CHAPTER 12: MIDDLE FORK WILLAMETTE SUBBASIN TMDL

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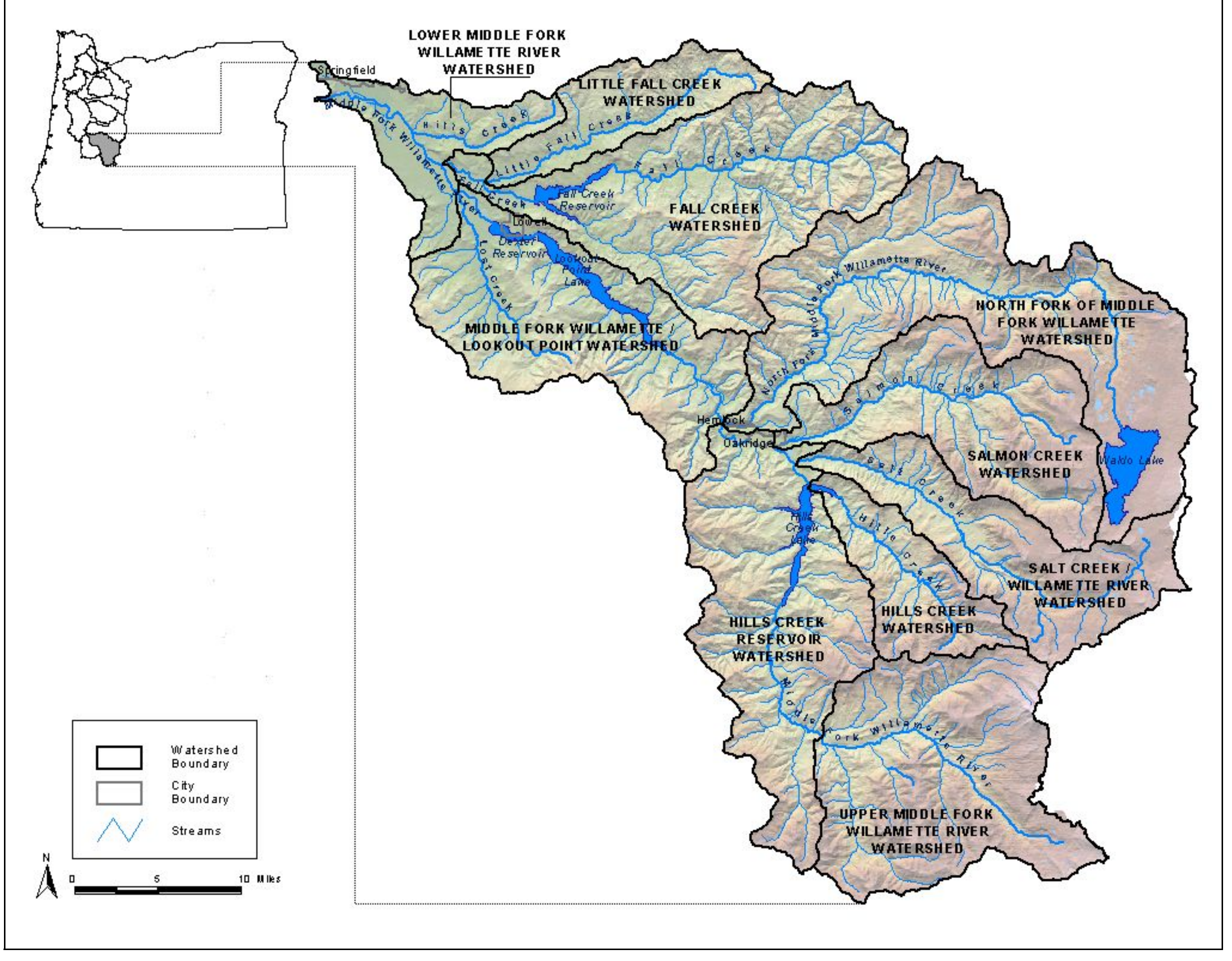
WATER QUALITY SUMMARY

Reason for action

The Middle Fork Willamette Subbasin (Map 12.1) has stream segments listed under section 303(d)[1] of the federal Clean Water Act (CWA) that are exceeding water quality criteria for temperature and dissolved oxygen. Total Maximum Daily Loads (TMDLs) for temperature are developed based on information for this parameter. TMDLs will not be developed for dissolved oxygen at this point in time for reasons noted in the following section. Wasteload allocation methodologics are discussed for individual facilities (point sources) that discharge heated effluent during the critical period. Load allocations for nonpoint sources are developed for each geomorphic unit and apply to all sectors in the subbasin.

This chapter only includes TMDLs for rivers and streams in the Middle Fork Willamette Subbasin. These subbasin rivers and streams are tributary to the Middle Fork Willamette River. For the portion of the Middle Fork Willamette River from the mouth to river mile (RM) 15.6 (Dexter Reservoir) and Fall Creek from the mouth to RM 7.0 (Fall Creek Reservoir), the temperature analysis is included in the mainstem Willamette River TMDLs, see Chapter 4. All other subbasin TMDLs are included in Chapters 5 – 13.

Map 12.1 The Middle Fork Willamette Subbasin



[1] The 303(d) list is a list of stream segments that do not meet water quality criteria.

Water Quality 303(d) Listed Waterbodies

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

All current 303(d) listings for the subbasin are presented in Table 12.1.

Table 12.1 Name and location of listed Middle Fork Willamette Subbasin waterbodies.

Waterbody Name	Listed River Mile	Parameter	Season	Addressed in TMDL
Anthony Creek	0 to 4.3	Dissolved Oxygen	October 1 - May 31	No
Anthony Creek	0 to 4.3	Dissolved Oxygen	June 1 - September 30	No
Anthony Creek	0 to 4.3	Temperature	Summer	Yes
Bohemia Creek	0 to 4.4	Temperature	September 15 - June 30	Yes
Coal Creek	0 to 8.9	Temperature	Summer	Yes
Fall Creek	0 to 7	Temperature	Summer	Chapter 4
Fall Creek	13 to 32.7	Temperature	Summer	Yes
Hills Creek	1.7 to 8.2	Temperature	Summer	Yes
Little Fall Creek	0 to 20.6	Temperature	September 15 - June 30	Yes
Lost Creek	0 to 14.7	Dissolved Oxygen	October 1 - May 31	No
Lost Creek	0 to 14.7	Dissolved Oxygen	June 1 - September 30	No
Lost Creek	0 to 8.2	Temperature	Summer	Yes
Lost Creek	0 to 8.2	Temperature	September 15 - June 30	Yes
Lost Creek	8.2 to 13.6	Temperature	September 15 - June 30	Yes
Lost Creek	13.6 to 14.7	Temperature	Summer	Yes
Middle Fork Willamette River	0 to 15.6	Temperature	Summer	Chapter 4
Middle Fork Willamette River	52.5 to 64.1	Temperature	Summer	Yes
Mike Creek	0 to 2.2	Temperature	Summer	Yes
N Fk Middle Fk Willamette River	0 to 14.1	Temperature	Summer	Yes
N Fk Middle Fk Willamette River	14.1 to 49.4	Temperature	September 15 - June 30	Yes
Packard Creek	0 to 5.2	Temperature	Summer	Yes
Portland Creek	0 to 3	Temperature	Summer	Yes
Salt Creek	0 to 13.6	Temperature	Summer	Yes
South Fork Winberry Creek	0 to 3.1	Temperature	Summer	Yes
Unnamed Waterbody	0 to 2.3	Temperature	Summer	Yes
Unnamed Waterbody	0 to 2.3	Temperature	September 15 - June 30	Yes
Winberry Creek	2.9 to 8	Temperature	Summer	Yes

Water Quality Parameters Addressed

- In the Middle Fork Willamette Subbasin temperature is the only parameter addressed with allocations.

- Bacteria has been addressed through a basin wide assessment with TMDLs developed for subbasins streams listed as water quality limited for bacteria, specifically the Upper Willamette Subbasin, Middle Willamette Subbasin, and Lower Willamette Subbasin. Planning targets have been identified for urban and agricultural land in the Middle Fork Willamette Subbasin where no streams have been listed. The appropriate use of planning targets is in water quality management planning. The ubiquitous nature of fecal bacteria suggests that water quality would benefit from implementation of these targeted reductions in the absence of documented violations. In general, targeted reductions for agricultural areas range from 66% to 83%, and reductions for urban areas range from 80% to 94%, relative to current concentrations. The details of this assessment and the planning targets are contained in the Allocation Section of Chapter 2, Willamette Basin Bacteria TMDL.

- Mercury is a parameter of concern throughout the Willamette Basin. A 27% reduction in mercury pollution is needed in the mainstem Willamette to remove fish consumption advisories. Pollutant load allocations are set for each sector but no effluent limits are specified at this time. Sources of mercury in the subbasin will be required to develop mercury reduction plans. Details of the mercury TMDL are included in Chapter 3, the Willamette Basin Mercury TMDL.

Water Quality Parameters Not Addressed

The Willamette Basin TMDL project began in early 2000 and was designed to address the 1998 303(d) listed waterbodies for parameters that exceeded water quality criteria. In 2002 the 303(d) list was updated. Where data were readily available, new parameter listings were addressed in this TMDL. However, there was not sufficient time to collect the additional data and complete the TMDL analysis for this TMDL for some of the newly listed parameters. These parameters will be addressed in subsequent TMDL efforts. Parameters that are specifically excluded from this TMDL are:

- Dissolved Oxygen

The dissolved oxygen (DO) listings for Anthony Creek and Lost Creek will not be addressed in this TMDL. These waterbodies were listed in 2002, which did not allow sufficient time to collect data needed for TMDL analysis. Until TMDLs for dissolved oxygen are developed for these streams riparian protection and restoration measures developed to address stream temperature concerns in the basin will benefit dissolved oxygen levels.

Who helped us

Many organizations assisted ODEQ in the development of this TMDL and data from many different sources were considered. ODEQ would like to acknowledge the assistance of the following organizations and agencies.

- Middle Fork Willamette Watershed Council
- Lost Creek Watershed Partnership
- Weyerhaeuser Company
- Oregon Department of Fish and Wildlife
- U.S. Bureau of Land Management (BLM)
- U.S. Forest Service (USFS)
- U.S. Geological Survey, Oregon District (USGS)
- U.S. Army Corps of Engineers
- Oregon Water Resources Department

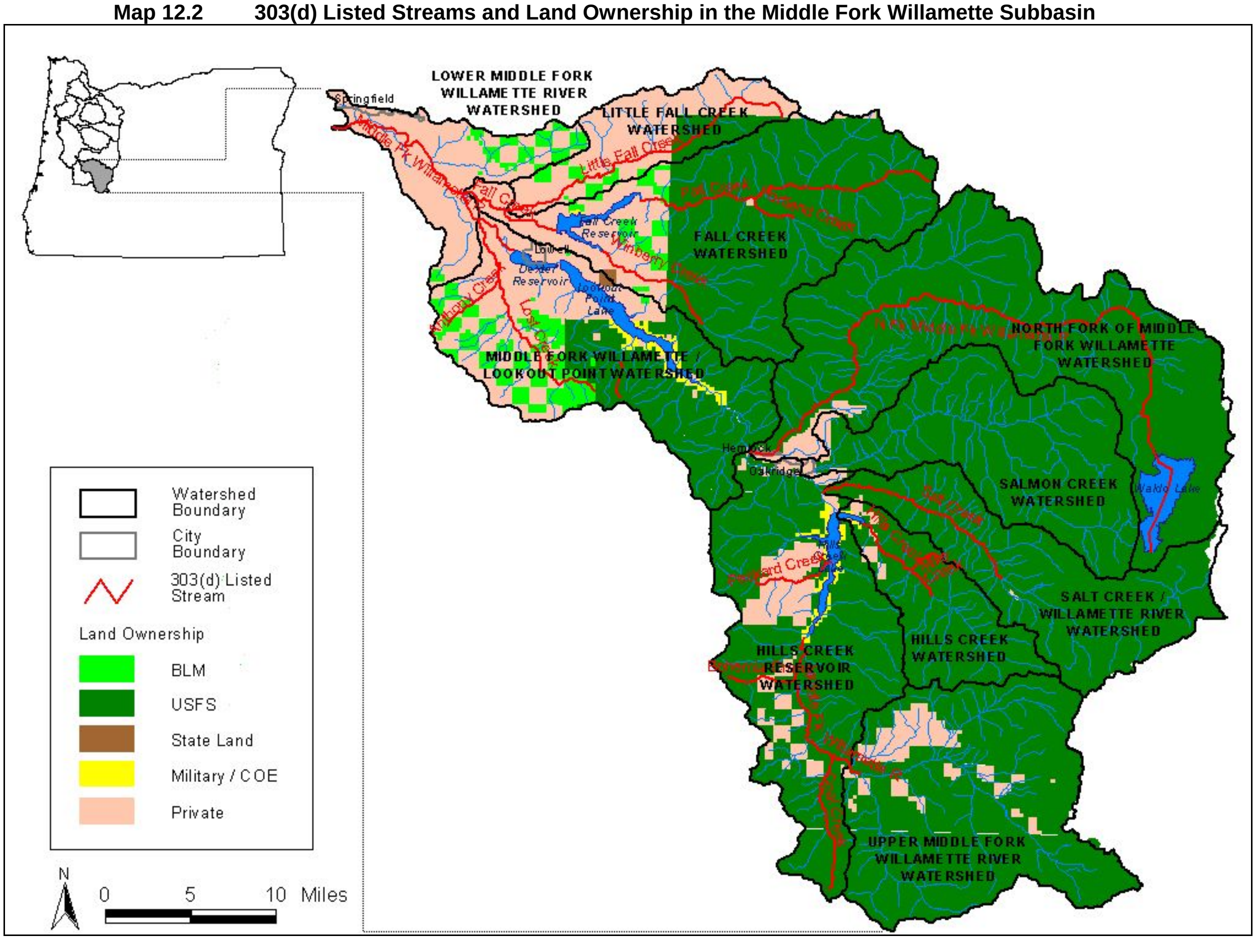
SUBBASIN OVERVIEW

The Middle Fork Willamette Subbasin (Hydrologic Unit Code 17090001) is located in the south eastern portion of the Willamette Basin and drains the Cascade Range. The Middle Fork Willamette River flows into the Willamette River at its mouth at RM 186. The Subbasin's 1,355 square miles (867,110 acres) include the following 10 watersheds:

- Fall Creek
- Hills Creek
- Hills Creek Reservoir
- Little Fall Creek
- Lower Middle Fork Willamette River
- Middle Fork Willamette / Lookout Point
- North Fork of Middle Fork Willamette
- Salmon Creek
- Salt Creek / Willamette River
- Upper Middle Fork Willamette River

The subbasin is located within Lane and Douglas Counties, and includes the cities of Lowell, Hemlock, Oakridge, and a portion of Springfield, Map 12.2. The subbasin is dominated by forested land use with some agriculture and residential land use near the mouth of the subbasin. Ownership is about 85% Federal, most of that managed by the Willamette National Forest (USFS) and the Eugene Bureau of Land Management (BLM). Small, private landholders and industrial timber companies operate throughout the remainder of the subbasin.

Map 12.2 303(d) Listed Streams and Land Ownership in the Middle Fork Willamette Subbasin



In March 2003, the Oregon Department of Agriculture (ODA) reported that there were no confined animal feeding operations in the Middle Fork Willamette Subbasin. In April 2003, ODEQ NPDES database identified a total of 19 NPDES permits in the subbasin, 14 are general NPDES permits and five are individual NPDES permits. Three NPDES permitted point sources have the potential to affect temperature and discharge to subbasin streams addressed in this chapter. These are the NPDES domestic permits for Oakridge and Westfir WWTP and one industrial NPDES permit for the CRS Corporation. Eight NPDES point sources discharge to the lower Middle Fork and are within the geographic scope of the mainstem temperature TMDL, see Chapter 4. The remaining eight sources were determined to not have the potential to affect stream temperature. This conclusion was based on rational presented in the "Waste Load Allocations in Small Streams" section on page 12-21.

The Middle Fork Willamette Subbasin has four man-made reservoirs, Fall Creek Reservoir, Dexter Reservoir, Lookout Point Lake, and Hills Creek Lake. Waldo Lake, located in the North Fork of the Middle Fork Willamette watershed, is the only large natural lake in the subbasin. The subbasin provides habitat for bull trout, spring Chinook, summer steelhead and winter steelhead. There are two real-time USGS flow monitoring stations in the subbasin, Middle Fork Willamette River near Dexter and Middle Fork Willamette River at Jasper.

MIDDLE FORK WILLAMETTE TEMPERATURE TMDL

The temperature TMDL for the Middle Fork Willamette Subbasin includes tributaries to the Middle Fork Willamette River within HUC 17090001. As per Oregon Administrative Rule (OAR) 340-042-0040 required components of a TMDL are listed in Table 12.2.

Table 12.2 Middle Fork Willamette Subbasin Temperature TMDL Components.

Waterbodies OAR 340-042-0040(4)(a)	Perennial and/or fish bearing, as identified in OAR 340-041- 0340; Figures 340A & 340B, streams in the Middle Fork Willamette Subbasin, HUCs 170900101, 170900102, 170900103, 170900104, 170900105, 170900106, 170900107, 170900108, 170900109, 170900110, 170900111, 170900112, and 170900113.
Pollutant Identification OAR 340-042-0040(4)(b)	*Pollutants:* Human caused temperature increases from (1) solar radiation loading and (2) warm water discharge to surface waters
Beneficial Uses OAR 340-042-0040(4)(c)	Salmonid fish spawning and rearing, anadromous fish passage, resident fish and aquatic life are the most sensitive beneficial uses in the Middle Fork Willamette Subbasin.
Target Criteria Identification OAR 340-042-0040(4)(c) OAR 340-041-0028(4)(f) OAR 340-041-0028(4)(a) OAR 340-041-0028(4)(b) OAR 340-041-0028(4)(c) *OAR* 340-041-0028(8) OAR 340-041 0028(12)(b)(B)	OAR 340-041-0028 provides numeric and narrative temperature criteria. Maps and tables provided in OAR 340-041-0101 to 0340 specify where and when the criteria apply. 12.0°C during times and at locations of bull trout spawning and juvenile rearing use. 13.0°C during times and at locations of salmon and steelhead spawning. 16.0°C during times and at locations of core cold water habitat identification. 18.0°C during times and at locations of salmon and trout rearing and migration. Natural Conditions Criteria: Where the department determines that the natural thermal potential temperature of all or a portion of a water body exceeds the biologically-based criteria in section 4 the natural thermal potential temperatures supersede the biologically-based criteria and are deemed the applicable criteria for that water body. Maps and tables provided in OAR 340-041-0101 to 0340 specify where and when the criteria apply. Following a temperature TMDL or other cumulative effects analysis, waste load and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5 Fahrenheit) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact.
Existing Sources OAR 340-042-0040(4)(f) *CWA §303(d)(1)*	Nonpoint source solar loading due to a lack of riparian vegetation from forestry, agriculture, rural residential and urban activities. Point source discharge of warm water to surface water.
Seasonal Variation OAR 340-042-0040(4)(j) *CWA §303(d)(1)*	Peak temperatures typically occur in mid-July through mid-August and often exceed the salmon and trout rearing and migration criterion. Temperatures are much cooler late summer through late spring but occasionally exceed the spawning criterion.
TMDL Loading Capacity and Allocations OAR 340-042-0040(4)(d) OAR 340-042-0040(4)(e) OAR 340-042-0040(4)(g) OAR 340-042-0040(4)(h) *40 CFR 130.2(f)* *40 CFR 130.2(g)* *40 CFR 130.2(h)*	*Loading Capacity:* OAR 340-041-0028 (12)(b)(B) states that no more than a 0.3°C increase in stream temperature above the applicable biological criteria or the natural condition criteria as a result of human activities is allowable. This condition is achieved when the cumulative effect of all point and nonpoint sources results in no greater than a 0.3 oC (0.5 oF) increase at the point of maximum impact. Loading capacity is the heat load that corresponds to the applicable numeric criteria plus the small increase in temperature of 0.3°C provided with the human use allowance. *Excess Load:* The difference between the actual pollutant load and the loading capacity of the waterbody. In these temperature TMDLs excess load is the difference between heat loads that meet applicable temperature criteria plus the human use allowance and current heat loads from background, nonpoint source and point source loads. *Wasteload Allocations (NPDES Point Sources):* Allowable heat load based on achieving no greater than a 0.3oC temperature increase at the point of maximum impact. This is achieved by limiting stream temperature increases from individual point sources to 0.075ºC. This may also be expressed as a limitation of 0.3ºC increase in 25% of the 7Q10 stream flow. Where multiple point sources discharge to a single receiving stream the accumulated heat increase for point sources is limited to 0.2˚C. *Load Allocations (Nonpoint Sources):* Background solar radiation loading based on system potential vegetation near the stream. An additional heat load equal to 0.05°C temperature increase at the point of maximum impact is available but is not explicitly allocated to individual sources.
Surrogate Measures OAR 340-042-0040(5)(b) *40 CFR 130.2(i)*	*Translates Nonpoint Source Load Allocations* Effective shade targets translate riparian vegetation objectives into the nonpoint source solar radiation loading capacity. These targets are based on vegetation communities appropriate for each geomorphic unit in the subbasin.
Margins of Safety OAR 340-042-0040(4)(i) *CWA §303(d)(1)*	*Margins of Safety* are demonstrated in critical condition assumptions for point source load calculations and are inherent in the methodology for determining nonpoint source loads.

Reserve Capacity OAR 340-042-0040(4)(k)	Allocation for increases in pollutant loads for future growth from new or expanded sources. Reserve capacity will be a percentage of the 0.3˚C human use allowance (HUA). The HUA will be divided among various sources. When point sources are present reserve capacity will be 0.05˚C, 17% of the HUA. Where there are no point sources in a subbasin, or less than the allowed 0.2˚C is used by point source discharges, the remainder is allocated to reserve capacity.
Water Quality Management Plan OAR 340-042-0040(4)(l)	The Water Quality Management Plan (WQMP) provides the framework of management strategies to attain and maintain water quality standards. The WQMP is designed to complement the detailed plans and analyses provided in specific implementation plans. See Chapter 14.
Standards Attainment & Reasonable Assurance OAR 340-042-0040(4)(l)(e) & (j)	Implementation of pollutant load reductions and limitations in the point source and non point source sectors will result in water quality standards attainment. Standards Attainment and Reasonable Assurance are addressed in the WQMP, Chapter 14.

Waterbodies Listed for Temperature

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

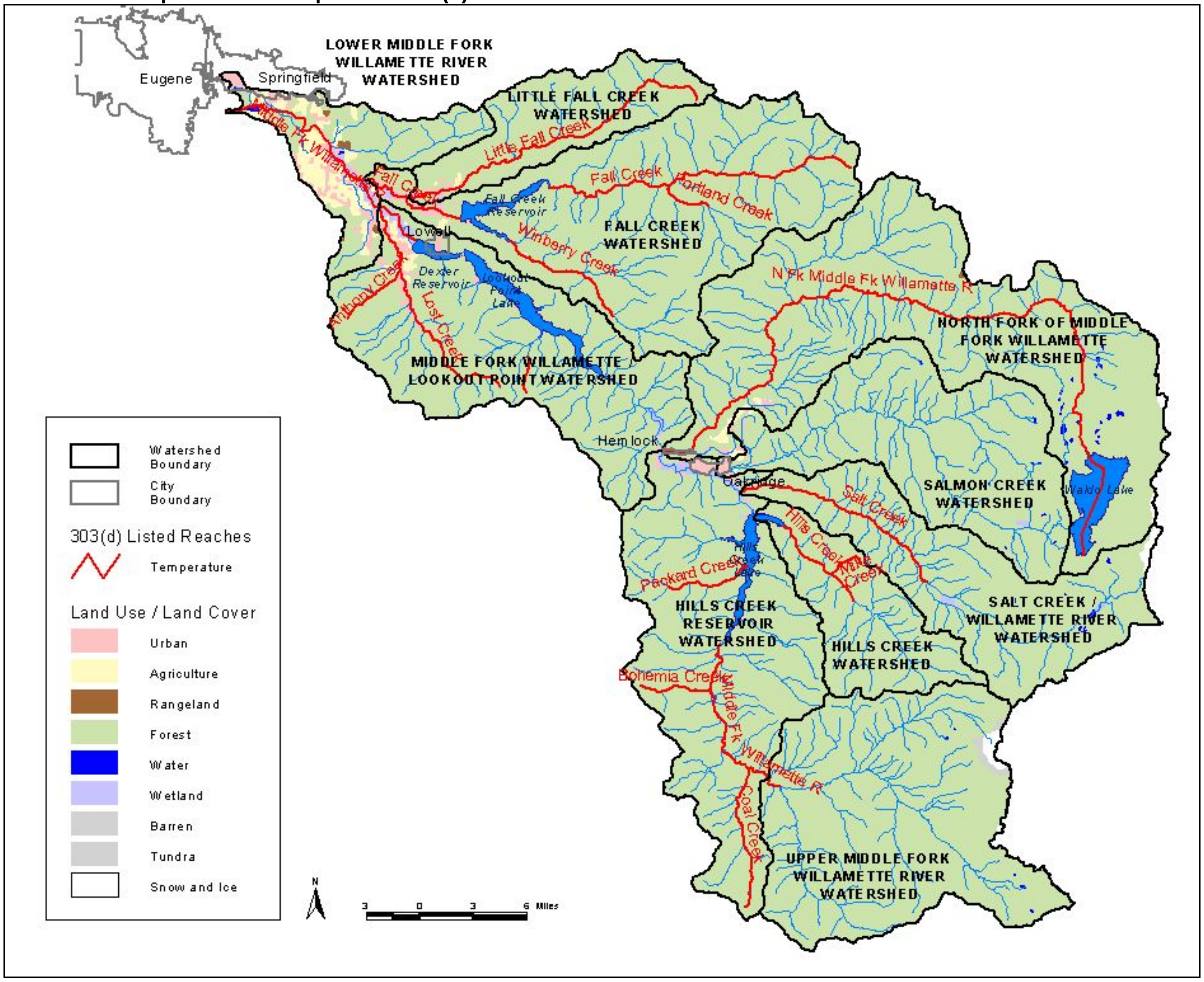
The Middle Fork Willamette Subbasin has 19 stream segments on the 303(d) list for exceeding the water temperature criteria**,** Table 12.3 and Map 12.3. Fifteen of the stream segments listed exceed the rearing temperature criterion during the summer, July through September: Anthony Creek, Fall Creek, Hills Creek, Lost Creek, North Fork Middle Fork Willamette River, Packard Creek, Portland Creek, Salt Creek, South Fork Winberry Creek, and an unnamed tributary to Goodman Creek. Bohemia Creek, Little Fall Creek, Lost Creek, North Fork Middle Fork Willamette River, and an unnamed tributary to Goodman Creek are listed during the Fall-Winter-Spring period, September through June. Several streams in the subbasin have been listed because they exceed the bull trout criterion of 12.0 ^{o}C: Coal Creek, Middle Fork Willamette River from RM 52.5 to 64.1, and the North Fork Middle Fork Willamette River. The Middle Fork Willamette River from the mouth to 15.6 (Dexter Reservoir) and Fall Creek from the mouth to RM 7.0 (Fall Creek Reservoir), are addressed in Chapter 4 of this document.

Stream segments were listed under the previous temperature standard because they exceeded the temperature criterion of 17.8^{o}C (64.0^{o}F) for salmonid migration and rearing, Table 12.3. However, in December 2003 the new temperature criteria was adopted by the Environmental Quality Commission and approved by USEPA in March 2004. The new temperature criterion for salmon and trout rearing and migration is 18.0°C (64.4°F). The new temperature criterion also has identified several streams segments in the subbasin as core cold water habitat with a numeric criterion of 16.0°C (60.8°F). A review of the temperature data for the streams listed in the Middle Fork Willamette Subbasin indicates that these streams exceed the recently adopted numeric criteria.

Table 12.3 Middle Fork Willamette Subbasin 303(d) Temperature Listed Stream Segments

Waterbody Name	Listed River Miles	Parameter	Listing Criterion	Season
Anthony Creek	0 to 4.3	Temperature	Rearing: 17.8^{o}C	Summer
Bohemia Creek	0 to 4.4	Temperature	Spawning: 12.8^{o}C	Sept. 15 – June 30
Coal Creek	0 to 8.9	Temperature	Rearing: 17.8^{o}C	Summer
Fall Creek	13 to 32.7	Temperature	Rearing: 17.8^{o}C	Summer
Hills Creek	1.7 to 8.2	Temperature	Rearing: 17.8^{o}C	Summer
Little Fall Creek	0 to 20.6	Temperature	Spawning: 12.8^{o}C	Sept. 1 – June 15
Lost Creek	0 to 8.2	Temperature	Rearing: 17.8^{o}C	Summer
Lost Creek	0 to 8.2	Temperature	Spawning: 12.8^{o}C	Sept. 1 – June 15
Lost Creek	8.2 to 13.6	Temperature	Rearing: 17.8^{o}C	Summer
Lost Creek	13.6 to 14.7	Temperature	Spawning: 12.8^{o}C	Jan. 1 – June 15
Middle Fork Willamette River	52.5 to 64.1	Temperature	Rearing: 17.8^{o}C	Summer
Mike Creek	0 to 2.2	Temperature	Rearing: 17.8^{o}C	Summer
North Fork Middle Fork Willamette	0 to 14.1	Temperature	Rearing: 17.8^{o}C	Summer
North Fork Middle Fork Willamette	14.1 to 49.4	Temperature	Rearing: 17.8^{o}C	Jan. 1 – June 15
Packard Creek	0 to 5.2	Temperature	Rearing: 17.8^{o}C	Summer
Portland Creek	0 to 3	Temperature	Rearing: 17.8^{o}C	Summer
Salt Creek	0 to 13.6	Temperature	Rearing: 17.8^{o}C	Summer
South Fork Winberry Creek	0 to 3.1	Temperature	Rearing: 17.8^{o}C	Summer
Unnamed Waterbody (Goodman trib)	0 to 2.3	Temperature	Rearing: 17.8^{o}C	Summer
Unnamed Waterbody (Goodman trib)	0 to 2.3	Temperature	Rearing: 17.8^{o}C	Sept. 15 – June 30
Winberry Creek	2.9 to 8	Temperature	Rearing: 17.8^{o}C	Summer

Map 12.3 Temperature 303(d) Listed Streams in the Middle Fork Willamette Subbasin



Pollutant Identification

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

ODEQ must establish a TMDL for any waterbody designated on the 303(d) list as exceeding water quality criteria. Although temperature criteria are designed to protect beneficial uses from excessive water temperature, the pollutant of concern is heat energy. Water temperature change is an expression of heat energy exchange per unit of volume:

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

Stream temperatures are affected by natural and human caused sources of heating. Disturbance processes such as wildfire, flood, and insect infestation influence the presence, height and density of riparian vegetation which in turn determines the amount of solar radiation reaching the stream. Such processes are recognized and incorporated as a natural condition in the TMDL. This temperature TMDL does address stream heating caused by human activities that affect characteristics of riparian vegetation in addition to point sources that discharge heat directly into surface waters in the Middle Fork Willamette Subbasin.

Beneficial Use Identification

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

Numeric and narrative water quality criteria are applied to protect the most sensitive beneficial uses. The most sensitive beneficial uses to temperature in the Middle Fork Willamette Subbasin are:

- Resident fish and aquatic life
- Salmonid spawning, rearing and migration
- Anadromous fish passage

At a minimum, beneficial uses are considered attainable wherever feasible or wherever attained historically.

Salmonid Stream Temperature Requirements

This temperature TMDL is focused on the protection of cold water salmonids, specifically steelhead and salmon, and bull trout. In general, there are three levels of thermally induced fish mortality. If stream temperatures become greater than 32 °C (>90°F), fish die almost instantly due to denaturing of critical enzyme systems in their bodies (Hogan, 1970). This level is termed *instantaneous lethal limit.* The second level is termed *incipient lethal limit* and can cause fish mortality in hours to days when temperatures are in the 21°C to 25°C (70°F to 77°F) range. The time period to death depends on the acclimation and life-stage of the fish. The cause of death is from the breakdown of physiological regulation, such as respiration and circulation, which are vital to fish health (Heath and Hughes, 1973). The third level is the most common and widespread cause of thermally induced fish mortality, termed *indirect or sub-lethal limit* and can occur weeks to months after the onset of elevated stream temperatures of 17.8°C to 23°C (64°F to 74°F). The cause of death is from interactive effects such as: decreased or lack of metabolic energy for feeding, growth, and reproductive behavior; increased exposure to pathogens (viruses, bacteria and fungus); decreased food supply because the macroinvertebrate populations are also impaired by high stream temperature; and increased competition from warm water tolerant species. Table 12.4 summarizes the modes of cold water fish mortality.

Table 12.4 Thermally Induced Cold Water Fish Mortality Modes (Brett, 1952; Bell, 1986, Hokanson et al., 1977)

Modes of Thermally Induced Fish Mortality	Temperature Range	Time to Death
Instantaneous Lethal Limit – Denaturing of bodily enzyme systems	> 32°C(> 90°F)	Instantaneous
Incipient Lethal Limit – Breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation	21°C - 25°C (70°F - 77°F)	Hours to Days
Sub-Lethal Limit – Conditions that cause decreased or lack of metabolic energy for feeding, growth or reproductive behavior, encourage increased exposure to pathogens, decreased food supply and increased competition from warm water tolerant species	17.8°C - 23°C (64°F - 74°F)	Weeks to Months

Target Criteria Identification

OAR 340-041-0028(4)(c), OAR 340-041-0028(4)(d),OAR 340-041-0028(9) CWA 303(d)(1)

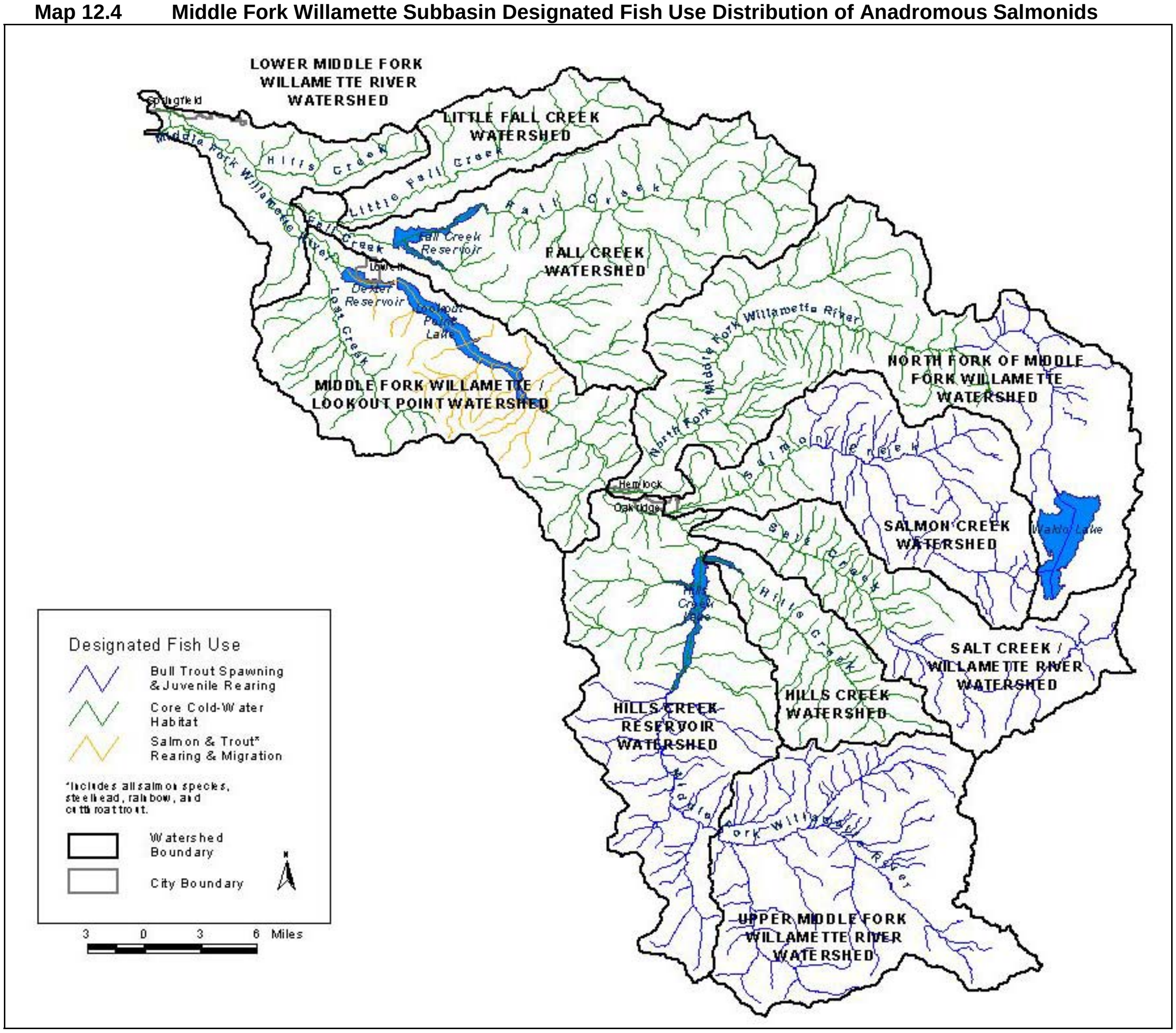
Oregon's water quality criteria for temperature are designed to protect beneficial uses, such as cold-water salmon and trout species, based on specific salmonid life stages. The temperature criteria include both narrative and numeric criteria. Table 12.5 lists the temperature criteria that are applicable to the Middle Fork Willamette Subbasin. Maps 12.4 and 12.5 illustrate designated subbasin fish use and salmonid spawning use. The maps indicate where salmonid spawning through fry emergence criterion, core cold water habitat criterion, bull trout spawning and rearing, and salmonid rearing and migration criterion apply. For subbasin waters where fisheries uses are not identified the applicable criteria are the same as the nearest downstream waterbody that is identified in fish use maps. Willamette Basin fish use and spawning use maps are available for electronic download on the ODEQ website at: http://www.deq.state.or.us/wq/standards/FishUseMapsFinal/FFigure340A_Willamette.pdf and http://www.deq.state.or.us/wq/standards/FishUseMapsFinal/FFigure340B_Willamette.pdf

Table 12.5 Oregon's Biologically Based Temperature Criteria.

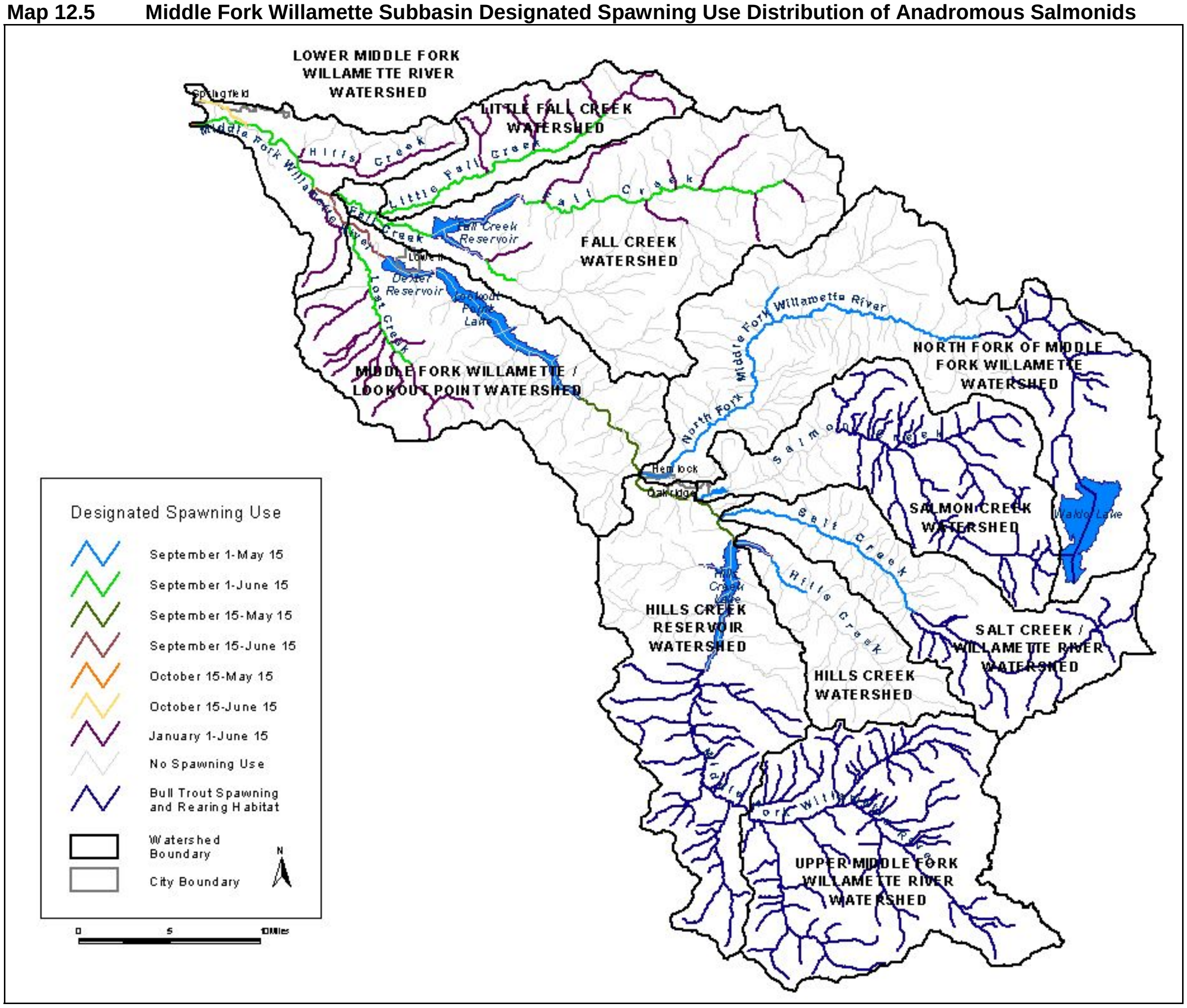
Beneficial Use	Criteria
Bull Trout Spawning and Juvenile Rearing	∗12.0°C (53.6°F)
Salmon and Steelhead Spawning	∗13.0°C (55.4°F)
Core Cold Water Habitat Identification	*16.0°C (60.8°F)
Salmon and Trout Rearing and Migration	∗18.0 °C (64.4 °F)

∗ Stream temperature is calculated using the average of seven consecutive daily maximum temperatures on a rolling basis (7-day calculation).

Map 12.4 Middle Fork Willamette Subbasin Designated Fish Use Distribution of Anadromous Salmonids



Map 12.5 Middle Fork Willamette Subbasin Designated Spawning Use Distribution of Anadromous Salmonids



The narrative criteria that apply to the Middle Fork Willamette Subbasin describe the conditions under which biological numeric criteria may be superseded. The criteria acknowledge that in some instances the biologically based numeric criteria may not be achieved because the natural thermal potential of the stream temperature is warmer than the biologically based numeric criteria. A stream that is free from anthropogenic influence is considered to be at natural thermal potential. When it exceeds the appropriate biologically based criterion, the natural thermal potential becomes the natural condition numeric temperature criterion for that specific stream or stream segment. This often occurs in low elevation streams in the basin during summer months.

Following a temperature TMDL or other cumulative effects analysis, waste load and load allocations will restrict all NPDES point sources and nonpoint sources to a cumulative increase of no greater than 0.3 degrees Celsius (0.5Fahrenheit) above the applicable criteria after complete mixing in the water body, and at the point of maximum impact.

A more extensive analysis of water temperature related to aquatic life and supporting documentation for the temperature standard can be found in the 1992-1994 Water Quality Standards Review Final Issue Papers (ODEQ, 1995) and in EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards (USEPA, 2003).

Existing Heat Sources

OAR 340-042-0040(4)(f), CWA §303(d)(1)

Sources of heat pollution include nonpoint sources and point sources. Nonpoint sources are generally more diffuse in nature and cannot be traced back to a particular location. These sources are defined below in terms of land use. Dams and reservoir operations are also included as nonpoint sources of pollution although their effects on water quality are generally more identifiable than dispersed land use activities. Point sources are individual facilities that discharge a pollutant from a defined conveyance (e.g. an outfall pipe) and are regulated by permit.

Nonpoint Sources of Heat

Land use activities. Riparian vegetation, stream morphology, hydrology (including groundwater interactions), climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, riparian condition, channel morphology and hydrology are affected by land use activities. Disturbance or removal of vegetation near a stream reduces stream surface shading because of decreased vegetation height, width and density. This results in greater amount of solar radiation reaching the stream surface.

Riparian vegetation also influences channel morphology. Vegetation supports stream banks during erosive, high flow events and slows floodwaters and promotes sediment deposition when floodwaters overtop the banks. Loss or disturbance of riparian vegetation may precede lateral stream bank erosion and channel widening. This decreases the effectiveness of remaining vegetation to shade the stream and increases the stream surface area exposed to heat exchange processes, particularly solar radiation.

Dam and Reservoir operations. Dams and reservoir operations affect stream temperature through the modification of flow regimes and through the delivery of heat stored within the system. Flow augmentation during the low flow periods of the year may be beneficial to stream segments below the dam as higher flows increase stream volume and therefore the loading capacity of the segment. Also, higher volumes correspond to greater stream velocities and shorter travel times through stream reaches exposed to solar radiation. However, operations that divert flows from natural channels during low flow periods may substantially diminish the loading capacity of the stream while also increasing solar loading to the stream because of lower velocities and greater travel times through exposed reaches.

The release of water from reservoirs may also increase down stream temperatures as the heat held by the impounded water is also released. The timing, duration and magnitude of such impacts are dependent upon reservoir characteristics such as surface area, depth, and whether water is released from the bottom of the reservoir or selectively withdrawn from various depths.

There are four reservoirs in the Middle Fork Willamette Subbasin: Dexter, Fall Creek, Hills Creek, and Lookout Point Reservoir. A discussion of the impacts of Dexter and Fall Creek reservoirs on the Middle Fork Willamette River is discussed in Chapter 4.

Point Sources of Heat

Point source discharges play a role in stream heating in the Middle Fork Willamette Subbasin. There are six individual NPDES permitted sources in the Middle Fork Willamette Subbasin, three of these sources discharge directly into the mainstem Middle Fork Willamette River and are discussed in Chapter 4. The remaining three individual NPDES point sources discharge year-round and are classified as minor discharges. Two are domestic individual NPDES discharges, City of Westfir and City of Oakridge WWTP, and the third individual NPDES discharger is Rosboro Lumber, Map 12.6 and Table 12.6. The Westfir WWTP discharges waste water to the North Fork of the Middle Fork Willamette River at RM 1.0. The North Fork of the Middle Fork Willamette River is a 303(d) temperature impaired stream. The Oakridge WWTP discharges waste water to RM 39.8 of the Middle Fork Willamette River. Rosboro Lumber discharges waste water to the Mill Race in Springfield. In addition to these individual NPDES permits, there are 14 general NPDES permits in the subbasin that include 12 storm water permits. Stormwater sources are not considered to have reasonable potential to contribute to exceedances of numeric temperature criteria.

Map 12.6 Middle Fork Willamette Subbasin NPDES Permit Locations. April, 2003.

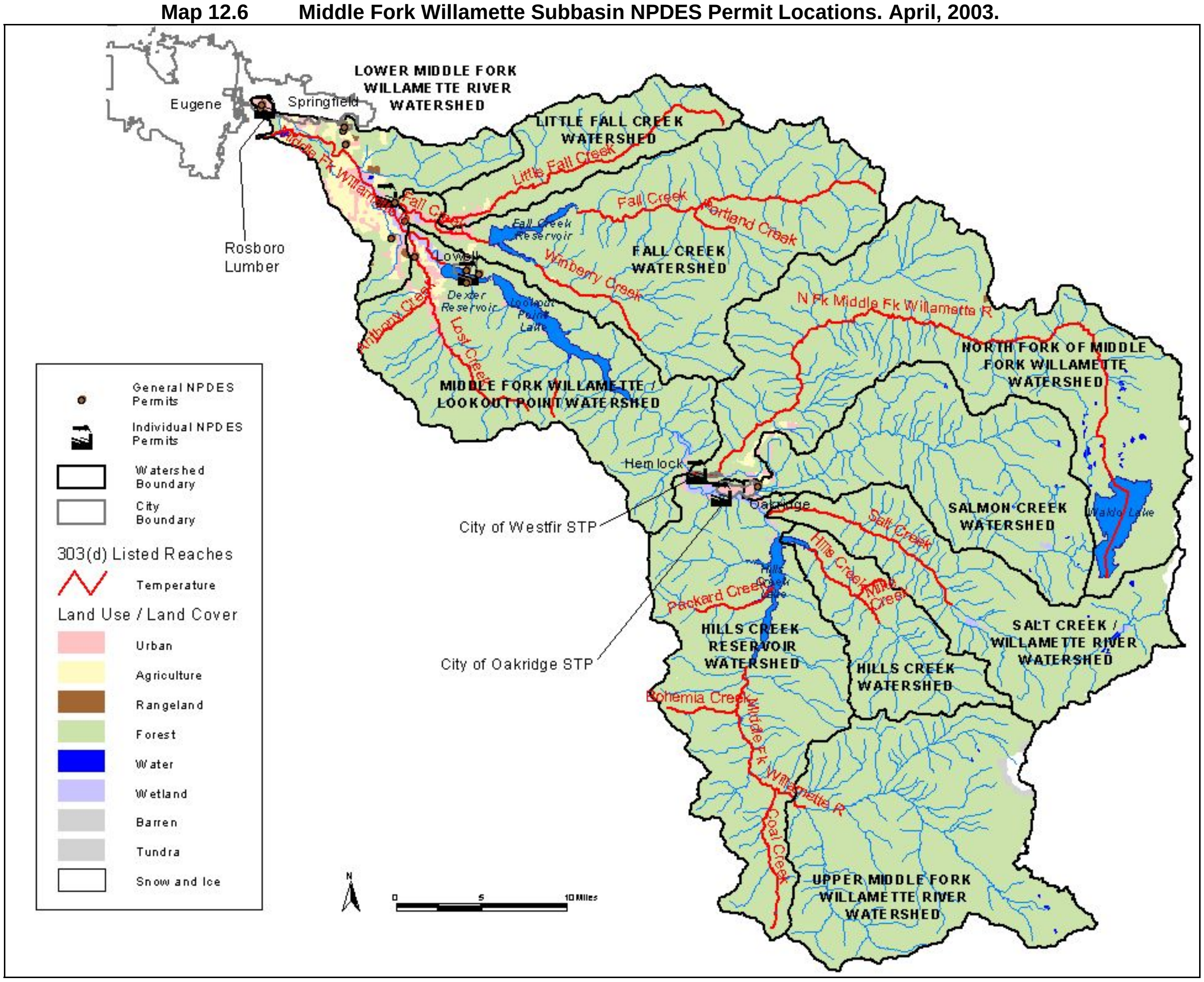


Table 12.6 Individual NPDES facilities in the Middle Fork Willamette Subbasin, which do not discharge to the mainstem Middle Fork Willamette River and Fall Creek. April, 2003.

Facility Name	Permit Type	Permit Description	Receiving Stream	River Mile	Type of Discharge	Season of Discharge
Oakridge WWTP	NPDES-DOM-Da	Sewage Disposal; NPDES less than 1 MGD, NEC with discharge lagoons	Middle Fork Willamette River	39.8	Wastewater	Year Round
Westfir WWTP	NPDES-DOM-Da	Sewage Disposal; NPDES less than 1 MGD, NEC with discharge lagoons	North Fork of Middle Fork Willamette River	1.0	Wastewater	Year Round
CRS Corperation	NPDES-IW-N	Industrial Wastewater; NPDES process wastewater NEC	Mill Race	2	Wastewater	Year Round

NEC = Not Elsewhere Classified

Temperature TMDL Approach Summary

Middle Fork Willamette Subbasin stream temperature TMDLs were developed at the watershed scale. These TMDLs include all surface waters that affect the temperatures of 303(d) listed water bodies because stream temperature is affected by heat loads from upstream as well as local sources. Point and nonpoint sources of heat may not cause an increase in temperature of more than the human use allowance (0.3˚C) when fully mixed with a stream and at the point of maximum impact. For the purposes of Willamette Basin TMDLs, the human use allowance has been divided among various sources using a framework established by DEQ with input from the Willamette TMDL Council. The framework allocates to point sources heat loads that yield a cumulative increase in stream temperature of no more than 0.2˚C. The framework allocates nonpoint sources an increase in temperatures of 0.05˚C and a heat load equivalent to 0.05˚C is held as reserve capacity. Where less than the 0.2˚C cumulative increase in temperature is actually used by point source discharges, the remainder is allocated to reserve capacity. The actual allocation of heat within the human use allowance is not specified in the water quality standards and this framework is used simply as guidance for implementation of the TMDL.

Point Source Approach. Allocations or permit limits are developed for individual point source discharges that ensure the combined increase in temperature for all discharges does not exceed 0.2˚C at the point of maximum impact. Wasteload allocations for individual point sources are generally based on a quarter of the human use allowance and yield less than a 0.08ºC increase in temperature at the point of maximum impact. Individual waste load allocations may be greater than 0.08 based on an analysis of site specific needs provided the overall point source allocation is within the established human use allowance framework. The specific methods and equations used to develop wasteload allocations are contained in the Allocation section of this chapter.

Nonpoint Source Approach. Removal or disturbance of riparian vegetation is the primary nonpoint source activity with respect to stream temperatures in the subbasin. Surrogate measures are used to represent nonpoint source heat loads. While heat from solar radiation in excess of natural background rates is considered the pollutant, the surrogate measure is effective shade. Effective shade targets, through the use of shade curves can be translated into site-specific load allocations such as langleys per day. Both shade curves and system potential vegetation objectives were developed for the fifteen geomorphic units in the Middle Fork Willamette Subbasin.

Temperature TMDL Analytical Methods Overview

Load capacity is the assimilative capacity of each stream when anthropogenic sources of heat warm the stream no more than 0.3ºC above its natural thermal potential. Natural thermal potential is realized when point sources discharges of heat are eliminated and vegetation near the stream is undisturbed by management activities. Small additional heat load allocations can be made once these conditions are identified. Wasteload allocations for individual point sources are based on a change in river temperature at the point of maximum impact. These allocations are expressed in energy units such as kilocalories per day. Load allocations for nonpoint sources are based on the surrogate measure of percent effective shade. Where waste load allocations consume 0.2°C of the human use allowance an additional 0.05°C increase in temperature or 1/6th of the human use allowance is available to nonpoint sources although it is not explicitly allocated to individual sources at this time. An additional 1/6th of the HUA is set aside for reserve capacity when other sectors are fully allocated.

Development of stream temperature TMDLs requires the identification of load capacity for each impaired stream. This often demands extensive data collection to support the development of detailed and complex models that are in turn used to simulate system responses to changes in pollutant loads. However, in many stream systems in the Middle Fork Willamette Subbasin the primary sources of anthropogenic heat are land use activities that affect riparian and near-stream vegetation. Identification of load capacity in these systems first requires determination of stream shade conditions when these disturbances of vegetation are eliminated. This drives the need to determine system potential vegetation and its shade producing characteristics.

System potential vegetation is vegetation that can grow and reproduce at a near-stream site given climate, elevation, soil properties, plant community requirements and hydrologic processes. System potential vegetation is an estimate of the riparian condition where land use activities that cause stream warming are minimized. It is not intended to be an estimate of pre-settlement conditions, but is an important element in the determination of the natural thermal potential of a stream. In the absence of significant point sources of heat or stream flow modification, system potential vegetation is the basis for identification of natural thermal potential temperatures. These natural thermal potential temperatures serve as the natural conditions temperature criterion in many low elevation streams throughout the Willamette Basin.

The Oregon Administrative Rule for temperature has defined both natural conditions and natural thermal potential:

- OAR 340-041-0002(38) states:
  "Natural conditions" means conditions or circumstances affecting the physical, chemical, or biological integrity of a water of the State that are not influenced by past or present anthropogenic activities. Disturbances from wildfire, floods, earthquakes, volcanic or geothermal activity, wind, insect infestation, diseased vegetation are considered natural conditions.

- OAR 340-041-0002(39) states:
  "*Natural Thermal Potential" means the determination of the thermal profile of a water body using best available methods of analysis and the best available information on the site potential riparian vegetation, stream geomorphology, stream flows and other measures to reflect natural conditions.*

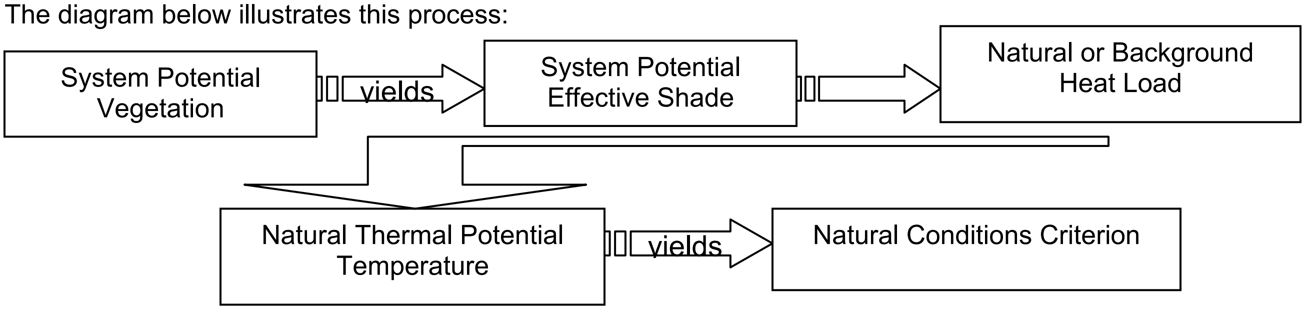
Middle Fork Willamette Subbasin temperature TMDLs are based on the identification of system potential vegetation for each impaired waterbody and the calculation of the amount of shade provided by that vegetation to the stream. System potential vegetation in this analysis does allow for some level of natural disturbance such as fire and this is reflected as smaller tree heights and lower canopy densities in the calculation of shade levels. Put another way, mature vegetation was not used to simulate target conditions throughout the subbasin.

Effective shade is the percent of daily solar radiation that is blocked by vegetation and topography. System potential vegetation characteristics are used to estimate effective shade for each riparian community. These estimated effective shade values are often referred to as system potential effective shade when in the absence of human disturbance.

Solar radiation is a function of regional and local characteristics and is a factor in determining water temperature in the absence of significant point source influences. Regional factors such as latitude and topography determine potential solar radiation loading whereas local factors such as stream aspect, stream width and streamside vegetation characteristics determine actual solar radiation loading to the stream. Streamside vegetation characteristics that determine effective shade include vegetation height, canopy density, overhang, setback or distance from the edge of the stream, and the width of the riparian buffer. Mature, well-stocked riparian stands generally provide more effective shade to a stream than sparsely stocked riparian stands or stands of early successional plant communities. For more information on system potential vegetation refer to Appendix C, "Potential Near-Stream Land Cover for Willamette Basin".

Effective shade is a surrogate measure used for development of temperature load allocations. The use of effective shade targets alone will not support calculation of natural thermal potential stream temperatures. Extensive modeling is required to describe heat and water movement through the stream system and support the estimation of stream temperatures. Effective shade targets allow for the calculation of the amount of solar loading reaching the stream and perhaps most importantly shade targets translate nonpoint source load allocations into site specific vegetation targets for land owners and managers. A description of the analyses used in this TMDL is described in Appendix C.

The diagram below illustrates this process:



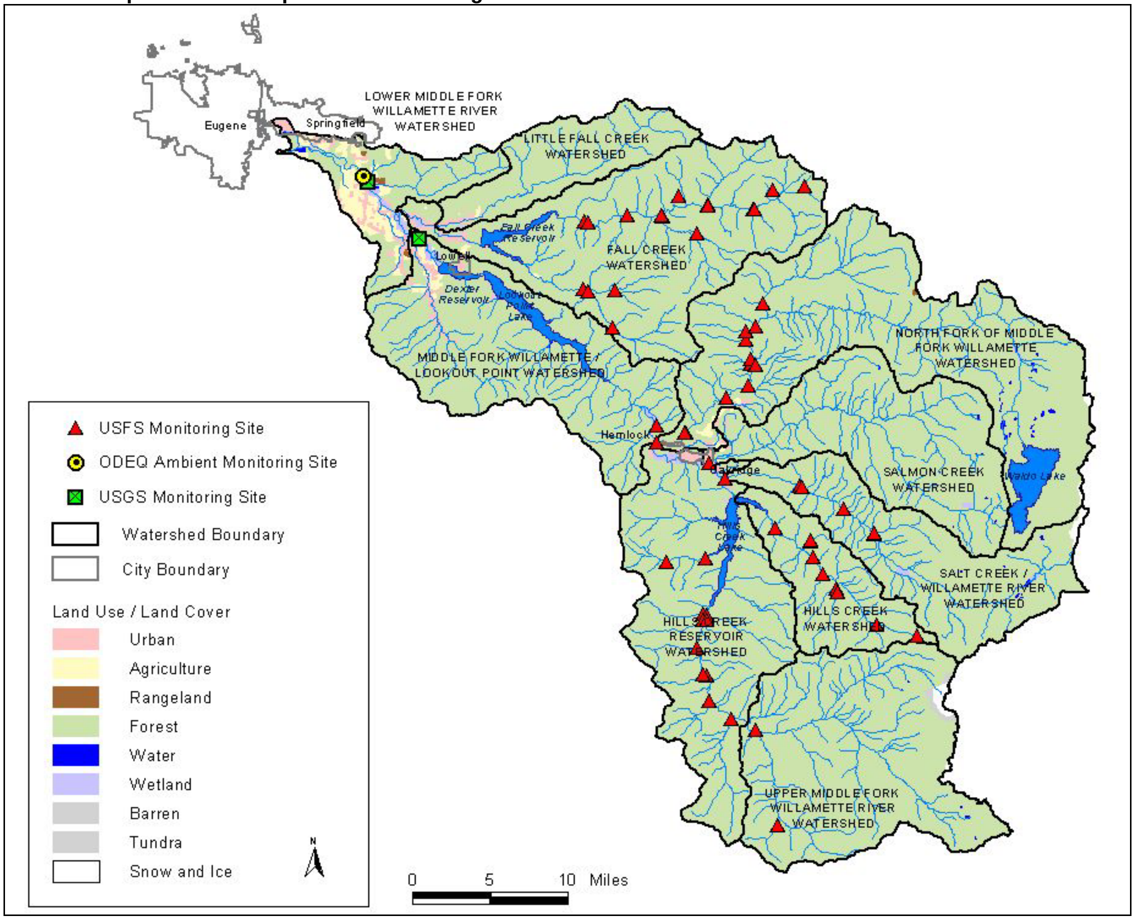
Stream temperature analysis discussed in this chapter is limited to tributary streams of the mainstem Middle Fork Willamette River and Fall Creek system. The water quality restoration strategies identified are applicable to all streams in the subbasin. Application of these strategies contributes to the basin-scale effort to restore and protect cooler water temperatures in other Willamette River tributaries. This broad scale application to all tributaries is an important element in the protection of coldwater aquatic life in the Willamette Basin. Although these streams are not likely to individually affect temperatures in the Willamette River, collectively they provide important localized sources of cool water and temporary thermal refugia for resident or migrating coldwater fish.

Seasonal Variation

OAR 340-042-0040(4)(j), CWA 303(d)(1)

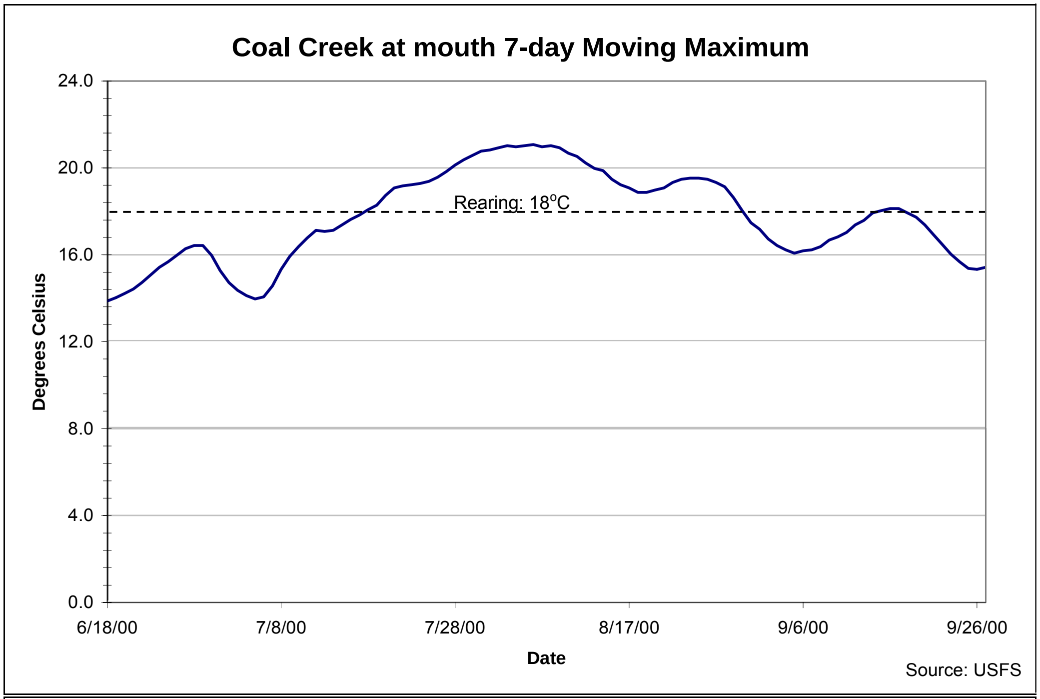
Streams in the Middle Fork Willamette Subbasin are monitored by USFS, USGS, and ODEQ, Map 12.7. The USFS samples upstream of Dexter and Fall Creek reservoirs. USFS temperature data was used to assess the seasonal variation at current condition in Middle Fork Willamette streams. There are two real-time USGS flow monitoring stations in the subbasin, Middle Fork Willamette River near Dexter and Middle Fork Willamette River at Jasper, both located downstream of Dexter Reservoir. ODEQ conducts ambient monitoring at one location in the Middle Fork Willamette Subbasin, Middle Fork Willamette at Jasper Bridge. This ambient monitoring location is also located downstream of Dexter Reservoir, a portion of the subbasin included in the mainstem Willamette analysis, Chapter 4. The Middle Fork Willamette Watershed Council also monitors in the lower subbasin, including the mainstem Middle Fork Willamette River. The Lost Creek Partnership has also completed temperature and other water quality monitoring in the Lost Creek drainage.

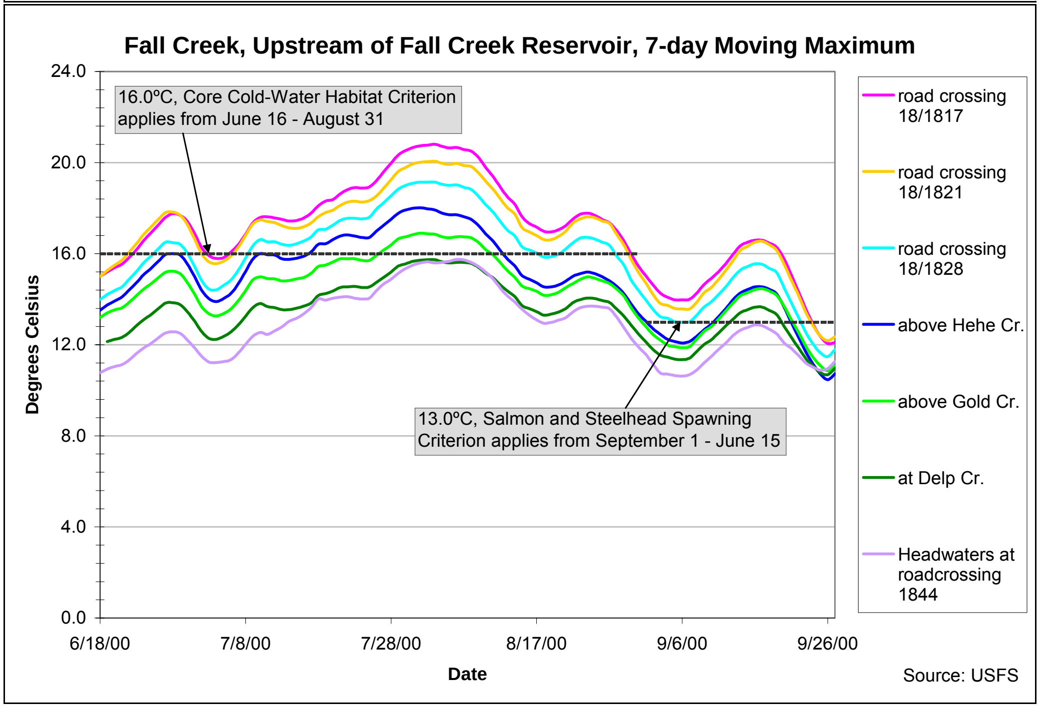
Map 12.7 Temperature Monitoring Locations in the Middle Fork Willamette Subbasin

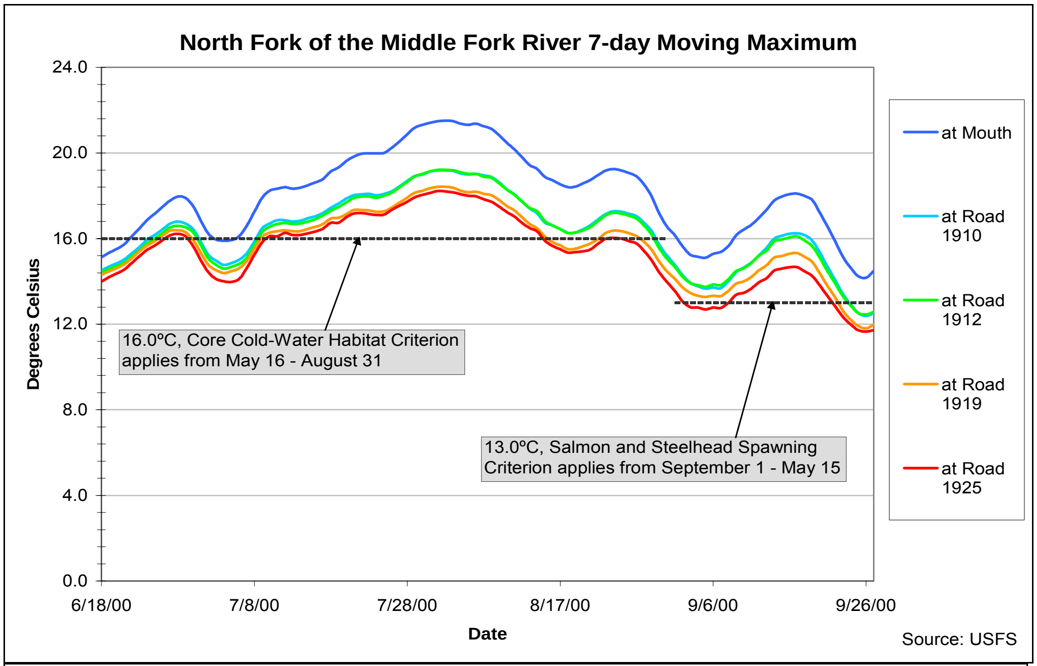


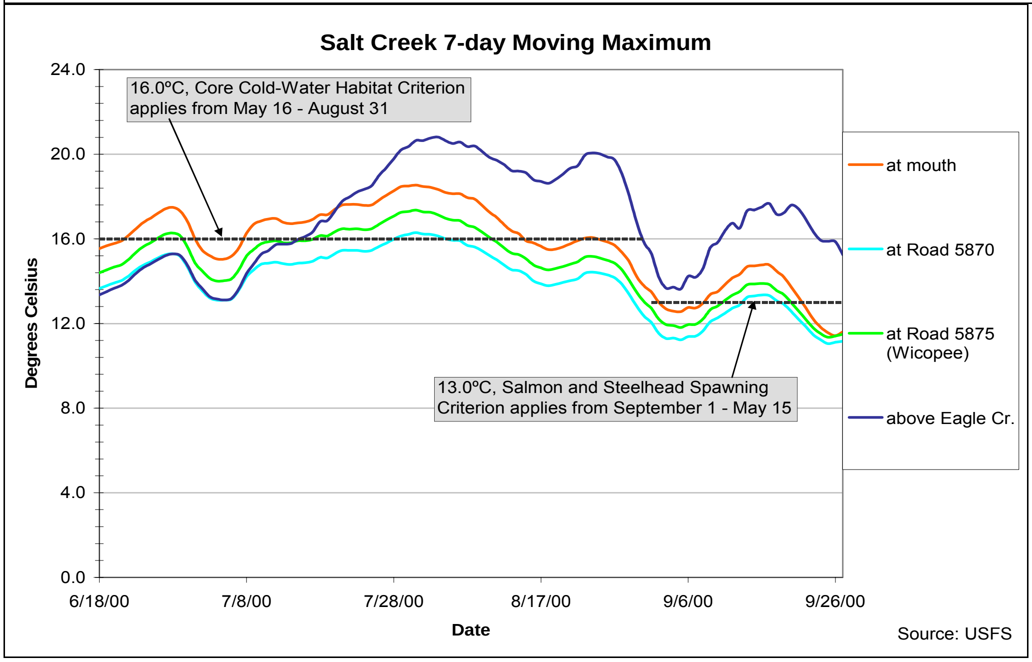
Middle Fork Willamette Subbasin streams exceed biologically based rearing criteria starting in late spring and through late summer. Maximum temperatures typically occurred in late July and early August. Long-term temperature recorders were deployed by USFS in several subbasin streams: Fall Creek, Winberry Creek, North Fork of the Middle Fork River, Salt Creek, Hills Creek, and the Middle Fork Willamette River upstream of Dexter Reservoir. Summer stream temperature data collected by the USFS indicate 18.0ºC (64.4ºF) migration and rearing criterion was exceeded in each of these creeks. Temperatures in Coal Creek, Fall Creek, North Fork of the Middle Fork River, and Salt Creek were commonly above the criterion during summer months, with temperatures ranging from 16.0°-22.0°C (60.8°-71.6°F) during summer, Figure 12.1.

Figure 12.1 Temperature Profiles for Coal Creek, Fall Creek, North Fork of the Middle Fork Willamette River, and Salt Creek.









In 1995, Willamette National Forest Service, USFS, conducted the Fall Creek Watershed Analysis, upstream of the Fall Creek Reservoir. The USFS stated that 64% of recognized slope failures in the watershed are road related, and 90% of the total identified failures are on managed ground (Willamette National Forest, 1995). Slope failures have the potential to impact watershed stream quality and habitat. Analysis by the USFS further showed that 93% of paved roads are within the riparian area (Willamette National Forest, 1995). Building roads in the riparian area reduces the opportunity for riparian vegetation restoration and does not allow for reduction in solar loading to the stream surface. However, roads in the riparian area do increase the magnitude and frequency of stream peak flows, as stated in the Watershed Analysis. The study also states that forest management activities including timber harvest and road construction and use have resulted in increased sediment delivery to streams within the watershed. The steep rugged debris flows found in Upper Portland, Upper Hehe, and Upper Fall/Delp subwatersheds are prone to landslides. Earth flows found in Timber and Andy Creeks are sources of fine sediment. High concentrations of fines within spawning gravels can result in the reduction of available habitat, suffocation of eggs, and a reduction of macroinvertebrates thus reducing trout food availability.

Historically, timber harvest began in Fall Creek during the 1940's. Many of the riparian trees were removed limiting the future input of large woody material to the stream channel. In addition, the 1964 flood removed riparian vegetation, and subsequent salvage of wood within the stream contributed to the reduction in channel complexity (Willamette National Forest, 1995). In pristine conditions riparian vegetation would primarily consist of large conifers. Much of the riparian condition has been altered so that large conifers are no longer as dominant (Willamette National Forest, 1995). The USFS also summarized the riparian reserve condition by subwatershed, within the Fall Creek watershed as presented in Table 12.7.

Table 12.7 Fall Creek Watershed Riparian Reserve Conditions (Willamette National Forest, 1995)

Subwatershed	Riparian Reserve Condition	Best Condition streams	Worst Condition streams
Lower Fall Creek	Parameters affecting riparian and aquatic habitat conditions can be characterized as good. However, timber harvest and road construction continue to impact tributaries.	Clark, Slick, Bedrock	Timber, Andy, Boundary, Upper north fork
Portland Creek	Current conditions w/in riparian reserves are the result of a wildfire in 1919, timber harvest and subsequent road construction. Many parameters affecting riparian and aquatic habitat conditions are below desired values.	Jones, Middle Fall	Upper Hehe, Lower Hehe
Hehe / Middle Fall Creeks	Riparian reserves in upper Hehe Creek drainage were impacted by 1951 fire. Further impacts were due to timber harvest including salvage logging of stands affected by the fire and resultant road construction.	Rubble, Lower Portland, Gales	Logan, Lower Portland North, Upper Portland, Nevergo
Delp / Upper Fall Creeks	These are in the best overall riparian condition although half the area associated with intermittent streams has been impacted.	Saturn, Platt, Briem	

Figure 12.2 Fall Creek RM 6, right bank, low density riparian area. USFS. September, 2001.

Both Fall Creek and the north fork of the Middle Fork Willamette River show signs of low riparian density and opportunities for riparian vegetation restoration, Figure 12.2 and 12.3. The north fork of the Middle Fork River at RM 53 has increased channel widths.

Figure 12.3 Middle Fork Willamette River, upstream of Dexter Reservoir, at RM 53, shows lack of riparian vegetation and an increase in stream channel width. USFS. September, 2001.

Loading Capacity

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

The loading capacity is the total amount of a pollutant that a water body can assimilate without exceeding a water quality criterion or impairing a beneficial use. This is the pollutant load that may be divided among all point and nonpoint sources as allocations.

The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with water quality standards. USEPA's current regulation defines loading capacity as "*the greatest amount of loading that a water can receive without violating water quality standards*" (40 CFR § 130.2(f)). Oregon's temperature criteria states that a surface water temperature increase of no more than 0.3°C (0.54ºF) above the applicable criterion is allowed from all anthropogenic sources at the point of maximum impact.

The loading capacity is dependent on the available assimilative capacity of the receiving water. For water bodies whose natural thermal potential temperatures are at or above the temperature criterion for a given period, there is no available assimilative capacity beyond the 0.3°C (0.54ºF) human use allocation. The loading capacity is essentially consumed by non-anthropogenic sources. When natural thermal potential temperatures are less than biological based numeric criteria, the load capacity may be somewhat greater than the human use allowance provided additional heat loads do not prevent attainment of water quality standards in downstream waters.

Critical Condition

The critical condition for stream temperature and heat loading is the seasonal period of maximum stream temperatures and lowest stream flows. Maximum stream temperatures are a function of combining the effects of atmospheric inputs (solar radiation) and low stream flows that usually occur during the summer period. For many point sources the most critical condition for complying with the human use allowance occurs during the period of low stream flow and when there is a large difference between effluent and river temperatures, usually in late summer to early fall.

Allocations

40 CFR 130.2(g), 40 CFR 130.2(h)

Loading capacity is allocated among point sources as wasteload allocations and to nonpoint sources as load allocations. Load allocations to anthropogenic sources are only available where surface water temperatures throughout a given stream meet the applicable water quality criteria plus the human use allowance. The general principle for allocation in the Middle Fork Willamette Subbasin is to target natural background heat inputs from nonpoint sources and to limit point source loads to small allocations within the human use allowance.

Wasteload Allocations

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

A wasteload allocation (WLA) is the amount of pollutant that a point source can contribute to the stream without violating water quality criteria. Waste load allocations for temperature are expressed as heat load limits assigned to individual point sources of treated industrial and domestic waste. Waste load allocations are provided for all NPDES facilities that have reasonable potential to warm the receiving stream when the applicable criteria are exceeded. The WLAs discussion in this chapter are for point sources to waterbodies other than the Middle Fork Willamette River from the mouth to river mile (RM)15.6 (Dexter Reservoir) and Fall Creek from the mouth to RM 7.0 (Fall Creek Reservoir). Point sources that discharge directly to this lower portion of the subbasin have been considered as part of Chapter 4. Point source facilities in the Middle Fork Willamette Subbasin that will be allocated heat load during the next renewal of their permits are identified in Table 12.8, below.

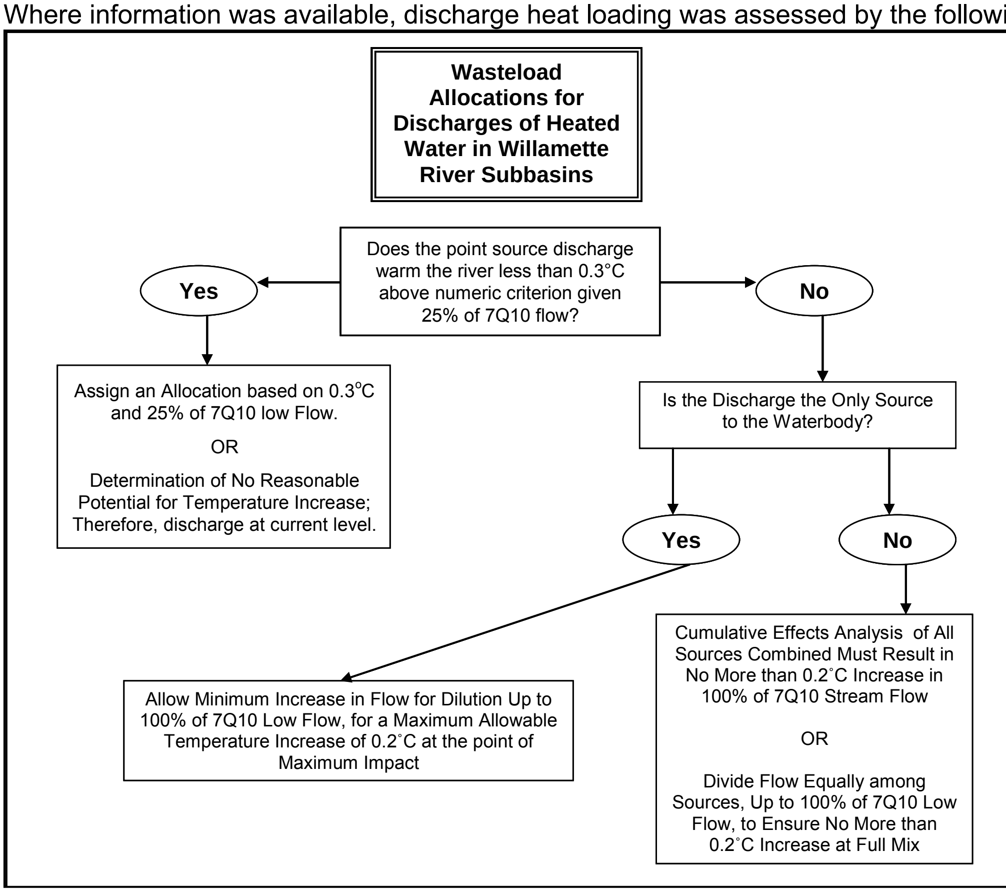
Waste Load Allocations in Small Streams

Discharges were screened to determine which would likely receive a wasteload allocation based on the type of discharge, and the volume and temperature of effluent. General permits that are unlikely to discharge significant volumes of warm water during critical periods (e.g., stormwater permits) are not expected to have a reasonable potential to increase instream temperatures. General permits that discharge heated effluent (e.g., boiler blowdown), were considered as potential sources. For discharges with insufficient information (absence of stream flow data) to screen for effects or develop a wasteload allocation (WLA), a WLA will be calculated at the time of permit renewal by the method described below.

Oregon's temperature standard [OAR 340-041-0028(12)] allows an insignificant increase in temperature from all point source and nonpoint sources combined as a Human Use Allowance (HUA = 0.3˚C). Prior to development of a TMDL, the standard allows the assumption that a 0.3˚C increase in ¼ of the receiving stream flow or the volume of the temperature mixing zone (whichever is more restrictive) will not cause an impairment.

The waste load allocation scheme below assumes an allowable change in temperature above criteria of 0.3˚C within 25% of the 7Q10 low flow (a calculation of the seven-day, consecutive low flow with a ten year return frequency). This is the initial step in the development of a waste load allocation on smaller streams or when information is insufficient to allow a greater proportion of receiving water flow for mixing. The resultant temperature increase in fully mixed receiving water would be limited to 0.08˚C. More than the minimum flow allowance (25% of 7Q10 low flow) may be allocated to an individual source when analysis demonstrates standards attainment. The resulting temperature increase in this scenario depends on the proportion of low flow allocated, but should not exceed the point source sector allocation of 0.2°C over the entire waterbody. Moreover, each discharge is also required to ensure the local effects of discharge will not cause impairment to health of fish by meeting thermal plume requirements adopted under OAR 340-41-0053(2)(d).

Where information was available, discharge heat loading was assessed by the following process:



The pre-TMDL limits in the flow chart above refer to currently permitted discharge limits for existing point sources. Wasteload allocations are expressed in terms of heat load (kilocalories per day). These heat loads are calculated from estimates of river flow, effluent flow, effluent temperature, and either the appropriate biologically based criterion or the natural thermal potential at the point of discharge. Heat load is calculated with Equation 1 (below). Where in-stream and effluent flow information is sufficient, allocations, and effluent limits may be developed based on flow rates for time periods other than monthly or an entire season (e.g., daily loads). The QZOD term may vary depending upon the situation for the discharger as explained in the decision tree above, but will usually be ¼ of the 7Q10 low flow on either a monthly or a yearly basis dependent on data availability.

Equation 1:

$$H_{PS} = (Q_{ZOD} + Q_{PS})\frac{1 \cdot ft^3}{1 \cdot sec} \cdot \frac{1 \cdot m^3}{35.31 \cdot ft^3} \cdot \frac{1000 \cdot kg}{1 \cdot m^3} \cdot \frac{86400 \cdot sec}{1 \cdot day} \cdot \Delta T_{ZOD} \cdot c = \frac{Kcal}{day}$$

where:

H_{PS}: Heat from point source effluent received by river (kcal/day)
Q_{ZOD}: River flow volume allowed for mixing- ¼ of 7Q10 low flow statistic (cfs)
Q_{PS}: Point source effluent discharge (cfs)
ΔT_{ZOD}: Change in river temperature at point of discharge - 0.3^{o}C allowable (^{o}C)
c: Specific heat of water (1 Kcal / 1kg 1ºC)

Estimates of effluent temperature were calculated using mass loading equations (**Equation 2**) taking into account river flow and temperature, and effluent flow and temperature. Allocations are usually calculated to ensure an increase in temperature of no more than 0.3°C (0.54°F) in one-quarter of the volume of the receiving stream. When this volume is fully mixed with the receiving stream, this increase in temperature would be limited to 0.08°C. Where more than the minimal flow volume is allocated, either to allow more heat load to an individual discharger on a stream, or to calculate the cumulative effects of multiple discharges, the allocation is no more than 0.2°C (0.36°F) increase given the entire flow of the river receiving the cumulative discharges. If new or more comprehensive information (e.g. flow data, temperature data, mixing zone characteristics) is available at the time permits are renewed, permit limits will reflect revised wasteload allocations as calculated using **Equation 1** above and the best information available.

Equation 2:

$$T_{WLA} = \frac{[(Q_{PS} + Q_{ZOD}) \cdot (T_R + \Delta T_{ZOD})] - (Q_{ZOD} \cdot T_R)}{Q_{PS}}$$

where:

T_R: Temperature Criterion or Upstream potential river temperature (^{o}C)
T_{WLA}: Maximum allowable point source effluent temperature (^{o} C)
ΔT_{ZOD}: Change in river temperature at point of discharge - 0.3^{o}C allowable (^{o}C)
Q_{ZOD}: River flow volume allowed for mixing- ¼ of 7Q10 low flow statistic (cfs)
Q_{PS}: Point source effluent discharge flow volume (cfs)

Four permitted discharges to subbasin streams in the Middle Fork Willamette Subbasin may require permit limits to ensure water quality standards are met, Table 12.8. These facilities are two sewage treatment plants Oakridge and Westfir WWTPs, Rosboro Lumber an industrial discharger, and ODFW Willamette Fish Hatchery. All discharges have the potential to increase water temperature, but currently available information is insufficient to allow calculation of wasteload allocations. This information will be gathered prior to renewal of these permits, and limits will be developed as described above to ensure temperature in receiving waters is not increased beyond permissible limits.

Table 12.8 NPDES permitted discharges potentially requiring permit limits to ensure water quality standards.

Facility Name	Permit Type	Permit Description	Receiving Stream	River Mile	Type of Discharge	Season of Discharge
Oakridge WWTP	NPDES-DOM-Da	Sewage Disposal; NPDES less than 1 MGD, NEC with discharge lagoons	Middle Fork Willamette River	39.8	Wastewater	Year Round
Westfir WWTP	NPDES-DOM-Da	Sewage Disposal; NPDES less than 1 MGD, NEC with discharge lagoons	North Fork of Middle Fork Willamette River	1.0	Wastewater	Year Round
CRS Corperation	NPDES-IW-N	Industrial Wastewater; NPDES process wastewater NEC	Mill Race	2	Wastewater	Year Round

a= Effluent temperatures are being characterized as requirement of current permit
b= Value based on approximate design flow.
c= Average annual flow.
e= Effluent temperature as per discussion w/ ODEQ permitting staff.

Load Allocations

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

Load Allocations are portions of the loading capacity divided among natural, current anthropogenic, and future anthropogenic nonpoint pollutant sources. In this TMDL, load allocations are allowed 0.05˚C of the human use allowance (0.3˚C). This heat allowance is in addition to the load that streams would receive when they are at system potential and would allow activities that might increase the loading (such as riparian management activities) or for human disturbance that may not easily be addressed (e.g. presence of a road near a stream that would limit shading). The 0.05°C increase in temperature above criteria (1/6th of the HUA) is dedicated to nonpoint sources but is not allocated to individual sources at this time.

The current loading from nonpoint sources is much greater than that which would exist under natural thermal potential. This requires nonpoint sources to reduce thermal inputs to reach natural thermal potential conditions through allocation of a surrogate measure, effective shade. The principal means of achieving this condition is through protection and restoration of riparian vegetation. Additional measures may also be taken to improve summer temperatures. For example, water conservation measures that improve summer stream flows will benefit stream temperatures through an increase in load capacity. Stream restoration efforts that result in narrower stream channel widths will improve the effectiveness of existing vegetation to shade the stream surface.

Nonpoint source allocations were assigned natural background loads and are implemented as shade curves for upland forests and each geomorphic unit. This allocation also applies to tributaries of temperature listed waterbodies. Shade curves illustrate the relationship between each potential vegetation cover type, channel width and the resulting effective shade level.

System potential vegetation and effective shade targets were developed to simulate a natural stream system. The effects of natural disturbance processes are reflected in riparian vegetation distribution and attributes. These attributes are determined for each geomorphic unit. The term "geomorphic unit" refers to quaternary geologic units shown as polygons that were differentiated on the basis of stratigraphic, topographic, pedogenic, and hydrogeologic properties (O'Connor et al, 2001). In other words, surface deposits of unconsolidated material above bed rock shaped by processes of erosion, sediment transport and deposition.

Natural disturbance includes among other processes:

- Flood
- Wind Throw
- Fire
- Insect Infestation

System potential vegetation includes the random distribution of conifer, mix conifer-hardwood, and hardwood species in each geomorphic unit. This random distribution of attributes within each geomorphic unit is intended to include the effects of natural disturbance in the system potential riparian vegetation condition. Some geomorphic units may also incorporate prairie. The proportions of forest, savanna and prairie to be used in each geomorphic unit were developed following rules detailed in Table 1 and on page 14 of the Potential Near-Stream Land Cover document included in Appendix C. As an example, in the quaternary alluvium unit (Qalc) which is unconsolidated silt, sand, and gravel of the Willamette River and major Cascade Range tributaries the vegetation distribution includes 80% forest, 17% savanna and 3% prairie. Forest land includes a mix of conifer (4%), hardwood (3%) and mixed (93%) forests, which determine the shade characteristics of the near-stream plant community.

In addition to system potential vegetation other restoration efforts may decrease stream temperatures. These include:

- Restoring stream channel morphology
- Increasing stream channel complexity
- Restoring floodplain processes
- Restoring natural stream flow
- Decreasing tributary stream temperatures

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

The excess load is the difference between the actual pollutant load and the loading capacity of a water body. Load allocations for nonpoint sources are based on system potential vegetation. Riparian information provided by the ODEQ and BLM indicates that there is inadequate shade throughout the Middle Fork Willamette Subbasin. ODEQ data also suggest shade levels are less than system potential in Middle Fork Willamette Subbasin creeks. Excess heat loading occurs wherever inadequate shade levels are widespread.

Surrogate Measures
OAR 340-042-0040(5)(b), 40 CFR 130.2(i)

The Middle Fork Willamette Subbasin Temperature TMDL incorporates measures other than “daily loads” in allocating heat to nonpoint sources. These measures are termed surrogate measures. The applied surrogate measure in this temperature TMDL is percent effective shade expressed as a shade curve. Shade curves have been developed for each geomorphic unit in the Willamette Valley and upland forest area of the Cascade and Coast Ranges in the Willamette Basin. Shade curves determine the nonpoint source load allocation. They were developed using trigonometric equations estimating the shade underneath tree canopies.

Percent effective shade is perhaps the most straightforward stream parameter to monitor and calculate. It is easily translated into quantifiable water quality management and recovery objectives. Percent effective shade is defined as the percentage of direct beam solar radiation attenuated and scattered before reaching the ground or stream surface, commonly measured with a Solar Pathfinder.

Shade curves represent general relationships between the percent effective shade reaching the stream surface, solar radiation loading of the stream, system potential vegetation, stream aspect from north, and the width of the channel. The channel width, Figure 12.4, is the distance from the edge of right bank vegetation to the edge of left bank vegetation.

Figure 12.4 Channel width measurement

System potential vegetation has been developed for each geomorphic unit in the Willamette Basin. It is defined as the riparian vegetation which can grow and reproduce on a site given the plant biology, site elevation, soil characteristics, and local climate. However, it does not include considerations for resource management, human use, and other human disturbances. A natural disturbance regime has been incorporated into the riparian composition for each geomorphic region that includes provisions for fire, disease, wind-throw, and other natural occurrences. Each shade curve translates the amount of effective shade that each streamside plant community provides to the stream based on the streams channel width and stream aspect from north. Each geomorphic unit is composed of a percentage of forest, savannah, and prairie and reflects the tree species composition that will grow and reproduce in each geomorphic unit. For a detailed description of system potential vegetation development and of the riparian tree species composition for each geomorphic unit please see "Potential Near Stream Vegetation" in Appendix C. A shade curve has been developed for each geomorphic and upland forest unit in the Middle Fork Willamette Subbasin, Map 12.8 – 12.11 and Figure 12.5. Watershed specific geomorphologic maps are only presented for watersheds that have more than one geomorphic classification. Watersheds not shown are to apply the upland forest shade curve to all streams. These watersheds include: Hills Creek, Hills Creek Reservoir, North Fork of Middle Fork Willamette, Salmon Creek, Salt Creek / Willamette River, and upper Middle Fork Willamette River watersheds.

The relative areas of the geomorphic classifications of the Middle Fork Willamette Subbasin are presented in Table 12.9. Despite the relatively fine scale of the geomorphic classifications, the differences among the various shade curves are subtle in some cases.

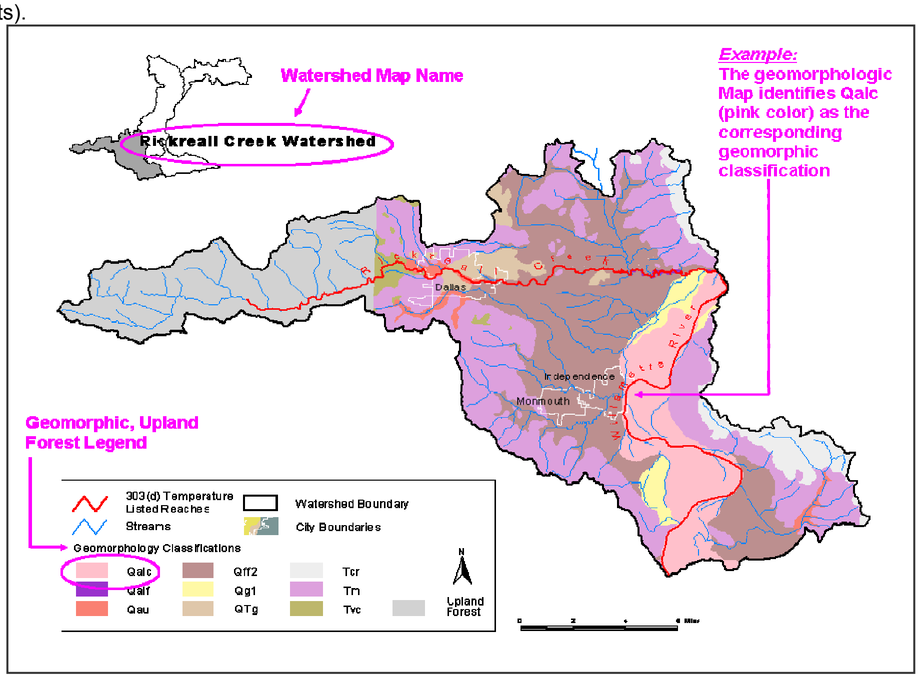
Table 12.9 Area of Geomorphic Units in Middle Fork Willamette Subbasin. Values are ranked in Order of Increasing Area.

Geomorphic Class	Acres	Square Miles	Relative Area (%)
Tertiary Marine sedimentary rock (Tm)	144	0.23	0.02
Pre-Flood Quaternary sand/gravel (Qg2)	411	1	0.05
Quaternary Landslide deposits (Qls)	631	1	0.07
Quaternary terrace gravels (QTg)	2,853	4	0.33
Post Flood Quaternary sand/gravel (Qg1)	4,358	7	0.50
Undifferentiated Quaternary Alluvium (Qau)	4,814	8	0.55
Quaternary alluvium floodplain deposits (Qalc)	8,274	13	0.95
Western Cascades tertiary volcanics (Tvw)	53,610	84	6.13
Upland Forest (UF)	798,357	1,247	91.29
Grand Total	**874,516**	**1,366**	**100.00**

How to Use a Shade Curve:

1. Determine the applicable geomorphic or upland forest unit that applies to the stream reach you are applying a Shade Curve to.

Example: You are located in the Rickreall Creek watershed, in the city of Independence along the west bank of the Willamette River. By using the appropriate map, below, you identify the geomorphic unit on your property to be Qalc (Quaternary alluvium floodplain deposits).



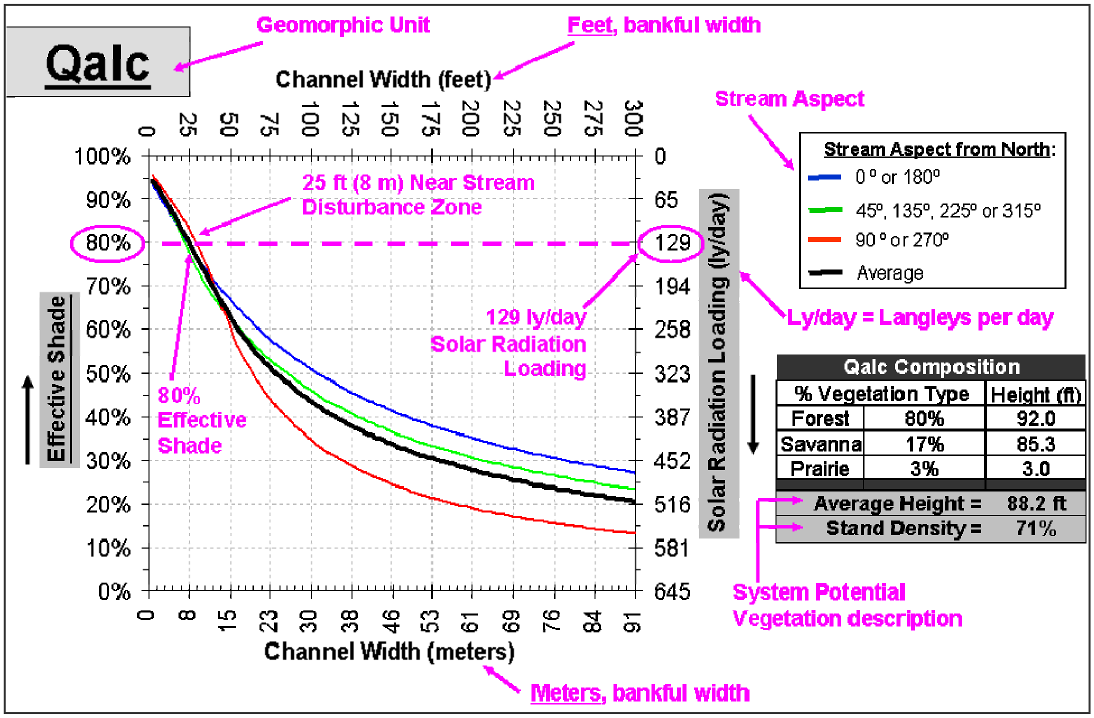
2. Determine the stream aspect from north.

Example: Based on your location on a tributary to the west bank of the Willamette River in Independence, 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 channel width of the stream reach.

Example: At your location you measure the channel width using a tape measure or lasar range finder, you determine the stream width is 25 feet.

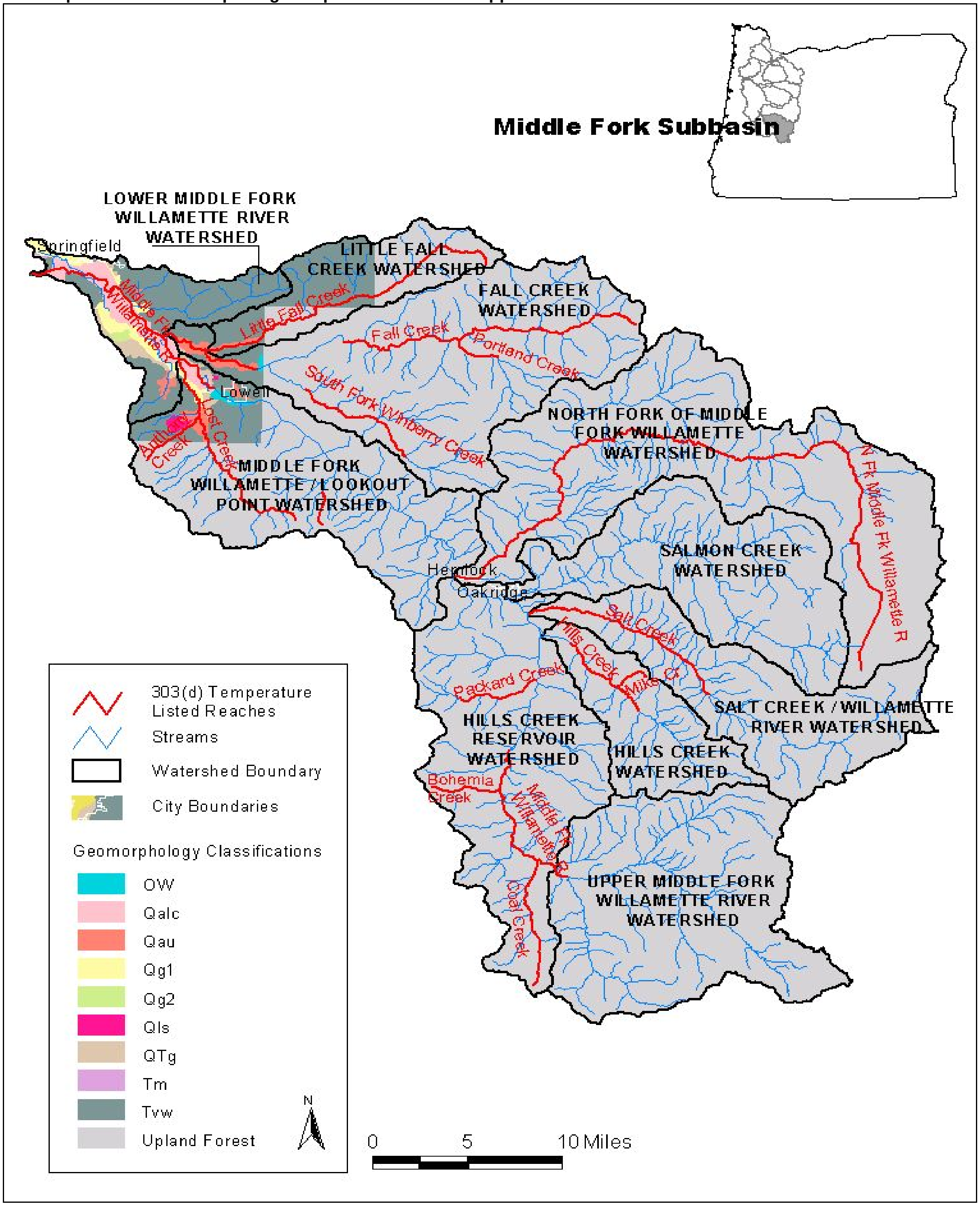
4. Using the appropriate geomorphic or upland forest Shade Curve, using the appropriate stream aspect line and channel width (x-axis), read the y-axis to determine the percent effective shade and solar radiation loading. This is the loading capacity of the stream reach at system potential vegetation.



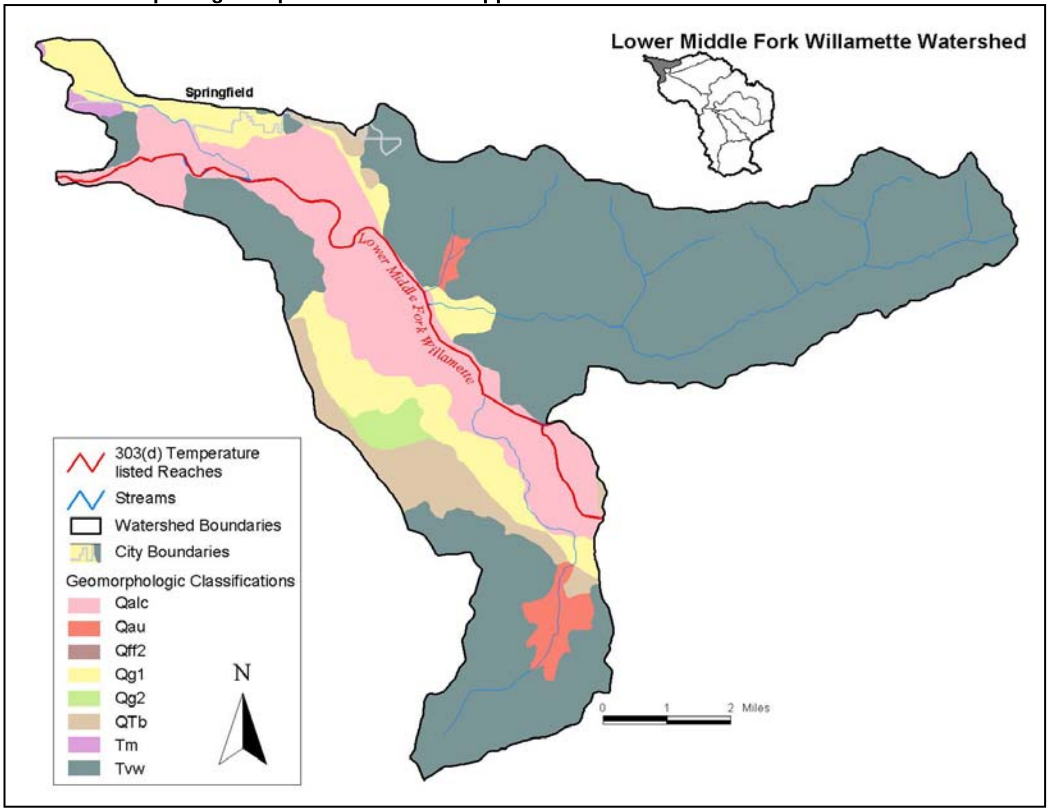
Example: A tributary to the Willamette River on the west bank near Independence with a stream aspect from north of 0º or 180º (blue line) and a channel width of 25 feet: using the blue line to determine the loading capacity from the x-axis identify the 25 feet (8 m) mark and read the y-axis, the solar radiation loading would be 129 Langleys/day with 80% effective shade when system potential vegetation is applied to the left and right bank of the stream reach. System potential vegetation identifies the riparian average height, 88.2 feet (26.9 m), and stand density (tree canopy density), 71 %, that would be established in the riparian area. If it is difficult to determine the streams aspect from north, the average stream aspect from north, black line, can be used to determine the solar radiation loading and effective shade.

Conclusion: A land owner or manager living on the west side of the Willamette River near the city of Independence, measures the channel width of the tributary stream as 25 feet (8 m), with a stream aspect from north of 0º or 180º. By using the geomorphic map for shade curve development that is specific to the areas watershed, provided by ODEQ, in this case Rickreall Creek Watershed geomorphic map. The land owner identifies their location and the corresponding geomorphic unit as Qalc in this example. The land owner then uses the Qalc shade curve to identify what the effective shade and solar radiation loading reaching the stream would be when the land owner establishes a riparian area corresponding to the system potential vegetation description. This is considered the nonpoint source load allocation.

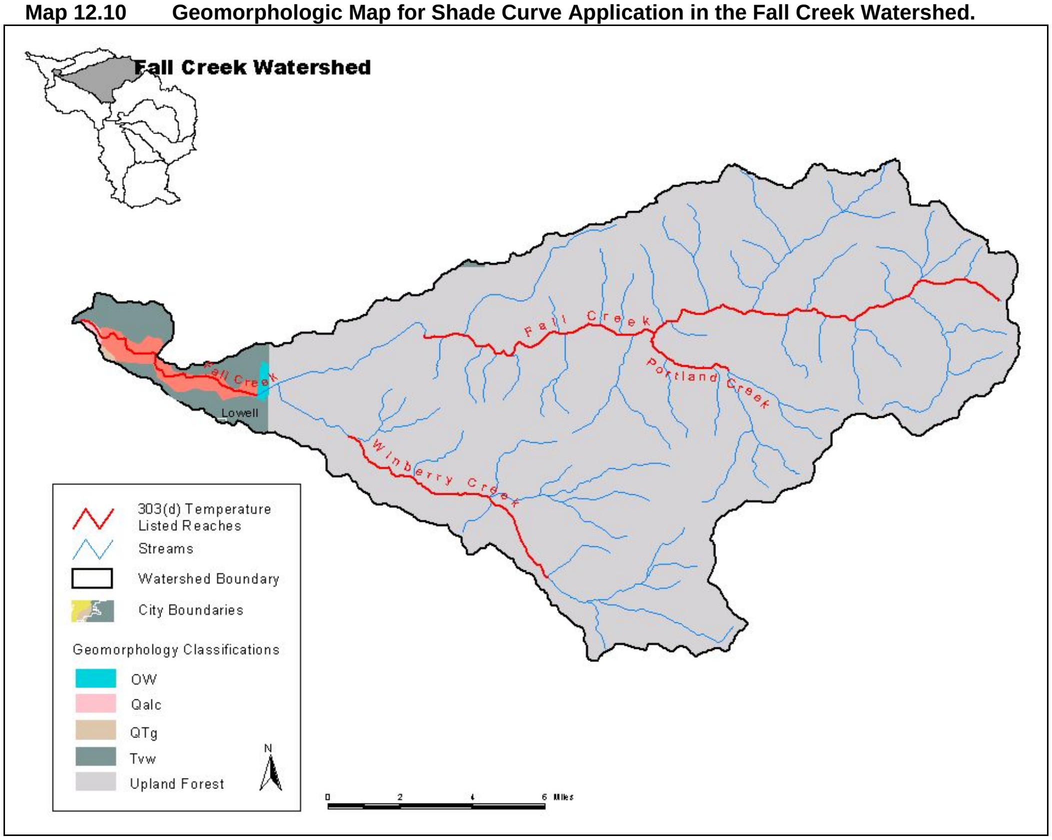
Map 12.8 Geomorphologic Map for Shade Curve Application in the Middle Fork Willamette Subbasin.



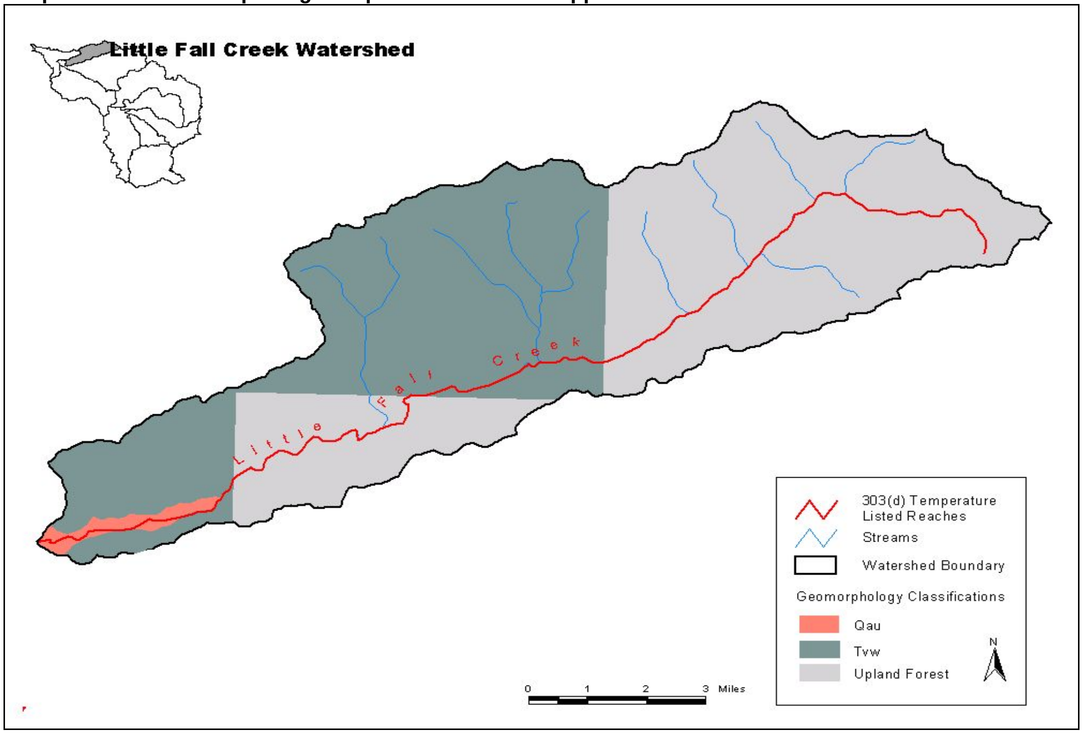
Map 12.9 Geomorphologic Map for Shade Curve Application in the Lower Middle Fork Willamette Watershed.



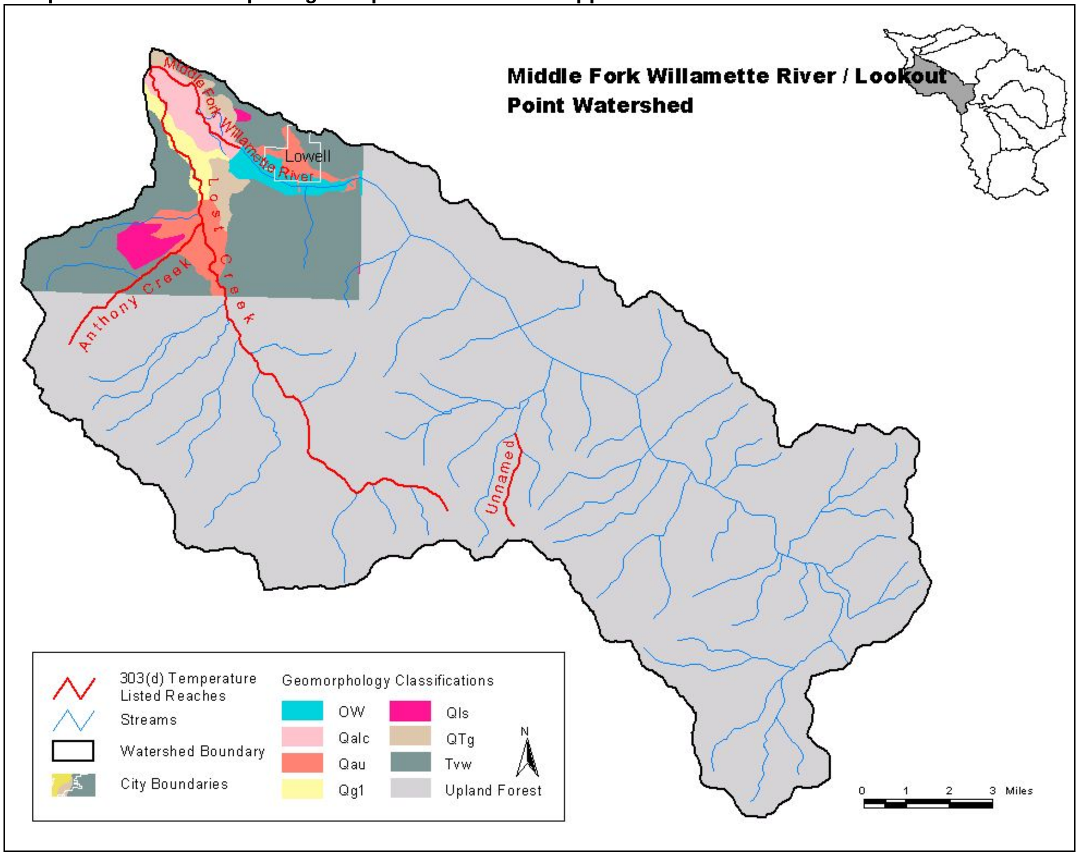
Map 12.10 Geomorphologic Map for Shade Curve Application in the Fall Creek Watershed.



Map 12.11 Geomorphologic Map for Shade Curve Application in the Little Fall Creek Watershed.



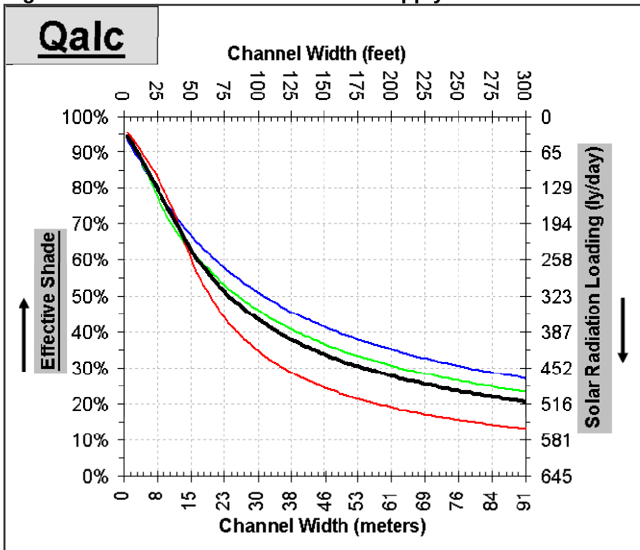
Map 12.12 Geomorphologic Map for Shade Curve Application in the Lookout Point Watershed.



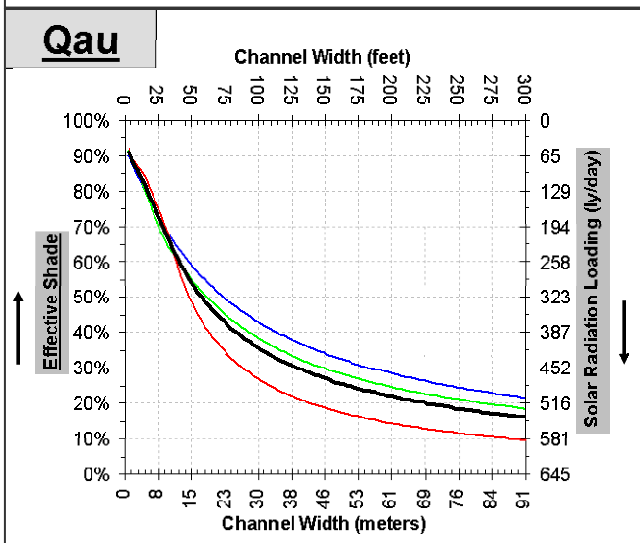
Shade curve methodology provides no information on existing shade conditions or the expected system potential stream temperature. It does provide reasonable estimates of the allocations necessary to eliminate temperature increases resulting from anthropogenic impacts on stream shading. The shade curves presented in Figure 12.5 apply to all water bodies in the Middle Fork Willamette Subbasin and are based on the geomorphic and upland forest units of the reach. The shade curves represented in each figure have been calculated based on the average height for each unit as defined by system potential vegetation. Interpretation of the shade curves requires the identification of the geomorphic or upland forest unit that applies to the stream reach (Map 12.8 to 12.11 above), measuring the stream channel width and stream aspect from north. For a list of geomorphic class abbreviations for each shade curve please see the Table 12.9 titled "Area of Geomorphic Units in the Middle Fork Willamette Subbasin", above.

Geomorphic unit code Pre Flood Quaternary Sand/Gravel (Qg2) is represented in the Middle Fork Willamette Subbasin. The shade curve for Qg2 has not been developed. Historically the geomorphic unit code Qg2 had 90% prairie vegetation along streams that historically became subsurface in the summer and for which water is currently artificially diverted to maintain summer flows. Historic vegetation is probably not a good guideline for modeling potential present day stream temperature. Instead, ODEQ will use the nearest adjacent geomorphic code as determined by the geomorphologic maps, Map 12.8 to 12.11.

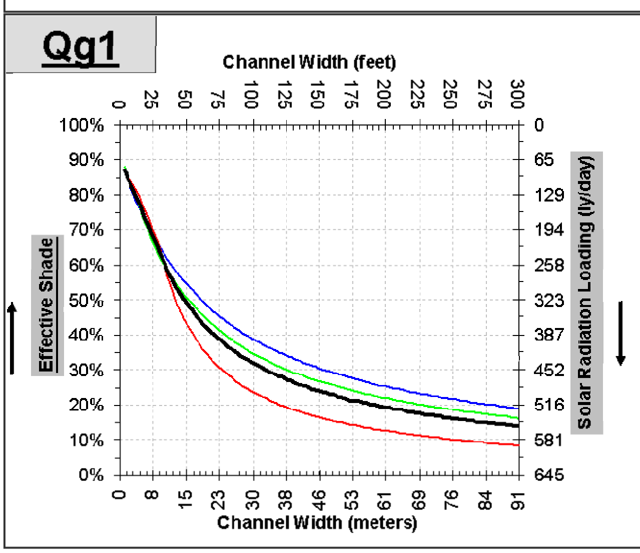
Figure 12.5 Shade Curves that apply to the Middle Fork Willamette Subbasin, based on geomorphology.



Qalc Composition		
% Vegetation Type		Height (ft)
Forest	80%	92.0
Savanna	17%	85.3
Prairie	3%	3.0
Average Height =		88.2 ft
Stand Density =		71%

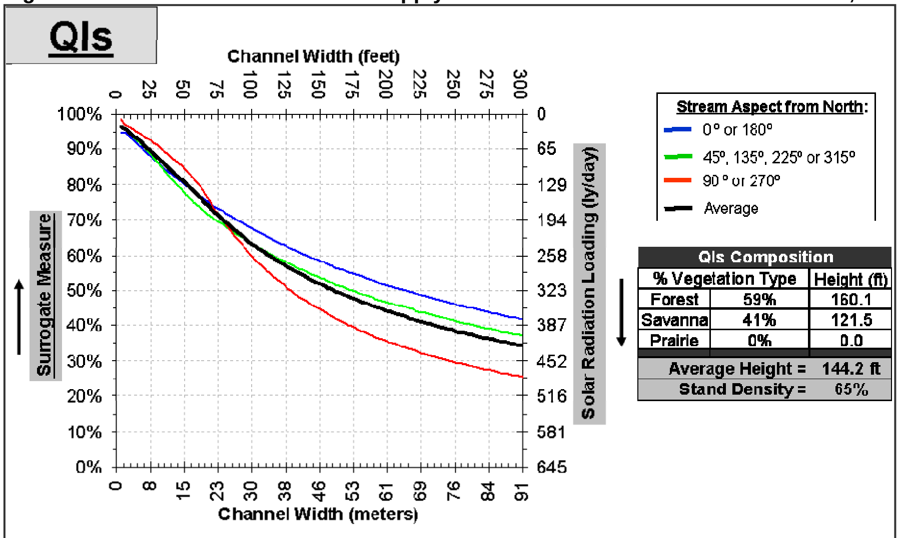


Qau Composition		
% Vegetation Type		Height (ft)
Forest	60%	93.9
Savanna	23%	75.5
Prairie	17%	3.0
Average Height =		74.2 ft
Stand Density =		69%

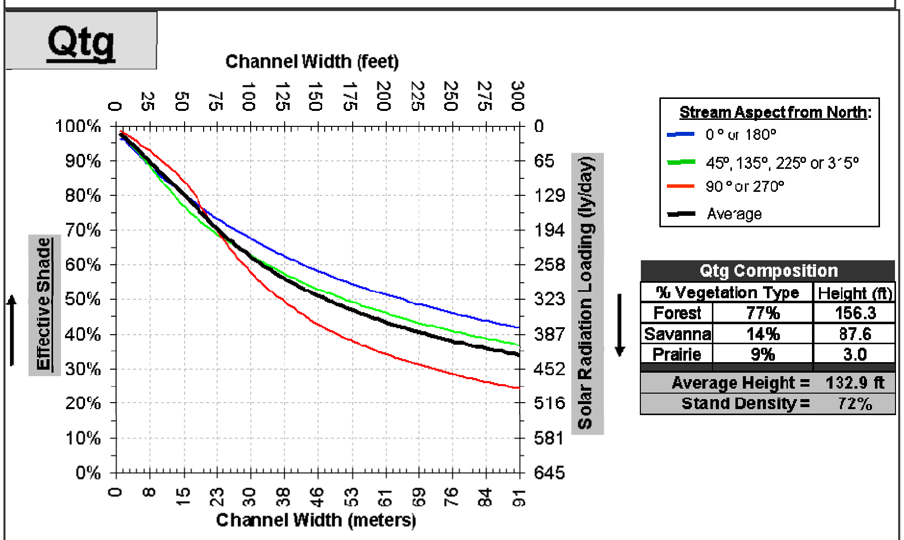


Qg1 Composition		
% Vegetation Type		Height (ft)
Forest	41%	87.9
Savanna	44%	76.4
Prairie	15%	3.0
Average Height =		71.0 ft
Stand Density =		64%

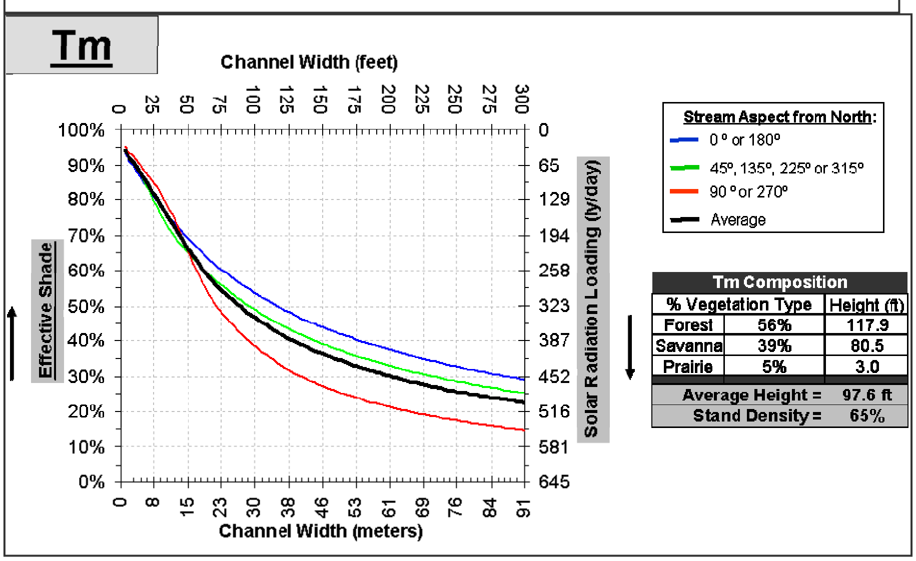
Figure 12.5 cont. Shade Curves that apply to the Middle Fork Willamette Subbasin, based on geomorphology.



Qls Composition		
% Vegetation Type		Height (ft)
Forest	59%	160.1
Savanna	41%	121.5
Prairie	0%	0.0
Average Height =		144.2 ft
Stand Density =		65%

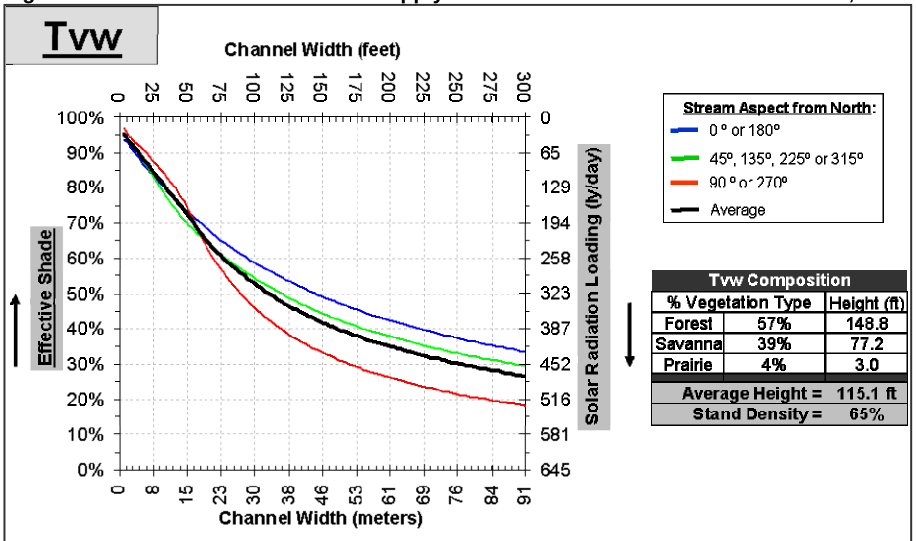


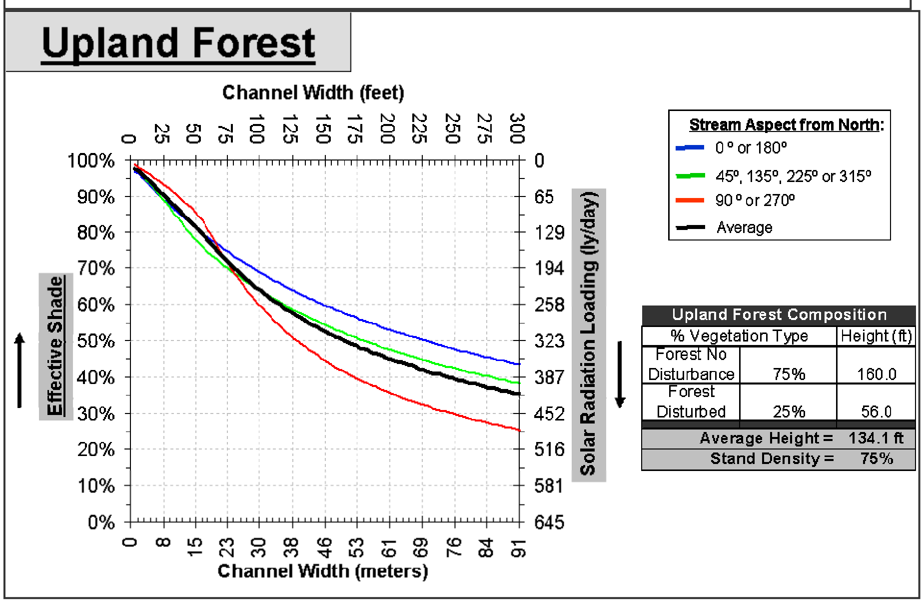
Qtg Composition		
% Vegetation Type		Height (ft)
Forest	77%	156.3
Savanna	14%	87.6
Prairie	9%	3.0
Average Height =		132.9 ft
Stand Density =		72%



Tm Composition		
% Vegetation Type		Height (ft)
Forest	56%	117.9
Savanna	39%	80.5
Prairie	5%	3.0
Average Height =		97.6 ft
Stand Density =		65%

Figure 12.5 cont. Shade Curves that apply to the Middle Fork Willamette Subbasin, based on geomorphology.





Margin of Safety

OAR 340-042-0040(4)(i), CWA 303(d)(1)

A margin of safety is intended to account for uncertainty in available data or in the effect controls will have on loading reductions and water quality. A margin of safety is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions).

The margin of safety may be implicit, as in conservative assumptions used in calculating the Loading Capacity, Wasteload Allocations, and Load Allocations. It may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the margin of safety documented. The margin of safety is not meant to compensate for a failure to consider known sources. Table 12.10 presents six approaches for incorporating a margin of safety into TMDLs.

The following factors may be considered in evaluating and deriving an appropriate MOS:

- *The analysis and techniques used in evaluating the components of the TMDL process and deriving an allocation scheme.*
- *Characterization and estimates of source loading (e.g., confidence regarding data limitation, analysis limitation or assumptions).*
- *Analysis of relationships between the source loading and instream impact.*
- *Prediction of response of receiving waters under various allocation scenarios (e.g., the predictive capability of the analysis, simplifications in the selected techniques).*
- *The implications of the MOS on the overall load reductions identified in terms of reduction feasibility and implementation time frames.*

A TMDL and associated margin of safety, which results in an overall allocation, represent the best estimate of how standards can be achieved. The selection of the margin of safety should clarify the implications for monitoring and implementation planning in refining the estimate if necessary (adaptive management). The TMDL process accommodates the ability to track and ultimately refine assumptions within the TMDL implementation-planning component.

Table 12.10 Approaches for Incorporating a Margin of Safety into a TMDL

Type of Margin of Safety	*Available Approaches*
Explicit	1. Set numeric targets at more conservative levels than analytical results indicate. 2. Add a safety factor to pollutant loading estimates. 3. Do not allocate a portion of available loading capacity; reserve for margin of safety.
Implicit	1. Conservative assumptions in derivation of numeric targets. 2. Conservative assumptions when developing numeric model applications. 3. Conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

A margin of safety has been incorporated into the temperature assessment methodology. Wasteload allocations are based on critical conditions that are unlikely to occur simultaneously. For example, it is unlikely that maximum effluent flows and maximum effluent temperatures are likely to occur simultaneously however those values were used to calculate point source heat loads. Furthermore, receiving stream values were also based on attainment of biological based criteria during low flow periods defined as the low flow of a ten year cycle.

Calculating a numeric margin of safety for nonpoint source loads is not easily performed with the methodology presented in this document. In fact, the basis for the loading capacities and load allocations is system potential conditions and it is not the purpose of this plan to promote riparian conditions and shade levels that exceed natural conditions.

Reserve Capacity

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

Reserve capacity has been allocated for temperature through much of the Willamette Basin. Explicit allocations have generally only been made in conjunction with point source wasteload allocations. Where there are multiple point sources in a waterbody, point sources in combination have been allocated 0.2˚C of the Human Use Allowance. Another 0.05˚C is allocated to nonpoint sources of heat although not currently assigned to individual sources. Nonpoint sources load allocations are limited to natural solar radiation levels determined by shade curves for a given area. The final 0.05˚C of the human use allowance is allocated to reserve capacity and will be available for use by point sources or nonpoint sources by application to ODEQ. In total, these allocations may not increase temperature in a water quality limited waterbody by more than 0.3°C (0.54°F) at the point of maximum impact.

In those situations where the point source allocation is less than 0.2˚C or if there are no point sources, the remaining portion of the Human Use Allowance will be set aside as reserve capacity. The nonpoint source allocation will remain at 0.05˚C unless special circumstances exist that require a larger or smaller allocation. More information regarding the use of reserve capacity may be found in Chapter 14, Water Quality Management Plan, Part 2, under Temperature Implementation.

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