WASHINGTON STATE DEPARTMENT OF ECOLOGY

Simpson Northwest Timberlands Temperature Total Maximum Daily Load Submittal

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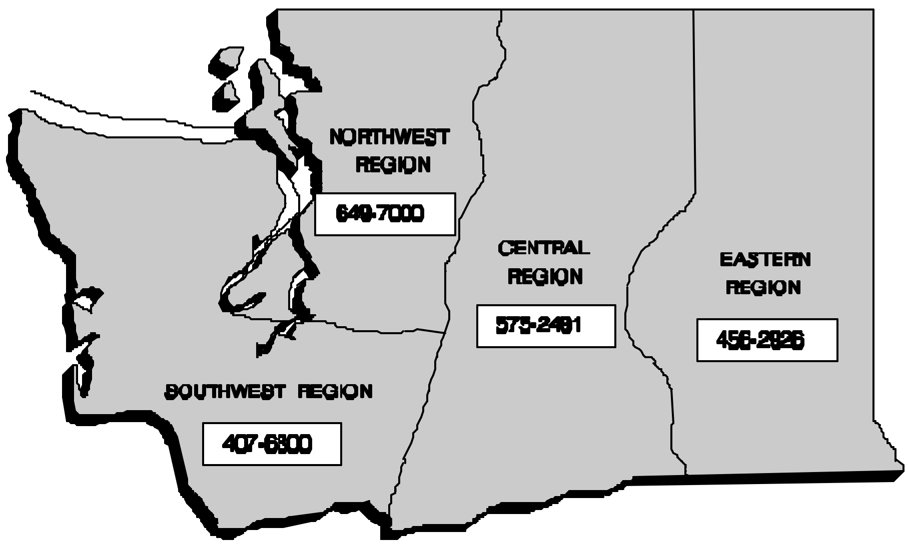

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Simpson Northwest Timberlands Temperature Total Maximum Daily Load Submittal

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Introduction

Section 303(d) of the federal Clean Water Act mandates that the State establish Total Maximum Daily Loads (TMDLs) for surface waters that do not meet 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 which 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.

This TMDL is being established for two pollutants: heat (i.e. incoming solar radiation) and sediment. The TMDL is designed to address impairments due to surface water temperature increases on one water quality-limited segment located within Simpson's 261,575 acres of Northwest Timberlands in the State of Washington. In addition, this TMDL sets allocation limits to protect the other streams from becoming water quality limited. Because of the unique and comprehensive approach used in the development of this non-point TMDL, more detail will be included in this submittal report than usual for better understanding. The appendices contain the entire technical assessment.

The two pollutants considered in this TMDL, singly and in concert, are major determinants of water quality that affect aquatic life. These factors vary naturally in their characteristics across the landscape (as a function of geology, topography and climate) as well as over time. The influence of both pollutants on water quality can also be significantly affected by changes associated with land use.

The five elements of this TMDL as required by federal statute and regulation are summarized below:

Loading Capacity: The loading capacity for heat (or solar radiation) is based on effective shade levels in the riparian corridor needed to meet state water quality standards for temperature. Using information about each channel class (e.g. drainage area, active channel width, range of flows, etc) effective shade targets can be developed. The channel classification system is used to assess stream reaches according to temperature groups, e.g. the dominant control(s) which influence water temperature, specifically shade, groundwater, or channel morphology. This approach leads to effective shade targets which recognize the variability in channel and riparian characteristics that occurs across the landscape. As such, these targets reflect the range of active channel widths and riparian vegetation heights within the TMDL area.

Load Allocations: Allocations in this TMDL are derived using effective shade and sediment delivery targets. These measures can be linked to source areas and, thus to actions (specifically riparian management and erosion control measures) needed to address processes which influence water temperature. Because factors that affect water temperature are interrelated, both measures are dependent upon each other to produce the desired responses.

Wasteload Allocation: There are no permitted discharges within the area covered by the TMDL. As such, the wasteload allocation is zero.

Margin of Safety: The margin of safety is represented by several elements:

- Allocations for effective shade contain an explicit margin of safety which is expressed as an unallocated portion of the loading capacity.

- Allocations for effective shade also contain an implicit margin of safety, specifically the point of measurement for the Riparian Conservation Reserve.

- Allocations give no *"credit"* for instream sediment storage because current excessive levels of instream stored sediment are contributing to temperature increases in one channel group (C-1). The allocation is lower than would be the case if instream storage credit were provided.

- The TMDL is intended to be adaptive in management implementation. This plan allows for future changes in loading capacities and surrogate measures (allocations) in the event that scientifically valid reasons support alterations.

Seasonal Variation: Existing conditions for stream temperatures in the Simpson HCP area reflect seasonal variation. Water quality standards for temperature are exceeded between May and October. In addition, the data show that the highest seven-day average maximum water temperatures occur between mid-July and mid-August. This time frame is used as the critical period for development and analysis of allocations in the TMDL.

Background

A Total Maximum Daily Load (TMDL) has been developed to address fisheries concerns on several tributaries of the lower Chehalis and Skokomish Rivers as well as several streams draining to South Puget Sound and Hood Canal. The scope of this TMDL includes waters located on land owned by Simpson Timber Company (STC) in the State of Washington. These forested watersheds include Simpson's long term commercial timberland in Thurston, Mason, and Grays Harbor counties. The area lies near Shelton and extends into the southern foothills of the Olympic Mountains across the Wynoochee River.

Excessive summer water temperatures in some of these streams reduce the quality of rearing habitat for coho salmon as well as for steelhead and cutthroat trout. Primary watershed disturbance activities that contribute to surface water temperature increases include forest management within riparian areas, timber harvest in sensitive areas outside the riparian zone, and roads. In light of current and pending fish listings under the Endangered Species Act, Simpson initiated a Habitat Conservation Plan (HCP) for this same area. This created the opportunity for the federal Services and EPA along with Department of Ecology to coordinate their parallel programs to protect and enhance water quality and aquatic habitat.

This TMDL is designed to address impairments due to surface water temperature increases on one listed water quality-limited segment located within Simpson's 261,575 acres of Northwest Timberlands in the State of Washington. In addition, this TMDL sets allocation limits to protect other streams within the Simpson HCP area from becoming water quality limited.

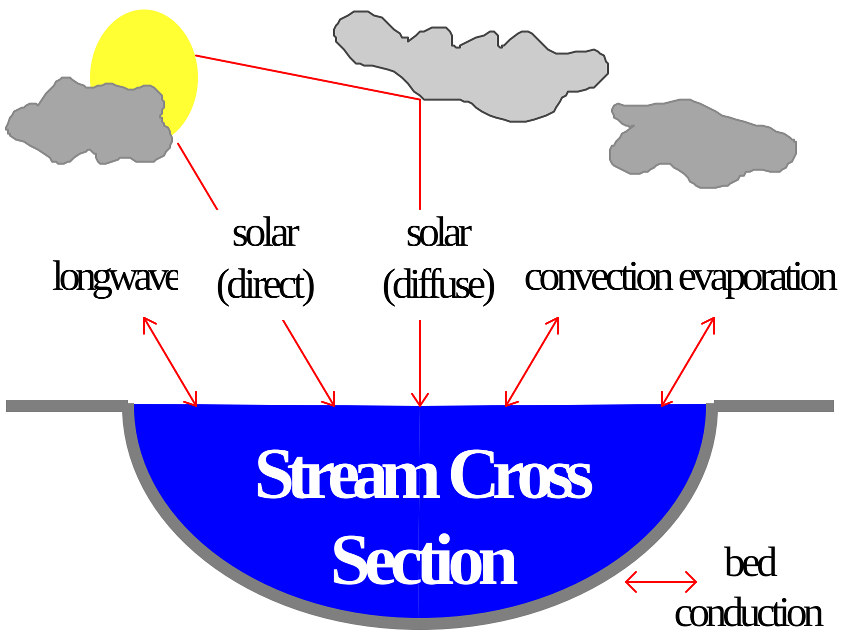
This TMDL is being established for two pollutants: heat and sediment. Both heat and sediment are considered pollutants under Section 502(6). These pollutants contribute to water temperature increases in two ways. First, heat transfer from excess amounts of solar radiation reaching the stream surface provides energy to raise water temperatures. Second, excessive delivery of sediment increases channel width through deposition and lateral scour. Wider channels then increase the amount of surface area exposed to heat transfer from solar radiation.

The two pollutants considered in this TMDL, singly and in concert, are major determinants of water quality that affect aquatic life. These factors vary naturally in their characteristics across the landscape (as a function of geology, topography and climate) as well as over time. The influence of both pollutants on water quality can also be significantly affected by changes associated with land use.

Water Temperature and Solar Radiation

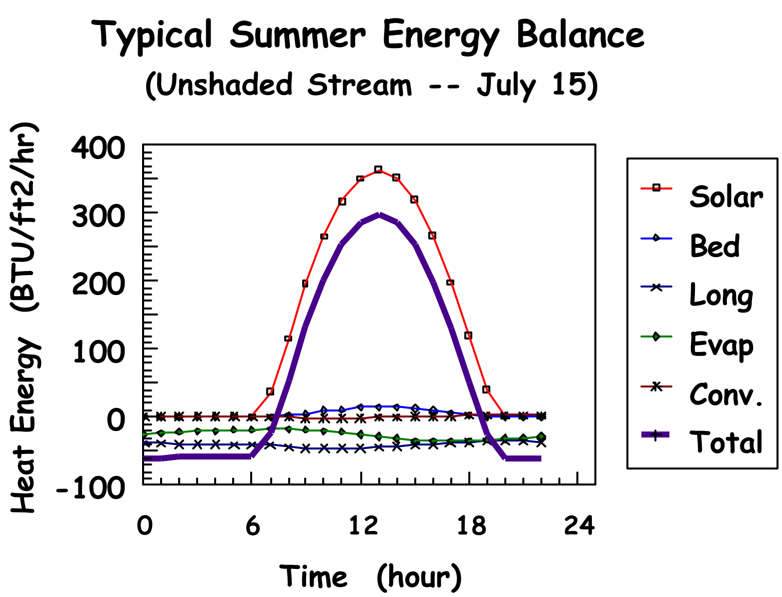
Stream temperature is an expression of heat energy per unit volume, or an indicator of the rate of heat exchange between a stream and its environment (Figure 1). In terms of water temperature increases, the principle source of heat energy is solar radiation directly striking the stream surface (Brown, 1970). Energy is acquired by a stream system when the heat entering the stream is greater than the heat leaving the stream. When there is a net addition of heat energy to the stream, the water temperature will increase.

Figure 1. Heat Transfer Processes that Affect Water Temperature



As discussed in many studies (Brown 1969, Beschta et al 1987, Holaday 1992, Li et al 1994), the daily profile for water temperature increases typically follows the same pattern as solar radiation delivered to an unshaded stream (Figure 2*)*. Other processes, such as longwave radiation and convection, also introduce energy into the stream, but at much smaller amounts when compared to solar radiation.

Figure 2: Typical Summer Energy Balance for an Unshaded Stream



This TMDL uses information from the HCP prepared by Simpson Timber Company (STC) for more than 80 percent of its Northwest Timberland holdings in the State of Washington. The plan area includes nearly 1,400 miles of streams that drain STC lands bordering the southern extent of the Olympic Mountains. The largest portion of these lands encompass major northern tributaries to the Chehalis River, including the Satsop and Wynoochee Rivers, which eventually drains to the Pacific Ocean. A smaller portion includes several Skokomish River tributaries draining to Hood Canal. A final portion includes streams draining to South Puget Sound (i.e. Goldsborough and Kennedy Creeks).

Rather than individually list stream segments for all 1,400 stream miles, information in the TMDL is summarized using lithotopo units (LTUs), channel types, or Riparian Management Strategies (RMSs) as defined in the HCP. There are five LTUs, 49 channel types, and eight RMSs described in the Simpson HCP which apply to all streams in the Plan area (both perennial and intermittent). Principle drainages within the HCP area include:

WRIA 14 => Kennedy - Goldsborough Watershed
WRIA 16 => Skokomish River (North & South Forks)
WRIA 22 => Chehalis River Basin (Lower), Satsop River (including the West, Middle, & East Forks), Decker Creek, Wildcat Creek, and the Wynoochee River.

Management activities can increase the amount of solar radiation delivered to a stream system, both by harvesting riparian shade trees and through the introduction of bedload sediment which can lead to channel widening. The Simpson HCP area has experienced a long history of forest land management, stemming back to the early twentieth century. This has resulted in degradation of the watershed condition.

Riparian Area Management and Timber Harvest

Riparian vegetation can effectively reduce the total daily solar radiation load. Without riparian shade trees, most incoming solar energy would be available to heat the stream. Harvest of riparian area trees can result in loss of shade. Limited work has been done to estimate the amount of shade loss due to source activities. The W.F. Satsop Watershed Analysis summarized causes for not meeting target shade requirements. The report indicated that approximately 59 percent of the stream miles assessed met the shade target. Of the remainder, 13 percent were too wide to be fully shaded and 28 percent did not meet the shade target because of riparian condition.

Sediment, Hillslope Failures, and Roads

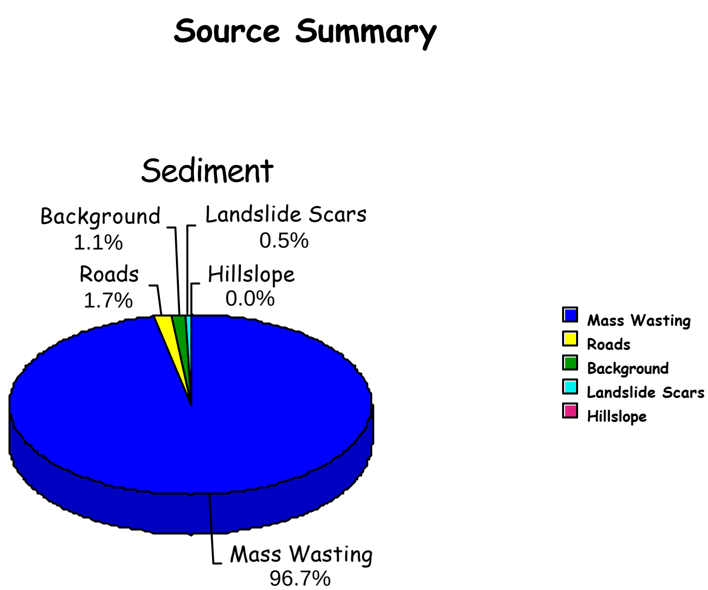
The sediment supply that enters stream channels in forested watersheds is generated by several processes: mass wasting (landsliding), surface erosion (especially from roads), soil creep (especially in unstable areas), and bank erosion (from streamside terraces) [*see* Paulson, 1997]. This is especially true where steep unstable terrain is subjected to major weather events that saturate hillslopes with large volumes of precipitation.

Unstable slope failures can occur, which deliver large amounts of surface soils to stream channels. These events can overwhelm the capacity of the channel to transport this material downstream, which in turn can lead to substantial channel widening, attendant bank erosion, and shallowing of surface flows. Important habitat features for salmonids and other aquatic life can be significantly affected by these processes. These features include stable spawning areas, pools and side channel rearing areas.

Controllable sediment is sediment delivered as a result of human activities which affects water quality and can be reasonably controlled. Rates of delivery have been estimated for these sources using several Watershed Analyses conducted within the Simpson HCP area *(Note: Watershed Analysis has not yet been conducted for the entire area, however, certain modules will be completed as part of the HCP).*

In addition, the W.F. Satsop Watershed Analysis developed an estimate of sediment from all sources to illustrate relative contributions (Figure 3). This estimate showed that the contribution from mass wasting is far greater than that from surface erosion. It should be noted, though, that the mass wasting value includes both fine and coarse sediment while the background and surface erosion values represent only fine sediment.

Figure 3. West Fork Satsop Sediment Yield



Applicable Criteria

Within the State of Washington, water quality standards are published pursuant to Chapter 90.48 of the Revised Code of Washington (RCW). Authority to adopt rules, regulations, and standards necessary to protect the environment is vested with the Department of 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, Washington has designated certain characteristic uses to be protected and the criteria necessary to protect these uses [Washington Administrative Code (WAC), Chapter 173-201A]. These standards were last adopted in November 1997.

This TMDL is designed to address impairments of characteristic uses caused by high temperatures. The characteristic uses designated for protection in the TMDL area streams are as follows:

> *"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 and mussel rearing, spawning, and harvesting.*
>
> *Crayfish rearing, spawning, and harvesting.*
>
> *(iv) Wildlife habitat.*
>
> *(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).*
>
> *(vi) Commerce and navigation."*
>
> WAC 173-201A-030(2)

The water quality standards describe criteria for temperature and polluting material such as sediment for the protection of characteristic uses. Streams in the TMDL area are designated either as Class AA or as Class A. These waters have temperature criteria assigned to protect the characteristic uses:

For Class AA waters:

> *"Temperature shall not exceed 16.0°C…due to human activities. When natural conditions exceed 16.0°C…, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C."*
>
> *"Incremental increases resulting from nonpoint activities shall not exceed 2.8°C."*
>
> WAC 173-201A030(1)(c)(iv)

For Class A waters:

> *"Temperature shall not exceed 18.0°C…due to human activities. When natural conditions exceed 18.0°C…, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C."*
>
> *"Incremental increases resulting from nonpoint activities shall not exceed 2.8°C."*
>
> WAC 173-201A-030(2)(c)(iv)

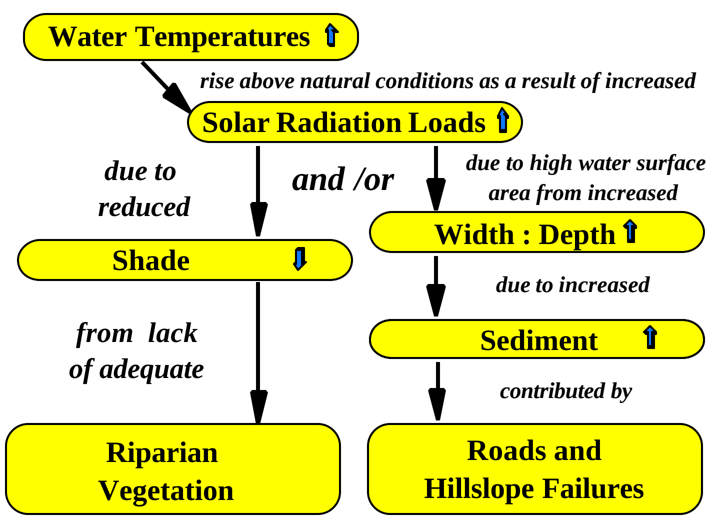
Finally, the applicable water quality standard for sediment states:

> *"deleterious material concentrations shall be below those which may adversely affect characteristic water uses ..."*
>
> WAC 173-201A-045(1)(c)(vii)

Surrogate Measures Used to Meet Criteria

Although a loading capacity for heat can be derived, it is of limited value in guiding management activities needed to solve identified water quality problems. Instead, the TMDL uses *"other appropriate measures"* (or surrogates) as provided under EPA regulations [40 CFR §130.2(i)]. The specific surrogates used are percent effective shade and sediment delivery. The relationship of water temperature increases to these surrogates is described in Figure 4.

Figure 4. Relationship of Water Temperatures to Surrogates



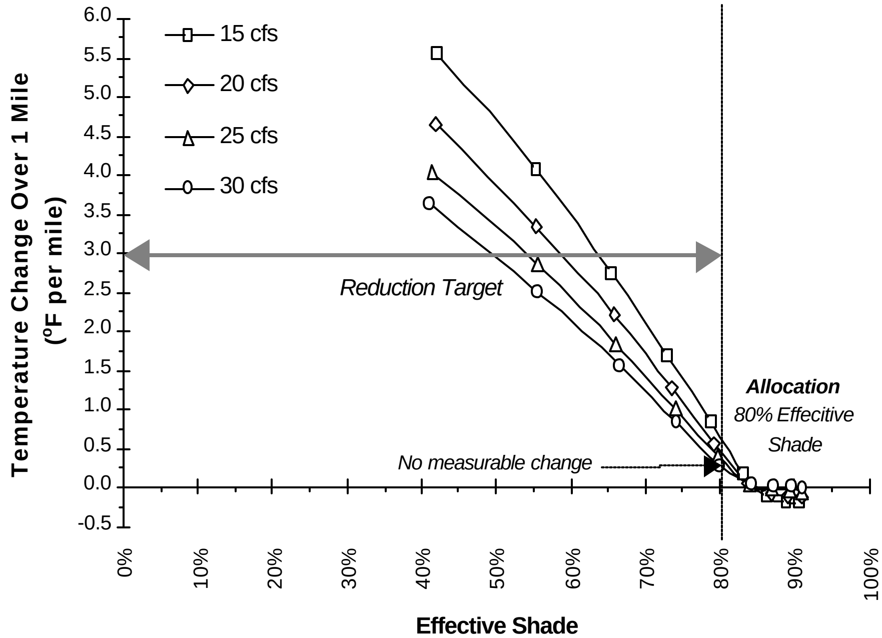
Note: **Boxes depict measured or calculated key indicators**

The *"Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program"* (FACA Report, July 1998) offers a discussion on the use of surrogate measures for TMDL development. The FACA Report indicates:

> *"When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional "pollutant," the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not. The criterion must be designed to meet water quality standards, including the waterbody's designated uses. The use of BPJ does not imply lack of rigor; it should make use of the "best" scientific information available, and should be conducted by "professionals." When BPJ is used, care should be taken to document all assumptions, and BPJ-based decisions should be clearly explained to the public at the earliest possible stage.*
>
> *If they are used, surrogate environmental indicators should be clearly related to the water quality standard that the TMDL is designed to achieve. Use of a surrogate environmental parameter should require additional post-implementation verification that attainment of the surrogate parameter results in elimination of the impairment. If not, a procedure should be in place to modify the surrogate parameter or to select a different or additional surrogate parameter and to impose additional remedial measures to eliminate the impairment."*

The concept regarding the effect of solar radiation loads on stream temperatures is illustrated in Figure 5. Information is presented in terms of the percent reduction of potential daily solar radiation load delivered to the water surface. This provides an alternative target (or *"other appropriate measure"*) which relates to stream temperatures, in this case, an 80% reduction in potential solar radiation delivered to the water surface.

Figure 5. Effect of Solar Radiation Reduction (Effective Shade) on Water Temperature



Water Quality and Resource Impairments

As a result of measurements that show temperature criteria are exceeded, one stream segment in the Simpson HCP area is included on the Washington 1998 Section 303(d) list. The Rabbit Creek segment in Township 21N- Range 06W- Section 28 is listed for exceeding temperature standards based on data collected by Rashin and Graber (1992). Other waters in the area were listed in 1996, but the measurements showing temperature violations were made far downstream of the Simpson HCP area.

While a simple TMDL addressing just Rabbit Creek could be done, Simpson's work on the HCP quickly led to dealing with the larger landscape area. Consequently, this TMDL uses broader resource functions and conditions to develop appropriate allocations across a diversity of local stream conditions and functions. In doing so, the TMDL allocations help guide better protection of existing conditions to prevent future impairments.

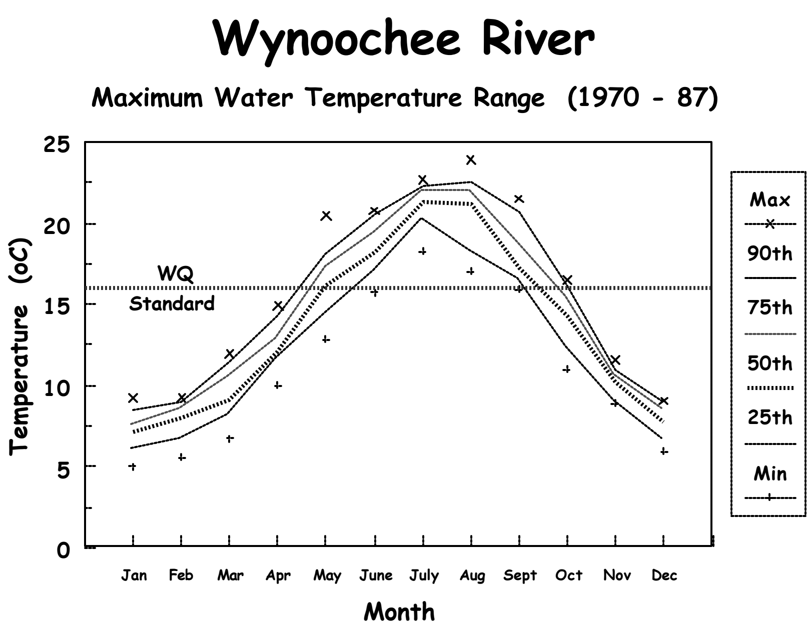
Seasonal Variation

Section 303(d)(1) requires that TMDLs *"be established at 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. This information is summarized in the following discussion.

Existing Conditions

Existing conditions for stream temperatures in the Simpson HCP area reflect seasonal variation. Cooler temperatures occur in the winter, while warmer temperatures are observed in the summer. Historical data has been collected by the U.S. Geological Survey (USGS) of stream temperatures in the Wynoochee River. Figure 6 summarizes the distribution of highest daily maximum water temperatures for each month between 1970 and 1987. The data indicates that the highest seven-day average maximum water temperatures occur between mid-July and mid-August. This time frame is used as the critical period for development and analysis of allocations in the TMDL.

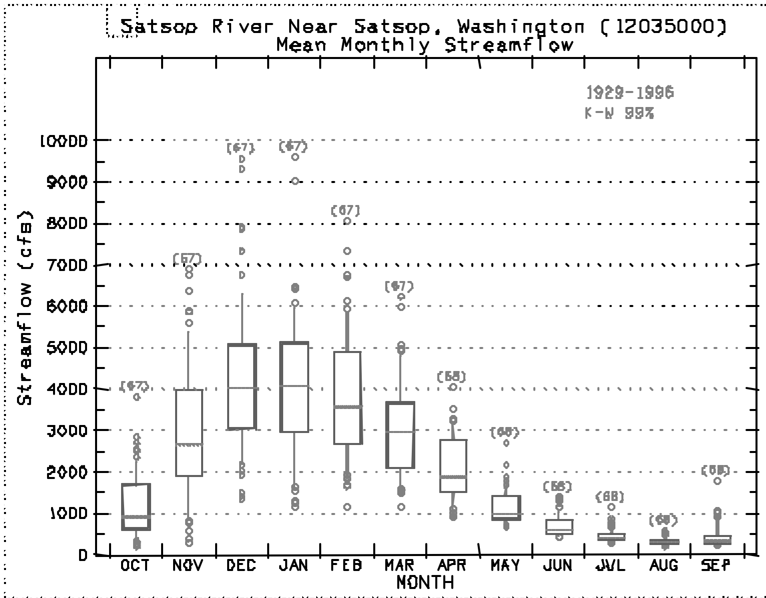
Figure 6. Seasonal Variation of Wynoochee Temperature Levels



Stream Flow

Monthly flow data is another way to describe seasonal variation that affects temperature. As illustrated in Figure 7 (shown by water year) flows decline through the summer reaching baseflow conditions in August, the same time we anticipate highest water temperatures. Flows then peak in December as a result of winter storm runoff. Because of the overlap between low flows and elevated temperatures, it is useful to know more about the pattern of low flows. The USGS data has also been used to describe the variation of 7Q2 (seven-day two year) values across the HCP area (Amerman and Orsborn, 1987). From this information, a relationship has been developed to estimate 7Q2 values for various LTU's within the HCP area. This value is important because it tends to coincide with the highest temperatures. In addition, the pattern of high flows is significant for eroding channel surfaces and moving sediment through the system

***Figure 7*. Flow Patterns for Satsop River**



Solar Radiation

Potential solar radiation varies throughout the year. The highest value occurs on the first day of summer when the earth's tilt towards the sun is greatest. Figure 8 illustrates the effect of seasonal variation on shadow length associated with different tree heights. As shown, shadows are shortest in mid-June. Figure 9 illustrates the effect of seasonal variation on maximum potential solar radiation. Mid-June is the period when solar radiation values are at their peak. As a result, mid-June can be used as a starting point for identifying the loading capacity for effective shade. This is the time that the water surface receives the maximum potential solar radiation and when riparian shade is least effective in reducing heat. This approach adds to the margin of safety because low flows and maximum water temperatures typically occur one to two months later.

Figure 8. Seasonal Variation of Shadow Lengths

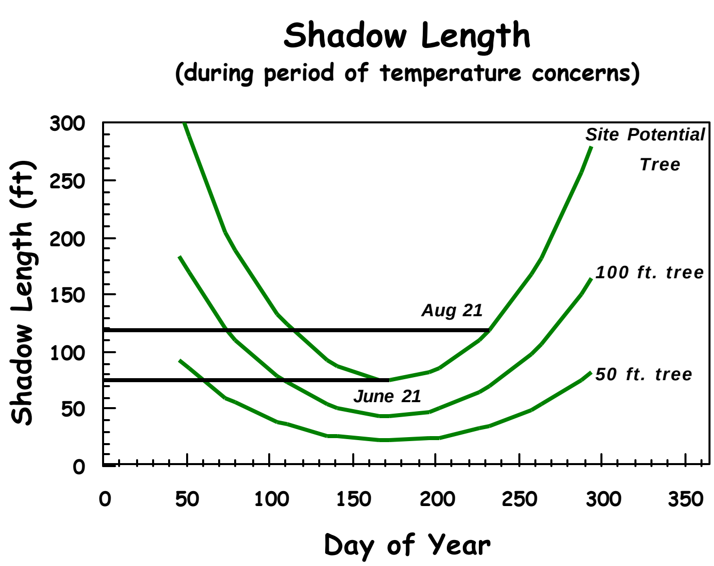
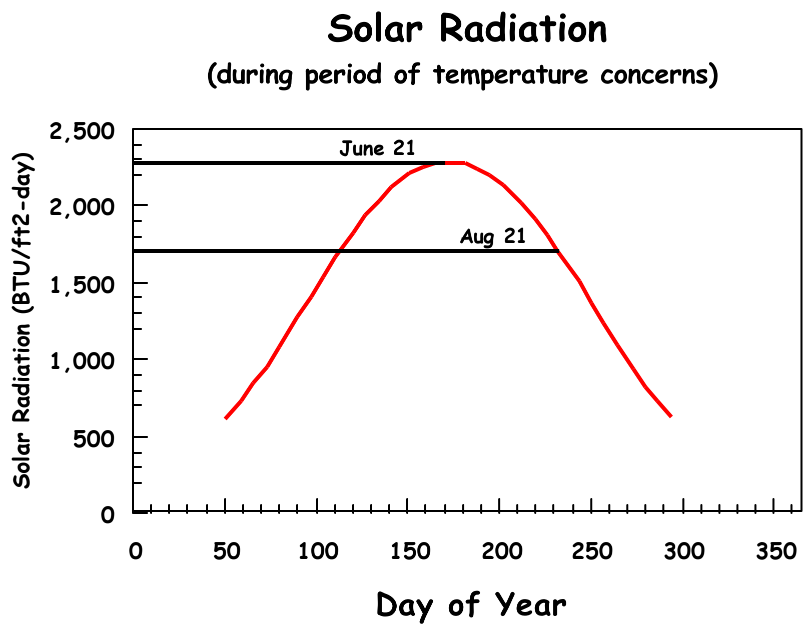


Figure 9. Seasonal Variation of Maximum Potential Solar Radiation



Critical Temperature Conditions

Estimates for streamflow, solar loading, and water quality parameters need to be taken into account in development of this TMDL. The analysis demonstrating the relationship of channel and riparian conditions to solar radiation loads requires a framework for identifying critical conditions. Based on historical data for the Wynoochee River (Figure 10*)*, the critical period used for the analysis is mid-July. This represents the time frame for which solar radiation is highest when the earliest summer maximum water temperatures were observed. This timeframe is also consistent with water temperature monitoring data collected by Simpson (Figure 11).

Figure 10. Wynoochee River Summer Water Temperatures

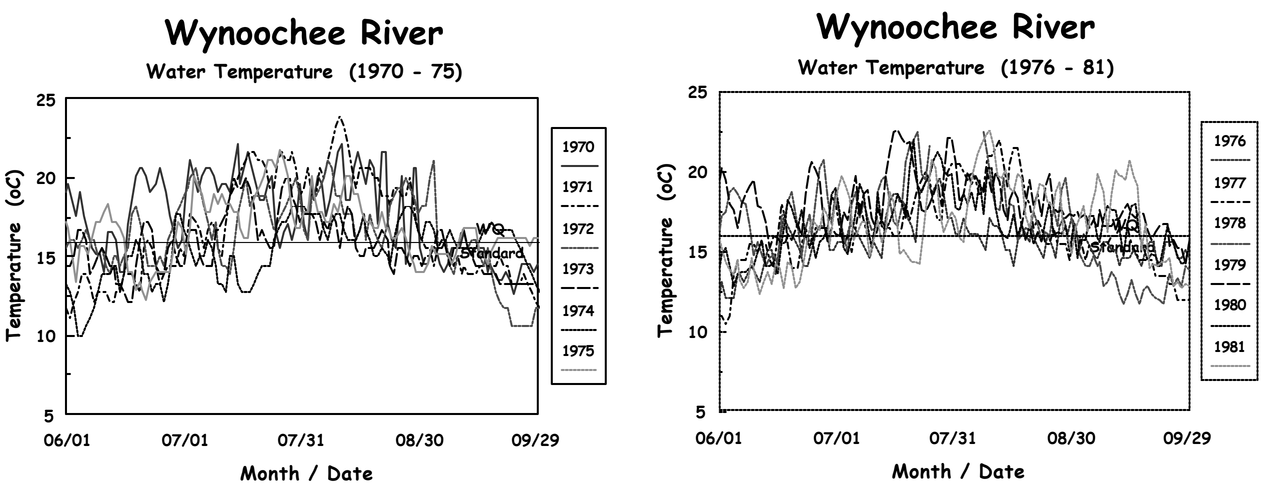
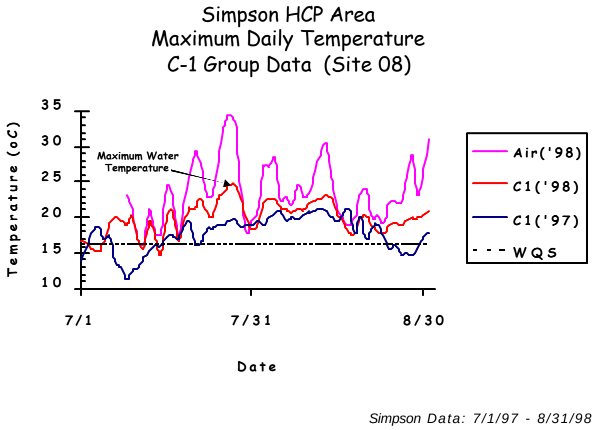
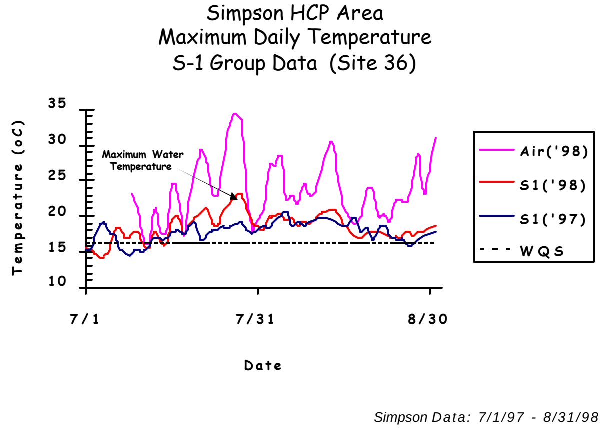


***Figure 11*.** Simpson HCP Area Summer Water Temperatures

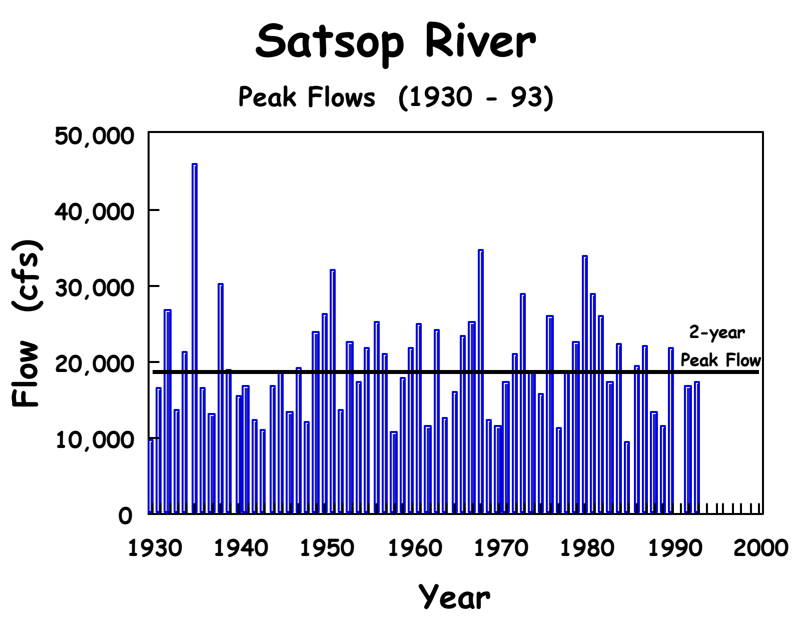




Annual Variability and Sediment

The annual variability of peak flows effects sediment delivery. USGS (1971) described sediment yield in the Chehalis basin. Consistent with sediment studies in other areas, the report noted that the greatest percentage of sediment transport occurred during peak flows. Figure 12 shows the variation in peak flows for the Satsop River.

***Figure 12*.** Satsop River Peak Flow History



Technical Analysis

Under the current regulatory framework for development of TMDLs, identification of the loading capacity for pollutants is the first step. The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring a water into compliance with standards. By definition, TMDLs are the sum of the allocations *[40 CFR §130.2(i)]*. Allocations are defined as the portion of a receiving water's loading capacity that is allocated to point or nonpoint sources and natural background. EPA's current regulation defines loading capacity as *"the greatest amount of loading that a water can receive without violating water quality standards"*. Following is a summary of the extensive technical analysis that was done for this TMDL. The complete analysis is found in Appendix A.

Landscape Scale Analyses

TMDL development for nonpoint sources presents some inherent challenges. Diffuse sources are often associated with watershed or landscape scale features and processes occurring over time. Consequently, water quality concerns associated with nonpoint source (NPS) pollutants require a different approach from traditional point source problems.

Landscape Stratification: The foundation of the proposed HCP lies within the system Simpson has developed to better understand the inherent characteristics and sensitivities of their lands, and how their long-term forest management plans interact with them. In short, these features are *geological settings, climatic factors and their interaction.*

Influences of geologic setting and associated physical processes within the HCP area are captured by stratifying the landscape into *"lithotopo"* units (LTU), i.e. areas of similar lithology and topography. LTU boundaries are determined by geology, geological history, and topographic relief. This approach divides Simpson's HCP area into units that share similar erosion, mass wasting and channel forming processes. The LTUs are:

- Alpine glacial (AGL)
- Crescent islands (CIS)
- Crescent uplands (CUP)
- Recessional outwash plain (ROP)
- Sedimentary inner gorges (SIG)

Channel Classification: Conditions in a stream are a function of channel morphology (e.g. source, transport, or response reaches). Methods exist to assess the condition of a stream, as well as departure from its potential (Rosgen, 1996). These methods, built around channel classification, are a useful starting point to develop specific TMDL surrogate measures for streams in the Simpson HCP area. Consequently, a second lower level of stratification consists of classifying stream segments of the channel network within each of the LTU's.

There are 49 individual stream segment types developed within this system). Riparian management strategies are keyed to each of the stream types. A description of these can be found within the HCP document. Additional details on channel characteristics, geology, morphology, large woody debris characteristics and recruitment processes, sediment delivery and processing mechanisms, riparian characteristics and biological community features are described in the HCP appendices. A summary table of the 49 types can also be found in the technical assessment (Appendix A) of this document.

Mechanistic Models

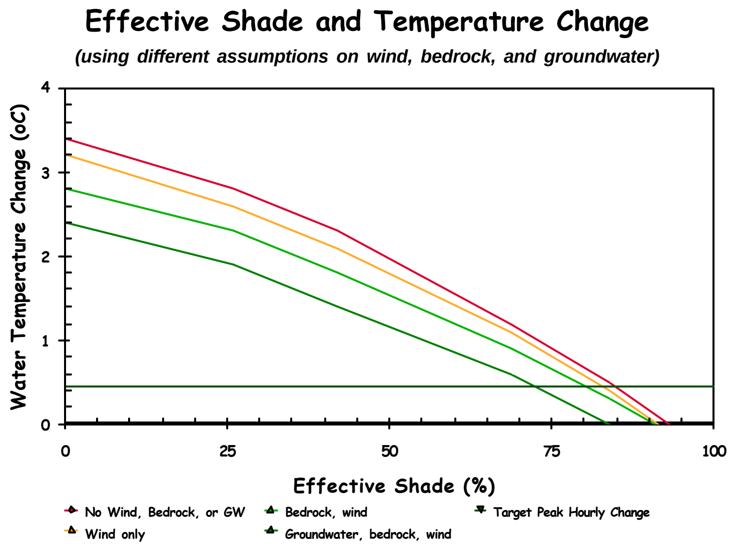
A loading capacity for heat (expressed as BTU/ft^2 per day) can be derived using mechanistic models. One of the most basic forms of these models is the fundamental equation applied by Brown (1969) for forest streams (Table 1).

***Table 1*.** Mathematical Relationship between Water Temperature and Heat

$\Delta T = \Delta H * A \;/\; (V * \rho * c_p)$
where: ΔT = temperature change (°F / hour) ΔH = rate that heat is received (BTU / hour) A = surface area (ft^2) V = volume (ft^3) ρ = density of water (62.4 lb / ft^3) c_p = specific heat of water (BTU/ lb / ? F)

The calculation of water temperature by a mechanistic model follows the basic relationship described in Table 1. A mechanistic model is essentially bookkeeping of different heat transfer processes to determine potential water temperature changes. Using such an approach, a family of curves can be developed which describes different ΔH values designed to achieve a known temperature change. Figure 13 illustrates one such set of curves for a class of streams in the Simpson HCP area.

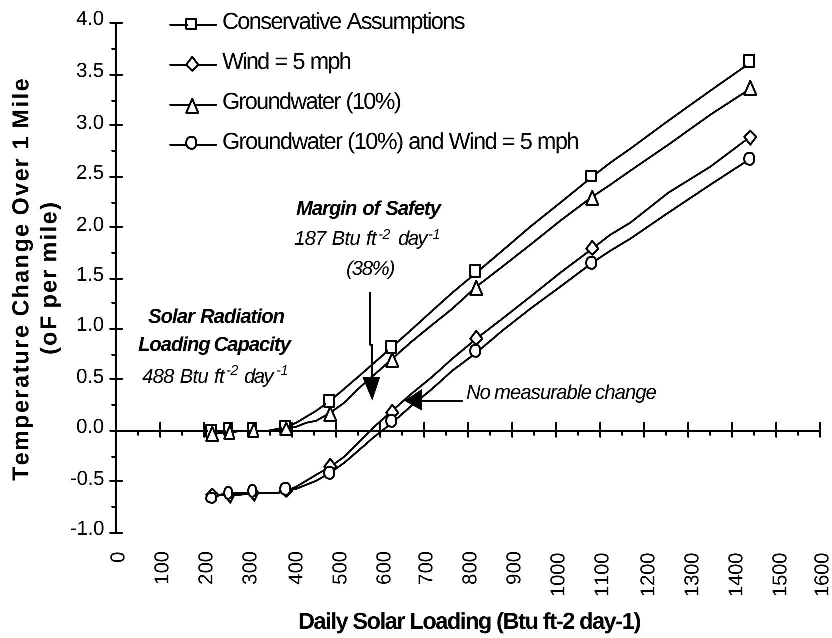
Figure 13. Simpson HCP Area Pool Riffle Channels



Other models have been developed based on a heat budget approach that estimate water temperature under different heat balance and flow conditions. Brown (1969) was the first to apply a heat budget to estimate water temperatures on small streams affected by timber harvest. Using mathematical relationships to describe heat transfer processes, the rate of change in water temperature on a summer day can be estimated. Relationships include both the total energy transfer rate to the stream (i.e. the sum of individual processes) and the response of water temperature to heat energy absorbed. Heat transfer processes considered in the analysis include solar radiation, longwave radiation, convection, evaporation, and bed conduction (Wunderlich 1972, Jobson and Keefer 1979, Beschta and Weatherred 1984, Sinokrot and Stefan 1993).

Figure 2 (Page 4) showed that solar radiation is the predominant energy transfer process which contributes to water temperature increases. A general relationship between solar radiation loads and stream temperature can be developed by quantifying heat transfer processes (Figure 14). In this example, average unit solar radiation loads greater than 675 BTU / ft^2 per day result in a noticeable increase in water temperature. This could represent a starting point to define a loading capacity (i.e. the greatest amount of loading that a water can receive without violating water quality standards).

***Figure 14*.** General Relationship between Solar Radiation Loads and Water Temperature



A drawback to the use of mechanistic models, however, is the difficulty in determining solar radiation loads over each stream mile of a large watershed. The curves that result from numerical calculations are influenced by a number of factors. These include stream flow, channel width, upstream water temperature, wind speed, relative humidity, stream bed composition, and groundwater contribution. Higher stream flows, for example, result in higher allowable solar radiation loads when width:depth ratios are held constant. Likewise, narrower channels result in higher allowable loads when stream flows are held constant.

Natural Conditions

Another complication in using mechanistic models to develop allowable loads is that the result may be the identification of loading capacities that are not achievable. This occurs when the vegetative height associated with a mature riparian forest is not tall enough to shade the entire active channel. For instance, on June 21 the shadow length of a 170 foot tall Douglas fir at 1pm (daylight time) is about 75 feet. This means that an active channel wider than 75 feet will not be completely shaded on that date. For such cases and for cases where the numeric criteria is naturally exceeded, the natural conditions clause of Washington's water quality standards is applied *[WAC 173-201A-070(2)]*. This means that where mature riparian vegetation will not fully shade the active channel, the temperature which results from shade achievable by a mature riparian forest becomes the standard. The loading capacity is then the solar load associated with these natural conditions.

To better quantify the linkage between solar loads associated with the natural conditions and the anticipated effect on water temperature, a discussion of diurnal variation is helpful. Diurnal variation in water temperature occurs naturally in stream systems. The magnitude of the temperature change (both diurnal range and peak hourly increase) has meaning for this TMDL because it is designed to decrease the pollutant load. Assessing the peak hourly change as a result of load reduction is much more straightforward than predicting attainment of an absolute water temperature. This approach incorporates natural conditions by looking at the change from a base temperature as opposed to making multiple site-specific evaluations to establish base temperatures.

In the absence of those site specific criteria modifications, this TMDL is developed by stratifying the landscape into temperature groups. From this framework, effective shade targets are identified for channel types within each temperature group that are needed to achieve a maximum peak hourly increase.

Temperature Groups

The channel classification system, in conjunction with some temperature data and field evaluations, was used to group stream reaches by the dominant control(s) which affect water temperature. Using information about each stream class in the HCP area (e.g. the range of stream flows, active channel widths, etc), effective shade targets can be developed for each group of streams. Table 2 identifies the seven groups and describes watershed process features that exert the greatest influence on water temperature in those channel classes. Dominant features include shade, groundwater, and channel morphology. '*RMS* 'in the table stands for Riparian Management Strategy. Each strategy was developed for the HCP to meet the functional needs of the various stream classes.

***Table 2*.** Groups for Identifying Targets to Address Water Temperature

Group	Features	HCP Channel
	Shade	
S-1	Small to medium sized pool riffle and forced pool riffle / plane bed channels of the ROP and SIG. Water temperature is driven by shade and low flows (poor water storage in these watersheds over glacial tills and shallow soils). Headwaters of these systems are usually in wetlands or bogs and beavers frequently pond water within the channel. *RMS: Temperature Sensitive.*	ROP-Qc1, -Qc2 ROP-Qc3 SIG-Qc3

***Table 2*. (cont)** Groups for Identifying Targets to Address Water Temperature

Group	Features	HCP Channel
	Shade	
S-2	Small to medium sized channels in the AGL and SIG. These systems most often have hardwood dominated riparian systems and subtle groundwater influence through wet side slopes. They are subject to heating with the loss of riparian shade which can happen through damage to riparian leave areas by natural factors or through insufficient leave area. *RMS: Alluvial Bedrock Transition or Reverse Break in Slope*.	AGL-Qo2, -Qo4 SIG-L1, -L2, -L3 SIG-M1, -M2, -M3 SIG-M4, -M6 SIG-Qo2
S-3	Small to medium sized streams in the recessional outwash sediments of the CIS and SIG. These channels have low summer flows, but the storage and character of the flows is different from the ROP in that lower terraces, floodplains, and valley walls of these systems are composed of fine, but fairly well draining unconsolidated outwash sediments. These materials do not store great quantities of water. However, there is a slow release of groundwater that appears to moderate temperatures, but it is not sufficient to offset heating as a result of riparian canopy loss. With loss of shade, these streams can heat up to moderate levels. *RMS: Channel Migration or Unstable Slopes / Intermittent*.	CIS-Qc1, -Qc2 CIS-Qc3 SIG-Qc1, -Qc2
S-4	Small to medium sized channels in glacial till landscape of the AGL and SIG with pool riffle and forced pool riffle / plane beds. These systems have moderate to low flows in summer with varying amounts of groundwater influence. Along the continuum, those with minimal groundwater influence are susceptible to elevated water temperatures with loss of shade. Those with significant amounts of groundwater influence are resistant to temperature changes. *RMS: Break in Slope.*	AGL-Qo3, -Qo5 AGL-Qo6, -Qo7 SIG-Qo3, -Qo4

***Table 2*. (cont)** Groups for Identifying Targets to Address Water Temperature

Group	Features	HCP Channel
	Groundwater	
G-1	Small to medium sized pool riffle and forced pool riffle / plane bed channels of the CIS and ROP that are strongly influenced by groundwater. These systems are resistant to changes to water temperature because flow is strong and comes from a cool source. Shade is a secondary influence, except during extreme low flow years. *RMS: Channel Migration*.	CIS-C5 ROP-Qc4, -Qc5 ROP-Qc6, -Qc7
G-2	Small to medium sized highly confined channels of the AGL, CIS, CUP, and SIG. These are topographically shaded and are *"near"* their water source with substantial groundwater influence which shows as side seeps and springs. These systems are typically cool and are resistant to water temperature changes, even in the absence of riparian vegetation. *RMS: Canyon*.	AGL-Qo1, -Qo8 CIS-C1 CUP-C1, -C2, -C3 CUP-C4, -C5, -C6 CUP-C8 SIG-Qo1
	Channel Morphology	
C-1	Large rivers of the AGL, ROP, and SIG are affected by high sediment supply and multiple thread channels over at least some of their length. Applies to the West and Middle Forks of the Satsop, the Canyon, Little and Wynoochee Rivers. Temperatures in these systems are strongly influenced by channel pattern and open canopies. Current and past sediment supply, long residence times, and channel pattern make it unlikely that water temperatures here will change for decades. *RMS: Inner Gorge or Channel Migration*.	AGL-Qa6 ROP-C7, -Qa7 ROP-Qc8 SIG-L4, -M5, -Qa6

These seven temperature groups allow refinement of assumptions used to develop effective shade targets. Development of effective shade targets is then based on a better description of site specific conditions. In addition, actual data collected on streams in the Simpson HCP area is used to validate anticipated responses. Figure 15 depicts information collected in 1997 and 1998 from sites representative of each temperature group. Maximum observations between July 1 and August 31 are shown for each year. This corresponds with the seasonal time frame when maximum water temperatures occur. Figure 16 shows the percentage of streams in the Simpson HCP area that lie within each temperature group. Figure 16 also shows the percentage of time that the 16°C was exceeded at each site used to represent the temperature group.

Figure 15. Annual Maximum Water Temperature by Group

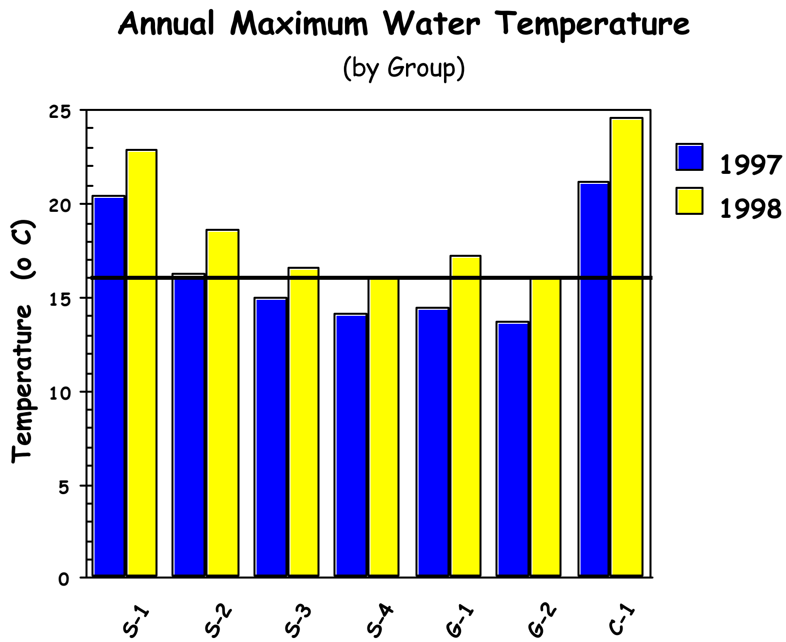
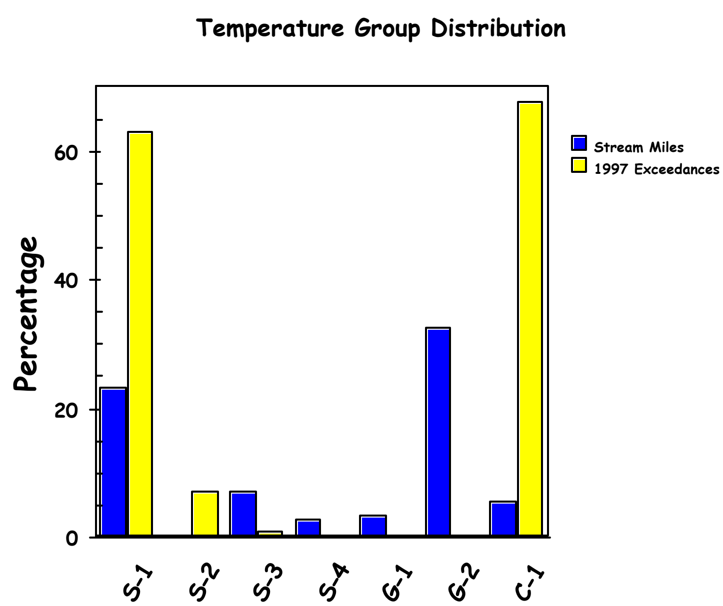


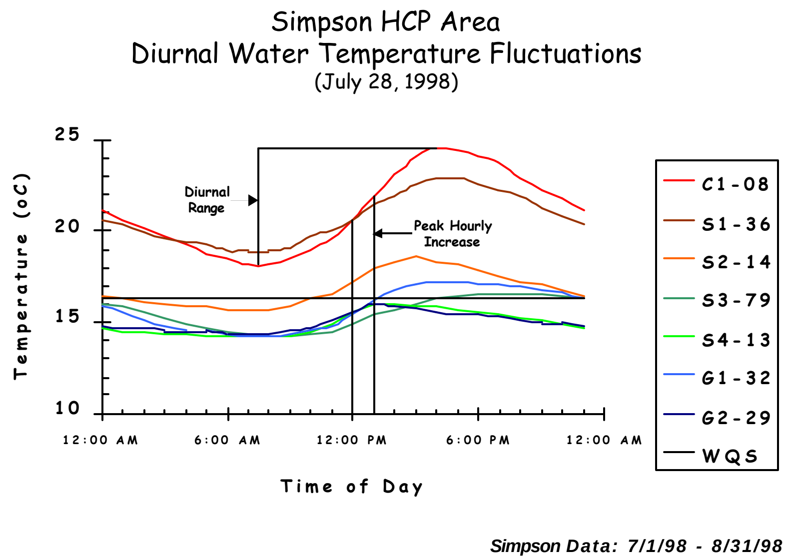
Figure 16. Distribution of Temperature Groups



Peak Hourly Change

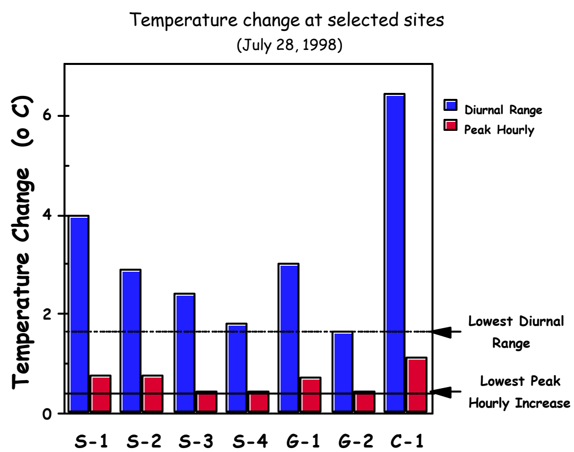
Development of loading capacities and allocations that focus on either maximum diurnal range or peak hourly water temperature increase is possible. An analysis can be constructed which evaluates solar radiation inputs and resultant water temperature change through a heat budget analysis. Figure 17 depicts the diurnal variation of the temperature group monitoring sites on July 28, 1998. This is the day when maximum water temperatures were observed over the 2-year period for monitoring data provided by Simpson.

Figure 17. Temperature Group Summary - Diurnal Water Temperature Fluctuations



July 28, 1998 also corresponds to the date when the maximum water temperature was observed by the U.S. Forest Service over a 5-year period in the Humptulips watershed (immediately west of the Simpson HCP area). Figure 18 shows both the diurnal change and peak hourly water temperature increase for each temperature group. Based on this relationship, the lowest peak hourly increase observed (0.45°C) is used to derive effective shade targets.

Figure 18. Temperature Group Summary - Temperature Change at Selected Sites



Loading Capacity

Identification of the loading capacity is an important step in developing TMDLs. The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring a water into compliance with water quality standards. By definition, a TMDL is the sum of the allocations. An allocation is defined as the portion of a receiving water's loading capacity that is assigned to a particular source. EPA defines the loading capacity as "the greatest amount of loading that a water can receive without violating water quality standards."

Effective Shade

Using information about each channel class (e.g. drainage area, range of flows, etc) effective shade targets can be developed. The channel classification system is used to assess stream reaches according to temperature groups. This approach leads to effective shade targets which recognize the variability in channel and riparian characteristics that occurs across the landscape. As such, these targets reflect the range of active channel widths and riparian vegetation heights by LTU within the HCP area (Table 3).

Table 3. Effective Shade Loading Capacity Targets

Active Channel Width[1] *(meters)*	**Vegetation Height[2] *(feet)***	**Effective Shade[3] — *by temperature group (%)***						
		C-1	**G-1**	**G-2**	**S-1**	**S-2**	**S-3**	**S-4**
≤4	**42.3**	90	84	84	77		65	
6 - 10	**105.7**	87	82		76	85	68	89
12 - 15	**158.5**	89	85			85	68	
16 - 18	**170.0**			83	81	75		85
20 - 25	**170.0**						65	76
>25	**170.0**							72

1 This table summarizes the effective shade loading capacity targets by active channel width. Active channel width determines the surface area requiring effective shade. The HCP identifies 49 channel classes which are used to identify 7 temperature groups. The Technical Assessment Report describes these temperature groups as well as information on active channel widths associated with each LTU, channel class, and Riparian Management Strategy.

2 Riparian vegetation height that completely shades a 45° aspect stream at 1pm (daylight time) on 6/21.

3 Effective shade targets calculated using a heat budget for channel types within each temperature group that are needed to achieve a maximum peak hourly increase of 0.45°C. This maximum peak hourly increase serves as a numeric interpretation of the narrative criteria for *"natural conditions"*. As new data and methods are developed to better describe *"natural conditions"*, the loading

capacities may be refined and the TMDL revised.

Sediment Delivery

The effect of sediment and its relationship to numeric water quality standards is incorporated into this TMDL through a temperature group approach as well. Stream Groups as described earlier are defined according to the dominant control which influences water temperature. One of those controls is channel morphology. *Group C-1* represents streams where temperatures are strongly influenced by channel patterns affected by high sediment supply. Changes in sediment input can lead to an alteration of channel form (Leopold et al, 1964; Megahan et al, 1980) through deposition and lateral scour. Water temperatures for *Group C-1* streams are among the warmest monitored.

Developing a load capacity for sediment considers Washington's Water Quality Standards which state *"deleterious material concentrations shall be below those which may adversely affect characteristics water uses"*. The approach includes:

- Focus on <u>*up-slope sediment source targets*</u> rather than looking exclusively at the suite of instream features that reflect the outcome of both natural and management related factors.

- Establish <u>*quantifiable targets for sediment delivery*</u> by erosion process (e.g. cubic yards delivered per mile per averaging period) associated with each channel class.

Up-slope sediment source targets are included because focusing on instream indicators would ignore the sediment input dynamics. Hillslope targets supplement instream criteria by providing measurable goals that are not subject to the variability of climatic conditions. Hillslope and road-related targets are easier to measure and are more controllable. Hillslope and road-related targets also have the advantage to a landowner of being easily converted to implementation plans and management practices that can be evaluated more frequently than instream targets. Finally, without addressing hillslope sources, the cycle of degradation could potentially be repeated until some beneficial use of the system could no longer recover.

Quantifiable targets for sediment delivery enable a focus on source input and hazard reduction. Sediment delivery targets for this TMDL are expressed in terms of cubic yards. Development of sediment delivery targets, i.e. the loading capacity, uses a framework suggested in the TFW Watershed Analysis Manual, specifically construction of a partial sediment budget (Reid and Dunne, 1992). This serves several purposes including:

- tie sediment problems recognized in streams to specific hillslope sources or activities;
- discriminate among the rates, effects, and hazards of various mass wasting, surface, and bank erosion processes in basins where all are significant sediment sources; and
- document the relative contributions of sediment delivery processes (e.g. road surface versus deep seated landslides).

Erosion processes considered in the partial sediment budget include mass wasting (shallow rapid landslides (SR), debris torrents (DT), large persistent deep-seated slides (LPD)), surface erosion, and bank erosion. Sediment delivery targets are based on information contained in three completed Watershed Analysis reports conducted in the Simpson HCP area (W.F. Satsop, S.F. Skokomish, Kennedy Creek). Included is landslide inventory data developed from air photos between 1946 - 96 described in the assessment reports. Loading capacities are summarized by lithotopo unit within the HCP area (Table 4).

Table 4. Sediment Loading Capacity by Lithotopo Unit

Lithotopo Unit	Size of HCP Area *(%)*	Length *(miles)*	Loading Capacity *(yd^3 / stream mile per year)*				
			Mass Wasting			Surface Erosion	Bank Erosion
			SR	*DT*	*LPD*		
AGL	8	137.7	25	1	15	4	8
CIS	12	163.7	15	1	1	2	4
CUP	11	265.2	35	35	1	3	6
ROP	45	376.7	15	0	1	1	2
SIG	24	454.5	25	1	60	8	10[1] - 25[2]
Total	100	1397.8					

NOTES: [1] Small channels; [2] Large channels
Loading capacities expressed as long term annual average values and do not reflect the wide range spatial and temporal variation observed in natural erosion processes. As new data and methods are developed to better describe sediment delivery mechanisms, the loading capacities may be refined and the TMDL revised.

Although an annual averaging period is used to express the loads, it is simply a referencing mechanism. Erosion processes which are responsible for sediment inputs to the system are highly dynamic, change from year-to-year, and vary in different locations in the basin.

Load Allocations

Once the Loading Capacity has been developed, then contributing sources can be allocated their fair contribution. This TMDL is designed to address impairments due to surface water temperature increases on one water quality-limited segment located in the Simpson HCP area. In addition to the listed Section 303(d) waters, this TMDL also applies to other potential water quality impairments from heat and sediment for all streams in the Plan area. In developing the allocations, this TMDL has benefited from portions of the analysis used in preparation of Simpson's HCP. Allocations in the TMDL are designed to achieve properly functioning aquatic systems in the HCP area.

Regulatory Framework: Under the current regulatory framework for development of TMDLs, flexibility is allowed for specifying allocations in that *"TMDLs can be expressed in terms of* *either mass per time, toxicity, or other appropriate measure"*. This TMDL does use other measures to fulfill requirements of Section 303(d). Although a loading capacity for heat can be derived [e.g. BTU/ft^2 per day], it is of limited value in guiding management activities needed to solve identified water quality problems.

Allocation Development: Allocations in this TMDL are derived using effective shade and sediment delivery targets. These measures can be linked to specific source areas, and thus to actions (specifically riparian management and erosion control) needed to solve problems which cause water temperature increases. Because factors that affect water temperature are interrelated, both measures are dependent upon each other to achieve desirable responses. Using riparian vegetation exclusively to reduce heat (e.g. increase shade) is difficult to achieve if sediment delivered from upland sources continues to deposit and widen channels. Likewise, narrower channels still require riparian vegetation to provide channel stability and shade, thus reducing heat loads (unless confined by canyon walls or shaded by topography).

The TMDL develops load allocations for each channel class in the Plan area, then summarizes them into eight separate groups. Streams within each group share common characteristics that relate to potential input of pollutants into those streams and point towards possible management strategies.

The HCP divides the stream segments into the same eight groups with corresponding individual riparian management strategies *(Table 5)*. These strategies have been developed to integrate the applicable physical processes and ecological functions. For ease of reference, each of the eight groups of streams analyzed separately in this TMDL is given the same name as the corresponding riparian management strategy in the HCP.

***Table 5*.** HCP Riparian Management Strategy Summary

Strategy	Purpose	Management Function
Canyon	Maintain sediment and organic matter storage capacity of the upper channel network, keep convective heat transfer to a minimum, and supply detritus to the channel as it's principle energy source.	Provision of LWD from off-site, and maintenance of on site shade and detrital inputs. Applied in the CUP along highly confined channel network of the Olympic foothills.
Channel Migration	Maintain the floodplain processes that contribute nutrient processing within the soil and hyporheic zone and ensure continued development of topographic complexity of floodplain surfaces.	Retention of sediment and organic matter and maintenance of nutrient processing. Applied to either very large meandering alluvial channels inset within well defined terrace systems or those low gradient smaller channels with highly erodible banks.
Temperature Sensitive	Mediation of water temperatures in channels that are vulnerable to summer time increases.	Protection of shade and control of streamside air temperature. RCRs established that provide the greatest shade from mid-day to early afternoon ensuring wide, denser leave area on south and west aspects.
Inner Gorge	Provide wood large enough to maintain position or lodge in channel classes like SIG-L4, SIG-L5, AGL-Qo8, and AGL-Qa6.	Provision of wood from unstable slopes to enhance development of productive main river habitat. Retain largest trees that have the highest likelihood of recruiting to the river.
Alluvial Bedrock Transition	Maintenance of an alluvial channel bed in channel classes likely to scour to bedrock in the absence of LWD.	Provision of LWD, particularly along channel classes SIG-M3 and SIG-M4. Protect principal recruitment zone for high value LWD.
Reverse Break in Slope	Maintain opportunity for conifer germination sites in an otherwise unfavorable environment by protecting LWD and providing nurse logs.	Provision of LWD and nurse logs. Settings typified by wet understory plant communities whose early seral stages are dominated by red alder.
Unstable Slopes / Intermittent Flow	Maintain important functional linkages between channel segments and their riparian areas for channel classes that typically have low average fish resource value.	Recognition of physical processes that may transmit significant impacts from these channel classes to other segments downstream for which on-site biological resource value is high.

Effective Shade Allocations The objective of the effective shade TMDL is to reduce heat from incoming solar radiation delivered to the water surface. The basis for effective shade allocations follows an analysis of processes that affect water temperature. Development of the effective shade allocations uses information about riparian management strategies described in the HCP. Minimum Riparian Conservation Reserve (RCR) widths described in the HCP recognize the relationship between active channel width and effective shade.

Effective shade allocations have been developed from targets based on channel class width and characteristics of mature riparian vegetation for that channel class including vegetative density. Effective shade allocations are a function of the vegetation that will shade the widest active channel for each class. The active channel width, the vegetative density associated with a particular RCR width, and the height associated with the expected riparian community (e.g. mixed conifer/hardwood) is used to determine effective shade allocations.

As channels become wider, larger RCR widths are needed to provide more effective shade, as well as to protect other riparian functions. This is reflected in the HCP where wider channels have larger RCR widths identified. Small channels (≤ 4m), on the other hand, can benefit from dense, emergent vegetation. Consequently, narrower RCR widths may still provide a high level of effective shade to these small streams. However, the benefit of the RCR to these smaller channels may go beyond effective shade. As indicated in the HCP, the purpose of the RCR is also to provide slope stability and a supply of large woody debris (LWD).

The TMDL and allocations for effective shade are summarized in Table 6. Because of the channel groupings, it becomes apparent that there are variations between active channel widths and minimum RCR widths. In many instances, channels of the same width size actually have different RCR widths. The temperature group and other considerations (e.g. LWD supply, sediment supply concerns) become important factors, particularly in terms of uncertainty for channel response and increasing the margin of safety.

Table 6. Effective Shade TMDL and Load Allocations Summary for Simpson HCP Area

Segment Name *Riparian Management Strategy*	*(length in mi.)*	**TMDL**	**TMDL Components**[1] *(Effective Shade as percent)*		
			WLA[2]	LA[2]	MOS[2]
Temperature Sensitive	*53.3*	88.7%	0%	90.0%	(1.3%)
Break in Slope	*171.1*	85.4%	0%	91.6%	(6.3%)
Canyon	*59.4*	68.0%	0%	94.1%	(26.1%)
Channel Migration	*83.7*	79.7%	0%	84.4%	(4.7%)
Inner Gorge	*50.4*	70.6%	0%	77.5%	(6.9%)
Alluvial Bedrock Transition	*15.6*	85.0%	0%	88.4%	(3.4%)
Reverse Break in Slope	*42.8*	83.9%	0%	95.0%	(11.1%)
Unstable Slopes / Intermittent Flow	*921.5*	77.0%	0%	93.0%	(16.0%)
TMDL					

NOTES:

1 Specific streams to which an RMS applies are identified in the HCP and are defined by LTU / channel class. The effective shade TMDL and allocations are designed to achieve a loading capacity that provides sufficient shade needed to minimize water temperature increases. Shade targets developed through use of temperature groups which consider topography, active channel width, groundwater, and potential natural riparian vegetation.

2 **WLA**: Waste load allocation; **LA**: Load allocation; **MOS**: Margin of Safety. There are no point sources within the HCP area covered by the TMDL, so the WLA for effective shade is 0.

Sediment Delivery Allocations: The loading capacity and allocations for sediment delivery are summarized in Table 7 using the same eight channel groups/strategies. The estimated total allowable sediment load is derived from targets based on lithotopo unit, channel class and erosion process (cubic yards per mile per averaging period). Sediment delivery information for the period 1946-96 was used from three completed Watershed Analysis reports conducted in the Simpson HCP area.

Sediment delivery allocations use information from three completed Watershed Analysis Reports in the area and from several inventories that supported preparation of the HCP. The quantitative comparison of estimated loading rates and controllable portions of various types of loading was considered. It is estimated that a 50 percent reduction in the frequency of catastrophic failures (e.g. sidecast or fill failures) over the rate observed for the previous 20-year period can be achieved during the first ten years of the Plan. This represents an interim target for measuring progress relative to achieving the load allocations. In addition, a target of 50 percent reduction of fine sediment input from roads during the first ten years of the plan is also included in the HCP.

The load allocations incorporate sediment reductions from management activities into the sediment delivery targets. Sediment delivered from shallow rapids landslides and debris torrents as a result of management activities is assumed to be 80 percent controllable. This is based on information used for development of prescriptions in the W.F. Satsop Watershed Analysis. Sediment delivered from large persistent deep-seated landslides as a result of management activities is assumed to be 50 percent controllable. The retention of large wood in RCRs and reducing peak flows due to hydrologic effects of the road network will address sediment delivery from bank erosion that resulted from management activities.

Sediment delivery targets expressed as annual average cubic yards per stream mile for each channel class is consistent with current EPA regulations. The regulations indicate that load allocations are *"best estimates of the loading which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" [40 CFR §130.2(g)]*.

The resultant load allocations for sediment are: 1) developed for erosion processes; 2) associated with land use activities where feasible; and 3) based on the source analysis of various erosion processes. The load allocations are expressed as long term annual average load delivered per mile at the channel class scale.

Table 7. Sediment Delivery TMDL and Load Allocations Summary for Simpson HCP Area

Riparian Strategy *(length in mi.)*		**TMDL[1]**	**WLA[2]**	**Load Allocations[1]** *(yd^3 / mile per year)*					**MOS**
				Mass Wasting			**Surface Erosion**	**Bank Erosion**	
				SR	***DT***	***LPD***			
T.S.	*53.3*	32.1	0	13.4	0.2	6.8	2.2	4.6	4.9
BIS	*171.1*	32.8	0	12.6	0.3	7.5	2.1	4.3	6.0
Canyon	*59.4*	80.0	0	15.0	15.0	1.0	3.0	6.0	40.0
C.M.	*83.7*	41.5	0	13.3	0.3	11.1	3.3	6.8	6.7
I.G.	*50.4*	111.5	0	18.6	2.6	40.7	10.1	21.0	18.5
A.B.T.	*15.6*	96.0	0	20.0	1.0	35.0	8.0	17.0	15.0
R. BIS	*42.8*	59.9	0	19.2	1.0	18.9	4.8	9.6	6.4
US/IF	*921.5*	51.0	0	15.5	3.7	9.0	3.3	6.6	12.9

NOTES:

1 Allocations expressed as long term annual average values. As new data and methods are developed to better describe sediment delivery mechanisms, the loading capacities may be refined and the TMDL revised.

2 There are no point sources within the HCP area covered by the TMDL, so the WLA for sediment delivery is 0.

Summary: Detailed allocations for effective shade and sediment by each channel type are described in Appendix A.

Margin of Safety

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

The margin of safety may be implicit, as in conservative assumptions used in calculating the loading capacity, WLAs, and LAs. The margin of safety may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the margin of safety documented. The margin of safety is not meant to compensate for a failure to consider known sources.

Assumptions

Effective Shade*:* Development of effective shade allocations results from an analysis of processes that affect water temperature and from information about Riparian Management Strategies described in the HCP. Table 8 summarizes uncertainties associated with development of effective shade targets. Adjustments that were made to account for these uncertainties are also described.

Table 8**.** Supporting Information for Margin of Safety - Effective Shade

Uncertainties in TMDL	Adjustments to Account for Uncertainties
Natural conditions of upstream ambient water temperature regimes for some segments may be above state criteria of 16°C.	Focus analysis on identifying heat input and effective shade targets to achieve a peak hourly temperature increase of 0.45°C which serves as a numeric interpretation of the *"natural conditions"* clause in Washington's water quality standards. As new data and methods are developed to better describe *"Natural conditions"*, the peak hourly temperature increase target may be refined.
Maximum water temperatures can occur over a range of days which vary from mid-July to mid-August.	Effective shade allocations are based on shadows cast on June 21 when shade angle and solar radiation are at their peak.
Very little information exists regarding factors that affect water temperature in the Simpson HCP area, particularly wind speed, relative humidity, stream bed composition, and groundwater contribution.	Once the HCP agreement is in place, monitoring of water temperature will continue with a focus on temperature group patterns. Information from this network will support modifications to assumptions, as warranted.

Allocations for effective shade contain an explicit margin of safety which is expressed as an unallocated portion of the loading capacity. In many cases, this portion is unallocated because of other factors in the Riparian Management Strategy which applies to that particular channel class. Considerations include providing for slope stability or future recruitment of large wood (e.g. Break in Slope, Canyon strategies).

In addition, allocations for effective shade also contain an implicit margin of safety, specifically the point of measurement for the Riparian Conservation Reserve (RCR). These buffer widths, identified in the HCP and in the load allocations, were determined by identifying the primary zones adjacent to each channel class where the functional interactions with the riparian forest are most pronounced. Because of the functional point of measurement, the HCP buffers reflected in the load allocations are sometimes wider than more traditional approaches that use the ordinary high water (OHW) mark as the measurement benchmark.

Sediment Delivery*:* Development of sediment budget values is an *"order of magnitude"* estimate which may result in over prediction or under prediction of loadings from different erosion processes. Uncertainties about mass wasting and streambank erosion portions of the analysis can be significant. Table 9 summarizes uncertainties from the sediment delivery source analysis. Adjustments that were made to account for these uncertainties are described.

***Table 9*.** Supporting Information for Sediment Margin of Safety

Uncertainties in TMDL	Adjustments to Account for Uncertainties
Instream indicators of sediment not used because of lack of site specific information for these parameters. Extrapolation of values derived from dissimilar areas may have limited relevance in development of instream targets for Simpson HCP area.	Once an HCP agreement is in place, the expectation is that such habitat information will be collected from the extensive monitoring program commitments made by Simpson. This issue can be revisited at year 10 of the plan implementation, and adjustments made, as deemed appropriate by the participants. Note that this alternative approach makes good use of the fundamental landscape and channel classification system Simpson has developed for the HCP.
The role of sediment storage in channel systems as both a source and sink for sediment is poorly understood.	The TMDL gives no *"credit"* for instream storage as a consideration in TMDL determination because current excessive levels of instream stored sediment are contributing to temperature increases in C-1 group. The TMDL is lower than would be the case if instream storage credit were provided.

Adaptive Management

"Adaptive management" is often defined as the reliance on scientific methods to test the results of actions taken so that the management and related policy can be changed promptly and appropriately. Above all it requires clear focus on elements with the greatest uncertainties or risks.

Some TMDL analytical techniques are widely used and applied in evaluating source loading and determining impacts on waterbodies. However, for certain pollutants, such as heat and sediment, the methods used are newer or still in development. The selection of analysis techniques is based on scientific rationale coupled with interpretation of observed data. Without the benefit now of long term experience and testing of the methods used to derive TMDLs, the potential for the estimates to require refinement is quite high. This uncertainty underscores the need for adaptive management. The selection of the margin of safety has clarified the implications for monitoring and implementation planning in refining the estimate if necessary.

A TMDL and margin of safety that is reasonable and results in an overall allocation represents the best estimate of how standards can be achieved.

The TMDL process accommodates the ability to track and ultimately refine assumptions within the implementation component. This TMDL plan allows for future changes in loading capacities and surrogate measures (allocations) in the event that scientifically valid reasons support alterations. It is important to recognize the continual study and progression of understanding of water quality parameters addressed in this TMDL (e.g. stream temperature, sediment, riparian condition, habitat). The Simpson HCP addresses future monitoring plans. In the event that data show that changes are warranted in the Simpson TMDL, these changes will be made.

Summary Implementation Strategy

Overview

The TMDL provides the framework and targets for long term monitoring and implementation activities. However, it does not include the details for what to do or the mechanisms that will ensure that water quality improvements will occur. This section summarizes the strategy and elements that should ensure effective actions to meet the established targets as well as to maintain compliance with water quality and temperature standards.

Temperature violations occur in late summer. However, the causes for elevated temperatures in forested environments are systemic conditions. These are past and current deficiencies in riparian conditions, road management and accelerated erosion and mass wasting from management activities. These are conditions that result from a variety of management actions taken throughout the years and across the landscape.

The Simpson TMDL benefits from the concurrent development under the Endangered Species

Act (Section 10) of an aquatic Habitat Conservation Plan (HCP) for the same geographic area. In this unique coordination of two federal programs, TMDL implementation is fundamentally based on the companion HCP developed by STC and proposed to the National Marine Fisheries Service (NMFS) and the US Fish and Wildlife Service (USFW) (known collectively as the Services) for approval. EPA and Ecology were parties to the HCP negotiations, while NMFS and USFW participated in some aspects of the TMDL development. Development of the HCP also included cooperative input from state agencies, environmental groups and tribal representatives supporting the core group of Simpson, NMFS, USFWS and EPA.

The TMDL temperature and sediment analysis have been adopted by the Services as the analytical basis for validating the effectiveness of the riparian prescriptions and sediment management prescriptions in the HCP and for guiding monitoring efforts. The TMDL relies on the HCP for articulating the management activities, environmental outcomes, monitoring requirements, adaptive management process, and progress reviews.

Operational assurance that the Plan will be faithfully carried out falls within several avenues related to the Forest Practice Rules of the State of Washington as well as the review requirements within the HCP.

Implementation Plan Development

The core of the HCP was developed by Simpson in consultation with NMFS, USFWS and EPA. At that time, STC entered a state pilot program to develop a landscape plan that addressed the same basic resource elements. Through that pilot, DOE, DNR and DFW, WEC, Audubon, the Quinault, Squaxin, Skokomish tribes, the Point No Point Treaty Council and the NWIFC began working with Simpson and the federal agencies to further develop details of the plan. The purpose of the pilot was to ensure compatibility between the two processes and state objectives and consistency in the outcomes.

Ecology and EPA are confident that the STC TMDL will be implemented for three key reasons. First, we believe that the TMDL has STC's support and commitment at the highest levels of management. Second, STC will receive an Incidental Take Permit (ITP) from the Services conditioned on implementation of the HCP. The permit would be withdrawn if STC for whatever reason, does not implement the HCP. The HCP directly complements the TMDL since the outcomes for sediment reduction activities and temperature maintenance in the HCP will, in the long term and with adaptive management, meet water quality standards.

Finally, regulatory authority over the implementation activities comes from the State of Washington Forest Practices Act (FPA). The Forest Practice Rules are as Simpson initiates forest management activities and receives forest practice permits from DNR, their proposed actions would need to show consistency with the HCP. As an alternative, Simpson may be able to complete the Pilot Landscape Plan for submittal to DNR before March 2000. Simpson could then receive one permit from DNR to cover management activities over the whole area for 25-50 years. STC may elect to seek future alternate plan status pursuant to the Forest Practices Act and regulations. The alternate plan would then be adopted as an enforceable agreement, and substitute for the standard forest practices rules and regulations. The Department of Natural

Resources (DNR) would oversee conformance with harvest and road elements of the HCP, consistent with their statutory responsibilities under state law. In any event, STC remains subject to the state Forest Practices Act, Hydraulic Projects Approval code requirements and other state regulatory mechanisms. Whether it is one long term permit or site by site, DNR and Ecology have clear authority and regulatory process to ensure compliance. DFW will administer the Hydraulic Project Approval for any in-water activity in the area consistent with the HCP.

Simpson's conservation program emphasizes the development and protection of riparian forests as a primary strategy to satisfy ESA Section 10 and to address requirements of the Clean Water Act (CWA). Activities to be covered by the HCP include all aspects of Simpson's forest practices and related land management (mechanized timber harvest, log transportation, road construction / maintenance / restoration, etc). Specific management prescriptions designed to reduce the input of pollutants into streams within the HCP area include:

- Riparian Conservation Reserves
- Road Management
- Unstable Slope Protection
- Hydrologic Mature Forest Development
- Wetlands Conservation Program

The HCP prescriptions and TMDL implementation activities are based on the principles of adaptive management. The approach for meeting the various load allocations is to increase shade amount and quality, increase LWD supply, shut down the sediment supply and maintain natural patterns of water routing and timing through sub-basins. The prescriptions involve setting appropriate riparian and wetland buffer widths and management constraints, completing inventory and mapping of sensitive areas, completing a schedule for road inventory, repair and removal, and annual reporting of monitoring results, activities and future plans. Compliance and effectiveness monitoring will be done by the company. Simpson will also establish a Science Advisory Team. This broad based technical team will review monitoring results, resource conditions and discuss alternative actions. They will be an integral part of the adaptive management process.

TMDL implementation will be assessed through site visits, review of monitoring results and the annual meetings established within the HCP. The HCP spells out a series of milestones and monitoring requirements. Systemic watershed conditions that result in elevated temperatures need time to respond to changed management. It also takes time to complete field and assessment work in conjunction with operational activities.

During the first five years, STC will complete an inventory and prioritization of all road segments for remediation. Remediation of known problem areas will continue at an aggressive but steady pace throughout the first 10 years and at a slower pace in the following years.

Within the first five years, STC will complete analysis for slope stability and mass wasting outside the areas already completed through the formal watershed analysis process. They will use WSA or equivalent and use a multi- disciplinary team to develop appropriate prescriptions.

Within the first five years, STC will establish experimental plots in wood placement and riparian hardwood stand conversion in conjunction with habitat monitoring activities.

During the first ten years, STC will inventory and classify all wetlands by hydro-geomorphic category and Cowardin vegetation classes. This will include delineating the local watershed boundary for wetlands in the ROP to maintain proper hydrology and fish connectivity.

STC is committed to an extensive monitoring program to track annual compliance, effectiveness of management activities and general background resource conditions. Table 22 in the HCP provides a chart of monitoring and assessment activities over the first ten years. Certain temperature, sediment supply and hydrologic monitoring will be done on an annual basis. Other types will occur at five or ten year intervals, in keeping with expectations for measurable change.

At year five and ten, a more formal review session of the progress of the plan itself, resource conditions and processes should occur in conjunction with the Services, state agencies, interested tribes and environmental groups. At a minimum this would include the SAT. This will be coordinated as one major element of the Adaptive Management process for the HCP. Future monitoring subjects, timing and assessment schedules would be adjusted at that time.

Implementation Activities

The TMDL responsible parties are Simpson Timber Company as the land manager, DNR as the permitting agency and Ecology as the CWA authority. Simpson is committed to signing the Implementation Agreement with the Services for the HCP. The HCP includes substantial commitments of money over time to cover inventory work, monitoring and roadwork. It also incorporates a ‘bank’ of acreage available to expand buffers as needed through adaptive management. Should the HCP or take permit be withdrawn, the prescriptions will continue to be the best available management practices for this landscape area.

The riparian management prescriptions and expected outcomes contained in the HCP are incorporated by reference into the TMDL. In summary, the overall conservation program includes:

- riparian and wetland buffers of various widths and management regimes designed to provide effective levels of stream shading to address temperature concerns;

- sediment source reduction actions (using basin specific estimates of sediment source areas, prioritized actions will be applied through unstable slope harvest restrictions, road construction, maintenance, and decommissioning commitments); and

- certain harvest limitations to minimize changes in precipitation runoff patterns during storm events.

Riparian and Shade Conditions: The key component of the HCP is a classification of channels across the landscape based on geomorphology and recruitment processes for wood and sediment. A series of riparian conservation reserve strategies (RCRs) were then set out to protect the key features and functions for groups of channels.

Riparian forest functions which are the focus of HCP management prescriptions include: (1) wildlife habitat, (2) recruitment of woody debris to streams and forest floor, (3) shade and control of stream side air temperature, (4) stream bank stabilization, (5) detrital inputs, (6) capture of sediment and organic matter on the floodplain, (7) maintenance and augmentation of nutrient dynamics and processing, and (8) provision of nurse logs.

In total, the RCRs represent a minimum estimate of 12.8 percent of the entire Plan area, These will be distributed throughout the HCP area along all stream classes, and will encompass the stream system components of - channel migration zones - riparian areas - wetlands, and to minimize sediment inputs, some adjoining upland areas. Outer boundaries of the RCR are determined in two ways: by functional widths as designated in the HCP *(see Appendix B, Table 19)* or by the extent of adjacent unstable slopes as determined through provisions in the HCP, whichever is greater. Details regarding the basis for RCR boundaries and implementation guidelines for the RCR are described in the HCP, Chapter 5.

Road Management Program: Implementation of road management prescriptions should reduce this source of chronic fine sedimentation input into streams, and the catastrophic sources of sediment input from failure of road fills and sidecast that generate and propagate hillslope and channel failures. Prescriptions include better road construction and maintenance, upgrading culvert sizes, minimizing ditch-line water routing and direct delivery, wet weather road use restrictions, storm patrols and road removal.

Unstable Slope Protection: The HCP recognizes the role unstable slopes play in delivering coarse sediment and woody debris to many channel classes in the plan area. Protection of unstable slopes is considered pivotal in the riparian strategies. Consequently, RCR boundaries are defined not only by the functional needs of the channel classes, but also by the extent of unstable side slopes that, if disturbed, pose a threat to fail and thereby deliver significant sediment volumes into stream courses.

Timing and Process: Roughly speaking, about half of the stream miles in the Plan area are forested with mature timber, while the other half has been harvested sometime in the last 40 years or so. In a significant number of stream miles with adequate shade and adjacent timber available for harvest, our analysis projects that the riparian management practices under this plan will be sufficient to protect stream shade and thus prevent ecologically significant changes in stream temperatures.

For those streams that currently exceed temperature standards or lack sufficient shade, exact projections of when water quality standards will be attained are not possible. Where stream temperatures are largely a function of shade, and past timber harvest has occurred in the present riparian zone, re-growth of trees of suitable size to meet shade functions may take many years. For wider streams it could perhaps take decades to meet the established temperature criteria.

Public involvement has occurred in a number of forms and at several times. As a part of the LLP process, Simpson held an evening meeting in Shelton in the fall of 1998. The management approach and resource issues were presented. It was sparsely attended by adjacent landowners but extensive discussions occurred with those present. Before and after the meeting, there was some newspaper coverage of the project.

The Services issued a scoping notice for the HCP in January of 1999 with the draft EIS and draft HCP going out for formal public review in September of 1999. In coordination with Ecology and the TMDL process, the NEPA notice included reference to the TMDL. As part of the TMDL development process, Ecology held a public meeting in September of 1999. This was held during the HCP review period with comments relating to the HCP going to the Services and those on the TMDL going to Ecology and EPA.

In addition, the HCP and portions of the TMDL included substantial interaction with the local tribal and environmental groups as well as affected state agencies.

Finally, to better engage the agencies and tribes routinely in the plan implementation, STC has agreed to convene a Scientific Advisory Team (SAT) which will meet annually to review progress, help interpret monitoring data, and determine if adjustments to the monitoring program or plan prescriptions are necessary. EPA, Ecology, the Services and Tribes are members of the SAT. This will be the principal means to engage the adaptive management feature of the TMDL and the HCP. The SAT will be advisory only, but it will allow each participant to actively participate in consideration of the evidence at hand, and to make independent judgements as to the overall effectiveness of the plan components. While the SAT meet at least annually, EPA and Ecology recommend that at 5 year increments the public be invited to a workshop for a retrospective on progress and plans for the future. A dispute resolution process exists and ultimately, DNR and Ecology could take enforcement on Simpson should they balk on a key issue.

At year five following plan agreement and implementation, an organized session is planned to review progress on:

- The overall spatial distribution of sediment budget and source assessment work, what specific abatement actions were taken, where and why, and what monitoring effort was focused on evaluating their effectiveness.
- Review the then completed road inventory and prioritization scheme. Match this with the Company’s forecast of what roads will be used in associated with planned timber harvest activities.
- Review the overall status of implementation for the various monitoring components, and re-visit the key questions for each component to affirm that they are still correct.
- Review the monitoring and research components for basin hydrology;
- Make site visits to representative harvests near wetlands to review approach.

At year ten after plan initiation, the general steps above will be repeated with the addition of reviewing temperature - riparian prescription information and sediment abatement actions and outcomes.

Monitoring Strategy

The monitoring and adaptive management provisions of the HCP are thorough if carried forward through time. Some monitoring will address compliance issues, some the effectiveness of management strategies. STC has incorporated required reporting and tracking elements of the Plan into their operational record keeping and GIS system. These records will be compiled and reported annually to the Services, EPA and DNR as part of the annual meeting review. See the HCP Chapter 7 key questions and focus for monitoring.

Extensive temperature monitoring across a variety of stream types will evaluate the performance of the shade component of the riparian prescriptions. Other monitoring will evaluate additional factors that may have a role in affecting stream temperatures in particular geomorphic contexts such as groundwater contributions or wetland/shallow aquifer influences.

Habitat assessment and monitoring will be conducted by Simpson in the spirit of adaptive management to validate assumptions made as a *"margin of safety"* and to evaluate the effectiveness of specific management prescriptions.

Adaptive management based on monitoring results over time and new information or conditions is a key component of the HCP. As indicated earlier in the monitoring section, temperature conditions will not be closely assessed until year ten of the Plan. Based on the rate of natural processes, Ecology and EPA anticipate that it will take at least that long for monitoring to begin to show impacts from HCP management. Management strategies or prescriptions may be adjusted following the ten-year review to improve temperature. It is anticipated that the TMDL load allocations will not require revisions until at least year fifteen of the Plan to allow for adaptive management adjustments. Events that could trigger a review and subsequent TMDL revision would include: new ESA listings, new water quality standards that apply to this area, and some unforeseen event affecting the landscape.

Potential Funding Sources

Ecology and EPA find that STC is a large and viable company, and has sufficient assets to meet its obligations. STC and cooperating agency staff have worked hard to keep HCP requirements operationally realistic and easily tracked as well as effective. The annual expenditures described in the HCP for monitoring and road remediation are reasonable and deemed sufficient to accomplish the objectives of the TMDL. Simpson has committed approximately $15 million to fund road maintenance and abandonment work over the 50-year period of the HCP ($500,000 annually for the first ten years of the plan and $250,000 annually thereafter). This is one area that will be watched particularly closely through adaptive management to ensure that road management by the company brings about needed improvements within company budget constraints.

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Appendix A: Technical Assessment Report

Basis of the TMDL Submittal Document

Appendix B: Endangered Species Act HCP: Excerpts

Set forth below are elements of the Habitat Conservation Plan developed by Simpson in consultation with the National Marine Fisheries Service and the US Fish and Wildlife Service under Section 10 of the Endangered Species Act. The elements included here are the DRAFT Table of Contents, Implementation Agreement and list of covered species.

One of the unique features of this TMDL and Simpson's HCP has been the close coordination between the Services and the state and federal agencies responsible for the implementation of the Clean Water Act. From the outset, Simpson has sought to structure a management regime and related analysis for its properties that would satisfy the requirements of Section 10 of the ESA as well as provide a framework for the preparation and implementation of a TMDL.

The development of this TMDL and the development of the HCP have proceeded simultaneously along parallel tracks. Neither is dependent on the other but much of the information and analysis developed for the preparation of the HCP has been useful in developing the TMDL and vice-versa. However, both the Services, Department of Ecology and EPA anticipate that the allocations, or targets, within the TMDL will help guide HCP implementation and adaptive management over time and that the HCP strategies will support maintaining or achieving compliance with the targets.

The HCP elements in this appendix are included for information only. The HCP is currently undergoing environmental review through a process parallel in time to review of this TMDL. The entire document can be obtained through Simpson or the Services. The public meeting required for TMDL's will include general discussion of the HCP in the context of implementation.