ROGUE RIVER BASIN TMDL
CHAPTER 2: TEMPERATURE

Prepared by
Oregon Department of Environmental Quality

DEQ
State of Oregon
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DEFINITIONS

Anthropogenic Nonpoint Source Heat Load: Heat load caused by human activities.

Anthropogenic Nonpoint Source Load Allocation: The amount of heat that anthropogenic nonpoint sources may contribute to a stream without exceeding the applicable criteria. For temperature TMDLs it includes the human use allowance of 0.3 °C.

Assimilative Capacity: The amount of heat above the background level that a waterbody can receive without exceeding water quality standards. Assimilative capacity gets divided amongst nonpoint source load allocations and point source waste load allocations.

Background Heat Load: The amount of heat that a stream would naturally receive in the absence of all anthropogenic impacts. It includes heat load from natural disturbances.

Critical Condition: Time of year when maximum stream temperatures are observed.

Current Total Heat Load: The amount of heat load a stream currently receives from all sources; including anthropogenic nonpoint sources, point sources, and background (including natural disturbance).

Diel: Refers to a 24-hour period involving a day and a night. In this document, a common usage is referring to the daily swings in temperature between the early morning lows and the late afternoon highs, e.g. diel variability.

Effective Shade: The percent reduction of potential daily solar radiation load delivered to the stream surface.

Heat Flux: The amount of heat per unit time per unit area (e.g. watts per square meter) measured at the stream surface.

Heat Load: The amount of heat received per 24-hour period by the stream (e.g. kilocalories). It is calculated by multiplying the stream surface area by the solar heat flux.

Human Use Allowance: Allowable anthropogenic heat load equivalent to a cumulative 0.3^{o}C increase above the applicable criteria at the point(s) of maximum impact.

Natural Thermal Potential (NTP): The determination of the thermal profile of a water body using best available methods of analysis and the best available information on the system potential riparian vegetation, stream geomorphology, stream flows and other measures to reflect natural conditions. (OAR 340-041-0002)

Nonpoint Source Loading Capacity: The amount of heat that a stream can receive from nonpoint sources (natural and anthropogenic) without exceeding the applicable criteria.

Point of Maximum Impact: The location in a stream where the cumulative impacts of all upstream sources is most severe or most critical. The point of maximum impact may vary seasonally as well as spatially. Some water bodies may have more than one point of maximum impact, depending on the unique spatial and temporal thermal profiles of that water body.

System Potential Vegetation: Model parameters that represent near stream vegetation that can grow and reproduce on a site given plant biology, site elevation, soil characteristics, local climate, channel morphology and stream flow.

2.1 OVERVIEW AND SCOPE

Human activities and aquatic species protected by water quality standards are called “beneficial uses”. Water quality standards are developed to protect the most sensitive beneficial use within a waterbody. Oregon’s stream temperature standard is designed to protect cold water fish (salmonids) rearing and spawning as the most sensitive beneficial use.

Oregon’s stream temperature standard is both numeric and narrative. Numeric criteria are based on temperatures that protect various salmonid life stages. Narrative triggers specify conditions that deserve special attention, such as outstanding resource waters and dissolved oxygen violations.

When stream temperature data indicate a criteria violation, the waterbody is designated as water quality limited and placed on the 303(d) list. Total Maximum Daily Loads (TMDLs) must then be completed for the 303(d) listed waterbodies.

This temperature TMDL addresses year round impairments to all perennial and intermittent streams and rivers within Oregon that drain to the mouth of the Rogue River with the exception of those within the Lobster Creek watershed, Sucker Creek watershed, Bear Creek watershed and Applegate Subbasin where TMDLs were completed and approved by the U.S. Environmental Protection Agency (EPA) (DEQ 1999, 2002a, 2002b, 2003 and 2007a)[1] (see **Chapter 1** for map). All land uses and ownerships are included in this TMDL: lands managed by the State of Oregon, U.S. Army Corp of Engineers, irrigation districts, the U.S. Forest Service (USFS) and U.S. Bureau of Land Management (BLM), private forestlands, agricultural lands, rural residences, transportation uses and urbanized areas.

Stream temperatures were simulated using a computer model (Heat Source) for the main rivers and their larger tributaries (**Table 2.1**) (see **Appendix A** for discussion). Source assessment and natural condition simulations focus on the larger streams that contain or influence primary fish habitat. Site-specific load allocations have been developed for the streams that were simulated. Other streams are assigned generalized load allocations based on potential vegetation and effective shade curves. This TMDL does not replace the existing TMDLs in the Rogue River Basin. The natural condition scenario of the Rogue River incorporated the information from existing TMDLs to estimate the impact of restored tributaries to the Rogue River. See **Appendix B** for details.

Table 2.1. Stream Temperature Simulation Extents

River/Stream	Simulation Extent
Rogue River	Upstream of estuary at river mile 5.3 to downstream of Lost Creek Reservoir at river mile 155
Little Butte Creek and North Fork Little Butte Creek	Mouth to Fish Lake at river mile 34
South Fork Little Butte Creek	Mouth to just upstream of Beaver Dam Creek at river mile 18
Antelope Creek	Mouth to just upstream of Yankee Creek at river mile 6
Elk Creek	Mouth to just upstream of Bitter Lick Creek at river mile 14
Evans Creek and West Fork Evans Creek	Mouth to near headwaters of West Fork Evans Creek at river mile 37
	Total Simulation Extent: 258.7 stream miles

Waste load allocations have been developed for point sources and will be incorporated into the National Pollutant Discharge Elimination System (NPDES) permits for those sources. Allocations within this TMDL apply to all temperature listings for all time periods. Nonpoint source load allocations use effective shade as a surrogate measure and are protective year-round. Point source waste load allocations have been calculated for a variety of stream temperatures and flows in order to address all time periods. The **Rogue**

[1] The TMDLs can be viewed at http://www.deq.state.or.us/wq/tmdls/rogue.htm.

River Basin Temperature TMDL Appendix A and **Appendix B** contain more detailed information regarding data sources, analytical methodology, and simulation results.

Temperature Issues in the Rogue River Subbasins

Salmonids, often referred to as cold water fish, and some amphibians are highly sensitive to temperature. In particular, Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) are among the most temperature sensitive of the cold water fish species in the Rogue River subbasins (DEQ 1995). Excessive summer water temperatures have been recorded in a number of tributaries. These high summer temperatures are reducing the quality of rearing and spawning habitat for chinook and coho salmon, steelhead and resident rainbow trout. The potential causes of high water temperatures in the Rogue River subbasins include urban and rural residential development near streams and rivers, reservoir management, irrigation water return flows, past forest management within riparian areas, NPDES regulated point sources, agricultural land use within the riparian area, water withdrawals, and road construction and maintenance.

Applying Oregon's Temperature Criteria

Oregon's water temperature criteria employ a logic that relies on using salmonids' life cycles as the indicator (see **Chapter 1** for water quality criteria). If temperatures are protective of these indicator species, other species will share in this protection. As a result of water quality criteria exceedances for temperature, 101 stream reaches (approximately 904.1 stream miles) in the Rogue River subbasins are on Oregon's 2004/2006 303(d) list. The reduction in thermal loading needed to meet the water quality criteria for temperature is evaluated in this TMDL. Attainment of the temperature criteria relies on simulating the thermal profile of Rogue River and tributaries under conditions termed "natural thermal potential". Natural thermal potential is defined as system potential vegetation, geomorphology, stream flows and other measures to reflect natural conditions.

Temperature TMDL Overview

Potential thermal pollutants identified include human-caused increases in solar radiation due to changes in riparian vegetation, warm water discharges due to dams, flow modification, irrigation district management, and NPDES permitted sources. The resultant TMDL loading capacities are expressed as pollutant loading limits plus a Human Use Allowance (HUA) for both point and nonpoint sources of pollution (see **Table 2.2** for summary). The human use allowance is a cumulative increase of no greater than 0.3^{o}C above the applicable criteria after complete mixing in the waterbody and at the point of maximum impact (OAR 340-041-0028 12(b)(B)). The 0.3^{o}C cumulative increase is distributed between point and nonpoint sources and reserve capacity. Allocations take the form of numeric loads as well as percent effective shade and hyporheic exchange targets for identified watershed sources. Since natural thermal potential temperatures exceed 16-18^{o}C, DEQ rules state that achieving natural thermal potential conditions are considered compliance with the TMDL.

Table 2.2. Temperature TMDL Component Summary based on Oregon Administrative Rule (OAR), federal Clean Water Act (CWA) and Code of Federal Regulations (CFR) requirements.

Waterbodies **OAR 340-042-0040(4)(a)**	All perennial and intermittent streams within the Rogue Basin that are not already addressed by an existing TMDL. Specifically, this TMDL includes areas within the Lower Rogue Subbasin (Hydrologic Unit Code [HUC] 17100310), Middle Rogue Subbasin (HUC 17100308), Upper Rogue Subbasin (HUC 17100307), and Illinois Subbasin (HUC 17100311). Areas with an existing TMDL that are not addressed by this TMDL include Losbster Creek watershed (HUC 1710031007), Sucker Creek watershed (HUC 1710031103), Bear Creek watershed (HUC 1710030801), and Applegate Subbasin (HUC 17100309).
Beneficial Uses **OAR 340-041-0271,** **Table 271A**	Beneficial uses impaired include fish and aquatic life, and fishing.
Pollutant Identification **OAR 340-042-0040(4)(b)**	*Pollutants:* Human caused temperature increases from (1) warm water discharge to surface waters (2) increased solar radiation loading, and (3) flow modification that affects natural thermal regimes.

Target Identification Applicable Water Quality Standards **OAR 340-041-0028(4)(a)** **OAR 340-041-0028(4)(b)** **OAR 340-041-0028(4)(c)** **OAR 340-042-0040(4)(c)** ***CWA §303(d)(1)***	OAR 340, Division 41 provides numeric and narrative temperature criteria. Figures 271A, 271B specify where and when the criteria apply. Biologically based numeric criteria applicable to the Rogue Basin, as measured using the seven day average of the daily maximum stream temperature include: 13.0°C during times and at locations of salmonid and steelhead spawning. 16.0°C during times and at locations of salmon and trout rearing and migration designated as core cold water habitat 18.0°C during times and at locations of salmon and trout rearing and migration.
Existing Sources **OAR 340-042-0040(4)(f)** ***CWA §303(d)(1)***	<u>Nonpoint sources</u> include excessive inputs of solar radiation due to the removal or reduction in stream side vegetation. Reservoirs, irrigation districts and dam operations are considered nonpoint sources that influence the quantity and timing of heat delivery to down stream river reaches. <u>Point sources</u> include municipal and industrial facilities that discharge warm water to receiving streams.
Seasonal Variation **OAR 340-042-0040(4)(j)** ***CWA §303(d)(1)***	Peak temperatures typically occur in mid-July through mid-August. On the Rogue River, the period of exceedance of the water quality standard and applicability of allocations is from April 1- October 31 but anthropogenic heat loads are of concern throughout the year.
TMDL **Loading Capacity and Allocations** **OAR 340-042-0040(4)(d)** **OAR 340-042-0040(4)(e)** **OAR 340-042-0040(4)(g)** **OAR 340-042-0040(4)(h)** **OAR 340-042-0040(4)(k)** ***40 CFR 130.2(f)*** ***40 CFR 130.2(g)*** ***40 CFR 130.2(h)***	This summary section focuses on the Rogue River; for specifics regarding tributaries, please refer the main text of this document. *<u>Loading Capacity</u>:* Oregon Administrative Rule 340-041-0028 (12)(b)(B) states that all anthropogenic sources of heat may cumulatively increase stream temperature no more than 0.3ºC (0.5 ºF) above the applicable criteria at the point of maximum impact. Loading capacity for the Rogue River is the heat load that corresponds to the Natural Conditions Criteria plus the small increase in temperature of 0.3ºC provided with the human use allowance. The point of maximum impact for the Rogue River is estimated to be at river mile 62 (river kilometer 100). *<u>Excess Load</u>*: The difference between the actual pollutant load and the loading capacity of the waterbody is the excess heat load. In Rogue River the difference between the heat load that meets applicable temperature criteria and current heat loads is 5.5 billion kilocalories per day. *<u>Load Allocations (Nonpoint Sources)</u>*: The load allocation for nonpoint sources in the Rogue River basin consists of the sum of the natural background heat loads from solar radiation plus the heat load that corresponds to 0.04ºC of the Human Use Allowance (HUA) above the criteria at the point of maximum impact in the Rogue River. A heat load corresponding to the HUA has been allocated to nonpoint source activities along the Rogue River to address anthropogenic heat loads in excess of background rates due to existing structures, or altered landscape features that are unlikely to achieve system potential shade. *<u>Load Allocations (Reservoir Operations and Irrigation Districts)</u>*: Load allocations for the reservoir/dam operations and the irrigation districts within the Rogue Basin are based on a portion of the HUA. Irrigation Districts are allowed a cumulative increase in temperature of not more than 0.01ºC in Rogue River above the applicable criteria at the point of maximum impact. Lost Creek Dam, Prospect Hydroelectric Project, Fish Lake Dam and low head dams along the Rogue River are allowed no increase above natural thermal potential temperatures at the point(s) of maximum impact when the biologically-based numeric criteria are exceeded in the Rogue River. *<u>Waste Load Allocations (NPDES Point Sources)</u>*: All NPDES permitted point source permittees combined are allowed a heat load equivalent to an increase in temperature of not more than 0.2ºC in the Rogue River above the applicable criteria at the point of maximum impact during the season of impairment: April 1 – October 31. *<u>Reserve Capacity</u>*: A heat load equivalent to a portion of the human use allowance is allocated for future growth and new or expanded sources. This heat load allowance is equivalent to a total of 0.05ºC increase in Rogue River at the point of maximum impact above natural thermal potential.
Surrogate Measures **OAR 340-042-0040(5)(b)** ***40 CFR 130.2(i)***	<u>Surrogate measures:</u> Effective shade targets translate nonpoint source solar radiation loads into measurable stream side vegetation targets.
Margins of Safety **OAR 340-042-0040(4)(i)** ***CWA §303(d)(1)***	*<u>Margins of Safety</u>* are implicit by including conservative factors in the TMDL analysis.
Water Quality Management Plan **OAR 340-042-0040(4)(l)** ***CWA §303(d)(1)***	The 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 **(Chapter 4**).

2.2 BENEFICIAL USE IDENTIFICATION

The Oregon Environmental Quality Commission (OEQC) has adopted numeric and narrative water quality standards to protect designated *beneficial uses* in the Rogue Basin (Administrative Rules OAR 340–041–0271, Table 271A, 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 beneficial uses affected by excessive temperatures include Fish and Aquatic Life and Fishing (DEQ 2005a) (**Chapter 1, Table 1.6**). Cold-water aquatic life such as salmon and trout are the most temperature sensitive *beneficial uses* occurring in the Rogue River subbasins (DEQ 1995). Biologically-based numeric criteria were developed that are specific to salmonid life stages such as spawning and rearing. Criteria were also developed for critical habitat areas that serve as the core for salmonid protection and restoration efforts. The complete Oregon temperature rule (OAR 340-041-0028) can be accessed at http://www.deq.state.or.us.

Salmonid Stream Temperature Requirements

Stream temperatures above 18.0°C (64.4°F) are considered sub-lethal and can be stressful for cold water fish species, such as salmon and trout.

If stream temperatures become too hot, salmonids die almost instantaneously due to denaturing of critical enzyme systems in their bodies (Hogan 1970). The ultimate *instantaneous lethal limit* occurs in high temperature ranges above 90°F (> 32°C). Such warm temperature extremes may never occur in the Rogue River subbasins. More common and widespread, however, is the occurrence of temperatures in the range of 70°F - 77°F (21°C - 25°C). These temperatures, termed *incipient lethal limit*, cause death of cold water fish species during exposure times lasting a few hours to one day. The exact temperature at which a cold water fish succumbs to such a thermal stress depends on the temperature that the fish is acclimated to, and on life-stage. This cause of mortality results from the breakdown of physiological regulation of vital processes such as respiration and circulation (Heath and Hughes 1973).

The most common and widespread cause of thermally induced fish mortality is attributed to interactive effects of decreased or lack of metabolic energy for feeding, growth or reproductive behavior, increased exposure to pathogens (viruses, bacteria and fungus), decreased food supply (impaired macroinvertebrate populations) and increased competition from warm water tolerant species. This mode of thermally induced mortality, termed indirect or *sub-lethal*, is more delayed, and occurs weeks to months after the onset of elevated temperatures of 64°F - 74°F (20°C - 23°C) (**Table 2.3**).

Table 2.3. Modes of Thermally Induced Cold Water Fish Mortality

Modes of Thermally Induced Fish Mortality[1]	Temperature Range	Time to Death
Instantaneous Lethal Limit – Denaturing of bodily enzyme systems	> 90°F (> 32°C)	Instantaneous
Incipient Lethal Limit – Breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation	70°F - 77°F (21°C - 25°C)	Hours to Days
Sub-Lethal Limit – Conditions that cause decreased or lack of metabolic energy for feeding, growth or reproductive behavior, encourage increased exposure to pathogens, decreased food supply and increased competition from warm water tolerant species	64°F - 74°F (20°C - 23°C)	Weeks to Months

[1]Brett, 1952; Hokanson et al, 1977; Bell, 1986.

2.3 TARGET IDENTIFICATION - APPLICABLE WATER QUALITY CRITERIA

Numeric stream temperature criteria are expressed as a seven-day average of daily maximum temperature (7DADM). **Table 2.4** and **Table 2.5** summarize the biologically-based temperature criteria that are applicable to specific salmonid life stages. Oregon water quality standards also specify where and when the specific salmonid life stages occur and, therefore, where and when numeric criteria apply. Salmonid distribution and timing maps are provided in **Figure 2.1 and Figure 2.2**.

Oregon water quality standards include provisions for periods and locations where biologically-based numeric criteria may not be achieved. If biologically-based numeric criteria are not achievable when waters are in their natural condition, stream temperatures achieved under natural conditions shall be the temperature criteria for that water body (OAR 340-041-0028(8)). In other words, a stream that does not meet the biologically-based numeric temperature criteria, but is free from anthropogenic influence is considered at its natural thermal potential. In these situations the natural thermal potential temperatures supersede the biological numeric criteria and are considered the applicable numeric criteria. Unlike the biologically-based criteria such as the rearing criterion of 18ºC, which is constant for the entire summer period, the natural thermal potential is site specific and varies over time. TMDLs attempt to quantify the natural thermal potential of major streams through computer modeling.

Oregon water quality standards also have provisions for human use (OAR 340-041-0028(12)(b)). The human use allowance limits cumulative anthropogenic heating of surface waters to no more than 0.3°C (0.5°F) above the applicable biological or natural conditions criteria at the point of maximum impact. Again, the metric for compliance is a seven-day average of the daily maximum temperature.

Among the antidegradation policies included in Oregon water quality standards, are provisions to prevent the unnecessary degradation of high quality water and to ensure full protection of all existing beneficial uses (OAR 340-041-0004). At a minimum, uses are considered attainable wherever feasible or wherever attained historically. Protection of cold water temperatures is further specified in OAR 340-041-0028 (11). Subsection (a) requires that streams with maximum summer temperatures less than applicable numeric criteria shall not be warmed by more than 0.3°C above ambient temperatures. This applies to all heat sources at the point of maximum impact in streams designated as critical habitat for threatened or endangered salmon, steelhead or bull trout. Subsection (b) of the rule limits the warming of salmon and steelhead spawning waters from point source discharges to 0.5°C above the 60 day average maximum temperature when the moving average is between 10 to 12.8°C. The allowable increase is 1°C when the 60 day rolling average maximum temperature is less than 10°C unless analysis demonstrates that a greater increase will not significantly impact the use.

Water quality standards for temperature including the antidegradation and mixing zone policies are available online at DEQ at http://www.deq.state.or.us/wq/wqrules/wqrules.htm. A much more extensive analysis of water temperature related to aquatic life and supporting documentation for the temperature standard can be found in the *1992-1994 Water Quality Standards Review Final Issue Papers* (DEQ 1995) and in *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards* (USEPA 2003).

Table 2.4. Biologically-Based Numeric Temperature Criteria

Use	Numeric Criteria (7-Day Average Maximum)	Season
Salmon and Steelhead Spawning	13.0°C/55.4°F	Varies by geography 9/15 – 6/15, 10/15-5/15, 10/15-6/15, 1/1/-5/15, 1/1-6/15
Core Cold Water Habitat	16.0°C/60.8°F	Year around
Salmon and Trout Rearing and Migration	18.0°C/64.4°F	Year around
Salmon and Steelhead Migration Corridors	20.0°C/68.0°C	Year around

Table 2.5. Criteria by river mile for the Rogue River. River mile estimates taken from Oregon Water Resources Department map (1980).

Reach (river mile)	Upstream extent feature	Rearing Criteria (°C)	Spawning period
0 - 33.6	Foster Creek	18	none
33.6 - 125.7	Gold Ray Dam	18	October 15 – May 15
125.7 - 155.5	Big Butte Creek	16	September 15 – June 15
155.5 - 157.4	Lost Creek Dam	16	October 15 – May 15
157.4 - 215.2	headwaters	18	none

Figure 2.1. Fish Use Designations (map from OAR 340-041-0028, Figure 271A)

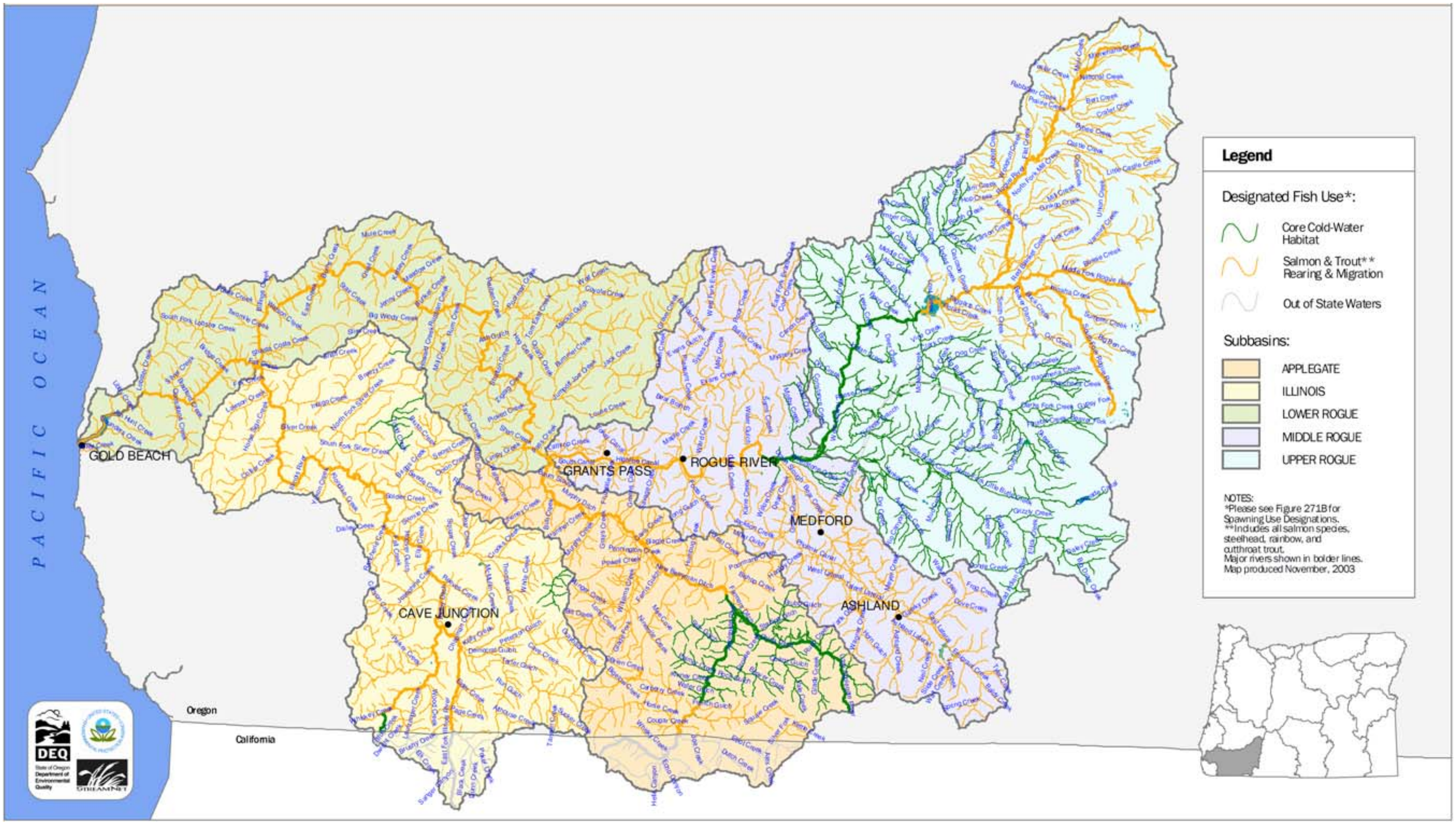
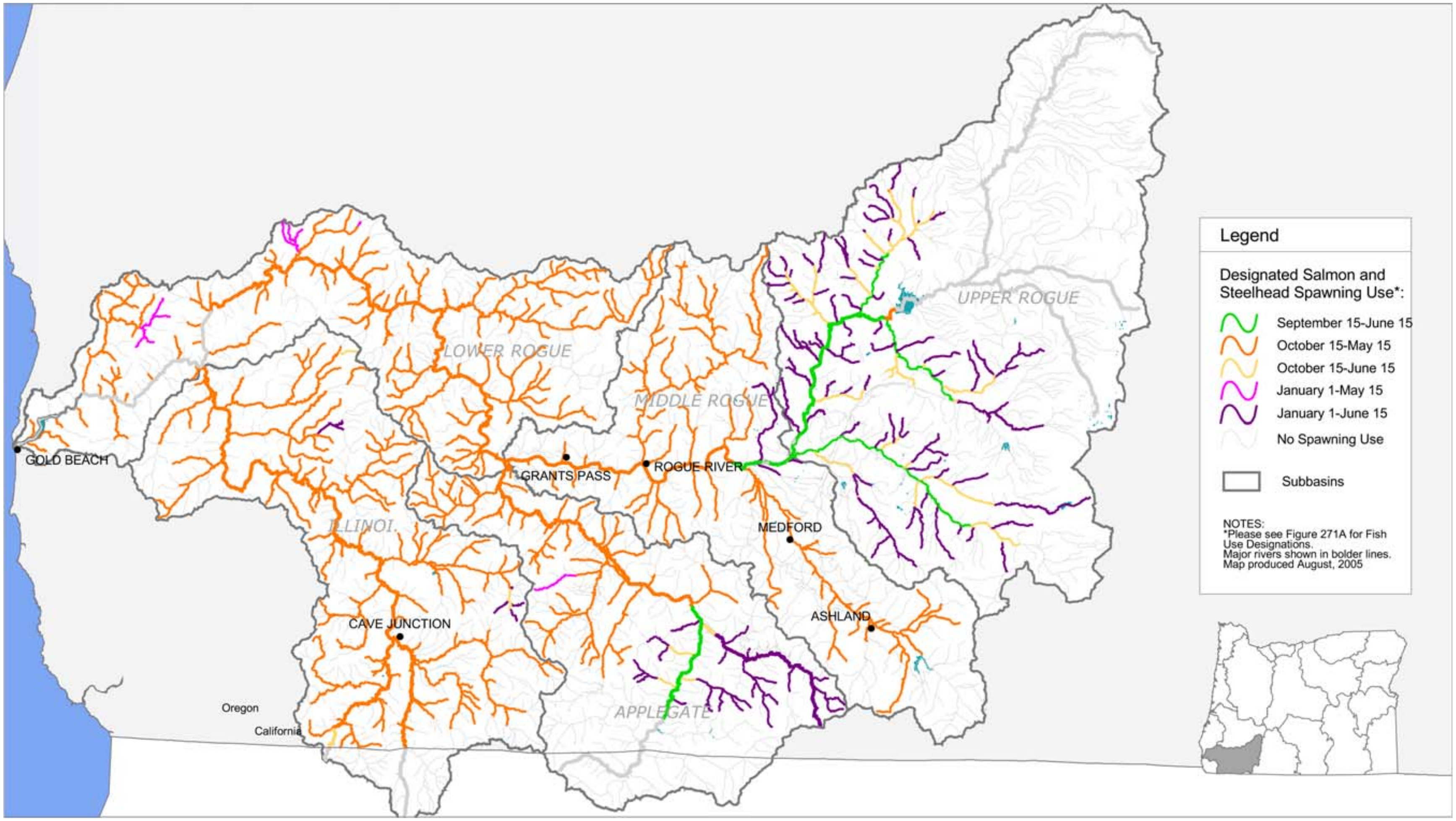


Figure 2.2. Salmon and Steelhead Spawning Use Designations (map from OAR 340-041-0028, Figure 271B)



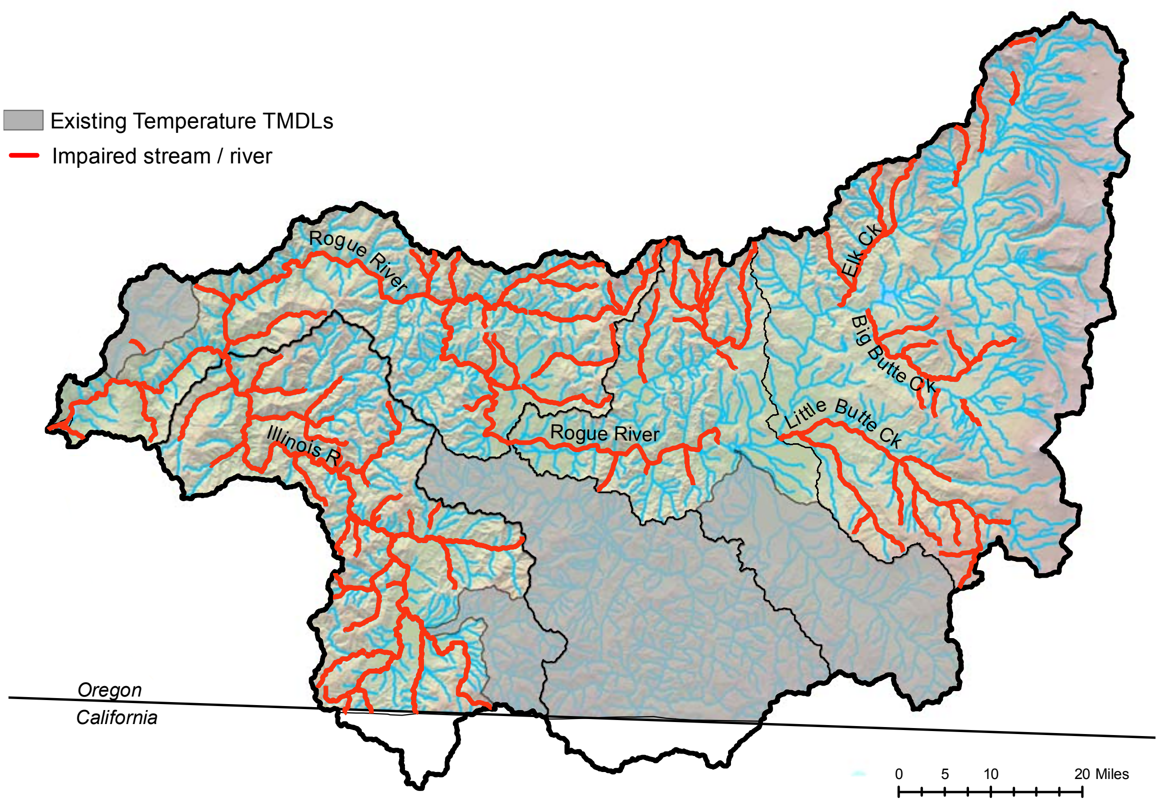
2.3.1 Waterbodies Listed for Temperature

Section 303(d) of the Federal Clean Water Act (1972) requires that waterbodies which exceed water quality critiera, thereby failing to fully protect *beneficial uses*, be identified and placed on a 303(d) list[2].

Monitoring has indicated that water temperatures in the Rogue River subbasins exceed the State of Oregon temperature criteria. The Rogue River basin has 101 individual temperature listings on the 2004/2006 Assessment (one of them is listed in error). Some streams may have more than one temperature listing. For example, Deer Creek in the Illinois River subbasin is listed for exceeding the rearing criteria *and* the spawning criteria. **Figure 2.3** and **Table 2.6** highlight the streams on the 2004/2006 303(d) list for temperature. One temperature listing in the Rogue Basin was determined to be in error due to the fact it is located within the Lobster Creek watershed for which a TMDL has already been developed (**Table 2.7**). **Figure 2.4** indicates the extent and magnitude of temperature criteria exceedances at monitoring locations in the Rogue Basin.

Based on the data reviewed and the modeling results for this TMDL effort, the portions of Rogue River mainstem appear to exceed the temperature water quality criteria during portions of the spawning season (see **Section 2.3.3** and **Appendix B** for further discussion).

Figure 2.3. 2004/2006 303(d) list for temperature (Red)



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[2] For specific information regarding Oregon's 303(d) listing procedures, and to obtain more information regarding the Rogue River basin 303(d) listed streams, visit the Oregon Department of Environmental Quality's web page at http://www.deq.state.or.us/.

Table 2.6. 2004/2006 303(d) Temperature Listings Addressed in the Rogue River Basin TMDL

Waterbody Name	River Mile	Season	List Date	Subbasin
Rogue River	0 to 124.8	Year Around (Non-spawning)	2004	Crosses Subbasins
Althouse Creek	0 to 18	Year Around (Non-spawning)	2004	Illinois
Anderson Creek	0 to 3.2	Year Around (Non-spawning)	2004	Illinois
Briggs Creek	0 to 15.5	Year Around (Non-spawning)	2004	Illinois
Canyon Creek	0 to 5.9	Summer	1998	Illinois
Collier Creek	0 to 4.5	Summer	1998	Illinois
Deer Creek	0 to 17	Year Around (Non-spawning)	2004	Illinois
Deer Creek	0 to 17	October 15 - May 15	2004	Illinois
East Fork Illinois River	0 to 14.4	Year Around (Non-spawning)	2004	Illinois
East Fork Illinois River	0 to 14.4	October 15 - May 15	2004	Illinois
Elk Creek	0 to 3.9	Year Around (Non-spawning)	2004	Illinois
Fall Creek	0 to 4.8	Year Around (Non-spawning)	2004	Illinois
Free and Easy Creek	0 to 2.1	Summer	1998	Illinois
Illinois River	0 to 56.1	Year Around (Non-spawning)	2004	Illinois
Illinois River	0 to 56.1	October 15 - May 15	2004	Illinois
Indigo Creek	0 to 8.2	Year Around (Non-spawning)	2004	Illinois
Josephine Creek	0 to 12.4	Summer	1998	Illinois
Klondike Creek	0 to 7.4	Summer	1998	Illinois
Lawson Creek	0 to 11.1	Summer	1998	Illinois
Little Sixmile Creek	0 to 1.2	Summer	2002	Illinois
McMullin Creek	0 to 6.6	Year Around (Non-spawning)	2004	Illinois
North Fork Indigo Creek	0 to 6	Summer	1998	Illinois
North Fork Silver Creek	0 to 7	Summer	1998	Illinois
Panther Creek	0 to 2.6	Year Around (Non-spawning)	2004	Illinois
Rancherie Creek	0 to 5.2	Summer	1998	Illinois
Rough & Ready Creek	0 to 6.1	Year Around (Non-spawning)	2004	Illinois
Silver Creek	0 to 10.9	Year Around (Non-spawning)	2004	Illinois
Sixmile Creek	0 to 5.2	Year Around (Non-spawning)	2004	Illinois
Soldier Creek	0 to 2	Summer	1998	Illinois
South Fork Canyon Creek	0 to 2.4	Summer	1998	Illinois
South Fork Rough & Ready Creek	0 to 6.3	Summer	1998	Illinois
South Fork Silver Creek	0 to 7	Summer	1998	Illinois
Squaw Creek	0 to 3	Year Around (Non-spawning)	2004	Illinois
West Fork Illinois River	0 to 14.7	October 15 - May 15	2004	Illinois
West Fork Illinois River	0 to 14.7	Year Around (Non-spawning)	2004	Illinois
West Fork Illinois River	14.7 to 17	Year Around (Non-spawning)	2004	Illinois
Whiskey Creek	0 to 4.2	Summer	2002	Illinois
Big Boulder Creek	0 to 1.8	Summer	1998	Lower Rogue
Boulder Creek	0 to 3.9	Summer	1998	Lower Rogue
Butte Creek	0 to 2.5	Summer	2002	Lower Rogue
Coyote Creek	0 to 7.4	Summer	1998	Lower Rogue
East Fork Whisky Creek	0 to 3.7	Year Around (Non-spawning)	2004	Lower Rogue
Foster Creek	0 to 5.2	Summer	1998	Lower Rogue
Grave Creek	0 to 37.6	Year Around (Non-spawning)	2004	Lower Rogue
Grave Creek	0 to 37.6	October 15 - May 15	2004	Lower Rogue
Hog Creek	0 to 5.2	Summer	1998	Lower Rogue

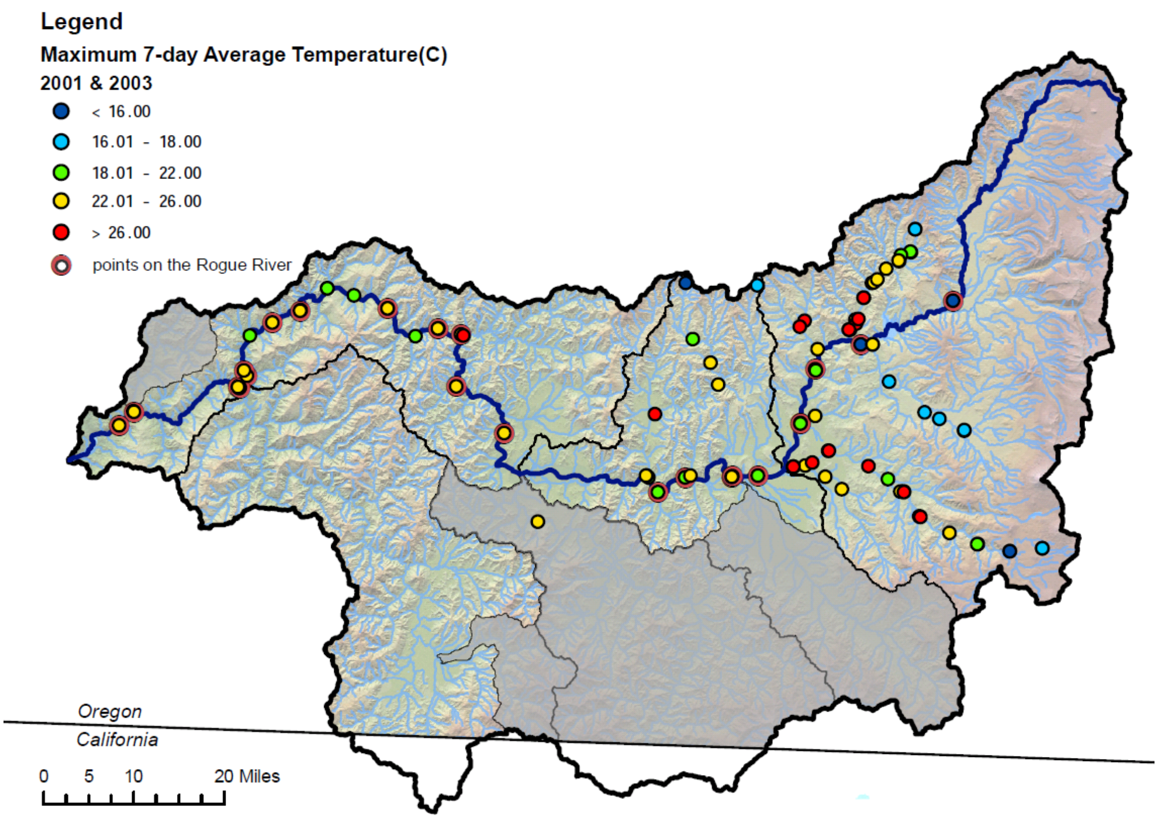
Waterbody Name	River Mile	Season	List Date	Subbasin
Indian Creek	0 to 3.4	Year Around (Non-spawning)	2004	Lower Rogue
Jumpoff Joe Creek	0 to 21.3	Year Around (Non-spawning)	2004	Lower Rogue
Louse Creek	0 to 12.3	Year Around (Non-spawning)	2004	Lower Rogue
Pickett Creek	0 to 3.9	Summer	1998	Lower Rogue
Quartz Creek	0 to 7.3	Summer	1998	Lower Rogue
Quosatana Creek	0 to 8.1	Summer	1998	Lower Rogue
Reuben Creek	0 to 6.5	Year Around (Non-spawning)	2004	Lower Rogue
Shasta Costa Creek	0 to 13.4	Year Around (Non-spawning)	2004	Lower Rogue
West Fork Whisky Creek	0 to 4.2	Summer	2002	Lower Rogue
Whisky Creek	0 to 2.4	Year Around (Non-spawning)	2004	Lower Rogue
Wolf Creek	0 to 14.7	Year Around (Non-spawning)	2004	Lower Rogue
Battle Creek	0 to 3.9	Summer	1998	Middle Rogue
Birdseye Creek	0 to 1.4	Summer	1998	Middle Rogue
Cold Creek	0 to 4.2	Summer	1998	Middle Rogue
East Fork Evans Creek	0 to 17.7	Year Around (Non-spawning)	2004	Middle Rogue
Galls Creek	0 to 4.5	Summer	1998	Middle Rogue
Pleasant Creek	0 to 12	Year Around (Non-spawning)	2004	Middle Rogue
Ramsey Canyon	0 to 3.1	Summer	1998	Middle Rogue
Rock Creek	0 to 6.5	Summer	1998	Middle Rogue
Salt Creek	0 to 6.2	Summer	1998	Middle Rogue
Savage Creek	0 to 4.8	Summer	1998	Middle Rogue
West Fork Evans Creek	0 to 17.1	Summer	1998	Middle Rogue
Abbott Creek	0 to 2.1	Summer	1998	Upper Rogue
Antelope Creek	0 to 19.7	Summer	1998	Upper Rogue
Big Butte Creek	0 to 11.6	Summer	1998	Upper Rogue
Bitter Lick Creek	0 to 8.6	Summer	1998	Upper Rogue
Burnt Canyon	0 to 3.2	Summer	1998	Upper Rogue
Clark Creek	0 to 7.7	Year Around (Non-spawning)	2004	Upper Rogue
Conde Creek	0 to 4.4	Year Around (Non-spawning)	2004	Upper Rogue
Dead Indian Creek	0 to 9.6	Year Around (Non-spawning)	2004	Upper Rogue
Dog Creek	0 to 4.7	Year Around (Non-spawning)	2004	Upper Rogue
Dog Creek	0 to 0.5	October 15 - June 15	2004	Upper Rogue
Doubleday Creek	0 to 3.4	Year Around (Non-spawning)	2004	Upper Rogue
Elk Creek	0 to 13.3	Summer	1998	Upper Rogue
Flat Creek	0 to 8.2	Summer	1998	Upper Rogue
Foster Creek	0 to 4.9	Summer	1998	Upper Rogue
Hukill Creek	0 to 3.6	Year Around (Non-spawning)	2004	Upper Rogue
Jackass Creek	0 to 4.8	Year Around (Non-spawning)	2004	Upper Rogue
Jackass Creek	0 to 0.3	October 15 - June 15	2004	Upper Rogue
Lake Creek	0 to 7.8	Summer	1998	Upper Rogue
Little Butte Creek	0 to 16.7	Summer	1998	Upper Rogue
Lost Creek	0 to 8.4	Summer	1998	Upper Rogue
North Fork Big Butte Creek	0 to 13.9	Year Around (Non-spawning)	2004	Upper Rogue
North Fork Big Butte Creek	0 to 7	October 15 - June 15	2004	Upper Rogue
North Fork Big Butte Creek	7 to 13.9	January 1 - June 15	2004	Upper Rogue
North Fork Little Butte Creek	0 to 6.5	Summer	1998	Upper Rogue
Soda Creek	0 to 5.6	Summer	1998	Upper Rogue
South Fork Little Butte Creek	0 to 16.4	Summer	1998	Upper Rogue

Waterbody Name	River Mile	Season	List Date	Subbasin
Sugarpine Creek	0 to 9.1	Year Around (Non-spawning)	2004	Upper Rogue
Sugarpine Creek	0 to 6	October 15 - June 15	2004	Upper Rogue
West Branch Elk Creek	0 to 7.4	Summer	1998	Upper Rogue
West Fork Muir Creek	0 to 3.3	Summer	1998	Upper Rogue
Willow Creek	0 to 4.5	Summer	1998	Upper Rogue
Woodruff Creek	0 to 6.2	Summer	1998	Upper Rogue
Miles listed for rearing temperature (TMDLs = 52)				**340.3**
Miles listed for rearing & migration temperature (TMDLs = 28)				**337.5**
Miles listed for core cold water temperature (TMDLs = 10)				**63.5**
Miles listed for spawning temperature (TMDLs = 10)				**160.5**
Total TMDLs = 100				**901.8**

Table 2.7. 2004/2006 303(d) Listings in error: covered by the Lobster Creek TMDL

Waterbody Name	River Mile	Season	List Date	Subbasin
Deadline Creek	0 to 2.3	Year Around (Non-spawning)	2004	Lower Rogue

Figure 2.4. Map of temperature monitoring sites with associated maximum 7-DADM. Areas with previously completed TMDLs are shaded in gray.



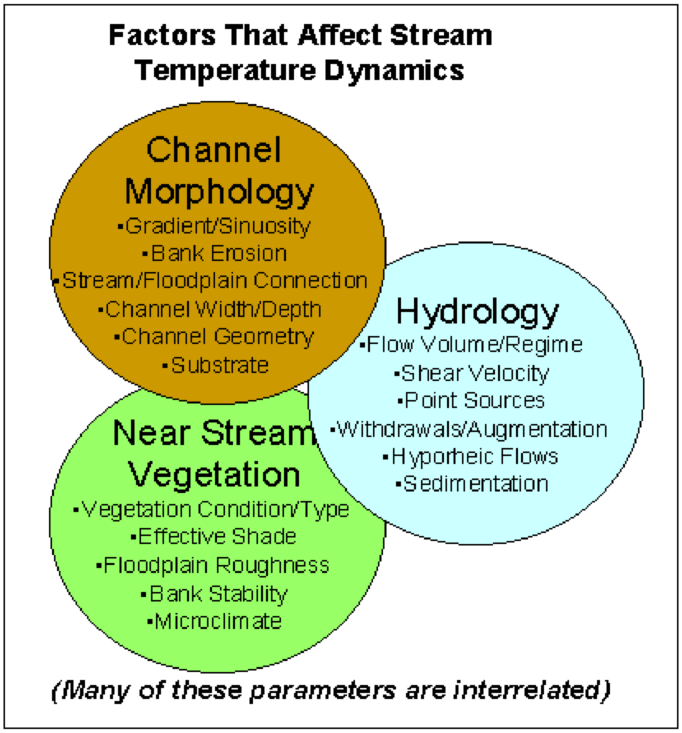
2.3.2 Pollutant Identification
OAR 340-042-0040(4)(b)

Development of stream temperature TMDLs requires an understanding of the natural and human processes that contribute to stream warming. 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 energy flux to waterbody:

$$\Delta Temperature \propto \frac{\Delta Heat \quad Energy}{Volume}$$

Stream temperature is influenced by natural factors such as climate, geomorphology, hydrology, and vegetation (**Figure 2.5**). 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 streamside vegetation and reductions in stream shading, changes to stream channel form, and reductions in natural stream flows and the reduction of cold water 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, and (3) heat from reservoirs and irrigation ditches which, through their operations, increase water temperatures or otherwise modify natural thermal regimes in downstream river reaches.

Figure 2.5. Factors affecting stream temperature



2.3.3 Seasonal Variation & Critical Condition

One TMDL requirement is the identification of seasonal variation and the critical condition. It is expected that the location on the Rogue River which exceeds the biologically based criteria for the longest period of a year is at approximately river mile 33.6, the furthest downstream location where a spawning criteria applies. The U.S. Geological Survey (USGS) site, Rogue River at Agness is approximately 4 miles downstream of this critical location and is used as an estimate of temperatures at the critical location. **Figure 2.6** shows the 90th percentile of the 7 day average of the daily maximum temperatures (7DADM) on the Rogue River at Agness after the construction of Lost Creek Dam. The 90th percentile was chosen as an appropriate metric because it examines the high end of the distribution of data while filtering out extreme events. At this site based on data between 1977 and 2006, the 90th percentile 7DADM exceeded the biologically based criteria from April 6 to October 26, so the season of possible impairment was determined to be **April 1st to October 31th**. This determination is conservative in that it does not consider whether exceedances of the biologically based criteria are anthropogenic. The 90th percentile 7DADM on the Rogue River at Dodge Bridge also exceeded the applicable criteria within this time period. This is the period in which allocations apply to point sources and dams. For point sources and dams, heat load allocations are likely the most stringent during the late summer or early fall, when flows are low and the spawning criteria applies.

The critical condition is determined by daily maximum temperatures at a site. The critical condition generally occurs in late July or early August when stream flows are low, radiant heating rates are high and ambient conditions are warm (**Figure 2.7**). The peak temperature measurement on Trail Creek occurred in early June, much earlier than the other sites. The quality of this data was double checked and met the requirements for ‘A’ level data. The physical process leading to this different temporal pattern is not known, although could be due to the influence of groundwater or stratification as flow decreases in the summer.

Figure 2.6. Rogue River temperatures at Agness used to define the season of possible impairment based on data collected between 1977 and 2006. The dashed line represents the biological based criteria.

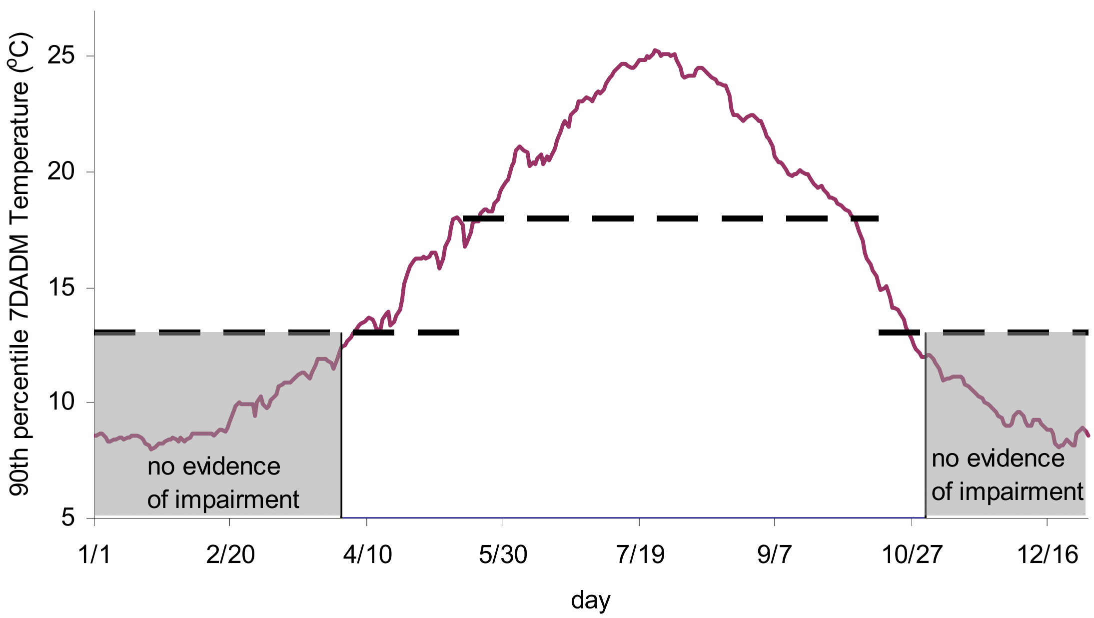
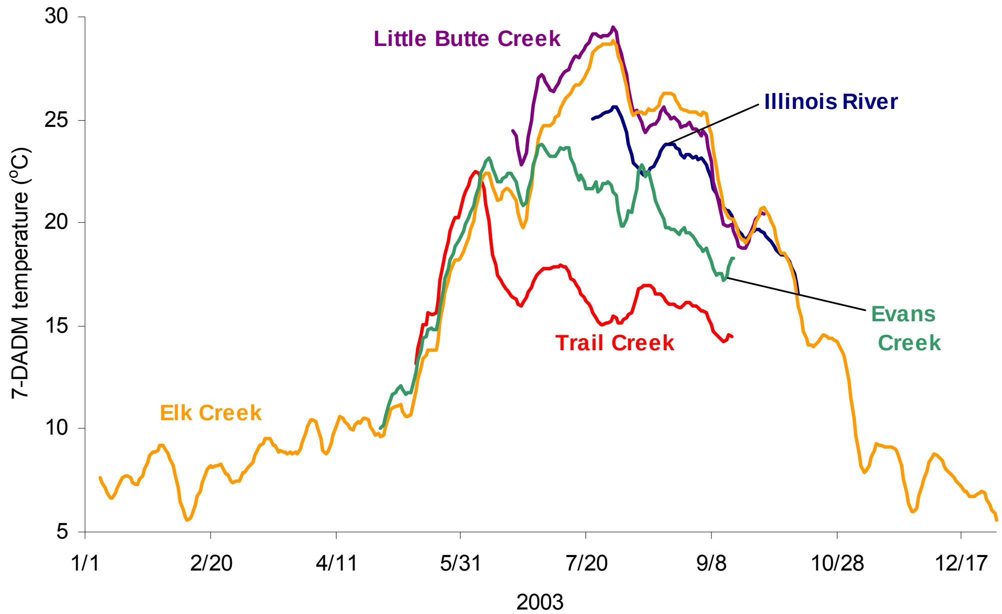


Figure 2.7. Stream temperatures representing seasonal variation near the mouths of tributaries to the Rogue River



2.4 EXISTING POLLUTION SOURCES

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

2.4.1 Natural Background Sources

Natural or background inputs of solar radiation are by far the largest heat source in the Rogue River basin. 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 actually 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 streamside vegetation. Streams generally warm in a downstream direction as they become wider and streamside 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.

In the absence of human disturbance, many low elevation streams were likely warmer at times than is optimal for salmonids which may not have occupied these waters during the peak heat of the summer period. Channel complexity, cool water inflows, and hyporheic exchange are thought to provide local but important thermal refuges in these inhospitable environments during the warmest months of the year.

Natural disturbance events are essential elements for healthy and productive salmonid streams. Flood, fire, windstorms and other natural disturbance processes contribute to the complexity of the riverine environment. These disturbances often affect streamside vegetation and the riparian tree canopy, potentially decreasing stream shade for decades. However, such disturbances are viewed as beneficial processes. In a functional riparian community, one with most of the structural components and ecological processes in place, riparian canopy and shade will recover with time and the salmon, trout and other native species will benefit from the large wood and habitat complexity these disturbance processes provide. For the purposes of this plan, these disturbance processes are considered natural and are part of the natural background thermal load.

2.4.2 Point Sources: Individual and General NPDES Permits

As discussed in Chapter 1, there are 216 general NPDES permits within the scope of this TMDL. One hundred ninety of these permits are for regulating stormwater which is usually not considered a source of heat load. The remaining 26 permits which regulate industrial wastewater have flow, temperature and / or dilution requirements which minimize their impact of receiving streams. Given the requirements within these permits and geographic spread of the facilities, it has been determined that there is no reasonable potential to impact stream temperatures.

Individual permitted sources have the potential to impact temperature in surface waters and are examined in more detail within this TMDL (**Table 2.8**). Eight of these 12 sources discharge into the Rogue River. These eight sources also have the largest permitted flow. Their impacts were evaluated using the water quality model Heat Source, Version 8 (**Appendices A and B**). Based on this analysis, point sources increase river temperatures by less than 0.3 °C. The current point source point of maximum impact (i.e. the largest increase) is approximately 4.1 miles downstream of the Medford Waste Water Treatment Plant (WWTP) outfall at river mile 130.8 (**Figure 2.8**). The estimated point of maximum impact for all sources is at river mile 62 (river kilometer 100) (presented below in Section 2.5). This maximum impact is caused by the effect of early morning effluent discharges from Medford WWTP not completely dissipating by late afternoon when stream temperatures are warmest. Early morning river temperatures tend to be coolest and have the greatest potential for warming from point source discharge. As the warmed water moves downstream it contributes to the maximum impact when river temperatures are warmest in the afternoon. Water moving by Medford WWTP in the morning only travels 4.1 miles downstream by mid afternoon because of the impoundment from Gold Ray dam at river mile 126.2.

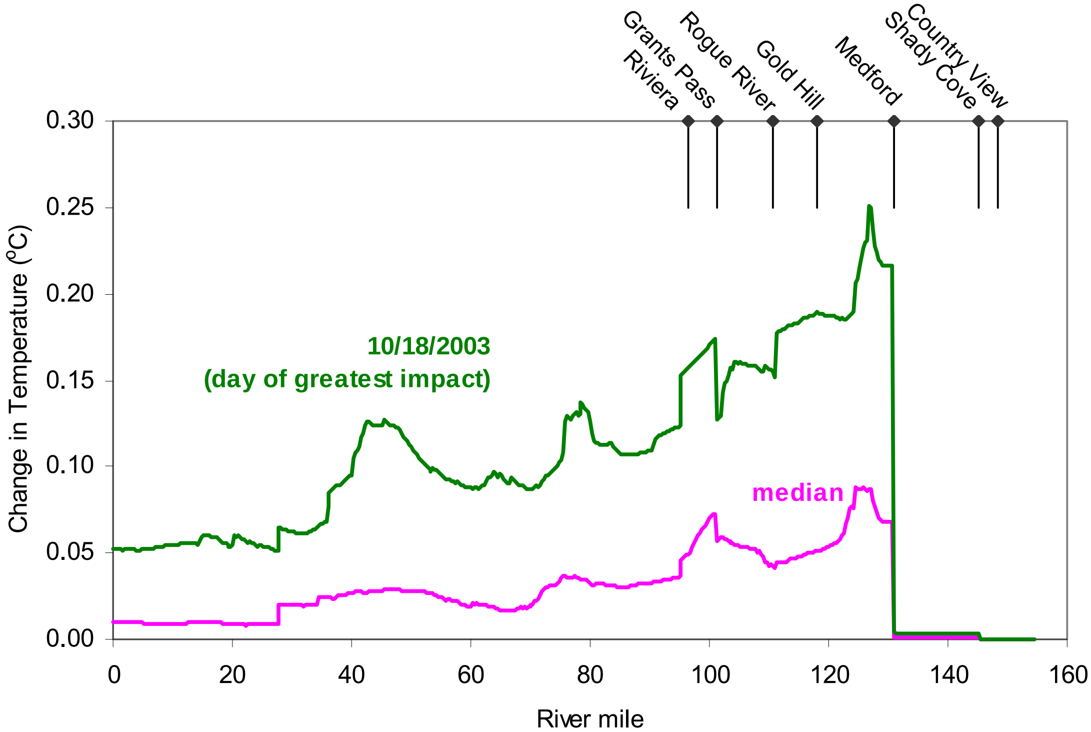
Data were not available to evaluate the impact of the other point sources on their receiving waterbodies, however three of the four do not discharge during the critical summer period. The cumulative impact of the four sources on the Rogue River is likely less than 0.01 °C based on a comparison with similar sized sources. The Illinois River is the only tributary with an individual NPDES source (Cave Junction WWTP) which is also identified as impaired for temperature during the spawning season (October 15 - May 15). The data summary presented in the 2004/2006 Integrated Report indicates temperatures greater than the biologically-based spawning criterion has occurred between 10/15 and 11/2. Cave Junction WWTP is not permitted to discharge between June 1 and October 31 (except under certain high flow conditions). Furthermore, based on an estimate mass balance using conservative assumptions, the impact of Cave Junction WWTP impact is likely less than 0.1 °C on November 1.

Table 2.8. Individually permitted sites in the Rogue Basin

Point Source name	Receiving Stream	River Mile	Maximum Permitted Flow (MGD)	Fall-Winter-Spring Discharge only
Town of Butte Falls	S. F. Big Butte Cr.	RR 155.5	0.07	Yes
Country View Mobile Home	Rogue River	148.2	0.01	Yes
City of Shady Cove WWTP	Rogue River	143.1	0.45	
Cascade Wood	Military Slough	RR 132.5	0.03[1]	
All Weather Wood Treaters	Rogue River	131.8	Stormwater	
City of Medford WWTP	Rogue River	130.8	20.0	
City of Gold Hill	Rogue River	118.1	0.35	
City of Rogue River WWTP	Rogue River	110.5	0.43	
City of Grants Pass	Rogue River	100.9	6.4	
Riviera Mobile Park	Rogue River	96.4	0.03	Yes
Three Rivers School District	Harris Creek	RR 83.5	0.02	Yes
City of Cave Junction	Illinois River	RR 27.5	0.52	Yes

Notes:
[1]Based on 2003 flows
RR refers to the river mile of the Rogue River at the confluence with the receiving stream.
MGD = million gallons per day

Figure 2.8. Thermal impact of point sources which discharge directly to the Rogue River. Results calculated from the differences between the 7DADM of the current condition model scenario and without point source model scenario between March and October 2003.



2.4.3 Nonpoint Sources

The term "Nonpoint Sources" applies to a diffuse or unconfined source of pollution where wastes can either enter into or be conveyed by the movement of water to waters of the state (OAR 340-41-0002 (40). For the purposes of the Rogue River basin temperature TMDL, nonpoint sources are *past or present human activities that contribute to warmer surface waters than that which would occur naturally either through increased thermal load or decreased assimilative capacity that do not require a NPDES permit.* Historically, human activities have altered the stream morphology and hydrology and decreased the amount of riparian vegetation in the basin. The basin includes urban, agricultural, and forested lands. Additionally, hydroelectric projects and multiple points of diversion in the Rogue River basin 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.

Riparian vegetation, stream morphology, hydrology, climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, riparian condition, channel morphology and hydrology are affected by human activities. For the Rogue River Basin temperature TMDL five nonpoint source categories are discussed below:

1. ***Near stream vegetation disturbance/removal***
2. ***Channel modifications and widening***
3. ***Hydromodification: Dams, Diversions, and Irrigation Districts***
4. ***Hydromodification: Water Rights***
5. ***Other Anthropogenic sources***

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[3]). Furthermore, forests even beyond the distance necessary to shade a stream can influence the micro-climate, providing cooler daytime temperatures (Chen et al. 1999). Riparian vegetation also plays an important role in shaping channel morphology, resisting erosive high flows, and maintaining floodplain roughness. **Table 2.9** shows the potential for improvement in shade for the Rogue River and selected tributaries as the difference between current and system potential effective shade. The system potential 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.

System potential <u>is</u> 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 the potential expected for the given plant community;
- Vegetation buffer is sufficiently wide to maximize solar attenuation (Note: Buffer widths required to meet the system potential target will vary given potential vegetation, topography, stream width, and aspect.),
- Vegetation buffer width accommodates channel migrations.

System potential is <u>not</u> an estimate of pre-settlement conditions. In many areas, changes in stream location and hydrology (channel armoring and wetland draining) have occurred and reversing these changes is not a part of establishing a target value. In addition, system potential does not account for potential major disturbances resulting from floods, drought, fires, insect damage, disease or other factors that could impact riparian areas. See **Appendix A** for the methodology used to determine system potential vegetation in the Rogue River Basin.

Table 2.9. TMDL Shade Targets for Rogue River and Selected Tributaries. Temperature impacts are the average increase to the 7DADM for the modeled reach.

Waterbody	Percent Effective Shade (August 1)		Shade deficit (% shade)	Predicted temperature increase due to decreased shading (°C)
	Current	System Potential		
Antelope Creek	41	82	41	5.7
South Fork Little Butte Creek	39	74	35	5.7
Evans and West Fork Evans Creek	29	78	48	5.3
Little Butte Creek	29	69	40	5.0
Elk Creek	44	80	36	4.4
North Fork Little Butte Creek	62	91	29	1.8
Rogue River Mainstem	8	17	9	0.5

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 can result in 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 Rogue River Basin, waterbodies within wide valleys with low gradients are likely to be more degraded due to channel

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

modifications than waterbodies in steep and narrow canyons. Channel modifications can impact water temperatures in the following ways:

<u>Sediment filled pools</u>
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, decreasing assimilative capacity for thermal loading in a reach (California Regional Water Board 2002).

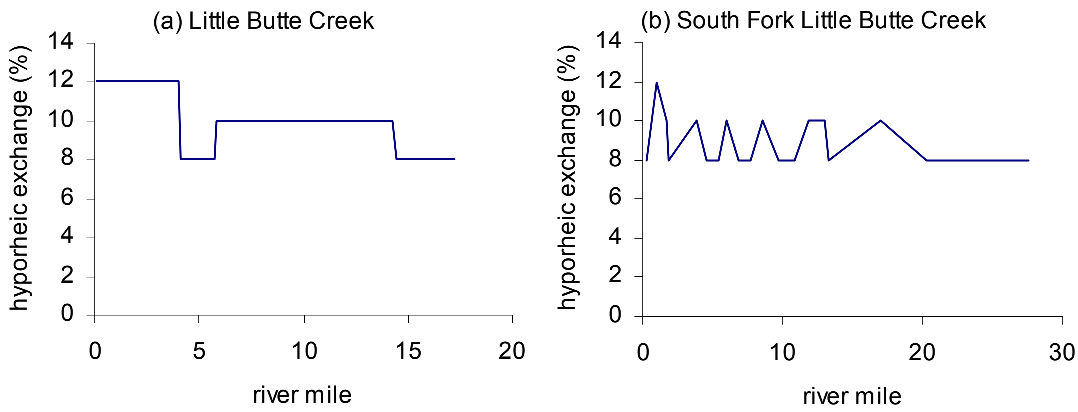
<u>Wider shallower streams</u>
Furthermore, human activities can cause wider, shallower streams (increased width to depth ratios) which increases surface area exposed to solar radiation and ambient air temperatures. Wider channels will have less effective shade than narrower channels with the same amount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

<u>Less storage base flow</u>
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).

<u>Fewer hyporheic seeps</u>
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 to cool 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).

Tetra Tech, an EPA-funded project consultant, examined the Little Butte Creek watershed for historic changes in morphology (**Appendix C**). This watershed was targeted because of the availability of historic information. There were temperatures models constructed as part of this TMDL and there are agricultural activities that could have led to alterations of the stream. The magnitude of changes in geomorphology and groundwater connectivity in Little Butte Creek from present conditions to natural conditions is estimated to be generally moderate. Results show that on average the hyporheic exchange of the natural conditions (predevelopment) was 5.7% (-2% to 10%) greater than current conditions. Estimates of natural hyporheic are presented in Figure 2.9. Actual hyporheic flow exchanges can vary widely spatially and temporally based on flow regime and variations in stream bank and substrate conditions, among other factors. The range of uncertainty in the estimates could be on the order of 5 to 10% or higher. There have been several land-use based causes of changes over time in the geomorphology and groundwater connectivity in Little Butte Creek. These include agricultural development, other types of development such as roadways and residential development, water diversions and their associated physical structures and channel modifications, and water supply reservoirs. Based on review of previous studies, observations within the watershed, and analysis of current and historical aerial photographs, the most prominent causes of change are believed to be (1) channel modifications associated with roadways adjacent to the stream and (2) channel and flow modifications related to water diversions and their structures.

Figure 2.9. Estimated natural hyporheic flow (as a percentage of stream flow).



Riparian vegetation disturbances

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

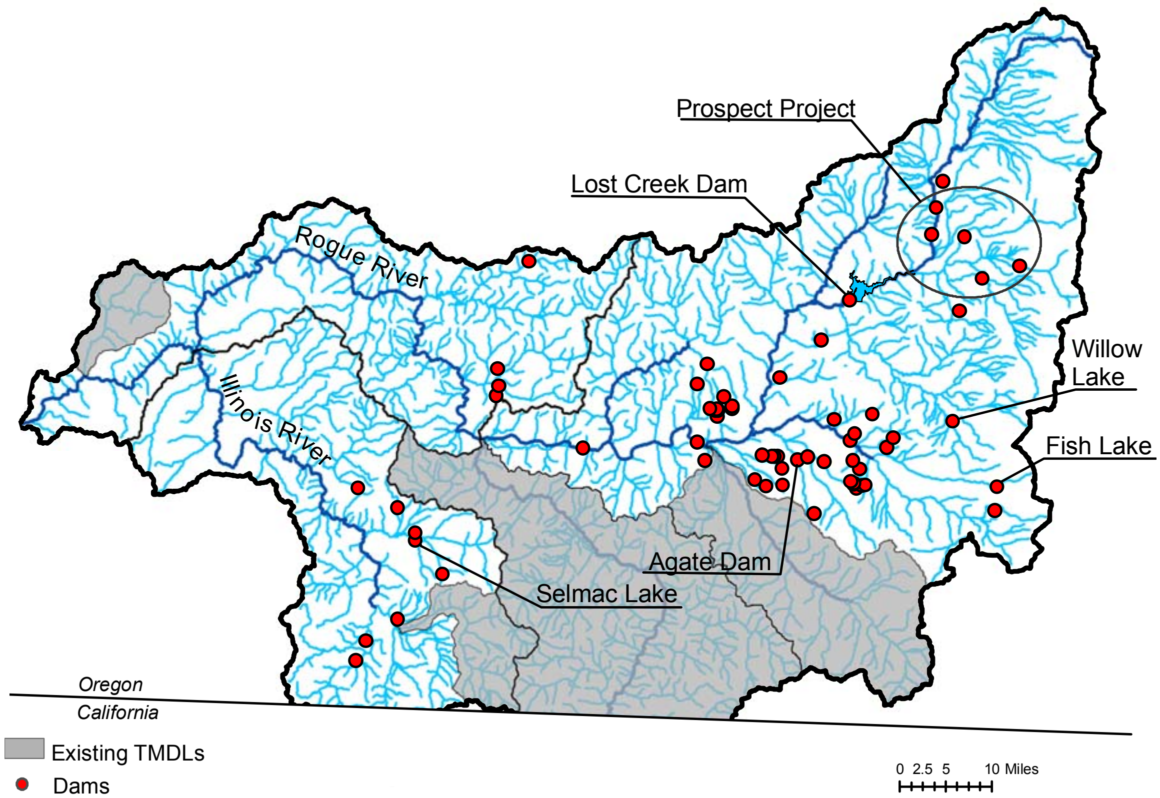
3. Hydromodification: Dams, Diversions, and Irrigation Districts

Grants Pass, Gold Hill, Fort Vannoy, Apple Rogue, Medford, Rogue River Valley, and Eagle Point Irrigation Districts are within the geographic scope of this TMDL. Below are some of the activities that could lead to warmer stream temperatures (see **Chapter 1** for map):

- Diversion dams are used to divert water from a stream to an irrigation ditch or canal. Diversion dams affect stream temperature by dewatering 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 of 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.

There are 63 dams identified by Oregon Water Resources Department (OWRD) which are greater than 10-feet high and storage greater than or equal to 9.2 acre-feet within the geographic scope of this TMDL (Figure 2.10) (Falk and Hormon 1998). Below is a description of the impacts of the largest of these projects.

Figure 2.10. Dams greater than 10-feet in height and storage greater than or equal to 9.2-acre-feet of water behind. Additional Prospect Hydroelectric Project dams also included.



Lost Creek Reservoir

The Lost Creek Reservoir (LCR) is a man-made water storage facility created when the US Army Corps of Engineers (USACE) completed construction of Lost Creek Dam (also known as William Jess Dam) in 1976. The reservoir is on the Rogue River at river mile 157.4. The United States Congress authorized construction of the dam to create a reservoir to be used for multiple purposes, including the enhancement of fishery resources in downstream areas (United States Congress 1962). The USACE operates and manages the dam and the reservoir with input from the Rogue Basin Interagency Advisory Group. Operation of LCR typically benefits summer river temperatures by providing decreased water temperature and increased summer flow (discussion below).

As water accumulates in the LCR, solar radiation warms the surface water and the lake stratifies. To regulate the outflow temperature from Lost Creek Dam, the USACE designed an intake structure capable of withdrawing water from five different levels of the reservoir. Selective opening of intake ports allows for mixing of water from various temperature strata in the reservoir. Choice of outflow temperature is greatest in early summer when the reservoir is full and thermally stratified. Control of release temperature diminishes in late summer as reservoir level decreases and the highest intake ports become dewatered. Control of release temperature becomes minimal in autumn after the reservoir destratifies (USACE 1983).

In this TMDL assessment, the impact of the dam on river temperature was evaluated using temperature data collected upstream and downstream, and before and after construction of the dam. Based on this data, the operation of the reservoir between 1977 and 2006 appears to have supplied cooler water and additional water from July through late August than would occur without the reservoir (**Figure 2.11 and Figure 2.12**). Flow and temperature differences upstream of the dam are not related to dam operations and are likely due to climatic variability. Between approximately August 23rd and October 22nd and April 1st and June 15th, the operation of the reservoir appears to result in river temperatures similar to the pre-dam temperature regime. Lastly, between approximately October 22nd and April 1st, the operations of the reservoir appear to result in warmer temperatures in the Rogue River than would otherwise occur.

Figure 2.11. Average 7-day average of daily maximum temperatures for 1970 - 1976 (pre dam) and 1978 - 2006 (post dam) for USGS gaging stations Rogue River downstream of Prospect (upstream of LCR) and Rogue River near McLeod (downstream of LCR). The solid black lines represent the biologically-based temperature criteria at the McLeod site but was kept consistent between the figures to provide reference to judge change.

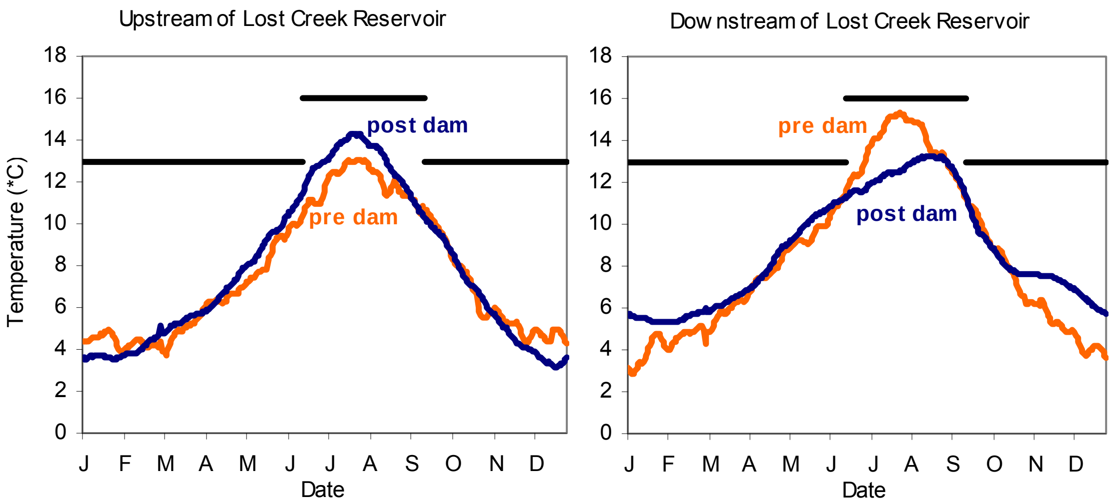
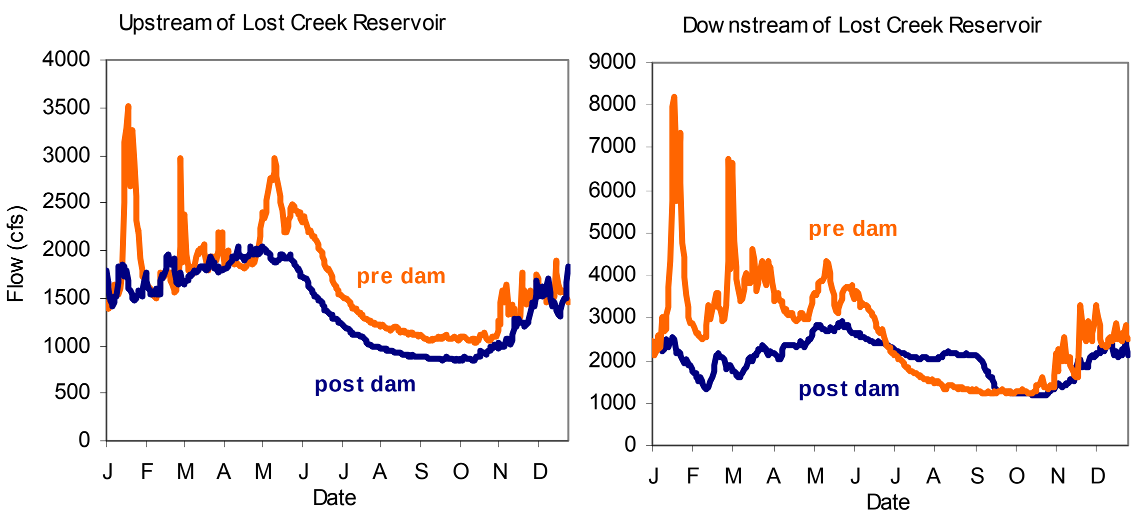


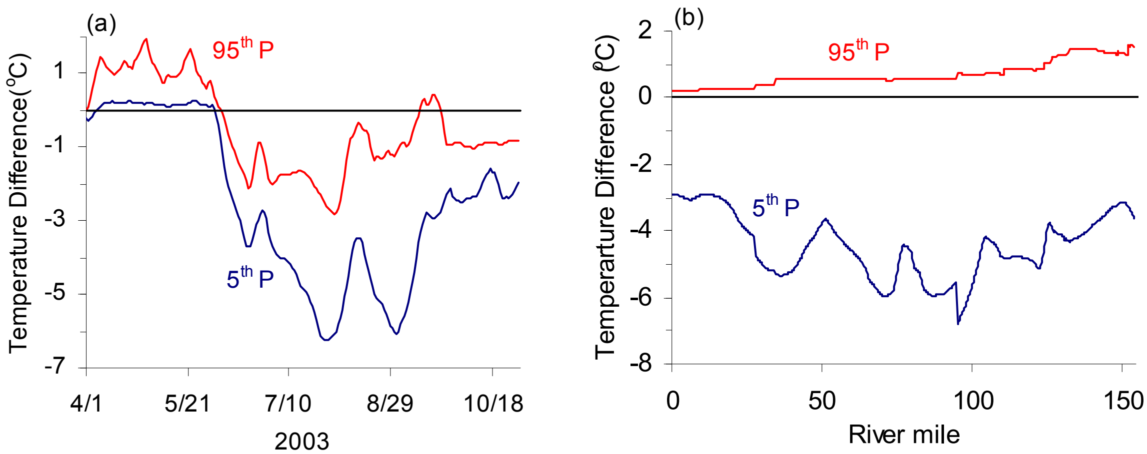
Figure 2.12. Average daily flow for 1970 - 1976 (pre dam) and 1978 - 2006 (post dam) for USGS gaging stations Rogue River downstream of Prospect (upstream of LCR) and Rogue River near McLeod (downstream of LCR).



Oregon Department of Fish and Wildlife (ODFW) has conducted long term fishery research projects concerning the Rogue River with recommendations for reservoir management strategies (ODFW 1990; ODFW 1991; ODFW 1992: ODFW 1994; ODFW 2000). ODFW found that reservoir and dam operations primarily affect spring Chinook salmon and fall Chinook salmon because these fish primarily spawn in the mainstem of the Rogue River. Coho salmon, summer steelhead, and winter steelhead were less affected because these fish spawn primarily in tributary streams. Fall chinook salmon have increased significantly because reservoir operations reduce water temperature in areas downstream of Grants Pass during summer (ODFW 1992). In contrast, spring chinook salmon have decreased significantly, and the decrease is linked to increased water temperatures in areas upstream of Gold Ray Dam during the fall and winter (ODFW 2000).

A water quality model was used to estimate the impact of Lost Creek Reservoir operations for 2003 on the Rogue River (see **Appendices A and B** for details). The model results confirm that operations of Lost Creek Reservoir result in substantially cooler temperatures during the summer than would otherwise occur (**Figure 2.13(a)**). However, model results also show that the reservoir operations could result in warmer temperatures between March and early June and briefly in late September. The reservoir impacts temperatures from its tailrace to the mouth of the river (**Figure 2.13(b)**). For the most part, operations of Lost Creek Reservoir lead to cooler river temperatures in the Rogue River during the season of impairment however there do appear to be limited times and places when operation are contributing to impairment in 2003 (**Appendix B, Figure B8**). Because Lost Creek Reservoir has a large potential to cause or contribute to impairments in the Rogue River (even if current operations do not), DEQ has determined it is a 'source' [as defined in OAR 340-042-0030(12)] and hence the US Army Corp of Engineers as a designated management agency.

Figure 2.13. Temporal (a) and spatial (b) thermal impact of Lost Creek Reservoir operations to the Rogue River based on April through October, 2003, from its mouth to downstream of Big Butte Creek (river mile 154.2). Graphs show the 5th and 95th percentile of the difference between current condition and predicted 7-DADM temperatures without Lost Creek Reservoir. Positive values indicate that the model predicts Lost Creek Reservoir is leading to warmer temperatures. Each date in (a) summarizes the entire length of the river and likewise each mile in (b) summaries all the dates.



Prospect Hydroelectric Project

The Prospect Hydroelectric Project operated by PacifiCorp is upstream of the Lost Creek Reservoir in the upper portion of the Rogue Basin. DEQ issued a 401 certification for a portion of the project (Plant nos. 1, 2, and 4) in March 2007 (DEQ 2007b). The Prospect No. 3 License was issued on 1/30/1989 (expires 12/31/2018 (FERC # 2337)) and DEQ waived issuing a water quality certification.

The project diverts water from the Rogue River, South Fork Rogue River, Middle Fork Rogue River, and Red Blanket Creek using a series of flumes and dams with minimal storage. Three of the powerhouses are adjacent to the Rogue River and the other is adjacent to the Middle Fork Rogue River. There are no 303(d) listed streams within the project boundaries, however based on the Pacificorp assessment the project diversions appear to cause an increase greater than 0.3 °C in Red Blanket Creek (DEQ 2007b). As part of the water quality certification of the project, PacifiCorp has proposed minimum instream flows that will achieve the biologically based temperature criterion within the project.

DEQ does not know of any quantified estimate of the Prospect Hydroelectric Project's impact on the Rogue River downstream of the powerhouses. An environmental assessment states:

> With regard to water quality, a multi-level intake tower and associated mixing chamber at the Corps [Lost Creek] dam results in summer water temperatures downstream that are cooler than upstream; therefore, Lost Creek Lake serves as a barrier to the water quality effects of actions occurring in the upper basin. (FERC 2006)

Given the short residence time in the project's dams (less than or equal to 1 hour), there is likely not a thermal shift that is commonly observed in large storage reservoirs. Due to the long residence time (approximately 0.4 years during the summer) and the temperature control structure of Lost Creek Reservoir, it appears unlikely that temperature increases from the project during the summer would have an effect on temperature downstream of Lost Creek Reservoir.

Rogue River Low Head Dams

Four low head dams with minimal storage were identified on the Rogue River: Gold Ray, Gold Hill Irrigation District, a diversion for a former powerhouse near Gold Hill and Savage Rapids (**Figure 2.14**). Gold Hill powerhouse dam was removed during the summer 2008 but was in place during the TMDL analysis. Although the dams are operated run-of-river and do not create storage, the slower and deeper reaches dampen the diel fluctuation of river temperature immediately downstream (**Figure 2.15**). This dampening tends to causing cooler daily maximum temperatures and warmer daily minimum temperatures directly downstream of the dams. The warmer minimum temperatures can lead to increased daily maximum temperatures 12 hours travel time downstream (Khangaonkar and Yang 2008). The cumulative impact of the four dams was evaluated using the temperature water quality model described in **Appendix A**. Between Gold Ray dam and the mouth, the average impact of the four low-head dams is estimated to be a warming by approximately 0.1 °C during July and August (**Figure 2.16**). However, given the simplistic representation of hydraulics in the water quality model, additional analysis should be conducted to better quantify the impact of these dams.

Figure 2.14. Rogue River low head dam vicinity map.

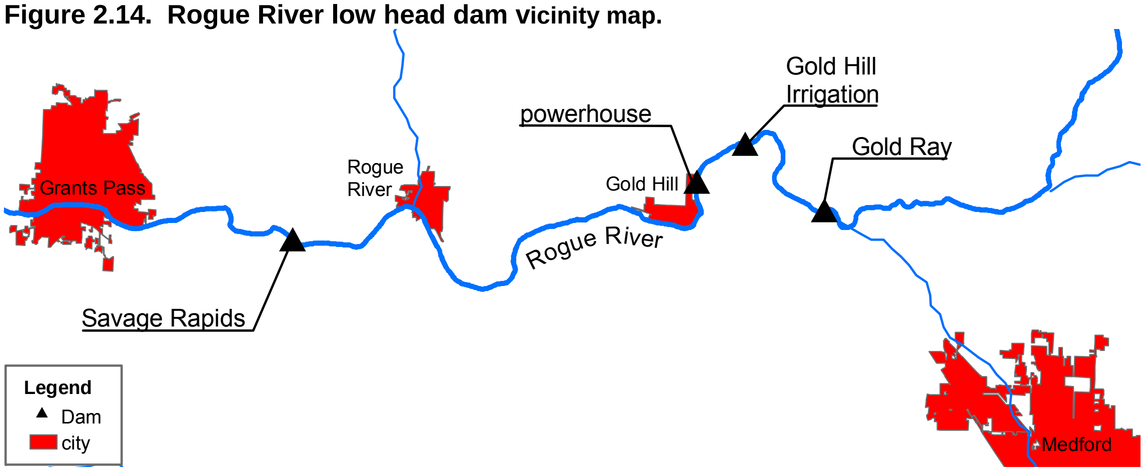


Figure 2.15. Time series of Rogue River temperature showing dampening of diel fluctuation and shift in timing of peak temperature near Gold Ray Dam

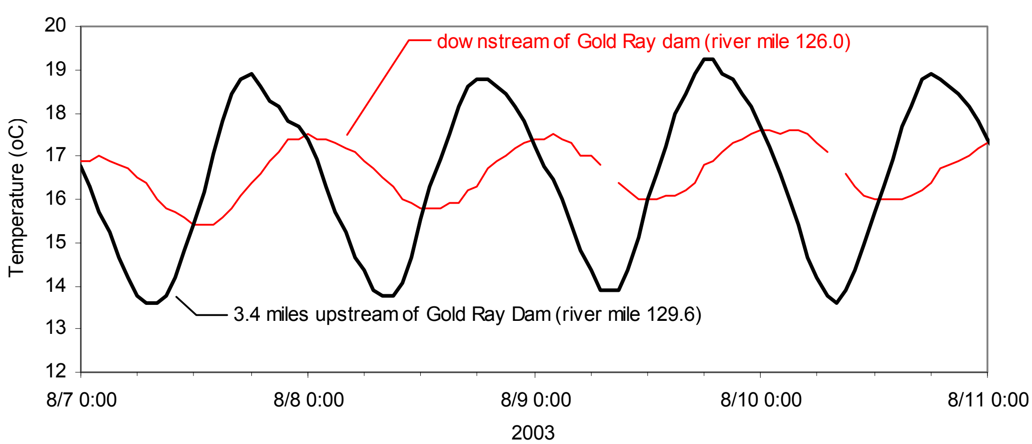
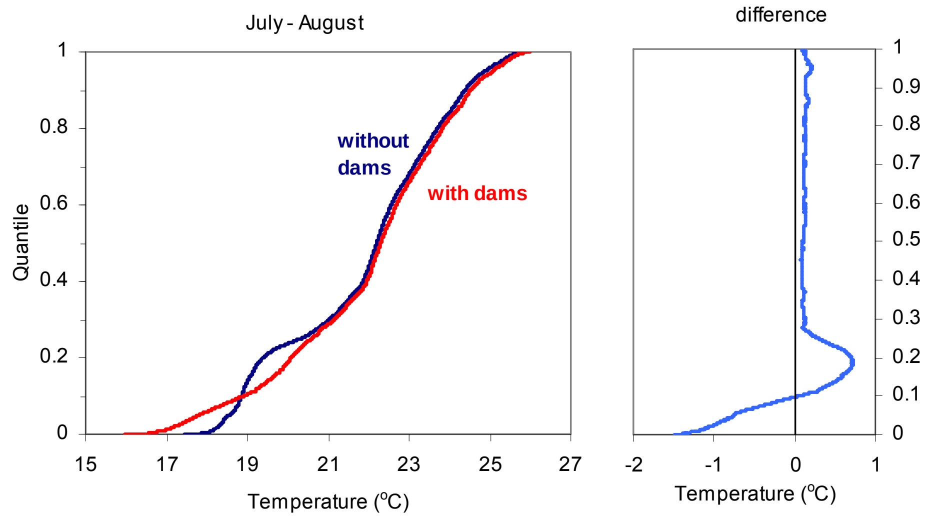


Figure 2.16. Cumulative frequency distribution of the predicted impact of the 4 low head dams on the Rogue River comparing the 7-DADMs from July – August, from Gold Ray dam to the mouth



Fish Lake Dam

Fish Lake, a large reservoir on the North Fork of Little Butte Creek, was formed from a small natural lake in 1915 (Johnson et al. 1985). It is currently operated by the Medford Irrigation District to store water for irrigation. The lake is fed by springs with no contributions from surface water. Water is also transferred from Fourmile Lake in the Klamath Basin via canal to a point nearby Fish Lake. Due to the high permeability of the volcanic material in the area, the transferred water infiltrates and is believed to contribute to the groundwater that feeds the lake. During the irrigation season, stored water is released into North Fork Little Butte Creek. Most of the water is withdrawn from North Fork Little Butte Creek near its mouth and transported via canal into the Bear Creek watershed.

Other Dams and Reservoirs

There are approximately 58 other dams within the geographic scope of this TMDL including some that form significant reservoirs: Agate Reservoir, Selmac Lake and Willow Lake (**Figure 2.10** and **Table 2.10**). The other dams form reservoirs less than 80 acres. All of the dams are on or upstream of waterbodies with temperature impairments. None of the dams are on reaches that were examined using water quality models. The individual and cumulative impact on temperature has not been quantified for this source assessment due to lack of data and limited resources.

Table 2.10. Basic physical characteristics of remaining reservoirs with area than greater than 100 acres.

Name	Area (acres)	Maximum Depth (feet)	Average Depth (feet)
Willow Lake	345	38	24
Agate Lake	239	55	21
Selmac Lake	148	33	7

Dams and reservoirs may contribute to stream warming. 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.

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 holding everything else unchanged. Diversion of water from the Rogue River and tributaries was generally shown via water quality modeling to decrease the ability of stream to assimilate heat load and result in warmer stream temperatures (**Table 2.11** and **Figure 2.17** and **Appendices A** and **B** for more detail). The method of deriving of flows without withdrawals varied between streams but was generally based on water balances and OWRD water rights.

Figure 2.17. Map of water rights in the Rogue Basin.

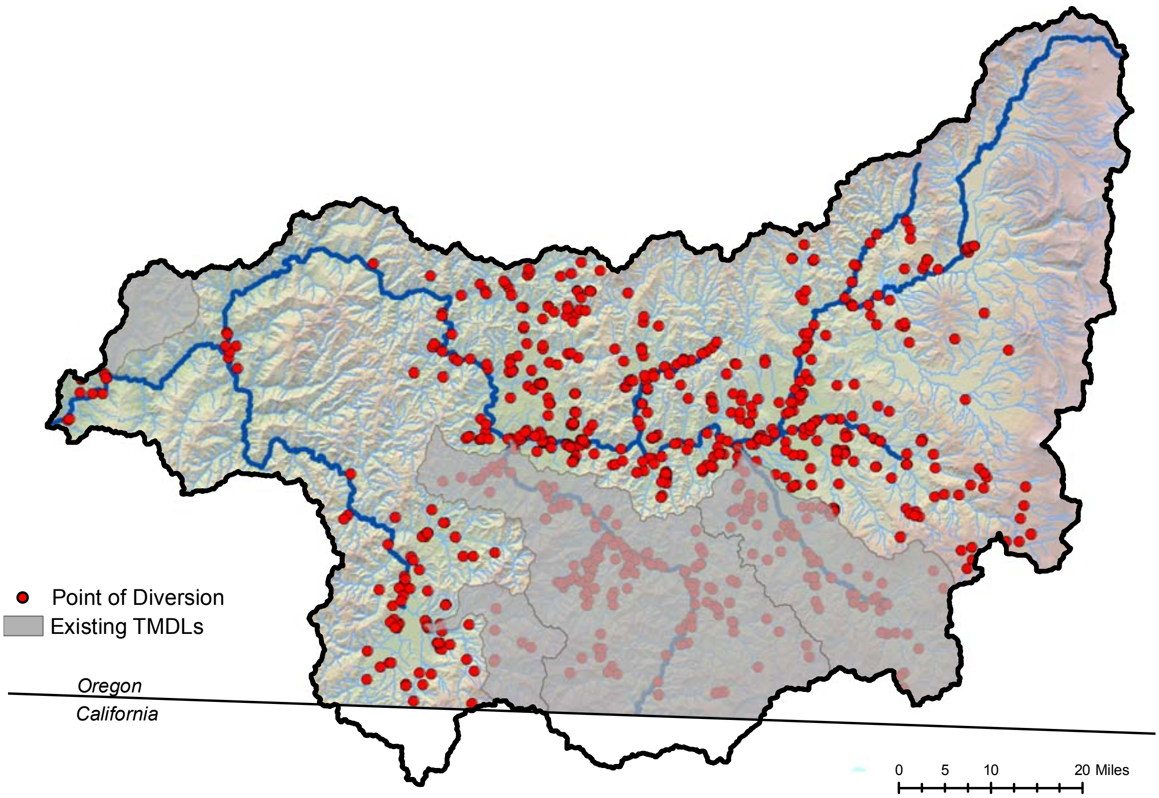


Table 2.11. Impact of water withdrawals on maximum 7-DADM temperatures for various waterbodies as predicted by water quality modeling. Flows are from August 1 of the applicable model year and temperatures based on average changes to the portion of the stream modeled (i.e. not predicted change at the mouth) .

Waterbody	Flow at mouth (cfs)		% Change	Predicted temperature increase due to decreased flow (°C)
	Current	Without withdrawals		
Little Butte Creek	17.5	56.2	304%	5.7
North Fork Little Butte Creek	13.7	36.1	264%	3.2
Antelope Creek	6.4	8.9	139%	1.4
Elk Creek	3.2	7.2	225%	1.6
Rogue River Mainstem	1957	2370	121%	0.9
Evans Creek	3.0	8.7	290%	0.5
South Fork Little Butte Creek	9.2	12.8	139%	0.5

5. Other Anthropogenic Sources

Upland and floodplain development has resulted in high percentages of impervious surfaces in some areas of the watershed. Increased impervious area results in greater stormwater runoff and diminished groundwater recharge. Studies have shown that base flows in small streams with substantial impervious area may be lower as a result of a loss of groundwater contribution during dry periods. Warmer stream temperatures and poorer water quality are associated with these diminished flows.

2.5 TMDL LOADING CAPACITIES 40 CFR 130.2(F)

Oregon's water quality standard mandates a loading capacity based on the condition where stream temperatures do not increase more than 0.3 °C (human use allowance) above the applicable criteria at the point(s) of maximum impact. 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. In this TMDL, no loading capacity was explicitly set aside as a margin of safety (see Section 2.10). Allocations for NPDES point sources are termed Waste Load Allocations, for nonpoint sources termed Load Allocations and for future sources termed Reserve Capacity.

The loading capacity is the sum of background, allowable nonpoint source heat, allowable point source heat, heat included in a margin of safety, and heat held as a reserve capacity:

$$\text{TMDL} = \text{Loading Capacity} = H_B + H_{NPS\ LA} + H_{WLA} + H_{MOS} + H_{RC} \qquad \textbf{Equation 2-1}$$

where:

$H_B =$ Background
$H_{NPS\ LA} =$ Nonpoint Source Load Allocations
$H_{WLA} =$ Waste Load Allocations
$H_{MOS} =$ Margin of Safety
$H_{RC} =$ Reserve Capacity

Loading capacity in this TMDL is expressed as a heat 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 terms of percent effective shade and/or change in seven day average of daily maximum stream temperature or ΔT (delta T). Thus allocations are expressed as follows:

1) Point source waste load allocations are expressed in kilocalories per day. A kilocalorie of energy increases the temperature of one liter of water by 1ºC.

2) Nonpoint source effective shade targets represent system potential riparian vegetative conditions. This is especially useful for nonpoint source activities that affect streamside vegetation and shade levels. Shade targets based on no anthropogenic disturbance identify TMDL objectives more clearly to land managers than change in stream temperature or energy units such as kilocalories.

3) Reservoir load allocations and point source waste load allocations may be expressed in terms of change in temperature or ΔT. This simple way to identify load allocations is commonly used in this document because it relates directly to the temperature standard and common metrics of measurement. The change in temperature refers to the change in stream temperature associated with an anthropogenic heat source and can be quantified in kilocalories per day as follows:

$$\text{Heat Load}\left(\frac{kcal}{day}\right) = (\Delta T)(Q_R + Q_e)C_F \qquad \text{Equation 2-2}$$

where:

ΔT = allowable temperature increase, ^oC

Q_R = river flow rate, upstream, m^3/s

Q_e = effluent flow rate, m^3/s

C_F = conversion factor

$$C_F = 86.4 \text{ x } 10^6 \frac{kcal \cdot s}{^oC \cdot m^3 \cdot day}$$

Alternatively, for flow as cfs:

Q_R, Q_e units: ft^3/s

$$C_F = 2{,}446{,}665 \frac{kcal \cdot s}{^oC \cdot ft^3 \cdot day}$$

For the purposes of this TMDL and application of temperature criteria elements addressed by it, loading capacity available for human use is based on an allowable 0.3°C temperature increase at the point of maximum impact relative to the applicable seven day temperature criteria. The temperature criteria may either be the biologically-based numeric criteria or the natural conditions criteria based on natural thermal potential. In this TMDL, the human use allowance has been divided up among the point source, nonpoint source and reserve capacity sectors. Regarding the specific division of the human use allowance, DEQ consulted with the Rogue TMDL technical advisory team which is made up various stakeholders and sources.

2.5.1 Excess Load

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

This element evaluates excess load which is the difference between current pollutant load in a waterbody and the loading capacity of the waterbody. The loading capacity of a system is the heat load equivalent of the human use allowance (see above). The temperature criteria may be based on natural thermal potential which necessitates additional analysis. The Heat Source 8.0 Model was used to simulate stream temperatures on the Rogue River and tributaries under natural thermal potential conditions during the period of maximum solar input (**Figure 2.18** and see **Appendices A** and **B** for more details on the calibration and modeling effort). The NTP simulation used the following assumptions:

- Restored riparian vegetation.
- Natural flow conditions – no dams, no irrigation or drinking water withdrawals, no point sources, no water imported into the watershed.
- Tributary temperatures and flows were adjusted to reflect an estimate of natural thermal potential conditions.

The excess load was calculated using **Equation 2-2** where *ΔT* is the difference between current temperatures and NTP plus the human use allowance of 0.3 °C and Q_R plus Q_e equals the flow at the mouth. NTP was used rather than applicable criteria to protect downstream waterbodies from exceeding the applicable criteria. The inputs for excess load calculation are present in **Table 2.12** along with the results. For most streams, current conditions are warmer than NTP and therefore there is an excess thermal load (see also **Figure 2.18**). The notable exception is the Rogue River in which Lost Creek Reservoir provides for cooler temperatures during the period in which the warmest temperatures would be expected.

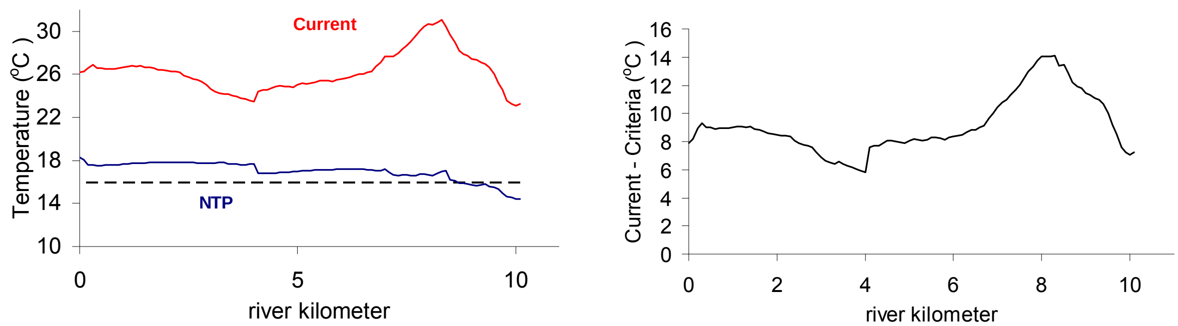
Table 2.12. Loading capacity and excess load at the mouth of various streams / rivers as calculated for model year.

Waterbody (model year)	Current temperature at mouth (maximum 7-DADM, °C)	NTP at mouth (maximum 7-DADM, °C)	Flow at mouth, August 1 (cfs)	Loading Capacity at mouth (million kcal / day)	Excess Heat Load at mouth (million kcal / day)
Rogue River[1] (2003)	20.0	18.2	1463	1073	5474
Little Butte Creek (2001)	30.6	18.0	18	13	526
North Fork Little Butte Creek (2001)	22.4	12.6	14	10	318
South Fork Little Butte Creek (2001)	29.6	22.1	9.2	6.7	162
Antelope Creek (2001)	26.2	18.3	6.4	4.7	119
Elk Creek (2001)	27.0	19.4	3.2	2.3	57
Evans Creek (2003)	28.3	22.7	3.0	2.2	39
Rogue River[2] (2003)	25.7	26.0	1921	1409	0

[1]Rogue River at the time of maximum excursion from the criteria (9/27/2003)
[2]Rogue River at the time of maximum river temperatures

Figure 2.18. Natural thermal potential profile and current conditions for modeled reaches (maximum of 7-DADM during the model period except where noted). The graphs on the left present scenario results with the biologically based criterion (dashed line). The graphs on the right compare the difference of the current minus the applicable criterion (biologically based or NTP, whichever is greater).

Antelope Creek



Elk Creek

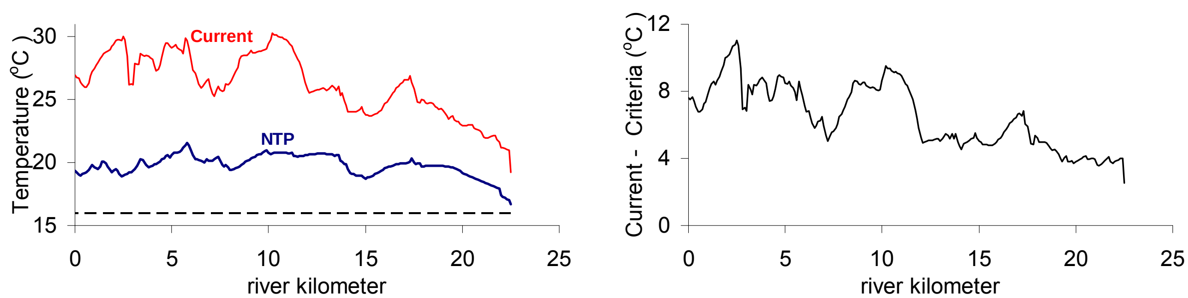
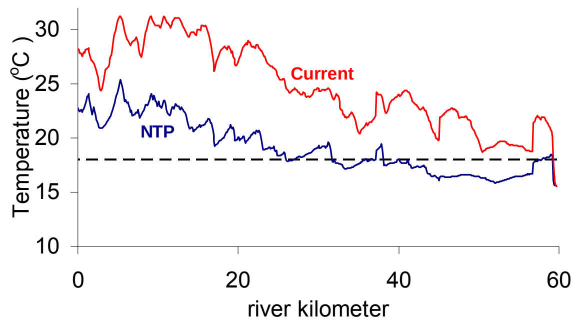
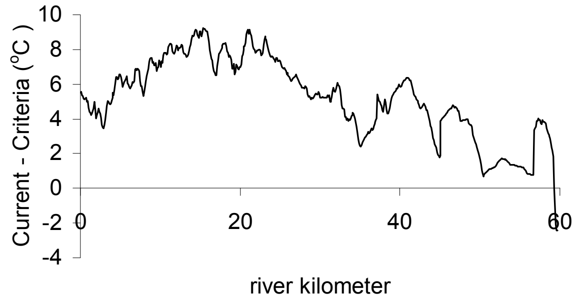


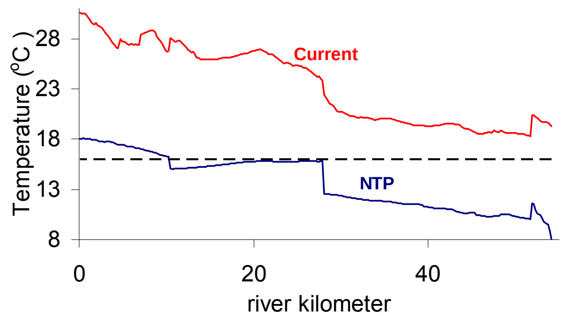
Figure 2.18 (continued)

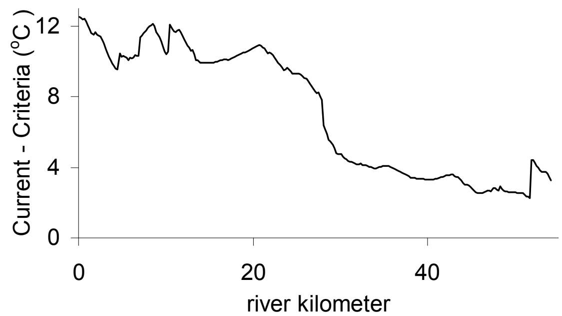
Evans Creek



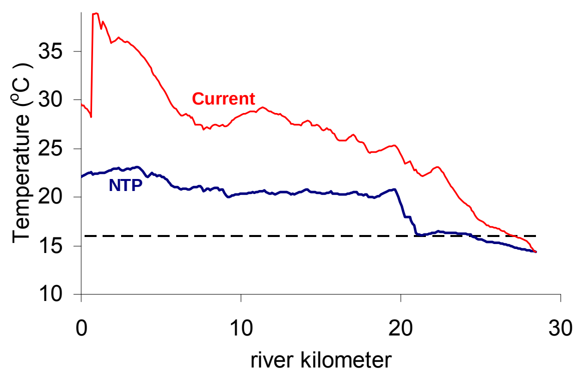


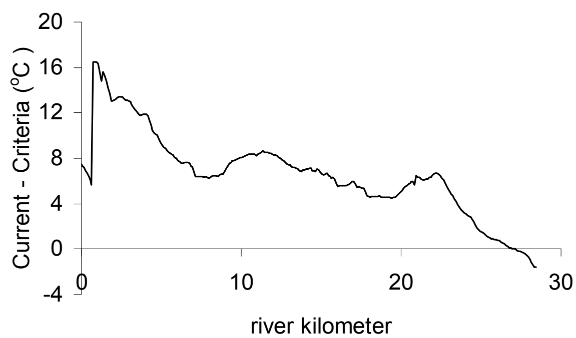
North Fork Little Butte and Little Butte Creeks



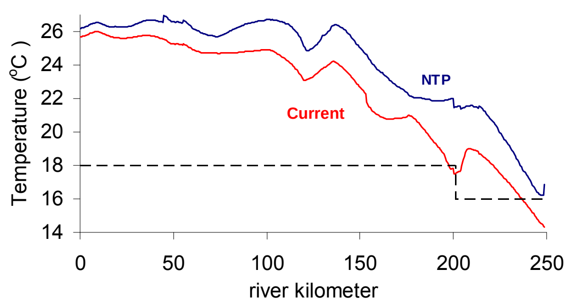


South Fork Little Butte Creek





Rogue River – 2003 maximum temperatures



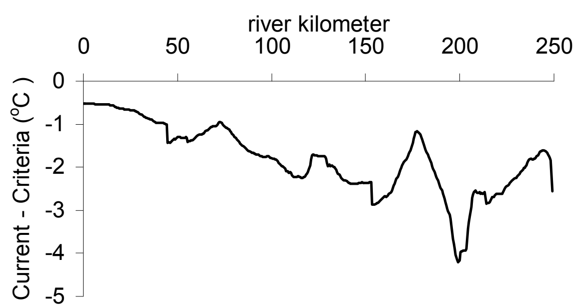
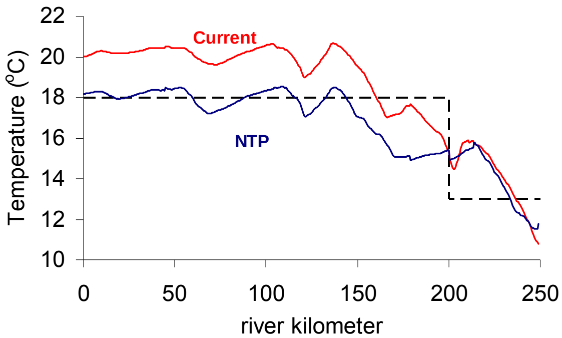
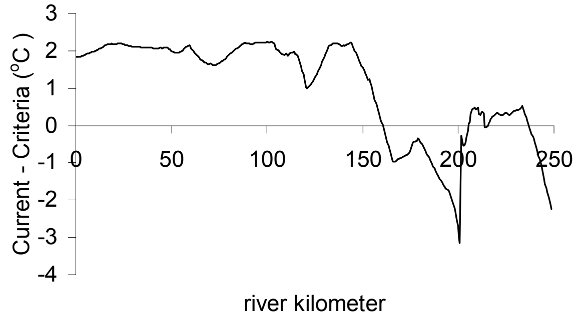


Figure 2.18 (continued)

Rogue River –day of greatest longitudinal average excursion from criteria, 9/27/2003





2.6 ALLOCATION APPROACH

The heat allocations add up to the equivalent of 0.3 ^{0}C cumulative human use allowance (**Table 2.13**). In this TMDL, no loading capacity was explicitly set aside as a margin of safety (see Section 2.10). If no point sources discharge into a waterbody, other sources may use a greater portion of the HUA if it does not translate into a greater temperature increase at the point of maximum impact as specified in **Table 2.13**. Specifically, this applied to bypass reaches within the Prospect Hydroelectric Project.

In the sections that follow the allocations are explained and surrogate targets, where appropriate, are designated for each source. Allocations are assigned to each designated management agency (DMA). As per OAR 340-042-0030(2), DMA 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”.

Table 2.13. Generalized distribution of the temperature human use allowance at the point(s) of maximum impact

Source Category	Allowed Temperature Increase
Point Sources	0.20 °C
Nonpoint Sources: Irrigation Districts	0.01 °C
Nonpoint Sources: Riparian and other	0.04 °C
Other Sources: Dams / reservoirs / power generation	0.00 °C
Reserve Capacity	0.05 °C

2.7 NONPOINT SOURCES: 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 of pollution or to background sources. Load allocations are a best estimate of loading, and may range from reasonably accurate estimates to gross allotments depending on the availability of data and appropriate techniques for predicting loading.

With the exception of irrigation diversions, return flows, reservoirs and dam operations, this temperature TMDL will target system potential effective shade as the surrogate measure to meet the TMDL load allocation for nonpoint sources. Impacts of irrigation districts and reservoir and dam operations should be calculated as a change in stream temperature. The nonpoint source HUA allocation may be used by any of the nonpoint sources located in the Rogue River basin, including agriculture, forestry, urban areas, irrigation, dam operations, or for heat trading.

2.7.1 Responsibilities of Designated Management Agencies:

Irrigation Districts

The irrigation districts within the scope of this TMDL are allowed a cumulative impact of 0.01 °C above the applicable criteria (use tables from point source section to determine the applicable criteria in area of impact). Because of the complexity and size of the irrigation system, it was not possible to quantify the thermal impact of each district's irrigation withdrawals, delivery and return into the Rogue River. If no point sources discharge to the receiving stream, then an additional portion of the human use allowance may be used if it is shown there is no additional thermal impact at the point of maximum impact on the Rogue River.

Lost Creek Reservoir

Lost Creek reservoir is a large impoundment with the ability to positively or negatively impact the temperature and flow of the entire river. In order to ensure no net negative impacts to beneficial uses occur anywhere downstream of the dam during the period of impairment, the heat load allocation assigned to the dam is no heating or river temperatures above natural thermal potential from April 1 to October 31. The dam was given no portion of the human use allowance.

Because heat load is a function of temperature and flow, reservoir effects on stream temperature are better expressed as water temperature targets rather than as a heat load in units of energy such as calories (DEQ 2006). The Lost Creek Reservoir (LCR) operation was assigned temperature targets as a surrogate measure for load allocation. The model range did not extend upstream of the Lost Creek Dam, so reservoir temperature impacts were based on an empirical regression equation of the temperatures upstream and downstream of the reservoir prior to construction of the dam (see **Appendix B**). The equation presented in **Figure B2** of **Appendix B** estimates NTP temperatures downstream of the LCR (Rogue River near McLeod gage 14337600) from current upstream temperatures (Rogue River below Prospect gage 14330000) (**Equation 2-3**). These sites were chosen because of the quantity of data collected prior to the construction of LCR. The temperature target is expressed as a daily average temperature.

Equation 2-3.

$$y = 0.9592x + 1.8508$$

where,

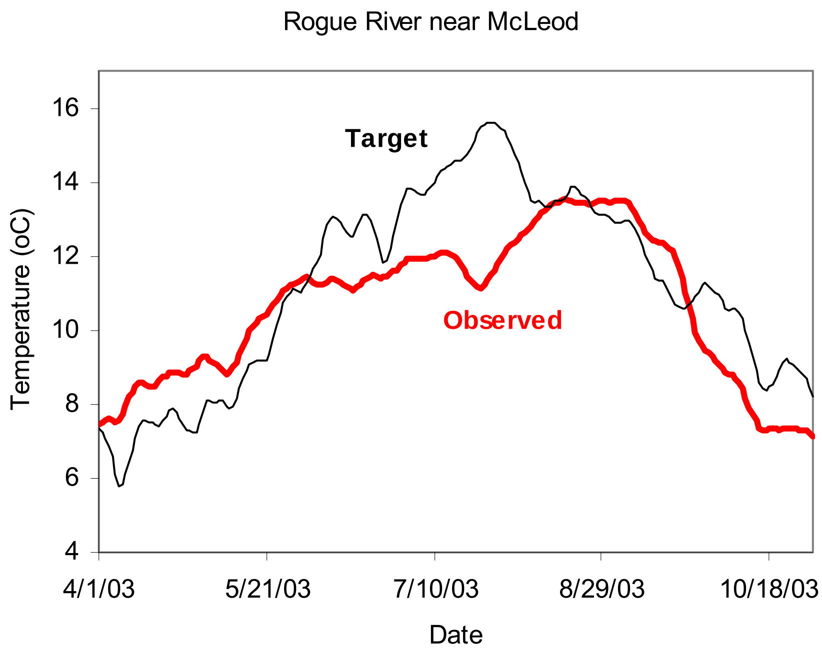
x = average daily temperature (ºC) measured at Rogue River below Prospect (gage 14330000)
y = average daily temperature target (ºC) at Rogue River near McLeod (gage 14337600)

To assist in the management of the reservoir, an example of temperature targets is shown in **Table 2.9** and **Figure 2.1**. The values in the table were calculated based on 2003 temperatures using **Equation 3**. The equation may be applied daily, weekly, or monthly at the discretion of the USACE to determine if reservoir operations are meeting the TMDL allocation. Stream temperature values presented in **Table 2.14** are not actual load allocations but are DEQ estimates of what target temperatures at the McLeod gage (14337600) would need to be to meet the load allocation for the dam based on the temperatures seen below Prospect (gage 14330000), calculated using a monthly average. These temperatures are not the target temperature of the dam release because they do not account for the natural heating between the dam and the McLeod gage. Additionally, Big Butte Creek influences temperature at the McLeod gage.

Table 2.14. Example target temperatures for Rogue River near McLeod for 2003, calculated as the monthly average.

Month	Average daily temperature (°C) at the Prospect Gage (14330000)	Calculated average target temperature (°C) McLeod Gage (14337600)
January – March	No allocation necessary	
April	5.5	7.1
May	7.9	9.4
June	11.4	12.7
July	13.4	14.7
August	12.1	13.5
September	10.1	11.5
October	7.6	9.2
November - December	No allocation necessary	

Figure 2.19. Lost Creek Reservoir target temperatures at McLeod gage versus actual temperatures for 2003



Temperature targets or other metrics from which to determine compliance with the load allocation should be incorporated into a temperature management plan. DEQ requests that the USACE work with the Department to submit a formal temperature management plan pursuant to OAR 340-041-0028(h): “Other Nonpoint Sources. The department may, on a case-by-case basis, require nonpoint sources (other than forestry and agriculture), including private hydropower facilities regulated by a 401 water quality certification, that may contribute to warming of State waters beyond 0.3 degrees Celsius (0.5 degrees Fahrenheit), and are therefore designated as water-quality limited, to develop and implement a temperature management plan to achieve compliance with applicable temperature criteria or an applicable load allocation in a TMDL pursuant to OAR 340-042-0080”.

The USACE in consultation with ODFW and Rogue Basin Interagency Advisory Group has successfully managed their operations to improve fall Chinook runs in the Rogue River Basin by reducing water temperature in areas downstream of Grants Pass during the summer (ODFW 1992). As discussed in Section 2.4.3, ODFW has concluded that spring Chinook are impaired due to warmer than natural temperatures from September 15th through April 30th between Lost Creek Lake and Gold Ray Dam and that operation of LCR is a major contributor to the elevated temperatures (ODFW 2000). ODFW has developed a conservation plan for spring Chinook salmon in the Rogue River which calls for reservoir management strategies that are designed to minimize negative impacts due to thermal loading during the fall and winter (ODFW 2007). The period of biological impairment determined by ODFW differs, for the most part, from the period determined by DEQ to exceed the water quality criteria and when allocations apply to LCR (April 1 - October 31). However, it is DEQ's intent that implementation of this TMDL will lead to operations of LCR that optimize production of salmonids throughout the year, during all life stages, not just when the current allocations apply.

DEQ requests that USACE work with ODFW and DEQ to set temperature and flow targets on an annual basis. These discussions are designed to set numeric targets for reservoir management that optimize downstream benefits for salmonid fishes and thus form the foundation of a temperature management plan. At such time when all sources of thermal impairment in the Rogue River Basin meet their load and wasteload allocations, stream temperatures will achieve the water quality standard. However, DEQ recognizes that current reservoir operations during much of the year benefit the Rogue mainstem by compensating for other sources' current impact. Therefore, DEQ recommends that the temperature management plan identify optimal conditions for beneficial uses during the specific year of water yield. If TMDL temperature targets conflict with the optimization of beneficial uses, the temperature management plan should document how other targets optimize salmonid production. The TMDL may be revised in the future to reflect any additional technical assessments of reservoir management strategies to optimize beneficial uses.

A temperature management plan must include a description of best management practices, measures, and/or control technologies (including eliminating the heat impact on the stream) that the source intends to use to reduce its temperature effect, a monitoring plan, and a compliance schedule for undertaking each measure. Once approved, a source complying with its temperature management plan is deemed in compliance with this rule. The Department may periodically require a source to revise its temperature management plan to ensure that all practical steps have been taken to mitigate or eliminate the temperature effect of the source on the water body. The USACE temperature management plan for Lost Creek Reservoir would benefit from additional simulations for water temperature of the Rogue River under varied strategies of reservoir management. These simulations may be needed to better allocate reservoir storage for the maintenance and possible enhancement of salmonids in areas downstream of Lost Creek Dam. At a minimum, water temperature should be simulated for years of low, average, and high water yield; and should also be simulated under alternative management strategies of (1) use of hypolimnetic storage in summer, (2) use of hypolimnetic storage in autumn, and (3) equal use of hypolimnetic storage in summer and autumn.

Rogue River Low Head Dams

The owners/operators must mitigate the impact of the existing low-head dams so that there is no individual or cumulative warming of river temperatures. Gold Hill powerhouse dam was removed during the summer 2008 and Savage Rapids dam is scheduled for removal during the spring of 2009.

Fish Lake Dam

The Medford Irrigation District must mitigate the impact of the Fish Lake dam so that there is no warming of tailwater above the natural thermal potential at the dam site. Because the reservoir is fed exclusively by springs, a conservative value for determining compliance could be to target temperatures of springs in the area (approximately 8.0 °C).

Prospect Hydroelectric Project

The heat load allocation assigned to Prospect Hydroelectric Project is no heating of river temperatures above NTP during the period of impairment (April 1 – October 31) downstream of the project. The project is given no portion of the human use allowance downstream of the project. Within the bypass reaches of the project and in waterbodies that do not achieve the biologically based temperature criterion operations may not lead to increases in temperatures by more than 0.2 °C. The bypass reaches include portions of the Rogue River, Middle and South Fork Rogue River and Red Blanket Creek. Since there are no point sources within these reaches, the Human Use Allowance is not exceeded.

Other dams / reservoirs

If further assessment shows that other dams cause or contribute to temperature impairment, a temperature management plan will be required. Consistent with the other allocations to dams /

reservoirs, the allocation is no individual or cumulative warming of river temperatures to thermally impaired waterbodies.

Urban, Transportation, Agriculture, Forestry.

There are two types of nonpoint source load allocations that apply to Urban DMAs, Agriculture, Forestry and Transportation:

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

2. Effective shade curves are generalized allocations that apply to all other Rogue River basin streams covered by this TMDL, but that have not been simulated.

2.7.2 Effective Shade Targets

The Rogue River Basin Temperature TMDL incorporates 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, this TMDL allocates "*other appropriate measures*" (or surrogate measures) as provided under EPA regulations (40 CFR 130.2(i)).

Effective shade is the surrogate measure that translates easily into solar heat load. It is simple to measure effective shade at the stream surface using a relatively inexpensive instrument called a Solar Pathfinder™.

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 heating by solar radiation and serve as a linear translator to the loading capacities.

Unless otherwise stated within this chapter, the applicable nonpoint source load allocations for Rogue River Basin streams are based upon potential effective shade values presented in this section and the human use allowance (0.04^{o}C cumulative increase at the point of maximum impact).

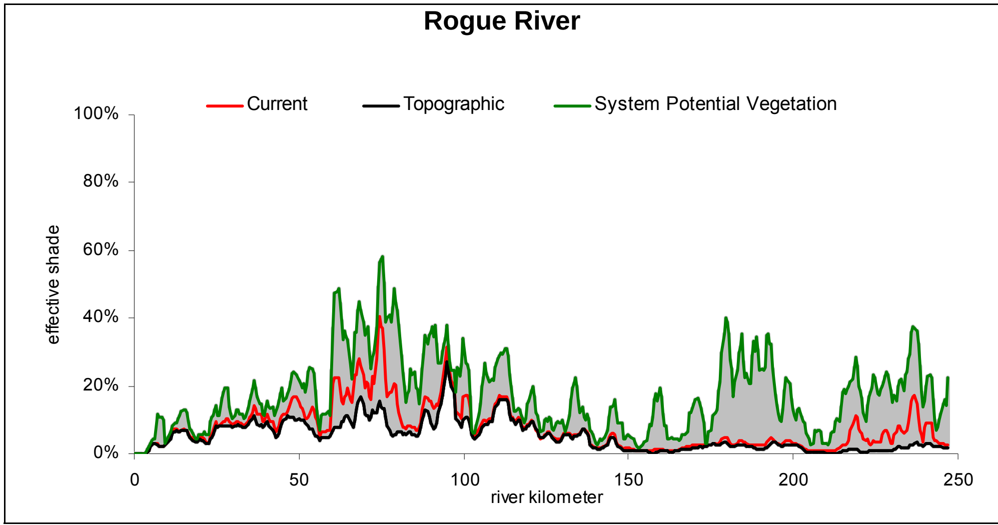
Most streams simulated have no assimilative capacity, which translates into a zero heat load allocation for nonpoint sources. When a stream has assimilative capacity, nonpoint and point sources may receive allocations greater than background.

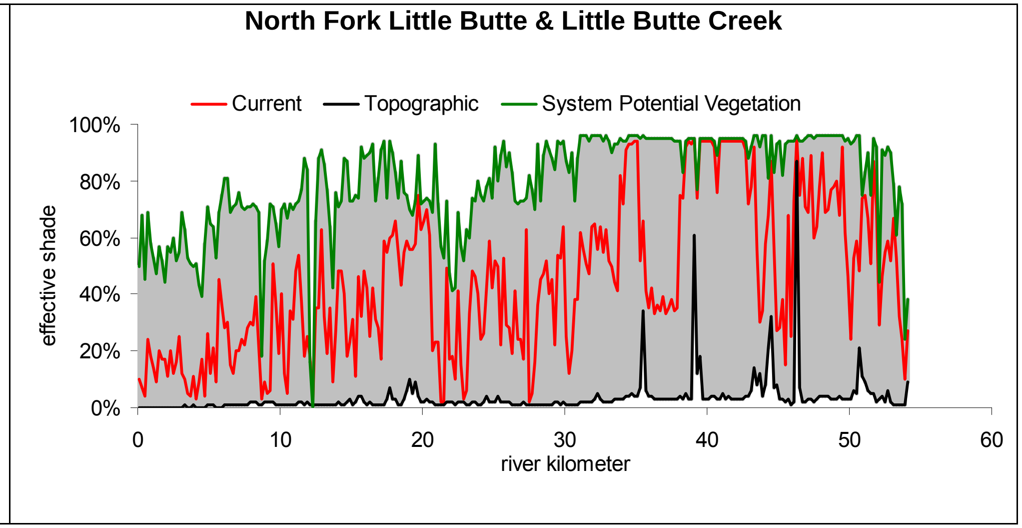
Site Specific Effective Shade Simulations

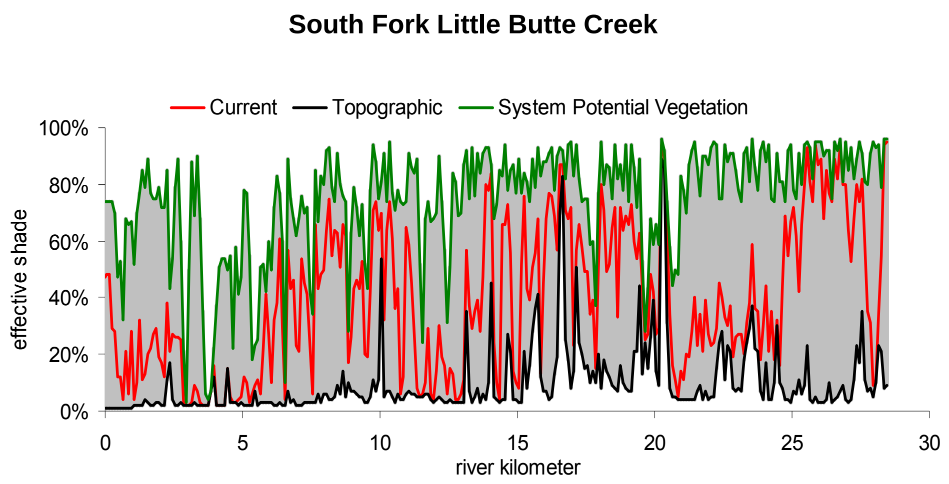
Site specific effective shade surrogates were developed to help translate the nonpoint source heat load allocations. Attainment of the effective shade surrogate measures is equivalent to attainment of the nonpoint source heat load allocations. **Figure 2.20** shows the simulated percent effective shade estimates on modeled streams by river kilometer. The "Current Condition" effective shade (in red) provided to the Rogue River and its tributaries is generally less than the "Nonpoint Source (NPS) Loading Capacity" effective shade (in green) at the stream surface under potential vegetation conditions. The "Natural Disturbance Range" 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 stream would receive if topography were the only shade-producing feature (i.e., no vegetation). **Appendices A and B** contain detailed descriptions of the methodology used to develop the temperature TMDL.

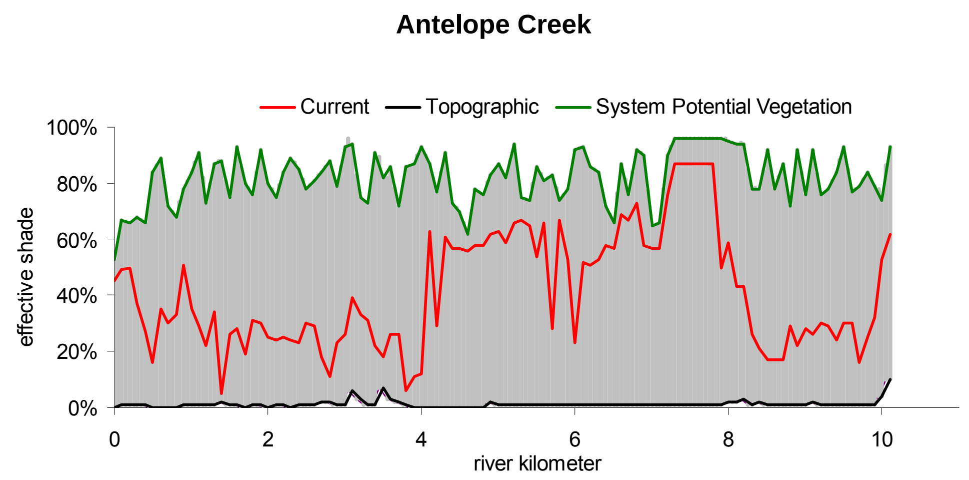
The "system potential vegetation" (green line) represents the maximum possible effective shade for a given location, assuming the vegetation is fully mature. Caution should be used when interpreting the charts in **Figure 2.20.** This TMDL recognizes that it is nearly impossible for an entire stream to be at its maximum potential effective shade everywhere, all the time. In reality, natural disturbances will create a variety of tree heights and densities and effective shade levels in many reaches will be lower than the "NPS Loading Capacity", or somewhere within the "Natural Disturbance Range". Reductions in effective shade caused by natural disturbance are not considered a violation of the TMDL or water quality standards.

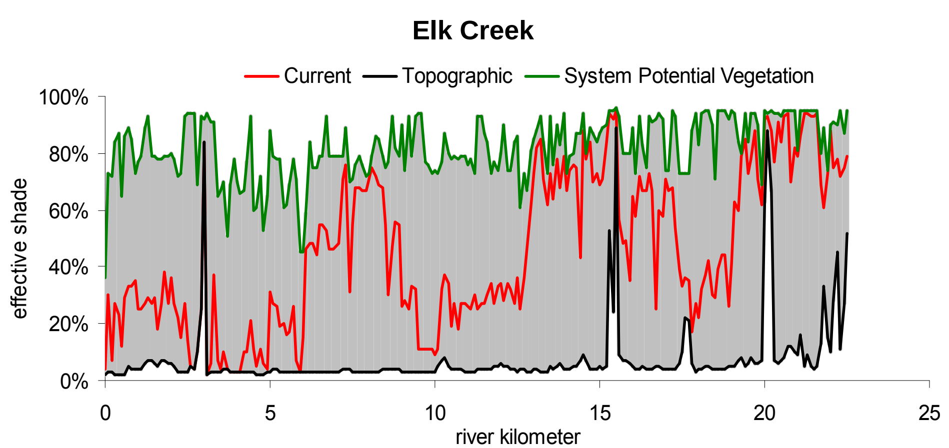
Figure 2.20. Effective shade targets for waterbodies in which a water quality model was developed. The area in gray between the topographic and system potential vegetation lines indicates the range of shade possible due to natural disturbance.

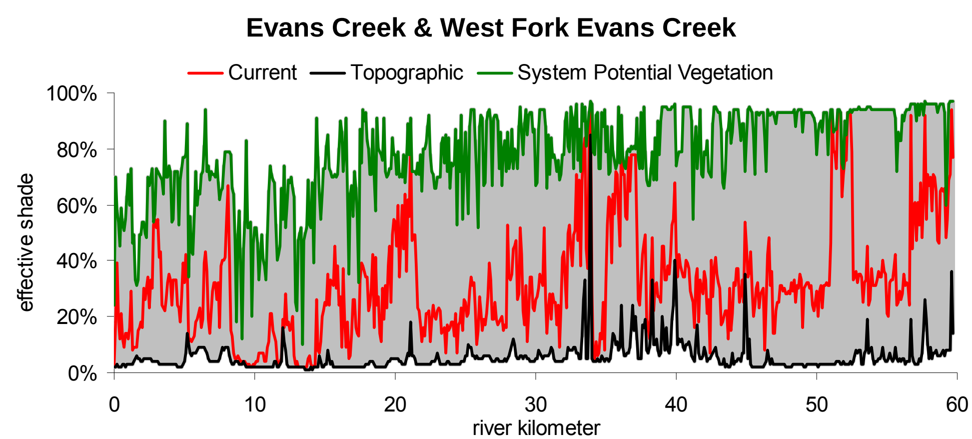





South Fork Little Butte Creek
Current
Topographic
System Potential Vegetation
effective shade
100%
80%
60%
40%
20%
0%
0
5
10
15
20
25
30
river kilometer


Antelope Creek
Current
Topographic
System Potential Vegetation
effective shade
100%
80%
60%
40%
20%
0%
0
2
4
6
8
10
river kilometer


Elk Creek
Current
Topographic
System Potential Vegetation
effective shade
100%
80%
60%
40%
20%
0%
0
5
10
15
20
25
river kilometer


Evans Creek & West Fork Evans Creek
Current
Topographic
System Potential Vegetation
effective shade
100%
80%
60%
40%
20%
0%
0
10
20
30
40
50
60
river kilometer

Effective Shade Curves

Effective shade curves are general heat load allocations applicable to any stream that was not specifically simulated for temperature. The heat load and effective shade surrogates are identified by region and channel width 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. See **Appendix B** for methodology to determine system potential vegetation in the Rogue River basin.

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 Rogue River Basin Temperature TMDL is to minimize anthropogenic impacts on effective shade. Natural conditions or natural disturbances (non-anthropogenic) that result in effective shade below the maximum potential will not be considered out of compliance with the TMDL. This TMDL recognizes that unpredictable natural disturbances may result in effective shade well below the levels presented in the effective shade curves.

Ecoregion-specific effective shade curves were derived for different vegetation types as a function of channel width and apply to all areas. The effective shade curves account for latitude, critical summertime period (August 1), elevation and stream aspect.

Site-specific effective shade simulations (i.e., Heat Source modeling) supersede the effective shade curves (see previous section). **Figure 2.21** displays the locations of each EPA Level IV ecoregion. The shade targets for each ecoregion and vegetation type are presented in **Figure 2.22**.

Figure 2.21. EPA Level IV Ecoregions used for the Effective Shade Curves

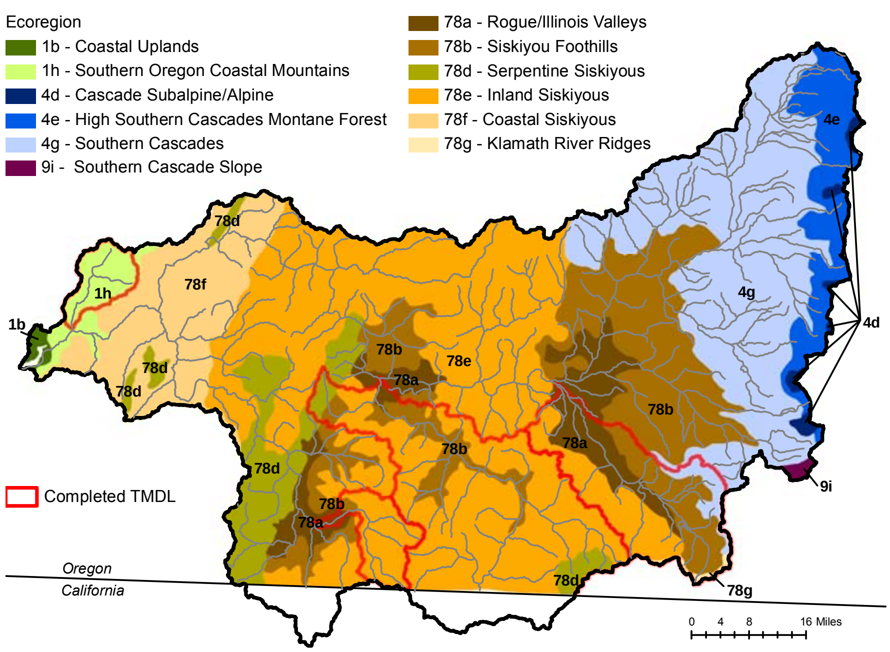
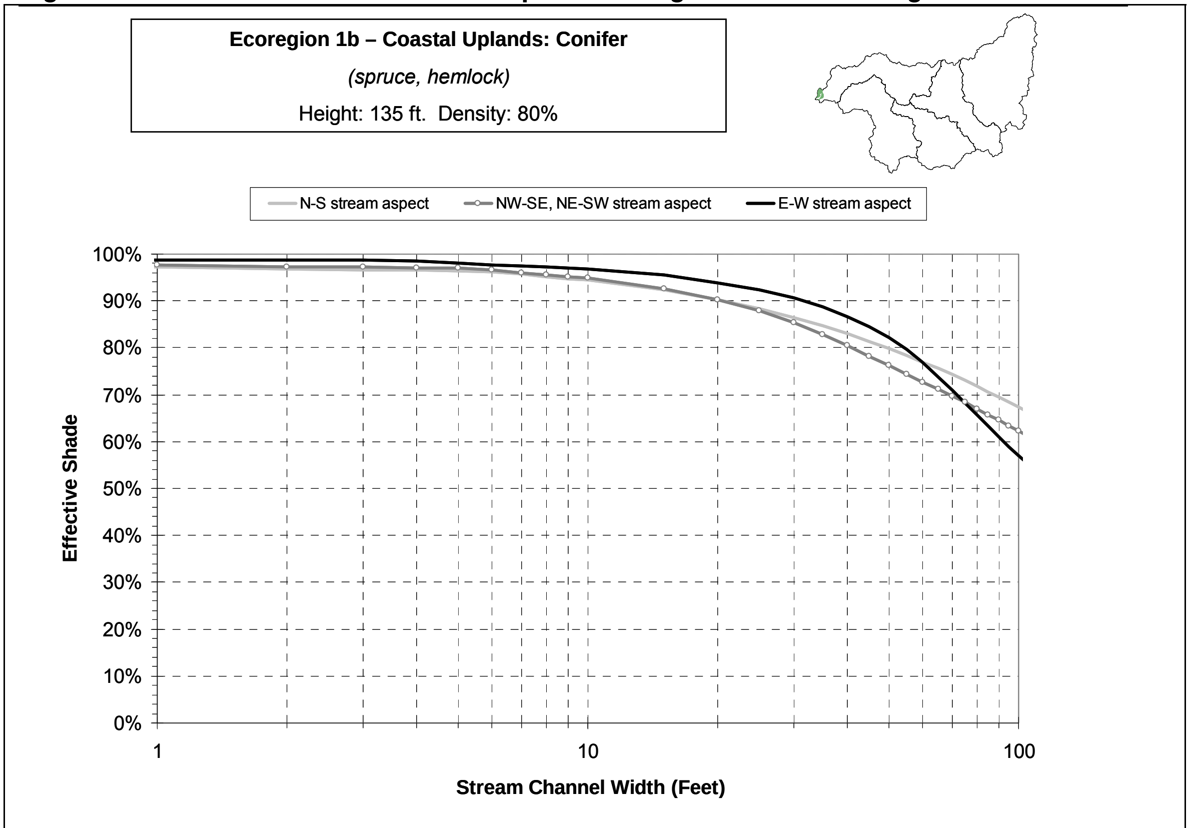


Figure 2.22. Effective shade curves for potential vegetation and ecoregion



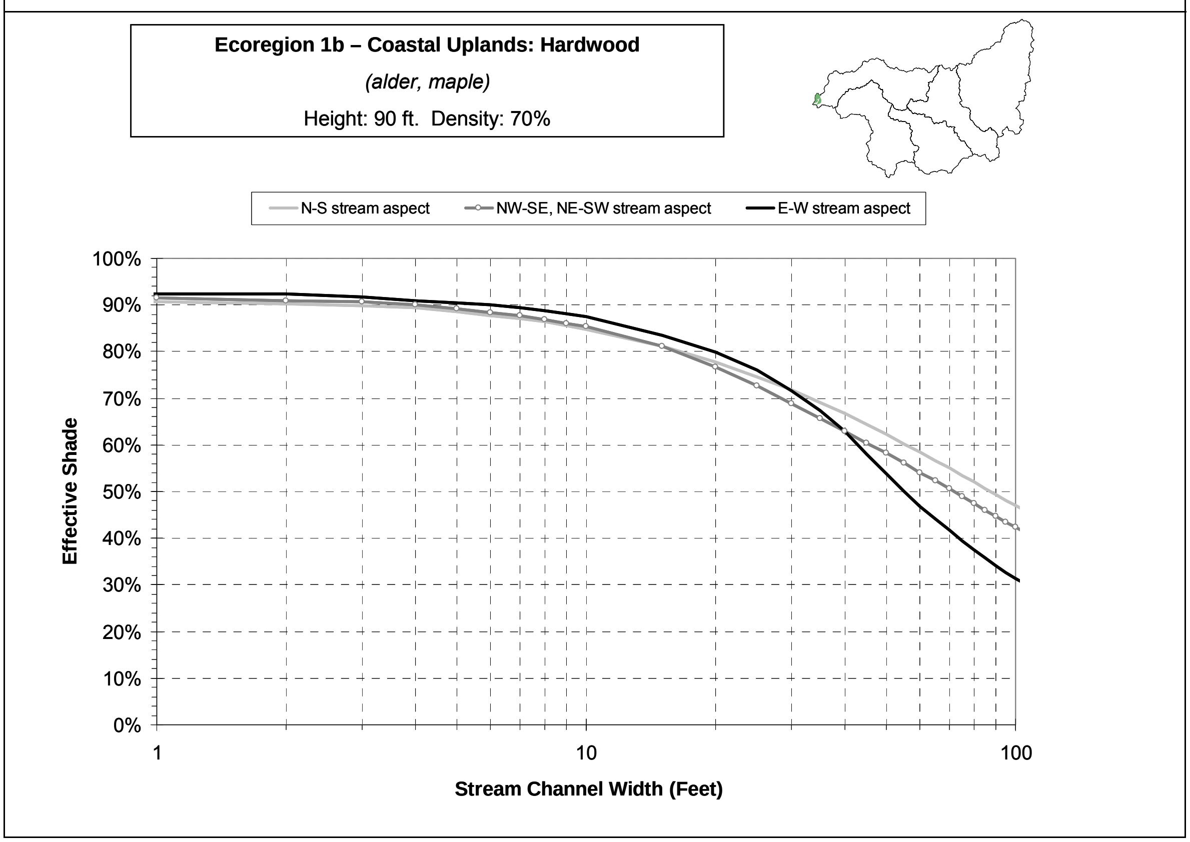
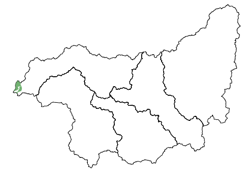


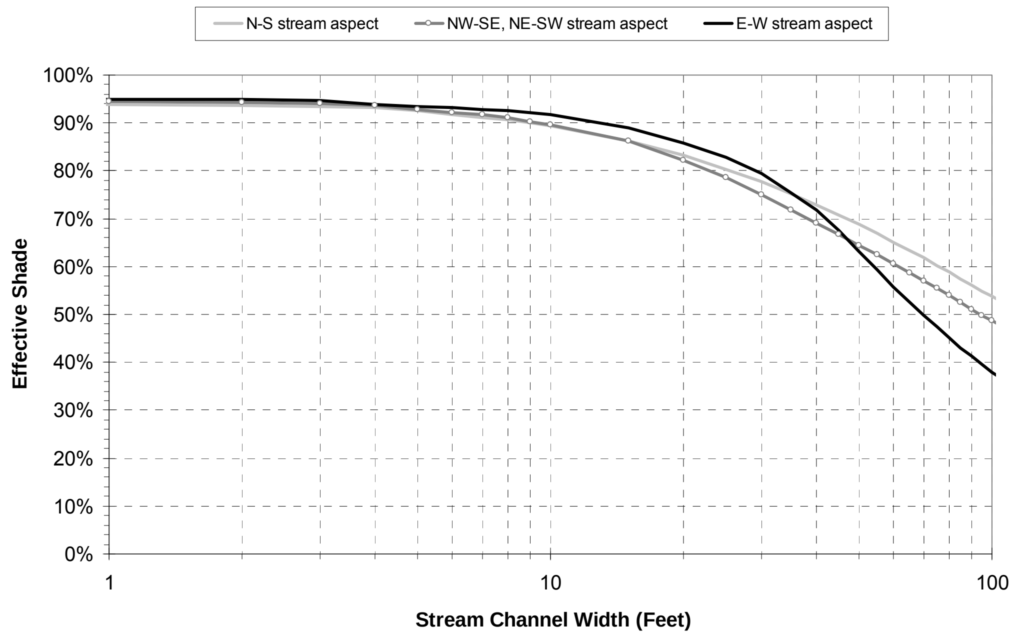
Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).

Ecoregion 1b – Coastal Uplands: Mixed forest

(spruce, hemlock, alder, maple)

Height: 100 ft. Density: 75%

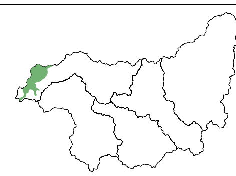




Ecoregion 1h – Southern Oregon Coastal Mountains

(western hemlock, western red cedar, Port Orford cedar, grand fir, tanoak, myrtle, red alder)

Height: 160 ft. Density: 70%



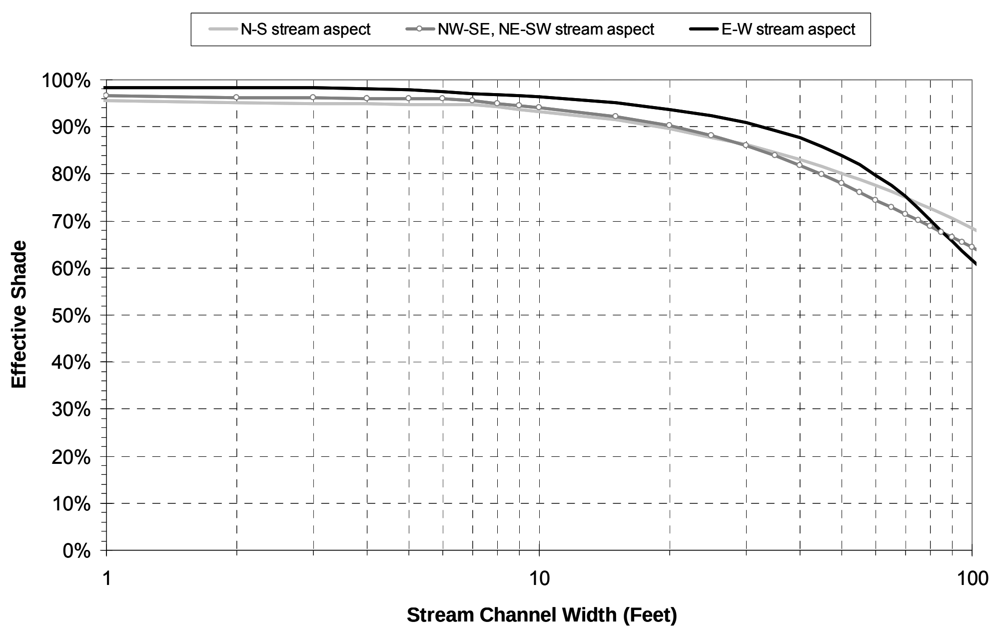
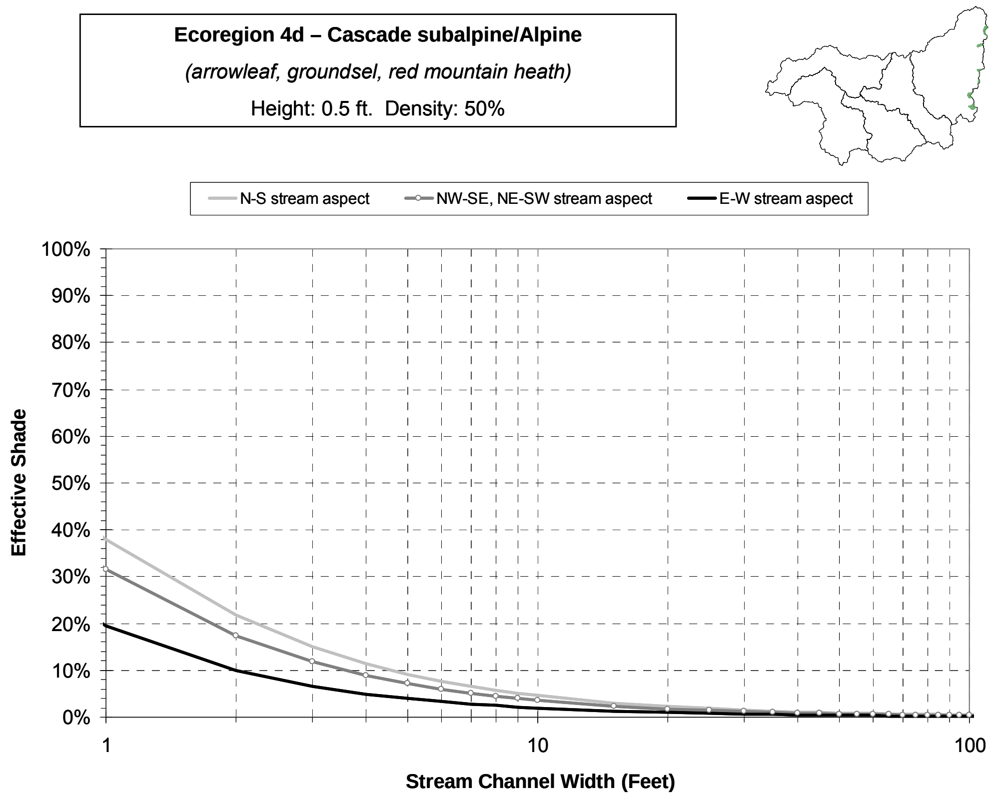


Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).

Ecoregion 4d – Cascade subalpine/Alpine

(arrowleaf, groundsel, red mountain heath)

Height: 0.5 ft. Density: 50%



Ecoregion 4e – High Southern Cascades Montane Forest: Conifer

(true fir, mountain hemlock, lodgepole pine)

Height: 140 ft. Density: 70%

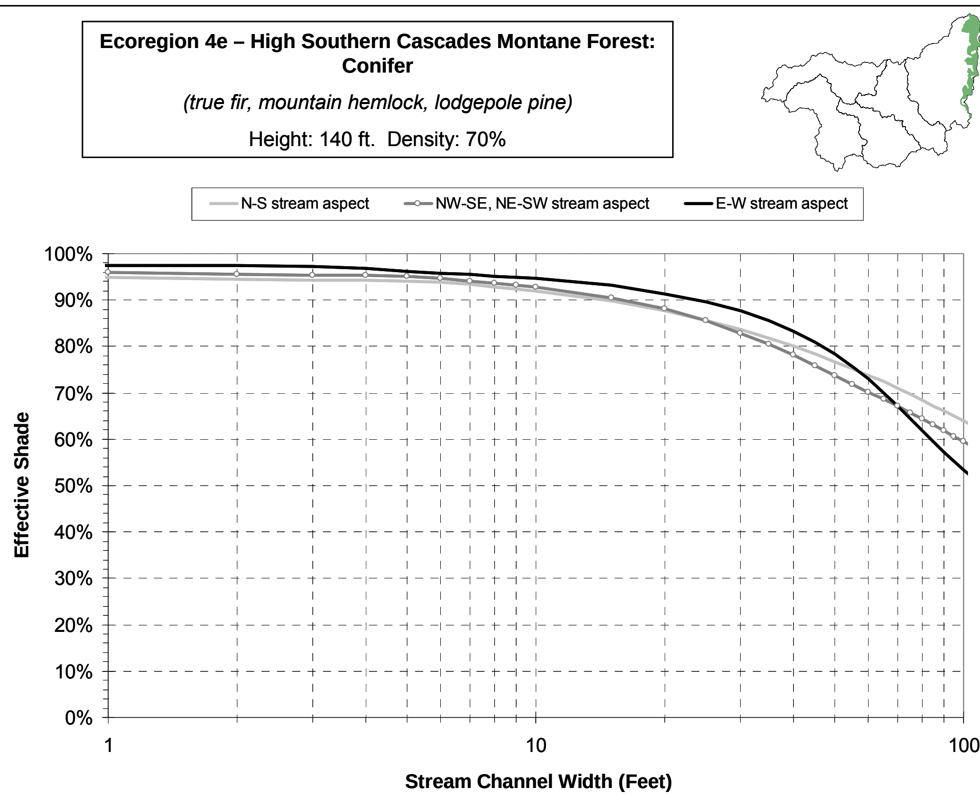
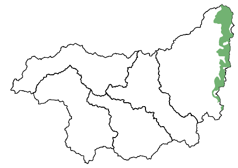


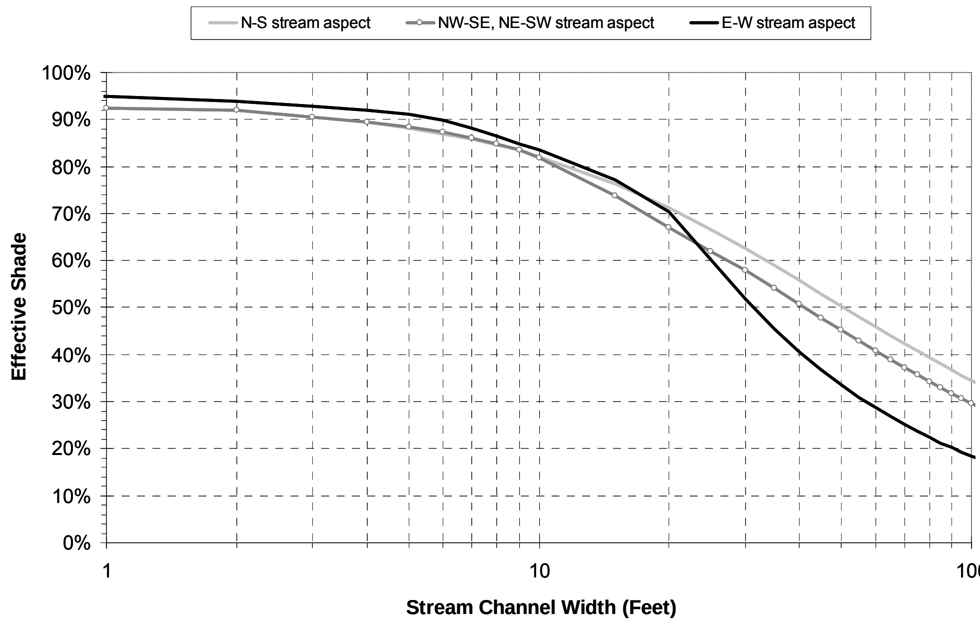
Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).

Ecoregion 4e – High Southern Cascades Montane Forest: Mixed forest

(mountain alder, bog blueberry, lodgepole pine, white fir)

Height: 49 ft. Density: 80%

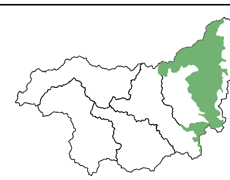




Ecoregion 4g – Southern Cascades: Hardwood

(mountain alder)

Height: 49 ft. Density: 80%



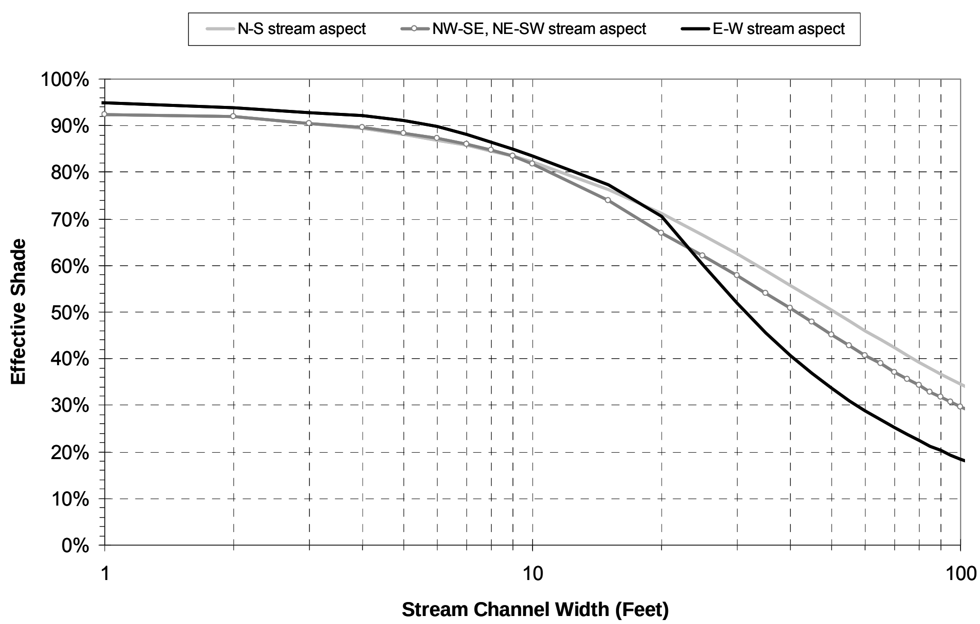
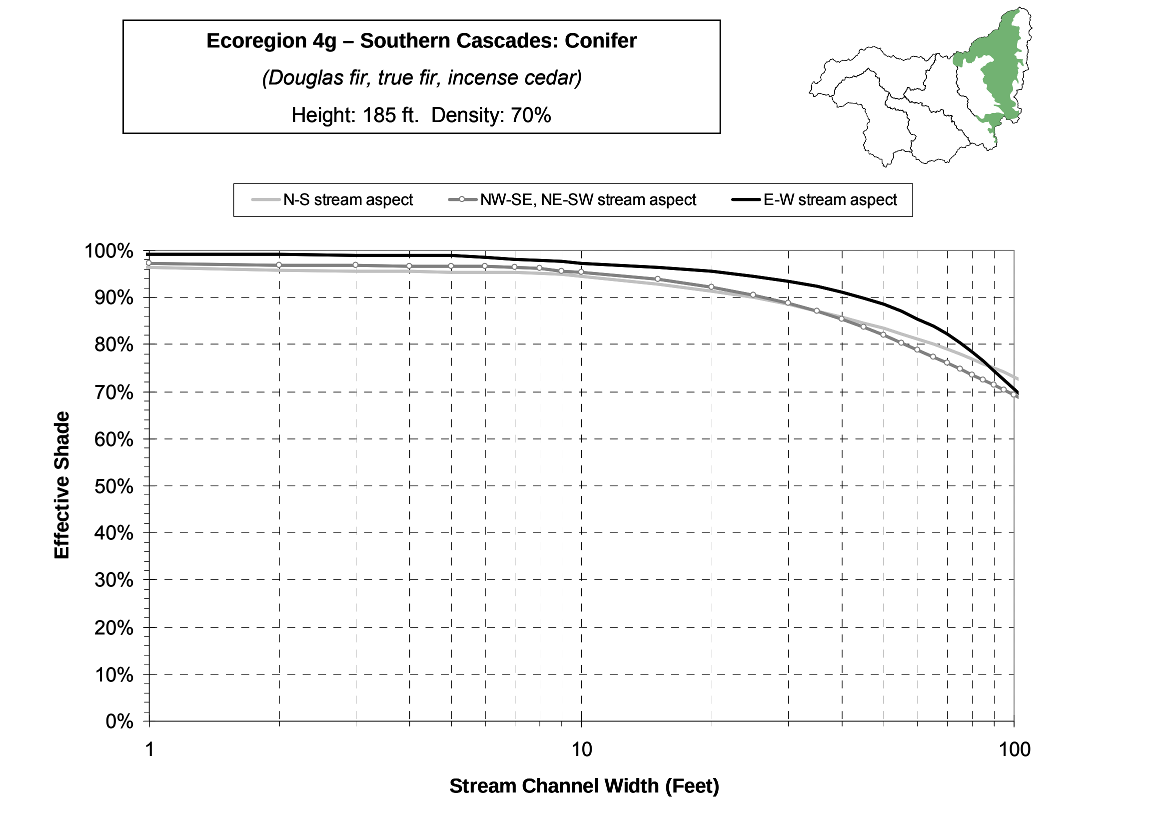


Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).



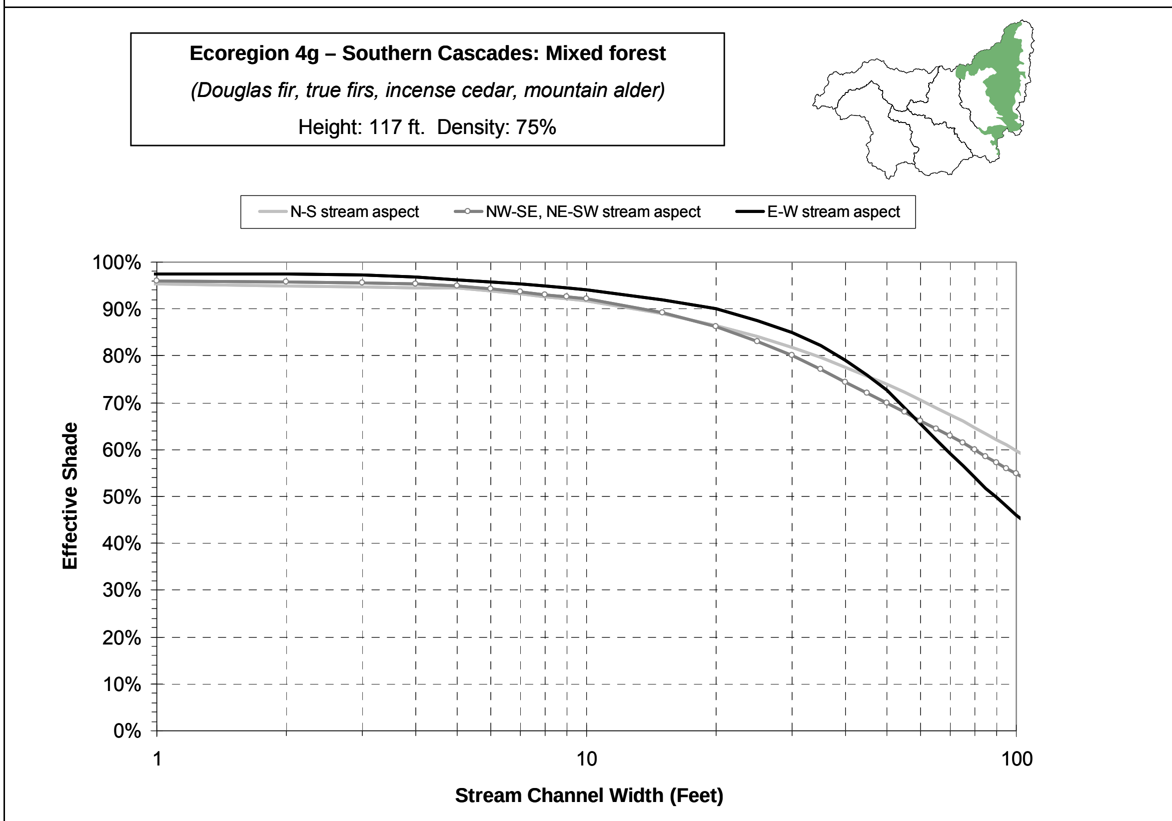
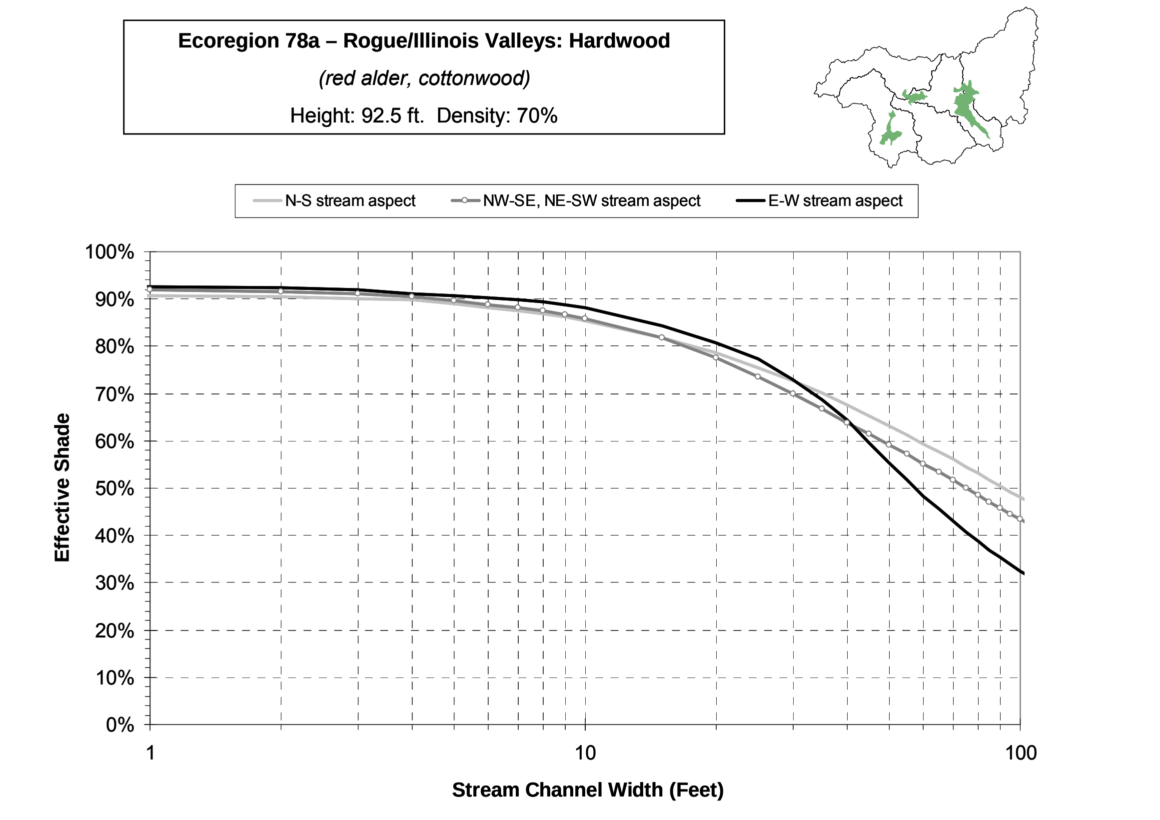


Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).



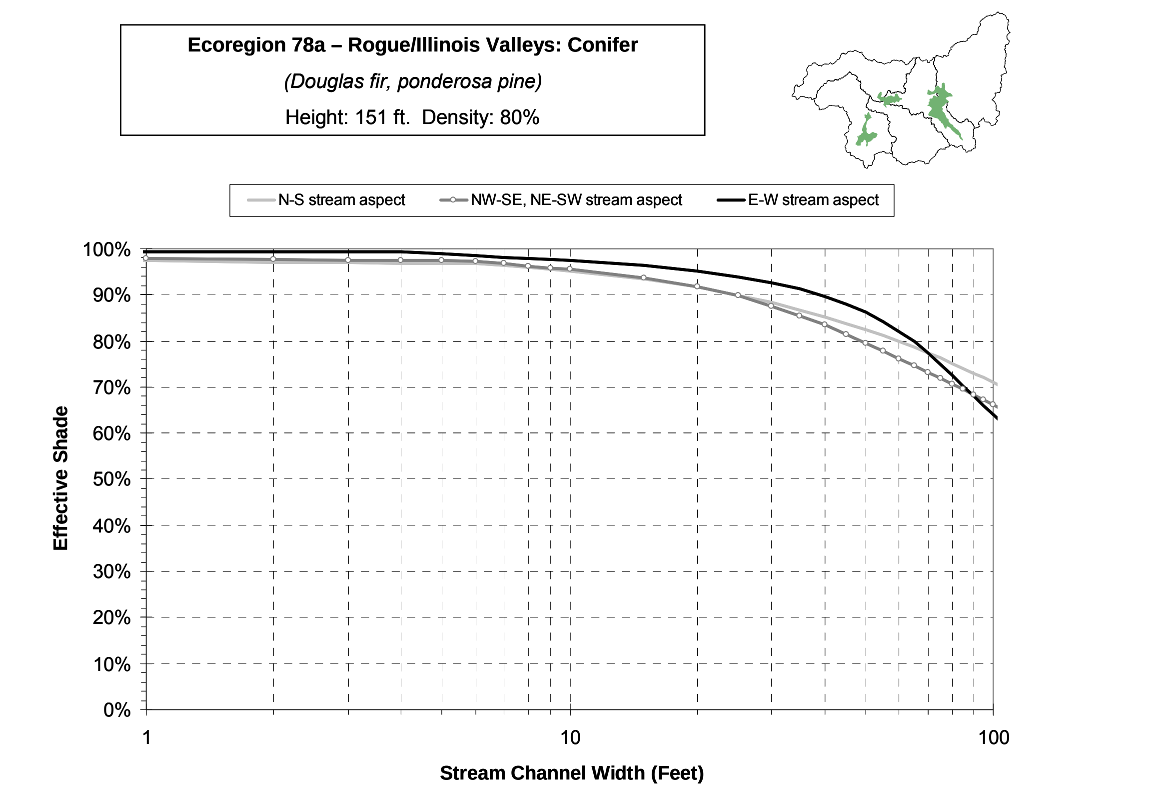
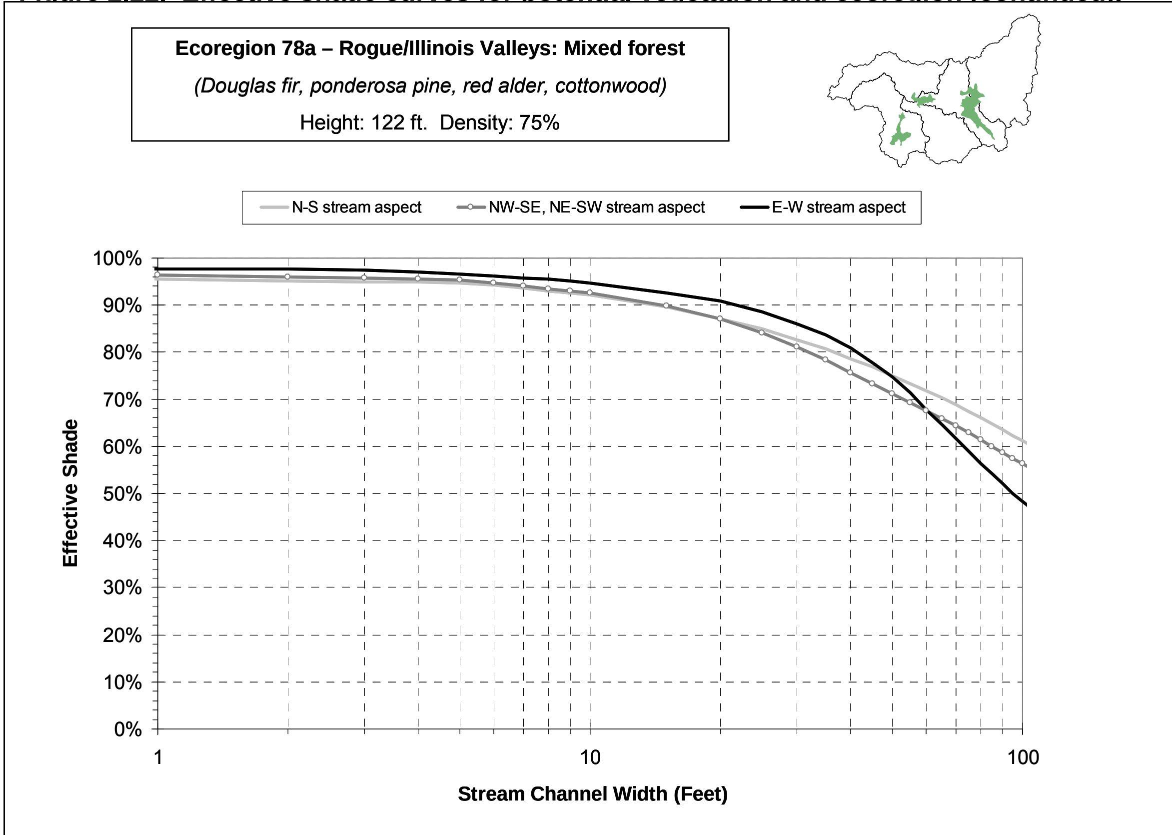


Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).



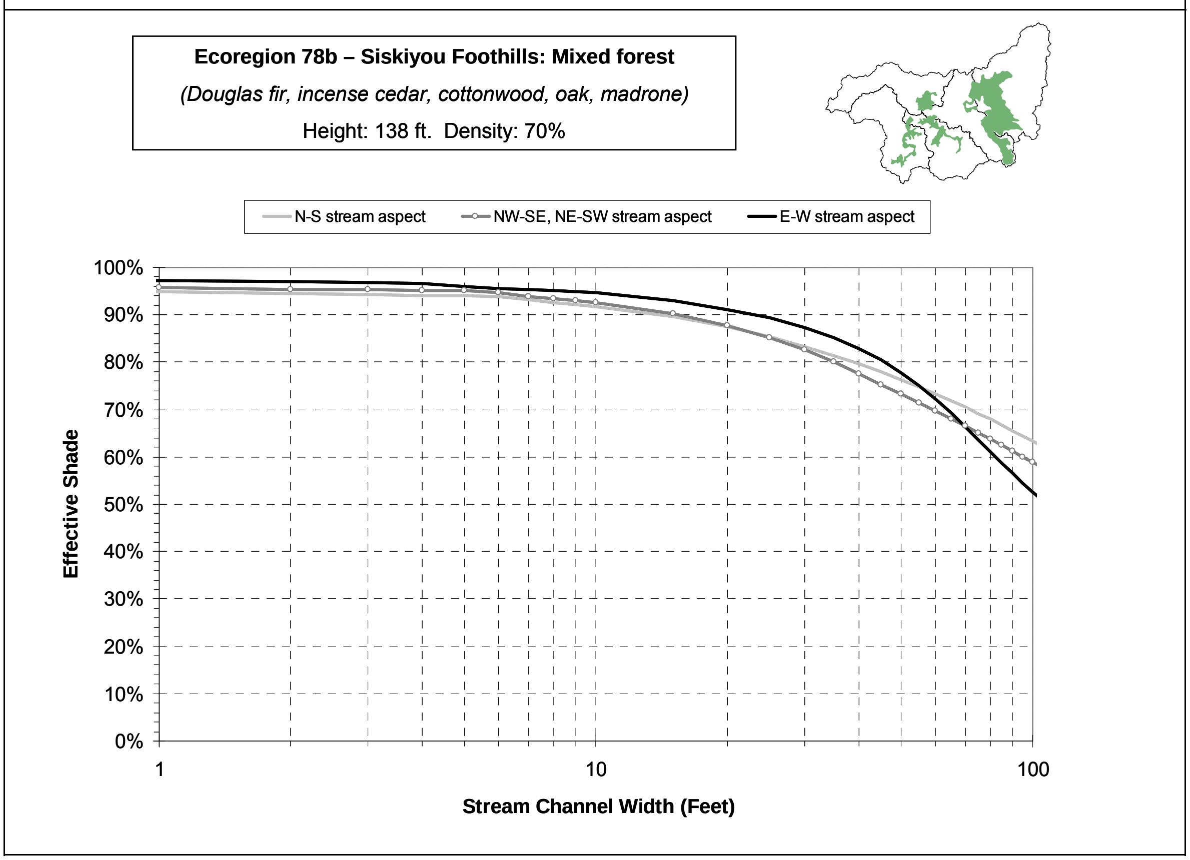
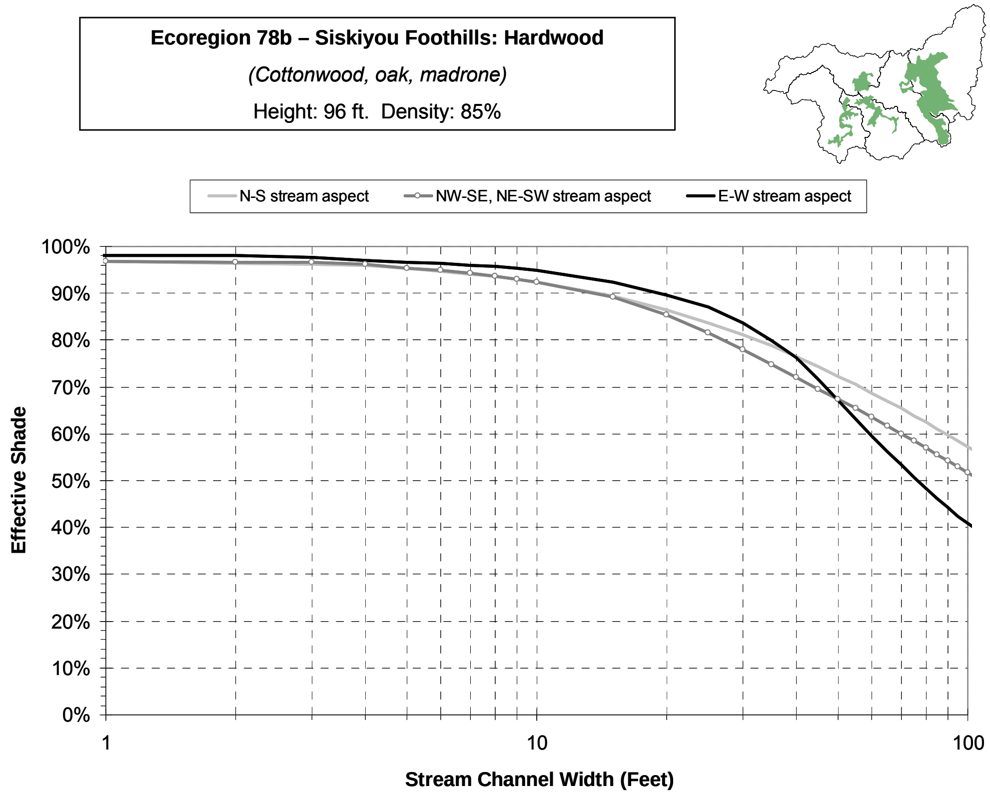


Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).

Ecoregion 78b – Siskiyou Foothills: Hardwood
(Cottonwood, oak, madrone)
Height: 96 ft. Density: 85%



Ecoregion 78b – Siskiyou Foothills: Conifer
(Douglas fir, incense cedar)
Height: 170 ft. Density: 80%

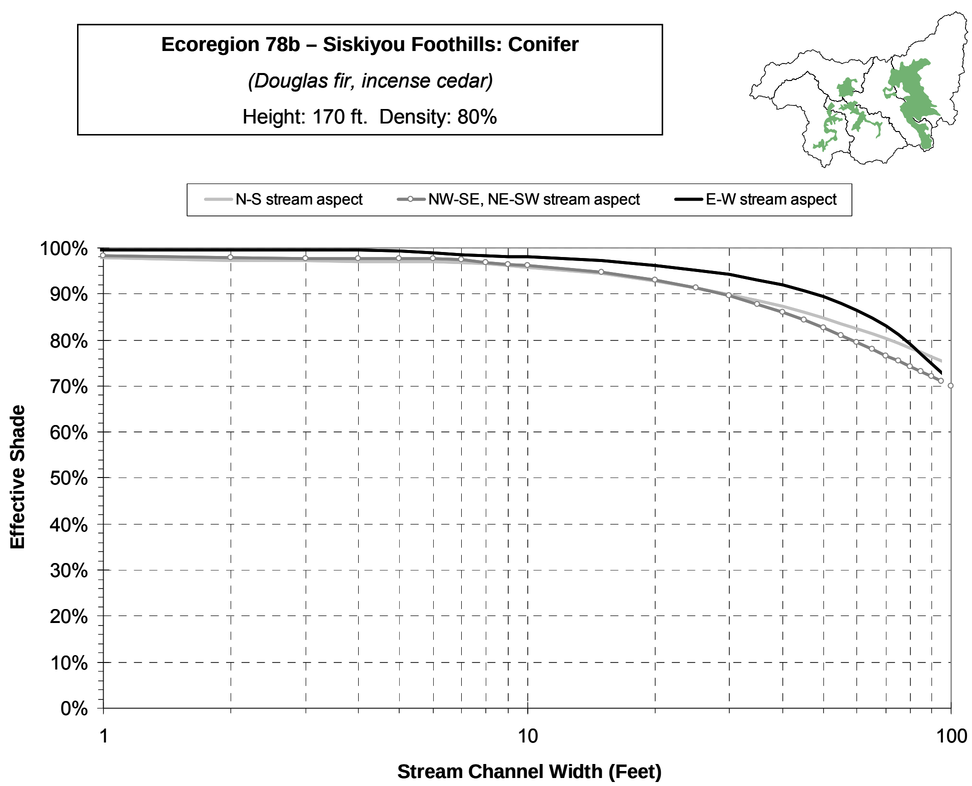
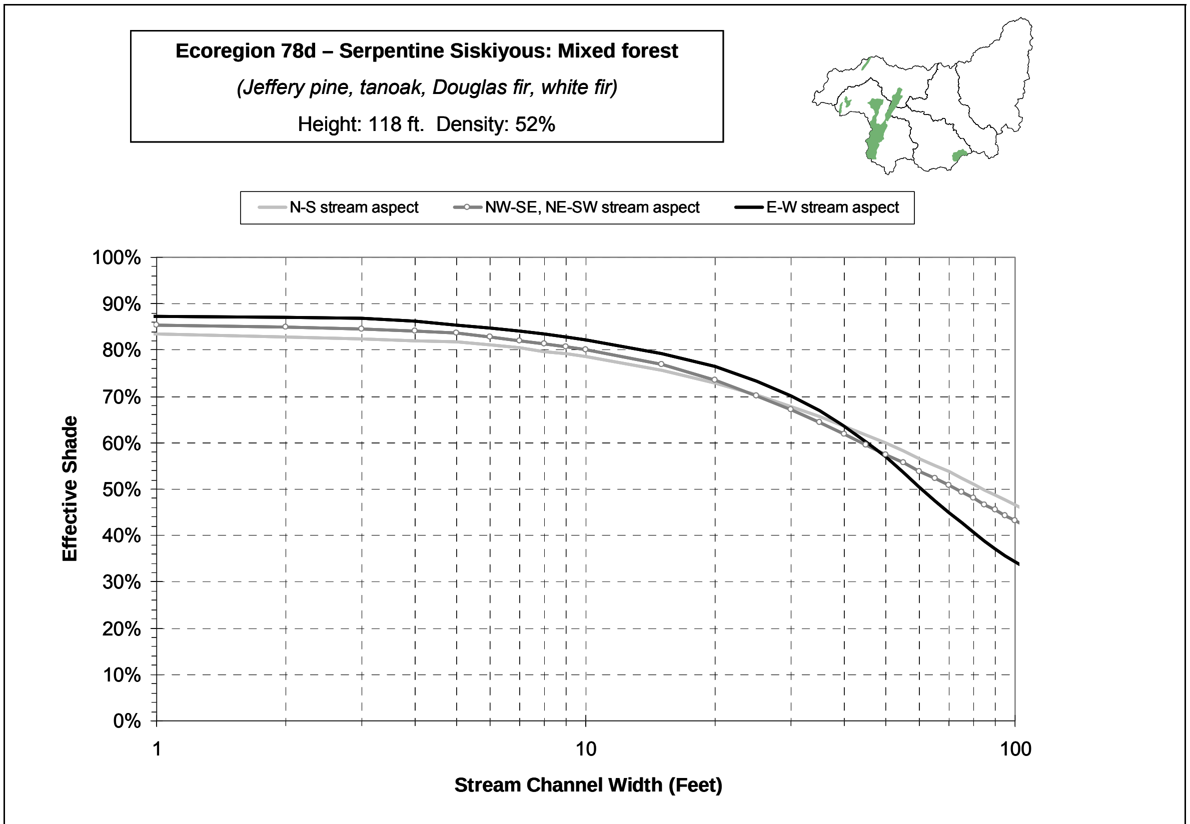


Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).



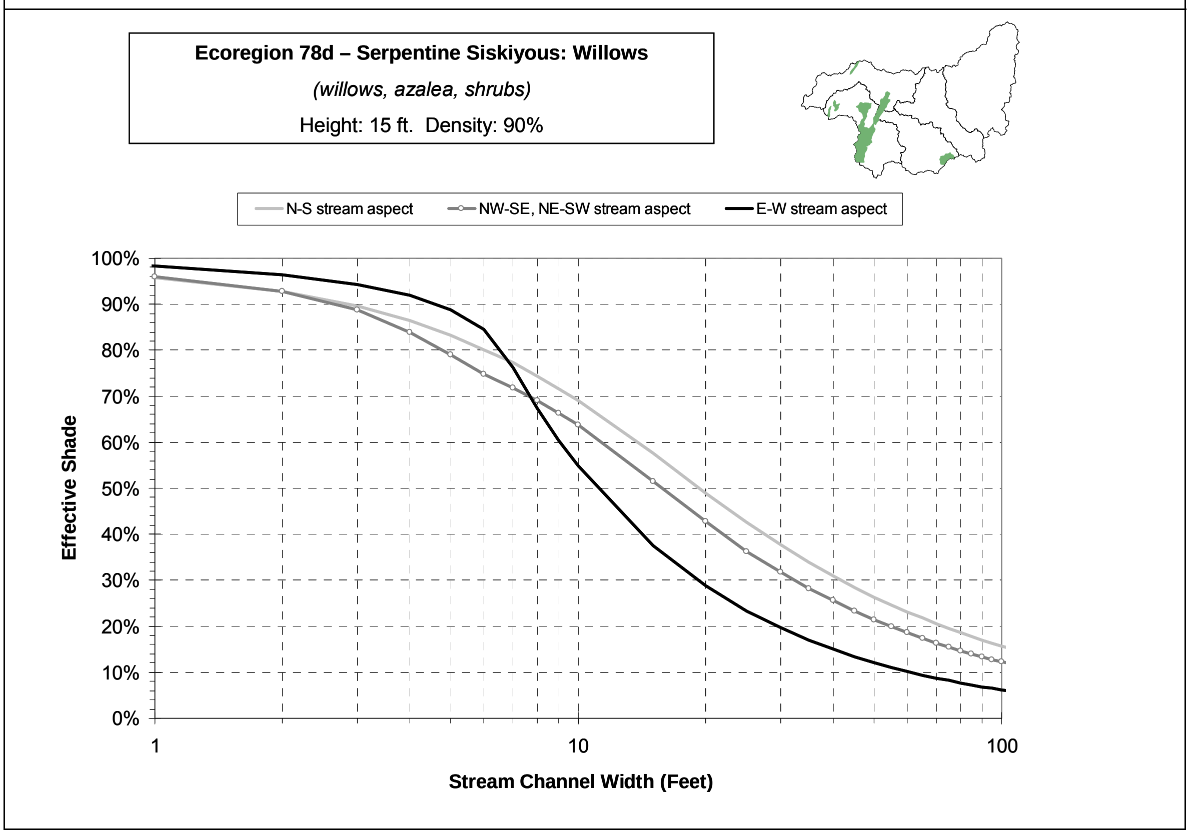
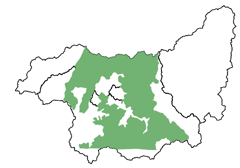


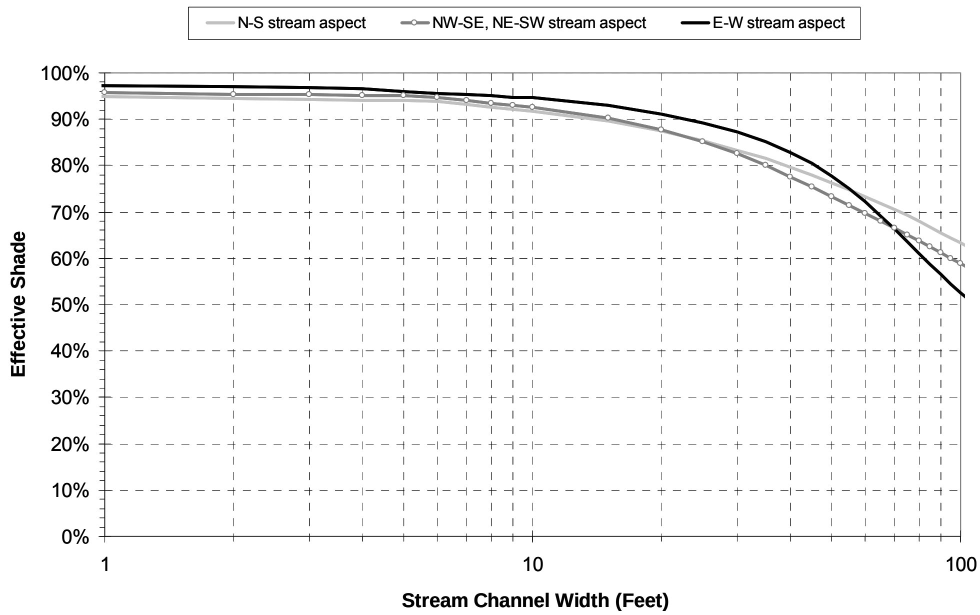
Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).

Ecoregion 78e – Inland Siskiyous: Mixed forest

(Douglas fir, ponderosa pine, incense cedar, white fir, oak, madrone)

Height: 138 ft. Density: 70%

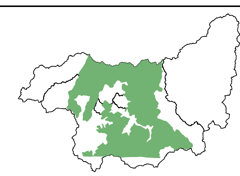




Ecoregion 78e – Inland Siskiyous: Hardwood

(oak, madrone)

Height: 96 ft. Density: 85%



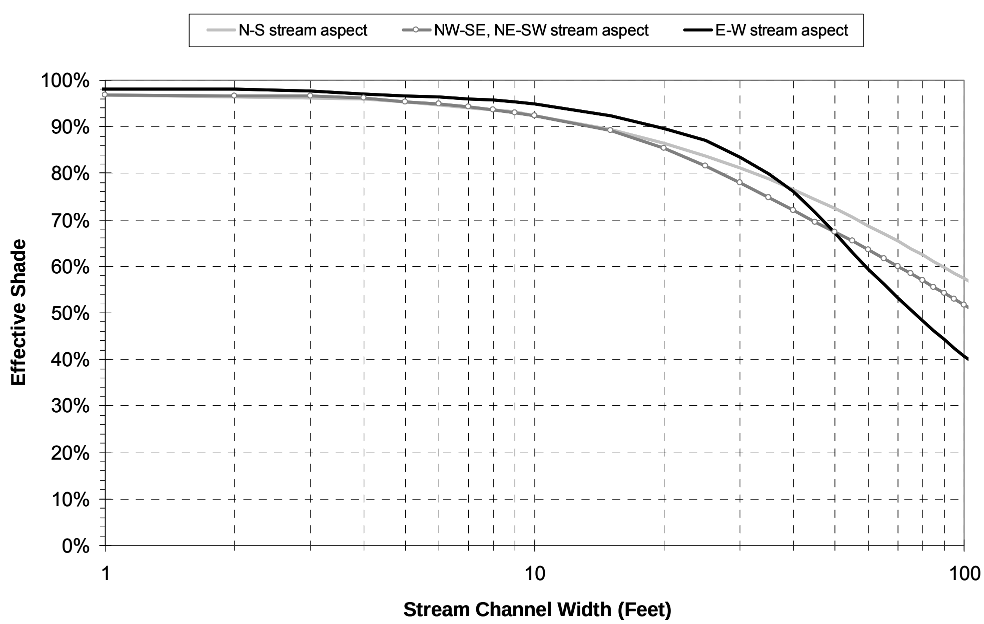
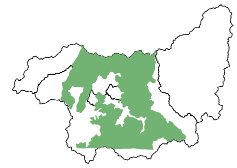
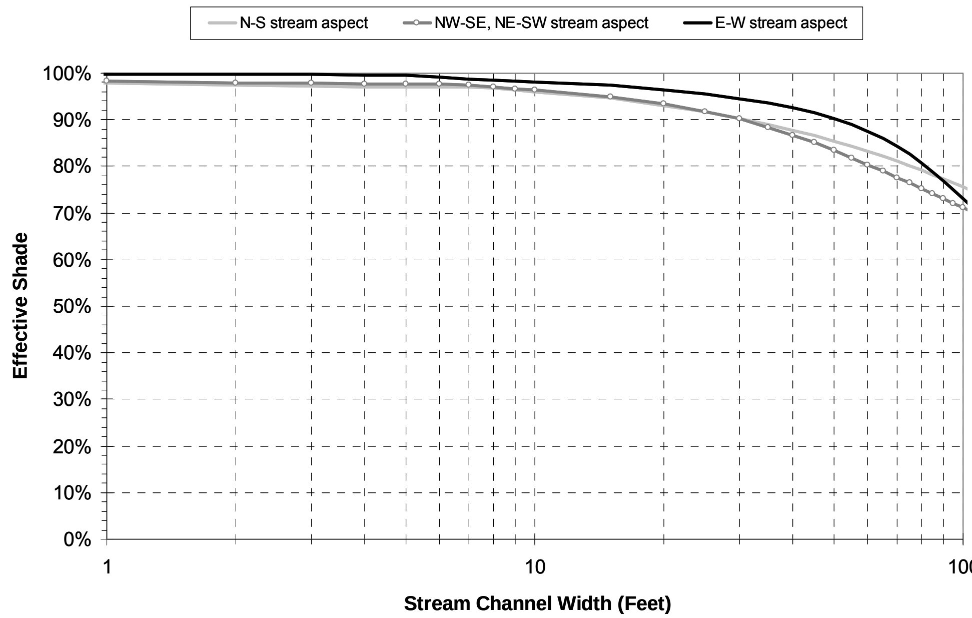


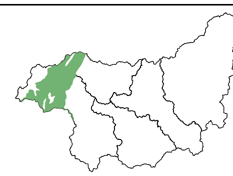
Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).

Ecoregion 78e – Inland Siskiyous: Conifer
(Douglas fir, ponderosa pine, incense cedar, white fir)
Height: 176 ft. Density: 80%





Ecoregion 78f – Coastal Siskiyous: Hardwood
(alder, myrtle, bigleaf maple)
Height: 90 ft. Density: 70%



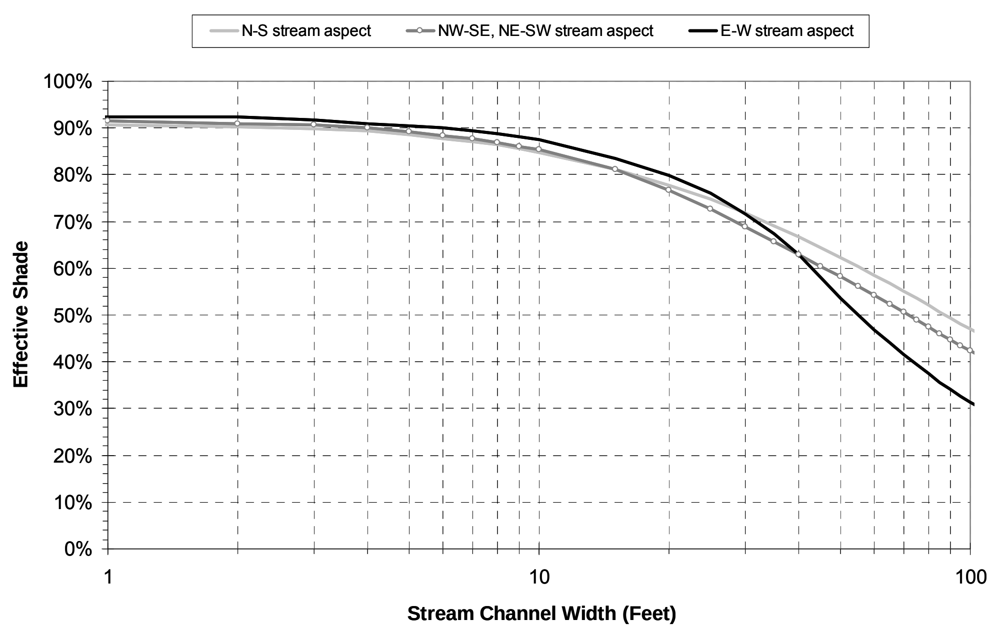
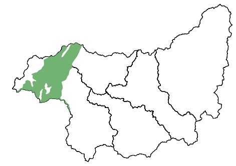


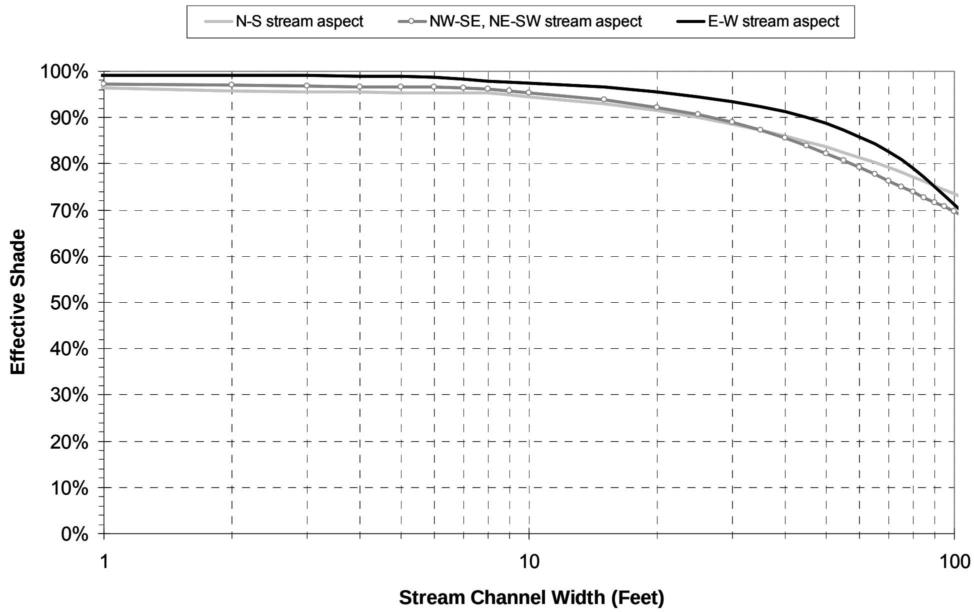
Figure 2.22. Effective shade curves for potential vegetation and ecoregion (continued).

Ecoregion 78f – Coastal Siskiyous : Conifer

(Sitka spruce, western hemlock, Douglas fir, Port Orford cedar, Jeffery pine)

Height: 187 ft. Density: 70%

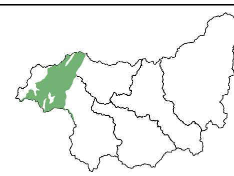


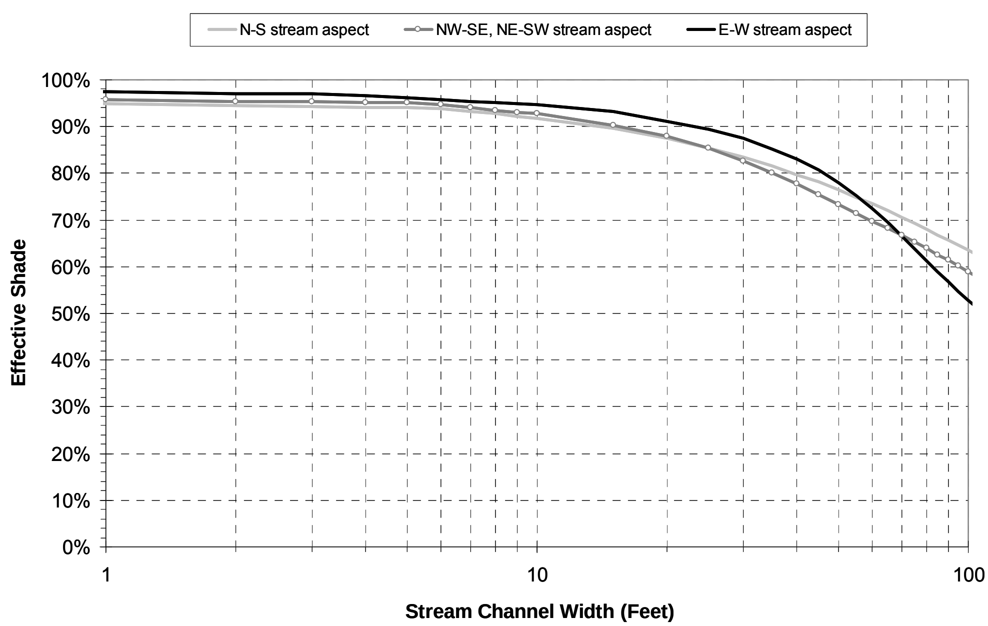


Ecoregion 78f – Coastal Siskiyous: Mixed forest

(Sitka spruce, western hemlock, Douglas fir, Port Orford cedar, Jeffery pine, alder, myrtle, bigleaf maple)

Height: 139 ft. Density: 70%





2.8 PERMITTED POINT SOURCES- WASTE LOAD ALLOCATIONS

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

Point source effects were assessed individually and cumulatively to ensure compliance with the human use allowance (OAR 340-0041-0028(b)). This element explains the waste load allocations for all point source discharges regulated under the NPDES permit process. WLAs apply during the critical period defined previously as April 1 through October 31. The allocations of sources with the greatest likelihood to impact stream temperatures have been quantified while the approach to quantifying other facilities' allocations is described below. If the thermal regime changes and there is a different period in which temperatures are greater than the biological based criteria, the WLA period would adjust accordingly.

As discussed in Section 2.4.2, it was determined that facilities with a general permit did not have a reasonable potential to impact stream temperatures. Therefore, these facilities are allocated their current heat load and the facilities' impact is expected to be negligible. If future data indicate otherwise, a portion of the reserve capacity may need to be allocated to that facility.

This section applies only to waterbodies with individual NPDES permitted point sources: the Rogue River, Illinois River, Big Butte Creek, Harris Creek, and Military Slough. Of these waterbodies, only the Rogue River was analyzed to determine NTP and to quantify cumulative impacts of point sources due to data and resource limitations. Cumulative effects of point source impacts are not possible in the tributaries to the Rogue River because there are not multiple point sources to any of the tributaries. Sources which discharge to tributaries of the Rogue are not likely to contribute to cumulative impact on the Rogue River (discussion following Rogue River WLAs).

Although the current impact of point source heat load to the Rogue River is within the 0.3 °C human use allowance, WLAs are necessary to protect from further degradation, to allow for allocations to other sources, and to establish a reserve capacity. WLAs are flow-based heat load allocations meant to restrict point sources to a 0.2 °C cumulative increase to the 7- day average of the daily maximum (7DADM) temperature at river flows equal to or greater than the 7-day average low flow with a 10-year recurrence (7Q10). The point sources which discharge directly to the Rogue River receive explicit waste load allocations, except for All Weather Wood Treaters. The All Weather Wood Treaters' permit is for stormwater discharge and is not believed to be a significant source of heat and therefore receives the same allocation as a general permit. For point sources which discharge to tributaries (Butte Falls, Cave Junction, Cascade Wood and Flemming Middle School), an allocation approach is described rather than a quantified allocation.

There are seven point sources which discharge into the Rogue River and received quantified WLAs. The WLA for each is determined by using the applicable criterion, the allowable temperature increase, and the river and effluent flow rates.

The applicable criterion is determined through the following methodology. At the outfall location of each of these sources, the temperature model was used to calculate the NTP. The NTP criterion was determined for nine time periods during the period of impairment using the median of the predicted 7DADM 2003 NTP for that time period. The applicable 7DADM criterion is the greater of the biologically based criteria or the NTP criteria (**Table 2.15 (A-G)**).

Table 2.15 (A-G). Applicable temperature criterion for the Rogue River at the location of each point source.

A. Country Wide Mobile Home Estates

Time Period	7-day average of the daily maximum (°C) Biologically Based Criterion	Median NTP	Applicable Criterion*
Apr 1 – Apr 30	13.0	8.3	13.0
May 1 – Oct 31	No discharge		

* As used in Box 2.1

B. Shady Cove WWTP

Time Period	7-day average of the daily maximum (°C) Biologically Based Criterion	Median NTP	Applicable Criterion*
Apr 1 - May 15	13.0	8.5	13.0
May16 - May 31	13.0	11.6	13.0
Jun 1 - Jun 15	13.0	14.3	14.3
Jun 16 - Jun 30	16.0	14.6	16.0
Jul 1 - Aug 31	16.0	16.1	16.1
Sep1 - Sep 15	16.0	15.1	16.0
Sep 16 - Sep 30	13.0	12.6	13.0
Oct 1 - Oct 15	13.0	11.3	13.0
Oct 16 - Oct 31	13.0	9.3	13.0

* As used in Box 2.1

C. Medford WWTP

Time Period	7-day average of the daily maximum (°C) Biologically Based Criterion	Median NTP	Applicable Criterion*
Apr 1 - May 15	13.0	9.3	13.0
May16 - May 31	13.0	13.5	13.5
Jun 1 - Jun 15	13.0	16.5	16.5
Jun 16 - Jun 30	16.0	16.7	16.7
Jul 1 - Aug 31	16.0	19.4	19.4
Sep1 - Sep 15	16.0	17.9	17.9
Sep 16 - Sep 30	13.0	15.5	15.5
Oct 1 - Oct 15	13.0	13.6	13.6
Oct 16 - Oct 31	13.0	11.4	13.0

* As used in Box 2.1

D. Gold Hill WWTP

Time Period	7-day average of the daily maximum (°C) Biologically Based Criterion	Median NTP	Applicable Criterion*
Apr 1 - May 15	13.0	9.8	13.0
May16 - May 31	18.0	13.7	18.0
Jun 1 - Jun 15	18.0	16.8	18.0
Jun 16 - Jun 30	18.0	17.4	18.0
Jul 1 - Aug 31	18.0	19.8	19.8
Sep1 - Sep 15	18.0	18.6	18.6
Sep 16 - Sep 30	18.0	15.3	18.0
Oct 1 - Oct 15	18.0	14.0	18.0
Oct 16 - Oct 31	13.0	10.9	13.0

* As used in Box 2.1

E. Rogue River WWTP

Time Period	7-day average of the daily maximum (°C) Biologically Based Criterion	Median NTP	Applicable Criterion*
Apr 1 - May 15	13.0	10.0	13.0
May16 - May 31	18.0	13.8	18.0
Jun 1 - Jun 15	18.0	17.0	18.0
Jun 16 - Jun 30	18.0	17.5	18.0
Jul 1 - Aug 31	18.0	19.8	19.8
Sep1 - Sep 15	18.0	18.8	18.8
Sep 16 - Sep 30	18.0	15.2	18.0
Oct 1 - Oct 15	18.0	14.1	18.0
Oct 16 - Oct 31	13.0	11.0	13.0

* As used in Box 2.1

F. Grants Pass WWTP

Time Period	7-day average of the daily maximum (°C) Biologically Based Criterion	Median NTP	Applicable Criterion
Apr 1 - May 15	13.0	10.1	13.0
May16 - May 31	18.0	14.0	18.0
Jun 1 - Jun 15	18.0	17.6	18.0
Jun 16 - Jun 30	18.0	18.2	18.2
Jul 1 - Aug 31	18.0	20.9	20.9
Sep1 - Sep 15	18.0	19.6	19.6
Sep 16 - Sep 30	18.0	16.2	18.0
Oct 1 - Oct 15	18.0	14.5	18.0
Oct 16 - Oct 31	13.0	11.0	13.0

* As used in Box 2.1

G. Riviera Mobile Park WWTP

Time Period	7-day average of the daily maximum (°C) Biologically Based Criterion	Median NTP	Applicable Criterion*
Apr 1 – Apr 30	13.0	9.9	13.0
May 1 – Oct 31		No discharge	

* As used in Box 2.1

The allowable temperature increase for each source is determined through the following methodology. Because their impacts are minor, the allowable temperature increases for Country View Mobile Home Estates, Shady Cove, Gold Hill, Rogue River and Riviera Mobile Park are based on their dry weather design flow as stated in their current NPDES permit and effluent temperatures reported in 2003. Country View Mobile Home Estates and Riviera Mobile Park current permits do not allow for discharge of effluent between May 1 and October 31. Therefore, their WLA is only applicable during April. The model was used to estimate how much of the heat load contributed by sources is dissipated in the downstream direction. The allowable temperature increases for Medford and Grants Pass were derived through iterative model runs so that the 95^{th} percentile of the cumulative impact of all point sources does not exceed 0.20 °C (**Figure 2.23)** The allowable temperature increases are shown in **Table 2.16**.

An apparent increase in temperature is noticeable between Medford WWTP and the confluence with Bear Creek, referenced as “A” in **Figure 2.23**. The apparent increase is an artifact due to the metric used in the water quality standard (change in daily maximum temperature) and is not an actual gain in heat load in that reach. A similar graph to **Figure 2.23** but showing the change in daily mean temperatures would not have this apparent increase in temperature and would show source impact dissipating in the downstream direction. The WLA allocation scenario represented in **Figure 2.23** assumes that point source flow and temperature are constant throughout each day (although the temperature varies from day to day). Since the flow and temperature of the source is constant but the river temperature is fluctuating, the greatest change in temperature is realized during the time of day when stream temperatures are the coolest. For example, at the Medford outfall, stream temperature are coolest at 9:00 AM and at this time Medford WWTP’s WLA is predicted to warm the river by 0.35 °C, even though their impact at the time of daily maximum temperatures (the water quality metric for which WLAs apply) is 0.18 °C. Therefore, the parcel of water that is heated by 0.35 °C in the morning results in a 0.20 °C increase in the afternoon at the confluence of Bear Creek, the point of maximum impact for Medford WWTP.

Given the allowable temperature increase at the outfall and the applicable criteria, flow-based heat load and effluent temperature targets for any of the sources can be calculated using the equations in **Box 2.1**. Example calculations of the WLA for October and April 2003 are shown in **Table 2.17** and **Table 2.18**, respectively. As per OAR 340-041-0028 12(b)(D)(d), an exceedance of the waste load allocation will not be considered a permit violation during stream flows that are less than a 7Q10 low flow condition. Applicable 7Q10s will be determined as part of the NPDES permitting process.

Figure 2.23. Modeled cumulative downstream impacts of WLAs on the Rogue River (95th percentile not to exceed 0.2 °C increase in 7DADM at the point of maximum impact)

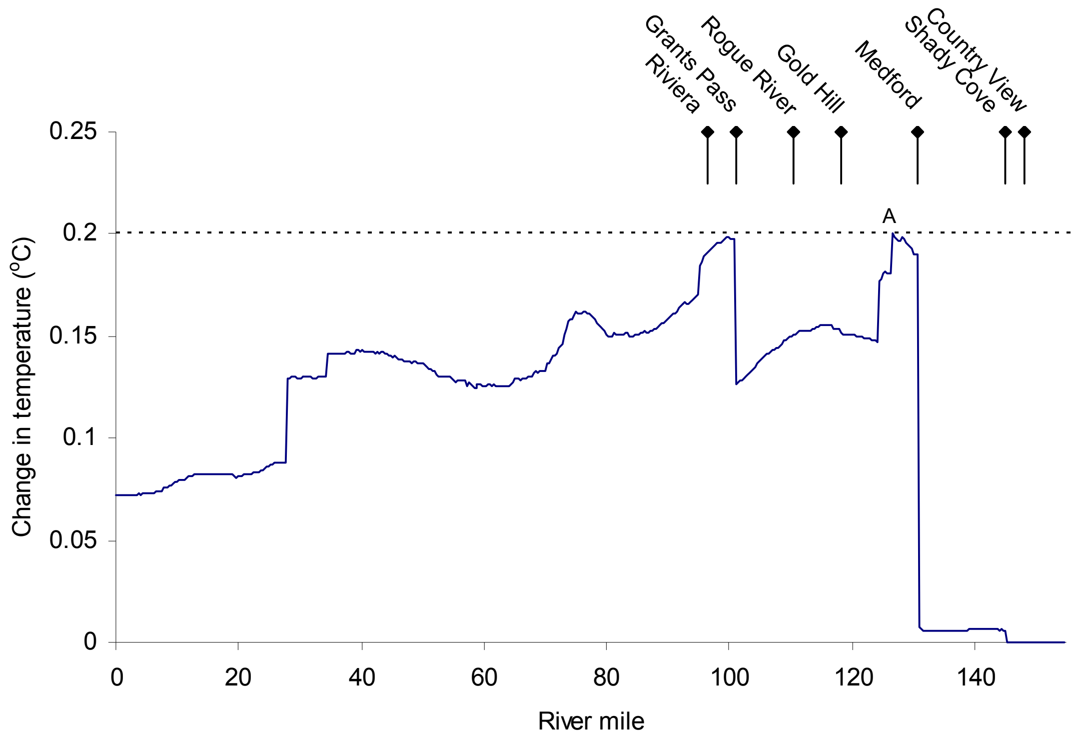


Table 2.16. Allowable temperature increases allocated to individual point sources

Point Source name	River Mile / km	Maximum Permitted Flow (MGD)[1]	Allowable Temperature Increase (°C)
Country View Mobile Home Estates[2,3]	148.2 / 238.6	0.01	0.000029
City of Shady Cove WWTP	143.1 / 233.6	0.45	0.0092
City of Medford WWTP	130.8 / 210.6	20.0	0.1772
City of Gold Hill WWTP	118.1 / 190.2	0.35	0.0057
City of Rogue River WWTP	110.5 / 178.0	0.43	0.0043
City of Grants Pass WWTP	100.9/ 162.8	6.4	0.0709
Riviera Mobile Park[2]	96.4 / 155.2	0.03	0.000055

1. Maximum Permitted Flow refers to dry weather design flow as stated in NPDES permits
2. Current permits do not allow for discharge of effluent between May 1 and October 31. Therefore, their WLA is only applicable during April.
3. No temperature data reported in the discharge monitoring reports for 2003, used Shady Cove data as a surrogate.

Box 2.1

Rogue River Basin Thermal Waste Load Allocations

Thermal waste load allocations are expressed as heat loads, which are dependent upon upstream river flow and effluent flow. Effluent flow and river flow change over time. The following equation is used to calculate the thermal waste load allocations in the Rogue River basin for any given effluent flow and river flow.

$$H_{WLA} = (\Delta T)(Q_e + Q_R)C_F \qquad \text{(Equation 2-4)}$$

Where,

H_{WLA} = Waste Load Allocation, heat load, $kcal/day$

ΔT = allowable temperature increase, ^{o}C

Q_R = river flow rate, upstream, ft^3/s

Q_e = effluent flow rate, ft^3/s

C_F = conversion factor

$$C_F = 2{,}446{,}665 \frac{kcal \cdot s}{^{o}C \cdot ft^3 \cdot day}$$

In order to translate a thermal waste load allocation into an effluent temperature, the applicable temperature criterion must also be accounted for. The applicable temperature criterion is either the biologically based numeric criteria presented in OAR 340-041-0028(4) or the natural thermal potential, if it has been calculated for that receiving water body during the applicable time period. The following equation is used to calculate the effluent temperature limit for any given effluent flow, river flow, and river temperature.

$$T_{WLA} = \frac{(Q_e + Q_R)(T_R + \Delta T) - (Q_R)(T_R)}{Q_e} \qquad \text{(Equation 2-5)}$$

Where,

T_{WLA} = Waste Load Allocation, Temperature as a 7-day average of the daily maximum (7DADM), ^{o}C

T_R = Applicable 7DADM criterion (see Tables 2.15 A - G), ^{o}C

Table 2.17. Example calculations of Waste Load Allocation for October 2003.

Point Source name	Allowable Temperature Increase (°C)	October 2003 Data			WLA (million Kcal/day)
		Rogue River Flow Average[2] (cfs)	Average Source flow, (MGD)	Average Source Flow (cfs)	
Country View Mobile Home Estates[1]	0.0000	1022	0.00	0.00	0.0
City of Shady Cove WWTP	0.0092	1023	0.24	0.37	23.0
City of Medford WWTP	0.1772	1063	14.6	22.6	471
City of Gold Hill WWTP	0.0057	1118	0.086	0.133	15.6
City of Rogue River WWTP	0.0043	1289	0.24	0.37	13.7
City of Grants Pass WWTP	0.0709	1250	3.97	6.14	218
Riviera Mobile Park[1]	0.0000	1250	0.00	0.00	0.0

[1] Country View Mobile Home Estates and Riviera Mobile Park current permits do not allow for discharge of effluent between May 1 and October 31. Therefore, their WLA is only applicable during April.
[2] As per OAR 340-041-0028 12(b)(D)(d) An exceedance of the waste load allocation will not be considered a permit violation during stream flows that are less than a 7Q10 low flow condition. Applicable 7Q10s will be determined as part of the NPDES permitting process.

Table 2.18. Example calculations of Waste Load Allocation for April 2003.

Point Source name	Allowable Temperature Increase (°C)	April 2003 Data			WLA (million Kcal/day)
		Rogue River Flow Average[2] (cfs)	Average Source flow, (MGD)	Average Source Flow (cfs)	
Country View Mobile Home Estates[1]	0.000029	3122	0.01	0.02	0.22
City of Shady Cove WWTP	0.0092	3124	0.51	0.79	70
City of Medford WWTP	0.1772	3498	22.53	34.9	1532
City of Gold Hill WWTP	0.0057	4481	0.09	0.133	63
City of Rogue River WWTP	0.0043	5689	0.38	0.59	60
City of Grants Pass WWTP	0.0709	5676	6.35	9.82	986
Riviera Mobile Park	0.000055	5678	0.02	0.02	0.76

[1] No temperature data reported in the discharge monitoring reports for 2003, used Shady Cove data as a surrogate.
[2] As per OAR 340-041-0028 12(b)(D)(d) An exceedance of the waste load allocation will not be considered a permit violation during stream flows that are less than a 7Q10 low flow condition. Applicable 7Q10s will be determined as part of the NPDES permitting process.

There are four sources which discharge into tributaries of the Rogue River that are within the scope of this TMDL (**Table 2.19**). The impact of these sources on their specific receiving waterbody is not known. Since these sources are the only point sources which discharge into their respective waterbody, there is no cumulative effect in the receiving streams. During the permit renewal process, it will be determined if the source warms its receiving waterbody by less than 0.3°C above the applicable criteria given 25% of the waterbody for mixing at a 7Q10 flow as per OAR 340-041-0028(12)(b). If so, then the WLA allocation is a 0.3 °C increase to the biologically based criterion based on 25% of the 7Q10 or the source's current heat load. If not, then the WLA is determined using a flow-based 0.2 °C increase to the biologically based criterion with up to 100% dilution of river flows equal or greater than the 7Q10. The equation to calculate the WLA is presented in **Box 2.1**.

The four sources which discharge into tributaries will likely not impact the temperature of the Rogue River at the outfall locations of Medford and Grants Pass (the two locations where point sources are predicted to use the entire allocated 0.2°C HUA)(Figure 2.1). This conclusion is based on the following: (1) comparing these sources to other sources on the Rogue River and using conservative assumptions, their cumulative impact is likely less than 0.01 °C, (2) the impact of two of the sources would be downstream of the points of maximum impact, and (3) a portion of the heat load would be dissipated in the receiving stream.

Table 2.19. Point sources that discharge to tributaries to the Rogue River. These sources are given an allocation in the form of equations which will be used to set numeric targets in the permits.

Point Source name	Stream name	Point of discharge (miles from Rogue River)	Tributary confluence with the Rogue River (miles from mouth of Rogue River)
Town of Butte Falls	South Fork Big Butte Creek	12.5	155.5
Cascade Wood	Military Slough	1.6	132.5
Three Rivers School District, Fleming Middle School WWTP	Harris Creek, tributary to Jumpoff Joe Creek	7.1	83.5
City of Cave Junction	Illinois River	54.6	27.5

Sources that may be required to upgrade their facilities to comply with their WLAs may wish to consider water quality trading. Trading programs allow regulated parties to meet their obligations by purchasing environmentally equivalent or greater protection from another point or nonpoint source, including dams and reservoirs. DEQ's policy is presented in Water Quality Trading, Internal Management Directive (2005b). The point of maximum impact for all sources was determined to occur at approximately river mile 62 (river kilometer 100) by taking the difference of current conditions from the applicable criteria (shown in Figure 2.18 for the day of greatest average excursion). Given that the point of maximum impact for all sources is at of river mile 62 (**Figure 2.18**), Medford WWTP could trade with nonpoint sources within the Bear Creek watershed to help meet its WLA.

2.9 ROGUE RIVER RESERVE CAPACITY

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

There is an explicit allocation for reserve capacity throughout the mainstem Rogue River and its tributaries set aside for future growth and new, expanded or unidentified sources. The general framework of the TMDL allocates 0.05°C or 1/6th of the human use allowance to reserve capacity, at the points of maximum impact. 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.

2.10 MARGINS OF SAFETY

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

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS) to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. An MOS 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 MOS may be implicit, as in conservative assumptions used in calculating the loading capacity, Waste Load Allocation, and Load Allocations. The MOS 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 MOS documented. The MOS is not meant to compensate for a failure to consider known sources. **Table 2.20** presents six approaches for incorporating a MOS into TMDLs.

Table 2.20. 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 MOS.
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* MOS has been incorporated into the temperature assessment methodology for the Rogue River Basin Temperature TMDL:

- Conservative estimates for unmeasured data were used in the stream temperature simulations.
- The natural thermal potential target for the WLAs was derived using the median natural thermal potential for each time period leading to a more conservative target than using a 90th percentile, for example.
- The cumulative effects analysis used the 95th percentile to predict heat dissipation between sources. Therefore, 95% of the time, there will actually be greater heat dissipation and less of the human use allowance will be utilized.
- The cumulative effects analysis also assumed that all sources would be discharging the maximum allowable load, likely a rare situation.
- The estimate of natural thermal potential temperature does not include an estimate of the impact of natural disturbance of the riparian area. This likely results in a cooler estimate than actual NTP.

For further information regarding stream temperature modeling assumptions, refer to the **Appendices A** and **B.**

2.11 REFERENCES

Bell, M. C. (1986). Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program, US Army Corps of Engineers, North Pacific Division. Portland, Oregon, 290 pp.

Brett, J. R. (1952). Temperature tolerance in young pacific salmon, genus *Oncorhynchus*. *J. Fish Res. Bd. Can*., 9(6):265-323.

Chen, J., Saunders, S. C., Crow, T. R., Naiman, R. J., Brosofske, K. D., Mroz, G. D., Brookshire, B. L., and Franklin, J. F. (1999). Microclimate in Forest Ecosystem and Landscape Ecology. BioScience, 49(4):288-297.

Department of Environmental Quality (1995). Temperature 1992-1994 Water Quality Standards Review. DEQ Standards and Assessment Section. 811 6th Ave., Portland, Oregon 97204.

Department of Environmental Quality (1999). *Water Quality Management Plan*, Rogue River Basin Illinois River Sub Basin.

Department of Environmental Quality (2002a). *Total Maximum Daily Load and Water Quality Management Plan.* Lower Sucker Creek, Illinois Subbasin,

Department of Environmental Quality (2002b). *Total Maximum Daily Load and Water Quality Management Plan.* Lobster Creek, Lower Rogue Subbasin

Department of Environmental Quality (2003). *Total Maximum Daily Load.* Applegate Subbasin

Department of Environmental Quality (2005a). Assessment Methodology for Oregon's 2004 Integrated Report on Water Quality Status. DEQ Water Quality Division, August 12, 2005.

Department of Environmental Quality (2005b). Water Quality Trading Internal Management Directive, available at http://www.deq.state.or.us/wq/trading/trading.htm

Department of Environmental Quality (2006). *Total Maximum Daily Load.* Willamette River Basin.

Department of Environmental Quality (2007a). *Total Maximum Daily Load.* Bear Creek Watershed

Department of Environmental Quality (2007b). Evaluation Report and Findings Record, Certification Pursuant to Section 401 of the Federal Clean Water Act, Prospect No. 1, 2, and 4 Hydroelectric Project.

Falk, J. & Harmon, R. (1995), Oregon Dams, ARC/INFO coverage, Oregon Water Resources Department, Salem, Oregon.

Federal Energy Regulatory Commission (2006). Final Environmental Assessment for Hydropower License, Prospect Nos. 1, 2, and 4 Hydroelectric Project, FERC Project No. 2630-004, Oregon, Page 18

Heath, A. G., & Hughes, G. M. (1973). Cardiovascular and respiratory changes during heat stress in rainbow trout (*Salmo gairneri*). *J. Exp. Biol*., 59:323-338.

Hogan, J. W. (1970). Water Temperature as a Source of Variation in Specific Activity of Brain

Acetylcholinesterase of Bluegills. *Bull. Environment. Contam. Toxicology. 5:347-353*.

Hokanson, K. E. F., Kleiner, C. F., and Thorslund, T. W. (1977). Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates and yield of juvenile rainbow trout, *Salmo gairdneri*. *J. Fish. Res. Bd. Can*., 34:639-648

Johnson, D.M., Petersen, R.R., Lycan, D.R., Sweet, J.W., Neuhaus, M.E., & Schaedel, A.L. (1985). *Atlas of Oregon Lakes*, Oregon State University Press, Corvallis, Oregon.

Khangaonkar, T. & Yang, Z. (2008). Dynamic Response of Stream Temperatures to Boundary and Inflow Perturbation due to Reservoir Operations, *River Research and Applications*, 24(4):420-433.

Oregon Department of Fish and Wildlife (1990). Effects of Lost Creek Dam on winter steelhead in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

Oregon Department of Fish and Wildlife (1991). Effects of Lost Creek Dam on coho salmon in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

Oregon Department of Fish and Wildlife (1992). Effects of Lost Creek Dam on fall chinook salmon in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

Oregon Department of Fish and Wildlife (1994). Effects of Lost Creek Dam on summer steelhead in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

Oregon Department of Fish and Wildlife (2000). Effects of Lost Creek Dam on spring chinook salmon in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

Oregon Department of Fish and Wildlife (2007). Rogue Spring Chinook Salmon Conservation Plan. Oregon Department of Fish and Wildlife, Salem.

Oregon Water Resources Department (1980). Rogue River Drainage Basin, Oregon, Map No. 15.6. Salem, Oregon.

U.S. Army Corps of Engineers (1972). Final environmental statement. Lost Creek Lake Project, Rogue River, Oregon. Portland District, Portland, Oregon.

U.S. Army Corps of Engineers (1983). Water quality investigations--1981, Lost Creek Lake Project, Rogue River, Oregon. Portland District, Portland, Oregon.

U.S. Congress (1962). Rogue River basin, Oregon and California. Public Law 87-874, 87th Congress, 2nd Session, House Document 566.

U.S. Environmental Protection Agency (2003). EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards, Office of Water, EPA 910-B-03-002.