



State of Oregon
DEQ Department of Environmental Quality

Note: DEQ plans to incorporate the draft TMDLs for the Willamette Mainstem and Major Tributaries project area into the draft Willamette Subbasins TMDLs. Eventually, these two TMDL project areas will be combined into one rule document. Documents and narrative included in the draft TMDLs and appendices from the Willamette Subbasins are provided as background information for this rulemaking.

In this particular TMDL document, DEQ used the Willamette Subbasins TMDL document for information specific to the area covered by the Willamette Mainstem and Major Tributaries.



Draft Total Maximum Daily Loads for the Willamette Subbasins (Willamette Mainstem and Major Tributaries)

Temperature

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1 Introduction

This TMDL project includes the following Willamette Subbasins: Coast Fork Willamette, McKenzie, Middle Fork Willamette, Upper Willamette, Middle Willamette, Molalla-Pudding, North Santiam, South Santiam, Lower Willamette, and Clackamas Subbasins. This TMDL will be adopted by reference in Oregon Administrative Rules 340-42-0090.

OAR 340-42-0040(3) requires DEQ or the EQC to prioritize and schedule TMDLs for completion considering various factors outlined in the rule. Temperature TMDLs for the Willamette Subbasins were identified as a high priority on Oregon's TMDL priority ranking submitted with Oregon's 2022 Integrated Report and due to court order to Oregon and the Environmental Protection Agency to establish TMDLs to replace the temperature TMDLs developed as part of the 2006 Willamette Basin TMDL (action ID 30674) and the 2008 Molalla-Pudding Subbasin TMDL and WQMP (action ID 35888) (Table 1-1).

1.1 Previous TMDLs

In 2006 and 2008 DEQ issued, and EPA approved, two TMDL actions addressing temperature impairments (Table 1-1) within the project area for the Willamette Subbasins temperature TMDLs. Once approved by EPA, the Willamette Subbasins TMDLs for temperature will replace the temperature TMDLs listed in Table 1-1. TMDLs for other water quality impaired parameters listed in Table 1-1 are still effective.

Table 1-1: Summary of previous temperature TMDLs developed for the Willamette Subbasins.

TMDL action ID	TMDL Name	EPA Approval Date	Water Quality Impairments Addressed
30674	Willamette Basin TMDL	9/29/2006	Ammonia, Bacteria (water contact recreation), DDT 4,4', Dieldrin, Dissolved Oxygen, Mercury, Temperature, Turbidity
35888	Molalla-Pudding Subbasin TMDL and WQMP	12/31/2008	Bacteria (water contact recreation), Chlordane, DDD 4,4', DDE 4,4', DDT 4,4', Dieldrin, Iron, Nitrates, Temperature

1.2 TMDL administrative process and public participation

Following completion of Oregon Department of Environmental Quality's drafting process, including engagement of a rule advisory committee on the fiscal impact statement and aspects of the rule, this revised temperature TMDL for the Willamette Subbasins will be proposed for adoption by Oregon's Environmental Quality Commission, by reference, into rule section OAR 340-042-0090. Any subsequently amended or renumbered rules cited in this document are intended to apply.

DEQ convened a rule advisory committee to provide input on drafts of the TMDL, Water Quality Management Plan, Technical Support Document, fiscal and economic impacts, and Environmental Justice and Racial Equity. The committee met on February 23, 2023, and April 6, 2023. The agency held two informational webinars about this TMDL. DEQ has submitted the drafts for public comment to fulfill the public participation requirements. DEQ considered all input received during these public participation opportunities and used input to guide the analyses and preparation of documents. DEQ will provide response to comments that will be available online.

2 TMDL name and location

Per Oregon Administrative Rule 340-042-0040(4)(a), this element describes the geographic area for which the TMDL is developed.

Temperature TMDLs for the Willamette Subbasins address Category 5 listed assessment units impaired for temperature (Table 2-3 through Table 2-12) and to serve as a protection plan for all other assessment categories, including unimpaired and unassessed.

The loading capacity, allocations, surrogate measures, and implementation framework apply to all waters of the state as defined under ORS 468B.005(10), including all perennial and intermittent streams, located in the Middle Fork Willamette Subbasin (HUC 17090001), Coast Fork Willamette Subbasin (HUC 17090002), Upper Willamette Subbasin (HUC 17090003), McKenzie Subbasin (HUC 17090004), North Santiam Subbasin (HUC 17090005), the South Santiam Subbasin (HUC 17090006), Middle Willamette Subbasin (HUC 17090007), Molalla-Pudding Subbasin (HUC 17090009), Clackamas Subbasin (HUC 17090011), and Lower Willamette Subbasin (HUC 17090012) (Table 2-1).

The implementation framework is presented in the Willamette Subbasins TMDL Water Quality Management Plan and includes implementation activities and timeframes to improve water quality, as well as measures of success. These and other protection plan elements are further explained in Section 12, below.

The map in Figure 2-1 provides an overview of where the temperature TMDLs are applicable. Appendix D of the Willamette Subbasin Technical Support Document provides a list of all assessment units addressed by the TMDL.

The Willamette Subbasins is comprised of ten 8-digit hydrologic unit code (HUC) subbasins as listed in Table 2-1.

Table 2-1: The Willamette Subbasins.

HUC	Subbasin Name
17090001	Middle Fork Willamette
17090002	Coast Fork Willamette
17090003	Upper Willamette
17090004	McKenzie
17090005	North Santiam
17090006	South Santiam
17090007	Middle Willamette
17090009	Molalla-Pudding
17090011	Clackamas
17090012	Lower Willamette

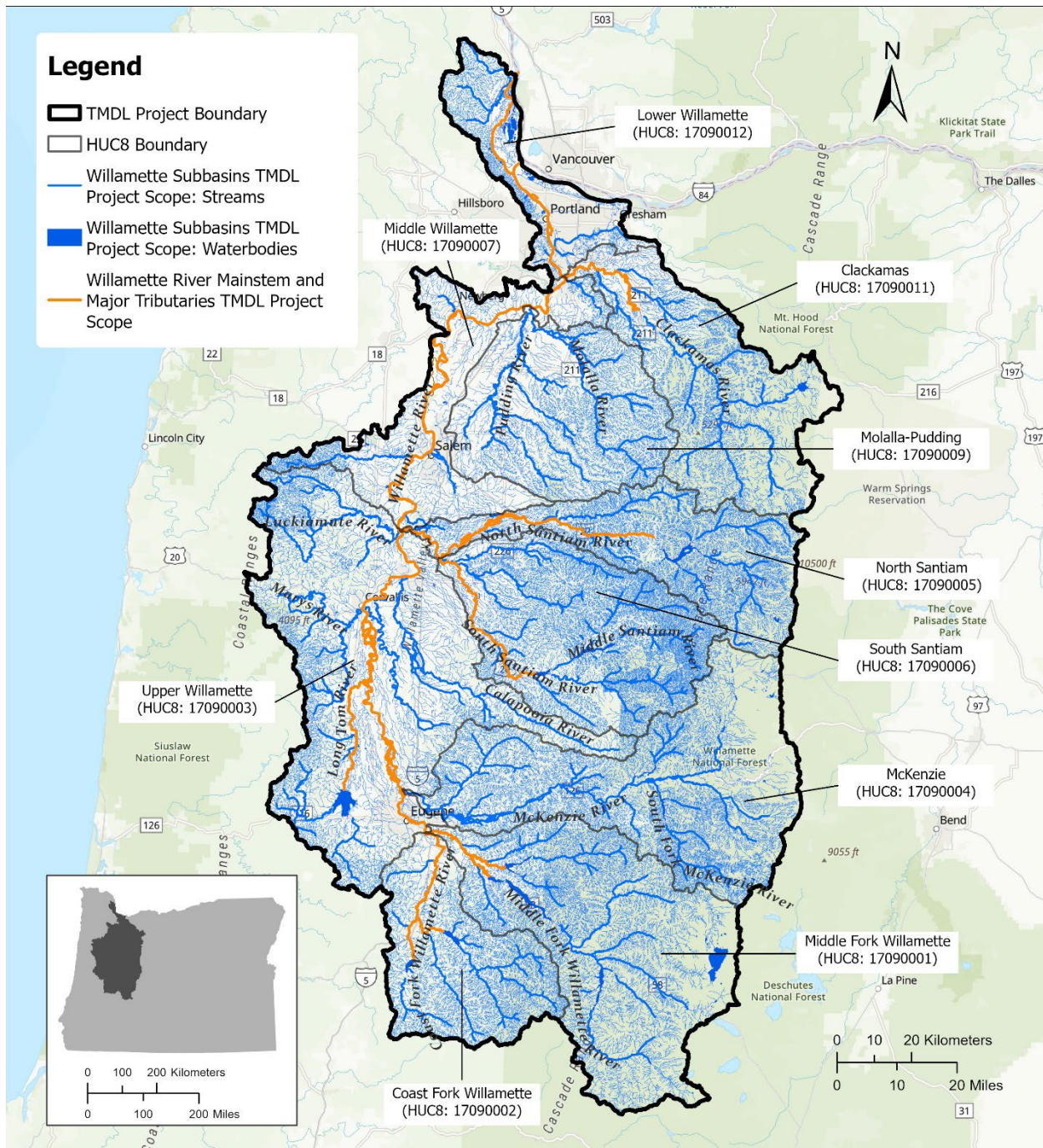


Figure 2-1: Willamette Subbasins temperature TMDLs project area overview.

Table 2-3 present stream assessment units within the Willamette Subbasins that were listed as impaired for temperature on DEQ’s 2022 Clean Water Act Section 303(d) List (as part of Oregon’s Integrated Report), which was approved by the EPA on September 1, 2022. Status category designations are prescribed by Sections 305(b) and 303(d) of the Clean Water Act. Assessment units listed in Category 5 (designated use is not supported or a water quality standard is not attained) require development of a TMDL. Locations of these listed segments are depicted in Figure 2-2.

Table 2-2: Willamette Mainstem and major tributaries project area Category 5 temperature impairments on the 2022 Integrated Report.

Assessment Unit ID	Assessment Unit Name	Use Period
OR_LK_1709000703_02_100792	Willamette Slough	year_round
OR_SR_1709000107_02_104583	Middle Fork Willamette River	year_round
OR_SR_1709000107_02_104583	Middle Fork Willamette River	spawn
OR_SR_1709000109_02_103735	Fall Creek	year_round
OR_SR_1709000109_02_103735	Fall Creek	spawn
OR_SR_1709000110_02_104584	Middle Fork Willamette River	year_round
OR_SR_1709000110_02_104584	Middle Fork Willamette River	spawn
OR_SR_1709000202_02_103779	Row River	year_round
OR_SR_1709000203_02_104585	Coast Fork Willamette River	year_round
OR_SR_1709000204_02_103787	Coast Fork Willamette River	year_round
OR_SR_1709000301_02_103791	Long Tom River	year_round
OR_SR_1709000306_05_103854	Willamette River	year_round
OR_SR_1709000306_05_103854	Willamette River	spawn
OR_SR_1709000504_02_103906	North Santiam River	spawn
OR_SR_1709000506_02_103927	Santiam River	year_round
OR_SR_1709000506_02_103927	Santiam River	spawn
OR_SR_1709000506_02_103930	North Santiam River	year_round
OR_SR_1709000506_02_103930	North Santiam River	spawn
OR_SR_1709000608_02_103925	South Santiam River	year_round
OR_SR_1709000608_02_103925	South Santiam River	spawn
OR_SR_1709000701_05_104005	Willamette River	year_round
OR_SR_1709000701_05_104005	Willamette River	spawn
OR_SR_1709000703_04_104013	Willamette River	year_round
OR_SR_1709000703_04_104013	Willamette River	spawn
OR_SR_1709000703_88_104015	Willamette River	year_round
OR_SR_1709000704_88_104020	Willamette River	year_round
OR_SR_1709001106_02_104597	Clackamas River	year_round
OR_SR_1709001106_02_104597	Clackamas River	spawn
OR_SR_1709001201_88_104019	Willamette River	year_round
OR_SR_1709001202_88_104175	Willamette River	year_round
OR_SR_1709001203_88_104184	Multnomah Channel	year_round

MAP GOES HERE

Figure 2-2: Willamette Subbasins category 5 temperature impairments on the 2022 Integrated Report.

3 Pollutant identification

As stated in OAR 340-042-0040(4)(b), this element identifies the pollutants causing impairment of water quality that are addressed by these TMDLs. The associated water quality standards and beneficial uses are identified in Section 4.

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

EPA regulations (40 CFR 130.2(i)) and OAR 340-042-0040(O)(5)(b) allow for TMDLs to utilize other appropriate measures (or surrogate measures). Surrogate measures are defined in OAR 340-042-0030(14) as “substitute methods or parameters used in a TMDL to represent pollutants.” In accordance with OAR 340-042-0040(5)(b), DEQ used effective shade as a surrogate measure for thermal loading caused by excessive solar radiation. Effective shade is the percent of the daily solar radiation flux blocked by vegetation and topography. Implementation of the surrogate measures ensures achievement of necessary pollutant reductions and the nonpoint load allocations for this temperature TMDL.

4 Water quality standards and beneficial uses

As stated in OAR 340-042-0040(4)(c), this element identifies the beneficial uses in the basin, specifying the most sensitive beneficial use, and the relevant water quality standards established in OAR 340-041-0202 through 340-041-0975.

Table 4-1 and Table 4-2 specify the designated beneficial uses in the Willamette Subbasins surface water and the applicable numeric and narrative water quality standards and antidegradation rule and policy addressed by these TMDLs, as well as indicate the most sensitive beneficial uses related to each standard. These TMDLs are designed such that meeting water quality standards for the most sensitive beneficial uses will be protective of all other uses for that parameter.

Table 4-1: Designated beneficial uses in the Willamette Subbasins as identified in OAR 340-041-0340 Table 340A.

Beneficial Uses	All waterbodies
Public Domestic Water Supply	X
Private Domestic Water Supply	X
Industrial Water Supply	X
Irrigation	X
Livestock Watering	X
Fish and Aquatic Life	X
Wildlife and Hunting	X
Fishing	X
Boating	X
Water Contact Recreation	X
Aesthetic Quality	X
Hydro Power	X
Commercial Navigation & Transportation	

Table 4-2: Applicable water quality standards and most sensitive beneficial uses.

Parameter	Rule Citation	Summary of applicable standards	Waters where standards are applicable	Most sensitive beneficial use
Statewide Narrative Criteria	OAR 340-041-0007(1)	The highest and best practicable treatment and/or control of wastes, activities, and flows must in every case be provided so as to maintain dissolved oxygen and overall water quality at the highest possible levels and <u>water temperatures</u> , coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor and other deleterious factors at the lowest possible levels.	All waters of the state	Fish and aquatic life
Temperature	OAR 340-041-0028(4) OAR 340-041-0340 Figures 340A and 340B	(a) The 7-day average maximum temperature may not exceed 13.0°C (55°F) at the times indicated on maps and tables (b) The 7-day average maximum temperature may not exceed 16.0°C (60.8°F) (c) The 7-day average maximum temperature may not exceed 18.0°C (64.4°F) (d) The 7-day average maximum temperature may not exceed 20.0°C (68.0°F) and must have cold water refugia that are sufficiently distributed so as to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body. (f) The 7-day average maximum temperature may not exceed 12.0°C (53.6 °F). From August 15 through May 15 there may be no more than a 0.3 degrees Celsius (0.5 Fahrenheit) increase between the water temperature immediately upstream of Carmen reservoir on the Upper McKenzie River and the water temperature immediately downstream of the spillway when the ambient seven-day-average maximum stream temperature is 9.0 degrees Celsius (48 degrees Fahrenheit) or greater, and no more than a 1.0 degree Celsius (1.8 degrees Fahrenheit) increase when the seven-day-average stream temperature is less than 9 degrees Celsius.	See OAR Figures 340A and 340B	Salmonid and steelhead Spawning Salmon and steelhead migration Bull Trout spawning and juvenile rearing use
	OAR 340-041-0028(6)	Natural lakes may not be warmed by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the natural condition unless a greater increase would not reasonably be expected to adversely affect fish or other aquatic life.	Natural Lake	Fish and aquatic life
	OAR 340-041-0028(9)	No increase in temperature is allowed that would reasonably be expected to impair cool water species.	Cool Water	Cool water aquatic life
	OAR 340-041-0028(11)	(a) Not warmed by more than 0.3°C (0.5°F) above the colder water ambient temperature, by	Cold water	Salmon, steelhead or bull

Parameter	Rule Citation	Summary of applicable standards	Waters where standards are applicable	Most sensitive beneficial use
		all sources taken together at the point of maximum impact		trout presence
	OAR 340-041-0028(12)(b)	(B) Human Use Allowance. Following a temperature TMDL or other cumulative effects analysis, wasteload and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3°C (0.5°F) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact.	All waters of the state	Salmonid and steelhead Spawning
	Antidegradation OAR 340-041-0004 and 40 CFR 131.12(a)(2)	(3)(c) Insignificant temperature increases authorized under OAR 340-041-0028(11) and (12) are not considered a reduction in water quality.		
		(5)(a) Riparian Restoration Activities Exemption: When DEQ determines that activities to restore geomorphology or riparian vegetation have a net ecological benefit, antidegradation review is not needed.		

4.1 Human Use Allowance

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

4.2 Cool Water Species

The narrative cool water species criterion in rule at OAR 340-041-0028(9)(a) states that “No increase in temperature is allowed that would reasonably be expected to impair cool water species.” Rickreall Creek (Middle Willamette Subbasin) and Long Tom River (Upper Willamette Subbasin) are the only waterbodies designated for cool water species use in the Willamette Subbasins.

4.2.1 Rickreall Creek

4.2.2 Long Tom River

The Long Tom River from Fern Ridge Lake to its confluence with the Willamette River is designated as Cool Water Species use. In consultation with ODFW, DEQ determined what cool water species are present in the Long Tom River and translated the narrative criterion into a target temperature based on the thermal tolerance information available for those species.

Redside shiner (*Richardsonius balteatus*) are the most temperature sensitive cool water species in the Long Tom River with studies showing an upper lethal temperature threshold between 22.8 and 27.7 degrees Celsius (Black, 1953). DEQ also determined that Chinook Salmon (*Oncorhynchus tshawytscha*) are present from approximately November 1 to June 14. Spawning of Chiselmouth, Northern Pikeminnow, Peamouth, and Mountain Sucker could occur in the lower reach between April and July. These species initiate spawning when water temperatures exceed 12-18 degrees Celsius. DEQ will rely upon the 18.0 degrees Celsius target temperature established for protection of salmon and trout rearing and migration uses suggested by EPA guidance (EPA, 2003) and adopted in Oregon's water quality standards (OAR 340-041-0028 (4)(c)).

Based on these findings, the temperature targets (Table 4-3) for the Long Tom River are:

- 1) 24.0°C + 0.3°C human use allowance (HUA) from June 15 through October 31 based upon thermal tolerance for Redside Shiner
- 2) 18.0°C + 0.3°C human use allowance (HUA) from November 1 to June 14 based upon Spring Chinook rearing and juvenile migration and spawning preferences for Mountain Sucker, Peamouth, and Chiselmouth.

If 7-day average daily maximum temperatures trend to always being cooler than temperature targets presented in Table 4 3, the protecting cold water criterion at OAR 340-041-0028 (11) shall be applied with the 0.3 degree human use allowance based on an increase above the cooler ambient temperature.

Analysis and rationale for the numeric temperature targets are further described in the TMDL Technical Support Document, Section 4.2.

See TSD_Willamette_Mainstem_Section4.2_Cool_Water_Species

The mixing zone and thermal plume limitations in OAR 340-041-0053 (2)(E)(d) will provide further protections against potential migration blockages and acute impacts. This TMDL assumes assessment and application of thermal plume limitations, as necessary, will be completed during the NPDES permit renewal process.

Table 4-3: Summary of temperature targets implementing the cool water species narrative in the Long Tom River.

Time period	7DADM Temperature Target (deg-C)	Most Temperature Sensitive Species
June 15 – October 31	24.0 + 0.3 HUA	Redside shiner (<i>Richardsonius balteatus</i>)
November 1 – June 14	18.0 + 0.3 HUA	Chinook Salmon (<i>Oncorhynchus tshawytscha</i>)

5 Seasonal variation and critical period for temperature

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

Maximum stream temperatures typically occur in July or August when stream flows are low, solar radiation fluxes are high, and ambient air temperature conditions are warmest.

The critical period is determined based on when seven-day average daily maximum stream temperatures (7DADM) exceed the applicable temperature criteria. DEQ uses the critical period to determine when allocations apply. In setting this period, DEQ relied upon monitoring sites with the longest period of exceedance. When downstream monitoring sites have longer exceedance periods relative to upstream waters, the longer period is used as the critical period for upstream waterbodies. This is a margin of safety to ensure warming of upstream waters does not contribute to downstream exceedances.

Based on review of available temperature data, the overall critical period is April 1 through November 15.

Allocations presented in the TMDL apply during these periods.

Section 5 of the Technical Support Document summarizes the critical period approach and presents plots of 7DADM temperature data used to determine seasonal variation and the critical period.

See TSD_Willamette_Mainstem_Section5_SeasonalVariation

6 Temperature water quality data evaluation overview

A critical TMDL element is water quality data evaluation and analysis to the extent that existing data allow. To understand the water quality impairment, quantify the loading capacity, identify pollutant sources, and assess various management scenarios that achieve the TMDL and applicable water quality standards, the analysis requires a predictive component. Certain models provide a means to evaluate potential stream warming sources and, to the extent existing data allow, their current and potential pollutant loads. Heat Source and CE-QUAL-W2 temperature models were used in this effort and are described in Technical Support Document model appendices.

The modeling framework needs for this project included the abilities to predict or evaluate hourly:

1. Stream temperatures spanning months at $\leq 500\text{m}$ longitudinal resolution.
2. Solar radiation fluxes and daily effective shade at $\leq 100\text{m}$ longitudinal resolution.
3. Stream temperature responses due to changes in:
 - a. Streamside vegetation,
 - b. Water withdrawals and upstream tributaries' stream flow,
 - c. Effluent temperature and flow discharge from NPDES permitted facilities.

Figure 6-1 provides an overview of the analyses completed for this TMDL.

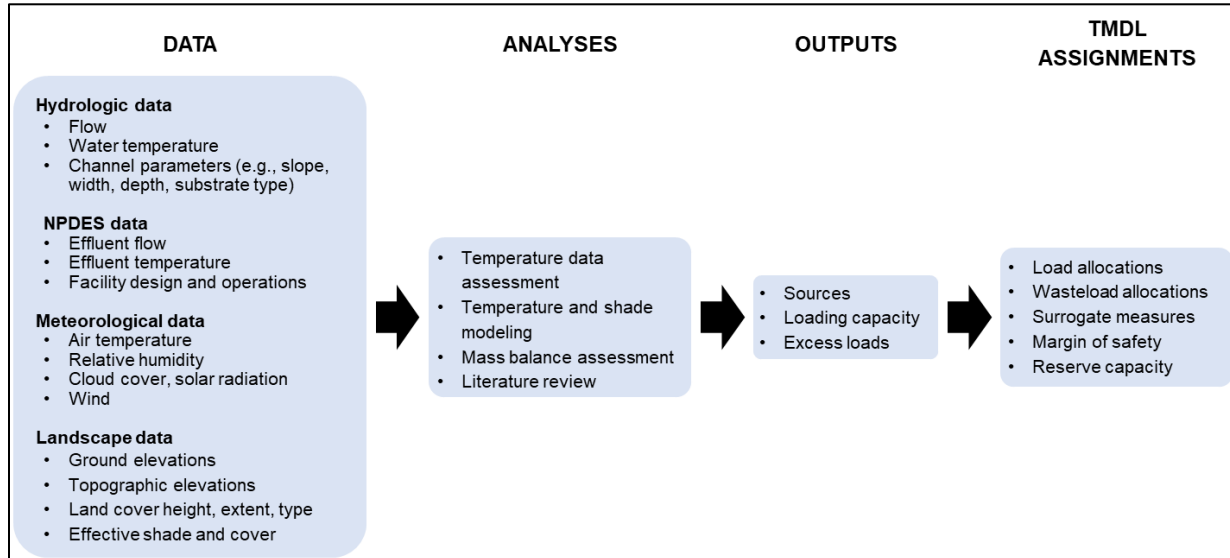


Figure 6-1: Willamette Subbasins temperature analysis overview.

7 Pollutant sources or source categories

As noted in OAR 340-042-0040(4)(f) and OAR 340-042-0030(12), a source is any process, practice, activity or resulting condition that causes or may cause pollution or the introduction of pollutants to a waterbody. This section identifies the various pollutant sources and estimates, to the extent existing data allow, the significance of pollutant loading from existing sources.

Both point and nonpoint sources are sources of thermal pollution to surface waters in the Willamette Subbasins. Within the nonpoint source category, both background and anthropogenic nonpoint sources contribute thermal pollution. Each source's thermal loading varies in frequency and magnitude based on the flow rate and temperature of discharge, prevalence of the activities, size of the land area on which the activities occur, locations of activities in relation to surface water, and transport mechanisms.

7.1 Thermal point sources

OAR 340-045-0010(17) defines a point source as “any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.”

There are 64 domestic or industrial individual NPDES permitted point source discharges within the Willamette Subbasins identified as potential sources of thermal load (Table 7-1). There also are 20 individual Municipal Separate Storm Sewer System (MS4) NPDES permittees.

Table 7-1: Individual NPDES permitted point sources discharging to waterbodies in the Mainstem Willamette River and major tributaries project area.

Permittee	Permit type	DEQ WQ File Number	EPA Number	Receiving water name	River mile
ADAIR VILLAGE STP	NPDES-DOM-Da	500	OR0023396	Willamette River	122.0
AM WRF	NPDES-DOM-Ba	1098	OR0028801	Willamette River	118.0
ARKEMA	NPDES-IW-B14	68471	OR0044695	Willamette River	7.2
ARKEMA	NPDES-IW-B16	68471	OR0001597	Willamette River	7.4
ASH GROVE CEMENT - RIVERGATE LIME PLANT	NPDES-IW-B16	3690	OR0001601	Willamette River	3.3
ATI Millersburg Teledyne Wah Chang	NPDES-IW-B07	87645	OR0001112	Truax Creek	2.0
BDC/WILLAMETTE LLC	NPDES-IW-B15	109444	OR0040363	Willamette River	15.8
BLUE HERON PAPER CO.	NPDES-IW-B01	72634	OR0000566	Willamette River	27.8
BROOKS SEWAGE TREATMENT PLANT	NPDES-DOM-Db	100077	OR0033049	Willamette River	71.7
CANBY REGENCY MOBILE HOME PARK	NPDES-DOM-Da	97612	OR0026280	Willamette River	31.6
CANBY STP	NPDES-DOM-C1a	13691	OR0020214	Willamette River	33.0
CASCADE PACIFIC PULP, LLC	NPDES-IW-B01	36335	OR0001074	Willamette River	147.7
CENTURY MEADOWS SANITARY SYSTEM (CMSS)	NPDES-DOM-Da	96010	OR0028037	Willamette River	42.8
CORVALLIS STP	NPDES-DOM-Ba	20151	OR0026361	Willamette River	130.8
COTTAGE GROVE LUMBER	NPDES-IW-B19	96188	OR0000698	Coast Fork Willamette River	24.2
COTTAGE GROVE STP	NPDES-DOM-C2a	20306	OR0020559	Coast Fork Willamette River	20.6
COVANTA MARION, INC	NPDES-IW-B16	89638	OR0031305	Willamette River	72.0
DUNDEE STP	NPDES-DOM-Db	25567	OR0023388	Willamette River	51.7
EVRAZ OREGON STEEL	NPDES-IW-B08	64905	OR0000451	Willamette River	2.4
FOREST PARK MOBILE VILLAGE	NPDES-DOM-Da	30554	OR0031267	Willamette River	28.2
FRANK LUMBER CO. INC.	NPDES-IW-B19	30904	OR0000124	North Santiam River	32.5
H&V - CORVALLIS	NPDES-IW-B15	28476	OR0000299	Willamette River	132.5
HALSEY MILL	NPDES-IW-B01	105814	OR0033405	Willamette River	147.7
HARRISBURG LAGOON TREATMENT PLANT	NPDES-DOM-Db	105415	OR0033260	Willamette River	158.4
INDEPENDENCE STP	NPDES-DOM-Db	41513	OR0020443	Willamette River	95.5

JASPER WOOD PRODUCTS, LLC	NPDES-IW-B21	100097	OR0042994	Middle Fork Willamette River	9.0
JEFFERSON STP	NPDES-DOM-Da	43129	OR0020451	Santiam River	9.2
LEBANON WWTP	NPDES-DOM-C1a	49764	OR0020818	South Santiam River	17.4
MONMOUTH STP	NPDES-DOM-Db	57871	OR0020613	Willamette River	95.5
MONROE STP	NPDES-DOM-Db	57951	OR0029203	Long Tom River	6.9
NEWBERG - WYNOOSKI ROAD STP	NPDES-DOM-C1a	102894	OR0032352	Willamette River	49.7
NW NATURAL GAS SITE REMEDIATION	NPDES-IW-B14	120589	OR0044687	Willamette River	6.4
OAK LODGE WATER SERVICES WATER RECLAMATION FACILITY	NPDES-DOM-C1a	62795	OR0026140	Willamette River	20.1
ODFW - CLACKAMAS RIVER HATCHERY	NPDES-IW-B17	64442	OR0034266	Clackamas River	22.6
ODFW - Minto Fish Facility (MARION FORKS HATCHERY)	NPDES-IW-B17	64495	OR0027847	North Santiam River	41.1
OHSU CENTER FOR HEALTH AND HEALING	NPDES-IW-B16	113611	OR0034371	Willamette River	14.5
OSU JOHN L. FRYER AQUATIC ANIMAL HEALTH LAB	NPDES-IW-B15	103919	OR0032573	Willamette River	130.6
SALEM WILLOW LAKE STP	NPDES-DOM-A2	78140	OR0026409	Willamette River	78.4
SCAPPOOSE STP	NPDES-DOM-Da	78980	OR0022420	Multnomah Channel	10.6
SILTRONIC CORPORATION	NPDES-IW-B14	93450	OR0030589	Willamette River	6.6
SLLI	NPDES-IW-B15	74995	OR0001741	Willamette River	7.0
STAYTON STP	NPDES-DOM-C2a	84781	OR0020427	North Santiam River	14.9
SWEET HOME STP	NPDES-DOM-C2a	86840	OR0020346	South Santiam River	31.5
TRYON CREEK WWTP	NPDES-DOM-Ba	70735	OR0026891	Willamette River	20.3
UNIVAR USA INC	NPDES-IW-B15	100517	OR0034606	Willamette River	9.0
VIGOR INDUSTRIAL	NPDES-IW-B15	70596	OR0022942	Willamette River	8.2
WES (Kellogg Creek WWTP)	NPDES-DOM-A3	16590	OR0026221	Willamette River	18.5
WES (Tri-city WPCP)	NPDES-DOM-A3	89700	OR0031259	Willamette River	25.5
WESTROCK, NEWBERG MILL	NPDES-IW-B01	72615	OR0000558	Willamette River	49.7
WILLAMETTE FALLS PAPER COMPANY	NPDES-IW-B01	21489	OR0000787	Willamette River	27.5
WILSONVILLE STP	NPDES-DOM-C1a	97952	OR0022764	Willamette River	38.5

Table 7-2: Individual NPDES Municipal Separate Storm Sewer System (MS4) permittees in the Willamette Subbasins.

Permittee	Permit type	DEQ WQ File Number	EPA Number
City of Eugene	NPDES-DOM-MS4-1	107989	ORS107989

City of Fairview	NPDES-DOM-MS4-1	108013	ORS108013
City of Gresham			
City Of Portland	NPDES-DOM-MS4-1	108015	ORS108015
Port of Portland			
City of Gladstone	NPDES-DOM-MS4-1	108016	ORS108016
City of Happy Valley			
City of Johnson City			
City of Lake Oswego			
City of Milwaukie			
City of Oregon City			
City of Rivergrove			
City of West Linn			
City of Wilsonville			
Clackamas County			
Oak Lodge Water Services			
WES (Clackamas Co. Service District #1)			
City of Salem			
ODOT	NPDES-DOM-MS4-1	110870	ORS110870
Multnomah County	NPDES-DOM-MS4-1	120542	ORS120542

There are multiple categories of general NPDES permit types with registrants in the Willamette Subbasins including:

- 100-J Industrial Wastewater: NPDES cooling water
- 200-J Industrial Wastewater: NPDES filter backwash
- 300-J Industrial Wastewater: NPDES fish hatcheries
- 400-J Industrial Wastewater: NPDES log ponds
- 1200-A Stormwater: NPDES sand & gravel mining
- 1200-C Stormwater: NPDES construction more than 1 acre disturbed ground
- 1200-Z Stormwater: NPDES specific SIC codes
- 1500-A Industrial Wastewater: NPDES petroleum hydrocarbon cleanup
- 1700-A Industrial Wastewater: NPDES wash water
- MS4 – Phase II – Stormwater: NPDES Municipal Separate Storm Sewer System

DEQ determined the following general permit categories have potential to discharge thermal loads that contribute to exceedances of the applicable temperature criteria:

- 100-J when river flow is < 44 cfs, or any flow range for hydropower facilities
- 200-J
- 300-J

There are xx registrants of the 100-J, xx registrants of the 200-J, and xx registrants of the 300-J general permits (Table 7-3) found to be potential significant sources of thermal load with a temperature impact. Other registrants to the industrial wastewater general permits were found to have a de minimis temperature increase based on the permit requirements, available dilution, or frequency and magnitude of discharge based on review of available discharge data.

- Human caused increases in solar radiation loading to the stream network from the disturbance or removal of near-stream vegetation;
- Channel modification and widening;
- Dam and reservoir operation;
- Activities that modify flow rate or volume; and
- Background sources, including natural sources and anthropogenic sources of warming through climate change and other factors.

Anthropogenically influenced thermal loads are targeted for reduction to attain the temperature water quality criteria. The following actions are needed to attain the TMDL allocations:

- Restoration of streamside vegetation to reduce thermal loading from exposure to solar radiation;
- Restoration of complex channel morphology and hyporheic or groundwater connection;
- Management and operation of dams and reservoirs to minimize temperature warming; and
- Maintenance of minimum instream flows.

In many of the modeled streams, thermal loading from nonpoint sources contributed to exceedances of the applicable temperature criteria and therefore were identified as significant sources of thermal loading. The maximum daily maximum or 7-day average daily maximum water temperature increase from nonpoint sources ranged from 0.43 deg-C in the Upper McKenzie River to 8.65 deg-C in the Pudding River. See the Technical Support Document for details. Reductions from nonpoint sources will be required to attain the applicable temperature criteria.

7.3 Thermal background sources

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

The amount of background thermal loading a stream receives is influenced by a number of landscape and meteorological characteristics, such as: substrate and channel morphology conditions; streambank and channel elevations; near-stream vegetation; groundwater; hyporheic flow; tributary inflows; precipitation; cloudiness; air temperature; relative humidity, and others. Many of these factors; however, are influenced by anthropogenic impacts related to the surrogate measures. As such, it was not possible to develop a model in which all human influences were controlled or accounted for. As a best estimate, background thermal sources were quantified for the modeled rivers with delineable anthropogenic influences (i.e., dams and reservoirs, vegetation alterations, point source discharges, channel modification) accounted for, thus isolating the remaining background sources.

In many of the modeled streams, thermal loading from background sources contributed to exceedances of the applicable temperature criteria and therefore were identified as significant source of thermal loading. The maximum daily maximum or 7-day average daily maximum temperature standard exceedances of background sources ranged from [coming soon]. See the Technical Support Document for detailed descriptions of analysis and results. Reductions from background sources will be required to attain the applicable temperature criteria.

8 Loading capacity and excess loads

Summarizing OAR 340-042-0040(4)(d) and 40 CFR 130.2(f), loading capacity is the amount of a pollutant or pollutants that a waterbody can receive and still meet water quality standards.

For temperature, thermal loading capacity is calculated on assessment units using Equation 8-1.

$$LC = (T_C + HUA) \cdot Q_R \cdot C_F \quad \text{Equation 8-1}$$

where,

LC = Loading Capacity (kilocalories/day).

T_C = The applicable river temperature criterion ($^{\circ}\text{C}$).

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

Q_R = The daily mean river flow rate (cfs).

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

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

Equation 8-1 shall be used to calculate the thermal loading capacity for any surface water location in the Willamette Subbasins. Table 8-1 presents the loading capacity for select temperature impaired category 5 assessment units modeled for the TMDL analysis at the critical 7Q10 low flow. Equation 8-1 may be used to calculate the loading capacity when river flows are greater than 7Q10. Equation 8-1 may also be used to calculate the loading capacity if in the future the applicable temperature criteria are updated and approved by EPA.

Table 8-1: Thermal loading capacity (LC) for select assessment units by applicable fish use period at 7Q10 flow.

AU Name and AU ID	Annual 7Q10 (cfs)	Year Round Criterion + HUA ($^{\circ}\text{C}$)	Spawning Criterion + HUA ($^{\circ}\text{C}$)	7Q10 LC Year Round (kcal/day)	7Q10 LC Spawning (kcal/day)
Clackamas River OR SR 1709001106 02 104597	668	16.3	13.3	26,635.59E+6	21,733.34E+6
Coast Fork Willamette River OR SR 1709000203 02 104585	38	18.3	13.3	1,694.62E+6	1,231.61E+6
Coast Fork Willamette River OR SR 1709000204 02 103787	131	18.3	13.3	5,858.71E+6	4,257.97E+6
Long Tom River OR SR 1709000301 02 103791	22	24.3	18.3	1,298.84E+6	978.14E+6
Middle Fork Willamette River OR SR 1709000107 02 104583	998	16.3	13.3	39,817.34E+6	32,488.99E+6
Middle Fork Willamette River OR SR 1709000110 02 104584	1272	16.3	13.3	50,746.58E+6	41,406.71E+6

North Santiam River OR_SR_1709000504_02_103906	857	16.3	13.3	34,159.82E+6	27,872.74E+6
North Santiam River OR_SR_1709000506_02_103930	910	16.3	13.3	36,301.08E+6	29,619.9E+6
Santiam River OR_SR_1709000506_02_103927	1138	18.3	13.3	50,968.52E+6	37,042.69E+6
South Santiam River OR_SR_1709000608_02_103925	613	16.3	13.3	24,433.9E+6	19,936.86E+6
Willamette River OR_SR_1709000306_05_103854	3870	18.3	13.3	173,272.72E+6	125,930.45E+6
Willamette River OR_SR_1709000701_05_104005	1980	18.3	13.3	88,652.46E+6	64,430.48E+6
Willamette River OR_SR_1709000703_04_104013	5667	18.3	13.3	253,741.92E+6	184,413.53E+6
Willamette River OR_SR_1709000703_88_104015	5688	20.3	NA	282,523.6E+6	NA
Willamette River OR_SR_1709000704_88_104020	2280	20.3	NA	113,241.44E+6	NA
Willamette River OR_SR_1709001201_88_104019	2240	20.3	NA	111,254.75E+6	NA
Willamette River OR_SR_1709001202_88_104175	6012	20.3	NA	298,586.17E+6	NA

In accordance with OAR 340-042-0040(4)(e), the excess load calculation evaluates, to the extent existing data allow, the difference between the actual pollutant load in a waterbody and the loading capacity of that waterbody.

Because flow monitoring data were not available at most temperature monitoring locations, it was not possible to calculate the excess load. Instead, the excess temperatures and percent load reduction were calculated for each assessment unit where temperature data were available (Table 8-2). The extensive monitoring across the Willamette subbasin represents a wide range of waterbodies; however not all streams in the Willamette subbasins have monitoring data. Equation 8-2 from the Technical Support Document can be used to determine excess temperature and percent reduction for additional streams if data becomes available in the future.

The excess temperatures are the maximum difference between the monitored 7DADM river temperatures and applicable numeric criteria plus the human use allowance. The percent load reduction represents the portion of the actual thermal loading that must be reduced to attain the TMDL loading capacity. The percent load reduction can be calculated from the excess temperature.

Table 8-2: Excess temperature and percent load reduction for various assessment units in the Willamette Subbasins.

Assessment Unit Name	Assessment Unit ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
Clackamas River	OR_SR_1709001106_02_104597	17.7	13.3	4.4	24.9
Clackamas River	OR_SR_1709001106_02_104597	20.5	16.3	4.2	20.5
Clackamas River	OR_SR_1709001106_02_104597	24.5	18.3	6.2	25.3
Coast Fork Willamette River	OR_SR_1709000203_02_104585	12.5	13.3	0	0.0

Assessment Unit Name	Assessment Unit ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
Coast Fork Willamette River	OR_SR_1709000203_02_104585	24.2	18.3	5.9	24.4
Fall Creek	OR_SR_1709000109_02_103735	21.9	13.3	8.6	39.3
Fall Creek	OR_SR_1709000109_02_103735	20.8	16.3	4.5	21.6
Long Tom River	OR_SR_1709000301_02_103791	24.7	24.0	0.7	
Middle Fork Willamette River	OR_SR_1709000107_02_104583	21.1	13.3	7.8	37.0
Middle Fork Willamette River	OR_SR_1709000107_02_104583	21.3	16.3	5	23.5
Middle Fork Willamette River	OR_SR_1709000110_02_104584	21.1	13.3	7.8	37.0
Middle Fork Willamette River	OR_SR_1709000110_02_104584	22.3	16.3	6	26.9
North Santiam River	OR_SR_1709000504_02_103906	16.7	13.3	3.4	20.4
North Santiam River	OR_SR_1709000504_02_103906	16.7	16.3	0.4	2.4
North Santiam River	OR_SR_1709000506_02_103930	19.2	13.3	5.9	30.7
North Santiam River	OR_SR_1709000506_02_103930	21.1	16.3	4.8	22.7
Row River	OR_SR_1709000202_02_103779	13.6	13.3	0.3	2.2
Row River	OR_SR_1709000202_02_103779	23	18.3	4.7	20.4
Santiam River	OR_SR_1709000506_02_103927	16.3	13.3	3	18.4
Santiam River	OR_SR_1709000506_02_103927	23.4	18.3	5.1	21.8
South Santiam River	OR_SR_1709000608_02_103925	15	13.3	1.7	11.3
South Santiam River	OR_SR_1709000608_02_103925	14.1	16.3	0	0.0
Willamette River	OR_SR_1709000306_05_103854	17.5	13.3	4.2	24.0
Willamette River	OR_SR_1709000306_05_103854	23.8	18.3	5.5	23.1
Willamette River	OR_SR_1709000703_04_104013	17.6	13.3	4.3	24.4
Willamette River	OR_SR_1709000703_04_104013	25.7	18.3	7.4	28.8
Willamette River	OR_SR_1709000703_88_104015	26.1	20.3	5.8	22.2
Willamette River	OR_SR_1709001202_88_104175	26.6	20.3	6.3	23.7

9 Allocations, reserve capacity, and margin of safety

ORAR 340-042-0040(4)(g),(h),(i) and (k) [and 40 CFR 130.2(h) and (g) and 130.7(c)(2)] respectively define the required TMDL elements of apportionment of the allowable pollutant load: point source wasteload allocations; nonpoint source load allocations (including background); margin of safety; and reserve capacity. Collectively, these elements add up to the

maximum load of a pollutant that still allows a waterbody to meet water quality standards. OAR 304-042-0040(5) and (6) describe the potential factors of consideration for determining and distributing these allocations of the allowable pollutant loading capacities. Water quality data analysis must be conducted to determine allocations, potentially including statistical analysis and mathematical modeling. Factors to consider in allocation distribution may include: source contributions; costs of implementing management measures; ease of implementation; timelines for attaining water quality standards; environmental impacts of allocations; unintended consequences; reasonable assurance of implementation; and any other relevant factor.

9.1 Thermal allocations

9.1.1 Human Use Allowance allocations

The human use allowance at OAR 340-041-0028(12)(b)(B) identifies the allowed temperature increase reserved for human uses. The rule requires that wasteload and load allocations restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.30°C (0.5°F) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact (POMI).

Table xxx present the assigned portion of the human use allowance to anthropogenic source categories across different streams and stream extents in the Willamette Subbasins. The dam and reservoir operations source category accounts for nonpoint source temperature impacts associated with the dam impoundment and release of the impounded water back into the natural channel. The water management activities and water withdrawals source category accounts for nonpoint source temperature impacts associated with the withdrawal of water that is intended for consumptive uses (such as irrigation) and the warming that might occur as that water moves through a canal or ditch before being returned to the natural river.

Table xxx present the assigned portion of the human use allowance to anthropogenic source categories across different streams and stream extents in the Willamette Subbasins. The assigned portion of the human use allowance represents the maximum cumulative warming anywhere in the waterbody and at the point of maximum impact from all nonpoint source activities within each source category. Therefore, DEQ expects the amount of warming for each unique nonpoint source activity to be less than the values shown in **Table xxx**. DEQ will implement the TMDL in a manner consistent with the human use allowance rule by requiring all nonpoint sources to implement management strategies and reduce their warming impact such that the assigned human use allowance is attained.

SEE TMDL_Report_WillametteMainstem_HUA_Assingments_RAC1.xlsx

9.1.2 Thermal wasteload allocations for point sources

Wasteload allocations are assigned to NPDES permitted point sources listed in Table 9-11. The wasteload allocation for registrants under the general stormwater permits (MS4, 1200-A, 1200-C and 1200-Z) and general permit registrants not identified in Table 9-11 is equal to any existing thermal load authorized under the current permit. More specific wasteload allocations can be considered if subsequent data and evaluation demonstrates a need and if capacity is available.

Wasteload allocations were calculated using Equation 9-1.

$$WLA = (\Delta T) \cdot (Q_E + Q_R) \cdot C_F \quad \text{Equation 9-1}$$

where,

WLA = Wasteload allocation (kilocalories/day).

ΔT = The assigned portion of the human use allowance and the maximum temperature increase (°C) above the applicable river temperature criterion using 100% of river flow not to be exceeded by each individual source from all outfalls combined. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, $\Delta T = 0.0$.

Q_E = The daily mean effluent flow (cfs).

When effluent flow is in million gallons per day (MGD) convert to cfs:

$$\frac{1 \text{ million gallons}}{1 \text{ day}} \cdot \frac{1.5472 \text{ ft}^3}{1 \text{ million gallons}} = 1.5472$$

Q_R = The daily mean river flow rate, upstream (cfs).

When river flow is $\leq 7Q_{10}$, $Q_R = 7Q_{10}$. When river flow $> 7Q_{10}$, Q_R is equal to the daily mean river flow, upstream.

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

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

The excess thermal load provided by an effluent may be calculated using Equation 9-2.

$$ETL = Q_E(T_E - T_C)C_F \quad \text{Equation 9-2}$$

where,

ETL = Excess Thermal Load wasteload allocation (kilocalories/day).

T_C = The applicable river temperature criteria.

Q_E = The daily mean effluent flow (cfs).

When effluent flow is in million gallons per day (MGD) convert to cfs:

$$\frac{1 \text{ million gallons}}{1 \text{ day}} \cdot \frac{1.5472 \text{ ft}^3}{1 \text{ million gallons}} = 1.5472$$

The effluent discharge used to calculate the wasteload allocations presented in Table 9-11 are based on the average dry weather facility design, a maximum discharge authorized by an NPDES permit, or an effluent discharge characterized from discharge data. Average dry weather facility design flows were obtained from the current NPDES permits or permit evaluation reports. More information on the specific source of the effluent discharge flow and the rationale behind the allocated human use allowance is described in the Technical Support Document Section 9.1, Table 9-1.

For the City of Scappoose STP discharge to Multnomah Channel, Equation 9-2 is used to calculate the current thermal load and wasteload allocation for the facility. This is discussed in the Technical Support Document.

Wasteload allocations may be implemented in NPDES permits in any of the following ways:

- (1) Incorporate the 7Q10 wasteload allocation in Table 9-11 as a static numeric limit. Permit writers may recalculate the static limit using different values for 7Q10 (Q_R), and effluent flow (Q_E), if better estimates are available.
- (2) Incorporate Equation 9-1 directly into the permit with effluent flow (Q_E), river flow (Q_R), and the wasteload allocation (WLA) being dynamic and calculated on a daily basis. The

assigned portion of the human use allowance (ΔT) is static and based on the value in Table 9-11.

Based on review of available temperature data presented in Section 5 of the Technical Support Document, the overall critical period is April 1 through November 15. Wasteload allocations apply during these periods.

Willamette mainstem and major tributary point sources are organized in the following order: Clackamas River, Coast Fork Willamette River, Long Tom River, McKenzie River, Middle Fork Willamette River, North Santiam River, Santiam River, South Santiam River, Willamette River, and Multnomah Channel (TAB). For each river, point sources are organized upstream to downstream.

Table 9-1: Thermal wasteload allocations (WLA) for point sources.

NPDES Permittee - WQ File Number – Permit Number – Outfall location	Assigned Human Use Allowance ΔT (°C)	WLA period start	WLA period end	Annual 7Q10 River flow (cfs)	Effluent discharge (cfs)	7Q10 WLA (x 10 ⁶ kcals/day)
1 ADAIR VILLAGE STP - 500 - 101701 - Willamette River RM 122	0.001	1-Apr	15-May	6,308	1.3	15.437
	0.002	15-Oct	15-Nov	4,443	1.3	21.747
AM WRF - ALBANY-MILLERSBURG WATER RECLAMATION FACILITY - 1098 - 102024 - Willamette River RM 118	0.01	1-Apr	15-May	6,308	14.3	154.686
	0.017	16-May	14-Oct	3,857	13.7	160.995
	0.037	15-Oct	15-Nov	4,443	25.1	404.482
ARKEMA - 68471 - 103075 - Willamette River RM 7.2	0.001	1-Jun	30-Sep	6,235	0.2	15.255
1 BROOKS SEWAGE TREATMENT PLANT - 100077 - 101397 - Willamette River RM 71.7	0.001	1-Apr	15-May	11,955	1.6	29.254
	0.002	15-Oct	15-Nov	7,134	1.6	34.917
CANBY REGENCY MOBILE HOME PARK - 97612 - 101644 - Willamette River RM 31.6	0.001	1-Jun	30-Sep	5,717	0.1	13.988
CANBY STP - 13691 - 101063 - Willamette River RM 33	0.004	1-Jun	30-Sep	5,634	3.1	55.168
CASCADE PACIFIC PULP, LLC - 36335 - 101114 - Willamette River RM 147.7	0.023	1-Apr	15-May	5,330	16.5	300.865
	0.05	16-May	14-Oct	3,442	17.3	423.187
	0.022	15-Oct	15-Nov	7,281	14.5	392.692
CENTURY MEADOWS SANITARY SYSTEM (CMSS) - 96010 - 101721 - Willamette River RM 42.8	0.001	1-Jun	30-Sep	5,717	0.6	13.989
CORVALLIS STP - 20151 - 101714 - Willamette River RM 130.8	0.016	1-Apr	15-May	5,330	15.3	209.251
	0.015	16-May	14-Oct	3,442	9.8	126.681
	0.042	15-Oct	15-Nov	4,281	33.3	443.337
COTTAGE GROVE STP - 20306 - 101300 - Coast Fork Willamette River RM 20.6	0.16	1-Apr	15-May	61	2.1	24.702
	0.22	16-May	15-Nov	36	1.3	20.077
COVANTA Marion County Solid Waste-to-Energy Facility - 89638 - 101240 - Willamette River RM 72	0.001	1-Apr	15-May	8,747	0.2	21.401
	0.002	16-May	14-Oct	5,634	0.3	27.57
	0.001	15-Oct	15-Nov	7,134	0.2	17.455

DUNDEE STP - 25567 - 101722 - Willamette River RM 51.7	0.001	1-Jun	30-Sep	5,717	1.1	13.99
EVRAZ OREGON STEEL - 64905 - 101007 - Willamette River RM 2.4	0.002	1-Jun	30-Sep	6,235	1.3	30.516
FOREST PARK MOBILE VILLAGE - 30554 - 102323 - Willamette River RM 28.2	0.001	1-Jun	30-Sep	5,717	0.1	13.988
FRANK LUMBER CO. INC. - 30904 - 101583 - North Santiam River RM 32.5	0.03	1-Apr	15-Jun	987	3	72.666
	0.04	16-Jun	31-Aug	799	3	78.489
	0.04	1-Sep	15-Nov	957	4.4	94.089
1 HARRISBURG LAGOON TREATMENT PLANT - 105415 - 101626 - Willamette River RM 158.4	0.002	1-Apr	30-Apr	5,204	1.9	25.474
	0.003	1-Nov	15-Nov	3,853	1.9	28.295
HOLLINGSWORTH & VOSE FIBER CO - CORVALLIS - 28476 - 101331 - Willamette River RM 132.5	0.001	15-Apr	15-May	5,330	0.1	13.041
	0.001	16-May	14-Oct	3,442	0.2	8.422
	0.001	15-Oct	15-Nov	4,281	0.1	10.474
INDEPENDENCE STP - 41513 - 101217 - Willamette River RM 95.5	0.005	1-Apr	15-May	10,688	3.9	130.797
	0.007	16-May	14-Oct	3,857	3.8	66.123
	0.004	15-Oct	15-Nov	7,134	6.2	69.879
JEFFERSON STP - 43129 - 101780 - Santiam River (enters WR at RM 109) RM 9.2	0.01	1-Apr	15-May	3,821	0.6	93.502
	0.01	16-May	14-Oct	1,065	0.8	26.077
	0.01	15-Oct	15-Nov	1,927	0.6	47.162
LEBANON WWTP - 49764 - 101771 - South Santiam River RM 17.4	0.02	1-Apr	15-May	1,433	4.1	70.322
	0.04	16-May	14-Oct	595	4.9	58.71
	0.08	15-Oct	15-Nov	817	12.3	162.322
MONMOUTH STP - 57871 - 101919 - Willamette River RM 95.5	0.005	1-Apr	15-May	9,945	5.8	121.731
	0.008	16-May	14-Oct	3,857	4.3	75.578
	0.003	15-Oct	15-Nov	7,103	5.8	52.179
MONROE STP - 57951 - 101692 - Long Tom River RM 6.9	0.07	1-Apr	1-May	55	1.2	9.625
MVMC - EUGENE/SPRINGFIELD STP - 55999 - 102486 - Willamette River RM 178	0.12	1-Apr	15-May	1,906	42.6	572.109
	0.107	16-May	14-Oct	1,466	55.1	398.214
	0.19	15-Oct	15-Nov	1,925	86.3	934.986
NEWBERG - WYNOOSKI ROAD STP - 102894 - 100988 - Willamette River RM 49.7	0.006	1-Jun	30-Sep	5,634	6.2	82.798
NW NATURAL GAS SITE REMEDIATION - 120589 - 103061 - Willamette River RM 6.4	0.001	1-Jun	30-Sep	6,235	0.7	15.257
OAK LODGE WATER SERVICES WATER RECLAMATION FACILITY - 62795 - 100986 - Willamette River RM 20.1	0.003	1-Jun	30-Sep	6,235	4.1	45.795
ODFW - CLACKAMAS RIVER HATCHERY - 64442 - 102663 - Clackamas River RM 22.6	0.05	1-Apr	15-Jun	1,186	22.9	147.889
	0.11	16-Jun	31-Aug	620	17.8	171.653
	0.07	1-Sep	15-Nov	646	22	114.406
	0.03	1-Apr	15-Jun	987	30	74.648

ODFW - Minto Fish Facility (MARION FORKS HATCHERY) - 64495 - 101917 - North Santiam River RM 41.13	0.03	16-Jun	31-Aug	799	36	61.289
	0.03	1-Sep	15-Nov	957	41	73.253
ODFW Dexter Ponds - 64450 - NA - Middle Fork Willamette River RM 15.7	0.04	1-Apr	15-Jun	986	48	101.191
	0.21	16-Jun	14-Sep	989	48	532.795
	0.27	15-Sep	15-Nov	1,280	48	877.256
ODFW South Santiam Hatchery - 64560 - GEN03: Industrial Wastewater; NPDES fish hatcheries - South Santiam River RM 37.8	0.02	1-Apr	15-Jun	841	10.6	41.672
	0.02	16-Jun	31-Aug	595	25.9	30.383
	0.02	1-Sep	15-Nov	678	28.5	34.571
OHSU CENTER FOR HEALTH AND HEALING - 113611 - 102833 - Willamette River RM 14.462	0.001	1-Jun	30-Sep	6,235	0.1	15.255
OSU JOHN L. FRYER AQUATIC ANIMAL HEALTH LAB - 103919 - 102512 - Willamette River RM 130	0.001	1-Apr	15-May	5,800	0.9	14.193
	0.001	16-May	14-Oct	3,710	1.2	9.08
	0.001	15-Oct	15-Nov	4,149	0.9	10.153
SALEM WILLOW LAKE STP - 78140 - 101145 - Willamette River RM 78.4	0.022	1-Apr	15-May	10,688	46.4	577.797
	0.052	16-May	14-Oct	5,634	39.8	721.858
	0.085	15-Oct	15-Nov	7,134	112.3	1,506.99
² SCAPPOOSE STP - 78980 - 100677 - Multnomah Channel RM 10.5796	NA	1-Jun	30-Sep	10	0.92	20.391 ²
SILTRONIC CORPORATION - 93450 - 101128 - Willamette River RM 6.6	0.007	1-Jun	30-Sep	6,235	4.2	106.857
SLLI - 74995 - 101180 - Willamette River RM 7	0.001	1-Jun	30-Sep	6,235	0.1	15.255
STAYTON STP - 84781 - 101601 - North Santiam River RM 14.9	0.02	1-Apr	15-Jun	1,482	1.8	72.607
	0.02	16-Jun	31-Aug	860	1.9	42.176
	0.02	1-Sep	15-Nov	1,019	1.8	49.951
SWEET HOME STP - 86840 - 101657 - South Santiam River RM 31.5	0.02	1-Apr	15-Jun	876	2.6	42.993
	0.03	16-Jun	31-Aug	595	2.1	43.827
	0.04	1-Sep	15-Nov	667	3.5	65.62
Teledyne Wah Chang Albany - 87645 - 100532 - Willamette River RM 115.5	0.001	1-Apr	15-May	6,308	0.1	15.434
	0.001	16-May	14-Oct	3,857	0.1	9.437
	0.001	15-Oct	15-Nov	4,443	0.1	10.871
TRYON CREEK WWTP - 70735 - 101614 - Willamette River RM 20.3	0.005	1-Jun	30-Sep	6,235	12.9	76.433
UNIVAR USA INC - 100517 - 101613 - Willamette River RM 9	0.001	1-Jun	30-Sep	6,235	0.1	15.255
VIGOR INDUSTRIAL - 70596 - 101393 - Willamette River RM 8.2	0.005	1-Jun	30-Sep	6,235	2.4	76.304
WES Kellogg Creek WWTP - 16590 - 100983 - Willamette River RM 18.5	0.007	1-Jun	30-Sep	6,235	15.5	107.05
WES Tri-city WPCP - 89700 - 101168 - Willamette River RM 25.5	0.014	1-Jun	30-Sep	6,235	18.5	214.203
WEST LINN PAPER COMPANY - 21489 - 100976 - Willamette River RM 27.5	0.013	1-Jun	30-Sep	6,235	6.5	198.521

WILSONVILLE STP - 97952 - 101888 - Willamette River RM 38.5	0.005	1-Jun	30-Sep	5,634	4.2	68.974
¹ NPDES specifies no discharge during summer period. Therefore, no WLA is required during the summer. ² Because Multnomah Channel is tidally influenced and includes water from both Willamette and Columbia Rivers, river flow rate is not applicable, and Equation 9-1 does not apply for Scappoose STP. 20.391 x 10 ⁶ kcal/day is the WLA for this facility (i.e., only WLA Option 1 above is available for this facility).						

9.1.3 Thermal load allocations for nonpoint sources

Load allocations are assigned to background sources and anthropogenic nonpoint sources on all waters, as defined in Section 2, in the Willamette Subbasins.

Load allocations for background sources are calculated using Equation 9-2.

$$LA_{BG} = (T_C) \cdot (Q_R) \cdot C_F \quad \text{Equation 9-3}$$

where,

- LA_{BG} = Load allocation to background sources (kilocalories/day).
- T_C = The applicable temperature criteria, not including the human use allowance. When there are two year-round applicable temperature criteria that apply to the same assessment unit, the more stringent criteria shall be used.
- Q_R = The daily average river flow rate (cfs). Conversion factor using flow in cubic feet per second (cfs): 2,446,665
- C_F = $\left(\frac{1 \text{ m}}{3.2808 \text{ ft}}\right)^3 \cdot \frac{1 \text{ m}^3}{35.31 \text{ ft}^3} \cdot \frac{1000 \text{ kg}}{1 \text{ m}^3} \cdot \frac{86400 \text{ sec}}{1 \text{ day}} \cdot \frac{1 \text{ kcal}}{1 \text{ kg} \cdot 1^\circ\text{C}} = 2,446,665$

Table 9-12 presents the load allocations assigned to background sources on temperature impaired category 5 assessment units that were modeled for the TMDL analysis. The load allocations are based on the 7Q10 low river flows and the minimum applicable criterion in the respective assessment units. Equation 9-2 shall be used to calculate the load allocations assigned to background sources on all other assessment units or stream location in the Willamette Subbasins not identified in Table 9-12; or for any assessment units identified in Table 9-12 when river flows are greater than 7Q10.

If the applicable temperature criteria are updated and approved by EPA, the background load allocations assigned to any assessment unit or stream location where the temperature criterion changed shall be recalculated using the updated criterion and Equation 9-2.

Table 9-2: Thermal load allocations (LA) for background sources.

AU Name and AU ID	Annual 7Q10 (cfs)	Year Round Criterion (°C)	Spawning Criterion (°C)	7Q10 LA Year Round (kcal/day)	7Q10 LA Spawning (kcal/day)
Clackamas River OR_SR_1709001106_02_104597	668	16.0	13.0	26,145.37E+6	21,243.11E+6
Coast Fork Willamette River OR_SR_1709000203_02_104585	38	18.0	13.0	1,666.84E+6	1,203.83E+6
Coast Fork Willamette River OR_SR_1709000204_02_103787	131	18.0	13.0	5,762.67E+6	4,161.93E+6
Long Tom River OR_SR_1709000301_02_103791	22	24.0	13.0	1,282.8E+6	694.85E+6
Middle Fork Willamette River OR_SR_1709000107_02_104583	998	16.0	13.0	39,084.5E+6	31,756.16E+6

Middle Fork Willamette River OR SR 1709000110 02 104584	1272	16.0	13.0	49,812.59E+6	40,472.73E+6
North Santiam River OR SR 1709000504 02 103906	857	16.0	13.0	33,531.11E+6	27,244.03E+6
North Santiam River OR SR 1709000506 02 103930	910	16.0	13.0	35,632.96E+6	28,951.78E+6
Santiam River OR SR 1709000506 02 103927	1138	18.0	13.0	50,132.97E+6	36,207.14E+6
South Santiam River OR SR 1709000608 02 103925	613	16.0	13.0	23,984.19E+6	19,487.16E+6
Willamette River OR SR 1709000306 05 103854	3870	18.0	13.0	170,432.19E+6	123,089.91E+6
Willamette River OR SR 1709000701 05 104005	1980	18.0	13.0	87,199.14E+6	62,977.16E+6
Willamette River OR SR 1709000703 04 104013	5667	18.0	13.0	249,582.22E+6	180,253.82E+6
Willamette River OR SR 1709000703 88 104015	5688	20.0	NA	278,348.38E+6	NA
Willamette River OR SR 1709000704 88 104020	2280	20.0	NA	111,567.92E+6	NA
Willamette River OR SR 1709001201 88 104019	2240	20.0	NA	109,610.59E+6	NA
Willamette River OR SR 1709001202 88 104175	6012	20.0	NA	294,173.57E+6	NA

Load allocations assigned to anthropogenic nonpoint sources on any assessment unit or stream location in the Willamette Subbasins are calculated using Equation 9-3. The portion of the human use allowance (ΔT) assigned to nonpoint sources or source categories are presented in Table 9-1 through Table 9-10.

$$LA_{NPS} = (\Delta T) \cdot (Q_R) \cdot C_F \quad \text{Equation 9-4}$$

where,

LA_{NPS} = Load allocation to anthropogenic nonpoint sources (kilocalories/day).

ΔT = The portion of the human use allowance assigned to each nonpoint source category representing the maximum cumulative temperature increase ($^{\circ}\text{C}$) from all source activity in the nonpoint source category. When the minimum duties provision at OAR 340-041-0028(12)(a) applies, $\Delta T = 0.0$.

Q_R = The daily average river flow rate (cfs).
Conversion factor using flow in cubic feet per second (cfs): 2,446,665

$$C_F = \left(\frac{1 \text{ m}}{3.2808 \text{ ft}} \right)^3 \cdot \frac{1 \text{ m}^3}{35.31 \text{ ft}^3} \cdot \frac{1000 \text{ kg}}{1 \text{ m}^3} \cdot \frac{86400 \text{ sec}}{1 \text{ day}} \cdot \frac{1 \text{ kcal}}{1 \text{ kg} \cdot 1^{\circ}\text{C}} = 2,446,665$$

9.1.4 Surrogate measures

EPA regulations (40 CFR 130.2(i)) and OAR 340-042-0040(O)(5)(b) allow for TMDLs to utilize other appropriate measures (or surrogate measures). This section presents surrogate measures that implement the load allocations.

9.1.4.1 Dam and reservoir operations

Dam and reservoir operations are assigned 0.00 $^{\circ}\text{C}$ of the human use allowance (Table xxx) and the equivalent load allocation as calculated using Equation 9-3. PGE's Willamette Falls project is assigned 0.10 $^{\circ}\text{C}$ of the human use allowance. Monitoring stream temperature, rather

than a thermal load, is easier and a more meaningful approach for reservoir management. Temperature is mathematically related to excess thermal loading and directly linked to the temperature water quality standard. For these reasons, DEQ is using a surrogate measure to implement the load allocation for dam and reservoir operations. The minimum duties provision in rule at OAR 340-042-0028(12)(a) states that anthropogenic sources are only responsible for controlling the thermal effects of their own discharge or activity in accordance with its overall heat contribution. For dam and reservoir operations, the minimum duties provision is implemented when 7DADM temperatures upstream of the reservoirs exceed the applicable temperature criteria, the dam and reservoir operations must not contribute any additional warming above and beyond those upstream temperatures entering the reservoir. DEQ has developed the following surrogate measure temperature approach to implement the load allocation. The surrogate measure compliance point is located just downstream of the dam or just downstream of where impounded water is returned to the free-flowing stream. The surrogate measure is:

- a) The 7DADM temperatures immediately upstream of the reservoirs. If multiple streams flow into the reservoir, 7DADM temperatures upstream of the reservoirs may be calculated as a flow weighted mean of temperatures from each inflowing tributary. With DEQ approval, the estimated free flowing (no dam) temperatures may also be calculated using a model to account for any warming or cooling that would occur through the reservoir reaches absent the dam and reservoir operations and applied as the temperature surrogate measure.
- b) On days the surrogate measure calculated or measured under item a) is cooler than the most restrictive applicable temperature criteria anywhere in the assessment unit immediately downstream of the dam, the surrogate 7DADM temperature may be no warmer than the applicable criteria when all of the following are true:
 - i. The protecting cold water criterion at OAR 340-041-0028(11) does not apply;
 - ii. DEQ approves a cumulative effects analysis demonstrating release temperatures warmer than the cooler ambient temperatures will not increase downstream 7DADM temperatures more than the portion of the HUA allocated to the dam and reservoir above the applicable criteria. Currently, dam and reservoir operations receive zero HUA (Table 9-1 through Table 9-10); however, in the future if warranted, a specific operation may receive a portion of the HUA currently allotted to reserve capacity.

For implementation of the low flow conditions provision at OAR 340-041-0028(12)(d), the 7Q10 shall be calculated at a gage upstream of the reservoir or at nearby monitoring gage that isn't influenced by the dam's operations.

9.1.4.2 Site specific effective shade surrogate measure

Effective shade surrogate measure targets shown in Table 9-13 through Table 9-17 represent a surrogate for the amount of solar loading that will attain the human use allowance and load allocations for nonpoint sources managing streamside vegetation. The surrogate measure is the arithmetic mean of the effective shade values at all model nodes assigned to each designated management agency (Equation 9-4). Equation 9-4 may be used to recalculate the mean effective shade targets if designated management agency boundaries change or the designated management agency boundary needs to be corrected. Equation 9-4 may also be used to

recalculate the mean effective shade targets based on an updated shade gap assessment following the process and methods outlined in the Water Quality Management Plan.

Changes in the target effective shade from the values presented in Table 9-13 result in redistribution of the sector or source responsible for excess load reduction. If the shade target increases, the equivalent portion of the excess load is reassigned from background sources to nonpoint sources. If the shade target decreases, the portion of the excess load is reassigned from nonpoint sources to background sources. The exact portion reassigned can only be determined in locations where temperature models have been developed. In locations without temperature models, the reassignment remains unquantified. Changes to the target effective shade do not impact the loading capacity, human use allowance, or the load allocations. They remain the same as presented in this TMDL.

$$\overline{ES} = \frac{\sum ES_{n_i}}{n_i} \quad \text{Equation 9-5}$$

Where,

- \overline{ES} = The mean effective shade for designated management agency *i*.
- $\sum ES_{n_i}$ = The sum of effective shade from all model nodes or measurement points assigned to designated management agency *i*.
- n_i = Total number of model nodes or measurement points assigned to designated management agency *i*.

Table 9-3: Effective shade surrogate measure targets to meet nonpoint source load allocations for designated management agencies in the Willamette mainstem and major tributary model area.

Designated Management Agency	Total Kilometers Assessed	Assessed Effective Shade (%)	TMDL Target Effective Shade (%)	Shade Gap
Albany & Eastern Railroad	0.2	46	51	5
Benton County	1.8	8	15	7
City of Albany	2.8	1	2	1
City of Corvallis	6.5	5	13	8
City of Cottage Grove	6.4	38	72	34
City of Creswell	0.4	16	32	16
City of Eugene	12.5	16	22	6
City of Gates	1.4	12	53	41
City of Gladstone	3.8	11	35	24
City of Happy Valley	1.9	13	42	29
City of Harrisburg	1.5	2	10	8
City of Jefferson	1.3	20	39	19
City of Lebanon	0.8	7	25	18
City of Lyons	0.9	9	22	13
City of Mill City	2.5	8	44	36
City of Millersburg	0.6	1	4	3
City of Monroe	0.9	13	32	19
City of Oregon City	0.1	2	30	28
City of Salem	3.2	25	26	1
City of Springfield	4.9	9	19	10

Designated Management Agency	Total Kilometers Assessed	Assessed Effective Shade (%)	TMDL Target Effective Shade (%)	Shade Gap
City of Stayton	4.9	32	47	15
City of Sweet Home	2.8	7	16	9
Clackamas County	10	13	38	25
Lane County	50.3	19	36	17
Linn County	24.2	12	22	10
Marion County	3.4	22	37	15
Oregon Department of Agriculture	283.6	18	36	18
Oregon Department of Fish and Wildlife	5.5	13	68	55
Oregon Department of Forestry - Private	33.7	16	38	22
Oregon Department of Forestry - Public	1.3	25	74	49
Oregon Department of Geology and Mineral Industries	2.2	28	43	15
Oregon Department of State Lands	2	23	33	10
Oregon Department of Transportation	15.5	17	37	20
Oregon Parks and Recreation Department	31.3	16	30	14
Portland & Western Railroad	0.4	33	3	0
Other State of Oregon Agencies	3.2	10	19	9
U.S. Army Corps of Engineers	3.5	19	54	35
U.S. Bureau of Land Management	4.7	10	28	18
U.S. Fish and Wildlife Service	1.9	1	7	6
Union Pacific Railroad	0.6	27	34	7

9.1.4.3 Effective shade curve surrogate measure

Effective shade curves are applicable to any stream that does not have site specific shade targets (9.1.4.2). Effective shade curves represent the maximum possible effective shade for a given vegetation type. The values presented within the effective shade curves (Figure 9-5 to Figure 9-26) represent the mean effective shade target for different mapping units, stream aspects, and active channel widths. The vegetation height, density, overhang, and buffer widths used for each mapping unit vegetation type is summarized in Table 9-18. See the Technical Support Document Appendix A and C for additional details on the model approach for shade curves and the methodologies used to determine the mapping units and vegetation characteristics. Section 14 provides tables of the plotted shade curve values. A map of all mapping units in the Willamette Basin can be found in Appendix H of the Technical Support Document.

Local geology, geography, soils, climate, legacy impacts, natural disturbance rates, and other factors may prevent effective shade from reaching the target effective shade. No enforcement action will be taken by DEQ for reductions in effective shade caused by natural disturbances.

Table 9-4: Vegetation height, density, overhang, and horizontal distance buffer widths used to derive generalized effective shade curve targets for each mapping unit.

Mapping Unit	Height (m)	Height (ft)	Density (%)	Overhang (m)	Buffer Width (m)
Qff1	40.7	134	70	4.9	36.8
Qfc	37.7	124	64	4.5	36.8
Qalc	26.9	88	71	3.2	36.8
Qg1	21.6	71	64	2.6	36.8
Qau	22.6	74	69	2.7	36.8
Qalf	17.5	57	68	2.1	36.8
Qff2	21.5	71	66	2.6	36.8
Qbf	22.0	72	68	2.6	36.8
Tvc	27.8	91	65	3.3	36.8
Qtg	40.5	133	72	4.9	36.8
Tvw	35.1	115	65	4.2	36.8
Tcr	36.9	121	68	4.4	36.8
Tm	29.7	97	68	3.6	36.8
QTt	25.2	83	66	3.0	36.8
QTb	35.2	115	64	4.2	36.8
Qls	44.0	144	65	5.3	36.8
OW	1.9	6	74	0.2	36.8
Upland Forest	40.9	134	75	4.9	36.8
1d/1f - Coast Range - Volcanics and Willapa Hills	36.0	118.1	75	3.9	36.8
3a -Willamette Valley - Portland/Vancouver Basin	26.0	85.3	75	1.9	36.8
3c -Willamette Valley - Prairie Terraces	33.2	108.9	75	1.9	36.8
3d - Willamette Valley – Valley Foothills	31.0	101.7	75	1.9	36.8

How to use a shade curve:

1. Determine the applicable mapping unit for the stream location you are applying a shade curve to.

Example: Your site of interest is in the Rickreall Creek watershed, in the City of Independence, along the west bank of a tributary to the Willamette River. By using the appropriate map (Figure 9-3), you identify the mapping unit at your site to be Qalc (Quaternary alluvium floodplain deposits).

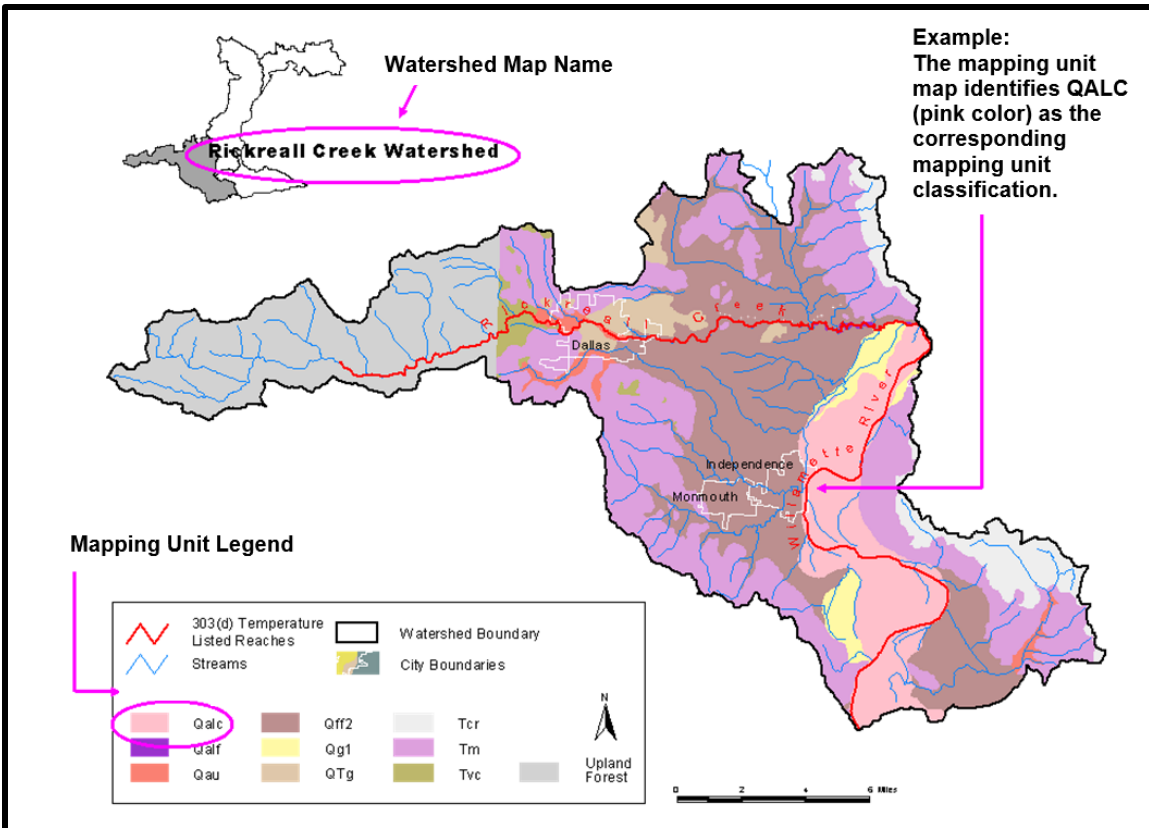


Figure 9-1: Mapping units in the Rickreall Creek Watershed.

- Determine the stream aspect from north.

Example: Standing in-stream mid-channel, facing north you determine the river's aspect as 0° or 180° from north (this means the river reach runs south to north).

- Determine the active channel width of the stream reach.

Example: At your location you measure the active channel width using a tape measure or laser range finder and determine that it is 25 feet.

- Use the appropriate mapping unit shade curve, stream aspect line, and active channel width (x-axis), to determine the percent effective shade of your site (y-axis). This is the surrogate measure effective shade target of that stream reach location.

Example: You have determined that the appropriate shade curve mapping unit for your site is Qalc (Figure 9-4). Since you are located on a tributary with a North- South stream aspect and an active channel width of 25 feet, you use the dashed line to determine the effective shade. By reading the y- axes, you determine that the effective shade to be ~83% when system potential vegetation is applied to the left and right bank of the stream reach. System potential vegetation defines the average riparian vegetation height as 88.2 feet (26.9 meters), and the stand density (canopy density) as 71%.

Qalc

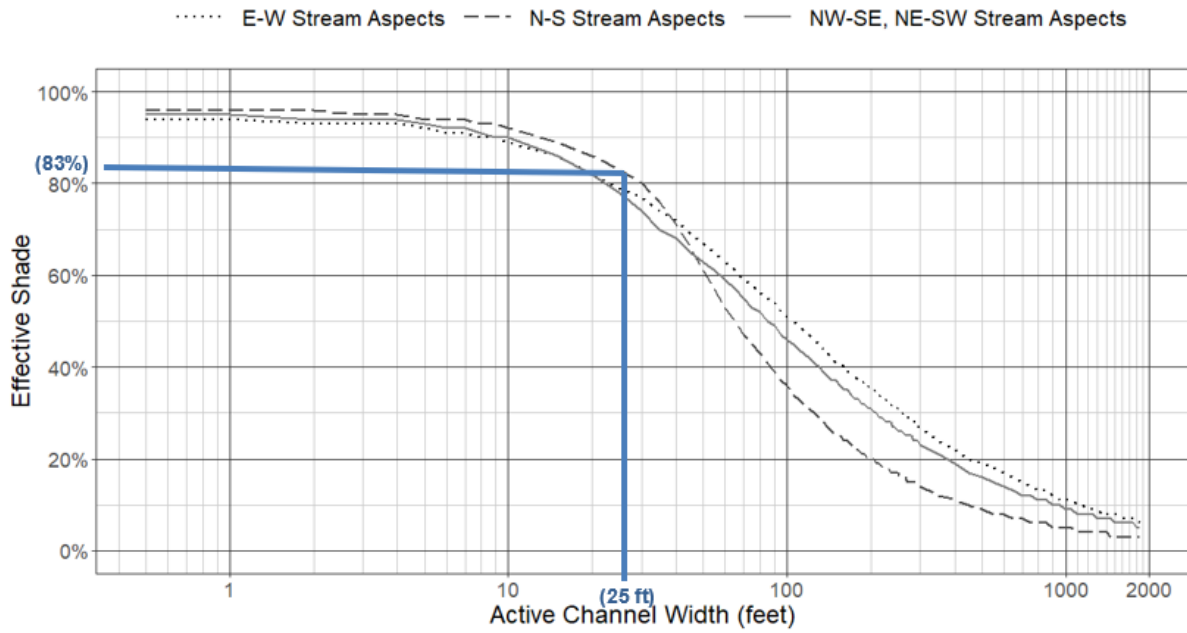


Figure 9-2: Example illustrating use of the shade curve for the Qalc mapping unit based on a north to south aspect and an active channel width of 25 feet.

Qff1

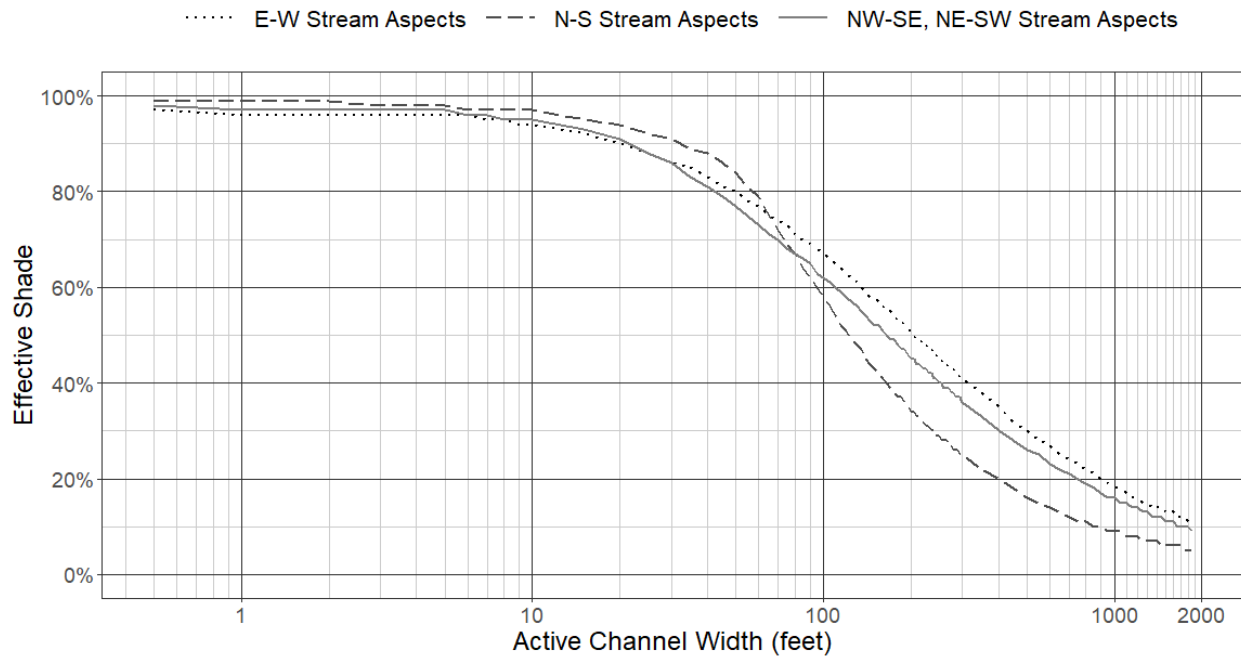


Figure 9-3: Effective shade targets for stream sites in the Qff1 mapping unit.

Qfc

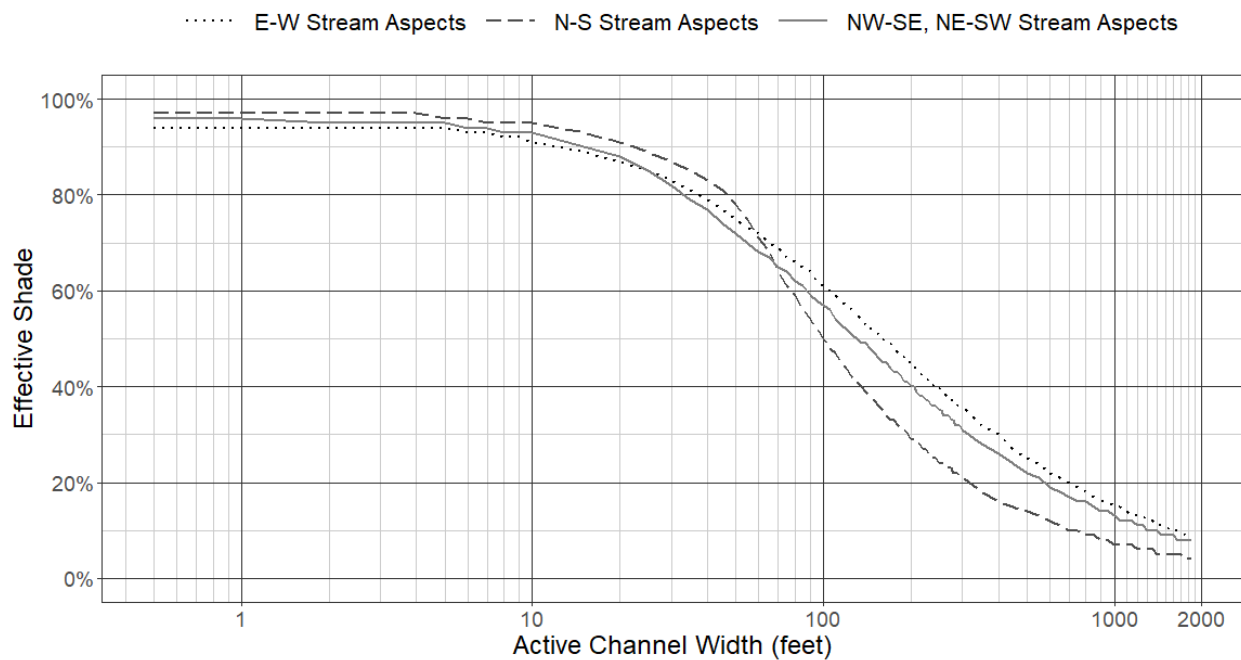


Figure 9-4: Effective shade targets for stream sites in the Qfc mapping unit.

Qalc

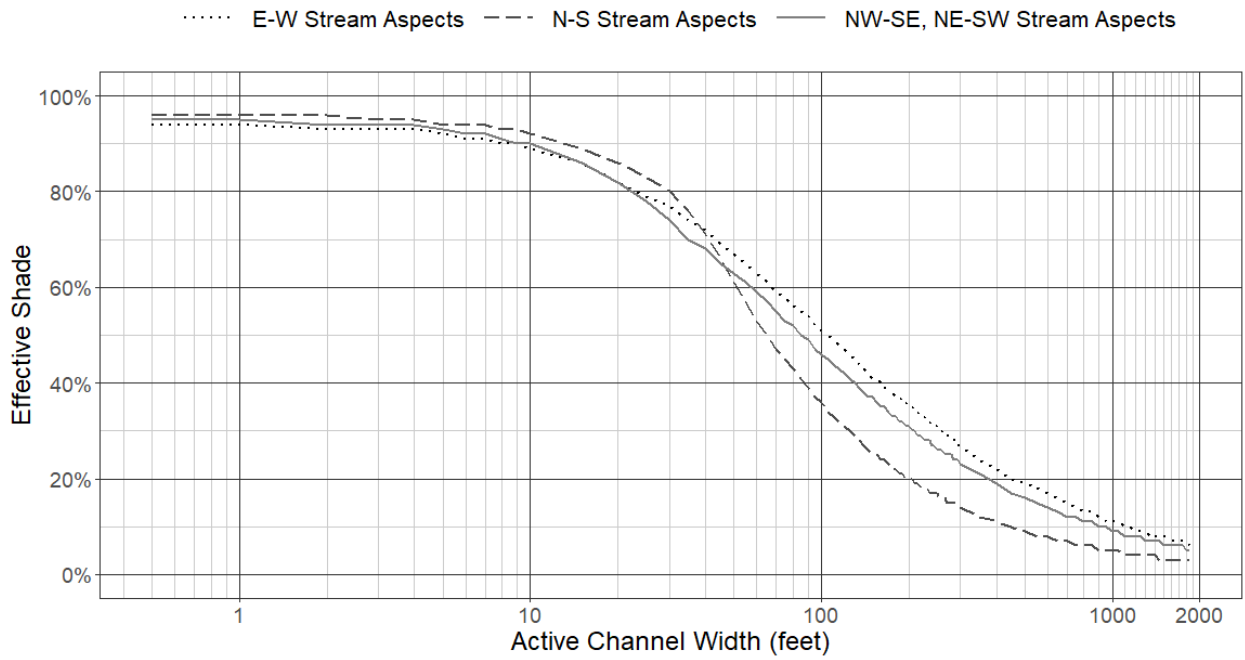


Figure 9-5: Effective shade targets for stream sites in the Qalc mapping unit.

Qg1

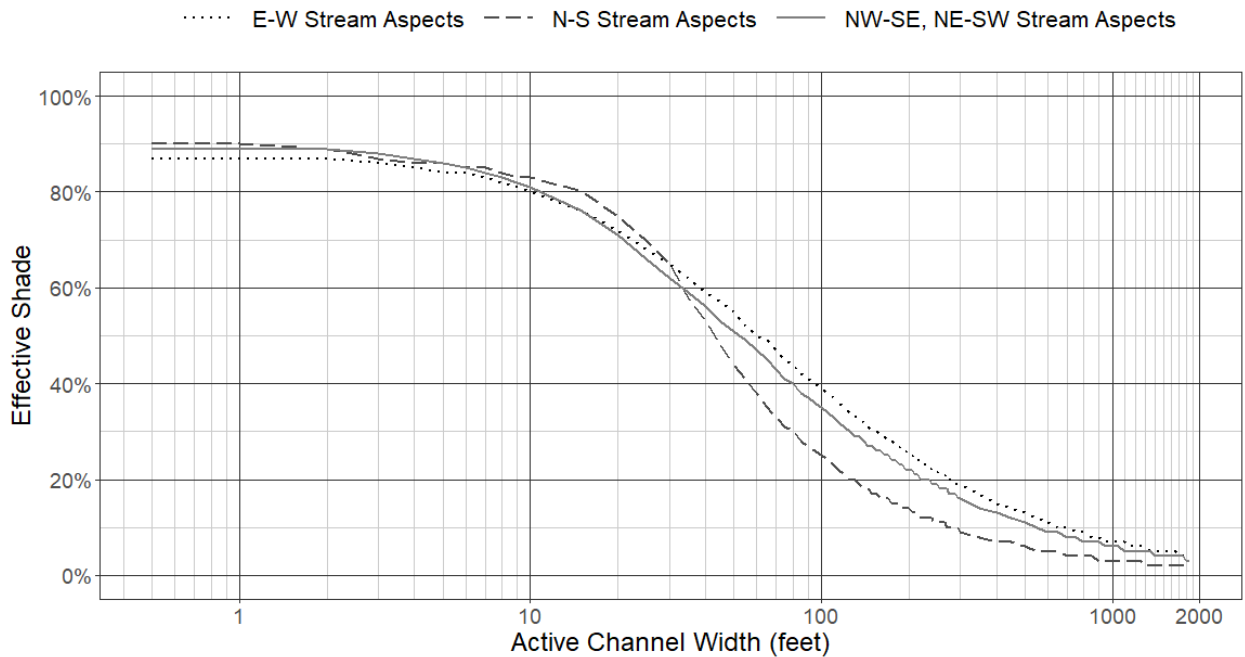


Figure 9-6: Effective shade targets for stream sites in the Qg1 mapping unit.

Qau

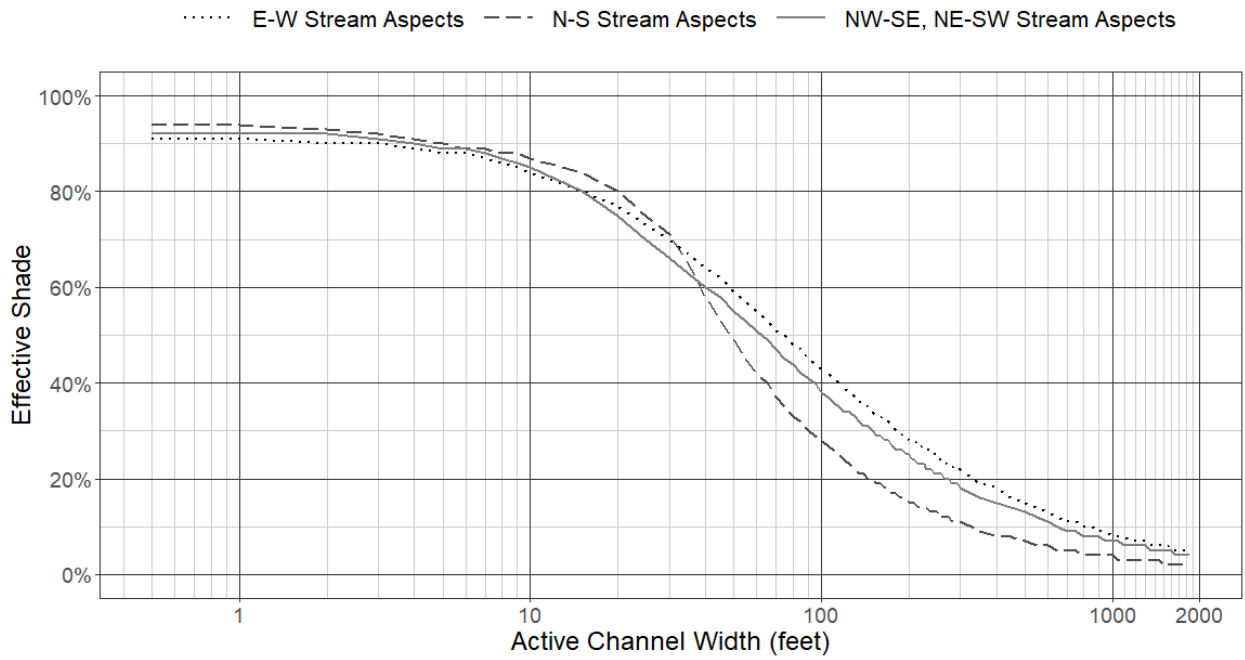


Figure 9-7: Effective shade targets for stream sites in the Qau mapping unit.

Qalf

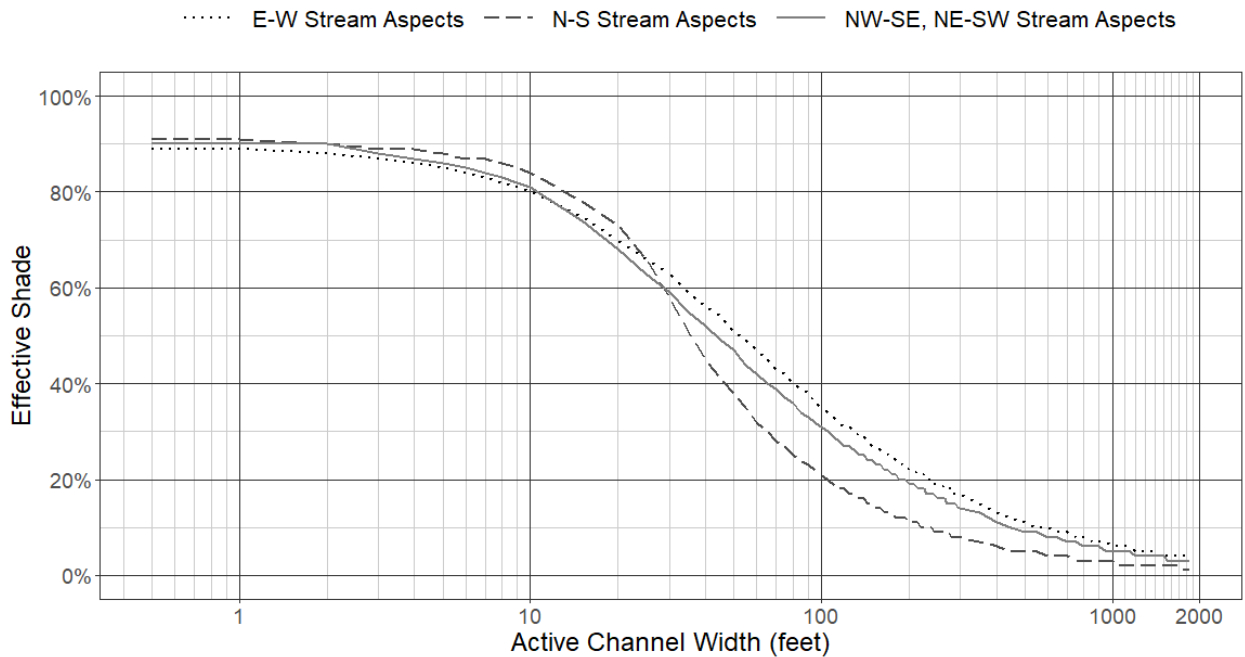


Figure 9-8: Effective shade targets for stream sites in the Qalf mapping unit.

Qff2

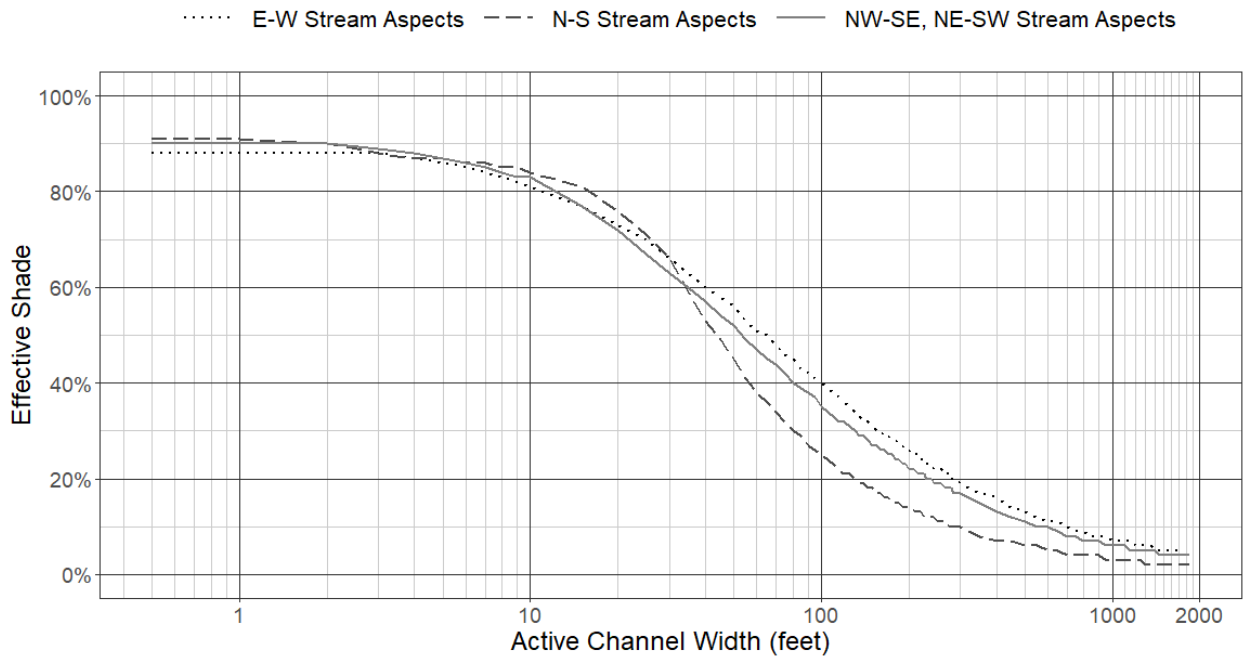


Figure 9-9: Effective shade targets for stream sites in the Qff2 mapping unit.

Qbf

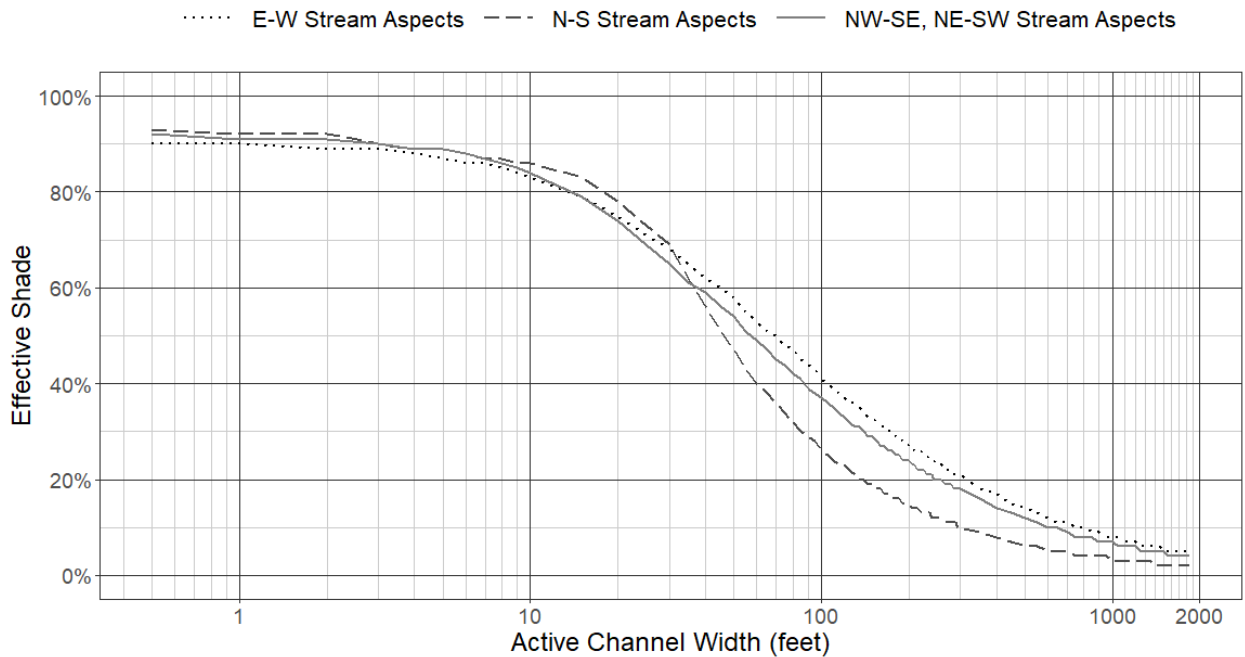


Figure 9-10: Effective shade targets for stream sites in the Qbf mapping unit.

Tvc

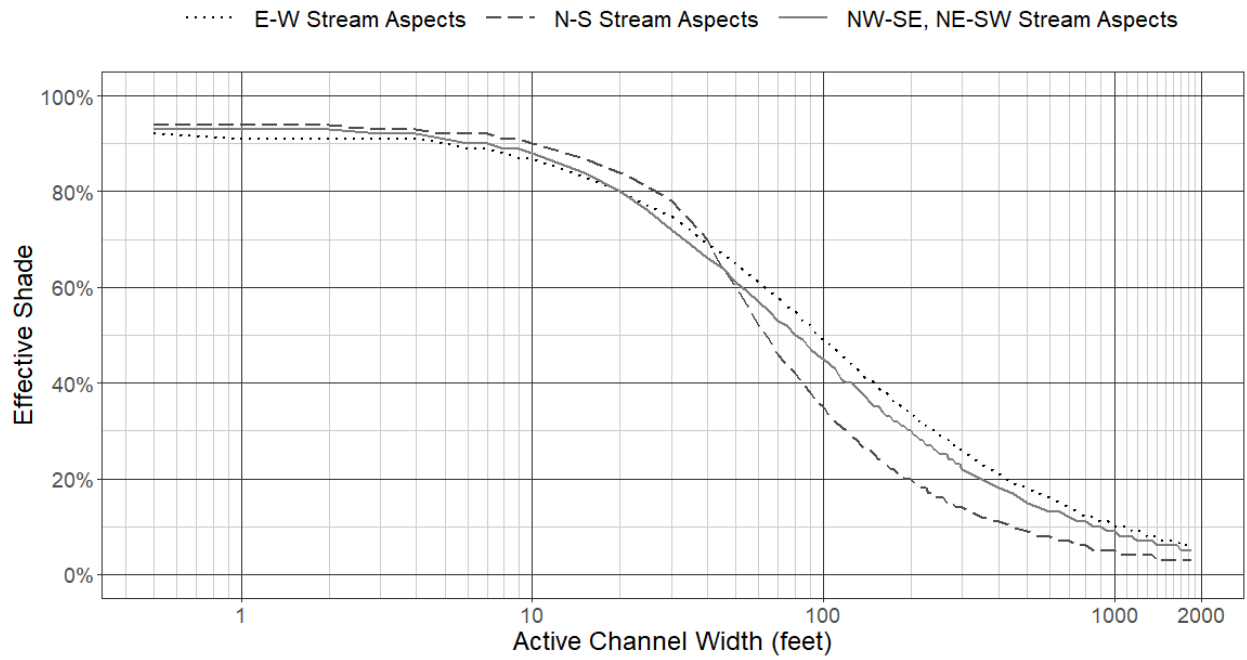


Figure 9-11: Effective shade targets for stream sites in the Tvc mapping unit.

Qtg

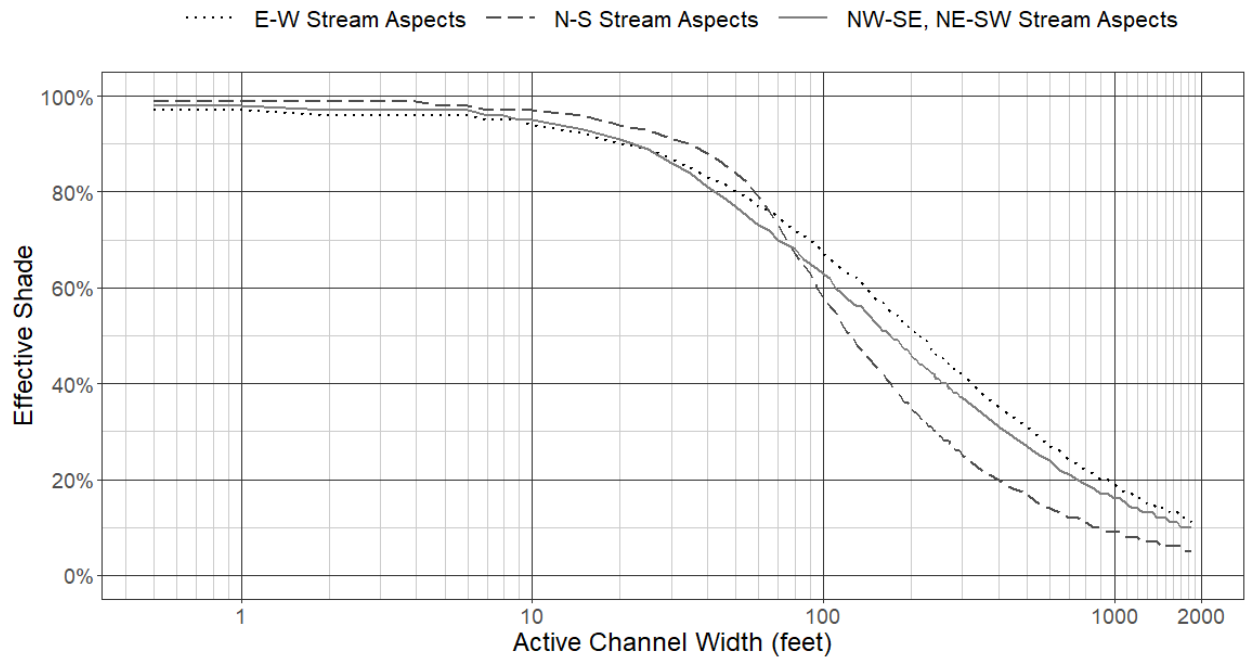


Figure 9-12: Effective shade targets for stream sites in the Qtg mapping unit.

T_w

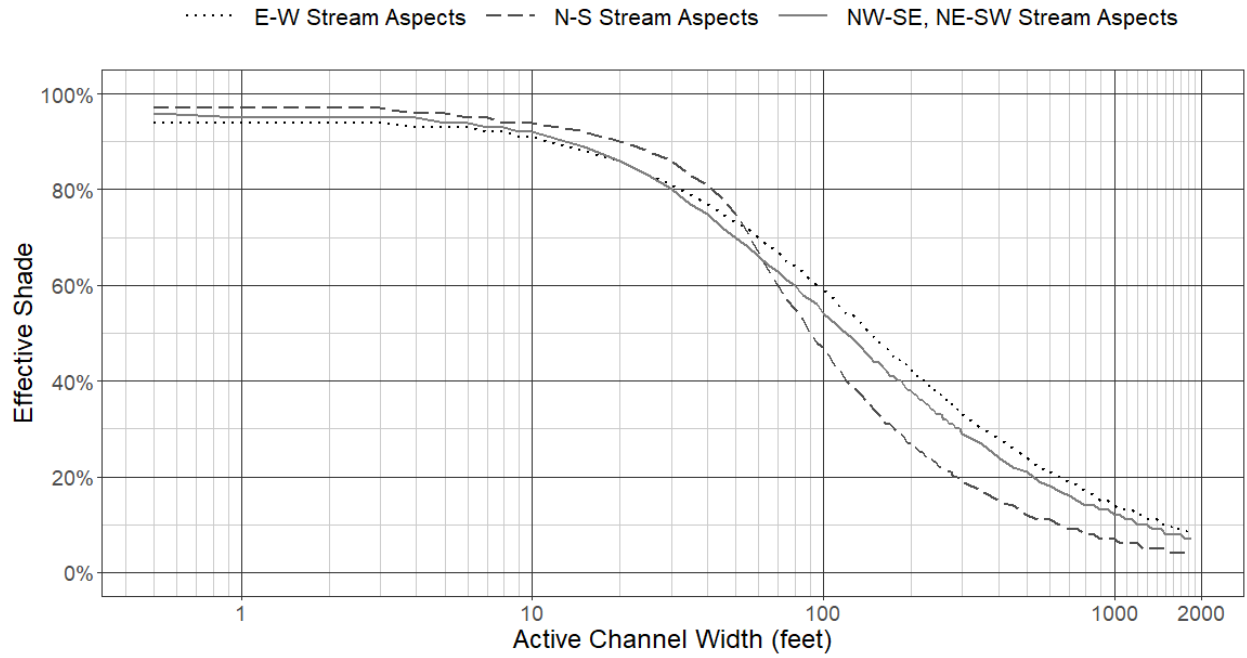


Figure 9-13: Effective shade targets for stream sites in the T_w mapping unit.

T_{cr}

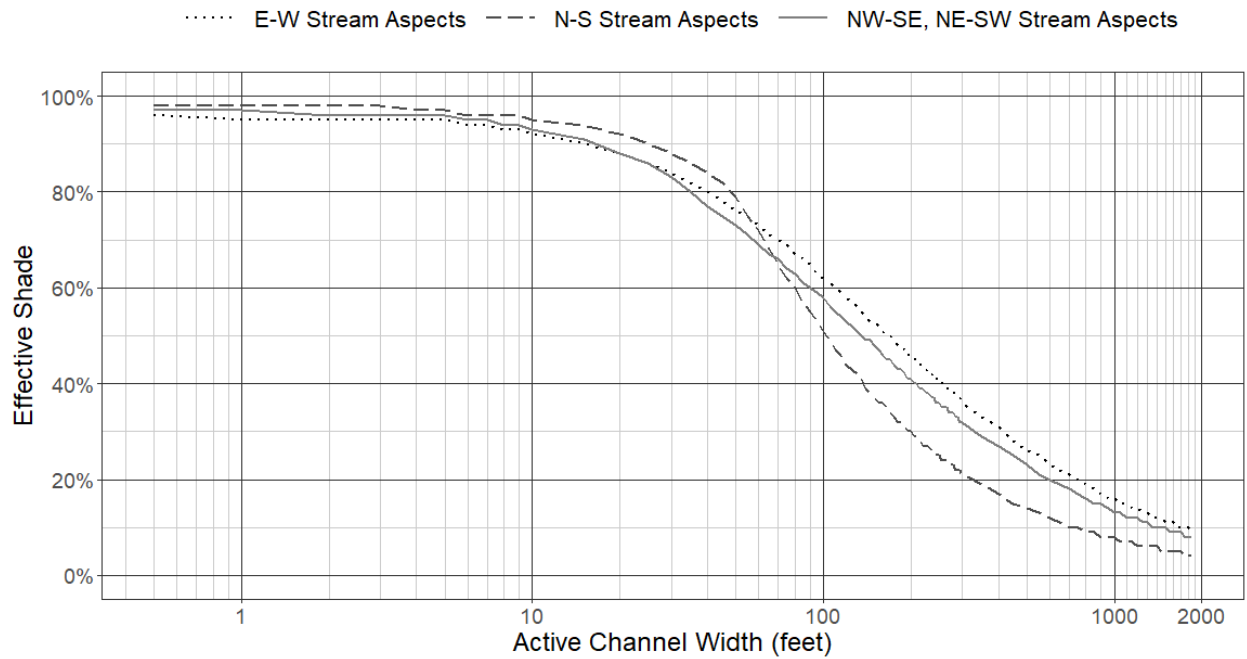


Figure 9-14: Effective shade targets for stream sites in the T_{cr} mapping unit.

Tm

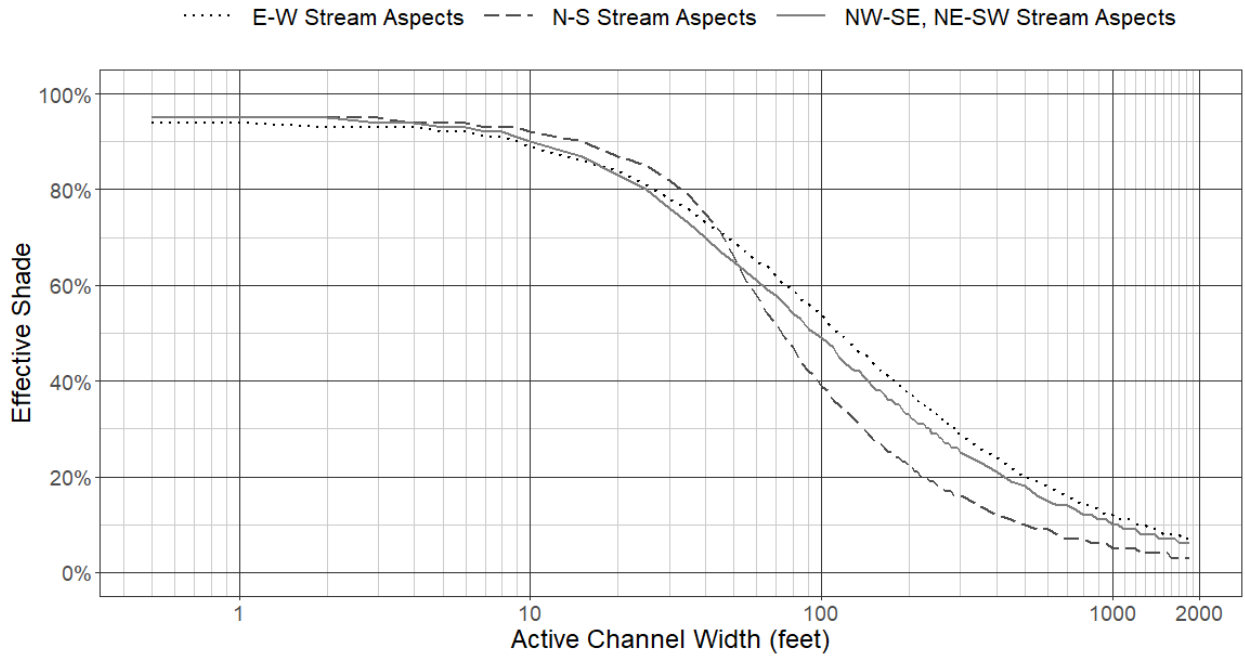


Figure 9-15: Effective shade targets for stream sites in the Tm mapping unit.

OW

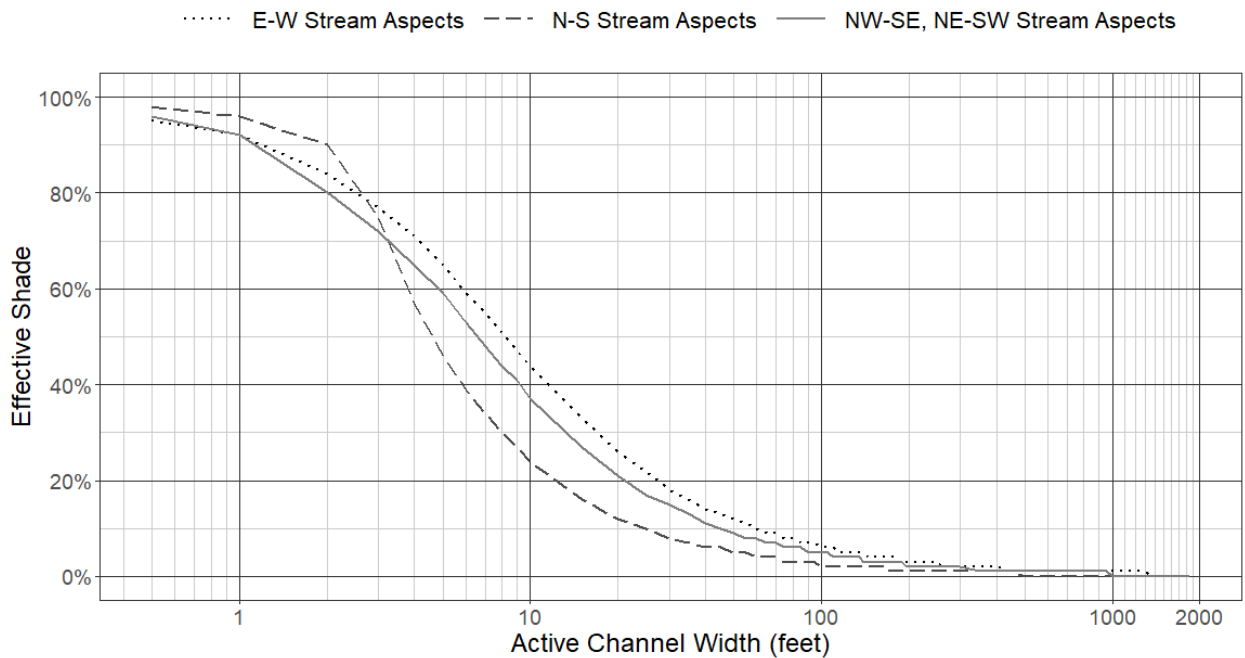


Figure 9-16: Effective shade targets for stream sites in the Open Water (OW) mapping unit.

Upland Forest

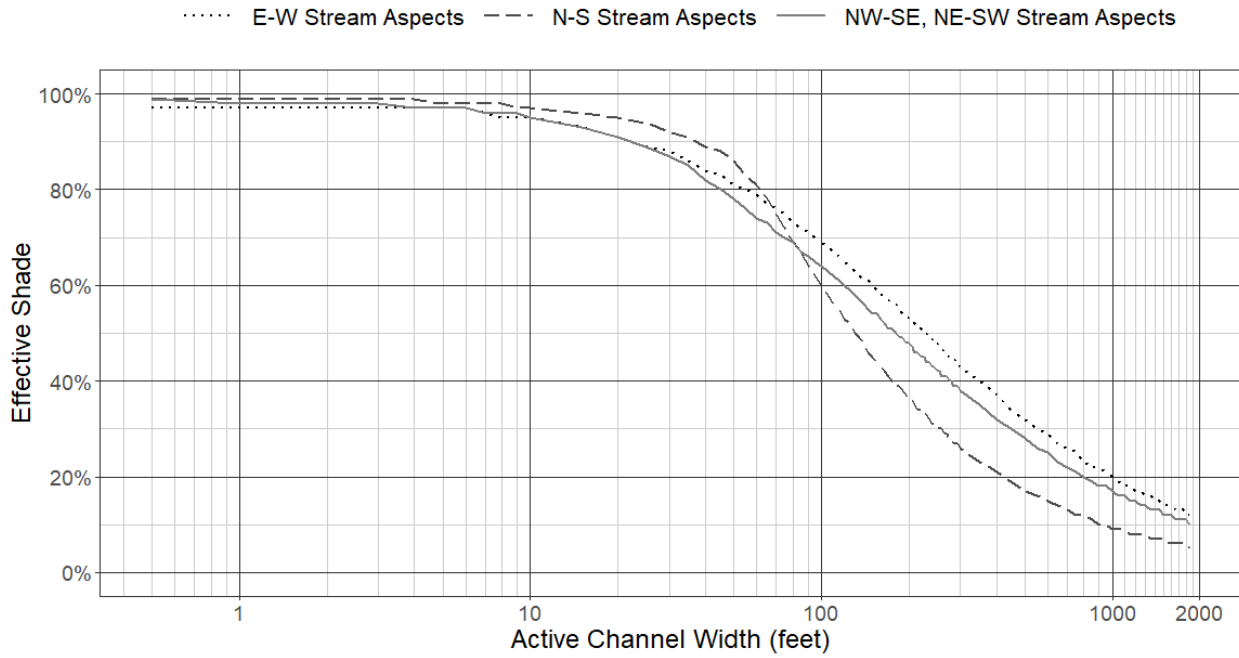


Figure 9-17: Effective shade targets for stream sites in the Upland Forest mapping unit.

QTt

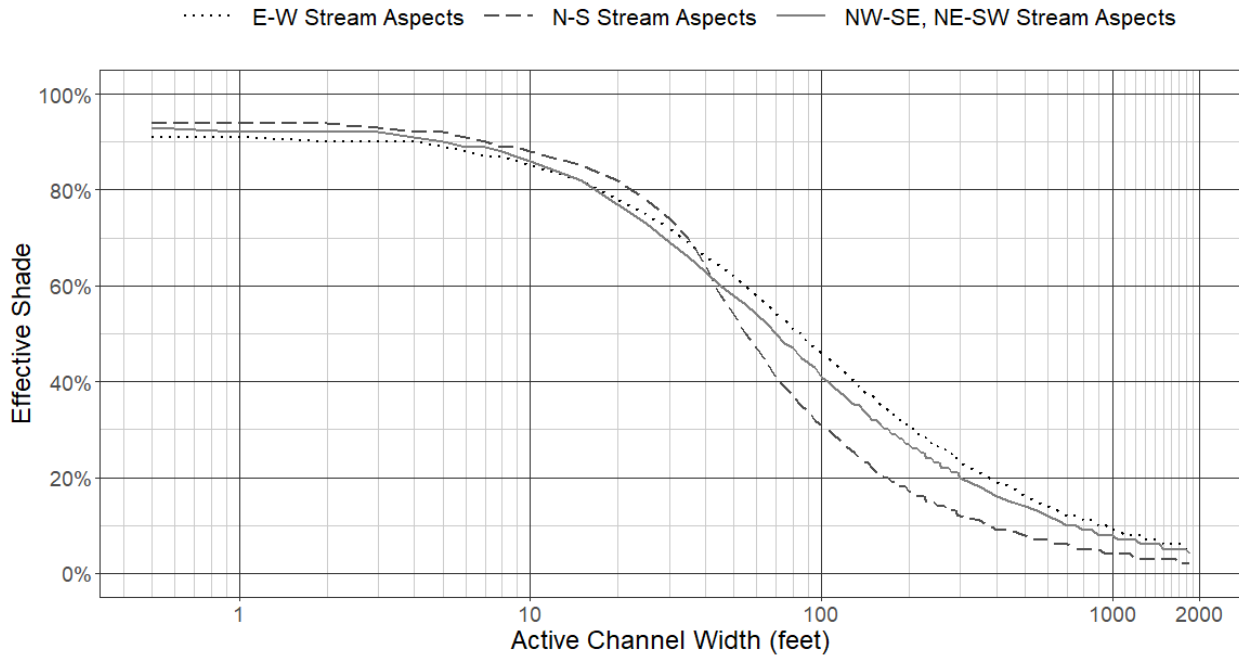


Figure 9-18: Effective shade targets for stream sites in the QTt mapping unit.

QTb

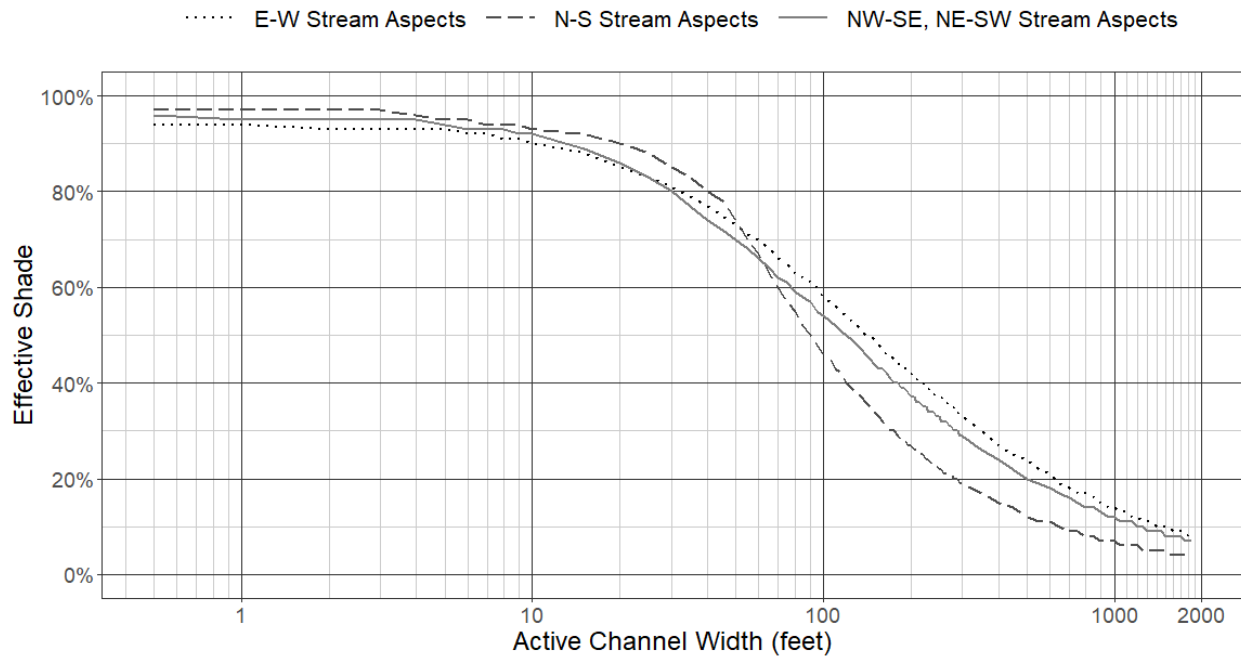


Figure 9-19: Effective shade targets for stream sites in the QTb mapping unit.

QIs

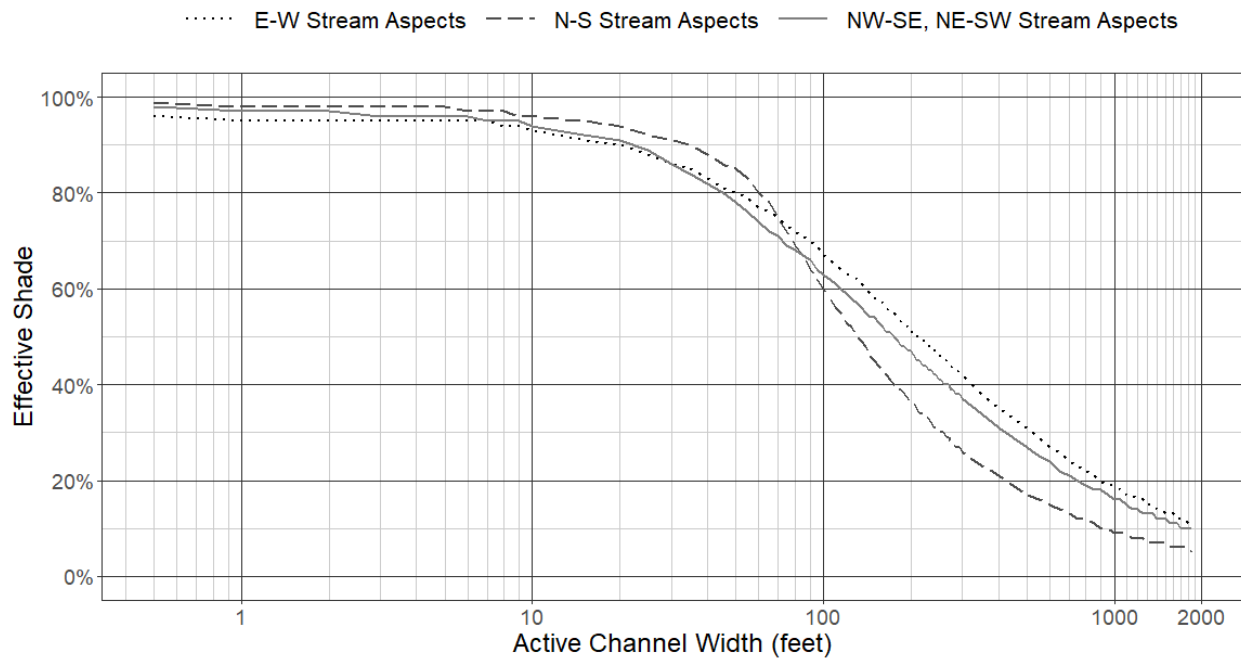


Figure 9-20: Effective shade targets for stream sites in the QIs mapping unit.

1d/1f - Volcanics and Willapa Hills

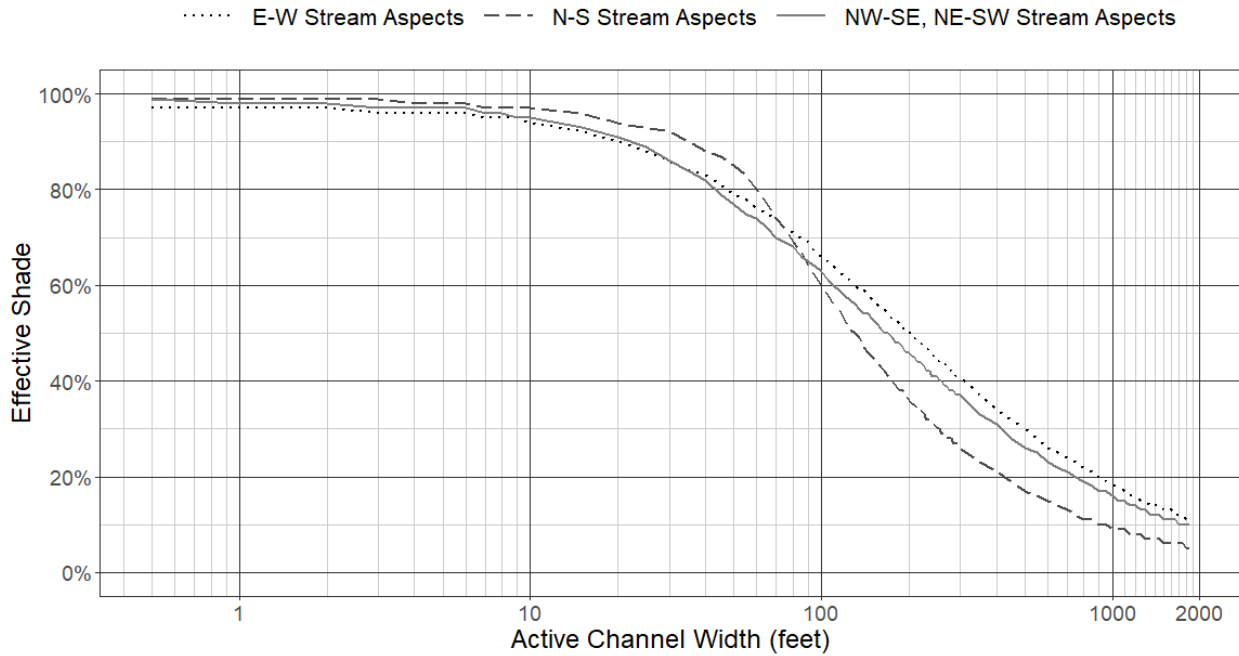


Figure 9-21: Effective shade targets for stream sites in Ecoregion 1d/1f - Volcanics and Willapa Hills.

3a - Portland/Vancouver Basin

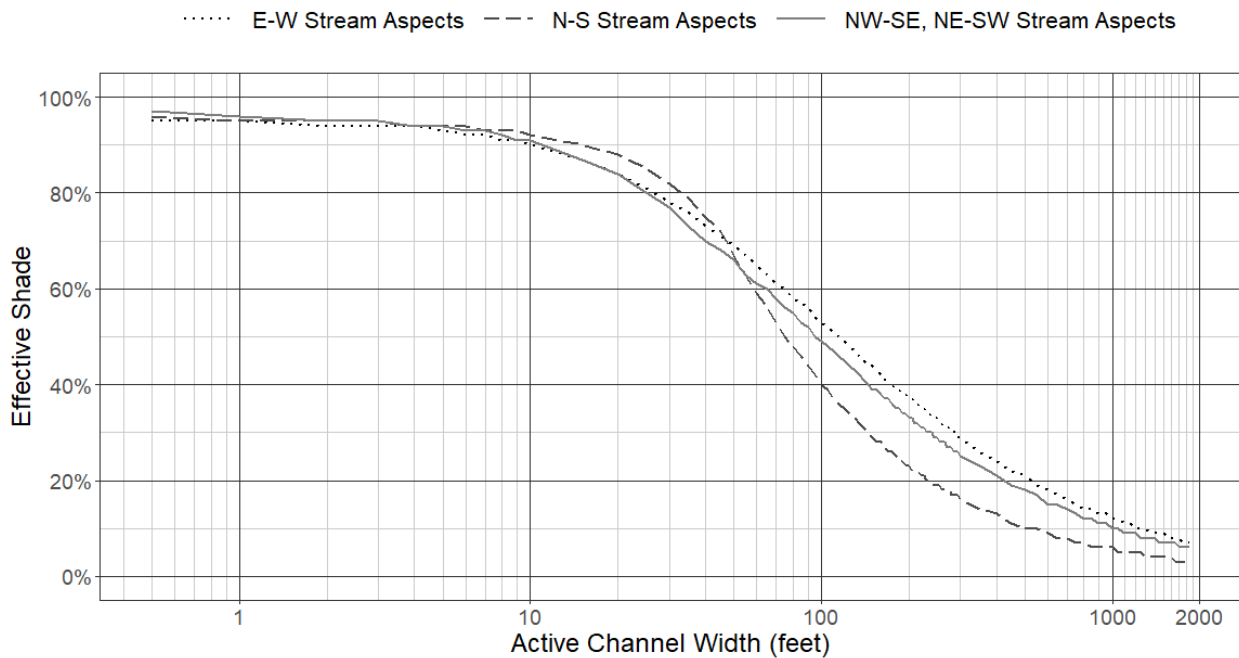


Figure 9-22: Effective shade targets for stream sites in Ecoregion 3a - Portland/Vancouver Basin.

3c - Prairie Terraces

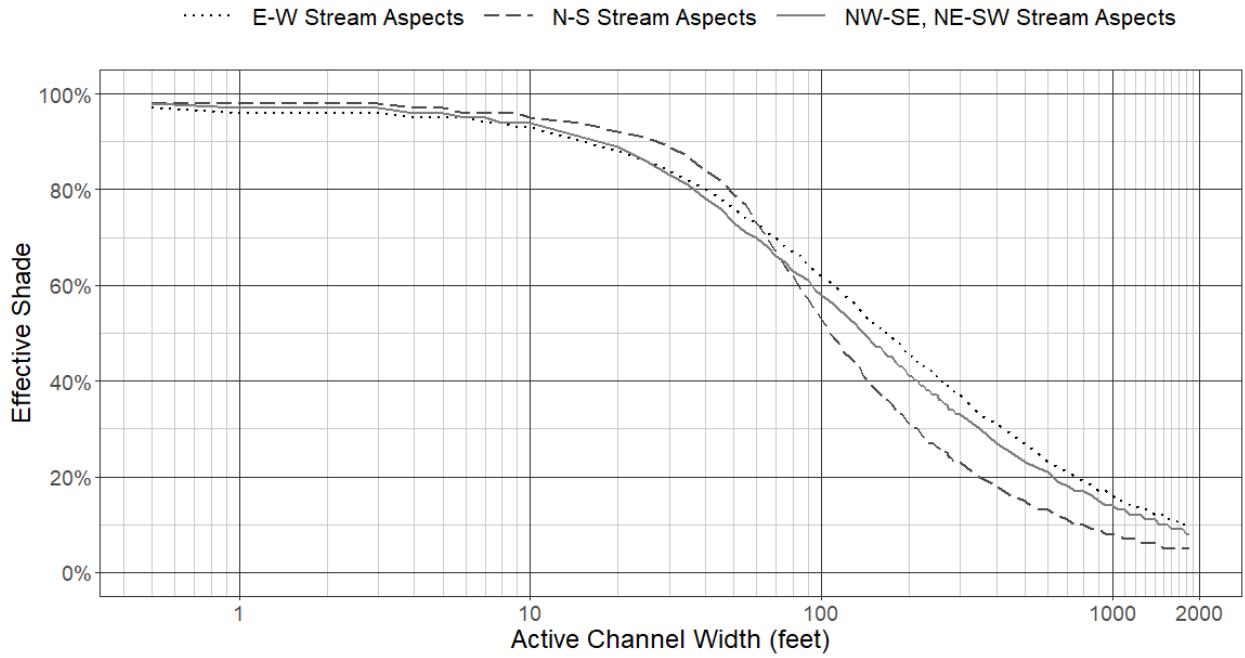


Figure 9-23: Effective shade targets for stream sites in Ecoregion 3c - Prairie Terraces.

3d - Valley Foothills

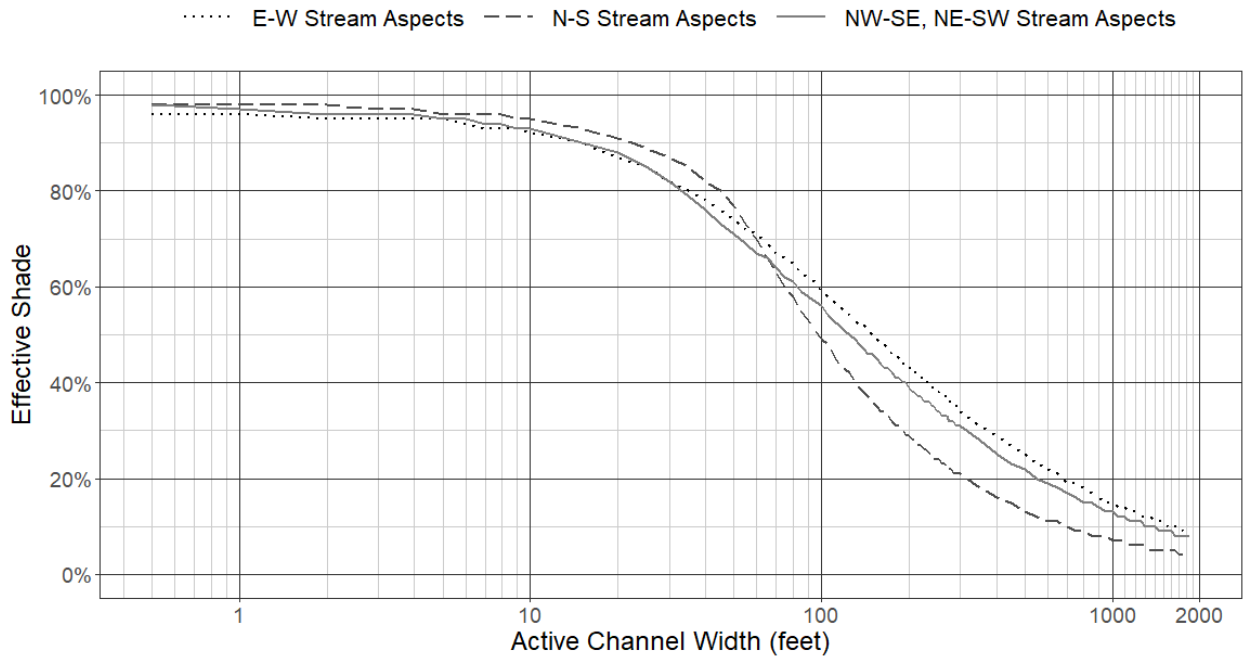


Figure 9-24: Effective shade targets for stream sites in Ecoregion 3d - Valley Foothills.

9.1.5 Reserve capacity

DEQ set aside explicit allocations for reserve capacity for providing either point or nonpoint source allocation(s) to new or increased thermal loads, or to assign corrected allocations to any existing source(s) that were assigned an erroneous allocation or may not have been identified during the development of this TMDL. The portion of the human use allowance associated with the reserve capacity is described in Table 9-1 through Table 9-9.

If DEQ determines the cumulative warming from all NPDES point sources is less than the assigned portion of the human use allowance, the remainder may be considered as reserve capacity for point sources.

DEQ will consider requests for allocation of reserve capacity submitted in writing on a case-by-case basis. Except when DEQ is correcting an error or omission, requesters must demonstrate that there are no reasonable alternatives to an increased load and may be required to prepare a modeling or similar analysis to ensure that loading capacity is available at the discharge location(s). DEQ will use its discretion in making determinations on requests, based on the information available and priorities appropriate at the time of the request. DEQ will track allocation of reserve capacity over time and will not approve requests once reserve capacity is depleted. Allocations of reserve capacity must be approved by DEQ's Director or designee.

9.2 Margin of safety

CFR 130.7(c)(1) and OAR 340-042-0040(4)(i) require a TMDL to include a margin of safety. The margin of safety accounts for lack of knowledge or uncertainty. This may result from limited data; an incomplete understanding of the exact magnitude or quantity of thermal loading from various sources; or the actual effect controls will have on loading reductions and receiving. The margin of safety is intended to account for such uncertainties in a manner that is conservative and will result in environmental protection. A margin of safety can be achieved through two approaches: (1) implicitly using conservative analytical assumptions to develop allocations, or (2) explicitly specifying a portion of the TMDL loading capacity as a margin of safety.

In the Willamette Subbasins, an implicit margin of safety was used in derivation of the allocations. The primary conservative assumptions include:

- Setting effluent flow rates at average dry weather design flow or a maximum flow obtained from discharge monitoring reports for the model scenario assessing the wasteload allocations. It is rare that actual discharges from point sources will reach design flows and sustain that discharge for long periods of time all at the same time.
- Setting effluent temperatures as high as 32 degrees Celsius for the model scenario assessing the wasteload allocations. On days when the current thermal load was less than the wasteload allocation, the maximum effluent temperatures were increased above the actual temperatures up to either 32 or the effluent temperature that would fully utilize the wasteload allocation. Actual maximum effluent temperatures are unlikely to get this warm or be sustained over multiple days or weeks.
- The cumulative effects analysis used the maximum increase as the basis for determining attainment of allocations. The cumulative effects analysis was performed for modeled reaches and is described in the modeling report (Technical Support Document Appendix A). The maximum increase does not happen more than 5% of the time and the median increase is less. This means that a portion of the loading capacity reserved for human use will go unutilized most of the time.

10 Water quality management plan

As described in OAR 340-042-0040(4)(I)(A)-(O), an associated WQMP is a required element of a TMDL and must include the following components: (A) Condition assessment and problem description; (B) Goals and objectives; (C) Proposed management strategies design to meet the TMDL allocations; (D) Timeline for implementing management strategies; (E) Explanation of how TMDL implementation will attain water quality standards; (F) Timeline for attaining water quality standards; (G) Identification of persons, including Designated Management Agencies, responsible for TMDL implementation; (H) Identification of existing implementation plans; (I) Schedule for submittal of implementation plans and revision triggers; (J) Description of reasonable assurance of TMDL implementation; (K) Plan to monitor and evaluate progress toward achieving TMDL allocations and water quality standards; (L) Plan for public involvement in TMDL implementation; (M) Description of planned efforts to maintain management strategies over time; (N) General discussion of costs and funding for TMDL implementation; and (O) citation of legal authorities relating to TMDL implementation.

DEQ sought and considered input from various persons, including DMAs, responsible for TMDL implementation and other interested public and prepared the Willamette Subbasins WQMP as a stand-alone document. DEQ intends to propose the draft WQMP as an element of Temperature TMDLs for the Willamette Subbasins for adoption as rule by the Oregon Environmental Quality Commission.

11 Reasonable assurance

OAR 340-042-0030(9) defines Reasonable Assurance as “a demonstration that a TMDL will be implemented by federal, state or local governments or individuals through regulatory or voluntary actions including management strategies or other controls.” EPA’s TMDL guidance describes that when a TMDL is developed for waters impaired by both point and nonpoint sources and WLAs are based on an assumption that NPS load reductions will occur, the TMDL must provide “reasonable assurances” that NPS control measures will achieve expected load reductions (USEPA 1991). Comprehensive explanations of reasonable assurances of implementation are provide in Section 7 of the Willamette Subbasins Water Quality Management Plan.

12 Protection plan

The scope of these temperature TMDLs includes all waters of the state, including freshwater perennial and intermittent streams in the Willamette Subbasins. As such, these TMDLs also serve as a “protection plan” to prevent impairment in waters currently attaining the applicable

water quality standards or for unassessed waters. The protection of these unimpaired waters has watershed-wide benefits such as:

- Clarity and consistency for implementation of management strategies throughout the watershed;
- Proactively applying management strategies and protections to waters where data is not available for establishing listing status;
- Improving TMDL outcomes by maintaining or improving water quality in streams that are tributary to listed streams;
- Creating efficiencies between TMDL and protection plan implementation (including monitoring, evaluating progress, adaptive management, enforcement and leveraging partner entities' efforts); and,
- Assisting with funding opportunities for implementation when grants require projects to be part of a larger watershed plan.

Protection plan core elements, as described in materials available on EPA's webpage (EPA 2023a and 2023b), are fulfilled by the statements and references to specific sections of the TMDLs, WQMP and TMDL Technical Support Document in the subsections that follow.

A full list of assessment units where the protection plan applies is in the TMDL Technical Support Document Appendix D.

12.1 Identification of specific waters to be protected and risks to their condition

Appendix D of the TMDL Technical Support Document lists all the assessments units within the Willamette Subbasins and their 2022 Integrated Report assessment status. Those assessment units with the status of Category 2 and Category 3 are included in the protection plan, along with any unassessed waters that may be found to be unimpaired for temperature in the future. The same sources and processes described in Section 7 that have caused temperature impairments to some reaches in the watershed also pose a risk to unimpaired waters.

12.2 Quantification of loads and activities expected to resist degradation

Monitoring stations that provided data used in the TMDLs analyses are shown in Technical Support Document Appendix A, Section 2.1. Water temperature data, along with flow measurements were used to calculate loading capacities of the pollutants and surrogates within the watershed. Applicable loading capacities for any unimpaired stream can be calculated using **Equation 8-1**.

Similar to loading capacities, relevant human use allowance allocations for anthropogenic sources are shown in Table 9-1 through Table 9-9. Loads for nonpoint sources are calculated using Equation 9-2.

The implementation of management practices specified in Sections 2 and 5 of the WQMP also protect against risks to unimpaired waters.

12.3 Timeframes for protection

Timelines for watershed-wide implementation of the TMDLs are described in Section 5 of the WQMP and estimated timelines for attainment of water quality standards in the impaired stream reaches are provided in Section 4 of the WQMP. DEQ's Watershed-wide approach ensures that the TMDLs and the protection plan will be implemented in a prioritized manner over the same timeframe that will be required demonstrate effectiveness of management strategies in reducing excess pollutant loads.

12.4 Measures of success

The WQMP describes in detail DEQ's approach to quantitative and qualitative measures of progress in attaining and maintaining water quality standards, which is applied watershed-wide. Section 6 of the WQMP discusses quantitative and qualitative evaluation of implementation of management strategies, development of a plan for periodic monitoring and an approach to adaptive management. Section 7 of the WQMP details the interconnected framework for accountability of implementation, including: engaging with sources; setting measurable objectives; evaluating progress; conducting enforcement; and tracking status and trends.

13 References

Black, E.C. 1953. "Upper lethal temperature of some British Columbia freshwater fishes". Journal of the Fisheries Board of Canada. 10(4):196-210.

DEQ (Oregon Department of Environmental Quality). 2003. Staff report to the Environmental Quality Commission from Stephanie Hallock, Director. "Agenda Item D, Rule Adoption: Water Quality Standards, Including Temperature Criteria, OAR Chapter 340, Division 41, December 4, 2003, EQC Meeting."

DEQ (Oregon Department of Environmental Quality). 2006. "Willamette River Basin Total Maximum Daily Load (TMDL)."

DEQ (Oregon Department of Environmental Quality). 2008a. Temperature Water Quality Standard Implementation – A DEQ Internal Management Directive.
<https://www.oregon.gov/deq/Filtered%20Library/IMDTemperature.pdf>

DEQ (Oregon Department of Environmental Quality). 2023a. "Draft Willamette River Subbasins TMDL Technical Support Document."

DEQ (Oregon Department of Environmental Quality). 2023b. "Draft Willamette River Subbasins TMDL Water Quality Management Plan."

EPA. 1991. Guidance for Water Quality-based Decisions: The TMDL Process. EPA/440/4-91-001. Washington, D.C.

EPA (U.S. Environmental Protection Agency). 2003. "EPA Region 10 guidance for Pacific northwest state and tribal temperature water quality standards". EPA 910-B-03-002.

EPA. 2023a. Impaired Waters and TMDLs – Protection Approaches webpage.
<https://www.epa.gov/tmdl/protection-approaches>. Accessed July 20, 2023.

14 Appendix of effective shade curve tables

14.1 Qff1 mapping unit

Table 14-1: Effective shade targets for stream sites in the Qff1 mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	97	98	99
0.3	1	96	97	99
0.6	2	96	97	99
0.9	3	96	97	98
1.2	4	96	97	98
1.5	5	96	97	98
1.8	6	96	96	97
2.1	7	95	96	97
2.4	8	95	95	97
2.7	9	94	95	97
3	10	94	95	97
4.6	15	92	93	95
6.1	20	90	91	94
7.6	25	88	88	92
9.1	30	86	86	91
10.7	35	85	83	89
12.2	40	83	81	88
13.7	45	81	79	86
15.2	50	80	77	84
16.8	55	78	75	81
18.3	60	77	73	79
19.8	65	75	71	75
21.3	70	74	70	72
22.9	75	73	68	69
24.4	80	71	67	67
25.9	85	70	66	64

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
27.4	90	69	65	62
29	95	68	63	60
30.5	100	67	62	58
32	105	66	61	56
33.5	110	65	60	54
35.1	115	64	59	52
36.6	120	63	58	51
38.1	125	62	57	49
39.6	130	61	56	48
41.1	135	60	55	47
42.7	140	59	54	45
44.2	145	58	53	44
45.7	150	58	52	43
47.2	155	57	52	42
48.8	160	56	51	41
50.3	165	55	50	40
51.8	170	55	49	39
53.3	175	54	49	38
54.9	180	53	48	37
56.4	185	53	47	37
57.9	190	52	47	36
59.4	195	51	46	35
61	200	51	45	34
62.5	205	50	45	34
64	210	49	44	33
65.5	215	49	44	33
67.1	220	48	43	32
68.6	225	48	43	31
70.1	230	47	42	31
71.6	235	47	42	30
73.2	240	46	41	30
74.7	245	46	41	29
76.2	250	45	40	29
77.7	255	45	40	28
79.2	260	44	39	28
80.8	265	44	39	28
82.3	270	43	39	27
83.8	275	43	38	27
85.3	280	43	38	26
86.9	285	42	37	26
88.4	290	42	37	26
89.9	295	41	37	25

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
91.4	300	41	36	25
106.7	350	38	33	22
121.9	400	35	30	20
137.2	450	32	28	18
152.4	500	30	26	16
167.6	550	28	25	15
182.9	600	27	23	14
198.1	650	25	22	13
213.4	700	24	21	12
228.6	750	23	20	11
243.8	800	22	19	11
259.1	850	21	18	10
274.3	900	20	17	10
289.6	950	19	16	9
304.8	1000	18	16	9
320	1050	18	15	9
335.3	1100	17	15	8
350.5	1150	16	14	8
365.8	1200	16	14	8
381	1250	15	13	7
396.2	1300	15	13	7
411.5	1350	14	12	7
426.7	1400	14	12	7
442	1450	14	12	6
457.2	1500	13	11	6
472.4	1550	13	11	6
487.7	1600	13	11	6
502.9	1650	12	10	6
518.2	1700	12	10	6
533.4	1750	12	10	5
548.6	1800	11	10	5
563.9	1850	11	9	5

14.2 Qfc mapping unit

Table 14-2: Effective shade targets for stream sites in the Qfc Quaternary geologic unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	94	96	97
0.3	1	94	96	97

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.6	2	94	95	97
0.9	3	94	95	97
1.2	4	94	95	97
1.5	5	94	95	96
1.8	6	93	94	96
2.1	7	93	94	95
2.4	8	92	93	95
2.7	9	92	93	95
3	10	91	93	95
4.6	15	89	90	93
6.1	20	87	88	91
7.6	25	85	85	89
9.1	30	83	82	87
10.7	35	81	79	85
12.2	40	79	77	83
13.7	45	77	74	81
15.2	50	75	72	78
16.8	55	73	70	75
18.3	60	72	68	71
19.8	65	70	67	68
21.3	70	69	65	64
22.9	75	67	64	61
24.4	80	66	62	59
25.9	85	65	61	56
27.4	90	64	59	54
29	95	62	58	52
30.5	100	61	57	50
32	105	60	56	48
33.5	110	59	54	47
35.1	115	58	53	45
36.6	120	57	52	44
38.1	125	56	51	42
39.6	130	55	50	41
41.1	135	54	49	40
42.7	140	53	49	39
44.2	145	52	48	38
45.7	150	52	47	37
47.2	155	51	46	36
48.8	160	50	45	35
50.3	165	49	45	34
51.8	170	49	44	33
53.3	175	48	43	33

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
54.9	180	47	43	32
56.4	185	47	42	31
57.9	190	46	41	31
59.4	195	45	41	30
61	200	45	40	29
62.5	205	44	40	29
64	210	44	39	28
65.5	215	43	38	28
67.1	220	42	38	27
68.6	225	42	37	27
70.1	230	41	37	26
71.6	235	41	36	26
73.2	240	40	36	25
74.7	245	40	36	25
76.2	250	40	35	24
77.7	255	39	35	24
79.2	260	39	34	24
80.8	265	38	34	23
82.3	270	38	34	23
83.8	275	37	33	23
85.3	280	37	33	22
86.9	285	37	32	22
88.4	290	36	32	22
89.9	295	36	32	21
91.4	300	36	31	21
106.7	350	32	28	18
121.9	400	30	26	16
137.2	450	27	24	15
152.4	500	25	22	14
167.6	550	24	21	13
182.9	600	22	19	12
198.1	650	21	18	11
213.4	700	20	17	10
228.6	750	19	16	10
243.8	800	18	16	9
259.1	850	17	15	9
274.3	900	16	14	8
289.6	950	16	14	8
304.8	1000	15	13	7
320	1050	15	12	7
335.3	1100	14	12	7
350.5	1150	13	12	7

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
365.8	1200	13	11	6
381	1250	13	11	6
396.2	1300	12	10	6
411.5	1350	12	10	6
426.7	1400	11	10	5
442	1450	11	9	5
457.2	1500	11	9	5
472.4	1550	10	9	5
487.7	1600	10	9	5
502.9	1650	10	8	5
518.2	1700	10	8	5
533.4	1750	9	8	4
548.6	1800	9	8	4
563.9	1850	9	8	4

14.3 Qalc mapping unit

Table 14-3: Effective shade targets for stream sites in the Qalc geomorphic region.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	94	95	96
0.3	1	94	95	96
0.6	2	93	94	96
0.9	3	93	94	95
1.2	4	93	94	95
1.5	5	92	93	94
1.8	6	91	92	94
2.1	7	91	92	94
2.4	8	90	91	93
2.7	9	90	90	93
3	10	89	90	92
4.6	15	86	86	89
6.1	20	82	82	86
7.6	25	79	78	83
9.1	30	77	74	80
10.7	35	74	70	76
12.2	40	72	68	71
13.7	45	69	65	66
15.2	50	67	63	61
16.8	55	65	61	57

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
18.3	60	63	59	53
19.8	65	61	57	50
21.3	70	59	55	47
22.9	75	58	53	45
24.4	80	56	52	43
25.9	85	55	50	41
27.4	90	54	49	39
29	95	52	47	37
30.5	100	51	46	36
32	105	50	45	34
33.5	110	49	44	33
35.1	115	48	43	32
36.6	120	47	42	31
38.1	125	46	41	30
39.6	130	45	40	29
41.1	135	44	39	28
42.7	140	43	38	27
44.2	145	42	37	26
45.7	150	41	37	25
47.2	155	41	36	25
48.8	160	40	35	24
50.3	165	39	35	24
51.8	170	39	34	23
53.3	175	38	33	22
54.9	180	37	33	22
56.4	185	37	32	21
57.9	190	36	32	21
59.4	195	36	31	20
61	200	35	31	20
62.5	205	35	30	20
64	210	34	30	19
65.5	215	34	29	19
67.1	220	33	29	18
68.6	225	33	28	18
70.1	230	32	28	18
71.6	235	32	28	17
73.2	240	31	27	17
74.7	245	31	27	17
76.2	250	31	26	17
77.7	255	30	26	16
79.2	260	30	26	16
80.8	265	29	25	16

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
82.3	270	29	25	15
83.8	275	29	25	15
85.3	280	28	25	15
86.9	285	28	24	15
88.4	290	28	24	15
89.9	295	27	24	14
91.4	300	27	23	14
106.7	350	24	21	12
121.9	400	22	19	11
137.2	450	20	17	10
152.4	500	19	16	9
167.6	550	18	15	8
182.9	600	17	14	8
198.1	650	16	13	7
213.4	700	15	12	7
228.6	750	14	12	6
243.8	800	13	11	6
259.1	850	13	11	6
274.3	900	12	10	5
289.6	950	11	10	5
304.8	1000	11	9	5
320	1050	11	9	5
335.3	1100	10	8	4
350.5	1150	10	8	4
365.8	1200	9	8	4
381	1250	9	8	4
396.2	1300	9	7	4
411.5	1350	8	7	4
426.7	1400	8	7	4
442	1450	8	7	3
457.2	1500	8	6	3
472.4	1550	8	6	3
487.7	1600	7	6	3
502.9	1650	7	6	3
518.2	1700	7	6	3
533.4	1750	7	6	3
548.6	1800	7	5	3
563.9	1850	6	5	3

14.4 Qg1 mapping unit

Table 14-4: Effective shade targets for stream sites in the Qg1 mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	87	89	90
0.3	1	87	89	90
0.6	2	87	89	89
0.9	3	86	88	87
1.2	4	85	87	86
1.5	5	84	86	86
1.8	6	84	85	85
2.1	7	83	84	85
2.4	8	82	83	84
2.7	9	81	82	83
3	10	80	81	83
4.6	15	76	76	80
6.1	20	72	71	75
7.6	25	68	66	70
9.1	30	65	62	65
10.7	35	62	59	58
12.2	40	59	56	53
13.7	45	57	53	48
15.2	50	55	51	44
16.8	55	52	49	41
18.3	60	50	47	38
19.8	65	49	45	35
21.3	70	47	43	33
22.9	75	45	41	31
24.4	80	44	40	30
25.9	85	42	38	28
27.4	90	41	37	27
29	95	40	36	26
30.5	100	39	35	25
32	105	38	34	24
33.5	110	37	33	23
35.1	115	36	32	22
36.6	120	35	31	21
38.1	125	34	30	20
39.6	130	33	29	20
41.1	135	33	29	19
42.7	140	32	28	18
44.2	145	31	27	18
45.7	150	30	27	17
47.2	155	30	26	17

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
48.8	160	29	26	16
50.3	165	29	25	16
51.8	170	28	25	16
53.3	175	28	24	15
54.9	180	27	24	15
56.4	185	27	23	15
57.9	190	26	23	14
59.4	195	26	22	14
61	200	25	22	14
62.5	205	25	22	13
64	210	24	21	13
65.5	215	24	21	13
67.1	220	24	20	12
68.6	225	23	20	12
70.1	230	23	20	12
71.6	235	23	20	12
73.2	240	22	19	12
74.7	245	22	19	11
76.2	250	22	19	11
77.7	255	21	18	11
79.2	260	21	18	11
80.8	265	21	18	11
82.3	270	20	18	10
83.8	275	20	17	10
85.3	280	20	17	10
86.9	285	20	17	10
88.4	290	19	17	10
89.9	295	19	16	10
91.4	300	19	16	9
106.7	350	17	14	8
121.9	400	15	13	7
137.2	450	14	12	7
152.4	500	13	11	6
167.6	550	12	10	5
182.9	600	11	9	5
198.1	650	10	9	5
213.4	700	10	8	4
228.6	750	9	8	4
243.8	800	9	7	4
259.1	850	8	7	4
274.3	900	8	7	3
289.6	950	7	6	3

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
304.8	1000	7	6	3
320	1050	7	6	3
335.3	1100	7	5	3
350.5	1150	6	5	3
365.8	1200	6	5	3
381	1250	6	5	3
396.2	1300	6	5	2
411.5	1350	5	5	2
426.7	1400	5	4	2
442	1450	5	4	2
457.2	1500	5	4	2
472.4	1550	5	4	2
487.7	1600	5	4	2
502.9	1650	5	4	2
518.2	1700	4	4	2
533.4	1750	4	4	2
548.6	1800	4	3	2
563.9	1850	4	3	2

14.5 Qau mapping unit

Table 14-5: Effective shade targets for stream sites in the Qau mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	91	92	94
0.3	1	91	92	94
0.6	2	90	92	93
0.9	3	90	91	92
1.2	4	89	90	91
1.5	5	88	89	90
1.8	6	88	89	89
2.1	7	87	88	89
2.4	8	86	87	88
2.7	9	85	86	88
3	10	84	85	87
4.6	15	80	80	84
6.1	20	77	75	80
7.6	25	73	70	75
9.1	30	70	66	71
10.7	35	67	63	65

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
12.2	40	64	60	58
13.7	45	62	58	53
15.2	50	59	55	49
16.8	55	57	53	45
18.3	60	55	51	42
19.8	65	53	49	40
21.3	70	51	47	37
22.9	75	50	45	35
24.4	80	48	44	33
25.9	85	47	42	32
27.4	90	45	41	30
29	95	44	40	29
30.5	100	43	38	28
32	105	42	37	27
33.5	110	41	36	26
35.1	115	40	35	25
36.6	120	39	34	24
38.1	125	38	34	23
39.6	130	37	33	22
41.1	135	36	32	21
42.7	140	36	31	21
44.2	145	35	31	20
45.7	150	34	30	20
47.2	155	33	29	19
48.8	160	33	29	19
50.3	165	32	28	18
51.8	170	32	28	18
53.3	175	31	27	17
54.9	180	30	26	17
56.4	185	30	26	16
57.9	190	29	26	16
59.4	195	29	25	16
61	200	28	25	15
62.5	205	28	24	15
64	210	28	24	15
65.5	215	27	23	14
67.1	220	27	23	14
68.6	225	26	23	14
70.1	230	26	22	14
71.6	235	26	22	13
73.2	240	25	22	13
74.7	245	25	21	13

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
76.2	250	25	21	13
77.7	255	24	21	12
79.2	260	24	21	12
80.8	265	24	20	12
82.3	270	23	20	12
83.8	275	23	20	12
85.3	280	23	19	11
86.9	285	22	19	11
88.4	290	22	19	11
89.9	295	22	19	11
91.4	300	22	18	11
106.7	350	19	16	9
121.9	400	18	15	8
137.2	450	16	14	8
152.4	500	15	13	7
167.6	550	14	12	6
182.9	600	13	11	6
198.1	650	12	10	5
213.4	700	11	9	5
228.6	750	11	9	5
243.8	800	10	8	4
259.1	850	10	8	4
274.3	900	9	8	4
289.6	950	9	7	4
304.8	1000	8	7	4
320	1050	8	7	3
335.3	1100	8	6	3
350.5	1150	7	6	3
365.8	1200	7	6	3
381	1250	7	6	3
396.2	1300	7	6	3
411.5	1350	6	5	3
426.7	1400	6	5	3
442	1450	6	5	3
457.2	1500	6	5	2
472.4	1550	6	5	2
487.7	1600	5	5	2
502.9	1650	5	4	2
518.2	1700	5	4	2
533.4	1750	5	4	2
548.6	1800	5	4	2
563.9	1850	5	4	2

14.6 Qalf mapping unit

Table 14-6: Effective shade targets for stream sites in the Qalf mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	89	90	91
0.3	1	89	90	91
0.6	2	88	90	90
0.9	3	87	88	89
1.2	4	86	87	89
1.5	5	85	86	88
1.8	6	84	85	87
2.1	7	83	84	87
2.4	8	82	83	86
2.7	9	81	82	85
3	10	80	81	84
4.6	15	75	74	78
6.1	20	70	68	73
7.6	25	66	63	66
9.1	30	63	59	58
10.7	35	59	55	51
12.2	40	56	52	45
13.7	45	54	49	41
15.2	50	51	47	38
16.8	55	49	44	35
18.3	60	47	42	32
19.8	65	45	40	30
21.3	70	43	39	28
22.9	75	42	37	27
24.4	80	40	36	25
25.9	85	39	34	24
27.4	90	38	33	23
29	95	36	32	22
30.5	100	35	31	21
32	105	34	30	20
33.5	110	33	29	19
35.1	115	32	28	18
36.6	120	31	27	18
38.1	125	31	27	17
39.6	130	30	26	17
41.1	135	29	25	16

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
42.7	140	29	25	16
44.2	145	28	24	15
45.7	150	27	24	15
47.2	155	27	23	14
48.8	160	26	23	14
50.3	165	26	22	13
51.8	170	25	22	13
53.3	175	25	21	13
54.9	180	24	21	12
56.4	185	24	20	12
57.9	190	23	20	12
59.4	195	23	20	12
61	200	22	19	11
62.5	205	22	19	11
64	210	22	19	11
65.5	215	21	18	11
67.1	220	21	18	10
68.6	225	21	18	10
70.1	230	20	17	10
71.6	235	20	17	10
73.2	240	20	17	10
74.7	245	19	17	9
76.2	250	19	16	9
77.7	255	19	16	9
79.2	260	19	16	9
80.8	265	18	16	9
82.3	270	18	15	9
83.8	275	18	15	9
85.3	280	18	15	8
86.9	285	17	15	8
88.4	290	17	15	8
89.9	295	17	14	8
91.4	300	17	14	8
106.7	350	15	13	7
121.9	400	13	11	6
137.2	450	12	10	5
152.4	500	11	9	5
167.6	550	10	9	5
182.9	600	10	8	4
198.1	650	9	8	4
213.4	700	9	7	4
228.6	750	8	7	3

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
243.8	800	8	6	3
259.1	850	7	6	3
274.3	900	7	6	3
289.6	950	7	5	3
304.8	1000	6	5	3
320	1050	6	5	2
335.3	1100	6	5	2
350.5	1150	6	5	2
365.8	1200	5	4	2
381	1250	5	4	2
396.2	1300	5	4	2
411.5	1350	5	4	2
426.7	1400	5	4	2
442	1450	4	4	2
457.2	1500	4	4	2
472.4	1550	4	3	2
487.7	1600	4	3	2
502.9	1650	4	3	2
518.2	1700	4	3	2
533.4	1750	4	3	1
548.6	1800	4	3	1
563.9	1850	4	3	1

14.7 Qff2 mapping unit

Table 14-7: Effective shade targets for stream sites in the Qff2 mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	88	90	91
0.3	1	88	90	91
0.6	2	88	90	90
0.9	3	88	89	88
1.2	4	87	88	87
1.5	5	86	87	87
1.8	6	85	86	86
2.1	7	84	85	86
2.4	8	83	84	85
2.7	9	82	83	85
3	10	81	83	84
4.6	15	77	77	81

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
6.1	20	73	72	76
7.6	25	70	67	71
9.1	30	66	63	66
10.7	35	63	60	59
12.2	40	60	57	53
13.7	45	58	54	49
15.2	50	56	52	45
16.8	55	53	49	41
18.3	60	51	47	38
19.8	65	50	45	36
21.3	70	48	44	34
22.9	75	46	42	32
24.4	80	45	40	30
25.9	85	43	39	29
27.4	90	42	38	27
29	95	41	37	26
30.5	100	40	35	25
32	105	39	34	24
33.5	110	38	33	23
35.1	115	37	32	22
36.6	120	36	32	21
38.1	125	35	31	21
39.6	130	34	30	20
41.1	135	33	29	19
42.7	140	32	29	19
44.2	145	32	28	18
45.7	150	31	27	18
47.2	155	30	27	17
48.8	160	30	26	17
50.3	165	29	26	16
51.8	170	29	25	16
53.3	175	28	25	15
54.9	180	28	24	15
56.4	185	27	24	15
57.9	190	27	23	14
59.4	195	26	23	14
61	200	26	22	14
62.5	205	25	22	14
64	210	25	22	13
65.5	215	25	21	13
67.1	220	24	21	13
68.6	225	24	21	12

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
70.1	230	23	20	12
71.6	235	23	20	12
73.2	240	23	20	12
74.7	245	22	19	12
76.2	250	22	19	11
77.7	255	22	19	11
79.2	260	22	19	11
80.8	265	21	18	11
82.3	270	21	18	11
83.8	275	21	18	10
85.3	280	20	18	10
86.9	285	20	17	10
88.4	290	20	17	10
89.9	295	20	17	10
91.4	300	19	17	10
106.7	350	17	15	8
121.9	400	16	13	7
137.2	450	14	12	7
152.4	500	13	11	6
167.6	550	12	10	6
182.9	600	11	10	5
198.1	650	11	9	5
213.4	700	10	8	4
228.6	750	9	8	4
243.8	800	9	7	4
259.1	850	8	7	4
274.3	900	8	7	4
289.6	950	8	6	3
304.8	1000	7	6	3
320	1050	7	6	3
335.3	1100	7	6	3
350.5	1150	7	5	3
365.8	1200	6	5	3
381	1250	6	5	3
396.2	1300	6	5	2
411.5	1350	6	5	2
426.7	1400	5	5	2
442	1450	5	4	2
457.2	1500	5	4	2
472.4	1550	5	4	2
487.7	1600	5	4	2
502.9	1650	5	4	2

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
518.2	1700	5	4	2
533.4	1750	4	4	2
548.6	1800	4	4	2
563.9	1850	4	4	2

14.8 Qbf mapping unit

Table 14-8: Effective shade targets for stream sites in the Qbf mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	90	92	93
0.3	1	90	91	92
0.6	2	89	91	92
0.9	3	89	90	90
1.2	4	88	89	89
1.5	5	87	89	89
1.8	6	86	88	88
2.1	7	86	87	87
2.4	8	85	86	87
2.7	9	84	85	86
3	10	83	84	86
4.6	15	79	79	83
6.1	20	75	74	78
7.6	25	71	69	73
9.1	30	68	65	69
10.7	35	65	61	62
12.2	40	62	59	56
13.7	45	60	56	51
15.2	50	58	54	47
16.8	55	55	51	43
18.3	60	53	49	40
19.8	65	51	47	38
21.3	70	50	45	36
22.9	75	48	44	34
24.4	80	47	42	32
25.9	85	45	41	30
27.4	90	44	39	29
29	95	43	38	28
30.5	100	41	37	26
32	105	40	36	25

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
33.5	110	39	35	24
35.1	115	38	34	23
36.6	120	37	33	23
38.1	125	36	32	22
39.6	130	36	31	21
41.1	135	35	31	20
42.7	140	34	30	20
44.2	145	33	29	19
45.7	150	33	29	19
47.2	155	32	28	18
48.8	160	31	27	18
50.3	165	31	27	17
51.8	170	30	26	17
53.3	175	30	26	16
54.9	180	29	25	16
56.4	185	29	25	16
57.9	190	28	24	15
59.4	195	28	24	15
61	200	27	24	15
62.5	205	27	23	14
64	210	26	23	14
65.5	215	26	22	14
67.1	220	26	22	13
68.6	225	25	22	13
70.1	230	25	21	13
71.6	235	24	21	13
73.2	240	24	21	12
74.7	245	24	20	12
76.2	250	23	20	12
77.7	255	23	20	12
79.2	260	23	20	12
80.8	265	22	19	11
82.3	270	22	19	11
83.8	275	22	19	11
85.3	280	22	19	11
86.9	285	21	18	11
88.4	290	21	18	11
89.9	295	21	18	10
91.4	300	21	18	10
106.7	350	18	16	9
121.9	400	17	14	8
137.2	450	15	13	7

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
152.4	500	14	12	6
167.6	550	13	11	6
182.9	600	12	10	5
198.1	650	11	10	5
213.4	700	11	9	5
228.6	750	10	8	4
243.8	800	10	8	4
259.1	850	9	8	4
274.3	900	9	7	4
289.6	950	8	7	4
304.8	1000	8	7	3
320	1050	8	6	3
335.3	1100	7	6	3
350.5	1150	7	6	3
365.8	1200	7	6	3
381	1250	6	5	3
396.2	1300	6	5	3
411.5	1350	6	5	3
426.7	1400	6	5	2
442	1450	6	5	2
457.2	1500	5	5	2
472.4	1550	5	4	2
487.7	1600	5	4	2
502.9	1650	5	4	2
518.2	1700	5	4	2
533.4	1750	5	4	2
548.6	1800	5	4	2
563.9	1850	5	4	2

14.9 Tvc mapping unit

Table 14-9: Effective shade targets for stream sites in the Tvc mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	92	93	94
0.3	1	91	93	94
0.6	2	91	93	94
0.9	3	91	92	93
1.2	4	91	92	93
1.5	5	90	91	92

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
1.8	6	89	90	92
2.1	7	89	90	92
2.4	8	88	89	91
2.7	9	87	89	91
3	10	87	88	90
4.6	15	83	84	87
6.1	20	80	80	84
7.6	25	77	76	81
9.1	30	75	72	78
10.7	35	72	69	74
12.2	40	69	66	70
13.7	45	67	64	64
15.2	50	65	61	60
16.8	55	63	59	56
18.3	60	61	57	52
19.8	65	59	55	49
21.3	70	58	53	46
22.9	75	56	52	44
24.4	80	55	50	42
25.9	85	53	49	40
27.4	90	52	47	38
29	95	50	46	36
30.5	100	49	45	35
32	105	48	44	33
33.5	110	47	43	32
35.1	115	46	41	31
36.6	120	45	40	30
38.1	125	44	40	29
39.6	130	43	39	28
41.1	135	42	38	27
42.7	140	41	37	26
44.2	145	41	36	26
45.7	150	40	35	25
47.2	155	39	35	24
48.8	160	38	34	24
50.3	165	38	33	23
51.8	170	37	33	22
53.3	175	36	32	22
54.9	180	36	32	21
56.4	185	35	31	21
57.9	190	35	31	20
59.4	195	34	30	20

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
61	200	34	30	20
62.5	205	33	29	19
64	210	33	29	19
65.5	215	32	28	18
67.1	220	32	28	18
68.6	225	31	27	18
70.1	230	31	27	17
71.6	235	30	27	17
73.2	240	30	26	17
74.7	245	30	26	16
76.2	250	29	25	16
77.7	255	29	25	16
79.2	260	29	25	16
80.8	265	28	25	15
82.3	270	28	24	15
83.8	275	27	24	15
85.3	280	27	24	15
86.9	285	27	23	14
88.4	290	27	23	14
89.9	295	26	23	14
91.4	300	26	22	14
106.7	350	23	20	12
121.9	400	21	18	11
137.2	450	19	17	10
152.4	500	18	15	9
167.6	550	17	14	8
182.9	600	16	13	8
198.1	650	15	13	7
213.4	700	14	12	7
228.6	750	13	11	6
243.8	800	12	11	6
259.1	850	12	10	5
274.3	900	11	10	5
289.6	950	11	9	5
304.8	1000	10	9	5
320	1050	10	8	4
335.3	1100	10	8	4
350.5	1150	9	8	4
365.8	1200	9	7	4
381	1250	9	7	4
396.2	1300	8	7	4
411.5	1350	8	7	4

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
426.7	1400	8	6	3
442	1450	7	6	3
457.2	1500	7	6	3
472.4	1550	7	6	3
487.7	1600	7	6	3
502.9	1650	7	6	3
518.2	1700	6	5	3
533.4	1750	6	5	3
548.6	1800	6	5	3
563.9	1850	6	5	%

14.10 Qtg mapping unit

Table 14-10: Effective shade targets for stream sites in the Qtg mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	97	98	99
0.3	1	97	98	99
0.6	2	96	97	99
0.9	3	96	97	99
1.2	4	96	97	99
1.5	5	96	97	98
1.8	6	96	97	98
2.1	7	95	96	97
2.4	8	95	96	97
2.7	9	95	95	97
3	10	94	95	97
4.6	15	92	93	96
6.1	20	90	91	94
7.6	25	89	89	93
9.1	30	87	86	91
10.7	35	85	84	90
12.2	40	83	81	88
13.7	45	82	79	86
15.2	50	80	77	84
16.8	55	79	75	82
18.3	60	77	73	79
19.8	65	76	72	76
21.3	70	75	70	73
22.9	75	73	69	70

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
24.4	80	72	68	67
25.9	85	71	66	65
27.4	90	70	65	63
29	95	69	64	60
30.5	100	67	63	58
32	105	66	62	56
33.5	110	65	60	55
35.1	115	64	59	53
36.6	120	63	58	51
38.1	125	63	57	50
39.6	130	62	56	48
41.1	135	61	56	47
42.7	140	60	55	46
44.2	145	59	54	45
45.7	150	58	53	44
47.2	155	57	52	43
48.8	160	57	51	42
50.3	165	56	51	41
51.8	170	55	50	40
53.3	175	55	49	39
54.9	180	54	49	38
56.4	185	53	48	37
57.9	190	53	47	36
59.4	195	52	47	36
61	200	51	46	35
62.5	205	51	45	34
64	210	50	45	34
65.5	215	50	44	33
67.1	220	49	44	32
68.6	225	49	43	32
70.1	230	48	43	31
71.6	235	47	42	31
73.2	240	47	42	30
74.7	245	46	41	30
76.2	250	46	41	29
77.7	255	46	40	29
79.2	260	45	40	28
80.8	265	45	40	28
82.3	270	44	39	28
83.8	275	44	39	27
85.3	280	43	38	27
86.9	285	43	38	26

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
88.4	290	43	38	26
89.9	295	42	37	26
91.4	300	42	37	25
106.7	350	38	34	22
121.9	400	35	31	20
137.2	450	33	29	18
152.4	500	31	27	17
167.6	550	29	25	15
182.9	600	27	24	14
198.1	650	26	22	13
213.4	700	24	21	12
228.6	750	23	20	12
243.8	800	22	19	11
259.1	850	21	18	10
274.3	900	20	17	10
289.6	950	20	17	9
304.8	1000	19	16	9
320	1050	18	16	9
335.3	1100	17	15	8
350.5	1150	17	14	8
365.8	1200	16	14	8
381	1250	16	13	7
396.2	1300	15	13	7
411.5	1350	15	13	7
426.7	1400	14	12	7
442	1450	14	12	6
457.2	1500	14	12	6
472.4	1550	13	11	6
487.7	1600	13	11	6
502.9	1650	13	11	6
518.2	1700	12	10	6
533.4	1750	12	10	5
548.6	1800	12	10	5
563.9	1850	11	10	5

14.11 Tww mapping unit

Table 14-11: Effective shade targets for stream sites in the Tww mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	94	96	97
0.3	1	94	95	97
0.6	2	94	95	97
0.9	3	94	95	97
1.2	4	93	95	96
1.5	5	93	94	96
1.8	6	93	94	95
2.1	7	92	93	95
2.4	8	92	93	94
2.7	9	91	92	94
3	10	91	92	94
4.6	15	88	89	92
6.1	20	86	86	90
7.6	25	83	83	88
9.1	30	81	80	86
10.7	35	79	77	83
12.2	40	77	75	81
13.7	45	75	72	78
15.2	50	73	70	75
16.8	55	72	68	71
18.3	60	70	66	67
19.8	65	68	64	63
21.3	70	67	63	60
22.9	75	65	61	57
24.4	80	64	60	55
25.9	85	63	58	53
27.4	90	61	57	50
29	95	60	56	48
30.5	100	59	54	47
32	105	58	53	45
33.5	110	57	52	43
35.1	115	55	51	42
36.6	120	54	50	40
38.1	125	54	49	39
39.6	130	53	48	38
41.1	135	52	47	37
42.7	140	51	46	36
44.2	145	50	45	35
45.7	150	49	44	34
47.2	155	48	44	33
48.8	160	48	43	32
50.3	165	47	42	31

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
51.8	170	46	41	31
53.3	175	45	41	30
54.9	180	45	40	29
56.4	185	44	40	29
57.9	190	44	39	28
59.4	195	43	38	27
61	200	42	38	27
62.5	205	42	37	26
64	210	41	37	26
65.5	215	41	36	25
67.1	220	40	36	25
68.6	225	40	35	24
70.1	230	39	35	24
71.6	235	39	34	24
73.2	240	38	34	23
74.7	245	38	33	23
76.2	250	37	33	22
77.7	255	37	33	22
79.2	260	36	32	22
80.8	265	36	32	21
82.3	270	36	31	21
83.8	275	35	31	21
85.3	280	35	31	20
86.9	285	35	30	20
88.4	290	34	30	20
89.9	295	34	30	19
91.4	300	33	29	19
106.7	350	30	27	17
121.9	400	28	24	15
137.2	450	26	22	14
152.4	500	24	21	12
167.6	550	22	19	11
182.9	600	21	18	11
198.1	650	20	17	10
213.4	700	19	16	9
228.6	750	18	15	9
243.8	800	17	14	8
259.1	850	16	14	8
274.3	900	15	13	7
289.6	950	15	13	7
304.8	1000	14	12	7
320	1050	13	12	6

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
335.3	1100	13	11	6
350.5	1150	13	11	6
365.8	1200	12	10	6
381	1250	12	10	5
396.2	1300	11	10	5
411.5	1350	11	9	5
426.7	1400	11	9	5
442	1450	10	9	5
457.2	1500	10	8	5
472.4	1550	10	8	4
487.7	1600	9	8	4
502.9	1650	9	8	4
518.2	1700	9	8	4
533.4	1750	9	7	4
548.6	1800	8	7	4
563.9	1850	8	7	4

14.12 Tcr mapping unit

Table 14-12: Effective shade targets for stream sites in the Tcr mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	96	97	98
0.3	1	95	97	98
0.6	2	95	96	98
0.9	3	95	96	98
1.2	4	95	96	97
1.5	5	95	96	97
1.8	6	94	95	96
2.1	7	94	95	96
2.4	8	93	94	96
2.7	9	93	94	96
3	10	92	93	95
4.6	15	90	91	94
6.1	20	88	88	92
7.6	25	86	86	90
9.1	30	84	83	88
10.7	35	82	80	86
12.2	40	80	77	84
13.7	45	78	75	82

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
15.2	50	76	73	79
16.8	55	75	71	75
18.3	60	73	69	72
19.8	65	71	67	68
21.3	70	70	66	65
22.9	75	69	64	62
24.4	80	67	63	60
25.9	85	66	61	57
27.4	90	65	60	55
29	95	63	59	53
30.5	100	62	58	51
32	105	61	56	49
33.5	110	60	55	47
35.1	115	59	54	46
36.6	120	58	53	44
38.1	125	57	52	43
39.6	130	56	51	42
41.1	135	55	50	41
42.7	140	54	49	39
44.2	145	53	49	38
45.7	150	53	48	37
47.2	155	52	47	36
48.8	160	51	46	36
50.3	165	50	45	35
51.8	170	50	45	34
53.3	175	49	44	33
54.9	180	48	43	32
56.4	185	48	43	32
57.9	190	47	42	31
59.4	195	46	41	30
61	200	46	41	30
62.5	205	45	40	29
64	210	45	40	29
65.5	215	44	39	28
67.1	220	44	39	27
68.6	225	43	38	27
70.1	230	42	38	27
71.6	235	42	37	26
73.2	240	41	37	26
74.7	245	41	36	25
76.2	250	41	36	25
77.7	255	40	35	24

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
79.2	260	40	35	24
80.8	265	39	35	24
82.3	270	39	34	23
83.8	275	38	34	23
85.3	280	38	34	23
86.9	285	38	33	22
88.4	290	37	33	22
89.9	295	37	32	22
91.4	300	36	32	21
106.7	350	33	29	19
121.9	400	31	27	17
137.2	450	28	25	15
152.4	500	26	23	14
167.6	550	25	21	13
182.9	600	23	20	12
198.1	650	22	19	11
213.4	700	21	18	10
228.6	750	20	17	10
243.8	800	19	16	9
259.1	850	18	15	9
274.3	900	17	15	8
289.6	950	16	14	8
304.8	1000	16	13	8
320	1050	15	13	7
335.3	1100	15	12	7
350.5	1150	14	12	7
365.8	1200	14	12	6
381	1250	13	11	6
396.2	1300	13	11	6
411.5	1350	12	10	6
426.7	1400	12	10	6
442	1450	12	10	5
457.2	1500	11	10	5
472.4	1550	11	9	5
487.7	1600	11	9	5
502.9	1650	10	9	5
518.2	1700	10	9	5
533.4	1750	10	8	4
548.6	1800	10	8	4
563.9	1850	9	8	4

14.13 Tm mapping unit

Table 14-13: Effective shade targets for stream sites in the Tm mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	94	95	95
0.3	1	94	95	95
0.6	2	93	95	95
0.9	3	93	94	95
1.2	4	93	94	94
1.5	5	92	93	94
1.8	6	92	93	94
2.1	7	91	92	93
2.4	8	91	92	93
2.7	9	90	91	93
3	10	89	90	92
4.6	15	86	87	90
6.1	20	84	83	87
7.6	25	81	80	85
9.1	30	78	76	82
10.7	35	76	73	79
12.2	40	73	70	75
13.7	45	71	67	71
15.2	50	69	65	66
16.8	55	67	63	61
18.3	60	65	61	58
19.8	65	64	59	54
21.3	70	62	58	52
22.9	75	60	56	49
24.4	80	59	54	47
25.9	85	57	53	44
27.4	90	56	51	42
29	95	55	50	41
30.5	100	54	49	39
32	105	52	48	38
33.5	110	51	47	36
35.1	115	50	45	35
36.6	120	49	44	34
38.1	125	48	43	33
39.6	130	47	42	32
41.1	135	46	42	31
42.7	140	46	41	30
44.2	145	45	40	29

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
45.7	150	44	39	28
47.2	155	43	38	27
48.8	160	42	38	27
50.3	165	42	37	26
51.8	170	41	36	25
53.3	175	40	36	25
54.9	180	40	35	24
56.4	185	39	35	24
57.9	190	39	34	23
59.4	195	38	33	23
61	200	37	33	22
62.5	205	37	32	22
64	210	36	32	21
65.5	215	36	31	21
67.1	220	35	31	20
68.6	225	35	31	20
70.1	230	34	30	20
71.6	235	34	30	19
73.2	240	34	29	19
74.7	245	33	29	19
76.2	250	33	29	18
77.7	255	32	28	18
79.2	260	32	28	18
80.8	265	32	27	17
82.3	270	31	27	17
83.8	275	31	27	17
85.3	280	30	26	17
86.9	285	30	26	16
88.4	290	30	26	16
89.9	295	29	26	16
91.4	300	29	25	16
106.7	350	26	23	14
121.9	400	24	21	12
137.2	450	22	19	11
152.4	500	20	18	10
167.6	550	19	16	9
182.9	600	18	15	9
198.1	650	17	14	8
213.4	700	16	14	7
228.6	750	15	13	7
243.8	800	14	12	7
259.1	850	14	12	6

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
274.3	900	13	11	6
289.6	950	12	11	6
304.8	1000	12	10	5
320	1050	11	10	5
335.3	1100	11	9	5
350.5	1150	11	9	5
365.8	1200	10	9	5
381	1250	10	8	4
396.2	1300	10	8	4
411.5	1350	9	8	4
426.7	1400	9	8	4
442	1450	9	7	4
457.2	1500	8	7	4
472.4	1550	8	7	4
487.7	1600	8	7	3
502.9	1650	8	7	3
518.2	1700	8	6	3
533.4	1750	7	6	3
548.6	1800	7	6	3
563.9	1850	7	6	3

14.14 QTt mapping unit

Table 14-14: Effective shade targets for stream sites in the QTt mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	91	93	94
0.3	1	91	92	94
0.6	2	90	92	94
0.9	3	90	92	93
1.2	4	90	91	92
1.5	5	89	90	92
1.8	6	88	89	91
2.1	7	87	89	90
2.4	8	87	88	89
2.7	9	86	87	89
3	10	85	86	88
4.6	15	82	82	85
6.1	20	78	77	82
7.6	25	75	73	78

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
9.1	30	72	69	74
10.7	35	69	66	70
12.2	40	66	63	64
13.7	45	64	60	58
15.2	50	62	58	54
16.8	55	60	56	50
18.3	60	58	54	47
19.8	65	56	52	44
21.3	70	54	50	41
22.9	75	53	48	39
24.4	80	51	47	37
25.9	85	50	45	35
27.4	90	48	44	34
29	95	47	43	32
30.5	100	46	41	31
32	105	45	40	30
33.5	110	44	39	29
35.1	115	43	38	28
36.6	120	42	37	27
38.1	125	41	36	26
39.6	130	40	35	25
41.1	135	39	35	24
42.7	140	38	34	23
44.2	145	37	33	23
45.7	150	37	32	22
47.2	155	36	32	21
48.8	160	35	31	21
50.3	165	35	30	20
51.8	170	34	30	20
53.3	175	33	29	19
54.9	180	33	29	19
56.4	185	32	28	18
57.9	190	32	28	18
59.4	195	31	27	18
61	200	31	27	17
62.5	205	30	26	17
64	210	30	26	17
65.5	215	29	26	16
67.1	220	29	25	16
68.6	225	29	25	16
70.1	230	28	24	15
71.6	235	28	24	15

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
73.2	240	27	24	15
74.7	245	27	23	15
76.2	250	27	23	14
77.7	255	26	23	14
79.2	260	26	22	14
80.8	265	26	22	14
82.3	270	25	22	13
83.8	275	25	22	13
85.3	280	25	21	13
86.9	285	24	21	13
88.4	290	24	21	13
89.9	295	24	21	12
91.4	300	23	20	12
106.7	350	21	18	11
121.9	400	19	16	9
137.2	450	18	15	9
152.4	500	16	14	8
167.6	550	15	13	7
182.9	600	14	12	7
198.1	650	13	11	6
213.4	700	12	10	6
228.6	750	12	10	5
243.8	800	11	9	5
259.1	850	11	9	5
274.3	900	10	8	5
289.6	950	10	8	4
304.8	1000	9	8	4
320	1050	9	7	4
335.3	1100	8	7	4
350.5	1150	8	7	4
365.8	1200	8	7	3
381	1250	8	6	3
396.2	1300	7	6	3
411.5	1350	7	6	3
426.7	1400	7	6	3
442	1450	7	6	3
457.2	1500	6	5	3
472.4	1550	6	5	3
487.7	1600	6	5	3
502.9	1650	6	5	3
518.2	1700	6	5	2
533.4	1750	6	5	2

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
548.6	1800	5	5	2
563.9	1850	5	4	2

14.15 QTb mapping unit

Table 14-15: Effective shade targets for stream sites in the QTb mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	94	96	97
0.3	1	94	95	97
0.6	2	93	95	97
0.9	3	93	95	97
1.2	4	93	95	96
1.5	5	93	94	95
1.8	6	92	93	95
2.1	7	92	93	94
2.4	8	91	93	94
2.7	9	91	92	94
3	10	90	92	93
4.6	15	88	89	92
6.1	20	85	86	90
7.6	25	83	83	88
9.1	30	81	80	85
10.7	35	79	77	83
12.2	40	77	74	80
13.7	45	75	72	78
15.2	50	73	70	74
16.8	55	71	68	70
18.3	60	70	66	67
19.8	65	68	64	63
21.3	70	66	62	60
22.9	75	65	61	57
24.4	80	63	59	55
25.9	85	62	58	52
27.4	90	61	57	50
29	95	60	55	48
30.5	100	58	54	46
32	105	57	53	45
33.5	110	56	52	43
35.1	115	55	51	42

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
36.6	120	54	50	40
38.1	125	53	49	39
39.6	130	52	48	38
41.1	135	51	47	37
42.7	140	50	46	36
44.2	145	50	45	35
45.7	150	49	44	34
47.2	155	48	43	33
48.8	160	47	43	32
50.3	165	46	42	31
51.8	170	46	41	30
53.3	175	45	40	30
54.9	180	44	40	29
56.4	185	44	39	28
57.9	190	43	39	28
59.4	195	43	38	27
61	200	42	37	27
62.5	205	41	37	26
64	210	41	36	26
65.5	215	40	36	25
67.1	220	40	35	25
68.6	225	39	35	24
70.1	230	39	34	24
71.6	235	38	34	23
73.2	240	38	34	23
74.7	245	37	33	23
76.2	250	37	33	22
77.7	255	37	32	22
79.2	260	36	32	21
80.8	265	36	32	21
82.3	270	35	31	21
83.8	275	35	31	21
85.3	280	35	30	20
86.9	285	34	30	20
88.4	290	34	30	20
89.9	295	33	29	19
91.4	300	33	29	19
106.7	350	30	26	17
121.9	400	27	24	15
137.2	450	25	22	14
152.4	500	24	20	12
167.6	550	22	19	11

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
182.9	600	21	18	11
198.1	650	19	17	10
213.4	700	18	16	9
228.6	750	17	15	9
243.8	800	17	14	8
259.1	850	16	14	8
274.3	900	15	13	7
289.6	950	14	12	7
304.8	1000	14	12	7
320	1050	13	11	6
335.3	1100	13	11	6
350.5	1150	12	11	6
365.8	1200	12	10	6
381	1250	11	10	5
396.2	1300	11	9	5
411.5	1350	11	9	5
426.7	1400	10	9	5
442	1450	10	9	5
457.2	1500	10	8	5
472.4	1550	10	8	4
487.7	1600	9	8	4
502.9	1650	9	8	4
518.2	1700	9	8	4
533.4	1750	9	7	4
548.6	1800	8	7	4
563.9	1850	8	7	4

14.16 QIs mapping unit

Table 14-16: Effective shade targets for stream sites in the QIs mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	96	98	99
0.3	1	95	97	98
0.6	2	95	97	98
0.9	3	95	96	98
1.2	4	95	96	98
1.5	5	95	96	98
1.8	6	95	96	97
2.1	7	95	95	97

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
2.4	8	94	95	97
2.7	9	94	95	96
3	10	93	94	96
4.6	15	91	92	95
6.1	20	90	91	94
7.6	25	88	89	92
9.1	30	86	86	91
10.7	35	85	84	90
12.2	40	83	82	88
13.7	45	81	80	86
15.2	50	80	78	85
16.8	55	79	76	83
18.3	60	77	74	80
19.8	65	76	72	78
21.3	70	75	71	75
22.9	75	73	69	72
24.4	80	72	68	69
25.9	85	71	67	67
27.4	90	70	66	64
29	95	69	64	62
30.5	100	67	63	60
32	105	66	62	58
33.5	110	65	61	56
35.1	115	64	60	55
36.6	120	63	59	53
38.1	125	63	58	52
39.6	130	62	57	50
41.1	135	61	56	49
42.7	140	60	55	48
44.2	145	59	54	46
45.7	150	58	54	45
47.2	155	58	53	44
48.8	160	57	52	43
50.3	165	56	51	42
51.8	170	55	51	41
53.3	175	55	50	40
54.9	180	54	49	39
56.4	185	53	48	39
57.9	190	53	48	38
59.4	195	52	47	37
61	200	51	47	36
62.5	205	51	46	36

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
64	210	50	45	35
65.5	215	50	45	34
67.1	220	49	44	34
68.6	225	49	44	33
70.1	230	48	43	33
71.6	235	48	43	32
73.2	240	47	42	31
74.7	245	47	42	31
76.2	250	46	41	30
77.7	255	46	41	30
79.2	260	45	40	30
80.8	265	45	40	29
82.3	270	44	40	29
83.8	275	44	39	28
85.3	280	43	39	28
86.9	285	43	38	27
88.4	290	43	38	27
89.9	295	42	38	27
91.4	300	42	37	26
106.7	350	38	34	23
121.9	400	35	31	21
137.2	450	33	29	19
152.4	500	31	27	17
167.6	550	29	25	16
182.9	600	27	24	15
198.1	650	26	22	14
213.4	700	24	21	13
228.6	750	23	20	12
243.8	800	22	19	12
259.1	850	21	18	11
274.3	900	20	18	10
289.6	950	19	17	10
304.8	1000	19	16	9
320	1050	18	16	9
335.3	1100	17	15	9
350.5	1150	17	14	8
365.8	1200	16	14	8
381	1250	16	13	8
396.2	1300	15	13	7
411.5	1350	15	13	7
426.7	1400	14	12	7
442	1450	14	12	7

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
457.2	1500	13	12	7
472.4	1550	13	11	6
487.7	1600	13	11	6
502.9	1650	12	11	6
518.2	1700	12	10	6
533.4	1750	12	10	6
548.6	1800	11	10	6
563.9	1850	11	10	5

14.17 Open Water (OW)

Table 14-17: Effective shade targets for stream sites classified as Open Water (OW).

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	95	96	98
0.3	1	92	92	96
0.6	2	84	80	90
0.9	3	77	72	75
1.2	4	71	65	57
1.5	5	65	59	46
1.8	6	59	53	39
2.1	7	55	48	34
2.4	8	51	44	30
2.7	9	47	41	27
3	10	44	37	24
4.6	15	33	27	16
6.1	20	26	21	12
7.6	25	22	17	10
9.1	30	18	15	8
10.7	35	16	13	7
12.2	40	14	11	6
13.7	45	13	10	6
15.2	50	12	9	5
16.8	55	11	8	5
18.3	60	10	8	4
19.8	65	9	7	4
21.3	70	9	7	4
22.9	75	8	6	3

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
24.4	80	8	6	3
25.9	85	7	6	3
27.4	90	7	5	3
29	95	7	5	3
30.5	100	6	5	2
32	105	6	5	2
33.5	110	6	4	2
35.1	115	5	4	2
36.6	120	5	4	2
38.1	125	5	4	2
39.6	130	5	4	2
41.1	135	5	4	2
42.7	140	5	3	2
44.2	145	4	3	2
45.7	150	4	3	2
47.2	155	4	3	2
48.8	160	4	3	2
50.3	165	4	3	2
51.8	170	4	3	1
53.3	175	4	3	1
54.9	180	4	3	1
56.4	185	3	3	1
57.9	190	3	3	1
59.4	195	3	2	1
61	200	3	2	1
62.5	205	3	2	1
64	210	3	2	1
65.5	215	3	2	1
67.1	220	3	2	1
68.6	225	3	2	1
70.1	230	3	2	1
71.6	235	3	2	1
73.2	240	3	2	1
74.7	245	3	2	1
76.2	250	3	2	1
77.7	255	3	2	1
79.2	260	2	2	1
80.8	265	2	2	1
82.3	270	2	2	1
83.8	275	2	2	1
85.3	280	2	2	1
86.9	285	2	2	1

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
88.4	290	2	2	1
89.9	295	2	2	1
91.4	300	2	2	1
106.7	350	2	1	1
121.9	400	2	1	1
137.2	450	1	1	1
152.4	500	1	1	0
167.6	550	1	1	0
182.9	600	1	1	0
198.1	650	1	1	0
213.4	700	1	1	0
228.6	750	1	1	0
243.8	800	1	1	0
259.1	850	1	1	0
274.3	900	1	1	0
289.6	950	1	1	0
304.8	1000	1	0	0
320	1050	1	0	0
335.3	1100	1	0	0
350.5	1150	1	0	0
365.8	1200	1	0	0
381	1250	1	0	0
396.2	1300	1	0	0
411.5	1350	0	0	0
426.7	1400	0	0	0
442	1450	0	0	0
457.2	1500	0	0	0
472.4	1550	0	0	0
487.7	1600	0	0	0
502.9	1650	0	0	0
518.2	1700	0	0	0
533.4	1750	0	0	0
548.6	1800	0	0	0
563.9	1850	0	0	0

14.18 Upland Forest

Table 14-18: Effective shade targets for stream sites in the Upland Forest mapping unit.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	97	99	99
0.3	1	97	98	99
0.6	2	97	98	99
0.9	3	97	98	99
1.2	4	97	97	99
1.5	5	97	97	98
1.8	6	97	97	98
2.1	7	96	96	98
2.4	8	95	96	98
2.7	9	95	96	97
3	10	95	95	97
4.6	15	93	93	96
6.1	20	91	91	95
7.6	25	89	89	94
9.1	30	88	87	92
10.7	35	86	85	91
12.2	40	84	82	89
13.7	45	83	80	88
15.2	50	81	78	86
16.8	55	80	76	83
18.3	60	79	74	81
19.8	65	77	73	78
21.3	70	76	71	75
22.9	75	75	70	72
24.4	80	73	69	69
25.9	85	72	67	67
27.4	90	71	66	64
29	95	70	65	62
30.5	100	69	64	60
32	105	68	63	58
33.5	110	67	62	56
35.1	115	66	61	55
36.6	120	65	60	53
38.1	125	64	59	52
39.6	130	63	58	50
41.1	135	62	57	49
42.7	140	61	56	48
44.2	145	61	55	46
45.7	150	60	54	45
47.2	155	59	54	44
48.8	160	58	53	43
50.3	165	58	52	42

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
51.8	170	57	51	41
53.3	175	56	51	40
54.9	180	56	50	39
56.4	185	55	49	39
57.9	190	54	49	38
59.4	195	54	48	37
61	200	53	48	36
62.5	205	52	47	36
64	210	52	46	35
65.5	215	51	46	34
67.1	220	51	45	34
68.6	225	50	45	33
70.1	230	50	44	33
71.6	235	49	44	32
73.2	240	49	43	31
74.7	245	48	43	31
76.2	250	48	42	30
77.7	255	47	42	30
79.2	260	47	41	30
80.8	265	46	41	29
82.3	270	46	41	29
83.8	275	45	40	28
85.3	280	45	40	28
86.9	285	45	39	27
88.4	290	44	39	27
89.9	295	44	39	27
91.4	300	43	38	26
106.7	350	40	35	23
121.9	400	37	32	21
137.2	450	34	30	19
152.4	500	32	28	17
167.6	550	30	26	16
182.9	600	29	25	15
198.1	650	27	23	14
213.4	700	26	22	13
228.6	750	25	21	12
243.8	800	23	20	12
259.1	850	22	19	11
274.3	900	22	18	10
289.6	950	21	18	10
304.8	1000	20	17	9
320	1050	19	16	9

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
335.3	1100	18	16	9
350.5	1150	18	15	8
365.8	1200	17	15	8
381	1250	17	14	8
396.2	1300	16	14	8
411.5	1350	16	13	7
426.7	1400	15	13	7
442	1450	15	13	7
457.2	1500	14	12	7
472.4	1550	14	12	6
487.7	1600	14	12	6
502.9	1650	13	11	6
518.2	1700	13	11	6
533.4	1750	13	11	6
548.6	1800	12	11	6
563.9	1850	12	10	5

14.19 1d/1f - Volcanics and Willapa Hills

Table 14-19: Effective shade targets for stream sites in Ecoregion 1d/1f - Volcanics and Willapa Hills.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	97	99	99
0.3	1	97	98	99
0.6	2	97	98	99
0.9	3	96	97	99
1.2	4	96	97	98
1.5	5	96	97	98
1.8	6	96	97	98
2.1	7	95	96	97
2.4	8	95	96	97
2.7	9	95	95	97
3	10	94	95	97
4.6	15	92	93	96
6.1	20	90	91	94
7.6	25	88	89	93
9.1	30	86	86	92
10.7	35	84	84	90

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
12.2	40	83	82	88
13.7	45	81	79	87
15.2	50	79	77	85
16.8	55	78	75	83
18.3	60	76	74	80
19.8	65	75	72	77
21.3	70	74	70	74
22.9	75	72	69	72
24.4	80	71	68	69
25.9	85	70	66	67
27.4	90	69	65	64
29	95	67	64	62
30.5	100	66	63	60
32	105	65	61	58
33.5	110	64	60	56
35.1	115	63	59	55
36.6	120	62	58	53
38.1	125	61	57	51
39.6	130	60	56	50
41.1	135	59	55	49
42.7	140	59	54	47
44.2	145	58	54	46
45.7	150	57	53	45
47.2	155	56	52	44
48.8	160	55	51	43
50.3	165	55	50	42
51.8	170	54	50	41
53.3	175	53	49	40
54.9	180	53	48	39
56.4	185	52	48	38
57.9	190	51	47	38
59.4	195	51	46	37
61	200	50	46	36
62.5	205	50	45	35
64	210	49	45	35
65.5	215	48	44	34
67.1	220	48	44	34
68.6	225	47	43	33
70.1	230	47	42	32
71.6	235	46	42	32
73.2	240	46	41	31
74.7	245	45	41	31

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
76.2	250	45	41	30
77.7	255	44	40	30
79.2	260	44	40	29
80.8	265	44	39	29
82.3	270	43	39	28
83.8	275	43	38	28
85.3	280	42	38	28
86.9	285	42	38	27
88.4	290	41	37	27
89.9	295	41	37	27
91.4	300	41	37	26
106.7	350	37	33	23
121.9	400	34	31	21
137.2	450	32	28	19
152.4	500	30	26	17
167.6	550	28	25	16
182.9	600	26	23	15
198.1	650	25	22	14
213.4	700	24	21	13
228.6	750	23	20	12
243.8	800	22	19	11
259.1	850	21	18	11
274.3	900	20	17	10
289.6	950	19	17	10
304.8	1000	18	16	9
320	1050	18	15	9
335.3	1100	17	15	9
350.5	1150	16	14	8
365.8	1200	16	14	8
381	1250	15	13	8
396.2	1300	15	13	7
411.5	1350	14	12	7
426.7	1400	14	12	7
442	1450	14	12	7
457.2	1500	13	11	6
472.4	1550	13	11	6
487.7	1600	13	11	6
502.9	1650	12	11	6
518.2	1700	12	10	6
533.4	1750	12	10	6
548.6	1800	11	10	5
563.9	1850	11	10	5

14.20 3a - Portland/Vancouver Basin

Table 14-20: Effective shade targets for stream sites in Ecoregion 3a - Portland/Vancouver Basin.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	95	97	96
0.3	1	95	96	95
0.6	2	94	95	95
0.9	3	94	95	95
1.2	4	94	94	94
1.5	5	93	94	94
1.8	6	92	93	94
2.1	7	92	93	93
2.4	8	91	92	93
2.7	9	91	91	93
3	10	90	91	92
4.6	15	87	87	90
6.1	20	84	84	88
7.6	25	81	80	85
9.1	30	78	77	82
10.7	35	76	73	79
12.2	40	73	70	75
13.7	45	71	68	72
15.2	50	69	66	67
16.8	55	67	63	63
18.3	60	65	61	59
19.8	65	63	60	56
21.3	70	61	58	53
22.9	75	60	56	50
24.4	80	58	55	48
25.9	85	57	53	46
27.4	90	56	52	44
29	95	54	50	42
30.5	100	53	49	40
32	105	52	48	39
33.5	110	51	47	37
35.1	115	50	46	36
36.6	120	49	45	35
38.1	125	48	44	34
39.6	130	47	43	33
41.1	135	46	42	32

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
42.7	140	45	41	31
44.2	145	44	40	30
45.7	150	44	39	29
47.2	155	43	39	28
48.8	160	42	38	28
50.3	165	41	37	27
51.8	170	41	37	26
53.3	175	40	36	26
54.9	180	39	35	25
56.4	185	39	35	24
57.9	190	38	34	24
59.4	195	38	34	23
61	200	37	33	23
62.5	205	37	33	22
64	210	36	32	22
65.5	215	36	32	22
67.1	220	35	31	21
68.6	225	35	31	21
70.1	230	34	30	20
71.6	235	34	30	20
73.2	240	33	30	20
74.7	245	33	29	19
76.2	250	33	29	19
77.7	255	32	28	19
79.2	260	32	28	18
80.8	265	31	28	18
82.3	270	31	27	18
83.8	275	31	27	18
85.3	280	30	27	17
86.9	285	30	26	17
88.4	290	30	26	17
89.9	295	29	26	17
91.4	300	29	25	16
106.7	350	26	23	14
121.9	400	24	21	13
137.2	450	22	19	11
152.4	500	21	18	10
167.6	550	19	17	10
182.9	600	18	15	9
198.1	650	17	15	8
213.4	700	16	14	8
228.6	750	15	13	7

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
243.8	800	14	12	7
259.1	850	14	12	6
274.3	900	13	11	6
289.6	950	13	11	6
304.8	1000	12	10	6
320	1050	12	10	5
335.3	1100	11	9	5
350.5	1150	11	9	5
365.8	1200	10	9	5
381	1250	10	8	5
396.2	1300	10	8	4
411.5	1350	9	8	4
426.7	1400	9	8	4
442	1450	9	7	4
457.2	1500	9	7	4
472.4	1550	8	7	4
487.7	1600	8	7	4
502.9	1650	8	7	3
518.2	1700	8	6	3
533.4	1750	7	6	3
548.6	1800	7	6	3
563.9	1850	7	6	3

14.21 3c - Prairie Terraces

Table 14-21: Effective shade targets for stream sites in Ecoregion 3c - Prairie Terraces.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	97	98	98
0.3	1	96	97	98
0.6	2	96	97	98
0.9	3	96	97	98
1.2	4	95	96	97
1.5	5	95	96	97
1.8	6	95	95	96
2.1	7	94	95	96
2.4	8	94	94	96
2.7	9	93	94	96

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
3	10	93	94	95
4.6	15	90	91	94
6.1	20	88	89	92
7.6	25	86	86	91
9.1	30	84	83	89
10.7	35	82	81	87
12.2	40	80	78	84
13.7	45	78	76	82
15.2	50	76	73	79
16.8	55	74	71	77
18.3	60	73	70	73
19.8	65	71	68	70
21.3	70	70	66	67
22.9	75	68	65	64
24.4	80	67	63	62
25.9	85	66	62	59
27.4	90	64	61	57
29	95	63	59	55
30.5	100	62	58	53
32	105	61	57	51
33.5	110	60	56	49
35.1	115	59	55	48
36.6	120	58	54	46
38.1	125	57	53	45
39.6	130	56	52	44
41.1	135	55	51	43
42.7	140	54	50	41
44.2	145	53	49	40
45.7	150	52	48	39
47.2	155	52	47	38
48.8	160	51	47	37
50.3	165	50	46	36
51.8	170	50	45	36
53.3	175	49	45	35
54.9	180	48	44	34
56.4	185	48	43	33
57.9	190	47	43	33
59.4	195	46	42	32
61	200	46	41	31
62.5	205	45	41	31
64	210	45	40	30
65.5	215	44	40	30

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
67.1	220	44	39	29
68.6	225	43	39	28
70.1	230	43	38	28
71.6	235	42	38	27
73.2	240	42	37	27
74.7	245	41	37	27
76.2	250	41	37	26
77.7	255	40	36	26
79.2	260	40	36	25
80.8	265	39	35	25
82.3	270	39	35	25
83.8	275	39	34	24
85.3	280	38	34	24
86.9	285	38	34	23
88.4	290	37	33	23
89.9	295	37	33	23
91.4	300	37	33	23
106.7	350	33	30	20
121.9	400	31	27	18
137.2	450	29	25	16
152.4	500	27	23	15
167.6	550	25	22	13
182.9	600	23	21	13
198.1	650	22	19	12
213.4	700	21	18	11
228.6	750	20	17	10
243.8	800	19	17	10
259.1	850	18	16	9
274.3	900	17	15	9
289.6	950	17	14	8
304.8	1000	16	14	8
320	1050	15	13	8
335.3	1100	15	13	7
350.5	1150	14	12	7
365.8	1200	14	12	7
381	1250	13	12	6
396.2	1300	13	11	6
411.5	1350	13	11	6
426.7	1400	12	11	6
442	1450	12	10	6
457.2	1500	12	10	5
472.4	1550	11	10	5

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
487.7	1600	11	9	5
502.9	1650	11	9	5
518.2	1700	10	9	5
533.4	1750	10	9	5
548.6	1800	10	8	5
563.9	1850	10	8	5

14.22 3d - Valley Foothills

Table 14-22: Effective shade targets for stream sites in Ecoregion 3d - Valley Foothills.

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
0.2	0.5	96	98	98
0.3	1	96	97	98
0.6	2	95	96	98
0.9	3	95	96	97
1.2	4	95	96	97
1.5	5	95	95	96
1.8	6	94	95	96
2.1	7	93	94	96
2.4	8	93	94	96
2.7	9	93	93	95
3	10	92	93	95
4.6	15	90	90	93
6.1	20	87	88	91
7.6	25	85	85	89
9.1	30	82	82	87
10.7	35	80	79	85
12.2	40	78	76	82
13.7	45	76	73	80
15.2	50	74	71	77
16.8	55	72	69	73
18.3	60	71	67	70
19.8	65	69	66	66
21.3	70	67	64	63
22.9	75	66	62	60
24.4	80	65	61	58
25.9	85	63	59	55

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
27.4	90	62	58	53
29	95	61	57	51
30.5	100	59	56	49
32	105	58	54	48
33.5	110	57	53	46
35.1	115	56	52	44
36.6	120	55	51	43
38.1	125	54	50	42
39.6	130	53	49	40
41.1	135	52	48	39
42.7	140	52	47	38
44.2	145	51	46	37
45.7	150	50	46	36
47.2	155	49	45	35
48.8	160	48	44	34
50.3	165	48	43	34
51.8	170	47	43	33
53.3	175	46	42	32
54.9	180	46	41	31
56.4	185	45	41	31
57.9	190	44	40	30
59.4	195	44	40	29
61	200	43	39	29
62.5	205	43	38	28
64	210	42	38	28
65.5	215	42	37	27
67.1	220	41	37	27
68.6	225	41	36	26
70.1	230	40	36	26
71.6	235	40	36	25
73.2	240	39	35	25
74.7	245	39	35	24
76.2	250	38	34	24
77.7	255	38	34	24
79.2	260	37	33	23
80.8	265	37	33	23
82.3	270	37	33	22
83.8	275	36	32	22
85.3	280	36	32	22
86.9	285	35	32	21
88.4	290	35	31	21
89.9	295	35	31	21

Active Channel Width (m)	Active Channel Width (feet)	Effective Shade Target for E-W Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for N-S Stream Aspects (%)
91.4	300	34	31	21
106.7	350	31	28	18
121.9	400	29	25	16
137.2	450	27	23	15
152.4	500	25	22	13
167.6	550	23	20	12
182.9	600	22	19	11
198.1	650	21	18	11
213.4	700	19	17	10
228.6	750	19	16	9
243.8	800	18	15	9
259.1	850	17	15	8
274.3	900	16	14	8
289.6	950	15	13	8
304.8	1000	15	13	7
320	1050	14	12	7
335.3	1100	14	12	7
350.5	1150	13	11	6
365.8	1200	13	11	6
381	1250	12	11	6
396.2	1300	12	10	6
411.5	1350	12	10	5
426.7	1400	11	10	5
442	1450	11	9	5
457.2	1500	11	9	5
472.4	1550	10	9	5
487.7	1600	10	9	5
502.9	1650	10	8	5
518.2	1700	10	8	4
533.4	1750	9	8	4
548.6	1800	9	8	4
563.9	1850	9	8	4