Total Maximum Daily Loads for the Willamette Subbasins

Temperature

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State of Oregon
Department of Environmental Quality

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Acronyms

7DADM	7-Day Average Daily Maximum
7Q10	7-Day, 10-Year Low Flow
ADWDF	Average Dry Weather Design Flow
AU	Assessment Unit
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
DEQ	Oregon Department of Environmental Quality
DMA	Designated Management Agency
DMR	Discharge Monitoring Report
EPA	Environmental Protection Agency
EQC	Oregon Environmental Quality Commission
EWEB	Eugene Water and Electric Board
GNIS	USGS Geographic Names Information System
HUA	Human Use Allowance
HUC	Hydrologic Unit Code
IMD	Internal Management Directive
LA	Load Allocation
LC	Loading Capacity
MGD	Millions of Gallons per Day
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
OAR	Oregon Administrative Rules
ODC	Oregon Department of Corrections
ODFW	Oregon Department of Fish & Wildlife
ORS	Oregon Revised Statutes
POMI	Point of Maximum Impact
SIC	Standard Industrial Classification
STP	Sewage Treatment Plant
TMDL	Total Maximum Daily Load
TSD	Technical Support Document
USGS	United States Geological Survey
WLA	Wasteload Allocation
WQMP	Water Quality Management Plan
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

1 Introduction

This Total Maximum Daily Load (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 was adopted by reference in Oregon Administrative Rules OAR 340-42-0090.

OAR 340-42-0040(3) requires the Oregon Department of Environmental Quality (DEQ) or the Oregon Environmental Quality Commission (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 (EPA) 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 Water Quality Management Plan (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 DEQ'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 was adopted by EQC, 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, WQMP, Technical Support Document (TSD) (DEQ, 2023a and 2023b), 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. A public comment period was held from January 10 through March 15, 2024. DEQ held a public hearing on February 16, 2024. DEQ considered all input received during these public participation opportunities and used input to guide the analyses and preparation of documents. DEQ developed a response to comments that is available online.

2 TMDL name and location

Per OAR 340-042-0040(4)(a), this element describes the geographic area for which the TMDL was developed.

The Willamette Subbasins comprise ten 8-digit hydrologic unit code (HUC) subbasins, including 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**). Waters excluded from the Willamette Subbasins TMDLs (**Table 2-2**) include the Willamette River, Multnomah Channel, and tributaries to the Willamette River downstream of the following dams: River Mill Dam, Detroit Dam, Foster Dam, Fern Ridge Dam, Dexter Dam, Fall Creek Dam, and Cottage Grove Dam.

Temperature TMDLs for the Willamette Subbasins address all Category 5 listed assessment units (AUs) impaired for temperature on Oregon’s 2022 Section 303(d) list (**Table 2-3** through **Table 2-12**) and, as applicable, any AUs identified as temperature impaired in the future. Likewise, this TMDL includes a protection plan for all other assessment categories, including AUs identified as a potential concern, attaining, or unassessed.

The loading capacity, allocations, surrogate measures, and implementation framework apply to all waters in the Willamette Subbasins determined to be waters of the state as defined under Oregon Revised Statutes ORS 468B.005(10), including all perennial and intermittent streams that have surface flow or residual pools during the TMDL allocation period.

The TMDL implementation framework is presented in the Willamette Subbasins TMDL WQMP 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.

The map in **Figure 2-1** provides an overview of where the temperature TMDLs are applicable. Appendix D of the Willamette Subbasin TSD provides a list of all AUs addressed by the TMDL.

Table 2-1: HUC8 codes and names in the Willamette Subbasins.

HUC8	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

Table 2-2: Waters not addressed by the Willamette Subbasins Temperature TMDLs.

Waterbody	Extent
Willamette River	From the confluence of the Columbia River upstream to the confluence of Coast Fork of the Willamette and Middle Fork of the Willamette Rivers.
Multnomah Channel	From the confluence of the Columbia River upstream to the Willamette River.
Clackamas River	From the confluence with the Willamette River upstream to River Mill Dam.
Santiam River	From the confluence with the Willamette River upstream to the confluence of the North and South Santiam Rivers.
North Santiam River	From the confluence with the Santiam River upstream to Detroit Dam.
South Santiam River	From the confluence with the Santiam River upstream to Foster Dam.
Long Tom River	From the confluence with the Willamette River upstream to Fern Ridge Dam.
Middle Fork Willamette River	From the confluence with the Willamette River upstream to Dexter Dam.
Fall Creek	From the confluence with the Middle Fork Willamette River upstream to Fall Creek Dam.
Coast Fork Willamette River	From the confluence with the Willamette River upstream to Cottage Grove Dam.
Row River	From the confluence with the Coast Fork Willamette River upstream to Dorena Dam.

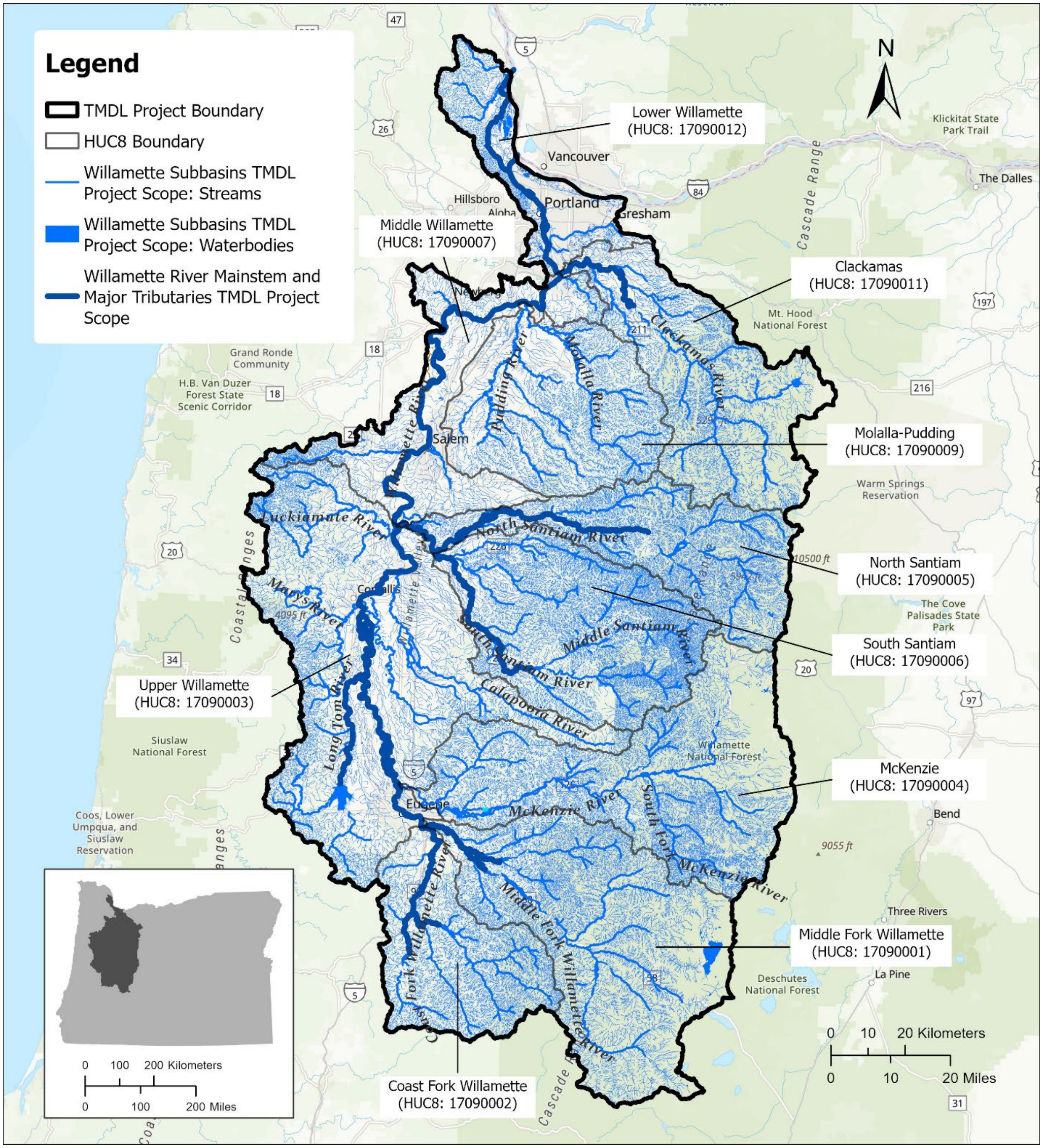

Figure 2-1: Willamette Subbasins temperature TMDLs project area overview.

Table 2-3 through **Table 2-12** present stream AUs 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. AUs listed in Category 5 (i.e., 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 2-3: Middle Fork Willamette Subbasin (17090001) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_SR_1709000106_02_103722	Christy Creek	Spawning
OR_SR_1709000109_02_103736	Fall Creek	Year Round
OR_SR_1709000109_02_103736	Fall Creek	Spawning
OR_SR_1709000109_02_103737	Fall Creek	Year Round
OR_SR_1709000109_02_103737	Fall Creek	Spawning
OR_SR_1709000109_02_103743	Fall Creek	Year Round
OR_SR_1709000109_02_103743	Fall Creek	Spawning
OR_LK_1709000109_02_100701	Fall Creek Lake	Year Round
OR_SR_1709000109_02_103734	Hehe Creek	Year Round
OR_SR_1709000102_02_103715	Hills Creek	Year Round
OR_SR_1709000102_02_103715	Hills Creek	Spawning
OR_SR_1709000110_02_103749	Hills Creek	Year Round
OR_WS_170900010904_02_104219	HUC12 Name: Andy Creek-Fall Creek	Year Round
OR_WS_170900010502_02_104200	HUC12 Name: Buck Creek-Middle Fork Willamette River	Year Round
OR_WS_170900010501_02_104199	HUC12 Name: Coal Creek	Year Round
OR_WS_170900010608_02_104210	HUC12 Name: Dartmouth Creek-North Fork Middle Fork Willamette River	Year Round
OR_WS_170900010701_02_104211	HUC12 Name: Deception Creek-Middle Fork Willamette River	Year Round
OR_WS_170900010901_02_104216	HUC12 Name: Delp Creek-Fall Creek	Year Round
OR_WS_170900010703_02_104213	HUC12 Name: Dexter Reservoir-Middle Fork Willamette River	Year Round
OR_WS_170900010106_02_104190	HUC12 Name: Echo Creek-Middle Fork Willamette River	Year Round
OR_WS_170900010607_02_104209	HUC12 Name: Eighth Creek-North Fork Middle Fork Willamette River	Year Round
OR_WS_170900010505_02_104202	HUC12 Name: Gray Creek-Middle Fork Willamette River	Year Round
OR_WS_170900010702_02_104212	HUC12 Name: Lost Creek	Year Round
OR_WS_170900010202_02_104192	HUC12 Name: Lower Hills Creek	Year Round
OR_WS_170900010403_02_104198	HUC12 Name: Lower Salmon Creek	Year Round
OR_WS_170900010303_02_104195	HUC12 Name: Lower Salt Creek	Spawning
OR_WS_170900010303_02_104195	HUC12 Name: Lower Salt Creek	Year Round
OR_WS_170900010302_02_104194	HUC12 Name: Middle Salt Creek	Year Round
OR_WS_170900010503_02_104201	HUC12 Name: Packard Creek-Middle Fork Willamette	Year Round
OR_WS_170900010105_02_104189	HUC12 Name: Staley Creek	Year Round
OR_WS_170900010102_02_104186	HUC12 Name: Tumblebug Creek	Year Round
OR_WS_170900010402_02_104197	HUC12 Name: Upper Salmon Creek	Year Round
OR_WS_170900010905_02_104220	HUC12 Name: Winberry Creek	Year Round
OR_SR_1709000108_02_103730	Little Fall Creek	Year Round
OR_SR_1709000108_02_103730	Little Fall Creek	Spawning
OR_SR_1709000109_02_103742	Logan Creek	Year Round
OR_SR_1709000107_02_103727	Lost Creek	Year Round
OR_SR_1709000107_02_103727	Lost Creek	Spawning
OR_SR_1709000107_02_103728	Lost Creek	Year Round
OR_SR_1709000107_02_103728	Lost Creek	Spawning
OR_SR_1709000101_02_103713	Middle Fork Willamette River	Year Round
OR_SR_1709000105_02_104579	Middle Fork Willamette River	Year Round
OR_SR_1709000105_02_104580	Middle Fork Willamette River	Year Round
OR_SR_1709000105_02_104580	Middle Fork Willamette River	Spawning
OR_SR_1709000107_02_103725	Middle Fork Willamette River	Year Round
OR_SR_1709000107_02_103725	Middle Fork Willamette River	Spawning
OR_SR_1709000106_02_103721	North Fork Middle Fork Willamette River	Year Round
OR_SR_1709000106_02_103721	North Fork Middle Fork Willamette River	Spawning

AU ID	AU Name	Use Period
OR_SR_1709000106_02_103723	North Fork Middle Fork Willamette River	Year Round
OR_SR_1709000109_02_103738	North Fork Winberry Creek	Year Round
OR_LK_1709000105_02_100684	Packard Creek	Year Round
OR_SR_1709000105_02_104578	Packard Creek	Year Round
OR_SR_1709000109_02_103741	Portland Creek	Year Round
OR_SR_1709000109_02_103744	Portland Creek	Year Round
OR_SR_1709000104_02_103719	Salmon Creek	Year Round
OR_SR_1709000104_02_103719	Salmon Creek	Spawning
OR_SR_1709000103_02_103716	Salt Creek	Year Round
OR_SR_1709000103_02_103716	Salt Creek	Spawning
OR_SR_1709000109_02_103745	South Fork Winberry Creek	Year Round
OR_SR_1709000109_02_103747	Winberry Creek	Year Round
OR_SR_1709000109_02_103747	Winberry Creek	Spawning

Table 2-4: Coast Fork Willamette Subbasin (17090002) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_SR_1709000202_02_103771	Brice Creek	Year Round
OR_SR_1709000203_02_104586	Coast Fork Willamette River	Year Round
OR_LK_1709000202_02_100705	Dorena Lake	Year Round
OR_WS_170900020401_02_104238	HUC12 Name: Hill Creek-Coast Fork Willamette River	Year Round
OR_WS_170900020204_02_104230	HUC12 Name: King Creek-Row River	Year Round
OR_WS_170900020203_02_104229	HUC12 Name: Sharps Creek	Year Round
OR_SR_1709000202_02_103765	Layng Creek	Year Round
OR_SR_1709000202_02_103756	Martin Creek	Year Round
OR_SR_1709000201_02_103752	Mosby Creek	Year Round
OR_SR_1709000201_02_103752	Mosby Creek	Spawning
OR_SR_1709000202_02_103761	Row River	Year Round
OR_SR_1709000202_02_103766	Row River	Year Round
OR_SR_1709000202_02_103755	Sharps Creek	Year Round
OR_SR_1709000202_02_103775	Sharps Creek	Year Round
OR_SR_1709000202_02_103776	Sharps Creek	Year Round

Table 2-5: Upper Willamette Subbasin (17090003) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_SR_1709000303_02_103815	Calapooia River	Year Round
OR_SR_1709000303_02_103815	Calapooia River	Spawning
OR_SR_1709000303_02_103816	Calapooia River	Year Round
OR_SR_1709000303_02_103816	Calapooia River	Spawning
OR_SR_1709000304_02_103821	Calapooia River	Year Round
OR_SR_1709000303_02_103819	Courtney Creek	Year Round
OR_SR_1709000301_02_103796	Coyote Creek	Year Round
OR_SR_1709000301_02_103790	Ferguson Creek	Year Round
OR_WS_170900030109_02_104251	HUC12 Name: Bear Creek-Long Tom River	Year Round
OR_WS_170900030510_02_104284	HUC12 Name: Berry Creek	Year Round
OR_WS_170900030302_02_104265	HUC12 Name: Bigs Creek-Calapooia River	Year Round
OR_WS_170900030603_02_104290	HUC12 Name: Flat Creek	Year Round
OR_WS_170900030204_02_104256	HUC12 Name: Greasy Creek	Year Round
OR_WS_170900030301_02_104264	HUC12 Name: Hands Creek-Calapooia River	Spawning
OR_WS_170900030301_02_104264	HUC12 Name: Hands Creek-Calapooia River	Year Round
OR_WS_170900030505_02_104279	HUC12 Name: Jont Creek-Luckiamute River	Year Round
OR_WS_170900030402_02_104273	HUC12 Name: Lower Oak Creek	Year Round
OR_WS_170900030503_02_104277	HUC12 Name: Maxfield Creek-Luckiamute River	Year Round
OR_WS_170900030504_02_104278	HUC12 Name: Pedee Creek-Luckiamute River	Year Round
OR_SR_1709000305_02_103822	Little Luckiamute River	Year Round
OR_SR_1709000305_02_103829	Luckiamute River	Year Round

AU ID	AU Name	Use Period
OR_SR_1709000302_02_103804	Marys River	Year Round
OR_SR_1709000302_02_103812	Marys River	Year Round
OR_SR_1709000302_02_103813	Marys River	Year Round
OR_SR_1709000305_02_103825	Miller Creek	Year Round
OR_SR_1709000302_02_103806	Muddy Creek	Year Round
OR_SR_1709000306_02_103838	Muddy Creek	Year Round
OR_SR_1709000305_02_103828	North Fork Pedee Creek	Year Round
OR_SR_1709000305_02_103833	Ritner Creek	Year Round
OR_SR_1709000305_02_103832	Soap Creek	Year Round
OR_SR_1709000305_02_103824	Teal Creek	Year Round

Table 2-6: McKenzie Subbasin (17090004) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_SR_1709000403_02_103865	Augusta Creek	Year Round
OR_SR_1709000407_02_103889	Camp Creek	Year Round
OR_SR_1709000407_02_103889	Camp Creek	Spawning
OR_SR_1709000406_02_103875	Cartwright Creek	Year Round
OR_SR_1709000406_02_103875	Cartwright Creek	Spawning
OR_SR_1709000407_02_103891	Cedar Creek	Year Round
OR_SR_1709000407_02_103891	Cedar Creek	Spawning
OR_SR_1709000407_02_103882	Deer Creek	Year Round
OR_SR_1709000407_02_103882	Deer Creek	Spawning
OR_SR_1709000403_02_103862	French Pete Creek	Year Round
OR_SR_1709000401_02_103855	Horse Creek	Year Round
OR_SR_1709000401_02_103856	Horse Creek	Year Round
OR_WS_170900040206_02_104310	HUC12 Name: Boulder Creek-McKenzie River	Year Round
OR_WS_170900040705_02_104336	HUC12 Name: Camp Creek	Year Round
OR_WS_170900040205_02_104309	HUC12 Name: Deer Creek	Year Round
OR_WS_170900040702_02_104333	HUC12 Name: East Fork Deer Creek-McKenzie River	Spawning
OR_WS_170900040702_02_104333	HUC12 Name: East Fork Deer Creek-McKenzie River	Year Round
OR_WS_170900040502_02_104326	HUC12 Name: Elk Creek-McKenzie River	Spawning
OR_WS_170900040502_02_104326	HUC12 Name: Elk Creek-McKenzie River	Year Round
OR_WS_170900040209_02_104313	HUC12 Name: Florence Creek-McKenzie River	Year Round
OR_WS_170900040202_02_104306	HUC12 Name: Hackleman Creek-McKenzie River	Year Round
OR_WS_170900040601_02_104327	HUC12 Name: Headwaters Mohawk River	Year Round
OR_WS_170900040204_02_104308	HUC12 Name: Kink Creek-McKenzie River	Year Round
OR_WS_170900040403_02_104324	HUC12 Name: Lower Blue River	Year Round
OR_WS_170900040105_02_104304	HUC12 Name: Lower Horse Creek	Year Round
OR_WS_170900040104_02_104303	HUC12 Name: Middle Horse Creek	Year Round
OR_WS_170900040304_02_104317	HUC12 Name: Rebel Creek-South Fork McKenzie River	Year Round
OR_WS_170900040602_02_104328	HUC12 Name: Shotgun Creek-Mohawk River	Year Round
OR_WS_170900040203_02_104307	HUC12 Name: Smith River	Year Round
OR_WS_170900040402_02_104323	HUC12 Name: Upper Blue River	Year Round
OR_SR_1709000404_02_104571	Lookout Creek	Year Round
OR_SR_1709000404_02_104569	Lower Blue River	Year Round
OR_SR_1709000404_02_104569	Lower Blue River	Spawning
OR_SR_1709000406_02_103879	McGowan Creek	Year Round
OR_SR_1709000406_02_103879	McGowan Creek	Spawning
OR_SR_1709000405_02_103866	McKenzie River	Year Round
OR_SR_1709000405_02_103866	McKenzie River	Spawning
OR_SR_1709000407_02_103884	McKenzie River	Year Round
OR_SR_1709000407_02_103884	McKenzie River	Spawning
OR_SR_1709000406_02_103873	Mill Creek	Year Round
OR_SR_1709000406_02_103874	Mill Creek	Year Round
OR_SR_1709000406_02_103870	Mohawk River	Year Round

AU ID	AU Name	Use Period
OR_SR_1709000406_02_103870	Mohawk River	Spawning
OR_SR_1709000406_02_103871	Mohawk River	Year Round
OR_SR_1709000406_02_103871	Mohawk River	Spawning
OR_SR_1709000406_02_103877	Mohawk River	Year Round
OR_SR_1709000406_02_103877	Mohawk River	Spawning
OR_SR_1709000405_02_103867	Quartz Creek	Year Round
OR_SR_1709000404_02_104576	Quentin Creek	Year Round
OR_SR_1709000406_02_103872	Shotgun Creek	Year Round
OR_SR_1709000403_02_104590	South Fork McKenzie River	Year Round
OR_SR_1709000403_02_104590	South Fork McKenzie River	Spawning
OR_SR_1709000404_02_104574	Upper Blue River	Year Round
OR_SR_1709000404_02_104577	Upper Blue River	Year Round

Table 2-7: North Santiam Subbasin (17090005) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_SR_1709000506_02_103928	Bear Branch	Year Round
OR_SR_1709000503_02_103907	Blowout Creek	Year Round
OR_SR_1709000503_02_103909	Blowout Creek	Year Round
OR_SR_1709000502_02_103902	Boulder Creek	Year Round
OR_SR_1709000506_02_103926	Chehulpum Creek	Year Round
OR_SR_1709000505_02_103923	Elkhorn Creek	Year Round
OR_WS_170900050602_02_104360	HUC12 Name: Bear Branch-North Santiam River	Year Round
OR_WS_170900050203_02_104345	HUC12 Name: Marion Creek	Year Round
OR_WS_170900050603_02_104361	HUC12 Name: Marion Creek-North Santiam River	Spawning
OR_WS_170900050603_02_104361	HUC12 Name: Marion Creek-North Santiam River	Year Round
OR_WS_170900050504_02_104563	HUC12 Name: Middle Little North Santiam River	Year Round
OR_WS_170900050301_02_104351	HUC12 Name: Upper Blowout Creek	Year Round
OR_WS_170900050503_02_104567	HUC12 Name: Upper Little North Santiam River	Year Round
OR_SR_1709000505_02_104564	Little North Santiam River	Year Round
OR_SR_1709000505_02_104564	Little North Santiam River	Spawning
OR_SR_1709000506_02_103929	Stout Creek	Year Round

Table 2-8: South Santiam Subbasin (17090006) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_SR_1709000606_02_103973	Beaver Creek	Year Round
OR_SR_1709000607_02_103986	Bilyeu Creek	Year Round
OR_SR_1709000607_02_103989	Bilyeu Creek	Year Round
OR_SR_1709000602_02_103949	Canyon Creek	Year Round
OR_SR_1709000606_02_103978	Crabtree Creek	Year Round
OR_SR_1709000606_02_103978	Crabtree Creek	Spawning
OR_LK_1709000604_02_100772	Foster Lake	Year Round
OR_LK_1709000603_02_100771	Green Peter Lake	Year Round
OR_SR_1709000608_02_103993	Hamilton Creek	Year Round
OR_SR_1709000608_02_103993	Hamilton Creek	Spawning
OR_SR_1709000608_02_103996	Hamilton Creek	Year Round
OR_SR_1709000608_02_103996	Hamilton Creek	Spawning
OR_WS_170900060804_02_104398	HUC12 Name: Hamilton Creek	Year Round
OR_WS_170900060501_02_104384	HUC12 Name: Little Wiley Creek	Year Round
OR_WS_170900060705_02_104394	HUC12 Name: Lower Thomas Creek	Year Round
OR_SR_1709000602_02_103955	Latiwi Creek	Year Round
OR_SR_1709000608_02_103994	McDowell Creek	Year Round
OR_SR_1709000601_02_103934	Middle Santiam River	Year Round
OR_SR_1709000601_02_103936	Middle Santiam River	Year Round
OR_SR_1709000601_02_103938	Middle Santiam River	Year Round
OR_SR_1709000603_02_103965	Middle Santiam River	Year Round

AU ID	AU Name	Use Period
OR_SR_1709000604_02_103969	Middle Santiam River	Spawning
OR_SR_1709000602_02_103954	Moose Creek	Year Round
OR_SR_1709000602_02_103954	Moose Creek	Spawning
OR_SR_1709000602_02_103941	Owl Creek	Year Round
OR_SR_1709000601_02_103935	Pyramid Creek	Year Round
OR_SR_1709000603_02_103957	Quartzville Creek	Year Round
OR_SR_1709000603_02_103960	Quartzville Creek	Year Round
OR_SR_1709000608_02_103997	Scott Creek	Year Round
OR_SR_1709000602_02_103953	Sheep Creek	Year Round
OR_SR_1709000602_02_103947	Soda Fork	Year Round
OR_SR_1709000607_02_103985	South Fork Neal Creek	Year Round
OR_SR_1709000602_02_103950	South Santiam River	Year Round
OR_SR_1709000602_02_103950	South Santiam River	Spawning
OR_SR_1709000604_02_103968	South Santiam River	Year Round
OR_SR_1709000604_02_103968	South Santiam River	Spawning
OR_SR_1709000607_02_103988	Thomas Creek	Year Round
OR_SR_1709000607_02_103991	Thomas Creek	Year Round
OR_SR_1709000607_02_103991	Thomas Creek	Spawning
OR_SR_1709000602_02_103942	Trout Creek	Year Round
OR_SR_1709000602_02_103948	Two Girls Creek	Year Round
OR_SR_1709000605_02_103971	Wiley Creek	Year Round
OR_SR_1709000605_02_103971	Wiley Creek	Spawning
OR_SR_1709000605_02_103972	Wiley Creek	Year Round
OR_SR_1709000605_02_103972	Wiley Creek	Spawning

Table 2-9: Middle Willamette Subbasin (17090007) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_SR_1709000704_02_104017	Abernethy Creek	Year Round
OR_SR_1709000704_02_104594	Abernethy Creek	Year Round
OR_WS_170900070306_02_104417	HUC12 Name: Chehalem Creek	Year Round
OR_WS_170900070301_02_104413	HUC12 Name: Croisan Creek-Willamette River	Spawning
OR_WS_170900070301_02_104413	HUC12 Name: Croisan Creek-Willamette River	Year Round
OR_WS_170900070303_02_104415	HUC12 Name: Glenn Creek-Willamette River	Year Round
OR_WS_170900070304_02_104599	HUC12 Name: Lambert Slough-Willamette River	Year Round
OR_WS_170900070204_02_104412	HUC12 Name: Lower Mill Creek	Year Round
OR_WS_170900070203_02_104411	HUC12 Name: McKinney Creek	Year Round
OR_SR_1709000703_02_104007	Mill Creek	Year Round
OR_SR_1709000703_02_104007	Mill Creek	Spawning
OR_SR_1709000703_02_104012	Pringle Creek	Year Round
OR_SR_1709000701_02_104591	Rickreall Creek	Year Round
OR_SR_1709000703_02_104008	Shelton Ditch	Year Round
OR_SR_1709000703_02_104008	Shelton Ditch	Spawning

Table 2-10: Molalla-Pudding Subbasin (17090009) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_SR_1709000901_02_104062	Abiqua Creek	Year Round
OR_SR_1709000902_02_104070	Butte Creek	Year Round
OR_SR_1709000902_02_104072	Butte Creek	Year Round
OR_SR_1709000901_02_104069	Drift Creek	Year Round
OR_SR_1709000901_02_104069	Drift Creek	Spawning
OR_WS_170900090303_02_104470	HUC12 Name: Bear Creek	Year Round
OR_WS_170900090204_02_104467	HUC12 Name: Brandy Creek-Pudding River	Year Round
OR_WS_170900090101_02_104454	HUC12 Name: Headwaters Pudding River	Year Round
OR_WS_170900090202_02_104465	HUC12 Name: Middle Butte Creek	Year Round
OR_WS_170900090403_02_104474	HUC12 Name: Pine Creek-Molalla River	Year Round

AU ID	AU Name	Use Period
OR_SR_1709000904_02_104086	Molalla River	Year Round
OR_SR_1709000904_02_104086	Molalla River	Spawning
OR_SR_1709000901_02_104067	Pudding River	Year Round
OR_SR_1709000905_02_104088	Pudding River	Year Round
OR_SR_1709000901_02_104595	Silver Creek	Year Round
OR_SR_1709000901_02_104066	South Fork Silver Creek	Year Round
OR_SR_1709000904_02_104087	Table Rock Fork	Year Round
OR_SR_1709000904_02_104087	Table Rock Fork	Spawning
OR_LK_1709000902_02_100830	Zollner Creek	Year Round

Table 2-11: Clackamas Subbasin (17090011) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_SR_1709001104_02_104154	Clackamas River	Year Round
OR_SR_1709001104_02_104154	Clackamas River	Spawning
OR_SR_1709001104_02_104155	Clackamas River	Year Round
OR_SR_1709001104_02_104155	Clackamas River	Spawning
OR_SR_1709001101_02_104142	Collawash River	Year Round
OR_SR_1709001101_02_104142	Collawash River	Spawning
OR_SR_1709001101_02_104144	Collawash River	Year Round
OR_SR_1709001105_02_104163	Eagle Creek	Year Round
OR_SR_1709001105_02_104163	Eagle Creek	Spawning
OR_SR_1709001104_02_104156	Fish Creek	Year Round
OR_SR_1709001104_02_104161	Fish Creek	Year Round
OR_SR_1709001104_02_104161	Fish Creek	Spawning
OR_WS_170900110406_02_104539	HUC12 Name: Helion Creek-Clackamas River	Year Round
OR_WS_170900110405_02_104538	HUC12 Name: North Fork Clackamas River	Year Round
OR_WS_170900110402_02_104535	HUC12 Name: Roaring River	Year Round
OR_WS_170900110607_02_104549	HUC12 Name: Rock Creek-Clackamas River	Year Round
OR_WS_170900110501_02_104540	HUC12 Name: Upper Eagle Creek	Year Round
OR_SR_1709001101_02_104145	Nohorn Creek	Year Round
OR_SR_1709001101_02_104145	Nohorn Creek	Spawning
OR_SR_1709001104_02_104152	North Fork Clackamas River	Year Round
OR_SR_1709001105_02_104165	North Fork Eagle Creek	Year Round
OR_SR_1709001104_02_104160	Roaring River	Spawning
OR_SR_1709001104_02_104157	Trout Creek	Year Round

Table 2-12: Lower Willamette Subbasin (17090012) Category 5 temperature impairments on the 2022 Integrated Report.

AU ID	AU Name	Use Period
OR_WS_170900120202_02_104555	HUC12 Name: Balch Creek-Willamette River	Year Round
OR_WS_170900120201_02_104554.1	HUC12 Name: Columbia Slough (Lower)	Year Round
OR_WS_170900120201_02_104554.2	HUC12 Name: Columbia Slough (Upper)	Year Round
OR_WS_170900120103_02_104552	HUC12 Name: Lower Johnson Creek	Spawning
OR_WS_170900120103_02_104552	HUC12 Name: Lower Johnson Creek	Year Round
OR_WS_170900120305_02_104561	HUC12 Name: Multnomah Channel	Year Round
OR_WS_170900120104_02_104553	HUC12 Name: Oswego Creek-Willamette River	Spawning
OR_WS_170900120104_02_104553	HUC12 Name: Oswego Creek-Willamette River	Year Round
OR_WS_170900120301_02_104557	HUC12 Name: South Scappoose Creek	Spawning
OR_WS_170900120101_02_104550	HUC12 Name: Upper Johnson Creek	Spawning
OR_WS_170900120101_02_104550	HUC12 Name: Upper Johnson Creek	Year Round
OR_SR_1709001201_02_104170	Johnson Creek	Year Round
OR_SR_1709001201_02_104170	Johnson Creek	Spawning
OR_SR_1709001203_02_104176	Milton Creek	Year Round
OR_SR_1709001203_02_104176	Milton Creek	Spawning
OR_SR_1709001203_02_104179	North Scappoose Creek	Year Round
OR_SR_1709001203_02_104179	North Scappoose Creek	Spawning

AU ID	AU Name	Use Period
OR_SR_1709001203_02_104180	South Scappoose Creek	Year Round
OR_SR_1709001203_02_104180	South Scappoose Creek	Spawning

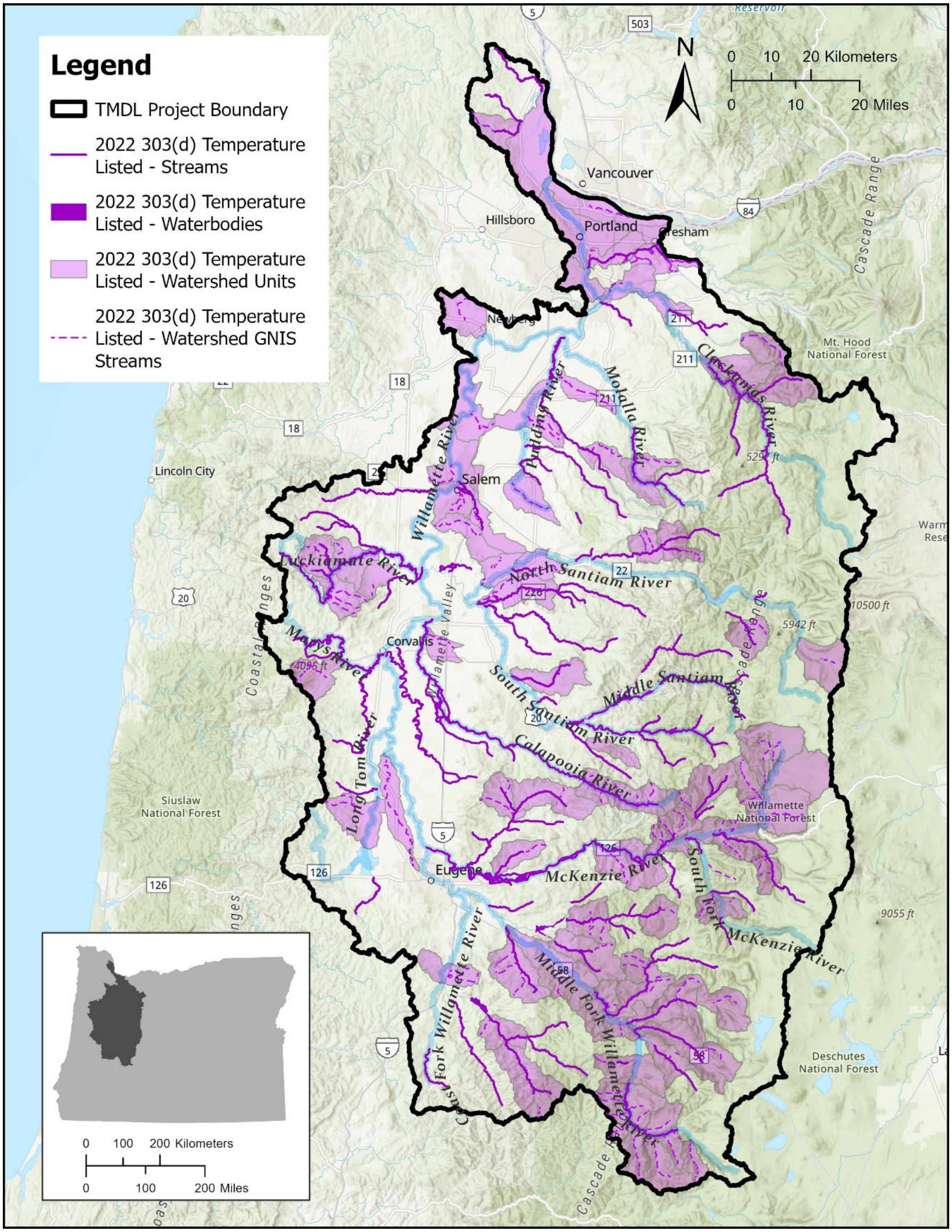

Figure 2-2: Willamette Subbasins Category 5 temperature impairments on the 2022 Integrated Report.

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

Beneficial Uses	All waterbodies
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 water temperatures, 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) (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°C (0.5°F) 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°C (48°F) or greater, and no more than a 1.0°C (1.8°F) increase when the seven-day-average stream temperature is less than 9°C.	See OAR Figures 340A and 340B (**Figure 4-1** and **Figure 4-2** in this document)	Salmonid and steelhead spawning Bull Trout spawning and juvenile rearing use

Parameter	Rule Citation	Summary of applicable standards	Waters where standards are applicable	Most sensitive beneficial use
	OAR 340-041-0028(6)	Natural lakes may not be warmed by more than 0.3°C (0.5°F) above the natural condition unless a greater increase would not reasonably be expected to adversely affect fish or other aquatic life.	Natural Lakes	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 all sources taken together at the point of maximum impact	Cold water	Salmon, steelhead or bull 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 waterbody, 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.		

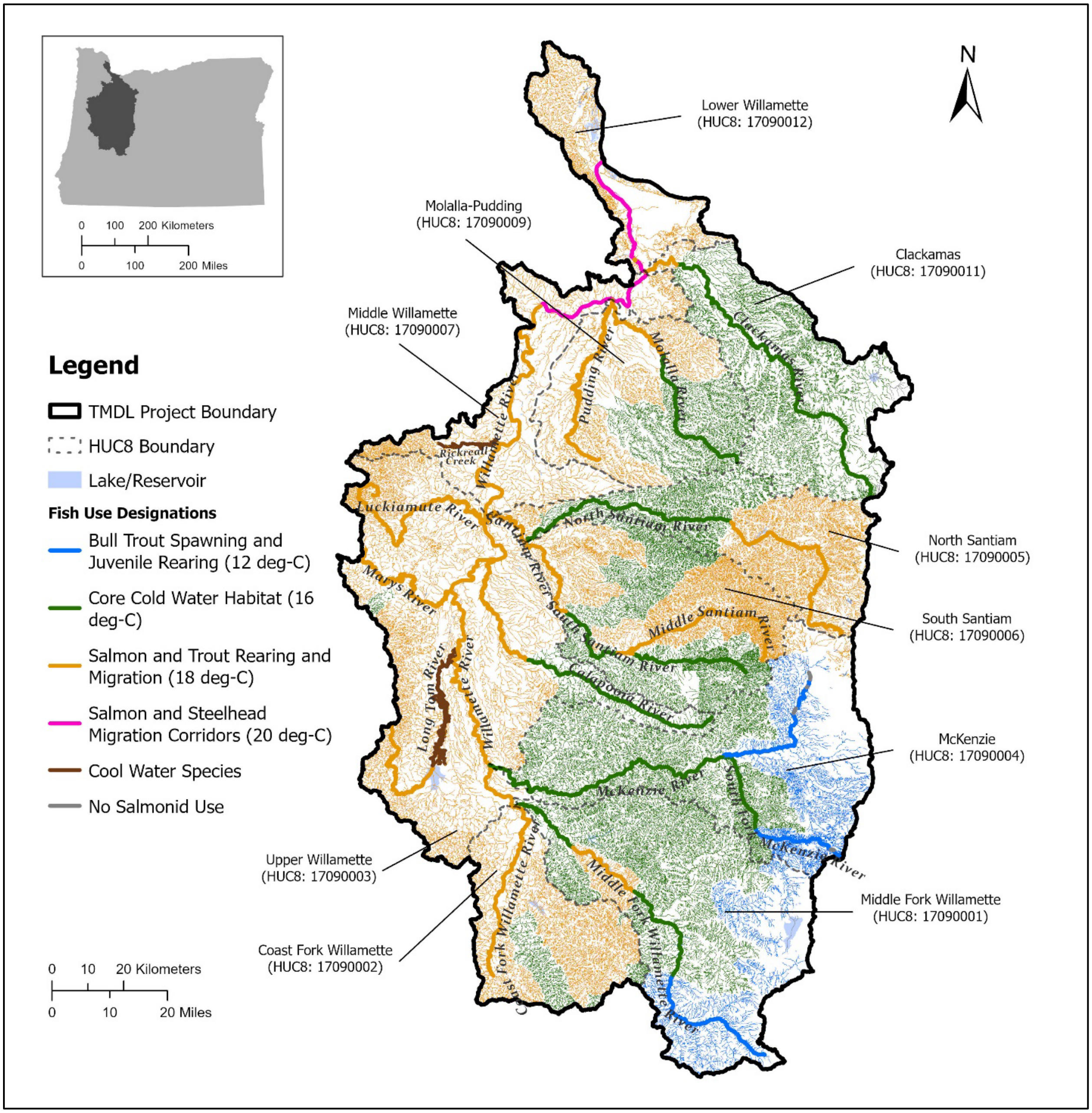

Figure 4-1: Fish use designations in the Willamette Subbasins TMDL project area.

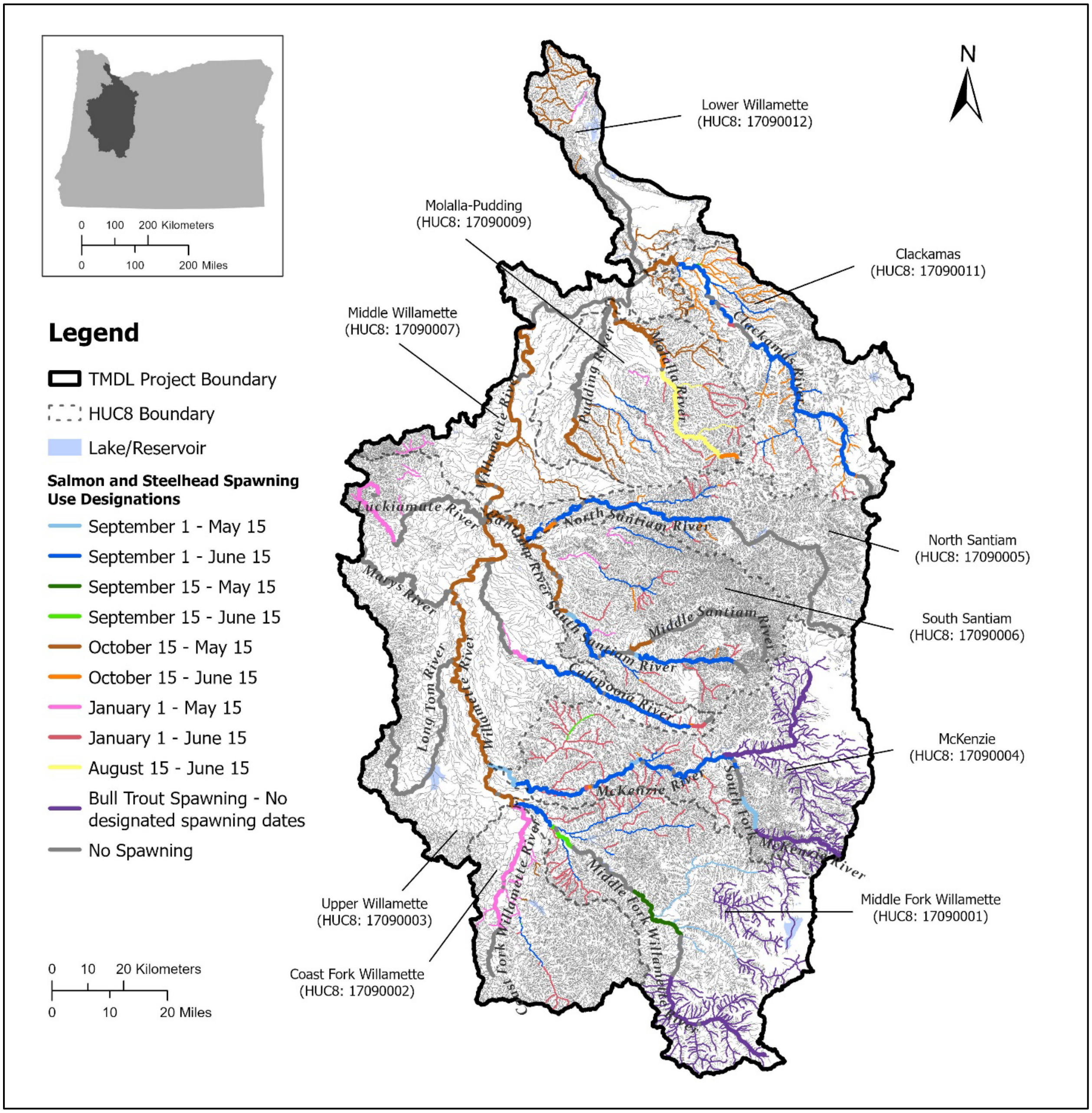

Figure 4-2: Salmon and steelhead spawning use designations in the Willamette Subbasins TMDL project area.

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 (HUA) is an insignificant addition of heat (0.3°C) authorized in waters that exceed the applicable temperature criteria. The applicable temperature criteria are defined in OAR 340-041-0002(4) to mean "the biologically based temperature criteria in OAR 340-041-0028(4), or the superseding cold water protection criteria in 340-041-0028(11)". Following a temperature TMDL, or other cumulative effects analysis, wasteload and load allocations will restrict all National Pollutant Discharge Elimination System (NPDES) point sources and nonpoint sources to a cumulative increase of no greater than 0.3°C (0.5°F) above the applicable biological criterion after complete mixing in the waterbody, and at the point of maximum impact (POMI). The rationale behind selection of 0.3°C for the HUA and how DEQ implements this portion of the standard can be found in the Staff Report to the EQC (DEQ, 2003) and DEQ's Internal Management Directive (IMD) for temperature water quality standard implementation (DEQ, 2008).

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) is the only waterbody designated for cool water species use in the Willamette Subbasins. The designation applies from the mouth at the confluence of the Willamette River (river mile 0) to the east end of Dallas City Park at approximately river mile 14. In consultation with the Oregon Department of Fish & Wildlife (ODFW), DEQ determined what cool water species are present in Rickreall Creek and translated the narrative criterion into a target temperature based on the thermal tolerance information available for those species. Prickly sculpin are the most temperature sensitive cool water species in lower Rickreall Creek with studies showing complete survival after 24 hours at 22.8°C (Black, 1953). DEQ also determined that adult winter steelhead (*Oncorhynchus mykiss*), Coho salmon, and Chinook salmon may be migrating through the lower reach of Rickreall Creek, and juvenile winter steelhead or Coastal Cutthroat trout (*Oncorhynchus clarkii*) may be rearing in lower Rickreall Creek. Based on ODFW's timing tables, steelhead may migrate through lower Rickreall Creek from February 15 through May 31. In addition, there may be resident trout present in this segment, particularly at the upper end, from October through spring. DEQ will rely upon the 18.0°C target temperature established for protection of salmon and trout rearing and migration uses suggested by EPA's guidance (EPA, 2003) and adopted in Oregon's water quality standards (OAR 340-041-0028 (4)(c)).

Based on these findings, from June 1 to September 30, where the cool water species criterion applies in Rickreall Creek, warming from anthropogenic sources shall be limited to a cumulative increase of no greater than 0.3°C above 22.8°C after complete mixing in the waterbody, and at the POMI. During the remainder of the year (October 1 – May 31), the numeric target protecting cool water fish and migrating or rearing cold water fish is an instream 7-day average daily maximum (7DADM) temperature target of 18.0°C plus an insignificant addition of heat for human use equal to 0.3°C after complete mixing in the waterbody, and at the POMI. A summary of the temperature targets are presented in **Table 4-3**.

The provisions of the protecting cold water criterion at OAR 340-41-0028(11) are also incorporated into the temperature target. If ambient 7DADM temperatures trend to always being cooler than both temperature targets presented in **Table 4-3** and all exceptions outlined in OAR 340-41-0028(11)(c) are not applicable, the protecting cold water shall be applied with the 0.3°C HUA based on an increase above the cooler ambient temperature.

Analysis and rationale for the numeric temperature targets are further described in the TMDL TSD Section 4.7.

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 lower Rickreall Creek.

Time period	7DADM Temperature Target (°C)	Most Temperature Sensitive Species
June 1 – September 30	22.8 + 0.3 HUA	Prickly sculpin (*Cottus asper*)
October 1 – May 31	18.0 + 0.3 HUA	Winter steelhead (*Oncorhynchus mykiss*)

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 7DADM 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. Maximum 7DADM temperatures downstream of some large dam and reservoir operations are shifted from July and August to September, October, and November.

The critical period is based on the frequency and period when 7DADM stream temperatures 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 and frequency 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.

The critical periods for waterbodies in the Willamette Subbasins are presented in **Table 5-1**. Allocations presented in the TMDL apply during these periods. Section 5 of the TSD summarizes the critical period approach and presents plots of 7DADM temperature data used to determine seasonal variation and the critical periods.

Table 5-1: Designated critical periods for waterbodies in the Willamette Subbasins.

HUC	Watershed or Waterbody Name	Critical Period
17090001	Middle Fork Willamette Subbasin	May 1 – October 31
170900010505	Middle Fork Willamette River from Hills Creek Dam to North Fork Middle Fork Willamette River OR_SR_1709000105_02_104580, OR_SR_1709000105_02_103720	May 1 – November 30
170900010701	Middle Fork Willamette River from North Fork Middle Fork Willamette River to Dexter Reservoir OR_SR_1709000107_02_103725	May 1 – November 15
170900010703	Lookout Point Lake OR_LK_1709000107_02_100700 Dexter Reservoir	May 1 – November 15

HUC	Watershed or Waterbody Name	Critical Period
	OR_LK_1709000107_02_100699	
17090002	Coast Fork Willamette Subbasin	May 1 – October 31
17090003	Upper Willamette Subbasin	May 1 – October 31
17090004	McKenzie River Subbasin excluding the Lower Blue River and McKenzie River Watershed	May 1 – October 31
1709000407	McKenzie River Watershed	April 1 – November 15
170900040403	Lower Blue River from Blue River Dam to McKenzie River AU: OR_SR_1709000404_02_104569	May 1 – November 15
17090005	North Santiam Subbasin	May 1 – October 31
17090006	South Santiam Subbasin excluding Middle Santiam River from Green Peter Dam to Foster Lake	May 1 – October 31
170900060402	Middle Santiam River from Green Peter Dam to Foster Lake AU: OR_SR_1709000604_02_103969	May 1 – November 30
17090007	Middle Willamette Subbasin	May 1 – October 31
17090009	Molalla-Pudding Subbasin	May 1 – October 31
17090011	Clackamas Subbasin	May 1 – October 31
17090012	Lower Willamette Subbasin excluding Johnson Creek Watershed	April 1 – October 31
1709001201	Johnson Creek Watershed	February 15 – November 15

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 the TSD model appendices.

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

1. Stream temperatures spanning months at ≤500 m longitudinal resolution.
2. Solar radiation fluxes and daily effective shade at ≤100 m longitudinal resolution.
3. Stream temperature responses due to changes in:

a. Streamside vegetation,
b. Water withdrawals and upstream tributaries' stream flow,
c. Channel morphology in the upstream catchment, and
d. Effluent temperature and flow discharge from NPDES permitted facilities.

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

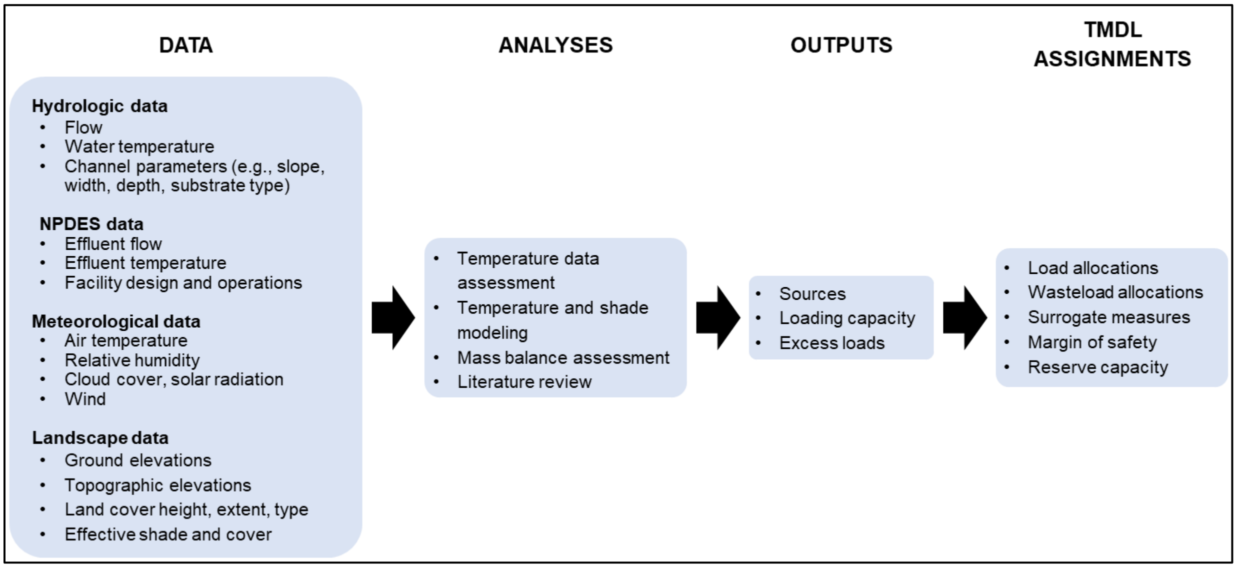

Figure 6-1: Willamette Subbasins temperature analysis overview.

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 69 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 21 individual Municipal Separate Storm Sewer System (MS4) NPDES permittees.

Portland International Airport is an individual NPDES permitted point source that only discharges stormwater during the TMDL allocation period. For this reason, Portland International Airport is included in **Table 7-2** as a facility where stormwater requirements apply.

Table 7-1: Individual NPDES permitted point source discharges that have the potential to contribute thermal loads to Willamette Subbasins streams at a frequency and magnitude to cause exceedances to the temperature standard.

Permittee	Permit type	DEQ WQ File Number	EPA Number	Receiving water name (AU ID)	River mile
Alpine Community	NPDES-DOM-Db	100101	OR0032387	Muddy Creek (OR_SR_1709000302_02_103808)	25.6
Arclin	NPDES-IW-B10	81714	OR0000892	Columbia Slough (OR_WS_170900120201_02_104554.1)	6
Arclin	NPDES-IW-B16	16037	OR0021857	Patterson Slough (OR_WS_170900030601_02_104287)	1.8
ATI Albany Operations	NPDES-IW-B08	64300	OR0001716	Oak Creek (OR_WS_170900030402_02_104273)	1.6
Aumsville STP	NPDES-DOM-Db	4475	OR0022721	Beaver Creek (OR_WS_170900070202_02_104410)	2.5
Aurora STP	NPDES-DOM-Db	110020	OR0043991	Pudding River (OR_SR_1709000905_02_104088)	8.8
Bakelite Chemicals LLC	NPDES-IW-B16	32864	OR0002101	Amazon Creek (OR_WS_170900030108_02_104250)	2.7
Bakelite Chemicals LLC	NPDES-IW-B16	32650	OR0032107	Murder Creek (OR_WS_170900030610_02_104298)	0.6
Blount Oregon Cutting Systems Division	NPDES-IW-B16	63545	OR0032298	Minthorne Creek (OR_WS_170900120102_02_104551)	0.9
Boeing Of Portland – Fabrication Division	NPDES-IW-B16	9269	OR0031828	Osburn Creek (OR_WS_170900120201_02_104554.2)	1.6
Brownsville STP	NPDES-DOM-Db	11770	OR0020079	Calapooia River (OR_SR_1709000303_02_103816)	31.6
Coburg Wastewater Treatment Plant	NPDES-DOM-Da	115851	OR0044628	Muddy Creek (OR_WS_170900030606_02_104294)	50.7
Coffin Butte Landfill	NPDES-IW-B15	104176	OR0043630	Roadside ditch to Soap Creek tributary (OR_WS_170900030511_02_104285)	4.5
Columbia Helicopters	NPDES-IW-B16	100541	OR0033391	Unnamed Stream (tributary to Pudding River) (OR_WS_170900090502_02_104481)	2
Creswell STP	NPDES-DOM-Db	20927	OR0027545	Unnames stream (tributary to Camas Swale Creek) (OR_WS_170900020403_02_104240)	4
Dallas STP	NPDES-DOM-C1a	22546	OR0020737	Rickreall Creek (OR_SR_1709000701_02_104591)	9.3
Duraflake	NPDES-IW-B20	97047	OR0000426	Murder Creek (OR_WS_170900030610_02_104298)	0.57

Permittee	Permit type	DEQ WQ File Number	EPA Number	Receiving water name (AU ID)	River mile
Estacada STP	NPDES-DOM-Da	27866	OR0020575	Clackamas River (OR_LK_1709001106_02_100850)	23.3
EWEB Carmen-Smith Trail Bridge Powerhouse	NPDES-IW-B16	28393	OR0000680	McKenzie River (OR_SR_1709000402_02_104588)	76
EWEB Carmen-Smith Carmen Powerhouse	NPDES-IW-B16	28393	OR0000680	Trail Bridge Reservoir/McKenzie River (OR_LK_1709000402_02_100742)	77
Falls City STP	NPDES-DOM-Da	28830	OR0032701	Little Luckiamute River (OR_SR_1709000305_02_103822)	12
Foster Farms	NPDES-IW-B04	97246	OR0026450	Camas Swale Creek (OR_SR_1709000204_02_103786)	3.3
Fujimi Corporation – SW Commerce Circle	NPDES-IW-B15	107178	OR0040339	Coffee Lake Creek (OR_WS_170900070402_02_104419)	1.8
Gervais STP	NPDES-DOM-Db	33060	OR0027391	Pudding River (OR_SR_1709000902_02_104073)	28.2
Halsey STP	NPDES-DOM-Db	36320	OR0022390	Muddy Creek (OR_SR_1709000306_02_103838)	23
Hubbard STP	NPDES-DOM-Da	40494	OR0020591	Mill Creek (OR_WS_170900090502_02_104481)	5.3
Hull-Oakes Lumber Co.	NPDES-IW-B19	107228	OR0038032	Oliver Creek (OR_SR_1709000302_02_103807)	4.8
International Paper – Springfield Paper Mill (Outfall 1 + Outfall 2)	NPDES-IW-B01	96244	OR0000515	McKenzie River (OR_SR_1709000407_02_103884)	8
International Paper – Springfield Paper Mill (Outfall 3)	NPDES-IW-B01	96244	OR0000515	Storm Ditch to Q Street Canal (OR_WS_170900030601_02_104287)	0
J.H. Baxter & Co., Inc.	NPDES-IW-B21	6553	OR0021911	Amazon Diversion Canal (OR_WS_170900030108_02_104250)	1.5
JLR, LLC	NPDES-IW-B05	32536	OR0001015	Pudding River (OR_SR_1709000902_02_104073)	27
Junction City STP	NPDES-DOM-Db	44509	OR0026565	Flat Creek (OR_WS_170900030603_02_104290)	9.2
Kingsford Manufacturing Company – Springfield Plant	NPDES-IW-B20	46000	OR0031330	Patterson Slough (OR_WS_170900030601_02_104287)	3.7
Knoll Terrace MHC	NPDES-DOM-Db	46990	OR0026956	Mountain View Creek (OR_WS_170900030609_02_104297)	0.4
Lakewood Utilities, Ltd	NPDES-DOM-Da	96110	OR0027570	Mill Creek (Molalla-Pudding Subbasin) (OR_WS_170900090502_02_104481 _	3.9
Lane Community College	NPDES-DOM-Db	48854	OR0026875	Russel Creek (OR_WS_170900020405_02_104242)	0.7

Permittee	Permit type	DEQ WQ File Number	EPA Number	Receiving water name (AU ID)	River mile
Lowell STP	NPDES-DOM-Da	51447	OR0020044	Dexter Reservoir 20 ft upstream of the Dexter dam penstock (OR_LK_1709000107_02_100699)	
Mcfarland Cascade Pole & Lumber Co	NPDES-IW-B21	54370	OR0031003	Storm Ditch to Amazon Creek (OR_WS_170900030108_02_104250)	1.8
Molalla STP	NPDES-DOM-Db	57613	OR0022381	Molalla River (OR_SR_1709000906_02_104093)	8.2
Mt. Angel STP	NPDES-DOM-Da	58707	OR0028762	Pudding River (OR_SR_1709000901_02_104064)	37.5
Murphy Veneer, Foster Division	NPDES-IW-B20	97070	OR0021741	Wiley Creek (OR_SR_1709000605_02_103971)	0.9
Norpac Foods – Brooks Plant No. 5	NPDES-IW-B04	84791	OR0021261	Fitzpatrick Creek (OR_WS_170900090109_02_104462)	1
Norpac Foods-Plant #1, Stayton	NPDES-IW-B04	84820	OR0001228	Salem Ditch (flows to Mill Creek) (OR_WS_170900070201_02_104409)	3.7
Oakridge STP	NPDES-DOM-Da	62886	OR0022314	Middle Fork Willamette River (OR_SR_1709000105_02_103720)	39.8
ODC – Oregon State Penitentiary	NPDES-IW-B15	109727	OR0043770	Mill Creek (Middle Willamette Subbasin) (OR_SR_1709000703_02_104007)	2.5
ODFW – Leaburg Hatchery	NPDES-IW-B17	64490	OR0027642	McKenzie River (OR_SR_1709000407_02_103884)	33.7
ODFW – Marion Forks Hatchery	NPDES-IW-B17	64495	OR0027847	Horn Creek (OR_WS_170900050203_02_104345)	0.1
ODFW – McKenzie River Hatchery	NPDES-IW-B17	64500	OR0029769	McKenzie River (OR_SR_1709000407_02_103884)	31.5
Philomath WWTP	NPDES-DOM-Db	103468	OR0032441	Marys River (OR_SR_1709000302_02_103813)	10.2
RSG Forest Products – Liberal	NPDES-IW-B19	72596	OR0021300	Unnamed ditch to Molalla River (OR_WS_170900090607_02_104488)	9.8
Sandy WWTP	NPDES-DOM-Da	78615	OR0026573	Tickle Creek (OR_WS_170900110604_02_104546)	3.1
Scio STP	NPDES-DOM-Db	79633	OR0029301	Thomas Creek (OR_SR_1709000607_02_103988)	7.2
Seneca Sawmill Company	NPDES-IW-B19	80207	OR0022985	Ditch to A-1 Amazon Channel (OR_WS_170900030108_02_104250)	7.0
SFPP, L.P.	NPDES-IW-B15	103159	OR0044661	Unnamed tributary to Flat Creek (OR_WS_170900030603_02_104290)	7.9
Sherman Bros. Trucking	NPDES-DOM-Db	36646	OR0021954	Little Muddy Creek (OR_SR_1709000306_02_103838)	8
Silverton STP	NPDES-DOM-C1a	81395	OR0020656	Silver Creek (OR_SR_1709000901_02_104595)	2.4
Sunstone Circuits	NPDES-IW-B15	26788	OR0031127	Milk Creek (OR_SR_1709000906_02_104091)	5.3
Tangent STP	NPDES-DOM-Db	87425	OR0031917	Calapooia River (OR_SR_1709000304_02_103821)	10.8
Timberlake STP	NPDES-DOM-Da	90948	OR0023167	Clackamas River (OR_SR_1709001104_02_104155)	51.1

Permittee	Permit type	DEQ WQ File Number	EPA Number	Receiving water name (AU ID)	River mile
U.S. Army Corp of Engineers Cougar Project	NPDES-DOM-Da	126712	Not Assigned	South Fork McKenzie River (OR_SR_1709000403_02_104590)	4.5
U.S. Army Corp of Engineers Detroit Project	NPDES-DOM-Da	126716	Not Assigned	Big Cliff Reservoir (OR_LK_1709000503_02_100770)	0
U.S. Army Corp of Engineers Green Peter Project	NPDES-DOM-Da	126717	Not Assigned	Middle Santiam River (OR_SR_1709000604_02_103969)	5.3
U.S. Army Corp of Engineers Hills Creek Project	NPDES-DOM-Da	126699	Not Assigned	Middle Fork Willamette River (OR_SR_1709000105_02_104580)	44.3
U.S. Army Corp of Engineers Lookout Point Project	NPDES-DOM-Da	126700	Not Assigned	Dexter Reservoir (OR_LK_1709000107_02_100699)	0
USFW – Eagle Creek National Fish Hatchery	NPDES-IW-B17	91035	OR0000710	Eagle Creek (OR_SR_1709001105_02_104162)	12.3
Veneta STP	NPDES-DOM-Db	92762	OR0020532	Long Tom River (OR_SR_1709000301_02_103789)	34.9
WES (Boring STP)	NPDES-DOM-Db	16592	OR0031399	North Fork Deep Creek (OR_WS_170900110605_02_104547)	3
Westfir STP	NPDES-DOM-Da	94805	OR0028282	Nork Fork Middle Fork Willamette River (OR_SR_1709000106_02_103721)	1
Willamette Leadership Academy	NPDES-DOM-Db	34040	OR0027235	Wild Hog Creek (OR_WS_170900020405_02_104242)	2
Woodburn WWTP	NPDES-DOM-C1a	98815	OR0020001	Pudding River (OR_SR_1709000902_02_104073)	21.4

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	NPDES-DOM-MS4-1	108919	ORS108919
ODOT	NPDES-DOM-MS4-1	110870	ORS110870
Multnomah County	NPDES-DOM-MS4-1	120542	ORS120542
Portland International Airport	NPDES-IW-B15	107220	OR0040291

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
- 200-J
- 300-J

There are twelve registrants of the 100-J, ten registrants of the 200-J, and two 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.

DEQ completed a review of published literature and other studies related to stormwater runoff and stream temperature in Oregon (see TSD Section 7.1.2) and concluded that stormwater discharges authorized under the current municipal (MS4), construction (1200-C) and industrial (1200-A and 1200-Z) general stormwater permits are unlikely to contribute to exceedances of the temperature standard. Therefore, no additional TMDL requirements are needed for stormwater sources to control temperature, other than those included in the current permit. More specific wasteload allocations can be considered if subsequent data and evaluation demonstrates a need and if reserve capacity is available.

Table 7-3: General NPDES permit registrants that have the potential to contribute thermal loads to Willamette Subbasins streams at a frequency and magnitude to cause exceedances to the temperature standard.

Registrant	General Permit	DEQ WQ File Number	EPA Number	Receiving water name (AU ID)	River mile
Americold Logistics, LLC	100-J	87663	ORG253544	Claggett Creek (OR_WS_170900070303_02_104415)	4.9
EWEB Leaburg	100-J	28391	ORG253525	Leaburg Canal (OR_SR_1709000407_02_103884)	34
EWEB Walterville	100-J	28395	ORG253526	Walterville Canal (OR_SR_1709000407_02_103884)	21
First Premier Properties - Spinnaker II Office Building	100-J	110603	ORG253511	Stone Quarry Lake (OR_LK_1709000703_02_100809)	0.8
Forrest Paint Co.	100-J	100684	ORG253508	Amazon Creek (OR_WS_170900030106_02_104248)	17.0
Holiday Plaza	100-J	108298	ORG253504	Stone Quarry Lake (OR_LK_1709000703_02_100809)	0.2
Malarkey Roofing	100-J	52638	ORG250024	Columbia Slough (OR_WS_170900120201_02_104554.1)	5.9
Miller Paint Company	100-J	103774	ORG250040	Columbia Slough OR_WS_170900120201_02_104554.2)	Un-known
Owens-Brockway Glass Container Plant	100-J	65610	ORG250029	Johnson Lake (OR_WS_170900120201_02_104554.2)	0
PCC Structurals, Inc.	100-J	71920	ORG250015	Mount Scott Creek (OR_WS_170900120102_02_104551)	2.3
Sundance Lumber Company, Inc.	100-J	107401	ORG253618	Ditch to Q Street Canal (OR_WS_170900030601_02_104287	14.0
Ventura Foods, LLC	100-J	103832	ORG250005	Unnamed tributary to Columbia Slough (OR_WS_170900120201_02_104554.2)	Un-known
Albany Water Treatment Plant	200-J	66584	ORG383501	Calapooia River (OR_SR_1709000304_02_103821)	0.1
City of Silverton Drinking WTP	200-J	81398	ORG383527	Unnamed tributary to Abiqua Creek (OR_WS_170900090107_02_104460	Un-known

Registrant	General Permit	DEQ WQ File Number	EPA Number	Receiving water name (AU ID)	River mile
Corvallis Rock Creek Water Treatment Plant	200-J	20160	ORG383513	Rock Creek (OR_WS_170900030204_02_104256)	13.5
Dallas Water Treatment Plant	200-J	22550	ORG383529	Rickreall Creek (OR_SR_1709000701_02_104591)	17.0
Deer Creek Estates Water Association	200-J	23650	ORG383526	Mill Creek OR_WS_170900090502_02_104481)	7.1
EWEB – Hayden Bridge Filter Plant	200-J	28385	ORG383503	McKenzie River (OR_SR_1709000407_02_103884)	11
International Paper	200-J	108921	ORG383548	Irving Slough (OR_WS_170900030601_02_104287)	Un-known
Molalla Municipal Water Treatment Plant	200-J	109846	ORG380014	Ditch to Molalla River (OR_WS_170900090607_02_104488)	Un-known
Philomath Water Treatment Plant	200-J	100048	ORG383536	Marys River (OR_SR_1709000302_02_103813)	12.2
Row River Valley Water District	200-J	100075	ORG383534	Layng Creek (OR_SR_1709000202_02_103765)	1.4
ODFW - Roaring River Hatchery	300-J	64525	ORG133506	Roaring River (OR_SR_1709000606_02_103974)	1.1
ODFW - Willamette Fish Hatchery	300-J	64585	ORG133507	Salmon Creek (OR_SR_1709000104_02_103719)	0.4

7.2 Thermal nonpoint sources

OAR 340-041-0002(42) defines nonpoint sources as “diffuse or unconfined sources of pollution where wastes can either enter, or be conveyed by the movement of water, into waters of the state.” Nonpoint sources of heat in the Willamette Subbasins streams include activities associated with agriculture, forestry, dam and reservoir management, and development.

Nonpoint sources or activities that contribute thermal load and may increase stream temperature include:

- 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 7DADM water temperature increase from nonpoint sources ranged from 0.43°C in the Upper McKenzie River to 8.65°C in the Pudding River. See the TSD 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 7DADM temperature standard exceedances of background sources ranged from 1.83°C in Johnson Creek to 9.16°C in the Molalla River. Background sources from seven of the nine modeled streams exceeded the applicable temperature criteria by more than 7°C. See the TSD 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 AUs using **Equation 8-1**.

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

where,

$LC =$ Loading Capacity (kilocalories/day).

$T_C =$ The applicable river temperature criterion (°C).

$\text{HUA} =$ 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 in cubic feet per second (cfs).

$C_F =$ Conversion factor using flow in cfs: 2,446,665

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

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 AUs 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 AUs by applicable fish use period at 7Q10 flow.

AU Name and AU ID	Annual 7Q10 (cfs)	Year Round Criterion + HUA (°C)	Spawning Criterion + HUA (°C)	7Q10 LC Year Round (kcal/day)	7Q10 LC Spawning (kcal/day)
Coyote Creek OR_SR_1709000301_02_103796	5.9	18.3	NA	264.17E+6	NA
Crabtree Creek OR_SR_1709000606_02_103978	25	16.3	13.3	997.02E+6	813.52E+6
Johnson Creek OR_SR_1709001201_02_104170	11	18.3	13.3	492.51E+6	357.95E+6
Little North Santiam River OR_SR_1709000505_02_104564	21	16.3	13.3	837.49E+6	683.35E+6
Luckiamute River OR_SR_1709000305_02_103829	16	18.3	13.3	716.38E+6	520.65E+6
McKenzie River OR_SR_1709000407_02_103884	1537	16.3	13.3	61,296.54E+6	50,014.97E+6
Mohawk River OR_SR_1709000406_02_103871	16	16.3	13.3	638.09E+6	520.65E+6
Molalla River OR_SR_1709000904_02_104086	38	16.3	13.3	1,515.46E+6	1,236.54E+6
Mosby Creek OR_SR_1709000201_02_103752	11	16.3	13.3	438.69E+6	357.95E+6
Pudding River OR_SR_1709000905_02_104088	10	18.3	NA	447.74E+6	NA
Thomas Creek OR_SR_1709000607_02_103988	6.9	18.3	NA	308.94E+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 AU 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 TSD 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 HUA. 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 AUs in the Willamette Subbasins.

AU Name	AU ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
Alex Creek	OR_SR_1709000202_02_103762	16.7	18.3	0.0	0.0
Big Creek	OR_SR_1709001104_02_104153	13.7	16.3	0.0	0.0
Blowout Creek	OR_SR_1709000503_02_103907	21.0	18.3	2.7	12.9
Boulder Creek	OR_SR_1709000502_02_103902	19.3	18.3	1.0	5.3
Breitenbush River	OR_SR_1709000501_02_103892	17.5	18.3	0.0	0.0
Brice Creek	OR_SR_1709000202_02_103771	23.1	18.3	4.8	20.6
Calapooia River	OR_SR_1709000303_02_103815	16.0	16.3	0.0	0.0
Camp Creek	OR_SR_1709000407_02_103889	19.3	13.3	6.0	31.1
Camp Creek	OR_SR_1709000407_02_103889	22.4	16.3	6.1	27.2
Canyon Creek	OR_SR_1709000602_02_103949	20.7	16.3	4.4	21.4
Cedar Creek	OR_SR_1709000407_02_103891	20.9	13.3	7.6	36.4
Cedar Creek	OR_SR_1709000407_02_103891	24.3	16.3	8.0	32.9
Christy Creek	OR_SR_1709000106_02_103722	15.5	16.3	0.0	0.0
Clackamas River	OR_SR_1709000704_02_104597	17.7	13.3	4.4	24.9
Clackamas River	OR_SR_1709000704_02_104597	20.5	16.3	4.2	20.5
Clackamas River	OR_SR_1709000704_02_104597	24.5	18.3	6.2	25.3
Clackamas River	OR_SR_1709001104_02_104154	16.6	13.3	3.3	19.8
Clackamas River	OR_SR_1709001104_02_104154	18.5	16.3	2.2	11.9
Clackamas River	OR_SR_1709001104_02_104155	16.2	13.3	2.9	17.9

AU Name	AU ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
Clackamas River	OR_SR_1709001104_02_104155	19.5	16.3	3.2	16.5
Collawash River	OR_SR_1709001101_02_104142	17.4	13.3	4.1	23.5
Collawash River	OR_SR_1709001101_02_104142	19.8	16.3	3.5	17.8
Collawash River	OR_SR_1709001101_02_104144	16.3	13.3	3.0	18.6
Collawash River	OR_SR_1709001101_02_104144	20.5	16.3	4.2	20.4
Fall Creek	OR_SR_1709000109_02_103737	21.6	13.3	8.3	38.3
Fall Creek	OR_SR_1709000109_02_103737	24.5	16.3	8.2	33.3
Fall Creek	OR_SR_1709000109_02_103743	18.6	13.3	5.3	28.5
Fall Creek	OR_SR_1709000109_02_103743	22.4	16.3	6.1	27.3
Fish Creek	OR_SR_1709001104_02_104161	19.1	13.3	5.8	30.4
Fish Creek	OR_SR_1709001104_02_104161	21.2	16.3	4.9	23.0
French Pete Creek	OR_SR_1709000403_02_103862	15.7	16.3	0.0	0.0
Grass Creek	OR_SR_1709000202_02_103780	15.6	16.3	0.0	0.0
Hamilton Creek	OR_SR_1709000608_02_103996	27.3	16.3	11.0	40.3
Hehe Creek	OR_SR_1709000109_02_103734	21.0	16.3	4.7	22.5
Hills Creek	OR_SR_1709000102_02_103715	16.5	13.3	3.2	19.4
Hills Creek	OR_SR_1709000102_02_103715	18.7	16.3	2.4	12.8
Horse Creek	OR_SR_1709000401_02_103856	13.8	12.3	1.5	10.9
HUC12 Name: Andy Creek-Fall Creek	OR_WS_170900010904_02_104219	18.3	16.3	2.0	10.7
HUC12 Name: Balch Creek-Willamette River	OR_WS_170900120202_02_104555	21.8	18.3	3.5	15.9
HUC12 Name: Boulder Creek-McKenzie River	OR_WS_170900040206_02_104310	14.4	12.3	2.1	14.8
HUC12 Name: Buck Creek-Middle Fork Willamette Riv*	OR_WS_170900010502_02_104200	18.9	12.3	6.6	34.9
HUC12 Name: Canyon Creek	OR_WS_170900090601_02_104482	8.2	18.3	0.0	0.0
HUC12 Name: Columbia Slough (Lower)	OR_WS_170900120201_02_104554.1	26.8	18.3	8.5	31.8
HUC12 Name: Columbia Slough (Upper)	OR_WS_170900120201_02_104554.2	29.5	18.3	11.2	38.0

AU Name	AU ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
HUC12 Name: Cougar Creek-South Fork McKenzie River	OR_WS_170900040308_02_104321	15.0	16.3	0.0	0.0
HUC12 Name: Cougar Reservoir-South Fork McKenzie *	OR_WS_170900040307_02_104320	14.6	16.3	0.0	0.0
HUC12 Name: Croisan Creek-Willamette River	OR_WS_170900070301_02_104413	19.6	13.3	6.3	32.0
HUC12 Name: Croisan Creek-Willamette River	OR_WS_170900070301_02_104413	24.8	18.3	6.5	26.2
HUC12 Name: Dartmouth Creek-North Fork Middle For*	OR_WS_170900010608_02_104210	16.5	16.3	0.2	1.2
HUC12 Name: Deer Creek	OR_WS_170900040205_02_104309	20.0	12.3	7.7	38.4
HUC12 Name: Echo Creek-Middle Fork Willamette Riv*	OR_WS_170900010106_02_104190	15.6	12.3	3.3	21.1
HUC12 Name: Eighth Creek-North Fork Middle Fork W*	OR_WS_170900010607_02_104209	16.2	16.3	0.0	0.0
HUC12 Name: Elk Creek-McKenzie River	OR_WS_170900040502_02_104326	15.3	13.3	2.0	12.9
HUC12 Name: Elk Creek-McKenzie River	OR_WS_170900040502_02_104326	17.9	16.3	1.6	8.8
HUC12 Name: Elk Creek-South Fork McKenzie River	OR_WS_170900040301_02_104314	8.4	12.3	0.0	0.0
HUC12 Name: Fish Creek	OR_WS_170900110403_02_104536	16.0	16.3	0.0	0.0
HUC12 Name: Flat Creek	OR_WS_170900030603_02_104290	25.7	18.3	7.4	28.8
HUC12 Name: Glenn Creek-Willamette River	OR_WS_170900070303_02_104415	27.2	18.3	8.9	32.7
HUC12 Name: Greasy Creek	OR_WS_170900030204_02_104256	25.0	16.3	8.7	34.8
HUC12 Name: Greasy Creek	OR_WS_170900030204_02_104256	19.1	18.3	0.8	4.1
HUC12 Name: Hackleman Creek-McKenzie River	OR_WS_170900040202_02_104306	12.3			
HUC12 Name: Helion Creek-Clackamas River	OR_WS_170900110406_02_104539	16.5	16.3	0.2	1.2
HUC12 Name: Hill Creek-Coast Fork Willamette River	OR_WS_170900020401_02_104238	25.9	18.3	7.6	29.3

AU Name	AU ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
HUC12 Name: Kink Creek-McKenzie River	OR_WS_170900040204_02_104308	12.7	12.3	0.4	3.1
HUC12 Name: Last Creek-Pinhead Creek	OR_WS_170900110204_02_104526	10.4	16.3	0.0	0.0
HUC12 Name: Layng Creek	OR_WS_170900020201_02_104227	17.6	18.3	0.0	0.0
HUC12 Name: Lowe Creek-Clackamas River	OR_WS_170900110203_02_104525	15.6	16.3	0.0	0.0
HUC12 Name: Lower Johnson Creek	OR_WS_170900120103_02_104552	19.9	13.3	6.6	33.1
HUC12 Name: Lower Johnson Creek	OR_WS_170900120103_02_104552	23.1	18.3	4.8	20.8
HUC12 Name: Lower Mill Creek	OR_WS_170900070204_02_104412	25.9	18.3	7.6	29.3
HUC12 Name: Lower Quartzville Creek	OR_WS_170900060305_02_104379	23.7	18.3	5.4	22.8
HUC12 Name: Maxfield Creek-Luckiamute River	OR_WS_170900030503_02_104277	21.1	18.3	2.8	13.3
HUC12 Name: McKinney Creek	OR_WS_170900070203_02_104411	26.9	18.3	8.6	32.0
HUC12 Name: Middle Little Luckiamute River	OR_WS_170900030507_02_104281	17.5	18.3	0.0	0.0
HUC12 Name: Minto Creek-North Santiam River	OR_WS_170900050205_02_104347	11.4	18.3	0.0	0.0
HUC12 Name: Morgan Creek-North Santiam River	OR_WS_170900050604_02_104362	23.0	16.3	6.7	29.1
HUC12 Name: Multnomah Channel	OR_WS_170900120305_02_104561	18.5	18.3	0.2	1.2
HUC12 Name: North Fork Clackamas River	OR_WS_170900110405_02_104538	17.0	16.3	0.7	4.2
HUC12 Name: North Fork Eagle Creek	OR_WS_170900110502_02_104541	12.8	16.3	0.0	0.0
HUC12 Name: Oswego Creek-Willamette River	OR_WS_170900120104_02_104553	14.1	13.3	0.8	5.7
HUC12 Name: Oswego Creek-Willamette River	OR_WS_170900120104_02_104553	20.7	18.3	2.4	11.7
HUC12 Name: Owl Creek	OR_WS_170900060205_02_104371	15.5	16.3	0.0	0.0
HUC12 Name: Paddys Valley-Middle Fork Willamette *	OR_WS_170900010101_02_104185	10.0	12.3	0.0	0.0
HUC12 Name: Pedee Creek-Luckiamute River	OR_WS_170900030504_02_104278	19.5	18.3	1.2	6.3
HUC12 Name: Pot Creek-Clackamas River	OR_WS_170900110205_02_104527	10.1	16.3	0.0	0.0

AU Name	AU ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
HUC12 Name: Quartz Creek	OR_WS_170900040501_02_104325	11.7	13.3	0.0	0.0
HUC12 Name: Quartz Creek	OR_WS_170900040501_02_104325	16.3	16.3	0.0	0.2
HUC12 Name: Roaring River	OR_WS_170900110402_02_104535	24.0	16.3	7.7	32.1
HUC12 Name: Sauers Creek-North Santiam River	OR_WS_170900050208_02_104350	15.8	18.3	0.0	0.0
HUC12 Name: Sharps Creek	OR_WS_170900020203_02_104229	16.3	16.3	0.0	0.0
HUC12 Name: Smith River	OR_WS_170900040203_02_104307	23.4	12.3	11.1	47.4
HUC12 Name: Smith River	OR_WS_170900040203_02_104307	18.7			
HUC12 Name: South Fork Clackamas River	OR_WS_170900110404_02_104537	12.8	16.3	0.0	0.0
HUC12 Name: Staley Creek	OR_WS_170900010105_02_104189	16.4	12.3	4.1	25.0
HUC12 Name: Straight Creek-North Santiam River	OR_WS_170900050202_02_104344	14.2	18.3	0.0	0.0
HUC12 Name: Tumblebug Creek	OR_WS_170900010102_02_104186	15.4	12.3	3.1	20.2
HUC12 Name: Upper Canyon Creek	OR_WS_170900060204_02_104370	17.6	16.3	1.3	7.6
HUC12 Name: Upper Clear Creek	OR_WS_170900110601_02_104543	13.1	16.3	0.0	0.0
HUC12 Name: Upper Eagle Creek	OR_WS_170900110501_02_104540	17.7	16.3	1.4	8.0
HUC12 Name: Upper Johnson Creek	OR_WS_170900120101_02_104550	19.4	13.3	6.1	31.4
HUC12 Name: Upper Johnson Creek	OR_WS_170900120101_02_104550	29.3	18.3	11.0	37.5
HUC12 Name: Whitewater Creek	OR_WS_170900050206_02_104348	14.1	18.3	0.0	0.0
HUC12 Name: Winberry Creek	OR_WS_170900010905_02_104220	19.5	16.3	3.2	16.4
Johnson Creek	OR_SR_1709001201_02_104170	21.3	13.3	8.0	37.6
Johnson Creek	OR_SR_1709001201_02_104170	28.9	18.3	10.6	36.6
Junetta Creek	OR_SR_1709000202_02_103763	16.6	18.3	0.0	0.0
Layng Creek	OR_SR_1709000202_02_103765	24.3	18.3	6.0	24.8
Layng Creek	OR_SR_1709000202_02_103770	16.6	18.3	0.0	0.0
Little Fall Creek	OR_SR_1709000108_02_103730	16.1	13.3	2.8	17.2
Little Fall Creek	OR_SR_1709000108_02_103730	18.1	16.3	1.8	10.1
Little North Santiam River	OR_SR_1709000505_02_104564	23.0	13.3	9.7	42.2

AU Name	AU ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
Little North Santiam River	OR_SR_1709000505_02_104564	28.1	16.3	11.8	42.0
Lookout Creek	OR_SR_1709000404_02_104571	20.9	16.3	4.6	22.0
Lower Blue River	OR_SR_1709000404_02_104569	21.8	13.3	8.5	39
Lower Blue River	OR_SR_1709000404_02_104569	21.6	16.3	5.3	24.5
Marion Creek	OR_SR_1709000502_02_103897	17.4	18.3	0.0	0.0
Martin Creek	OR_SR_1709000202_02_103756	19.9	18.3	1.6	8.0
McDowell Creek	OR_SR_1709000608_02_103994	21.7	18.3	3.4	15.6
McKenzie River	OR_SR_1709000402_02_104587	8.4	12.3	0.0	0.0
McKenzie River	OR_SR_1709000402_02_104588	11.8	12.3	0.0	0.0
McKenzie River	OR_SR_1709000407_02_103884	19.5	13.3	6.2	31.8
McKenzie River	OR_SR_1709000407_02_103884	21.2	16.3	4.9	23.1
Middle Fork Willamette River	OR_SR_1709000101_02_103713	13.4	12.3	1.1	8.1
Middle Fork Willamette River	OR_SR_1709000105_02_104579	21.0	12.3	8.7	41.4
Middle Fork Willamette River	OR_SR_1709000105_02_104580	17.7	13.3	4.4	24.9
Middle Fork Willamette River	OR_SR_1709000105_02_104580	18.1	16.3	1.8	9.9
Middle Fork Willamette River	OR_SR_1709000107_02_103725	17.8	13.3	4.5	25.3
Middle Fork Willamette River	OR_SR_1709000107_02_103725	19.2	16.3	2.9	15.1
Middle Santiam River	OR_SR_1709000601_02_103936	19.7	18.3	1.4	7.3
Middle Santiam River	OR_SR_1709000603_02_103965	24.0	18.3	5.7	23.8
Middle Santiam River	OR_SR_1709000604_02_103969	16.0	13.3	2.7	16.9
Middle Santiam River	OR_SR_1709000604_02_103969	14.4	18.3	0.0	0.0
Mill Creek	OR_SR_1709000702_02_104007	18.6	13.3	5.3	28.6
Mill Creek	OR_SR_1709000702_02_104007	25.3	18.3	7.0	27.8
Moose Creek	OR_SR_1709000602_02_103954	19.3	16.3	3.0	15.4
Nohorn Creek	OR_SR_1709001101_02_104145	17.1	16.3	0.8	4.7
North Fork Clackamas River	OR_SR_1709001104_02_104152	19.2	16.3	2.9	15.1
North Fork Middle Fork Willamette River	OR_SR_1709000106_02_103721	20.7	13.3	7.4	35.7

AU Name	AU ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
North Fork Middle Fork Willamette River	OR_SR_1709000106_02_103721	22.9	16.3	6.6	28.8
North Fork Pedee Creek	OR_SR_1709000305_02_103828	20.2	18.3	1.9	9.5
North Santiam River	OR_SR_1709000502_02_103899	17.9	18.3	0.0	0.0
North Santiam River	OR_SR_1709000503_02_103906	16.7	13.3	3.4	20.4
North Santiam River	OR_SR_1709000503_02_103906	16.7	16.3	0.4	2.4
Oak Grove Fork Clackamas River	OR_SR_1709001103_02_104149	12.2	16.3	0.0	0.0
Oak Grove Fork Clackamas River	OR_SR_1709001103_02_104150	12.6	13.3	0.0	0.0
Oak Grove Fork Clackamas River	OR_SR_1709001103_02_104150	13.8	16.3	0.0	0.0
Owl Creek	OR_SR_1709000602_02_103941	19.2	16.3	2.9	15.2
Portland Creek	OR_SR_1709000109_02_103741	22.5	16.3	6.2	27.4
Pringle Creek	OR_SR_1709000703_02_104012	25.1	18.3	6.8	27.1
Pyramid Creek	OR_SR_1709000601_02_103935	20.3	18.3	2.0	9.8
Quartz Creek	OR_SR_1709000405_02_103867	12.1	13.3	0.0	0.0
Quartz Creek	OR_SR_1709000405_02_103867	16.3	16.3	0.0	0.2
Quartzville Creek	OR_SR_1709000603_02_103957	19.3	18.3	1.0	5.2
Quartzville Creek	OR_SR_1709000603_02_103960	22.0	18.3	3.7	16.7
Rebel Creek	OR_SR_1709000403_02_103861	13.3	16.3	0.0	0.0
Ritner Creek	OR_SR_1709000305_02_103833	21.8	18.3	3.5	16.0
Roaring River	OR_SR_1709000403_02_103864	7.2	12.3	0.0	0.0
Roaring River	OR_SR_1709001104_02_104160	14.2	13.3	0.9	6.3
Roaring River	OR_SR_1709001104_02_104160	15.4	16.3	0.0	0.0
Row River	OR_SR_1709000202_02_103761	25.1	18.3	6.8	27.1
Row River	OR_SR_1709000202_02_103766	25.1	18.3	6.8	27.1
Salmon Creek	OR_SR_1709000104_02_103719	13.5	12.3	1.2	9.1
Salmon Creek	OR_SR_1709000104_02_103719	18.4	13.3	5.1	27.6
Salmon Creek	OR_SR_1709000104_02_103719	19.3	16.3	3.0	15.7
Salt Creek	OR_SR_1709000103_02_103716	16.1	13.3	2.8	17.1

AU Name	AU ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
Salt Creek	OR_SR_1709000103_02_103716	17.9	16.3	1.6	8.7
Separation Creek	OR_SR_1709000401_02_103857	10.0	12.3	0.0	0.0
Sharps Creek	OR_SR_1709000202_02_103755	24.0	18.3	5.7	23.8
Sharps Creek	OR_SR_1709000202_02_103775	19.2	18.3	0.9	4.6
Sheep Creek	OR_SR_1709000602_02_103953	20.9	16.3	4.6	21.9
Shelton Ditch	OR_SR_1709000703_02_104008	18.5	13.3	5.2	28.2
Shelton Ditch	OR_SR_1709000703_02_104008	23.8	18.3	5.5	23.1
Soda Fork	OR_SR_1709000602_02_103947	16.1	16.3	0.0	0.0
South Fork McKenzie River	OR_SR_1709000403_02_104589	8.7	12.3	0	0
South Fork McKenzie River	OR_SR_1709000403_02_104589	13.1	13.3	0	0
South Fork McKenzie River	OR_SR_1709000403_02_104589	14.9	16.3	0	0
South Fork McKenzie River	OR_SR_1709000403_02_104589	8.7	12.3	0.0	0.0
South Fork McKenzie River	OR_SR_1709000403_02_104589	13.1	13.3	0.0	0.0
South Fork McKenzie River	OR_SR_1709000403_02_104589	14.9	16.3	0.0	0.0
South Fork McKenzie River	OR_SR_1709000403_02_104590	16.2	13.3	2.9	17.9
South Fork McKenzie River	OR_SR_1709000403_02_104590	17.8	16.3	1.5	8.4
South Santiam River	OR_SR_1709000506_02_103925	15.0	13.3	1.7	11.3
South Santiam River	OR_SR_1709000506_02_103925	14.1	16.3	0.0	0.0
South Santiam River	OR_SR_1709000602_02_103950	18.1	13.3	4.8	26.4
South Santiam River	OR_SR_1709000602_02_103950	21.4	16.3	5.1	23.7
South Santiam River	OR_SR_1709000604_02_103968	21.8	13.3	8.5	39.0
South Santiam River	OR_SR_1709000604_02_103968	24.4	16.3	8.1	33.2
Teal Creek	OR_SR_1709000305_02_103824	20.3	18.3	2.0	9.9
Trout Creek	OR_SR_1709000602_02_103942	17.2	16.3	0.9	5.5
Trout Creek	OR_SR_1709001104_02_104157	16.3	16.3	0.0	0.0
Upper Blue River	OR_SR_1709000404_02_104574	20.6	16.3	4.3	20.9
Whitewater Creek	OR_SR_1709000502_02_103898	12.4	18.3	0.0	0.0

AU Name	AU ID	Maximum 7DADM River Temperature (°C)	Applicable Criterion + HUA (°C)	Excess Temperature (°C)	Percent Load Reduction
Winberry Creek	OR_SR_1709000109_02_103747	20.2	13.3	6.9	34.2
Winberry Creek	OR_SR_1709000109_02_103747	22.5	16.3	6.2	27.6

9 Allocations, reserve capacity, and margin of safety

OAR 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 assignments

The HUA 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 waterbody, and at the POMI.

Table 9-1 through **Table 9-23** present the portions of the HUA assigned to anthropogenic source categories across different AUs 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. Dam and reservoir discharges associated with an NPDES permit are included in the NPDES assigned HUA.

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.

The assigned HUA for NPDES point sources is the maximum for all NPDES induvial permittees and registrants to general NPDES permits.

The assigned portion of the HUA represents the maximum cumulative warming allowed anywhere in the AU and stream extents at the POMI from all point and nonpoint source activities within each source category. Therefore, DEQ expects the amount of warming for each unique point or nonpoint source activity to be less than the values shown in **Table 9-1** through **Table 9-23**. DEQ will implement the TMDL in a manner consistent with the HUA rule by requiring all nonpoint sources to implement management strategies and reduce their warming impact such that the assigned HUA is attained. Point sources will be required to implement their wasteload allocations through their NPDES permits such that the assigned HUA is attained.

The HUA assignments in **Table 9-1** through **Table 9-23** for nonpoint source categories are achieved through the implementation of the load allocations described in Section 9.1.4 and the surrogate measures described in Section 9.1.5. Designated Management Agencies (DMAs) are responsible for implementing management activities that achieve the surrogate measure targets appropriate to their source category and location. A DMA has achieved their load allocation when surrogate measure targets are met. When all DMAs within a nonpoint source category have met their surrogate measure targets and achieved their load allocations, the HUA assigned to that nonpoint source category is achieved.

Table 9-1: HUA assignments on the Molalla River, Pudding River, Silver Creek, Mill Creek, Abiqua Creek, and Lower Abiqua Creek AUs (Molalla-Pudding Subbasin).

Portion of HUA (°C)	Source or source category
0.20	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.03	Reserve capacity
0.30	**Total**
AUs include Molalla River (OR_SR_1709000906_02_104093, OR_SR_1709000906_02_104094, OR_LK_1709000906_02_100834, OR_WS_170900090607_02_104488), Pudding River (OR_SR_1709000902_02_104073, OR_SR_1709000905_02_104088, OR_SR_1709000901_02_104064), Silver Creek (OR_SR_1709000901_02_104595), Abiqua Creek (OR_SR_1709000901_02_104062), Mill Creek (OR_WS_170900090502_02_104481), and Lower Abiqua Creek (OR_WS_170900090107_02_104460).	

Table 9-2: HUA assignments on Eagle Creek, Deep Creek, and North Fork Deep Creek AUs (Clackamas Subbasin).

Portion of HUA (°C)	Source or source category
0.20	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.03	Reserve capacity
0.30	**Total**
AUs include Eagle Creek (OR_SR_1709001105_02_104162, OR_SR_1709001105_02_104163), Deep Creek (OR_SR_1709001106_02_104166), and North Fork Deep Creek (OR_WS_170900110605_02_104547).	

Table 9-3: HUA assignments on Camas Swale Creek and Lower Camas Swale Creek AUs (Coast Fork Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.20	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.03	Reserve capacity
0.30	**Total**
AUs include Camas Swale Creek (OR_SR_1709000204_02_103786) and Lower Camas Swale Creek (OR_WS_170900020403_02_104240).	

Table 9-4: HUA assignments on Oak Creek and the Calapooia River AUs (Upper Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.21	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.02	Reserve capacity
0.30	**Total**
AUs include Oak Creek (OR_WS_170900030402_02_104273) and the Calapooia River (OR_SR_1709000303_02_103816, OR_SR_1709000304_02_103821).	

Table 9-5: HUA assignments on Amazon Creek AUs (Upper Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.15	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.08	Reserve capacity
0.30	**Total**
AUs include Amazon Creek (OR_WS_170900030106_02_104248, OR_WS_170900030108_02_104250, OR_WS_170900030109_02_104251).	

Table 9-6: HUA assignments on Muddy Creek, Colorado Lake, Mary's River, Greasy Creek, Rock Creek, Long Tom River, Fern Ridge Lake AUs, Murder Creek, and other tributary Watershed AUs (Upper Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.20	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.03	Reserve capacity
0.30	**Total**
AUs include Muddy Creek (OR_SR_1709000306_02_103838) and tributaries in OR_WS_170900030606_02_104294, Colorado Lake (OR_LK_1709000306_02_100720), Mary's River (OR_SR_1709000302_02_103813), Greasy Creek (OR_SR_1709000302_02_103810), tributaries to Greasy Creek and Rock Creek (OR_WS_170900030204_02_104256), Fern Ridge Lake (OR_LK_1709000301_02_100708), the Long Tom River and tributaries in OR_SR_1709000301_02_103789 and OR_WS_170900030107_02_104249, and Murder Creek and other streams in OR_WS_170900030610_02_104298.	

Table 9-7: HUA assignments on the Spring Creek-Willamette River AU (Upper Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.30 0.225	NPDES point sources (May 1 – May 31) NPDES point sources (June 1 – Oct 31)
0.00	NPS dam and reservoir operations
0.00	Water management activities and water withdrawals
0.00	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.00 0.075	Reserve capacity (May 1 – May 31) Reserve capacity (June 1 – Oct 31)
0.30	**Total**
Spring Creek – Willamette River AU OR_WS_170900030601_02_104287.	

Table 9-8: HUA assignments on the Middle Fork Willamette River (Middle Fork Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.06	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.17	Reserve capacity
0.30	**Total**
Middle Fork Willamette River AU OR_SR_1709000105_02_104580.	

Table 9-9: HUA assignments on Dexter Reservoir (Middle Fork Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.073	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.157	Reserve capacity
0.30	**Total**
Dexter Reservoir AU OR_LK_1709000107_02_100699.	

Table 9-10: HUA assignments on Mount Scott Creek (Lower Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.15	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.08	Reserve capacity
0.30	**Total**
AUs include Mount Scott Creek (OR_SR_1709001201_02_104171, OR_WS_170900120102_02_104551).	

Table 9-11: HUA assignments on the Columbia Slough (Lower Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.225	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.005	Reserve capacity
0.30	**Total**
AUs include Columbia Slough (OR_WS_170900120201_02_104554.1, OR_WS_170900120201_02_104554.2).	

Table 9-12: HUA assignments on Big Cliff Reservoir (North Santiam Subbasin).

Portion of HUA (°C)	Source or source category
0.10	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.13	Reserve capacity
0.30	**Total**
Big Cliff Reservoir AU OR_LK_1709000503_02_100770.	

Table 9-13: HUA assignments on Roaring River and Crabtree Creek AUs (South Santiam Subbasin).

Portion of HUA (°C)	Source or source category
0.10	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.13	Reserve capacity
0.30	**Total**
AUs include Roaring River (OR_SR_1709000606_02_103974) and Crabtree Creek (OR_SR_1709000606_02_103978).	

Table 9-14: HUA assignments on Middle Santiam River and Foster Lake AUs (South Santiam Subbasin).

Portion of HUA (°C)	Source or source category
0.10	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.13	Reserve capacity
0.30	**Total**
AUs include Middle Santiam River (OR_SR_1709000604_02_103969) and Foster Lake (OR_LK_1709000604_02_100772).	

Table 9-15: HUA assignments on Wiley Creek AU (South Santiam Subbasin).

Portion of HUA (°C)	Source or source category
0.20	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.03	Reserve capacity
0.30	**Total**
Wiley Creek AU OR_SR_1709000605_02_103971.	

Table 9-16: HUA assignments on the South Fork McKenzie River AU (McKenzie Subbasin).

Portion of HUA (°C)	Source or source category
0.01	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.22	Reserve capacity
0.30	**Total**
South Fork McKenzie AU OR_SR_1709000403_02_104590.	

Table 9-17: HUA assignments on the McKenzie River AU from Trail Bridge Dam to Leaburg Diversion (McKenzie Subbasin).

Portion of HUA (°C)	Source or source category
0.03	NPDES point sources
0.00	NPS dam and reservoir operations
0.03	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.22	Reserve capacity
0.30	**Total**
AUs include OR_SR_1709000402_02_104588, OR_SR_1709000402_02_103858, OR_SR_1709000405_02_103868, OR_SR_1709000405_02_103869, OR_SR_1709000405_02_103866, and OR_SR_1709000407_02_103884 from Ennis Creek to Leaburg Diversion (McKenzie River Miles 35.7 – 48.2).	

Table 9-18: HUA assignments on the McKenzie River AU from Leaburg Diversion to International Paper Springfield outfall (McKenzie Subbasin).

Portion of HUA (°C)	Source or source category
0.08	NPDES point sources
0.00	NPS dam and reservoir operations
0.16	EWEB Walterville project NPS and NPDES increases
0.00	EWEB Leaburg project NPS and increases
0.02	Other water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.02	Reserve capacity
0.30	**Total**
AU OR_SR_1709000407_02_103884 from McKenzie River Mile 12.4 – 35.7.	

Table 9-19: HUA assignments on the McKenzie River AU from International Paper Springfield's outfall to the mouth (McKenzie Subbasin).

Portion of HUA (°C)	Source or source category
0.20 0.22 0.23	NPDES point sources (Spring spawning period) NPDES point sources (Summer non-spawning period) NPDES point sources (Fall spawning period)
0.00	NPS dam and reservoir operations
0.02	EWEB Walterville project NPS and NPDES increases
0.00	EWEB Leaburg project NPS increases
0.02	Other water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.04 0.02 0.01	Reserve capacity (Spring spawning period) Reserve capacity (Summer non-spawning period) Reserve capacity (Fall spawning period)
0.30	**Total**
AU OR_SR_1709000407_02_103884 from McKenzie River Mile 0 – 12.4.	

Table 9-20: HUA assignments on Rickreall Creek AU (Middle Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.22	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.01	Reserve capacity
0.30	**Total**
Rickreall Creek AU OR_SR_1709000701_02_104591.	

Table 9-21: HUA assignments for the Coffee Lake Creek- Willamette River AU and the Upper Mill Creek AU (Middle Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.20	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.03	Reserve capacity
0.30	**Total**
AUs include Coffee Lake Creek- Willamette River (OR_WS_170900070402_02_104419) and Upper Mill Creek (OR_WS_170900070201_02_104409).	

Table 9-22: HUA assignments for Stone Quarry Lake AU (Middle Willamette Subbasin).

Portion of HUA (°C)	Source or source category
0.15	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.08	Reserve capacity
0.30	**Total**
Stone Quarry Lake AU OR_LK_1709000703_02_100809.	

Table 9-23: HUA assignments for all other AUs in the Willamette Subbasins.

Portion of HUA (°C)	Source or source category
0.075	NPDES point sources
0.00	NPS dam and reservoir operations
0.05	Water management activities and water withdrawals
0.02	Solar loading from existing transportation corridors, existing buildings, and existing utility infrastructure
0.00	Solar loading from other NPS sectors
0.155	Reserve capacity
0.30	**Total**
Applicable AUs are listed in TSD Appendix D.	

9.1.2 Thermal wasteload allocations for point sources

Wasteload allocations are assigned to NPDES permitted point sources listed in **Table 9-24**. The wasteload allocation for the Phase I individual MS4 stormwater permits and registrants under the general stormwater permits (MS4 phase II, 1200-A, 1200-C and 1200-Z), and registrants under the 400-J, 1500-A, and 1700-A general permits are set equal to loads permitted by these NPDES permits. This means that individual permittees and registrants must follow their permit conditions to meet the narrative wasteload allocation. Beyond current permit limits, no additional TMDL requirements are needed for these sources to control temperature. For all general wastewater and stormwater NPDES permits, more precise wasteload allocations may be considered if subsequent data analysis indicates a need and capacity is available.

Wasteload allocations were calculated using **Equation 9-1**.

$WLA = (\Delta T) \cdot (Q_E + Q_R) \cdot C_F$ **Equation 9-1**

where,

$WLA =$ Wasteload allocation (kilocalories/day), expressed as a rolling seven-day average.

$\Delta T =$ The assigned portion of the HUA from **Table 9-24**. It is 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, ΔT = 0.0. See **Table 9-25** for list of NPDES permittees where minimum duties provision may apply.

$Q_E =$ The daily mean effluent flow (cfs).

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

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

$Q_R =$ The daily mean river flow rate, upstream (cfs).
When river flow is <= 7Q10, Q_R = 7Q10. When river flow > 7Q10, Q_R is equal to the daily mean river flow, upstream.

$C_F =$ Conversion factor using flow in cfs: 2,446,665

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

The effluent discharge used to calculate the wasteload allocations presented in **Table 9-24** 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. More information on the specific source of the effluent discharge flow and the rationale behind the assigned HUA is described in the TSD Section 9.2.

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

(1) Incorporate the 7Q10 wasteload allocation in **Table 9-24** as a static numeric limit. Permit writers may recalculate the static limit using different values for 7Q10 (Q_R) and effluent discharge (Q_E), if better estimates are available (including the use of seasonal values, as appropriate).

(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 HUA (ΔT) is static and based on the value in **Table 9-24**. Permit writers may recalculate the 7Q10 using seasonal or annual values, as appropriate, if better estimates are available.

The wasteload allocation period for each facility is consistent with the critical period of the receiving waterbody, which is presented in Section 5: Seasonal variation and critical period for temperature.

Table 9-24: Thermal wasteload allocations (WLA) for point sources.

NPDES Permittee WQ File Number : EPA Number	Assigned HUA ΔT (°C)	WLA period start	WLA period end	7Q10 River flow (cfs)	Effluent discharge (cfs)	7Q10 WLA[1] (kcals/day)
Albany Water Treatment Plant 66584 : ORG383501	0.20	5/1	10/31	24	1.30	12.38E+6
Alpine Community 100101 : OR0032387	0.00	5/1	10/31	0.4	0.03	0
Arclin 16037 : OR0021857	0.075	5/1	10/31	0	1.55	0.284E+6
Arclin 81714 : OR0000892	0.075	4/1	10/31	30	0.93	5.675E+6
ATI Albany Operations 64300 : OR0001716	0.01	5/1	10/31	1.4	3.52	0.12E+6
Aumsville STP 4475 : OR0022721	0.00	5/1	10/31	0.7	0.52	0
Aurora STP 110020 : OR0043991	0.00	5/1	10/31	10	0.1	0
Bakelite Chemicals LLC 32650 : OR0032107	0.00	5/1	10/31	0	0.0	0
Bakelite Chemicals LLC 32864 : OR0002101	0.075	5/1	5/31	0	0.0	0
	0.00	6/1	10/31	0	0.0	0
Blount Oregon Cutting Systems Division 63545 : OR0032298	0.075	2/15	11/15	0	0.19	0.034E+6
Boeing Of Portland - Fabrication Division 9269 : OR0031828	0.075	4/1	10/31	0	0.46	0.085E+6
Brownsville STP 11770 : OR0020079	0.00	5/1	10/31	14	0.0	0
City of Silverton Drinking WTP 81398 : ORG383527	0.20	5/1	10/31	0	0.08	0.038E+6
Coburg Wastewater Treatment Plant 115851 : OR0044628	0.20	5/1	10/31	0	0.68	0.333E+6
Coffin Butte Landfill 104176 : OR0043630	0.075	5/1	10/31	0	0.0	0
Columbia Helicopters 100541 : OR0033391	0.075	5/1	10/31	0	0.01	0.002E+6
Corvallis Rock Creek WTP 20160 : ORG383513	0.20	5/1	10/31	0	0.37	0.182E+6
Creswell STP 20927 : OR0027545	0.20	5/1	5/31	0	5.09	2.491E+6
	0.00	6/1	10/31	0	0.31	0
Dallas STP 22546 : OR0020737	0.11	5/1	10/31	4.2	3.09	1.963E+6
Dallas WTP 22550 : ORG383529	0.11	5/1	10/31	3.3	0.17	0.934E+6
Deer Creek Estates Water Association 23650 : ORG383526	0.20	5/1	10/31	0.7	0.004	0.344E+6

NPDES Permittee WQ File Number : EPA Number	Assigned HUA ΔT (°C)	WLA period start	WLA period end	7Q10 River flow (cfs)	Effluent discharge (cfs)	7Q10 WLA[1] (kcals/day)
Duraflake 97047 : OR0000426	0.20	5/1	10/31	0	0.55	0.270E+6
Estacada STP 27866 : OR0020575	0.075	5/1	10/31	317	0.84	58.323E+6
EWEB Carmen Powerhouse (Outfalls 001A and 001B) 28393 : OR0000680	0.075	5/1	10/31	146	2.68	27.282E+6
EWEB Trail Bridge Powerhouse (Outfalls 002A and 002B) 28393 : OR0000680	0.030	5/1	10/31	496	0.93	36.475E+6
EWEB Hayden Bridge Filter Plant 28385 : ORG383503	0.011	4/1	11/15	1538	2.09	41.449E+6
Falls City STP 28830 : OR0032701	0.00	5/1	10/31	5.3	0.0	0
Foster Farms 97246 : OR0026450	0.00	5/1	10/31	0	0.0	0
Fujimi Corporation - SW Commerce Circle 107178 : OR0040339	0.20	5/1	10/31	0	0.2	0.094E+6
Gervais STP 33060 : OR0027391	0.00	5/1	10/31	6.6	0.34	0
Halsey STP 36320 : OR0022390	0.00	5/1	10/31	5.0	0.30	0
Hubbard STP 40494 : OR0020591	0.20	5/1	10/31	0	0.35	0.169E+6
Hull-Oakes Lumber Co. 107228 : OR0038032	0.075	5/1	10/31	0	0.08	0.014E+6
International Paper - Springfield 108921 : ORG383548 (200-J discharge)	0.075	5/1	10/31	0	0.01	0.001E+6
International Paper - Springfield (Outfall 001 + Outfall 002) 96244 : OR0000515	0.12	4/1	6/15	2,442	28.9	725.456E+6
	0.20	6/16	8/31	1,537	28.9	766.247E+6
	0.19	9/1	11/15	1,630	28.9	771.167E+6
International Paper - Springfield (Outfall 003) 96244 : OR0000515	0.075	5/1	10/31	0	3.09	0.568E+6
J.H. Baxter & Co 6553 : OR0021911	0.075	5/1	10/31	0.6	0.12	0.132E+6
JLR 32536 : OR0001015	0.01	5/1	10/31	6.9	0.5	0.181E+6
Junction City STP 44509 : OR0026565	0.00	5/1	10/31	0	0.0	0
Kingsford Manufacturing Company - Springfield Plant 46000 : OR0031330	0.075	5/1	5/31	0	0.08	0.015E+6
	0.00	6/1	10/31	0	0	0
Knoll Terrace Mhc 46990 : OR0026956	0.00	5/1	10/31	0	0.09	0

NPDES Permittee WQ File Number : EPA Number	Assigned HUA ΔT (°C)	WLA period start	WLA period end	7Q10 River flow (cfs)	Effluent discharge (cfs)	7Q10 WLA[1] (kcals/day)
Lakewood Utilities, Ltd 96110 : OR0027570	0.00	5/1	10/31	0	0.0	0
Lane Community College 48854 : OR0026875	0.00	5/1	10/31	0	0.22	0
Lowell STP 51447 : OR0020044	0.013	5/1	11/15	1,002	1.22	31.909E+6
Mcfarland Cascade Pole & Lumber Co 54370 : OR0031003	0.00	5/1	10/31	0	0.0	0
Molalla Municipal Drinking WTP 109846 : ORG380014	0.20	5/1	10/31	0	0.16	0.078E+6
Molalla STP 57613 : OR0022381	0.10	5/1	10/31	56	3.46	14.547E+6
Mt. Angel STP 58707 : OR0028762	0.00	5/1	10/31	6.6	0.87	0
Murphy Veneer, Foster Division 97070 : OR0021741	0.20	5/1	10/31	4.2	1.11	2.598E+6
Norpac Foods- Plant #1, Stayton 84820 : OR0001228	0.20	5/1	10/31	0	6.19	3.028E+6
Oakridge STP 62886 : OR0022314	0.075	5/1	11/30	514	0.73	94.452E+6
ODC - Oregon State Penitentiary 109727 : OR0043770	0.075	5/1	10/31	6.5	2.48	1.647E+6
ODFW - Marion Forks Hatchery 64495 : OR0027847	0.075*	5/1	10/31	6.3	18.6	4.562E+6*
ODFW - Roaring River Hatchery 64525 : ORG133506	0.10*	5/1	10/31	0.5	14.2	3.597E+6*
ODFW - Willamette Fish Hatchery 64585 : ORG133507	0.075*	5/1	10/31	110	79.0	34.681E+6*
ODFW Leaburg Hatchery 64490 : OR0027642	0.074*	4/1	6/15	2,442	92.4	458.861E+6*
	0.012*	6/16	8/31	1,537	39.1	46.274E+6*
	0.026*	9/1	11/15	1,630	78.3	108.671E+6*
ODFW McKenzie River Hatchery 64500 : OR0029769	0.002	4/1	6/15	2,442	12.7	12.012E+6
	0.033	6/16	8/31	1,537	11.8	125.05E+6
	0.002	9/1	11/15	1,630	1.0	7.981E+6
Philomath WTP 100048 : ORG383536	0.20	5/1	10/31	6.7	0.32	3.435E+6
Philomath WWTP 103468 : OR0032441	0.00	5/1	10/31	6.7	0.0	0
PNW Veg Co DBA Norpac Foods No. 5 84791 : OR0021261	0.00	5/1	10/31	0	0.0	0
Row River Valley Water District 100075 : ORG383534	0.075	5/1	10/31	12	0.04	2.210E+6
RSG Forest Products - Liberal 72596 : OR0021300	0.20	5/1	10/31	0	1.24	0.606E+6

NPDES Permittee WQ File Number : EPA Number	Assigned HUA ΔT (°C)	WLA period start	WLA period end	7Q10 River flow (cfs)	Effluent discharge (cfs)	7Q10 WLA[1] (kcals/day)
Sandy WWTP 78615 : OR0026573	0.00	5/1	10/31	0.2	0.00	0
Scio STP 79633 : OR0029301	0.00	5/1	10/31	6.9	0.14	0
Seneca Sawmill Company 80207 : OR0022985	0.00	5/1	10/31	0	1.19	0
SFPP 103159 : OR0044661	0.075	5/1	10/31	0	0.02	0.004E+6
Sherman Bros. Trucking 36646 : OR0021954	0.00	5/1	10/31	0.2	0.02	0
Silverton STP 81395 : OR0020656	0.20	5/1	10/31	14	3.87	8.743E+6
Sunstone Circuits 26788 : OR0031127	0.04	5/1	10/31	10.5	0.065	1.034E+6
Tangent STP 87425 : OR0031917	0.00	5/1	10/31	20	0.17	0
Timberlake STP 90948 : OR0023167	0.00	5/1	10/31	254	0.22	0
U.S. Army Corp of Engineers Cougar Project 126712: Not Assigned	0.01	5/1	10/31	236**	0.21	5.779E+6
U.S. Army Corp of Engineers Detroit Project 126716: Not Assigned	0.10	5/1	10/31	743**	7.94	183.729E+6
U.S. Army Corp of Engineers Green Peter Project 126717 : Not Assigned	0.10	5/1	11/30	33**	2.12	8.592E+6
U.S. Army Corp of Engineers Hills Creek Project 126699 : Not Assigned	0.06	5/1	11/30	309**	2.85	45.78E+6
U.S. Army Corp of Engineers Lookout Point Project 126700 : Not Assigned	0.06	5/1	11/15	1145**	2.82	168.50E+6
USFW - Eagle Creek National Fish Hatchery 91035 : OR0000710	0.20*	5/1	10/31	0	52.6	25.739E+6*
Veneta STP 92762 : OR0020532	0.20	5/1	5/31	6.4	0.98	3.611E+6
	0.00	6/1	9/30	6.4	0.00	0
	0.20	10/1	10/31	6.4	0.98	3.611E+6
WES - Boring STP 16592 : OR0031399	0.20	5/1	10/31	0.24	0.06	0.145E+6
Westfir STP 94805 : OR0028282	0.075	5/1	10/31	174	0.05	31.937E+6
Willamette Leadership Academy 34040 : OR0027235	0.00	5/1	10/31	0	0.01	0
Woodburn WWTP 98815 : OR0020001	0.20	5/1	10/31	6.7	7.79	7.092E+6

NPDES Permittee WQ File Number : EPA Number	Assigned HUA ΔT (°C)	WLA period start	WLA period end	7Q10 River flow (cfs)	Effluent discharge (cfs)	7Q10 WLA[1] (kcals/day)

[1] Listed WLAs were calculated based on the 7Q10 flow.

Notes:

WLA = wasteload allocation; kcals/day = kilocalories/day

* When the minimum duties provision at OAR 340-041-0028(12)(a) applies, ΔT = 0.0 and the WLA = 0 kilocalories/day.

** Listed 7Q10s calculated based on a seasonal period corresponding to WLA period.

The minimum duties provision at OAR 340-041-0028(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 point sources, DEQ is implementing the minimum duties provision if a facility operation meets acceptable operation and design requirements. The facility must be operated as a “flow through” facility where intake water moves through the facility and is not processed as part of an industrial or wastewater treatment operation. If a facility mixes the intake water with other wastewater or as a method to cool equipment DEQ considers the thermal effects of this operation to be part of the facility’s own activity and the minimum duties provision does not apply. The intake water must also be returned to the same stream where the intake is located. If the water is not returned to the same stream the thermal effects do not originate from the receiving stream and therefore are considered as part of the facilities own discharge.

When the minimum duties provision applies, the facility cannot add any additional thermal loading to the intake temperatures when the intake temperatures are warmer than the maximum effluent discharge temperatures allowed by the wasteload allocation. The purpose is to ensure the facility controls for thermal effects resulting from passing the water through and not from upstream sources. The specific equations to implement this approach in NPDES permits are included in the TSD Section 9.2.2 through Section 9.2.9. DEQ determined the minimum duties provision is applicable to the facilities listed in **Table 9-25**.

Table 9-25: NPDES permittees where the minimum duties provision may be implemented as part of the TMDL wasteload allocation.

NPDES Permittee	WQ File Number : EPA Number	Intake and Receiving Stream	AU
ODFW - Marion Forks Fish Hatchery	64495 : OR0027847	Horn Creek	OR_WS_170900050203_02_104345
ODFW - Roaring River Fish Hatchery	64525 : ORG133506	Roaring River	OR_SR_1709000606_02_103974
ODFW - Willamette Fish Hatchery	64585 : ORG133507	Salmon Creek	OR_SR_1709000104_02_103719
ODFW - Leaburg Fish Hatchery	64490 : OR0027642	McKenzie River	OR_SR_1709000407_02_103884
USFW - Eagle Creek National Fish Hatchery	91035 : OR0000710	Eagle Creek	OR_SR_1709001105_02_104162

9.1.3 Wasteload allocations for 100-J general permit registrants

The TMDL includes narrative wasteload allocation requirements for registrants to the 100-J general permit. The wasteload allocation for current and future registrants to the 100-J general permit is equal to loads permitted by the 100-J general permit and the TMDL requirements identified in **Table 9-26** and **Table 9-27**.

With some exceptions, 100-J registrants have been assigned a cumulative HUA of 0.075°C (**Table 9-26**). In addition, each AU has a maximum number of registrants that may discharge based on the 7Q10 stream flow at the discharge location. With some exceptions noted in **Table 9-26**, watershed (WS) AUs may only have one registrant due to low flows. The maximum number of registrants ensures the assigned HUA is attained based on DEQ's estimated temperature impacts. Additional registrants above the maximum require reserve capacity. The flow categories in **Table 9-26** are set up so the combined sum of warming from each registrant at the point of discharge does not exceed the maximum warming allowed for that AU. As the river flow increases and provides increased dilution, the maximum number of registrants allowed also increases. On select AUs (Columbia Slough, McKenzie River, and Stone Quarry Lake) the maximum number of registrants and assigned HUA reflect the current number of 100-J registrants. Some AUs do not have sufficient loading capacity for new 100-J registrants. On these AUs the capacity has been assigned to other NPDES permittees. **Table 9-27** identifies the AUs with insufficient loading capacity. On these AUs, the assigned HUA is zero and new 100-J registrants cannot increase stream temperature above the applicable temperature criteria. A maximum number of registrants is not needed on these AUs as there is no temperature increase allowed.

Table 9-26: TMDL requirements for 100-J registrants in the Willamette Subbasins.

AU 7Q10 stream flow (cfs)	Assigned HUA (°C)*	Maximum number of registrants per AU
<= 149	0.075	1
> 149 and <= 297	0.075	2
> 297 and <= 521	0.075	3
> 521 and <= 652	0.075	4
> 652 and <= 990	0.075	5
> 990 and <= 1154	0.075	6
> 1154 and <= 1319	0.075	7
> 1319 and <= 1484	0.075	8
> 1484	0.075	9
McKenzie River OR_SR_1709000407_02_103884	0.02	2
Columbia Slough OR_WS_170900120201_02_104554.2	0.225	3
Other Watershed AUs	0.075	1
Stone Quarry Lake OR_LK_1709000703_02_100809	0.15	2
Other natural lakes or ponds where the Natural Lakes temperature criterion apply (OAR 340-041-0028(6))	0.075	1
*Assigned HUA is zero for AUs listed in **Table 9-26**.		

Table 9-27 AUs where new 100-J general permit registrants may not increase temperature above the applicable criteria.

AU ID	AU or GNIS Name	Assigned HUA (°C)
OR_LK_1709000107_02_100699	Dexter Reservoir	0.00
OR_LK_1709000402_02_100742	Trail Bridge Reservoir	0.00
OR_LK_1709000503_02_100770	Big Cliff Reservoir	0.00
OR_LK_1709001106_02_100850	Estacada Lake	0.00
OR_LK_1709001202_02_100858	Fairview Lake	0.00
OR_SR_1709000104_02_103719	Salmon Creek	0.00
OR_SR_1709000105_02_103720	Middle Fork Willamette River	0.00
OR_SR_1709000106_02_103721	North Fork Middle Fork Willamette River	0.00
OR_SR_1709000202_02_103765	Layng Creek	0.00
OR_SR_1709000301_02_103789	Long Tom River	0.00
OR_SR_1709000302_02_103807	Oliver Creek	0.00
OR_SR_1709000302_02_103813	Marys River	0.00
OR_SR_1709000402_02_103858	McKenzie River	0.00
OR_SR_1709000105_02_104580	Middle Fork Willamette River	0.00
OR_SR_1709000402_02_104587	McKenzie River	0.00
OR_SR_1709000402_02_104588	McKenzie River	0.00
OR_SR_1709000403_02_104590	South Fork McKenzie River	0.00
OR_SR_1709000405_02_103866	McKenzie River	0.00
OR_SR_1709000405_02_103868	McKenzie River	0.00
OR_SR_1709000405_02_103869	McKenzie River	0.00
OR_SR_1709000605_02_103971	Wiley Creek	0.00
OR_SR_1709000606_02_103974	Roaring River	0.00
OR_SR_1709000701_02_104591	Rickreall Creek	0.00
OR_SR_1709000703_02_104007	Mill Creek	0.00
OR_SR_1709000901_02_104595	Silver Creek	0.00
OR_SR_1709000902_02_104073	Pudding River	0.00
OR_SR_1709001105_02_104162	Eagle Creek	0.00
OR_WS_170900020403_02_104240	Unnamed tributary to Camas Swale Creek	0.00
OR_WS_170900030108_02_104250	Amazon Creek, Amazon Diversion Canal	0.00
OR_WS_170900030204_02_104256	Rock Creek	0.00
OR_WS_170900030511_02_104285	Ditch to Soap Creek tributary	0.00
OR_WS_170900030603_02_104290	Unnamed tributary to Flat Creek	0.00
OR_WS_170900030606_02_104294	Muddy Creek	0.00
OR_WS_170900030610_02_104298	Murder Creek	0.00
OR_WS_170900050203_02_104345	Horn Creek	0.00
OR_WS_170900070201_02_104409	Salem Ditch	0.00
OR_WS_170900070402_02_104419	Coffee Lake Creek	0.00
OR_WS_170900090107_02_104460	Unnamed tributary to Abiqua Creek	0.00
OR_WS_170900090502_02_104481	Mill Creek	0.00
OR_WS_170900090607_02_104488	Unnamed tributary to Molalla River	0.00
OR_WS_170900110605_02_104547	North Fork Deep Creek	0.00

9.1.4 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.

The allocation period is consistent with the critical period of each waterbody, which is presented in Section 5: Seasonal variation and critical period for temperature.

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

$LA_{BG} = (T_C) \cdot (Q_R) \cdot C_F$ **Equation 9-2**

where,

$LA_{BG} =$ Load allocation to background sources (kilocalories/day), expressed as a rolling seven-day average.

$T_C =$ The applicable temperature criteria, not including the HUA. When there are two year-round applicable temperature criteria that apply to the same AU, the more stringent criteria shall be used.

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

$C_F =$ Conversion factor using flow in cfs: 2,446,665

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

Table 9-28 presents the load allocations assigned to background sources on temperature impaired Category 5 AUs 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 AUs. **Equation 9-2** shall be used to calculate the load allocations assigned to background sources on all other AUs or stream location in the Willamette Subbasins not identified in **Table 9-28**; or for any AUs identified in **Table 9-28** 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 AU or stream location where the temperature criterion changed shall be recalculated using the updated criterion and **Equation 9-2**.

Table 9-28: Thermal load allocations (LA) for background sources.

AU Name and AU ID	Annual 7Q10 (cfs)	Year Round Criterion (°C)	Spawning Criterion (°C)	LA period start	LA period end	7Q10 LA Year Round (kcal/day)	7Q10 LA Spawning (kcal/day)
Coyote Creek OR_SR_1709000301_02_103796	5.9	18	NA	5/1	10/31	259.84E+6	NA
Crabtree Creek OR_SR_1709000606_02_103978	25	16	13	5/1	11/30	978.67E+6	795.17E+6
Johnson Creek OR_SR_1709001201_02_104170	11	18	13	2/15	11/15	484.44E+6	349.87E+6
Little North Santiam River OR_SR_1709000505_02_104564	21	16	13	5/1	10/31	822.08E+6	667.94E+6
Luckiamute River OR_SR_1709000305_02_103829	16	18	13	5/1	10/31	704.64E+6	508.91E+6
McKenzie River OR_SR_1709000407_02_103884	1537	16	13	4/1	11/15	60,168.39E+6	48,886.81E+6
Mohawk River OR_SR_1709000406_02_103871	16	16	13	3/15	11/15	626.35E+6	508.91E+6
Molalla River OR_SR_1709000904_02_104086	38	16	13	5/1	10/31	1,487.57E+6	1,208.65E+6
Mosby Creek OR_SR_1709000201_02_103752	11	16	13	5/1	10/31	430.61E+6	349.87E+6
Pudding River OR_SR_1709000905_02_104088	10	18	NA	5/1	10/31	440.4E+6	NA
Thomas Creek OR_SR_1709000607_02_103988	6.9	18	NA	5/1	11/30	303.88E+6	NA

Load allocations assigned to anthropogenic nonpoint sources on any AU or stream location in the Willamette Subbasins are calculated using **Equation 9-3**. The portions of the HUA (ΔT) assigned to nonpoint sources or source categories are presented in Section 9.1.1. When all of the load allocations assigned to a nonpoint source or source category have been achieved, the HUA allocation to that nonpoint source or source category is achieved.

$$LA_{NPS} = (\Delta T) \cdot (Q_R) \cdot C_F \qquad \textbf{Equation 9-3}$$

where,

$LA_{NPS} =$ Load allocation to anthropogenic nonpoint sources (kilocalories/day), expressed as a rolling seven-day average.

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

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

$C_F =$ Conversion factor using flow in cfs: 2,446,665

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

9.1.5 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.

9.1.5.1 Dam and reservoir operations

Dam and reservoir operations have been assigned 0.00 °C of the HUA (Section 9.1.1) and the equivalent load allocation as calculated using **Equation 9-3**. 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.

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. The estimated free flowing (no dam) temperatures may be calculated using a mechanistic or empirical model to account for any warming or cooling that would occur through the reservoir reaches absent the dam and reservoir operations. The results may be applied as the temperature surrogate measure or to adjust the 7DADM temperatures monitored immediately upstream of the reservoirs. Use of the model approach for the surrogate measure must be approved by DEQ.

b) Additional adjustments to the surrogate temperature target calculated or measured under item a) may be allowed when all the following are true:

   i. Monitoring data shows 7DADM temperatures do not exceed the applicable temperature criteria in the AU downstream of the dam;
   ii. The protecting cold water criterion at OAR 340-041-0028(11) does not apply. DEQ has evaluated which dams the protecting cold water criterion likely apply in the TSD Section 9.4.1.1;
   iii. A cumulative effects analysis, approved by DEQ, demonstrates that dam release water temperatures warmer than the surrogate measure calculated or measured under item a) will result in attainment of the dam and reservoir assigned HUA above the applicable criteria in downstream waters.

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

9.1.5.2 Site specific effective shade surrogate measure

Effective shade surrogate measure targets shown in **Table 9-29** through **Table 9-33** represent a surrogate for the amount of solar loading that will attain the HUA 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 DMA (**Equation 9-4**). **Equation 9-4** may be used to recalculate the mean effective shade targets if DMA boundaries change or the DMA 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 WQMP.

Changes in the target effective shade from the values presented in **Table 9-29** through **Table 9-33** may 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, HUA, or the load allocations. They remain the same as presented in this TMDL.

$$\overline{ES} = \frac{\sum ES_{n_i}}{n_i}$$ **Equation 9-4**

Where,

$\overline{ES} =$ The mean effective shade for DMA *i.*

$\sum ES_{n_i} =$ The sum of effective shade from all model nodes or measurement points assigned to DMA *i.*

$n_i =$ Total number of model nodes or measurement points assigned to DMA *i.*

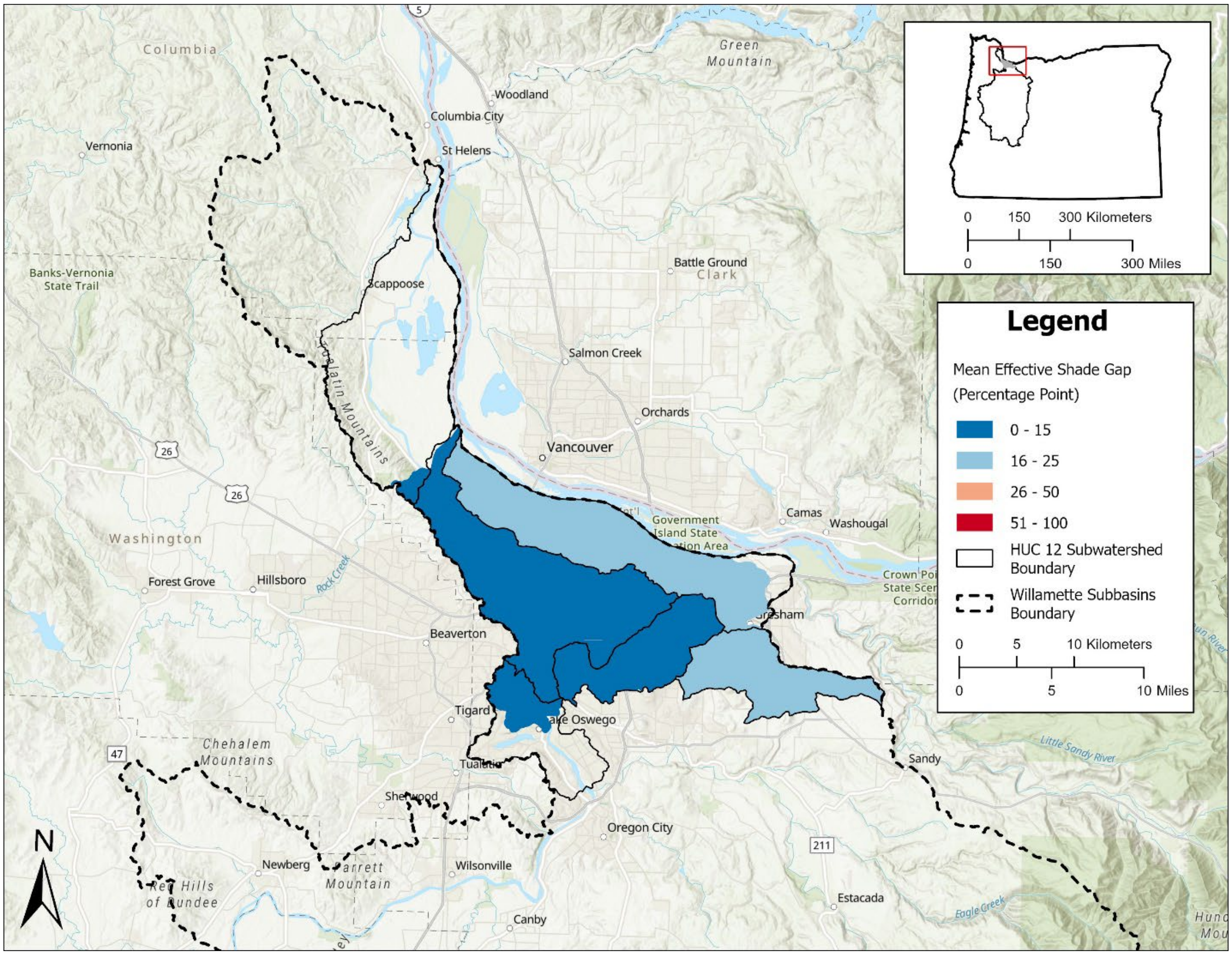

Figure 9-1: Lower Willamette Subbasin model area and mean effective shade gap for each HUC12 subwatershed within the model extent.

Table 9-29: Effective shade surrogate measure targets to meet nonpoint source load allocations for DMAs in the Lower Willamette Subbasin model area.

DMA	Total Kilometers Assessed	Assessed Effective Shade (%)	TMDL Target Effective Shade (%)	Shade Gap
BNSF	0.1	35	42	7
City of Fairview	0.1	21	54	33
City of Gresham	16	63	81	18
City of Happy Valley	0.8	79	90	11
City of Lake Oswego	5.8	83	90	7
City of Milwaukie	2.9	62	80	18
City of Portland	127.4	61	73	12
Clackamas County	13.3	66	86	20
Multnomah County	9.7	75	90	15
Oregon Department of Agriculture	13.5	65	85	20
Oregon Department of Forestry - Private	6.6	89	92	3
Oregon Parks and Recreation Department	0.1	91	91	0
Port of Portland	2.1	29	45	16
Portland & Western Railroad	<0.1	82	89	7
Roads	3.1	54	77	23
Union Pacific Railroad	0.1	34	62	28

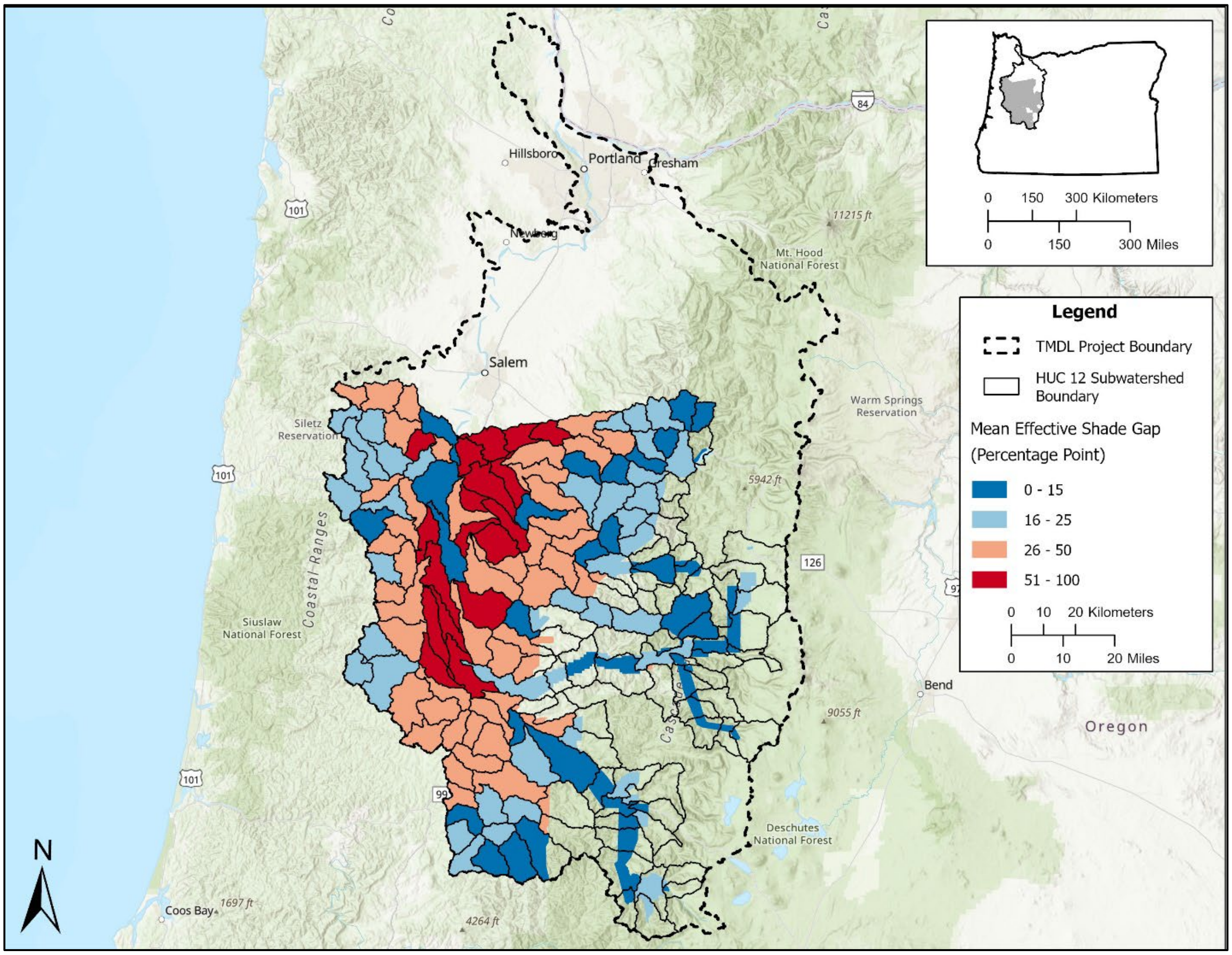

Figure 9-2: Southern Willamette model area and mean effective shade gap for each HUC12 subwatershed within the model extent.

Table 9-30: Effective shade surrogate measure targets to meet nonpoint source load allocations for DMAs in the Southern Willamette model area.

DMA	Total Kilometers Assessed	Assessed Effective Shade (%)	TMDL Target Effective Shade (%)	Shade Gap
Albany & Eastern Railroad	0.1	95	97	2
Benton County	119.3	57	89	32
Bonneville Power Administration	2.3	34	94	60
Central Oregon & Pacific Railroad	0.2	8	86	78
City of Adair Village	2	27	93	66
City of Albany	47.7	35	76	41
City of Brownsville	4	28	67	39
City of Coburg	2.8	22	91	69
City of Corvallis	63.8	59	86	27
City of Cottage Grove	6.2	38	85	47
City of Creswell	4.6	18	91	73
City of Eugene	139.4	27	81	54
City of Falls City	9	56	96	40

DMA	Total Kilometers Assessed	Assessed Effective Shade (%)	TMDL Target Effective Shade (%)	Shade Gap
City of Gates	4.7	36	85	49
City of Halsey	1.6	8	87	79
City of Harrisburg	0.8	3	88	85
City of Jefferson	3.2	22	82	60
City of Junction City	11.6	9	85	76
City of Lebanon	16.2	37	85	48
City of Lowell	2.7	33	90	57
City of Lyons	2.3	32	88	56
City of Mill City	2.9	18	76	58
City of Millersburg	17.2	26	78	52
City of Monmouth	0.5	82	89	7
City of Monroe	1.2	26	75	49
City of Oakridge	9.2	28	75	47
City of Philomath	7.6	37	88	51
City of Salem	0.8	24	45	21
City of Scio	1.7	51	59	8
City of Springfield	45.9	30	83	53
City of Stayton	3.9	41	86	45
City of Sweet Home	26.2	33	87	54
City of Tangent	10.9	48	82	34
City of Veneta	8.7	50	95	45
City of Waterloo	0.4	48	94	46
City of Westfir	3.1	29	80	51
Lane County	773.3	49	84	35
Lincoln County	0.2	9	96	87
Linn County	180.7	42	88	46
Marion County	49	42	78	36
Oregon Department of Agriculture	4823	32	85	53
Oregon Department of Aviation	0.2	1	92	91
Oregon Department of Fish and Wildlife	13.8	37	73	36
Oregon Department of Forestry - Private	8603.4	70	96	26
Oregon Department of Forestry - Public	526.6	85	97	12
Oregon Department of Geology and Mineral Industries	5	40	93	53
Oregon Department of State Lands	3.7	37	56	19
Oregon Department of Transportation	54.9	35	78	43
Oregon Military Department	0.2	0	86	86
Oregon Parks and Recreation Department	28.2	48	72	24
Polk County	64.9	50	93	43
Port of Coos Bay	1.9	56	93	37
Portland & Western Railroad	1.9	46	74	28
State of Oregon	2.5	63	68	5
U.S. Army Corps of Engineers	73.6	59	81	22
U.S. Bureau of Land Management	2574.4	89	97	8
U.S. Department of Agriculture	1.2	30	46	16
U.S. Department of Defense	1.5	47	85	38
U.S. Fish and Wildlife Service	39.7	47	77	30
U.S. Forest Service	2985.3	84	95	11
U.S. Government	10.3	59	82	23
Union Pacific Railroad	5.4	65	90	25

Table 9-31: Effective shade surrogate measure targets to meet nonpoint source load allocations for specific model extents.

Model Stream	Total Kilometers Assessed	Assessed Effective Shade (%)	TMDL Target Effective Shade (%)	Shade Gap
Pudding River	85.55	44	52	8
Molalla River	75.36	27	41	14

Table 9-32: Effective shade surrogate measure targets to meet nonpoint source load allocations for DMAs in the Pudding River model extent.

DMA	Total Kilometers Assessed	Assessed Effective Shade (%)	TMDL Target Effective Shade (%)	Shade Gap
City of Aurora	0.2	28	33	5
Clackamas County	0.5	33	49	16
Marion County	0.2	43	63	20
Oregon Department of Agriculture	96.1	47	57	10
Oregon Department of Transportation	0.2	74	77	3
Oregon Parks and Recreation Department	1.6	36	42	6
State of Oregon	0.1	66	64	-2

Table 9-33: Effective shade surrogate measure targets to meet nonpoint source load allocations for DMAs in the Molalla River model extent.

DMA	Total Kilometers Assessed	Assessed Effective Shade (%)	TMDL Target Effective Shade (%)	Shade Gap
City of Canby	3.1	26	42	16
City of Molalla	0.1	5	29	24
Clackamas County	2.9	19	33	14
Oregon Department of Agriculture	26.8	13	27	14
Oregon Department of Forestry - Private	13.8	40	51	11
Oregon Department of Transportation	0.1	16	51	35
Oregon Parks and Recreation Department	2.1	13	23	10
State of Oregon	0.7	16	24	8
U.S. Bureau of Land Management	24.4	51	65	14
U.S. Government	0.1	49	44	-5
Union Pacific Railroad	0.3	24	47	23

9.1.5.3 Effective shade curve surrogate measure

Effective shade surrogate measure targets represent a surrogate for the amount of solar loading that will attain the HUA and load allocations for nonpoint sources managing streamside vegetation. Effective shade curves are applicable to any stream that does not have site specific shade targets (Section 9.1.5.2). Effective shade curves represent the maximum possible effective shade for a given vegetation type. The values presented within the effective shade curves (**Figure 9-6** to **Figure 9-27**) 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 is summarized in **Table 9-34**. See the TSD Appendix A: Heat Source Model Report and Appendix C: Potential Near-Stream Land Cover for additional details on the model approach for shade curves and the methodologies used to determine the mapping units and vegetation characteristics. Section 14 of this TMDL document provides tables of the plotted shade curve values. A map of all mapping units in the

Willamette Basin can be found in the TSD Appendix H: Willamette Subbasins Interactive TMDL Map. This is an interactive HTML map that can be opened in an internet browser.

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. Where natural disturbances prevent achievement of the target effective shade, DEQ will work with the DMAs to develop plans to restore riparian vegetation.

Table 9-34: 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. Open the Willamette Subbasins Interactive TMDL Map (TSD Appendix H) and select the Shade Curve Mapping Units Layer in the Map Legend to add it to the map. You may also want to select the City Boundaries Layer and the Stream Names Layer to help identify your site of interest. Once you have identified your site of interest, click that point on the map and you will see a pop-up box that identifies the Shade Curve Mapping Unit for that point. In this example, you identify the mapping unit at your site to be Qalc (Quaternary alluvium floodplain deposits) (**Figure 9-4**).

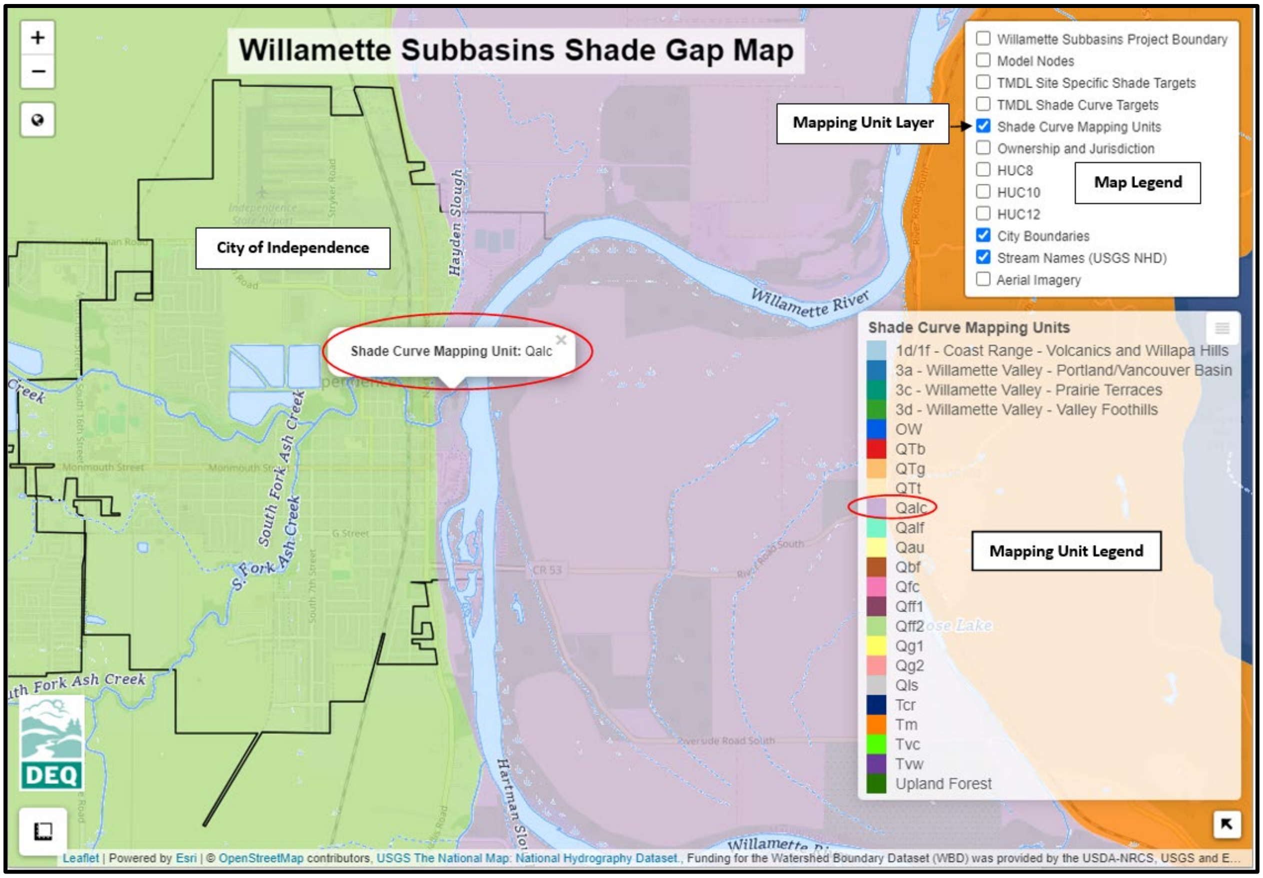

Figure 9-3: Mapping units in the example area of interest from the Willamette Subbasins Interactive TMDL Map.

2. Determine the stream aspect from north.

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

3. 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 ft.

4. 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 9-5**). Since you are located on a tributary with an East-West stream aspect and an active channel width of 25 ft, you use the dotted 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 ft (26.9 m), and the stand density (canopy density) as 71%.

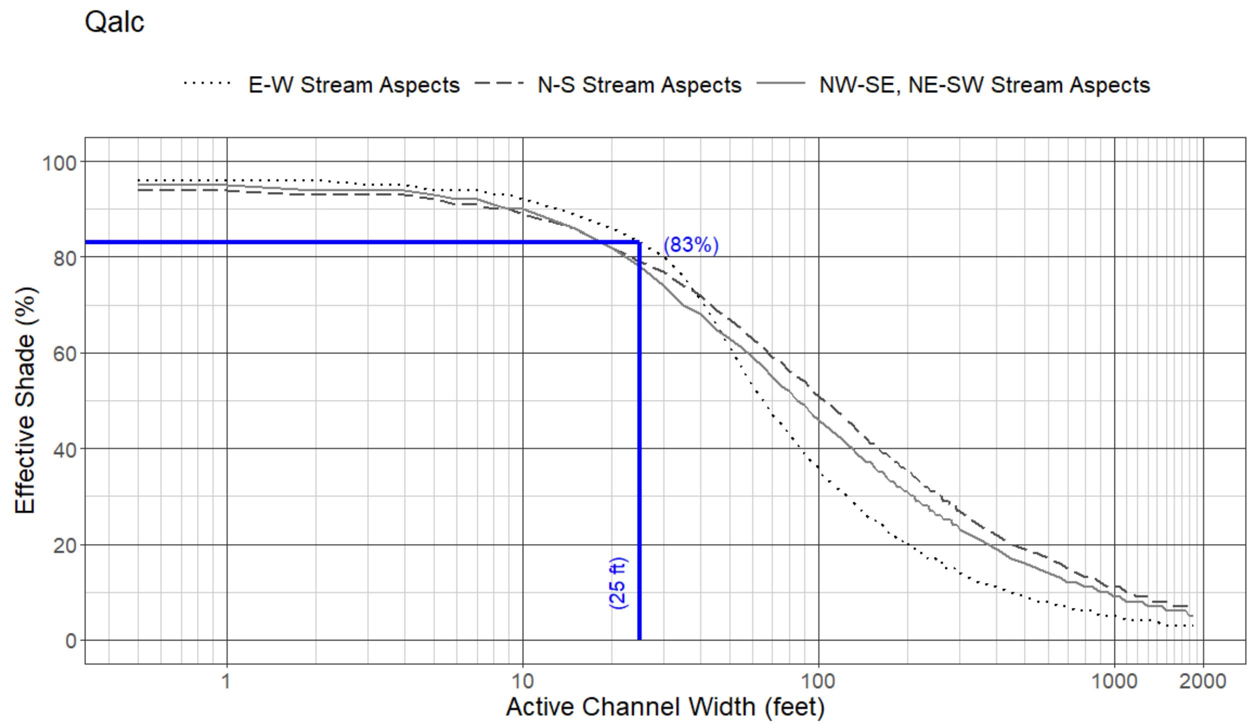

Figure 9-4: Example illustrating use of the shade curve for the Qalc mapping unit based on an east to west aspect and an active channel width of 25 ft.

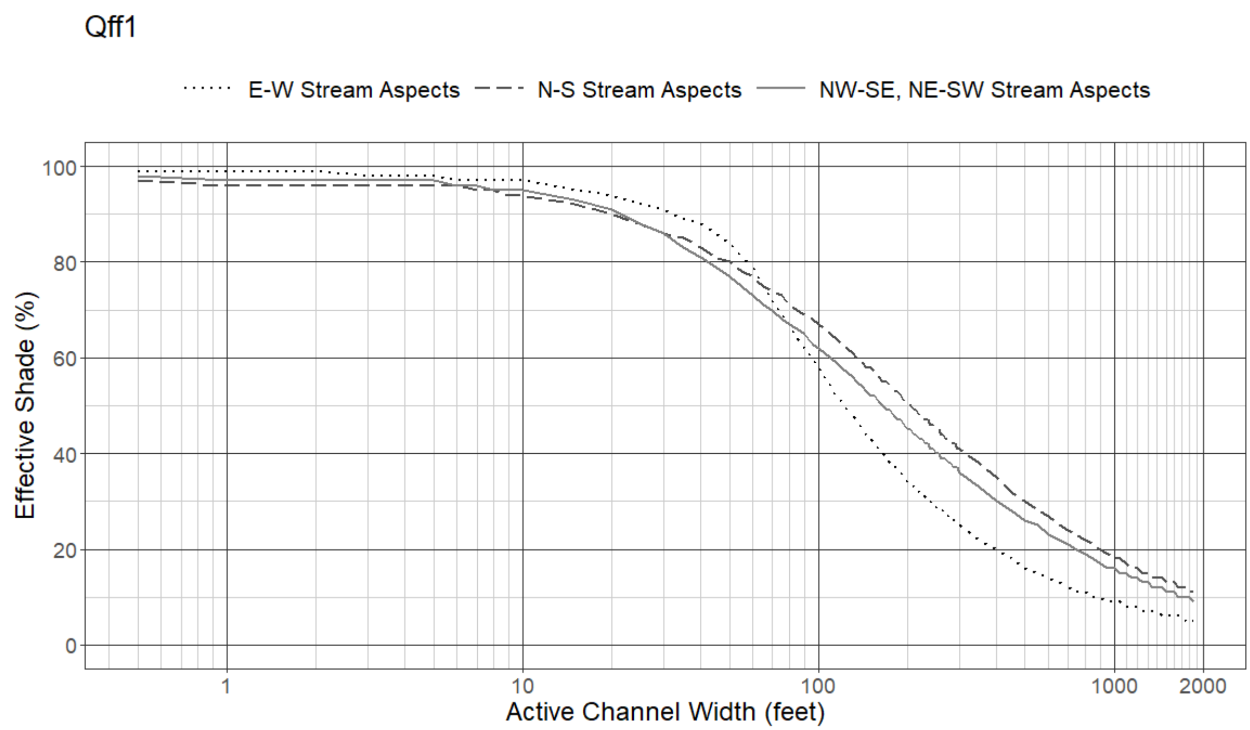

Figure 9-5: Effective shade targets for stream sites in the Qff1 mapping unit.

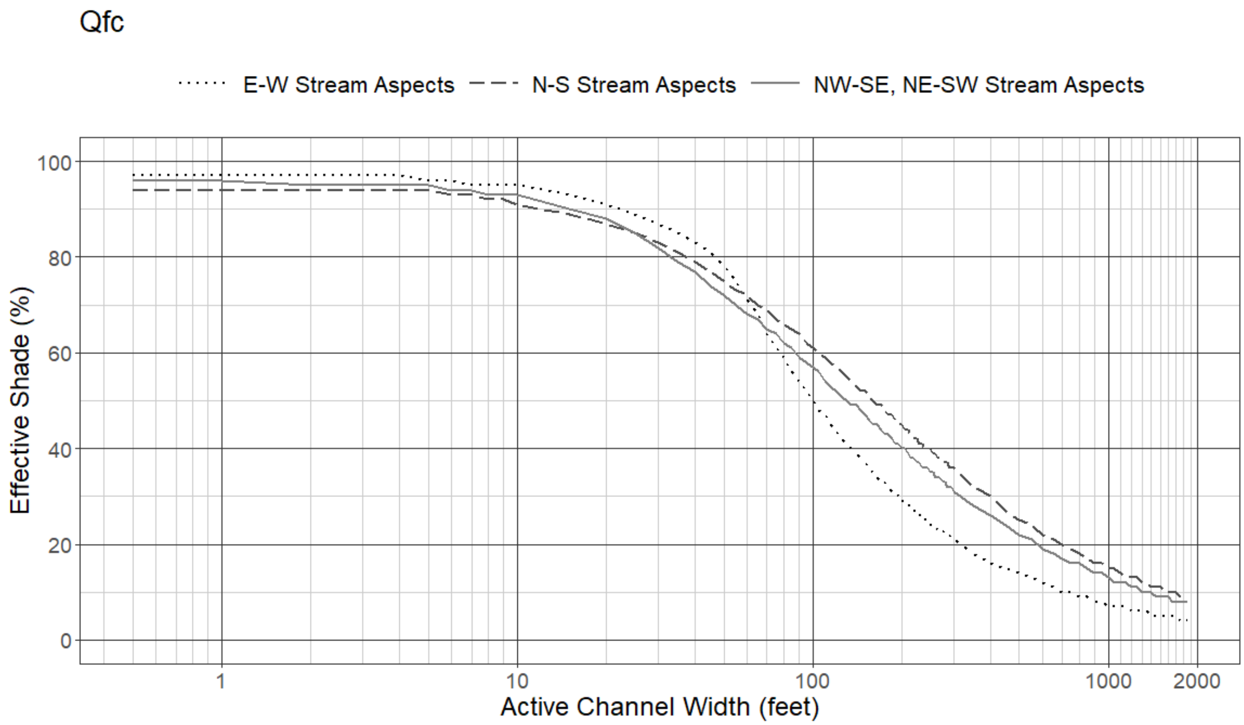

Figure 9-6: Effective shade targets for stream sites in the Qfc mapping unit.

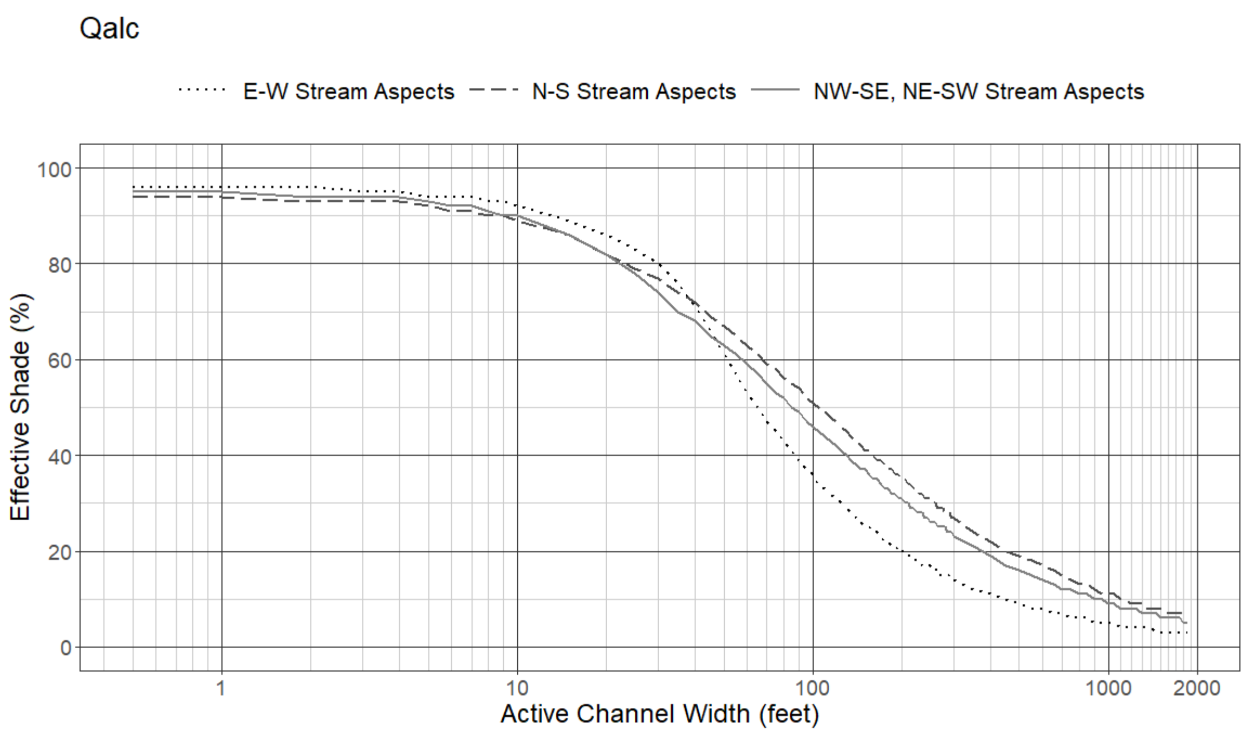

Figure 9-7: Effective shade targets for stream sites in the Qalc mapping unit.

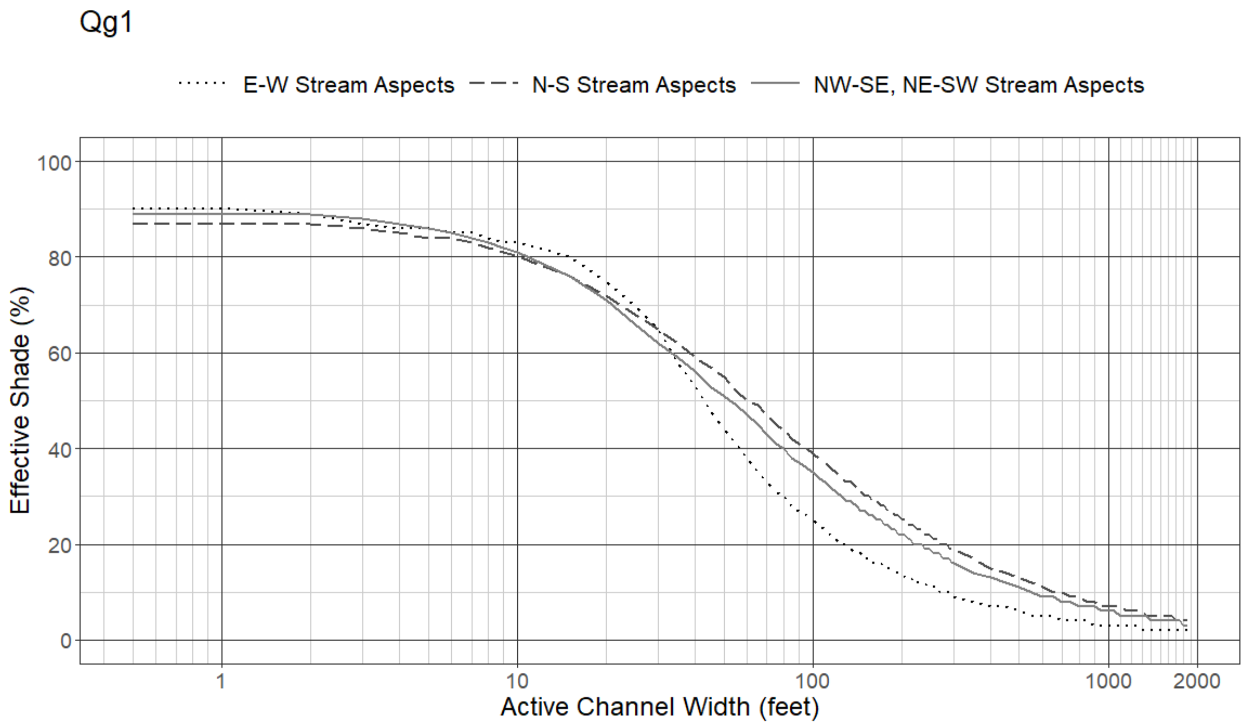

Figure 9-8: Effective shade targets for stream sites in the Qg1 mapping unit.

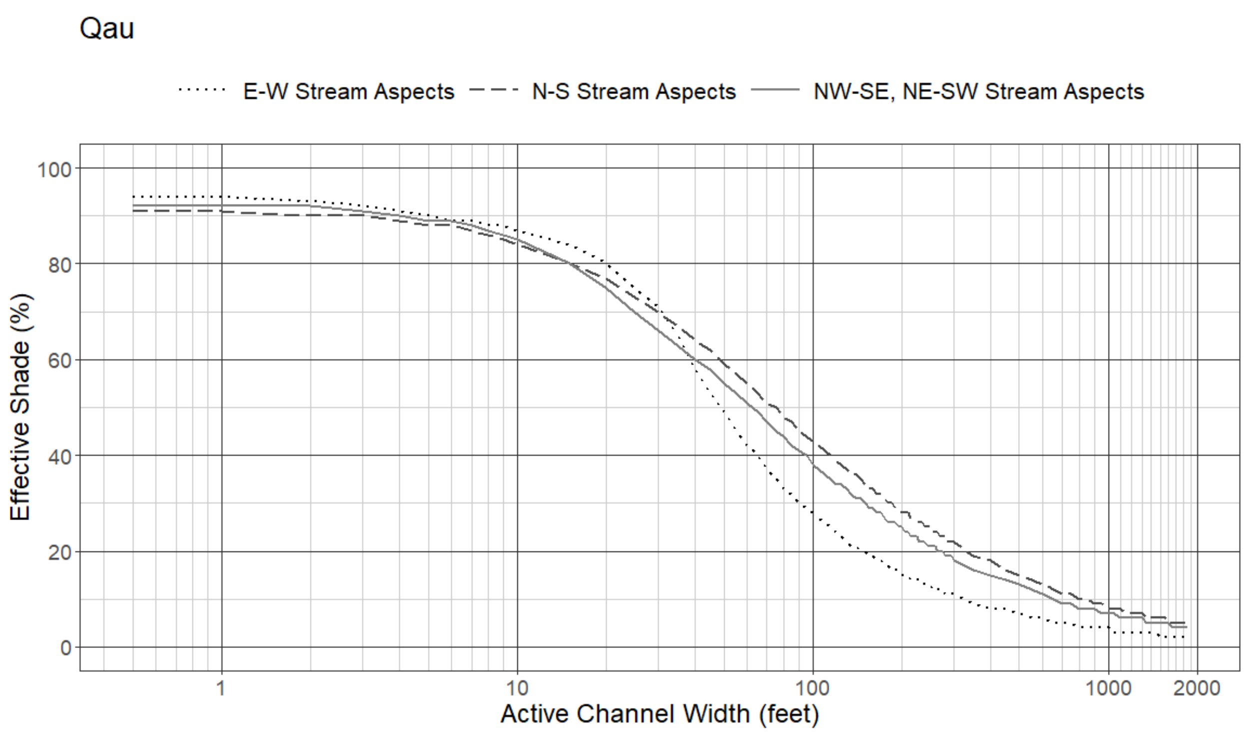

Figure 9-9: Effective shade targets for stream sites in the Qau mapping unit.

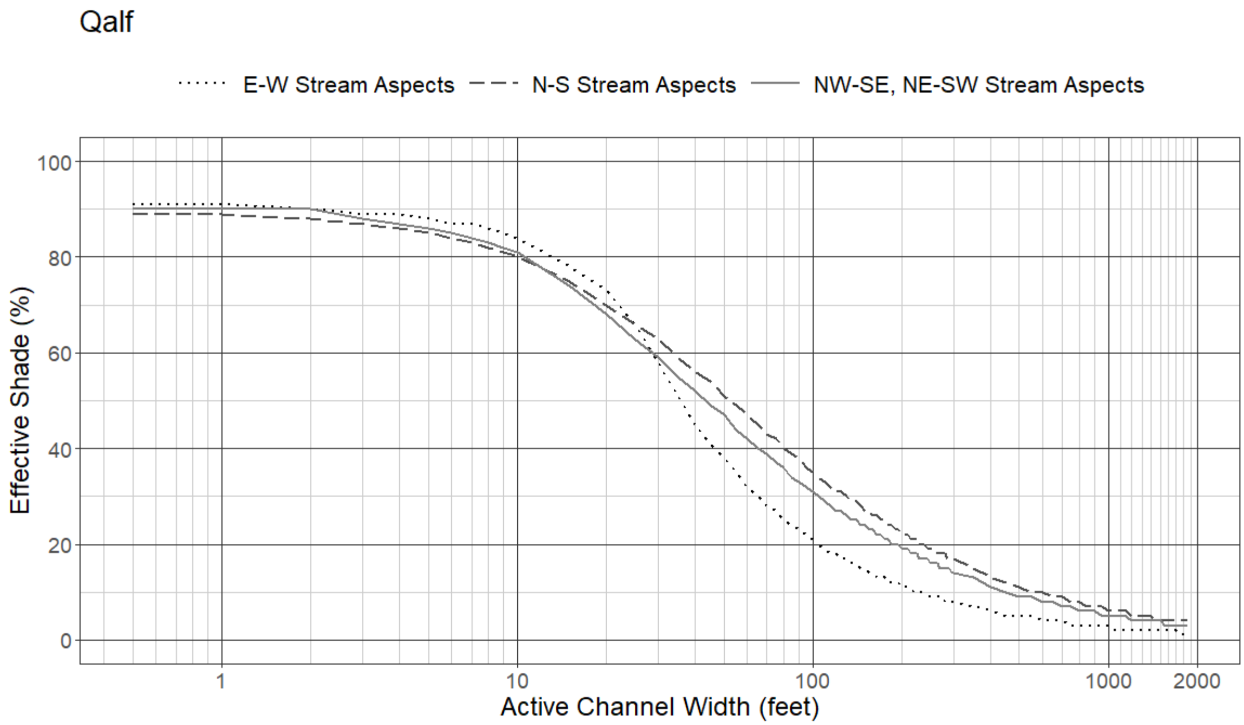

Figure 9-10: Effective shade targets for stream sites in the Qalf mapping unit.

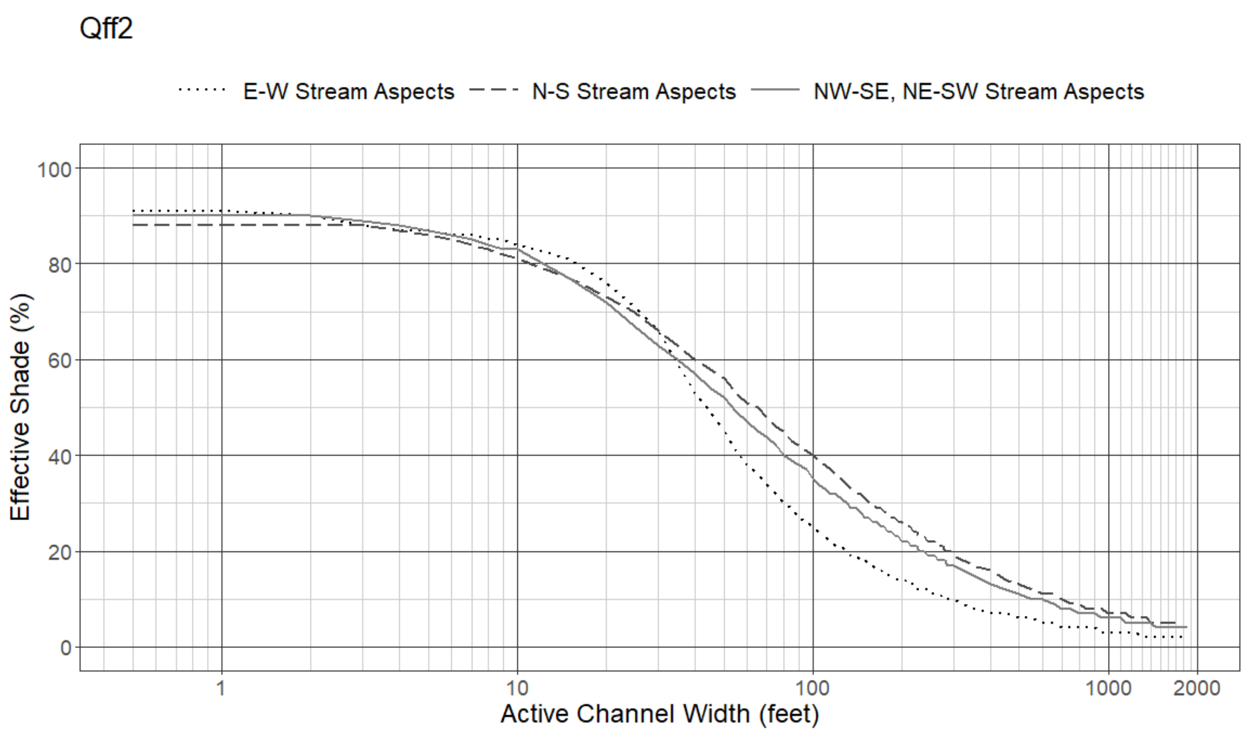

Figure 9-11: Effective shade targets for stream sites in the Qff2 mapping unit.

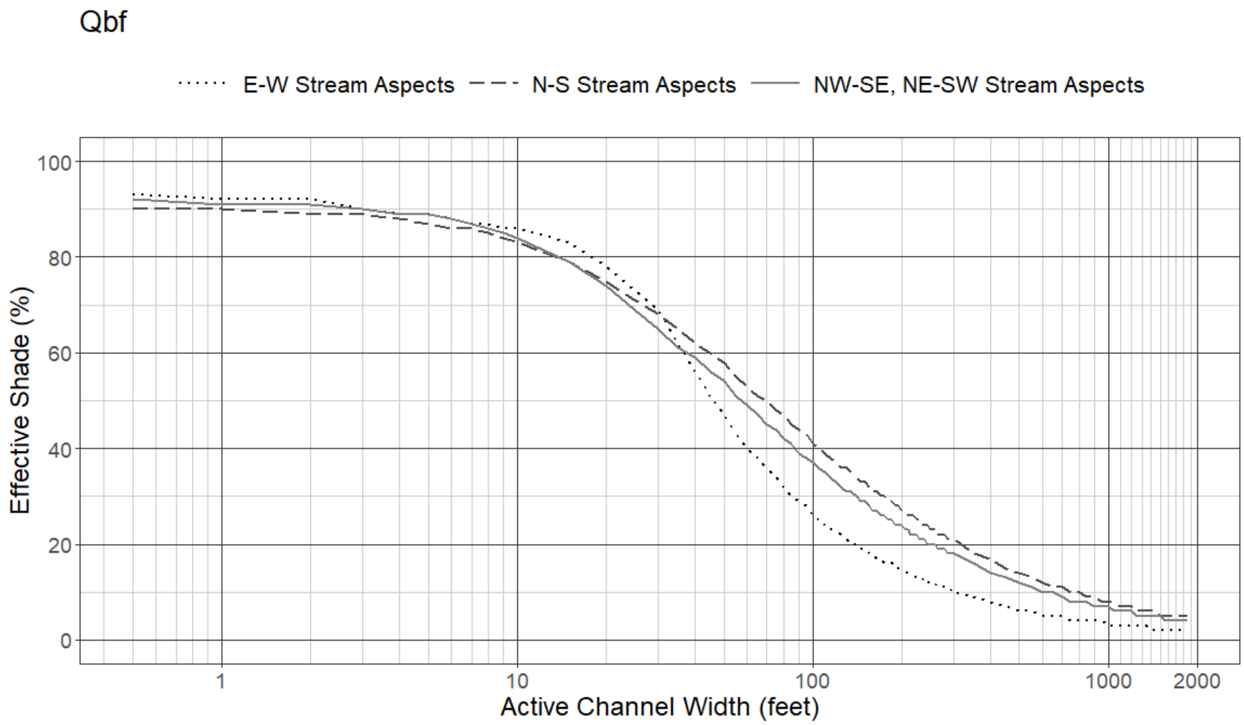

Figure 9-12: Effective shade targets for stream sites in the Qbf mapping unit.

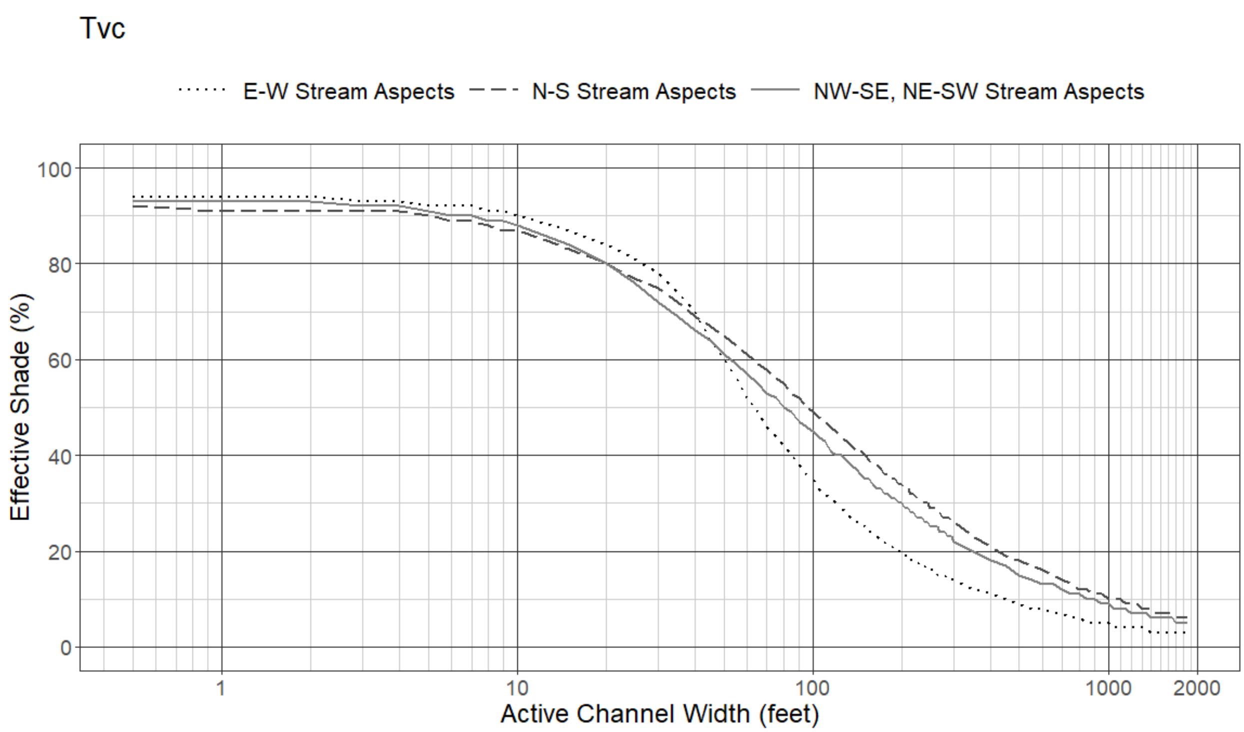

Figure 9-13: Effective shade targets for stream sites in the Tvc mapping unit.

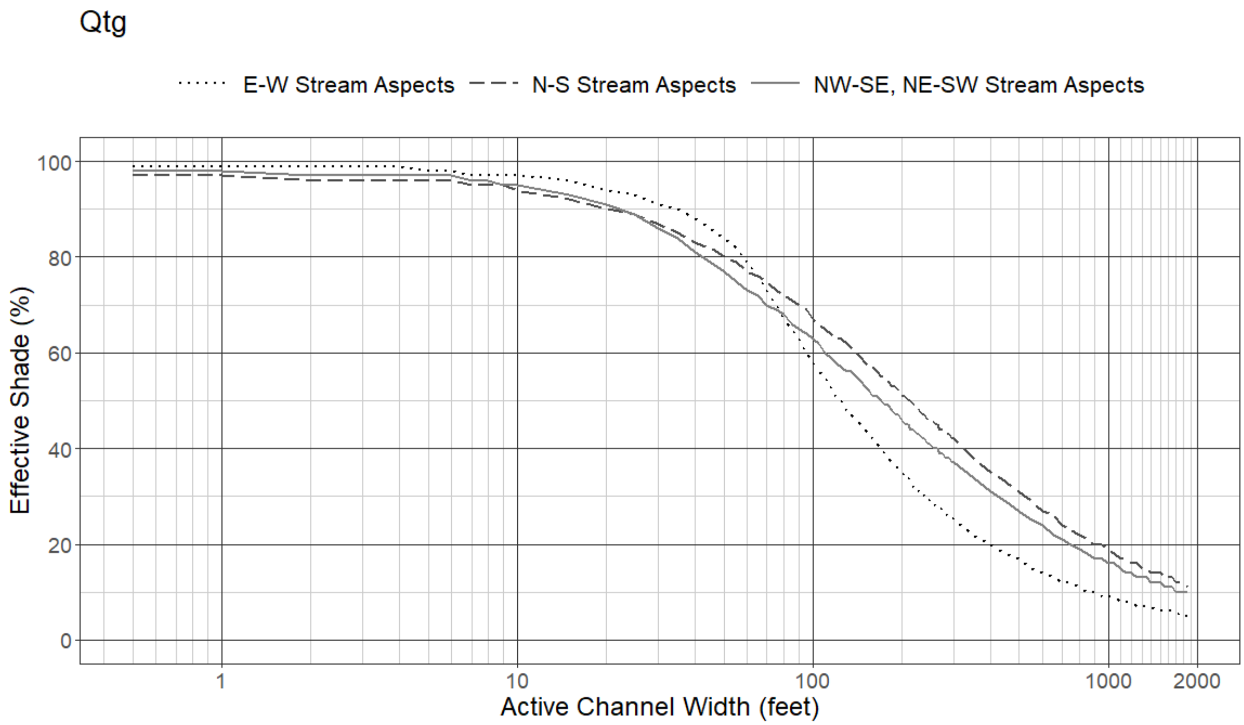

Figure 9-14: Effective shade targets for stream sites in the Qtg mapping unit.

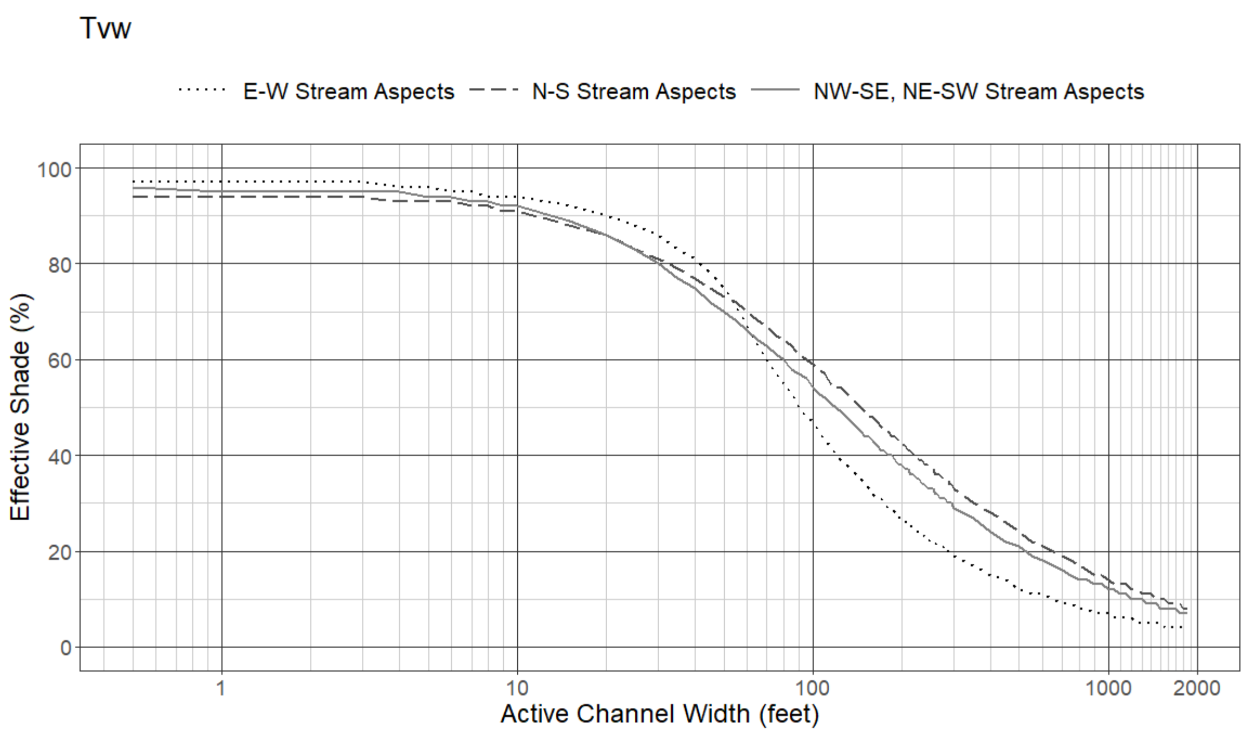

Figure 9-15: Effective shade targets for stream sites in the Tvw mapping unit.

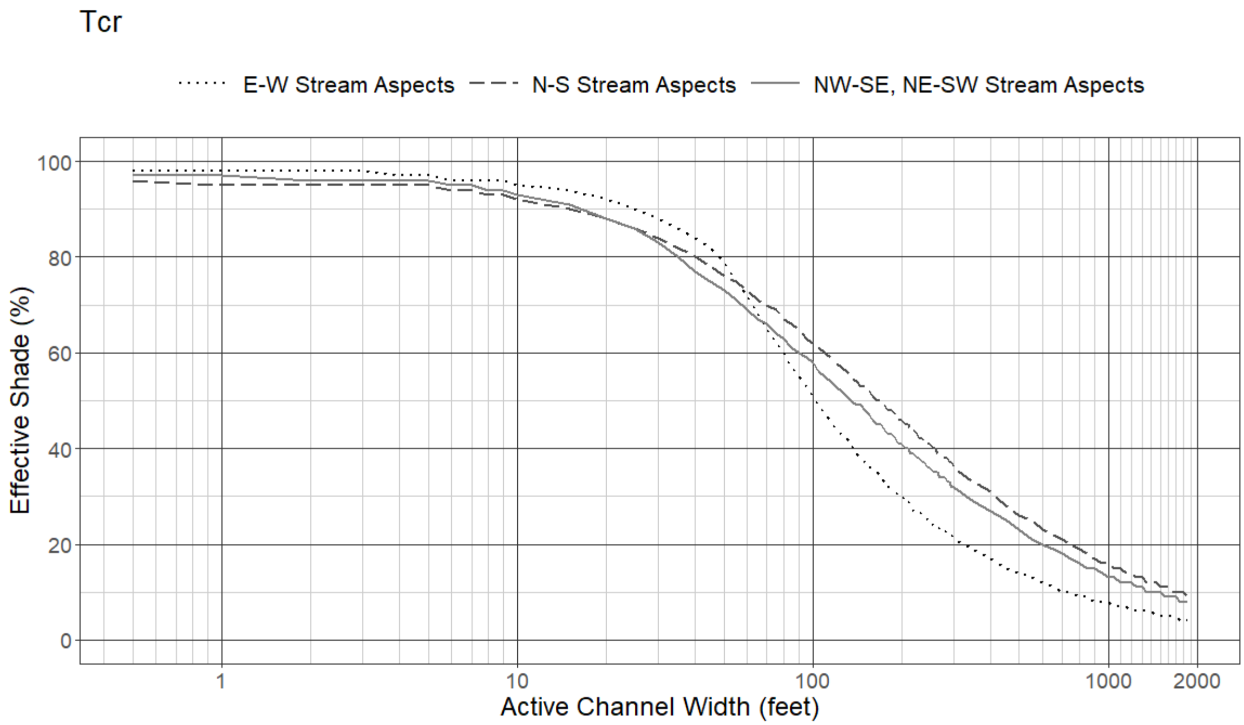

Figure 9-16: Effective shade targets for stream sites in the Tcr mapping unit.

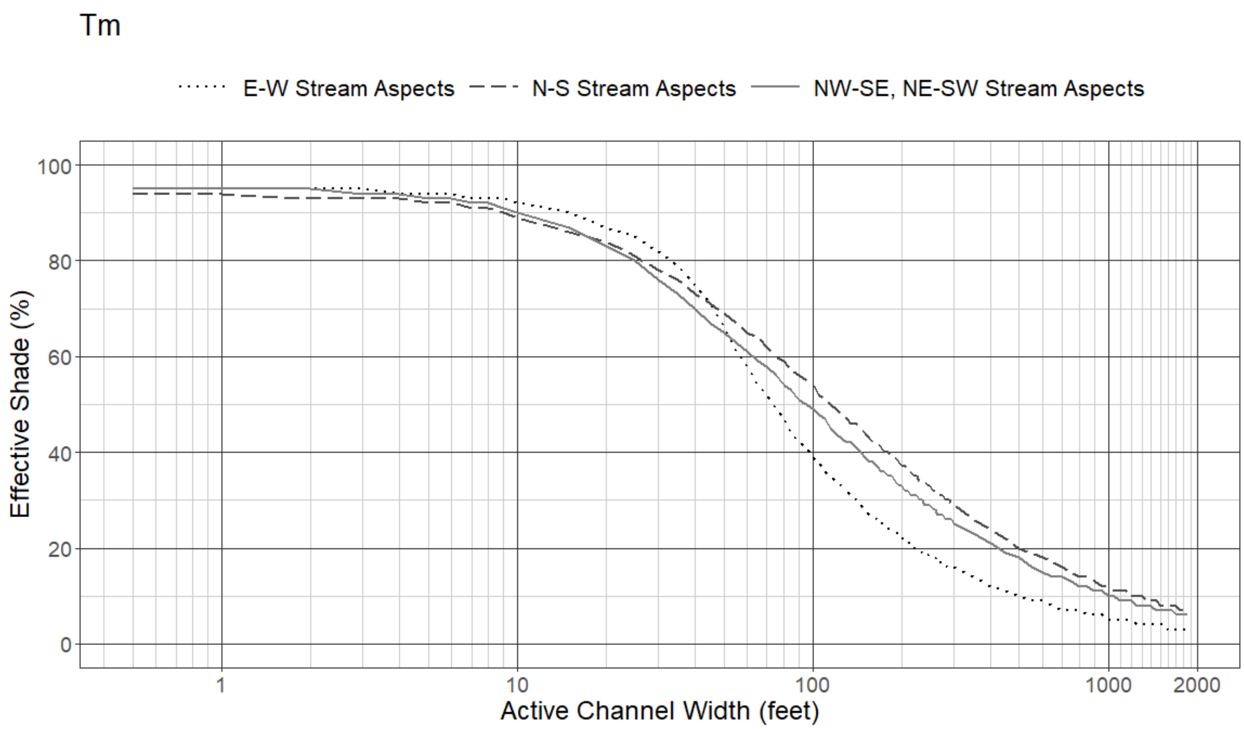

Figure 9-17: Effective shade targets for stream sites in the Tm mapping unit.

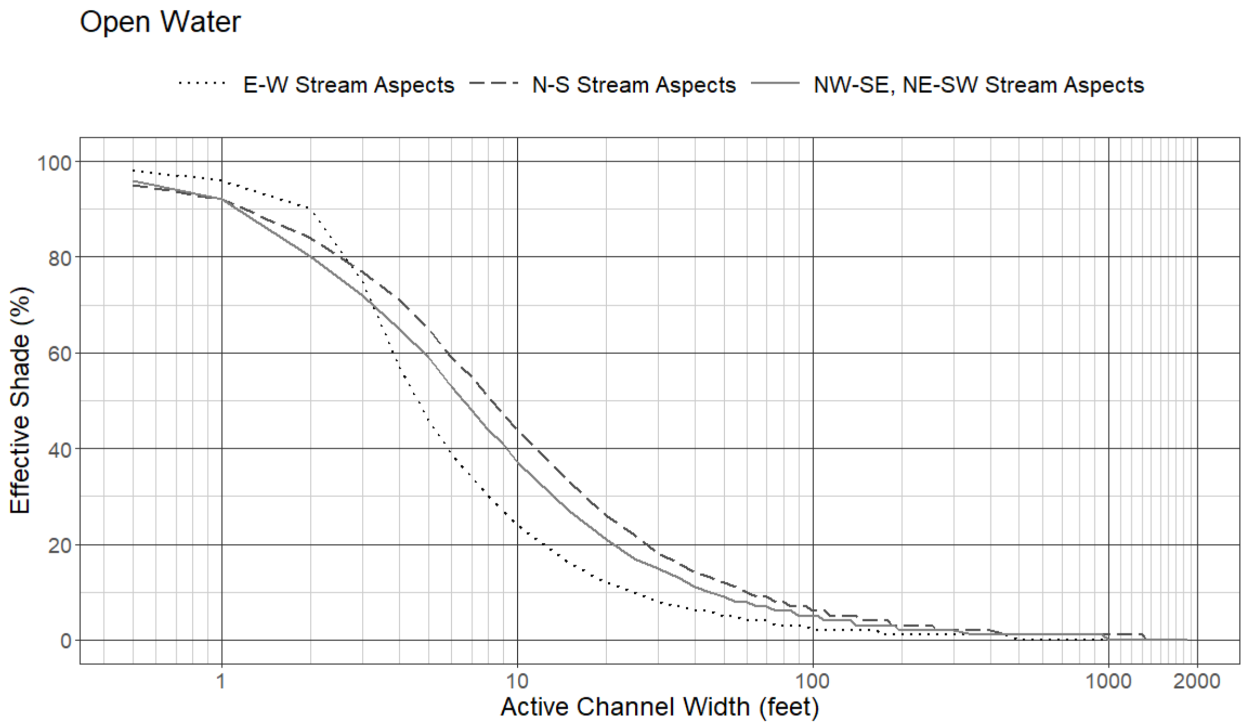

Figure 9-18: Effective shade targets for stream sites in the Open Water (OW) mapping unit.

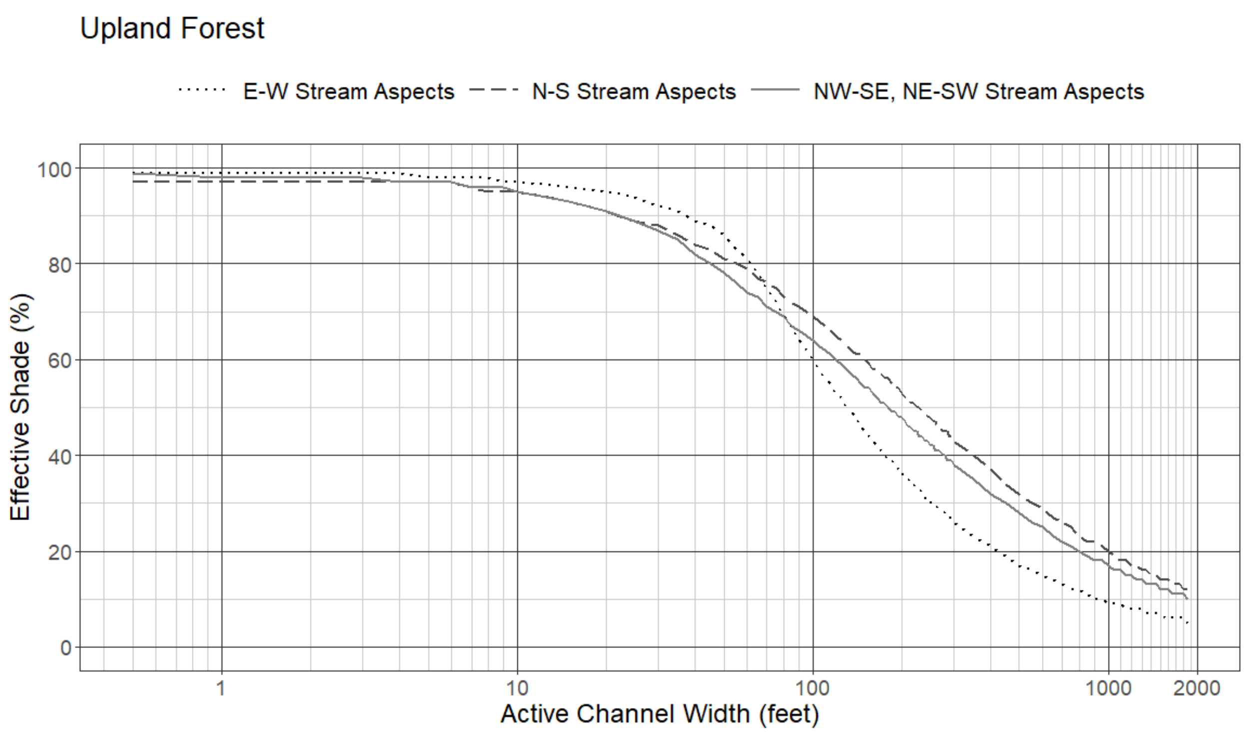

Figure 9-19: Effective shade targets for stream sites in the Upland Forest mapping unit.

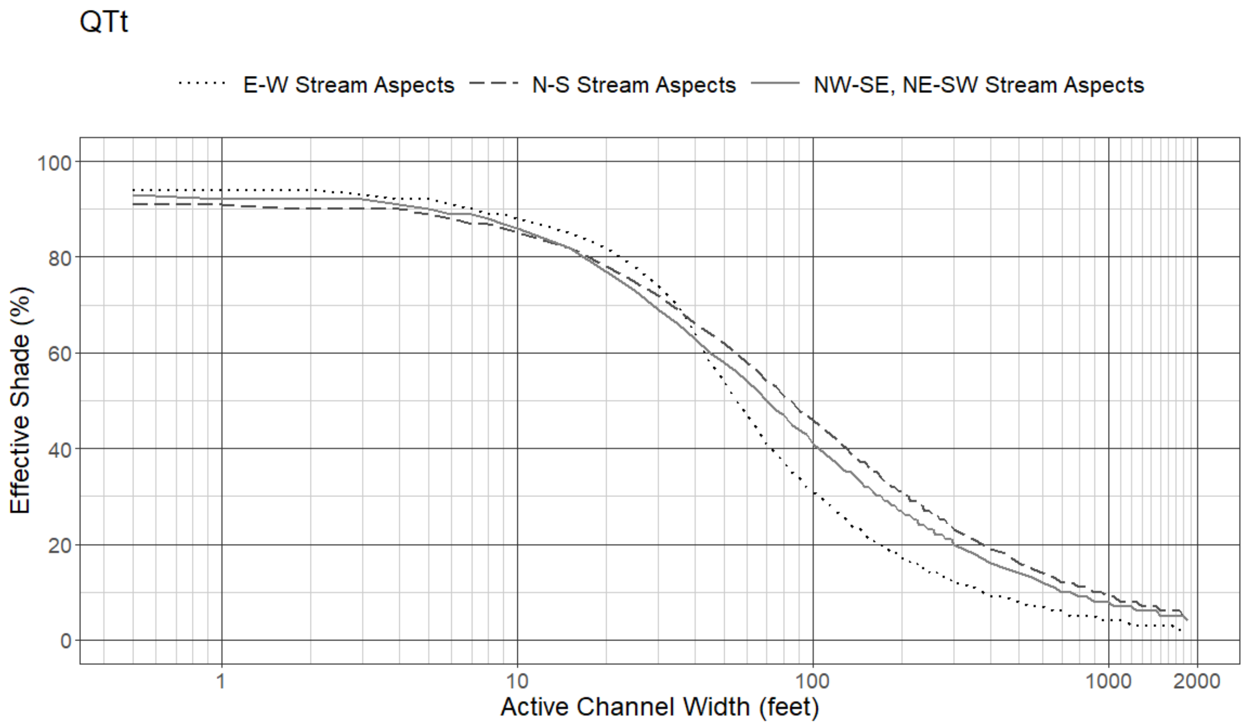

Figure 9-20: Effective shade targets for stream sites in the QTt mapping unit.

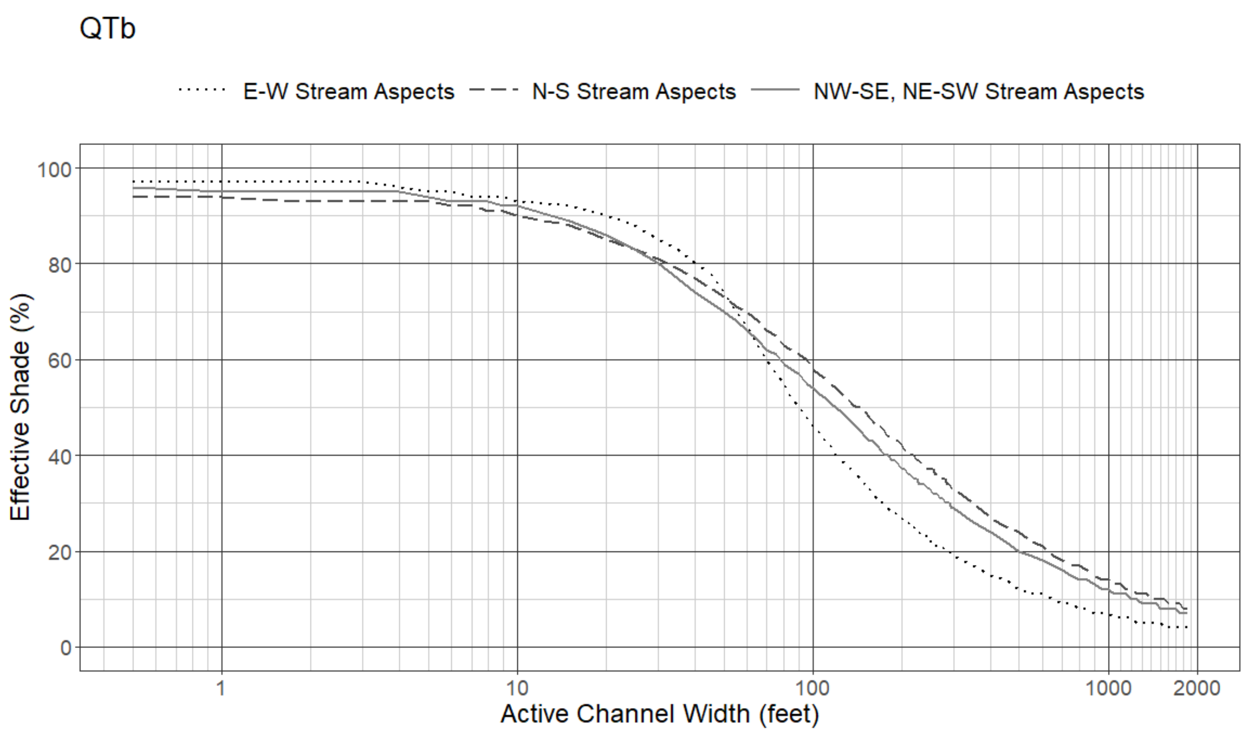

Figure 9-21: Effective shade targets for stream sites in the QTb mapping unit.

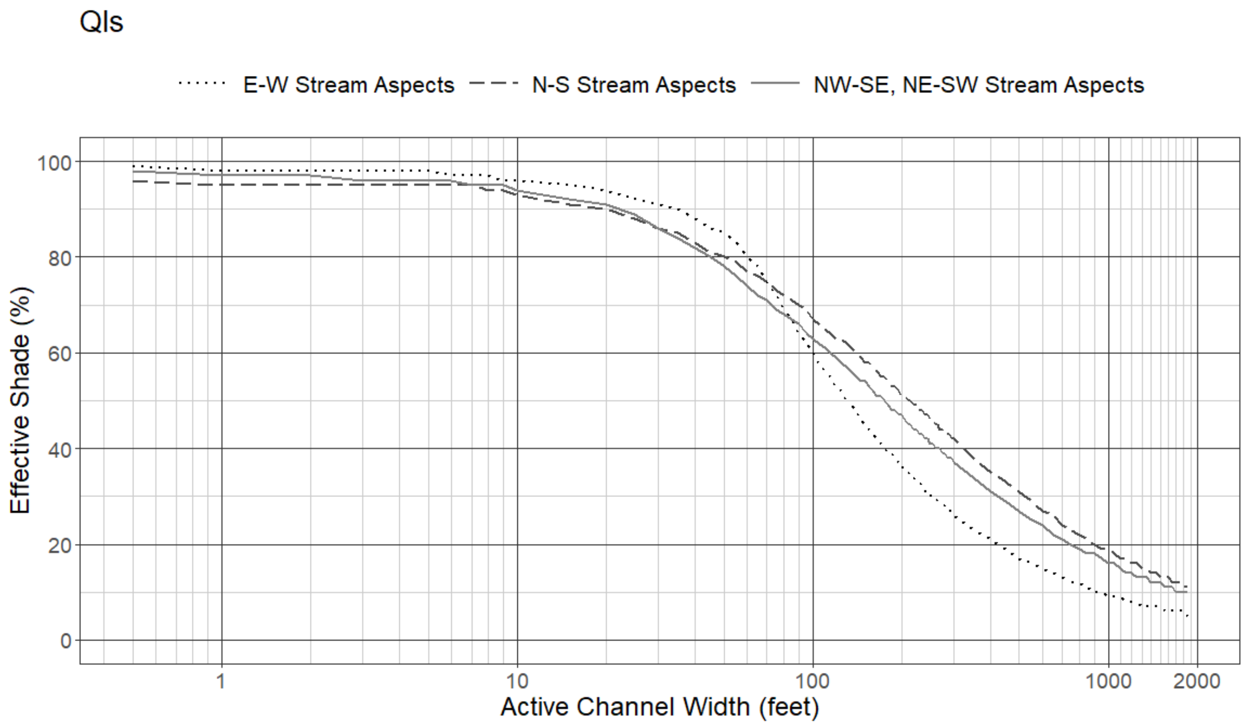

Figure 9-22: Effective shade targets for stream sites in the Qls mapping unit.

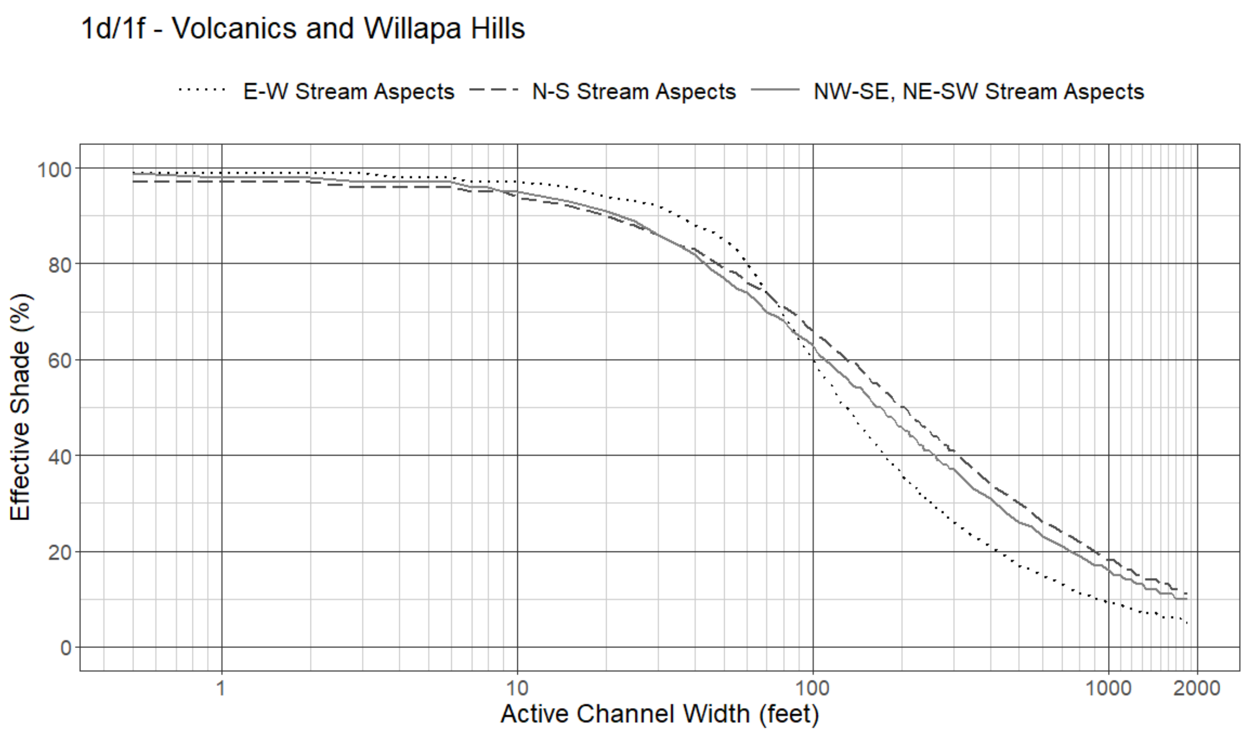

Figure 9-23: Effective shade targets for stream sites in Ecoregion 1d/1f - Volcanics and Willapa Hills.

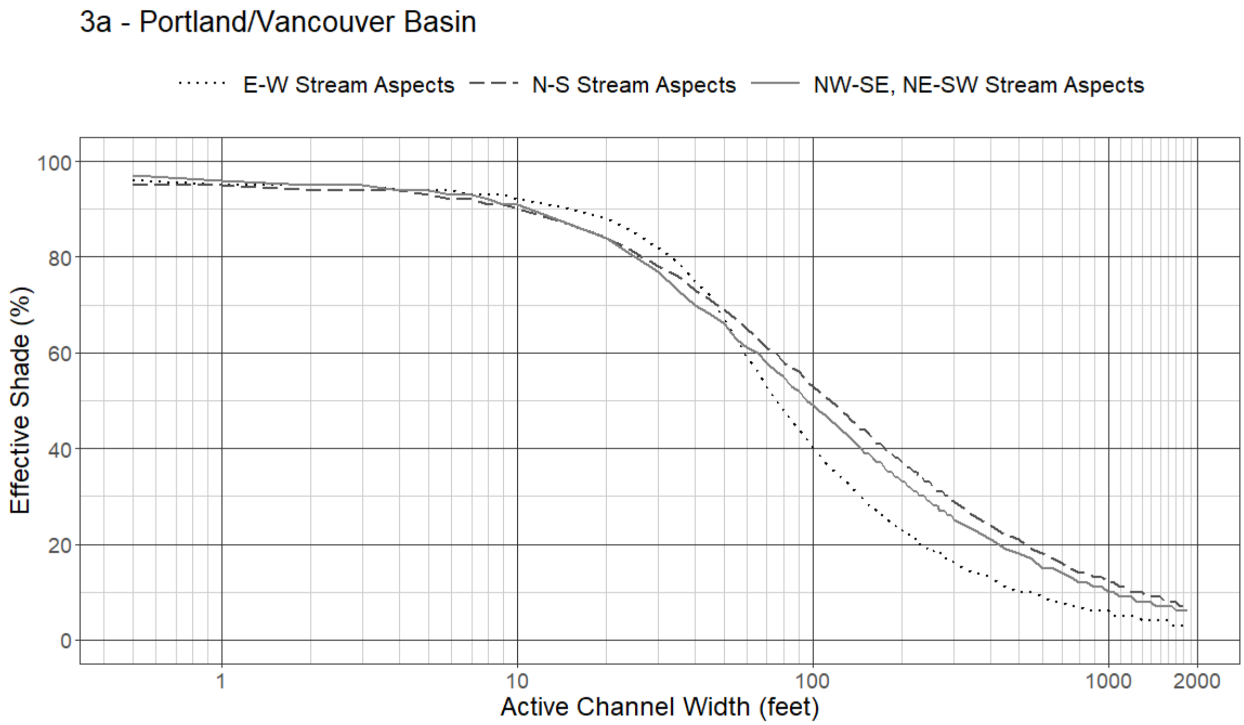

Figure 9-24: Effective shade targets for stream sites in Ecoregion 3a - Portland/Vancouver Basin.

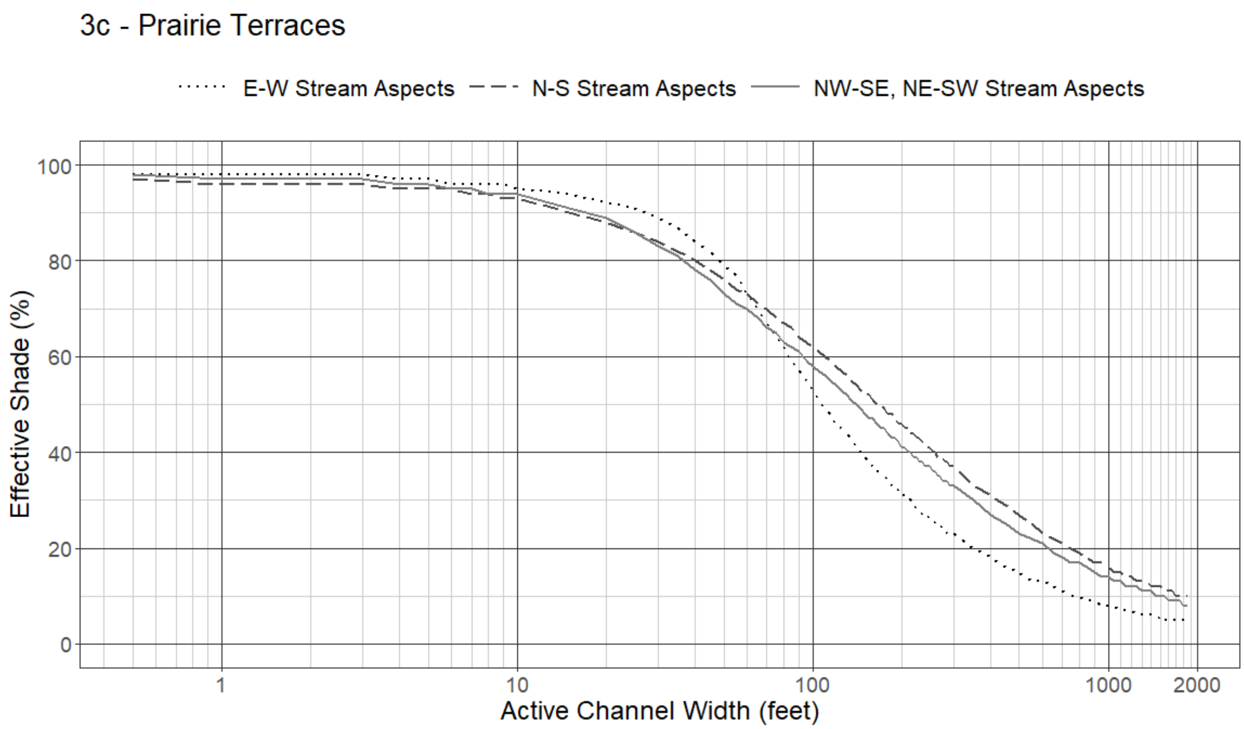

Figure 9-25: Effective shade targets for stream sites in Ecoregion 3c - Prairie Terraces.

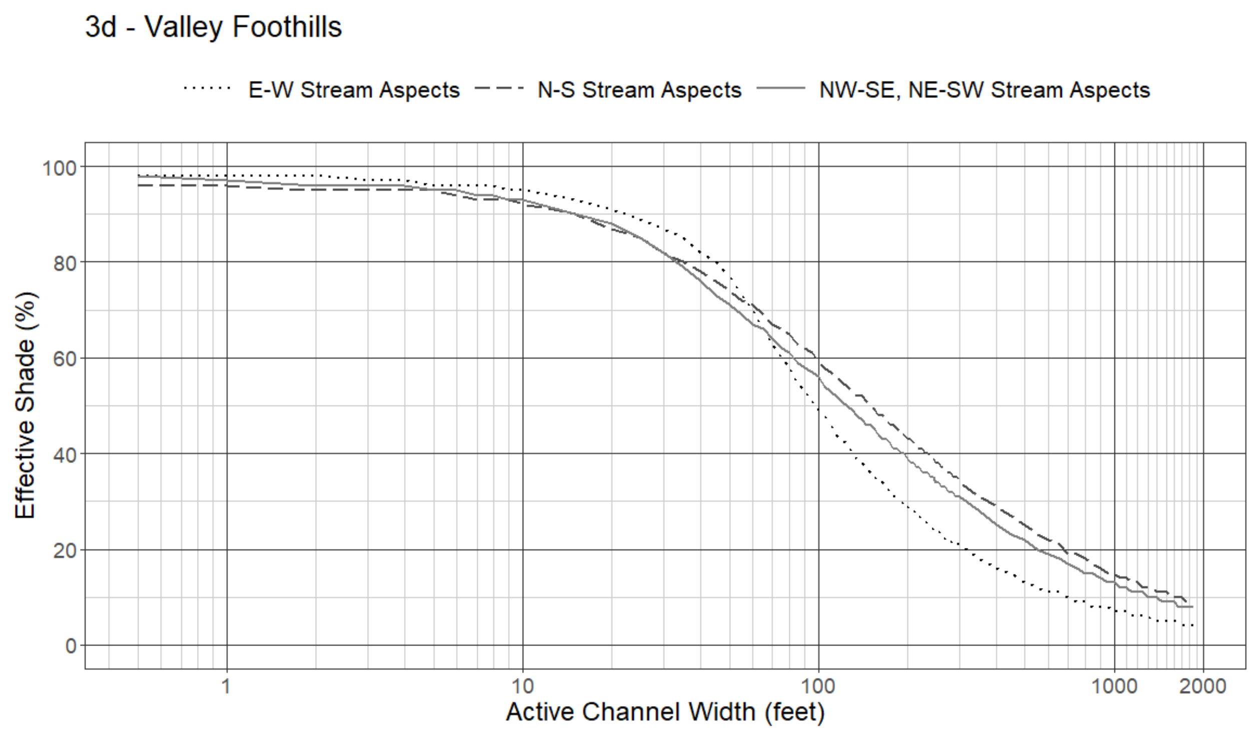

Figure 9-26: Effective shade targets for stream sites in Ecoregion 3d - Valley Foothills.

9.1.6 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 HUA associated with the reserve capacity is described Section 9.1.1.

If DEQ determines the cumulative warming from all NPDES point sources is less than the assigned portion of the HUA, 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, DEQ may require requesters to demonstrate that there are no reasonable alternatives to an increased load and to prepare modeling or similar analysis to ensure that loading capacity is available at the discharge location(s) or in downstream waters. The HUA assigned to reserve capacity may not be available for allocation due to cumulative warming and points of maximum impact downstream. 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 (ADWDF) or a maximum flow obtained from discharge monitoring reports (DMRs) for the model scenario assessing the wasteload allocations and for assessments of current thermal loading. It is rare that actual discharges from point sources will reach design flows and sustain that discharge for long periods of time.
- Setting effluent temperatures as high as 32°C 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°C 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 applied the maximum assigned HUA to each source category to assess cumulative allocation attainment. The modeling shows the maximum allowed temperature increase is limited to one or two days and is generally less than 5% of the time. Additionally, the maximum temperature increase is geographically limited and focused to distinct locations. This means that a portion of the loading capacity reserved for human use will go unutilized most of the time. The cumulative effects analysis was performed for modeled reaches and is described in the modeling reports (TSD Appendix A, Appendix J and Appendix K).
- Groundwater inflows were assumed to be zero in most models. Because groundwater directly cools stream temperatures via mixing, this means that actual instream temperatures would be lower than modeled temperatures anywhere that groundwater influences exist.
- 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.
- The sum of individual human use allocations was used to assess cumulative attainment across the entirety of a given AU. This method does not account for longitudinal instream heat dissipation downstream from each thermal source. Thus, the total thermal load and corresponding temperature increase is likely to result in a maximum temperature increase of less than 0.3°C.
- The nonpoint source HUA allocation will be implemented by assessing the cumulative warming of a waterbody by all nonpoint sources. This is a margin of safety that ensures cumulative warming from all nonpoint sources will not exceed the portion of the HUA allocated to nonpoint sources.

10 Water quality management plan

As described in OAR 340-042-0040(4)(l)(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 DMAs, 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 EQC.

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 (EPA, 1991). Comprehensive explanations of reasonable assurances of implementation are provided in Section 7 of the Willamette Subbasins WQMP.

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 are 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, 2023b), are fulfilled by the statements and references to specific sections of the TMDLs, WQMP, and TSD in the subsections that follow. A full list of AUs where the protection plan applies is in the TSD Appendix D.

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

Appendix D of the TMDL TSD lists all the assessments units within the Willamette Subbasins and their 2022 Integrated Report assessment status. Those AUs with the status of Category 2 or 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 the TSD 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 HUA assignments for anthropogenic sources are shown in **Table 9-1** through **Table 9-22**. 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 to 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

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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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
0.2	0.5	87	89	90
0.3	1	87	89	90

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
48.8	160	29	26	16
50.3	165	29	25	16
51.8	170	28	25	16
53.3	175	28	24	15

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
304.8	1000	7	6	3
320	1050	7	6	3
335.3	1100	7	5	3
350.5	1150	6	5	3

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
12.2	40	64	60	58
13.7	45	62	58	53
15.2	50	59	55	49
16.8	55	57	53	45

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
76.2	250	25	21	13
77.7	255	24	21	12
79.2	260	24	21	12
80.8	265	24	20	12

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
42.7	140	29	25	16
44.2	145	28	24	15
45.7	150	27	24	15
47.2	155	27	23	14

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
243.8	800	8	6	3
259.1	850	7	6	3
274.3	900	7	6	3
289.6	950	7	5	3

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
6.1	20	73	72	76
7.6	25	70	67	71
9.1	30	66	63	66
10.7	35	63	60	59

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
70.1	230	23	20	12
71.6	235	23	20	12
73.2	240	23	20	12
74.7	245	22	19	12

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 Tvw mapping unit

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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
45.7	150	44	39	28
47.2	155	43	38	27
48.8	160	42	38	27
50.3	165	42	37	26

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
274.3	900	13	11	6
289.6	950	12	11	6
304.8	1000	12	10	5
320	1050	11	10	5

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
9.1	30	72	69	74
10.7	35	69	66	70
12.2	40	66	63	64
13.7	45	64	60	58

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
73.2	240	27	24	15
74.7	245	27	23	15
76.2	250	27	23	14
77.7	255	26	23	14

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 Qls mapping unit

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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
51.8	170	57	51	41
53.3	175	56	51	40
54.9	180	56	50	39
56.4	185	55	49	39

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
335.3	1100	18	16	9
350.5	1150	18	15	8
365.8	1200	17	15	8
381	1250	17	14	8

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
12.2	40	83	82	88
13.7	45	81	79	87
15.2	50	79	77	85
16.8	55	78	75	83

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
76.2	250	45	41	30
77.7	255	44	40	30
79.2	260	44	40	29
80.8	265	44	39	29

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
42.7	140	45	41	31
44.2	145	44	40	30
45.7	150	44	39	29
47.2	155	43	39	28

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
243.8	800	14	12	7
259.1	850	14	12	6
274.3	900	13	11	6
289.6	950	13	11	6

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
3	10	93	94	95
4.6	15	90	91	94
6.1	20	88	89	92
7.6	25	86	86	91

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
67.1	220	44	39	29
68.6	225	43	39	28
70.1	230	43	38	28
71.6	235	42	38	27

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

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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 (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W 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
27.4	90	62	58	53
29	95	61	57	51
30.5	100	59	56	49
32	105	58	54	48

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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
91.4	300	34	31	21
106.7	350	31	28	18
121.9	400	29	25	16
137.2	450	27	23	15

Active Channel Width (m)	Active Channel Width (ft)	Effective Shade Target for N-S Stream Aspects (%)	Effective Shade Target for NW-SE, NE-SW Stream Aspects (%)	Effective Shade Target for E-W Stream Aspects (%)
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