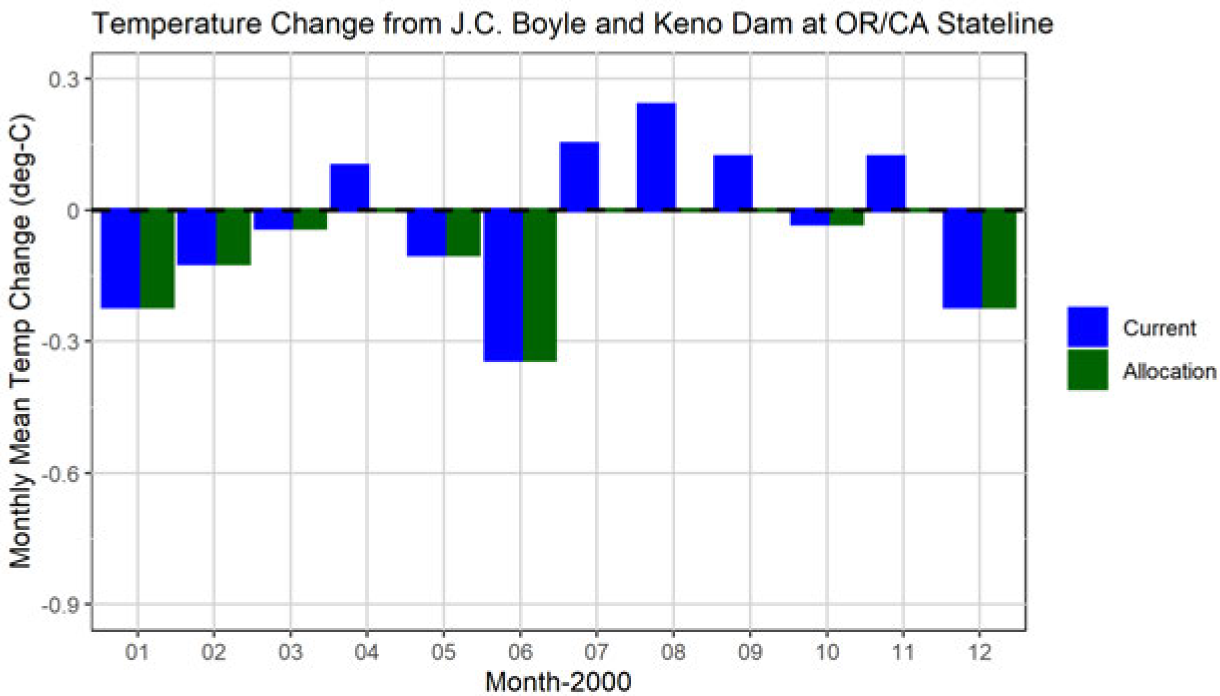

Figure 2-15. Warming at OR/CA Stateline from J.C Boyle and Keno Dam. Each bar represents the maximum warming above the monthly mean temperature under current conditions and at allocations with the dams achieving required reductions.

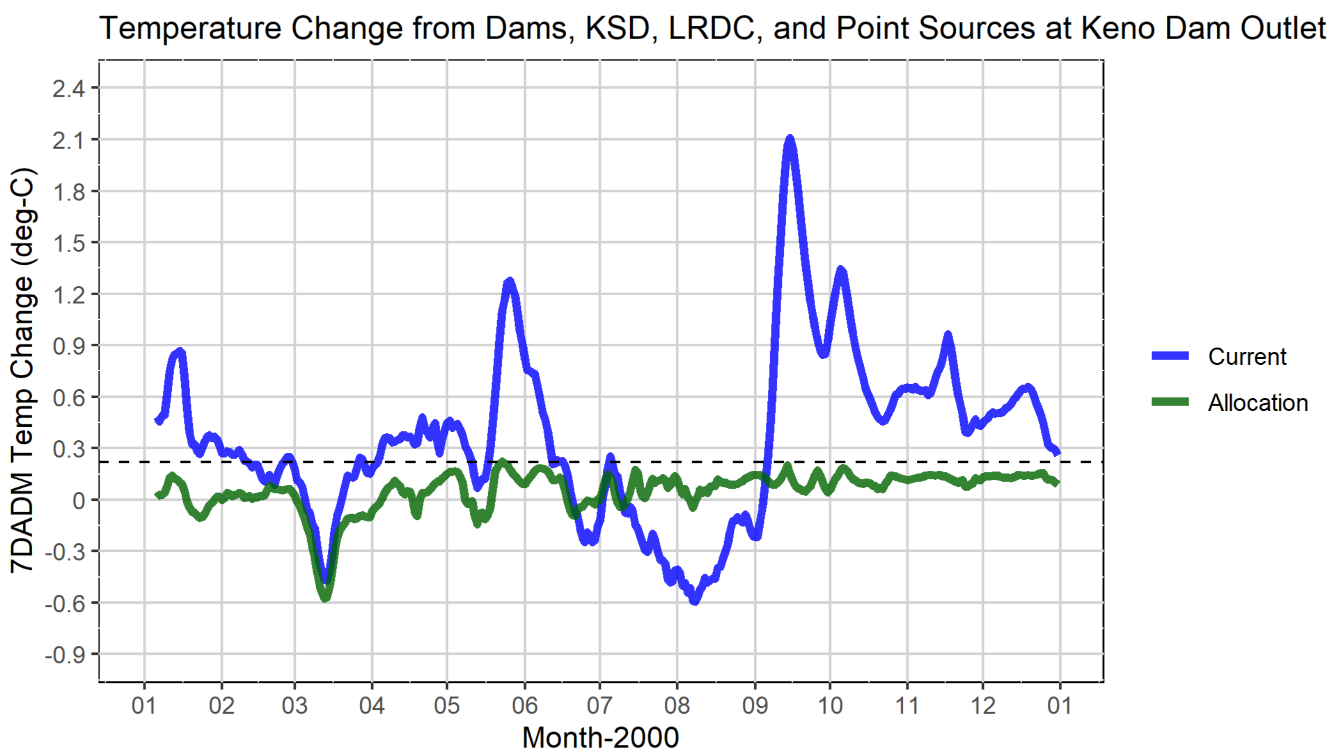

Figure 2-16. Warming of 7DADM temperature at Keno Dam outlet from multiple sources at current conditions and at allocations with Keno dam achieving required reductions. The allocated portion of the human use allowance for Keno Dam at this location is 0.22 C (dashed line).

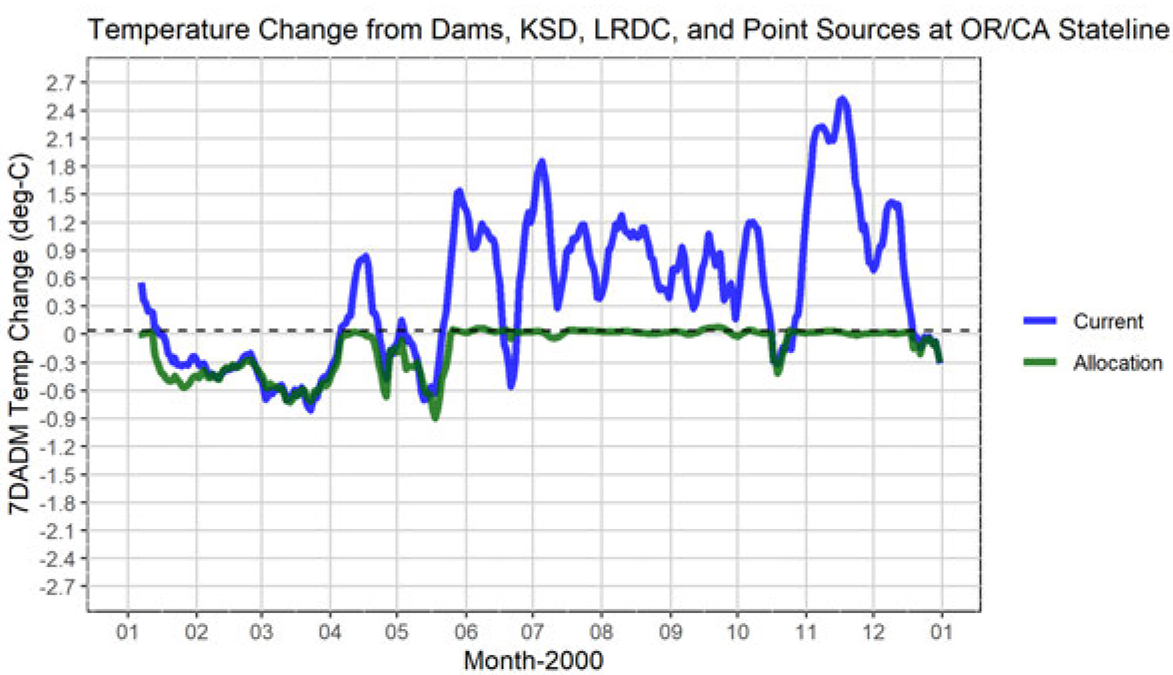

Figure 2-17. Warming of 7DADM temperature at OR/CA Stateline from point and nonpoint sources under current conditions and at allocations with the dams achieving required reductions.

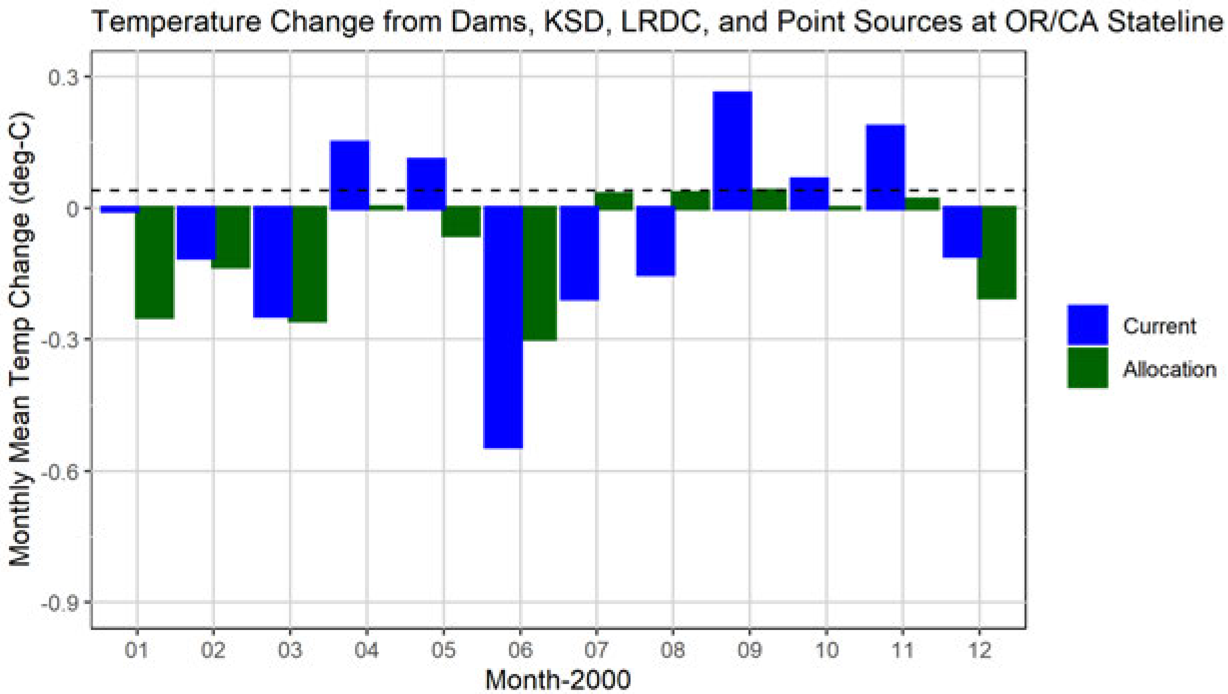

Figure 2-18. Warming at OR/CA Stateline from multiple sources. Each bar represents the maximum warming above the monthly mean temperature under current conditions and at allocations with the dams achieving required reductions. The dashed line represents 0.04 C implementing California's requirements.

2.8 Reserve Capacity

OAR 340-042-0040(4)(k), 40 CFR 130.2(h)

There is an explicit allocation for reserve capacity in the Klamath River set aside for future growth and new, expanded, or unidentified sources. The change in stream temperature associated with the reserve capacity (Table 2-16) is 0.05 °C at Keno Dam and 0.3 °C at the OR/CA Stateline. Reserve capacity is available for use by either nonpoint or point sources to accommodate future growth as well as to provide an allocation to any existing source that may not have been identified during the development of this TMDL. In the event that any new individual facility permits are issued on the Klamath River, they will be written to ensure that all TMDL related issues are addressed in the permit. DEQ has a process for setting or revising WLAs for new or expanding point sources discharges to waterbodies with an approved TMDL. This process will be used to update allocations in approved TMDLs for new or expanding dischargers whose permitted effluent limits are at or below the in-stream target and will ensure that the effluent will not exceed applicable water quality standards or surrogate measures. The process for modifying or adding WLAs to the TMDL will be administered by DEQ, with input and involvement by the EPA, once a permit request is submitted. Once DEQ determines that the new or expanded discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL allocation(s) will be made. DEQ may allocate none, some, or all of reserve capacity if sufficient capacity is available and an analysis is conducted to demonstrate attainment of the applicable water quality targets, including targets established by California's North Coast Water Quality Control Board at the Oregon/California border.

2.9 Margin of Safety

OAR 340-042-0040(4)(1)

The Clean Water Act requires that each TMDL be established with a margin of safety to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A margin of safety is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (i.e., derivation of numeric targets, modeling assumptions, or effectiveness of proposed management actions).

A margin of safety may be implicit through the use of conservative assumptions that result in more protective loading capacity, wasteload allocations, or load allocations. The margin of safety may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the margin of safety documented. The margin of safety is not meant to compensate for a failure to consider known sources.

An *implicit* margin of safety has been incorporated into the temperature assessment methodology, resulting in conservative estimates of loads and required reductions:

- The thermal loading capacities were calculated using the lowest flow estimate for each flow condition; however, the loading capacity applies to the entire range of flows within that condition (Appendix H). This approach captures the expected range of flows for each impaired segment. It results in a conservative application of the loading capacity when the observed flow in a specific condition is higher than the lowest flow estimate used in the TMDL calculations.
- Allocations were developed to meet all flow conditions. During September of the model year (year 2000) the flows was very low approaching 7Q10 conditions. These flows are less than more recent flow requirements (i.e. BOR Klamath Project Operations and PacifiCorp Klamath Hydro Project Biological Opinion flows).
- When existing condition point source loads were lower than allocations, DEQ increased temperatures as high as was allowed by the allocation often resulting in discharge temperatures as high as 32 degrees Celsius for multiple days in a row and for some sources over the entire year. This is unlikely to occur in practice, so the resulting river temperatures will be slightly cooler than assumed in the model allocation scenario.

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3. Upper Klamath Subbasin Tributaries Temperature TMDLs

Table 3-1. Summary of Upper Klamath Subbasin Tributaries temperature TMDL components.

Waterbodies OAR 340-042-0040(4)(a)	All perennial and intermittent streams, ditches, and canals that discharge within the Upper Klamath subbasin (18010206) except for the Mainstem Klamath River (addressed in Chapter 2).
Designated Beneficial Uses OAR 340-041-0271, Table 180A	The most sensitive designated beneficial uses are fish and aquatic life, and fishing.
Pollutant Identification OAR 340-042-0040(4)(b)	Heat.
Target Identification and Applicable Water Quality Standards OAR 340-042-0040(4)(c) *CWA §303(d)(1)* OAR 340-041-0028(4)(e) OAR 340-041-0028 (11) OAR 340-041-0028 (12)(b)	OAR 340-041-0028(4)(e): (e) **Redband or Lahontan Cutthroat Trout Use**. The seven-day-average maximum temperature of a stream identified as having Lahontan cutthroat trout or redband trout use may not exceed 20.0 degrees Celsius (68.0 degrees Fahrenheit). OAR 340-041-0028 (12)(b)(B) **Human Use Allowance**. Following a temperature TMDL or other cumulative effects analysis, wasteload and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5 Fahrenheit) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact. OAR 340-041-0028 (5) **Unidentified Tributaries**. For waters that are not identified on the “Fish Use Designations” maps referenced in section (4) of this rule, the applicable criteria for these waters are the same criteria as is applicable to the nearest downstream water body depicted on the applicable map. OAR 340-041-0028 (11) (a) **Protecting Cold Water**: Except as described in subsection (c) of this rule, waters of the State that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria in section (4) of this rule, may not be warmed by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This provision applies to all sources taken together at the point of maximum impact where salmon, steelhead, or bull trout are present. California Water Quality Standards: It is the policy of Oregon DEQ to achieve water quality standards established by neighboring states in interstate waters.
Existing Sources *CWA §303(d)(1)* OAR 340-042-0040(4)(f)	**Nonpoint sources** include warming from natural sources; excessive inputs of heat due to the removal or reduction in near-stream vegetation; water management district operations; channel modification; and dam and reservoir operation, and hydromodification. These sources are considered nonpoint sources that influence the quantity and timing of heat delivery to downstream river reaches.

Seasonal Variation *40 CFR 130.7(c)(2)* OAR 340-042-0040(4)(j)	Peak temperatures typically occur in mid-July through mid-August. The critical period in this TMDL is June 1 – September 30.
Excess Load OAR 340-042-0040(4)(e)	See Section 3.6
TMDL Loading Capacity and Allocations *40 CFR 130.2(f)* *40 CFR 130.2(g)* *40 CFR 130.2(h)* OAR 340-042-0040(4)(d), (g), (h), (k)	**Loading Capacity**: See Section 3.5 **Human Use Allowance (All Sources)** – See Section 3.7.1 **Wasteload Allocations (Point Sources)** - See Section 3.7.2 **Load Allocations (Non-Point Sources)** – See Section 3.7.3. **Reserve Capacity** – See Section 3.8.
Surrogate Measures OAR 340-042-0040(5)(b) 40 CFR 130.2(i)	**Surrogate Measure – Effective Shade**: Effective shade targets translate nonpoint source load allocations into measurable near-stream vegetation targets.
Margins of Safety *40 CFR 130.7(c)(2)* OAR 340-042-0040(4)(i)	The margin of safety is implicit using conservative assumptions.
WQ Standard Attainment Analysis OAR 340-042-040(4)(l)(E) *CWA §303(d)(1)*	Analytical modeling of TMDL loading capacities demonstrates attainment of water quality standards. The Water Quality Management Plan (WQMP) will consist of Implementation Plans and other strategies that contain measures to attain allocations. The TMDL and WQMP will incorporate multiple elements that together will provide reasonable assurance that the TMDL will be implemented. This reasonable assurance and accountability framework is discussed in Chapter 5.
Water Quality Management Plan OAR 340-042-0040(4)(l)	Provided in Chapter 6.

Waterbody Name and Location OAR 340-042-0040(a): This TMDL covers all waters of the State of Oregon in the Upper Klamath subbasin (18010206).
Specifically, this TMDL analysis covers 11 water quality limited segments and upstream waters for temperature in the Upper Klamath River subbasin (Table 3-2). These waterbodies and their TMDL analyses are described below and in Appendices A and B.

Table 3-2. Impaired waterbodies addressed in Chapter 3 by this TMDL.

Waterbody Name	Watershed (HUC)	Length (River Miles)
Beaver Creek	Jenny Creek (1801020604)	5.5
Grizzly Creek	Jenny Creek (1801020604)	3
Hoxie Creek	Jenny Creek (1801020604)	3.6
Jenny Creek	Jenny Creek (1801020604)	17.8
Johnson Creek	Jenny Creek (1801020604)	9.4
Klamath River	John C Boyle Reservoir (1801020602) Lake Ewauna-Klamath River (1801020412) <u>Upstream Watersheds:</u> Copco Reservoir-Klamath River (1801020603) Iron Gate Reservoir-Klamath River (1801020605) Cottonwood Creek (1801020606) Beaver Creek (1801020609)	24.1
Keene Creek[1]	Jenny Creek (1801020604)	9.4
Mill Creek	Jenny Creek (1801020604)	3.9
South Fork Keene Creek	Jenny Creek (1801020604)	3.1
Spencer Creek	Spencer Creek (1801020601)	18.9

[1] There are two water quality limited segments for Keene Creek, a 7.2-mile segment and a 2.2-mile segment. This TMDL covers the full 9.4-mile segment, which is inclusive of both 303(d) listed segments.

3.1 Designated Beneficial Uses and Water Quality Standards

Beneficial uses are those uses of water that the state has identified for waters of the state. The beneficial uses of waters of the state are identified in state statute with the EQC adopting by rule beneficial uses by basin. Water quality standards are adopted by the EQC to protect the most sensitive beneficial uses.

3.1.1 Beneficial Uses

Beneficial Uses: OAR 340-042-0040(4)(c): This TMDL identifies the beneficial uses in the TMDL geographic area and developed to protect the most sensitive beneficial uses.

The most sensitive beneficial uses relevant to these TMDLs are salmonid fish spawning and rearing and resident fish and aquatic life. Water quality problems are of great concern because of their potential impact on native fish in the Klamath River basin including the shortnose sucker (*Chasmistes brevirostris*), Lost River sucker (*Deltistes luxatus*), and interior redband trout (*Oncorhynchus mykiss* ssp.). Both sucker species were listed as endangered under the federal Endangered Species Act in 1988 (Williams 1988).

There are many beneficial uses in the Klamath River basin[1]; however, only a subset apply to temperature impairments in the Upper Klamath River subbasin tributaries addressed in this TMDL. The beneficial uses affected by excessive temperatures include Fish and Aquatic Life and Fishing (DEQ 2005). Oregon's stream temperature standards in the Upper Klamath River subbasin protect cold-water fish (salmonids) rearing and spawning as the most sensitive beneficial use.

EQC issued and EPA approved numeric and narrative water quality standards to protect designated *beneficial use*s in the Klamath River basin (Administrative Rules OAR 340–041–0180 - 0185, Table 180A, November 2003), and antidegradation policies to protect overall water quality. In practice, water quality criteria have been set at a level to protect the most sensitive beneficial uses and seasonal criteria may be applied for uses that do not occur year-round.

3.1.2 Applicable Water Quality Standards

Water Quality Standards: OAR 340-042-0040(4)(c): This TMDL is developed to meet the relevant water quality standards for protection of the most sensitive beneficial uses.
In order to protect the salmonid, water quality criteria have been developed in Oregon (OAR 340-041-0028). Oregon's water temperature criteria use salmonids' life cycles as indicators. If temperatures are protective of these indicator species, other species will share in this protection. Numeric stream temperature criteria are expressed as a seven-day average of daily maximum temperature (7DADM). They specify where and when the fish use occurs, and, therefore, where and when numeric criteria apply. The fish use designation map provided in OAR 340-041-0180 Figure 180A is shown in Figure 3-1. All tributaries addressed in this TMDL chapter (within the light blue subbasin in Figure 3-1) are designated as "Redband or Lahontan Cutthroat Trout" fish use.

3.1.2.1 Redband or Lahontan Cutthroat Trout Use

Waters that have been designated for "Redband or Lahontan Cutthroat Trout" use are identified in OAR 340-041-0180 Figure 180A is shown in Figure 3-1. The applicable Oregon criterion for these streams is 20°C year-round. The mainstem of the Klamath River is designated as "Cool water species" fish use from Upper Klamath Lake to the Keno Dam and "Redband or Lahontan Cutthroat Trout" from Keno Dam to the Oregon/California Stateline. The applicable Oregon criterion for the listed segment of the Klamath River is 20°C year-round for "Redband or Lahontan Cutthroat Trout".

3.1.2.2 Protecting Cold Water

The "protecting cold water" criterion in OAR 340-041-0028(11) applies to waters of the state that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria (typically 20°C redband or Lahontan cutthrout trout use). With some exceptions, these waters may not be warmed cumulatively by anthropogenic point and nonpoint sources by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This applies to all anthropogenic sources taken together at the point of maximum impact where salmon, steelhead or bull trout are present.

[1] https://www.oregon.gov/deq/Rulemaking%20Docs/table180a.pdf

3.1.2.3 Human Use Allowance

Oregon water quality standards also have provisions for human use (OAR 340-041-0028(12)(b)). The human use allowance is an insignificant addition of heat (0.3° C) authorized in waters that exceed the applicable temperature criteria. The applicable temperature criteria are defined in OAR 340-041-0002(4) to mean “the biologically based temperature criteria in OAR 340-041-0028(4), or the superseding cold water protection criteria in 340-041-0028(11)”. Following a temperature TMDL, or other cumulative effects analysis, wasteload and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5 Fahrenheit) above the applicable biological criterion after complete mixing in the waterbody, and at the point of maximum impact. The rationale behind selection of 0.3 deg-C for the human use allowance and how DEQ implements this portion of the standard can be found in DEQ (2003) and the Temperature IMD (DEQ 2008).

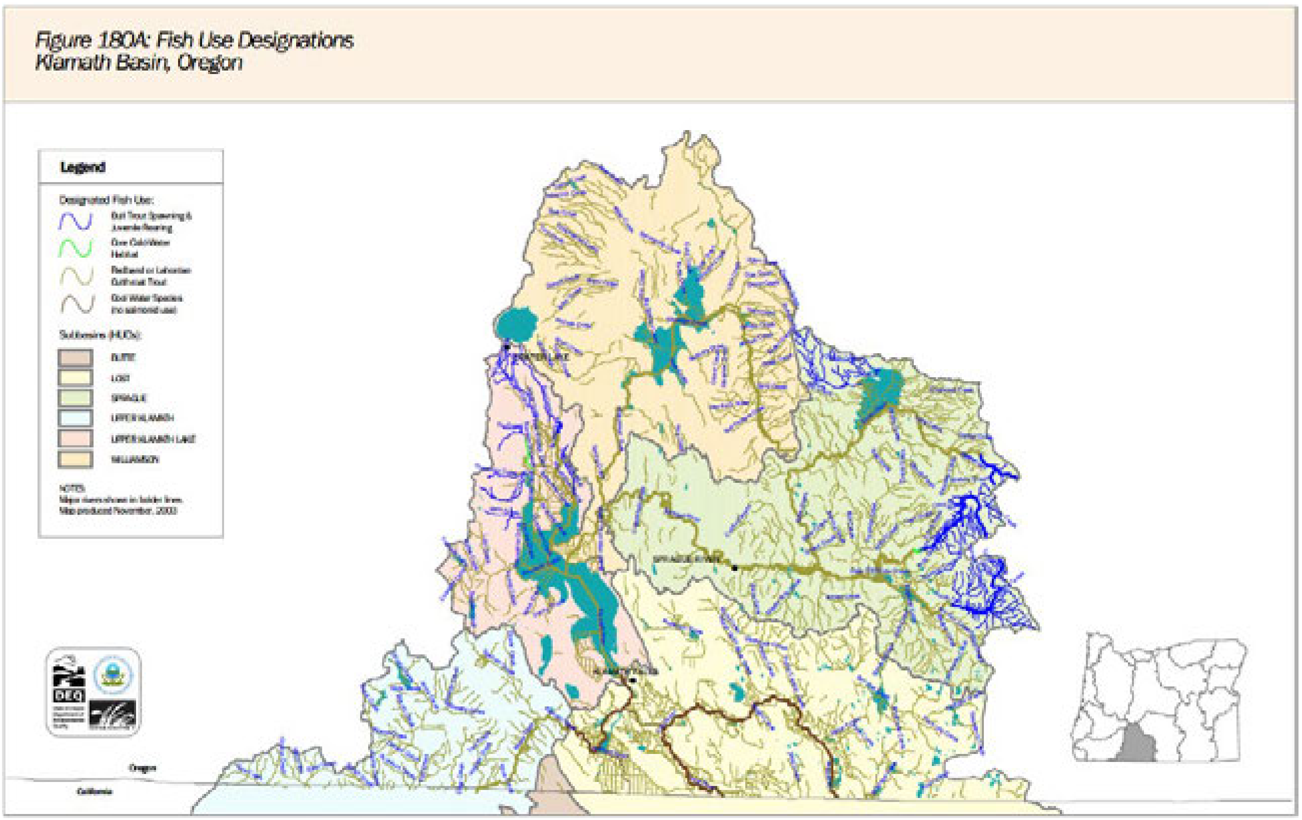

Figure 3-1. Oregon fish use designations for the Klamath basin[2]

[2] http://www.oregon.gov/deq/Rulemaking%20Docs/figure180a.pdf

3.1.2.4 State of California Water Quality Standards

Jenny Creek and numerous impaired upstream waterbodies in the Jenny Creek Watershed flow from Oregon into California. Therefore, allocations established in the Jenny Creek Watershed and other watersheds in Oregon's TMDL must also achieve the water quality standards and numeric targets established in California.

The North Coast Regional Water Quality Control Board has outlined the water quality targets on Jenny Creek for DEQ in a memorandum (Creager et al. 2019) and attached to the this TMDL as Appendix D. Water temperature objectives for ambient waters in California immediately south of the border with Oregon are contained in the North Coast Regional Water Quality Control Board's Water Quality Control Plan for the North Coast Region. This plan is commonly referred to as the Basin Plan (NCRWQCB 2018).

Jenny Creek is considered a COLD interstate water and supports salmonid core rearing habitat for populations of rainbow trout. "COLD" refers to water designated as Cold Freshwater Habitat in the Basin Plan (NCRWQCB 2018). The criterion for COLD interstate waters is 16ºC as a 7-day average maximum temperature. If the natural temperatures of Jenny Creek exceed this threshold then the Basin Plan holds that no controllable factors shall contribute to any further warming. "Controllable water quality factors are those actions, conditions, or circumstances resulting from human activities that may influence the quality of the waters of the state and that may be reasonably controlled." This means that when natural water temperatures are warmer than the basin objectives, controllable warming is prohibited.

See Appendix D for additional background on the North Coast Regional Water Quality Control Board's temperature water quality standards and targets.

3.1.3 Impaired Waterbodies and 303(d) Listings

DEQ is one of several entities that monitors the water quality of streams, lakes, estuaries, and groundwater in Oregon. This information is used to determine whether water quality standards are not being met, and consequently, whether the beneficial uses of the waters are impaired. Specific State and Federal plans and regulations are used to determine if water quality standards are not being met. These regulations include the Federal Clean Water Act of 1972 and its amendments Title 40 Code of Federal Regulations 131, Oregon's Administrative Rules (OAR Chapter 340), and Oregon's Revised Statutes (ORS Chapter 468).

Section 303(d) of the Federal Clean Water Act (1972) requires that waterbodies that exceed water quality criteria, thereby failing to fully protect beneficial uses, be identified and placed on a 303(d) list[3]. Monitoring has indicated that water temperatures in the Upper Klamath subbasin exceed the State of Oregon temperature criteria with 11 individual temperature listings equaling 98.7 miles. All of these water quality limited segments are addressed in this TMDL report. The tributaries to the Klamath River and the 303(d) listed Klamath River are identified in Figure 3-2. Table 3-3 also identifies the applicable criterion for each listed tributary segment in the Upper

[3] For specific information regarding Oregon's 303(d) listing procedures, and to obtain more information regarding the Klamath River basin 303(d) listed streams, visit the Oregon Department of Environmental Quality's web page at https://www.oregon.gov/deq/wq/Pages/WQ-Assessment.aspx.

Klamath subbasin and addressed in this chapter. The mainstem Klamath River is addressed in Chapter 2.

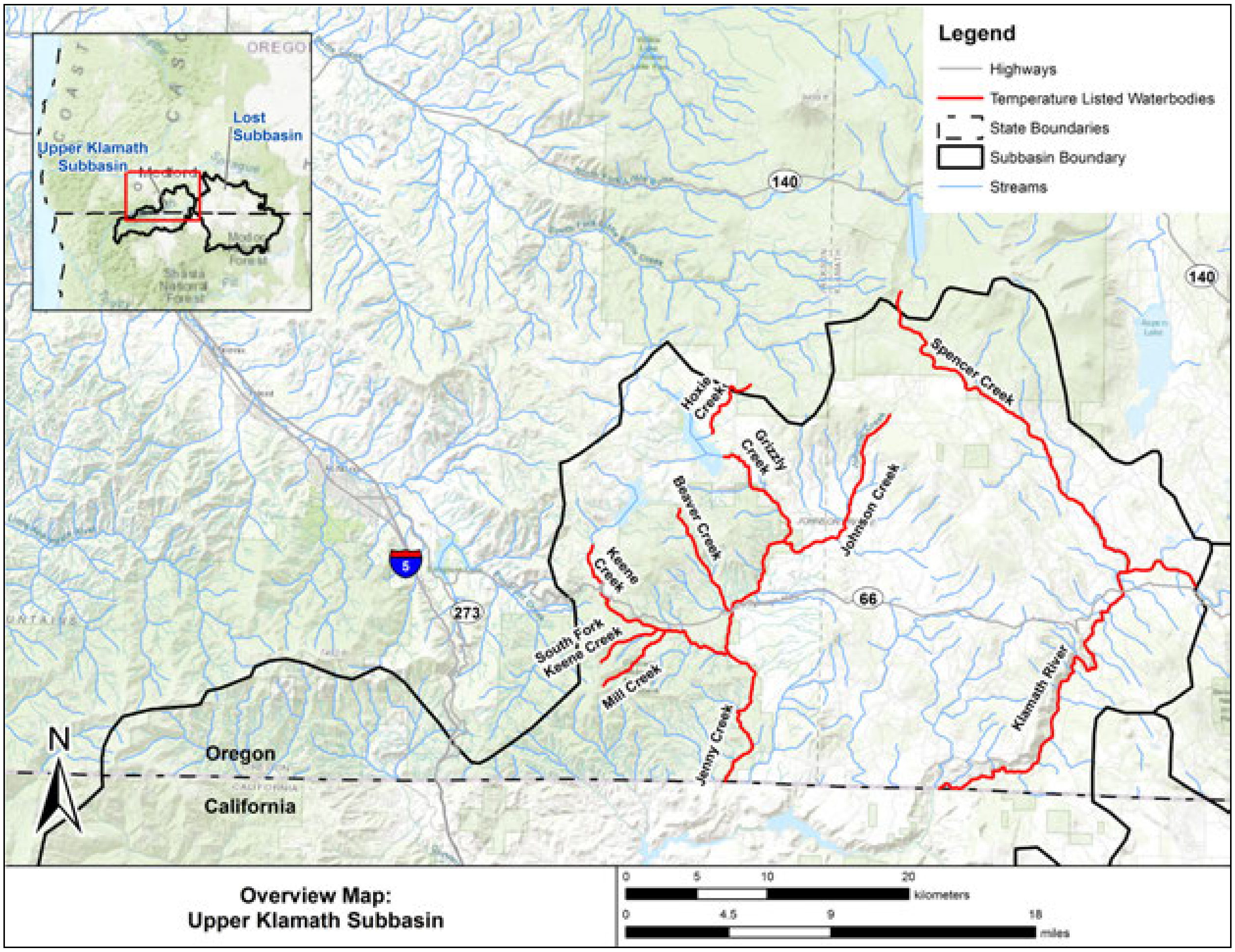

Figure 3-2. Oregon 2012 water quality limited segments in the Upper Klamath subbasin

Table 3-3. Temperature impaired tributary segments addressed in this chapter and their water quality criteria.

303(d) ID	Waterbody Name	LLID	River Mile	Use: Applicable Criterion (°C)
12872	Beaver Creek	1223661421184	0 to 5.5	Redband trout: 20.0 7DADM
2158	Grizzly Creek	1223412421963	0 to 3	Redband trout: 20.0 7DADM
2180	Hoxie Creek	1224003422276	0.8 to 4.4	Redband trout: 20.0 7DADM
1984	Jenny Creek	1223747420009	0 to 17.8	Redband trout: 20.0 7DADM
2159	Johnson Creek	1223226421639	0 to 9.4	Redband trout: 20.0 7DADM
2163	Keene Creek	1223681420918	0 to 7.2	Redband trout: 20.0 7DADM

303(d) ID	Waterbody Name	LLID	River Mile	Use: Applicable Criterion (°C)
2178	Keene Creek	1223681420918	7.5 to 9.7	Redband trout: 20.0 7DADM
2168	Mill Creek	1224229421048	0 to 3.9	Redband trout: 20.0 7DADM
2181	South Fork Keene Creek	1224296421059	0 to 3.1	Redband trout: 20.0 7DADM
12815	Spencer Creek	1220277421487	0 to 18.9	Redband trout: 20.0 7DADM

3.2 Subbasin Characterization

The Upper Klamath subbasin (Figure 3-2) is part of the larger Klamath River basin (Figure 1-1). The Klamath River basin is of vital economic and cultural importance to the states of Oregon and California, as well as the Klamath Tribes in Oregon; the Hoopa, Karuk, and Yurok tribes in California; the Quartz Valley Indian Reservation in California, and the Resighini Rancheria in California. It provides fertile lands for a rich agricultural economy in the Upper Basin. Irrigation facilities known as the Klamath Project owned by the U.S. Bureau of Reclamation support this economy as well as hydroelectric power provided via a system of five dams operated by PacifiCorp. Historically, the basin once supported vast spawning and rearing fishery habitat with cultural significance to the local Indian tribes. The watershed supports an active recreational industry, including activities that are specific to the Wild and Scenic portions of the river designated by both the state and federal governments in both Oregon and California. Finally, the watershed continues to support what were once historically significant mining and timber industries.

The following sections discuss characteristics of the region. Either the Upper Klamath subbasin or the larger Klamath River basin is discussed in each section below, depending on the scale of the characteristic being discussed.

3.2.1 Upper Klamath Subbasin Location and Description

The portion of the Upper Klamath subbasin (HUC 18010206) within Oregon includes all the tributaries that flow to the Klamath River downstream of Keno Dam. Portions of the subbasin are also in California. The area of the Upper Klamath subbasin in Oregon and included in this TMDL is 364,442 acres (569 square miles; Figure 3-2). The largest city near the subbasin is Klamath Falls with a population of 20,840 in 2010 and an estimated current population of 21,359 (U.S. Census Bureau 2018). The portion of the Klamath River downstream of Keno Dam to the Oregon/California border is within the Upper Klamath subbasin but is excluded from the TMDLs in this chapter. See chapter 2 for the Temperature TMDL on the Klamath River.

3.2.2 Ecoregions

The Upper Klamath subbasin is dominated by the Eastern Cascades Slopes and Foothills ecoregion, but also contains portions of the Cascades and Klamath Mountains ecoregions (Thorson et al. 2003) (Figure 3-3). The Eastern Cascades Slopes and Foothills ecoregion is in the rain shadow of the Cascade Range. The dominant vegetation includes open forests of ponderosa pine and some lodgepole pine. The vegetation is adapted to the prevailing dry, continental climate and frequent fire. Historically, creeping ground fires consumed accumulated fuel, while crown fires were less common.

The mountains of the Cascades ecoregion are underlain by volcanic rocks and have been affected by alpine glaciation. Maximum elevations of up to 11,239 feet occur on active and dormant volcanic peaks in the eastern part of the ecoregion (Thorson et al. 2003). The western Cascades are older, lower, and dissected by numerous, steep-sided stream valleys. The moist, temperate climate supports a large highly productive coniferous forest that is intensively managed for logging. Subalpine meadows occur at high elevations.

The Klamath Mountains ecoregion encompasses the highly dissected ridges, foothills, and valleys of the Klamath and Siskiyou mountains (Thorson et al. 2003). The ecoregion has a mix of granitic, sedimentary, metamorphic, and extrusive rocks in contrast with the predominantly volcanic rocks of the Cascades ecoregion. The mild, subhumid climate is characterized by a lengthy summer drought. The vegetation of the ecoregion consists of northern Californian and Pacific Northwestern conifers and hardwoods.

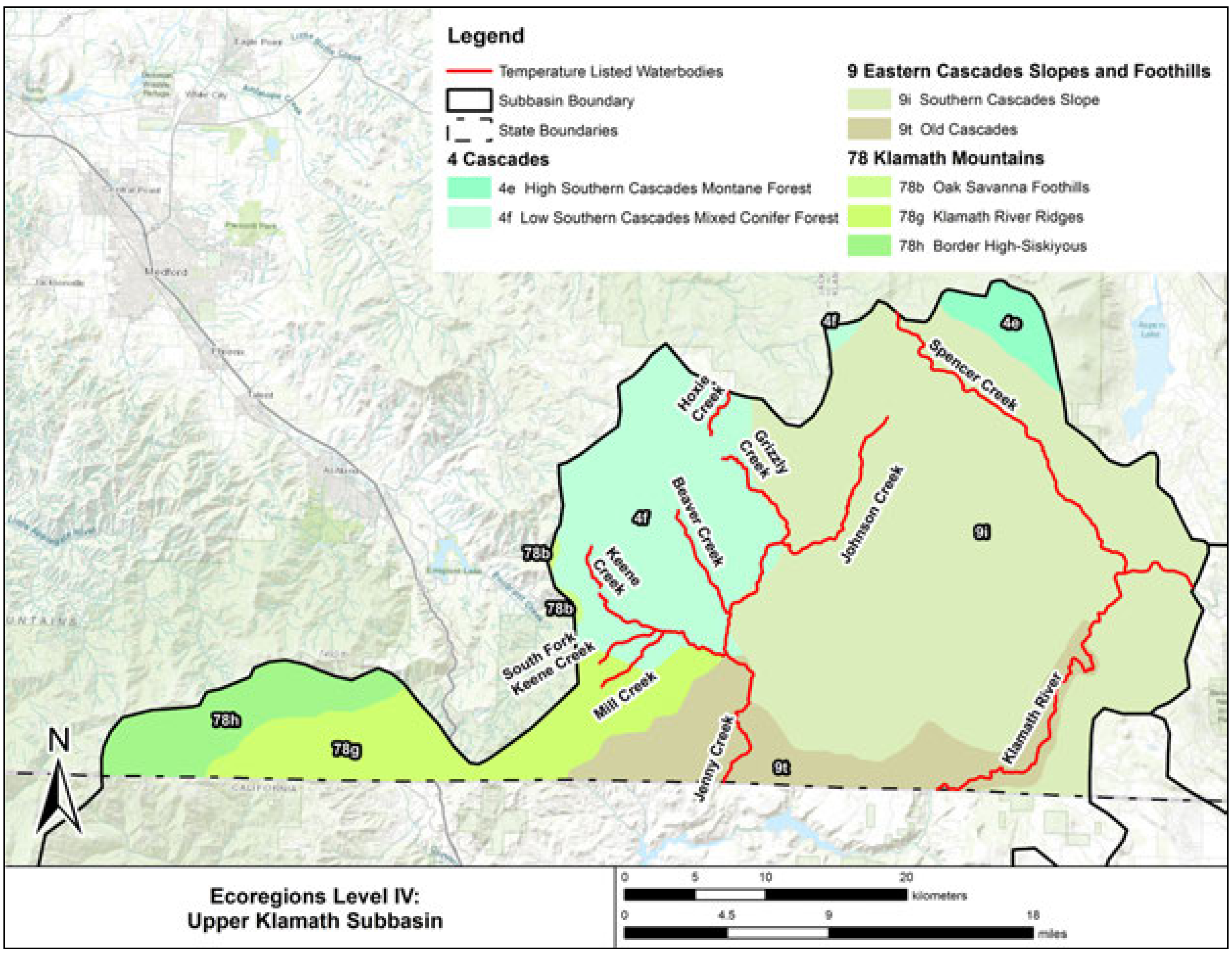

Figure 3-3. Ecoregions of the Upper Klamath Subbasin.

3.2.3 Soils and Geology

3.2.3.1 Soils

Data from the Natural Resources Conservation Service were used to characterize soils in the Upper Klamath subbasin. The soil data set is a combined coverage including detailed Soil Survey Geographic Database (SSURGO) data where available and State Soil Geographic Database (STATSGO) data when SSURGO data were not available (NRCS 2017a, 2017b). The Hydrologic Soil Group classification is a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have lower infiltration rates, while sandy soils that are well drained have the greatest infiltration rates. NRCS has defined four hydrologic groups for soils (Table 3-4). The majority of the soils in the Upper Klamath subbasin belong to Hydrologic Soil Group C (40 percent of the drainage area) and Hydrologic Soil Group B (37 percent of the drainage area). Group B soils are moderately well drained, while Group C soils have high clay content and fairly low infiltration rates and low permeability. The rest of the watershed consists of Hydrologic Soil Groups A (3 percent), B/D (<1 percent), C/D (2 percent) and D (16 percent). The remaining one percent of the watershed is lacking Hydrologic Soil Group data. Table 3-5 and Figure 3-4 summarize the Upper Klamath subbasin soil information.

Table 3-4. Characteristics of hydrologic soil groups. Source: NRCS 1972.

Hydrologic Soil group	Characteristics	Minimum infiltration capacity (inches/hour)
A	Sandy, deep, well-drained soils; deep loess; aggregated silty soils	0.30 to 0.45
B	Sandy loams, shallow loess, moderately deep and moderately well-drained soils	0.15 to 0.30
C	Clay loam soils, shallow sandy loams with a low permeability horizon impeding drainage (soils with a high clay content), soils low in organic content	0.05 to 0.15
D	Heavy clay soils with swelling potential (heavy plastic clays), water-logged soils, certain saline soils, or shallow soils over an impermeable layer	0.00 to 0.05

Table 3-5. Soil distribution in the Upper Klamath subbasin.

Hydrologic Soil Group	Area (acres)	Percent Area
A	10,682	3%
B	131,994	37%
B/D	1,678	0%
C	143,713	40%
C/D	5,851	2%
D	57,605	16%
Null	3,863	1%

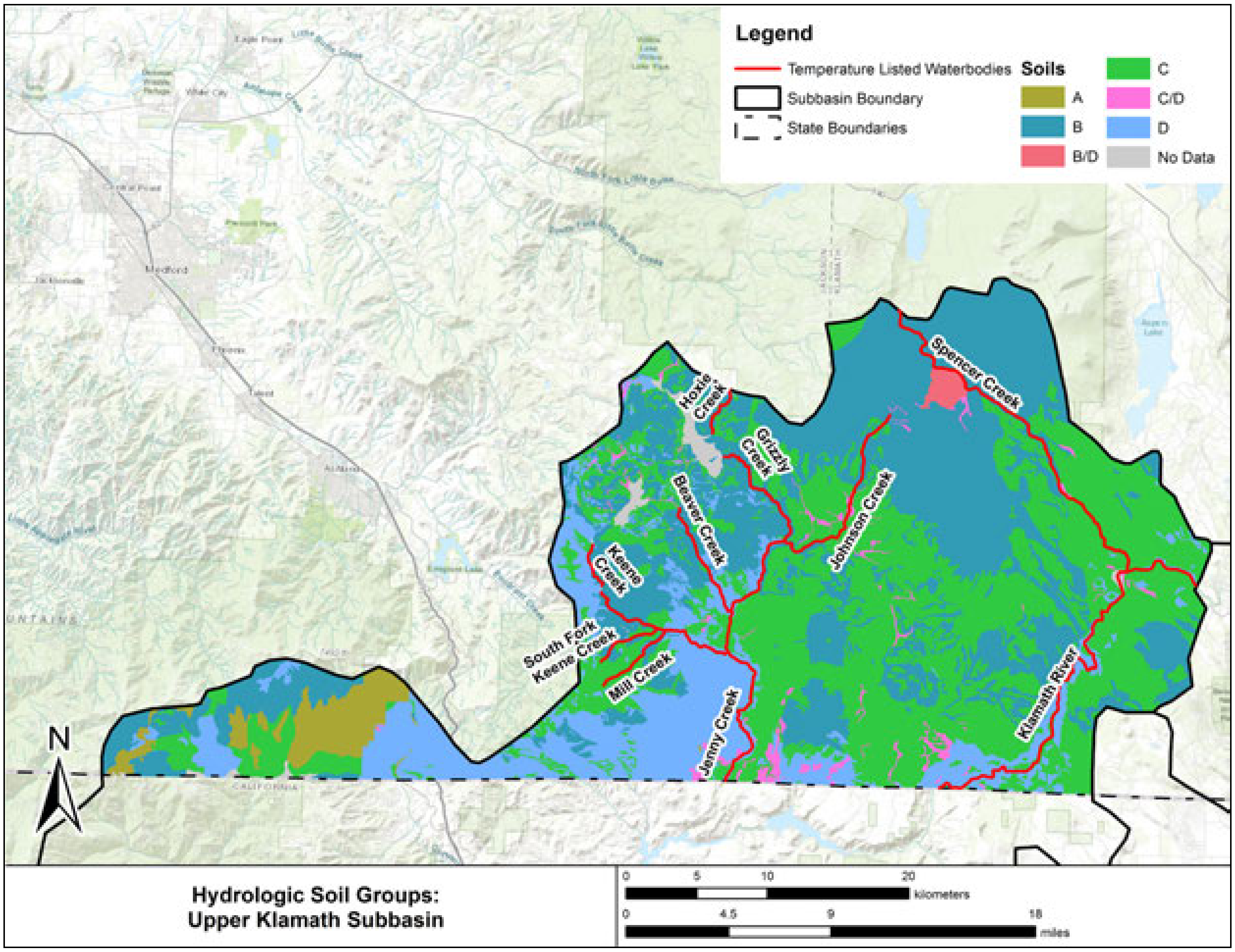

Figure 3-4. Soils in the Upper Klamath subbasin (NRCS 2017a, 2017b).

3.2.3.2 Geology

The Klamath River Watershed crosses four geomorphic provinces. From east (upstream) to west (downstream) these provinces are the Modoc Plateau, Cascade Range, Klamath Mountains, and Coast Ranges (Figure 3-5). The geology of the Klamath basin (including the Klamath River and the Lost River subbasins) within Oregon has been dominated by volcanic activity for the past 35 million years. The Western Cascades subprovince of the Cascade consists of lava flows, andesitic mudflows, tuffaceous sedimentary rocks and vent deposits. The rocks range in age from 20 to 33 million years and have very low permeability, which retards the movement of groundwater flow (Gannett et al. 2007). The High Cascade subprovince overlies the Western Cascades subprovince and range in age from 7 million years to recent. Deposits consist of volcanic vents and lava flows. The High Cascades rocks are relatively permeable compared to the underlying older rocks.

The major water-bearing rocks in the Klamath River basin in Oregon are the late Miocene to Pliocene volcanic rocks of the Basin and Range Province (Gannett et al. 2007). The Basin and Range Province extends over much of the Western U.S. and is characterized by down-dropped basins separated by fault-block ranges. Although the Basin and Range province is primarily a structural feature, faulting has been accompanied by widespread volcanism with rocks consisting of volcanic vent deposits and flow rocks located east of Upper Klamath Lake and

Lower Klamath Lake (DOGAMI 2008). These features probably underlie most of the valley and basin-fill deposits (Gannett et al. 2007).

Pliocene (5 million years before present) to Recent (age) deposits comprise the youngest rock in the study area, consisting of alluvium, basin-fill, and glacial drift and outwash. Alluvium thickness reaches 1,740 feet in the historic Tule Lake Valley, and Lower Klamath Lake basins.

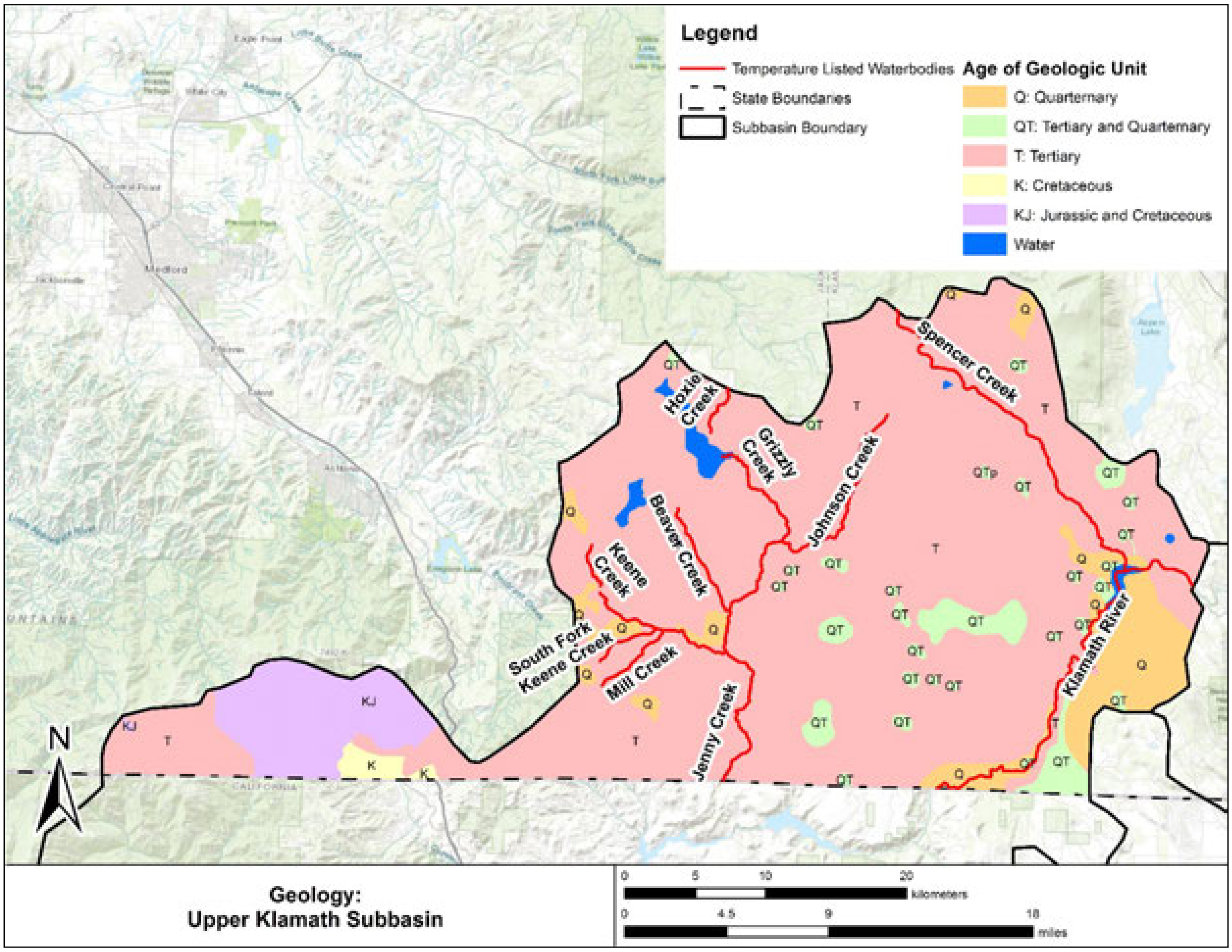

Figure 3-5. Geologic map of the Klamath River watershed.

3.2.4 Climate

The great geographic extent and topographic relief of the Klamath River basin produces a wide variety of climatological conditions. The climate is characterized by dry summers with high daytime temperatures, and wet winters with moderate to low temperatures. Due to its location east of the Cascade Mountain Range, it is in the path of storms originating in the north Pacific Ocean. Winter precipitation is derived from these storms traversing in an easterly direction. The Cascade Range creates a rain shadow that affects the distribution of precipitation throughout the subbasin. Over two-thirds of the annual precipitation falls between October and March. Wintertime produces a snowpack in the higher mountain ranges that feeds streamflow in many lower areas through the summer.

Climate data (air temperature and precipitation) representative of the TMDL area were available from the Klamath Falls, Oregon AgriMet Weather Station (KFLO) from March 1999 to present (Figure 3-6). Mean annual temperature is about 47°F. The coldest month is January with a mean temperature of 27°F. The warmest month is July with a mean temperature of 69°F. The mean annual precipitation from 1999 to 2017 was 11.3 inches, but local averages in the basin range from as little as 10 inches to more than 60 inches in mountains (Figure 3-7).

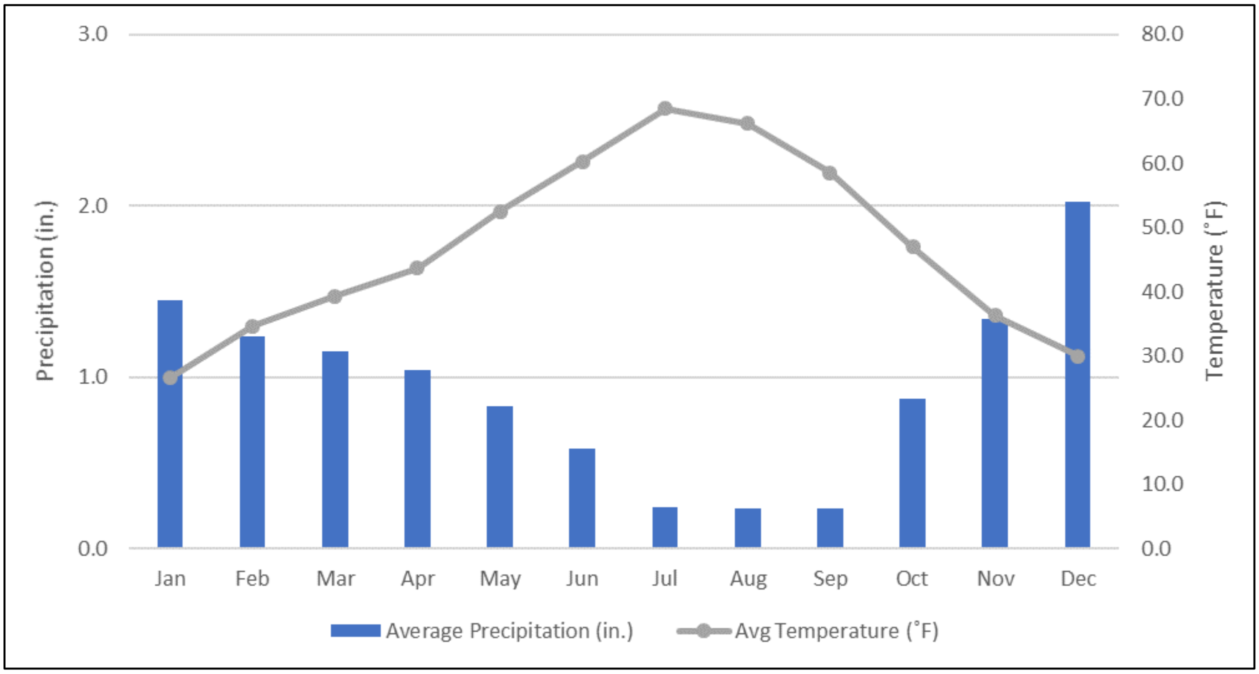

Figure 3-6. Climate summary – Klamath Falls, Oregon (KFLO 1999-2017).

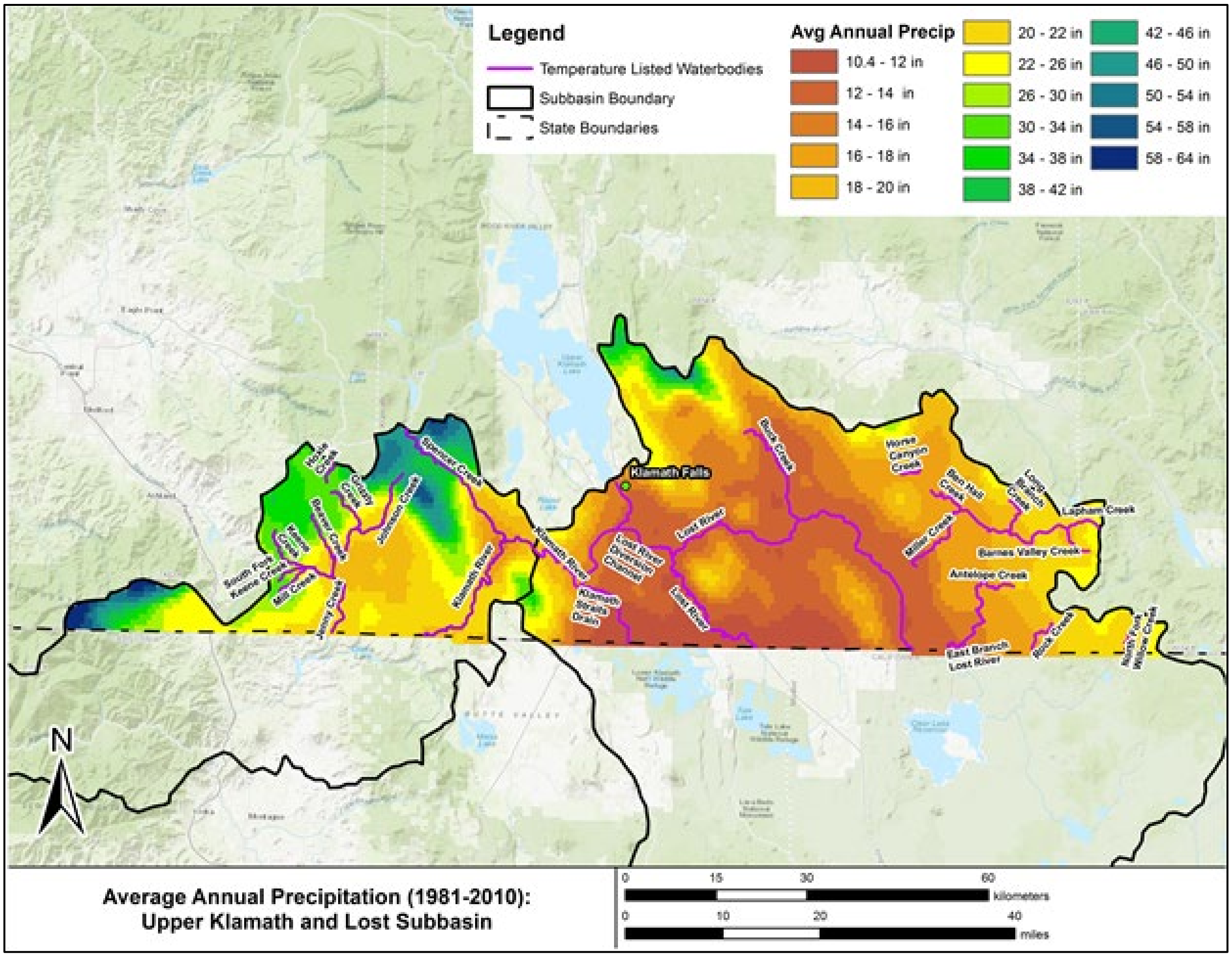

Figure 3-7. Average annual precipitation in the Upper Klamath and Lost subbasins in inches (1981-2010).

3.2.5 Land Use

All land uses and ownerships are included in this TMDL: lands managed by the State of Oregon, U.S. Bureau of Reclamation, irrigation and drainage districts, the U.S. Forest Service and U.S. Bureau of Land Management, private forestlands, agricultural lands, rural residential, transportation uses, and urbanized areas.

Land ownership in the Upper Klamath subbasin is comprised of 52 percent private, 48 percent federally managed, and <1 percent state managed. Spatial distribution of land ownership in the Upper Klamath subbasin is displayed in Figure 3-8.

Land use in the Upper Klamath subbasin is dominated by evergreen forest, scrub/shrub and grassland (97 percent). One percent of the area is developed, another one percent represents open water, and a small remaining fraction is associated with agriculture. Figure 3-9 shows the spatial distribution of major land use/cover types for the Upper Klamath subbasin.

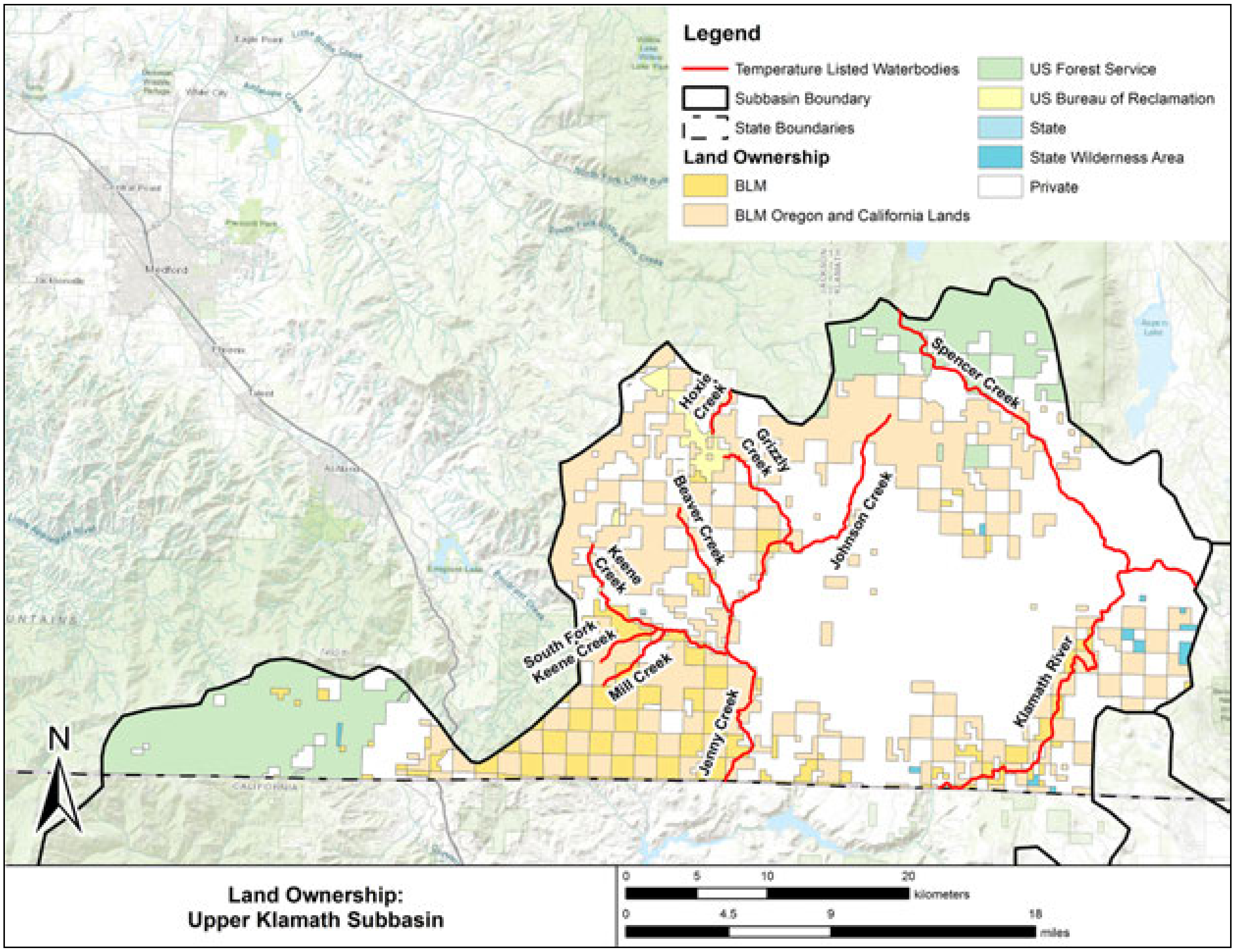

Figure 3-8. Land ownership distribution in the Upper Klamath subbasin.

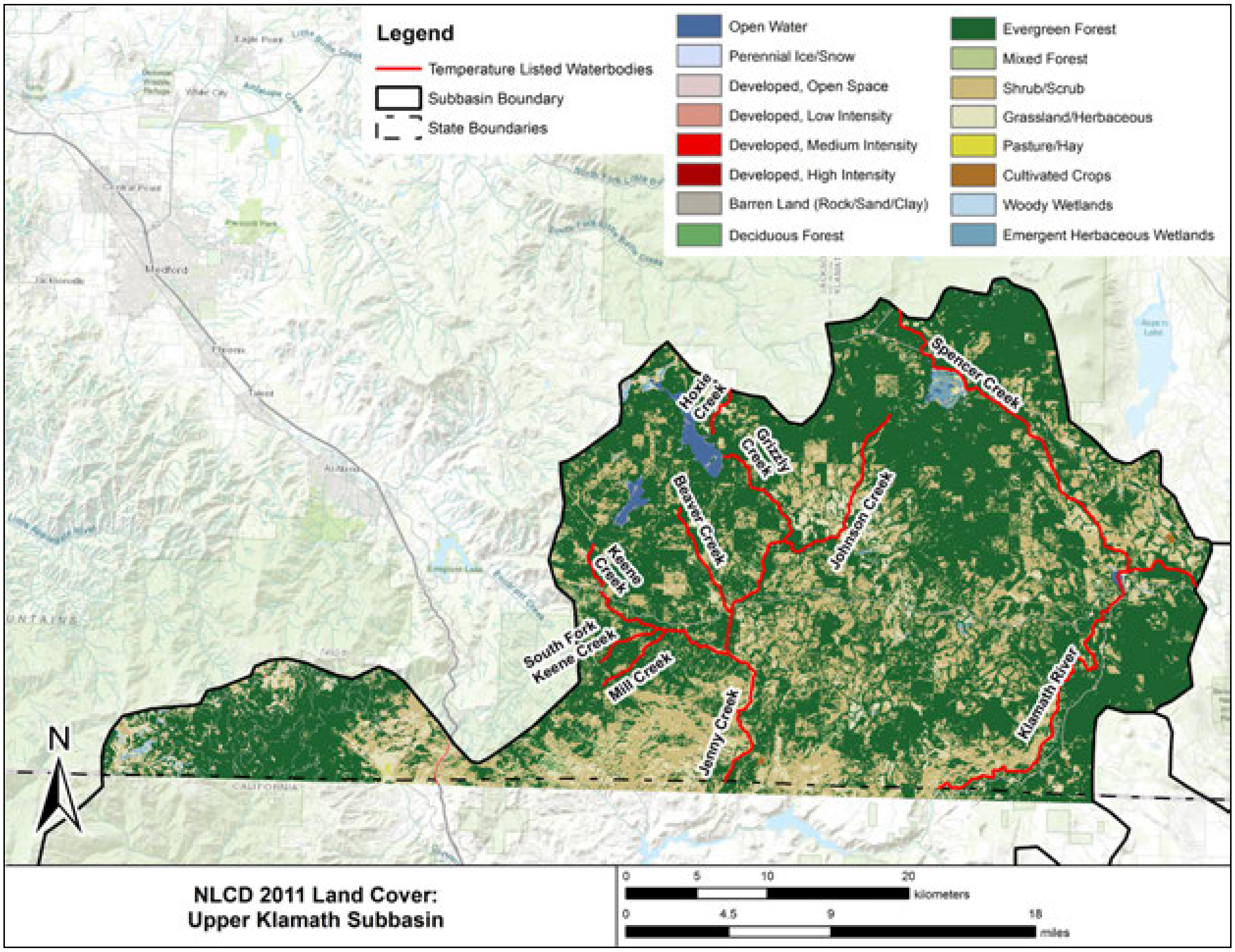

Figure 3-9. Land use and land cover distribution in the Upper Klamath subbasin.

3.2.6 Hydrology (Streamflow)

The temperature impaired tributaries of the Upper Klamath subbasin included in this TMDL include Spencer Creek and several smaller segments that contribute to Jenny Creek before its confluence with the Klamath River in California. Spencer Creek is the northernmost drainage of the Upper Klamath subbasin and drains forest and grasslands before reaching the Klamath River at the JC Boyle Reservoir. Flow in the upper watershed is influenced by Buck Lake.

In the western portion of the Subbasin, multiple tributaries drain to Jenny Creek. Flow in this portion of the system is highly managed as part of the Rogue River Basin Project (see Section), including multiple canals and several reservoirs. In addition, farther downstream, PacifiCorp diverts water from Spring Creek, a tributary to Jenny Creek 3.35 kilometers upstream of the OR/CA border. The water is diverted to a powerhouse on Fall Creek, which like Jenny Creek, flows into Iron Gate Reservoir in California. The diverted water also contributes to water availability for the City of Yreka's water supply. PacifiCorp has a water right to divert up to 16.5 cubic feet per second from Spring Creek (PacifiCorp 2004a). Apparently, there were water rights disputes between PacifiCorp and a landowner, and PacifiCorp did not divert water from Spring Creek from 1990 to April 2003 (PacifiCorp 2004b & L. Prendergast, pers. comm., 2009). The Oregon Water Resources Department ultimately determined that PacifiCorp did in fact have the right to this water (PacifiCorp 2004b). In addition to the PacifiCorp diversion, there are additional permitted water diversions for irrigation, aquaculture, and fish culture on Spring

Creek. U.S. Bureau of Land Management reports that the Fall Creek Hydroelectric Project impacts to Spring Creek warm the waters of Jenny Creek by up to 3.1°C (5.4°F) for 1-3 miles downstream of the confluence (BLM 2004).

3.2.7 Temperature Data

Temperature data from various monitoring stations in the Upper Klamath (Figure 3-10) were plotted and compared to the applicable temperature criteria (Figure 3-11 through Figure 3-19).

There are limited amounts of data available for the tributaries in the Upper Klamath subbasin. Most of the available data were obtained from the BLM, except for Spencer Creek data, which were obtained from the Oregon Water Resources Department. These data included observed instantaneous stream temperatures for eight tributaries in the Upper Klamath subbasin including Grizzly Creek, Keene Creek, Jenny Creek, Johnson Creek, and Spencer Creek (Figure 3-11 and Table 3-6).

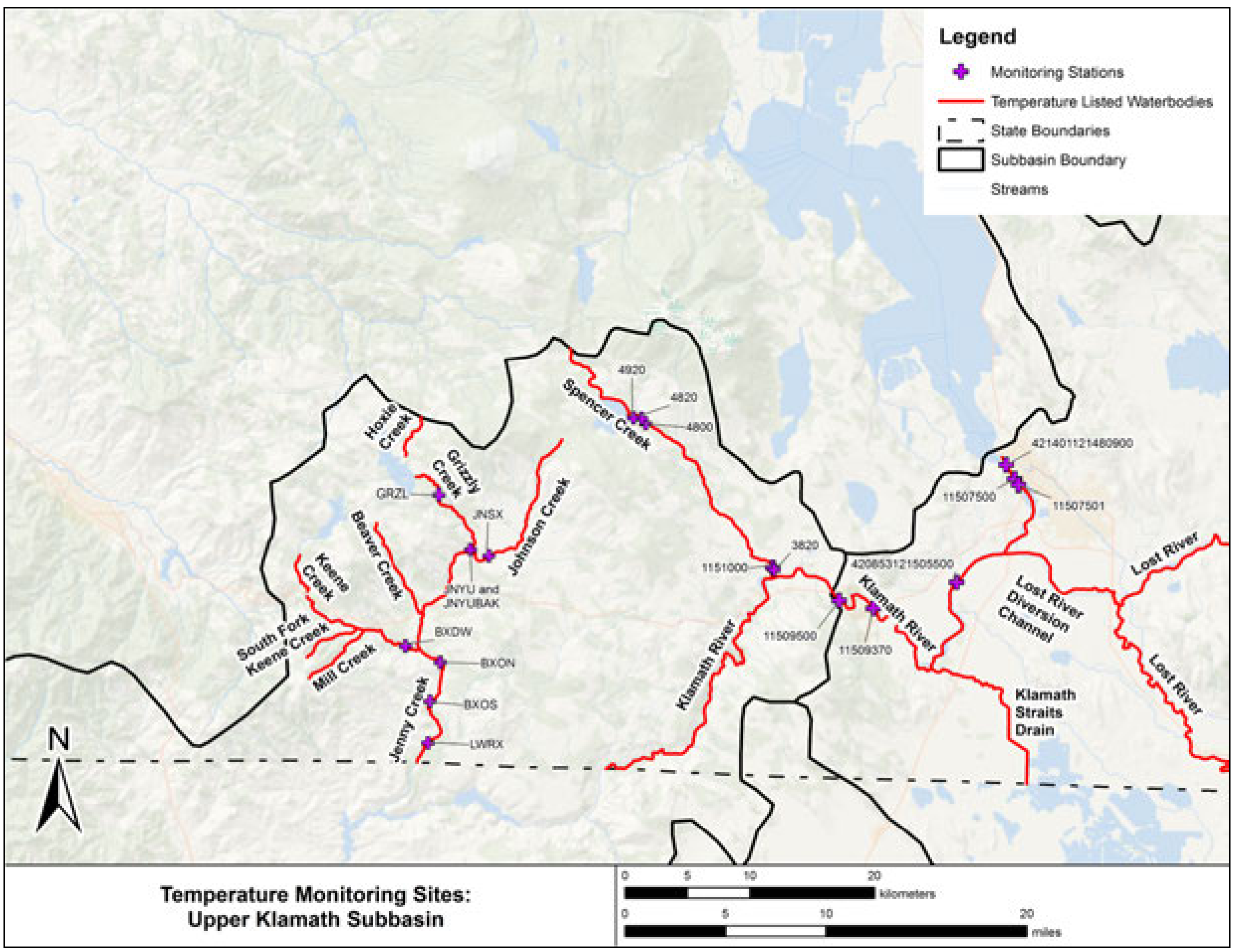

Figure 3-10. Temperature monitoring stations.

Table 3-6. Summary of stream temperature data and percent exceedances.

Waterbody Name	Data Source and Station ID	Period of Record	Number of Results	Applicable Criterion (°C)	Maximum Temperature	Percent Exceedance[1]
Keene Creek	BLM/BXDW Keene Creek below Lincoln Creek, @ lower BLM line Sec.17 NW1/4	4/30/2001-9/22/2001	146	20 (7DADM)	20	0%
Jenny Creek	BLM/ BXON Jenny Creek below Keene Creek, @ Box O Ranch north boundary	5/1/2001 – 9/15/2001	138	20 (7DADM)	24.2	64%
Jenny Creek	BLM/ BXOS Jenny Creek below Oregon Gulch, @ Box O Ranch south boundary	5/1/2001 – 9/15/2001	138	20 (7DADM)	26.6	80%
Jenny Creek	BLM/JNYU Jenny Creek above Johnson Creek	4/30/2001 – 9/22/2001	146	20 (7DADM)	22.5	16%
Jenny Creek	BLM/LWRX Jenny Creek below Spring Creek, @ Road 41-2E-10.1	4/30/2001 – 9/22/2001	146	20 (7DADM)	22.2	49%
Grizzly Creek	BLM/GRZL Grizzly Creek above Soda Creek	4/30/2001 – 9/22/2001	146	20 (7DADM)	20.6	10%
Johnson Creek	BLM/JNSX Johnson Creek below 39-04-27 Road crossing in Section 23	4/30/2001 – 6/11/2001	43	20 (7DADM)	23.2	30%
Spencer Creek	OWRD/11510000	4/6/2018 – 10/26/2018	203	20 (7DADM)	25.9	41%

[1] **portion of result values that exceed the criteria**

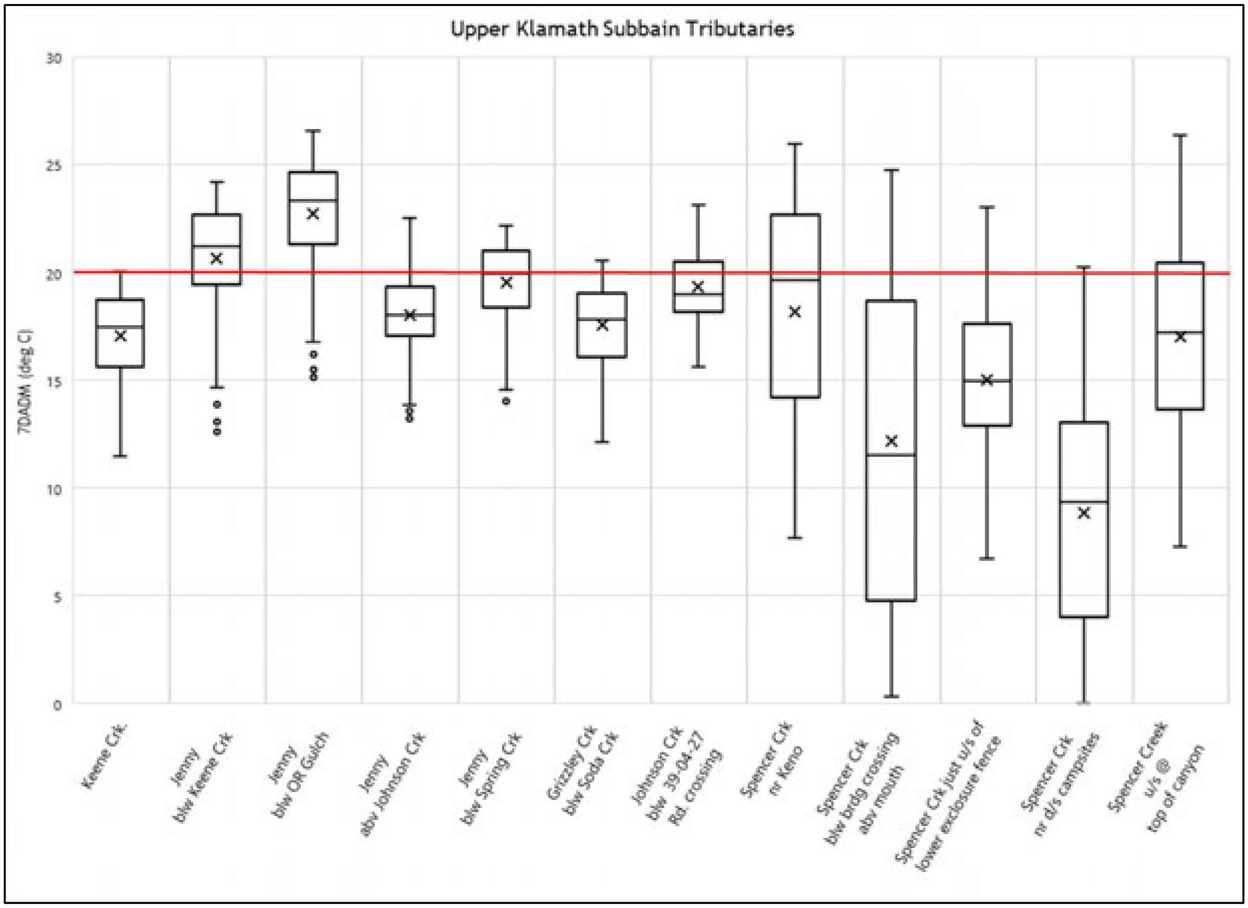

Figure 3-11. Box plot of 7-day average daily maximum stream temperature (using all available data) on streams in the Upper Klamath subbasin. The red line represents the applicable criterion, the x represents the mean, the horizontal line in the box represents the median, the bounds of the box represent the interquartile range (i.e., 25th and 75th percentile), the overall range is represented by the vertical line, and the dots represent outliers.

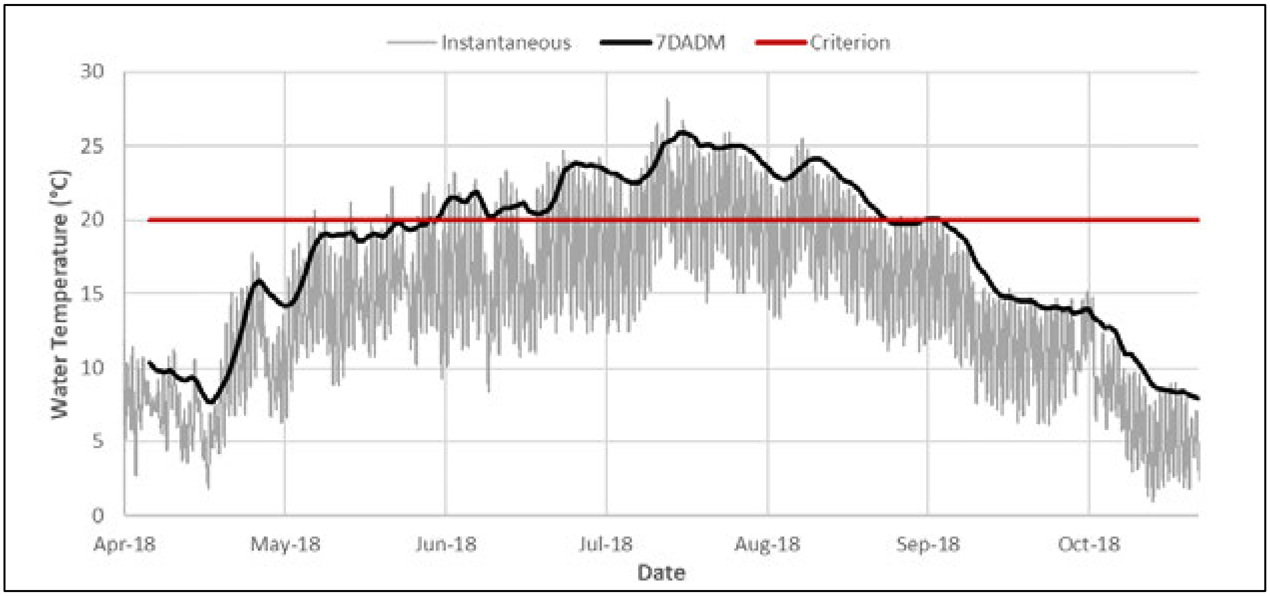

Figure 3-12. Instantaneous and 7-day average daily maximum stream temperatures on Spencer Creek at OWRD Station 11510000. (Data source: Oregon Water Resources Department; period of record April 6, 2018 – October 26, 2018)

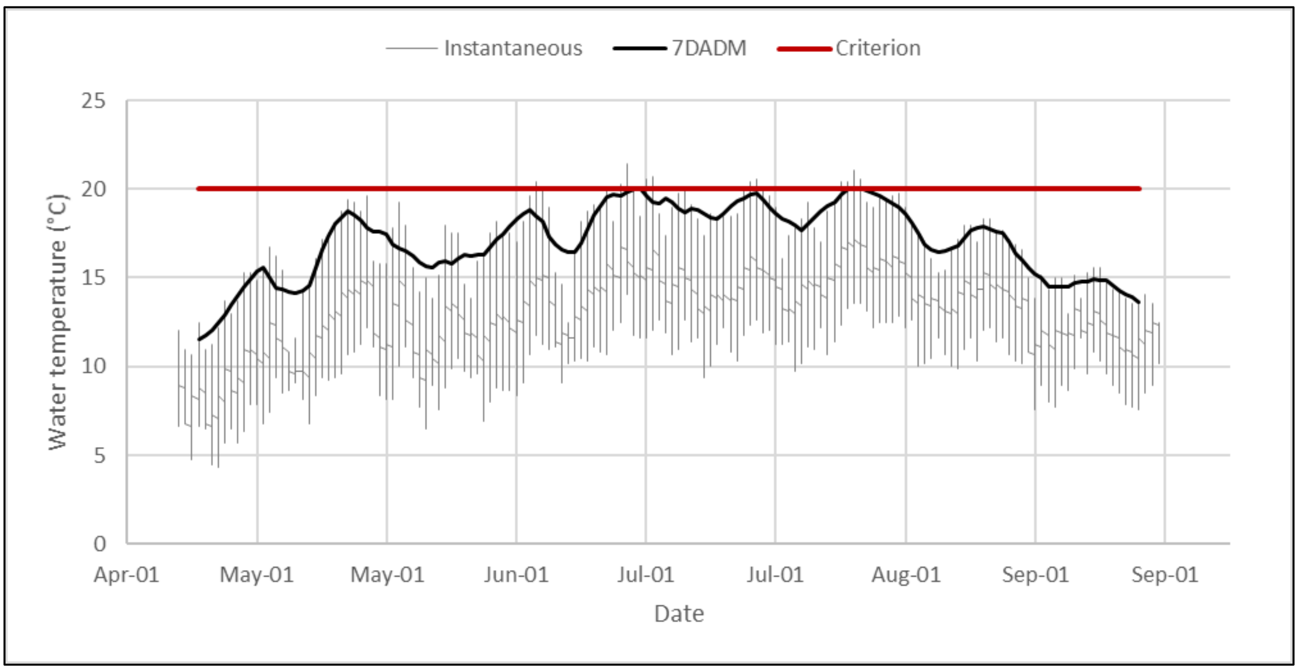

Figure 3-13. Instantaneous and 7-day average daily maximum stream temperatures at Station BXDW -Keene Creek below Lincoln Creek, @ lower BLM line Sec.17 NW1/4. (Data source: BLM; period of record April 30, 2001 – September 22, 2001)

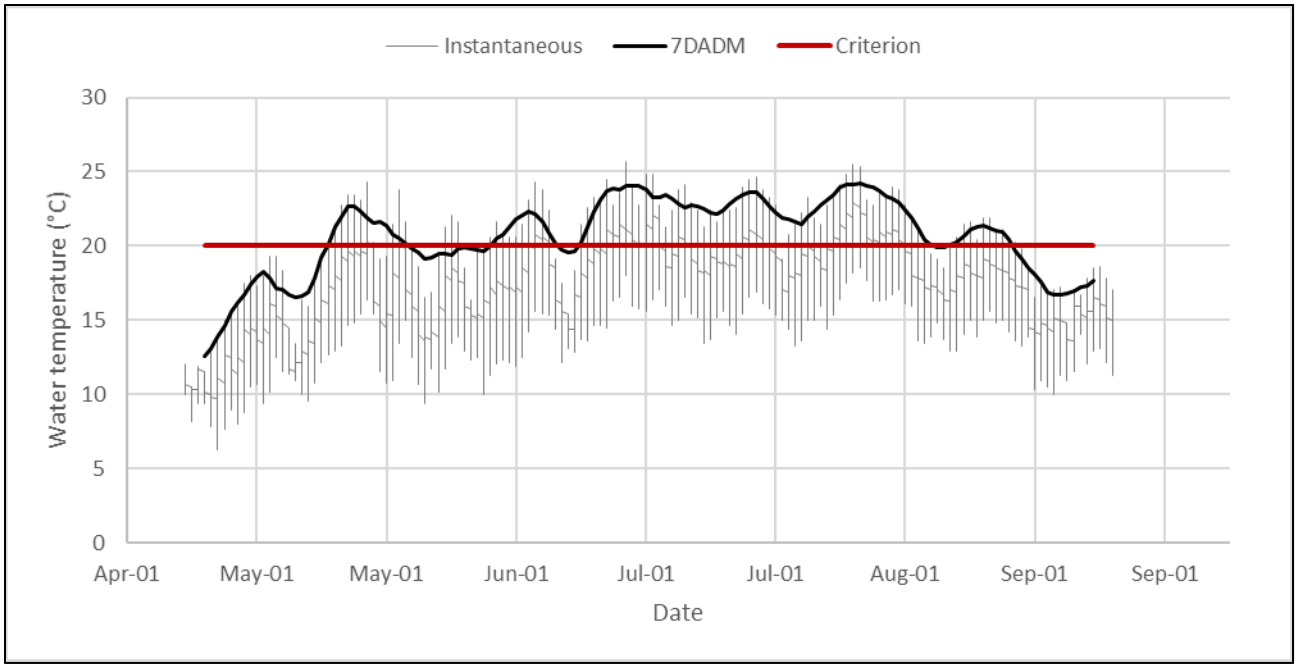

Figure 3-14. Instantaneous and 7-day average daily maximum stream temperatures at Station BXON - Jenny Creek below Keene Creek, @ Box O Ranch north boundary. (Data source: BLM; period of record May 1, 2001 – September 15, 2001)

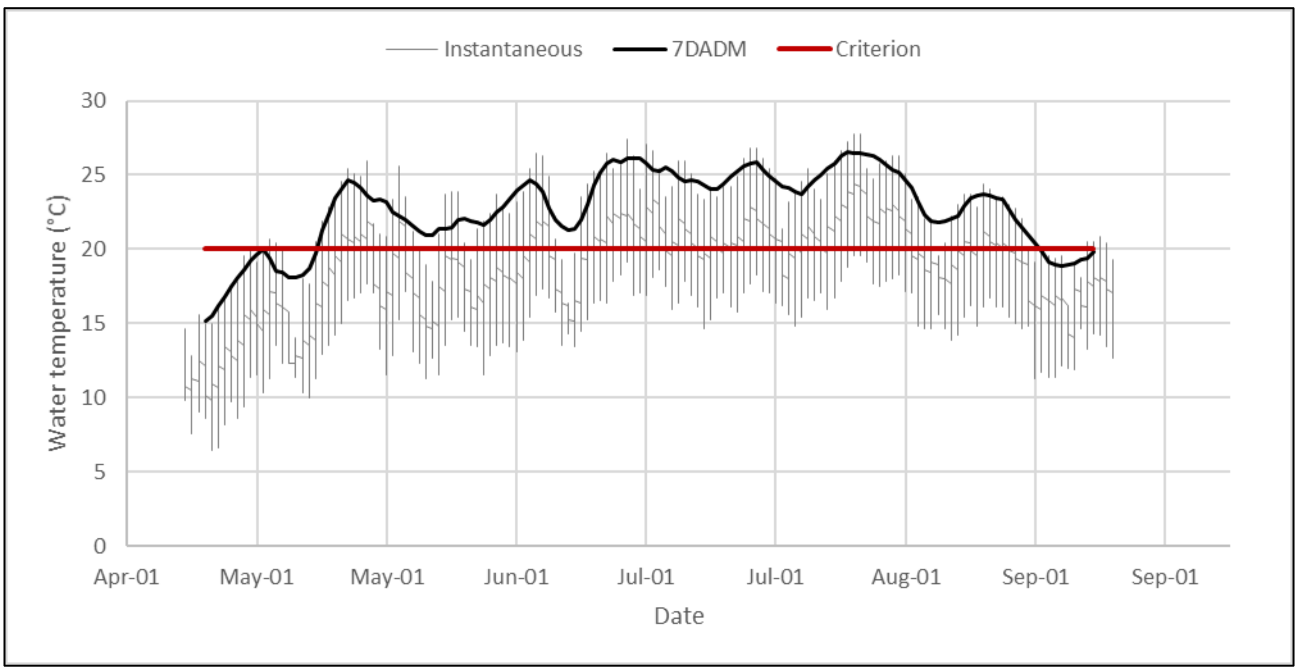

Figure 3-15. Instantaneous and 7-day average daily maximum stream temperatures at Station BXOS, Jenny Creek below Oregon Gulch, @ Box O Ranch south boundary. (Data source: BLM; period of record May 1, 2001 – September 15, 2001)

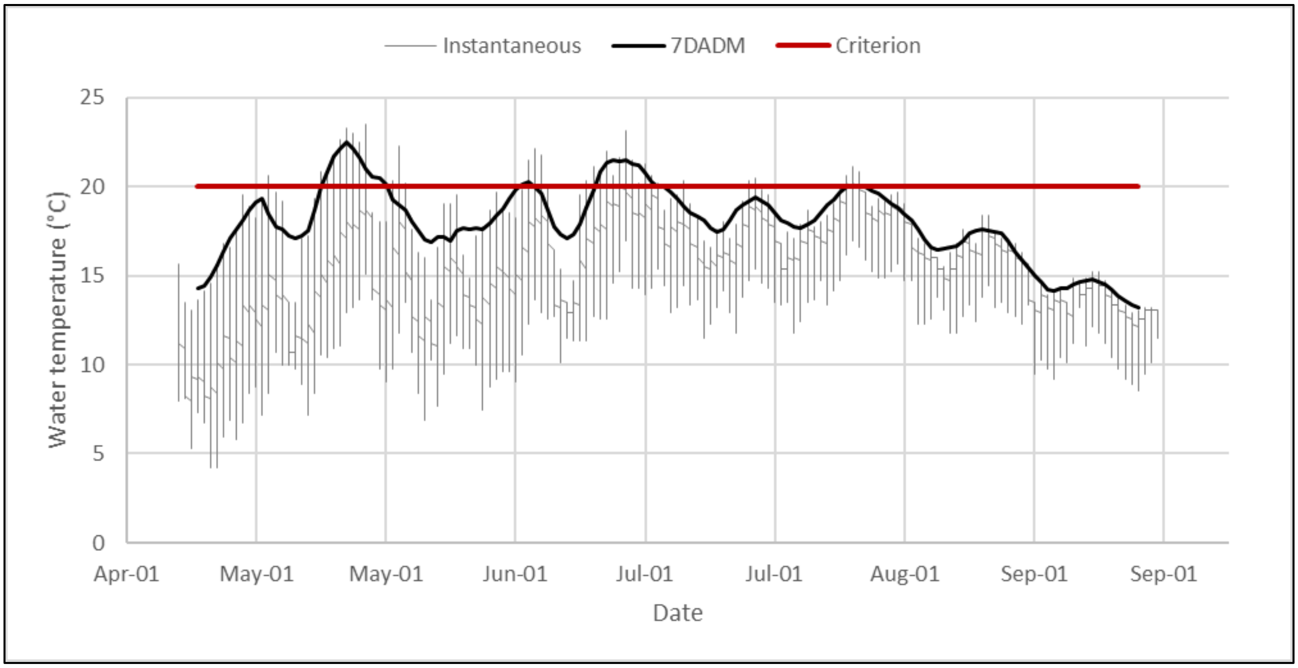

Figure 3-16. Instantaneous and 7-day average daily maximum stream temperatures at Station JNYU - Jenny Creek above Johnson Creek. (Data source: BLM; period of record April 30, 2001 – September 22, 2001)

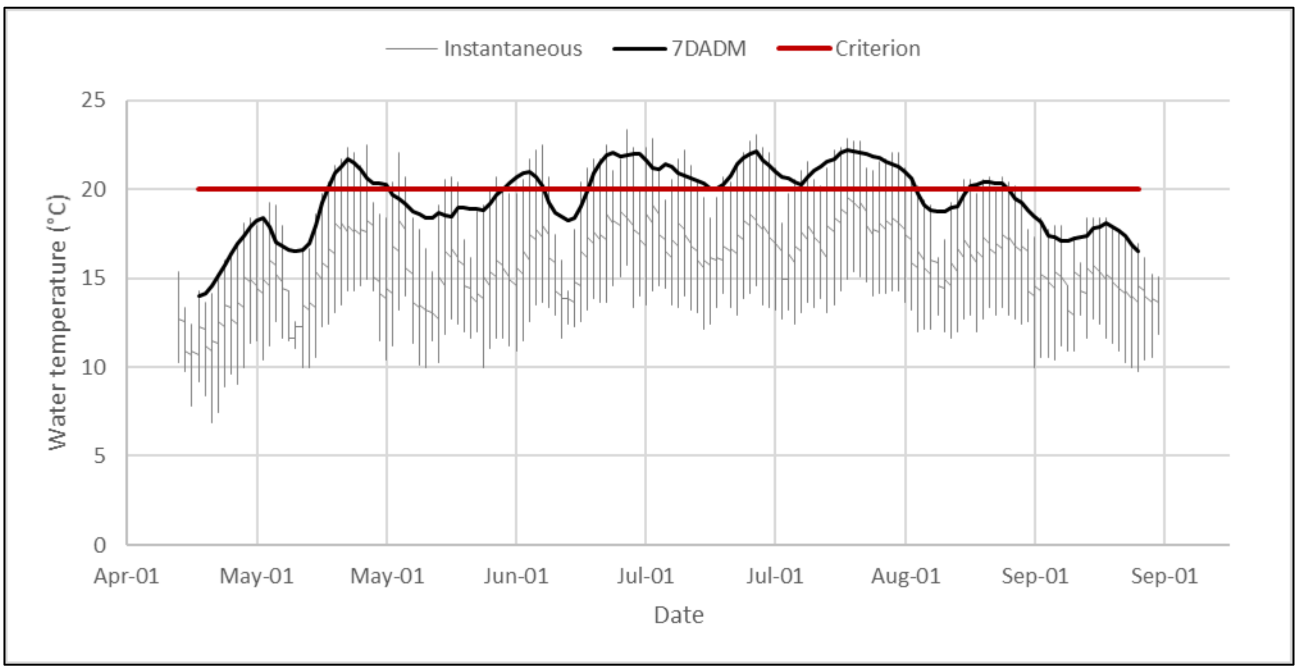

Figure 3-17. Instantaneous and 7-day average daily maximum stream temperatures at Station LWRX - Jenny Creek below Spring Creek, @ Road 41-2E-10.1. (Data source: BLM; period of record April 30, 2001 – September 22, 2001)

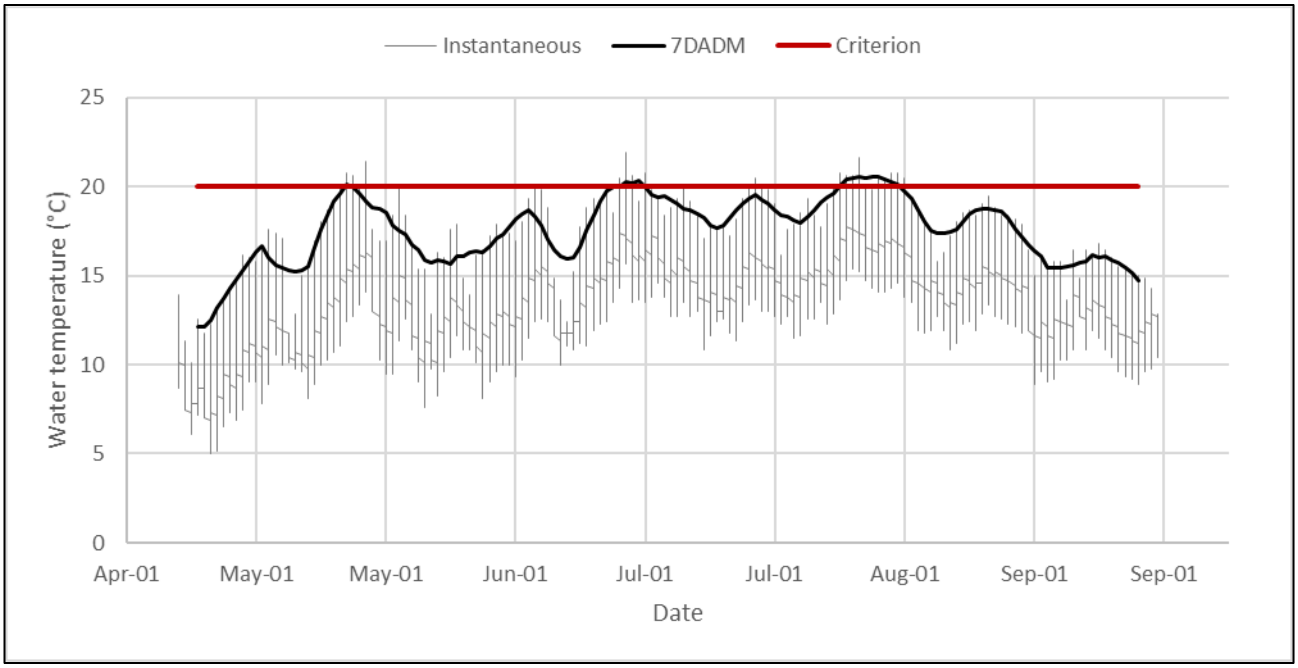

Figure 3-18. Instantaneous and 7-day average daily maximum stream temperatures at Station GRZL - Grizzly Creek above Soda Creek. (Data source: BLM; period of record April 30, 2001 – September 22, 2001)

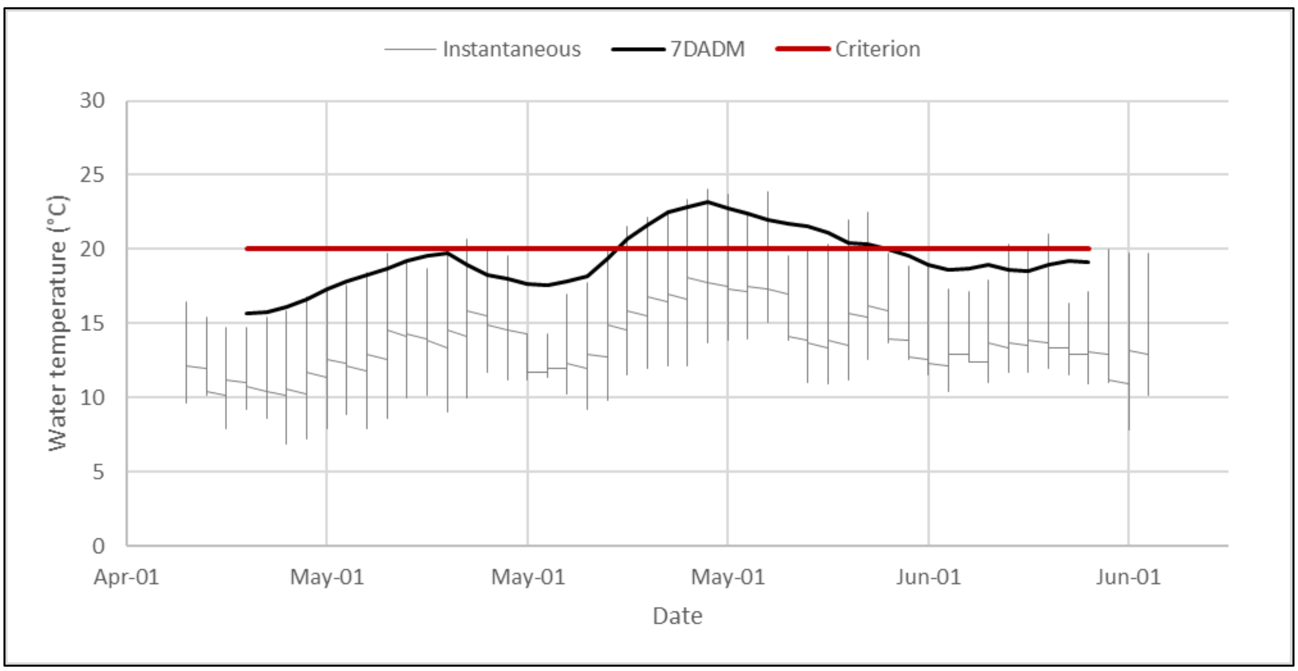

Figure 3-19. Instantaneous and 7-day average daily maximum stream temperatures at Station JNSX - Johnson Creek below 39-04-27 Road crossing in Section 23. (Data source: BLM; period of record April 30, 2001 – June 22, 2001)

3.3 Seasonal Variation and Critical Period

OAR 340-042-0040(4)(j), 40 CFR 130.7(c)(2)

TMDLs must also identify seasonal variation and the critical condition.

Seasonal variation in stream temperature typically follows a pattern where the peak seven-day average daily maximum (7DADM) stream temperatures occur in late July or early August when stream flows are low, radiant heating rates are high, and ambient conditions are warm. The coolest temperatures occur during the winter. Using available data, the peak 7DADM temperature in Spencer Creek (station ID 11510000) was 25.9°C and occurred in late July of 2018 (Figure 3-12). A similar pattern occurs on other tributaries (Figure 3-12 through Figure 3-18).

The critical condition is determined as the period when the available data show the 7DADM temperatures exceed the applicable criterion. The critical period also defines the time period when the TMDL allocations, reserve capacity, and margin of safety apply. As illustrated in Figure 3-11 through Figure 3-18 seven day average daily maximum temperatures in Upper Klamath tributaries exceed the applicable criterion generally mid-May through mid-September. Based on these data, the critical condition is defined as May 1 through September 30 in order to account for year-to-year variability when seven day average daily maximum stream temperature may exceed the applicable criteria for a longer period than was observed in available data.

Allocations, reserve capacity, and margin of safety developed for waterbodies addressed in this chapter shall only apply during the May 1 – September 30 critical period. However, supplementary surrogate implementation measures include shade targets provided by the restored vegetation that apply year-round. In addition, varying flow values were used to calculate the thermal loading capacities for a suite of flow regimes. These flow regimes represent the range of flow expected to occur on each stream throughout the year, so TMDLs are protective year-round, including during the critical conditions. If future data demonstrate that exceedances occur outside the identified May 1 through September 30 critical period, the TMDL's critical period will be extended to account for the time period of the new monitoring data. Additional NPDES wasteload allocations may also be developed outside the critical period as needed to protect designated uses and implement applicable antidegradation policies.

3.4 Existing Pollution Sources

OAR 340-042-0040(4)(f), OAR 340-042-030(12)

A source is any process, practice, activity or resulting condition that causes or may cause pollution or the introduction of pollutants to a waterbody. This section identifies the pollutant sources and estimates, to the extent existing data allow, the amount of actual pollutant loading from existing sources. Sources of heat to streams include point and nonpoint sources. Specific sources are described below and are subsequently allocated a portion of the Loading Capacity (Section 3.5). The thermal load in the Upper Klamath Subbasin is a mixture of natural background loads and loads from anthropogenic sources.

3.4.1 Point Sources

Point Source means a discernible, confined, and discrete conveyance including, but not limited to, a pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel or other floating craft, or leachate collection system from which pollutants are or may be discharged but does not include agricultural storm water discharges and return flows from irrigated agriculture (OAR 340-041-0002(46)). DEQ issues NPDES permits for sources that discharge to surface waters according to OAR 340-045-0015. NPDES permits fall into two categories: general and individual. Existing permit information was obtained for the Upper Klamath subbasin. There are no communities that require a MS4 stormwater permit in the subbasin. MS4 permits are issued for municipalities meeting specific size requirements. Municipalities that need to obtain an MS4 permit are classified as either "Phase I" or "Phase II". Phase I MS4s cover areas with populations greater than 100,000 while regulated Phase II (or "small") MS4s serve populations less than 100,000 that are located fully, or partially, within an Urbanized Area in the State of Oregon as defined by a Decennial Census conducted by the U.S. Bureau of Census. There are no municipalities in the Upper Klamath subbasin that meet these requirements. Therefore, there are no MS4 permits in the subbasin.

No individual or general industrial stormwater permit registrants were identified as discharging directly or indirectly to tributaries in the Upper Klamath subbasin. However, there is one entity covered under the 1200-C construction stormwater general permit as of September 2018 but they are not listed in this TMDL because they are ephemeral in nature and the number and location of registrants will vary year-to-year. Refer to DEQ's permits database for current permit information: http://www.deq.state.or.us/wq/sisdata/sisdata.asp.

3.4.2 Nonpoint Sources

Nonpoint sources are diffuse or unconfined sources of pollution where wastes can either enter, or be conveyed by the movement of water, into waters of the state (OAR 340-41-0002 (42)). Historically, human activities have altered the stream morphology and hydrology and decreased the amount of riparian vegetation in the subbasin. The subbasin includes urban, agricultural, and forested lands. Additionally, hydroelectric projects and multiple points of diversion in the Upper Klamath subbasin have altered stream flow levels. Low summertime flows decrease the thermal assimilative capacity of streams. Pollutant (solar radiation) loading causes larger temperature increases in stream segments where flows are reduced by human uses.
Five nonpoint source categories are discussed below for the Upper Klamath subbasin temperature TMDL:

1. Near stream vegetation disturbance/removal
2. Channel modifications and widening
3. Hydromodification: Dams, Diversions, and Water Management Districts
4. Hydromodification: Water Rights
5. Unidentified anthropogenic sources

3.4.2.1 Near Stream Vegetation Disturbance/Removal

Near-stream vegetation disturbance/removal reduces stream surface shading via decreased riparian vegetation height, width and/or density, thus increasing the amount of solar radiation reaching the stream surface (shade is commonly measured as percent-effective shade or open

sky percentage[4]). Riparian vegetation also plays an important role in shaping channel morphology, resisting erosive high flows, and maintaining floodplain roughness. Table 3-7 shows the potential for improvement in shade for the tributaries as the difference between current and the shade from restored near-stream vegetation. The restored near stream vegetation condition as defined in this TMDL is the near-stream vegetative community that can grow on a site at a given elevation and aspect in the absence of human disturbance.
The restored near stream vegetation conditions **is an estimate** of a condition without anthropogenic activities that disturb or remove near-stream vegetation. Restored near-stream vegetation conditions are listed below.

- Vegetation is mature and undisturbed;
- Vegetation height and density are at or near what is expected for the given plant community;
- Vegetation buffer is sufficiently wide to maximize solar attenuation (Note: Buffer widths required to meet the effective shade target will vary given potential vegetation, topography, stream width, and aspect.),
- Vegetation buffer width accommodates channel migrations.

The restored near-stream vegetation condition is **not** an estimate of pre-settlement conditions. It is the estimate of the vegetation communities that could be planted given the site conditions today. In addition, restored effective shade does not account for potential major disturbances resulting from floods, drought, fires, insect damage, disease, or other non-human caused factors that could impact riparian areas. See Appendix A for the methodology used to determine restored condition vegetation. See Section 3.7.3.3 for discussion of the shade target surrogate measure that implements the load allocations. The average shade deficit is the average difference between current and potential shade at each model node.

Table 3-7. TMDL Shade deficit for selected tributaries in the Upper Klamath subbasin.

Waterbody	Average Percent Effective Shade		Average Shade deficit (% Effective shade)
	Current (%)	Restored Condition (%)	
Jenny Creek	38	65	26
Spencer Creek	35	65	28

Findings from the TMDL analysis include:

- Vegetation removal on Jenny Creek increased 7-day average daily maximum temperatures a maximum of 5.8ºC (excess thermal loading of 9.66×10^7 kilocalories per day) during the modeled period (Figure 3-20).
- Vegetation removal on Spencer Creek increased 7-day average daily maximum temperatures a maximum of 8.2ºC (excess thermal load of 1.88×10^8 kilocalories per day) during the modeled period (Figure 3-21).

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[4]Percent-effective shade is defined as ((total solar radiation – total solar radiation reaching the stream)/total radiation) x 100

- Vegetation removal on other waterbodies was not explicitly quantified.

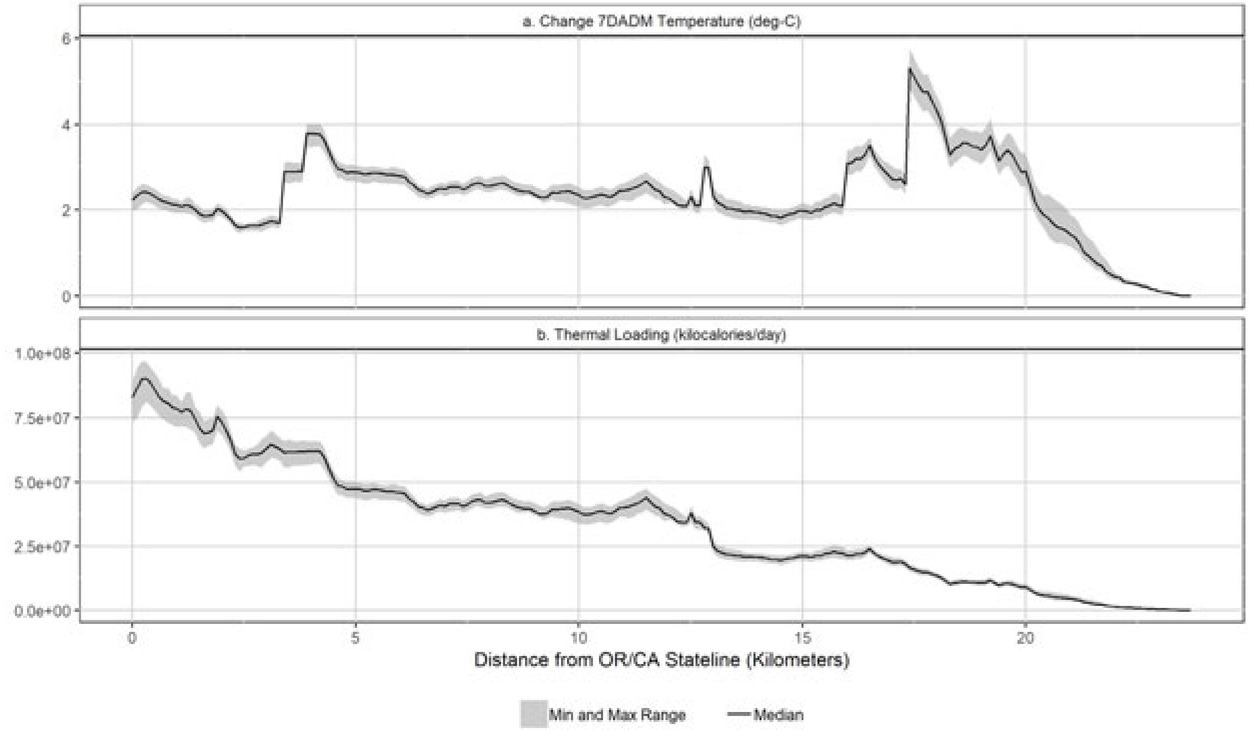

Figure 3-20. (a) Modeled increases to 7-day average daily maximum stream temperatures from vegetation removal on Jenny Creek during the July modeled period. (b) Portion of the excess thermal load during the July modeled period on Jenny Creek attributed to vegetation removal.

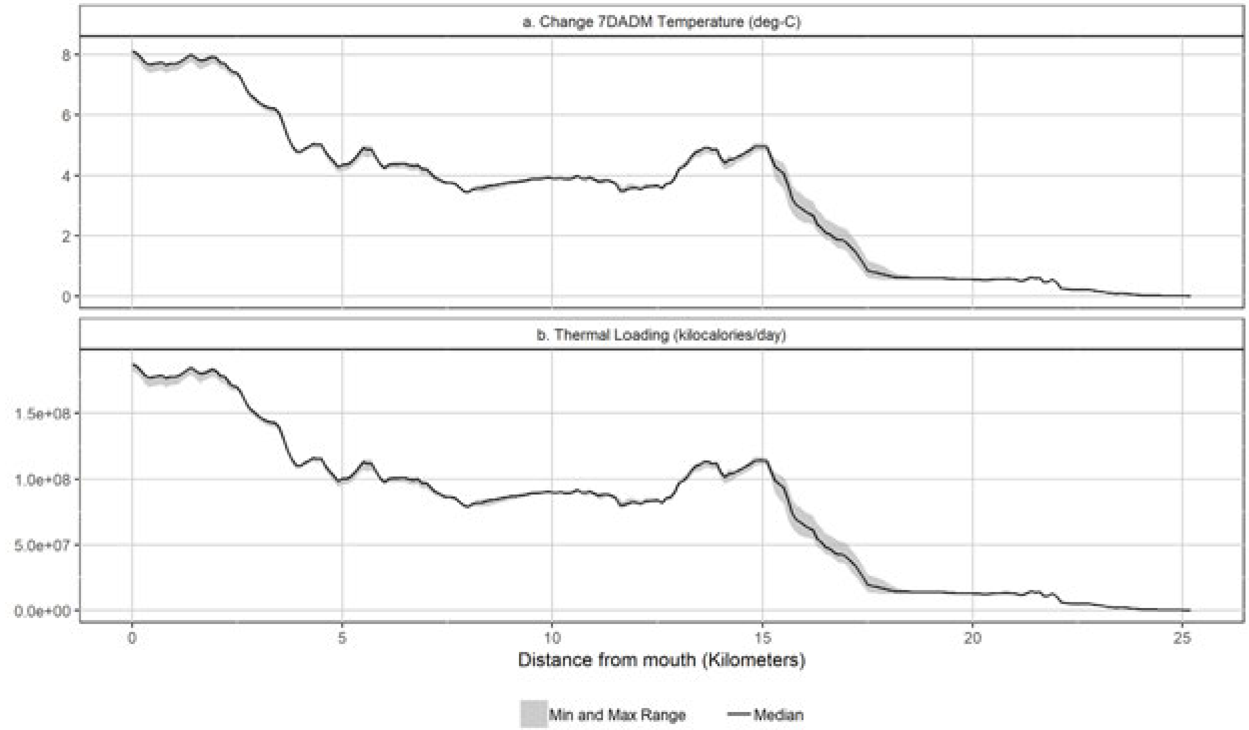

Figure 3-21. (a) Modeled increases to 7-day average daily maximum stream temperatures from vegetation removal on Spencer Creek during the July modeled period. (b) Portion of the excess thermal load during the July modeled period on Spencer Creek attributed to vegetation removal.

3.4.2.2 Channel Modifications and Widening

Human activities that have altered channel form generally fall into one of three categories: direct modification, increased sediment load, and removal of riparian vegetation. Direct modification includes changes to channel form associated with road building, flood control, gravel extraction, or channel realignment. Increased sediment loading can result from agricultural, logging, and mining activities which may lead to increased runoff, landslides, debris torrents, and other mass wasting events. Lastly, removal of riparian vegetation can lead to bank instability and increased erosion. In the Upper Klamath subbasin, waterbodies within wide valleys with low gradients are likely to be more degraded due to channel modifications than waterbodies in steep and narrow canyons. Channel modifications can impact water temperatures in the following ways:

Sediment filled pools

In California, a Mattole River study observed that thermally stratified pools often contained sediments decreasing the depth of thermal refugia, therefore decreasing the volume and frequency of the pools, and decreasing assimilative capacity for thermal loading in a reach (California Regional Water Board 2002). The Mattole River is a coastal, lower-gradient stream, with considerable alluvium flowing through redwood and Douglas Fir forests as opposed to the tributaries in the Upper Klamath subbasin that are higher-gradient streams with snowmelt and spring hydrology flowing through volcanic terrain.

Wider shallower streams

Furthermore, human activities can cause wider, shallower streams (increased width to depth ratios), which increases surface area exposed to solar radiation and ambient air temperatures. Wider channels will have less effective shade than narrower channels with the same amount of riparian vegetation. A lower potential effective shade condition allows more direct solar radiation to reach the stream surface (DEQ 2000).

Less storage base flow

Many land use activities that disturb riparian vegetation and associated flood plain areas affect the connectivity between river and groundwater sources (DEQ 2000). Natural morphology created areas of temporary water storage which was slowly released during dry periods, increasing base flow. Reduced summertime saturated riparian soils reduce the overall watershed ability to capture and slowly release stored water. Reductions in stream flow slow the movement of water and generally increase the amount of time the water is exposed to solar radiation (DEQ 2007). There are some thermal benefits gained from connecting the cooler, spring-fed pools and off-channel areas to the main channel (DEQ 2007). For example, on Jenny Creek, an existing spring fed by cool groundwater near river kilometer 17 has a cooling influence on stream temperatures as illustrated in Figure 3-20(a).

Fewer hyporheic seeps

Groundwater inflow has a cooling effect on summertime stream temperatures. Subsurface water is insulated from surface heating processes and most often groundwater temperatures fluctuate little and are cool (45°F to 55°F) (DEQ 2000). A Mattole River study observed intra-gravel flow seeps in areas of higher streambed complexity as well as cooler temperatures in morphologically complex areas. within the main channel (California Regional Water Board 2002). A study in the Upper Grande Ronde River basin demonstrated that riparian disturbance can separate the connectivity of the groundwater and the stream and occurs when a permeability barrier prevents normal flood plain functions. The groundwater disconnection prevented water from the riparian zone from cooling water in the main channel (DEQ 2000). Channel complexity, cool water inflows, and hyporheic exchange are thought to provide local thermal refugia (DEQ 2007). Excess fine sediment can also decrease permeability and porosity in the hyporheic zone, greatly reducing hyporheic flow, and resulting in less cool water inputs (Rehg et al. 2005).

Riparian vegetation disturbances

Geomorphological changes such as mass wasting events change the physical channel, and further disturb riparian vegetation reducing stream surface shading.

Findings from the TMDL analysis include:

- On Jenny Creek, a model scenario evaluated the temperature increase from channel widening in lower Jenny Creek. In this scenario the restored channel width to depth ratios were set at four (down from eight) along the 10 kilometer reach upstream of the Oregon California border. The wider channel in this section increased 7-day average daily maximum temperatures by a maximum of 1.4ºC (thermal loading of 5.15×10^7 kilocalories per day) during the modeled period (Figure 3-22).

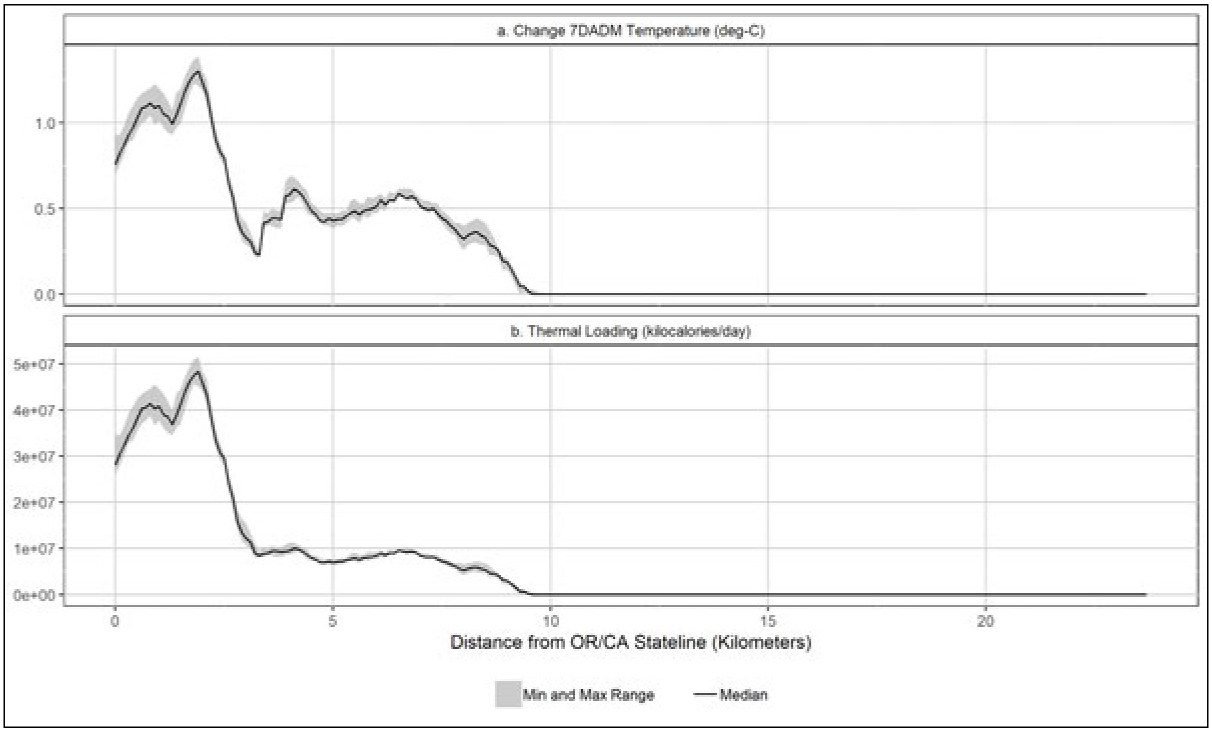

Figure 3-22. (a) Modeled increases to 7-day average daily maximum stream temperatures from channel morphology changes on Jenny Creek during the July modeled period. (b) Portion of the excess thermal load during the July modeled period on Jenny Creek attributed to channel morphology changes.

3.4.2.3 Hydromodification: Dams and Diversions

There are several water management districts (irrigation and drainage districts) operating in the Upper Klamath subbasin (Figure 3-23). Some of the activities that could lead to warmer stream temperatures are listed below:

- Diversion dams are used to divert water from a stream to an irrigation ditch or canal. Diversion dams affect stream temperature by reducing discharge in the downstream reach of the river. Reductions in stream flow in a natural channel slow the movement of water and generally increase the amount of time the water is exposed to solar radiation. Stream temperatures downstream of diversion dams can be substantially warmer than those above.
- Canals and other unpiped water conveyance systems generally are open ditches. These ditches are usually unshaded and increase the surface area of water exposed to solar radiation. Where canal waters are allowed to mix with natural stream flows, such as at diversion dams and at places where natural stream channels are used to convey irrigation water to downstream users, stream temperatures can increase.
- Irrigation return flows come off fields or pastures after irrigation. These excess waters may end up in a stream or the irrigation ditch to be used by the next water right holder. These waters are generally warm and may be nutrient-rich as well.
- Operational spills are places in the irrigation delivery system where excess unused irrigation water in the canals is discharged back into either a downslope canal or lateral or a natural stream channel without being delivered to or used on an individual field. These waters may

be picked up by the next water right holder. These waters can also increase stream temperatures.

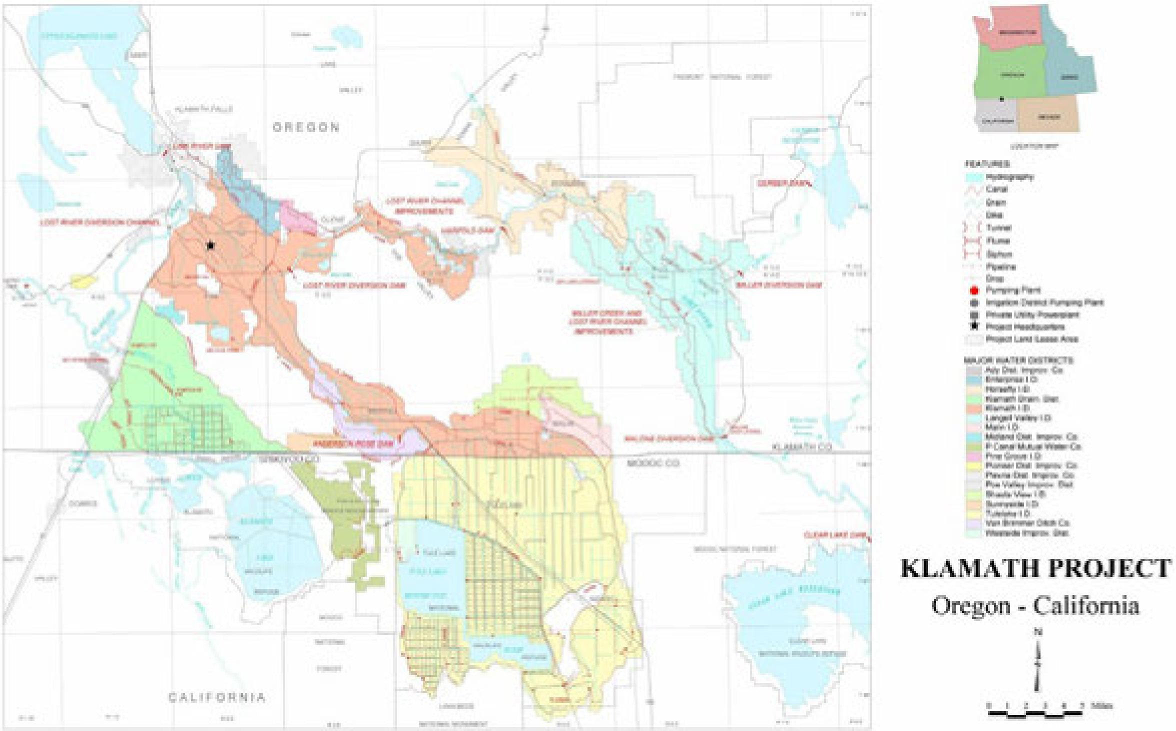

Figure 3-23. Map of Water Management Districts in the Upper Klamath and Lost subbasins (source: BOR).

There are 46 dams identified by Oregon Water Resources Department (OWRD) on tributaries within the geographic scope of this TMDL that are greater than 10-feet high and storage greater than or equal to 9.2 acre-feet (Figure **3-**24) (Falk and Harmon 1995).

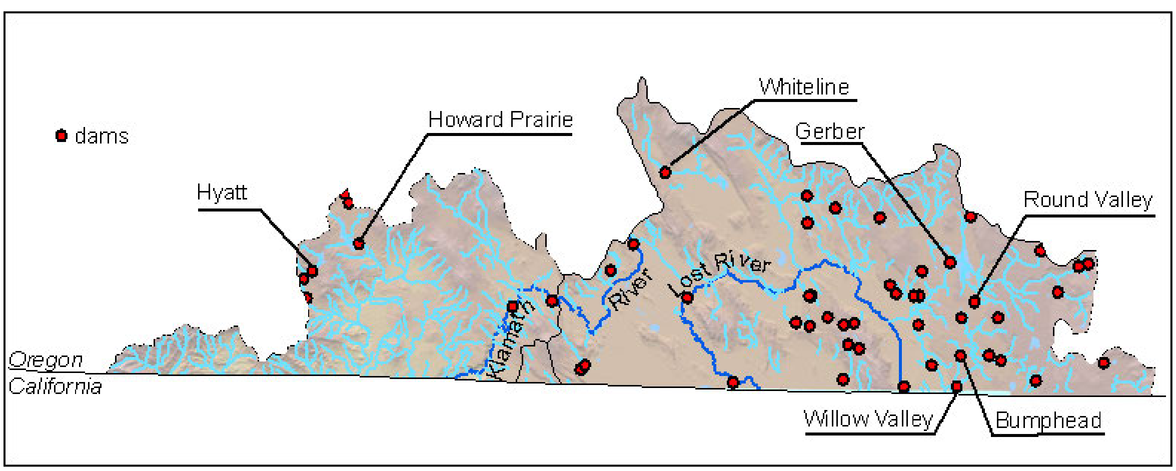

Figure 3-24. Dams greater than 10-feet in height and storage greater than or equal to 9.2 acre-feet of water.

3.4.2.3.1 Rogue River Basin Project

Hyatt, Howard Prairie, and Keene Creek reservoirs are part of a US Bureau of Reclamation (BOR) Rogue River Basin Project that provides irrigation water to Bear Creek watershed. Inflow to Howard Prairie is from several streams from the 27.2 square mile drainage basin and from two canals from the Rogue Basin that originate in the Little Butte Watershed (Figure 3-25). Outflow from Howard Prairie is into a canal and joins with water from Hyatt Reservoir. From there, the water leaves the Klamath Basin and flows into Emigrant Lake in the Bear Creek Watershed. Keene Creek Dam and reservoir is used to reregulate releases from Howard Prairie and Hyatt Reservoirs as well as support hydroelectric power generation by providing forebay pondage for Green Springs Powerplant. Hyatt, Howard Prairie, and Keene Creek reservoirs are all located in the Jenny Creek Watershed. Hyatt and Keene Creek Dams are located on Keene Creek. Howard Prairie Dam is located on Beaver Creek. BOR (2003) calculated that the Jenny Creek watershed contributed 24,230 acre-feet per water year to the Rogue River Basin Project. BOR also predicts that without the project, flows in Jenny Creek would be an average of 6 cfs greater in July and 4 cfs greater in August.

Table 3-8. Basic physical characteristics of Rogue River Basin Project reservoirs in the Upper Klamath subbasin.

Reservoir Name	Storage (acre feet) *	Area (acres) *	Maximum Depth (feet) **	Average Depth (feet) **
Howard Prairie	62100	1930	80	35
Hyatt	16200	880	38	18
Keene Creek	390			

* from Falk and Harmon, 1995
** from Johnson et al., 1985

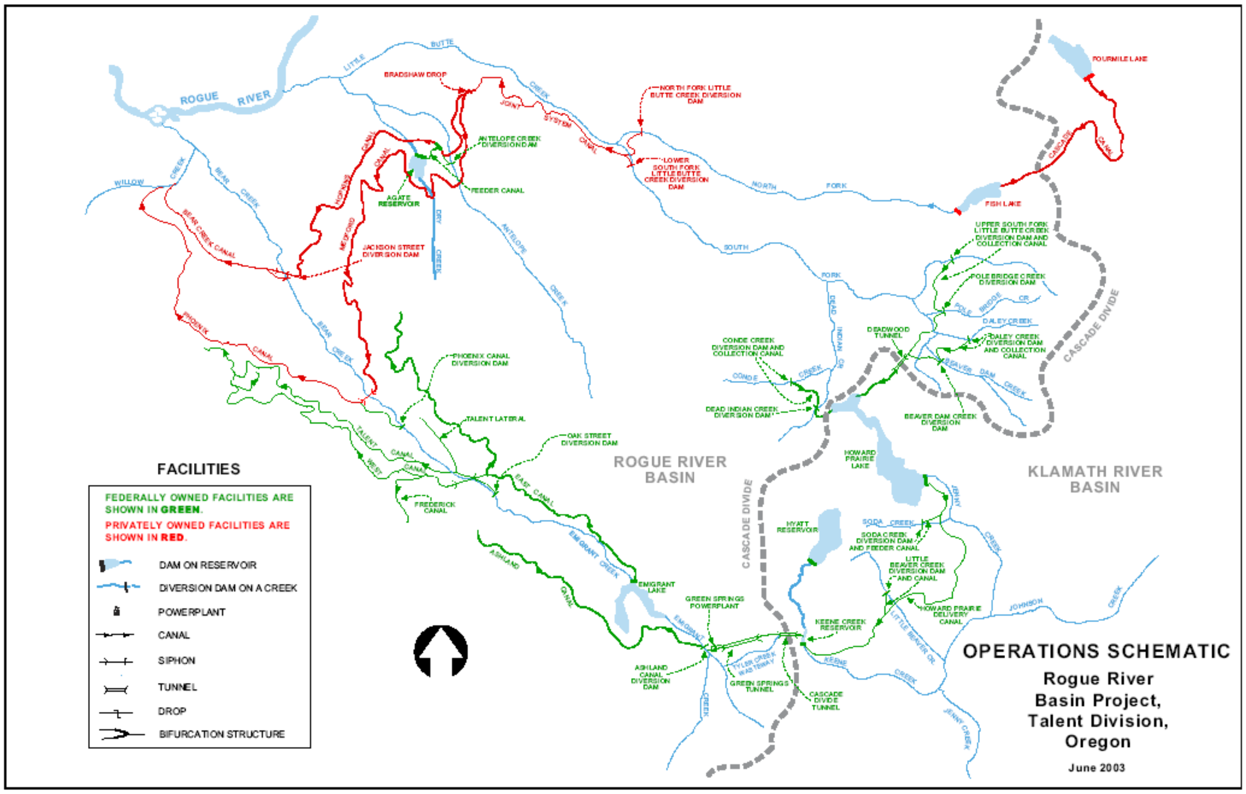

Figure 3-25. Map of water diversions between the Rogue River and Klamath River Basins. (BOR 2003)

3.4.2.3.2 PacifiCorp's Klamath River Hydroelectric Projects

PacifiCorp's Klamath River Hydroelectric Project include operations in the Jenny Creek Watershed.

PacifiCorp diverts water from Spring Creek, a tributary to Jenny Creek 3.35 km upstream of the OR/CA border. The water is diverted to a powerhouse on Fall Creek, which like Jenny Creek, flows into Iron Gate Reservoir in California. In addition to the PacifiCorp diversion, there are additional permitted water diversions for irrigation, aquaculture, and fish culture on Spring Creek. BLM reports that the Fall Creek Hydroelectric Project impacts to Spring Creek warm the waters of Jenny Creek by up to 3.1 °C (5.4 °F) for 1-3 miles downstream of the confluence (BLM 2004).

Since PacifiCorp was not diverting water from Spring Creek during the year Jenny Creek was modeled, the impact to temperatures in Jenny Creek from Pacificorp withdrawals and diversions was simulated. Under the current scenario, Spring Creek contributes about 6.5 cfs to Jenny Creek. Assuming Pacificorp withdraws 5 cfs from Spring Creek, warming the remaining 1.5cfs instream temperatures by 2ºC, the impacted Spring Creek flows are expected to warm Jenny Creek by an average of 2.6ºC between river km 3.35 and the OR/CA border (Figure 3-26).

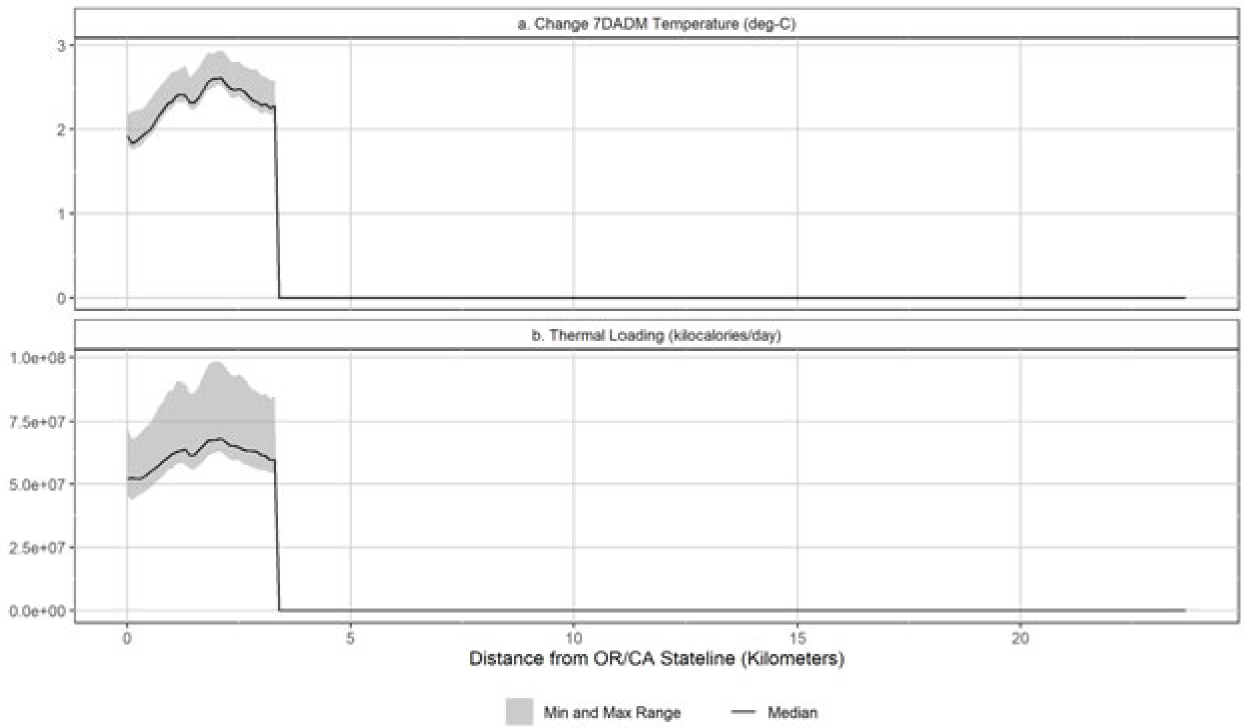

Figure 3-26. Modeled impact of Pacificorp withdrawals to Jenny Creek in July.

3.4.2.4 Hydromodification: Water Rights

The influence of river flow is generally inversely related to the daily maximum stream temperature with higher flows moderating the diel swing of temperatures. Diversion of water from the tributaries was generally shown via water quality modeling to decrease the ability of streams to assimilate heat load and result in warmer stream temperatures. See Appendix A for more detail. The method of estimating what stream flows would be without withdrawals varied between streams but was generally based on water balances and OWRD water rights. The potential flow of Jenny Creek was compared to the flow during the model year, which was a year that PacifiCorp was not diverting water to Spring Creek. Water rights in the Upper Klamath subbasin are illustrated in Figure 3-27.

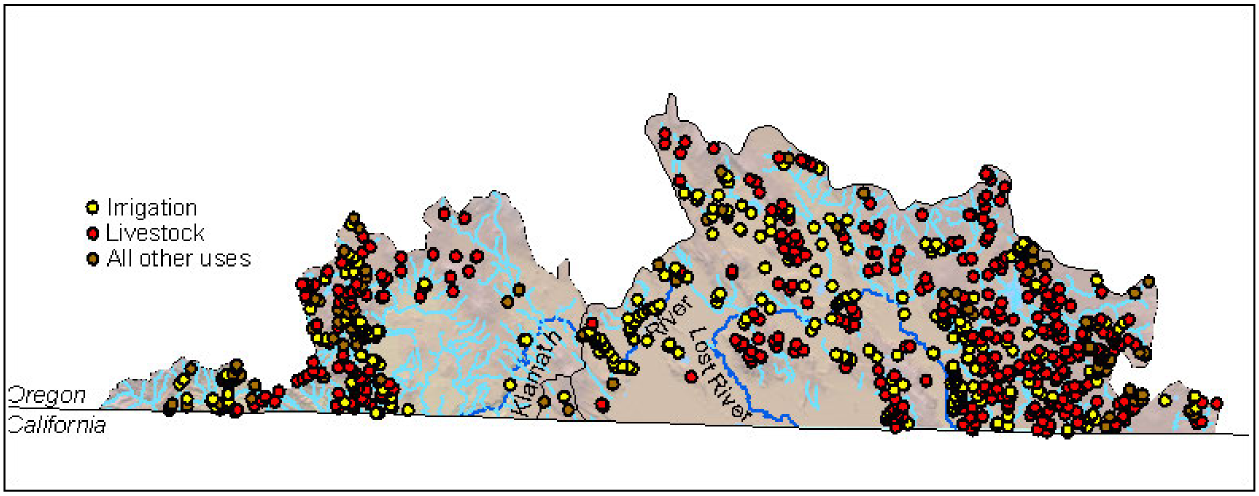

Figure 3-27. Map of water rights in the Upper Klamath and Lost subbasins.

Table 3-9. Estimated change in flow during the model period at the mouth of Jenny and Spencer Creeks by keeping water withdrawals as instream flow.

Waterbody	Flow at mouth (cfs)		% Change
	Current	Without withdrawals	
Jenny Creek (at CA/OR border) (7/24/01)	15.2	31.9	210
Spencer Creek (7/21/01)	9.4	33.8	360

Findings from the TMDL analysis include:

- Water withdrawals in Jenny Creek and in upstream tributaries are estimated to have increased 7-day average daily maximum temperatures a maximum of 4.4ºC (excess thermal loading of 1.09 x 10^8 kilocalories per day) during the modeled period (Figure 3-28).
- The Spring Creek water withdrawal by PacifiCorp are estimated to have increased Jenny Creek 7-day average daily maximum temperature a maximum of 2.9ºC (excess thermal loading of 9.81 x 10^7 kilocalories per day) (Figure 3-26).
- Water withdrawals in Spencer Creek and in upstream tributaries are estimated to have increased 7-day average daily maximum temperatures a maximum of 9.0ºC (excess thermal loading of 2.07 x 10^8 kilocalories per day) during the modeled period (Figure 3-29).

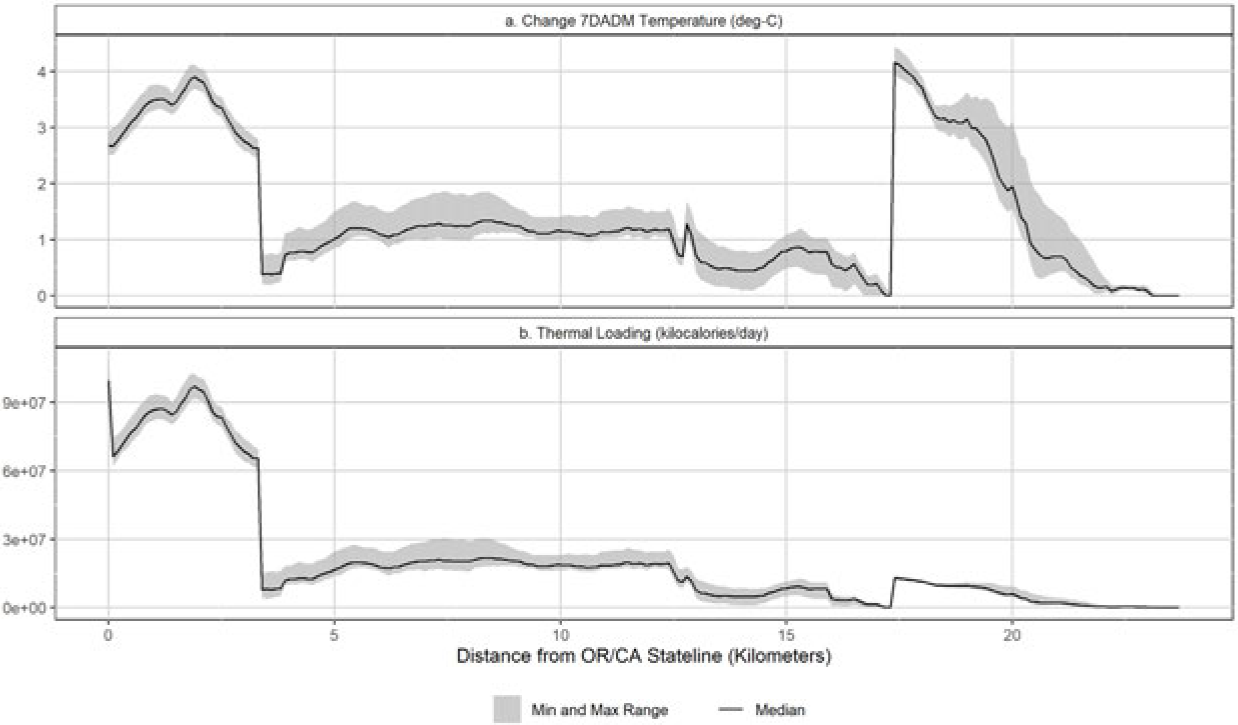

Figure 3-28. (a) Increases to 7-day average daily maximum stream temperatures from water withdrawals on Jenny Creek during the modeled period. (b) Portion of the excess thermal load during the modeled period on Jenny Creek attributed to water withdrawals.

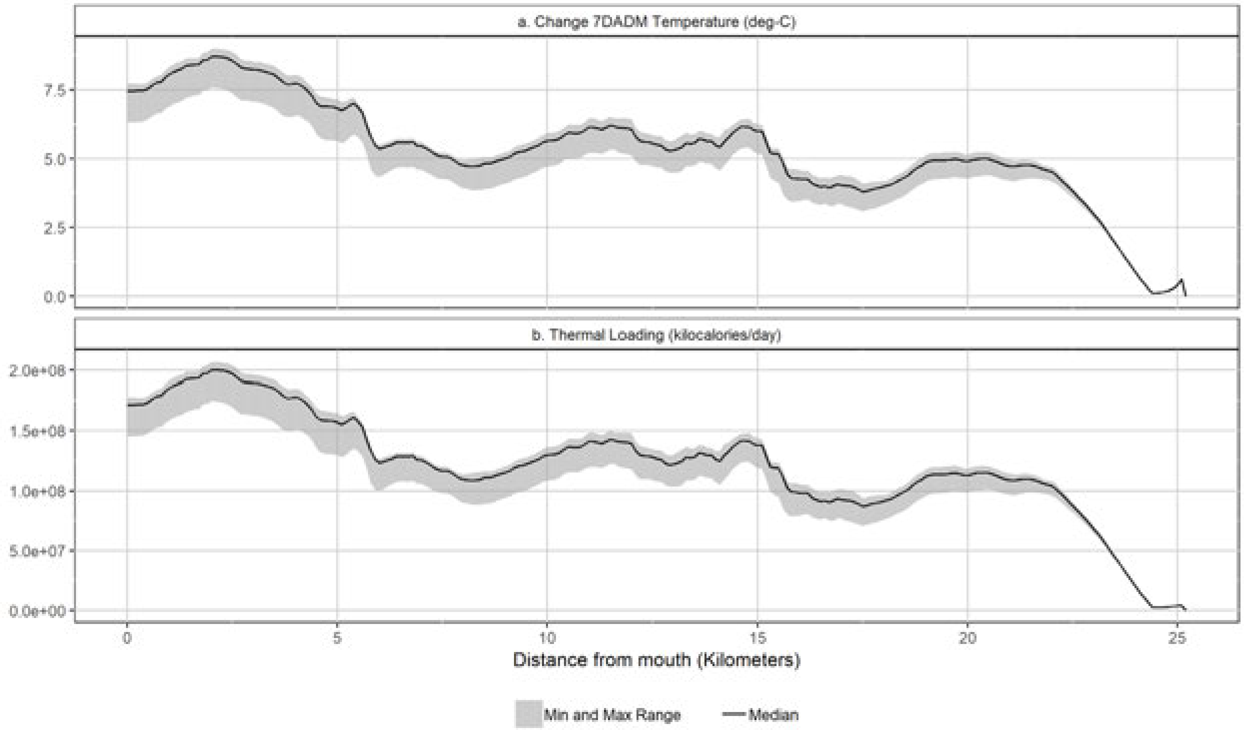

Figure 3-29. (a) Increases to 7-day average daily maximum stream temperatures from water withdrawals on Spencer Creek during the modeled period. (b) Portion of the excess thermal load during the modeled period on Spencer Creek attributed to water withdrawals.

3.4.2.5 Unidentified Anthropogenic Sources

Unidentified anthropogenic sources are other sources of warming (not mentioned in the sections above) that may contribute to exceedances to the applicable criteria but were not explicitly quantified in the TMDL modeling. Some examples may include warming attributed to climate change, illicit discharges, unquantified surface or ground water withdrawals, warm groundwater seepage from nearby irrigation ponds, or other unidentified anthropogenic sources. Because these sources are unquantified, it is not possible to separate their loading from background loading. The warming and loading from both unidentified anthropogenic sources and background sources are presented together in Section 3.4.3. This is important because the TMDL analysis indicates that background and unidentified anthropogenic sources contribute excess warming above the applicable criteria on Jenny Creek and the Klamath River downstream of Keno. Excess warming from these sources are targeted for reduction under this TMDL.

3.4.3 Background Sources

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

Background sources account for non-anthropogenic sources of warming. The amount of background loading a stream receives is influenced by a number of landscape and meteorological characteristics. Those characteristics include but are not limited to substrate and channel morphology conditions, streambank and channel elevations, near stream vegetation, groundwater, hyporheic, or tributary surface flows, and climate related factors including precipitation, cloudiness, air temperature, relative humidity, and others. When these features exist in a condition DEQ determines to be natural, reference, or restored the loading received on the stream is background loading as defined under OAR 340-042-0030(1). When stream conditions are in a natural, reference, or restored condition, examples of loading from background sources include, but are not limited to, direct and diffuse solar and longwave radiation received by the stream; mass transfer of thermal load as a result of advection, dispersion, and exchange from mixing with groundwater, hyporheic flows, or tributary surface flows; heat exchange between the water column and the substrate through conduction; and between the water column and the atmosphere through evaporation and convection.

When landscape conditions are not in a natural, reference, or restored condition due to current or legacy human practices; AND the loading from processes identified in the paragraph above result in stream temperature warming above and beyond that of background loading, DEQ considers the excess loading to be anthropogenic loading. Only in cases where DEQ or another Oregon state agency does not have the authority to regulate the loading (as defined in OAR 340-042-0030(1)) does DEQ consider it background loading.

Background loading, including inputs of solar radiation, are one of the largest heat sources in the Upper Klamath subbasin. Streams in Oregon are generally warmest in summer when solar radiation inputs are greatest and stream flows are low. The amount of solar energy that reaches the surface of a stream is determined by many factors, including the position of the sun in the sky, cloud cover, local topography, stream aspect, stream width, and near-stream vegetation.

Streams generally warm in a downstream direction as they become wider and near-stream vegetation is less effective at shading the surface of the water. Also, the cooling influences of groundwater inflow and the impact of smaller tributaries have less of an impact downstream as a stream becomes larger. Greater reach volumes are associated with a reduction in stream sensitivity to natural and human sources of heat.

Background sources of warming were explicitly quantified on Jenny Creek and Spencer Creek. This was determined by subtracting the quantified anthropogenic warming from the current condition stream temperatures. The portion that exceeds the applicable criteria and human use allowance was considered excess warming and is targeted for reduction. As discussed in Section 3.4.2.5 (Unidentified Anthropogenic Sources) background loading estimates may include some portion of unquantified anthropogenic sources.

On Spencer Creek, background sources warmed the stream to a maximum 7-day average daily maximum of 18.8°C. Background sources are not a source of warming above the applicable criteria.

On Jenny Creek, background sources warmed the stream to a maximum 7-day average daily maximum of 20.7°C. Excess background warming (Figure 3-30) above the applicable criterion and human use allowance is 0.37°C (thermal loading of 1.44×10^7 kilocalories per day).

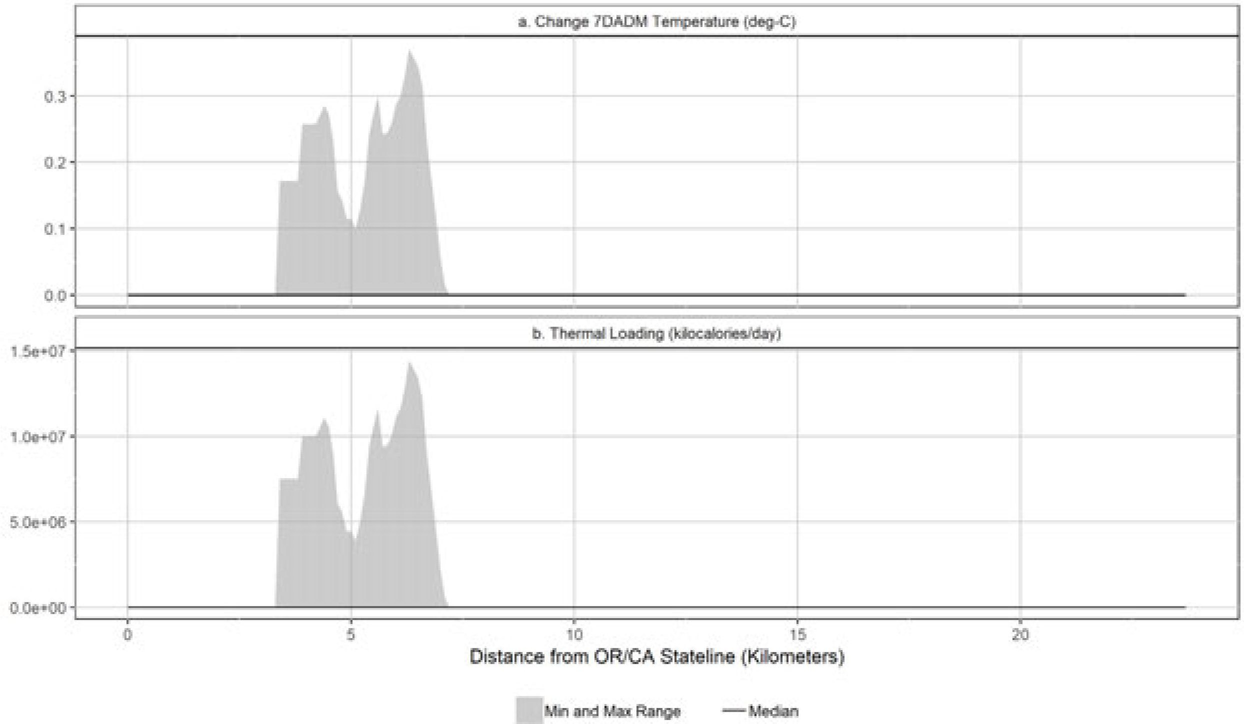

Figure 3-30. (a) Modeled increases to 7-day average daily maximum stream temperatures above the applicable criteria from background sources and unidentified anthropogenic sources on Jenny Creek during the July modeled period. (b) Portion of the excess thermal load during the July modeled period on Jenny Creek attributed to background and unidentified anthropogenic sources.

3.5 Loading Capacity

OAR 340-042-0040(4)(d), 40 CFR 130.2(f)

Loading capacity is the amount of a pollutant or pollutants that a waterbody can receive and still meet water quality standards (OAR 340-042-0040(4)(d)).

Except where the cool water species narrative applies on the Klamath River upstream of Keno dam, the loading capacity for this temperature TMDL is based on the applicable temperature criterion plus the human use allowance (HUA). The HUA is used in temperature TMDLs to restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3°C (0.5 °F) above the applicable criterion at the point of maximum impact (OAR 340-041-0028(12)(b)(B)). The loading capacity is calculated using the river flow, numeric temperature criteria, and the HUA to develop the heat load that can be allocated to meet the temperature water quality standard. The HUA is allocated to identify nonpoint sources as Load Allocations, NPDES point sources as Wasteload Allocations, the margin of safety, and reserve capacity for future sources. Background sources and unidentified nonpoint sources are not allocated any of the HUA but are assigned a Load Allocation.

The approaches used to calculate the thermal loading capacities for these TMDL segments are documented in Appendix H. This appendix describes the use of the United States Geological Survey (USGS) StreamStats[5] program to estimate river flow as well as available data and information to supplement other calculations.

For all waterbodies, the thermal loading capacity was calculated using Equation 3-1 below. The loading capacity values for each TMDL waterbody are provided as examples in the tables below, while specific loading capacities can be calculated for any given flow measurement using Equation 3-1.

Loading Capacity Equation

$$\boldsymbol{LC = (T_C + HUA) \times Q_R \times C_F} \qquad \textbf{Equation 3-1}$$

where,

LC = Loading Capacity (kilocalories per day).

T_C = The applicable temperature criteria (°C).

HUA = The 0.3°C human use allowance allocated to point sources, nonpoint sources, margin of safety, or reserve capacity.

Q_R = The daily mean river flow rate, upstream (cubic feet per second [cfs]).

C_F= Conversion factor using cubic feet per second: (2,446,622 kcal-s/°C-ft^3-day)

$$\frac{1\ m^3}{35.314\ ft^3} \times \frac{1000\ kg}{1\ m^3} \times \frac{86{,}400\ sec}{1\ day} \times \frac{1\ kcal}{1\ kg \times 1°C} = 2{,}446{,}622$$

Loading capacities were calculated for each of the TMDL waterbodies using flow estimates described in Appendix H. Flow values were incorporated into Equation 3-1 to calculate the allowable thermal load at that flow. Estimated flows are presented for a variety of flow conditions, representing the full suite of expected flows in the watershed and capturing the seasonal variation required in a TMDL. The flow conditions are defined in Table 3-10 and loosely correspond to flow intervals described by EPA (2007). The lower flow values are exceeded a majority of the time, while the floods are exceeded infrequently (USEPA 2007). The loading capacity for each flow condition is calculated using the lowest flow estimate for that flow condition; however, the loading capacity applies to the entire range of flows within that condition. For example, the "dry" condition loading capacity is calculated using the 95th percentile flow duration. This loading capacity applies to all flows up to the 50th percentile flow duration, which is then used to calculate the "mild" condition loading capacity (Table 3-10).

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[5] https://streamstats.usgs.gov/ss/

Table 3-10. Flow conditions used in thermal loading capacity calculations.

Flow Condition	StreamStats Representation	Applicable Flow Duration Range*	Description
Low	7Q10	Q_R < 95th percentile	Lowest 7-day average flow that occurs (on average) once every 10 years (7Q10)
Dry	95th percentile	95th percentile ≤ Q_R < 50th percentile	Flow that is exceeded approximately 95%, or the vast majority, of the time
Mild	50th percentile	50th percentile ≤ Q_R < 25th percentile	Flow that is considered within the typical or normal range; includes the median flow for a stream
Moderate	25th percentile	25th percentile ≤ Q_R < 10th percentile	Flow that is exceeded only 25% of the time, considered to be above the normal range
High	10th percentile	10th percentile ≤ Q_R < 5th percentile	Flow that is exceeded only 10% of the time, considered to be far above the normal range; often associated with the rainy season and higher storm flows
Very High	5th percentile	Q_R ≥ 5th percentile	Flow that is infrequently exceeded; represents very high flows that do not occur often

*Q_R = river flow

Table 3-10 through Table 3-19 present the thermal loading capacities for each TMDL waterbody including the flow estimate used to represent each flow condition.

Table 3-11. Thermal loading capacity by flow condition for Beaver Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0.3	1.49E+07	<1 cfs
Dry	20.0	0.3	0.5	4.97E+07	1 cfs to <4 cfs
Mild	20.0	0.3	4	1.99E+08	4 cfs to <14 cfs
Moderate	20.0	0.3	14	6.95E+08	14 cfs to <36 cfs
High	20.0	0.3	36	1.79E+09	36 cfs to <58 cfs
Very High	20.0	0.3	58	2.88E+09	≥58 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 3-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 3-12. Thermal loading capacity by flow condition for Grizzly Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	6	2.98E+08	<7 cfs
Dry	20.0	0.3	7	3.48E+08	7 cfs to <16 cfs
Mild	20.0	0.3	16	7.95E+08	16 cfs to <41 cfs
Moderate	20.0	0.3	41	2.04E+09	41 cfs to <97 cfs
High	20.0	0.3	97	4.82E+09	97 cfs to <144 cfs
Very High	20.0	0.3	144	7.15E+09	≥144 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 3-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 3-13. Thermal loading capacity by flow condition for Hoxie Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0.24	9.93E+06	<0.4 cfs
Dry	20.0	0.3	0.4	1.99E+07	0.4 cfs to <4 cfs
Mild	20.0	0.3	4	1.99E+08	4 cfs to <12 cfs
Moderate	20.0	0.3	12	5.96E+08	12 cfs to <32 cfs
High	20.0	0.3	32	1.59E+09	32 cfs to <49 cfs
Very High	20.0	0.3	49	2.43E+09	≥49 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 3-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 3-14. Thermal loading capacity by flow condition for Jenny Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	29	1.43E+09	<37 cfs
Dry	20.0	0.3	37	1.83E+09	37 cfs to <70 cfs
Mild	20.0	0.3	70	3.48E+09	70 cfs to <156 cfs
Moderate	20.0	0.3	156	7.75E+09	156 cfs to <327 cfs
High	20.0	0.3	327	1.62E+10	327 cfs to <471 cfs
Very High	20.0	0.3	471	2.34E+10	≥471 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 3-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. The HUA is not applicable to interstate waters. This loading capacity applies to the flow range in the last column of the table.

Table 3-15. Thermal loading capacity by flow condition for Johnson Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	7	3.48E+08	<8 cfs
Dry	20.0	0.3	8	3.97E+08	8 cfs to <19 cfs
Mild	20.0	0.3	19	9.44E+08	19 cfs to <51 cfs
Moderate	20.0	0.3	51	2.53E+09	51 cfs to <119 cfs
High	20.0	0.3	119	5.91E+09	119 cfs to <181 cfs
Very High	20.0	0.3	181	8.99E+09	≥181 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 3-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 3-16. Thermal loading capacity by flow condition for Keene Creek (303(d) ID 2163[1]).

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[2]	LC (kilocalories per day)[3]	Applicable Flow Range
Low	20.0	0.3	5	2.48E+08	<6 cfs
Dry	20.0	0.3	6	2.98E+08	6 cfs to <15 cfs
Mild	20.0	0.3	15	7.45E+08	15 cfs to <41 cfs
Moderate	20.0	0.3	41	2.04E+09	41 cfs to <98 cfs
High	20.0	0.3	98	4.87E+09	98 cfs to <147 cfs
Very High	20.0	0.3	147	7.30E+09	≥147 cfs

[1] Two segments of Keene Creek are listed as impaired for temperature (303(d) ID 2163 and 303(d) ID 2178). Note that the listings were combined into a single TMDL for the most downstream listed segment, which is 303(d) ID 2163.

[2] Estimated from StreamStats analysis (Appendix H).

[3] Loading capacity calculated using Equation 3-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 3-17. Thermal loading capacity by flow condition for Mill Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0	0.00E+00	0
Dry	20.0	0.3	0	0.00E+00	0 cfs to <1 cfs
Mild	20.0	0.3	1	4.97E+07	1 cfs to <3 cfs
Moderate	20.0	0.3	3	1.49E+08	3cfs to <11 cfs
High	20.0	0.3	11	5.46E+08	11 cfs to <18 cfs
Very High	20.0	0.3	18	8.94E+08	≥18 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 3-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 3-18. Thermal loading capacity by flow condition for South Fork Keene Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0	0.00E+00	0
Dry	20.0	0.3	0	0.00E+00	0 cfs to <2 cfs
Mild	20.0	0.3	2	9.93E+07	2 cfs to <8 cfs
Moderate	20.0	0.3	8	3.97E+08	8 cfs to <24 cfs
High	20.0	0.3	24	1.19E+09	24 cfs to <42 cfs
Very High	20.0	0.3	42	2.09E+09	≥42 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 3-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 3-19. Thermal loading capacity by flow condition for Spencer Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	4.2	2.08E+08	<7 cfs
Dry	20.0	0.3	7	3.68E+08	7 cfs to <21cfs
Mild	20.0	0.3	21	1.04E+09	21 cfs to <35 cfs
Moderate	20.0	0.3	35	1.74E+09	35 cfs to <68 cfs
High	20.0	0.3	68	3.38E+09	68 cfs to <98 cfs
Very High	20.0	0.3	98	4.87E+09	≥98 cfs

[1] Estimated from analysis of 2002-2018 observed flows at OWRD Station 11510000 (Appendix H).

[2] Loading capacity calculated using Equation 3-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

A load capacity curve was developed using different flow conditions for each TMDL waterbody, which characterizes the allowable thermal load capacity for a range of expected flows throughout the year (see Appendix H). Allocations divide the loading capacity between individual point sources and nonpoint sources of heat and set the thermal load targets which will result in achieving the water quality standards (see Section 3.7). In addition to individual point sources and nonpoint sources, a portion of the thermal loading capacity was set aside as a reserve capacity (Section 3.8).

3.6 Excess Load

OAR 340-042-0040(4)(e)
Excess thermal loads are used to evaluate, to the extent existing data allow, the difference between the actual pollutant load in a waterbody and the loading capacity of that waterbody. Equation 3-2 is used to calculate the excess thermal load, if observed temperature and flow data are available.

Excess Load Equation

$$\boldsymbol{EL = (T_R - T_C + HUA) \times Q_R \times C_F}$$ **Equation 3-2**

where,

EL = Excess thermal load above the applicable temperature criteria (kilocalories per day).

T_R = The current stream temperatures (°C), expressed as a 7-day average daily maximum or daily maximum depending on the applicable criteria.

T_C = The applicable temperature criteria (°C).

HUA = The 0.3°C human use allowance allocated to point sources, nonpoint sources, margin of safety, or reserve capacity.

Q_R = The daily mean river flow rate, upstream (cubic feet per second [cfs]).

C_F = Conversion factor using cubic feet per second: (2,446,622 kcal-s/°C-ft^3-day)

$$\frac{1\ \text{m}^3}{35.314\ \text{ft}^3} \times \frac{1000\ \text{kg}}{1\ \text{m}^3} \times \frac{86{,}400\ \text{sec}}{1\ \text{day}} \times \frac{1\ \text{kcal}}{1\ \text{kg} \times 1°\text{C}} = 2{,}446{,}622$$

Although excess loads cannot be calculated with the available data for most tributaries, there are some recent temperature measurements for Spencer Creek that were used to calculate excess load. The excess thermal load was calculated from the available flow and 7DADM temperature values using Equation 3-2. Loads exceeding the thermal loading capacity based on the applicable criterion plus the 0.3°C HUA are the excess loads and are presented as a function of flow (Figure 3-31) and are also summarized based on the minimum and maximum percent reductions (Table 3-20). The excess loads were observed in flows ranging from 4.9 to 11.9 cubic feet per second (Figure 3-31) and overall percent reductions ranged from 0.2 to 22 percent (Table 3-19). These exceedances typically occurred in the low and dry flow conditions. The percent of thermal load reductions needed to meet the applicable criterion plus the 0.3°C HUA are shown below for the various flow rates, with darker colors indicating a higher percent reduction (Figure 3-31). The largest percent reductions are required at the lower end of the observed flows (Figure 3-31).

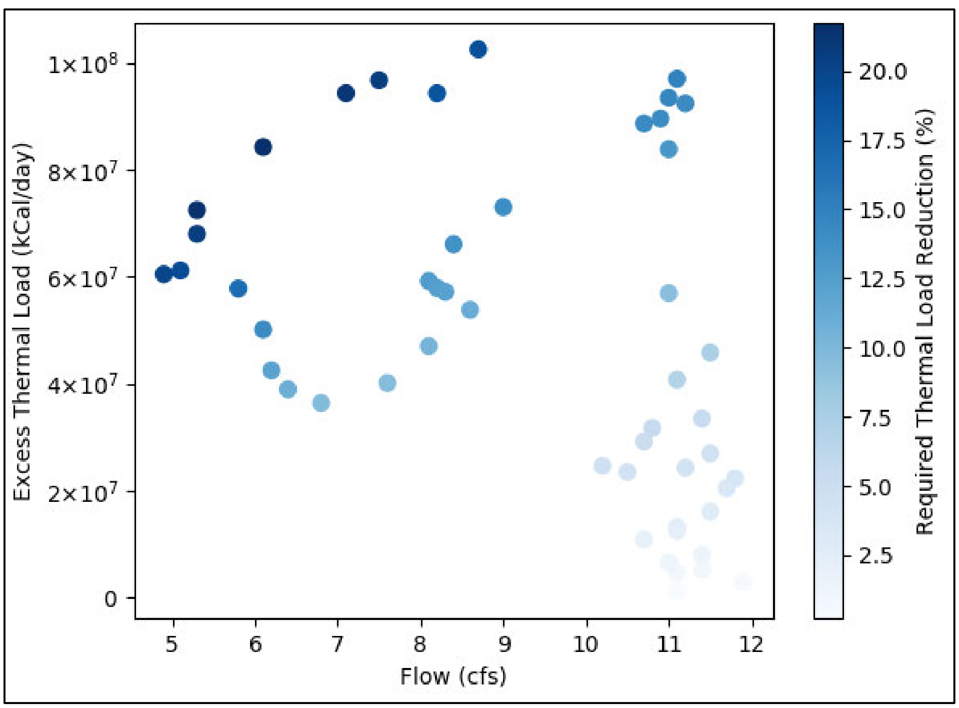

Figure 3-31. Spencer Creek excess thermal load and percent reductions by flow (4/18-7/18).

Table 3-20. Loading capacity and range of excess loads for Spencer Creek (April to July 2018 data only).

Condition	Observed Current Conditions temperature (7DADM, °C)	Applicable criterion plus HUA (7DADM, °C)	Flow at mouth (cfs)	Loading Capacity (kcal / day)	Excess Heat Load (kcal / day)	Percent Reduction (%)
Highest percent reduction	25.9	20.3	6.1	3.03E+08	8.47E+07	22
Lowest percent reduction	20.34	20.3	11.1	551E+08	1.16E+06	0.2

Figure 3-32 and Figure 3-33 shows the modeled minimum, median, and maximum excess load and the required temperature reductions on Jenny Creek and Spencer Creek (respectively) in year 2001 as a function of the model stream length. The required temperature reduction is the difference between the current 7-day average daily maximum stream temperatures as modeled in the current condition calibration and the applicable criterion plus human use allowance.

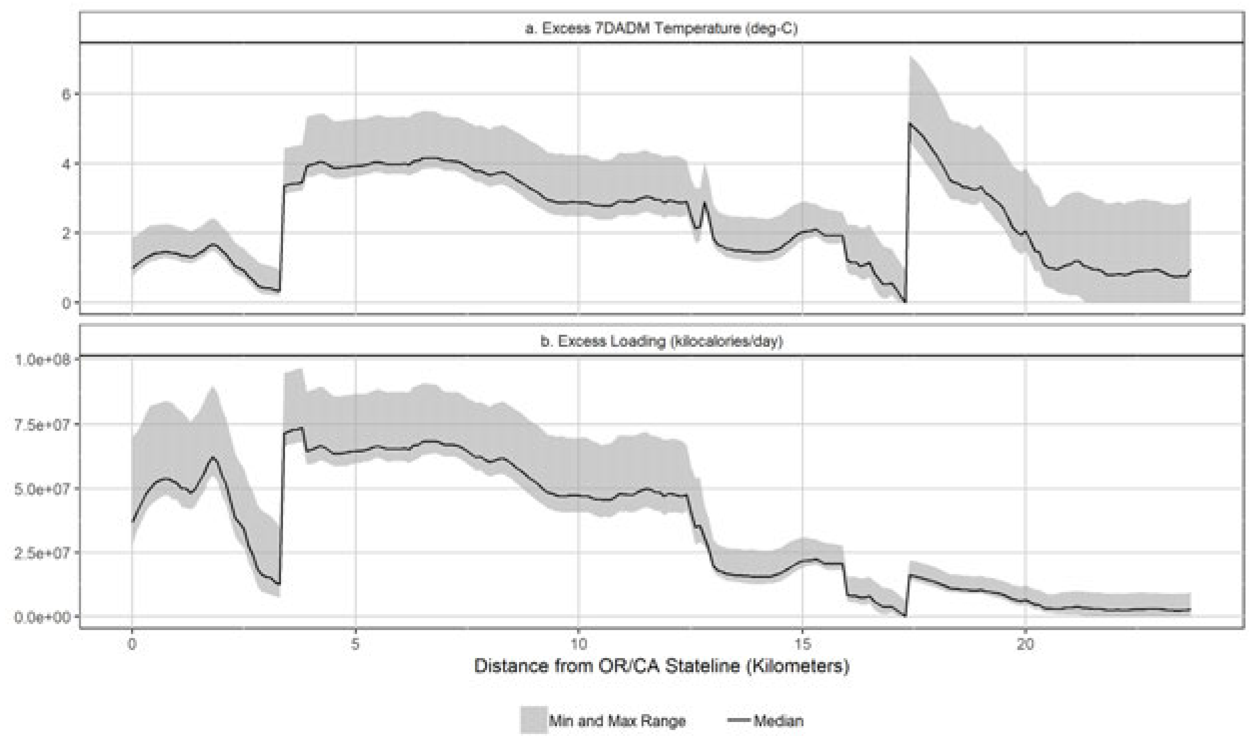

Figure 3-32. (a) Excess 7-day average daily maximum stream temperatures on Jenny Creek during the modeled period. These temperatures must be reduced in order to achieve the applicable criterion plus human use allowance. (b) Excess Load during the modeled period on Jenny Creek.

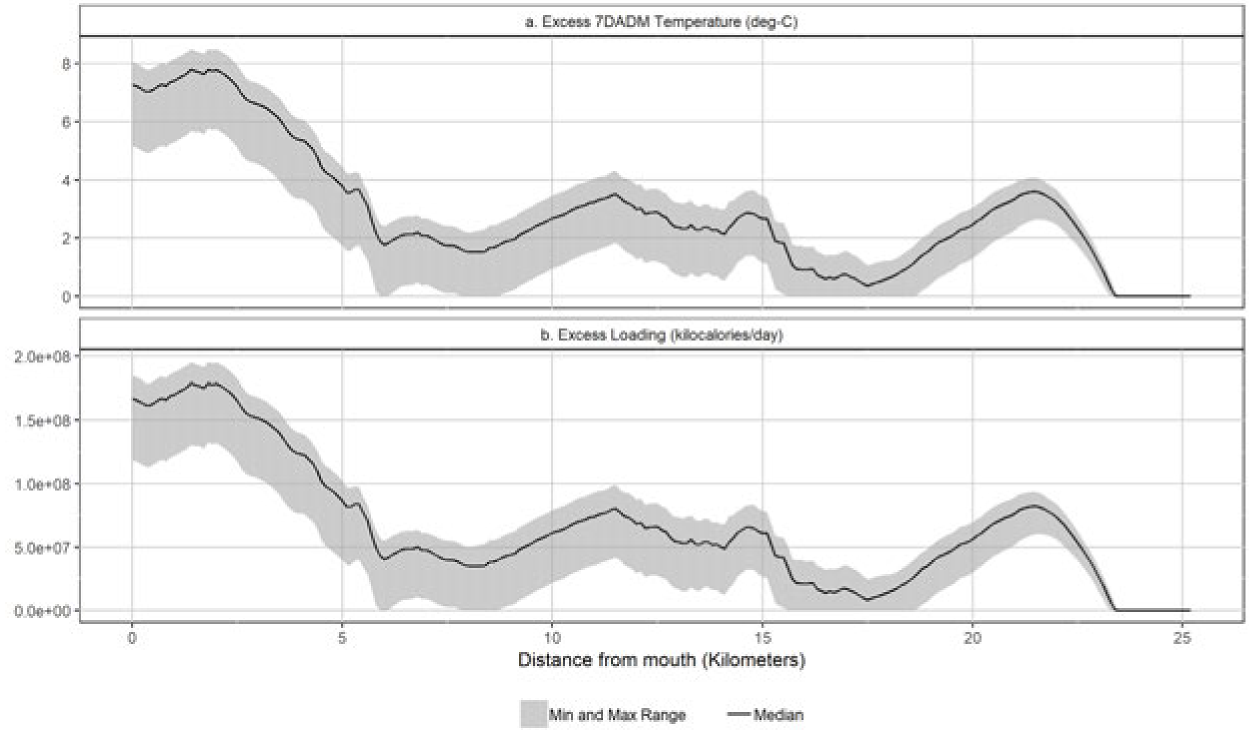

Figure 3-33. (a) Excess 7-day average daily maximum stream temperatures on Spencer Creek during the modeled period. These temperatures must be reduced in order to achieve the applicable criterion plus human use allowance. (b) Excess Load during the modeled period on Spencer Creek.

3.7 Allocations

Loading capacity in this TMDL is expressed as a thermal load in kilocalories per day; however, in order for the TMDL to be more meaningful to the public and guide implementation efforts, allocations have also been expressed in thermal loads for each source, as a change in seven day average of daily maximum stream temperature or ΔT (delta T), and in terms of the surrogate measure percent effective shade. The loading capacity was separated into load allocations for background sources and identified nonpoint sources, wasteload allocations for point sources, and a reserve capacity. In this TMDL, no loading capacity was explicitly set aside as a margin of safety, instead an implicit margin of safety was used (Section 3.9). The allocations for the nonpoint sources, point sources, and reserve capacity were calculated from the human use allowance (Section 3.7.1). Allocations apply during the critical period (Section 3.3) from June 1 – September 30 when the available data show the seven-day average daily maximum temperatures exceed the applicable criterion. Background sources were not allocated any of the HUA but were assigned a Load Allocation (Section 3.4.3).

$$\boldsymbol{Allocation = \Delta T \times Q_R \times C_F}$$ **Equation 3-3**

where,

$Allocation$ = Allocation of the thermal loading capacity to a source (kilocalories per day).

ΔT = Allowable temperature increase (°C).

Q_R = The daily mean river flow rate, upstream (cubic feet per second [cfs]).

C_F = Conversion factor using cubic feet per second: (2,446,622 kcal-s/°C-ft^3-day)

$$\frac{1\,m^3}{35.314\,ft^3} \times \frac{1000\,kg}{1\,m^3} \times \frac{86{,}400\,sec}{1\,day} \times \frac{1\,kcal}{1\,kg \times 1°C} = 2{,}446{,}622$$

A summary of the thermal loading capacity allocations are presented in Table 3-20 through Table 3-30 by flow condition for the TMDL waterbodies. These summaries represent the maximum estimated loading under each flow condition. Because stream temperature warming can be cumulative, some of the load allocations and human use allowance allocations (Section 3.7.1) were limited to zero warming in order to ensure attainment of temperature criteria in downstream waters. In the sections that follow, the allocations for individual sources are provided in greater detail. Surrogate measures, where appropriate, are identified (Section 3.7.3.4).

Table 3-21. Beaver Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
Loading Capacity	20.3	4.97E+07	1.99E+08	6.95E+08	1.79E+09	2.88E+09	1.49E+07
Load Allocation (Background)[2]	20	4.89E+07	1.96E+08	6.85E+08	1.76E+09	2.84E+09	1.47E+07
Load Allocation (Nonpoint Sources)[2]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wasteload Allocation (Point Sources)[2]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[2]	0.3	2.20E+05	7.34E+05	2.94E+06	1.03E+07	2.64E+07	4.26E+07
Maximum Excess Load (Total Reduction)	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]

[1] Data were not available to characterize current stream temperatures, current loading, or excess loads.
[2] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 3-22. Grizzly Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	20.6	3.02E+08	3.53E+08	8.06E+08	2.07E+09	4.89E+09	7.26E+09
Loading Capacity	20.3	2.98E+08	3.48E+08	7.95E+08	2.04E+09	4.82E+09	7.15E+09
Load Allocation (Background)[1]	20.0	2.94E+08	3.43E+08	7.83E+08	2.01E+09	4.75E+09	7.05E+09
Load Allocation (Nonpoint Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wasteload Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.3	4.40E+06	5.14E+06	1.17E+07	3.01E+07	7.12E+07	1.06E+08
Maximum Excess Load (Total Reduction)	0.3	4.40E+06	5.14E+06	1.17E+07	3.01E+07	7.12E+07	1.06E+08

[1] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 3-23. Hoxie Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
Loading Capacity	20.3	9.93E+06	1.99E+07	1.99E+08	5.96E+08	1.59E+09	2.43E+09
Load Allocation (Background)[2]	20	9.79E+06	1.96E+07	1.96E+08	5.87E+08	1.57E+09	2.40E+09
Load Allocation (Nonpoint Sources)[2]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wasteload Allocation (Point Sources)[2]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[2]	0.3	1.47E+05	2.94E+05	2.94E+06	8.81E+06	2.35E+07	3.60E+07
Maximum Excess Load (Total Reduction)	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]

[1] Data were not available to characterize current stream temperatures or excess loads.
[2] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 3-24. Jenny Creek sector allocations by flow condition in kilocalories per day at point of maximum impact (km 23.7).

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	27.4	1.93E+09	2.47E+09	4.69E+09	1.05E+10	2.19E+10	3.16E+10
Loading Capacity	20.3	1.43E+09	1.83E+09	3.48E+09	7.75E+09	1.62E+10	2.34E+10
Load Allocation (Background)[1]	20	1.41E+09	1.81E+09	3.43E+09	7.63E+09	1.60E+10	2.30E+10
Load Allocation (Nonpoint Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wasteload Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.3	2.11E+07	2.71E+07	5.14E+07	1.15E+08	2.40E+08	3.46E+08
Maximum Excess Load (Total Reduction)	7.1	5.00E+08	6.41E+08	1.22E+09	2.71E+09	5.68E+09	8.18E+09
Reduction From Background and Unquantified Sources	0.37	2.61E+07	3.34E+07	6.34E+07	1.41E+08	2.96E+08	4.26E+08
Reduction from Human Sources	6.73	4.74E+08	6.08E+08	1.15E+09	2.57E+09	5.38E+09	7.76E+09

[1] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 3-25. Jenny Creek sector allocations by flow condition in kilocalories per day at OR/CA Stateline.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	22.18	1.56E+09	2.00E+09	3.80E+09	8.47E+09	1.77E+10	2.56E+10
Loading Capacity	20.3	1.43E+09	1.83E+09	3.48E+09	7.75E+09	1.62E+10	2.34E+10
Load Allocation (Background)[1]	20	1.41E+09	1.81E+09	3.43E+09	7.63E+09	1.60E+10	2.30E+10
Load Allocation (Nonpoint Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wasteload Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.3	2.11E+07	2.71E+07	5.14E+07	1.15E+08	2.40E+08	3.46E+08
Maximum Excess Load (Total Reduction)	1.88	1.32E+08	1.70E+08	3.22E+08	7.18E+08	1.50E+09	2.17E+09
Reduction From Background and Unquantified Sources	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reduction from Human Sources	1.88	1.32E+08	1.70E+08	3.22E+08	7.18E+08	1.50E+09	2.17E+09

[1] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 3-26. Johnson Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	23.2	3.97E+08	4.54E+08	1.08E+09	2.89E+09	6.75E+09	1.03E+10
Loading Capacity	20.3	3.48E+08	3.97E+08	9.44E+08	2.53E+09	5.91E+09	8.99E+09
Load Allocation (Background)[1]	20.0	3.43E+08	3.91E+08	9.30E+08	2.50E+09	5.82E+09	8.86E+09
Load Allocation (Nonpoint Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wasteload Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.3	4.28E+06	4.89E+06	1.16E+07	3.12E+07	7.28E+07	1.11E+08
Maximum Excess Load (Total Reduction)	2.9	4.97E+07	5.68E+07	1.35E+08	3.62E+08	8.44E+08	1.28E+09

[1] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 3-27. Keene Creek (303(d) ID 2163[1]) sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	20.0	2.45E+08	2.94E+08	7.34E+08	2.01E+09	4.80E+09	7.19E+09
Loading Capacity	20.3	2.48E+08	2.98E+08	7.45E+08	2.04E+09	4.87E+09	7.30E+09
Load Allocation (Background)[1]	20.0	2.45E+08	2.94E+08	7.34E+08	2.01E+09	4.80E+09	7.19E+09
Load Allocation (Nonpoint Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wasteload Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.3	3.67E+06	4.40E+06	1.10E+07	3.01E+07	7.19E+07	1.08E+08
Maximum Excess Load (Total Reduction)	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

[1] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 3-28. Mill Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	**Dry**	**Mild**	**Moderate**	**High**	**Very High**
Current	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
Loading Capacity	20.3	0.00E+00	0.00E+00	4.97E+07	1.49E+08	5.46E+08	8.94E+08
Load Allocation (Background)[1]	20	0.00E+00	0.00E+00	4.89E+07	1.47E+08	5.38E+08	8.81E+08
Load Allocation (Nonpoint Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wasteload Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.3	0.00E+00	0.00E+00	7.34E+05	2.20E+06	8.07E+06	1.32E+07
Maximum Excess Load (Total Reduction)	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]

[1] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 3-29. South Fork Keene Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
Loading Capacity	20.3	0.00E+00	0.00E+00	9.93E+07	3.97E+08	1.19E+09	2.09E+09
Load Allocation (Background)[2]	20	0.00E+00	0.00E+00	9.79E+07	3.91E+08	1.17E+09	2.06E+09
Load Allocation (Nonpoint Sources)[2]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Wasteload Allocation (Point Sources)[2]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[2]	0.3	0.00E+00	0.00E+00	1.47E+06	5.87E+06	1.76E+07	3.08E+07
Maximum Excess Load (Total Reduction)	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]

[1] Data were not available to characterize current stream temperatures or excess loads.
[2] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 3-30. Spencer Creek (at mouth) sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	28.3	2.90E+08	5.12E+08	1.45E+09	2.42E+09	4.71E+09	6.79E+09
Loading Capacity	20.3	2.08E+08	3.68E+08	1.04E+09	1.74E+09	3.38E+09	4.87E+09
Load Allocation (Background)[1]	20.0	2.05E+08	3.62E+08	1.03E+09	1.71E+09	3.33E+09	4.80E+09
Load Allocation (Nonpoint Sources)[1]	0.2	2.05E+06	3.62E+06	1.03E+07	1.71E+07	3.33E+07	4.80E+07
Wasteload Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	1.02E+06	1.81E+06	5.14E+06	8.56E+06	1.66E+07	2.40E+07
Maximum Excess Load (Total Reduction)	8.0	8.18E+07	1.45E+08	4.11E+08	6.85E+08	1.33E+09	1.92E+09

[1] Allocations were calculated using equation 3-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

3.7.1 Human Use Allowance

OAR340-041-0028(12)(b)
The human use allowance is defined as insignificant additions of heat that are authorized in waters that exceed the applicable biologically based numeric temperature criteria.

Where the 20ºC "Redband or Lahontan Cutthroat Trout" uses are identified, the loading capacity available for human use is based on an allowable 0.3°C temperature increase at the point of maximum impact. For example, the total load from anthropogenic sources, considering both point and nonpoint sources, cannot exceed the HUA of 0.3°C. This includes any permits, dams/reservoirs, identified nonpoint sources, and a reserve capacity for future growth. Designated management agencies[6], permittees, or other responsible persons are responsible for implementing the TMDL and achieving their allocations.

Loading capacities for the TMDL waterbodies were allocated between the various known sources in their drainage. Anthropogenic sources were assigned a portion of the HUA (equivalent to 0.3°C), as identified in Table 3-30 through Table 3-33 for the impaired waterbodies in the Upper Klamath subbasin. Anthropogenic sources in Jenny Creek Watershed (Table 3-31)

Table 3-31. HUA allocations to anthropogenic sources in the Jenny Creek Watershed (HUC 1801020604), Copco Reservoir-Klamath River Watershed (HUC 1801020603), Iron Gate Reservoir-Klamath River Watershed (HUC 1801020605), Cottonwood Creek Watershed (HUC 1801020606), and Beaver Creek Watershed (HUC 1801020609).

Source	Cumulative Warming (ºC)	Cumulative HUA at Oregon/California Stateline (ºC)
Point Sources (None)	0.0	0.0
Keene Creek Dam and Reservoir	0.0	0.0
Hyatt Dam and Reservoir	0.0	0.0
Little Hyatt Dam and Reservoir	0.0	0.0
Howard Prairie Dam and Reservoir	0.0	0.0
PacifiCorp diversion for Fall Creek Hydroelectric Project	0.0	0.0
ODA and agricultural practices	0.0	0.0
ODF (state and private forest practices)	0.0	0.0
USFS	0.0	0.0
BLM	0.0	0.0
Klamath County	0.0	0.0
Water withdrawals Water management Districts	0.0	0.0

[6] As per OAR 340-042-0030(2), designated management agency means a "federal, state or local governmental agency that has legal authority over a sector or source contributing pollutants, and is identified as such by the Department of Environmental Quality in a TMDL."

Source	Cumulative Warming (°C)	Cumulative HUA at Oregon/California Stateline (°C)
Currently existing transportation infrastructure, buildings, and utility corridors		
All other anthropogenic sources	0.0	0.0
Reserve Capacity	0.3	0.3
1. Human use allowance at point of heat loading refers to the maximum warming allowed at the location where the source's loading occurs in the waterbody. For point sources the point of heat loading is at the edge of the mixing zone For water management districts the point of heat loading is the loading from all locations where heat is contributed caused by district practices. For dams and reservoirs the point of heat loading is within the reservoir impoundment and where water is returned to the natural river channel downstream of the dam. For diversions and water withdraws the point of heat loading refers to the cumulative warming from all points of diversion. For transportation infrastructure, buildings, utility corridors, and for land management DMAs including USFS, BLM, ODF, or ODA where hydromodification or vegetation removal activities occur, the point of heat loading refers to the cumulative warming at all locations along the waterbody where these sources exist.		

Table 3-32. HUA allocations to anthropogenic sources in the Spencer Creek Watershed (HUC 1801020601).

Source	Cumulative Warming [1] (°C)
Point Sources (None)	0.0
Dam and Reservoir Operation	0.0
ODA and agricultural practices	0.0
ODF (state and private forest practices)	0.0
USFS	0.0
BLM	0.0
Klamath County	0.0
Water withdrawals Water Management Districts Currently existing transportation infrastructure, buildings, and utility corridors	0.2
All other anthropogenic sources	0.0
Reserve Capacity	0.1
1. Human use allowance at point of heat loading refers to the maximum warming allowed at the location where the source's loading occurs in the waterbody. For point sources the point of heat loading is at the edge of the mixing zone. For water management districts the point of heat loading is the loading from all locations where heat is contributed caused by district practices. For dams and reservoirs the point of heat loading is within the reservoir impoundment and where water is returned to the natural river channel downstream of the dam. For diversions and water withdraws the point of heat loading refers to the cumulative warming from all points of diversion. For transportation infrastructure, buildings, utility corridors, and for land management DMAs including USFS, BLM, ODF, or ODA where hydromodification or vegetation removal activities occur, the point of heat loading refers to the cumulative warming at all locations along the waterbody where these sources exist.	

Table 3-33. HUA allocations to anthropogenic sources on tributaries to the Klamath River within the John C Boyle Reservoir-Klamath River Watershed (HUC 1801020602).

Sources	Cumulative Warming [1] (ºC)	Cumulative HUA at Oregon/California Stateline (ºC)
Point Sources (None)	0.0	0.0
ODA and agricultural practices	0.0	0.0
ODF and private forest practices	0.0	0.0
USFS	0.0	0.0
BLM	0.0	0.0
Klamath County	0.0	0.0
Water withdrawals Water Management Districts Currently existing transportation infrastructure, buildings, and utility corridors	0.0	0.0
State of California (waters entering Oregon)	0.0	0.0
All other anthropogenic sources	0.0	0.0
Reserve Capacity	0.3	0.3

[1]Human use allowance at point of heat loading refers to the maximum warming allowed at the location where the source's loading occurs in the waterbody. For point sources the point of heat loading is at the edge of the mixing zone. For water management districts the point of heat loading is the loading from all locations where heat is contributed caused by district practices. For dams and reservoirs the point of heat loading is within the reservoir impoundment and where water is returned to the natural river channel downstream of the dam. For diversions and water withdraws the point of heat loading refers to the cumulative warming from all points of diversion. For transportation infrastructure, buildings, utility corridors, and for land management DMAs including USFS, BLM, ODF, or ODA where hydromodification or vegetation removal activities occur, the point of heat loading refers to the cumulative warming at all locations along the waterbody where these sources exist.

3.7.2 Wasteload Allocations

OAR 340-042-0040(4)(g), 40 CFR 130.2(g)
This section describes the portions of the receiving water's loading capacity that are allocated to existing point sources of pollution, including all point source discharges regulated under the Federal Water Pollution Control Act Section 402 (33 USC Section 1342).
Since there are no point sources identified as sources of temperature impairment in tributaries of the Upper Klamath subbasin, wasteload allocations were not assigned. Any existing or future point source that was not assigned a wasteload allocation may apply to DEQ for use of the reserve capacity (see Section 3.8).

3.7.3 Load Allocations

Load Allocations OAR 340-042-0040(4)(h), 40 CFR 130.2(h): This element determines the portions of the receiving water's loading capacity that are allocated to existing nonpoint sources including background sources. The thermal load allocations in the Upper Klamath subbasin is a mixture of background loads (including natural sources and unidentified or lack of authority loads from anthropogenic sources) and loads from identified anthropogenic nonpoint sources. Load allocations for each TMDL waterbody are presented in Table 3-20 through Table 3-29 and descriptions of the source categories are provided below.

The following equation is used to calculate thermal load allocations for water management districts.

$$LA = (\Delta T) \cdot (Q_D + Q_R) \cdot C_F \qquad \textbf{Equation 3-4}$$

where,

$\boldsymbol{LA} =$ Load allocation (kilocalories/day).

$\boldsymbol{\Delta T} =$ The maximum allowed temperature increase (°C).

$\boldsymbol{Q_D} =$ The daily mean discharge from the source (if applicable, otherwise = zero) (cfs).

$\boldsymbol{Q_R} =$ The daily mean river flow rate, upstream (cfs).

$\boldsymbol{C_F} =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

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

3.7.3.1 Background Sources

Background sources are defined in Section 3.4.3.

For all TMDL waterbodies, addressed in this chapter, the thermal load equivalent to the applicable criterion (20°C) is allocated to background sources (Table 3-20 through Table 3-23). This background load allocation is a portion of the loading capacity equal to the product of the applicable criterion, the stream flow, and a conversion factor and can be calculated using Equation 3-3 if the criterion is incorporated as delta T.

3.7.3.2 Dams and Reservoirs

Designated management agencies or responsible persons that manage and operate dams and reservoirs within the scope of this TMDL are allocated a zero HUA (Table 3-31 to Table 3-33) and equivalent load allocation of zero kilocalories per day. This means that no stream warming is allowed from operation or management of the dam and reservoir.

Flow based load allocations for the dams and reservoirs can be calculated using Equation 3-5 and represent the equivalent thermal load resulting in the allowed temperature increase (ΔT) allocated to each dam and reservoir in Table 3-31 to Table 3-33.

The following equation is used to calculate thermal load allocations for dams and reservoirs.

$$LA = (\Delta T) \cdot (Q_R) \cdot C_F \quad \textbf{Equation 3-5}$$

where,

$\boldsymbol{LA} =$ Load allocation (kilocalories/day).

$\boldsymbol{\Delta T} =$ The maximum allowed temperature increase (°C).

$\boldsymbol{Q_R} =$ The daily mean river flow rate (cfs).

$\boldsymbol{C_F} =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

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

Evaluating compliance using the change in temperature, rather than a thermal load, is often a more useful approach for reservoir management because it relates directly to the temperature standard and is easier to evaluate and understand.

To evaluate compliance, the change in temperature (ΔT) may be calculated as the difference between the 7DADM stream temperatures upstream of the reservoir and the 7DADM near the dam outlet where water is returned to the natural river channel; or quantified with a model that has been reviewed and accepted by DEQ. If analysis shows the point of maximum impact from the dam and reservoir operation to be in another location other than the dam outlet, that point of maximum impact is used instead. Differences between the upstream and downstream 7DADM temperatures may be adjusted to account for any natural warming or cooling that would occur absent the dam and reservoir operations.

The department may, on a case-by-case basis, require the Upper Klamath subbasin dams to develop and implement a temperature management plan. (OAR 340-041-0028 (12)(e)).

3.7.3.3 Near-stream Vegetation Management

Designated management agencies or responsible persons with near-stream vegetation or authority to manage near-stream vegetation within the scope of this TMDL are allocated a zero HUA (Table 3-31 to Table 3-33) and equivalent load allocation of zero kilocalories per day. This means that no stream warming is allowed from human-caused removal or absence of vegetation.

Load allocations for these designated management agencies or responsible persons with near-stream vegetation are expressed in the surrogate measure effective shade (Section 3.7.3.4). There are two types of effective shade targets that apply to designated management agencies or responsible persons:

1. Site-specific effective shade allocations apply to the streams that have been simulated with computer modeling.

2. Effective shade curves are generalized allocations that apply to all other streams covered within the geographic scope of this TMDL, but that have not been modeled.

3.7.3.4 Surrogate Measures

OAR 340-042-0040(5)(b), OAR 340-042-030(14), 40 CFR 130.2(i)

These TMDLs incorporate other measures in addition to '*daily loads*' to fulfill requirements of the Clean Water Act §303(d). Although a loading capacity for heat energy is derived (e.g., kilocalories), it is of limited value in guiding management activities needed to solve identified water quality problems. In addition to heat energy loads (i.e., kilocalorie daily loads), this TMDL provides supplementary implementation allocations '*other appropriate measures*' (or surrogate measures) as provided under EPA regulations (40 CFR 130.2(i)).

Effective shade is the surrogate measure that translates load allocations for land management DMAs. It is simple to measure effective shade at the stream surface using a relatively inexpensive instrument called a Solar Pathfinder™. Solar Pathfinder™ data were used to collect all ground level data. Section A.2.1 of Appendix A summarizes where and when ground level data were obtained.

The mean restored condition effective shade values presented in Table 3-34 are to be used for evaluating attainment with the site specific effective shade targets on Jenny Creek and Spencer Creek. For other streams, the effective shade curves are to be used to determine the appropriate amount of effective shade.

The term 'shade' has been used in several contexts, including its components such as shade angle or shade density. For purposes of this TMDL, effective shade is defined as the percent reduction of daily solar radiation load delivered to the water surface. The role of effective shade in this TMDL is to prevent or reduce stream warming caused by solar radiation.

Implementation of the effective shade target is a key implementation measure for DMAs in the subbasin, although, it is not the sole implementation measure needed to meet their allocations. TMDL compliance is evaluated based on the allocation calculated using the source's portion of the HUA. When implemented, effective shade is one method DMAs can use to achieve a portion of their zero load allocation.

3.7.3.4.1 Site Specific Effective Shade

Site specific effective shade surrogates were developed to implement the nonpoint source heat load allocations. Figure 3-34 and Figure 3-35 show the simulated percent effective shade estimates on Jenny Creek and Spencer Creek by river kilometer; these were the only creeks simulated in the Upper Klamath subbasin. The "Current Condition" effective shade (in blue) provided to the tributaries is generally less than the "Restored Vegetation" effective shade (in green). The natural "Disturbance Range" (in grey) indicates the shade levels that could potentially occur in the event of natural disturbances. The lower end of that range represents that amount of shade that the streams would receive if topography were the only shade-producing feature (i.e., no vegetation). Appendix A contains detailed descriptions of the methodology used to develop these effective shade simulations.

Reductions in effective shade caused by natural disturbance are not considered a violation of the TMDL or water quality standards.

An increase in effective shade to implement the temperature TMDL will likely result in larger riparian vegetation, which will increase the potential for contributions of large woody debris to streams. Increases in large woody debris benefit stream temperatures and associated cool water habitat by increasing the number and depth of pools, which provide areas of cooler water for fish (EPA 2004). Large woody debris provides shelter and supports food sources that are crucial for the survival of salmon in the Upper Klamath subbasin.

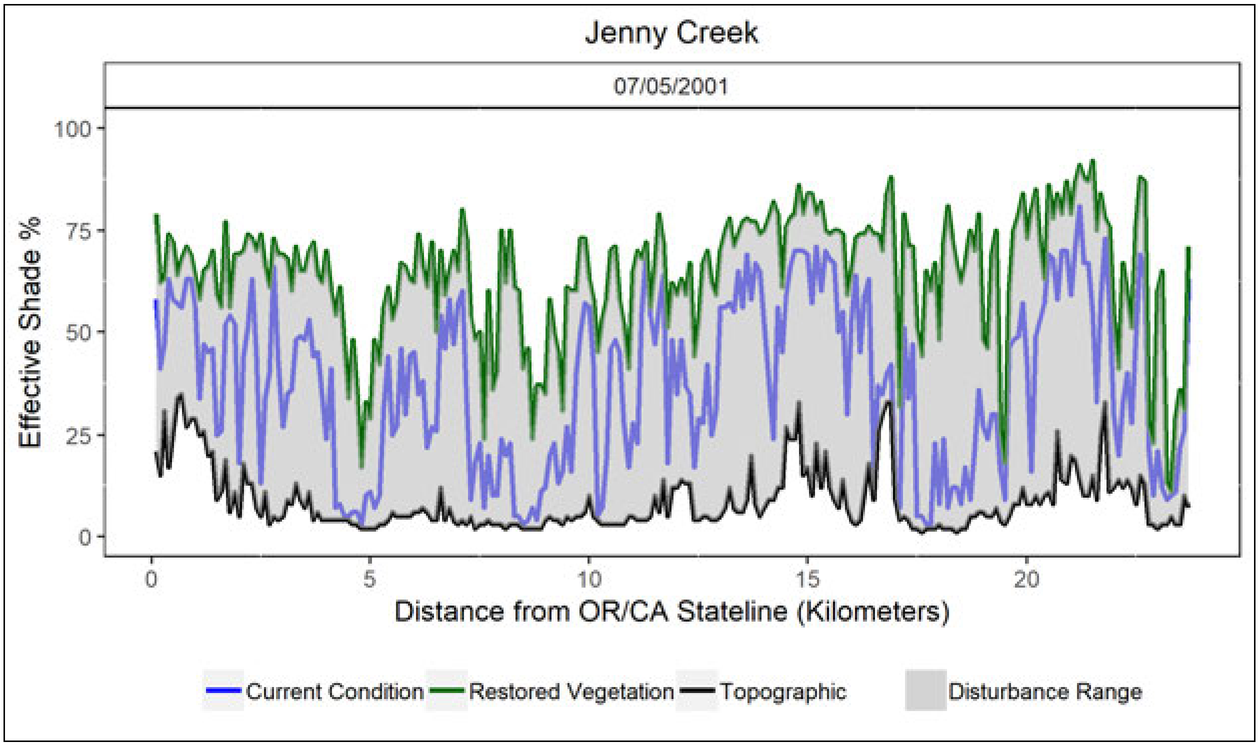

Figure 3-34. Effective shade targets for Jenny Creek in the Upper Klamath subbasin.

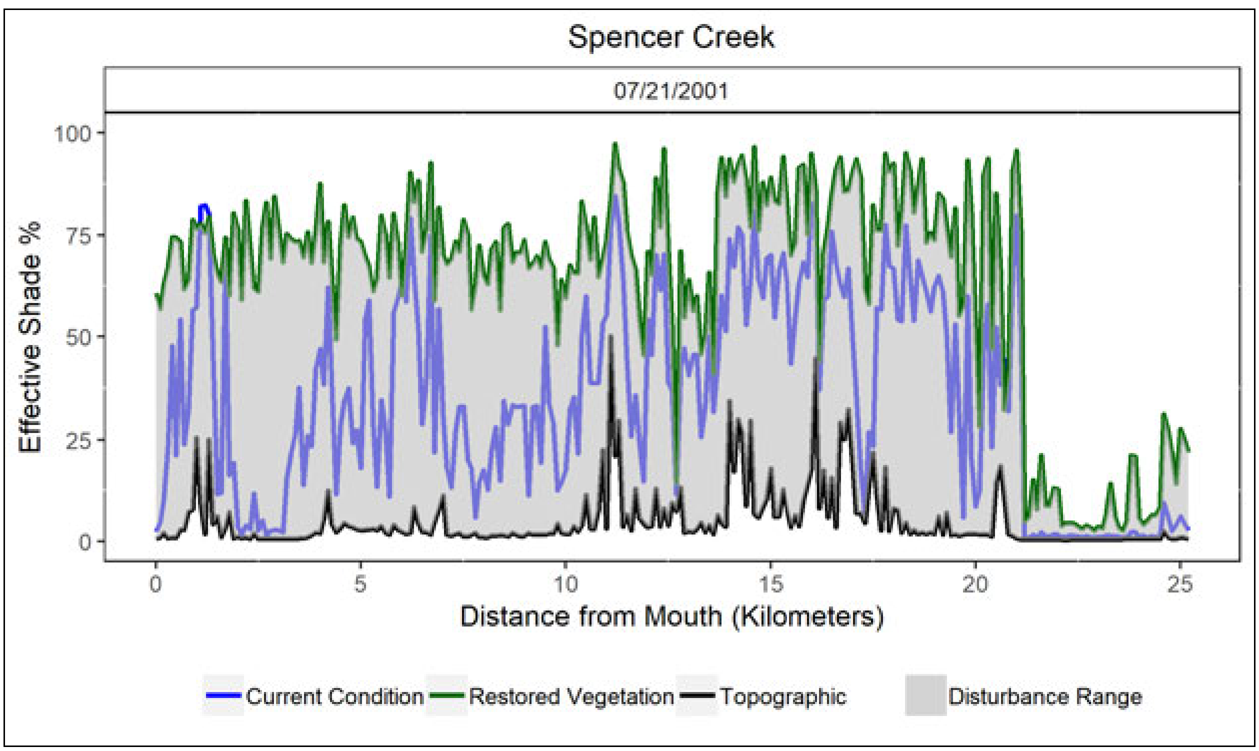

Figure 3-35. Effective shade targets for Spencer Creek in the Upper Klamath subbasin.

Appendix A describes the methodology used to determine restored vegetation. A summary of restored shade for the modeled reaches is provided in Table 3-33. The average shade deficit is the average percentage point difference between current and restored vegetation shade at each model node.

Table 3-34. Surrogate measures for shade for selected tributaries (temperature impacts are the average increase to the 7DADM for the modeled reach).

Waterbody	Mean Percent Effective Shade		Mean Effective Shade deficit (% shade)
	Current (%)	Restored Vegetation (%)	
Jenny Creek	38	64	26
Spencer Creek	35	63	28

3.7.3.4.2 Effective Shade Curves

Effective shade curves are applicable to any stream that was not specifically modeled for shade or temperature. The heat load and effective shade surrogates are identified by ecoregion for different types of restored vegetation. Effective shade curves represent the *maximum* possible effective shade for a given vegetation type. Natural disturbance was not included in the effective shade curve calculations. The values presented within the effective shade curves represent the effective shade that would be attained if the vegetation were at its stated restored height and density. The vegetation heights and densities were determined for the Jenny Creek and Spencer Creek watersheds. See Appendix A for methodology to determine restored vegetation.

Local geology, geography, soils, climate, legacy impacts, natural disturbance rates, and other factors may prevent effective shade from reaching the values presented in the effective shade curves. The goal of the TMDL is to achieve water quality standards. Minimizing anthropogenic impacts on effective shade is an important implementation strategy. This TMDL recognizes that unpredictable natural disturbances may result in effective shade well below the levels presented in the effective shade curves.

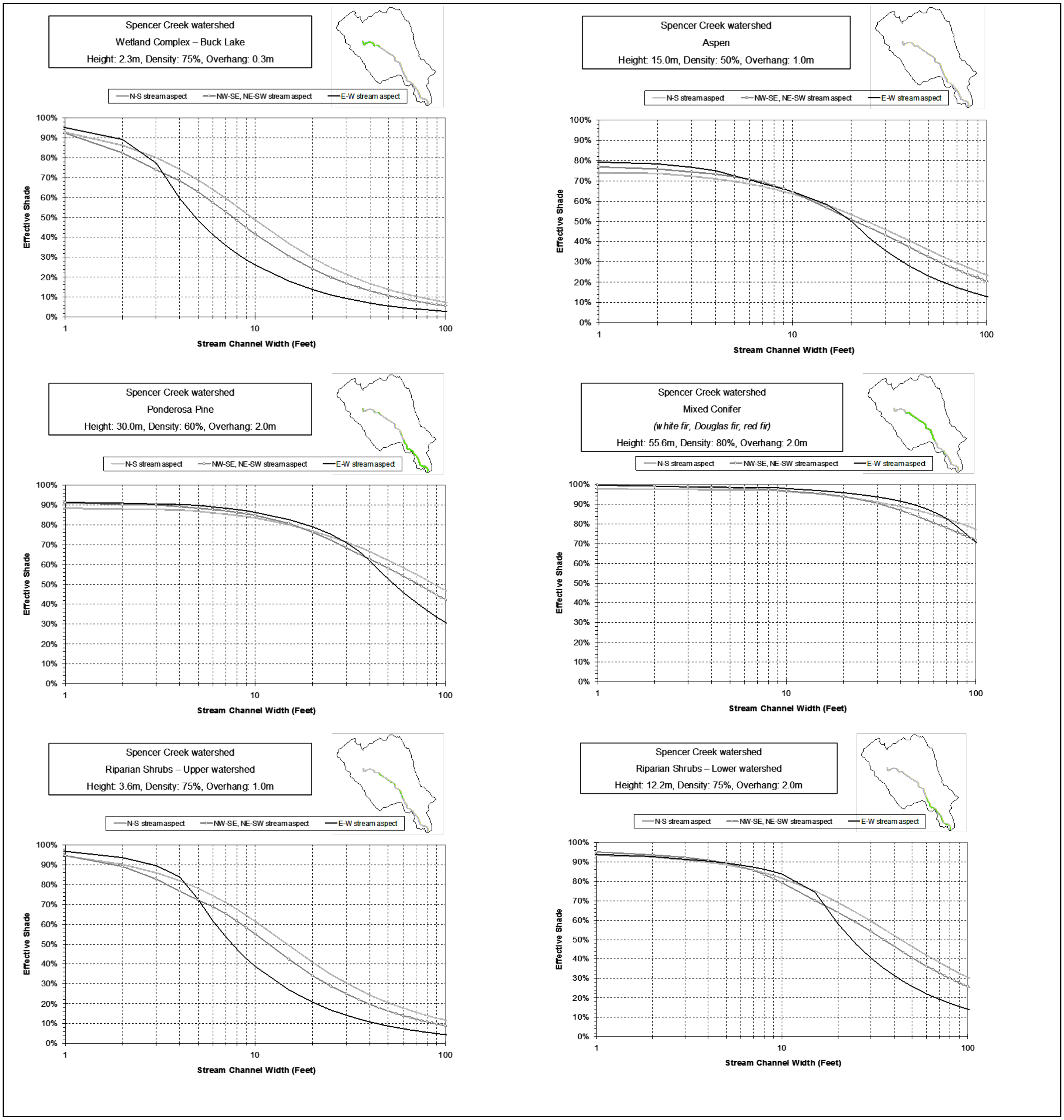

Figure 3-36. Effective shade curves for restored vegetation in the Spencer Creek Watershed.

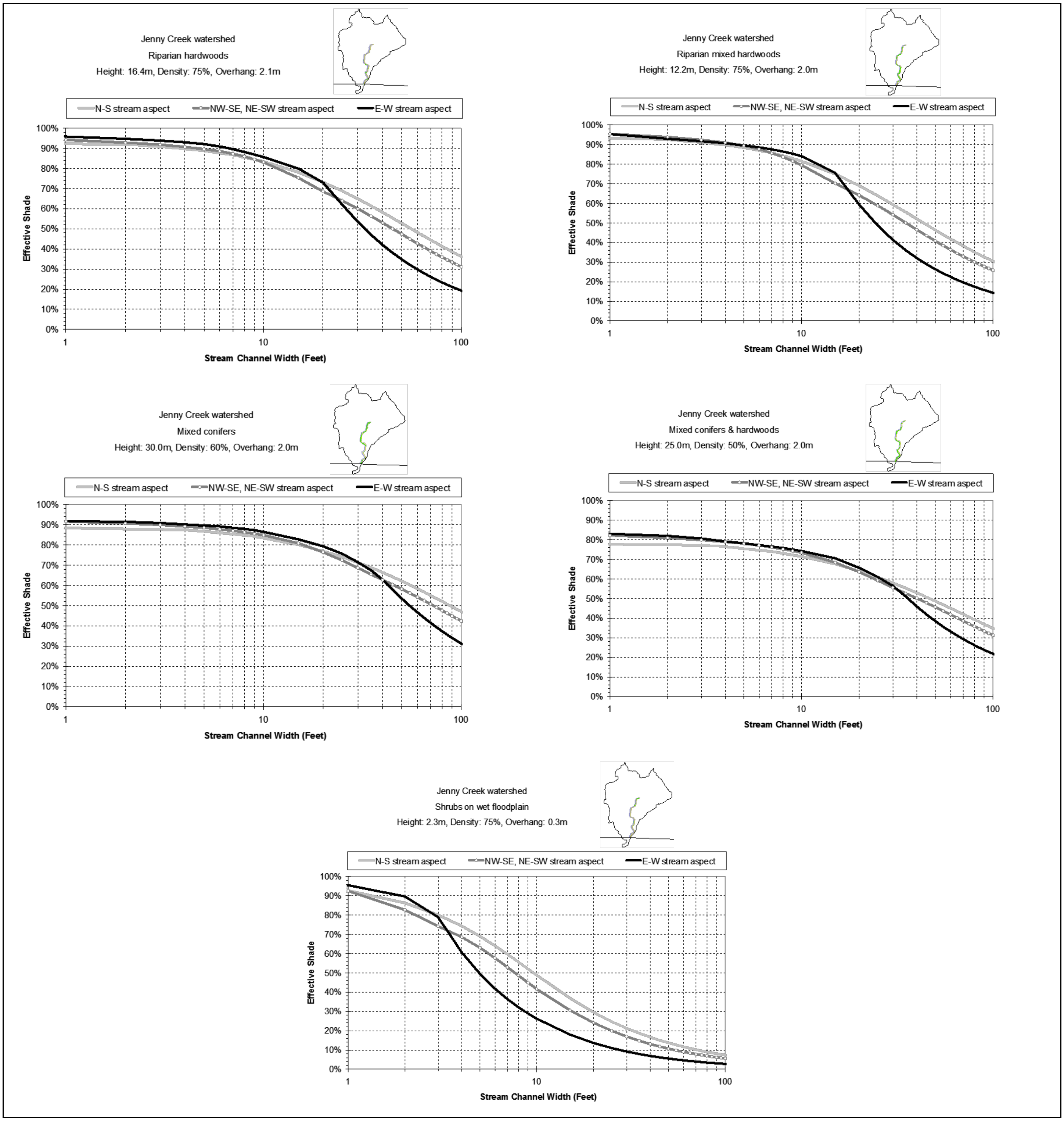

Figure 3-37. Effective shade curves for restored vegetation in the Jenny Creek Watershed.

3.8 Reserve Capacity

OAR 340-042-0040(4)(k), 40 CFR 130.2(h)

There is an explicit allocation for reserve capacity throughout the tributaries set aside for future growth and new, expanded or unidentified sources. The change in stream temperature associated with the reserve capacity was quantified in kilocalories per day where the ‘portion of HUA allocated’ was incorporated as delta T to calculate the allocation. Reserve capacity is available for use by either nonpoint or point sources to accommodate future growth as well as to provide an allocation to any existing source that may not have been identified during the development of this TMDL. In the event that any new individual facility permits are issued in the subbasin, they will be written to ensure that all TMDL related issues are addressed in the permit. DEQ has a process for setting or revising WLAs for new or expanding point sources discharges to waterbodies with an approved TMDL. This process will be used to update allocations in approved TMDLs for new or expanding dischargers whose permitted effluent limits are at or below the in-stream target and will ensure that the effluent will not exceed applicable water quality standards or surrogate measures. The process for modifying or adding and WLAs to the TMDL will be handled by DEQ, with input and involvement by the EPA, once a permit request is submitted. Once DEQ determines that the new or expanded discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made. DEQ may allocate none, some, or all of reserve capacity if sufficient capacity is available and an analysis is conducted to demonstrate attainment of the applicable water quality targets, including targets established by California’s North Coast Water Quality Control Board at the Oregon/California border. Table 3-30 to Table 3-32 present the reserve capacity for each TMDL waterbody and the allocations are illustrated graphically in Appendix A and Appendix H.

3.9 Margin of Safety

OAR 340-042-0040(4)(1)

The Clean Water Act requires that each TMDL be established with a margin of safety to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A margin of safety is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (i.e., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions).

A margin of safety may be implicit through the use of conservative assumptions that result in more protective loading capacity, wasteload allocations, or load allocations. The margin of safety may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the margin of safety documented. The margin of safety is not meant to compensate for a failure to consider known sources.

An *implicit* margin of safety has been incorporated into the temperature assessment methodology, resulting in conservative estimates of loads and required reductions:

- The thermal loading capacities were calculated using the lowest flow estimate for each flow condition; however, the loading capacity applies to the entire range of flows within that condition (Appendix H). This approach captures the expected range of flows for each impaired segment. It results in a conservative application of the loading capacity when the observed flow in a specific condition is higher than the lowest flow estimate used in the TMDL calculations.

- Conservative estimates for unmeasured data and inputs were used in the stream temperature simulations (Appendix A). These values often result in higher estimates for existing conditions, resulting in higher estimates for required reductions and excess thermal loads.
- Effective shade targets (and resulting shade estimates) do not explicitly account for natural disturbances (Appendix A). These estimates result in higher estimates for restored shade and set a higher bar to meet the surrogate measures. In reality, natural disturbances will create a variety of tree heights and densities and the natural disturbance processes are generally beneficial to overall salmonid habitat as they may result in pools and refugia. The effective shade targets are not the only implementation strategy available to meet the TMDL; however, it is important to meeting the TMDL.

For further information regarding stream temperature modeling assumptions, refer to Appendix A.

3.10 References

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4. Lost Subbasin Temperature TMDLs

Table 4-1. Summary of Lost subbasin temperature TMDL components.

Waterbodies OAR 340-042-0040(4)(a)	All perennial and intermittent streams, ditches, and canals that discharge within the Lost subbasin (18010204) except for the Mainstem Klamath River (addressed in Chapter 2). This TMDL also includes the entire extent of the Klamath Straits Drain in Oregon and Lost River Diversion Channel.
Designated Beneficial Uses OAR 340-041-0271, Table 180A	The most sensitive designated beneficial uses are fish and aquatic life, and fishing.
Pollutant Identification OAR 340-042-0040(4)(b)	Heat.
Target Identification and Applicable Water Quality Standards OAR 340-042-0040(4)(c) *CWA §303(d)(1)* OAR 340-041-0028(4)(e) OAR 340-041-0028 (9)(a) OAR 340-041-0028 (11) OAR 340-041-0028 (12)(b) California's downstream water quality standards	OAR 340-041-0028(4)(e): (e) **Redband or Lahontan Cutthroat Trout Use**. The seven-day-average maximum temperature of a stream identified as having Lahontan cutthroat trout or redband trout use may not exceed 20.0 degrees Celsius (68.0 degrees Fahrenheit). OAR 340-041-0028 (12)(b)(B) **Human Use Allowance**. Following a temperature TMDL or other cumulative effects analysis, wasteload and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5 Fahrenheit) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact. OAR 340-041-0028 (5) **Unidentified Tributaries**. For waters that are not identified on the "Fish Use Designations" maps referenced in section (4) of this rule, the applicable criteria for these waters are the same criteria as is applicable to the nearest downstream water body depicted on the applicable map. OAR 340-041-0028 (9) (a) **Cool Water Species**. No increase in temperature is allowed that would reasonably be expected to impair cool water species. The numeric benchmark in this TMDL implementing the cool water species narrative is an instream daily maximum temperature target of 28°C. OAR 340-041-0028 (11) (a) **Protecting Cold Water**: Except as described in subsection (c) of this rule, waters of the State that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria in section (4) of this rule, may not be warmed by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This provision applies to all sources taken together at the point of maximum impact where salmon, steelhead or bull trout are present. California Water Quality Standards: It is the policy of Oregon DEQ to achieve water quality standards established by neighboring states in interstate waters.

Existing Sources *CWA §303(d)(1)* OAR 340-042-0040(4)(f)	**Nonpoint sources** include warming from natural sources; excessive inputs of heat caused by the removal or reduction in near-stream vegetation; water management district operations; channel modification; dam and reservoir operation, and hydromodification. These sources are considered nonpoint sources that influence the quantity and timing of heat delivery to downstream river reaches.
Seasonal Variation *40 CFR 130.7(c)(2)* OAR 340-042-0040(4)(j)	Peak temperatures typically occur in mid-July through mid-August. The critical period in this TMDL is June 1 – September 30.
Excess Load OAR 340-042-0040(4)(e)	See Section 4.6.
TMDL Loading Capacity and Allocations *40 CFR 130.2(f)* *40 CFR 130.2(g)* *40 CFR 130.2(h)* OAR 340-042-0040(4)(d), (g), (h), (k)	**Loading Capacity:** See Section 4.5 **Human Use Allowance (All Sources)** – See Section 4.7.1 **Wasteload Allocations (Point Sources)** - See Section 4.7.2 **Load Allocations (Non-Point Sources)** – See Section 4.7.3 **Reserve Capacity** – See Section 4.8
Surrogate Measures OAR 340-042-0040(5)(b) 40 CFR 130.2(i)	**Surrogate Measure – Effective Shade**: Effective shade targets translate nonpoint source load allocations into measurable stream side vegetation targets. **Surrogate Measure – Instream Flow Target**: Instream flow targets translate nonpoint source load allocations for water management districts and Malone and Anderson Rose Dam into measurable flow objectives that maintain and attain the cool water species criterion.
Margins of Safety *40 CFR 130.7(c)(2)* OAR 340-042-0040(4)(i)	The margin of safety is implicit using conservative assumptions.
WQ Standard Attainment Analysis OAR 340-042-040(4)(l)(E) *CWA §303(d)(1)*	Analytical modeling of TMDL loading capacities demonstrates attainment of water quality standards. The Water Quality Management Plan (WQMP) will consist of Implementation Plans and other strategies that contain measures to attain allocations. The TMDL and WQMP will incorporate multiple elements that together will provide reasonable assurance that the TMDL will be implemented. This reasonable assurance and accountability framework is discussed in Chapter 5.
Water Quality Management Plan OAR 340-042-0040(4)(l)	Provided in Chapter 6.

The TMDL analysis in this chapter covers 15 water quality limited segments and upstream waters for temperature in the Lost subbasin (Table 4-2 and Table 4-4). These waterbodies and their TMDL analyses are described below and in the appendices.

Table 4-2. Waterbodies addressed by this TMDL.

Waterbody Name	Watershed (HUC)	Length (River Miles)
Antelope Creek[1]	Rock Creek-Lost River (1801020404)	14.1
Barnes Valley Creek	Gerber Reservoir-Miller Creek (1801020405)	14
Ben Hall Creek	Gerber Reservoir-Miller Creek (1801020405)	8.7
Buck Creek	Yonna Valley-Lost River (1801020407)	11.8
East Branch Lost River	Rock Creek-Lost River (1801020404)	2.4
Klamath Straits Drain	Lower Klamath Lake (1801020414) Lake Ewauna-Klamath River (1801020412)	10.2
Lapham Creek	Gerber Reservoir-Miller Creek (1801020405)	4
Long Branch Creek	Gerber Reservoir-Miller Creek (1801020405)	4.9
Lost River	Rock Creek-Lost River (1801020404) Langell Valley-Lost River (1801020406) Yonna Valley-Lost River (1801020407) Mills Creek-Lost River (1801020409)	60.6
Lost River Diversion Channel	Mills Creek-Lost River (1801020409) Lake Ewauna-Klamath River (1801020412)	7.8
Miller Creek	Gerber Reservoir-Miller Creek (1801020405)	9.6
North Fork Willow Creek	North Fork Willow Creek-Willow Creek (1801020402)	2.3
Rock Creek	Rock Creek-Lost River (1801020404)	4.3
Unnamed (Horse Canyon Creek)	Gerber Reservoir-Miller Creek (1801020405)	2.2

[1] There are two water quality limited segments for Antelope Creek, a 14.1-mile segment and a 1-mile segment. This TMDL covers the full 14.1-mile segment, which is inclusive of the 1-mile segment.

4.1 Designated Beneficial Uses and Water Quality Standards

DEQ monitors the water quality of streams, lakes, estuaries, and groundwater in Oregon. This information is used to determine whether water quality standards are being violated, and consequently, whether the beneficial uses of the waters are impaired. Specific State and Federal plans and regulations are used to determine if violations have occurred. These regulations include the Federal Clean Water Act of 1972 and its amendments Title 40 Code of Federal Regulations 131, Oregon's Administrative Rules (OAR Chapter 340), and Oregon's Revised Statutes (ORS Chapter 468).

4.1.1 Beneficial Uses

DEQ has adopted numeric and narrative water quality standards to protect designated *beneficial use*s in the Klamath River Basin (Administrative Rules OAR 340–041–0180 - 0185, Table 180A, November 2003), and antidegradation policies to protect overall water quality. In practice, water quality criteria have been set at a level to protect the most sensitive beneficial uses and seasonal criteria may be applied for uses that do not occur year-round. The most sensitive beneficial uses relevant to these TMDLs are salmonid fish spawning and rearing and resident fish and aquatic life. Water quality problems are of great concern because of their potential impact on native fish in the Klamath River Basin including the shortnose sucker (*Chasmistes brevirostris*), Lost River sucker (*Deltistes luxatus*), and interior redband trout (*Oncorhynchus mykiss* ssp.). Both sucker species were listed as endangered under the federal Endangered Species Act in 1988 (Williams 1988).

There are many beneficial uses in the Klamath River Basin[1]; however, only a subset apply to temperature impairments in the Lost subbasin tributaries addressed in this TMDL. The beneficial uses affected by excessive temperatures include Fish and Aquatic Life and Fishing (DEQ 2005).

4.1.2 Applicable Water Quality Standards

In order to protect fish and aquatic life uses, Oregon's water temperature criteria (OAR 340-041-0028) primarily use salmonids' life cycles as indicators. If temperatures are protective of these indicator species, other species will share in this protection. They specify where and when the fish use occurs, and, therefore, where and when numeric or narrative criteria apply. The fish use designation map provided in OAR 340-041-0180 Figure 180A is shown in Figure 4-1. All tributaries of the Lost River within the scope of this TMDL chapter (within the light yellow subbasin in Figure 4-1) are designated as "Redband or Lahontan Cutthroat Trout" fish use.

The Lost River, Klamath Straits Drain, and The Lost River Diversion Channel are designated for Cool Water species use. See sections below and Table 4-4 for specific water quality criteria for 303(d) listed waters covered in the Lost River subbasin.

4.1.2.1 Redband or Lahontan Cutthroat Trout Use

Waters that have been designated for redband or Lahontan cutthroat trout use are identified in OAR 340-041-0180 Figure 180A and is shown in Figure 4-1. The applicable criterion for these streams is a year-round 20°C expressed as a seven-day average of daily maximum temperature (7DADM).

[1] https://www.oregon.gov/deq/Rulemaking%20Docs/table180a.pdf

4.1.2.2 Protecting Cold Water

The protecting cold water criterion in OAR 340-041-0028(11) applies to waters of the state that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria (i.e. 20°C Redband or Lahontan Cutthrout Trout use). With some exceptions, these waters may not be warmed by anthropogenic nonpoint sources by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This applies to all anthropogenic nonpoint sources taken together at the point of maximum impact where salmon, steelhead or bull trout are present.

4.1.2.3 Human Use Allowance

Oregon water quality standards also have provisions for human use (OAR 340-041-0028(12)(b)). The human use allowance is an insignificant addition of heat (0.3° C) authorized in waters that exceed the applicable temperature criteria. The applicable temperature criteria is defined in OAR 340-041-0002(4) to mean “the biologically based temperature criteria in OAR 340-041-0028(4), or the superseding cold water protection criteria in 340-041-0028(11)”. Following a temperature TMDL or other cumulative effects analysis, wasteload and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5 Fahrenheit) above the applicable biological criteria after complete mixing in the water body, and at the point of maximum impact. The rationale behind selection of 0.3 deg-C for the human use allowance and how DEQ implements this portion of the standard can be found in DEQ (2003) and the Temperature IMD (DEQ 2008).

Note that the cool water species criterion is not considered a biologically based numeric criterion so the human use allowance provision does not apply to waters designated for this use. Warming from human sources is limited where needed in order to achieve the temperature target implementing the cool water species narrative criterion.

4.1.2.4 Cool Water Species

Waters that have been designated for cool water species use in the Lost subbasin include the Lost River, Klamath Straits Drain, and the Lost River Diversion Channel.

The Cool Water Species criteria rule in OAR 340-041-0028(9)(a) states that “No increase in temperature is allowed that would reasonably be expected to impair cool water species.” The criteria apply to all sources from June 1 – September 30.

The Department has determined that Lost River and shortnose suckers are the most sensitive cool water species that may be present in reaches designated for cool water species. A review of available studies evaluating the temperature tolerance of Lost River and shortnose suckers was completed in order to identify a numeric TMDL temperature target to implement the cool water species narrative rule. A summary of the studies reviewed follows.

Castleberry and Cech (1993) reported a critical thermal maximum of 32.7°C for juvenile shortnose suckers. The critical thermal maximum was determined by gradually increasing temperature over a period of several minutes to a few hours until loss of equilibrium or death occurred.

Bellerud and Saiki (1995) found that in 96 hour exposure tests complete survival of Lost River juveniles, shortnose juveniles, and shortnose larvae occurred at temperatures below 28.1°C, 30.7°C, and 30.8 °C respectively. The full results for this study appear to also be summarized by Saiki et al. (1999) in a per reviewed journal article (next paragraph).

Saiki et al. (1999) calculated the upper median lethal tolerance limit (LC_{50}) from exposures lasting 24 hours, 48 hours, 72 hours, and 96 hours. Their results are reproduced in Table 4-3. Generally speaking the minimum reported LC_{50} lethal temperature within the confidence interval was 29.4°C for shortnose juveniles. Saiki et al. (1999) also reported that fish exposed to the highest temperature treatments (32.5°C – 33.8°C) all died within one hour.

Table 4-3. Upper median lethal temperature tolerance limits for Lost River and shortnose suckers as reported by Saiki et al. (1999).

Species and Life Stage	Mean LC_{50} (95% confidence intervals) after each exposure time (Celsius)			
	24 hours	48 hours	72 hours	96 hours
Lost River Larvae	31.9 (31.8-32.0)	31.8 (31.7-32.0)	31.8 (31.6-32.0)	31.7 (31.5-31.9)
Lost River Juveniles	30.8 (30.0-31.5)	30.8 (30.0-31.5)	30.6 (30.0-31.3)	30.5 (30.0-31.0)
Shortnose Larvae	31.8 (31.7-32.0)	31.8 (31.7-32.0)	31.8 (31.7-32.0)	31.8 (31.7-31.9)
Shortnose Juveniles	31.1 (29.4-32.8)	30.3 (29.4-31.3)	30.3 (29.4-31.3)	30.3 (29.4-31.3)

Loftus (2001) concluded that 28°C is a high stress threshold for the Lost River Sucker and Shortnose Sucker.

The U.S. Fish and Wildlife Service recommended 28°C as a primary constituent element temperature threshold for Lost River sucker and shortnose suckers in their final critical habitat designation (USFWS 2012). The U.S. Fish and Wildlife Service also found temperatures above 28°C are likely to adversely affect Lost River sucker and shortnose sucker in their biological opinion evaluating USEPA’s approval of Oregon’s Temperature Standards (USFWS 2015).

Based on review of available tolerance information and recommendations from U.S. Fish and Wildlife Service, DEQ believes that water temperatures greater than 28°C result in impairment to Lost River and shortnose suckers. Lost River modeling demonstrates temperatures may actually exceed 32°C as a daily maximum. To be protective, the TMDL target will be expressed as a daily maximum instead of the 7-day average of the daily maximums. This ensures river temperatures do not reach levels that would adversely affect and impair Lost River Sucker and Shortnose Sucker.

Therefore, the numeric benchmark in this TMDL implementing the cool water species narrative criterion designated on the Lost River, Klamath Straits Drain, and Lost River Diversion Channel is an instream daily maximum temperature target of 28°C. Where the cool water species criterion applies, warming from anthropogenic sources shall be limited in order to attain and maintain temperatures no greater than 28°C.

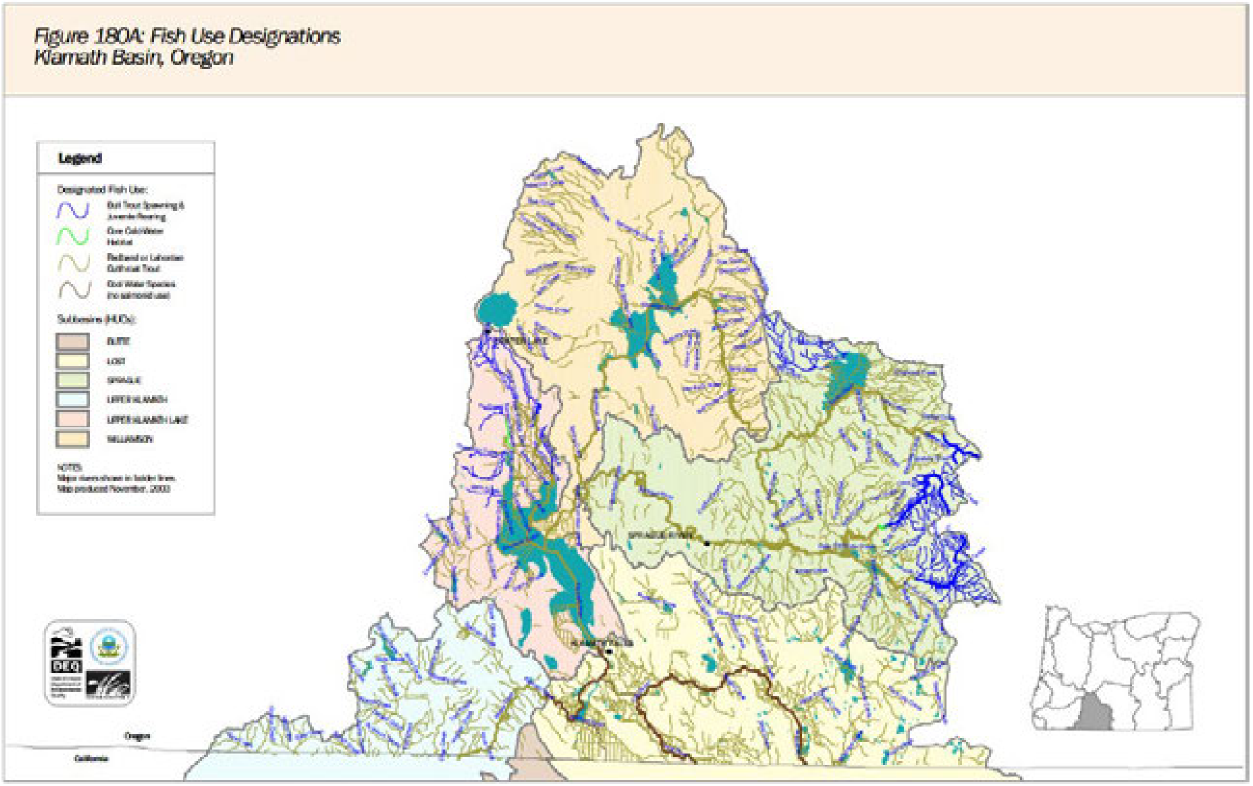

Figure 4-1. Oregon fish use designations for the Klamath basin[2]

4.1.2.5 State of California Water Quality Standards

In addition to the Oregon water quality standards, the mainstem Lost River is subject to downstream temperature targets. In 2006, California delisted the Lost River for temperature. California's downstream water quality criteria for the Lost River are based on the Water Quality Control Plan for the North Coast Region (the Basin Plan) (NCRWQCB 2018a). The temperature objective contained in the Basin Plan says: "The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses" (NCRWQCB 2018a). An estimate of natural receiving water temperatures in the Lost River is difficult because the Lost River system has been highly modified dating back to the early 1900s. The temperatures necessary to support the most sensitive beneficial use in the Lost River is used as a surrogate for an estimate of natural temperatures. The most sensitive beneficial use of the Lost River is use by the Lost River Sucker, a threatened and endangered species found in the Lost River watershed. A 2017 DEQ memorandum identified water temperatures greater than a 7DADM of 28°C as the threshold above which the Lost River Sucker (and Shortnose Sucker) would reasonably be expected to be impaired. Based on these findings and for the purpose of Oregon's Lost River TMDL for temperature, California's North Coast Water Board concluded that a 7DADM temperature of 28°C is a reasonable numeric criterion by which to interpret the Basin Plan's narrative temperature objective for the Lost River as it re-enters California from Oregon. Because the criterion represents the threshold above

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[2] http://www.oregon.gov/deq/Rulemaking%20Docs/figure180a.pdf

which impairment can reasonably be expected, there is no allowable increase above a 7DADM temperature of 28°C (Mangelsdorf 2018). See Appendix E for more details about the water quality criterion for the Lost River.

The North Coast Regional Water Quality Control Board has outlined for DEQ in a memorandum (Creager et al. 2019) the water quality targets on Lost subbasin tributaries impaired for temperature flowing directly to California. The tributaries include Rock Creek, North Fork Willow Creek, and the East Branch Lost River.

Water temperature objectives for ambient waters in California immediately south of the border with Oregon are contained in the North Coast Regional Water Quality Control Board's Water Quality Control Plan for the North Coast Region. This plan is commonly referred to as the Basin Plan (NCRWQCB 2018b).

All Oregon tributaries impaired for temperature draining directly to California, including, Rock Creek, North Fork Willow Creek, and the East Branch Lost River, are in hydrologic areas that have existing or potential beneficial uses as COLD interstate waters. "COLD" refers to water designated as Cold Freshwater Habitat in the Basin Plan (NCRWQCB 2018b). Therefore, the applicable downstream water quality objective is "Elevated temperature waste[3] discharges into cold interstate waters are prohibited" (California State Water Board 1998). In regard to the interstate tributaries in the Lost River subbasin, California's North Coast Water Board concluded that a 7DADM temperature of 20°C is a reasonable numeric criterion to protect redband trout in the downstream waters in California. If the natural temperatures of Lost River tributaries exceed this threshold then the Basin Plan holds that no controllable factors shall contribute to any further warming. "Controllable water quality factors are those actions, conditions, or circumstances resulting from human activities that may influence the quality of the waters of the state and that may be reasonably controlled." This means that when natural water temperatures are warmer than the basin objectives, controllable warming is prohibited.

4.1.3 Impaired Waterbodies and 303(d) Listings

Section 303(d) of the Federal Clean Water Act (1972) requires that waterbodies that exceed water quality criteria, thereby failing to fully protect *beneficial uses*, be identified and placed on a 303(d) list[4]. Monitoring has indicated that water temperatures in the Lost subbasin exceed the state of Oregon temperature criteria with 13 individual temperature listings equaling 140.6 miles. These tributaries to the Lost River and the Lost River itself are identified in Table 4-4. This table also identifies the applicable criterion for each segment.

[3] From State Water Board (1998): Liquid, solid, or gaseous material including thermal waste discharged at a temperature higher than the natural temperature of receiving water. Irrigation return water is not considered elevated temperature waste for the purpose of this plan.

[4] For specific information regarding Oregon's 303(d) listing procedures, and to obtain more information regarding the Klamath River basin 303(d) listed streams, visit the Oregon Department of Environmental Quality's web page at https://www.oregon.gov/deq/wq/Pages/WQ-Assessment.aspx.

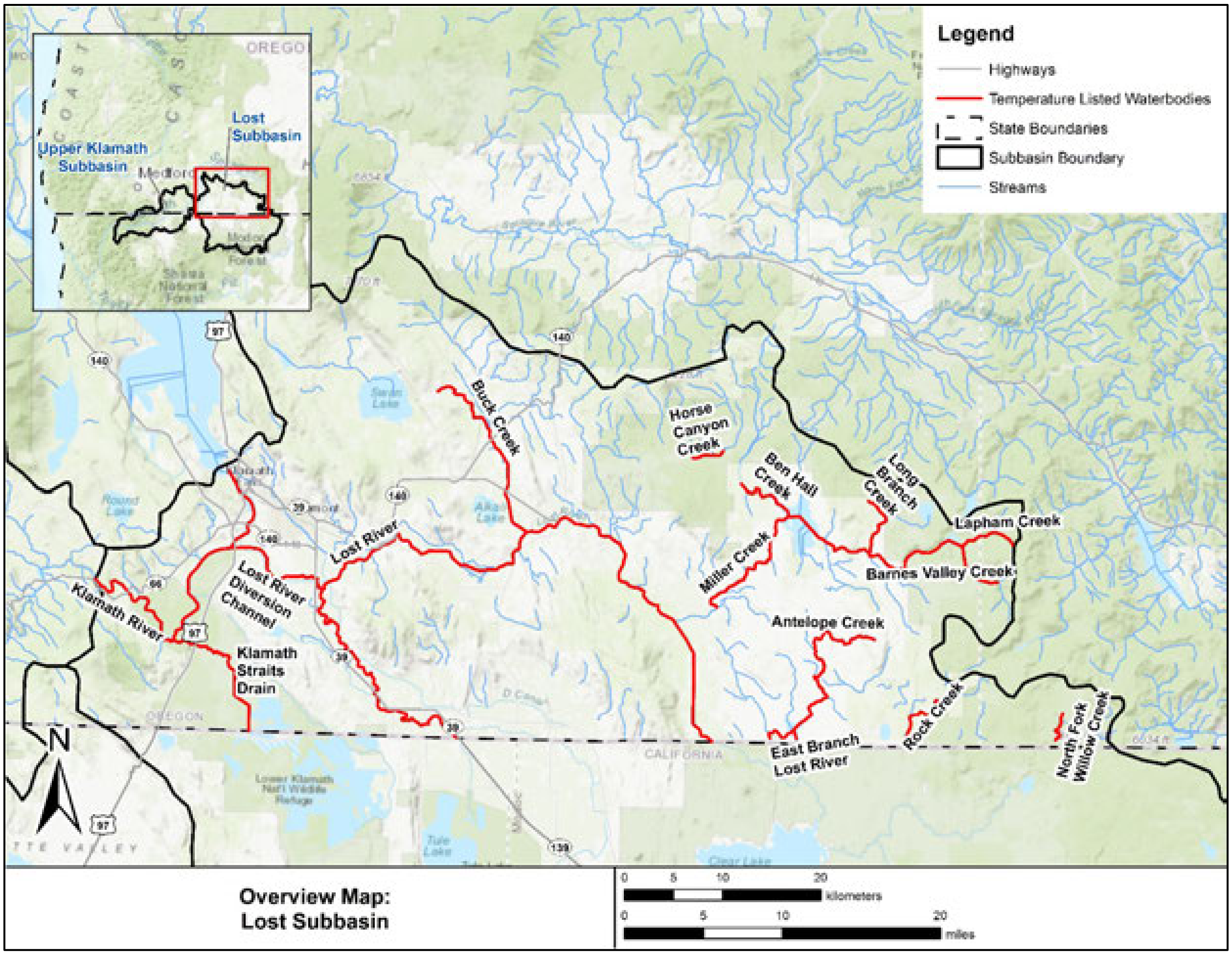

Figure 4-2. Oregon water quality limited segments in the Lost subbasin.

Table 4-4. Water quality limited segments for temperature in this TMDL and their water quality criteria (final 2012 303(d) list).

303(d) ID	Waterbody Name	LLID	River Mile	Use: Applicable Criterion (°C as 7DADM)
24458	Antelope Creek	1211052420002	0 to 14.1	Redband trout: 20.0 7DADM
2182	Antelope Creek	1211052420002	2 to 3	Redband trout: 20.0 7DADM
12738	Barnes Valley Creek	1210575421742	0 to 14	Redband trout: 20.0 7DADM
12737	Ben Hall Creek	1210575421741	0 to 8.7	Redband trout: 20.0 7DADM
12766	Buck Creek	1214385421880	0 to 12.8	Redband trout: 20.0 7DADM
24459	East Branch Lost River	1211376420003	0 to 2.4	Redband trout: 20.0 7DADM
NA	Klamath Straits Drain	1218729420836	0 to 9.8	Cool water: 28.0 daily maximum
12726	Lapham Creek	1209025421777	0 to 4	Redband trout: 20.0 7DADM
12732	Long Branch Creek	1210179421718	0 to 4.6	Redband trout: 20.0 7DADM
24463	Lost River	1212146420011	4.8 to 65.4	Cool water: 28.0 daily maximum
NA	Lost River Diversion Channel	1217911421801	0 to 7.9	Cool water: 28.0 daily maximum
1993	Miller Creek	1212045421207	0 to 9.6 (3.1 to 12.7)[5]	Redband trout: 20.0 7DADM
1994	North Fork Willow Creek	1207871420005	0 to 2.3	Redband trout: 20.0 7DADM
12729	Rock Creek	1209316420368	0 to 4.3	Redband trout: 20.0 7DADM
2166	Unnamed (Horse Canyon Creek)	1212355422566	0 to 2.2	Redband trout: 20.0 7DADM

[5] The final 2012 303(d) list identifies Miller Creek as impaired for temperature from river mile 0 to 9.6. We believe the river miles are incorrect and instead should be 3.1 to 12.7. The source of the inconsistency is likely the GIS stream features used when Miller Creek was originally assessed and first listed as impaired for temperature in the 1998 303(d) list. The GIS features used for that assessment identify the portion of Miller Creek downstream of Pine Creek as an "Unnamed Stream" with a different LLID number. This is likely why river mile zero was assumed to start at the confluence with Pine Creek.

4.2 Subbasin Characterization

The Lost subbasin is part of the larger Klamath River basin (Figure 1-1). The Klamath River basin is of vital economic and cultural importance to the states of Oregon and California, as well as the Klamath Tribes in Oregon; the Hoopa, Karuk, and Yurok tribes in California; the Quartz Valley Indian Reservation in California, and the Resighini Rancheria in California. It provides fertile lands for a rich agricultural economy in the upper basin. Irrigation facilities known as the Klamath Project owned by the U.S. Bureau of Reclamation support this economy as well as hydroelectric power provided via a system of five dams operated by PacifiCorp. Historically, the basin once supported vast spawning and rearing fishery habitat with cultural significance to the local Indian tribes. The watershed supports an active recreational industry. Finally, the watershed continues to support what were once historically significant mining and timber industries.

The following sections discuss characteristics of the region. Either the Lost subbasin or the larger Klamath River basin is discussed in each section below, depending on the scale of the characteristic being discussed.

4.2.1 Lost Subbasin Location and Description

The Lost subbasin straddles the Oregon-California border. The headwaters of the Lost River lie within California. The Lost River drainage originates in tributaries to Clear Lake in California, continues north into Oregon, and then loops to the south and ends in California at Tule Lake. The area of the Lost subbasin in Oregon and included in this TMDL is 842,901 acres (1,289 mi^2). The basin includes the Klamath Falls Lakeview Forest State Park and parts of the Fremont and Winema national forests. There are many tributaries to the Lost River and the river is channelized, including several impoundments to facilitate water storage and support diversion canals and return flow drains. The largest city in the area is Klamath Falls with a population of 20,840 in 2010 and an estimated current population of 21,359 (U.S. Census Bureau 2018).

4.2.2 Ecoregions

The Lost subbasin is located in the Eastern Cascades Slopes and Foothills Ecoregion in the rainshadow of the Cascade Range (Thorson et al. 2003). The ecoregion experiences greater temperature extremes and receives less precipitation than ecoregions to the west. The dominant vegetation includes open forests of ponderosa pine and some Lodgepole pine. The vegetation is adapted to the prevailing dry, continental climate and frequent fire. Historically, creeping ground fires consumed accumulated fuel, while crown fires were less common.

Within the Eastern Cascades Slopes and Foothills Ecoregion, the Lost subbasin is dominated by the Klamath Juniper Woodland, Klamath/Goose Lake Basins and Fremont Pine/Fir Forest ecoregions, with smaller areas of Southern Cascades Slope and Pumice Plateau ecoregions (Thorson et al. 2003).

The Klamath Juniper Woodland ecoregion is composed of undulating hills, benches, and escarpments covered with a mosaic of rangeland and woodland (Thorson et al. 2003). Western juniper grows on shallow, rocky soils with an understory of low sagebrush, big sagebrush, bitterbrush, and bunchgrasses. Other shrubland/grasslands include shrub species such as woolly wyethia, Klamath plum, and birchleaf mountain mahogany. The diverse shrublands provide important wildlife habitat.

The Klamath/Goose Lake Basins ecoregion covers river floodplains, terraces, and lake basins (Thorson et al. 2003). A variety of wildrye, bluegrass, and wheatgrass species once covered the basins, but most of the wet meadows and wetlands have been drained for agriculture.

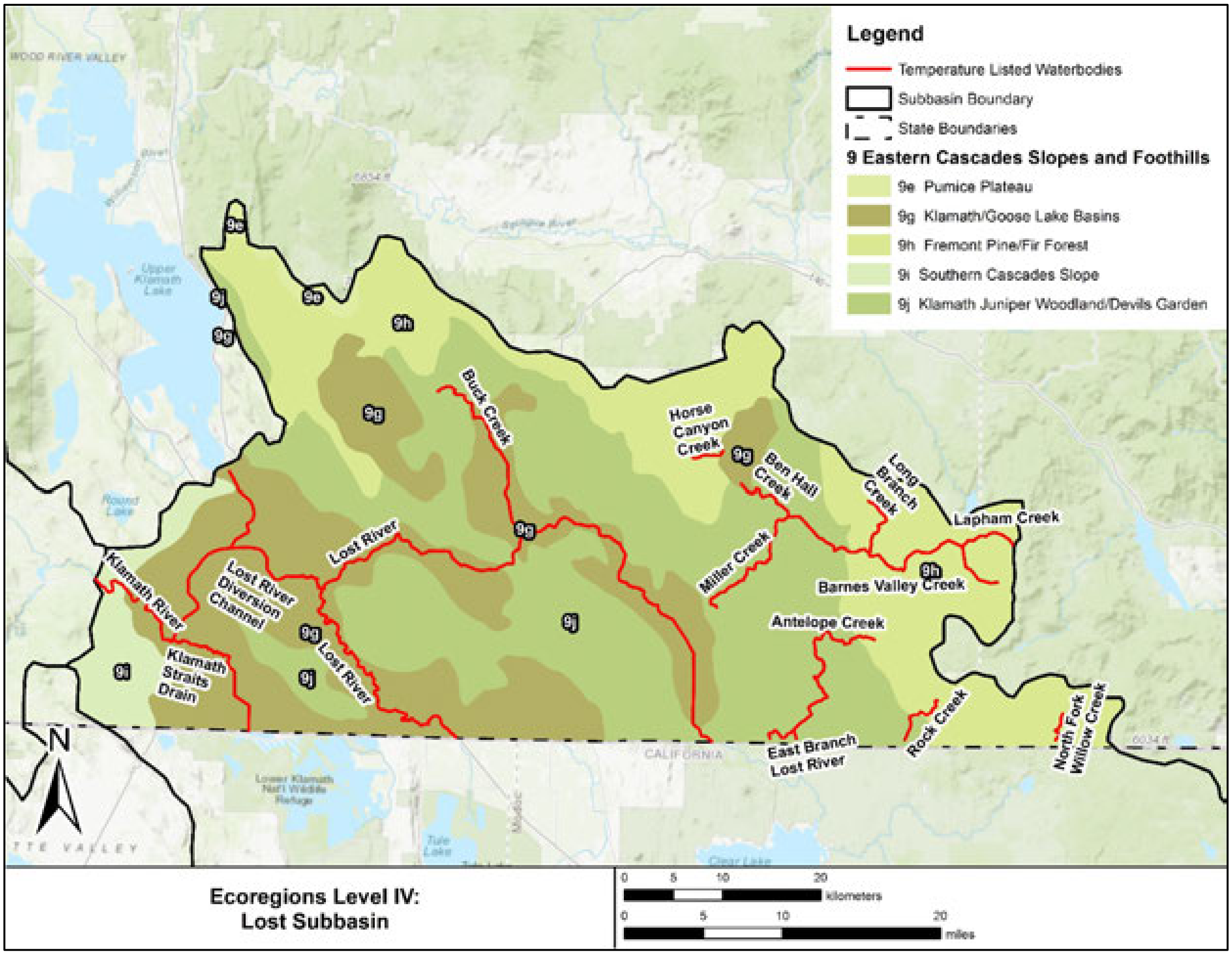

Figure 4-3. Ecoregions of the Lost subbasin

The Fremont Pine/Fir Forest ecoregion contains mid-elevation mountains and high plateaus that rarely exceed timberline (Thorson et al. 2003). Ponderosa pine is common in this ecoregion, but white fir, sugar pine, and incense cedar also grow at higher elevations (above 6,500 feet and on north slopes). This ecoregion also has a high density of lakes and reservoirs.

4.2.3 Soils and Geology

4.2.3.1 Soils

Data from the Natural Resources Conservation Service were used to characterize soils in the Lost subbasin. The soil data set is a combined coverage including detailed Soil Survey Geographic Database (SSURGO) data where available and State Soil Geographic Database (STATSGO) data when SSURGO data were not available (NRCS 2017a, 2017b).

The Hydrologic Soil Group classification is a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have lower infiltration rates, while sandy soils that are well drained have the greatest infiltration rates. NRCS has defined four hydrologic groups for soils (Table 4-5). The majority of the soils in the Lost subbasin belong to Hydrologic Soil Group D (40 percent of the drainage area) and Hydrologic Soil Group B (37 percent of the drainage area). Group B soils are moderately well drained, while Group D soils have high runoff potential and very low infiltration rates with a clay layer at or near the surface. The rest of the watershed consists of Hydrologic Soil Groups A (5 percent), B/D (1 percent), C (9 percent) and C/D (7 percent). The remaining one percent of the watershed is lacking Hydrologic Soil Group data. Table 4-6 and Figure 4-4 summarize the Lost subbasin soil information.

Table 4-5. Characteristics of hydrologic soil groups. Source: NRCS 1972

Hydrologic Soil group	Characteristics	Minimum infiltration capacity (inches/hour)
A	Sandy, deep, well-drained soils; deep loess; aggregated silty soils	0.30 to 0.45
B	Sandy loams, shallow loess, moderately deep and moderately well-drained soils	0.15 to 0.30
C	Clay loam soils, shallow sandy loams with a low permeability horizon impeding drainage (soils with a high clay content), soils low in organic content	0.05 to 0.15
D	Heavy clay soils with swelling potential (heavy plastic clays), water-logged soils, certain saline soils, or shallow soils over an impermeable layer	0.00 to 0.05

Table 4-6. Soil distribution in the Lost subbasin.

Hydrologic Soil Group	Area (acres)	Percent Area
A	39,298	5
B	302,955	37
B/D	11,792	1
C	76,843	9
C/D	58,213	7
D	331,110	40
Null	10,979	1

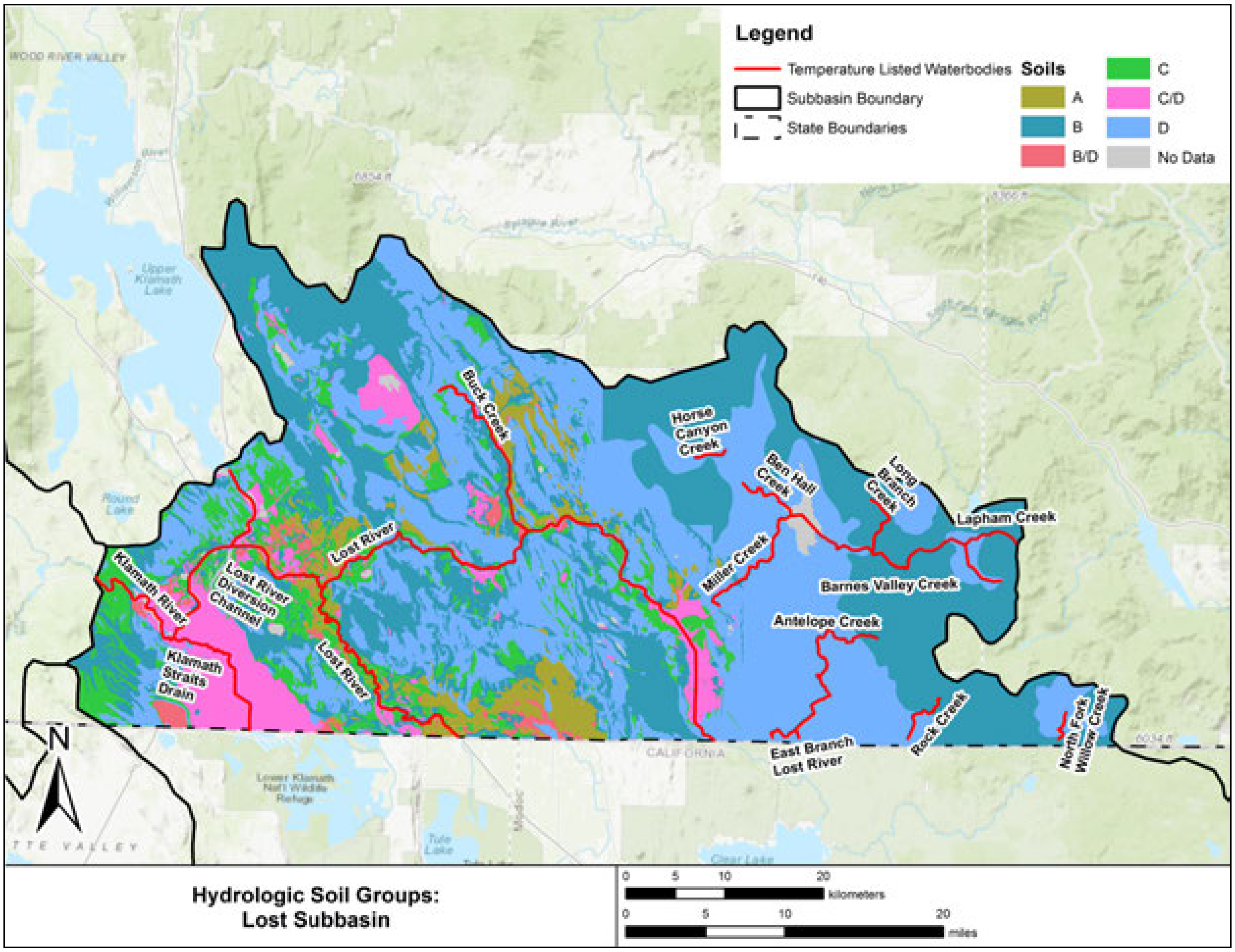

Figure 4-4. Soils in the Lost subbasin (NRCS 2017a, 2017b).

4.2.3.2 Geology

The Klamath River watershed crosses four geomorphic provinces. From east (upstream) to west (downstream) these provinces are the Modoc Plateau, Cascade Range, Klamath Mountains, and Coast Ranges (Figure 4-5). The geology of the Klamath basin (including the Klamath river and the Lost subbasins) within Oregon has been dominated by volcanic activity for the past 35 million years. The Western Cascades subprovince of the Cascade consists of lava flows, andesitic mudflows, tuffaceous sedimentary rocks and vent deposits. The rocks range in age from 20 to 33 million years and have very low permeability, which retards the movement of groundwater flow (Gannett et al. 2007). The High Cascade subprovince overlies the Western Cascades subprovince and range in age from 7 million years to recent. Deposits consist of volcanic vents and lava flows. The High Cascades rocks are relatively permeable compared to the underlying older rocks.

The major water-bearing rocks in the Klamath River basin in Oregon are the late Miocene to Pliocene volcanic rocks of the Basin and Range Province (Gannett et al. 2007). The Basin and Range Province extends over much of the Western US and is characterized by down-dropped basins separated by fault-block ranges. Although the Basin and Range province is primarily a structural feature, faulting has been accompanied by widespread volcanism with rocks consisting of volcanic vent deposits and flow rocks located east of Upper Klamath Lake and

Lower Klamath Lake (DOGAMI 2008). These features probably underlie most of the valley and basin-fill deposits (Gannett et al. 2007).

Pliocene (5 million years before present) to Recent (age) deposits comprise the youngest rock in the study area, consisting of alluvium, basin-fill, and glacial drift and outwash. Alluvium thickness reaches 1,740 feet in the historic Tule Lake Valley, and Lower Klamath Lake basins.

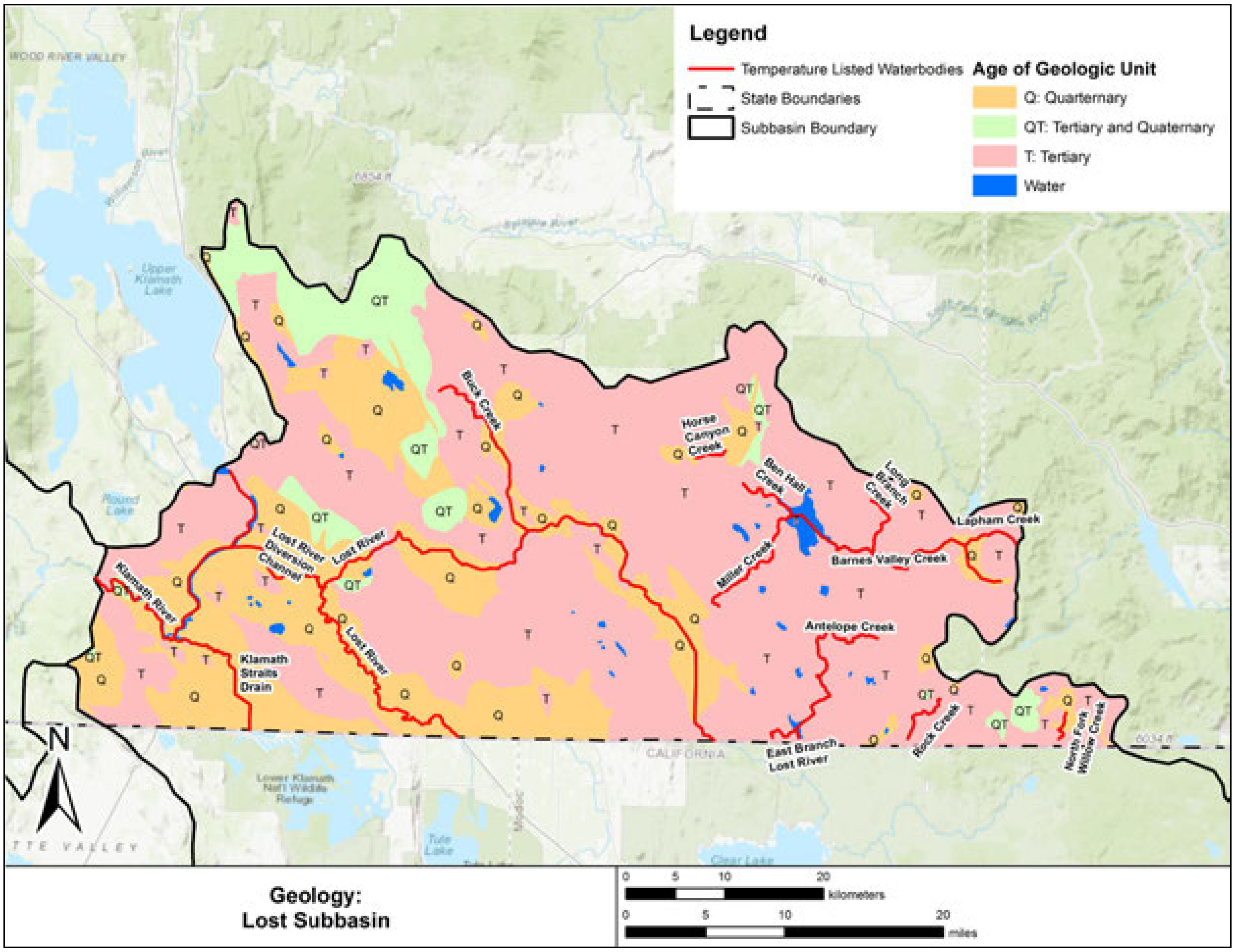

Figure 4-5. Geologic map of the Lost subbasin.

4.2.4 Climate

The great geographic extent and topographic relief of the Klamath River basin produces a wide variety of climatological conditions. The climate is characterized by dry summers with high daytime temperatures, and wet winters with moderate to low temperatures. Due to its location, approximately 120 miles east of the Cascade Mountain Range, it is in the path of storms originating in the north Pacific Ocean. Winter precipitation is derived from these storms traversing in an easterly direction. The Cascade Range creates a rain shadow that affects the distribution of precipitation throughout the subbasin. Over two-thirds of the annual precipitation falls between October and March. Wintertime produces a snowpack in the higher mountain ranges that feeds streamflow in many lower areas through the summer.

Climate data (air temperature and precipitation) representative of the TMDL area were available from the Klamath Falls, Oregon AgriMet Weather Station (KFLO) from March 1999 to present (Figure 4-6). Mean annual temperature is about 47°F. The coldest month is January with a mean temperature of 27°F. The warmest month is July with a mean temperature of 69°F. The mean annual precipitation from 1999 to 2017 was 11.3 inches, but local averages in the basin range from as little as 10 inches to more than 60 inches in mountains (Figure 4-7).

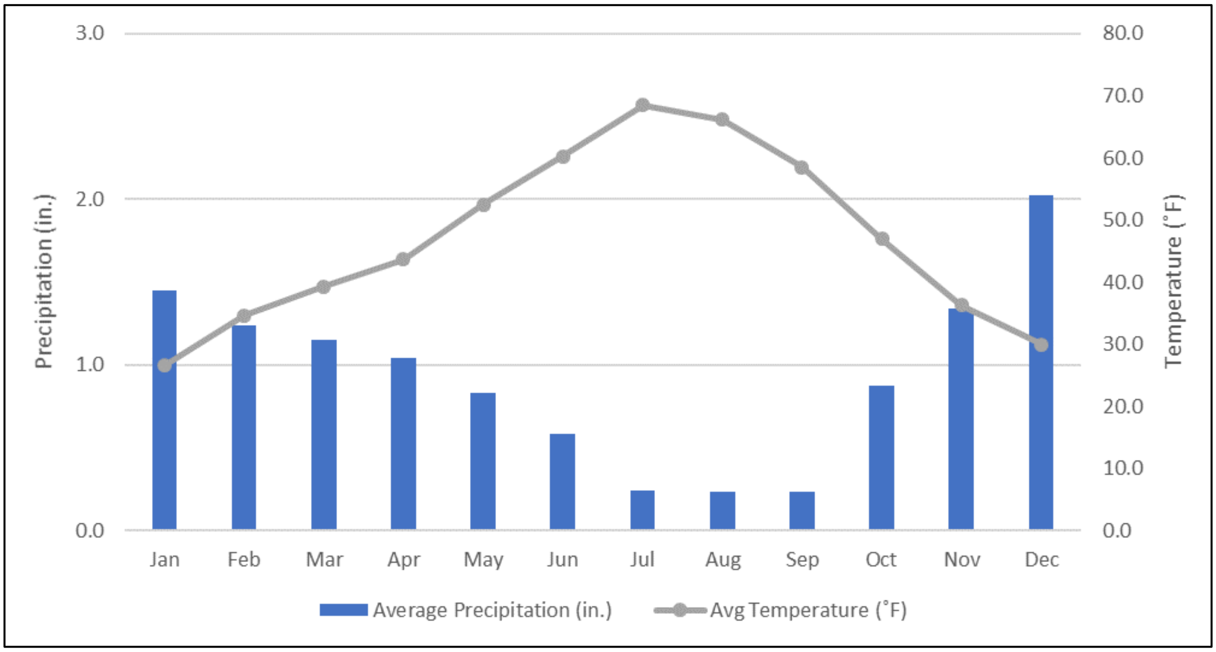

Figure 4-6. Climate summary – Klamath Falls, Oregon (KFLO 1999-2017).

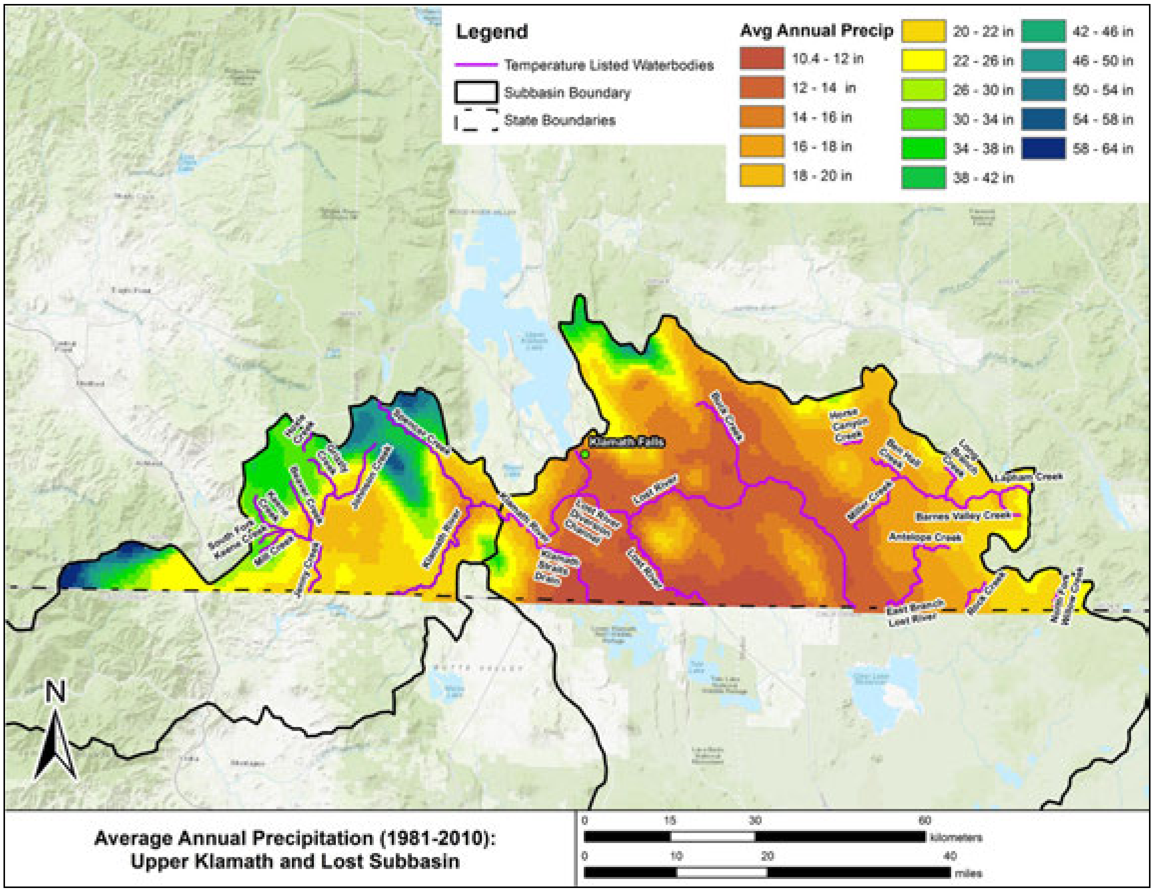

Figure 4-7. Average annual precipitation in the Upper Klamath and Lost subbasins in inches (1981-2010).

4.2.5 Land Use

All land uses and ownerships are included in this TMDL: lands managed by the State of Oregon, U.S. Bureau of Reclamation, irrigation and drainage districts, the U.S. Forest Service and U.S. Bureau of Land Management, private forestlands, agricultural lands, rural residential, transportation uses and urbanized areas.

Land ownership in the Lost subbasin is comprised of 64 percent private, 35 percent federally managed, and 1 percent state managed. Spatial distribution of land ownership in the Lost subbasin is displayed in Figure 4-8.

Land use related to agriculture in the Lost subbasin is approximately 24 percent. The rest of the subbasin is dominated by evergreen forest, scrub/shrub and grassland (70 percent). Three percent of the area is developed. Figure 4-9 shows the spatial distribution of major land use/cover types for the Lost subbasin.

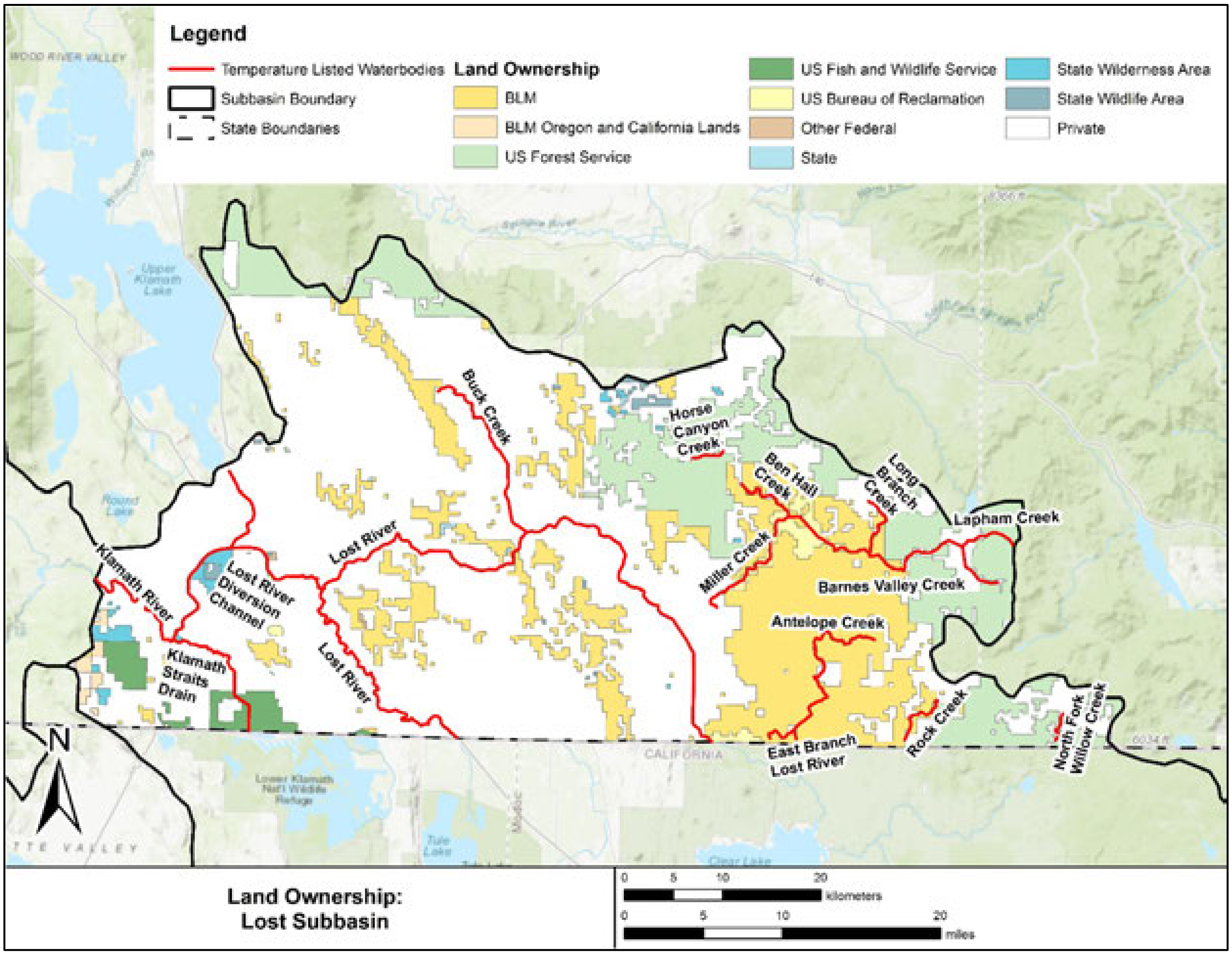

Figure 4-8. Land ownership distribution in the Lost subbasin.

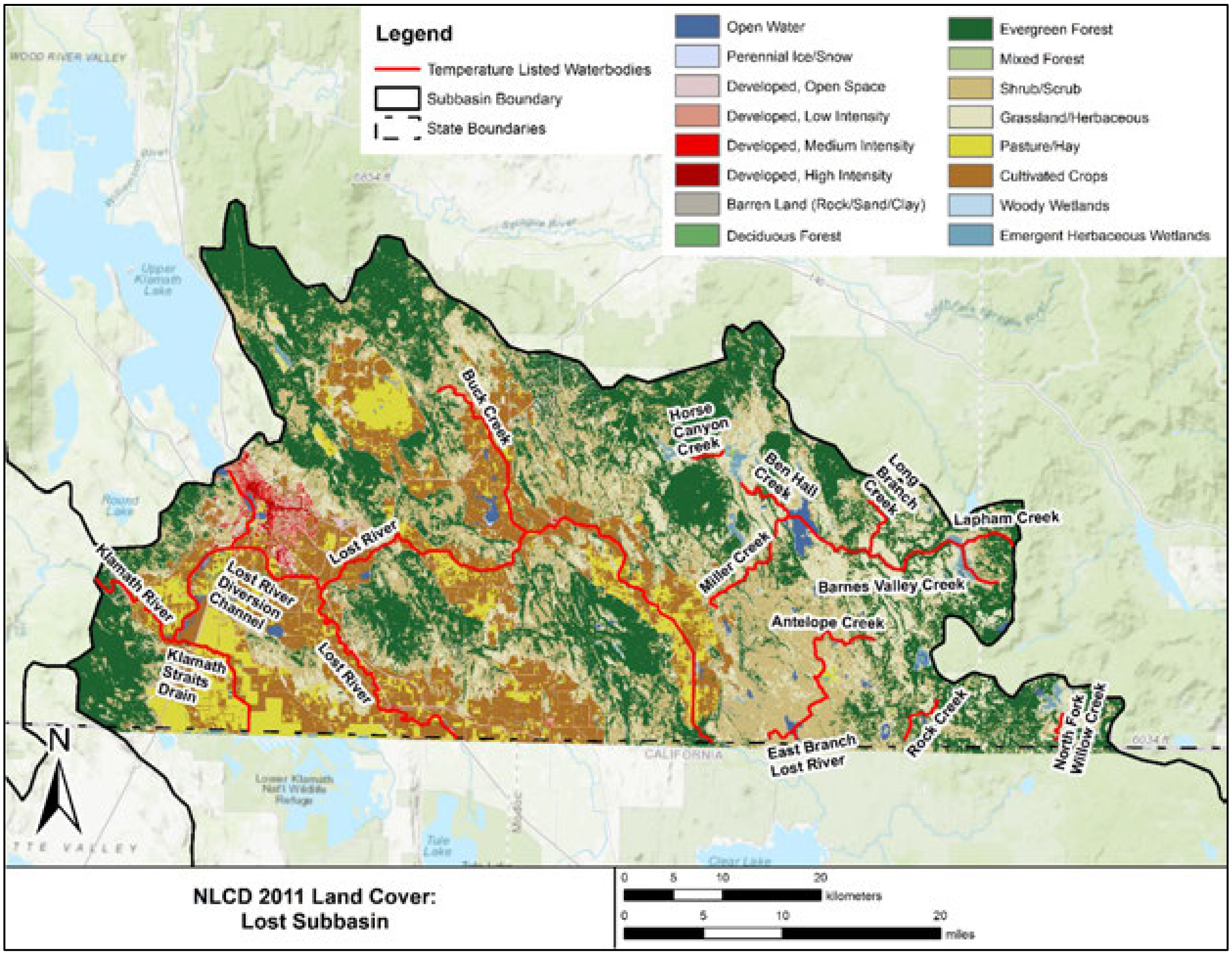

Figure 4-9. Land use and land cover distribution in the Lost subbasin.

4.2.6 Hydrology (Streamflow)

The Lost subbasin straddles the Oregon-California border. The headwaters of the Lost River lie within California. Many of the tributaries impaired for temperature are on the eastern portion of the drainage area and some drain directly into California. Gerber Reservoir receives drainage from many of the impaired segments and subsequently influences the flow in Miller Creek before its flow eventually reaches the Lost River through canals.

Prior to development of the Klamath Reclamation Project, the Klamath River and Lost River drainages were connected via the Lost River Slough, which occasionally allowed water from the Klamath River into the Lost River (NRC 2004). The Lost River drainage originates in tributaries to Clear Lake and terminus (Tule Lake) both being located in California with the river reach linking the two through the state of Oregon. Along its course, the Lost River gains water from several tributary sources, including Miller Creek and Buck Creek. The mainstem of the Lost River is highly channelized and includes several impoundments (Harpold Dam, Wilson Diversion Dam, and Anderson Rose Dam) for water storage and to support diversion canals and return flow drains. To facilitate irrigation water delivery and flood control, water from the Lost River drainage can be discharged to Keno Reservoir through the Klamath Straits Drain, and the Lost River Diversion Channel (Figure 4-10).

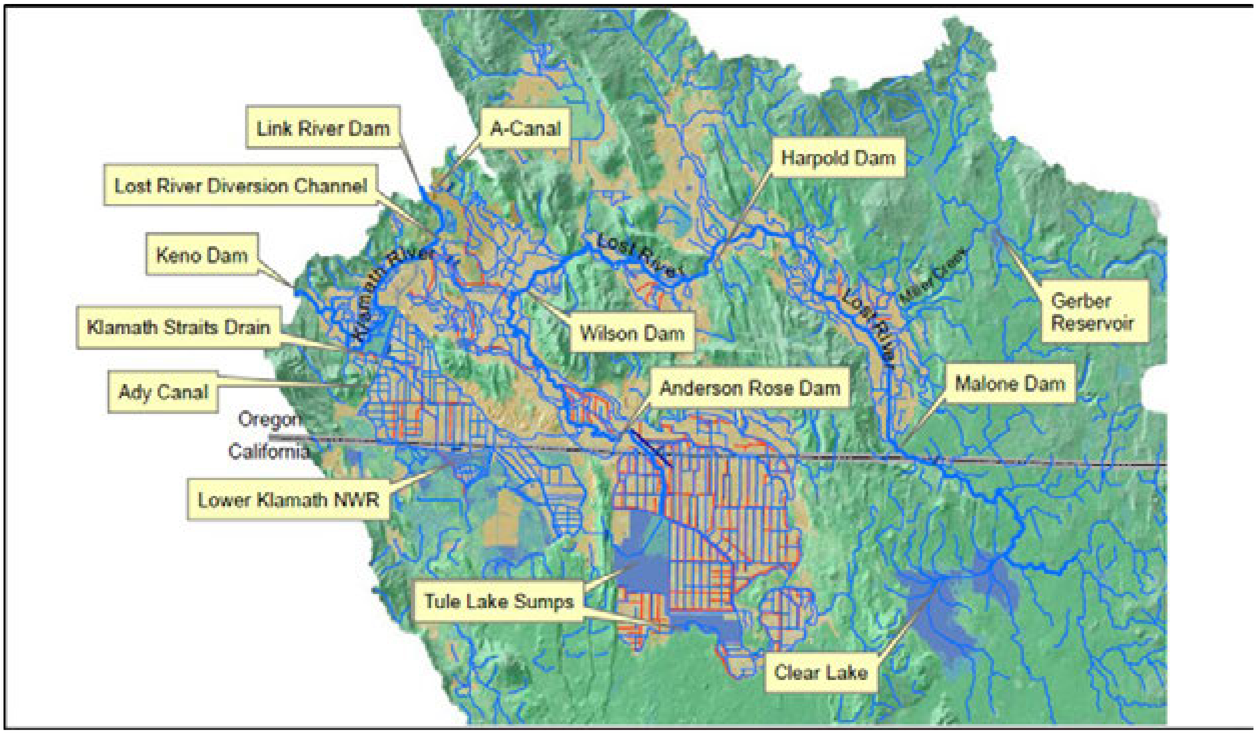

Figure 4-10. Lost River and major hydrologic features.

Water surface elevations in Lower Klamath Lake and upstream along the channel of the Klamath River to the outlet of Lake Ewauna were historically controlled by a natural basalt reef in the channel at Keno. A similar bedrock reef at the outlet of Lake Ewauna held upstream water surface elevations about 1 foot higher, more or less, at low flow. At higher flows, backwater in Lower Klamath Lake was stored within the lake which raised the water surface elevation, thereby inundating Lake Ewauna, which then became a continuous part of Lower Klamath Lake. Just at the outlet of Lake Ewauna, a natural overflow channel, the Lost River Slough also carried water out of the lake system when the water surface exceeded elevation 4,085 feet (USBR 2008). The decision to drain and reclaim Tule Lake and Lower Klamath Lake for agricultural production resulted in substantial alteration to the hydrology of the Lost River watershed. Figure 4-11 depicts the hydrology of the Lost River prior to the draining of Lower Klamath Lake, based on survey collected in the 1890s.

Figure 4-11. Lower Klamath Lake and Tule Lake drainages 1905 (USRS 1905).

4.2.6.1 Klamath Reclamation Project

The Klamath Reclamation Project delivers water to approximately 200,000 acres comprised of 130,000 acres in Oregon and 70,000 in California (Carlson and Todd 2003). The project supplies water to 63 percent of the 2,239 farms in the Klamath basin and up to 80 percent of all irrigated farms in the Klamath basin. Principal crops grown in the Project area include alfalfa hay, pasture (for beef), barley, potatoes, and wheat. Other crops include oats, onions, peppermint, and horseradish. This section presents features of the Klamath Reclamation Project identified in Figure 4-10, which influence hydrology in both the Lost River and Upper Klamath subbasins.

The A Canal, constructed in 1905, was the first irrigation canal completed on the Klamath Project. The canal supplies water through subsidiary lateral canals and drains to the majority of the Project. Water diversions through the A-Canal can be as high as 1,000 cubic feet per second with the average summer diversion rate ranging from 600-800 cubic feet per second.

Clear Lake is located in California and provides storage for irrigation. The Clear Lake dam was originally constructed in 1910 (and rebuilt in 2003) to prevent the re-inundation of former wetlands in the Tule Lake area by providing a shallow reservoir to enhance evaporation. Annual evaporation and seepage loses from this lake account for over half of the average inflow of water to Clear Lake.

Gerber Reservoir is located on Miller Creek holds an active capacity of 94,270 acre-feet. Construction of the Gerber Dam was completed in 1925. The reservoir is used to store seasonal runoff to meet irrigation needs (17,000 acres) primarily for the Langell Valley Irrigation District. Average releases from Gerber Reservoir for water years 1991 to 2000 were 41,000 acre-feet. Average inflow to the reservoir is approximately 55,000 acre-feet.

The Lost River Diversion Channel begins at the Lost River Diversion Dam and ends at the confluence with the Klamath River. It was constructed in 1912 and improved in 1948. The channel is capable of moving water from the Klamath River during irrigation season, or from the Lost River during periods of high flow in the Lost River drainage. During irrigation season, water is delivered from the Klamath River using the Miller Hill Pumping Plant and via the Station 48 Drop into the Lost River. Depending on the operational needs, water that cannot be delivered from Lost River must be delivered from the Klamath River via the Lost River Diversion Channel.

Tule Lake Sumps: Tule Lake was historically the terminus of the Lost River. However, under high flow conditions, water from the Klamath River would flow into Tule Lake via the Lost River Slough. In the 1880s, settlers built a dike across the Lost River Slough to “reclaim” portions of Tule Lake for agriculture production. Active “reclamation” of Tule began in 1910. In 1932, a dike system was constructed to confine drainage waters entering Tule Lake to central sump. Following repeated failures of the dikes from higher flows in the Lost River drainage, Pumping Station D was installed to maintain water levels in the Tule Lake Sumps and provide water to the Lower Klamath National Wildlife Refuge (NWR). Water discharged from Pumping Station D is delivered through a 1,220 feet long tunnel beneath Sheepy Ridge to the Lower Klamath NWR. During irrigation season, most of the water entering Tule Lake is from the Keno Reservoir via the Lost River Diversion Channel at Station 48. In the winter, most of the Lost River flows are diverted into the Lost River Diversion Channel to Keno Reservoir.

Klamath Straits Drain was constructed in 1941 to drain water from the wetlands of the Lower Klamath NWR. The Klamath Straits Drain was enlarged in 1976 to provide additional capacity to drain the water from the NWR. Maximum flow is about 600 cubic feet per second and is operated by U.S. Bureau of Reclamation. Water is lifted by pumps at two locations to discharge water into the Klamath River.

The Ady Canal was constructed in 1912 to control water flow into the Lower Klamath Lake area. The Ady Canal diverts water from the Keno Reservoir to the Lower Klamath Lake area. Approximately 250 cubic feet per second is diverted for irrigation. During the fall, winter and spring water is also delivered to the Lower Klamath NWR.

Lower Klamath NWR extends over 53,000 acres and was established in 1908 by President Theodore Roosevelt and is one of the nation’s first refuges for migratory birds. Lower Klamath NWR was created after the Congress authorized the Klamath Project in 1905. Following court challenges from conservationists, U.S. Bureau of Reclamation drained Lower Klamath Lake and in 1915 reduced the refuge from 80,000 to 53,600 acres freeing up the remaining land for drainage and sale or lease (NRC 2004). Today the refuge supports important breeding populations of ducks, herons, egrets, terns, avocets, white-faced ibis, and white pelicans. Approximately 6,000 acres of land within the refuge are leased for agricultural production that is consistent with waterfowl production in accordance with the Kuchel Act (1964).

4.2.6.2 Water Management Districts

Water is delivered to the irrigation projects by several canals at A-Canal, Lost River Diversion Channel, Station 48, North Canal and Ady Canals. Management of water within the federal irrigation project is largely controlled by individual irrigation and drainage districts (Figure 4-12). Most of the irrigation districts in Oregon are members of the Klamath Water Users Association. The Association is a non-profit corporation that has represented Klamath Reclamation Project farmers and ranchers since 1953. Association members include rural and suburban irrigation districts and other public agencies as well as private individuals who operate on both sides of the California-Oregon border.

The Klamath Water Users Association represents over 1,400 family farms and ranches that encompass over 200,000 acres. The mission of the organization is to preserve, protect and defend the water and power rights of the landowners of the Klamath basin while promoting wise management of ecosystem resources.

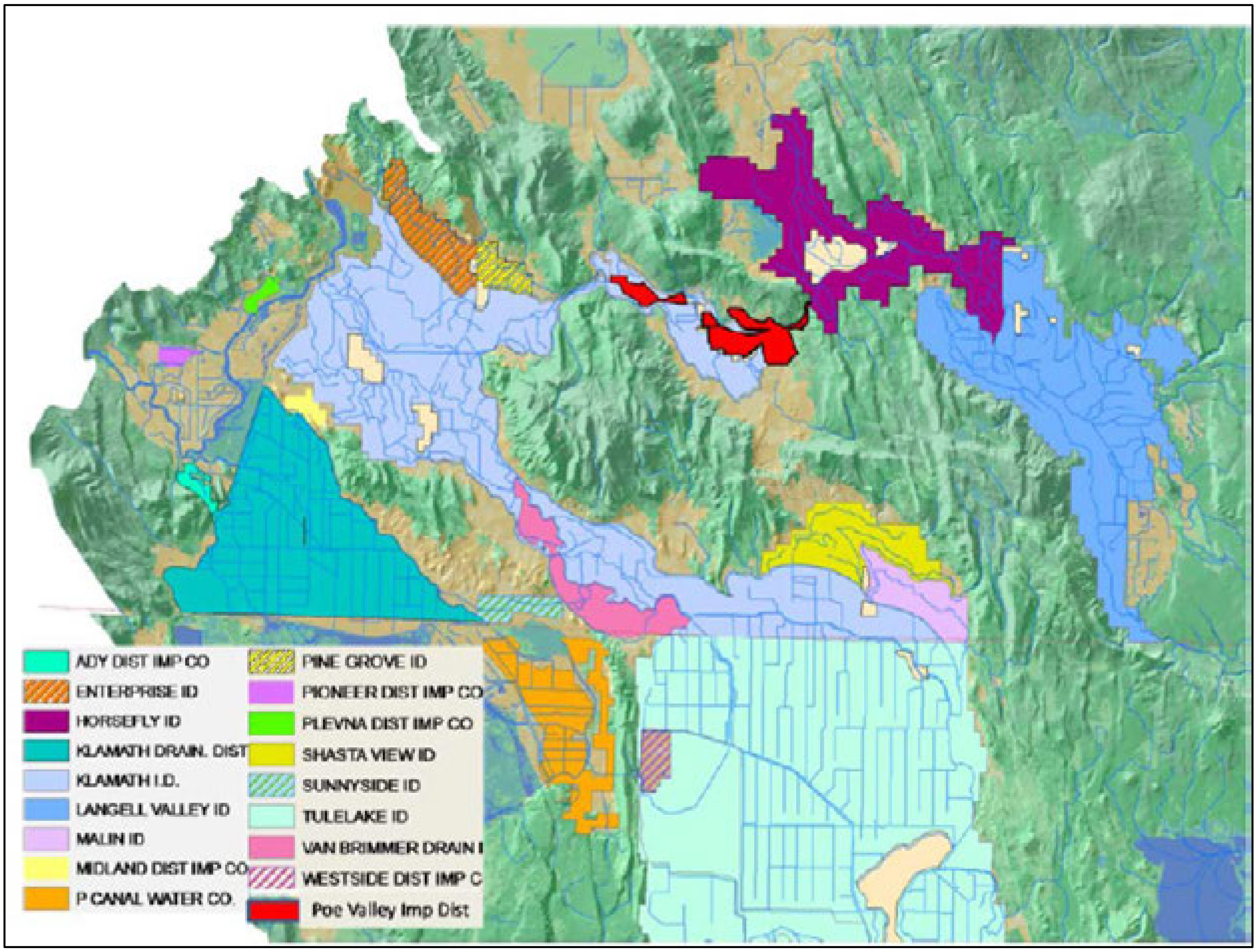

Figure 4-12. Water management districts in the Lost River subbasin.

4.2.7 Temperature Data

Temperature data from various monitoring stations in the Lost subbasin (Figure 4-13) were plotted and compared to the applicable temperature criteria (Table 4-7 and Figure 4-14).

Most of the available data were obtained from the U.S. Forest Service NorWeST regional database (Chandler et al. 2016). These data included observed daily stream temperatures for nine tributaries in the Lost subbasin including Antelope Creek, Barnes Valley Creek, Ben Hall Creek, Buck Creek, East Branch Lost River, Lapham Creek, Long Branch Creek, North Fork Willow Creek, and Rock Creek (Figure 4-13). The data were collected by the U.S. Forest Service Fremont-Winema National Forest and DEQ. The period of record ranges from 1 year to 10 years of data (2001 to 2011).

Table 4-7, Figure 4-14, and Figure 4-15 show the maximum temperature at each monitoring station compared to the applicable criterion. Exceedances of the criteria ranged from to 0 to 100 percent. Continuous temperature data were not available on the Lost River and the maximum temperatures reflect grab data. There was one exceedance of the 28°C criterion on the Lost River with the available grab data.

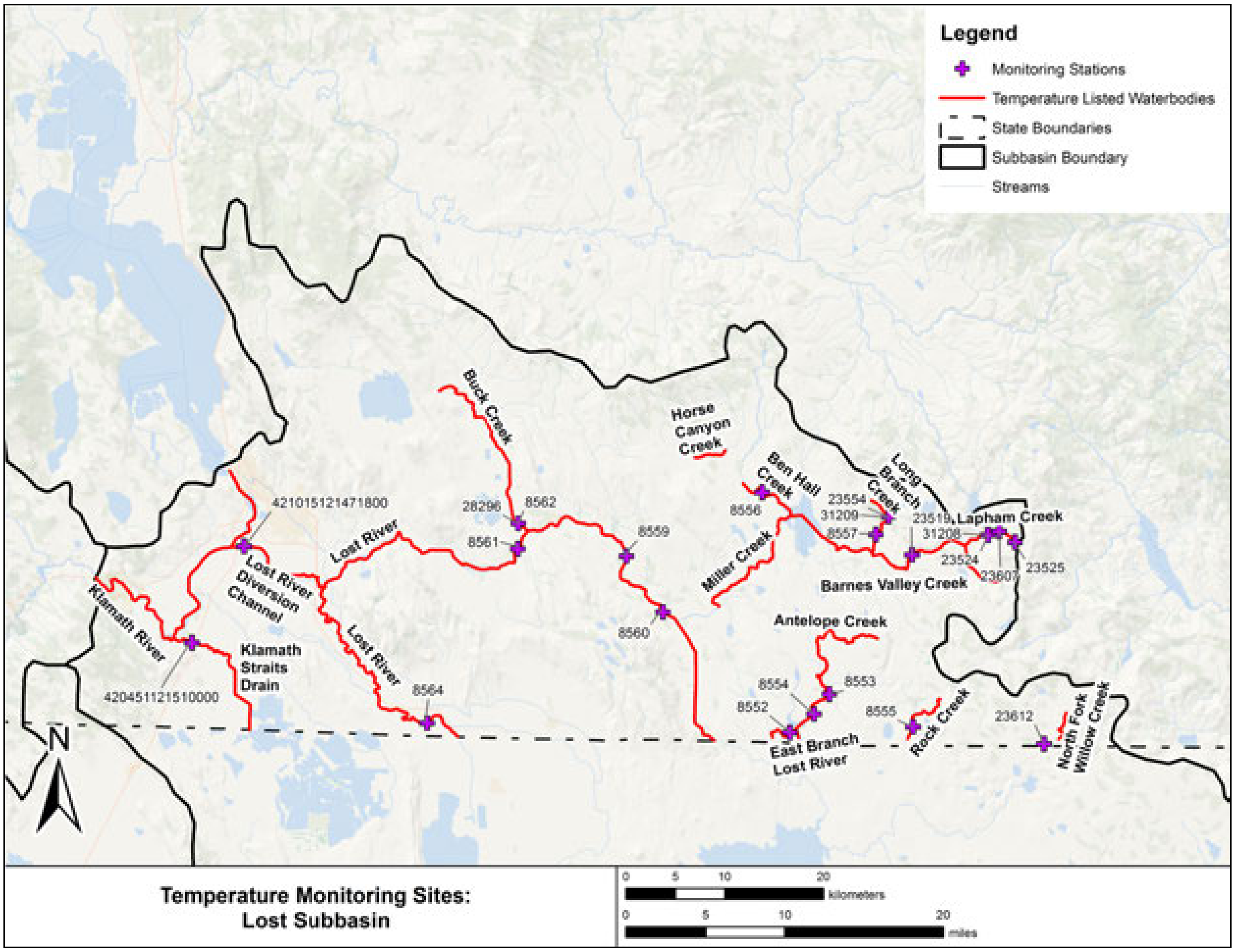

Figure 4-13. Lost subbasin monitoring stations

Table 4-7. Summary of stream temperature data and percent exceedances.

Waterbody Name	Data Source and Station ID	Period of Record	Number of Results	Applicable Criterion (°C)	Maximum Temperature	Percent Exceedance[1]
Antelope Creek	U.S. Forest Service NorWeST station 8553	8/1/2001 – 8/31/2001	25	20 (7DADM)	21.2	72%
Antelope Creek	U.S. Forest Service NorWeST station 8554	8/1/2001 – 8/31/2001	25	20 (7DADM)	25.8	100%

Waterbody Name	Data Source and Station ID	Period of Record	Number of Results	Applicable Criterion (°C)	Maximum Temperature	Percent Exceedance[1]
Barnes Valley Creek	U.S. Forest Service NorWeST station 23519	8/1/ – 8/31/2001 through 2011	200	20 (7DADM)	25.4	68%
Ben Hall Creek	U.S. Forest Service NorWeST station 8556	8/1/2001 – 8/31/2001	25	20 (7DADM)	27.5	100%
Buck Creek	U.S. Forest Service NorWeST station 8562	8/1/2001 – 8/31/2001	25	20 (7DADM)	23.3	76%
Buck Creek	U.S. Bureau of Reclamation 28296	7/24/2001 – 10/18/2001	81	20 (7DADM)	24.4	38%
East Branch Lost River	U.S. Forest Service NorWeST station 8552	8/1/2001 – 8/31/2001	25	20 (7DADM)	21.8	80%
Klamath Straits Drain	USGS 420451121510000	10/1/2007 – present	4,183	28 (Daily Max)	29.7	0.14%
Lapham Creek	U.S. Forest Service NorWeST station 23525	8/1 – 8/31/2005 through 2011	175	20 (7DADM)	25.4	86%
Lapham Creek	U.S. Forest Service NorWeST station 23607	8/1/2008 – 8/31/2008	25	20 (7DADM)	21.2	60%
Lapham Creek	U.S. Forest Service NorWeST station 23524	8/1/2008 – 8/31/2008	250	20 (7DADM)	24.8	75%
Lapham Creek	BLM 31208	4/29/2002 – 10/1/2002	150	20 (7DADM)	27.4	61%
Long Branch Creek	U.S. Forest Service NorWeST station 8557	8/2/2001 – 8/31/2001	25	20 (7DADM)	26.2	100%
Long Branch Creek	U.S. Forest Service NorWeST station 23554	8/1 – 8/31/2008 through 2010	75	20 (7DADM)	21.1	35%
Long Branch Creek	BLM 31209	5/23/2002 – 7/25/2002	58	20 (7DADM)	24.8	60%
Lost River	U.S. Forest Service NorWeST station 8560	8/1/2001 – 8/31/2001	25	28 (Daily Max)	25.4	0%

Waterbody Name	Data Source and Station ID	Period of Record	Number of Results	Applicable Criterion (°C)	Maximum Temperature	Percent Exceedance[1]
Lost River	U.S. Forest Service NorWeST station 8559	8/1/2001 – 8/31/2001	25	28 (Daily Max)	24.0	0%
Lost River	U.S. Forest Service NorWeST station 8561	8/1/2001 – 8/31/2001	25	28 (Daily Max)	22.3	0%
Lost River	U.S. Forest Service NorWeST station 8564	8/1/2001 – 8/31/2001	25	28 (Daily Max)	24.5	0%
Lost River	U.S. Bureau of Reclamation station LRGR (Lost River at Gift Road)	6/1/1993 – 9/14/1998	154	28 (Daily Max)	28.85	0.6%
Lost River	U.S. Bureau of Reclamation station LRSR (Lost River at Stateline Road)	5/31/1996 – 6/24/1998	30	28 (Daily Max)	24.0	0%
Lost River Diversion Channel	USGS 421015121471800	10/1/2007 – 2/21/2008; 2/28/2008 – 2/22/2010; 3/11/2010 – 11/30/2010; 4/20/2011 – 11/30/2011; 4/5/2012 – 11/28/2012; 3/6/2013 – 8/24/2017; 8/31/2017 - present	3,790	28 (Daily Max)	27.8	0%
Miller Creek	BLM MR4320,	1997-05-07 - 1997-09-30, 1998-05-08 - 1998-12-31, 1999-01-01 - 1999-03-28, 2000-05-07 - 2000-11-26, 2003-05-29, - 2003-06-01	680	20 (7DADM)	21.8	17%
Miller Creek	BLM MR4760	1997-05-07 - 1997-09-30, 1998-05-07 - 1998-07-12, 2000-05-07 - 2000-11-19,	673	20 (7DADM)	21.8	16%

Waterbody Name	Data Source and Station ID	Period of Record	Number of Results	Applicable Criterion (°C)	Maximum Temperature	Percent Exceedance[1]
		2001-05-10 - 2001-09-23, 2003-05-29 - 2003-09-30				
North Fork Willow Creek	U.S. Forest Service NorWeST station 23612	8/1 – 8/31/2003 through 2011	24	20 (7DADM)	26.7	88%
Rock Creek	U.S. Forest Service NorWeST station 8555	8/1/2001 – 8/31/2001	25	20 (7DADM)	25.8	100%

[1] portion of result values that exceed the criteria

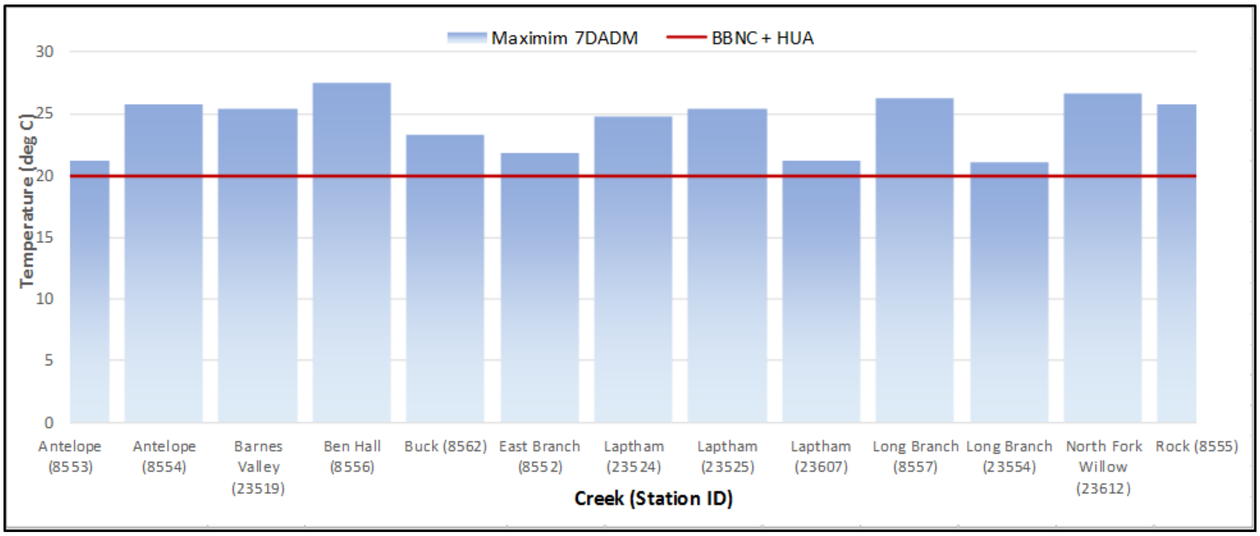

Figure 4-14. Maximum 7DADM temperature in tributaries to the Lost River compared to the applicable BBNC (biologically based numeric criterion) plus the 0.3°C HUA (human use allowance). Data source: Chandler et al. 2016.

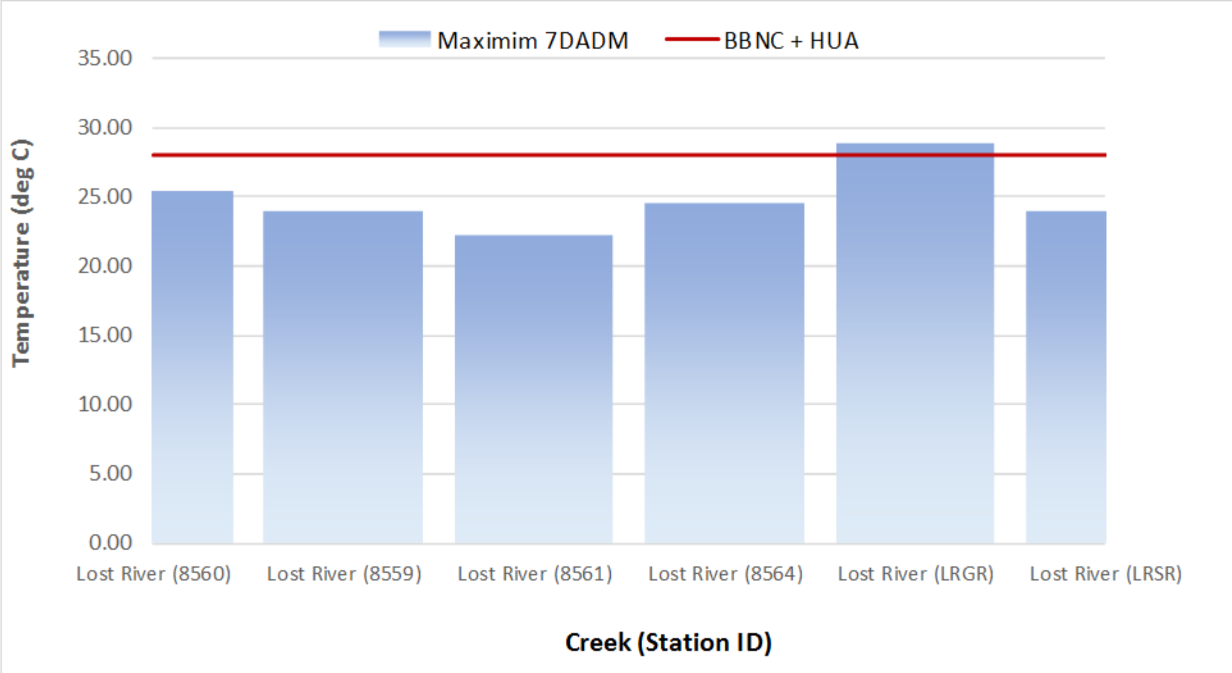

Figure 4-15. Maximum 7DADM temperature in the Lost River compared to the applicable BBNC (biologically based numeric criterion) plus the 0.3°C HUA (human use allowance). Data source: Chandler et al. 2016.

4.3 Seasonal Variation and Critical Period

TMDLs must also identify seasonal variation and the critical condition. Seasonal variation in stream temperature typically follows a pattern where the peak seven-day average daily maximum (7DADM) stream temperatures occurs in late July or early August when stream flows are low, radiant heating rates are high, and ambient conditions are warm. The coolest temperatures occur during the winter. The critical condition was determined by reviewing the 7DADM temperatures at available monitoring gages in the watershed with recent data as well as reviewing simulated temperature for the Lost River. As illustrated in Figure 4-14, stream temperatures in tributaries throughout the Lost subbasin exceed the applicable criterion consistently in August (the only month with data available).

Continuous daily data were not available in the Lost River for comparison to the applicable criterion therefore, simulated temperatures for the existing conditions on the Lost River at the Oregon-California state line were evaluated and compared to the cool water species target to support the selection of the critical period. The daily maximum values were calculated based on the 1999 modeled hourly temperature output. The year 1999 was used to configure and calibrate the Lost River model because of data availability and exceedances of the water quality criteria. See Appendix F Lost River Model for TMDL Development for more details.

Figure 4-16 shows the temperature plot for the Lost River at the state line, where the target of 28°C is typically exceeded from June through August.

The critical condition is determined as the period when the available data show the daily maximum temperatures exceed the applicable criterion. The critical period also defines the time period when the TMDL allocations, reserve capacity, and margin of safety apply. Based on these data, the critical condition is defined as May 1 through September 30 in order to account for year to year variability when seven day average daily maximum stream temperature may exceed the applicable criteria past August. Allocations, reserve capacity, and margin of safety developed for waterbodies addressed in this chapter shall apply during the May 1 – September 30 critical period. However, supplementary surrogate implementation measures include shade targets provided by restored vegetation apply year-round. In addition, varying flow values were used to calculate the thermal loading capacities for a suite of flow regimes. These flow regimes represent the range of flow expected to occur on each stream throughout the year, so TMDLs are protective year-round including the critical conditions. If future data demonstrate that exceedances occur outside the identified May 1 through September 30 critical period, the TMDL's critical period will be extended to account for the time period of the new monitoring data. Additional NPDES wasteload allocations may also be developed outside the critical period as needed to protect designated uses and implement applicable antidegradation policies.

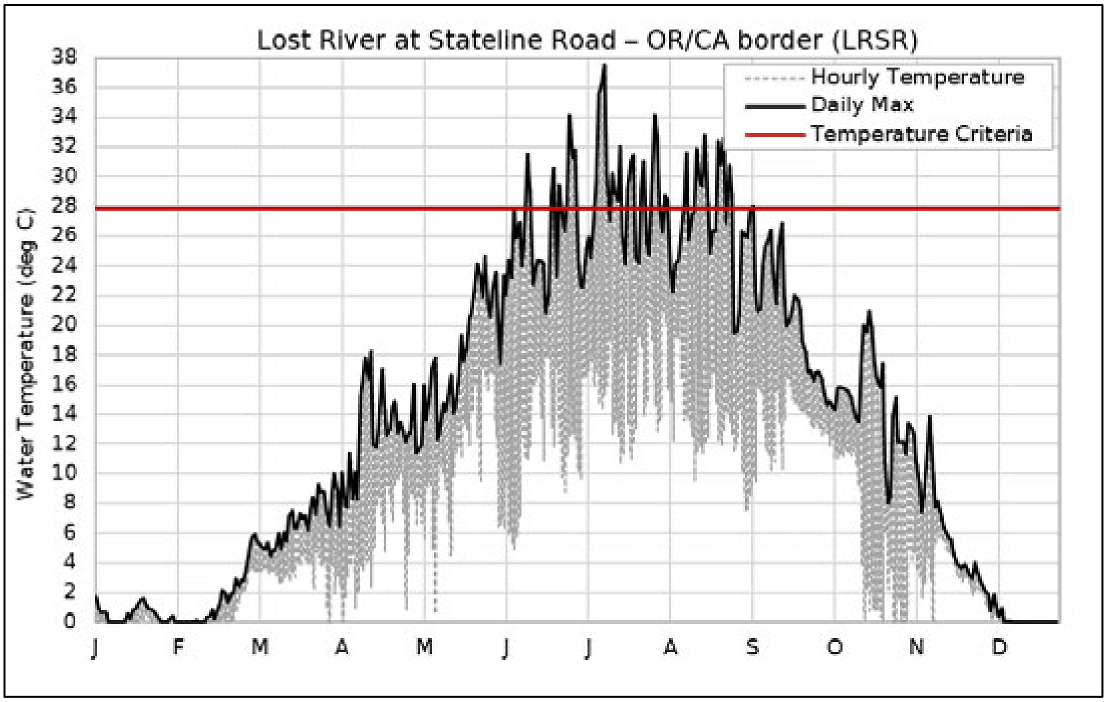

Figure 4-16. Lost River simulated temperature at the Oregon-California state line (1999).

4.4 Existing Pollution Sources

CWA §303(d)(1) and Allocations of Thermal Load 40 CFR 130.2(g) and 40 CFR 130.2(H)

This section identifies the pollutant sources and estimates, to the extent existing data allow, the amount of actual pollutant loading from these sources. Sources of heat to streams include point and nonpoint sources. Specific sources are described below and are subsequently allocated a portion of the Loading Capacity (Section 4.5). The thermal load in the Lost subbasin is a mixture of natural background loads and loads from anthropogenic sources.

4.4.1 Point Sources

Point Source means a discernible, confined, and discrete conveyance including, but not limited to, a pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel or other floating craft, or leachate collection system from which pollutants are or may be discharged but does not include agricultural storm water discharges and return flows from irrigated agriculture (OAR 340-041-0002(46)). DEQ issues NPDES permits for sources that discharge to surface waters according to OAR 340-045-0015. NPDES permits fall into two categories: general and individual. Existing permit information was obtained for the Lost subbasin. NPDES permits fall into two categories: general and individual.

The point sources in the Lost subbasin include general permits for stormwater (industrial, sand and gravel mining, and construction activities), and concentrated animal feeding operations (CAFOs) permits (Table 4-8). There are no communities that require a MS4 stormwater permit in the subbasin. Municipalities that need to obtain an MS4 permit are classified as either "Phase I" or "Phase II". Phase I MS4s cover areas with populations greater than 100,000 while regulated Phase II (or "small") MS4s serve populations less than 100,000 that are located fully, or partially, within an Urbanized Area in the State of Oregon as defined by a Decennial Census conducted by the U.S. Bureau of Census. The largest municipality in the Lost subbasin is Klamath Falls with a population of approximately 20,000, which does not meet the population threshold of 100,000 to be considered for a MS4 permit. Klamath Falls is also not identified as a Urbanized Area. Therefore, there are no MS4 permits in the subbasin.

There are fourteen general NPDES permit registrants in the subbasin as of September 2018. The general permits in the Lost subbasin include one entity under the 1200-Z industrial stormwater general permit (Table 4-8), two entities under the 1200-A stormwater permit for sand and gravel mining activities (Table 4-8), and eleven entities that have coverage under the 1200-C construction stormwater general permit. Registrants that have coverage under the 1200-C construction stormwater general permit are not listed in this TMDL because they are ephemeral in nature and the number and location of registrants will vary year-to-year. Refer to DEQ's permits database for current permit information:
http://www.deq.state.or.us/wq/sisdata/sisdata.asp

There are also 13 CAFO permits in the Lost subbasin (Table 4-8). Any person who owns or operates a CAFO in Oregon is required to have a permit. There are two permit options. Any person who owns or operates a CAFO that discharges to surface water of the state is required to obtain NPDES permit coverage. Any person who owns or operates a CAFO that discharges to groundwater of the state or operates a disposal system is required to obtain Water Pollution Control Facilities (WPCF) permit coverage.

Data were not available in sufficient quantity to characterize the temperature impact from the stormwater dischargers identified in Table 4-8. Instead DEQ conducted a review of literature from studies in the mid-west and east coast of the United States on stormwater and stream temperature. This review provides evidence that, under certain conditions, runoff from impervious pavement or runoff that is retained in uncovered open ponds can produce short duration warm discharges (Herb et. al. 2008, Jones and Hunt 2009, UNH Stormwater Center 2011, Winston et. al. 2011, Hester and Bauman 2013). Increases in runoff temperature are highly dependent on many factors including air temperature, dewpoint, pavement type, percent impervious, and the amount of impervious surface blocked from solar radiation (Nelson and Palmer 2007, Herb et. al. 2008, Thompson et. al. 2008, Winston et. al. 2011, Jones et. al. 2012, Sabouri et. al. 2013, and Zeiger and Hubbert 2015). These warm runoff discharges can create "surges" that produce increases in stream temperature typically for short durations (Hester and Bauman 2013, Wardynski et. al. 2014, Zeiger and Hubbert 2015). However, studies that evaluated stormwater discharges over weekly averaging periods did not indicate exceedances above biologically based critical thresholds (Wardynski et. al. 2014, Washington Department of Ecology 2011a and 2011b).

Stormwater permit registrants are not expected to be a source of flow during the summer critical period as the average monthly rainfall is less than one inch (see Section 4.2.4 Figure 4-7). CAFO permits do not authorize discharge and therefore are not a source of heat.

Therefore, these general permits and CAFOs are not likely to contribute significant thermal loading to the tributaries during the critical water quality condition (see Section 4.7.2 for more detail). Although not considered a source of thermal loading during the TMDL's critical period, the CAFOs' influence on riparian shading will be considered for implementation purposes.

Table 4-8. Permits in the Lost subbasin.

File Number	Permittee	Permit Type
12926	City of Klamath Falls, Crater Lake – Klamath Regional Airport	General 1200-Z
16237	Rocky Mountain Construction, LLC - Klamath Pacific Company - South Balsam Pit	General 1200-A
14559	Southern Oregon Rock, LLC	General 1200-A
AG-P0062958CAFG	Bonanza View Dairy, Inc.	CAFO-NPDES
AG-P0062960CAFG	JD Dairy, LLC	CAFO-NPDES
AG-P0062962CAFG	Holland's Dairy, Inc.	CAFO-NPDES
AG-P0062965CAFG	Solid Rock Dairy, LLC	CAFO-NPDES
AG-P0156431CAFG	Matney Way Dairy	CAFO-NPDES
AG-P0175702CAFG	Hill, Drew	CAFO-NPDES
AG-P1000140CAFG	Noonan Farms	CAFO-WPCF
AG-P1000098CAFG	Brave Colt Goat Farm	CAFO-NPDES
AG-P1000016CAFG	Windy Ridge LLC	CAFO-NPDES
AG-P1000081CAFG	Orella Dairy	CAFO-NPDES
AG-P1000072CAFG	Hammerich Goat Dairy	CAFO-NPDES
AG-P1000125CAFG	Red Bird Ranch, LLC	CAFO-NPDES
AG-P1000143CAFG	McFarland Livestock, LLC	CAFO-NPDES

4.4.2 Nonpoint Sources

The term *Nonpoint Sources* applies to a diffuse or unconfined source of pollution where wastes can either enter, or be conveyed by the movement of water to, waters of the state (OAR 340-41-0002 (42). Historically, human activities have altered the stream morphology and hydrology and decreased the amount of riparian vegetation in the subbasin. The subbasin includes urban, agricultural, and forested lands. Additionally, hydroelectric projects and multiple points of diversion in the Lost subbasin have altered stream flow levels. Low summertime flows decrease the thermal assimilative capacity of streams. Pollutant (solar radiation) loading causes larger temperature increases in stream segments where flows are reduced by human uses.

Five nonpoint source categories are discussed below for the Lost subbasin temperature TMDL:

1. Near stream vegetation disturbance/removal
2. Channel modifications and widening
3. Hydromodification: Dams, Diversions, and Water Management Districts
4. Hydromodification: Water Rights.
5. Unidentified anthropogenic sources

4.4.2.1 Near Stream Vegetation Disturbance/Removal

Near-stream vegetation disturbance/removal reduces stream surface shading via decreased riparian vegetation height, width and/or density, thus increasing the amount of solar radiation reaching the stream surface (shade is commonly measured as percent-effective shade or open sky percentage[6]). Riparian vegetation also plays an important role in shaping channel morphology, resisting erosive high flows, and maintaining floodplain roughness. Table 4-9 shows the potential for improvement in shade for the tributaries as the difference between current and the shade from restored near stream vegetation. The restored near stream vegetation condition as defined in this TMDL is the near-stream vegetative community that can grow on a site at a given elevation and aspect in the absence of human disturbance.

The restored near stream vegetation conditions **is an estimate** of a condition without anthropogenic activities that disturb or remove near stream vegetation.

- Vegetation is mature and undisturbed;
- Vegetation height and density is at or near what is expected for the given restored conditions plant community;
- Vegetation buffer width is sufficiently wide to maximize solar attenuation (Note: Buffer widths required to meet the effective shade target will vary given potential vegetation, topography, stream width, and aspect.),
- Vegetation buffer width accommodates channel migrations.

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[6]Percent-effective shade is defined as ((total solar radiation – total solar radiation reaching the stream)/total radiation) x 100

The restored near stream vegetation condition is **not** an estimate of pre-settlement conditions. It is the estimate of the vegetation communities that could be planted given the site conditions today. In addition, restored effective shade does not account for potential major disturbances resulting from floods, drought, fires, insect damage, disease or other non-human caused factors that could impact riparian areas. See Appendix A for the methodology used to determine restored condition vegetation. See Section 4.7.4 for discussion of the shade target surrogate measure that implements the load allocations. The average shade deficit is the average difference between current and restored shade at each model node.

Table 4-9. TMDL Shade deficit for selected tributaries.

Waterbody	Average Percent Effective Shade		Average Shade deficit
	Current (%)	Restored Condition (%)	(% Effective shade)
Antelope	45	40	-4
Barnes Valley	18	12	6
Horse Canyon	5	4	-1
Lapham	18	24	7
Long Branch	12	20	8
Lost River	3	26	23
Miller Creek	11	13	2
NF Willow	13	21	9

Findings from the TMDL analysis include

- As shown in Table 4-9, the shade assessments on Antelope Creek and Horse Canyon do not have average shade deficits indicating that vegetation removal is likely not a significant source of warming on these streams. Portions of these streams do have shade deficits but they are limited to short reaches mostly on private lands. Miller Creek has a shade deficit but it is very small. For example, vegetation removal along Miller Creek contribute a maximum of 0.19°C (thermal loading of 1.22×10^7 kilocalories per day) above the applicable criteria (Figure 4-17). The extent of these streams evaluated are mostly on federal lands however vegetation conditions on private agricultural lands, appear to differ from those on federal lands.

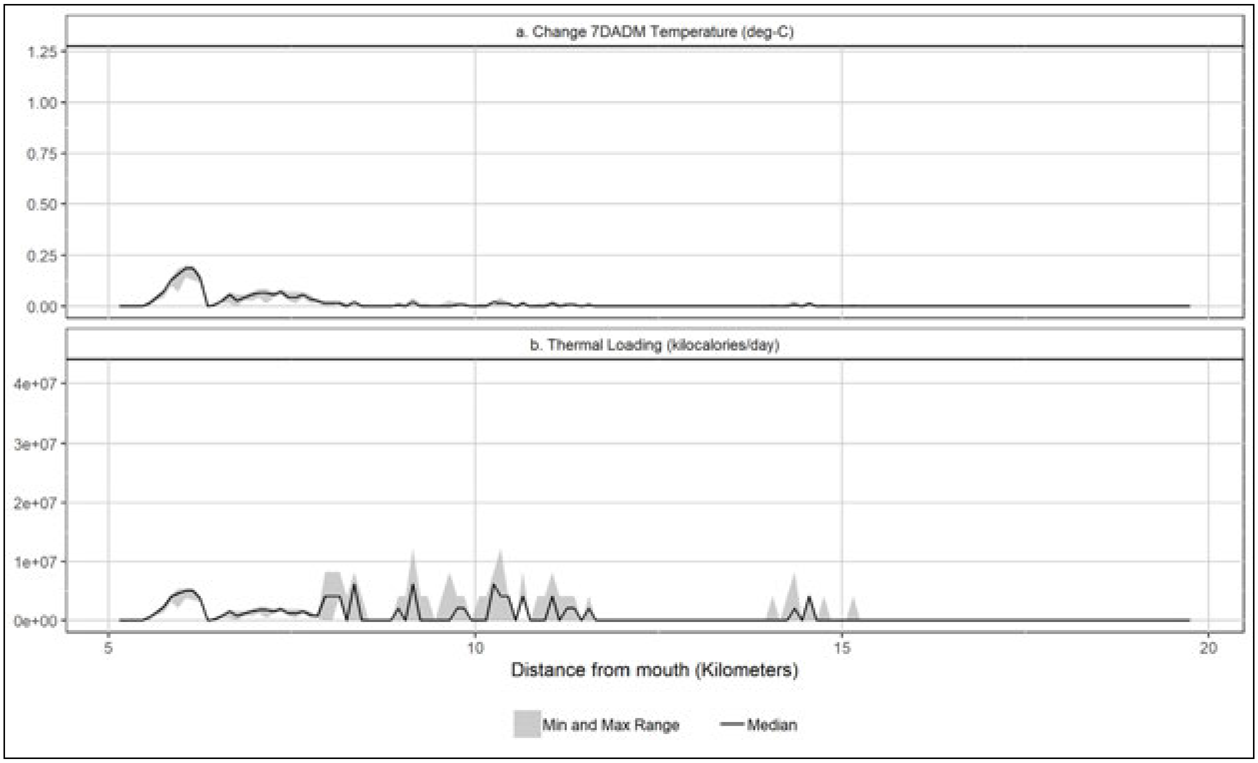


Figure 4-17. (a) Increases to 7-day average daily maximum stream temperatures above the applicable criteria from vegetation removal on Miller Creek during the modeled period. (b) Portion of the excess thermal load during the modeled period on Miller Creek attributed to vegetation removal.

4.4.2.2 Channel Modifications and Widening

Human activities that have altered channel form generally fall into one of three categories: direct modification, increased sediment load and removal of riparian vegetation. Direct modification includes changes to channel form associated with road building, flood control, gravel extraction or channel realignment. Increased sediment loading can result from agricultural, logging and mining activities which may lead to increased runoff, landslides, debris torrents and other mass wasting events. Lastly, removal of riparian vegetation can lead to bank instability and increased erosion. In the Lost subbasin, waterbodies within wide valleys with low gradients are likely to be more degraded due to channel modifications than waterbodies in steep and narrow canyons. Channel modifications can impact water temperatures in the following ways:

Sediment filled pools

In California, a Mattole River study observed that thermally stratified pools often contained sediments decreasing the depth of thermal refugia, therefore decreasing the volume and frequency of the pools, and decreasing assimilative capacity for thermal loading in a reach (California Regional Water Board 2002).

Wider shallower streams

Furthermore, human activities can cause wider, shallower streams (increased width to depth ratios) which increases surface area exposed to solar radiation and ambient air temperatures.

Wider channels will have less effective shade than narrower channels with the same amount of riparian vegetation. A lower effective shade condition allows more direct solar radiation to reach the stream surface (DEQ 2000).

Less storage base flow

Many land use activities that disturb riparian vegetation and associated flood plain areas affect the connectivity between river and groundwater sources (DEQ 2000). Natural morphology created areas of temporary water storage which was slowly released during dry periods, increasing base flow. Reduced summertime saturated riparian soils reduce the overall watershed ability to capture and slowly release stored water. Reductions in stream flow slow the movement of water and generally increase the amount of time the water is exposed to solar radiation (DEQ 2007). There are some thermal benefits gained from connecting the cooler, spring-fed pools and off-channel areas to the main channel (DEQ 2007).

Fewer hyporheic seeps

Groundwater inflow has a cooling effect on summertime stream temperatures. Subsurface water is insulated from surface heating processes and most often groundwater temperatures fluctuate little and are cool (45°F to 55°F) (DEQ 2000). A Mattole River study observed intra-gravel flow seeps in areas of higher streambed complexity. Also, within the main channel, morphologically complex areas were cooler (California Regional Water Board 2002). A study in the Upper Grande Ronde River basin demonstrated that riparian disturbance can separate the connectivity of the groundwater and the stream and occurs when a permeability barrier prevents normal flood plain functions. The groundwater disconnection prevented water from the riparian zone from cooling water in the main channel (DEQ 2000). Channel complexity, cool water inflows, and hyporheic exchange are thought to provide local thermal refugia (DEQ 2007). Excess fine sediment can also decrease permeability and porosity in the hyporheic zone, greatly reducing hyporheic flow, and resulting in less cool water inputs (Rehg et al. 2005).

Riparian vegetation disturbances

Geomorphological changes such as mass wasting events change the physical channel, and further disturb riparian vegetation reducing stream surface shading.

Channel modification and widening was not quantified on Miller Creek but is considered a potential source of warming. The lower three miles of Miller Creek lack vegetation and the stream channel appears to have been straightened and heavily modified.

4.4.2.3 Hydromodification: Dams, Diversions, and Water Management Districts

There are several diversion dams and water management districts (irrigation and drainage districts) operating in the Lost subbasin (Figure 4-18) along with multiple points of water diversion (Figure 4-19). Some of the practices of dams, diversions, and water management districts that could lead to warmer stream temperatures are listed below:

- Diversion dams are used to divert water from a stream to an irrigation ditch or canal. Diversion dams and other points of diversion affect stream temperature by reducing discharge in the downstream reach of the river and subsequent reduction of loading capacity. Thus, the diversion of water is a practice that causes the existing heat loading to be heat pollution that warms the river. In addition, reductions in stream flow in a natural channel slow the movement of water and increase the amount of time the water is exposed to solar radiation. Stream temperatures downstream of diversion dams can be substantially warmer than those above. DEQ considers the diversion of water to be a source of pollution when the diversion results in stream temperature increases.

- Canals and other unpiped water conveyance systems generally are open ditches. These ditches are usually unshaded and increase the surface area of water exposed to solar radiation. Where canal waters are allowed to mix with natural stream flows, such as at diversion dams and at places where natural stream channels are used to convey irrigation water to downstream users, stream temperatures can increase.
- Irrigation return flows come off fields or pastures after irrigation. These excess waters may end up in a stream or the irrigation ditch to be used by the next water right holder. These waters are generally warm and may be nutrient-rich as well.
- Operational spills are places in the irrigation delivery system where excess unused irrigation water in the canals is discharged back into either a downslope canal or lateral or a natural stream channel without being delivered to or used on an individual field. These waters may be picked up by the next water right holder. These waters can also increase stream temperatures.

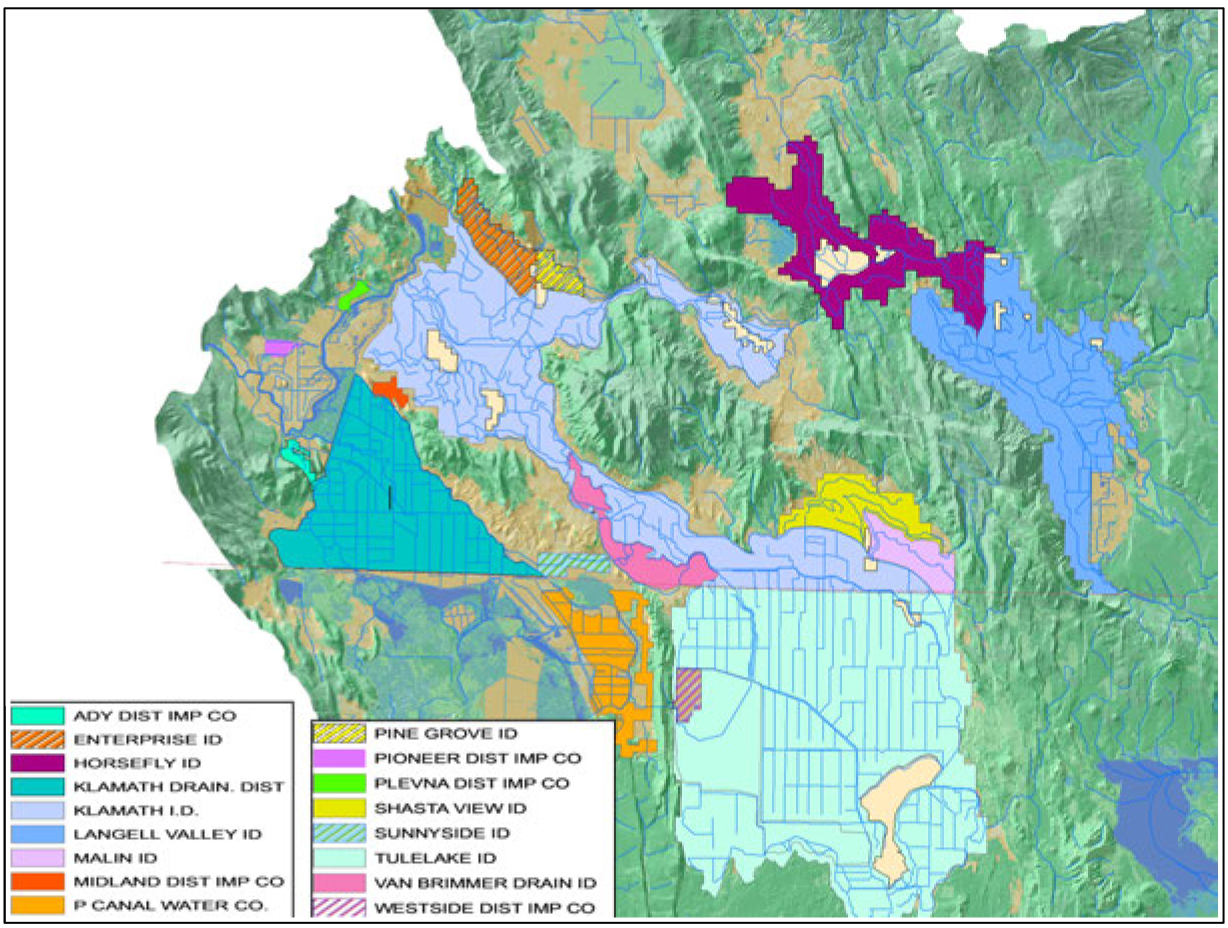


Figure 4-18. Map of Water Management Districts in the Klamath River Basin.

Modeling on the Lost River indicates that water diversions Malone and Anderson Rose can cause rapid warming and exceedances to the cool water species criteria downstream. During the irrigation season (typically April through September) Malone and Anderson Rose divert water into the Lost River canal system. In many years, including the model years of 1999 and 2004, the dams diverted nearly all the water for most of the irrigation season. The remaining flow downstream in the Lost River is approximately 1-2 cfs and is typically the result of leakage through the weir gates. The very low flow results in accelerated warming downstream and exceedance to the cool water species target. The Lost River modeling analysis found that reduction of solar radiation loads alone do not reduce temperatures sufficiently below the 28°C target (Figure 4-19 and Figure 4-20).

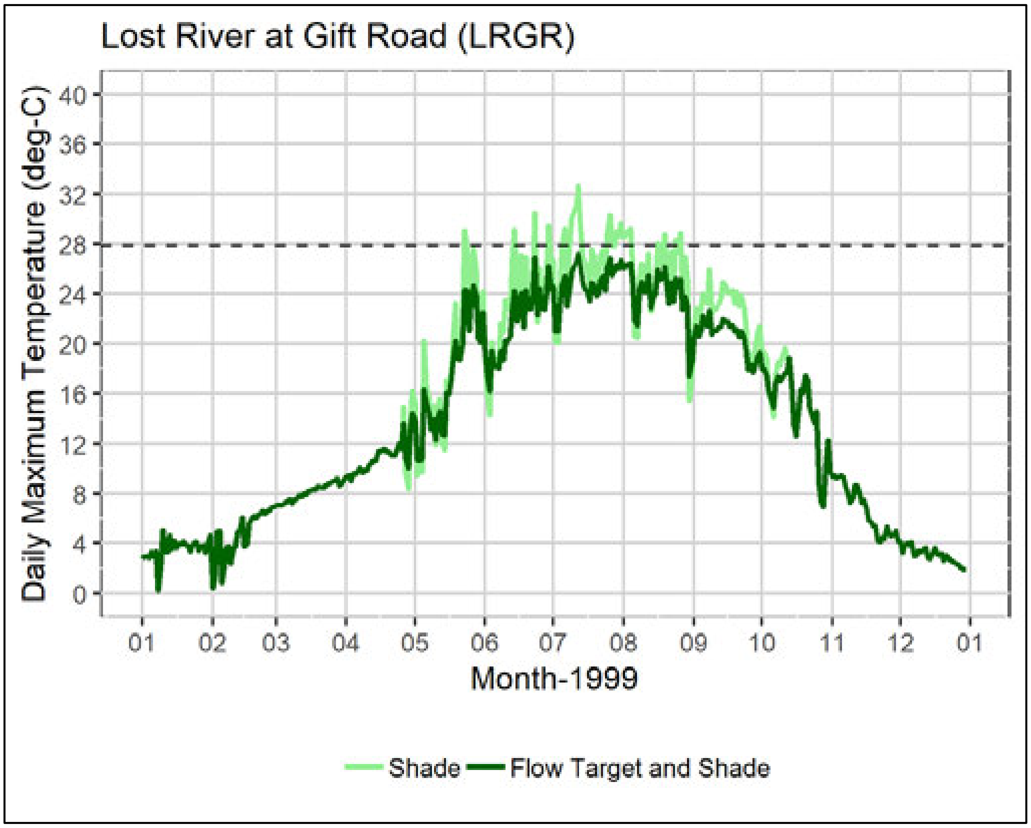


Figure 4-19. Modeled daily maximum temperatures at Lost River at Gift Road with implementation of increased effective shade along the Lost River and instream flow targets at Malone and Anderson Rose diversion dams.

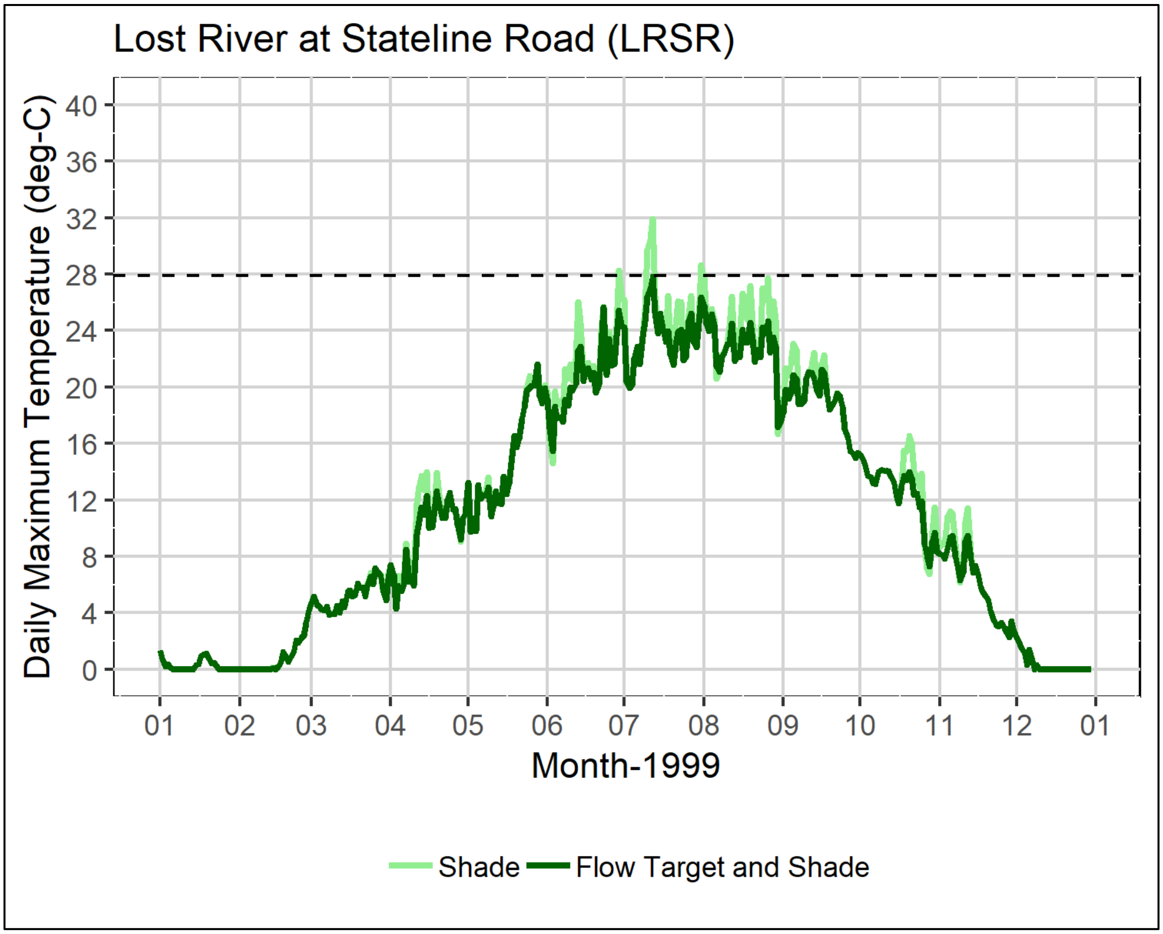


Figure 4-20. Modeled daily maximum temperatures at Lost River at Stateline Road with implementation of increased effective shade along the Lost River and instream flow targets at Malone and Anderson Rose diversion dams.

There are 46 dams identified by Oregon Water Resources Department (OWRD) on tributaries within the geographic scope of this TMDL which are greater than 10-feet high and storage greater than or equal to 9.2 acre-feet (Figure 4-21) (Falk and Harmon 1995). Of these dams, five are in the Lost subbasin and create reservoirs greater than or equal to 1,450 acre-feet (Table 4-10) (Falk and Harmon 1995).

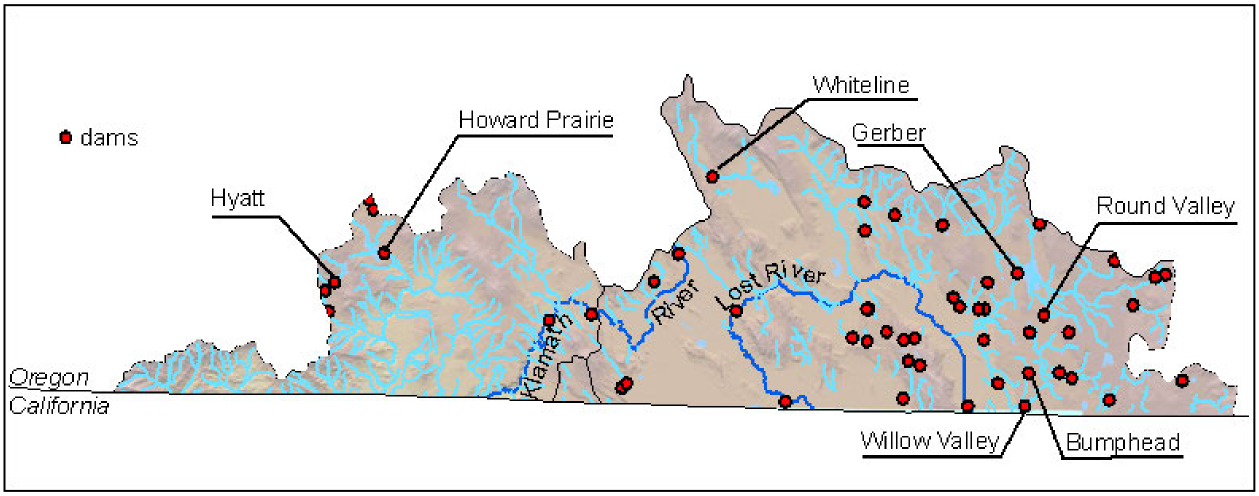


Figure 4-21. Dams greater than 10-feet in height and storage greater than or equal to 9.2 acre-feet of water.

Table 4-10. Basic physical characteristics of remaining reservoirs with area greater than or equal to 1450 acre feet.

Reservoir Name	Storage (acre feet) *	Area (acres) *	Maximum Depth (feet) **	Average Depth (feet) **
Gerber	94500	3830	65	27
Round Valley	2719	273	6	5
Whiteline	2692	434	not reported	not reported
Willow Valley	2038	127	25	12
Bumphead	1450	125	15	8

* from Falk and Harmon, 1995
** from Johnson et al., 1985

Gerber Reservoir is a large impoundment on Miller Creek which stores water for release during the irrigation season (Table 4-10). The stored water is routed through Miller Creek until being withdrawn at a diversion dam approximately 8 miles downstream. The flows in Miller Creek are almost entirely dependent on releases from Gerber Reservoir and therefore are likely much greater during the irrigation season than would otherwise be. Water quality modeling presented later in this chapter and in Appendix A show that the increased flow in Miller Creek during the critical season likely results in lower stream temperatures than would have occurred under a natural thermal potential scenario. Therefore, Gerber Reservoir does not appear to be causing or contributing to a temperature water quality impairment.

Most of the other dams and reservoirs within the scope of this TMDL are in the eastern portion of the Lost subbasin and were constructed to supply water for irrigation. This TMDL does not quantify the individual or cumulative impact of these reservoirs on stream temperatures. These reservoirs have the potential to cause warmer or cooler stream temperatures. Reservoirs increase the surface area of water exposed to solar radiation and may delay the movement of water through the river system. Throughout the summer months, reservoirs store solar radiation as heat in the warm surface waters pooled behind the dam. These reservoirs may become strongly thermally stratified in late summer. Accumulated heat is discharged with the stored water from each reservoir into downstream river reaches during annual draw down which occurs in early summer and continues into late fall. However, the increased volume of water in a reservoir can dampen the diel fluctuation of temperature, resulting in cooler daily maximum temperatures. Additionally, water supply reservoirs can result in increased stream flow downstream of the dam which could benefit stream temperatures.

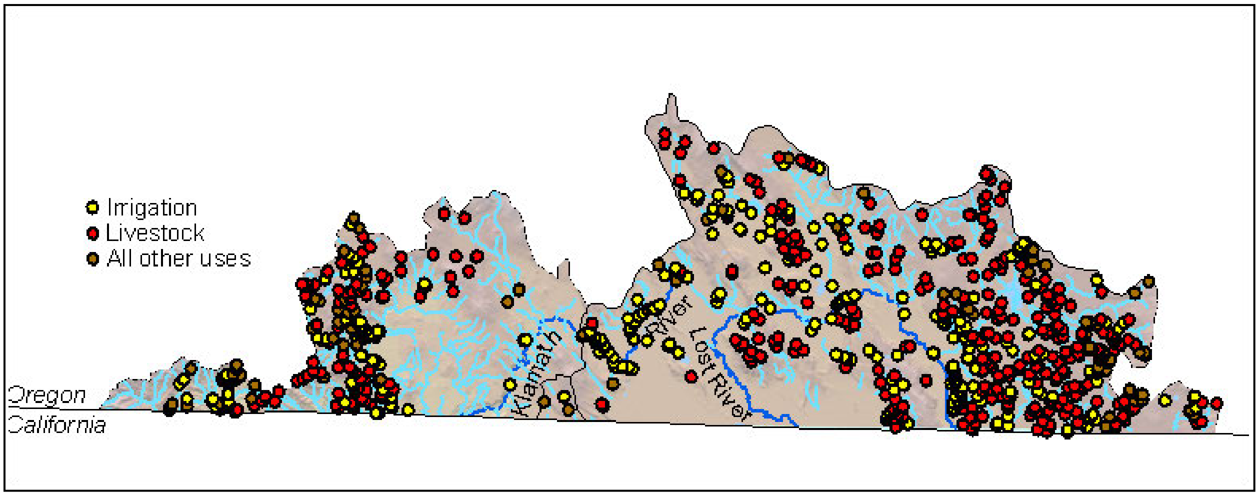


Figure 4-22. Map of points of water diversion and indented use of water in the Upper Klamath and Lost subbasins.

4.4.2.4 Unidentified Anthropogenic Sources

Unidentified anthropogenic sources are sources of warming not explicitly quantified in the TMDL modeling. Some examples may include warming attributed to climate change, illicit discharges, unpermitted water withdrawals, warm groundwater seepage from nearby irrigation ponds, or other unidentified anthropogenic sources. Because these sources are unquantified, it is not possible to separate their loading from background loading. The warming and loading from both unidentified anthropogenic sources and background sources are presented together in Section 4.4.3. This is important because the TMDL analysis indicates that background and unidentified anthropogenic sources contribute excess warming above the applicable criteria along Miller Creek. These sources are targeted for reduction under this TMDL.

4.4.3 Background Sources

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

Background sources account for non-anthropogenic sources of warming. Background sources account for non-anthropogenic sources of warming. The amount of background loading a stream receives is influenced by a number of landscape and meteorological characteristics. Those characteristics include but are not limited to substrate and channel morphology conditions, streambank and channel elevations, near stream vegetation, groundwater, hyporheic, or tributary surface flows, and climate related factors including precipitation, cloudiness, air temperature, relative humidity, and others. When these features exist in a condition DEQ determines to be natural, reference, or restored the loading received on the stream is background loading as defined under OAR 340-042-0030(1). When stream conditions are in a natural, reference, or restored condition, examples of loading from background sources include, but are not limited to, direct and diffuse solar and longwave radiation; mass transfer of thermal load as a result of advection, dispersion, and exchange from mixing with groundwater, hyporheic flows, or tributary surface flows; heat exchange between the water column and the substrate through conduction; and between the water column and the atmosphere through evaporation and convection.

When landscape conditions are not in a natural, reference, or restored condition due to current or legacy human practices; AND the loading from processes identified in the paragraph above result in stream temperature warming above and beyond that of background loading, DEQ considers the excess loading to be anthropogenic loading. Only in cases where DEQ or another Oregon state agency does not have the authority to regulate the loading (as defined in OAR 340-042-0030(1)) does DEQ consider it background loading.

Background loading, including inputs of solar radiation, are one of the largest heat sources in the Lost subbasin. Streams in Oregon are generally warmest in summer when solar radiation inputs are greatest and stream flows are low. The amount of solar energy that reaches the surface of a stream is determined by many factors, including the position of the sun in the sky, cloud cover, local topography, stream aspect, stream width, and near-stream vegetation. Streams generally warm in a downstream direction as they become wider and near-stream vegetation is less effective at shading the surface of the water. Also, the cooling influences of ground water inflow and the impact of smaller tributaries have less of an impact downstream as a stream becomes larger. Greater reach volumes are associated with a reduction in stream sensitivity to natural and human sources of heat.

Background sources of warming were explicitly quantified on Miller Creek. This was determined by subtracting the known anthropogenic warming from the current condition stream temperatures. The portion that exceeds the applicable criteria and human use allowance was considered warming from background sources and is targeted for reduction. As discussed in Section 4.4.3, background loading estimates may include some portion of unquantified anthropogenic sources.

On Miller Creek, background sources, which may include some portion of unquantified anthropogenic sources, contribute a maximum of 8.7°C (thermal loading of 2.47 x10^8 kilocalories per day) above the applicable criteria (Figure 4-23).

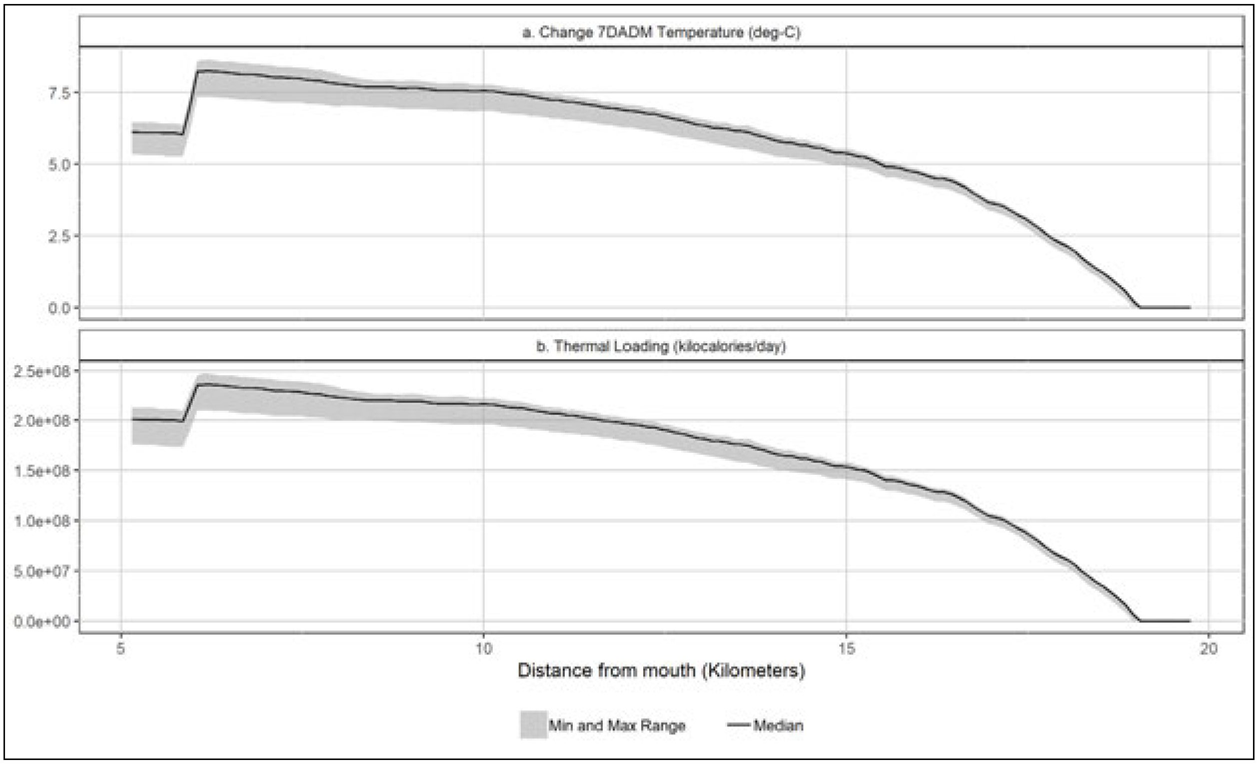


Figure 4-23. (a) Increases to 7-day average daily maximum stream temperatures above the applicable criteria from background and unidentified anthropogenic sources on Miller Creek during the modeled period. (b) Portion of the excess thermal load during the modeled period on Miller Creek attributed to background and unidentified anthropogenic sources.

4.5 Loading Capacity

This section of the TMDL presents the loading capacity for each impaired segment, while Sections 4.6 and 4.7 present the excess loads and allocations, respectively.

Loading capacity specifies the amount of pollutant a waterbody can receive and still meet water quality standards. For temperature TMDLs, the loading capacity is based on the applicable temperature criterion and the HUA allowance allocated to nonpoint sources thermal load (Load Allocations), allowable point source thermal loads (Wasteload Allocations), the thermal load included in a margin of safety, and the thermal load held as a reserve capacity for future sources. Oregon Administrative Rule 340-041-0028 (12)(b)(B) states that all anthropogenic sources of heat may cumulatively increase stream temperature no more than 0.3°C (0.5 °F) above the applicable criterion at the point of maximum impact; this is known as the human use allowance. The human use allowance is included in the allocations.

The approaches used to calculate the thermal loading capacities for these TMDL segments are documented in Appendix H. This appendix describes the use of the United States Geological

Survey (USGS) StreamStats[7] program to estimate river flow as well as available data and information to supplement other calculations.

For all waterbodies, the thermal loading capacity was calculated using Equation 4-1 below. The loading capacity values for each TMDL waterbody are provided as examples in the tables below, while specific loading capacities can be calculated for any given flow measurement using Equation 4-1.

Loading Capacity Equation

$$\boldsymbol{LC = (T_C + HUA) \times Q_R \times C_F} \qquad \textbf{Equation 4-1}$$

where,

LC = Loading Capacity (kilocalories per day).

T_C = The applicable temperature criteria (°C).

HUA = The 0.3°C human use allowance allocated to point sources, nonpoint sources, margin of safety, or reserve capacity. The HUA provision does not apply for waters designated for cool water species criterion. On these waters this portion of the equation can removed.

Q_R = The daily mean river flow rate, upstream (cubic feet per second [cfs]).

C_F= Conversion factor using cubic feet per second: (2,446,622 kcal-s/°C-ft^3-day)

$$\frac{1\,m^3}{35.314\,ft^3} \times \frac{1000\,kg}{1\,m^3} \times \frac{86{,}400\,sec}{1\,day} \times \frac{1\,kcal}{1\,kg \times 1°C} = 2{,}446{,}622$$

Loading capacities were calculated for each of the TMDL waterbodies using flow estimates described in Appendix H. Flow values were incorporated into Equation 4-1 to calculate the allowable thermal load at that flow. Estimated flows are presented for a variety of flow conditions, representing the full suite of expected flows in the watershed and capturing the seasonal variation required in a TMDL. The flow conditions are defined in Table 4-11 and loosely correspond to flow intervals described by EPA (2007). The lower flow values are exceeded a majority of the time, while the floods are exceeded infrequently (USEPA 2007). The loading capacity for each flow condition is calculated using the lowest flow estimate for that flow condition; however, the loading capacity applies to the entire range of flows within that condition. For example, the "dry" condition loading capacity is calculated using the 95th percentile flow duration. This loading capacity applies to all flows up to the 50th percentile flow duration, which is then used to calculate the "mild" condition loading capacity (Table 4-11).

[7] https://streamstats.usgs.gov/ss/

Table 4-11. Flow conditions used in thermal loading capacity calculations.

Flow Condition	StreamStats Representation	Applicable Flow Duration Range*	Description
Low	7Q10	Q_R < 95th percentile	Lowest 7-day average flow that occurs (on average) once every 10 years (7Q10)
Dry	95th percentile	95th percentile ≤ Q_R < 50th percentile	Flow that is exceeded approximately 95%, or the vast majority, of the time
Mild	50th percentile	50th percentile ≤ Q_R < 25th percentile	Flow that is considered within the typical or normal range; includes the median flow for a stream
Moderate	25th percentile	25th percentile ≤ Q_R < 10th percentile	Flow that is exceeded only 25% of the time, considered to be above the normal range
High	10th percentile	10th percentile ≤ Q_R < 5th percentile	Flow that is exceeded only 10% of the time, considered to be far above the normal range; often associated with the rainy season and higher storm flows
Very High	5th percentile	Q_R ≥ 5th percentile	Flow that is infrequently exceeded; represents very high flows that do not occur often

*Q_R = river flow

Table 4-12 through Table 4-25 present the thermal loading capacities for each TMDL waterbody including the flow estimate used to represent each flow condition.

Table 4-12. Thermal loading capacity by flow condition for Antelope Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0.4	1.99E+07	<1 cfs
Dry	20.0	0.3	1	4.97E+07	1 cfs to <7 cfs
Mild	20.0	0.3	7	3.48E+08	7 cfs to <23 cfs
Moderate	20.0	0.3	23	1.14E+09	23 cfs to <59 cfs
High	20.0	0.3	59	2.93E+09	59 cfs to <103 cfs
Very High	20.0	0.3	103	5.12E+09	≥103 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion. The HUA is not applicable to interstate waters. This loading capacity applies to the flow range in the last column of the table.

Table 4-13. Thermal loading capacity by flow condition for Barnes Valley Creek

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	4	1.99E+08	<6 cfs
Dry	20.0	0.3	6	2.98E+08	6 cfs to <16 cfs
Mild	20.0	0.3	16	7.95E+08	16 cfs to <48 cfs
Moderate	20.0	0.3	48	2.38E+09	48 cfs to <115 cfs
High	20.0	0.3	115	5.71E+09	115 cfs to <186 cfs
Very High	20.0	0.3	186	9.24E+09	≥186 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 4-14. Thermal loading capacity by flow condition for Ben Hall Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	2.7	1.34E+08	<3.9 cfs
Dry	20.0	0.3	3.9	1.94E+08	3.9 cfs to <13 cfs
Mild	20.0	0.3	13	6.46E+08	13 cfs to <39 cfs
Moderate	20.0	0.3	39	1.94E+09	39 cfs to <97 cfs
High	20.0	0.3	97	4.82E+09	97 cfs to <160 cfs
Very High	20.0	0.3	160	7.95E+09	≥160 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 4-15. Thermal loading capacity by flow condition for Buck Creek.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	3	1.49E+08	<4 cfs
Dry	20.0	0.3	4	1.99E+08	4 cfs to <14 cfs
Mild	20.0	0.3	14	6.95E+08	14 cfs to <44 cfs
Moderate	20.0	0.3	44	2.19E+09	44 cfs to <108 cfs
High	20.0	0.3	108	5.36E+09	108 cfs to <181 cfs
Very High	20.0	0.3	181	8.99E+09	≥181 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 4-16. Thermal loading capacity by flow condition for East Branch Lost River.

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0.5	2.42E+07	<1 cfs
Dry	20.0	0.3	1.2	6.06E+07	1 cfs to <7 cfs
Mild	20.0	0.3	7	3.32E+08	7 cfs to <23 cfs
Moderate	20.0	0.3	23	1.15E+09	23 cfs to <61 cfs
High	20.0	0.3	61	3.00E+09	61 cfs to <105 cfs
Very High	20.0	0.3	105	5.22E+09	≥105 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion. The HUA is not applicable to interstate waters. This loading capacity applies to the flow range in the last column of the table.

Table 4-17. Thermal loading capacity by flow condition for Horse Canyon Creek

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0	0.00E+00	<0.2 cfs
Dry	20.0	0.3	0.23	1.14E+07	0.2 cfs to <4 cfs
Mild	20.0	0.3	4	1.99E+08	4 cfs to <14 cfs
Moderate	20.0	0.3	14	6.95E+08	14 cfs to <39 cfs
High	20.0	0.3	39	1.94E+09	39 cfs to <68 cfs
Very High	20.0	0.3	68	3.38E+09	≥68 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 4-18. Thermal loading capacity by flow condition for Klamath Straits Drain

Flow Condition	T_C (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	28.0	0.24	1.64E+07	<1
Dry	28.0	1	6.85E+07	1 cfs to <39 cfs
Mild	28.0	39	2.67E+09	38 cfs to <78 cfs
Moderate	28.0	78	5.34E+09	78 cfs to <135 cfs
High	28.0	135	9.25E+09	135 cfs to <173 cfs
Very High	28.0	173	1.19E+10	≥173 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion. This loading capacity applies to the flow range in the last column of the table.

Table 4-19. Thermal loading capacity by flow condition for Lapham Creek

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0	0.00E+00	0
Dry	20.0	0.3	0	0.00E+00	0 cfs to <2 cfs
Mild	20.0	0.3	2	9.93E+07	2 cfs to <8 cfs
Moderate	20.0	0.3	8	3.97E+08	8 cfs to <22 cfs
High	20.0	0.3	22	1.09E+09	22 cfs to <38 cfs
Very High	20.0	0.3	38	1.89E+09	≥38 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 4-20. Thermal loading capacity by flow condition for Long Branch Creek

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0	0.00E+00	<0.1 cfs
Dry	20.0	0.3	0.1	4.97E+06	0.1 cfs to <4 cfs
Mild	20.0	0.3	4	1.99E+08	4 cfs to <13 cfs
Moderate	20.0	0.3	13	6.46E+08	13 cfs to <36 cfs
High	20.0	0.3	36	1.79E+09	36 cfs to <61 cfs
Very High	20.0	0.3	61	3.03E+09	≥61 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 4-21. Thermal loading capacity by flow condition for the Lost River.

Flow Condition	T_C (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	28	3	2.06E+08	< 4 cfs
Dry	28	4	2.74E+08	4 cfs to <28 cfs
Mild	28	28	1.92E+09	28 cfs to <63 cfs
Moderate	28	63	4.32E+09	63 cfs to < 89 cfs
High	28	89	6.10E+09	89 cfs to < 123 cfs
Very High		123	8.43E+09	≥123 cfs

[1] Estimated from analysis of 1999 modeled flows at the Stateline (Appendix F in DEQ 2018).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion. The HUA is not applicable to interstate waters. This loading capacity applies to the flow range in the last column of the table.

Table 4-22. Thermal loading capacity by flow condition for Lost River Diversion Channel.

Flow Condition	T_C (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	28.0	1.7	1.16E+08	< 8 cfs
Dry	28.0	8	5.48E+08	8 cfs to <93 cfs
Mild	28.0	93	6.37E+09	93 cfs to <203 cfs
Moderate	28.0	203	1.39E+10	203 cfs to < 321 cfs
High	28.0	321	2.20E+10	321 cfs to < 392 cfs
Very High	28.0	392	2.69E+10	≥392 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion. This loading capacity applies to the flow range in the last column of the table.

Table 4-23. Thermal loading capacity by flow condition for Miller Creek

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	13	6.61E+08	< 19 cfs
Dry	20.0	0.3	19	9.44E+08	19 cfs to <44 cfs
Mild	20.0	0.3	44	2.19E+09	44 cfs to <115 cfs
Moderate	20.0	0.3	115	5.71E+09	115 cfs to < 255 cfs
High	20.0	0.3	255	1.27E+10	255 cfs to < 401 cfs
Very High	20.0	0.3	401	1.99E+10	≥401 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion plus HUA. This loading capacity applies to the flow range in the last column of the table.

Table 4-24. Thermal loading capacity by flow condition for North Fork Willow Creek

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0.016	9.93E+05	<0.5 cfs
Dry	20.0	0.3	0.5	2.48E+07	0.5 cfs to <4 cfs
Mild	20.0	0.3	4	1.99E+08	4 cfs to <15 cfs
Moderate	20.0	0.3	15	7.45E+08	15 cfs to <41 cfs
High	20.0	0.3	41	2.04E+09	41 cfs to <70 cfs
Very High	20.0	0.3	70	3.48E+09	≥70 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion. The HUA is not applicable to interstate waters. This loading capacity applies to the flow range in the last column of the table.

Table 4-25. Thermal loading capacity by flow condition for Rock Creek

Flow Condition	T_C (°C)	HUA (°C)	Q_R (cubic feet per second)[1]	LC (kilocalories per day)[2]	Applicable Flow Range
Low	20.0	0.3	0	0.00E+00	0
Dry	20.0	0.3	0	0.00E+00	0 cfs to <2 cfs
Mild	20.0	0.3	2	9.93E+07	2 cfs to <8 cfs
Moderate	20.0	0.3	8	3.97E+08	8 cfs to <24 cfs
High	20.0	0.3	24	1.19E+09	24 cfs to <42 cfs
Very High	20.0	0.3	42	2.09E+09	≥42 cfs

[1] Estimated from StreamStats analysis (Appendix H).

[2] Loading capacity calculated using Equation 4-1, the representative flow estimate from the fourth column, and the applicable criterion. The HUA is not applicable to interstate waters. This loading capacity applies to the flow range in the last column of the table.

A load capacity curve was developed using different flow conditions for each TMDL waterbody, which characterizes the allowable thermal load capacity for a range of expected flows throughout the year (see Appendix H). Allocations divide the loading capacity between individual point and nonpoint sources of heat and set the thermal load targets which will result in achieving the water quality standards (see Section 4.7). In addition to individual point and nonpoint sources, a portion of the thermal loading capacity was set aside as a reserve capacity (Section 4.8).

4.6 Excess Load

OAR 340-042-0040(4) (e)

Excess thermal loads are used to evaluate, to the extent existing data allow, the difference between the actual pollutant load in a waterbody and the loading capacity of that waterbody. Equation 4-2 is used to calculate the excess thermal load, if observed temperature and flow data are available.

Excess Load Equation

$$\boldsymbol{EL = (T_R - T_C + HUA) \times Q_R \times C_F}$$ **Equation 4-2**

where,

EL = Excess thermal load above the applicable temperature criteria (kilocalories per day).

T_R = The current stream temperatures (°C), expressed as a 7-day average daily maximum or daily maximum depending on the applicable criteria.

T_C = The applicable temperature criteria (°C).

HUA = The 0.3°C human use allowance allocated to point sources, nonpoint sources, margin of safety, or reserve capacity. The HUA provision does not apply for waters designated for cool water species criterion. On these waters this portion of the equation can removed.

Q_R = The daily mean river flow rate, upstream (cubic feet per second [cfs]).

C_F = Conversion factor using cubic feet per second: (2,446,622 kcal-s/°C-ft^3-day)

$$\frac{1\ \mathrm{m}^3}{35.314\ \mathrm{ft}^3} \times \frac{1000\ \mathrm{kg}}{1\ \mathrm{m}^3} \times \frac{86{,}400\ \mathrm{sec}}{1\ \mathrm{day}} \times \frac{1\ \mathrm{kcal}}{1\ \mathrm{kg} \times 1°\mathrm{C}} = 2{,}446{,}622$$

Although excess loads cannot be calculated with the available data for most tributaries, 1999 simulated temperatures in the Lost River were used to calculate excess load. The excess thermal load was calculated from the flow and temperatures values using Equation 4-1. Loads exceeding the thermal loading capacity based on the applicable criterion are presented as a function of flow (Figure 4-24) and are also summarized based on the minimum and maximum percent reductions (Table 4-26). The excess loads were observed in flows ranging from 5 to 86 cubic feet per second (Figure 4-24) and percent reductions range from 1 to 26 percent (Table 4-26). Most of the reductions were required in the low through mild flow conditions. The largest percent reductions are required at the lower end of the observed flows (Figure 4-24).

Table 4-26. Lost River excess thermal load summary at locations not meeting criteria.

Statistic	Flows with Exceedances (cfs)	Observed DM Exceeding Criteria (°C)	Percent Reduction to Meet Criteria	Excess Heat Load (kcal/day)
Lost River at Gift Road (LRGR)				
Minimum	8.4	19.1	1.4%	9.15E+06
Maximum	10.1	39.47	24%	2.00E+08
Lost River at Stateline Road – OR/CA border (LRSR)				
Minimum	4.7	28.02	0.4%	1.38E+06
Maximum	19.0	37.61	26%	1.12E+08

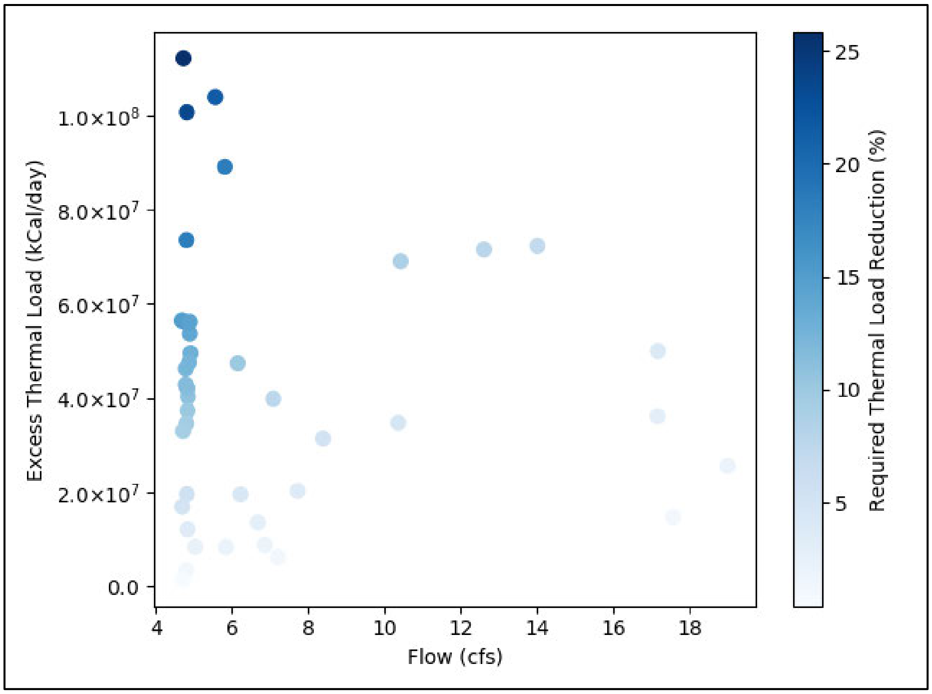


Figure 4-24. Lost River excess thermal load and percent reductions by flow (1999 model output). Temperature data available for the Lost subbasin tributaries were summarized in Figure 4-14.

BLM collected temperature data on Miller Creek over five years at two sites - MR4760 - Miller Creek downstream from Gerber Dam and MR4320 Miller Creek in 39S-13E-33. Based on these data (Figure 4-25), Miller Creek exceed the applicable criterion plus human use allowance of 20.3 °C in four out of the six years of available data with a maximum of 71 days exceeding in 1997 at site MR4320 and a minimum of 7 days exceeding in year 2000 at site MR4760. The maximum 7DADM temperature observed at MR4760 downstream of Gerber dam was 21.8 °C on August 8th 2003. Downstream at MR4320 the maximum 7DADM observed was 24.3 °C on July 31st,, 2003.

Because stream flow information was not available at these temperature sites, the excess load was calculated from model output using model derived flows and temperatures. The model provides temperature and flow output on Miller Creek from Gerber Dam to a point just over three miles from the mouth in July and August of 2001. See Appendix A for more information on the model setup and results. The stream flow as modeled in the current condition calibration was used for Q_R in Equation 4-2. During the 2001 model period, the maximum 7-day average daily maximum stream temperature reduction needed to achieve the applicable temperature criterion is 8.7°C. This reduction equals an instream excess load of 8.33 x10^7 kilocalories per day.

Figure 4-26a shows the modeled minimum, median and maximum excess load and the required temperature reductions on Miller Creek in year 2001 as a function of the model stream length. The required temperature reduction is the difference between the current 7-day average daily maximum stream temperatures as modeled in the current condition calibration and the applicable criterion plus human use allowance. The sharp decrease in excess thermal load in Figure 4-26b at model kilometer 8 corresponds to the location of a major water withdrawal. The sharp reduction in flow reduces the excess load but at the same time increases 7DADM shown in Figure 4-26a.

Sources contributing excess load include known anthropogenic sources that have been quantified via modeling (i.e., water withdrawals), potential sources that were unquantified but known to be a typical source of heat (i.e., changes in channel morphology, hydromodification), unidentified anthropogenic sources, and background sources. Excess load from these sources must be reduced to attain the loading capacity and applicable criteria. After the full implementation of these reductions the applicable criteria will be met at all times in all places.

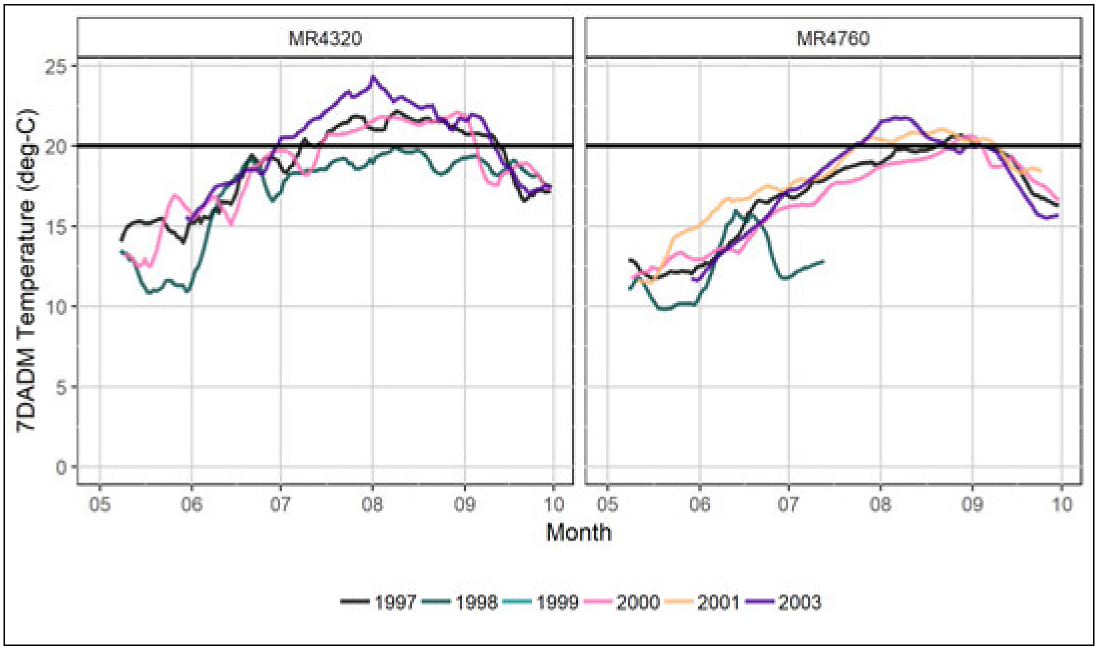


Figure 4-25. Observed 7-day average daily maximum stream temperatures on Miller Creek over a five year period at site MR4760 - Miller Creek downstream from Gerber Dam and MR4320 - Miller Creek in 39S-13E-33.

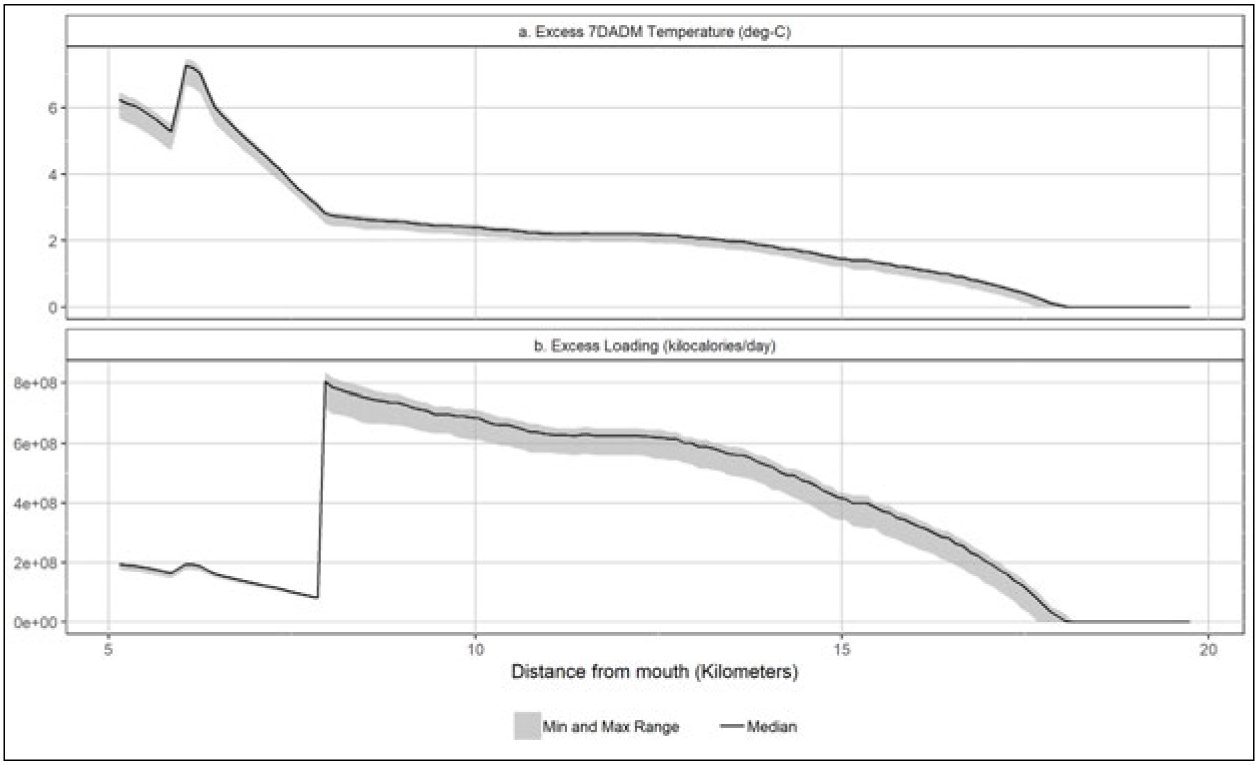


Figure 4-26. (a) Excess 7-day average daily maximum stream temperatures on Miller Creek during the modeled period. These temperatures must be reduced in order to achieve the applicable criterion plus human use allowance. (b) Excess Load during the modeled period on Miller Creek.

4.7 Allocations

Loading capacity in this TMDL is expressed as a thermal load in kilocalories per day; however, in order for the TMDL to be more meaningful to the public and guide implementation efforts, allocations have also been expressed in thermal loads to each source, a change instream temperature or ΔT (delta T), and in terms of the surrogate measure percent effective shade or flow target. The loading capacity was separated into load allocations for background sources and nonpoint sources, waste load allocations for point sources, a margin of safety, and a reserve capacity. In this TMDL, no loading capacity was explicitly set aside as a margin of safety, instead an implicit margin of safety was used (Section 4.9). The allocations for the nonpoint sources, point sources, and reserve capacity were calculated from the human use allowance (Section 4.7). Allocations apply during the critical period (Section 4.3) from June 1 – September 30 when the available data show the seven-day average daily maximum temperatures exceed the applicable criterion. Background sources were not allocated any of the HUA but were assigned a Load Allocation (Section 4.7.3).

On the Lost River, Klamath Straits Drain, and Lost River Diversion Channel it was not possible to explicitly differentiate background loading and anthropogenic loading so the load allocation is presented together with load reduction requirements (zero warming) for certain anthropogenic nonpoint sources when temperatures exceed the temperature criteria.

$$\boldsymbol{Allocation} = \boldsymbol{\Delta T} \times \boldsymbol{Q_R} \times \boldsymbol{C_F}$$ **Equation 4-3**

where,

$Allocation$ = Allocation of the thermal loading capacity to a source (kilocalories per day).

ΔT = Allowable temperature increase (°C).

Q_R = The daily mean river flow rate, upstream (cubic feet per second [cfs]).

C_F = Conversion factor using cubic feet per second: (2,446,622 kcal-s/°C-ft^3-day)

$$\frac{1\ m^3}{35.314\ ft^3} \times \frac{1000\ kg}{1\ m^3} \times \frac{86{,}400\ sec}{1\ day} \times \frac{1\ kcal}{1\ kg \times 1°C} = 2{,}446{,}622$$

A summary of the thermal loading capacity allocations are presented in Table 4-27 through Table 4-40 by flow condition for the TMDL waterbodies. These summaries represent the maximum estimated loading under each flow condition. Because stream temperature warming can be cumulative, some of the load allocations and human use allowance allocations were limited to zero warming in order to ensure attainment of temperature criteria in downstream waters. In the sections that follow, the allocations for individual sources are provided in greater detail. Surrogate measures, where appropriate, are identified (Section 4.7.4).

Table 4-27. Antelope Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	25.8	2.52E+07	6.31E+07	4.42E+08	1.45E+09	3.72E+09	6.50E+09
Loading Capacity	20.3	1.99E+07	4.97E+07	3.48E+08	1.14E+09	2.93E+09	5.12E+09
Load Allocation (Background)[1]	20.0	1.96E+07	4.89E+07	3.43E+08	1.13E+09	2.89E+09	5.04E+09
Load Allocation (Nonpoint Sources)[1]	0.2	1.96E+05	4.89E+05	3.43E+06	1.13E+07	2.89E+07	5.04E+07
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	9.79E+04	2.45E+05	1.71E+06	5.63E+06	1.44E+07	2.52E+07

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Maximum Excess Load (Total Reduction)	5.5	5.38E+06	1.35E+07	9.42E+07	3.10E+08	7.94E+08	1.39E+09

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-28. Barnes Valley Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	25.4	2.49E+08	3.73E+08	9.94E+08	2.98E+09	7.15E+09	1.16E+10
Loading Capacity	20.3	1.99E+08	2.98E+08	7.95E+08	2.38E+09	5.71E+09	9.24E+09
Load Allocation (Background)[1]	20.0	1.96E+08	2.94E+08	7.83E+08	2.35E+09	5.63E+09	9.10E+09
Load Allocation (Nonpoint Sources)[1]	0.2	1.96E+06	2.94E+06	7.83E+06	2.35E+07	5.63E+07	9.10E+07
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	9.79E+05	1.47E+06	3.91E+06	1.17E+07	2.81E+07	4.55E+07
Maximum Excess Load (Total Reduction)	5.1	4.99E+07	7.49E+07	2.00E+08	5.99E+08	1.43E+09	2.32E+09

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-29. Ben Hall Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	27.5	1.82E+08	2.62E+08	8.75E+08	2.62E+09	6.53E+09	1.08E+10
Loading Capacity	20.3	1.34E+08	1.94E+08	6.46E+08	1.94E+09	4.82E+09	7.95E+09
Load Allocation (Background)[1]	20.0	1.32E+08	1.91E+08	6.36E+08	1.91E+09	4.75E+09	7.83E+09
Load Allocation (Nonpoint Sources)[1]	0.2	1.32E+06	1.91E+06	6.36E+06	1.91E+07	4.75E+07	7.83E+07
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	6.61E+05	9.54E+05	3.18E+06	9.54E+06	2.37E+07	3.91E+07
Maximum Excess Load (Total Reduction)	7.2	4.76E+07	6.87E+07	2.29E+08	6.87E+08	1.71E+09	2.82E+09

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-30. Buck Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	24.4	1.79E+08	2.39E+08	8.36E+08	2.63E+09	6.45E+09	1.08E+10
Loading Capacity	20.3	1.49E+08	1.99E+08	6.95E+08	2.19E+09	5.36E+09	8.99E+09
Load Allocation (Background)[1]	20.0	1.47E+08	1.96E+08	6.85E+08	2.15E+09	5.28E+09	8.86E+09
Load Allocation (Nonpoint Sources)[1]	0.2	1.47E+06	1.96E+06	6.85E+06	2.15E+07	5.28E+07	8.86E+07
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	7.34E+05	9.79E+05	3.43E+06	1.08E+07	2.64E+07	4.43E+07

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Maximum Excess Load (Total Reduction)	4.1	3.01E+07	4.01E+07	1.40E+08	4.41E+08	1.08E+09	1.82E+09

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-31. East Branch Lost River sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	25	2.98E+07	7.46E+07	4.09E+08	1.41E+09	3.70E+09	6.42E+09
Loading Capacity	20.3	2.42E+07	6.06E+07	3.32E+08	1.15E+09	3.00E+09	5.22E+09
Load Allocation (Background)[1]	20.0	2.39E+07	5.97E+07	3.27E+08	1.13E+09	2.96E+09	5.14E+09
Load Allocation (Nonpoint Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.3	3.58E+05	8.95E+05	4.90E+06	1.70E+07	4.44E+07	7.71E+07
Maximum Excess Load (Total Reduction)	4.7	5.61E+06	1.40E+07	7.68E+07	2.66E+08	6.96E+08	1.21E+09

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-32. Horse Canyon Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]
Loading Capacity	20.3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Load Allocation (Background)[2]	20.0	0.00E+00	1.14E+07	1.99E+08	6.95E+08	1.94E+09	3.38E+09
Load Allocation (Nonpoint Sources)[2]	0.2	0.00E+00	1.13E+07	1.96E+08	6.85E+08	1.91E+09	3.33E+09
Waste Load Allocation (Point Sources)[2]	0.0	0.00E+00	1.13E+05	1.96E+06	6.85E+06	1.91E+07	3.33E+07
Reserve Capacity[2]	0.1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Maximum Excess Load (Total Reduction)	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]	NA[1]

[1] Data were not available to characterize current stream temperatures, current loading, or excess loads.
[2] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-33. Klamath Straits Drain allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	29.7	1.74E+07	7.27E+07	2.83E+09	5.67E+09	9.81E+09	1.26E+10
Loading Capacity	28.0	1.64E+07	6.85E+07	2.67E+09	5.34E+09	9.25E+09	1.19E+10
Load Allocation (Background + Nonpoint Sources)[1]	27.9	1.64E+07	6.83E+07	2.66E+09	5.32E+09	9.22E+09	1.18E+10
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	5.87E+04	2.45E+05	9.54E+06	1.91E+07	3.30E+07	4.23E+07

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Maximum Excess Load (Total Reduction)	1.7	9.98E+05	4.16E+06	1.62E+08	3.24E+08	5.62E+08	7.20E+08

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase

Table 4-34. Lapham Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	27.4	0.00E+00	0.00E+00	1.34E+08	5.36E+08	1.47E+09	2.55E+09
Loading Capacity	20.3	0.00E+00	0.00E+00	9.93E+07	3.97E+08	1.09E+09	1.89E+09
Load Allocation (Background)[1]	20.0	0.00E+00	0.00E+00	9.79E+07	3.91E+08	1.08E+09	1.86E+09
Load Allocation (Nonpoint Sources)[1]	0.2	0.00E+00	0.00E+00	9.79E+05	3.91E+06	1.08E+07	1.86E+07
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	0.00E+00	0.00E+00	4.89E+05	1.96E+06	5.38E+06	9.30E+06
Maximum Excess Load (Total Reduction)	7.1	0.00E+00	0.00E+00	3.47E+07	1.39E+08	3.82E+08	6.60E+08

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-35. Long Branch Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	26.2	0.00E+00	6.41E+06	2.56E+08	8.33E+08	2.31E+09	3.91E+09
Loading Capacity	20.3	0.00E+00	4.97E+06	1.99E+08	6.46E+08	1.79E+09	3.03E+09

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Load Allocation (Background)[1]	20.0	0.00E+00	4.89E+06	1.96E+08	6.36E+08	1.76E+09	2.98E+09
Load Allocation (Nonpoint Sources)[1]	0.2	0.00E+00	4.89E+04	1.96E+06	6.36E+06	1.76E+07	2.98E+07
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	0.00E+00	2.45E+04	9.79E+05	3.18E+06	8.81E+06	1.49E+07
Maximum Excess Load (Total Reduction)	5.9	0.00E+00	1.44E+06	5.77E+07	1.88E+08	5.20E+08	8.81E+08

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-36. Lost River allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	37.88	2.78E+08	3.71E+08	2.60E+09	5.84E+09	8.25E+09	1.14E+10
Loading Capacity	28.0	2.06E+08	2.74E+08	1.92E+09	4.32E+09	6.10E+09	8.43E+09
Load Allocation (Background + Nonpoint Sources)[1]	27.9	2.05E+08	2.73E+08	1.91E+09	4.30E+09	6.08E+09	8.40E+09
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	7.34E+05	9.79E+05	6.85E+06	1.54E+07	2.18E+07	3.01E+07

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Maximum Excess Load (Total Reduction)	9.9	7.25E+07	9.67E+07	6.77E+08	1.52E+09	2.15E+09	2.97E+09

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from analysis of 1999 modeled flows at the state line – Appendix F in DEQ 2018), and the allowable temperature increase.

Table 4-37. Lost River Diversion Channel sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	27.8	1.16E+08	5.44E+08	6.33E+09	1.38E+10	2.18E+10	2.67E+10
Loading Capacity	28.0	1.16E+08	5.48E+08	6.37E+09	1.39E+10	2.20E+10	2.69E+10
Load Allocation (Background + Nonpoint Sources)[1]	27.9	1.16E+08	5.46E+08	6.35E+09	1.39E+10	2.19E+10	2.68E+10
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	4.16E+05	1.96E+06	2.28E+07	4.97E+07	7.85E+07	9.59E+07
Maximum Excess Load (Total Reduction)	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-38. Miller Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	25	8.14E+08	1.16E+09	2.70E+09	7.03E+09	1.56E+10	2.45E+10
Loading Capacity	20.3	6.61E+08	9.44E+08	2.19E+09	5.71E+09	1.27E+10	1.99E+10
Load Allocation (Background)[1]	20	6.51E+08	9.30E+08	2.16E+09	5.63E+09	1.25E+10	1.96E+10
Load Allocation (Nonpoint Sources)[1]	0.2	6.51E+06	9.30E+06	2.16E+07	5.63E+07	1.25E+08	1.96E+08
Waste Load Allocation (Point Sources)[1]	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.1	3.25E+06	4.65E+06	1.08E+07	2.81E+07	6.24E+07	9.81E+07
Maximum Excess Load (Total Reduction)	4.7	1.53E+08	2.18E+08	5.07E+08	1.32E+09	2.93E+09	4.61E+09
Reduction From Background and Unquantified Sources	4	1.30E+08	1.86E+08	4.32E+08	1.13E+09	2.50E+09	3.92E+09
Reduction from Human Sources	0.7	2.28E+07	3.25E+07	7.55E+07	1.97E+08	4.37E+08	6.87E+08

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-39. North Fork Willow Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	26.7	1.31E+06	3.27E+07	2.61E+08	9.80E+08	2.68E+09	4.57E+09
Loading Capacity	20.3	9.93E+05	2.48E+07	1.99E+08	7.45E+08	2.04E+09	3.48E+09
Load Allocation (Background)[1]	20.0	9.79E+05	2.45E+07	1.96E+08	7.34E+08	2.01E+09	3.43E+09
Load Allocation (Nonpoint Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.3	1.47E+04	3.67E+05	2.94E+06	1.10E+07	3.01E+07	5.14E+07
Maximum Excess Load (Total Reduction)	6.4	3.13E+05	7.82E+06	6.25E+07	2.35E+08	6.41E+08	1.09E+09

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

Table 4-40. Rock Creek sector allocations by flow condition in kilocalories per day.

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
Current	25.8	0.00E+00	0.00E+00	1.26E+08	5.04E+08	1.51E+09	2.65E+09
Loading Capacity	20.3	0.00E+00	0.00E+00	9.93E+07	3.97E+08	1.19E+09	2.09E+09
Load Allocation (Background)[1]	20.0	0.00E+00	0.00E+00	9.79E+07	3.91E+08	1.17E+09	2.06E+09
Load Allocation	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

	Temp (deg-C)	Flow Condition					
		Low	Dry	Mild	Moderate	High	Very High
(Nonpoint Sources)[1]							
Waste Load Allocation (Point Sources)[1]	0.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Reserve Capacity[1]	0.3	0.00E+00	0.00E+00	1.47E+06	5.87E+06	1.76E+07	3.08E+07
Maximum Excess Load (Total Reduction)	5.5	0.00E+00	0.00E+00	2.67E+07	1.07E+08	3.20E+08	5.60E+08

[1] Allocations were calculated using equation 4-3, with the representative flow estimate (from StreamStat Analysis – Appendix H), and the allowable temperature increase.

4.7.1 Human Use Allowance

OAR 340-041-0028(12)(b)

The human use allowance is defined as insignificant additions of heat that are authorized in waters that exceed the applicable biologically based numeric temperature criteria.

Where the 20°C Redband or Lahontan Cutthroat Trout use are identified, the loading capacity available for human use is based on an allowable 0.3°C temperature increase at the point of maximum impact. For example, the total load from anthropogenic sources, considering both point and nonpoint sources, cannot exceed the HUA of 0.3°C. This includes any permits, dams/reservoirs, human-caused nonpoint sources, and a reserve capacity for future growth. Designated management agencies[8], permittees, or other responsible persons are responsible for implementing the TMDL and achieving the load allocation and portion of the human use allowance allocated to them.

Loading capacities for the other TMDL waterbodies were allocated between the various known sources in their drainage. Anthropogenic sources were assigned a portion of the HUA (equivalent to 0.3°C), as identified in Table 4-41 through Table 4-43 for the impaired waterbodies in the Lost subbasin.

On the Lost River, Klamath Straits Drain, and Lost River Diversion Channel, where the cool water species use criteria applies, the loading capacity available for human use is based on warming that does not exceed the instream TMDL target of 28°C,or where applicable, warming

[8] As per OAR 340-042-0030(2), designated management agency means a “federal, state or local governmental agency that has legal authority over a sector or source contributing pollutants, and is identified as such by the Department of Environmental Quality in a TMDL.”

necessary to meet criteria in downstream waters. Unlike the human use allowance provision for the applicable biologically based numeric criteria, the cool water species rule does not authorize warming when temperatures exceed a level that would impair cool water species. OAR 340-041-0028(9)(a) states "no increase in temperature is allowed that would reasonably be expected to impair cool water species". As discussed in Section, this TMDL is using an instream temperature target of 28°C to implement the cool water species narrative criterion. Therefore, the department is allocating a temperature increase and thermal load of zero to all existing anthropogenic sources when the daily maximum river temperatures are ≥27.9 C (0.1°C is held for future sources as reserve capacity). For designated management agencies or responsible persons with near-stream vegetation, or authority to manage near-stream vegetation, the allowed warming is equal to natural background warming with zero warming from anthropogenic sources. Warming from anthropogenic sources in the Klamath Straits Drain and Lost River Diversion Channel are also limited to achieve criteria in the Klamath River.

Table 4-41. Allowed warming from anthropogenic sources on the Lost River.

Sources	Allowed Warming[1] in the Lost River (°C)	Warming at Oregon/California Stateline (°C)
Point Sources	0.0	0.0
Bureau of Reclamation Langell Valley Irrigation District Tulelake Irrigation District for operation of: Anderson Rose Diversion Dam Malone Diversion Dam and Reservoir	No limit assigned when the Lost River daily maximum < 27.9°C. 0.0 increase when the Lost River daily maximum ≥ 27.9°C implemented using the flow surrogate measure or other management strategies approved by DEQ.	0.0
Bureau of Reclamation Klamath Irrigation District Tulelake Irrigation District For operation of: Lost River Diversion Channel Lost River Diversion Dam (Wilson Dam) Harpold Dam	No limit assigned when the Lost River daily maximum < 27.9°C. 0.0 when the Lost River daily maximum ≥ 27.9°C	0.0 when the Lost River 7DADM daily maximum ≥ 27.9°C
State of California at Lost River Stateline		
Other anthropogenic sources		
ODA and agricultural practices	0.0 warming above background warming implemented using the effective shade surrogate measure.	0.0
ODF and private forest practices		
Bureau of Reclamation		
City of Bonanza		
City of Merrill		
Klamath County		

Sources	Allowed Warming[1] in the Lost River (°C)	Warming at Oregon/California Stateline (°C)
Reserve Capacity	0.1	0.1
1. Allowed warming refers to the maximum warming allowed at the location where the source's heat loading occurs in the waterbody. For point sources the point of loading is at the edge of the mixing zone. For water management districts the point of heat loading is the loading from all locations where heat is contributed caused by district practices. For instream dams and reservoirs the point of heat loading is within the reservoir impoundment and where water is returned to the natural river channel and downstream of the dam. For diversions and water withdraws the point of heat loading refers to the cumulative warming in the river from all points of diversion. For transportation infrastructure, buildings, utility corridors, and for land management DMAs including USFS, BLM, ODF, or ODA where hydromodification or vegetation removal activities occur, the point of heat loading refers to the cumulative warming at all locations along the waterbody where these sources exist.		

Table 4-42. Allowed warming from anthropogenic sources on the Lost River Diversion Channel.

Source	Allowed Warming (°C)
Point Sources (None)	0.0
Klamath Irrigation District Tulelake Irrigation District Bureau of Reclamation ODA and agricultural practices All other anthropogenic warming in LRDC	Warming that results in no more than a 0.015 °C increase in the Klamath River when the LRDC daily maximum < 27.9°C 0.0 when the LRDC daily maximum ≥ 27.9°C
Reserve Capacity	0.1

Table 4-43. Allowed warming from anthropogenic sources on Klamath Straits Drain

Source	Allowed Warming (°C)
Point Sources (None)	0.0
Klamath Drainage District Bureau of Reclamation ODA and agricultural practices State of California: anthropogenic warming at Stateline. All other anthropogenic warming in KSD	Warming that results in no more than a 0.015 °C increase in the Klamath River when the KSD daily maximum < 27.9°C 0.0 when the KSD daily maximum ≥ 27.9°C
Reserve Capacity	0.1

Table 4-44. HUA allocations to anthropogenic sources in the Rock Creek-Lost River watershed (HUC 1801020404) and North Fork Willow Creek-Willow Creek watershed (HUC 1801020402)[1].

Source	Cumulative warming upstream of Willow Valley Reservoir [1] (°C)	Cumulative warming (°C) at Willow Valley Reservoir Dam outlet[2]	Cumulative warming at Oregon/California Stateline (°C)
Point Sources (None)	0.0	0.0	0.0
State of California (waters entering Oregon)	N/A	0.0	0.0
Willow Valley Reservoir	0.0	0.0	0.0
ODA and agricultural practices	0.0	0.0	0.0
ODF (state and private forest practices)	0.0	0.0	0.0
USFS	0.0	0.0	0.0

Source	Cumulative warming upstream of Willow Valley Reservoir [1] (°C)	Cumulative warming (°C) at Willow Valley Reservoir Dam outlet[2]	Cumulative warming at Oregon/California Stateline (°C)
BLM	0.0	0.0	0.0
Water withdrawals Water management districts Currently existing transportation infrastructure, buildings, and utility corridors	0.2	0.0	0.0
All other anthropogenic sources	0.0	0.0	0.0
Reserve Capacity	0.1	0.3	0.3

1. Cumulative warming refers to the maximum warming allowed at the location where the source's heat loading occurs in the waterbody. For point sources the point of loading is at the edge of the mixing zone. For water management districts the point of heat loading is the loading from all locations where heat is contributed caused by district practices. For instream dams and reservoirs the point of heat loading is within the reservoir impoundment and where water is returned to the natural river channel and downstream of the dam. For diversions and water withdraws the point of heat loading refers to the cumulative warming in the river from all points of diversion. For transportation infrastructure, buildings, utility corridors, and for land management DMAs including USFS, BLM, ODF, or ODA where hydromodification or vegetation removal activities occur, the point of heat loading refers to the cumulative warming at all locations along the waterbody where these sources exist.
2. The cumulative warming at Willow Valley Reservoir Dam is located where water is released from Willow Valley Reservoir into the natural river channel of the East Branch Lost River.

Table 4-45. HUA allocations to anthropogenic sources in the Gerber Reservoir-Miller Creek watershed (HUC 1801020405)[1].

Source	Cumulative warming upstream of Gerber Reservoir (°C)	Cumulative warming (°C) at Gerber Dam outlet[2]	Cumulative HUA at mouth of Miller Creek (°C)
Point Sources (None)	0.0	0.0	0.0
Gerber Dam and Reservoir	0.0	0.0	0.0
Miller Diversion Dam	NA	NA	0.2
ODA and agricultural practices	0.0	0.0	0.0
ODF (state and private forest practices)	0.0	0.0	0.0
USFS	0.0	0.0	0.0
BLM	0.0	0.0	0.0
Water withdrawals Water Management Districts Currently existing transportation infrastructure, buildings, and utility corridors	0.2	0.0	0.0
All other anthropogenic sources	0.0	0.0	0.0
Reserve Capacity	0.1	0.3	0.1

1. Human use allowance at point of heat loading refers to the maximum warming allowed at the location where the source's loading occurs in the waterbody. For point sources the point of heat loading is at the edge of the mixing zone. For water management districts the point of heat loading is the loading from all locations where heat is contributed caused by district practices. For dams and reservoirs the point of heat loading is within the reservoir impoundment and where water is returned to the natural river channel downstream of the dam. For diversions and water withdraws the point of heat loading refers to the cumulative warming from all points of

diversion. For transportation infrastructure, buildings, utility corridors, and for land management DMAs including USFS, BLM, ODF, or ODA where hydromodification or vegetation removal activities occur, the point of heat loading refers to the cumulative warming at all locations along the waterbody where these sources exist. The cumulative warming at Gerber Dam is where water is released from Gerber Dam into the natural river channel of Miller Creek. 2. The cumulative warming at Gerber Dam is located where water is released from Gerber Dam into the natural river channel of Miller Creek.

Table 4-46. HUA allocations to anthropogenic sources on all tributaries of the Lost River in the Yonna Valley-Lost River watershed (1801020407)[1].

Source	Cumulative warming (^oC)
Point Sources (None)	0.0
ODA and agricultural practices	0.0
ODF (state and private forest practices)	0.0
USFS	0.0
BLM	0.0
Water withdrawals Water Management Districts Currently existing transportation infrastructure, buildings, and utility corridors	0.2
All other anthropogenic sources	0.0
Reserve Capacity	0.1
1. Human use allowance at point of heat loading refers to the maximum warming allowed at the location where the source's loading occurs in the waterbody. For point sources the point of heat loading is at the edge of the mixing zone. For water management districts the point of heat loading is the loading from all locations where heat is contributed caused by district practices. For dams and reservoirs the point of heat loading is within the reservoir impoundment and where water is returned to the natural river channel downstream of the dam. For diversions and water withdraws the point of heat loading refers to the cumulative warming from all points of diversions. For transportation infrastructure, buildings, utility corridors, and for land management DMAs including USFS, BLM, ODF, or ODA where hydromodification or vegetation removal activities occur, the point of heat loading refers to the cumulative warming at all locations along the waterbody where these sources exist.	

Table 4-47. HUA allocations to anthropogenic sources on waterbodies within the Lower Klamath Lake Watershed (HUC 1801020414) except Klamath River and Klamath Straits Drain[1].

Source	Cumulative warming [1] (^oC)
Point Sources (None)	0.0
ODA and agricultural practices	0.0
ODF (state and private forest practices)	0.0
USFS	0.0
BLM	0.0
Water Management Districts Currently existing transportation infrastructure, buildings, and utility corridors	0.2
All other anthropogenic sources	0.0
Reserve Capacity	0.1
1. Human use allowance at point of heat loading refers to the maximum warming allowed at the location where the source's loading occurs in the waterbody. For point sources the point of heat loading is at the edge of the mixing zone. For water management districts the point of heat loading is the loading from all locations where heat is contributed caused by district practices. For dams and reservoirs the point of heat loading is within the reservoir impoundment and where water is returned to the natural river channel downstream of the dam. For diversions and water withdraws the point of heat loading refers to the	

cumulative warming from all points of diversions. For transportation infrastructure, buildings, utility corridors, and for land management DMAs including USFS, BLM, ODF, or ODA where hydromodification or vegetation removal activities occur, the point of heat loading refers to the cumulative warming at all locations along the waterbody where these sources exist.

4.7.2 Waste Load Allocations

OAR 340-042-0040(4)(g), 40 CFR 130.2(g)

This section describes the portions of the receiving water's loading capacity that are allocated to existing point sources of pollution, including all point source discharges regulated under the Federal Water Pollution Control Act Section 402 (33 USC Section 1342). Since the point sources identified in the Lost subbasin are not expected to be sources of thermal loading during the summer critical period of June 1 – September 30, waste load allocations were assigned zero excess warming (Table 4-27 through Table 4-40). Any existing source determined to be a source of warming or new future point source may apply to the department for use of reserve capacity. An existing source or future source may also discharge with a zero excess thermal load. On the Lost River a zero excess thermal load is measured as no increase above the upstream ambient temperature or above 27.9 deg-C when daily maximum river temperatures are >= 27.9 deg-C. See conditions and procedures outlined in reserve capacity Section 4.8.

4.7.2.1 General Stormwater Discharges

Industrial and construction stormwater sources have been determined to not have a reasonable potential to increase Lost River stream temperatures and are assigned a wasteload allocation equal to their current thermal load.

If data collected after the TMDL is issued indicates that stormwater in the Lost subbasin is a source of thermal loading that is causing an increase in stream temperature, then stormwater facilities may access a portion of the reserve capacity. At that time, the use of additional BMPs to reduce thermal loading shall also be evaluated. Effective BMPs include: reducing the amount of solar exposure on the runoff by directing it through covered or underground storage detention facilities; reducing the volume of runoff using bioretention or other filtration methods; and providing thermal protection through the use of vegetated buffers (Jones and Hunt 2009; Natarajan and Davis 2010; UNH Stormwater Center 2011; Winston et. al. 2011, Wardynski et. al. 2013, Long and Dymond 2014).

4.7.3 Load Allocations

OAR 340-042-0040(4)(h), 40 CFR 130.2(h)

This element determines the portions of the receiving water’s loading capacity that are allocated to current nonpoint sources of pollution. The thermal load from nonpoint sources in the Lost River is a mixture of natural background loads, including unidentified anthropogenic loads, and loads from anthropogenic sources. Load allocations for each TMDL waterbody are presented in Table 4-27 through Table 4-40 and descriptions of the source categories are provided below.

4.7.3.1 Background

For all Lost River tributaries, an allocation equivalent to the applicable criterion (20°C) is reserved for background sources (Table 4-27 through Table 4-40). This background load allocation is a portion of the loading capacity equal to the product of the applicable criterion, the stream flow, and a conversion factor and can be calculated using Equation 4-3 if the criterion is incorporated as the ΔT (delta T).

On the Lost River, the warming from background sources was not quantified so background and anthropogenic nonpoint source load allocations are equal to a temperature increase of 27.9°C.

Background sources account for an undifferentiated mixture of natural sources and anthropogenic sources of warming. Examples of loading from background sources include, but are not limited to, direct and diffuse solar and longwave radiation received by the stream under natural or restored near-stream vegetation, channel morphology, and streambank elevations conditions; mass transfer of thermal load as a result of advection, dispersion, and exchange from mixing with groundwater, hyporheic flows, or tributary surface flows which also have natural or restored near-stream vegetation, channel morphology, and streambank elevations; heat exchange between the water column and a natural or restored substrate through conduction; and between the water column and the atmosphere through evaporation and convection (Section 4.4.3). Background sources may also include some anthropogenic warming that the Department or another Oregon state agency does not have authority to regulate, such as pollutants emanating from another state, tribal lands, or sources otherwise beyond the jurisdiction of the state (OAR 340-042-0030(1)).

4.7.3.2 Water Management Districts

The load allocations for water management districts can be calculated using Equation 4-4 and represent the equivalent thermal load resulting in the allowed temperature increase (ΔT) allocated to each source in Table 4-44 through Table 4-47 (HUA allocation tables).

Water Management Districts Load Allocation Equation

The following equation is used to calculate thermal load allocations for water management districts.

$$LA = (\Delta T) \cdot (Q_D + Q_R) \cdot C_F$$ **Equation 4-4**

where,

$LA =$ Load allocation (kilocalories/day).

$\Delta T =$ The maximum allowed temperature increase (°C).

$Q_D =$ The daily mean discharge from the source (if applicable, otherwise = zero) (cfs).

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

$C_F =$ Conversion factor using flow in cubic feet per second (cfs): 2,446,665

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

4.7.3.3 Dams and Reservoirs: Lost River

The Lost River is influenced by four different impoundments (Malone Diversion Dam, Harpold Dam, Lost River Diversion Dam (also known as Wilson Dam), and Anderson Rose Diversion Dam. Load allocations for DMAs and responsible persons that manage and operate these dams are no warming (zero kilocalories per day) when the Lost River daily maximum ≥ 27.9°C. In addition, load allocations for DMAs and responsible persons that manage and operate Malone and Anderson Rose Diversion Dams are also expressed as a surrogate measure instream flow targets (Section 4.7.4).

The department may, on a case-by-case basis, require the Lost River dams to develop and implement a temperature management plan. (OAR 340-041-0028 (12)(e)).

4.7.3.4 Dams and Reservoirs: Lost River Tributaries

Several dams influence temperature in the Lost River tributaries. Willow Valley Reservoir influences the East Branch Lost River. Allocations for DMAs and responsible persons that manage and operate this reservoir are provided in Table 4-31 and the allowed warming for this reservoir is provided in Table 4-44. Allocations for Gerber Reservoir, which is associated with Miller Creek, are shown in Table 4-38. A number of other dam and reservoirs that are located upstream of impaired waterbodies may also be potential sources.

Load allocations for DMAs and responsible persons that manage and operate the dams and reservoirs on the Lost River tributaries can be calculated using Equation 4-5 and represent the equivalent thermal load resulting in the allowed temperature increase (ΔT) allocated to each dam and reservoir in Table 4-44 through Table 4-47.

The following equation is used to calculate thermal load allocations for dams and reservoirs.

$$LA = (\Delta T) \cdot (Q_R) \cdot C_F$$ **Equation 4-5**

where,

$LA =$ Load allocation (kilocalories/day).

$\Delta T =$ The maximum allowed temperature increase (°C).

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

Conversion factor using flow in cubic feet per second (cfs): 2,446,665

$$C_F = \frac{1\,ft^3}{1\,sec} \cdot \frac{1\,m^3}{35.31\,ft^3} \cdot \frac{1000\,kg}{1\,m^3} \cdot \frac{86400\,sec}{1\,day} \cdot \frac{1\,kcal}{1\,kg\,\cdot 1℃} = 2{,}446{,}665$$

Evaluating compliance using the change in temperature, rather than a thermal load, is often a more useful approach for reservoir management because it relates directly to the temperature standard and is easier to evaluate and understand.

To evaluate compliance, the change in temperature (ΔT) may be calculated as the difference between the 7DADM stream temperatures upstream of the reservoir and the 7DADM near the dam outlet where water is returned to the natural river channel; or quantified with a model that has been reviewed and accepted by DEQ. If analysis shows the point of maximum impact from the dam and reservoir operation to be in another location other than the dam outlet, that point of maximum and impact is used instead to evaluate warming. Differences between the upstream and downstream 7DADM temperatures may be adjusted to account for any natural warming or cooling that would occur absent the dam and reservoir operations.

The department may, on a case-by-case basis, require dams in the Lost subbasin to develop and implement a temperature management plan. (OAR 340-041-0028 (12)(e)).

4.7.3.5 Near-Stream Vegetation Management

Designated management agencies or responsible persons with near-stream vegetation or authority to manage near-stream vegetation within the scope of this TMDL are allocated a zero HUA (Table 4-27 through Table 4-40) and equivalent load allocation of zero kilocalories per day. This means that no stream warming is allowed from human caused removal or absence of vegetation and the loading must be equal to background loading.

Load allocations for these designated management agencies or responsible persons with near-stream vegetation are expressed in the surrogate measure effective shade (Section 4.7.4). There are two types of effective shade targets that apply to designated management agencies or responsible persons:

1. Site-specific effective shade allocations apply to the streams that have been simulated with computer modeling.
2. Effective shade curves are generalized allocations that apply to all other streams covered within the geographic scope of this TMDL, but that have not been modeled.

4.7.4 Surrogate Measures

These TMDLs incorporate other measures in addition to ‘daily loads’ to fulfill requirements of the Clean Water Act §303(d). Although a loading capacity for heat load is derived (e.g., kilocalories), it is of limited value in guiding management activities needed to solve identified water quality problems. In addition to heat loads (i.e., kilocalorie daily loads), this TMDL provides supplementary implementation allocations ‘*other appropriate measures*’ (or surrogate measures) as provided under EPA regulations (40 CFR 130.2(i)). The surrogate measures include in-stream flow targets downstream of Malone and Anderson dams as well as effective shade targets. Together these surrogate measures implement the load allocations assigned to sources in this TMDL.

4.7.4.1.1 In-Stream Flow Target

When Lost River temperatures exceed 27.9 degrees Celsius as measured using instream temperature monitoring equipment anywhere downstream of the Malone Diversion Dam to the confluence of Miller Creek, a minimum of 25 cfs of instream flow shall be maintained in the Lost River in order minimize warming in the Lost River above 27.9^{o}C.

When Lost River temperatures exceed 27.9 degrees Celsius as measured using instream temperature monitoring equipment anywhere downstream of the Anderson Rose Diversion Dam to the Oregon/California Stateline, a minimum of 11 cfs of instream flow shall be maintained in the Lost River in order minimize warming in the Lost River above 27.9^{o}C.

DMAs or responsible persons may also propose alterative management strategies to be used in lieu or in conjunction with the instream flow target if those management strategies are demonstrated to result in maintenance of temperatures at or below 27.9 degrees Celsius. DMA’s or responsible persons may propose alternative management strategies in a TMDL implementation plan. Following DEQ’s review and approval of the TMDL implementation plan the alternative management strategies may be implemented in lieu of the instream flow targets.

Figure 4-26 and Figure 4-28 illustrates the flow targets compared to the flows in 1999, the model year.

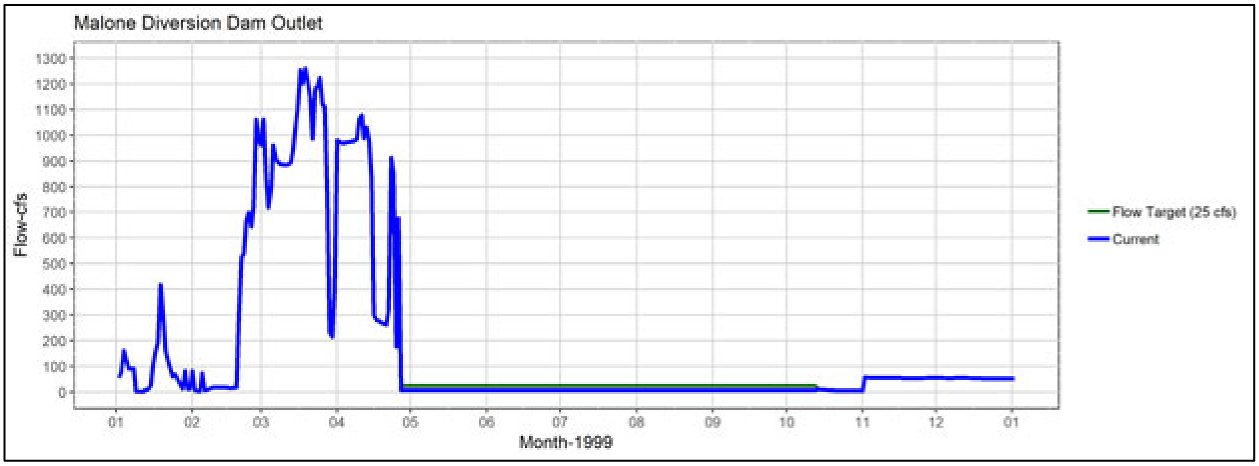


Figure 4-27. Current flows (1999) and in-stream target flows downstream of Malone Diversion Dam.

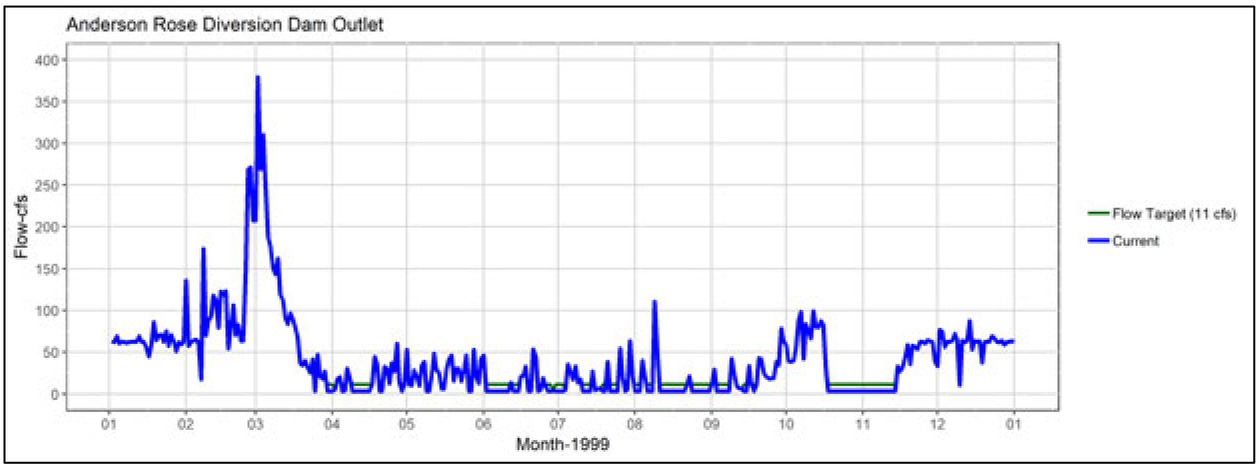


Figure 4-28. Current flows (1999) and in-stream target flows downstream of Anderson Rose Diversion Dam.

4.7.4.1.2 Site Specific Effective Shade

Effective shade is the surrogate measure that translates load allocations for land management DMAs. It is simple to measure effective shade at the stream surface using a relatively inexpensive instrument called a Solar Pathfinder™.

The mean restored condition effective shade values presented in Table 4-48 through Table 4-50 are to be used for evaluating attainment with the site specific effective shade targets on the Lost River, Miller Creek, Antelope Creek, Barnes Valley Creek, Horse Canyon Creek, Lapham Creek, Long Branch Creek and North Fork Willow Creek . For other streams, the effective shade curves are to be used to determine the appropriate amount of effective shade.

The term ‘shade’ has been used in several contexts, including its components such as shade angle or shade density. For purposes of this TMDL, effective shade is defined as the percent reduction of potential daily solar radiation load delivered to the water surface. The role of effective shade in this TMDL is to prevent or reduce stream warming caused by solar radiation.

Implementation of the effective shade surrogate measure is a key implementation measure for DMAs in the subbasin. Although it is not the sole implementation measure needed to meet their allocations. TMDL compliance is evaluated based on the allocation calculated using the source's portion of the HUA. When implemented, effective shade is one method DMAs can use to achieve a portion of their zero load allocation.

Figure 4-29 through Figure 4-31 show the longitudinal profile of the simulated percent effective shade estimates on the Lost River, Miller Creek, Antelope Creek, Barnes Valley Creek, Horse Canyon Creek, Lapham Creek, Long Branch Creek and Willow Creek by river kilometer. The loading under "Current Condition" effective shade (in blue) is generally greater than the loading under the restored condition effective shade (in green). The "Natural Disturbance Range" (in grey) indicates the shade levels that could potentially occur in the event of natural disturbances. The lower end of that range (in black) represents that amount of shade that the stream would receive if topography were the only shade-producing feature (i.e., no vegetation). Appendix A contains detailed descriptions of the methodology used to develop these simulations of effective shade. LiDAR data from 2011 were used to characterize vegetation along the Lost River. Appendix A includes limitations of the data and methodology.

The "Restored Condition" (green line) represents the estimated maximum effective shade for a given location, assuming the vegetation is fully mature. Caution should be used when interpreting the charts**.** This TMDL recognizes that it is unlikely for an entire stream to be at its maximum restored effective shade everywhere, all the time. In reality, natural disturbances will create a variety of tree heights and densities. Even at restored conditions effective shade levels may be lower than those depicted in the "Restored Vegetation" condition. Instead the shade will be somewhere within the "Disturbance Range". Reductions in effective shade caused by natural disturbance are not considered a violation of the TMDL or water quality standards.

An increase in effective shade to implement the temperature TMDL will likely result in larger riparian vegetation, which will increase the potential for contributions of large woody debris to streams. Increases in large woody debris benefit stream temperatures and associated cool water habitat by increasing the number and depth of pools, which provide areas of cooler water for fish (USEPA 2004). Large woody debris provides shelter and supports food sources that are crucial for the survival of fish in the Lost subbasin.

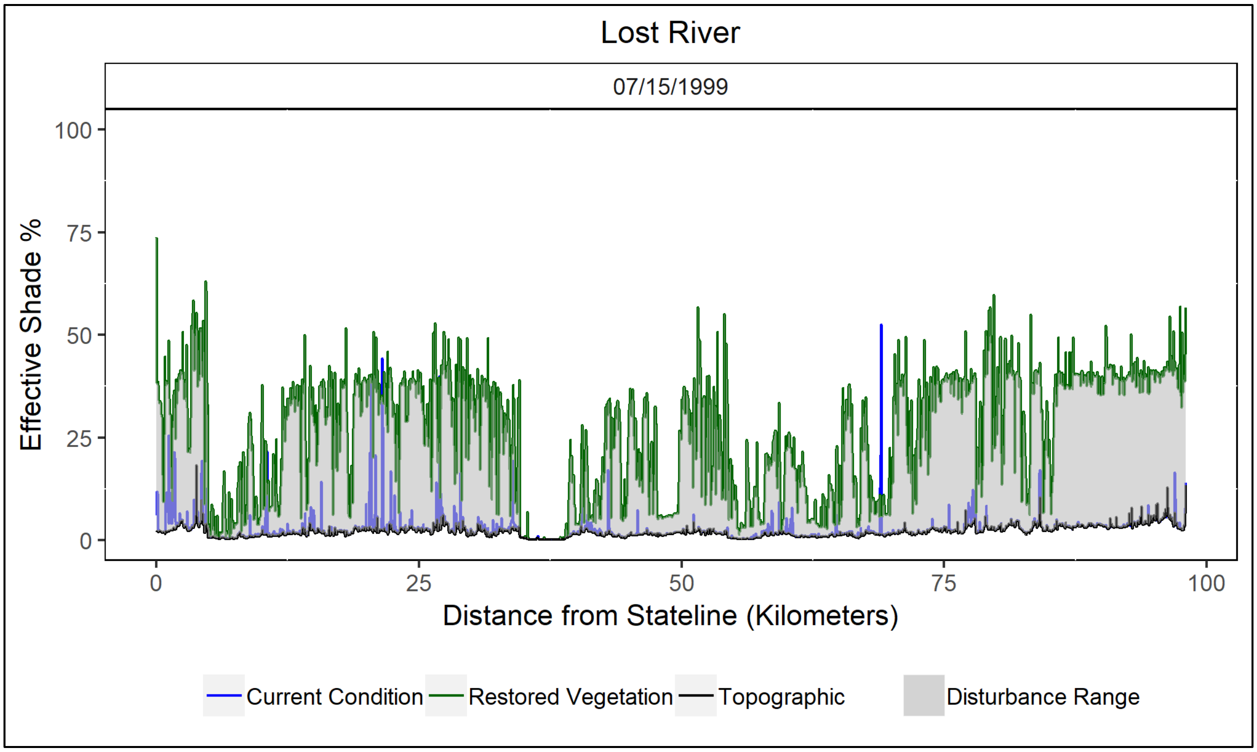


Figure 4-29. Effective shade targets on the Lost River.

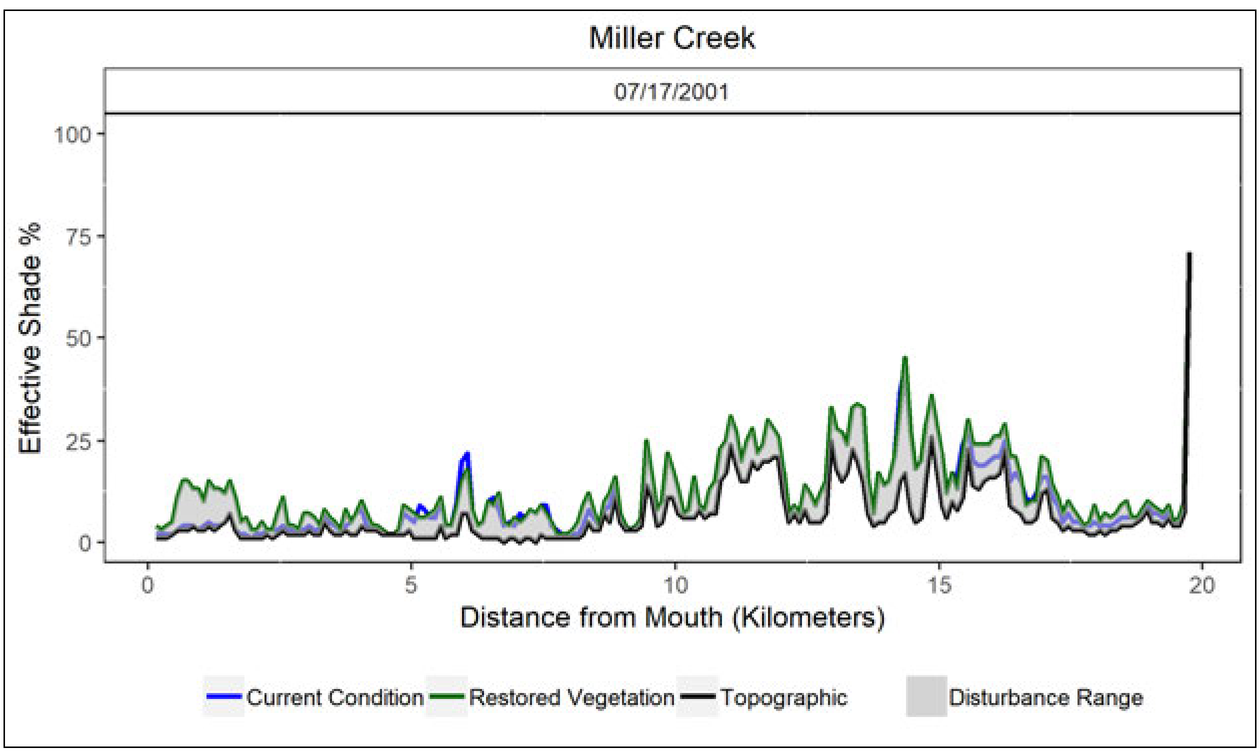
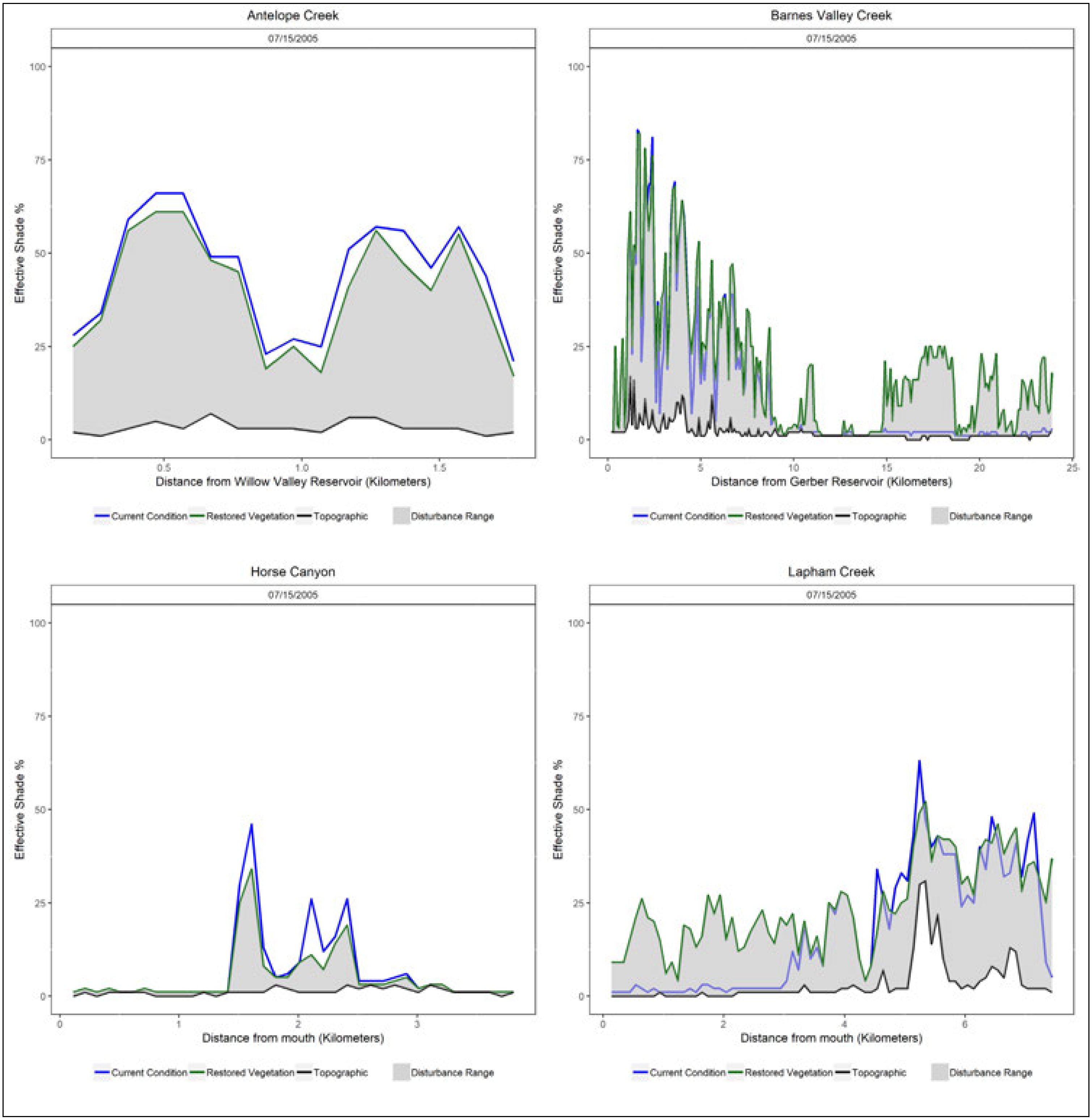


Figure 4-30. Effective shade targets on Miller Creek.



Antelope Creek
07/15/2005
Effective Shade %
100
75
50
25
0
0.5
1.0
1.5
Distance from Willow Valley Reservoir (Kilometers)
Current Condition
Restored Vegetation
Topographic
Disturbance Range
Barnes Valley Creek
07/15/2005
0
5
10
15
20
25
Distance from Gerber Reservoir (Kilometers)
Horse Canyon
07/15/2005
1
2
3
Distance from mouth (Kilometers)
Lapham Creek
07/15/2005
2
4
6
Distance from mouth (Kilometers)

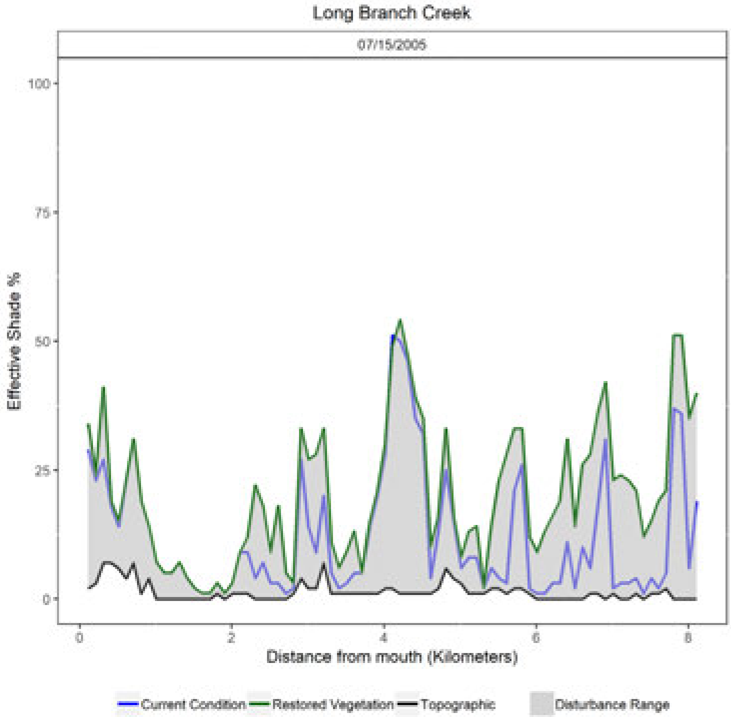


Figure 4-31. Effective shade targets for six tributaries in the Lost subbasin.

Appendix A describes the methodology used to determine restored vegetation. The mean effective shade for the modeled reaches is provided in Table 4-48 through Table 4-50. These values are to be used as the surrogate measure and for purposes of evaluating attainment. The average shade deficit is the average difference between current and restored vegetation shade.

Table 4-48. Lost River Surrogate effective shade measures for selected reaches.

Lost River Reach	Mean Percent Effective Shade		Mean Effective Shade deficit (% shade)
	Current (%)	Restored Vegetation (%)	
Lost River (Malone Dam to Stateline)	3	26	23
Malone to Harpold	3%	30%	27%
Harpold to Ranch	1%	12%	11%
Ranch-Wilson Reservoir	2%	20%	18%
Wilson Reservoir	0%	0%	0%
Wilson Dam to Anderson Rose Dam	3%	27%	24%
Anderson Rose Dam to Stateline	6%	37%	31%

Table 4-49. Surrogate effective shade measures for Miller Creek.

Miller Creek Reach	Mean Percent Effective Shade		Mean Effective Shade deficit (% shade)
	Current (%)	Restored Vegetation (%)	
Miller Creek (Gerber Dam to Lost River)	11	13	2
Gerber Dam to Pine Creek	14	15	1
Pine Creek to Lost River	4	7	3

Table 4-50. Surrogate effective shade measures for selected Lost River tributaries.

Waterbody	Mean Percent Effective Shade		Mean Effective Shade deficit (% shade)
	Current (%)	Restored Vegetation (%)	
Antelope	45	40	-4
Barnes Valley	18	12	6
Horse Canyon	5	4	-1
Lapham	18	24	7
Long Branch	12	20	8
Miller Creek	11	13	2
Nork Fork Willow	13	21	9

4.7.4.1.1 Effective Shade Curves

Effective shade curves are general heat load allocations applicable to any stream that was not specifically modeled for shade or temperature. The heat load and effective shade surrogates are identified by ecoregion for different types of potential vegetation. Effective shade curves represent the *maximum* possible effective shade for a given vegetation type. Natural disturbance was not included in the effective shade curve calculations. The values presented within the effective shade curves represent the effective shade that would be attained if the vegetation were at its stated potential height and density. The potential heights and densities were determined for the Lost subbasin. See Appendix A for methodology to determine restored vegetation.

Local geology, geography, soils, climate, legacy impacts, natural disturbance rates, and other factors may prevent effective shade from reaching the values presented in the effective shade curves. The goal of the TMDL is to achieve water quality standards. Minimizing anthropogenic impacts on effective shade is an important implementation strategy. This TMDL recognizes that unpredictable natural disturbances may result in effective shade well below the levels presented in the effective shade curves.

The effective shade curves account for latitude, critical summertime period (Lost subbasin August 1, 2001), elevation, stream width and stream aspect. Site-specific effective shade simulations (i.e., results from Heat Source modeling illustrated in Appendix A) supersede the following effective shade curves. Reaches and tributaries that were not modeled are represented by the ecoregion and vegetation type presented in Figure 4-32 and Figure 4-33 for the Lost subbasin.

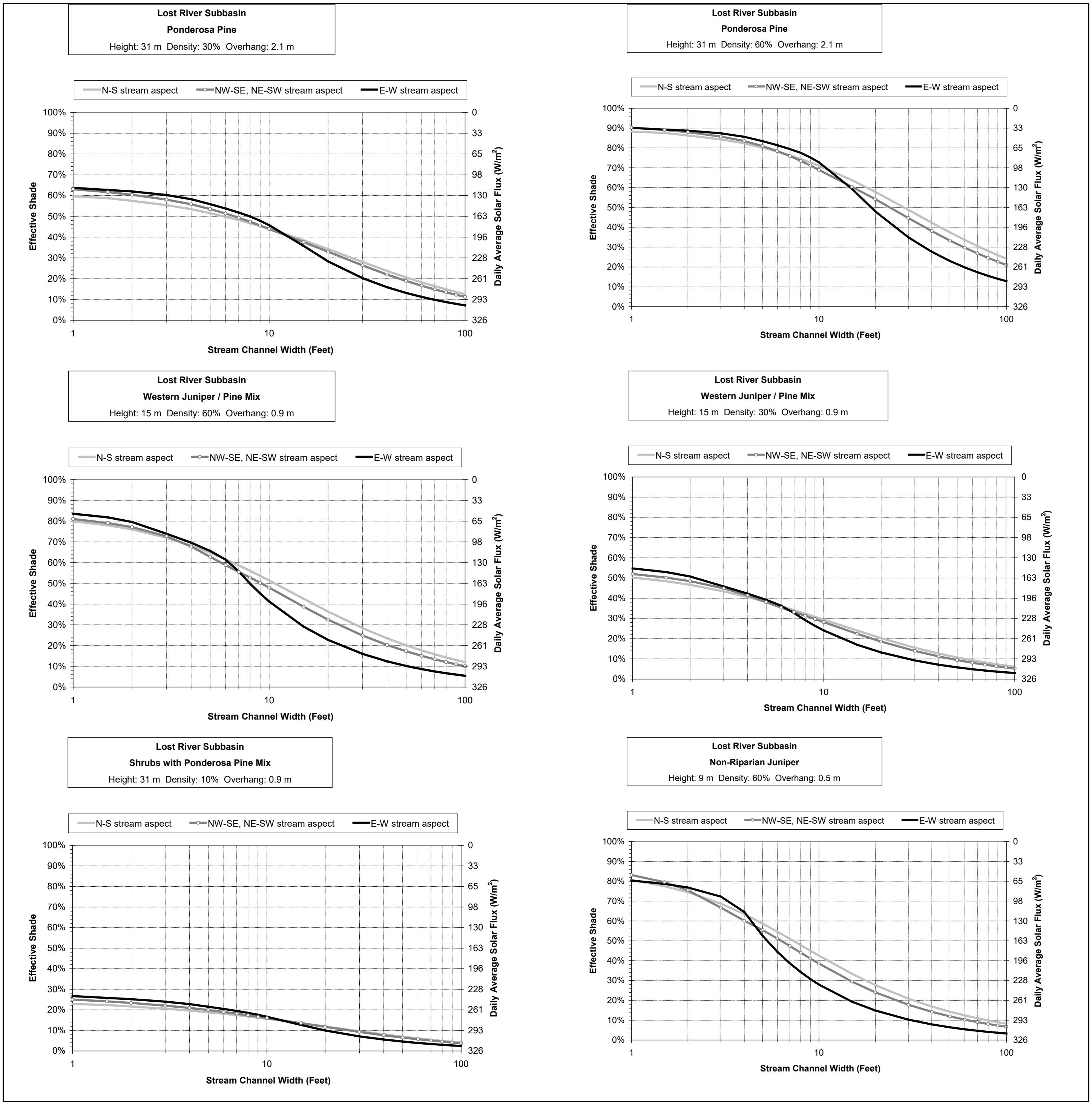


Figure 4-32. Effective shade curves for potential vegetation in the Lost subbasin (1 of 2).

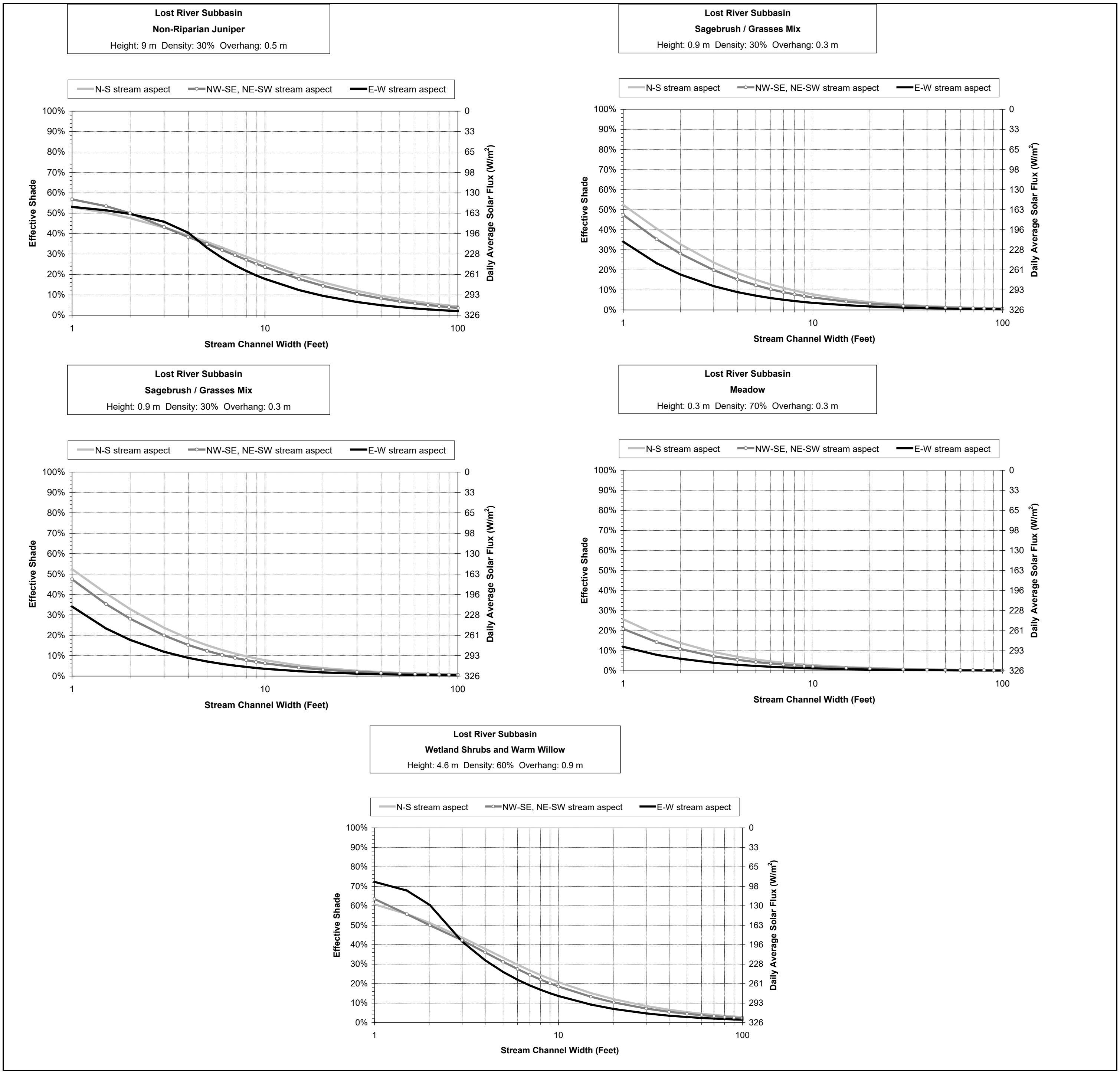


Figure 4-33. Effective shade curves for potential vegetation in the Lost subbasin (2 of 2).

4.8 Reserve Capacity

OAR 340-042-0040(4)(k)

There is an explicit allocation for reserve capacity throughout set aside for future growth and new, expanded or unidentified sources. The change in stream temperature associated with the reserve capacity was quantified in kilocalories per day where the 'portion of HUA allocated' was incorporated as delta T to calculate the allocation. Reserve capacity is available for use by either nonpoint or point sources to accommodate future growth as well as to provide an allocation to any existing source that may not have been identified during the development of this TMDL. In the event that any new individual facility permits are issued in the subbasin, they will be written to ensure that all TMDL related issues are addressed in the permit. DEQ has a process for setting or revising WLAs for new or expanding point sources discharges to waterbodies with an approved TMDL. This process will be used to update allocations in approved TMDLs for new or expanding dischargers whose permitted effluent limits are at or below the in-stream target and will ensure that the effluent will not exceed applicable water quality standards or surrogate measures. The process for modifying or adding and WLAs to the TMDL will be handled by DEQ, with input and involvement by the EPA, once a permit request is submitted. Once DEQ determines that the new or expanded discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made. The department may allocate none, some, or all of reserve capacity if sufficient capacity is available and an analysis is conducted to demonstrate attainment of the applicable water quality targets, including targets established by California's North Coast Water Quality Control Board at the Oregon/California border. Table 4-27 to Table 4-40 present the reserve capacity for each TMDL.

4.9 Margin of Safety

OAR 340-042-0040(4)(1)

The Clean Water Act requires that each TMDL be established with a margin of safety to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A margin of safety is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (i.e., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions).

The margin of safety may be implicit, as in conservative assumptions used in calculating the loading capacity, wasteload allocations, and load allocations. The margin of safety may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the margin of safety documented. The margin of safety is not meant to compensate for a failure to consider known sources. Table 4-51 presents six approaches for incorporating a margin of safety into TMDLs.

Table 4-51. Approaches for incorporating a margin of safety into a TMDL

Type of Margin of Safety	Available Approaches
Explicit	1. Set numeric targets at more conservative levels than analytical results indicate. 2. Add a safety factor to pollutant loading estimates. 3. Do not allocate a portion of available loading capacity; reserve for margin of safety.
Implicit	1. Conservative assumptions in derivation of numeric targets. 2. Conservative assumptions when developing numeric model applications. 3. Conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

An *implicit* margin of safety has been incorporated into the temperature assessment methodology, resulting in conservative estimates of loads and required reductions:

- The thermal loading capacities were calculated used the lowest flow estimate for each flow condition; however, the loading capacity applies to the entire range of flows within that condition (Appendix H). This approach captures the expected range of flows for each impaired segment. It results in a conservative application of the loading capacity when the observed flow in a specific condition is higher than the lowest flow estimate used in the TMDL calculations.
- Conservative estimates for unmeasured data and inputs were used in the stream temperature simulations (Appendix A). These values often result in higher estimates for existing conditions, resulting in higher estimates for required reductions and excess thermal loads.
- Restored vegetation effective shade targets do not explicitly account for natural disturbances (Appendix A). These estimates result in higher estimates of average shade and set a higher bar to meet the surrogate effective measures. In reality, natural disturbances will create a variety of tree heights and densities and the natural disturbance processes are generally beneficial to overall salmonid habitat as they may result in pools and refugia. Effective shade is not the only implementation strategy available to meet the TMDL; however, it is important to meeting the TMDL.
- Although exceedances of the temperature criterion at the Lost River at the state line typically occur June through August, DEQ has defined the critical period as May 1 – September 30 in order to account for periods warming where warm air temperatures may occur earlier or later than is typical.

For further information regarding stream temperature modeling assumptions, refer to Appendix A.

4.10 References

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5. Reasonable Assurance

Reasonable Assurance OAR 340-042-0030(9): is a demonstration that a TMDL will be implemented by federal, state or local governments or individuals through regulatory or voluntary actions including management strategies or other controls. In the Water Quality Management Plan there is a description of reasonable assurance that management strategies and sector-specific or source-specific implementation plans will be carried out through regulatory or voluntary actions (OAR 340-042-0040(l)(J)).

The Clean Water Act (CWA) section 303(d) requires that a TMDL be "established at a level necessary to implement the applicable water quality standard." Federal regulations define a TMDL as "the sum of the individual WLAs for point sources and LAs for nonpoint sources and natural background" [40 CFR 130.2(i)]. Documenting adequate reasonable assurance increases the probability that regulatory and voluntary mechanisms will be applied such that the pollution reduction levels specified in the TMDL are achieved and, therefore, applicable WQS are attained.

When a TMDL is developed for waters impaired by point sources only, the existence of the National Pollutant Discharge Elimination System (NPDES) regulatory program and the issuance of an NPDES permit provide the reasonable assurance that the WLAs in the TMDL will be achieved. That is because federal regulations implementing the CWA require that water quality-based effluent limits in permits be consistent with "the assumptions and requirements of any available [WLA]" in an approved TMDL [40 CFR 122.44(d)(1)(vii)(B)].

Where a TMDL is developed for waters impaired by both point and nonpoint sources, in the State's and EPA's best professional judgment, determinations of reasonable assurance that the TMDL's LAs will be achieved could include whether practices capable of reducing the specified pollutant load: (1) exist; (2) are technically feasible at a level required to meet allocations; and (3) have a high likelihood of implementation. Where there is a demonstration that nonpoint source load reductions can and will be achieved, a determination that reasonable assurance exists and, on the basis of that reasonable assurance, allocate greater loadings to point sources. Without a demonstration of reasonable assurance that relied-upon nonpoint source reductions will occur, there would need to be reductions to point sources wasteload allocations.

For the Upper Klamath and Lost Rivers Temperature TMDL there are several elements that combine to provide the reasonable assurance to meet federal and state requirements. Education, outreach, technical and financial assistance, permit administration, permit enforcement, DMA or Responsible Person's implementation and enforcement of TMDL implementation plans will all be used to ensure that the goals of this TMDL are met. Although it is anticipated that improvements to instream water temperatures could take decades because it will take that long for vegetation restoration to grow tall enough to provide the needed shade, the following rationale links the components and provides reasonable assurance to meet state and federal requirements. The TMDL, the WQMP including DMA or Responsible Person's TMDL implementation plans (see Section 4), and the *Monitoring Strategy to Support Implementation of Water Temperature Total Maximum Daily Loads for the Upper Klamath and Lost subbasins* (EPA & DEQ 2019) incorporate multiple elements that, together, provide reasonable assurance that the TMDL will be implemented and when implemented attain and maintain the water quality standard.

5.1 Programs to Achieve Point Source Reductions

Point sources in the Upper Klamath subbasin include two WWTPs and two industrial NPDES permittees (Klamath Falls WWTP, South Suburban WWTP, Columbia Plywood, and Collins Forest Products). Permit compliance for wastewater frequently requires implementation of monitoring and reporting. Requirements differ by permit type. Opportunities and resources associated with wastewater are discussed below. These activities already support this TMDL and add to the assurance that the temperature will meet the WLAs and Oregon's water quality standards.

NPDES point sources are addressed through the EPA's NPDES permit program, which is administered by DEQ and provides guidance for permit compliance and enforcement actions. The WLAs allocated to these NPDES point sources will be incorporated into the permit when the permit is renewed and it is expected that these facilities will meet their WLAs.

The WLAs given to the four point source facilities will be implemented through modifications to their NPDES permits. These permits will either include numeric effluent limits for thermal inputs or provisions to develop and implement management plans, whichever is appropriate (DEQ 2019). Reserve capacity has been set aside (Section 2.7, Section 3.8 and Section 4.8) for new or unidentified sources including NPDES permits for any new individual facilities in the subbasin. This approach will ensure that new or unidentified sources will meet the TMDL allocations and Oregon's water quality standards.

5.2 Programs to Achieve Nonpoint Source Reductions

Load allocations were assigned to nonpoint sources which were non-NPDES permitted sources of the pollutant. The TMDL provides reasonable assurances that nonpoint source control measures will achieve the expected load allocation and reductions. This section discusses the reasonable assurance that nonpoint source controls will be implemented and maintained and that nonpoint source reductions will be verified through an effective monitoring program. Reasonable assurance may include the application or use of local ordinances, grant conditions, or other enforcement authorities.

Reasonable assurance that nonpoint source load reductions will be achieved is based on DEQ authorities under OAR 340-042, the Agricultural Water Quality Management Act, Forest Practices Act, and an accountability framework incorporated into the WQMP, including DMA or Responsible Person's TMDL implementation plans, monitoring framework and adaptive management process. This framework is similar to the accountability framework adopted by EPA for the Chesapeake Bay TMDL (EPA 2010). The accountability framework incorporates an adaptive management approach that documents implementation actions, assesses progress, and identifies the need for any additional or alternative management strategies based on feedback from the process (EPA 2010).

The reasonable assurance and accountability framework includes the following elements listed here and discussed in more detail below:

- Identification of the management strategies and specific implementation actions needed to achieve the identified pollutant reductions in the WQMP;
- Timelines for implementing management strategies including schedules for revising permits, achieving appropriate incremental and measurable water quality targets, and completion of other measurable milestones;
- Identification of persons, including DMAs, responsible for implementing the WQMP management strategies and for developing or revising an implementation plan (if the one in the WQMP is not used);
- Direction to DEQ to evaluate new or revised DMA implementation plans in order to determine they are at least as effective as the strategy set out in the TMDL and WQMP;
- Commitment by DEQ to track the management strategies being implemented and evaluate achievements against established timelines and milestones;
- Commitment by DEQ to take appropriate action if the DMAs or responsible persons fail to develop or effectively implement their implementation plan or fulfill milestones; and
- Commitment by DEQ to track water quality status and trends concurrently as management strategies are implemented.

Recommended management strategies are presented in the WQMP (see Section 6) and can be implemented through the programs described below. In addition to the accountability framework, reasonable assurance for the Upper Klamath subbasin TMDLs is based on the existence and implementation of numerous existing federal, state, and local programs that provide pollutant source controls.

5.2.1 DMAs, Responsible Persons, Management Strategies, and Implementation Actions

DEQ has authority (OAR 340-042(4)(l)) to develop a WQMP that identifies the strategies for implementing the TMDL including identifying the DMAs, responsible persons, associated land uses, management strategies, and legal authorities to achieve the TMDL allocations and implement the applicable temperature water quality standards through load reductions of heat (DEQ 2019).

The WQMP establishes timelines for DMAs and responsible persons to develop TMDL implementation plans (OAR340-042(4)(l)). Persons, including DMAs other than the Oregon Department of Forestry or the Oregon Department of Agriculture, identified in a WQMP as responsible for developing and revising sector-specific or source-specific implementation plans must:

- Prepare an implementation plan and submit the plan to the Department for review and approval according to the schedule specified in the WQMP. The implementation plan must:
    - Identify the management strategies the DMA or other responsible person will use to achieve load allocations and reduce pollutant loading;
    - Provide a timeline for implementing management strategies and a schedule for completing measurable milestones;
    - Provide for performance monitoring with a plan for periodic review and revision of the implementation plan;

  - o To the extent required by ORS 197.180 and OAR chapter 340, division 18, provide evidence of compliance with applicable statewide land use requirements; and
  - o Provide any other analyses or information specified in the WQMP.
- Implement and revise the plan as needed.

DEQ will work with the DMAs and responsible persons to develop TMDL implementation plans that contain site specific information, costs, and timelines for the implementation process (DEQ 2019). It is expected that DMAs will conduct a cost and funding analysis as part of the implementation planning process. Potential sources of funding are included in Section 6.3.13 of the WQMP. The DMAs, responsible persons and their management strategies are described below. See the WQMP in Section 6 for more details.

5.2.1.1 Agricultural Lands

The Oregon Department of Agriculture (ODA) is the DMA responsible for regulating agricultural activities that affect water quality. In areas subject to the Agricultural Water Quality Management Act, the ODA, under ORS 568.900 to 568.933 and 561.190 to 561.191, and OAR chapter divisions 90 and 95, develops and implements Agricultural Water Quality Management Area Plans (Area Plans) and Agricultural Water Quality Management Area Rules (Area Rules) to prevent and control water pollution from agricultural activities. Area Plans and Area Rules are the TMDL implementation mechanism for agricultural activities. In areas where a TMDL has been approved, Area Plans and Area Rules must be sufficient to meet the TMDL load allocations. ODA must consult with the DEQ or the Environmental Quality Commission in the adoption and review of Area Plans and in the adoption of Area Rules (ORS 568.930 (2)). If DEQ determines that the Area Plan and Area Rules are not adequate to implement and achieve the TMDL load allocations, DEQ will provide ODA with guidance on what would be sufficient to meet the TMDL load allocations. If a resolution cannot be achieved, DEQ will request the Environmental Quality Commission to petition ODA for a review of part or all of the Area Plans and Area Rules (ORS 568.930 (3)) implementing the TMDL.

The Klamath Headwaters Agricultural Water Quality Management Area Rules (ODA 2004) and Area Plan (ODA 2017) and the Lost River Agricultural Water Quality Management Area Rules (ODA 2004) and Area Plan (ODA 2017) apply to nonfederal and nontribal agricultural lands in the Upper Klamath subbasin and the Lost subbasin, respectively. The Area Rules are regulatory outcome-based requirements that can be enforced by ODA, whereas the Area Plans are setup to be voluntary and identify strategies to prevent and control water pollution from agricultural lands through a combination of outreach programs, suggested land treatments, management activities, and monitoring. The combination of Area Rules and Area Plans are to implement TMDL load allocations for agriculture nonpoint sources and is expected to aid in the achievement of water quality standards. The Area Plans are reviewed and revised every two years, with the most recent reviews completed in 2017. DEQ expects ODA and the Local Advisory Committees in the Klamath basin to revise the Area Plans to address the Load Allocations and surrogate measures in the Upper Klamath and Lost subbasin temperature TMDLs.

5.2.1.2 Non-Federal Forest Lands

The Oregon Department of Forestry (ODF) is the DMA for non-federal forestlands timber management in Oregon. Nonpoint source discharges of pollutants from forest operations on state or private lands are subject to BMPs and other control measures established by the ODF under the ORS 527.610 to 527.992 and according to OAR chapter 629, divisions 600 through 665. Forest operations, when conducted in compliance with the Forest Practices Act (FPA) requirements, are generally deemed not to cause exceedances of water quality standards as provided in ORS 527.770 and are the initial mechanism for TMDL implementation for timber management on nonfederal forestland. The FPA applies to state forest lands and provides for watershed-specific protection rules. Watershed-specific protection rules are a mechanism for subbasin-specific TMDL implementation in non-federal forest land where water quality impairment is attributable to current forest practices.

In areas where a TMDL has been approved, site specific rules under the FPA will need to be revised if DEQ determines that the generally applicable FPA rules are not adequate to implement the TMDL LAs. If a resolution cannot be achieved, DEQ will request the Environmental Quality Commission to petition the Board of Forestry for a review of part or all FPA rules implementing the TMDL. The FPA rules apply in non-federal forest areas in the Upper Klamath subbasin. Watershed-specific rules have not been established. DEQ expects ongoing implementation of the FPA.

Coordination between ODF and DEQ is guided by a Memorandum of Understanding (MOU) signed in April of 1998. This MOU was designed to improve the coordination between the ODF and the DEQ in evaluating and proposing possible changes to the FPA rules as part of the TMDL process. ODF and DEQ are involved in several statewide and regional efforts to analyze the existing FPA measures and to better define the relationship between the TMDL LAs and the FPA measures designed to protect water quality.

5.2.1.3 Federal Lands – U.S. Forest Service and the U.S. Bureau of Land Management

The U.S. Forest Service (USFS) and U.S. Bureau of Land Management (BLM) are the DMAs for federal lands in the Upper Klamath subbasin. Both agencies have signed memorandums of agreement with DEQ that include an agreement to prepare and implement Water Quality Restoration Plans (WQRPs) to implement TMDL allocations (DEQ 2019).

All management activities in the BLM Klamath Falls Resource Area follow the Klamath Falls Resource Area 1995 *Record of Decision and Resource Management Plan* (BLM 1995), which incorporates the Aquatic Conservation Strategy (ACS) and standards and guidelines from the Northwest Forest Plan. The ACS outlines a framework for protecting and restoring aquatic and riparian systems. The Resource Management Plan also includes specific BMPs to protect water quality.

DEQ will also review the existing WQRPs for the BLM Medford and Lakeview Districts. DEQ expects development of a WQRP by USFS within 18 months from the adoption of the TMDLs. WQRPs that address TMDLs have not been prepared for the USFS managed lands in the Upper Klamath subbasin. The WQRPs are revised as needed to implement TMDLs. It is expected that the WQRPs will serve as the TMDL implementation plans for all lands managed by BLM and USFS in the Upper Klamath subbasin.

5.2.1.4 Federal Irrigation Project

The Bureau of Reclamation (BOR) is the DMA responsible for developing a source specific implementation plan to address LAs associated with water delivery and drainage facilities that are federally owned and/or operated in the Klamath Reclamation Project. The WQMP identifies the current status and expectations for BOR TMDL implementation and DEQ will continue to work with the BOR to pursue innovative changes to project operations including reduction of discharge to the Klamath River from the Lost River Diversion Channel to address their combined pollutant load reductions for Klamath Straits Drain and Lost River Diversion Channel.

The BOR currently owns the Link River Dam and upon completion of dam removal on the Klamath River, as referenced in section 5.2.1.7, will assume ownership of the Keno Dam. Should dam removal occur, BOR would take over operation and maintenance of Link River and Keno dams and incorporate the management of these two facilities in their source specific implementation plans. DEQ and the NCWQCB have been working with BOR, USFWS, and the Klamath Water Users Association to draft a Stewardship Agreement Plan that will cover source specific implementation planning in Oregon and California. DEQ will continue working with the Stewardship Agreement and the planning process or continue to work with individual source-specific planning.

5.2.1.5 Water Management Districts

Various water management districts comprised of drainage and irrigation districts are identified in the WQMP as responsible persons that have responsibility for developing source specific implementation plans to address LAs associated with the operations and management of water delivery and drainage systems in the Klamath Reclamation Project.

As responsible persons, DEQ is requiring the water management districts develop a unified or district-specific implementation plan within 18 months from the adoption of the TMDL. The water management districts that choose to be part of the Stewardship Agreement discussed in the Federal Irrigation Project section above will have the opportunity to develop a joint implementation plan. All districts that opt out of the Stewardship Agreement will be required to develop individual source specific TMDL implementation plans. DEQ will assist the districts in preparing a TMDL implementation plan that complies with OAR 340-042-0080(4).

5.2.1.6 Urban and Rural Lands

Oregon cities and counties have authority to regulate land use activities through city and county ordinances and local comprehensive land use plans. The Oregon land use planning system, administered through the Oregon Department of Land Conservation and Development, requires local jurisdictions to address water quality protection through Statewide Planning Goals 5 and 6. Both the city of Klamath Falls and Klamath County were identified as DMAs and are required to submit TMDL implementation plans to fulfill their TMDL responsibilities (See Section 6 WQMP).

The City of Klamath Falls manages stormwater runoff in the drainage ditches within the City limits. Klamath Falls also manages riparian areas and roads that are adjacent to waterbodies in the Upper Klamath subbasin. Klamath Falls has mapped the location and sources of stormwater drainage within the city limits. DEQ expects the city to develop a TMDL implementation plan to control nonpoint source pollution related to stormwater and runoff from roads along perennial and intermittent tributaries. The implementation plans are to be completed within 18 months of the adoption of the TMDLs.

Klamath County manages stormwater runoff in the drainage ditches within the designated Klamath County Drainage Service District. The County also manages roads that are adjacent to waterbodies in the Upper Klamath subbasin. Klamath County has mapped the location and sources of stormwater drainage in the Klamath County Drainage District. Klamath County currently has an implementation plan in place and provides annual reports to DEQ. DEQ will continue working with Klamath County to keep their plan current with the temperature TMDL and WQMP.

5.2.1.7 PacifiCorp Hydroelectric Facilities

PacifiCorp is identified in the WQMP as a responsible person that has responsibility for developing source specific TMDL implementation plans to address load allocations associated with the John C Boyle Dam and the Keno Dam. PacifiCorp is negotiating a basin-wide agreement for decommissioning, and removing, JC Boyle Dam in Oregon and Copco 1, Copco 2, and Irongate dams in California. Conditions of the proposed settlement include interim measures to address TMDL implementation for the two PaciCorp dams in Oregon and decommissioning of the two hydroelectric facilities on the Link River. Link River Dam is a U.S. Bureau of Reclamation facility that PacifiCorp operates. PacifiCorp will transfer the Keno Dam facility to the BOR and will develop a TMDL implementation plan before the transfer is complete. BOR is expected to adopt and implement the implementation plan as part of the transfer agreement. DEQ expects PacifiCorp or the entity responsible for dam management to develop a source-specific TMDL implementation plan within 18 months of the final TMDL or in accordance with the schedule stipulated in the settlement agreement and begin implementation of the plan or agreement upon approval by DEQ.

5.2.1.8 Voluntary Efforts and Public Funding

Environmental watershed planning in Oregon is supported through outreach, technical assistance, monetary incentives and cost share funding through a variety of organizations and programs (see Section 6.4 in the WQMP). As watershed programs continue to develop and more projects are implemented, landowner adoption of water quality practices broadens through increasing knowledge, familiarity, and success.

5.2.1.9 Education

The TMDL and WQMP recognize that actions to implement the TMDL must be worked out by communities and landowners, with local knowledge of problems and ownership in solutions. Watershed councils, soil and water conservation districts, and other grassroots efforts are vehicles for getting the work done and provide education and outreach to the public along with local, state, and federal governments. Government programs will provide regulatory and technical support to these efforts, but the local community will do the bulk of the work to conserve and restore watersheds. Education and information outreach is a fundamental part of the community based action. When people are more informed about the needs of the beneficial uses such as fish and wildlife, and the complex water quality issues, it improves the ability of local communities to make informed decisions and take action to achieve TMDL allocations and water quality standards.

5.2.2 Timeline for Implementation

Individual TMDL implementation plans developed by the DMAs and responsible persons will address timelines for completing measurable milestones (DEQ 2019). Timelines will be as specific as possible and will include a schedule for BMP installation and/or evaluation, monitoring schedules, reporting dates and milestones for evaluating progress. The WQMP identifies the goals and objectives for TMDL implementation with timelines and requirements for TMDL implementation plan development, approval, and implementation. DEQ will work with ODA through the biennial review process of AgWQMA plans for inclusion of timelines and milestones into the area plans for the Klamath Headwaters AgWQMA and the Lost subbasin AgWQMA. DEQ will work with ODF for biennial reporting on timelines and milestones for compliance with FPA regulatory requirements and voluntary measures that are more protective than FPA management practices.

5.2.3 New or Revised DMA Implementation Plans

Responsible persons, including DMAs other than the Oregon Department of Forestry or the Oregon Department of Agriculture, identified in the WQMP are responsible for developing and revising sector-specific or source-specific implementation plans. They must prepare an implementation plan and submit the plan to DEQ for review and approval according to the schedule specified in the WQMP. The implementation plan must:

- Identify the management strategies the DMA or other responsible person will use to achieve load allocations and reduce pollutant loading;
- Provide a timeline for implementing management strategies and a schedule for completing measurable milestones;
- Provide for performance monitoring with a plan for periodic review and revision of the implementation plan;
- To the extent required by ORS 197.180 and OAR chapter 340, division 18, provide evidence of compliance with applicable statewide land use requirements; and
- Provide any other analyses or information specified in the WQMP.

DMAs and responsible persons will implement and revise the plan as needed. See Section 6.3.2 of the WQMP for more details.

5.2.4 Failure to Develop or Implement Implementation Plans and Meet Milestones

The TMDL and WQMP are issued as orders by the State and as such, DEQ has the regulatory authority to take enforcement action to compel a DMA or responsible person to develop and implement a TMDL implementation plan in accordance with OAR 340-042. However, DEQ will first attempt to work collaboratively with the entity to achieve compliance with the WQMP and approved TMDL implementation plan.

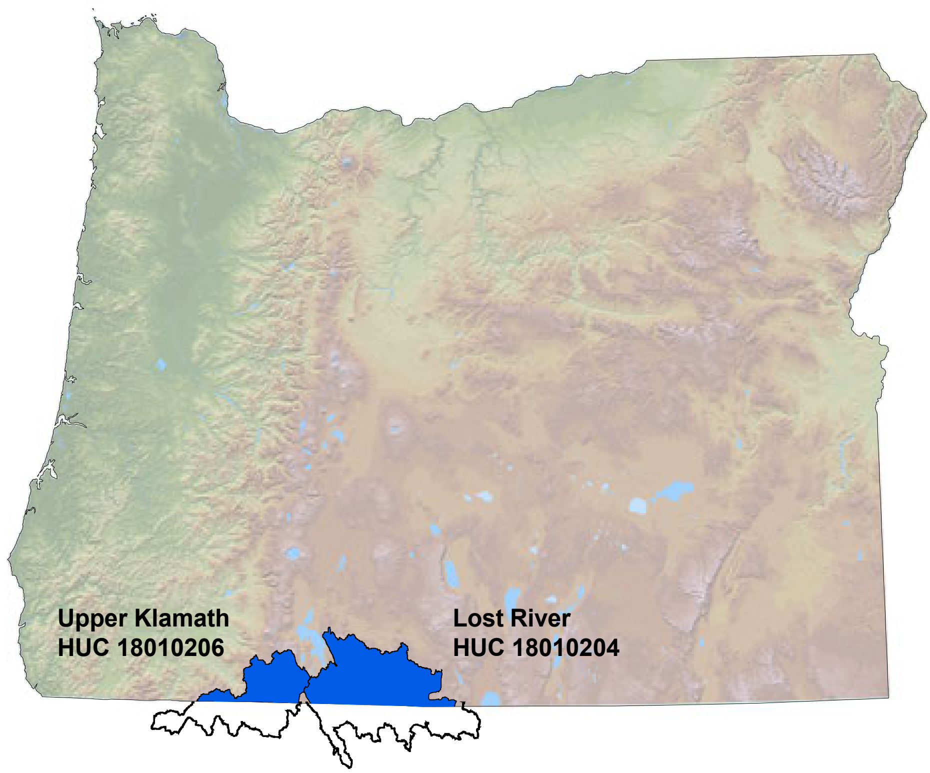
5.2.5 Tracking of Management Strategies and Water Quality Status

Tracking and reporting of implementation; riparian and landscape response; and the instream water quality status and trends are important information for understanding the result of TMDL implementation for adaptive management. The WQMP along with the Monitoring Strategy to Support Implementation of Water Temperature Total Maximum Daily Loads for the Upper Klamath and Lost subbasins (EPA & DEQ 2019) provide the framework for evaluating TMDL effectiveness. This monitoring strategy will inform adaptive implementation of the Upper Klamath subbasin TMDLs, assess the effectiveness of management strategies, and better understand sources of thermal loads to the impaired segments. The monitoring strategy document identifies monitoring objectives and reporting requirements that DEQ expects to be incorporated into site-specific Quality Assurance Project Plans (QAPPs) developed and implemented by the DMAs or responsible persons in the subbasins. These objectives and requirements will be used to evaluate progress toward meeting the TMDL allocations and make adjustments as necessary.

The WQMP includes reporting requirements to support adaptive management, project tracking, and implementation assurance. Each DMA or responsible person listed in Table 6.4 of the WQMP shall submit monitoring data and a project tracking summary to DEQ on an annual basis with the exception of ODA and ODF which will submit these reports every two years. This information will be used by DEQ to determine whether management actions are resulting in the desired improvements or if changes to planned management stratigies are needed. A management stratigies performance and effectiveness evaluation report will also be submitted by each DMA or responsible person on a 5-year cycle. If progress is insufficient, then the appropriate DMA or responsible person will be contacted with a request for corrective action.

In conjunction with the statewide integrated report, DEQ will complete a biennial status and trend evaluation using the data collected by DMAs, responsible person, or other parties. For more details on the monitoring strategy for the Upper Klamath and Lost subbasins, see Monitoring Strategy to Support Implementation of Water Temperature Total Maximum Daily Loads for the Upper Klamath and Lost subbasins (EPA & DEQ 2019).

6. Water Quality Management Plan



6.1 Introduction

A Total Maximum Daily Load (TMDL) defines the amount of a pollutant that can be present in a water body while still meeting water quality standards. A Water Quality Management Plan (WQMP) provides the framework of management strategies to attain and maintain water quality standards. The framework is designed to work in conjunction with detailed plans and analyses provided in sector-specific or source-specific implementation plans. TMDLs, WQMPs and associated planning work together to restore water quality and protect designated beneficial uses, such as aquatic life, drinking water supplies, and water contact recreation.

In December of 2002, the State of Oregon's Environmental Quality Commission (EQC) adopted a rule, commonly referred to as the "TMDL rule" (OAR 340-042). The TMDL rule defines DEQ's responsibilities for developing, issuing, and implementing TMDLs as required by the federal Clean Water Act (CWA). The WQMP is one of the twelve TMDL elements called for in the TMDL rule. Oregon Administrative Rule **340-042-0040-(4)(l)** states:

> *(l) Water quality management plan (WQMP). This element provides the framework of management strategies to attain and maintain water quality standards. The framework is designed to work in conjunction with detailed plans and analyses provided in sector-specific or source-specific implementation plans.*

This WQMP lays out strategies for implementing the Upper Klamath and Lost River subbasins TMDL. As indicated above, two scales of planning are addressed. The WQMP itself serves as a framework plan for the entire Upper Klamath and Lost River subbasins. It describes and references various plans and programs that are specific to a given land use or management sector. The sector-specific plans, or *TMDL Implementation Plans*, comprise a second tier of planning prepared by the local land use or water quality authorities identified as Designated Management Agencies (DMAs) or persons responsible for implementing the TMDL. Figure 6-1 depicts the relationships in the implementation process.

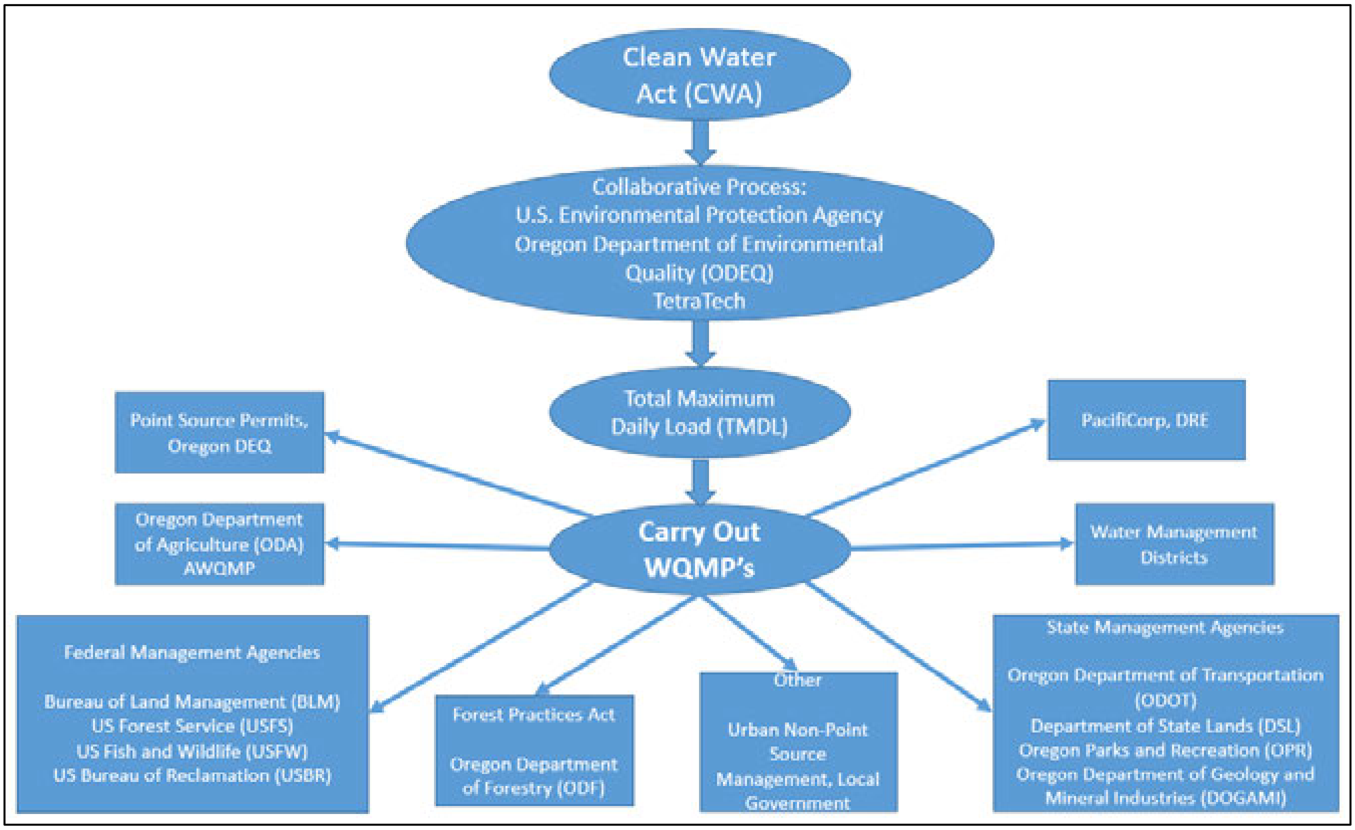


Figure 6-1. Lost River – Upper Klamath Subbasins TMDL Implementation Schematic.

TMDL Implementation Plans are source-specific plans developed and implemented by Designated Management Agencies (DMAs) and responsible persons identified in the TMDL. A DMA is “a federal, state, or local governmental agency that has legal authority of a sector or source contributing pollutants, and is identified as such by the Department of Environmental Quality in a TMDL” (Oregon Administrative Rules (OAR 340-042-0030(2)). PacifiCorp, Dam Removal Entity (DRE) and the Water Management Districts are responsible for development of source-specific implementation plans that address their TMDL responsibilities. The TMDL Implementation Plans, due 18 months after DEQ issues the TMDL, are expected to fully describe the efforts of DMAs and responsible persons to achieve their applicable TMDL allocations.

This WQMP establishes timelines for DMAs and responsible persons to develop TMDL Implementation Plans. DEQ, DMAs and the responsible persons will work collaboratively to assure that the WQMP and TMDL Implementation Plans collectively address the elements described below under “TMDL Water Quality Management Plan Guidance”. In short, this document is a building block for the development of management strategies being developed by DEQ and the DMAs to attain water quality goals.

DEQ recognizes that relationships between management strategies and pollutant load reductions cannot always be precisely quantified. An adaptive management approach is encouraged, including interim objectives and feedback through monitoring. A monitoring strategy has been included as an additional mechanism in which DEQ can track improvements through adaptive management. The monitoring strategy will be included by DMA’s and responsible persons in their source specific TMDL implementation plans and periodic reports will be submitted to DEQ including the results of monitoring.

Klamath TMDL implementation will be coordinated with the DEQ and the EPA. The Regional Water Board, DEQ, and EPA Regions 9 and 10 have developed a Memorandum of Agreement (MOA, 2009) that establishes a framework for joint implementation of the Klamath River and Lost River TMDLs. The MOA includes commitments such as:

- Work to develop and implement a joint adaptive management program, including joint time frames for reviewing progress and considering adjustments to TMDLs;
- Work with the Klamath basin Water Quality Monitoring Coordination Group and other appropriate entities to develop and implement basinwide monitoring programs designed to track progress, fill in data gaps, and provide a feedback loop for management actions on both sides of the common state border;
- Work jointly with common implementation parties (e.g., BOR, U.S. Forest Service, USFWS, BLM, PacifiCorp, and the Klamath Water Users Association (KWUA) to develop effective implementation plans and achieve water quality standards;
- Explore engineered treatment options such as treatment wetlands, algae harvesting, and package wastewater treatment systems to reduce nutrient loads to the Klamath River and encourage implementation of these options where feasible.

6.2 Adaptive Management

The goals of the Clean Water Act, Oregon Revised Statute and Oregon Administrative Rules are that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest water quality attainable. These are long-term goals in many watersheds, particularly where non-point sources are the main concern. To achieve these goals, implementation must begin as soon as possible.

TMDLs are numerical pollutant loadings that are set to limit pollutant levels such that in-stream water quality standards are met. DEQ recognizes that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict complex physical, chemical, and biological processes. Models and techniques are simplifications of these complex processes and, as such, are unlikely to exactly reproduce how streams and other waterbodies will respond to the application of various management strategies. Therefore, TMDLs have a varying level of uncertainty depending on factors, such as data available and how well the natural processes are understood. For this reason, TMDLs have been established with a margin of safety.

For point sources, TMDLs will be implemented through permits issued by DEQ. For nonpoint sources, TMDLs will be implemented through TMDL Implementation Plans. For facilities covered by a permit or license issued by the federal government, the TMDL will be implemented through a Water Quality Standards Certification issued by DEQ pursuant to Section 401 of the federal Clean Water Act.

DEQ recognizes that it may take time—from several years to several decades--after full implementation before management practices identified in a TMDL implementation plan become fully effective in reducing and controlling pollutants, such as heat loads from lack of riparian vegetation. In addition, DEQ recognizes that technology for controlling some pollutant sources such as nonpoint sources is, in many cases, in the development stages and will likely take one or more iterations to develop effective techniques. It is possible that after application of all reasonable best management practices, some TMDLs or their associated surrogates cannot be achieved as originally established.

DEQ also recognizes that despite all efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDL and/or its associated surrogates. Such events could be, but are not limited to, floods, fire, insect infestations, and drought.

DEQ will regularly review progress of TMDL Implementation plans. If and when DEQ determines that implementation plans have been fully implemented, that all feasible management practices have reached maximum expected effectiveness, and a load allocation cannot be achieved, DEQ shall reopen the TMDL and adjust the load allocation and its associated water quality standard(s) as necessary. If a use attainability analysis (UAA) and/or site specific criteria show that the targeted standards or beneficial uses cannot be achieved, then revisions to the TMDL may include recalculating the TMDL loading capacity and allocations. DEQ would also consider reopening the TMDL, subject to available resources, should new scientific information become available that indicates the TMDL or its associated surrogates need modification. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance. Figure 6-2 is a graphical representation of this adaptive management concept.

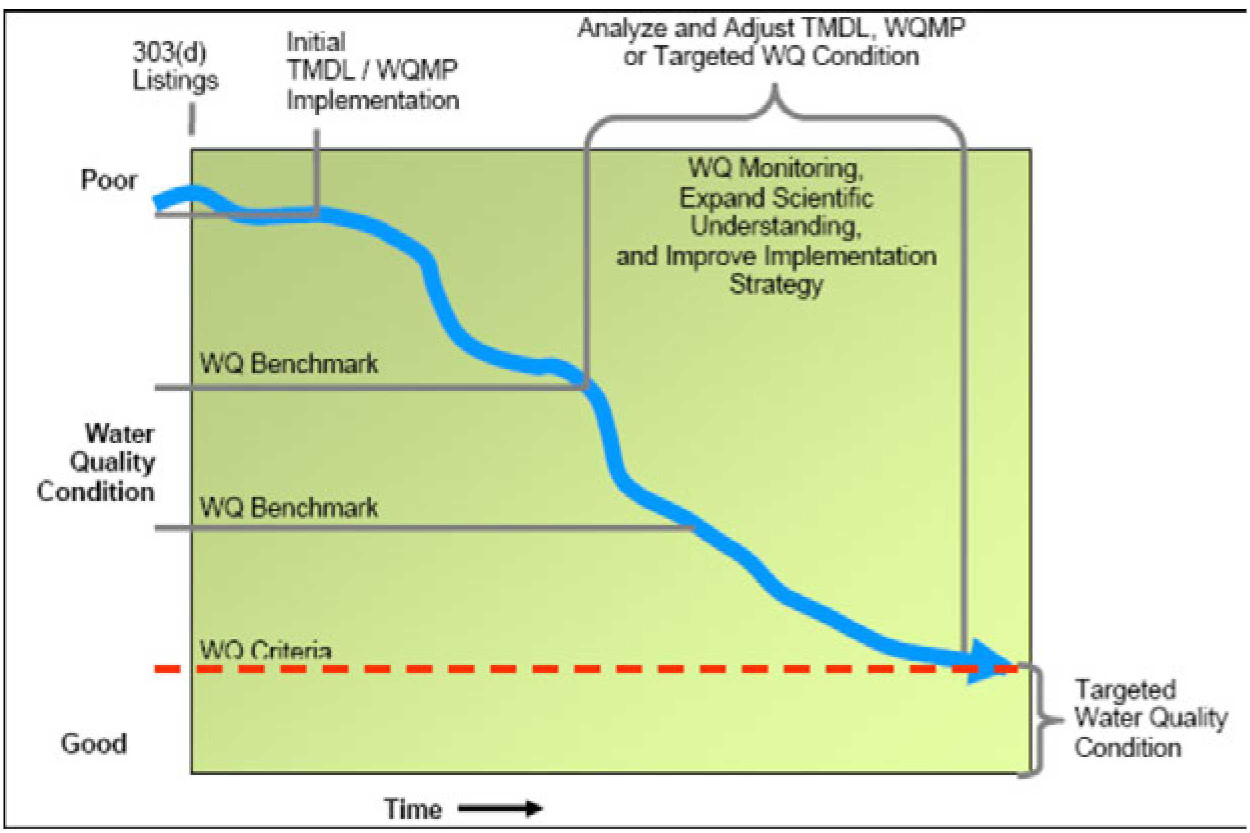


Figure 6-2. Idealize progress of adaptive management

In employing an adaptive management approach to this TMDL, DEQ has the following expectations and intentions:

- Subject to available resources, DEQ will review and, if necessary, modify TMDLs and the TMDL Implementation Plan established on a five-year basis or possibly sooner if DEQ determines that new scientific information is available that indicates significant changes to the TMDL are needed.
- When developing water quality-based effluent limits for NPDES permits, DEQ will ensure that effluent limits developed are consistent with the assumptions and requirements of the waste load allocation (CFR 122.44(d)(1)(vii)(B)).
- DEQ will evaluate the progress towards achieving the TMDL (and water quality standards) and the success of implementing the TMDL Implementation Plan.
- DEQ expects that each DMA and responsible person will also monitor and document its progress in implementing the provisions of its individual implementation plan. This information will be provided to DEQ for its use in reviewing the TMDL.
- As implementation of a plan proceeds, DEQ expects that DMAs and responsible persons will develop benchmarks which can be used to measure progress towards meeting allocated loads. Where implementation of the implementation plan or effectiveness of management techniques are found to be inadequate, DEQ expects management agencies to revise the components of the plan to address these deficiencies.

6.3 Water Quality Management and Implementation Plan Guidance

The TMDL rule of OAR 340-042-0040(4)(l) lists the required elements of a WQMP. These elements, identified below, serve as the outline for this WQMP.

1) Condition assessment and problem description
2) Goals and objectives
3) Proposed management strategies
4) Timeline for implementing management strategies
5) Relationship of management strategies to attainment of water quality standards
6) Timeline for attainment of water quality standards
7) Identification of responsible persons or DMAs
8) Identification of sector-specific or source-specific implementation plans
9) Schedule for preparation and submission of implementation plans
10) Reasonable assurance
11) Monitoring and evaluation
12) Public involvement
13) Planned efforts to maintain management strategies over time
14) Costs and funding
15) Citation to legal authorities

This WQMP also presents a discussion of water quality trading opportunities and TMDL incentives/voluntary efforts. Some of the elements listed above are sufficiently addressed in the

WQMP and others are partly or largely deferred to the DMA programs and implementation plans.

General discussion of the expected content of TMDL Implementation Plans can be found in *TMDL Implementation Plan Guidance* (DEQ, 2007) and on DEQ's website http://www.deq.state.or.us/WQ/TMDLs/implementation.htm. Nonpoint source pollution reduction measures are described in *Nonpoint Source Pollution Control Guidebook for Local Government*, (DEQ and Oregon Department of Land Conservation and Development, 1994). More recent guidance for urban settings is available on the DEQ website http://www.deq.state.or.us/wq/, including the *Water Quality Model Code and Guide Book*, (DEQ and Oregon Department of Land Conservation and Development, 2000). Most Federal and State natural resource agencies publish watershed planning guidance as well.

6.3.1 Condition Assessment and Problem Description

The temperature water quality standards are not being met during the summer in much of the Upper Klamath and Lost subbasins stream network. A description of the impaired waterbodies are presented in Table 6-1.

Table 6-1. Temperature impaired waterbodies.

Waterbody Name	River Mile	Parameter	Period
Klamath River	231.1- 254.9	Temperature	Summer
Klamath River	207 – 231.1	Temperature	Summer
Beaver Creek	0 to 5.5	Temperature	Year around
Grizzly Creek	0 to 3	Temperature	Summer
Hoxie Creek	0.8 to 4.4	Temperature	Summer
Jenny Creek	0 to 17.8	Temperature	Summer
Johnson Creek	0 to 9.4	Temperature	Summer
Keene Creek	0 to 7.2	Temperature	Summer
Keene Creek	7.5 to 9.7	Temperature	Summer
Mill Creek	0 to 3.9	Temperature	Summer
South Fork Keene Creek	0 to 3.1	Temperature	Summer
Spencer Creek	0 to 18.9	Temperature	Year around
Unnamed Creek (Horse Canyon Creek) LLID 1212355422566	0 to 2.2	Temperature	Year around
Antelope Creek	2 to 3	Temperature	Year around

Waterbody Name	River Mile	Parameter	Period
Antelope Creek	0 to 14.1	Temperature	Year around
Barnes Valley Creek	0 to 14	Temperature	Year around
Ben Hall Creek	0 to 8.7	Temperature	Year around
Buck Creek	0 to 12.8	Temperature	Year around
East Branch Lost River	0 to 2.4	Temperature	Year around
Lapham Creek	0 to 4	Temperature	Year around
Long Branch Creek	0 to 4.6	Temperature	Year around
Miller Creek	0 to 9.6	Temperature	Year around
North Fork Willow Creek	0 to 2.3	Temperature	Year around
Rock Creek	0 to 4.3	Temperature	Year around
Lost River	4.8 to 65.4	Temperature	Year around
Lost River Diversion Channel	0 to 7.9	Temperature	Year around
Klamath Straits Drain	0 to 9.8	Temperature	Year around

6.3.2 Goals and Objectives

The overarching goal of this WQMP is to identify the DMAs, responsible persons, associated land uses, management strategies, and legal authorities to achieve compliance with the applicable temperature water quality standards through loading reductions of heat, and solar radiation. The WQMP combines a description of all implementation plans that are in place or will be developed to address the load and wasteload allocations in the TMDL. This WQMP is designed to be adaptive as more information and knowledge is gained regarding the pollutants, allocations, management strategies, and other related areas. As defined in OAR 340-042-0080(3), it is expected that all persons, including DMAs other than the Oregon Department of Forestry or the Oregon Department of Agriculture, identified in this WQMP will develop Implementation Plans, which will serve as the tool for implementing the TMDL and will accomplish the following:

- Develop management strategies and other Best Management Practices (BMPs) to achieve TMDL allocations or surrogate measures
- Give reasonable assurance that management strategies will achieve allocations or surrogate measures through both quantitative and qualitative analysis
- Develop and adhere to measurable milestones to determine and report progress
- Develop a timeline for implementation, with reference to costs and funding
- Develop and implement a monitoring plan to determine if:

- Management strategies and other BMPs are being implemented
- Management strategies and Individual BMPs are effective
- Allocations or surrogate measures are being achieved
- Water quality standards are being met

The TMDL does not mandate or imply that a DMA or responsible person must alter water diversions in order to meet this TMDL and the water quality standard. How a DMA or responsible person makes its operations consistent with the allocation is to be established through the sector-specific or source-specific TMDL Implementation Plans.

Oregon Administrative Rules (OAR) Chapter 340 Division 042 – Total Maximum Daily Loads (TMLDs)

OAR 340-042-0080

Implementing a Total Maximum Daily Load

1) Management strategies identified in a WQMP to achieve wasteload and load allocations in a TMDL will be implemented through water quality permits for those sources subject to permit requirements in ORS 468B.050 and through sector-specific or source-specific implementation plans for other sources. WQMPs will identify the sector and source-specific implementation plans required and the persons, including DMAs, responsible for developing and revising those plans.

2) Nonpoint source discharges of pollutants from forest operations on state or private lands are subject to best management practices and other control measures established by the Oregon Department of Forestry under the ORS 527.610 to 527.992 and according to OAR chapter 629, divisions 600 through 665. Such forest operations, when conducted in good faith compliance with the Forest Practices Act requirements are generally deemed not to cause violations of water quality standards as provided in ORS 527.770. Where the Department determines that there are adequate resources and data available, the Department will also assign sector or source specific load allocations needed for nonpoint sources of pollution on state and private forestlands to implement the load allocations. In areas where a TMDL has been approved, site specific rules under the Forest Practices Act rules will need to be revised if the Department determines that the generally applicable Forest Practices Act rules are not adequate to implement the TMDL load allocations. If a resolution cannot be achieved, the Department will request the Environmental Quality Commission to petition the Board of Forestry for a review of part or all of Forest Practices Act rules implementing the TMDL.

3) In areas subject to the Agricultural Water Quality Management Act the Oregon Department of Agriculture (ODA) under ORS 568.900 to 568.933 and 561.191 and according to OAR chapter 603, divisions 90 and 95 develops and implements agricultural water quality management area plans and rules to prevent and control water pollution from agricultural activities and soil erosion on agricultural and rural lands. Where the Department determines that there are adequate resources and data available, the Department will also assign sector or source specific load allocations needed for agricultural or rural nonpoint sources to implement the load allocations. In areas where a TMDL has been approved, agricultural water quality management area plans and rules must be sufficient to meet the TMDL load allocations. If the Department determines that the plan and rules are not adequate to

implement the load allocation, the Department will provide ODA with comments on what would be sufficient to meet TMDL load allocations. If a resolution cannot be achieved, the Department will request the Environmental Quality Commission to petition ODA for a review of part or all of water quality management area plan and rules implementing the TMDL.

4) Persons, including DMAs other than the Oregon Department of Forestry or the Oregon Department of Agriculture, identified in a WQMP as responsible for developing and revising sector-specific or source-specific implementation plans must::

    a) Prepare an implementation plan and submit the plan to the Department for review and approval according to the schedule specified in the WQMP. The implementation plan must:

        A. Identify the management strategies the DMA or other responsible person will use to achieve load allocations and reduce pollutant loading;

        B. Provide a timeline for implementing management strategies and a schedule for completing measurable milestones;

        C. Provide for performance monitoring with a plan for periodic review and revision of the implementation plan;

        D. To the extent required by ORS 197.180 and OAR chapter 340, division 18, provide evidence of compliance with applicable statewide land use requirements; and

        E. Provide any other analyses or information specified in the WQMP.

    b) Implement and revise the plan as needed.

5) For sources subject to permit requirements in ORS 468B.050, wasteload allocations and other management strategies will be incorporated into permit requirements.

6.3.3 Proposed Management Strategies

DEQ is reliant on the DMAs and responsible persons for programs and projects providing strategies to minimize thermal loading and impairments related to temperature.

This section of the plan outlines the proposed management strategies that are designed to meet the wasteload allocations and load allocations of each TMDL. The timelines for implementing these strategies are given in Section 6.3.4.

The management strategies to meet the load and wasteload allocations may differ depending on the source of the pollutant. Below are categorizations of the sources and a description of the management strategies being proposed for each source category.

Wastewater Treatment Plants

The wasteload allocations given to the two municipal wastewater treatment plants (WWTPs) will be implemented through modifications to their National Pollutant Discharge Elimination System (NPDES) permits. These permits will either include numeric effluent limits for thermal inputs or provisions to develop and implement management plans, whichever is appropriate.

General and Individual NPDES Permitted Sources

All individual NPDES permits will be reviewed and, if necessary, modified to ensure compliance with allocations. Either numeric effluent limits will be incorporated into the permits or specific management strategies and plans will be developed. The conditions of the general permits can be used to implement wasteload allocations.

Other Sources

For discharges from sources other than the WWTPs and those permitted under general or minor NPDES permits, DEQ has assembled an initial listing of management categories. This listing, given in Table 6-2 below, is designed to be used by the designated management agencies (DMAs) and responsible persons as guidance for selecting management strategies to be included in their Implementation Plans. Each DMA and responsible person will be responsible for examining the categories in Table 6-2 to determine if the source and/or management measure is applicable within their jurisdiction. This listing is not comprehensive.

Other sources and management strategies will likely be added by the DMAs or responsible person in their implementation plans. For each source or measure deemed applicable in an implementation plan, a listing of the frequency and areal extent of management strategies should be provided. In addition, each of the DMAs and responsible persons are responsible for source assessment and identification, which may result in additional categories. It is crucial that management strategies be directly linked with their effectiveness at reducing pollutant loading contributions.

Table 6-2. Pollutant management strategies for Temperature.

Management Strategy	Temperature
Public Awareness/Education	X
New Development and Construction	
Planning Procedures	X
Permitting/Design	X
Education and Outreach	X
Protection/Enhancement of Existing Near Stream Vegetation	X
Control Erosion from Construction Activities	X
Inspection/Enforcement	X
Storm Drain Construction	
Existing Development	
Storm Drain Operations and Maintenance	

Management Strategy	Temperature
Retrofit Existing Systems	
Inspect Septic Systems	
Inspection/Enforcement	
Eliminate Illicit Connections and Illegal Dumping	
Streets, Roads, Bridges	
Control Erosion from Maintenance Activities	X
New Construction	X
Commercial and Industrial Facilities	
Parking Lot Runoff	
Track and Enforce against Illegal Dumping	
Eliminate Illicit Discharges and Cross Connections	
Control Pollutants at Source	
Reduce Fertilizers in Runoff	
Dam and Reservoir Operation	
Dam Removal	X
Temperature Control Structures	X
Flow Augmentation or Storage	X
Residential	
Eliminate Illegal Dumping	X
Eliminate Illicit Discharges and Cross Connections	X
Riparian Area Management	
Restore Near Stream Vegetation	X
Protection/Enhancement of Existing Near Stream Vegetation	X

Management Strategy	Temperature
Streambank Stabilization	X
Restore Channel morphology	X
Public/Governmental Facilities Including Parks	
Public Waterbodies Protection	X
Operations and Maintenance	X
LID at Public Buildings and Facilities	X
Reduce Pet Wastes and Fertilizers in Runoff	
Forest Practices	
Implement Forest Protection Act (State)	X
Implement Resource Management Plans (Fed)	X
Restore Near Stream Vegetation	X
Protection/Enhancement of Existing Near Stream Vegetation	X
Restore natural channel morphology	X
Replace/Restore Roads/Culverts	X
Agricultural Practices	
Implement SB 1010 AgWQMP	X
Livestock Management Training	X
Nutrient Management Plans	
Restore Near Stream Vegetation	X
Protection/Enhancement of Existing Near Stream Vegetation	X
Restore natural channel morphology	X
Wetland Protection/Enhancement	X
Reconnect Sloughs and Rivers	X
Replace Defective Culverts	X

Management Strategy	Temperature
Setback Levies and Dikes	
CAFO Implementation	X
Planning and Assessment	
Source Assessment/Identification	X
Source Control Planning	X
Track and Communicate frequently on Forest Conversions	
Monitoring and Evaluation	
BMP Monitoring and Evaluation	X
Instream Monitoring	X
BMP Implementation Monitoring	X
Mechanical Cooling	X
Natural Wetlands/Lagoons/Evaporation Basins	X
Temperature Trading	X

Table 6-3 and Table 6-4 present quantitative estimates of near-stream vegetation management strategies in acres and linear miles for the modeled portions Jenny Creek and Spencer Creek. DEQ estimates that the effective shade targets will be achieved with implementation of these strategies. Table 6-5 provides describes each of the strategies.

Table 6-3. Estimate of Spencer Creek vegetation management strategies.

Vegetation Management Strategy	Acres	Stream Miles
Planting or Establishment	98	4.5
Enhancement, Maintenance, and Growth	277	12.2
Thinning and Management	9	0.6

Table 6-4. Estimate of Jenny Creek vegetation management strategies.

Vegetation Management Strategy	Acres	Stream Miles
Planting or Establishment	99	6.3
Enhancement, Maintenance and Growth	258	12.4
Thinning and Management	0	0

Table 6-5. Vegetation management strategies.

Planting or Establishment	Estimated linear stream miles or number of acres within 100 feet from the stream bank that need vegetation established or planted to achieve TMDL effective shade targets.
Enhancement, Maintenance, and Growth	Estimated linear stream miles or number of acres within 100 feet from the stream bank that have existing vegetation that needs to grow and mature. Maintenance, growth, and protection strategies.
Thinning and Management	Estimated linear stream miles or number of acres within 100 feet from the stream bank that might need vegetation density reduction. Current site conditions are dense trees that might need thinning management strategies.

6.3.4 Timeline for Implementing Management Strategies

Individual TMDL Implementation Plans will address timelines for completing measurable milestones as appropriate. Time frames for temperature water quality standards attainment, the schedule for implementing control actions, and Implementation Plan submittal are addressed in Sections 6.3.5 and 6.3.9.

DEQ recognizes that there has been and continues to be much effort towards improving water quality in the Upper Klamath and Lost River subbasins. Natural resource agencies, local jurisdictions, landowners, and nongovernmental organizations have been active both directly and through outreach. This report does not attempt a timeline addressing the many ongoing and voluntary efforts.

Table 6-6 provides a schedule for implementation of control actions (management strategies) on Jenny Creeks and Spencer Creeks with the year of attainment of temperature standards in Table 6-7. Based of feedback received during the public comment period priority was placed on implementing strategies in Jenny and Spencer Creeks, with overall attainment occurring sooner in tributaries to the Klamath River and Lost River. The attainment schedule reflects a lag in temperature response that is expected to occur between the time management strategies are implemented and full attainment.

Table 6-8, below, gives the timeline for activities related to the WQMP and associated DMA and responsible persons Implementation Plans.

Table 6-6 Percenatge of needed control actions (management strategies) implemented on Jenny and Spencer Creeks.

Waterbody Name	2020	2025	2030	2035
Jenny Creek	0%	33%	66%	100%
Spencer Creek	0%	33%	66%	100%

Table 6-7 Timeline for attainment of temperature water quality standards

Waterbody Name	Year of Temperature Standards Attainment
Klamath River	2060
Beaver Creek	2050
Grizzly Creek	2050
Hoxie Creek	2050
Jenny Creek	2050
Johnson Creek	2050
Keene Creek	2050
Mill Creek	2050
South Fork Keene Creek	2050
Spencer Creek	2050
Unnamed Creek (Horse Canyon Creek) LLID 1212355422566	2060
Antelope Creek	2050
Barnes Valley Creek	2050
Ben Hall Creek	2050
Buck Creek	2050
East Branch Lost River	2050

Waterbody Name	Year of Temperature Standards Attainment
Lapham Creek	2050
Long Branch Creek	2050
Miller Creek	2050
North Fork Willow Creek	2050
Rock Creek	2050
Lost River	2060
Lost River Diversion Channel	2035
Klamath Straits Drain	2035

Table 6-8. Water Quality Management Plan and DMA Specific Implementation Plan Timeline.

Activity	2019		2020		2021		2022		2023		2024	
Modification of NPDES Permits												
Implementation of NPDES Permits												
DEQ Modification of General and Minor Permits	5 Year Cycle											
Development and Submittal of NPS Implementation Plans												
Revision of Agricultural Water Quality Management Plans	2 Year Cycle											
Implementation of NPS Plans												
DEQ/DMA/Public Review of TMDL and WQMP												

6.3.5 Relationship of Management Strategies to Attainment of Water Quality Standards

The purpose of this element of the WQMP is to demonstrate a strategy for implementing and maintaining the plan and achieving the water quality standards over the long term. Included in the previous section are timelines for the implementation of DEQ activities. Each DMA-specific and responsible person-specific Implementation Plan will also include timelines for the implementation of identified milestones. Timelines should be as specific as possible and should include a schedule for BMP installation and/or evaluation, monitoring schedules, reporting dates, and milestones for evaluating progress.

For the Upper Klamath and Lost River subbasin TMDLs, pollutant surrogates have been defined as alternative targets for meeting the TMDL for some parameters. DEQ expects that the Implementation Plans will address how human activities will be managed to achieve the surrogates. DEQ also recognizes that full attainment of pollutant surrogates (restored or potential vegetation, for example) at all locations may not be feasible due to physical, legal, or other regulatory constraints. To the extent possible, the Implementation Plans should identify potential constraints, and should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of restored vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that support TMDL load allocations and pollutant surrogates such as restored vegetation.

DEQ intends to regularly review the progress of the Implementation Plans. Individual Implementation Plans, this WQMP, and the TMDLs are part of an adaptive management process. Modifications to the WQMP and the Implementation Plans are expected to occur annually or on a more frequent basis. Pending available resources, review of the TMDLs are expected to occur approximately five years after the final approval of the TMDLs, or whenever deemed necessary by DEQ. Pending the availability of adequate resources, DEQ will review the water quality model used to develop the Upper Klamath Lake TMDL and work cooperatively with USGS, BOR, and other stakeholders for revising the TMDL for Upper Klamath Lake.

DEQ will use the information obtained from the reporting and monitoring efforts throughout the coverage area to identify additional management practices needed. In addition, the monitoring information will be used to track progress through planning to base additional management strategies. The assessment and monitoring strategy will be a useful tool for assisting with this effort

6.3.6 Identification of DMAs or Responsible Person

The purpose of this element is to identify the organizations responsible for the implementation of the Upper Klamath and Lost River subbasins TMDLs (Table 6-4). DMAs and responsible persons are recognized by the State of Oregon as being those entities with the legal authority to ensure that the targets set forth in the TMDL are met (OAR 340-042-0030 (2)). DMAs and responsible persons are responsible for implementing management strategies and developing and revising sector-specific or source-specific implementation plans. The management strategies necessary to meet the TMDL load and wasteload allocations differ based upon the source of pollution and the responsibilities and resources of the DMAs and responsible persons. Many DMAs and responsible persons are already implementing or planning to implement management strategies for improving and protecting water quality, but may need to take additional actions to meet the TMDL allocations. Other organizations share in TMDL implementation responsibility and are discussed in this and following sections, but are not required to submit TMDL implementation plans. Also with regard to TMDL responsibilities, DEQ recognizes that organizations are not responsible for land use activities or load allocations outside of their area of jurisdictional authority. DEQ has the regulatory authority to take enforcement action to compel a DMA or responsible person to develop and implement a TMDL implementation plan. DEQ, however, will first make every attempt to work collaboratively with the entity to achieve compliance.

Table 6-9. List of organizations with TMDL responsibilities.

Management Agency	Area of Jurisdiction	Expected Form of Planning in Response to TMDL
Oregon Department of Agriculture	Agricultural and associated rural residential land use along the mainstem Klamath River, Lost River, irrigation canals/drains, and perennial and intermittent tributaries	SB1010 Agricultural Water Quality Management Area Plans or Rules, updated as needed in 2019 and 2021 to address the TMDL
PacifiCorp	Keno Dam, J.C. Boyle, and Klamath Hydroelectric Project facilities	TMDL implementation by a source-specific Implementation Plan
Oregon Department of Forestry	Conifer and Mixed Forest on non-federal forest lands.	Ongoing implementation of the Forest Practices Act
Oregon Department of Geology and Mineral Industries (DOGAMI)	Regulation of aggregate mines	TMDL Implementation Plan
US Forest Service	Fremont-Winema National Forest	USFS Water Quality Restoration Plan
US Bureau of Land Management (Medford and Lakeview Districts)	BLM managed lands	BLM Water Quality Restoration Plan
US Fish and Wildlife Service	USFWS managed lease lands	TMDL Implementation Plan
Klamath County and Jackson County	County roads along subbasin perennial tributaries, drainage ditches within the County Service District, unincorporated urban and rural residential areas.	Klamath County TMDL Implementation Plan
US Bureau of Reclamation	Operation of Lost River Diversion Channel and Reservoir, Anderson Rose Impoundment, and Klamath Straits Drain facilities	TMDL Implementation Plan
Water Management Districts	Canals, drains, and diversions within the Klamath Reclamation Project	TMDL Implementation Plan
Municipalities – City of Klamath Falls, Merill, Malin, and Bonanza	Operation and maintenance of sewer systems, land use planning, maintenance of city-owned property	TMDL Implementation Plans

6.3.7 Identification of Sector-Specific Implementation Plans

Several organizations utilize existing programs as TMDL Implementation Plans. This is typically documented in a memorandum of understanding or agreement with the DEQ. The following planning efforts provide for TMDL implementation in the Upper Klamath and Lost River subbasins. DEQ expects that they will be updated as needed to lay out all feasible steps toward meeting the TMDL. The sections below describe the general form of the anticipated DMA responsibilities. Expected elements of TMDL Implementation Plans are listed in DEQs guidance for developing Implementation Plans, *TMDL Implementation Plan Guidance – for State and Local Government Designated Management Agencies, 2007.* https://www.oregon.gov/deq/wq/tmdls/Pages/TMDLs-Implementation.aspx

6.3.7.2 NPDES Permit Program – Point Sources

DEQ administers the National Pollutant Discharge Elimination System (NPDES) permits for surface water discharge and is delegated to do so by EPA. The NPDES permit is a Federal permit, required under the Clean Water Act for discharge of waste into waters of the United States. As required in OAR 340-043-0040(4)(I)(E), the following section describes management strategies for point sources.

6.3.7.1.1 NPDES Wastewater Permits

Individual facility NPDES permits are unique to a discharge facility. General NPDES permits address categories of facilities or aggregate pollutant sources, such as sewage treatment or stormwater. There is presently one individual facility NPDES permit issued in the Lost River subbasin. This facility, Henley School will not be permitted to discharge directly to surface water. Henley School is in the process of piping their wastewater to South Suburban Sanitary District treatment facility. The four point sources (Klamath Falls WWTP, South Suburban WWTP, Columbia Plywood, and Collins Forest Products) discharging to Keno Reservoir will have their respective permits modified to address wasteload allocations. The permit application and renewal process will begin in 2019. In the event that any new individual facility permits are issued in the subbasin, they will be written to ensure that all TMDL related issues are addressed in the permit. Nonpoint Sources

6.3.7.2 Agricultural Lands

The Oregon Department of Agriculture (ODA) is the DMA responsible for regulating agricultural activities that affect water quality. The mission of the ODA is 1) to ensure food safety and provide consumer protection; 2) to protect the natural resource base for present and future generations of farmers and ranchers, and 3) to promote economic development and expand market opportunities for Oregon agricultural products. ODA employs *Agricultural Water Quality Management Area Plans* (AgWQMAP) and associated rules to implement TMDLs throughout the state. Periodic review of the progress of AgWQMAP implementation is called for in rule (OAR 603-090-0020). The AgWQMAPs are reviewed biennially by ODA and selected agricultural stakeholders.

ODA has primary responsibility for implementing TMDLs on private agricultural lands through a 1998 Memorandum of Agreement (MOA). The MOA (ODA 2012) states that "*Load allocations for agricultural nonpoint sources will be provided by DEQ to ODA which will then begin* *developing an AgWQMAP, or modifying an existing AgWQMAP, to address the load allocation*" and, specific to situations where AgWQMAP development has proceeded a TMDL: "*At the time that DEQ develops load allocations for agricultural nonpoint sources or groups of sources, ODA will evaluate the AgWQMAP previously developed plan to assure the* ***attainment*** *of DEQ's load allocations for agriculture*."

Local Management Agencies are funded to conduct outreach and education, develop individual farm plans for operations in the planning area, work with landowners to implement management practices, and help landowners secure funding to cost-share water quality improvement practices. The Local Management Agency is the Klamath County Soil and Water Conservation District, working under contract to ODA.

Progress reports, which are submitted to the Board of Agriculture after the biennial review process, are developed based on data collected by Local Management Agencies and ODA on progress of implementation of the plans and rules. Reports to the Board of Agriculture and Director will include statistics on numbers of farm plans developed and types of management practices being employed. These reports are available to DEQ for review in assessing implementation progress.

Current Status. Private agricultural lands within the Upper Klamath subbasin are addressed in the Klamath Headwaters AWQMP which was adopted in 2004 and revised in 2007. The first Lost River subbasin AgWQMAP and rule were adopted by the Board of Agriculture on April 17, 2002. The plans are revisited once every two years with the most recent review completed in September of 2017. The plans are an effective measure to help improve efforts for improved environmental conditions leading to enhanced water quality. The Klamath Headwaters and Lost River subbasin AWQMAPs (ODA 2017) and Rules are available from ODA's website at: http://www.oda.state.or.us/nrd/water_quality/areapr.html.

DEQ Expectations. DEQ expects ODA and the Local Advisory Committees in the Klamath basin will revise the AWQMAP's to address the load allocations for the Upper Klamath and Lost River subbasin TMDLs.

6.3.7.3 Non Federal Forest Lands

The Oregon Department of Forestry (ODF) is the DMA for water quality protection from nonpoint source discharges or pollutants resulting from forest operations on non-federal forestlands in Oregon.

The Forest Practices Act (FPA) applies broadly to state forest lands and also provides for watershed-specific protection rules. Watershed-specific protection rules are a mechanism for subbasin-specific TMDL implementation in non-Federal forest land where water quality impairment is attributable to current forest practices. Legacy issues are addressed through management planning with ODF as a participant.

Coordination between ODF and DEQ is guided by a Memorandum of Understanding (MOU) signed in April of 1998. This MOU was designed to improve the coordination between the ODF and the DEQ in evaluating and proposing possible changes to the forest practice rules as part of the TMDL process. ODF and DEQ are involved in several statewide efforts to analyze the existing FPA measures and to better define the relationship between the TMDL load allocations and the FPA measures designed to protect water quality.

Current Status. The Forest Practice Rules apply in non-federal forest areas in the Upper Klamath and Lost River subbasins. Watershed-specific rules have not been established in the basin.

DEQ Expectations. DEQ expects ongoing implementation of the Forest Practices Act.

6.3.7.4 Federal Lands – US Forest Service and the US Bureau of Land Management

The US Forest Service (USFS) and Bureau of Land Management (BLM) are DMAs for federal lands in the subbasin in Oregon. In July 2003, both agencies signed memorandums of agreement with DEQ defining how water quality rules and regulations regarding TMDLs will be met. The agencies generally respond to TMDLs by developing and implementing Water Quality Restoration Plans (WQRPs) which will be the equivalent of TMDL Implementation Plans. The WQRPs are revised as needed in order to implement TMDLs. All management activities on BLM Klamath Falls Resource Area-managed lands follow the Klamath Falls Resource Area 1995 *Record of Decision and Resource Management Plan,* which incorporates the Aquatic Conservation Strategy (ACS), and standards and guidelines from the Northwest Forest Plan. The ACS outlines a comprehensive framework for protecting and restoring aquatic and riparian systems. The ACS contains four components: riparian reserves, key watersheds, watershed analysis, and watershed restoration. The ACS contains nine objectives that guide maintenance and restoration of watershed processes and water quality. Standards and guidelines associated with the ACS are designed to meet or attain ACS objectives, and prohibit and regulate activities that retard or prevent ACS objective attainment. The Resource Management Plan also includes specific best management practices (BMPs) to protect water quality.

Current Status. WQRPs for BLM managed lands in portions of the Upper Klamath and Lost River subbasins have been developed. It is expected that the WQRPs will serve as TMDL implementation plans for all lands managed by BLM in the Upper Klamath and Lost River Subbasins. WQRPs that address TMDLs have not been prepared for the USFS managed lands in the Upper Klamath and Lost River subbasins.

DEQ Expectations. DEQ will review the existing WQRPs for the BLM Medford and Lakeview Districts. DEQ expects development of a WQRP by USFS.

6.3.7.4.1 Federal Irrigation Project - US Bureau of Reclamation (BOR)

The Bureau of Reclamation (BOR) is the DMA responsible for developing a source-specific implementation plan to address load allocations associated with water delivery and drainage facilities that are federally owned and/or operated in the Klamath Reclamation Project, and facilities used to supply water to the irrigation project. This includes BOR responsibilities for meeting load allocations in both the Upper Klamath and Lost River subbasins TMDL, and the previously issued and EPA approved TMDL for Upper Klamath Lake Drainage. DEQ encourages BOR to pursue innovative changes to project operations including reduction of discharge to the Klamath River from Lost River Diversion Channel (LRDC) to address their combined pollutant load reductions for Klamath Straits Drain and LRDC.

The BOR currently owns the Link River Dam and upon completion of dam removal on the Klamath River, will assume ownership of the Keno Dam. Should dam removal occur, BOR would take over operation and maintenance of Link River and Keno dams and incorporate the management of these two facilities in their source-specific implementation plans.

Current Status. The BOR has drafted a source specific implantation plan for the project area. DEQ and the NCWQCB have been working with BOR, USFWS, and the Klamath Water Users Association (KWUA) to draft a Stewardship Agreement Plan that will cover source specific implementation planning in Oregon and California.

DEQ Expectations. DEQ will continue working with the Stewardship Agreement and the planning process or continue to work with individual source specific planning. DEQ and the NCWQCB will work with the group to include the temperature component into the plan within 18 months of the issuance date of the TMDL.

6.3.7.5 Water Management Districts

Irrigation districts, drainage districts, and other water delivery and conveyance systems could influence the quantity and timing of pollutant delivery to downstream river reaches. Return flows can enter waters of the state through ditches and pipes. Consequently, owners and operators of these systems are included as responsible persons in this WQMP because maintenance and management of these systems could impact temperature. Such systems are responsible only for temperature effects resulting from conveyance systems, not from upland agricultural activities.

While irrigated agriculture continues to be an important and potentially growing demand, there remains a need to characterize the location and extent of irrigation systems in the basin, as well as the management practices used to maintain and operate these systems.

Drainage districts and systems exist primarily to manage stormwater drainage and flooding. Many of these districts were originally formed to help protect the land from flooding so that farming could occur year round. Presently, drainage districts that are registered with the state as special districts often have a tax base that comprise rural tracts of land, as well as commercial and residential properties and parks. Levees, pump stations, ditches, sloughs, streams and culverts are important components of a drainage system and must be continually maintained in order to protect the environment, property and safety.

Irrigation and drainage districts are responsible persons responsible for developing implementation plans to address load allocations associated with non-federal water delivery and drainage systems in the Klamath Reclamation Project.

Current Status. Source-specific implementation not yet developed. The Water Management Districts that choose to be part of the Stewardship Agreement will have the opportunity to develop a joint plan. All districts that opt out of the Stewardship Agreement will be required to develop source specific implementation plans.

DEQ Expectations. As responsible persons, DEQ recommends the water management districts develop a unified or district-specific implementation plan within 18 months from the adoption of the TMDL. However, individual water management districts may choose to develop implementation plans. DEQ will assist the districts in preparing a plan that complies with OAR 340-042-0080(3).

Klamath County – Klamath County manages stormwater runoff in the drainage ditches within the designated Klamath County Drainage Service District. The County also manages roads and urban or rural residential landuse that are adjacent to waterbodies in the Upper Klamath and Lost River subbasins.

Current Status – Klamath County has mapped the location and sources of stormwater drainage in the Klamath County Drainage District. Klamath County currently has an implementation plan in place and provide annual reports to DEQ.

DEQ Expectations. DEQ will continue working with Klamath County to keep their plan current.

***City of Klamath Falls* –** Klamath Falls manages stormwater runoff in the drainage ditches within the city limits. Klamath Falls also manages riparian areas and roads that are adjacent to waterbodies in the Upper Klamath and Lost River subbasins.

Current Status – Klamath Falls has mapped the location and sources of stormwater drainage within the city limits.

DEQ Expectations. DEQ expects the City to develop a TMDL implementation plan to control nonpoint source pollution related to stormwater and runoff from roads along perennial and intermittent tributaries. These roads should be evaluated for impediments to load allocation attainment. DEQ requests that the City clarify these objectives in their TMDL implementation plan.

6.3.7.6 Other Sources

Hydroelectric Facilities - PacifiCorp owns and operates JC Boyle and Keno Dams. PacifiCorp is designated as a responsible person for developing a source-specific implementation plan to address the water temperature allocations associated with JC Boyle and Keno Dams. In the event that ownership of Keno Dam is transferred to BOR, then the new owner will have responsibility for implementing the plan.

Current Status: PacifiCorp is negotiating a basin-wide agreement for decommissioning JC Boyle and three dams in California. Conditions of the proposed settlement include interim measures to address TMDL implementation for the two PaciCorp dams in Oregon and decommissioning of the two hydroelectric facilities on Link River (East and West Side). PacifiCorp will transfer the Link River and Keno Dam facilities to the BOR and will develop a TMDL implementation plan before the transfer is complete in which BOR will be expected to adopt and implement as part of the transfer agreement.

DEQ Expectations: DEQ expects PacifiCorp or the entity responsible for dam management to implement a source-specific plan within 18 months of the final TMDL or in accordance with the schedule stipulated in the settlement agreement.

6.3.8 Schedule for Preparation of Implementation Plans

This section specifies a timeline for the preparation and submission of implementation plans by DMAs and responsible persons. In accordance with OAR 340-042-0060, TMDLs are issued as a DEQ order, effective on the date signed by the Director or his or her designee. DEQ will notify all affected NPDES permittees, DMAs, and responsible persons identified in this document and persons who provided formal comment on the draft TMDL within 20 business days of TMDL issuance. DEQ expects that the USFS, BLM, BOR, Klamath County, other DMAs, and responsible persons will fulfill the planning expectations of Section 6.3.8 within **18 months** of the date of receipt of their notification letter and provide an annual report summarizing progress toward development and implementation of the respective plans. The Forest Practice Rules of ODF are already in effect and ODA follows a two year timeline from the last AgWQMAP review as specified by rule.

DEQ review and approval of TMDL implementation plans is called for in OAR 340-042. Following Implementation Plan submittal, DEQ will work closely with DMAs and responsible persons to ensure a successful and timely review/approval process. In accordance with MOUs, once a USFS or BLM WQRP is reviewed by DEQ, DEQ will provide a letter of the approval or disapproval decision within 60 days of the submittal of the plan with any appropriate requirements for revision.

The implementation plans, this WQMP, and the TMDLs are part of an adaptive management process. Review of the TMDLs, WQMP and Implementation Plans will tentatively target a 5 year cycle; this is subject to available staff time and varying levels of priorities within and outside of DEQ. Evaluations that trigger revision of the Implementation Plans will include, but not be limited to, consideration of: 1) DMA/responsible persons recommendations; 2) the periodic evaluation called for in Section 6.3.12; 3) new 303(d) listings; 4) TMDL revisions; and 5) other BMP effectiveness and water quality trend evaluations.

6.3.9 Reasonable Assurance

This section of the WQMP is intended to provide reasonable assurance that the WQMP (along with the associated DMA and responsible person Implementation Plans) will be implemented and that the TMDL and associated allocations will be met. See chapter 5 for additional discussion of reasonable assurance. NPDES point sources are addressed through the DEQ and EPA permit program. This section will focus on nonpoint sources.

6.3.9.1 Federal Lands

The BLM and USFS are DMAs for federal lands in the Lost River subbasin and both agencies have signed Memorandums of Agreement with DEQ. These MOAs include agreement to prepare and implement Water Quality Restoration Plans (WQRPs) addressing TMDLs. For further discussion, refer to Sections 6.3.8 and 6.3.14.

6.3.9.2 Federal Irrigation Project

The Bureau of Reclamation is the DMA responsible for developing a source specific implementation plan to address load allocations associated with water delivery and drainage facilities that are federally owned and/or operated in the Klamath Reclamation Project.

6.3.9.3 PacifiCorp Facilities

PacifiCorp is the responsible person responsible for developing source specific implementation plans to address load allocations associated with the John C Boyle Dam and the Keno Dam.

6.3.9.4 Water Management Districts

Various water management districts comprised of drainage and irrigation districts are responsible persons responsible for developing source specific implementation plans.

6.3.9.5 Non Federal Forest Lands

The Oregon Department of Forestry (ODF) is the DMA, by statute, for water quality protection from nonpoint source discharges or pollutants resulting from forest operations on non-federal forestlands in Oregon. Linkage to TMDLs and legal authority are discussed in Sections 6.3.8 and 6.3.14.

6.3.9.6 Agricultural Lands

The Oregon Department of Agriculture (ODA) is the DMA responsible for regulating agricultural activities that affect water quality. AgWQMA Plans are the TMDL implementation mechanism for agricultural and related rural residential land use. An AgWQMA Plan has been prepared for the Upper Klamath subbasin (Klamath Headwater AWQMP, ODA 2017) and Lost River subbasin and ODA has institutionalized a 2-year update cycle.

Voluntary Farm Plans are a key component of the SB1010 planning process. In addition, ODA has the ability to assess civil penalties when local operators do not follow their local Agricultural Water Quality Management Area rules. Legal authority is discussed in Sections 6.3.8 and 6.3.14.

6.3.9.7 Urban and Rural Lands

Oregon cities and counties have authority to regulate land use activities through city and county ordinances and local comprehensive land use plans. The Oregon land use planning system, administered through the Oregon Department of Land Conservation and Development, requires local jurisdictions to address water quality protection through Statewide Planning Goals 5 and 6. Both the City of Klamath Falls and Klamath County will be submitting implementation plans to fulfill their TMDL responsibilities.

6.3.9.8 Voluntary Efforts and Public Funding

Environmental watershed planning in Oregon is supported through outreach, technical assistance, monetary incentives and cost share funding through a variety of organizations and programs (refer to Sections 6.3.13 and 6.3.16). As watershed programs continue to develop and more projects are implemented, landowner adoption of water quality practices broadens through increasing knowledge, familiarity, and success.

6.3.10 Monitoring and Evaluation

Monitoring and evaluation has three basic components: 1) implementation of TMDL implementation plans identified in this document; 2) management practice effectiveness monitoring and; 3) assessment of water quality improvement. DEQ generally expects that DMAs and responsible persons will monitor implementation efforts and that DEQ and various natural resource organizations including DMAs and responsible persons will participate in effectiveness and water quality monitoring.

The information generated by each of these organizations will be pooled and used to determine whether management strategies are having the desired effects or if changes in management strategies and/or TMDLs are needed. This detailed evaluation (refer to Section 6.3.12) will be planned, as feasible, roughly on a five year cycle. If progress is insufficient, then the appropriate management agency will be contacted with a request for additional action. This monitoring and feedback mechanism is a major component of the “reasonable assurance of implementation” for the Upper Klamath and Lost River subbasin WQMP.

It is anticipated that monitoring efforts will consist of some of the following types of activities:

- Reports on the numbers, types and locations of projects, management strategies, and educational activities completed
- Monitoring of channel type, width, and depth

Monitoring riparian vegetation communities and shade to assess progress towards achieving system potential targets established in the TMDLDEQ recognizes that such coordinated local efforts are important and encourages them accordingly. As available, DEQ will contribute resources to such efforts.

6.3.10.1 Monitoring Objectives

DEQ acknowledges that monitoring data throughout the TMDL coverage area exists to an extent. To that end, DEQ suggests that each DMA or responsible person incorporate a monitoring plan in their source specific implementation plan. The plan can include existing efforts where data are present or can provide new data where applicable. The monitoring objectives can be found in the Klamath and Lost River Monitoring Strategy document. The document can be accessed on the Klamath basin TMDL web page at the following link: https://www.oregon.gov/deq/wq/tmdls/Pages/TMDLs-Klamath-Basin.aspx

The Klamath and Lost River Monitoring Strategy document identifies the locations of potential monitoring stations for monitoring the progress and status of the listed waterbodies. The locations of these proposed monitoring locations are shown in Figure 6-3 and Figure 6-4 for the Upper Klamath and Lost River Subbasins, respectively. These locations may be updated based on access and monitoring objectives.

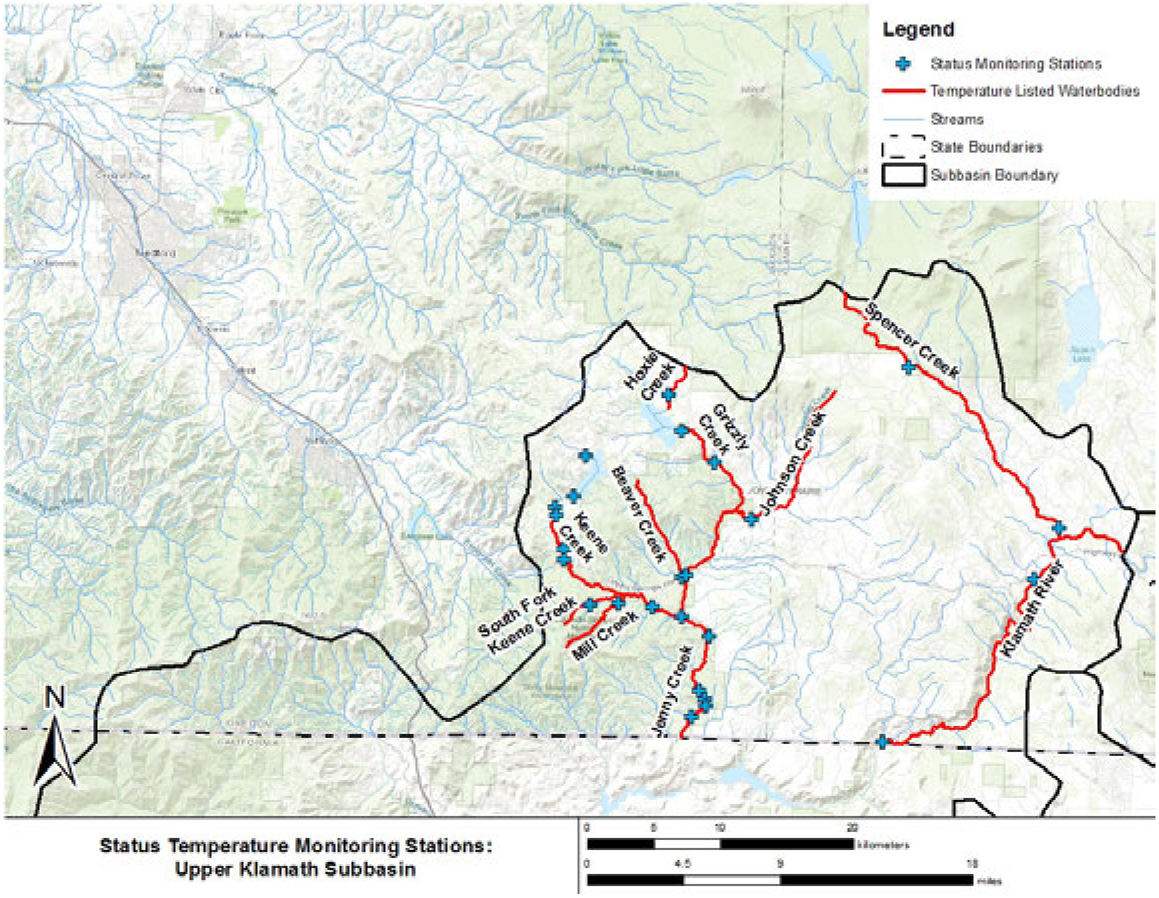


Figure 6-3. Locations of proposed status monitoring stations in the Upper Klamath subbasin.

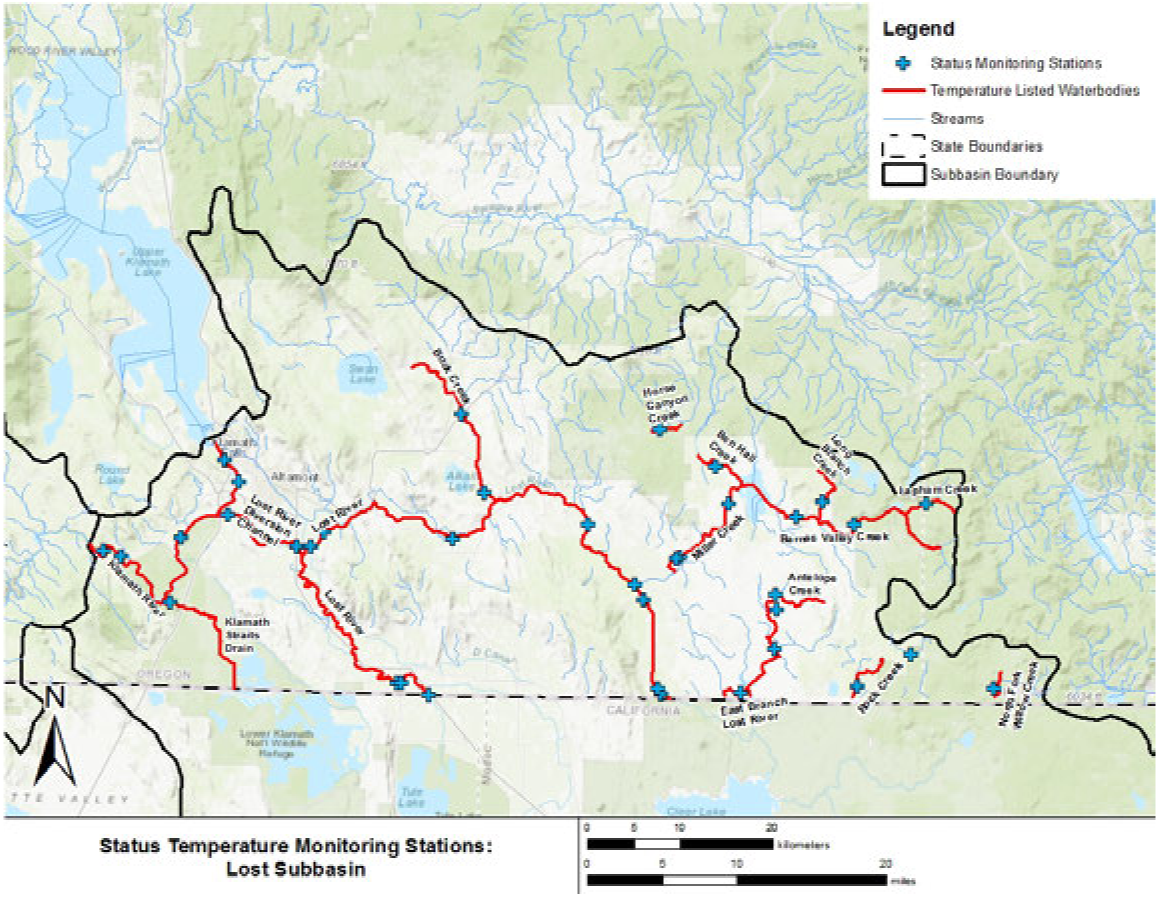


Figure 6-4. Locations of proposed status monitoring stations in the Lost River subbasin.

DEQ will review and approve these plans along with or as part of the source specific TMDL implementation plans. As with the implementation planning process DEQ would suggest an adaptive management strategy be implemented within the monitoring plan.

6.3.10.2 Persons responsible for monitoring

OAR 340-042-0040(K)(i), provides DEQ authority to identify in a WQMP persons responsible for monitoring. DEQ will work with organizations collaboratively to collect monitoring data to support the monitoring strategy. Should these efforts fail after a period of five years, DMAs, and responsible persons listed in Section 6.3.6 are the persons responsible for monitoring.

For the Lost River, The Bureau of Reclamation (or persons designated by the Bureau of Reclamation) shall be responsible for monitoring continuous temperature from June 1 – September 30 at locations specified in Table 6-10. New locations may be added or existing locations dropped with DEQ approval.

Monitoring data shall be collected based on an approved DEQ QAPP. Temperature monitoring data, audit information, and other monitoring data shall be submitted to DEQ annually, along with the annual report, in electronic format using DEQ approved templates or through internet protocols.

Table 6-10. Continuous temperature monitoring locations on the Lost River.

Station ID	Location	Latitude	Longitude
New Site	Lost River at Stateline (Hwy 161) Rd.	41.9984	-121.5227
10761-ORDEQ	Lost River at Malone Dam (Langell Valley)	42.0068	-121.2241
38907-ORDEQ	Lost River at Gift Road	42.09316	-121.2438
28293-ORDEQ	Lost River at Malone Bridge (downstream of Anderson Rose Dam)	42.0102	-121.5609

6.3.10.3 Plan and schedule for reviewing monitoring information

DEQ will review water quality monitoring data annually in the form of a status and trend report.

6.3.11 Public Involvement

DEQ believes that public involvement is essential to any successful water quality improvement process.

When developing and implementing TMDL Implementation Plans, DMAs, and responsible persons will determine how best to provide for public involvement based on their local needs and requirements. DEQ will also promote public involvement through direct association and contact with existing groups that have an interest in the Upper Klamath and Lost River TMDL, such as watershed councils, and SB 1010 Local Advisory Committees, federal and state agencies, and others.

6.3.12 Maintaining Management Strategies over Time

In response to the Upper Klamath and Lost River subbasins TMDL, each DMA and responsible person will review their TMDL Implementation Plan or program for its effectiveness in addressing load allocations. In addition, each DMA and responsible person will submit a report describing the implementation efforts underway and noting changes in water quality every five years. DEQ will review these submittals and recommend changes to individual Implementation Plans if necessary. The 303(d)/TMDL process and the management planning associated with WQRP, forest practices, and agricultural planning are ongoing by design.

6.3.13 Costs and Funding

One purpose of this element is to demonstrate there is sufficient funding available to begin implementation of the WQMP. Another purpose is to identify potential future funding sources for project implementation. Following TMDL issuance, DEQ will work with the DMAs and responsible persons to develop TMDL implementation plans that contain site specific information and costs and timelines for how the DMA and responsible persons would implement the TMDL. It may be necessary for DMAs and responsible persons to prioritize among the strategies if resources are limited. This may mean addressing some sources of pollution before others or focusing implementation efforts in a particular geographic area. To the extent possible, the selection of priorities should be driven by the greatest opportunities for achieving pollutant reductions. DMAs and responsible persons may need to conduct a fiscal analysis to determine what additional resources are necessary to develop, implement, and maintain the management strategies, and how these resources will be obtained. The results of this analysis could be briefly described in the implementation plan.

The cost of restoration projects varies considerably and can range from zero cost, or even profit due to improvements, to full channel reconstruction and land acquisition which can cost hundreds of thousands of dollars per river mile. Restoration can be passive or active. Passive restoration results from removing stresses to the channel, vegetation, and floodplain, and allowing the river system to naturally recover. Active restoration involves channel construction, installation of structures to capture sediment or re-direct water, etc., and tends to cost more than passive. Passive restoration can be accomplished through measures such as fencing or allowing natural vegetation to grow between farm fields and streams. Different measures are appropriate for different management styles, land uses, and types of geomorphic or vegetative impairment. Restoration can be accomplished by simply changing management as a matter of business, such as changing the timing of pasture use. Given these complexities and uncertainties, a cost analysis is not attempted here. It is expected that DMAs will conduct a cost and funding analysis as part of the Implementation Planning process.

Potential Sources of Project Funding

Financial assistance is provided through a mix of cost-share, tax credit, and grant funded incentive programs designed to improve on-the-ground watershed conditions. Some of these programs, due to the sources of their funding, have specific qualifying factors and priorities. The following is a partial list of assistance programs available in the subbasin.

Program	Agency Source
Oregon Plan for Salmon and Watersheds	OWEB
Environmental Quality Incentives Program	USDA-NRCS
Wetland Reserve Program	USDA-NRCS
Conservation Reserve Enhancement Program	USDA-NRCS
Stewardship Incentive Program	ODF
Access and Habitat Program	ODFW
Partners for Wildlife Program	USDA-FSA
Conservation Implementation Grants	ODA
Conserved Water Program and Other Water Projects	WRD
Nonpoint Source Water Quality Control (EPA 319)	DEQ-EPA
Riparian Protection/Enhancement	COE
State Revolving Fund Low Interest Loans	DEQ-EPA
Nonpoint Source Pollution Reduction Tax Credit	DEQ

Grant funds are available for water quality improvement projects, typically on a competitive basis. Field specialists assist landowners in identifying, designing, and submitting eligible projects for these grant funds. Assistance is available through the Klamath County Soil and Water Conservation District.

6.3.14 Citation of Legal Authorities

Clean Water Act Section 303(d)

Section 303(d) of the 1972 Federal Clean Water Act as amended requires states to develop a list of rivers, streams, and lakes that cannot meet water quality standards without application of additional pollution controls beyond the existing requirements on industrial sources and sewage treatment plants. Such water bodies are referred to as “water quality limited”, and are identified by DEQ. DEQ works to update the list of water quality limited waters every two years. The list is commonly referred to as the 303(d) list. Section 303(d) of the Clean Water Act further requires that Total Maximum Daily Loads (TMDLs) be developed for all waters on the 303(d) list.

Oregon Revised Statute

The Oregon Department of Environmental Quality is authorized by law to prevent and abate water pollution within the State of Oregon pursuant to ORS 468B.015, which declares that it is the public policy of the state to maintain and protect quality of waters of the state. The statute ORS 468B.020 (Prevention of pollution) provides that:

(1) Pollution of any of the waters of the state is declared to be not a reasonable or natural use of such waters and to be contrary to the public policy of the State or Oregon, as set forth in ORS 468B.015.

(2) In order to carry out the public policy set forth in ORS 468B.015, DEQ shall take such action as is necessary for the prevention of new pollution and the abatement of existing pollution by:

  (a) Fostering and encouraging the cooperation of the people, industry, cities and counties, in order to prevent, control and reduce pollution of the waters of the State; and

  (b) Requiring the use of all available and reasonable methods necessary to achieve the purposes of ORS 468B.015 and to conform to the standards of water quality and purity established under ORS 468B.048.”

Oregon Administrative Rules

The following Oregon Administrative Rules provide numeric and narrative criteria (water quality standards):

Antidegradation – OAR 340-041-0004

Statewide Narrative Criteria – OAR 340-041-0007

Forest Practices

The Oregon Forest Practices Act (FPA) was enacted in 1971. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describes BMPs for forest operations. The Environmental Quality Commission

(EQC), Board of Forestry, DEQ and ODF have agreed that these pollution control measures will be relied upon to result in achievement of state water quality standards. Forest operators conducting operations in accordance with the Forest Practices Act (FPA) are considered to be in compliance with water quality standards. In areas where a TMDL has been approved, site specific rules under the Forest Practices Act rules will need to be revised if DEQ determines that the generally applicable Forest Practices Act rules are not adequate to implement the TMDL load allocations. A 1998 Memorandum of Understanding between both agencies guides the implementation of this agreement, as described in Section 6.3.8.

ODF and DEQ statutes and rules also include provisions for adaptive management that provide for revisions to FPA practices where necessary to meet water quality standards. These provisions are described in ORS 527.710, ORS 527.765, ORS 183.310, OAR 340-041-0026, OAR 629-635-110, OAR 340-042-0080 and OAR 340-041-0120.

Agricultural Lands

The Oregon Department of Agriculture (ODA) is the DMA responsible for regulating agricultural activities that affect water quality through the Agricultural Water Quality Management Act of 1993 (SB1010, ORS 569.000 through 568.933) and Senate Bill 502 (adopted 1995, ORS 561.191).

SB1010 directs ODA to work with local communities, including farmers, ranchers, and environmental representatives, to develop Agricultural Water Quality Management Area Plans (AgWQMAP) and rules throughout the State. SB502 stipulates that ODA "*shall develop and implement any program or rules that directly regulate farming practices that are for the purpose of protecting water quality and that are applicable to areas of the state designated as exclusive farm use zones or other agricultural lands*." The plans are accompanied by regulations in OAR 603-90 and portions of OAR 603-95, which are enforceable by ODA. As discussed in Section 6.3.8, TMDL implementation coordination between ODA and DEQ is guided by an MOA signed in 2012 and according to OAR 340-042-0080.

Federal Land Managers

DEQ maintains Memorandums of Agreement with BLM and the USFS; both were signed in July, 2003. The MOAs define processes by which the agencies will work with DEQ to meet State and Federal water quality rules and regulations. This agreement recognizes the BLM and USFS as DMAs for the lands they administer in Oregon, and clarifies that WQRPs are the TMDL Implementation Plans for these agencies.

6.4 TMDL - Related Programs, Incentives and Voluntary Efforts

TMDLs in Oregon are designed to coordinate with and support other watershed protection and restoration efforts. Watershed enhancement in the Upper Klamath and Lost River subbasins is ongoing and is, for the most part, consistent with or directly implements the load allocations of the TMDL. While regional programs are in place, much of the restoration is locally based. Collectively, these organizations and programs produce technical assistance, financial assistance, restoration opportunities, outreach, discussion forums, incentives, and planning.

6.4.1 Water Quality Credit Trading Opportunities

DEQ encourages Upper Klamath and Lost Subbasins DMAs to develop a basin-specific, water quality credit trading program that meets the TMDL allocations for the Upper Klamath and Lost River subbasins. Water quality credit trading is an innovative TMDL implementation approach to achieve water quality goals more efficiently. Trading is based on the fact that sources in a watershed can face very different costs to control the same pollutant. Trading programs allow facilities facing higher pollution control costs to meet their regulatory obligations by exchanging environmentally equivalent (or superior) pollution reductions from another source at lower cost, thus achieving the same water quality improvement at lower overall cost. The successful trading process allows a source with high TMDL implementation costs to exchange the same or greater level of load reduction from other sources with lower costs. For more information please refer to DEQ's web page on water quality credit trading at http://www.deq.state.or.us/wq/trading/faqs.htm.

Program Goals

The overall program goals are to achieve water quality improvements required in all Klamath basin TMDLs, in a manner that is consistent with state and federal policy and regulations, is technically sound, and is tailored to meet the specific needs and conditions in the Klamath basin. More specifically, the goals are to develop a basin-wide accountability program to track water quality improvements, facilitate planning, and coordinate TMDL implementation based upon a market-like system. The Tracking and Accounting Program should also:

- Provide a decision tool to guide expenditure of implementation resources towards projects with greatest/earliest impact.
- Encourage the pooling of resources to support engineered solutions and enable the spending of resources across state boundaries by tracking and accounting for the contribution of each project participant.

Program Objectives

Establish and operate a program for tracking water quality improvements that:

- Encourages early reductions and progress towards water quality improvements;
- Reduces the cost of TMDL implementation through greater efficiency and flexible approaches;

- Creates economic incentives for innovation, emerging technology, voluntary pollutant reductions from all sources, and for potential trading and/or offsets amongst these sources;
- Achieves ancillary environmental benefits beyond the required reductions in specific pollutant loads, such as the creation and restoration of wetlands, floodplains, and fish and/or waterfowl habitat;
- Establishes an accountability program whereby a common metric (or sets of metrics) is/are used for estimating and tracking water quality improvements;
- Establishes a credible baseline, linked to the two states' TMDLs, and incorporates effectiveness monitoring and an adaptive management approach;
- Uses standardized protocols to quantify pollutant loads, load reductions, and credits/offsets, or other water quality improvements (e.g., stream channel restoration) that contribute to supporting conditions for beneficial uses;
- Recognizes cross-pollutant benefits (e.g. acknowledges that upstream nutrient reductions can improve downstream low dissolved oxygen levels and algal bloom conditions); and
- Allows participants to contribute to program-sponsored projects without having to develop partner-specific agreements or contracts thus minimizing administrative and transaction costs.

6.4.2 Local Collaborative Watershed Enhancement Processes

The following is a list of several broad-scale watershed enhancement processes or programs in the Lost River and Upper Klamath subbasins, some overlap the state border.

US Fish and Wildlife Service, Ecological Restoration office and US Bureau of Reclamation provide funding for potential projects that enhance and restore habitat conditions, improve water-quality conditions, remove fish-passage barriers, reduce entrainment through the installation of fish screens, and result in water conservation efficiencies.

The Klamath Tribes fisheries program includes substantial resources invested in monitoring and watershed restoration efforts to achieve recovery of Lost River and shortnose suckers (c'waam and qapdo, respectively) and assist in reintroduction of Coho salmon into the upper basin. Habitat restoration and water quality improvements that help the c'waam and qapdo recover will also help restore healthy populations of the threatened Coho salmon in downstream Klamath River waters.

Trout Unlimited is actively engaged in restoration and conservation of the quality and quantity of water in Oregon's Wood River Valley and the Upper Klamath basin to enhance the natural ecosystem and supply needed water for downstream agriculture, ranching, native fish, and wildlife populations.

The Klamath Basin Watershed Partnership is working to conserve, enhance, and restore the natural resources of the Klamath basin, while ensuring the long-term sustainability of the regional economy and local communities.

6.4.3 The Oregon Plan for Salmon and Watersheds

The Oregon Plan for Salmon and Watersheds represents a major process, unique to Oregon, to improve watersheds and restore endangered fish species. The Plan consists of several essential elements:

(1) Coordinated Agency Programs

Many state and federal agencies administer laws, policies, and management programs that have an impact on salmonids and water quality. These agencies are responsible for fishery harvest management, production of hatchery fish, water quality, water quantity, and a wide variety of habitat protection, alteration, and restoration activities. Previously, agencies conducted business independently. Water quality and salmon suffered because they were affected by the actions of all the agencies, but no single agency was responsible for comprehensive life-cycle management. Under the Oregon Plan, all government agencies that impact salmon are accountable for coordinated programs in a manner that is consistent with conservation and restoration efforts.

(2) Community-Based Action

Government, alone, cannot conserve and restore salmon across the landscape. The Oregon Plan recognizes that actions to conserve and restore salmon must be worked out by communities and landowners, with local knowledge of problems and ownership in solutions. Watershed councils, soil and water conservation districts, and other grassroots efforts are vehicles for getting the work done. Government programs will provide regulatory and technical support to these efforts, but local people will do the bulk of the work to conserve and restore watersheds. Education is a fundamental part of the community-based action. People must understand the needs of fish and wildlife, and how rivers function, in order to make informed decisions about how to make changes to their way of life that will accommodate clean water and the needs of fish.

(3) Monitoring

The monitoring program combines an annual appraisal of work accomplished and results achieved. Work plans will be used to determine whether agencies meet their goals as promised. Biological and physical sampling will be conducted to determine whether water quality and salmon habitats and populations respond as expected to conservation and restoration efforts.

(4) Appropriate Corrective Measures

The Oregon Plan includes an explicit process for learning from experience, discussing alternative approaches, and making changes to current programs. The Plan emphasizes improving compliance with existing laws rather than arbitrarily establishing new protective laws. Compliance will be achieved through a combination of education and prioritized enforcement of laws that are expected to yield the greatest benefits for salmon.

6.5 References

DEQ, 1997. Guidance for Developing Water Quality Management Plans that will Function as TMDLs for Nonpoint Sources.

DEQ and Oregon Department of Land Conservation and Development, 1994. Nonpoint Source Pollution Control Guidebook for Local Government.

DEQ and Oregon Department of Land Conservation and Development, 2000. Water Quality Model Code and Guide Book, http://www.deq.state.or.us/wq/.

Oregon Department of Environmental Quality, North Coast Regional Water Quality Control Board, Region 9 and 10 U.S. Environmental Protection Agency. 2009. Memorandum of Agreement Klamath River/Lost River TMDL Implementation

USDA Forest Service, USDI Bureau of Land Management, Environmental Protection Agency, 1999. Forest Service and Bureau of Land Management Protocol for Addressing Clean Water Act Section 303(d) Listed Waters.