Little Klickitat River Watershed Temperature Total Maximum Daily Load

Submittal Report

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by

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Introduction

Section 303(d) of the federal Clean Water Act mandates that states establish Total Maximum Daily Loads (TMDLs) for surface waters that do not meet water quality standards after application of technology-based pollution controls. The U.S. Environmental Protection Agency (EPA) has promulgated regulations (40 CFR 130) and developed guidance (EPA, 1991) for establishing TMDLs.

Under the Clean Water Act, every state has its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses, such as cold water biota and drinking water supply, and criteria, usually numeric criteria, to achieve those uses. When a lake, river or stream fails to meet water quality standards after application of required technology-based controls, the Clean Water Act requires the state to place the water body on a list of "impaired" water bodies and to prepare an analysis called a Total Maximum Daily Load (TMDL).

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant that can be discharged to the water body and still meet standards, the loading capacity, and allocates that load among the various sources. If the pollutant comes from a discrete source (referred to as a point source) such as an industrial facility's discharge pipe, that facility's share of the loading capacity is called a wasteload allocation. If it comes from a diffuse source (referred to as a nonpoint source) such as a farm, that facility's share is called a load allocation.

The TMDL must also consider seasonal variations and include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. The sum of the individual allocations and the margin of safety must be equal to or less than the loading capacity.

Components of the TMDL

The Washington State Department of Ecology (Ecology) is establishing a Total Maximum Daily Load (TMDL) for temperature in the Little Klickitat River watershed. This TMDL will address potential impairments of beneficial uses on eight 303(d) listed segments. The TMDL (covers or addresses) an additional five stream segments that monitoring indicated are also impaired for temperature, but were not on the 303(d) list. This TMDL report addresses temperatures in surface waters throughout the Little Klickitat River Watershed. The recommendations and implementation strategies are intended to be implemented not only on the segments identified as impaired on the 303(d) list, but throughout the watershed.

The five components of any TMDL as required by the Clean Water Act are defined as:

Loading Capacity: The amount of pollutants that a waterbody can receive without violating water quality standards. In the case of the Little Klickitat watershed, the loading capacity for temperature is better viewed as site potential shade and its effect on heat loading to surface waters.

Wasteload Allocation: The portion of a receiving water's loading capacity that is allocated to one of the existing or future point sources of pollution. The wasteload allocations for the WWTP is calculated based on meeting the proposed water quality-based permit limits.

Load Allocations: The portion of a receiving water's capacity that is attributed either to one of its existing or potential nonpoint sources of pollution or to natural background sources.

Margin of Safety: There are several implicit assumptions in the loading capacity calculations that provide a margin of safety.

Seasonal Variation: Temperature data collected in the Little Klickitat River watershed show a definite pattern of seasonal variation. June through September is the critical period for temperature levels in the watershed, corresponding to lower flows and higher temperatures. The critical period is when water quality is most likely to exceed water quality temperature standards

Background

The Little Klickitat River Basin is located in south-central Washington State. It flows from the southwest flank of the Simco Mountains, west across the Munson Prairie and through the Little Klickitat canyon to its confluence with the Klickitat River. The Little Klickitat Watershed encompasses approximately 285 square-miles and runs solely through Klickitat County and the Central Klickitat Conservation District (CKCD). The Little Klickitat River, East Prong, West Prong, and Butler Creek are listed on the 1996 and 1998 Washington State 303(d) list for elevated water temperatures. Fieldwork by Ecology, the CKCD, and Yakama Nation Fisheries staff confirmed many cases of high surface water temperatures throughout the basin.

Effective shade is used as a surrogate measure of heat flux (heating of the river caused by solar radiation) to fulfill the requirements of Section 303(d) for a Total Maximum Daily Load (TMDL) for temperature. Effective shade is defined as the fraction of incoming solar short wave radiation above the vegetation and topography that is blocked from reaching the surface of the stream. In general, the load allocations for effective shade under this TMDL are as follows:

- For the entire Little Klickitat watershed, including Butler Creek, East Prong, and West Prong, 95 to 50% effective shade produced by a mature riparian corridor is the load allocation for shade from riparian vegetation.
- For portions of the Little Klickitat River and West Prong, additional temperature reduction may be possible through the reduction of the wetted width-to-depth (W/D) ratio. As riparian vegetation stabilizes the banks and captures sediment it will reduce the width of the stream.
- For all perennial streams in the Little Klickitat River watershed that were not specifically modeled, including Bowman, Mill, Spring, and Blockhouse creeks, and that exceeded the water quality standard during critical and median conditions (Figures 6 and 7), 73% effective shade produced by mature riparian vegetation is the load allocation. An effective shade of 73% is the average load allocation for all modeled segments on the Little Klickitat River, West Prong, and Butler Creek. Additionally, Bloodgood Creek, which does not exceed numeric water quality standards, provides the only source of cooling water to the Little Klickitat River. Efforts should be made to protect this source of cool water.

In addition to the load allocations for effective shade, other management activities are recommended for reduction of water temperature including measures to reduce sediment loading and to promote water use efficiency.

The Goldendale Wastewater Treatment Plant (WWTP) is the sole point source discharger in the Little Klickitat basin. Under the current load allocations, the upstream temperature complies with the water quality standard of 18^{o}C; consequently, the wasteload allocation for the Goldendale WWTP effluent is established as 18.3^{o}C.

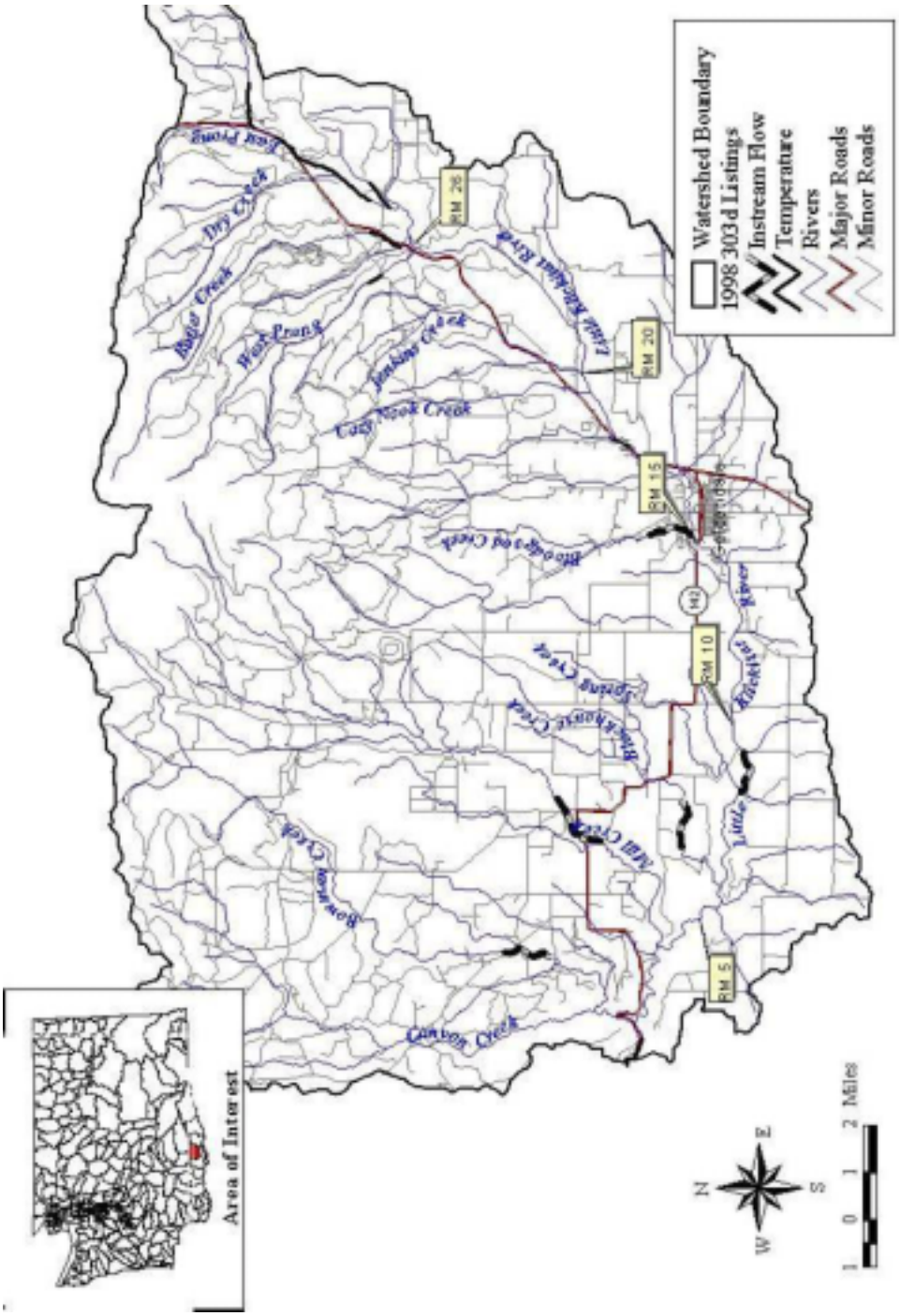


Figure 1: Little Klickitat Watershed

Applicable Water Quality Standards

Within the state, water quality standards are published pursuant to Chapter 90.48 of the Revised Code of Washington (RCW). Authority to adopt rules, regulations, and standards as necessary to protect the environment, is vested with Ecology. Under the federal Clean Water Act, the EPA Regional Administrator must approve the water quality standards adopted by the state (Section 303(c)(3)). Through adoption of these water quality standards, the state has designated certain characteristic uses to be protected and the standards necessary to protect these uses [Chapter 173-201A of the Washington Administrative Code (WAC)]. These standards were last adopted in November 1997.

The mainstem Little Klickitat River and its tributaries are designated as Class A waterbodies. The characteristic beneficial uses and water quality standards for this classification are listed below. State law does not establish a ranking or priority among the beneficial uses, but individual waters are expected to support all uses within the classification. This TMDL is designed to address impairments of characteristic (beneficial) uses in the mainstem Little Klickitat River and its tributaries as listed below:

(2) Class A (excellent)

General characteristic. Water quality of this class shall meet or exceed the requirements for all or substantially all uses.

Characteristic uses. Characteristic uses shall include, but not be limited to, the following:

(i) Water supply (domestic, industrial, agricultural).

(ii) Stock watering.

(iii) Fish and shellfish:

Salmonid migration, rearing, spawning, and harvesting.
Other fish migration, rearing, spawning, and harvesting.
Clam, oyster, and mussel rearing, spawning, and harvesting.
Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing, spawning, and harvesting

(iv) Wildlife habitat.

(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).

(vi) Commerce and navigation.caused activities.

The state water quality standards describe temperature standards for the protection of characteristic uses and describe a specific standard for temperature as well as a narrative standard for streams where the natural background temperature is higher than that of the numeric criteria.

(iv) Temperature shall not exceed 18.0°C (freshwater) or 16.0°C (marine water) due to human activities. When natural conditions exceed 18.0°C (freshwater) and 16.0°C (marine water), no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C.

Incremental temperature increases resulting from point source activities shall not, at any time, exceed t=28/(T+7) (freshwater) or t=12/(T-2) (marine water). Incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8°C.

For purposes hereof, "t" represents the maximum permissible temperature increase measured at a mixing zone boundary; and "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

Water Quality and Resource Impairments

As a result of data showing temperature criteria are exceeded, the segments listed in Table 1 are included on Washington State's 1998 and 1996 Section 303(d) list. In total, the Little Klickitat River has 14 water quality impaired sections. Table 1 provides a list of all river segments and corresponding parameters identified as limited according to the Water Quality Standards for Surface Waters of the State of Washington (segments listed for temperature are shown in italics). Because instream flow is not considered a "pollutant," load allocations were not developed. However, flow does impact temperature and its effect on temperature was considered.

Table 1. 303(d) Listings for the Little Klickitat basin (temperatures listings in italics)

Name	T	R	S	New WBID#	Old WBID#	Parameter	Medium	Action	96list	98list
Butler Creek	*05N*	*17E*	*17*	*YU86SG*	*WA-30-1029*	*Temp*	*Water*	*TMDL*	*yes*	*yes*
East Prong	*06N*	*17E*	*35*	*PU81CT*	*WA-30-1028*	*Temp*	*Water*	*TMDL*	*yes*	*yes*
East Prong	*05N*	*17E*	*10*	*PW77VQ*	*WA-30-1028*	*Temp*	*Water*	*TMDL*	*yes*	*yes*
East Prong	*05N*	*17E*	*03*	*PW77VQ*	*WA-30-1028*	*Temp*	*Water*	*TMDL*	*yes*	*yes*
East Prong	*05N*	*17E*	*09*	*PW77VQ*	*WA-30-1028*	*Temp*	*Water*	*TMDL*	*yes*	*yes*
East Prong	*05N*	*17E*	*16*	*AG85MX*	*WA-30-1028*	*Temp*	*Water*	*TMDL*	*yes*	*yes*
Little Klickitat River	*04N*	*14E*	*09*	*AY21LB*	*WA-30-1029*	*Temp*	*Water*	*TMDL*	*yes*	*yes*
West Prong	*05N*	*17E*	*18*	*XU95ML*	*WA-30-1029*	*Temp*	*Water*	*TMDL*	*yes*	*yes*

Table 2 Impaired stream segments not listed on the 303(d) list, but addressed by this TMDL.

Name	*T*	*R*	*S*	*New Water Body Number*	*Old Water Body Number*	*Medium*	*Parameter*
Blockhouse Creek	04N	15E	17	ID95ML	WA-30-1023	Water	Temperature
Bowman Creek	05N	14E	35	TN94DB	WA-3001021	Water	Temperature
Little Klickitat River	04N	15E	28	AY21LB	WA-30-1020	Water	Temperature
Mill Creek	04N	15E	05	FF43IZ	WA-30-1022	Water	Temperature
Mill Creek	04N	15E	15	FF43IZ	WA-30-1022	Water	Temperature

The 303(d) listings for temperature are also confirmed by recent and ongoing monitoring by Ecology, Central Klickitat Conservation District, and Yakama Nation (Figures 2 and 3). Data demonstrates that for 18 of 20 segments, water temperatures exceed the Class A standard of 18 degrees C greater than 50% of the time during July and August 2000 (Figure 4).

While a simple TMDL that addresses only the listed segments could be done, due to the large amount of data that are available it is more efficient to develop the present TMDL to address water temperature in the entire watershed.

Table 2 lists the water body segments that this TMDL report identifies as impaired but not 303(d) listed. Also, since this TMDL sets load allocations for all perennial streams in the watershed, whether listed or not, it is intended to address all temperature problems throughout the watershed.

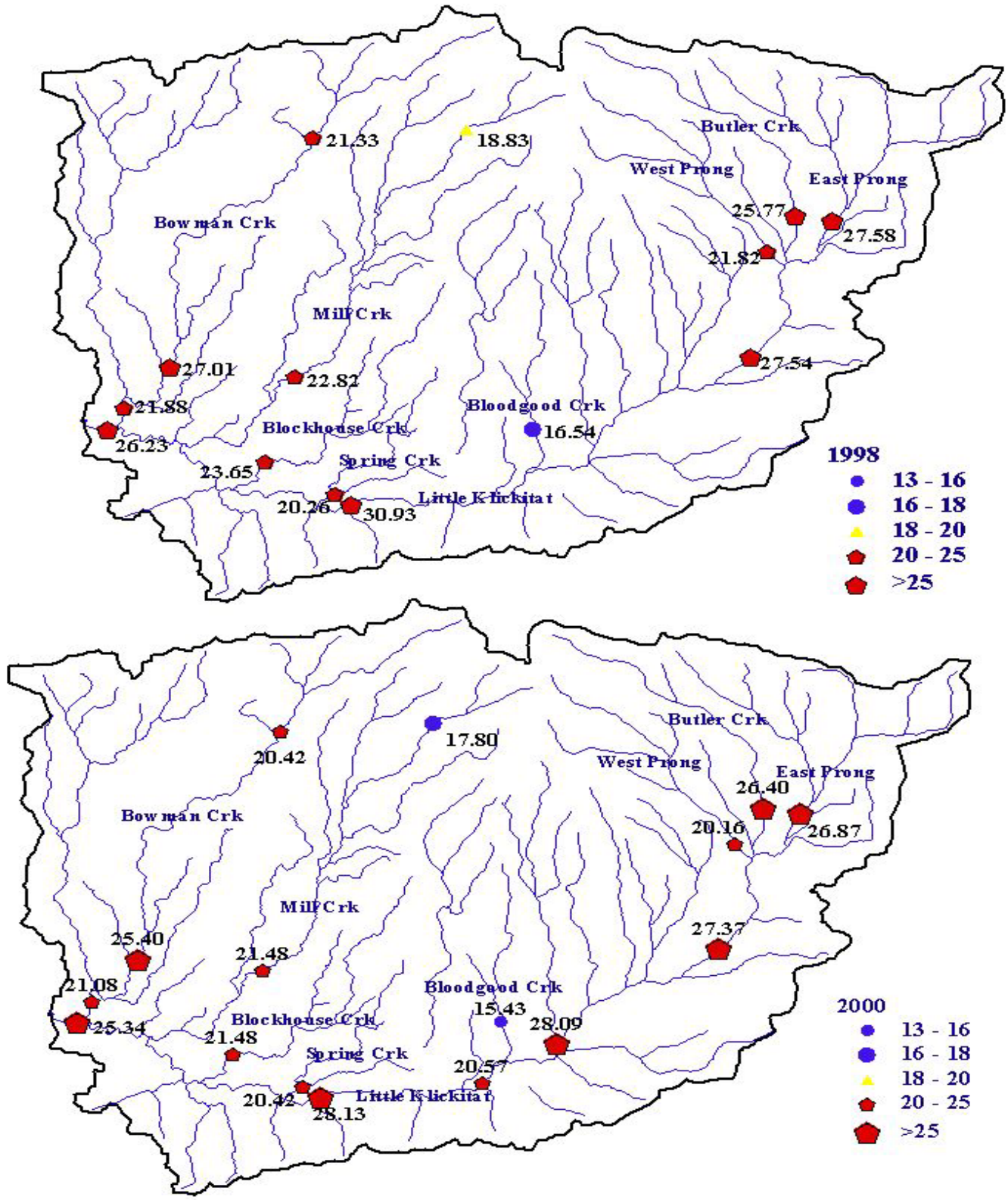


Figure 2: Maximum daily temperatures in the Little Klickitat Watershed in 1998 and 2000 on the hottest day of the year at each station

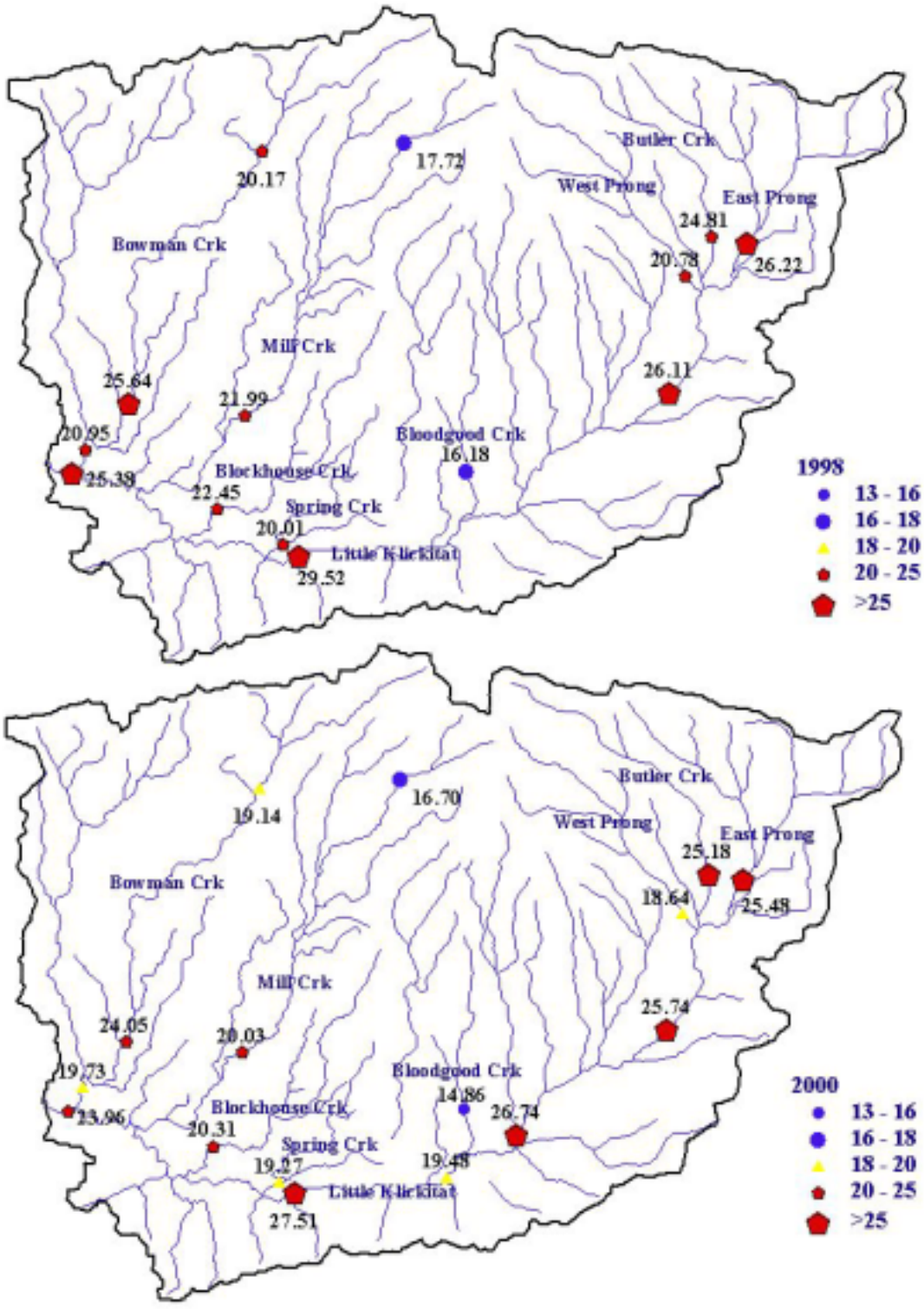


Figure 3: Maximum 7-day averages of daily maximum temperatures in the Little Klickitat River Watershed in 1998 and 2000

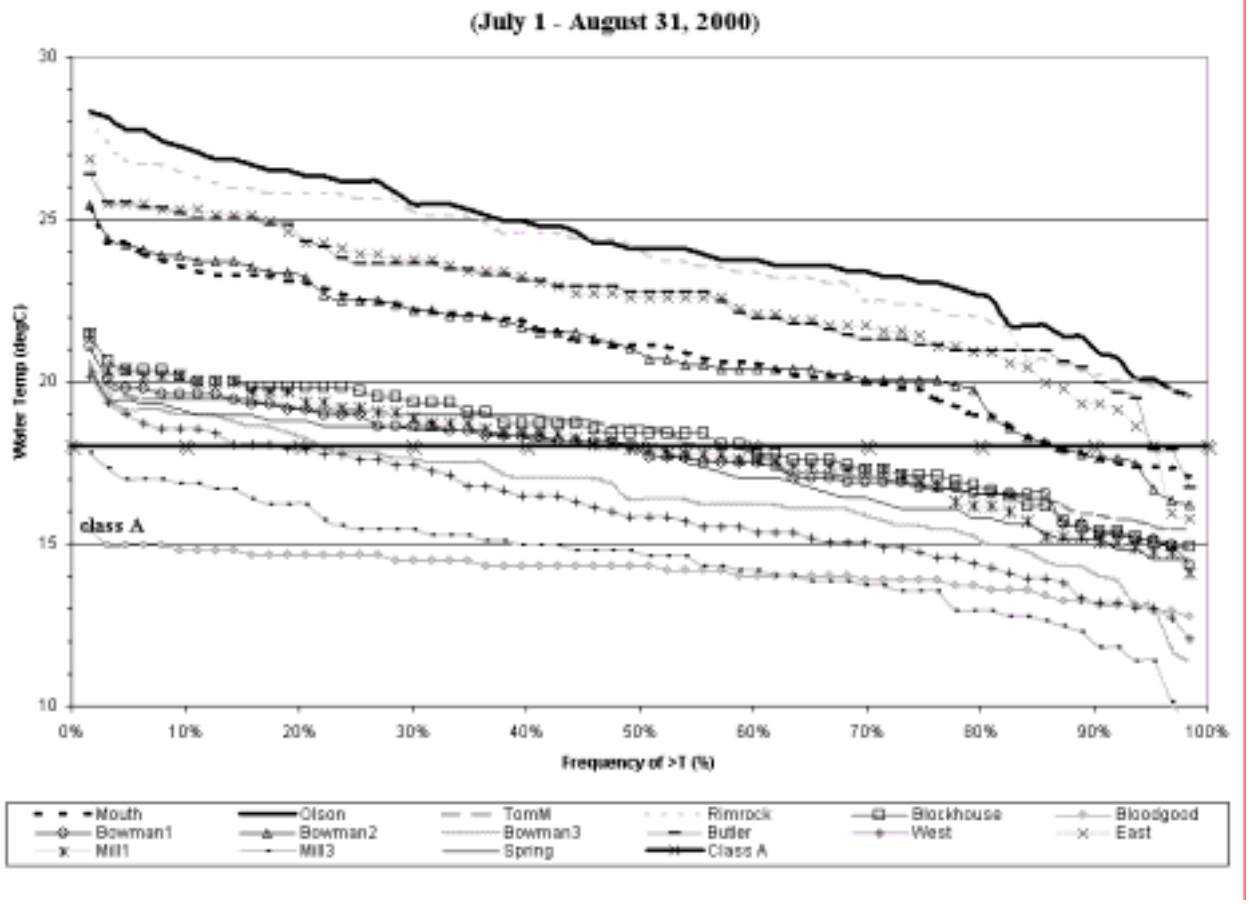


Figure 4: Daily maximum water temperature exceedence frequency distribution for July-August 2000

The 303(d) listings for temperature are also confirmed by the recent and ongoing monitoring by Ecology, CKCD, and Yakama Nation (Figures 2 and 3, Appendix A). Data demonstrate that for 18 of 20 segments, water temperatures exceed the Class A standard of 18°C greater than 50% of the time during July and August, 2000 (Figure 4).

Seasonal Variation

Clean Water Act (CWA) Section 303(d)(1) requires that TMDLs "be established at a level necessary to implement the applicable water quality standards with seasonal variations". The current regulation also states that determination of "TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters" [40 CFR 130.7(c)(1)]. Finally, Section 303(d)(1)(D) suggests consideration of normal conditions, flows, and dissipative capacity.

Existing conditions for stream temperatures in the Little Klickitat watershed reflect seasonal variation. Cooler temperatures occur in the winter, while warmer temperatures are observed in the summer. Figures 2 and 3 summarize the highest daily maximum and the highest seven-day average maximum water temperatures for 1998 and 2000. Monitoring data show that the majority of the temperature measurements exceeding the criteria occur in July and August (Figure 5). Since it is not possible to change allocations of shade over a season, they were set

based on this critical summer period. The modeling analysis used climatic conditions during this critical period for TMDL development.

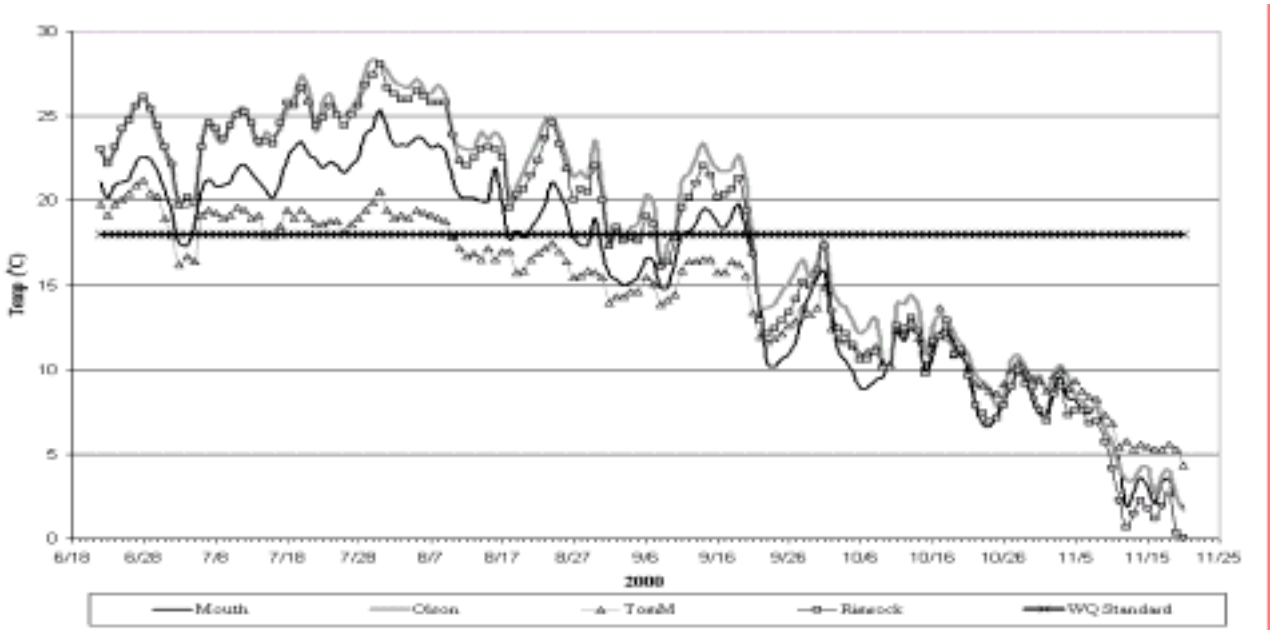


Figure 5: Mainstem Little Klickitat River temperature profile

Seasonal estimates for stream flow, solar flux, and climatic variables for the TMDL are taken into account to develop critical conditions for the TMDL model. The critical period for evaluation of solar flux and effective shade was assumed to be July 15 because it is the approximate mid-point between solar equinox and the period when maximum air and water temperatures occur.

Critical stream flows for the TMDL were evaluated as the lowest seven-day average flows with a two-year recurrence interval (7Q2) and ten-year recurrence interval (7Q10) for the months of July and August. The 7Q2 stream flow was assumed to represent conditions that would occur during a typical climatic year, and the 7Q10 stream flow was assumed to represent a reasonable worst-case climatic year.

Critical conditions for air temperature were represented by the minimum and maximum air temperatures which occurred on the hottest days of 2000 and 1998 (35^{th} percentile and reasonable worst case climatic conditions, respectively). The design years for the 35^{th} percentile and worst-case climatic conditions (2000 and 1998) were selected based on the distribution of maximum one-day-average-daily-maximum air temperatures for each year of observation at the Goldendale Airport from 1931 through 2000. Climatic data from 2000, a 35^{th} percentile year, was used instead of data from a median year because extensive monitoring by Ecology, CKCD, and the Yakama Nation Fisheries show that water temperatures for all stations except four exceed the Class A (18^{o}C) Water Quality Standard over 50% of the time for the critical period of July and August (Figure 4). Additionally, stream flows measured during 2000 correspond with 7Q2 stream flows for the basin (Williams and Pearson, 1985).

Technical Analysis

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 land use activities. The goal of the technical analysis for this TMDL was to assess temperature conditions in the watershed, and to assess the watershed conditions contributing to any temperature impairments in surface waters of the watershed. Additionally, the report modeled target conditions for riparian vegetation along waterways in the Little Klickitat River Watershed.

Ecology collected and analyzed available water temperature data, stream flow data, groundwater data, hydraulic geometry, and riparian vegetation data for input into analytical software that helped Ecology staff model and predict temperature conditions in the watershed.

The data collected for this TMDL allowed the development of a temperature simulation methodology that is both spatially continuous and spans full-day lengths. The geographic information and modeling analysis was conducting using three specialized software tools:

- ODEQ's tools extension for Arcview (ODQ, 2001) was used to sample and process GIS data for input to the HeatSource and QUAL2K models.
- ODEQ's HeatSource model (ODEQ, 2000) was used to estimate effective shade along the mainstem of the Little Klickitat River, West Prong, East Prong, and Butler Creek.
- The QUAL2K model (Chapra, 2001) was used to simulate water temperatures. QUAL2K is a model of water quality for streams and rivers that simulates diurnal variation s in stream temperature for a steady flow condition.

The model was calibrated and verified with and against field data collected during August of 2000.

Appendix B, Little Klickitat River Watershed Temperature Total Maximum Daily Load Technical Report, provides more details on the technical analysis used to calculate the following Loading Capacity, Load Allocation, and Waste Load Allocation.

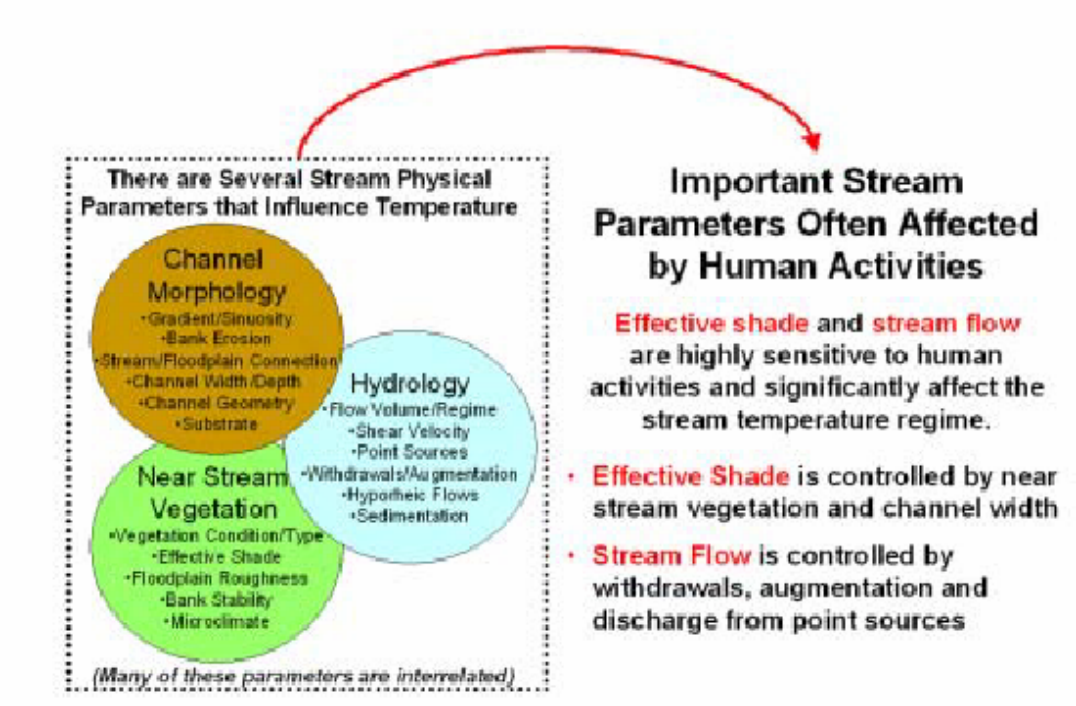


Figure 6: Shade and channel characteristics that impact water temperature (ODEQ, 2002)

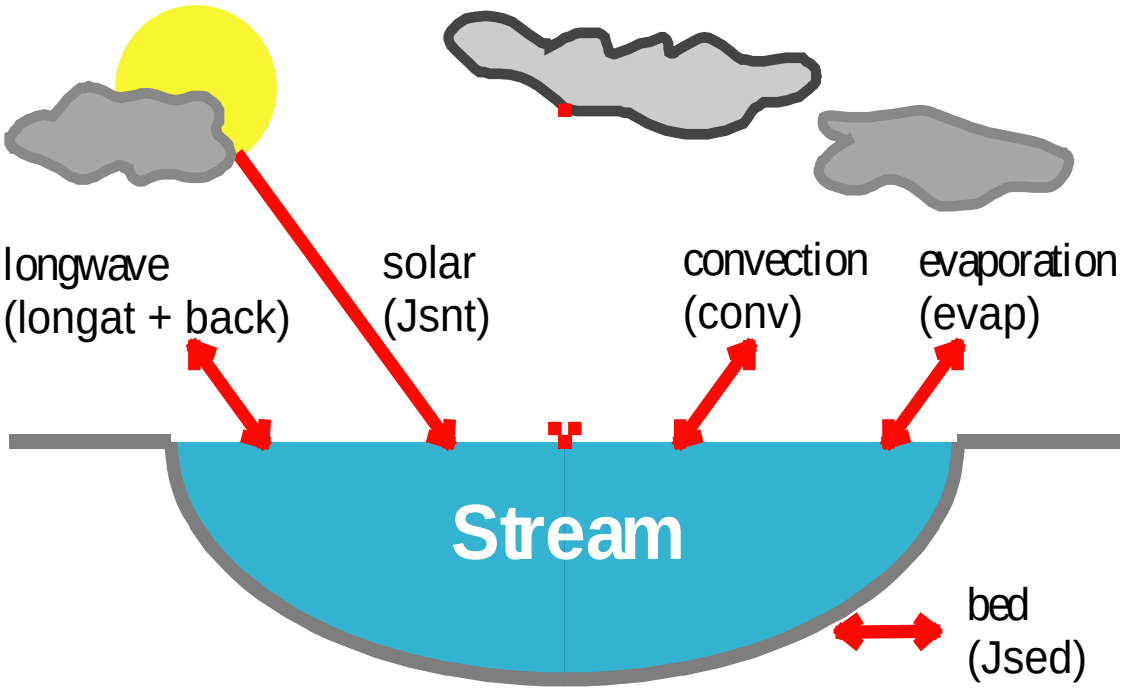


Figure 7 Heat transfer processes in the qual2k model that affect water temperature

Effective Shade

Effective shade is defined as the fraction of the potential solar shortwave radiation that is blocked by vegetation and topography before it reaches the stream surface. Effective shade is a function of several landscape and stream geometric relationships. Some of the factors that influence shade include the following:

- latitude and longitude
- time of year
- stream aspect and width
- vegetation buffer height, width, overhang, and canopy density
- topographic shade angles

In the Northern Hemisphere, the earth tilts on its axis toward the sun during summertime months allowing longer day length and higher solar altitude, both of which are functions of solar declination (i.e., a measure of the earth's tilt toward the sun). Geographic position (i.e., latitude and longitude) fixes the stream to a position on the globe, while aspect provides the stream/riparian orientation. Riparian height, width and density describe the physical barriers between the stream and sun that can attenuate and scatter incoming solar radiation (i.e., produce shade). The solar position has a vertical component (i.e., altitude) and a horizontal component (i.e., azimuth) that are both functions of time/date (i.e., solar declination) and the earth's rotation (i.e., hour angle). While the interaction of these shade variables may seem complex, the math that describes them is relatively straightforward geometry, much of which was developed decades ago by the solar energy industry.

Percent effective shade can be monitored or calculated and is easily translated into quantifiable water quality management and recovery objectives. Using solar tables or mathematical simulations, the potential daily solar load can be quantified. The solar load at the stream surface can easily be measured with hemispherical photography, a solar pathfinder, or estimated using mathematical shade simulation computer programs (Boyd, 1996). Effective shade was calculated for the Little Klickitat, East Prong, West Prong, and Butler Creeks using the HeatSource model developed by the Oregon Department of Environmental Quality (ODEQ, 2000).

For more details on effective shade calculations and field verifications of effective shade please see the technical report.

Loading Capacity

The calibrated QUAL2K model was used to determine the loading capacity for effective shade for streams in the Little Klickitat basin. Loading capacity was determined based on prediction of water temperatures under typical and extreme conditions of flow and climate conditions combined with a range of effective shade conditions.

The 7Q2 low flow was selected to represent a typical climatic year, and the 7Q10 low flow was selected to represent a reasonable worst-case condition for the July-August period. Air temperatures and weather conditions for the 7Q2 condition were assumed to be the same as those observed on the hottest day of 2000, which was the 35th percentile condition from the historical record at the Goldendale airport. The air temperatures and weather conditions for the 7Q10 condition were assumed equal to the hottest day of 1998, which is the hottest year of record.

The following scenarios for effective shade were evaluated for the 7Q2 and 7Q10 flow and climate conditions:

- Current vegetation from field data and sampled from the Washington Department of Fish and Wildlife (WDFW) and Department of Natural Resources (DNR) Priority Habitat and Species database.
- Mature riparian (site potential) vegetation defined in Table 5 as 160-foot buffers on each side of the stream, with a 20-foot near-stream zone of small dense deciduous vegetation and a 140-ft outer zone with variable tree height and density.
- Mature riparian (site potential) vegetation (Table 5) and a channel wetted width to depth ratio (W/D) of 24. A W/D of 24 corresponds to the average W/D defined by Rosgen for streams classified as Class C (Rosgen, 1996)
- Site potential vegetation and a channel wetted width to depth ratio of 16. Natural migration for a Class C stream is to Class B, which has an average W/D of 16. Portions of the Little Klickitat may be able to reduce their W/D as a mature riparian corridor is established.

Little Klickitat River

Figure 8 shows the predicted water temperature in the Little Klickitat River for the lowest seven-day average flow during July-August with two-year recurrence interval (7Q2) and en-year recurrence interval (7Q10). Figure 8 shows that an increase in effective shade from riparian vegetation buffers have the potential to significantly decrease the water temperatures in the mainstem of the Little Klickitat River. Additional riparian vegetation significantly attenuates the irregular thermal profile on the mainstem Little Klickitat and brings the portion of the Little Klickitat River below Bloodgood Creek into compliance with the Class A water quality standard of 18^{o}C. Decreasing the channel average wetted width-to-depth ratio (W/D) decreases the water temperature further with the exception of the section below Bloodgood Creek, which has a low W/D ratio due to man-made channelization.

Butler Creek

Figure 9 shows the predicted water temperature in Butler for the 7Q2 and 7Q10 conditions. The same four riparian vegetation and morphology conditions were evaluated for Butler as was done for Little Klickitat River. Site potential vegetation does not bring the maximum temperature in compliance with the Class A water quality standard of 18^{o}C; however, it does decrease the maximum daily temperature significantly during critical conditions. Figure 9 illustrates that added riparian shade decreases the difference between the daily maximum and minimum temperatures. This attenuation of the diurnal thermal range on Butler Creek is beneficial to salmonids and other fish species using the creek for refugia. Decreasing the W/D ratio increases the maximum temperature slightly because the current W/D ratio is less than 24 or 16.

East Prong

Figure 10 shows the predicted water temperature in East Prong for the 7Q2 and 7Q10 conditions. Increases in effective shade from the vegetation buffers have the potential to significantly reduce water temperatures in the mainstem of East Prong. Again, added riparian shade decreases the difference between the daily maximum and minimum temperatures. This attenuation of the diurnal thermal range on East Prong is beneficial to salmonids and other fish species using the creek for refugia. Decreasing the W/D ratio increases the maximum temperature slightly because the current W/D ratio is less than 24 or 16.

West Prong

Figure 11 shows the predicted water temperature in West Prong for the 7Q2 and 7Q10 conditions. Increases in effective shade from the vegetation buffers have the potential to decrease maximum water temperatures under critical conditions on the mainstem of West Prong. Added riparian shade decreases the difference between the daily maximum and minimum temperatures. This attenuation of the diurnal thermal range on West Prong is beneficial to salmonids and other fish species using the creek for refugia. Decreasing the channel W/D ratio decreases the temperature very slightly because the current W/D ratio is between 16 and 24.

Scenario 1:	Scenario 2:	Scenario 3:
NSDZ equal BFW	NSDZ equals BFW	NSDZ equal BFW
Site Potential Veg	Site Potential Veg	Site Potential Veg
	W/D equals 24	W/D equals 16

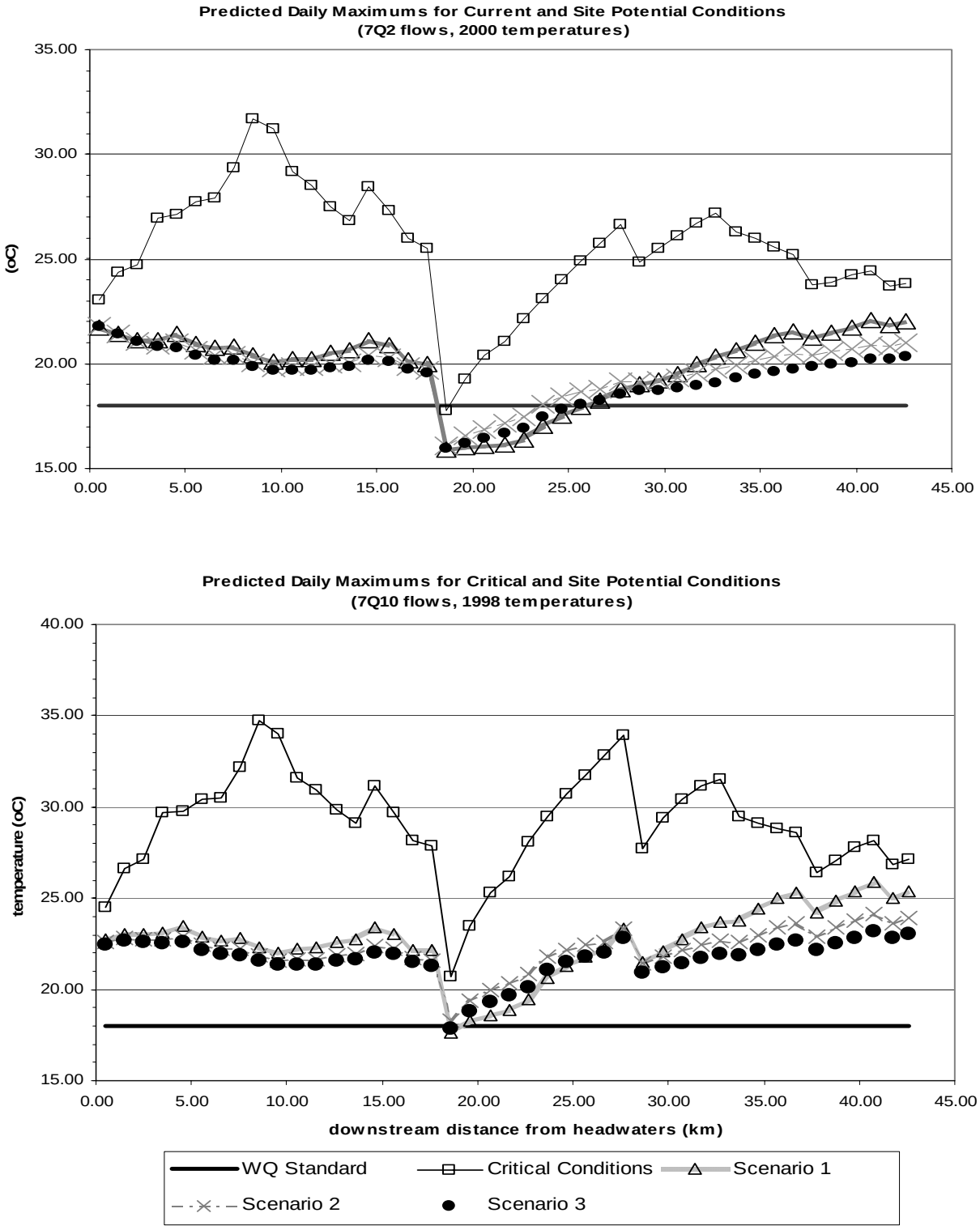
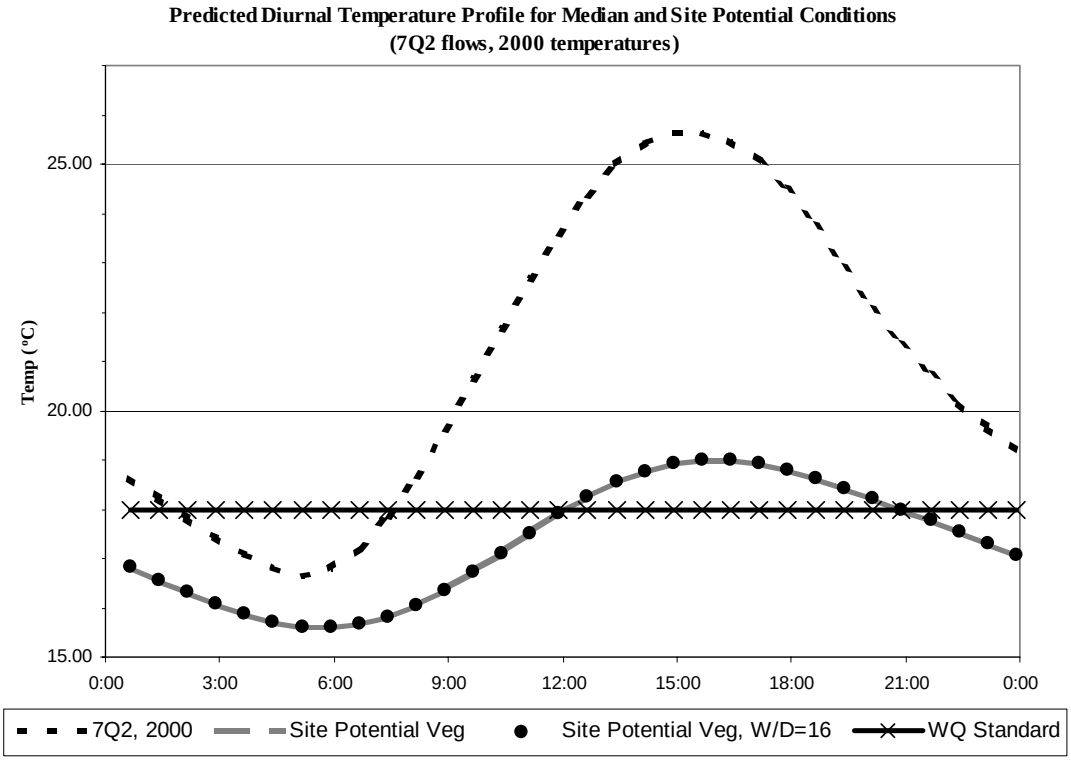


Figure 8: Predicted daily maximum temperature for Little Klickitat River under critical conditions



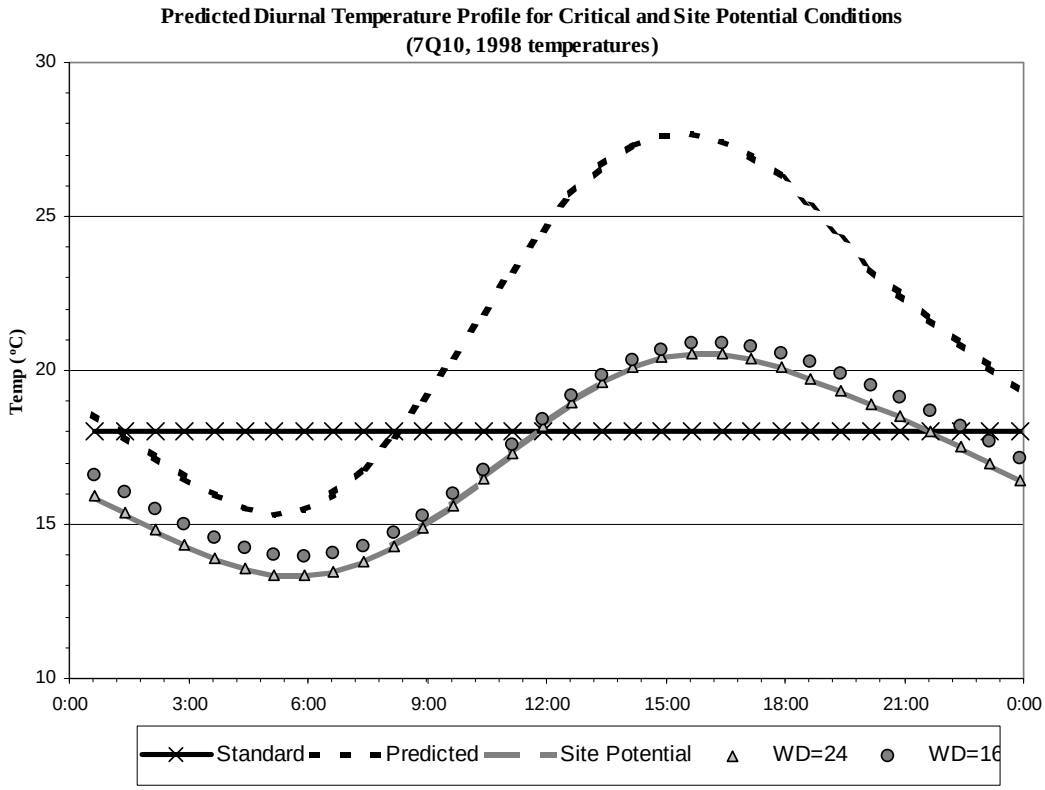


Figure 9: Predicted daily temperature for Butler Creek under critical conditions.

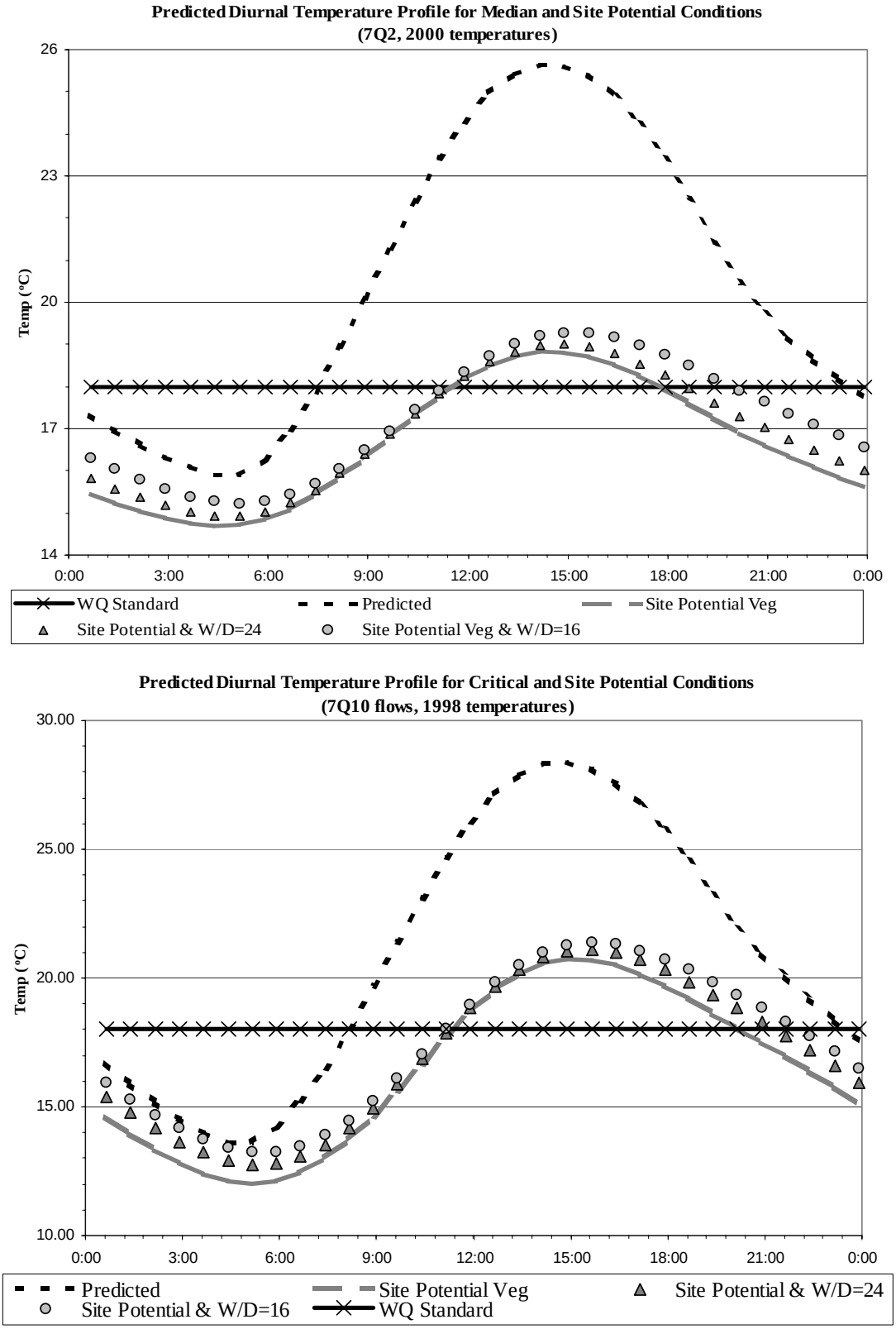
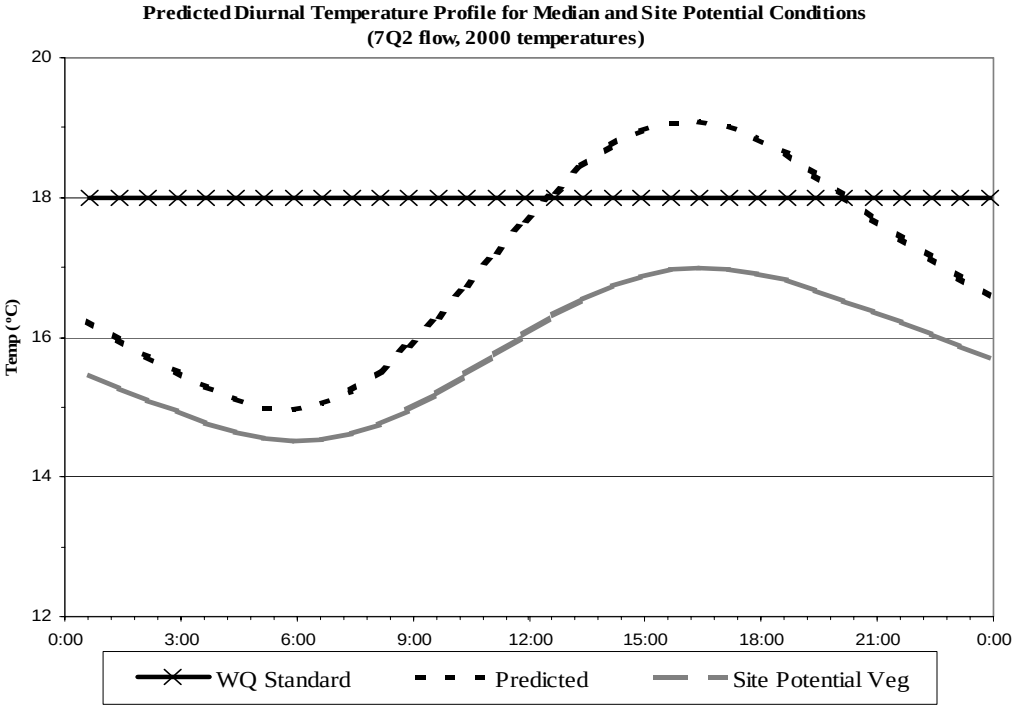


Figure 10: Predicted daily temperature for East Prong under critical conditions



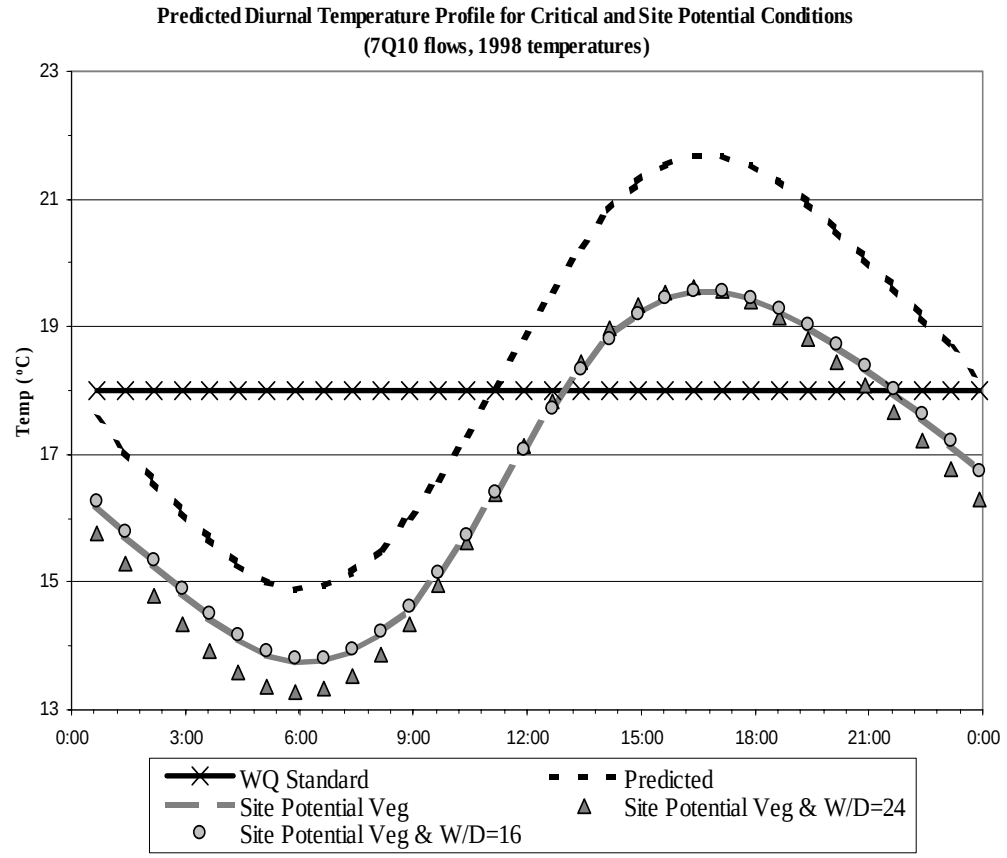


Figure 11: Predicted daily temperature for West Prong under critical conditions.

Estimated Solar Flux at Loading Capacity for Effective Shade

The loading capacity in terms of the flux of short-wave solar radiation to the water surface was estimated as the flux that would occur due to the effective shading from the recommended riparian vegetation condition (Figures 12 and Table 3). The loading capacity was translated into the solar flux that would occur under site potential riparian vegetation. The recommended load allocations for effective shade are predicted to result in significant reductions on the flux of solar radiation to streams in the Little Klickitat basin.

Figure 12: Solar radiation load allocation for Little Klickitat River

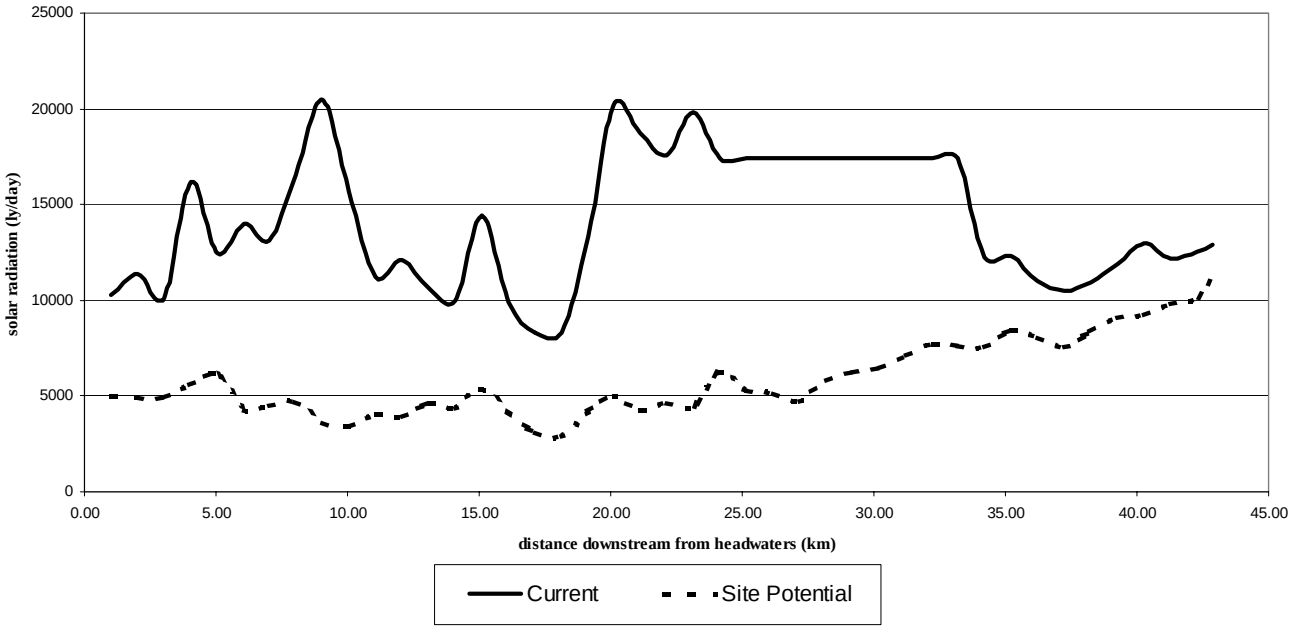


Table 3: Load capacity and load allocation for the Little Klickitat River

Station Name				Load Allocation		
	Distance downstream from headwater (km)	Current Effective Shade (%)	Current Solar Load (ly/day)	Target Solar Load (ly/dy)	Required Solar % Reduction	Target Effective Shade (%)
3 Creeks	1.0	58.7%	10274	5397	31	78
	2.0	54.4%				79
	3.0	59.4%				79
	4.0	34.9%				76
	5.0	50.0%				74
	6.0	43.7%				81
	7.0	47.4%				80
	8.1	33.5%				79
	9.1	17.8%				83
	10.1	37.2%				82
	11.1	55.1%				83
	12.1	51.5%				83
	13.1	57.4%				79
Rimrock	14.1	60.0%	14413	5746	43	81
	15.1	42.1%				77
	16.1	60.2%				82
	17.1	66.6%				86
	18.1	66.7%				86
Tom Miller	19.1	46.4%	20203	5065	60%	82
	20.1	18.9%				76
	21.1	24.8%				78
	22.1	29.4%				77
	23.1	20.4%				75

Station Name				Load Allocation		
	Distance downstream from headwater (km)	Current Effective Shade (%)	Current Solar Load (ly/day)	Target Solar Load (ly/dy)	Required Solar % Reduction	Target Effective Shade (%)
	24.2	30.0%				71
	25.2	30.0%				72
	26.2	30.0%				74
Olson	27.2	30.0%	17432	6577	45	76
	28.2	30.0%				74
	29.2	30.0%				71
	30.2	30.0%				66
	31.2	30.0%				63
	32.2	30.0%				62
	33.2	30.0%				62
	34.2	50.8%				62
	35.2	50.7%				59
	36.2	55.9%				61
	37.2	58.0%				62
	38.2	56.0%				60
	39.3	52.3%				54
	40.3	48.0%				53
	41.3	51.1%				52
	42.3	49.7%				51
Mouth	42.9	48.1	12930	12451	2	50

Load Allocations

The load allocations for effective shade for the Little Klickitat River, Butler Creek, East Prong, and West Prong are presented in Table 3 and Table 4. The solar flux estimated at the Load Allocations for effective shade is presented in Figures 12. In general, the load allocations for effective shade are as follows:

- For the entire Little Klickitat watershed, including Butler Creek, East Prong, and West Prong, 95 to 50% effective shade produced by a mature riparian corridor is the load allocation for shade from riparian vegetation.
- For portions of the Little Klickitat River and West Prong, additional temperature reduction may be possible through the reduction of the wetted width-to-depth (W/D) ratio.
- For all perennial streams in the Little Klickitat River watershed that were not specifically modeled, including Bowman, Mill, Spring, and Blockhouse creeks, and that exceeded the water quality standard during critical and median conditions (Figures 6 and 7), 73% effective shade produced by mature riparian vegetation is the load allocation. An effective shade of 73% is the average load allocation for all modeled segments on the Little Klickitat River, West Prong, and Butler Creek.
- Additionally, Bloodgood Creek, which does not exceed numeric water quality standards, provides the only source of cooling water to the Little Klickitat River. Efforts should be made to protect this cool source of water.

Table 4 Loading Capacity and Load Allocations for Butler Creek, East Prong, West Prong and all un-modeled tributaries in the watershed.

			Load Allocation		
Tributary	Current Effective Shade (%)	Current Solar Load (%)	Target Solar Load (%)	Required Solar Reduction (%)	Target Effective Shade(%)
Butler	55.0	284	111	44	95
East Prong	62.3	224	33	75	94
West Prong	77.5	36	12	50	93
Spring Creek	38.6				73
Blockhouse	68.1				73
Mill Creek	59.2				73
Bowman Creek	50.7				73

Wasteload Allocations

Goldendale Wastewater Treatment Plant

The Goldendale Wastewater Treatment Plant (WWTP) is the only point source discharger in the Little Klickitat River Watershed that could potentially discharge heat loading to the Little Klickitat River. The NPDES (National Pollution Discharge Elimination System) permit, filed in the 1970s, authorizes discharge to the main stem Little Klickitat River. The WWTP's NPDES identification number is WA-00-2112-1. In 1999, the city of Goldendale initiated the process to upgrade the plant with a cascade-pool cooling system in order to discharge during the summer low-flow months.

State Water Quality Standards (WAC 173-201A) say, "no temperature increase will be allowed which raises the receiving water temperature greater than 0.3^{o}C." These rules govern the wasteload allocation for the Goldendale WWTP. Upstream of the Goldendale WWTP discharge, which occurs at RM 14.1 (20.2 kilometers from the headwaters), Bloodgood Creek enters the system and lowers the Little Klickitat temperature significantly. Additional effective shade in this section will bring the water temperature into compliance with the Class A Water Quality Standard of 18^{o}C (Figure 8). Therefore, the wasteload allocation for the Goldendale WWTP must stipulate that the effluent discharge temperature should not cause the receiving water temperature to rise greater than 18.3^{o}C (Table 5).

Table 5: Wasteload allocation for Goldendale Wastewater Treatment Plant

					Wasteload Allocation		
Facility Name, City	**Receiving Water Body, RM**	**7Q10 Low Flow (cfs)**	**Facility Design Flow**	**System Potential Temperature**	**Current Effluent Temperature**	**Allowable Temperature Change at Edge of Mixing Zone**	**Allowable Effluent Temperature (oC)**
Goldendale WWTP	Little Klickitat, RM 14.0	4.48	0.774	18	n/a	0.3	18.3

Bloodgood Creek water withdrawal impact analysis

Bloodgood creek is the critical source of cold, constant flow to the Little Klickitat River. Figure 8 shows that as Bloodgood Creek enters the Little Klickitat River at River Mile 14.8 the Little Klickitat River temperature drops significantly. An impact analysis, which used a simple mixing equation, illustrates that as flow is removed from Bloodgood Creek, the temperature of the Little Klickitat increases exponentially (figure 13). Water resources of Bloodgood Creek should be managed to lessen the impact on the Little Klickitat River.

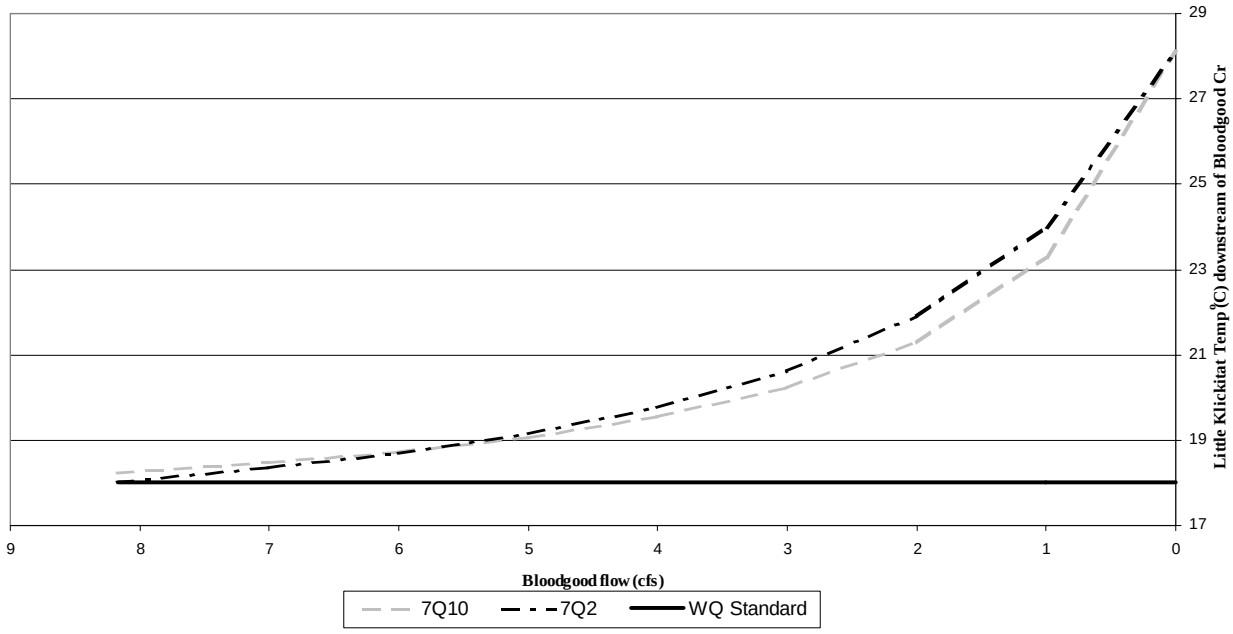


Figure 13: Water withdrawal impact analysis for Bloodgood Creek

Margin of Safety

Statute requires that a margin of safety be identified to account for uncertainty when establishing a TMDL. The margin of safety can be explicit in the form of an allocation, or implicit in the use of conservative assumptions in the analysis. Several assumptions and critical conditions used in the modeling analysis of the Little Klickitat Temperature TMDL provide an inherent margin of safety over uncertainty as required by the statute. In this TMDL, the margin of safety is addressed by using critical climatic conditions in the modeling analysis. Conservative assumptions for critical conditions include the following:

- Climatic conditions measured during 1998, the hottest year of record at the Goldendale airport weather station, were used to represent reasonable worst case conditions.
- Cloud cover of 0% was used to model maximum solar load available.
- 7Q10 flow conditions were used to represent reasonable worst-case conditions in this analysis. Typical conditions were evaluated using 7Q2 flow conditions.
- Boundary and tributary water temperatures were held constant in the loading capacity and load allocation analysis.

Summary Implementation Strategy

Implementation Overview

Under section 303(d) of the Federal Clean Water Act, the U.S. Environmental Protection Agency requires states to identify impaired water bodies. The Little Klickitat River and some of its tributaries are on Washington State's 1996 and 1998 303(d) list for temperature. In 1999, the Washington State Department of Ecology (Ecology) identified the Little Klickitat River as a candidate to conduct a TMDL. Ecology used existing data and conducted field work to model current and potential conditions of streams in the Little Klickitat Watershed during the year 2000. After review from local government and the Yakama Nation, Ecology published the *Little Klickitat River Watershed TMDL Technical Report* (the technical report). The technical report identified low levels of potential shade throughout the watershed as the primary cause of elevated temperatures in the watershed. The technical report also recognized the existence of natural factors that contribute to elevated water temperatures. This summary implementation strategy (SIS) summarizes a strategy to improve riparian zone conditions and thus stream temperature conditions through point and non point source control using existing programs, rules and organizations. Additionally, this SIS discusses the development of a monitoring and adaptive management strategy needed to guide implementation of this TMDL.

A summary implementation strategy (SIS) is needed to meet the requirements of a TMDL submittal for approval as outlined in the 1997 Memorandum of Agreement between EPA and Ecology. It presents a clear, concise, and sequential concept (i.e. vision statement) of how the Little Klickitat River and its tributaries will ultimately achieve the Class A temperature water quality standards (the conditions modeled in the technical report) over time. This SIS complies with the federal mandate of the Clean Water Act, Washington State laws to control point and non-point source pollution, and the 1997 Memorandum of Agreement between EPA and Ecology.

This SIS will serve as guidance for developing a detailed implementation plan (DIP) during the one year period after the TMDL has been approved. The DIP will describe specific implementation activities that need to be performed to achieve the TMDL temperature targets. The DIP will also present a thorough plan for monitoring implementation of this TMDL. It is anticipated that implementation of this TMDL will return the Little Klickitat river and its tributaries to conditions that comply with the Class A temperatures water quality standards as reported in the technical report by the year 2083.

This is a plan to protect and restore riparian areas. It is based in large measure on existing laws, regulations and the voluntary actions of property owners with lands adjacent to streams.. Implementation of this TMDL relies on the continuation of the many existing voluntary efforts to reduce stream temperature and protect riparian areas throughout the watershed. Additional non-point source pollution prevention activities will be encouraged by Ecology with voluntary and incentive-based processes in order to pursue the goals outlined in this report. The one known contributing NPDES permitted point source (the Goldendale Wastewater Treatment Plant) will be assigned a compliance schedule to be presented in the Developed Implementation Plan. It is anticipated that implementation goals of this TMDL will be reached by 2083.

Implementation Plan Development

Chronology

1979	USGS surveyed water quality in the Upper Klickitat River Watershed. Some data was collected from surface water and groundwater in the Little Klickitat River Watershed.
1985	Ecology evaluated the impacts of the Goldendale Wastewater Treatment Plant on the Little Klickitat River between river mile 10.5 and river mile 16.3. High stream temperatures were documented in this reach.
1990	Temperature data collected as part of an Instream Flow Incremental Methodology study on the Little Klickitat River reported six instances of water temperatures that exceeded the state numeric criteria of 18.0 C.
1992	In a study about eastern Washington stream temperature, James Mathews of the Yakama Nation noted that the Little Klickitat River and its tributaries were exceptionally warm, even considering their location in south central Washington.
1995	Central Klickitat CD began monitoring stream conditions in the Little Klickitat Watershed. They currently monitor temperature, width, depth, flow, and canopy cover at various sites throughout the watershed.
1996	Boise Cascade conducted a watershed analysis in the upper Little Klickitat Watershed.
1999	Ecology identified the Little Klickitat for a TMDL in its scoping and 303(d) list prioritizing for fiscal year 1998.
2000	Ecology collected field data and modeled temperature conditions in the Little Klickitat Watershed for this TMDL.
2001	Central Klickitat Conservation District (CKCD) received a grant to help monitor and implement the TMDL
2001-02	Ecology sent draft of Little Klickitat River Watershed TMDL Technical Report for review to Technical Advisory Group (TAG). TAG consisted of representatives from CKCD, city of Goldendale, Klickitat County, Yakama Nation, Boise Cascade, and Ecology's regional TMDL staff
2002	Ecology published the Little Klickitat Temperature TMDL Technical Report.

Implementation Activities

The technical report clearly identifies effective shade as a surrogate for heat loading in surface waters in the Little Klickitat River Watershed. The report mentions hydraulic geometry, flow, and groundwater as other important watershed features that need further attention in order to fully protect surface water temperatures. Also, the report mentions the importance of conserving cool water flows from Bloodgood Creek.

Implementation Activities to Control Non Point Sources:

The Little *Klickitat River Watershed Temperature TMDL* technical report recommends increasing riparian shade as the most effective change landowners and managers could make in order to cool stream temperature in surface waters in the Little Klickitat Watershed. The load allocation section of this TMDL has various effective shade targets for various stretches of the Little Klickitat River and its tributaries. Many existing activities will eventually yield better riparian conditions in the watershed, including increased stream shading. Although this SIS concentrates on riparian protection and improvement projects in the watershed, there are other land and water protection practices that can be employed to enhance water quality conditions, especially temperature, in the streams throughout the Little Klickitat Watershed.

Past and ongoing activities by the Central Klickitat Conservation District, city of Goldendale, Washington Department of Fish and Wildlife, Natural Resources Conservation Service (NRCS), Ecology, Yakama Nation Fisheries Program, landowners, and others already support the goals of this TMDL. These efforts include water quality monitoring, riparian area restoration projects, sediment reduction projects and water use practices that consider in stream flows.

The Central Klickitat Conservation District (CKCD) is an important partner of Ecology's for implementation of this TMDL, and they are a valuable resource to the community in the Little Klickitat Watershed. Ecology awarded the CKCD a grant that supports implementation and public involvement with this TMDL. Also, the CKCD assists the implementation of the Conservation Reserve Enhancement Program projects and other riparian area projects. Additionally, the monitoring that CKCD performs provides valuable data to track water quality conditions related to this TMDL.

Participation by the Natural Resource Conservation Service (NRCS) is also a critical part of implementation of this TMDL. The NRCS promotes and administrates the Conservation Reserve Enhancement Program (CREP) and the Continuous Conservation Reserve Program (CCRP). Voluntary participation by local landowners is sought through a cost share program designed to restore and enhance habitat and increase bank stability along waterways on private lands with a cropping history. The program offers payments for annual rental, signing, cost share, practice, and maintenance in exchange for removing land from production and grazing, under 10-15 year contracts.

The NRCS also has funds available through its Environmental Quality Incentives Program (EQIP). EQIP provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The program is implemented through conservation plans that include structural, vegetative, and land management practices. Contracts are five to ten years long. Cost-share payments may be made to implement one or more eligible structural or vegetative practices, such as livestock exclusion fencing, filter strips, tree planting, and permanent wildlife habitat. Incentive payments can be made to implement one or more land management practices, such as grazing management or nutrient management.

The Washington State Legislature has authorized the creation of a Small Forest Landowner Office to provide technical assistance, develop standards for forest practice alternative plans, and administer a Forestry Riparian Easement Program (FREP). FREP is a compensation program intended to partially compensate qualifying small forest landowners for leaving forest and fish riparian management zones in exchange for a fifty-year easement. The purpose of the program is to provide an incentive to small forest landowners to keep their lands in forest use.

Ecology staff can continue to identify and make people aware of funding sources that can increase implementation opportunities for landowners and land managers in the watershed.

Under the Watershed Planning Act (RCW 90.82), the Klickitat Basin Watershed Planning Unit also is assessing water supply and use in the basin, and is developing strategies for future use. A process to evaluate instream flow further will be available in the DIP.

The Central Klickitat Conservation District, NRCS, Ecology and other agencies also have provided and can continue to provide educational, and technical services to individual and groups in the area.

Point Sources

The Little Klickitat River Watershed TMDL technical report identified the Goldendale Wastewater Treatment Plant as the only NPDES permitted point source in the watershed that was assigned a portion of the load allocation.

The Goldendale Wastewater Treatment Plant (WWTP) is the only NPDES point source currently discharging to surface water in the Little Klickitat Watershed. The WWTP recently upgraded to a Biolac treatment system and installed a cascade staircase. The Biolac system eliminates the use, and thus discharge, of chlorine in the discharge from the WWTP. The cascade staircase increases the dissolved oxygen in the effluent of the WWTP. The WWTP is an existing discharger, which will be provided a schedule for achieving compliance with TMDL-based effluent limitations.

Table 6: This table presents general actions and entities responsible for implementing such actions. The information listed in the table is part of the overall strategy and may change as personnel and monetary resources are better defined during the development of the DIP.

Entity	Responsibilities to be met	1	2	3	4	5	6	7	8	9	Beyond 10 Years
CMER	Monitoring of Forests and Fish rules in support of adaptive management	X	X	X	X	X	X	X	X	X	X
DNR and Ecology	Administration and enforcement of Forests and Fish rules	X	X	X	X	X	X	X	X	X	X
Homeowners with waterfront property	Avoid actions that will cause stream bank destabilization or erosion, or will otherwise add sediment to area waterways or decrease shading of the riparian area	X	X	X	X	X	X	X	X	X	X
Irrigators and Irrigation Entities (Districts and Companies)	Implement BMPs to conserve water and provide in stream flow	X	X	X	X	X	X	X	X	X	X
CKCD, NRCS and Ecology	Continue to fund agricultural BMP implementation:	X	X	X	X	X	X	X	X	X	X
CKCD, NRCS	Extend outreach efforts and technical assistance to all agricultural producers (irrigators, livestock managers, others) in the watershed	X	X	X	X	X	X	X	X	X	X
Central Klickitat CD	Continue to monitor water quality of the watershed's surface waters	X	X	X	X	X	X	X	X	X	X
Klickitat County	Administration of Critical Area Ordinances and Shoreline Master Programs	X	X	X	X	X	X	X	X	X	X
Private and state timber owners	Implement forest management practices that lead to achieving the LAs of this TMDL as required by Forests and Fish rules	X	X	X	X	X	X	X	X	X	X
Ranchers	Implement livestock management BMPs to prevent stream bank de-vegetation and erosion	X	X	X	X	X	X	X	X	X	X

Responsible Entities and Actions

Agriculture and Livestock: The conservation agencies (the CKCD and NRCS) are the primary entities for technical assistance and financial support (where possible) to assist in the implementation of agricultural and livestock BMPs throughout the watershed. . . . Livestock managers are responsible for implementing BMPs that prevent bank erosion and riparian vegetation damage associated with grazing in areas near streams.

Forestry: Private and state timber owners are responsible for implementing appropriate BMPs (as specified in the Forests and Fish rules) on their lands. The Washington Department of

Natural Resources (DNR) is responsible for oversight of the Forest and Fish rules. The Cooperative Monitoring, Evaluation and Research (CMER) committee is responsible for evaluation of the Forests and Fish rules to support the adaptive management process.

Monitoring: The CKCD is the entity currently conducting water quality monitoring on agricultural lands in Klickitat County per grant agreement- this may be modified in future years.

Ecology is the responsible entity for determining compliance of interim and final targets.

Other: Klickitat County and the Washington State Department of Transportation (WSDOT) are responsible for maintaining unpaved roads and roadside ditches within their various jurisdictions. Individual homeowners who live adjacent to water bodies within the project area are responsible for avoiding actions that cause destabilization and erosion of stream banks.

Supporting Regulations and Land Management Plans

Private and State-Owned Forested Lands

In 1999, various state and federal agencies, counties, some tribes, and the timber industry negotiated the Forests and Fish Report (F&F) to address impacts caused by forest harvesting activities on water quality and fish and six riparian-dependent amphibians. This agreement was contingent on the state adopting improved forest practice regulations as well as funding and implementing a monitoring program to demonstrate the effectiveness of the new rules in protecting water quality and fisheries habitat. Landowners also agreed to share water quality information with the other parties to the agreement.

Emergency forest practice regulations were adopted by the Washington Forest Practices Board and became effective March 20, 2000. These rules are representative of the F&F agreement. Permanent rules have now been adopted.

Negotiated "assurances" were provided to the timber industry under the agreement for supporting improved forest practice regulations. These assurances include 1) development of TMDLs for 303(d) listed water bodies impacted primarily or solely by forest practices may be delayed to the year 2009, 2) EPA and Ecology would not ask the Forest Practices Board to adopt any more stringent rules except through the adaptive management program set out in F&F, and 3) the F&F adaptive management process will be used to adjust forest practices, if necessary, to meet load allocations of TMDLs produced for streams in mixed use watersheds.

Load allocations are included in this TMDL for forest lands in the Little Klickitat Watershed in accordance with the section of F&F entitled "TMDLs produced prior to 2009 in mixed use watersheds". Also consistent with the F&F agreement, implementation of the load allocations established in this TMDL for private and state forestlands will be accomplished via implementation of the revised forest practice regulations. The effectiveness of the Forests and Fish rules will be measured through the adaptive management process and monitoring of streams in the watershed. If shade is not moving on a path toward the TMDL load allocation by 2009, Ecology will suggest changes to the Forest Practices Board.

Fish and Forest assurances are provided for forest harvesting activities conducted under regulations adopted pursuant to F&F; the 20 acres exempt rule is not covered. Accordingly, it is recommended that forest practices conducted under the 20-acre exempt rule comply with the allocations for stream shade established in this TMDL. Therefore, Washington State Department of Natural Resources (DNR) is encouraged to condition forest practices to prohibit any further reduction of stream shade and not waive or modify any shade requirements for timber harvesting activities on state and private lands. Ecology is committed to assisting DNR in identifying those site-specific situations where reduction of shade has the potential for or could cause material damage to public resources.

New emergency rules for roads also apply. These include new road construction standards, as well as new standards and a schedule for upgrading existing roads. Under the new rules, roads must provide for better control of road-related sediments; provide better stream bank stability protection; and meet current Best Management Practices. DNR is also responsible for oversight on these activities.

Riparian Habitat Areas

Shorelands within 200 feet of rivers, on non-federal lands

Under the Shoreline Management Act (SMA), local governments have the primary responsibility for initiating the planning programs and administering the regulatory requirements in support of the Act, with Ecology serving in a supportive and review capacity. Klickitat County and Ecology share the responsibility for permit review and enforcement, as described in Chapter 173-27 WAC. Under SMA, "shorelands" include lands 200 feet landward from the edge of designated waters (RCW 90.58.030).

The Klickitat County Shoreline Master Plan provides the following definition of shorelines.

"The term Shoreline means all of the water areas of the state, including reservoirs, and their associated shoreline areas, together with the lands underlying them except:

1. Shorelines of State-Wide Significance.
2. Shorelines on segments of streams upwards of a point where the mean annual flow is 20 cubic feet per second or less and the wetlands associated with such upstream segments; and
3. Shorelines on lakes less than 20 acres in size and wetlands associated with such small lakes."

Water Use Laws and Regulations

The Washington Water Code is based on the doctrine of prior appropriation. In times of water shortages, the junior water rights are partially or fully shut off to enable holders of senior rights to fully use the water to which they are entitled. The Little Klickitat Watershed surface waters were adjudicated in 1987; therefore, no additional water rights can be granted. Metering systems should be installed and checked on a regular basis to ensure that existing water rights use does not exceed the allocated right.

All Listed Waters In The Basin

State water quality laws and regulations also support implementation of this TMDL. The state water pollution control law (RCW 90.48.010) states that, "It is declared to be the policy of the state of Washington to maintain the highest possible standards to insure the purity of all waters of the state consistent with public health and public enjoyment thereof, the propagation and protection of wildlife, birds, game, fish and other aquatic life…" Pollution is defined to

specifically include alteration of any waters of the state, including change in temperature and sediment. State law and regulations (RCW 90.48.142; WAC 173-201A-160(2)) provide for issuing penalties for actions that cause death or injury to fish, animals, vegetation, or other resources of the state.

Reasonable Assurances

See Supporting Regulations and Land Management Plans below.

Ecology feels that the following activities are already supporting this TMDL and add to the assurance that temperatures in the Little Klickitat River Watershed will meet the conditions provided by state water quality standards:

- Past and ongoing activities by the CKCD, city of Goldendale, Washington Department of Fish and Wildlife, NRCS, Ecology, Yakama Nation Fisheries Program, and landowners already support the goals of this TMDL.

- The NRCS promotes and administers the Conservation Reserve Enhancement Program (CREP) and the Continuous Conservation Reserve Program (CCRP). These programs are available to landowners for incentive to protect and enhance riparian zones.

- In 2001, the Department of Ecology granted the CKCD a Centennial Clean Water Fund grant to assist with public outreach and implementation of this TMDL.

Full recovery of stream temperatures depends on the restoration of shade and stream corridors to near natural conditions. This plan is primarily based existing laws, regulations, and on the voluntary actions of property owners with lands adjacent to streams, to protect and restore riparian areas. Local residents, the Central Klickitat Conservation District, NRCS, and others are already implementing riparian restoration activities and conservation measures. For example, projects are currently being implemented under the CCRP, CREP, Fish and Wildlife Regional Fisheries Enhancement Program, the Shoreline Protection Account Program, and the Governor's Salmon Recovery Funding Board.

Timber harvesting activities by state and private forest landowners are conducted according to the Forests Practices Rules and the Forest and Fish (F&F) Agreement, which includes provisions for monitoring rule effectiveness and for adaptive management of the rules. Although it is anticipated these rules will result in greater protection of water quality than afforded by previous timber harvesting regulations, there is not yet any information available with which F&F can be evaluated. Long-term monitoring of this TMDL will provide information needed to direct future management of the Forests and Fish Agreement.

Ecology's NPDES program is working with the city of Goldendale's Wastewater Treatment Plant to develop a compliance schedule for this TMDL.

Adaptive Management

A Detailed Implementation Plan will be developed that will include a monitoring plan to evaluate implementation measures. If planned implementation activities are not producing expected or required results, Ecology or other entities may choose to do additional studies to identify the significant sources of heat input to the river system. If the causes can be determined, additional implementation measures may be needed. For non-federal forested areas, the agreements in the Forests and Fish Report incorporate adaptive management as needed to meet the allocations in this report. Re-evaluation is anticipated to occur at five to ten-year intervals. The TMDL may be modified as a result of monitoring results.

Monitoring procedures will be used to evaluate progress toward attainment of the water quality standards. Milestones will be developed as part of the Detailed Implementation Plan (DIP). If it appears progress is not being made, both the implementation measures and the need for additional studies will be re-evaluated. Additional studies may also be identified as needed to evaluate existing conditions or implementation activities.

Monitoring Strategy

Monitoring is included as part of the implementation strategy. It serves to track and evaluate the effectiveness of implementation measures. Four general monitoring procedures, to be implemented concurrently, are described below. Baseline inventories of riparian vegetation and channel conditions will be established. More information will be provided in the Detailed Implementation Plan (DIP).

Procedure 1: Track stream temperature

Stream temperature will be monitored for attainment of standards and the results evaluated at five to ten-year intervals or consistent with timelines established within the Forests and Fish Rules. This will be determined with the development of the Detailed Implementation Plan. This is expected to continue for decades, and results may not be observed for a decade or more.

In addition, the relationship between stream temperature and air temperature will be used to track progress. The regression of water temperature against air temperature will be plotted over time to determine whether water temperatures are cooler for specific air temperatures. If stream temperature does not decrease relative to the air temperature, a reassessment of modeling parameters and/or adaptive management may be needed

Procedure 2: Monitor physical Parameters Known to Affect Stream Temperatures

Parameters that may be monitored include shade, active channel zone widths, width to depth ratio, sediment (bedload, suspended sediment, turbidity), temperature, and flow. Baselines will be established and surveys conducted in at least five to ten-year intervals. Aerial photos may be used to determine completeness over all reaches of concern.

Procedure 3: Track implementation

Implementation of voluntary riparian restoration activities and instream flow restoration will be tracked, as well as implementation of existing regulations. A more detailed monitoring plan will be presented in the DIP.

Procedure 4: Track temperature-dependent biota and other parameters as appropriate

The health of macroinvertebrate and salmonid populations and/or other indicators may be used to track recovery of the riparian and river systems. The presence of a healthy aquatic ecosystem typical of this type of stream will be a useful indicator of success of this project.

Potential Funding Sources

Potential funding sources include resources offered through the Centennial Clean Water Fund and the state 319 grants and loan program. Additionally, there are other sources of funding available for salmon habitat, salmon restoration efforts and associated projects that support actions that could increase riparian shade and instream flows. These will be further investigated and reported in the DIP.

Potentially, the above funding resources could be utilized by the city of Goldendale to implement improvements in their WWTP as the compliance schedule progresses. Any NPDES permitted point sources discharging effluent to the WWTP are also eligible for State Revolving Fund (SRF) loans to make capital improvements that improve water quality.

References Cited

Boyd, M.S. 1996. Heat source: stream, river, and open channel temperature prediction. Oregon State University. M.S. Thesis October

Chapra, S.C., 2001. Water-Quality Modeling Workshop for TMDLs, Washington State Department of Ecology, Olympia, Washington. June 25-28

EPA, 1991. Guidance for Water Quality-based Decisions: The TMDL Process. U.S. Environmental Protection Agency. EPA 440/4-91-001.

ODEQ, 2000. Umatilla River Basin Total Maximum Daily Load (TMDL and Water Quality Management Plan (WQMP). Oregon Department of Environmental Quality), Portland, Oregon, October http://www.deq.state.or.us/wq/TMDLs/Umatilla/UmatillaTMDLAppxA-4.pdf

ODEQ, 2001. Tools 3.0 User Manual. Oregon Department of Environmental Quality, Portland, Oregon. http://www.deq.state.or.us/wq/TMDLs/WQAnalTools.htm

ODEQ, 2002. Overview of the Upper Klamath Lake Drainage Temperature TMDL Analysis. Oregon Department of Environmental Quality, Portland, Oregon. January. http://www.deq.state.or.us/wq/TMDLs/UprKlamath/Overview-Temp.pdf

Rosgen, D., 1996. Applied River Morphology. Wildland Hydrology Publishers. Pagosa Springs, Colorado.

Williams, J.R. and H.E. Pearson, 1985. Streamflow statistics and drainage basin characteristics for the southwestern and eastern regions, Washington. Volume II. Eastern Washington. U.S. Geological Survey Open File Report 84-145-B. Tacoma, Washington.

List of Acronyms

BMPs – Best Management Practices

cfs – cubic feet per second

CREP – Conservation Reserve Enhancement Program

CCRP- Continuous Conservation Reserve Program

CWA – Federal Clean Water Act

DIP – Detailed Implementation Plan

DNR – Washington Department of Natural Resources

EAP – Ecology's Environmental Assessment Program

EPA – US Environmental Protection Agency

EQIP – NRCS's Environmental Quality Incentive Program

F&F – Forests & Fish Agreement

FREP – Forestry Riparian Easement Program

MOA – Memorandum of Agreement

NPDES- National Pollution Discharge Elimination System

NRCS – Natural Resources Conservation Service

RCW – Revised Code of Washington

SIS – Summary Implementation Strategy

SMA – Shorelines Management Act (RCW 90.58)

SRF – State Water Pollution Control Revolving Fund

TFW - Timber, Fish and Wildlife

TMDL - total maximum daily load

USGS – U.S. Geological Survey

WAC – Washington Administrative Code

WWTP- Waste Water Treatment Plant

WQ – Water Quality

Appendix A

Summary of Public Involvement

SUMMARY OF PUBLIC INVOLVEMENT:

Chronology

January 8th 2003	Met with Klickitat County Livestock Producers Presented information about the TMDL and SIS
February 3, 2003	Released a press release regarding public meeting and public comment period of TMDL
February 6th, 2003	Held public meeting in Goldendale to explain TMDL and comment period. This was the opening of the public comment period.
March 3, 2003	Presented information about the TMDL to Goldendale City Council
March 5th, 2003	Participated in radio talk show on KLCK in Klickitat County to market the TMDL and solicit comments and participation.

March 8th through March 13th- 25 Public Service Announcements read on the air (KLCK)

March 5th and March 12th-	Ran display adds in the Goldendale Sentinel advertising the public comment period

Responsiveness Summary

Ecology received comments from two organizations. Below are Ecology's responses to those comments.

One commenter felt that the load allocations calculated by Ecology would not result in the Little Klickitat River achieving the temperature of 18°C in the summer months, and that a waste load allocation of 18.3°C would be cost prohibitive to reach.

Ecology appreciates that the city of Goldendale (the only point source at which the wasteload allocation is applied) has undertaken expense and time to make improvements to its wastewater treatment plant, and to the riparian areas managed by the city.

The Little Klickitat River Watershed Temperature TMDL will be implemented using an adaptive management approach that will strive to be cooperative and fair, while at the same time bring the Little Klickitat River into compliance with state temperature standards as determined by the *Little Klickitat River Watershed Temperature TMDL* technical report and additional monitoring. Given the climatic, geologic and hydrologic conditions of the Little Klickitat River Watershed this will take continued cooperation, monitoring and participation by many people and organizations in the watershed.

The following comments in italics are followed by Ecology's response in non-italicized font.

". . . shade *is not the only factor affecting stream temperature. . . . other factors can also play a significant role (e.g. flows, convective heating from air temperatures, conductive heating transferred from the substrate and banks, alterations of groundwater inputs and cooling effects, sediment inputs affecting width-to depth ratios, increases in peak flows that open up riparian vegetation, etc.) To be effective, the TMDL needs to make every effort to address and correct the various elements that lead to stream heating."*

Ecology agrees that shade is not the only factor that affects stream temperature. As illustrated by figure 1 and 2 in the *Little Klickitat River Watershed Temperature TMDL* technical report, various stream channel characteristics affect multiple pathways that heat can enter surface water. Research noted in the technical report assures that Ecology recognizes that ". . . riparian buffers affect microclimate factors such as air temperature and relative humidity proximal to the stream." It is anticipated that meeting effective shade load allocations with riparian vegetation protection and enhancement will provoke the effect of microclimate cooling. It is not Ecology's intent to prescribe only one corrective practice (shading the stream) that will solve all of the problems causing elevated temperatures in the Little Klickitat Watershed. Ecology is advised to provide a numeric load allocation target, and thus uses effective shade targets as a surrogate for heat loading when determining temperature TMDLs. For implementation we will rely on not only increasing shade, but also on the cumulative improvements caused by implementing BMPs, conserving water where possible, improving forest practices and conducting other watershed improvements.

". . . the draft mentions a blanket shade target allocation of 73% for the tributary streams. . .. The shade target or allocation should be set at the maximum level of shade/vegetation that a given stream reach can provide."

Ecology set load allocations on un-modeled tributary streams at "73% effective shade produced by mature riparian vegetation." Ecology determined that this was the average percent effective shade attainable at all modeled stream segments throughout the watershed. It will be noted in the SIS and DIP that there may be some areas that can support more vegetation and thus yield a higher percent effective shade.

"the document mentions in stream flow problems on some of the stream system. Reduced summer flows from diversions can have a major effect on stream temperatures. Yet, the TMDL does not address flow."

Ecology does not have the authority to change the amount of water being diverted by state water rights holders. Ecology will encourage water users to adopt conservation measures to improve in stream flows.

". . . much of the Little Klickitat has livestock grazing activities. From what I can tell, the TMDL does not deal at all with grazing."

The TMDL does mention grazing in both the technical report and SIS. In response to this comment, the "Responsible Entities and Actions" section will be amended to read:

"Agriculture and Livestock: The conservation agencies (the CKCD and NRCS) are the primary entities for technical assistance and financial support (where possible) to assist in the implementation of agricultural and livestock BMPs throughout the watershed. . . . Livestock managers are responsible for implementing BMPs that prevent bank erosion and riparian vegetation damage associated with grazing in areas near streams."

". . . the TMDL has little discussion on effects of agricultural practices on stream temperatures. The loss of riparian vegetation and delivery of fine sediment to the stream system from agricultural practices can have significant effects on stream temperatures. The reliance on agricultural BMPs may help, but is not going to totally alleviate excessive stream temperatures. BMPs have been used for many years and yet we still have agricultural impacts to streams, including temperature. BMPs are also for the most part voluntary, so some landowners do not use them.

It is recognized that implementation of Best Management Practices (BMPs) will not totally alleviate excessive stream temperatures. It is anticipated that implementation of BMPs can have a positive effect on stream temperature, and knowing such, it would be prudent to recommend their use. BMPs that prevent erosion can keep un-wanted sediment out of streams. BMPs that conserve water might free up water for in stream flow. BMPs that establish riparian vegetation can provide shading, reduce stream bank erosion and cool the air temperature near the stream. Although these are voluntary, different organizations provide economic incentives for agriculture and livestock producers to implement BMPs. The effectiveness and sustainability of BMPs implemented in the Little Klickitat Watershed will be evaluated through a process of adaptive management.

". . . sediment delivery and its effects on stream temperatures has little discussion or means to fix it. Fine sediment can be delivered from grazing, agricultural practices, timber harvest practices, logging roads and skid trails, and housing development. The sediment delivery can have a multitude of deleterious effects on salmonid populations including elevated stream temperatures. Sediment deposition can greatly increase the width-to-depth ratio of a stream allowing greater solar exposure. Sediment delivery from all sources needs to be evaluated and corrected in order to comprehensively deal with temperature impairments to streams."

It is noted in the Load Allocation section of the TMDL that "For portions of the Little Klickitat River and West Prong, additional temperature reduction may be possible through reduction of the wetted width-to-depth (w/d) ratio. As mature riparian vegetation is established, reduction of the current wetted W/D ratio may occur on stream segments in the Little Klickitat River Watershed." Fine sediment delivery from the sources you mention may potentially be a problem in the Little Klickitat Watershed. Monitoring sediment (bed load, suspended sediment, turbidity) is part of the monitoring strategy, and will be planned for in the Detailed Implementation Plan (DIP).

" . . and of major concern, the TMDL attempts to address the documented temperature deficiencies by compliance with existing regulations and additional voluntary measures. The existing forestry and agricultural regulations have been in place for at least two decades now, and yet temperature and other water quality problems have persisted or gotten worse. Granted some minor changes have been made recently to regulations (e.g. Forest and Fish Rules for timber harvest practices), but their efficacy is unknown or unproven. These recent changes to rules are also not dramatically different than the past rules, so it is unexpected that they will create a significant improvement to past conditions. The existing rules should therefore not be accepted as a panacea to correct the temperature impairments in the Little Klickitat. Additional measures and efforts are generally needed beyond existing regulations when excessive water quality impairments, such as found in the Little Klickitat, are occurring.

TMDLs are not intended to create new regulations, they are intended to evaluate the water quality impairments on a stream, quantify the improvements that are possible and necessary to reach state standards, and then detail a plan that focuses on reaching the load allocations and waste load allocations for the stream. In the case of watershed-based temperature TMDLs, it is nearly impossible to enforce water quality regulations for nonpoint source temperature simply because of the complexity of the manner that streams heat up. Existing regulations and incentive programs to protect streams and water quality have the potential to successfully restore temperatures and riparian habitat quality in the Little Klickitat watershed with the cooperation of agencies, land owners, land managers and other community members.

"Additionally, the TMDL advocates voluntary actions to correct remaining problems. While voluntary measures may help in select circumstances with cooperative landowners, they have not been universally applied or implemented to the degree necessary to address water quality problems. Voluntary measures are also not used by uncooperative landowners. If voluntary measures were so effective, why is it that stream temperatures and other water quality impairments have persisted over the years? If voluntary actions worked so well, most temperature and other water quality impairments should have been corrected by landowners several years ago. We appreciate the voluntary efforts by landowners to correct problems. However, we also question whether voluntary measures will largely improve stream conditions, particularly when landowners may choose to either participate, or only take limited actions to improve conditions.

This is a concern that is shared by many. Again, it is nearly impossible for Ecology to use water quality laws to enforce against individual landowners based on something as difficult to identify as non point source heat loading from sunlight. Each individual parcel of land with a stream on it should have a natural amount of heat loading associated with its unique land and water features. The challenge of calculating an amount of non natural heat load reduction for each individual land owner/manager is too expensive and Ecology's limited resources are better spent building cooperation with these landowners and convincing them to adopt good land stewardship principles. Ecology will address this issue in more detail in the DIP.

Appendix B

Technical Report

Little Klickitat River Watershed Temperature TMDL

July 2002
Ecology Publication Number 02-03-031

This publication may viewed at the following website:
http://www.ecy.wa.gov/biblio/0203031.html

Paper copy may be obtained upon request.