CHAPTER 6: CLACKAMAS SUBBASIN TMDL

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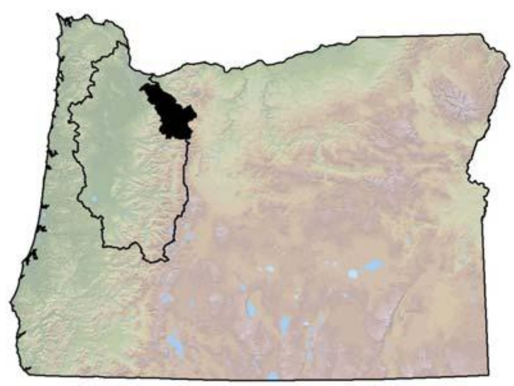
WATER QUALITY SUMMARY

Reason for action

The Clackamas River Subbasin (Map 6.1) comprises six 5th-field watersheds (the next smallest division of the hydrologic unit code the U.S. Geological Survey assigns to the Clackamas Subbasin). Analysis of temperature and bacteria data have indicated that parts of the subbasin do not meet water quality standards for these parameters at all times. Four stream segments are listed on the 2002 Oregon 303(d) list for temperature and eight stream segments also violate the *E. coli* bacteria criteria for water quality.



Map 6.1 Clackamas Subbasin and 5th field watersheds.

The temperature TMDL addresses tributaries to the Clackamas River and the mainstem upstream of all hydroelectric facilities. The Willamette River main stem temperature modeling and analysis (Chapter 4) extend to Clackamas river mile (RM) 23 and the River Mill Dam. There are also hydroelectric facilities in the Oak Grove Fork drainage, a tributary in the upper portion of the Clackamas watershed, that influence stream temperature. ODEQ assumes the analysis of the Clackamas River downstream of RM 23 reflects the upstream temperature influence from Oak Grove facilities even though the Oak Grove Fork is not explicitly modeled. This chapter does not analyze the temperature effect of Oak Grove Fork hydroelectric facilities, but discussion of nonpoint source heat effects and the associated allocations and remedies do apply to the Oak Grove Fork as well as the remaining tributaries to the Clackamas River and the upper Clackamas River. The bacteria TMDL allocations apply to urban and agricultural land uses across the entire subbasin, both tributaries and the mainstem Clackamas River.

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 subbasins will be required to develop mercury reduction plans. Details of the mercury TMDL are included in Chapter 3, the Willamette Basin Mercury TMDL.

Who helped us

Many groups collect temperature data in the Clackamas Subbasin, which was useful for assessing current conditions, but ODEQ did not develop a temperature model for Clackamas tributaries that would have required continuous temperature data. Rather, ODEQ used shade curves based on geomorphic coverages in the Willamette Basin (for an explanation of geomorphic coverages, see Chapter 4 and the Surrogate Measures section of this chapter).

Portland General Electric (PGE) collected continuous temperature data from approximately 40 sites on the mainstem and tributaries between April and October 2000, and from approximately 20 sites through the winter, as input for a temperature model on the mainstem Clackamas River. Portland General Electric and Portland State University developed a two-dimensional CE-QUAL-W2 model to evaluate the effects of hydroelectric project operations on stream temperatures, as explained in Chapter 4. The model quantifies temperature sensitivity to shade, channel hydraulic geometry, and hydroelectric project operations, and allows ODEQ to develop load allocations for the 303(d) listed reach downstream of River Mill Dam.

In developing the bacteria TMDL, ODEQ used bacteria data collected by Clackamas County Water Environment Services and the Clackamas Soil and Water Conservation District, as well as its own data. ODEQ performs ambient monitoring as part of its Three Basin Ambient Monitoring Network program at three locations on the Clackamas River, at river miles 1.2 (High Rocks), 22.6 (McIver Park), and 35.7 (Memaloose Rd).

Subbasin 303(d) Listed Parameters Addressed by a TMDL

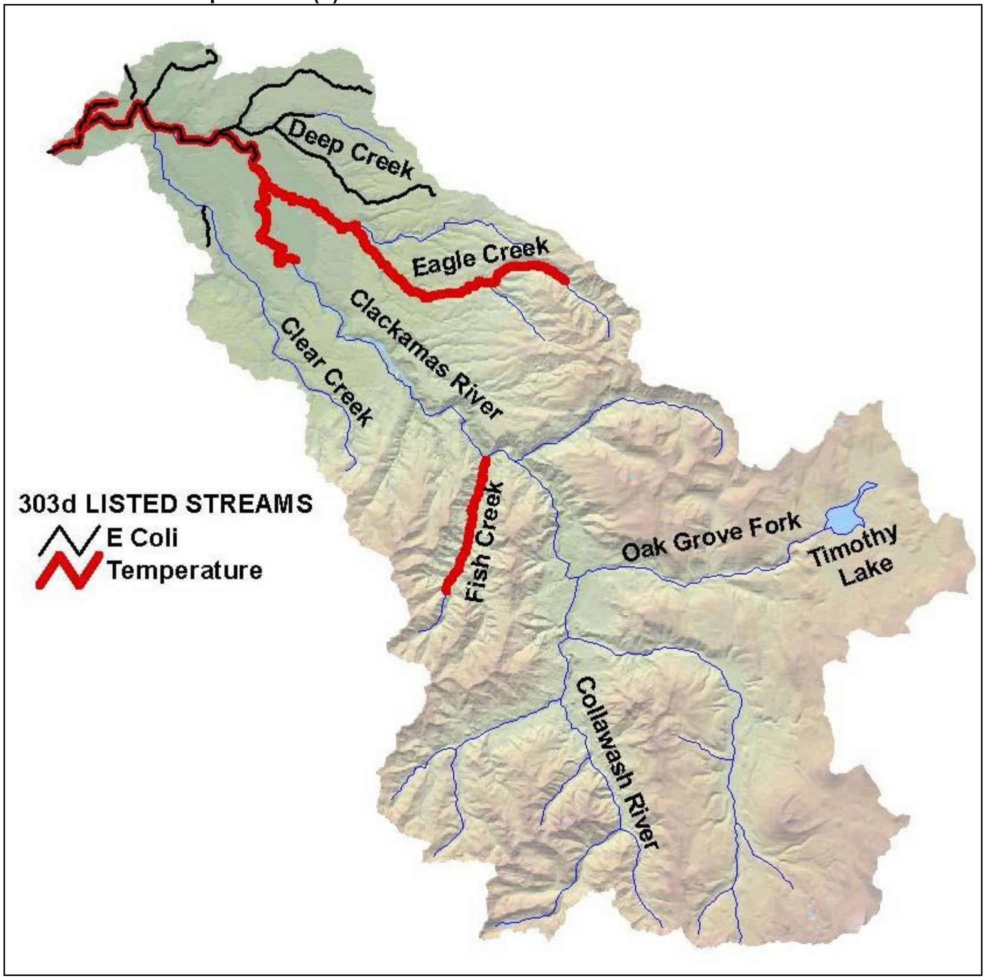
ODEQ used its own water quality information as well as data collected by other agencies through 2001 to determine violations and threatened beneficial uses. The Clackamas River downstream of RM 23, Eagle Creek, Fish Creek, and Cow Creek were included on the 2002 303(d) List for temperature standard violations, specifically the 64°F (17.8°C) numeric criteria that applied at the time of the listing. The lower 15 miles of the Clackamas River as well as portions of the following waterbodies violated the *E. coli* standard in the summer based on a screening against the single sample maximum criterion (406 *E. coli* organisms/100ml): Bargfeld, Deep, North Fork Deep, and Tickle Creeks. Cow, Rock, and Sieben Creeks violated the *E. coli* criteria between October 1 and May 31.

Table 6.1 shows the water quality listings in the Clackamas Subbasin based on the maximum 7-day average of the daily maximum temperature or at least five discrete samples analyzed for bacteria. Map 6.2 shows the 303(d) listed reaches.

Listed waterbodies in the Clackamas Subbasin

Waterbody Name	Listed Reaches (River Mile)	Parameter	Covered in Chapter
Clackamas River	RM 0 – 22.9	Temperature	4
Eagle Creek	0 – 20	Temperature	6
Fish Creek	0 – 6.8	Temperature	6
Cow Creek	0 – 2.6	Temperature, Bacteria (October 1 – May 31)	6
Rock Creek	0 – 6.1	Bacteria (October 1 – May 31)	6
Sieben Creek (Drainage Ditch)	0 – 1.0	Bacteria (October 1 – May 31)	6
Sieben Creek (Drainage Ditch)	1.0 – 1.8	Bacteria (October 1 – May 31)	6
Clackamas River	0 - 15	Bacteria (June 1 – September 30)	6
Bargfeld Creek	0 – 2.3	Bacteria (summer)	6
Deep Creek	1.9 – 14.1	Bacteria (summer)	6
North Fork Deep Creek	0 – 9	Bacteria (summer)	6
Tickle Creek	0 – 2.3	Bacteria (summer)	6

Map 6.2 303(d) listed reaches in the Clackamas Subbasin.

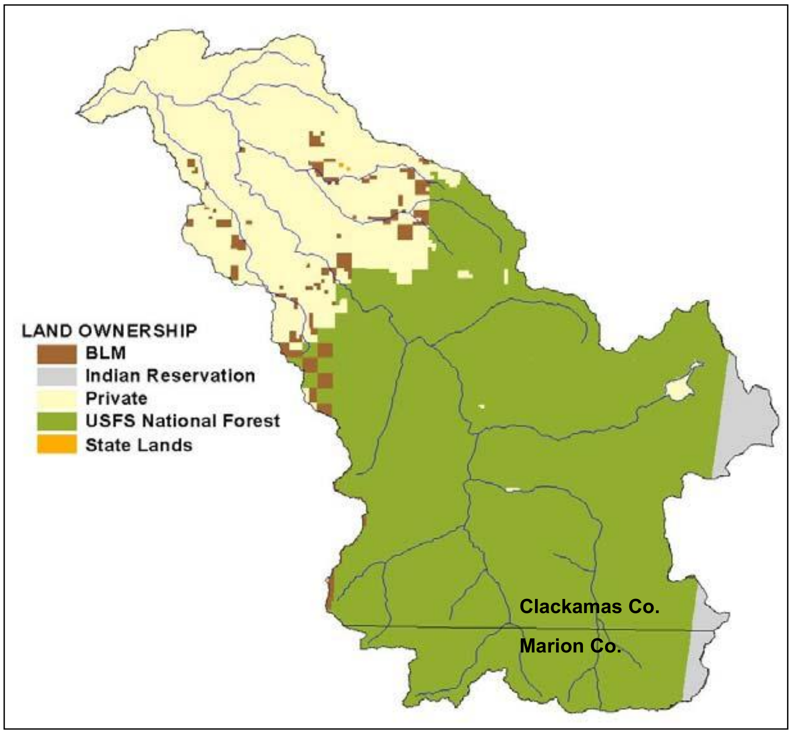


SUBBASIN OVERVIEW

The Clackamas River and tributaries drain the Clackamas Subbasin (Hydrologic Unit Code 17090011), located in the Willamette Basin. The subbasin's 940 square miles extend from the Mt. Hood National Forest northwest to the Willamette River. Political jurisdictions include portions of Clackamas and Marion Counties and the cities of Oregon City, Gladstone, Sandy, and Estacada. The subbasin also contains the smaller communities of Damascus and Boring. The Clackamas River provides drinking water for approximately 175,000 people in Clackamas County, the metro area, and Estacada.

The Clackamas Subbasin also includes a small portion of the Warm Springs Indian Reservation. The Tribes are not required to promulgate their own water quality standards or TMDLs under the Clean Water Act (CWA), and state-promulgated TMDLs approved by USEPA are not in effect within Indian reservations. If Tribes wish to create TMDLs that apply under the Clean Water Act, they must first apply to USEPA for a determination that the Tribe is eligible for "Treatment as a State" to administer section 303(d) of the CWA. Since none of the Oregon Tribes currently have been approved for 303(d), USEPA is responsible for developing and issuing the TMDLs within Indian reservations with the assistance of and in close cooperation with Tribes. The Confederated Tribes of the Warm Springs Reservation have water quality standards on their Tribal lands.

Land Use and Ownership



Map 6.3 Land ownership in the Clackamas Subbasin

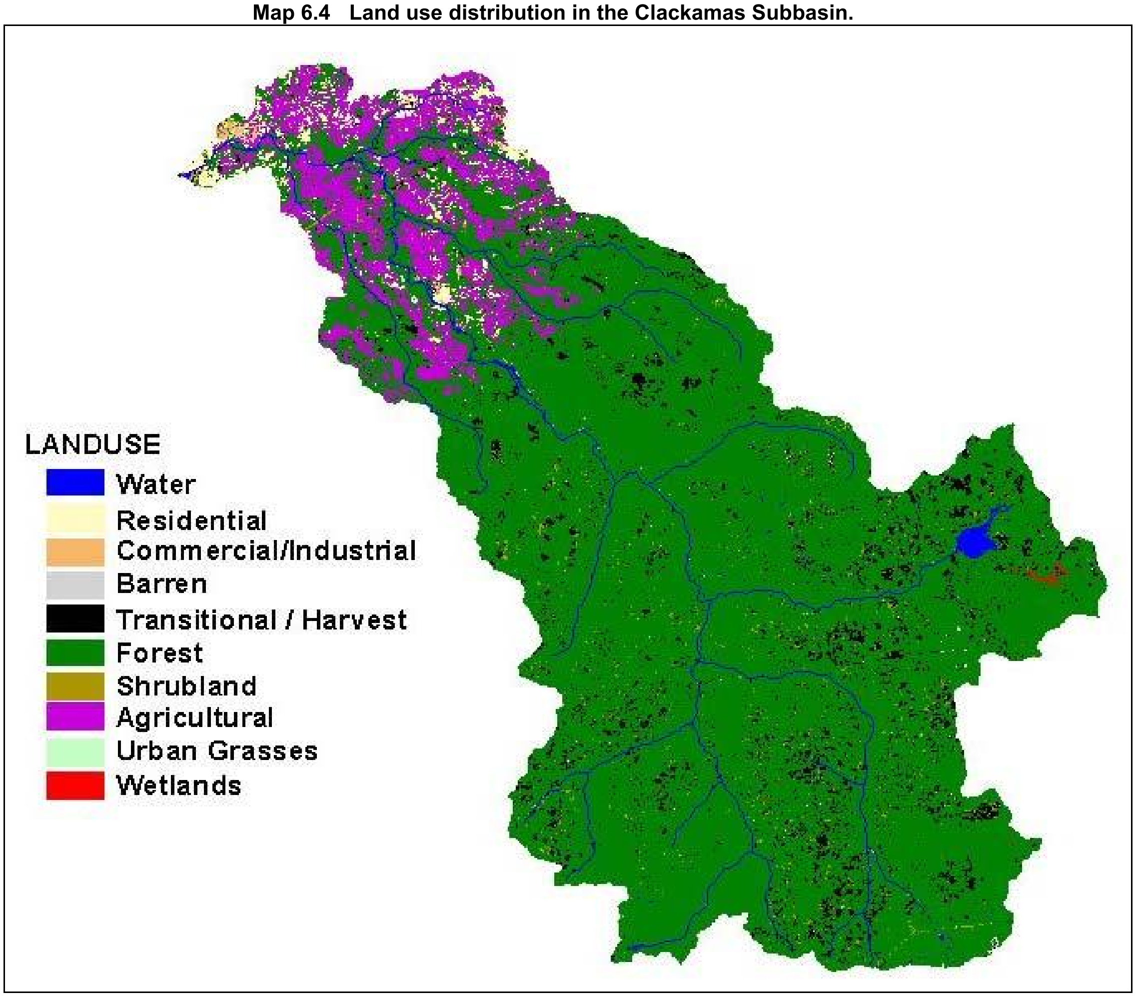
The U.S. Forest Service manages most of the 72% of the subbasin that is publicly owned; the U.S. Bureau of Land Management manages about 2% of the total land in the subbasin, usually in portions smaller than one square mile (Metro 1997).

Approximately 25% of land in the Clackamas Subbasin, mostly in the lower watershed, is privately owned. Timber companies own private land within and outside the Mt. Hood National Forest boundaries, and PGE owns land associated with its hydropower facilities. Individual, commercial and industrial land owners operate in the lower watershed. Map 6.3 illustrates land ownership in the Clackamas Subbasin.

Map 6.4 illustrates land use in the Clackamas Subbasin. Forestry is the dominant land use by area, although a significant portion of the land in the upper watershed is protected to varying degrees from timber harvest. Little or no timber harvest is allowed on lands that are Administratively Withdrawn, Late Successional Reserves, Riparian Reserves, or congressionally reserved areas such as Wilderness Areas and Wild and Scenic River segments. The Clackamas Subbasin contains two wilderness areas: the Bull of the Woods Wilderness Area protects 34,900 acres in the Collawash and Hot Springs Fork of the Collawash drainages, and the Salmon Huckleberry Wilderness Area protects 44,600 acres, including a portion of the Eagle Creek drainage. Approximately 50 miles of the Clackamas River, and 14 miles of the Roaring River, are designated Federal Wild and Scenic Rivers. The Clackamas River designation extends from Big Spring, in the Olallie Lake Scenic Area, to Big Cliff, just upstream of North Fork Reservoir.

Commercial and industrial land use is concentrated near the mouth of the Clackamas River, as well as in and around smaller urban areas and along major transportation corridors. Agricultural production consumes much of the lower third of the watershed.

Map 6.4 Land use distribution in the Clackamas Subbasin.



Watershed Descriptions

Six 5th field watersheds comprise the Clackamas Subbasin (Map 6.1). The characteristics of each of the 5th field watersheds and some of the smaller watersheds they contain are described below.

Upper Clackamas Watershed

The Upper Clackamas Watershed extends from the headwaters of the Clackamas River to the confluence with the Collawash River and encompasses 100,380 acres (U.S. Forest Service 1995a). With the exception of 5,600 acres in the Confederated Tribes of the Warm Springs Indian Reservation and one privately owned hot spring area (150 acres), the entire watershed is within the Mt. Hood National Forest. The highest point in the watershed is Ollallie Butte at 7,215 feet in elevation, and the confluence with the Collawash River is at 1,500 feet in elevation. The watershed receives between 70 and 130 inches of rain and snow annually and many springs provide consistent baseflow throughout the summer. Average winter flows at Big Bottom, on the Upper Clackamas River, approach 700 cfs, and summer flows may be less than 300 cfs. While overall gentle slopes characterize the watershed, landslides do occur on steeper slopes, often associated with roads or clear cuts. Most landslides occur in the northwest portion of the watershed.

About one-quarter of the watershed is designated Tier I, providing crucial refugia for at-risk fish species, and is in late successional reserves. The watershed supports late-run coho, winter steelhead, and spring Chinook. Approximately 29,000 acres have been harvested since logging began in the 1940s. Of the remaining vegetation, 27% is in early seral stage, 35% in mid seral stage, and 38% in late seral stage. The watershed's vegetation is roughly divided into thirds between western hemlock, pacific fir, and mountain hemlock series.

Collawash River and Hot Springs Fork Drainages

The Collawash and Hot Springs Fork drainages are almost entirely composed of U.S. Forest Service land. Together they drain 97,000 acres between approximately 1,480 and 5,710 feet above mean sea level, including 34,900 acres that is Bull of the Woods wilderness. The Collawash River enters the Clackamas River at RM 57. Ecoregions represented in the two drainages are Western Cascade Montane Highlands and Western Cascades Lowlands and Valleys. The U.S. Forest Service characterizes the Collawash/Hot Springs Fork drainage as mature forest; most of the large conifer stands are between 200 and 350 years old. About one-quarter of the drainage area is early and mid seral stages, and one-half in the late seral stage. Seral stages are based on percentages of three species: Western hemlock, Pacific silver fir, and mountain hemlock. Other vegetative groupings include sitka spruce/alder patches, wetlands (grasses, shrubs and red alder swamps).

Precipitation ranges from 70 to 130 inches annually, and the U.S. Forest Service watershed analysis (1995b) suggests that the Collawash/Hot Springs Fork drainages retain less winter precipitation than the Upper Clackamas Watershed retains, and consequently groundwater contributes less to Collawash/Hot Spring Fork baseflow. Flow data from the late 1960's indicates a range from 115 cfs in August to about 1,600 cfs in February. According to the U.S. Forest Service Watershed Analysis (1995), these two drainages contain a large amount of potentially unstable land; channel side slopes range from 35% to 55%. Small boulders and cobbles make up most of the channel substrate, with high gradients responsible for the flushing of finer sediments. Smaller streams in these drainages include Hugh Creek, Elk Lake Creek, East Fork Collawash River, and Fan Creek.

Oak Grove Fork

The Oak Grove Fork of the Clackamas River drains 91,000 acres that range in elevation from 1,340 feet at the mouth to 5,400 feet. The far western portion of the Oak Grove Fork drainage is owned by the Warm Springs Indian Reservation. The U.S. Forest Service owns the remainder, exclusive of the land associated with the PGE hydroelectric project. Although the northern portion of the watershed is protected as a late successional reserve, the U.S. Forest Service characterizes the watershed as a whole as fragmented (1996). PGE operates hydroelectric facilities in the Oak Grove Fork including two dammed lakes, Timothy and Harriet, Frog Lake (an off-stream reservoir), and the associated powerhouse, pipelines, and power transmission facilities. The Forest Service Watershed Analysis (1996) reports that the 5-year flow recurrence interval was 110 cfs before the dam at Lake Harriet was constructed and 33 cfs after dam construction. The Oak Grove Fork is entirely composed of the Cascade Crest Montane Forest Ecoregion. Anadromous fish passage is limited by a 20-foot water fall at RM 3.8. Coho, spring Chinook, and winter steelhead spawn in this lower portion of the stream.

Roaring River Watershed

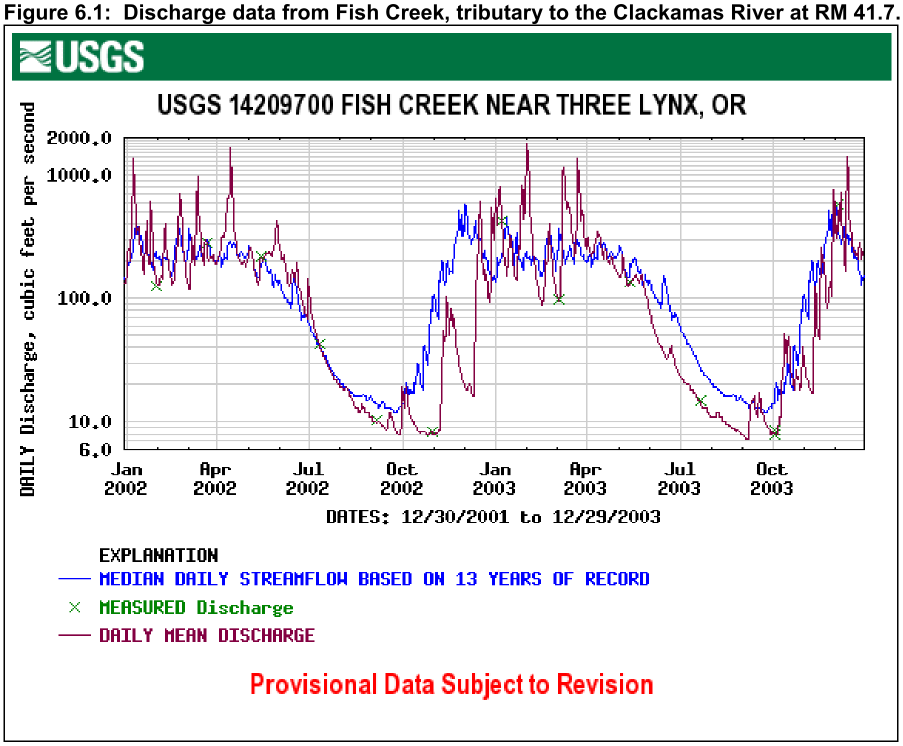
The Roaring River 5th field watershed includes Fish Creek (30,000 acres), the middle Clackamas River mainstem, and the North and South Forks of the Clackamas River. The higher elevations in these drainages (up to 5000 feet) are within the Western Cascade Montane Highlands ecoregion. Lower elevations (down to less than 2000 feet) are within the Western Cascades Lowlands and Valleys ecoregion.

The Roaring River drains 27,250 acres and is designated as a Wild and Scenic River. At 996 feet elevation, the Roaring River joins the Clackamas River at RM 44. Glaciation steepened the valley walls in the upper watershed. Forested and talus slopes descend from the basalt and andesite ridges. Steep slopes along the Roaring River and its tributaries contribute to unstable soils and landslides. Several lakes and meadows dot the watershed, Squaw Meadows being the most developed and high quality wetland. Snow covers most of the Roaring River drainage about six months of the year. Steamflow data from the late 1960's cited in the U.S. Forest Service Watershed Analysis (1996) shows that flows can range from 30 to 1,240 cfs. The Roaring River supports Coho, steelhead, spring Chinook, cutthroat trout and rainbow trout. Late-run coho and winter steelhead use only the lower 3.3 miles of the river, below the first falls. Eleven miles of the Roaring River provide excellent cutthroat trout habitat. Topography, soil types, and past fires are mostly responsible for the distribution of vegetation in the Roaring River drainage. Compared to surrounding drainages, relatively little logging (155 acres) has altered the landscape. About 21% of the drainage is in late seral reserve, 11% early, and 68% mid seral. Early seral forests tend to be on the high elevation ridges and late seral forests in the river corridors and the mouth of Roaring River.

Fish Creek Watershed

Fish Creek violates the temperature standard and is also a Tier 1 watershed, identified as critical habitat for anadromous species (Metro 1997). According to the Fish Creek Watershed Analysis (U.S. Forest Service, 1994), this drainage receives between 70 and 80 inches of precipitation annually, 70% of which falls from October through March and only 3% in July and August. Elevations range from 900 feet at the mouth to over 5,000 feet at the crest. Fish Creek is approximately 13 miles long and has a boulder and cobble substrate. Monthly mean flows range from 13 cfs in late summer to 350 in late winter/early spring. Figure 6.1 illustrates Fish Creek flow over a period of 18 months.

Figure 6.1: Discharge data from Fish Creek, tributary to the Clackamas River at RM 41.7.



Dominant tree species include Douglas fir, Western hemlock, Western red cedar, Pacific silver fir, noble fir, red alder, and big leaf maple. Understory species include vine maple, rhododendron, sword fern, salal, Alaskan huckleberry, and bear grass. The watershed supports anadromous salmonids including summer and winter steelhead trout, spring Chinook salmon, and coho salmon. Tributary streams in the upper watershed support resident rainbow and cutthroat trout. A substantial portion of Fish Creek drainage is in late successional reserves, although in a dendritic (branching), rather than continuous pattern.

Fish Creek is the most geologically unstable watershed (largest proportion of area with potential for shallow mass wasting) in the Mt. Hood National Forest (U.S. Forest Service, 1994). The U.S. Forest Service Pacific Northwest Research Station completed studies in the late 1990's in Fish Creek prompted by the high incidence of landslides and their effects on fish populations. The Forest Service published the "Fish Creek Restoration Plan" in 2000 that responded to the studies' findings such as: the highest incidence of landslides occurred in areas of young forest stands or old roads. After damage caused by flooding in the late 1990s, the Forest Service measured temperatures in Fish Creek similar to those measured in urban streams in the lower Clackamas watershed. Restoration projects included road obliteration, and other road and stream crossing maintenance, tree thinning and planting, erosion control and channel restoration. The U.S. Forest Service decommissioned 73% of the road system and repaired or storm-proofed the remaining roads. They also treated, planted, or otherwise restored 3 stream miles and planted 3 acres of riparian areas. They thinned 3,487 acres of trees and planted 50 acres of landslides. In August 2001, the U.S. Forest Service released a monitoring plan to track the effectiveness of their restoration efforts in Fish Creek.

South Fork Clackamas Watershed

The South Fork Clackamas Watershed drains 17,647 acres. Elevations range from 650 to 4,485 feet along the eight mile run of the river. The side slopes in the valleys are steep (30 – 60 %) and this combined with weak and resistant rock, make landslide potential high. Much of the drainage area of the South Fork itself is in late successional reserves. The southern and eastern portions of the drainage are less pristine from more road building and logging (U.S. Forest Service, 1997; Metro, 1997). Anadromous fish (steelhead, coho, and spring Chinook) can only migrate 0.4 miles up the South fork because of a 70 foot high waterfall.

North Fork Clackamas

The North Fork Clackamas drains into North Fork Reservoir on the mainstem Clackamas upstream of river mile 31. Most of the land is matrix land, and 32% is in riparian reserves. The North Fork drainage is more geologically stable than Fish Creek and the South Fork Clackamas. A 50 foot water fall at RM 2.4 stops anadromous fish passage (steelhead and late run Coho).

The Roaring River Watershed includes the middle portion of the Clackamas River mainstem. ODFW operates a fish hatchery at McIver State Park at RM 22.6. The hatchery produces spring Chinook and winter steelhead.

Lower Clackamas Tributaries

The main tributaries to the lower Clackamas River include Clear Creek, Deep Creek, Richardson Creek and Rock Creek. Cow Creek, included on the 303(d) list, also enters the lower Clackamas near the mouth. Most of the land contributing flow to the lower Clackamas tributary streams is in the Valley Foothills ecoregion. The lower portions of the tributaries and the lower Clackamas itself are in the Prairie Terraces ecoregion. The lower Clackamas includes the communities of Estacada and Sandy (Deep Creek) as well as the metro area cities of Oregon City and Gladstone near the mouth of the Clackamas River. Downstream from Estacada, virtually all land in the watershed is privately owned. The lower watershed is all below 1,000 feet. Land used for agriculture and timber comprises the most area in the lower watershed, with residential, industrial and commercial use concentrated around the population centers.

Clear Creek Watershed

Clear Creek originates above 4,200 ft. and enters the Clackamas River (river mile 8) at 79 feet elevation. “The Clear Creek Watershed Assessment “(WPN, 2002) reports that most of the watershed is below 1,500 feet. At higher elevations, annual precipitation reaches about 93 inches, while only 47 inches falls on lower elevations.

In the upper and middle watershed, Clear Creek flows over volcanic and sedimentary rocks and has eroded steep-sided ravines. Clear Creek becomes wider and gradient lessens as the substrate changes to alluvial materials. Most soils in the watershed are moderate to slow draining, with less than 5% very slow draining. Clear Creek ecoregions progress from Western Cascades Lowlands and Valleys in Upper Clear Creek to Valley Foothills and Prairie Terraces in the lower watershed. Low elevation vegetation includes Oregon white oak, Oregon ash, Douglas-fir, and grand fir. Madrone, Western red cedar, Western hemlock, vine maple, and Western red alders appear at middle and higher elevations. Fall Chinook, winter steelhead, and coho salmon spawn, rear, and migrate in the Clear Creek.

Historical flow data (1936) cited in the WPN watershed assessment indicates flows between 450 cfs in late February and less than 30 cfs after July 1. More than 300 points of diversion withdraw surface and groundwater from the Clear Creek Watershed, and approximately 60% by volume is used for irrigation. Fish use (probably ponds) accounts for slightly less than 20%, and agriculture (probably nurseries) another 6%. Domestic use accounts for less than 10%. Analysis of the total water rights, including instream water rights shows that consumptive uses plus storage can exceed natural stream flow in the summer months (WPN, 2002).

Private landowners own most of the Clear Creek Watershed; BLM and the U.S. Forest Service manage a small percentage. Except in the Administratively Withdrawn areas, over 90% of the land use in the upper watershed and over 60% in the middle watershed is forestry. About 20% of the lower watershed is used for timber, and 60% for agriculture. Rural residential use comprises over 10% of the lower Clear Creek Watershed.

Richardson and Rock Creeks

The Clackamas River Basin Council has completed watershed assessments for Rock and Richardson Creeks (Ecotrust, October 2000). Rock Creek Watershed area is approximately 6,200 acres and Richardson Creek is slightly more than 2,700 acres. Estimated annual average flow from Rock Creek is 21 cfs, and Richardson Creek, 7.5 cfs. Rainfall averages between 45 to 53 inches annually, depending on elevation. Rock and Richardson Creek land cover is about 40% agriculture and 35% forestry. Slightly over 10% of land in both drainages is developed for urban use, and the remainder is open space including shrub and grass lands, as well as developed parks. Historically Douglas-fir, grand fir, big leaf maple, hazelnut, Pacific dogwood, vine maple, and Pacific yew forested higher elevations in both watersheds. Hemlock and red cedar were present in wetter areas. Closed hardwood forests, including Oregon ash, cottonwood, alder, maple, and white oak with some conifer patches characterized lower elevations near the streams. Lower Rock and Richardson Creeks support small populations of spawning and rearing coho and winter steelhead as well as rearing and migrating Chinook. A 20-foot waterfall about one half mile upstream of the mouth limits fish passage in Rock Creek, although resident cutthroat trout inhabit the middle reach of Rock Creek. Degraded habitat and culverts limit upstream fish passage in Richardson Creek.

Eagle Creek Drainage

The Eagle Creek drainage comprises 57,000 acres and joins the Clackamas River at RM 16.7. U.S. Forest Service manages the upper portion of Eagle Creek a portion of which lies within the Salmon-Huckleberry Wilderness. Private timber companies own most of the land in the mid watershed, excepting BLM managed land. The lower drainage is all privately owned and zoned for forestry, agriculture, and residential use.

The mouth of Eagle Creek is at 300 feet elevation and the highest peak in the drainage exceeds 4200 feet. Geology and topography make the eastern portion of the watershed geologically unstable (U.S. Forest Service 1995).

Precipitation ranges from 55 inches per year at the mouth to over 100 inches annually at higher elevations. The lower three miles of the channel are depositional, while upstream gradients exceed 2%. Tributaries to Eagle Creek lose up to 4 ft. elevation over 100 ft. Most of the water rights in Eagle Creek are used for irrigation, but also supply fire protection, domestic use, recreation, livestock, fisheries, wildlife, nurseries, and other agricultural uses. Timber and agricultural activities in areas with lower infiltration rates (middle and lower watershed) have increased the peak flows over natural conditions (U.S. Forest Service 1995).

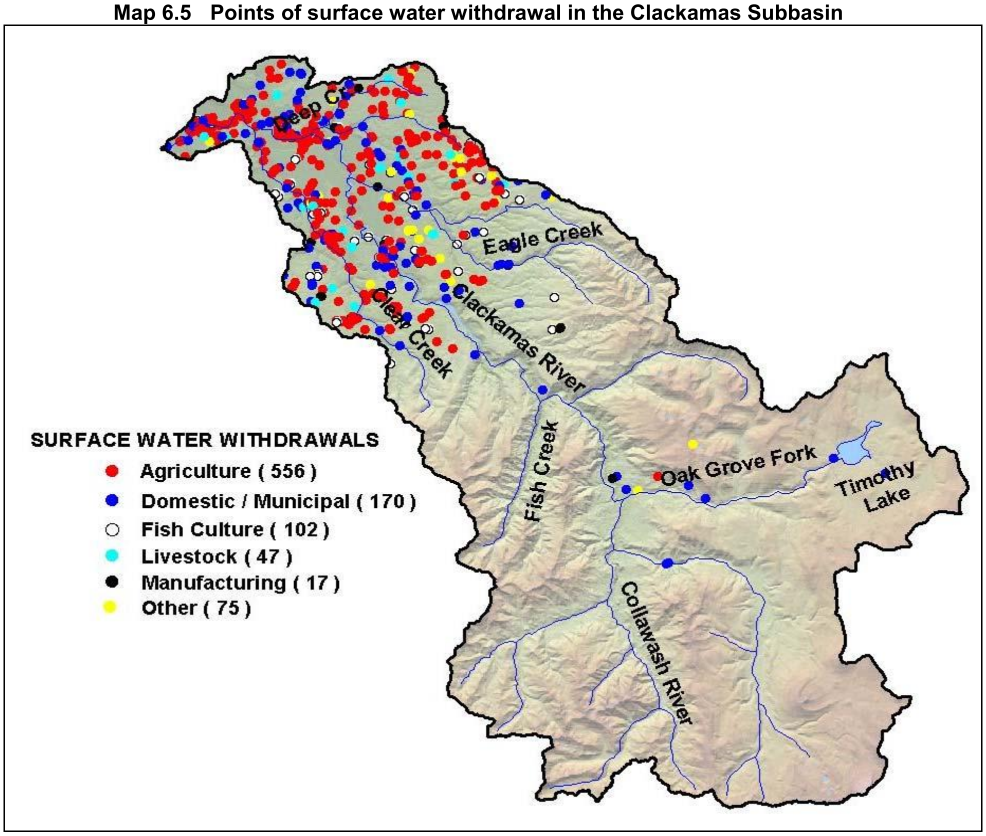
The Eagle Creek drainage is almost entirely within the Western Cascades Lowlands and Valleys ecoregion. Dominant tree species include Douglas fir, Western hemlock, Western red cedar, Pacific silver fir, noble fir, red alder, and big leaf maple. Understory contains vine maple, rhododendron, salal, Alaska huckleberry, and bear grass. Only 10% of the drainage is in late seral stage, 64% in mid seral, and 25% in early seral stage (USFS, 1995). Timber harvest in upper and middle Eagle Creek has reduced less than 7% of the riparian reserves to early seral stage deciduous vegetation; logging in the lower drainage has reduced 22% of riparian reserves to early seral stage.

A U.S. Fish and Wildlife hatchery is located at approximately RM 13, just upstream of the uppermost falls on Eagle Creek. The hatchery currently produces Coho and winter steelhead, although in the past produced spring and fall Chinook. Two falls downstream are equipped with fish passage ladders and once likely limited further upstream fish migration. Resident cutthroat trout inhabit Eagle Creek upstream of the uppermost falls. ODFW also stocked rainbow trout in North Fork Eagle Creek (RM 1.8) from 1966 to 1994.

Water Use

More than 950 points of diversion draw water from the Clackamas River and its tributaries (Map 6.5). Figure 6.2 illustrates the relative proportions of flow that each of the uses consume. Domestic use, fish culture, and agriculture consume the largest percentages of surface water.

Map 6.5 Points of surface water withdrawal in the Clackamas Subbasin



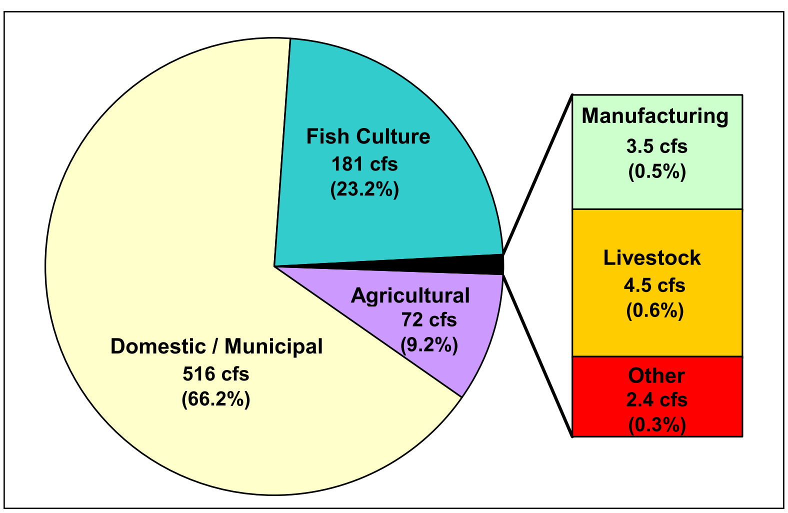
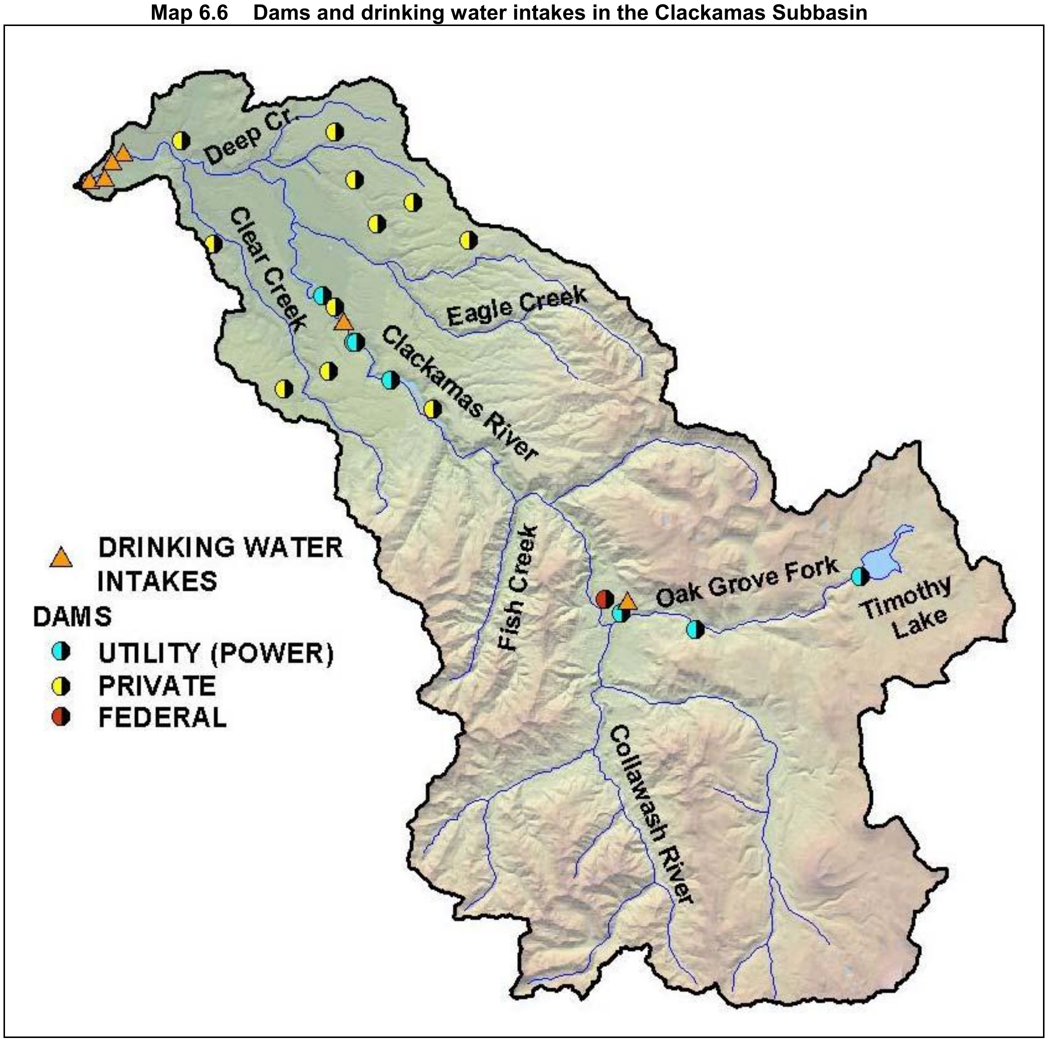


Figure 6.2: Relative consumption of water uses in the Clackamas Subbasin.

Portland General Electric (PGE) operates the Clackamas River Hydroelectric Project in the Clackamas Subbasin. The Oak Grove Fork development is the highest, located between approximately 1,500 feet of elevation at the confluence with the Clackamas and approximately 4,000 feet of elevation at Timothy Lake. The Stone Creek Project (operated by PGE for Eugene Water and Electric Board) diverts and returns flow to the Oak Grove Fork. Approximately 20 miles downstream from the Oak Grove Fork, PGE operates three more dams and associated facilities: North Fork, Faraday, and River Mill. Fish passage facilities bypass the three lower projects. Map 6.6 illustrates dams and drinking water intakes throughout the subbasin.

Map 6.6 Dams and drinking water intakes in the Clackamas Subbasin



The Oregon Water Resources Department grants instream flow requirements for fish and wildlife protection. Several tributaries as well as the mainstem Clackamas must maintain certain flows throughout the year. Table 6.2 summarizes in-stream water rights in the Clackamas Subbasin, all holding 1967 priority dates. Some streams have flow requirements only in drier months, and for other streams, flow requirements change seasonally.

In-stream flow requirements in the Clackamas Subbasin.

Stream	Flow requirement (cfs)	Dry season flow requirements (cfs)				
		June	July	August	September	October
Clackamas River u/s Three Lynx			400	400		
Clackamas River Three Lynx to mouth	640		400	400	400 until Sept. 15 640 after Sept. 15	
Clackamas River u/s UGSS gauge 14-2080	240		150	150	150 until Sept. 15 240 after Sept. 15	
Tickle Creek	30	6	4	4	4	4
Lowe Creek (Clackamas)	8		2	2	2	2
Clear Creek at mouth		40	40	20	20	
Clear Creek u/s Viola		25	25 until July 15 15 after July 15	15	15	
Deep Creek	35	20	20 until July 15 10 after July 15	10	10	10
North Fork Deep Creek	20	3	3	1	1	1
North Fork Eagle Creek	45	30	20	10	10	10
Eagle Creek	125	100	100 40	40	40	40
Roaring River	100	100	40	40	40	40[1]
Fish Creek u/s Wash Creek		10	3	3	3	3
Fish Creek	60		15	15	15	15
Wash Creek (Fish)	25	10[2]	3	3	3	3
Hot Springs Fork (Collawash)	75		15[3]	15	15[4]	
East Fork Collawash				10	10	
Elk Lake Creek (Collawash)				15	15	
Oak Grove				10	10	

1 = until October 15. 2 = after June 15. 3 = after July 15. 4 = until September 15.

Flow Gauges

Several groups operate flow gauges in the subbasin: U.S. Fish and Wildlife Service, Portland General Electric, Oregon Department of Water Resources, and the U.S. Geological Survey. Figures 6.3 and 6.4 illustrate two years of daily mean discharge on the Clackamas River at two locations.

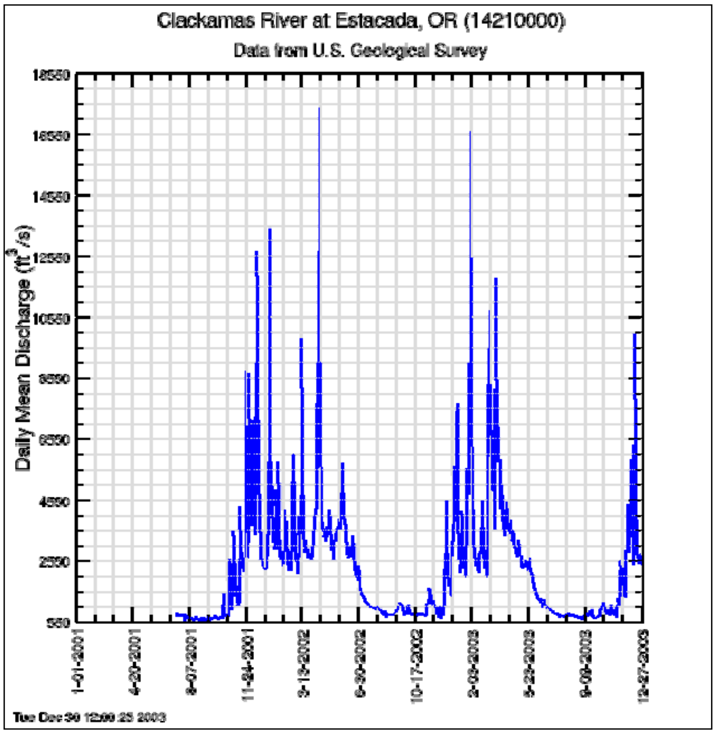


Figure 6.3: Discharge data collected by the U.S. Geological Survey on the Clackamas River at Estacada.

The Clackamas Subbasin is one of three basins addressed by Oregon Administrative Rule 340-041-0350, that prohibits new or increased waste discharges in order to preserve high quality water for municipal water supplies, recreation, and aquatic life. Waste discharges include any that require an NPDES permit, WPCF permit, or 401 Certification. Exemptions apply to individual on-site sewage disposal systems subject to issuance of a construction-installation permit, domestic sewage facilities that discharge less than 5,000 gallons per day under a WPCF permit, and biosolids or reclaimed domestic waste water applied within agronomic loading rates pursuant to OAR Chapter 340, Divisions 50 and 55, respectively.

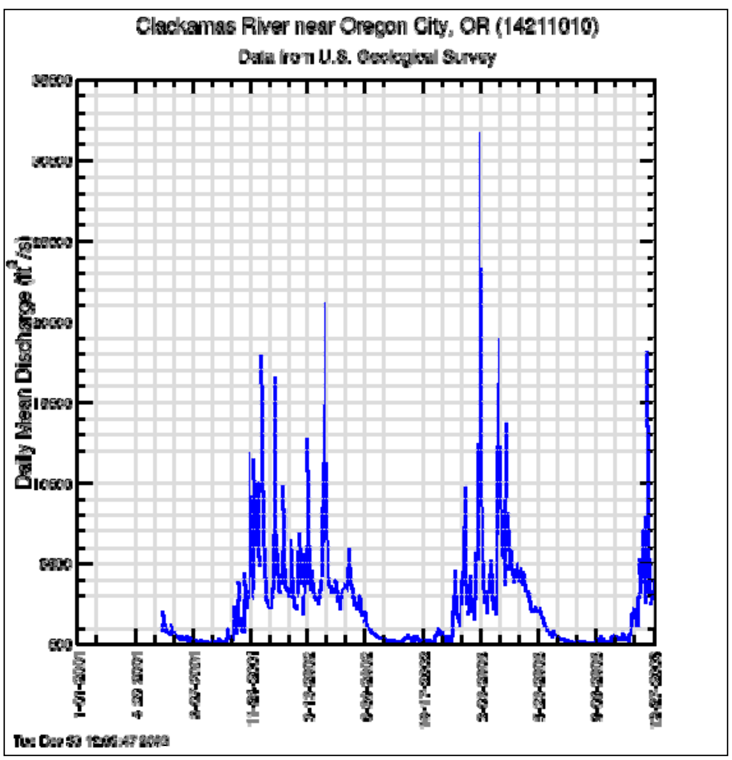


Figure 6.4: Discharge data collected by the U.S. Geological Survey on the Clackamas River at Oregon City.

CLACKAMAS SUBBASIN TEMPERATURE TMDL

Temperature Pollutant Identification

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

The temperature TMDL for the Clackamas Subbasin includes tributaries to the Clackamas River within HUC 17090011. As per Oregon Administrative Rule (OAR) 340-042-0040 required components of a TMDL are listed in Table 6.3.

Clackamas 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 Clackamas Subbasin, HUC 17090011
Pollutant Identification **OAR 340-042-0040(4)(b)**	<u>*Pollutants*</u>*:* 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 Clackamas Subbasin.
Target Criteria Identification **OAR 340-042-0040(4)(c)** ***CWA §303(d)(1)*** **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. 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 ºC (0.5ºF) 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)***	<u>Nonpoint source</u> solar loading due to a lack of riparian vegetation from forestry, agriculture, rural residential, and urban activities. Reservoir and dam operations are considered nonpoint sources that increase the quantity and timing of heat delivery to down stream river reaches. <u>Point source</u> 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 early-August. Rearing and Migration temperature criteria are exceeded from approximately mid-July to mid-August. 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)*** ***OAR* 340-041-0028(12b)**	<u>*Loading Capacity*</u>*:* 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 °C (0.5 °F) 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. <u>*Excess Load*</u>: 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. <u>*Wasteload Allocations (NPDES Point Sources)*</u>: Allowable heat load based on achieving no greater than a 0.3°C temperature increase from all sources 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. <u>*Load Allocations (Nonpoint Sources)*</u>: 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)***	<u>*Translates Nonpoint Source Load Allocations*</u> 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. DEQ allocates 0.05ºC for reserve capacity in this TMDL.
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 Clackamas Subbasin has four stream segments on the 2002 303(d) list for water temperature violations, based on the former 17.8 °C (64°F) criteria: Eagle Creek, Fish Creek, Cow Creek and the Clackamas River from river mile 0 to 22.9 (see Table 6.1). In December 2003, the Environmental Quality Commission adopted the new temperature criteria, and USEPA approved the criteria in March 2004. The new temperature criterion for salmon and trout rearing and migration is 18.0°C (64.4°F) and the criterion for Core Cold Water habitat is 16.0°C (60.8°F). A review of the temperature data for the listed reaches in the Clackamas Subbasin indicates that these streams exceed the recently adopted numeric criteria in the summer. The Clackamas River from river mile 0 to 22.9 will be addressed in Chapter 4 of this document.

For specific information regarding Oregon's 303(d) listing procedures, and to obtain more information regarding the Clackamas Subbasin 303(d) listed streams, visit the ODEQ's web page at http://www.deq.state.or.us/.

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:

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

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 Clackamas 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 Clackamas 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. 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 6.4 summarizes the modes of cold water fish mortality.

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 6.5 lists the temperature criteria that are applicable to the Clackamas Subbasin. Maps 6.7 and 6.8 illustrate designated subbasin fish use and salmonid spawning use. The maps indicate where the salmonid spawning through fry emergence criterion, core cold water habitat criterion, 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 ODEQ's 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

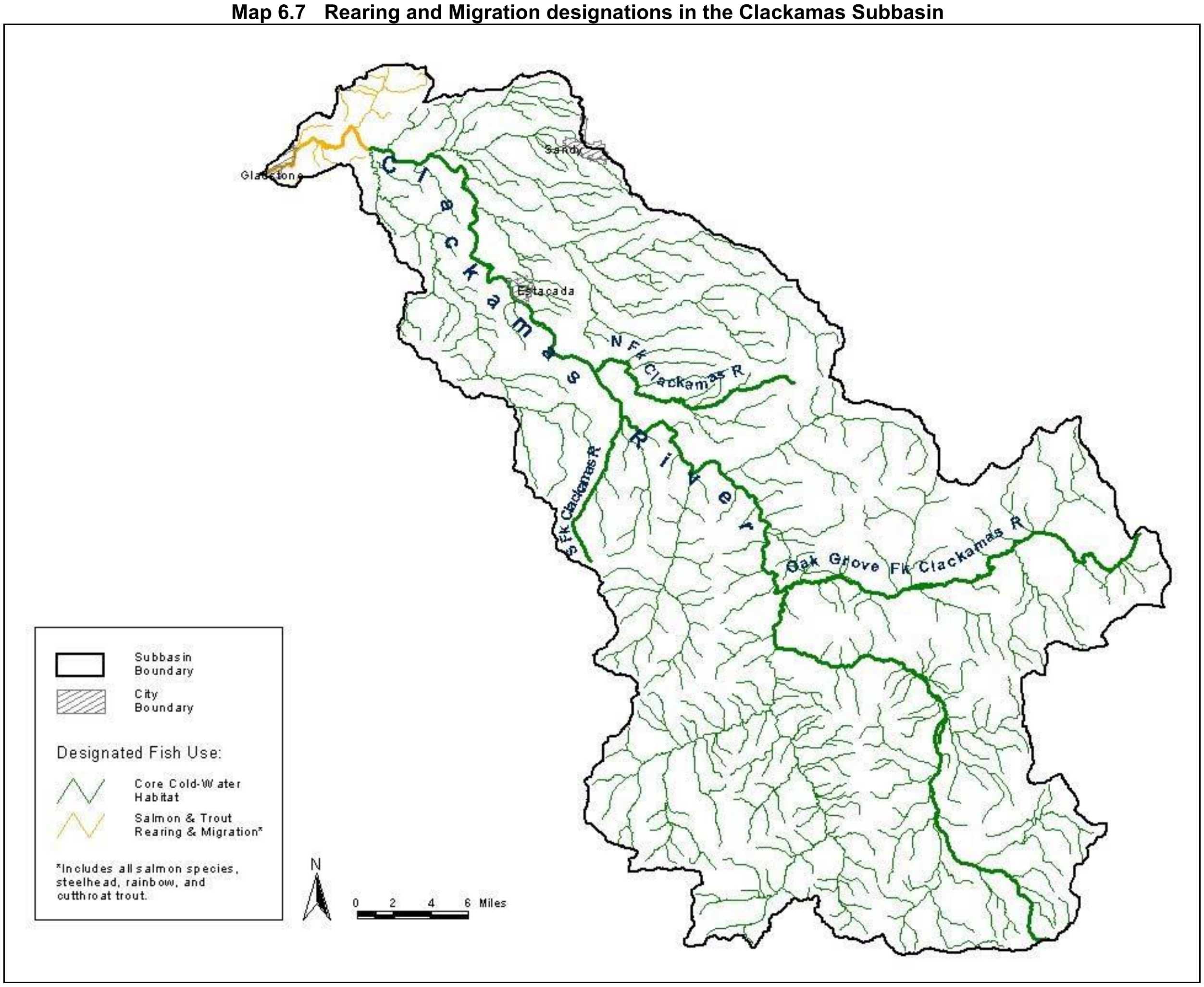
Oregon's Biologically Based Temperature Criteria.

Beneficial Use	Temperature Criteria
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)

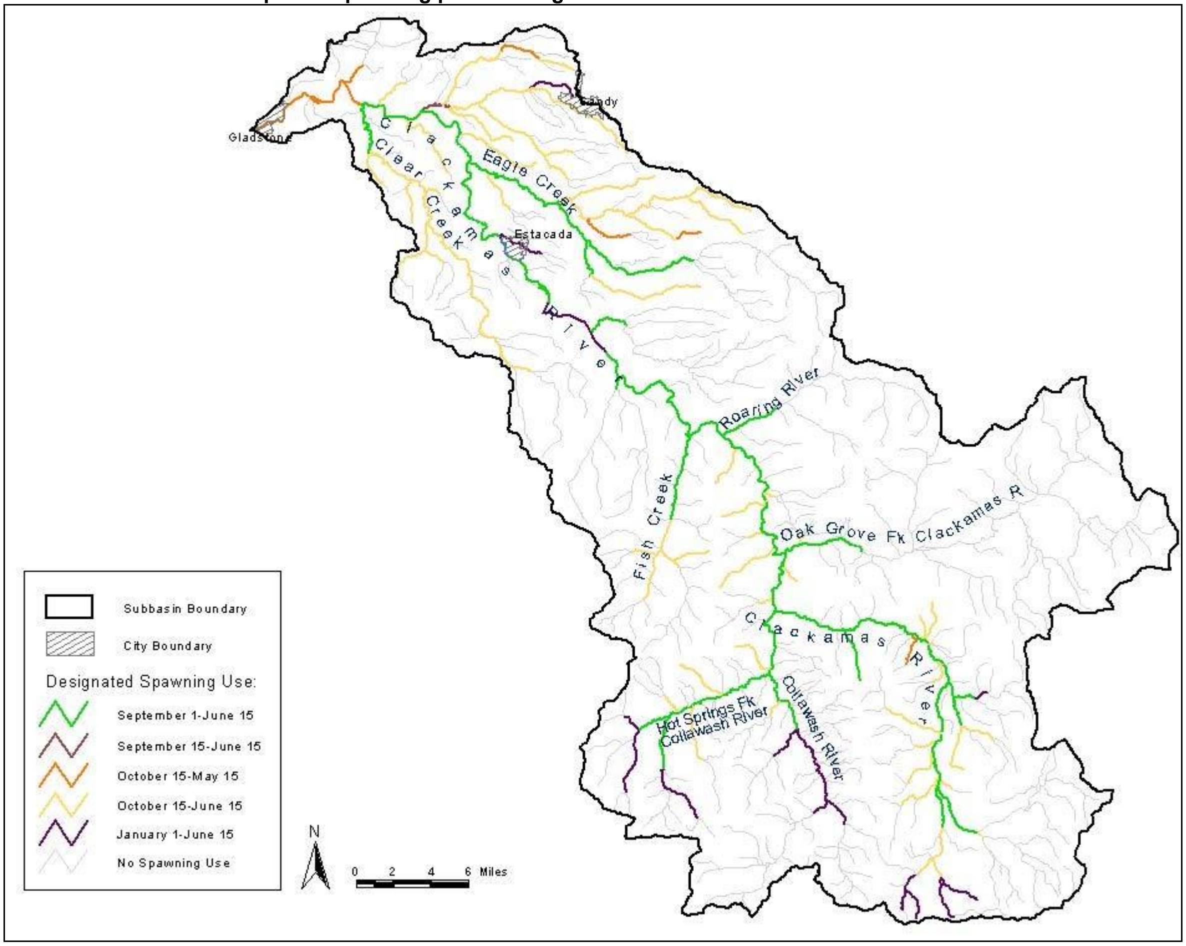
∗ Stream temperature is calculated using the average of seven consecutive daily maximum temperatures on a rolling basis (7-day calculation).

From the mouth to RM 8.15, the confluence with Clear Creek, the Clackamas River is designated for Salmon and Trout Rearing and Migration (18°C). Spawning season requirements in this reach (13°C) extend from October 15 – May 15. The rest of the Clackamas Subbasin is designated Core Cold-Water Habitat (16°C), except during spawning season which begins as early as September 1 and extends as late as June 15.

Map 6.7 Rearing and Migration designations in the Clackamas Subbasin



Map 6.8 Spawning period designations in the Clackamas Subbasin



The narrative criteria that apply to the Clackamas 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.

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)

Nonpoint Sources of Heat

Riparian vegetation, stream morphology, hydrology, climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, riparian condition, channel morphology and hydrology are affected by human activities.

Specifically, the elevated summertime stream temperatures in the listed tributaries attributed to anthropogenic nonpoint sources result from:

1. *Near stream vegetation disturbance or removal reduces stream surface shading via decreased riparian vegetation height, width and/or density, thus increasing the amount of solar radiation reaching the stream surface (shade is commonly measured as percent effective shade or open sky percentage). Riparian vegetation also plays an important role in shaping the channel morphology, resisting erosive high flows and maintaining floodplain roughness.*
2. *Channel modifications and widening (increased width to depth ratios) increases the stream surface area exposed to solar radiation. Near-stream disturbance zone (NSDZ) widening decreases potential shading effectiveness of shade-producing near-stream vegetation. Instream ponds in the watershed may prevent the timely movement of water through the system, increasing exposure to solar radiation.*
3. *Impoundment of water behind dams alters the natural thermal profile of the water downstream of the dam depending on how and when water is released from the dam.*
4. *Reduction of summertime flows decrease the thermal assimilative capacity of streams, causing larger temperature increases in stream segments where flows are reduced.*

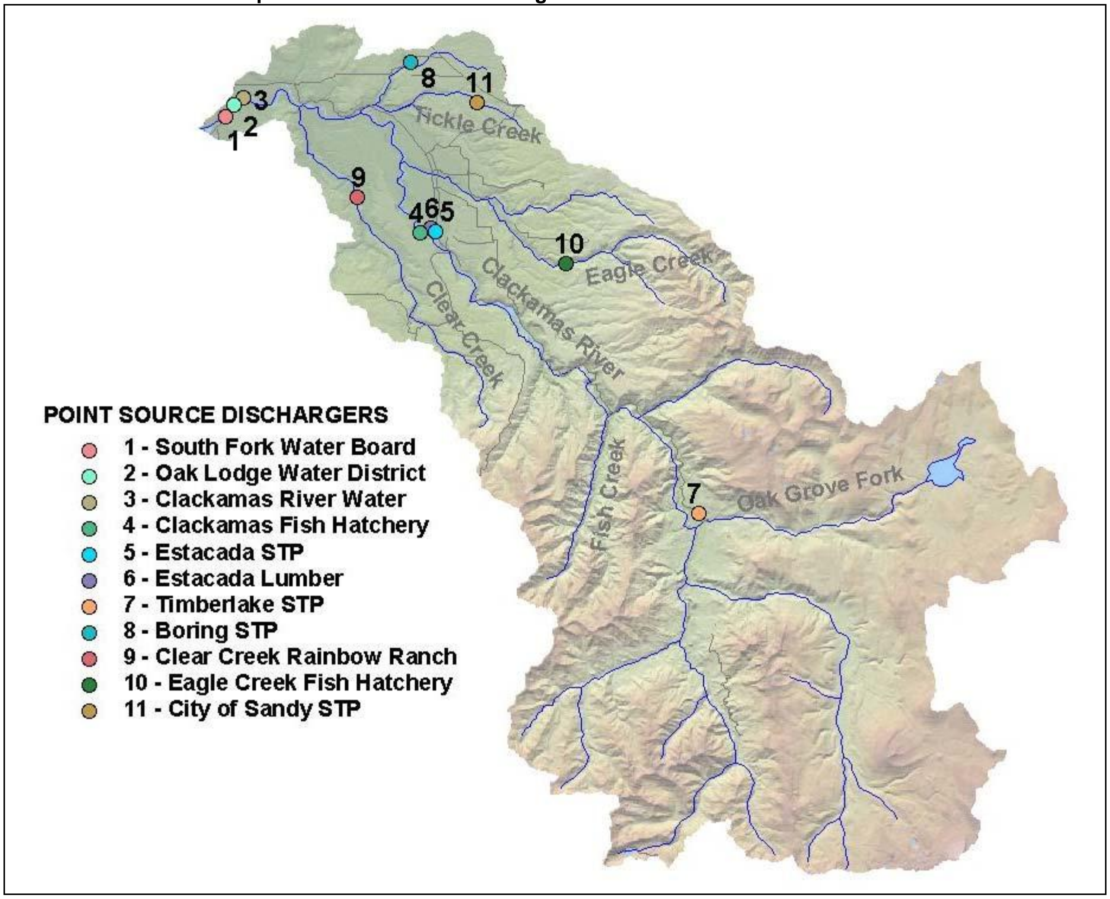
ODEQ does not directly address channel morphology or flow reduction in this TMDL. While channel morphology is an important factor regulating stream temperatures, particularly in smaller tributaries, ODEQ did not collect data or perform modeling to investigate the potential effects of channel morphology on temperature. Stream flow and effects from dams are covered by the mainstem Willamette River analysis (see Chapter 4). However, improvements in riparian vegetation are expected to stabilize and restore overly wide channels.

Heat loading of the mainstem Clackamas River related to dams can occur by two primary mechanisms. Water diverted at a dam can result in a lower flow volume in the stream, which tends to increase stream temperature. Water impounded behind a dam can also impact downstream temperatures depending on the water release during operation of the dam. The mainstem Willamette analysis (Chapter 4) includes effects the River Mill dam on temperature in the Lower Clackamas and Willamette River

Point Sources of Heat

Point source discharges are potential sources of stream heating in the Clackamas Subbasin (Map 6.9 and Table 6.6). Seven NPDES permitted sources and four general permitees discharge in the Clackamas Subbasin. Seven of the sources are on the mainstem of the Clackamas, and four on tributaries. Those sources that discharge to the mainstem Clackamas River downstream of RM 23 (River Mill Dam) are addressed in Chapter 4.

Map 6.9 Point source discharges in the Clackamas Subbasin



NPDES facilities in the Clackamas Subbasin

Facility Name	Permit Type	Receiving Stream	River Mile	Map Number	Analyzed in Chapter
South Fork Water Board	GEN02	Clackamas River	2	1	4
North Clackamas Water Commission (previously called Oak Lodge Water District)	GEN02	Clackamas River	2	2	4
Clackamas River Water	GEN02	Clackamas River	3.5	3	4
ODFW Clackamas Fish Hatchery	NPDES-IW-O	Clackamas River	22.6	4	4
Estacada Sewage Treatment Plant	NPDES-DOM-Da	Clackamas River	23.3	5	6
RSG Forest Products (Estacada Lumber)	GEN01	Clackamas River	24	6	6
Mt. Hood Nat'l Forest, Timberlake WWTP	NPDES-DOM-Da	Clackamas River	51.1	7	6
Boring WWTP (Clackamas County Service District #1)	NPDES-DOM-Db	North Fork Deep Creek	3	8	6
Clear Creek Rainbow Ranch, Inc.	NPDES-IW-O	Clear Creek	8.0	9	6
US Fish and Wildlife Service, Eagle Creek Hatchery	NPDES-IW-O	Eagle Creek	12.3	10	6
City of Sandy WWTP	NPDES-DOM-Da	Tickle Creek	3.1	11	6

In addition to the point sources identified above, there are several stormwater NPDES permits for facilities in the Clackamas Subbasin. ODEQ did not develop waste load allocations for stormwater permitted facilities because stormwater is rarely discharged during critical period for temperature and ODEQ has no data that indicate stormwater discharges significantly contribute to stream temperature standards violations.

City of Sandy WWTP

The City of Sandy wastewater treatment plant serves about 7,500 people and discharges treated wastewater only between November 1 and April 30. Between May 1 and October 31, treated effluent is reclaimed for use at a nearby nursery. Because the facility does not discharge in the summer months, ODEQ assumed the facility will not have a significant effect on stream temperature and did not calculate a waste load allocation.

Mt. Hood Nat'l Forest, Timberlake WWTP

This treatment plant serves about 450 people at a Civilian Conservation Corps camp. The facility discharges treated wastewater through an outfall to a polishing pond, and then from the polishing pond to the Clackamas River at RM 51.1. The permit does not allow discharge from the polishing pond between May 1 and October 31. Typically, the facility discharges two times during the winter months for a few days. Each discharge totals about 80,000 gallons. Because the facility does not discharge in the summer months, ODEQ assumed the facility will not have a significant effect on stream temperature and did not calculate a waste load allocation.

RSG Forest Products (Estacada Lumber)

This facility holds a general permit that allows discharge of non-contact cooling water. The facility produces two-by-four lumber. City water cools the blade of a lumber edger, runs across the floor, and then enters the storm sewer system. This facility's general permit (100J) requires that the flow cannot exceed 0.5 MGD, flow in MGD times the temperature °F cannot exceed 25, and the maximum temperature cannot exceed 100°F. Analysis of the temperature effect from this facility is included in the Waste Load Allocation section of this chapter.

Estacada Sewage Treatment Plant
The Estacada wastewater treatment plant serves approximately 2,500 people and discharges treated wastewater year-round into an impoundment on the Clackamas River upstream of River Mill dam (RM 23.6). The permit sets an average weekly thermal load limit of 12,937,942 kcal/day (51,341,040 BTU/day) between May 1 and October 31 and dry weather design flow of 0.54 MGD (0.84 cubic feet per second). The permit states that upon approval of the TMDL for the subbasin, the permit will be reopened and new temperature or thermal load limits assigned if necessary. The City of Estacada and ODEQ signed a mutual agreement and order in October 2003 that states the City of Estacada must upgrade or expand its facilities to meet the permit requirements within 3.5 years from permit issuance. Analysis of the temperature effect from this facility is included in the Waste Load Allocation section of this chapter.

Boring WWTP (Clackamas County)
The Boring wastewater treatment plant serves approximately 50 homes and discharges treated wastewater all year into North Fork Deep Creek. ODEQ required that Clackamas County Water Environment Services submit a temperature management plan including continuous temperature data with their application for permit renewal in 2002. ODEQ's analysis of the 2002 temperature data (April through November) indicated that the Boring wastewater treatment plant cannot meet the seasonally appropriate temperature standards applicable in North Fork Deep Creek at the permitted design flow of 0.02 MGD. Current plant dry weather flow is approximately 0.012 MGD. Analysis of the temperature effect from this facility is included in the Waste Load Allocation section of this chapter.

Although the facility currently causes an increase in temperature in North Fork Deep Creek, the maximum temperature of the plant effluent measured in 2002 does not exceed the incipient lethal temperature (25°C) that would cause acute thermal shock to aquatic life. The temperature management plan that Clackamas County submitted to ODEQ in October 2002 evaluated alternatives that could bring the facility into compliance with the temperature standard. Two options Clackamas County identified as feasible in the temperature management plan were installing cooling ponds or pumping sewage to an interceptor to the Kellogg Creek WWTP. Clackamas County would have to purchase land to install cooling ponds, which makes this option less attractive. While pumping sewage to the Kellogg Creek facility is cost prohibitive at this time, the option becomes feasible if the urban growth boundary and Clackamas County Water Environment Service (WES) sanitary service were expanded to the Boring WWTP service area. WES is also considering two additional potential solutions: 1.) On-site disposal of some treated effluent with a WPCF-permitted system, and 2.) Transferring some wastewater in truck tankers to another WES-operated WWTP.

Clear Creek Rainbow Ranch, Inc.
Clear Creek Rainbow Ranch, Inc. is a private aquatic animal production facility that discharges wastewater containing fish waste. The operations at the site have been suspended since February 28, 2003, although ODEQ recently renewed the wastewater permit for this facility. The permit requires a Pollution Prevention plan be written and implemented to reduce temperature and heat loading to Clear Creek. The site consists of five inline bare earth raceways 100 feet long and approximately 3.5 feet deep which discharge to a settling pond 350 feet long and approximately 7 feet deep. The fish waste is treated in a settling pond prior to discharge. Temperature data collected in June 2002 by the site operator indicate that site operations increase temperature by approximately 0.5°F (0.3°C), probably because of lack of shading of the raceways and ponds. The facility also uses all the flow in Clear Creek in the summer months. The renewed permit requires late afternoon temperature monitoring five days per week between July 1 and Sept. 30, for one season, to evaluate the effects of shade netting placed over raceways. Analysis of the temperature effect from this facility is included in the Waste Load Allocation section of this chapter.

US Fish and Wildlife Service, Eagle Creek Hatchery
The US Fish and Wildlife Service operate the Eagle Creek Hatchery at RM 12.3 on Eagle Creek. The permit allows discharge of treated water containing waste from fish rearing. The hatchery intake is located approximately 0.1 mile upstream of the hatchery, and water flows through 75 raceways. Water from the operations, including raceway cleaning and sand filter backwash, settles in a pollution lagoon before being discharged to Eagle Creek. Temperature data collected in August and September of 2003, indicate that effluent water is cooler than intake water probably because intake water travels through 530 feet of underground pipe. Effluent limits (77°F, 25°C) and other conditions of the permit related to temperature constitute a temperature management plan. The permit also specifies that shaded fabric will be the temperature control strategy over ponds that don't otherwise have vegetation around them. The permit

requires temperature monitoring at two outfalls and the inlet between June 1 and Sept. 30. Because the hatchery dewaters the stream in the summer months, ODEQ assumed the annual 7Q10 flow as maximum effluent flow and did not allow for any dilution with stream water. Analysis of the temperature effect from this facility is included in the Waste Load Allocation section of this chapter.

Temperature TMDL Approach Summary

The Clackamas River Subbasin stream temperature TMDL was developed at the watershed scale. The TMDL includes 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 six geomorphic units in the Clackamas Subbasin.

Temperature TMDL Analytical Methods Overview

All stream temperature TMDLs allocate heat loading as heat per unit time (kcal per day). Nonpoint sources are expected to eliminate the anthropogenic portion of solar radiation heat loading. USEPA regulations (40 CFR 130.2(i)) allow a TMDL to allocate "other appropriate measures" (or surrogates measures). Effective shade can translate solar radiation loading into a measurable surrogate. ODEQ developed load allocations for the Clackamas Subbasin tributaries by applying shade curves. Shade curves illustrate the relationship between each potential vegetation cover type, channel width and the resulting effective shade level. Effective shade surrogate measures provide site-specific targets for land managers and attainment of the surrogate measures ensures compliance with the nonpoint source allocations.

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 (see Appendix C; "Near-Stream Land Cover" for detailed information). 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(34) 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(35) 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.*

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.

Stream temperature analysis and water quality restoration strategies discussed in this chapter 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)

The approximate dates of standard violations define the critical period which tends to coincide with the highest water temperatures and lowest flows. The generalized critical period for Migration and Rearing is during the summer months. The 1995 data pictured in Figure 6.5 indicate that the lower mainstem Clackamas River exceeds the Migration and Rearing temperature criteria from at least mid July to early September. The 1995 data set is insufficient to indicate whether or not the lower Clackamas River violates the spawning criteria (13°C) between October 15 and May 15. The maximum daily temperature change recorded in the 1995 High Rocks data set is 4.1ºC in late July (Figure 6.6).

The 1999 data collected from Fish Creek (Figure 6.7) indicate that the creek violates the spawning criterion from at least early June to mid June. No temperature data are available after September 1, so violation of the spawning temperature criterion is uncertain but likely based on the last recorded data point on September 1. Fish Creek violates the Core Cold Water Habitat criterion from early July until at least early September. Figure 6.8 indicates daily temperature variation can exceed 16°C in late July in Fish Creek.

Temperatures in Eagle Creek exceed the spawning criterion from approximately early May to mid June, and again from early September until early October (Figure 6.9). The Creek violates the Core Cold Water Habitat criterion from early June until September 1 when the spawning criterion begins to apply. In 2001, the maximum daily temperature change in Eagle Creek (6.9°C) occurred on May 31 (Figure 6.10). All tributaries to 303(d) temperature listed reaches will be considered in the temperature targets developed to achieve the temperature TMDL.

Figure 6.5: Continuous temperature seven-day moving averages from Clackamas River at High Rocks.

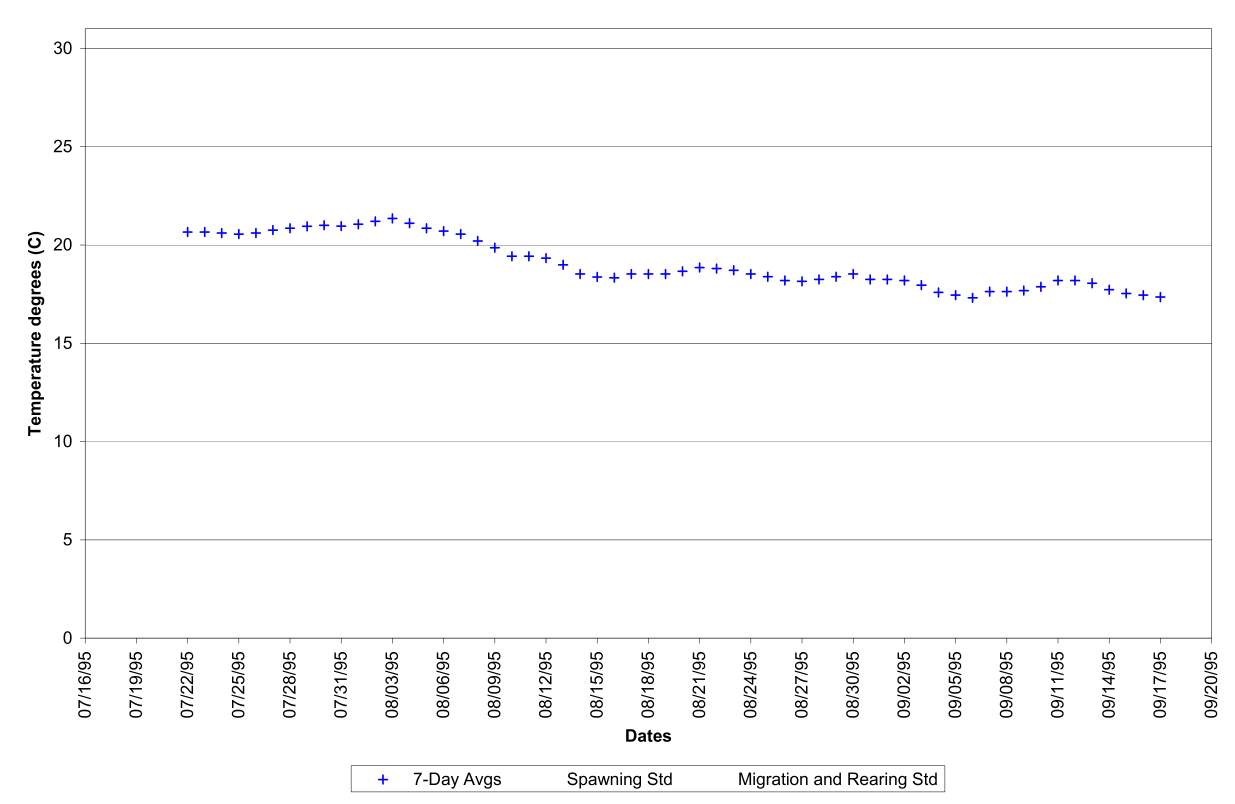


Figure 6.6: Daily maximum and minimum temperatures from Clackamas River at High Rocks.

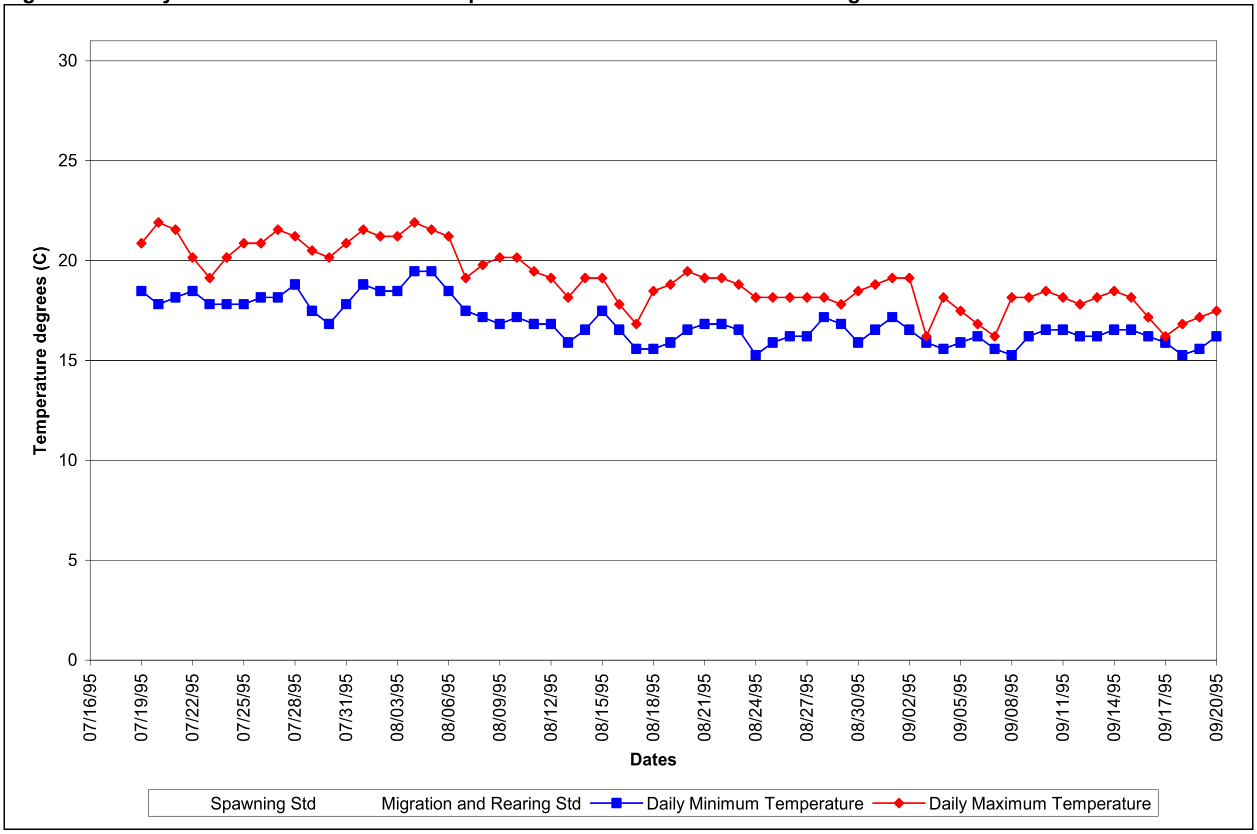


Figure 6.7: Continuous temperature seven-day moving averages from Fish Creek approximately 3 miles up Fish Creek Road (approximately RM 4).

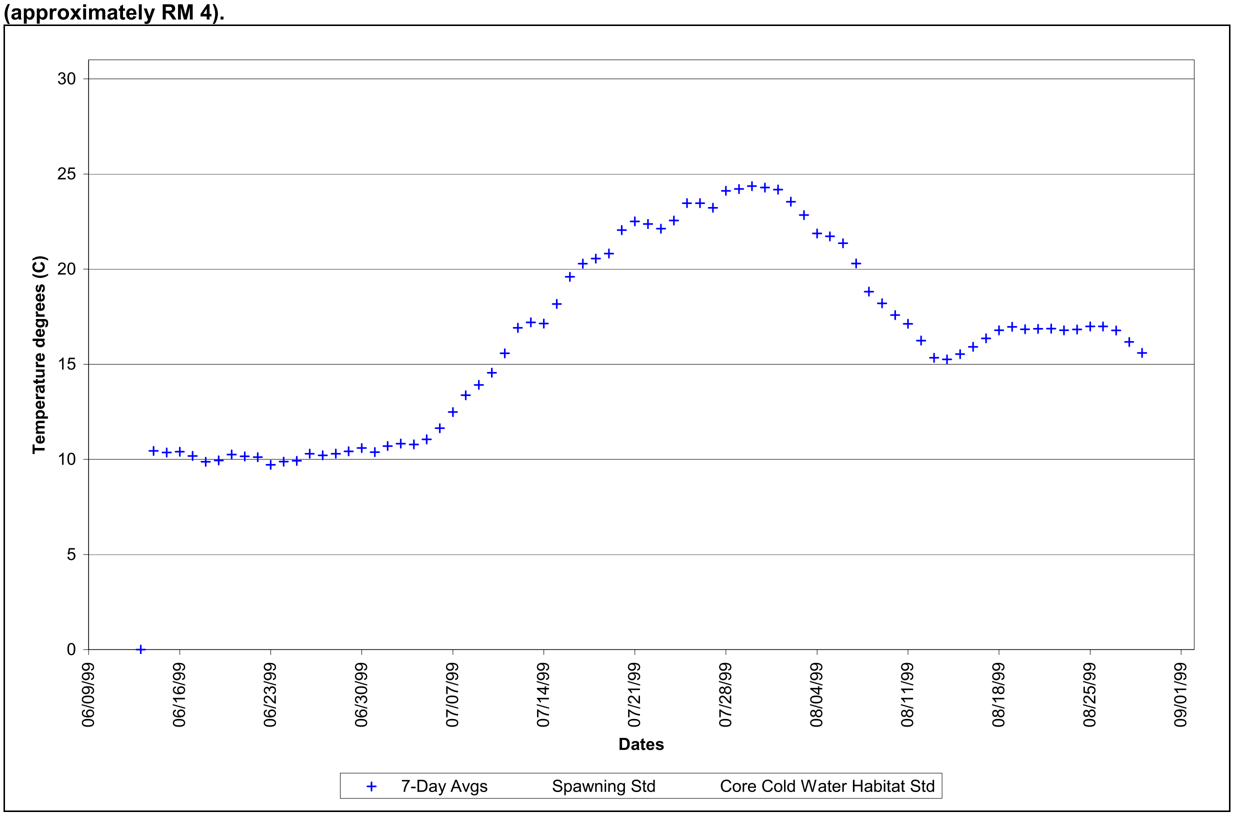


Figure 6.8: Daily maximum and minimum temperatures from Fish Creek approximately 3 miles up Fish Creek Road (approximately RM 4).

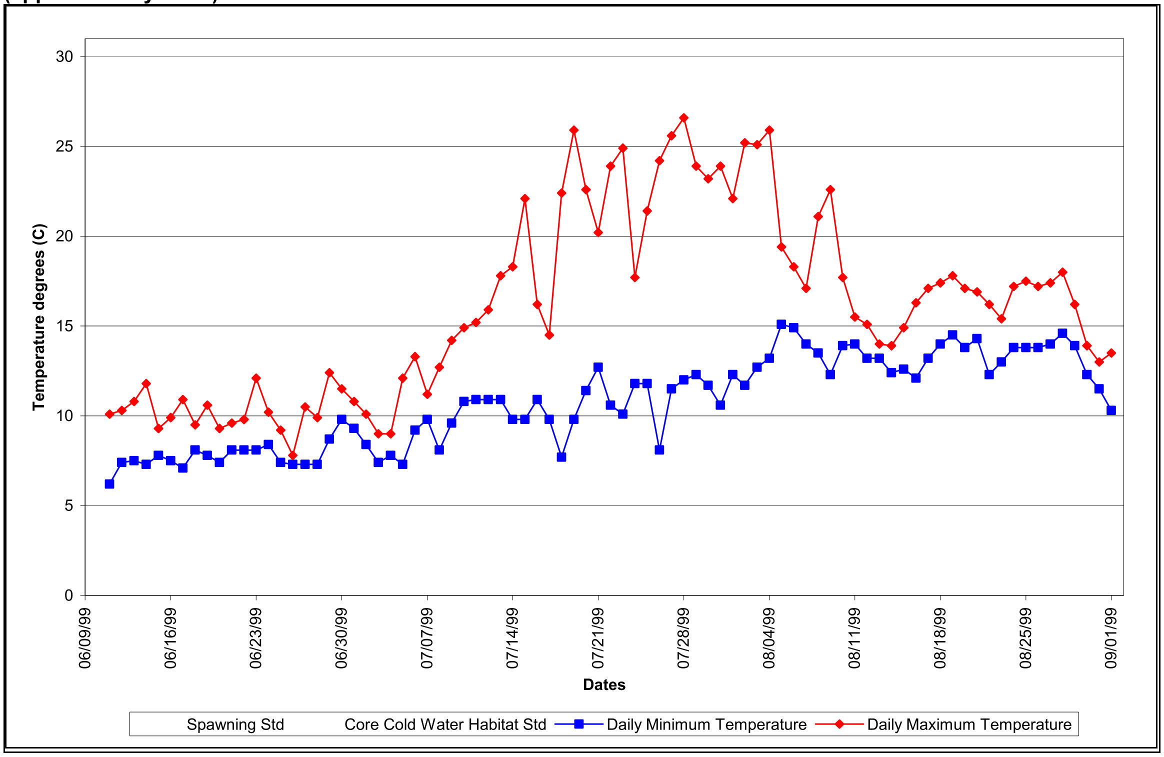


Figure 6.9: Continuous temperature seven-day moving averages from Eagle Creek at mouth, collected by Portland General Electric in 2001.

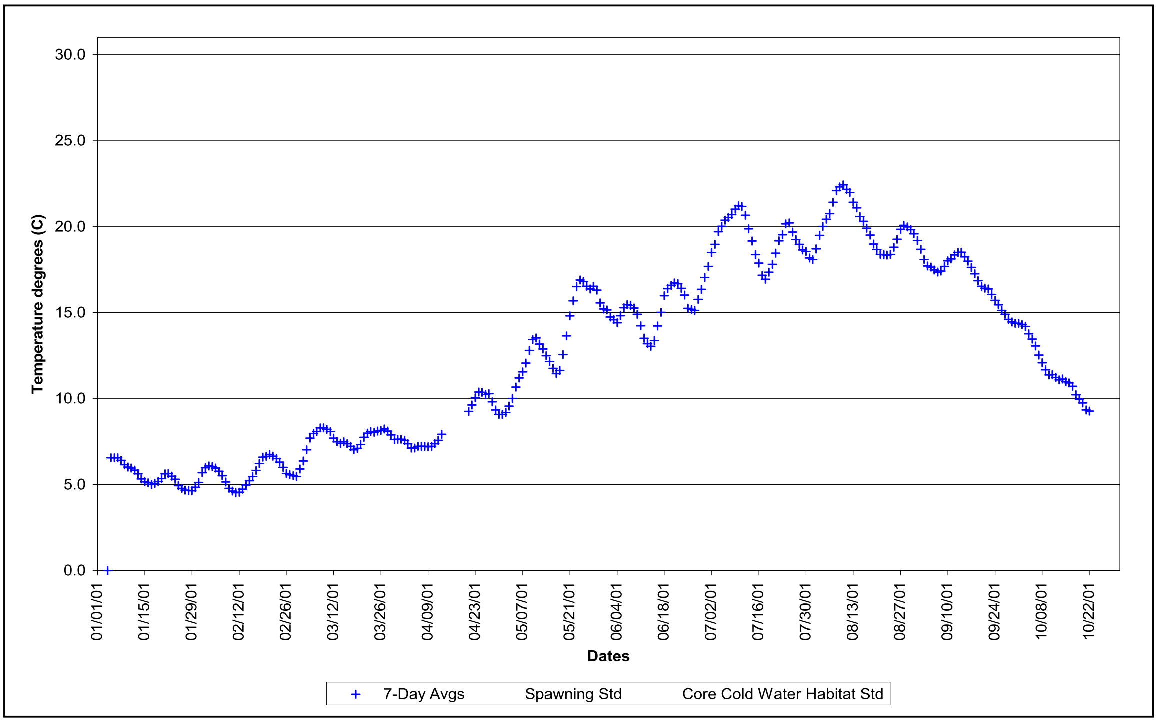
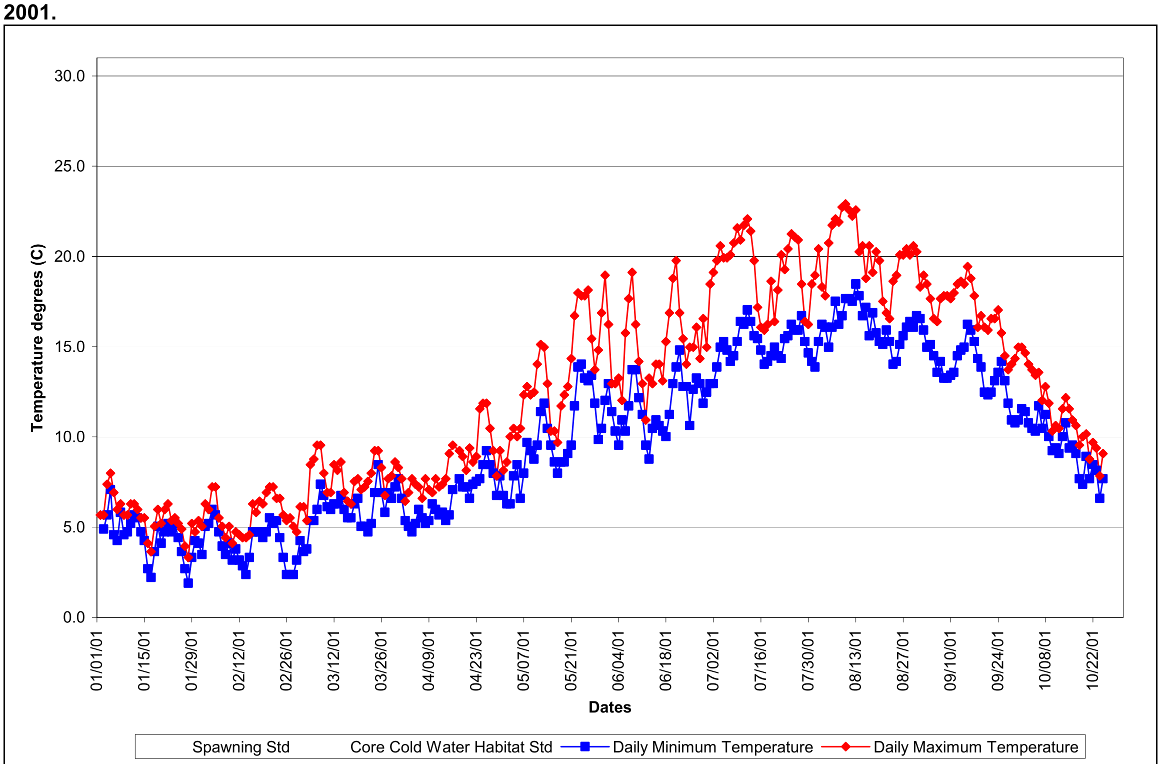


Figure 6.10: Daily maximum and minimum temperatures from Eagle Creek at mouth, collected by Portland General Electric in 2001.



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 (0.5°F) 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 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.

ODEQ considers background loading to be the solar radiation heat loading that would result with system potential near stream vegetation. This background condition reflects an estimate of nonpoint source heat load that would occur while meeting the temperature standard. In theory, once the system potential condition with respect to nonpoint source pollution is known, ODEQ could then calculate the amount of additional nonpoint source loading that a waterbody can assimilate without resulting in more than a 0.3°C increase in water temperature at the point of maximum impact. ODEQ did not attempt to calculate this additional allowable heat load or incorporate the information into nonpoint source load allocations. Rather, ODEQ considers the conservative methodology that bases nonpoint source load allocations on system potential conditions to be part of the explicit margin of safety. Any allocation to nonpoint sources would occur only after restoration efforts had reduced solar radiation to near system potential conditions: a matter of decades in most cases.

Existing and future thermal point sources in the subbasin may be permitted to discharge under the following conditions:

1) They do not cause more than a 0.3°C increase in stream temperature above the applicable criteria after mixing with 25 percent of the stream flow or at the edge of a defined mixing zone, whichever is more restrictive.

2) The sum of waste load and load allocations result in an increase in stream temperature of no greater than 0.3°C above the applicable criteria after complete mixing and at the point of maximum impact.

Pollutant trading opportunities may be available to new or existing point sources in order to offset temperature impacts.

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 combined effect of low stream flow and the greatest difference between effluent and river temperatures, usually in late summer to early fall. Waste load allocations will address all periods when ambient temperatures exceed biologically based numeric criteria.

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 Clackamas 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 in this chapter are for point sources other than those that discharge to the Clackamas River downstream of RM 23. ODEQ considers point sources that discharge directly to the Clackamas River downstream of RM 23 in Chapter 4.

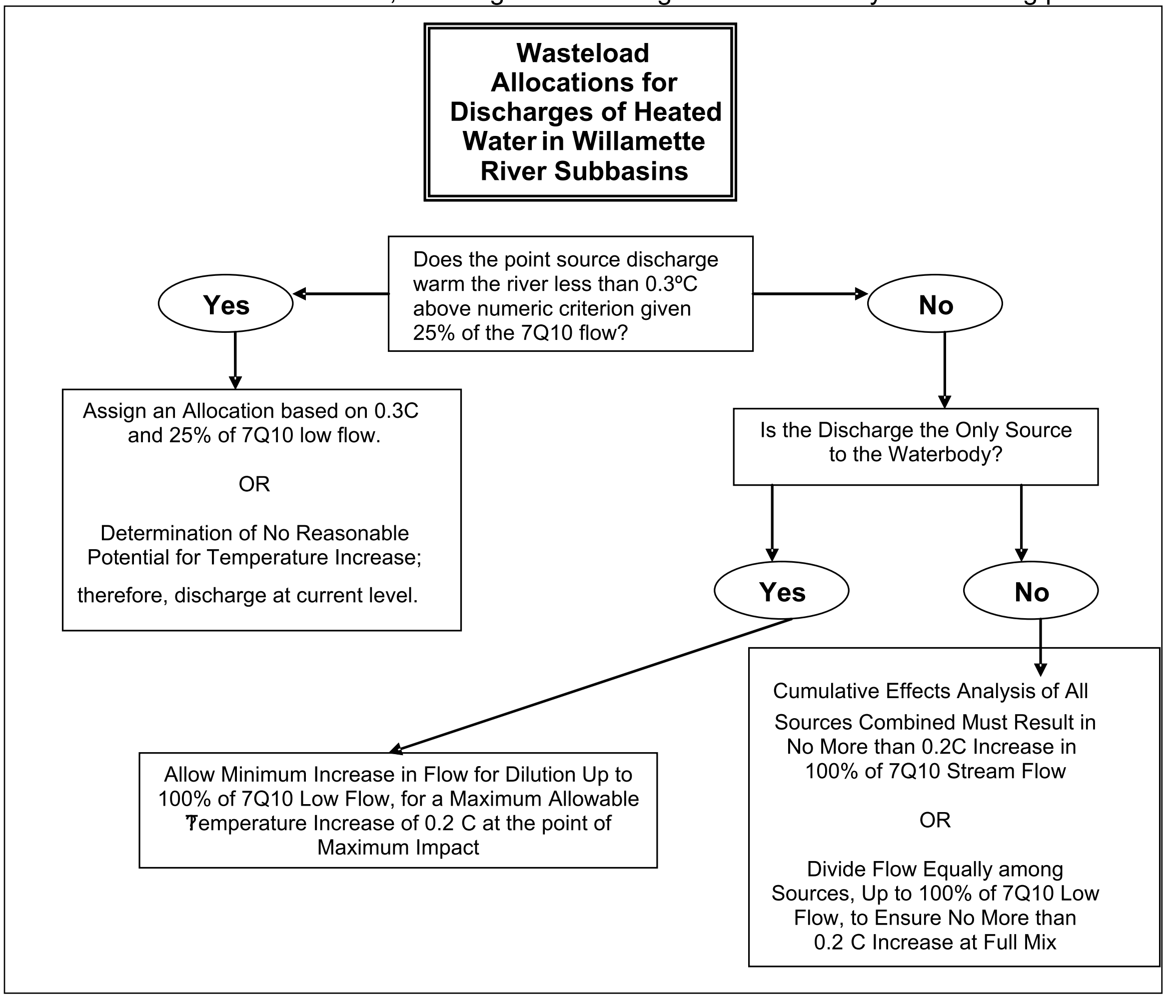
Waste Load Allocations in Small Streams

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, log ponds) 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 criteria [OAR 340-041-0028(12)] allow 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 criteria allow 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 6.1** (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 Q_{ZOD} 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 6.1:

$$H_{PS} = \left(Q_{ZOD} + Q_{PS}\right) \cdot \frac{1 ft^3}{\sec} \cdot \frac{1 m^3}{35.3 ft^3} \cdot \frac{1000 kg}{m^3} \cdot \frac{86400 \sec}{day} \cdot \Delta T_{ZOD} \cdot c = \frac{Kcal}{day}$$

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°C allowable (°C)
c: Specific heat of water (1 Kcal / 1kg 1ºC)

Estimates of effluent temperature were calculated using mass loading equations (**Equation 6.2**) 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 6.1** above and the best information available.

Equation 6.2:

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

where:

T_R: Temperature Criterion or Upstream potential river temperature (°C)
T_{WLA}: Maximum allowable point source effluent temperature (° C)
ΔT_{ZOD}: Change in river temperature at point of discharge - 0.3°C allowable (°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)

Point source discharges that did not increase river temperature more than 0.3ºC (the human use allowance) with 25% of instream flow allowed for mixing did not receive a waste load allocation. ODEQ calculated that the potential temperature increase from two discharges (Estacada WWTP and Estacada Lumber) would be an order of magnitude less than the human use allowance (Table 6.7). Sources that do not contribute to temperature impairment do not require numeric limits in their NPDES permits. These facilities may continue to discharge at their current heat load.

Screened point sources that did not receive waste load allocations.

Source	Temperature Increase ºC at ¼ 7Q10 flow	Temperature Increase ºC at 100% 7Q10 flow	Decision
Estacada Lumber	0.022	0.005	Allow discharge at current levels.
Estacada WWTP	0.044	0.011	

ODEQ calculated waste load allocations for the remaining three sources. During development of a TMDL, when more than the minimum flow allowance (25% of 7Q10 low flow) is considered, a portion of the HUA goes to nonpoint sources of heat (0.05˚C) and a portion goes to Reserve Capacity (0.05˚C) for future uses, leaving 0.2˚C for allocation to point sources. The resulting temperature increase in this scenario depends on the proportion of flow allocated, but will not exceed 0.2˚C in any case. ODEQ calculated the allowable heat load that each of the sources can contribute (their waste load allocation) with Equation 6.3, assuming 100% of the 7Q10 flow:

Equation 6.3

$$H_{ps} = (Q_R + Q_{ps}) \cdot \frac{1\,ft^3}{sec} \cdot \frac{1\,m^3}{35.3\,ft^3} \cdot \frac{1000\ kg}{m^3} \cdot \frac{86400\ \ sec}{day} \cdot c \cdot \Delta T = \frac{kcal}{day}$$

Max ΔT:	Maximum Allowable Change in river temperature at edge of zone of dilution (0.2^{o}C)
Q_R:	Upstream river flow - Calculated as 100% 7Q10 low flow statistic (cfs)
Q_{PS}:	Point source effluent discharge (cfs)
H_{PS}:	Heat from point source effluent received by river (kcal/day)
c:	Specific heat of water $\frac{1 \cdot Kcal}{1kg \cdot 1^oC}$

Discharge flows are those specified as flow limitations in the source's current discharge permit or the maximum reported flows based upon a review of Discharge Monitoring Reports submitted to ODEQ by the permitee.

ODEQ calculated the Clackamas 7Q10 low flow (595 cubic feet per second) by analysis of flow data collected at the USGS flow gauging station (#14210000) at Estacada. ODEQ used historical flow data (1933-1939) collected at UGSG gauging station #14210050 on Eagle Creek to calculate Eagle Creek's 7Q10 flow of 8 cubic feet per second. ODEQ performed a regression of historical Clear Creek 1936 and 1937 data (USGS #14210650) with Gales Creek data to estimate Clear Creek's 7Q10 flow of 8 cubic feet per second.

Because two fish hatcheries (Clear Creek Rainbow Ranch, Inc. and Eagle Creek) consume the entire stream flow during the summer, ODEQ did not allow any dilution when calculating their allocations. Rather, ODEQ used Equation 6.4 to calculate summer waste load allocations for these two hatcheries, simply calculating the heat load that results if the streams are allowed to increase in temperature 0.2ºC.

Equation 6.4

$$H_{wla} = M_R \cdot c \cdot \Delta T$$

where:

ΔT:	Maximum Allowable Change in river temperature at edge of zone of dilution (0.2^{o}C)
M_R:	Daily mass of river flow, all diverted to hatchery
H_{wla}:	Maximum allowable heat load from point source (kcal/day)
c:	Specific heat of water $\frac{1 \cdot Kcal}{1kg \cdot 1^oC}$

A waste load allocation is assigned to each point source for each distinct period of fish use (Table 6.8). The categories of fish use in the Clackamas Subbasin that affect allocated point sources are Core Cold Water Habitat (16°C) and Salmon and Steelhead Spawning Use (13°C).

Applicable Temperature Criteria for Clackamas Subbasin Point Sources

Point Source	Applicable Criteria °C	Time Criteria Applies
Eagle Creek Fish Hatchery	16 13	June 16 – August 31 Sept. 1 – June 15
Clear Creek Rainbow Ranch, Inc. Fish Hatchery	16 13	June 16 – October 14 October 15 – June 15
Boring WWTP	16 13	June 16 – October 14 October 15 – June 15

WLAs for the Core Cold Water (CCW) and Salmon and Trout Rearing and Migration periods were based on the annual 7Q10 flow (Table 6.9). WLAs for the Salmon and Steelhead Spawning periods (Table 6.9) were based on the October 7Q10 flow, if sufficient data were available (i.e. point sources located on the mainstem Clackamas). ODEQ estimated the lowest likely spawning period flow by calculating seven day averages of data collected daily in fall through spring months, and calculating the 10th percentile of those data. Clear Creek had only one year of data from 1936. Eagle Creek had limited October through December data collected in three years: 1933, 1936, and 1938. ODEQ used the same 7Q10 flow for all fish use periods in North Fork Deep Creek. Clackamas County reports the estimated North Fork Deep Creek 7Q10 flow (0.65 cfs) in the temperature management plan for the Boring WWTP. This flow is based on extrapolation of the only available flow data on Deep Creek from 1936.

Temperature waste load allocation summary for point sources to meet temperature criteria.

Facility Name	Receiving Water	Max. Critical Condition Effluent Temperature (C)	Permit Limit or Maximum Reported Flow (cfs)	Use Type	Stream Flow (7Q10) (cfs)	Waste Load Allocation (kcal/day)	Allowable Effluent Temperature (C)*
Boring WWTP[a]	North Fork Deep Creek	23.96	0.03	CCW Spawning	0.65	3.33×10^5 3.57×10^5	20.5 17.8
Eagle Creek Fish Hatchery[b]	Eagle Creek	17.2 reported	52.6	CCW Spawning	8 9	3.91×10^6 4.40×10^6	16.2 13.2
Clear Creek Rainbow Ranch, Inc. Fish Hatchery[c]	Clear Creek	17.8 reported	9.91	CCW Spawning	8 16	3.91×10^6 7.78×10^6	16.2 13.3

a = Based on 0.2°C increase and 100% of stream flow for mixing.
b = Based on 0.2°C increase with no dilution.
c = Based on 0.2°C increase with no dilution during CCW period; 0.2°C increase and 37.5% of stream flow for mixing during spawning period.
CCW = Core Cold Water during all times except spawning period.
Spawning; see map 6.7 and 6.8 for period of application for each discharge.

In the case of the hatcheries, the allowable allocation is lower than both the maximum reported temperature and the effluent permit limit of 25°C. The hatcheries that consume the entire creek flow in the summer (Clear Creek Rainbow Ranch, Inc. and Eagle Creek) should not increase stream temperature more than 0.2°C above the applicable criteria during critical periods.

There are not sufficient fall through spring temperature data to judge whether or not the hatcheries' effluent temperatures are likely to exceed the allowable spawning period criteria. Eagle Creek Hatchery's spawning criteria waste load allocation was calculated by the same method as its summer waste load allocation (Equation 6.4). The Clear Creek Rainbow Ranch, Inc. spawning criteria allocation was calculated with Equation 6.3 assuming that 9.9 cfs of the river's 16 cfs (62.5 %) is consumed by the hatchery.

Excess Load

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

ODEQ used shade curves to determine load capacity for listed reaches in the Clackamas Subbasin. The use of shade curves alone does not allow the direct calculation of heat loading under current or system potential conditions. Therefore, excess loading cannot be calculated directly. The difference between solar radiation from potential effective shade and the current effective shade levels is considered a pollutant load contributed by nonpoint sources. Point sources will not be allowed to increase stream temperature more than 0.2°C beyond the loading capacity of the waterbody.

Surrogate Measures

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

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 Clackamas 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. These shade curves apply to all tributaries in the Clackamas Subbasin.

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 is the distance from the edge of right bank vegetation to the edge of left bank vegetation. The particular curve that applies to a given reach depends on the expected system potential vegetation for the reach and its expected height, density, and channel overhang at maturity.

While the method provides no information on existing shade conditions or the expected system potential stream temperature, it does provide quick and accurate estimates of the allocations necessary to eliminate temperature increases resulting from anthropogenic impacts on shade.

ODEQ recognizes that it may take several years to several decades after full implementation of shade-producing measures to achieve the shade targets identified in this TMDL. Simply put, wide stream segments typically require taller, older riparian vegetation in order to achieve shade targets and narrow stream segments may achieve the shade targets with shorter, younger riparian vegetation. Shade targets identified in Figure 6.11 apply to the tributaries of the mainstem Clackamas River and to the mainstem upstream of

River Mill Dam. The targets can be used to help guide and prioritize implementation efforts to maximize the near-term effectiveness of implementation efforts. ODEQ expects that DMAs will focus initial implementation efforts on improving shade conditions through establishing and/or enhancing riparian vegetation conditions and in ensuring that existing and future development practices allow the attainment of shade targets.

Clackamas Subbasin Shade Curves

ODEQ developed shade curves for the Willamette Basin based on potential vegetation growth under different soil conditions. The geomorphic coverages extend only a few miles into the Clackamas Subbasin from the mouth (Map 6.10) and include flood plain deposits, terrace gravels, alluvial deposits, and Boring lava, Table 6.10. Potential vegetation communities include upland forest, valley bottom forest, savannah and prairie. ODEQ designated the remainder of the subbasin Upland Forest. This broad designation is appropriate for the Clackamas because the U. S. Forest Service-designated plant associations (Logan, et. al. 1987) on which the Upland Forest shade curve is based reflect realistic potential vegetation in most of the subbasin. Figure 6.11 illustrates the six shade curves applied to the Clackamas subbasin tributaries.

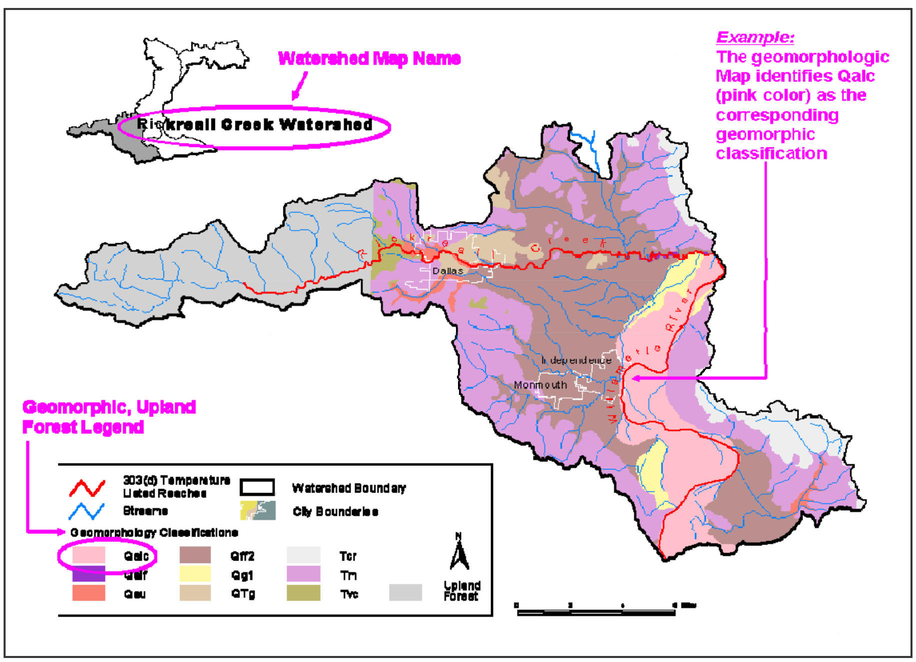
Geomorphic Classes in the Clackamas Subbasin

Geomorphic Class	Acres	Square Miles	Relative Area (%)
Quaternary terrace gravels (QTg)	16	0.03	0.00
Quaternary Troutdale Formation (QTt)	212	0.33	0.04
Quaternary Boring Lava (QTb)	282	0.44	0.05
Quaternary alluvium floodplain deposits (Qalc)	294	0.46	0.05
Quaternary fine-grained Flood deposits (Qff2)	417	0.65	0.07
Upland Forest (UF)	601,270	939.49	99.8
Grand Total	**602,490**	**941.39**	**100.0**

<u>How to Use a Shade Curve:</u>

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).



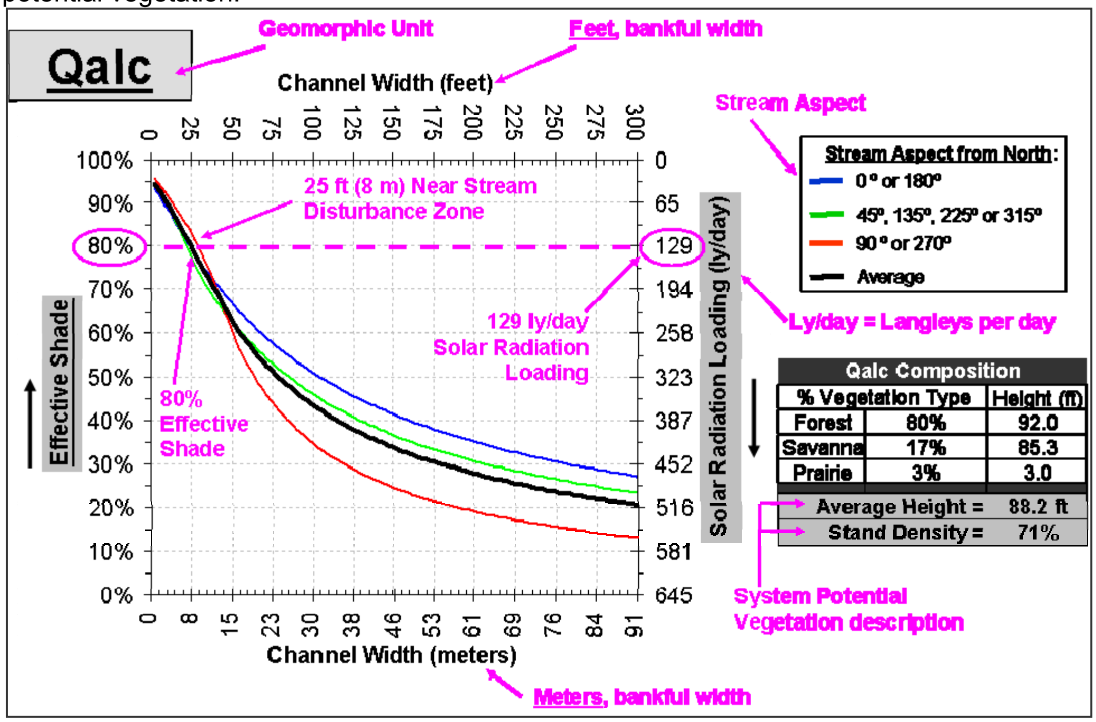
2. Determine the stream aspect from north.

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 non-point source load allocation 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 6.10 Geomorphic coverages in the Lower Clackamas Subbasin.

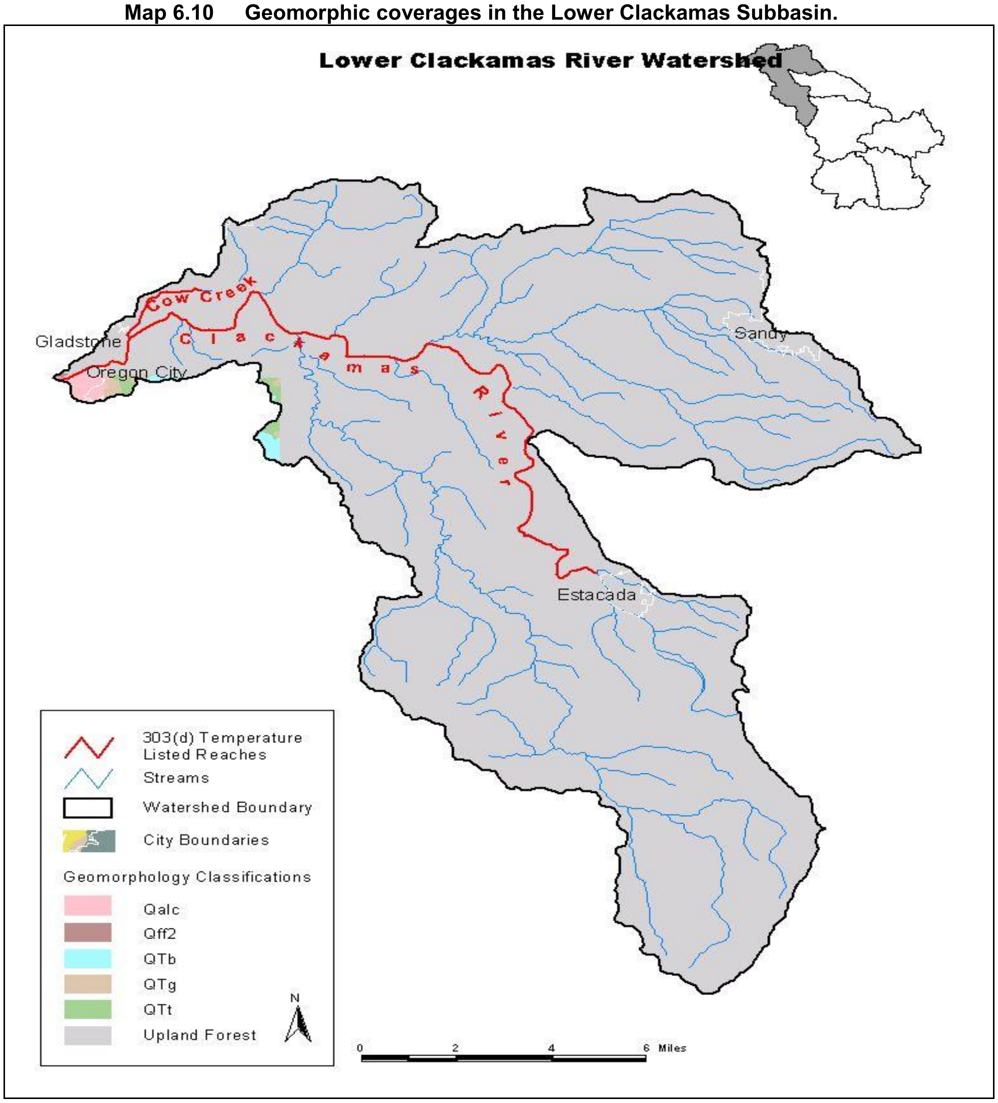


Figure 6.11: Shade curves applied to the Clackamas Subbasin tributaries.

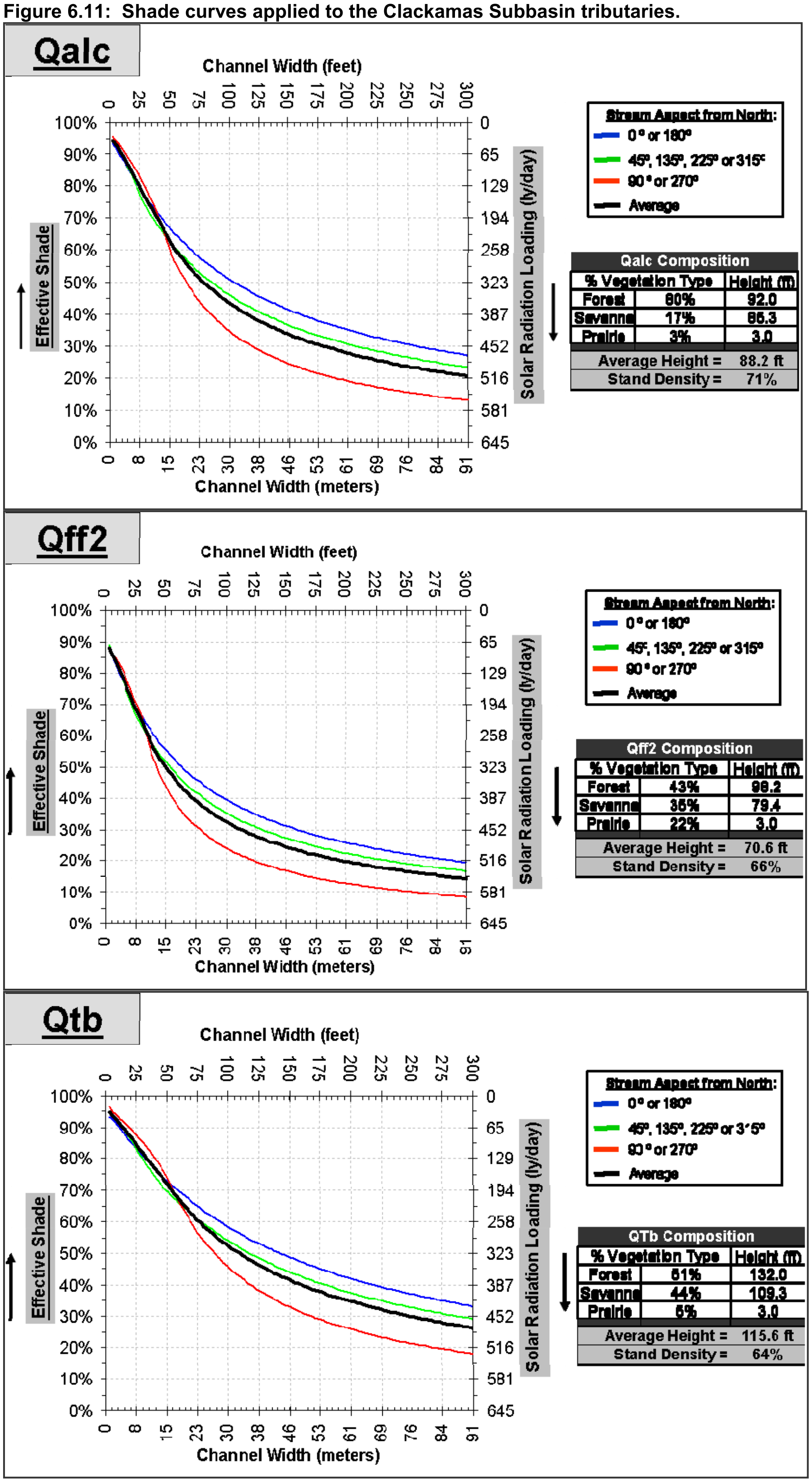
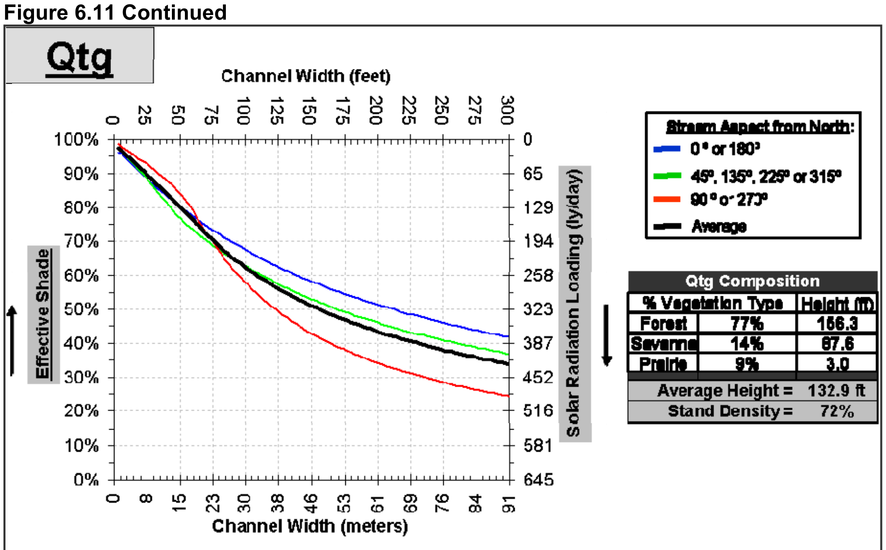
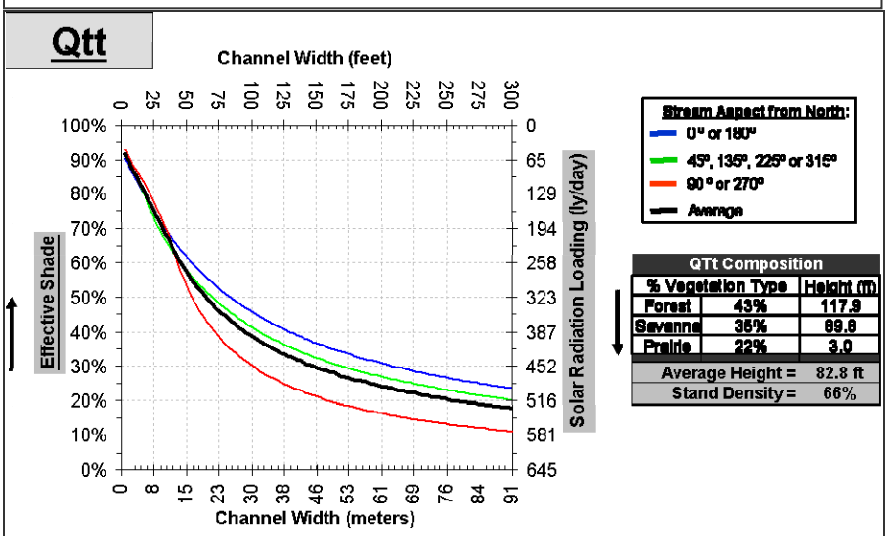
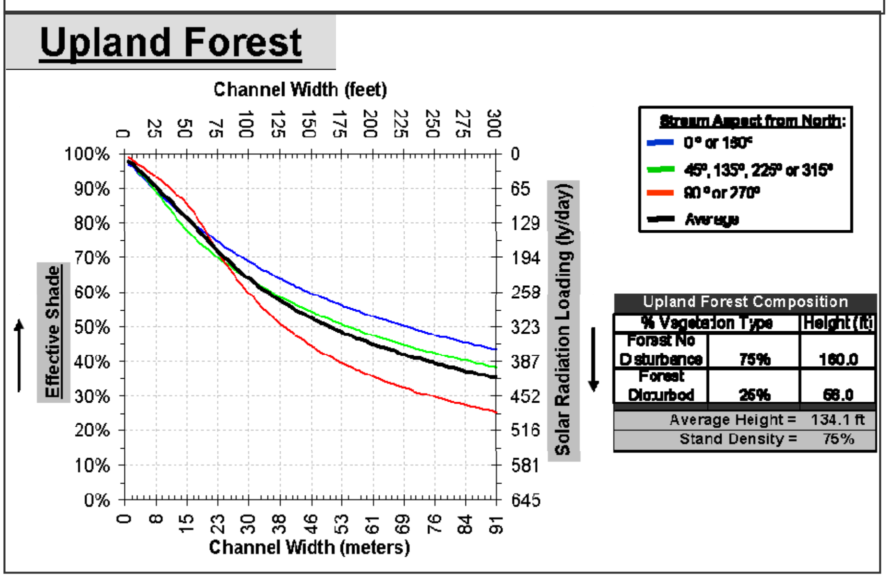


Figure 6.11 Continued







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

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS). The statutory requirement that TMDLs incorporate a MOS is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A MOS 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 MOS may be implicit, as in conservative assumptions used in calculating the Loading Capacity, Waste Load Allocations, and Load Allocations. The MOS 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 MOS documented. The MOS is not meant to compensate for a failure to consider known sources. Table 6.11 presents six approaches for incorporating a MOS 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 MOS, which results in an overall allocation, represent the best estimate of how standards can be achieved. The selection of the MOS 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.

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 MOS.
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.

<u>Implicit Margins of Safety</u>

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.
Description of the MOS for the Clackamas Subbasin temperature TMDL nonpoint source load allocations begins with a statement of assumptions. A MOS has been incorporated into the temperature assessment methodology. Calculating a numeric MOS is not easily performed with the methodology presented in this document. In fact, the basis for the loading capacities and load allocations is the definition of 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(5)(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. These latter sources have generally been limited to natural solar radiation levels determined by shade curves for a given area. The final 0.05˚C 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) above the applicable criterion 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.

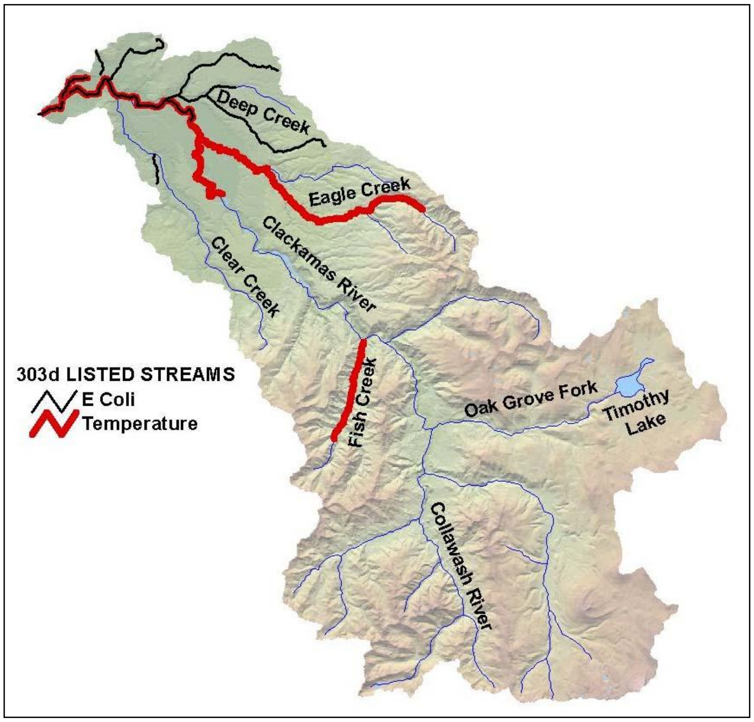
CLACKAMAS SUBBASIN BACTERIA TMDL

The Clackamas Subbasin bacteria TMDL includes several streams that have been listed as water quality limited due to excessive concentrations of fecal bacteria. These bacteria are produced in the gastro-intestinal tracks of warm-blooded vertebrate animals, and indicate the presence of pathogens that cause illness in humans. Oregon's bacteria water quality standard uses an indicator group of bacteria, *Escherichia coli* (*E. coli*), to assess the risk of disease from human pathogens found in water. Human contact with bacteria-impaired surface water typically occurs during recreational use. The 2002 303(d) list includes eight waterbodies in the Clackamas Subbasin that violate the bacteria water quality standard (Table 6.12). All the bacteria listings were based on the *E. coli* criteria in force since 1996.

Stream reaches listed for bacteria violations in the Clackamas Subbasin.

Waterbody	Listed Reaches	List Date	Parameter	Criterion	Season
Rock Creek	0 – 6.1	2002	*E. Coli*	126 organisms per 100 ml, no single sample <406	Winter/Fall/Spring
Sieben Creek (Drainage Ditch)	0 – 1.0	2002	*E. Coli*	126 organisms per 100 ml, no single sample <406	Winter/Fall/Spring
Sieben Creek (Drainage Ditch)	1.0 – 1.8	2002	*E. Coli*	126 organisms per 100 ml, no single sample <406	Winter/Fall/Spring
Cow Creek	0 – 2.6	2002	*E. coli*	126 organisms per 100 ml, no single sample <406	Winter/Fall/Spring
Clackamas River	0 – 15	2002	*E. Coli*	126 organisms per 100 ml, no single sample <406	Summer
Bargfeld Creek	0 – 2.3	2002	*E. Coli*	126 organisms per 100 ml, no single sample <406	Summer
Deep Creek	1.9 – 14.1	2002	*E. Coli*	126 organisms per 100 ml, no single sample <406	Summer
North Fork Deep Creek	0 – 9	2002	*E. Coli*	126 organisms per 100 ml, no single sample <406	Summer
Tickle Creek	0 – 2.3	2002	*E. Coli*	126 organisms per 100 ml, no single sample <406	Summer

Map 6.11 Bacteria listings in the Clackamas Subbasin



The mainstem Clackamas River downstream of RM 15, Sieben Creek (also called Sieben Drainage Ditch), Rock Creek, Bargfeld Creek, Deep Creek, North Fork Deep Creek, and Tickle Creek are water quality limited (Map 6.11). The sources of the bacteria violations may include residential septic systems, sewage treatment plants, livestock waste, wildlife waste, pet waste and urban runoff. Based on the locations and timing of violations, nonpoint sources (including urban storm water) likely contribute more significantly to bacterial loading in the lower Clackamas subbasin than do point sources. ODEQ developed allocations as percent reductions of *E. coli* bacteria for an adjacent subbasin (Johnson Creek) and applied those reductions to the Clackamas subbasin. ODEQ expects water bodies in the Clackamas Subbasin to meet water quality standards once those allocations are implemented. Table 6.13 presents a summary of TMDL components.

Clackamas Subbasin Bacteria TMDL Components.

Waterbodies **OAR 340-042-0040(4)(a)**	Waterbodies within the Clackamas Subbasin, HUC (Hydrologic Unit Code) 17090011, providing beneficial uses as defined in OAR 340-41, water contact recreation.
Pollutant Identification **OAR 340-042-0040(4)(b)**	*Pollutants:* Fecal bacteria from various sources, particularly *E. coli* as an indicator of human pathogens for recreational contact and fecal coliform bacteria as an indicator of human pathogens for bacteria data collected prior to 1996.
Beneficial Uses **OAR 340-042-0040(4)(c)** **OAR 340-41**	Water contact recreation.
Target Criteria Identification **OAR 340-042-0040(4)(c)** **OAR 340-041-0009(1)(a)(A)** **OAR 340-041-0009(1)(a)(B)** ***CWA §303(d)(1)***	OAR 340, Division 41 provides numeric and narrative bacteria criteria. (A) Numeric Criteria: Organisms of the *E. coli* group commonly associated with fecal sources (MPN or equivalent membrane filtration using a representative number of samples) shall not exceed the criteria described in subparagraphs (i) and (ii) of this paragraph. Freshwaters and Estuarine Waters: (i) A 30-day log mean of 126 *E. coli* organisms per 100 ml, based on a minimum of five (5) samples; (ii) No single sample shall exceed 406 *E. coli* organisms per 100 ml.
Seasonal Variation **OAR 340-042-0040(4)(j)** ***CWA §303(d)(1)***	Violations of the bacteria criteria occur throughout the year and under both high and low observed flow conditions.
Existing Sources **OAR 340-042-0040(4)(f)** ***CWA §303(d)(1)***	Multiple point and nonpoint sources during runoff and non-runoff events, including urban storm water discharge and agricultural run-off.
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:* The loading capacity is expressed as a count that will achieve the logarithmic mean 126 *E. coli* organisms per 100 ml standard and not exceed the 406 *E. coli* organisms per 100 ml standard under all flow conditions, thereby protecting beneficial uses. *Waste Load Allocations (Point Sources)*: Waste load allocations applicable to municipal stormwater permits are expressed as a percent reduction necessary to meet the numeric criteria. Waste load allocations applicable to sewage treatment plants require effluent to meet the *E. coli* standard. *Load Allocations (Nonpoint Sources)*: Load allocations are expressed as a percent reduction necessary to meet the numeric criteria, in this case ranging from 78% to 90% reduction of bacteria loads for urban and agricultural land uses. Excess Load: The difference between the actual pollutant load and the loading capacity of a waterbody.
Surrogate Measures **OAR 340-042-0040(5)(b)** ***40 CFR 130.2(i)***	*Translates Nonpoint Source Load Allocations* Allocations are in terms of percent reduction needed to achieve the numeric criteria. This translates load allocations into more applicable measures of management practices' performance.
Margins of Safety **OAR 340-042-0040(4)(i)** ***CWA §303(d)(1)***	*Margins of Safety* are applied as conservative assumptions in the development and percent reduction of current *E. coli* counts. No numeric margin of safety is developed.
Reserve Capacity **OAR 340-042-0040(4)(k)**	Allocation for increases in pollutant loads from future growth and new or expanded sources. No reserve capacity is allocated at this time and future sources will be required to meet criteria at the point of discharge.
Water Quality Management Plan **OAR 340-042-0040(4)(l)** ***CWA §303(d)(1)***	The Water Quality Management Plan, Chapter 14, provides the framework of management strategies to attain and maintain water quality standards. The framework is designed to work in conjunction with detailed plans and analyses provided in sector-specific or source-specific implementation plans.
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.

Beneficial Use Identification

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

Oregon Administrative Rules (OAR 340–41–340, Table 6) list the beneficial uses occurring within the Willamette River Basin tributaries and are applicable to the Clackamas Subbasin (Table 6.14). Numeric and narrative water quality criteria are designed to protect the most sensitive beneficial uses. Water contact recreation is the beneficial use most sensitive to bacterial contamination in the Clackamas Subbasin. The Clackamas River is a drinking water source for approximately 200,000 people. While this is also a sensitive beneficial use, the water is chlorine-treated before consumption. The bacteria TMDL targets reductions in bacteria concentrations that will limit loading and result in protection of water contact recreation.

Beneficial Uses in the Willamette (OAR 340-41-340, Table 340A).

Beneficial uses occurring in the Clackamas Subbasins *OAR 340-41-442* *Bacteria-Sensitive Beneficial uses are marked in gray*			
Beneficial Use	**Occurring**	**Beneficial Use**	**Occurring**
Public Domestic Water Supply	✓	Anadromous Fish Passage	✓
Private Domestic Water Supply	✓	Salmonid Fish Spawning	✓
Industrial Water Supply	✓	Salmonid Fish Rearing	✓
Irrigation	✓	Resident Fish and Aquatic Life	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Aesthetic Quality	✓	Water Contact Recreation	✓
Commercial Navigation & Trans.		Hydro Power	✓

Target Criteria Identification

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

The Oregon Administrative Rules (Table 6.15) contain bacterial criteria for the waters of the Clackamas Subbasin. Standards were established to ensure that contact recreation (swimming, wading, etc.) does not result in an unacceptable risk to human health. Under the standard, water contact recreation is protected as long as the 30-day log-mean of sample concentrations does not exceed 126 *E. coli* organisms per 100 mL of water. No single sample is to exceed 406 *E. coli* organisms per 100 mL. This TMDL will be based entirely on *E. coli* data and the current criteria.

Bacteria water quality criteria for the Clackamas Subbasin.

Beneficial Use	**Description**
Recreational Contact in Water OAR 340-41-0009:	Effective March 1996 to present: a 30-day log mean of 126 ***E. coli*** organisms per 100 ml, based on a minimum of five samples; and no single sample shall exceed 406 ***E. coli*** organisms per 100 ml. No sewage may be discharged into or be allowed to enter waters of the State. Runoff contaminated with domesticated animal wastes must be minimized and treated to the maximum extent practicable.

Analytical Approach

The method of fecal coliform bacteria analysis has changed over time; typically, older samples were analyzed using the membrane filtration technique (MF) and more recent samples analyzed by the Most Probable Number (MPN) technique. According to Bacterial Indicators of Pollution (Pipes, 1982) "the differences between MPN estimates and MF counts were not of any practical significance mainly because of the inherently low degree of reproducibility of the MPN estimates." ODEQ combined MF and MPN data for this report.

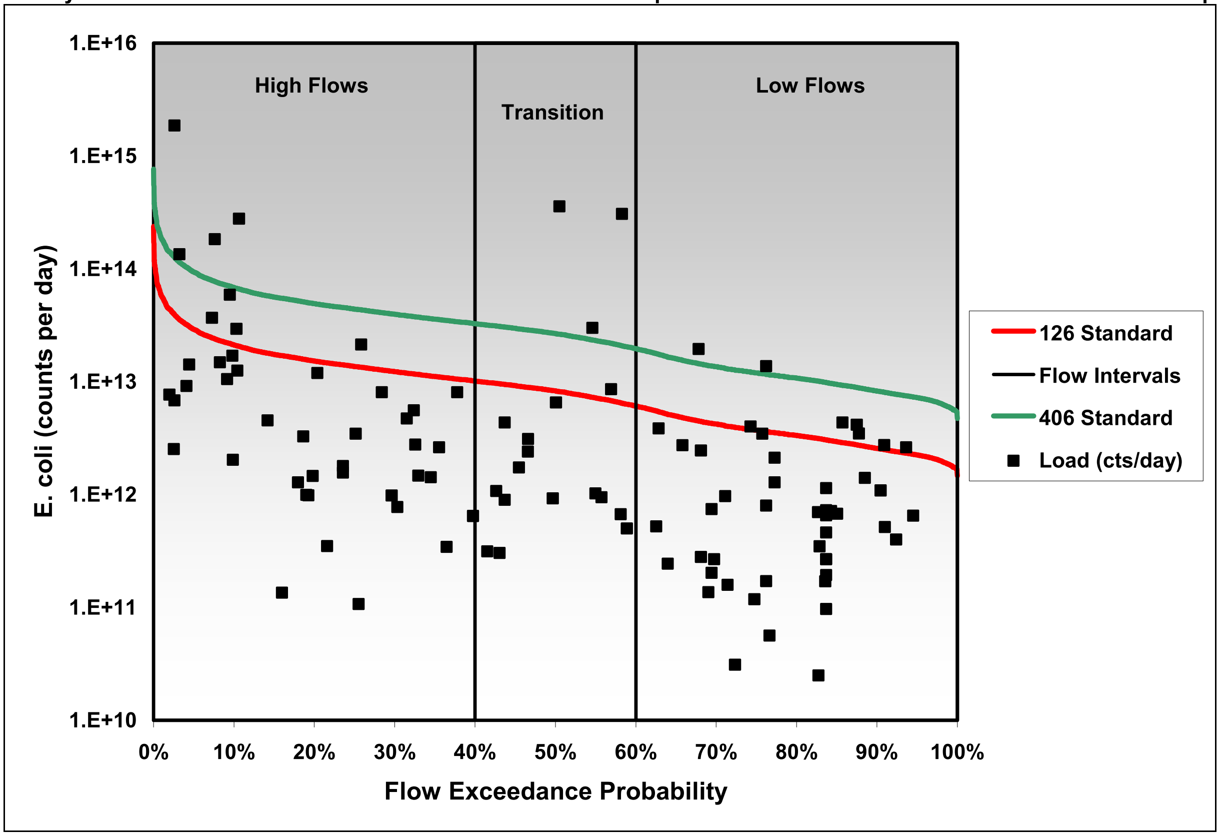
E. coli data used in this analysis were collected during a variety of weather and flow conditions between 1996 and 2002. In all calculations, "less than" and "greater than" values were treated as the value without the qualifier. Because a significant portion of the data were reported less than the reporting limit, ODEQ felt that eliminating these values from the calculations would not represent true conditions. Treating "less than" values as the reporting limit is also a conservative assumption. Only 1% of the data was reported "greater than" an upper limit of detection. While assigning the upper detection limit to those values is not a conservative assumption, this assumption affects only a small percentage of data. Because the bacteria violations are primarily based on outliers, again, ODEQ felt that eliminating the qualified maximum values would not represent true conditions.

ODEQ developed the Clackamas Subbasin Bacteria TMDL by applying concentration-based reductions to meet water quality standards. This technique was applied because bacteria data collected on some tributaries did not represent all flow regimes and sufficient flow data were not available on the tributaries to build load duration curves.

ODEQ used a load duration curve to compare the data collected from mainstem Clackamas River with the loading capacity under different flow regimes, but did not use the load duration curve to develop the reductions by land use needed to meet water quality standards. The load duration curve method is primarily based on TMDLs completed by the Kansas Department of Health and Environment and through technical assistance provided by Bruce Cleland of USEPA and America's Clean Water Foundation (www.acwf.org). Load duration curves (e.g., Figure 6.12) illustrate relative effects of bacterial loads under various flow conditions and can be used in targeting appropriate water quality restoration efforts (Cleland 2002).

ODEQ chose a percent reduction to develop the Clackamas Subbasin bacteria TMDL, rather than loads, to clearly convey the reduction target. ODEQ based the reduction target on the TMDL developed for the Johnson Creek Subbasin, an adjacent watershed with a robust data set and land use similar to the Lower Clackamas Subbasin. This reduction, when applied to Clackamas data will bring the populations of data into compliance with the log mean standard, with two exceptions arising from unusually small data sets (eight samples each). The percent reduction adopted from the Johnson Creek TMDL applies basin-wide to urban and agricultural land uses in the Clackamas subbasin. The data indicate that forestry land use in the upper Clackamas Subbasin does not contribute to bacteria criteria violations. ODEQ applies allocations basin-wide (to agricultural and urban land uses) to ensure contributions from all sources are minimized and that new sources will be appropriately controlled. This subbasin-wide allocation strategy ensures that all waterbodies meet water quality standards regardless of 303(d) listing status.

Figure 6.12: Example of a load duration curve demonstrating load capacity and bacteria load. To describe bacteria conditions within different flow regimes, this example curve is separated into three categories (High, Transitional, and Low) relative to probability of flow exceedance. Load duration curves are further explained in the Load Duration Curve section of this chapter.



Existing Sources

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

The following section describes possible sources of bacteria, but is not meant to represent an exhaustive source assessment. Watershed managers from the designated management agencies must conduct further investigations of watershed-specific bacteria sources in order to develop an effective strategy for bacteria control. Bacteria enter surface waters from a variety of sources, both point and nonpoint, during run-off precipitation driven events and non run-off dry weather periods.

Nonpoint Sources of Bacteria

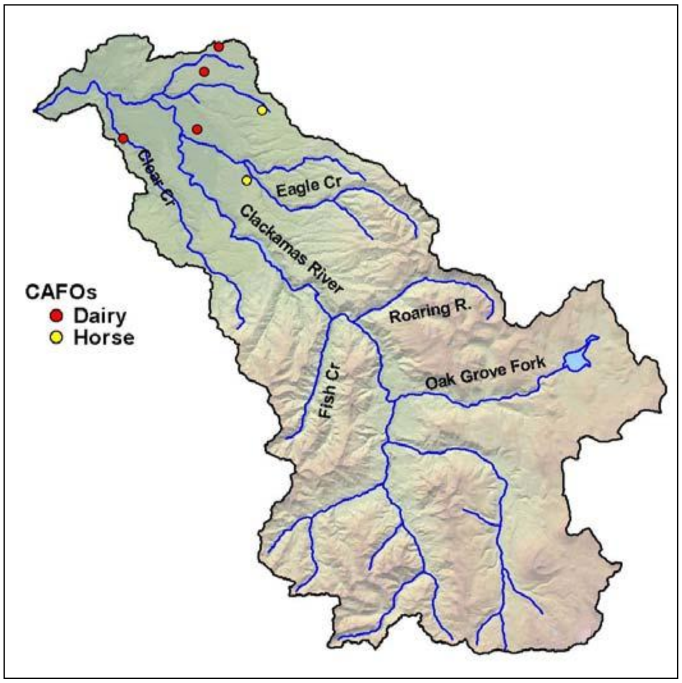
Runoff from urban, rural residential and agricultural lands, failing septic systems, pet waste, wildlife waste, and livestock waste all contain fecal bacteria and are examples of nonpoint sources located in the Clackamas Subbasin. Urban areas include Estacada, Oregon City, Gladstone, and Sandy. Rural residential areas are ubiquitous, but are more common in lowlands near rivers and streams.

Small acreage farms, pastures, and especially horse facilities that are not regulated as Confined Animal Feeding Operations (CAFOs) are likely a significant nonpoint source of bacterial contamination in the lower Clackamas. According to the Agricultural Census for 2002, Clackamas County ranks near the top 10 counties nationally for horse population and contains 1,500 horse farms. According to the Clackamas County Soil and Water Conservation District, the horse population generates as much as 81,000 tons of manure annually.

Point Sources of Bacteria

Point sources occur on the mainstem as well as on North Fork Deep Creek and Tickle Creek. Facilities that confine and feed animals for specified periods and manage accumulated manure operate as point sources under CAFO permits administered by the Oregon Department of Agriculture (ODA). CAFO facilities are considered point sources, and under the terms of these permits, no discharge is allowed from areas of animal confinement, or manure management and storage. There are six CAFOs in the Clackamas Subbasin as shown in Map 6.12. Four CAFOs house dairy cows, one houses horses, and one is listed as containing no animals (perhaps a data entry error). The horse operation and one of the dairy operations each house only eight animals. The remaining three dairy CAFOs contain from 77 to 400 animals.

Map 6.12 Confined animal feeding operations in the Clackamas Subbasin.



ODEQ has issued seven National Pollution Discharge Elimination System (NPDES) permits and four general permits to facilities in the Clackamas Subbasin (Table 6.16). Of these facilities, seven sources discharge directly into the mainstem Clackamas and four into tributaries. There are four domestic sewage treatment plants and three fish hatcheries under NPDES permits. The four general permit holders (three water districts and RSG Forest products) are not expected to contribute *E. coli* bacteria to surface waters because they discharge only filter backwash or cooling water, respectively. While the fish hatcheries may contribute fish waste, this would not contain *E. coli* bacteria (only from warm blooded animals). Of the current NPDES-permitted facilities in the subbasin, only the waste water treatment plants (WWTPs) are potential point sources of *E. coli* bacteria, though unpermitted point sources of bacteria may also exist.

Major and Minor NPDES facilities in the Clackamas Subbasin

Facility Name	Permit Type	Receiving Stream	River Mile
South Fork Water Board	GEN02	Clackamas River	2
Oak Lodge Water District	GEN02	Clackamas River	2
Clackamas River Water	GEN02	Clackamas River	3.5
ODFW Clackamas Fish Hatchery	NPDES-IW-O	Clackamas River	22.6
Estacada Sewage Treatment Plant	NPDES-DOM-Da	Clackamas River	23.3
RSG Forest Products (Estacada Lumber)	GEN01	Clackamas River	24
Mt. Hood Nat'l Forest, Timberlake WWTP	NPDES-DOM-Da	Clackamas River	51.1
Boring WWTP (Clackamas County Service District #1)	NPDES-DOM-Db	North Fork Deep Creek	3
Clear Creek Rainbow Ranch, Inc.	NPDES-IW-O	Clear Creek	8.0
US Fish and Wildlife Service, Eagle Creek Hatchery	NPDES-IW-O	Eagle Creek	12.3
City of Sandy WWTP	NPDES-DOM-Da	Tickle Creek	3.1

Seasonal Variation

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

ODEQ considered seasonal and longitudinal variation of in-stream *E. coli* in the analysis of current conditions and in assigning loading allocations. ODEQ separated the data into those collected during summer low flow period from June 1 to September 30, and for the high flow fall-winter-spring period, October 1 to May 31.

Current Conditions

Several waterbodies in the Clackamas Subbasin violate bacteria water quality standards. Descriptions of current conditions in the Clackamas River, Sieben Creek, Cow Creek, Rock Creek, Deep Creek, North Fork Deep Creek and Bargfeld Creek are included in the following subsections. ODEQ used the Clackamas River Watershed Atlas (Metro, 1997) to describe land use in each of the watersheds. ODEQ used two techniques to analyze and target problem areas in the various watersheds: box and whisker plots and a load duration curve.

ODEQ built the box plots and load duration curve from ODEQ and Clackamas County data. Clackamas County Water Environment Services supplied ODEQ with data for Sieben Creek, Cow Creek, Rock Creek, Deep Creek, North Fork Deep Creek, Bargfeld Creek and Tickle Creek. Clackamas County also provided data from the Highway 99, Carver Bridge, and River Mill dam sites on the Clackamas River. ODEQ has been collecting *E. coli* data at the High Rocks (old Highway 213), McIver Park, and Memaloose Bridge sites eight times per year since 1996 as part of the state-wide ambient water quality monitoring program. ODEQ uses ambient network data for compliance monitoring, long-term trending, and calculating the Oregon Water Quality Index (OWQI). The OWQI represents general water quality over 10 or more water years.

Box and Whisker Plots

E. coli distributions are presented in box and whisker plots, as described in Figure 6.13. Box and whisker plots illustrate the distribution of data collected through time by determining the median, 25th percentile, and 75th percentile sample concentrations. These plots are used in the following sections to compare seasonal concentrations among sites.

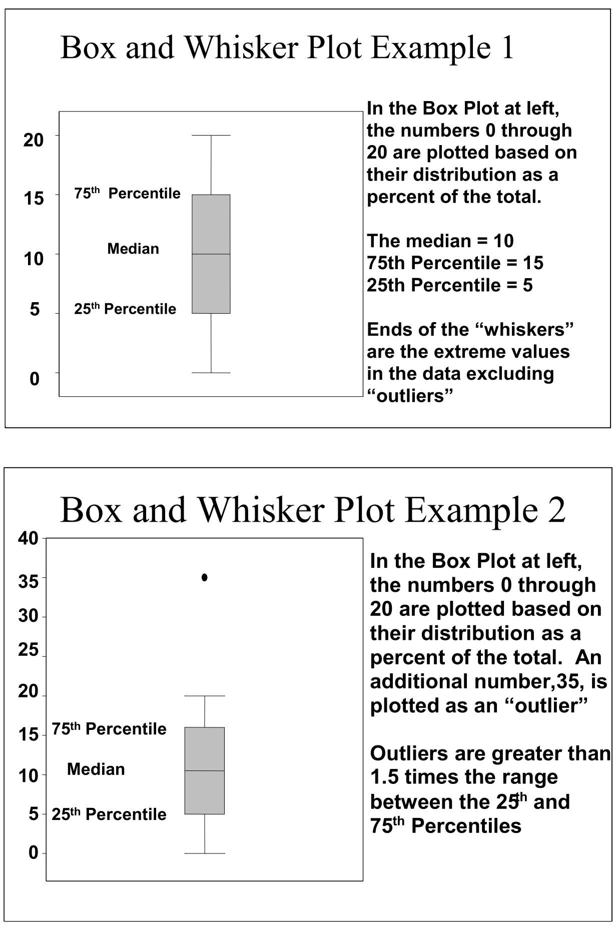


Figure 6.13: Example and Description of Box and Whisker Plots

Clackamas River

Land use in the lower portion of the Clackamas Subbasin is mainly urban near the mouth and increasingly rural residential and agricultural upstream to approximately RM 10. Upstream of river mile 10, forest management becomes a more significant land use and is the exclusive land use upstream of approximately river mile 20. During the summer (June 1 – September 30), the Clackamas River is water quality limited for bacteria from its mouth to RM 15 (approximately 7 miles downstream of the lowest dam). Fewer than 10% of samples collected from the Clackamas River during fall, winter and spring indicate bacteria concentrations exceeding the 406 MPN/100 mL standard (Table 6.17). Sampling results indicate that the highest bacterial concentrations occurred in samples collected at the Highway 99 Bridge, the furthest site downstream. While three out of 16 summer samples yielded bacterial concentrations exceeding 5000 MPN/100 mL, the geometric mean of those samples is only 76 MPN/100 mL.

The four tributaries that contribute the greatest bacterial concentrations to the mainstem Clackamas during the summer are Cow Creek, Rock Creek, Sieben Creek, and Deep Creek (Figure 6.14). Reviewing the tributary data within a day of each of the 12 summer violations on the lower Clackamas River shows that in two thirds of the cases, one or more of three tributaries (Cow, Sieben, Rock) also violated the 406 MPN/100 mL standard (Summer sampling dates on Deep Creek did not coincide with mainstem sampling dates). The remaining third of mainstem violations without coincident tributary violations occurred during either unusually high or unusually low mainstem river flows.

Available data suggest that fall, winter, and spring tributary bacterial contributions (Figure 6.15) have less effect on mainstem violations than they do during summer months, but fewer fall-winter-spring coincident data sets exist. Still, two mainstem violations (mid May1999 and 2001) that correspond with Cow, Sieben, and Rock Creek violations suggest tributary input is important during high-flow spring events. Insufficient fall, winter, spring data are available from Deep Creek (four samples) to assess its contribution to the mainstem during those seasons.

Clackamas River Bacteria Data Summary

	Clackamas River	Summer				Fall-Winter-Spring			
RM	**Station**	**Count**	**Log Mean**	**Maximum**	**Percent >406**	**Count**	**Log Mean**	**Maximum**	**Percent >406**
40	Clackamas River At Memaloose Road	15	2	12	0%	41	3	38	0%
22.6	Clackamas River D/S Of River Mill Dam	5	14	64	0%	9	6	12	0%
22.4	Clackamas River at McIver Pk. (Upper Boat Ramp)	11	3	16	0%	37	4	68	0%
8	Clackamas River at Carver Bridge	15	44	590	7%	29	11	249	0%
1.4	Clackamas River at High Rocks (Old Hwy 213)	16	83	520	13%	46	19	960	2%
0.4	Clackamas River at Hwy 99E Bridge	16	76	6000	25%	32	25	6000	6%

Figure 6.14: Summer bacteria data from the mainstem Clackamas River and tributaries, 1996 - 2002.

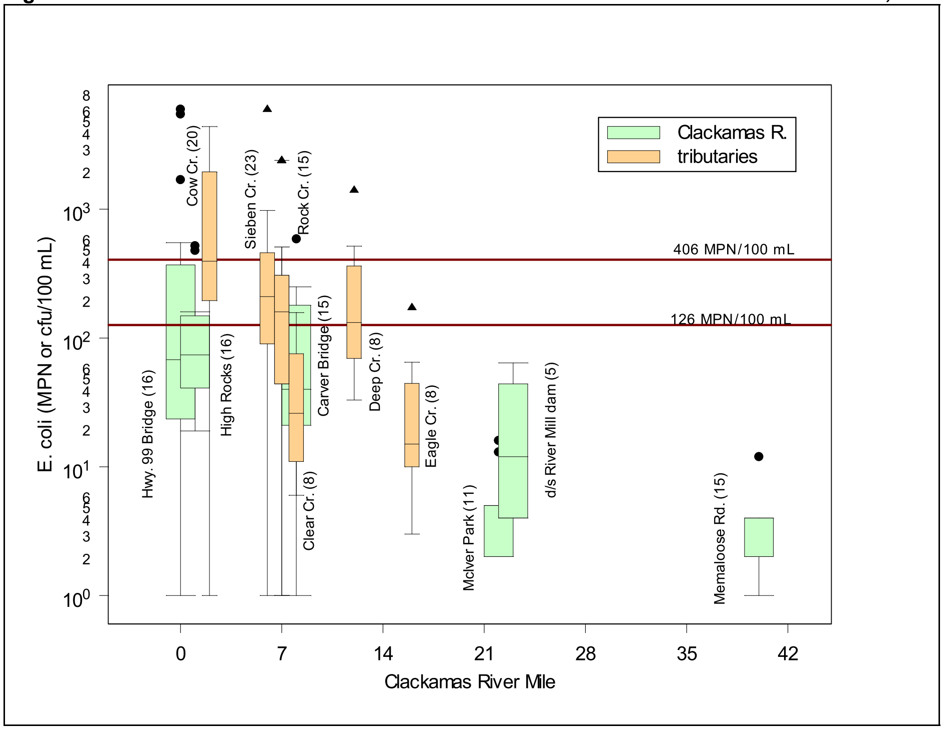
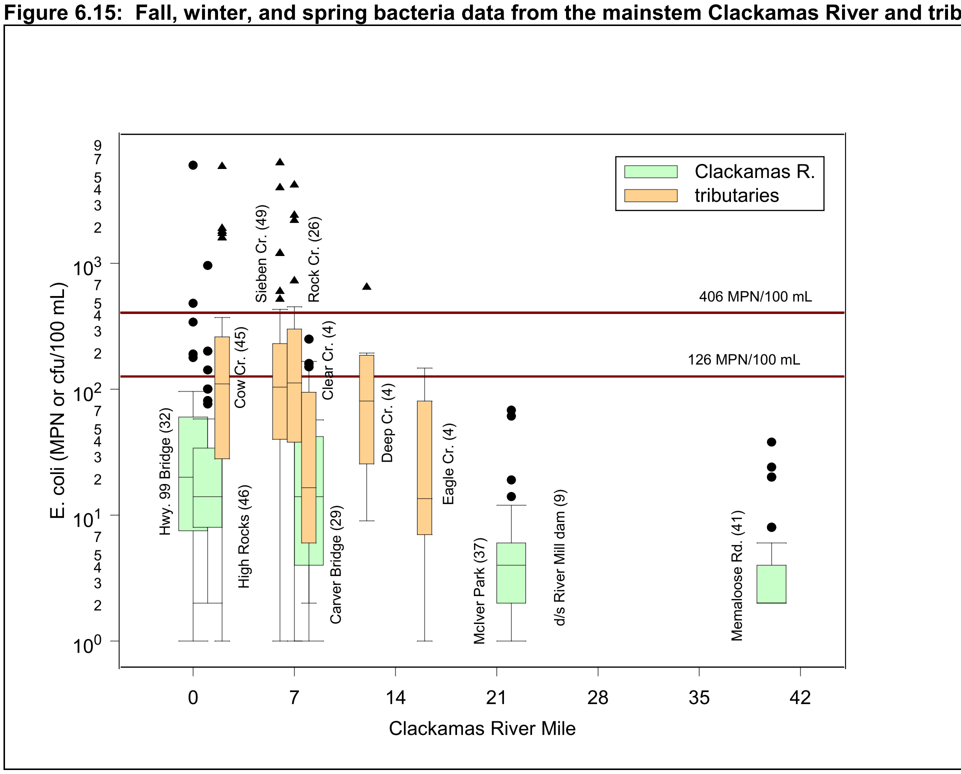


Figure 6.15: Fall, winter, and spring bacteria data from the mainstem Clackamas River and tributaries, 1996 - 2002.



Cow Creek

Land use surrounding Cow Creek is almost entirely urban (including industrial and commercial zoning), although land zoned as exclusive farm use is located near the mouth on the east bank. Based on available data, median bacterial concentrations are greater in the summer months (Table 6.18, Figure 6.16), but analysis shows more outliers exceeding 406 MPN/100 mL in fall, winter, and spring samples (Figure 6.17). Both summer and winter data from Cow Creek show an increase in bacterial contamination from upstream to downstream. One sample collected from the furthest upstream site (SE 102nd) yielded 6000 bacterial counts/100 mL, but only two samples are available to asses this location.

Cow Creek Bacteria Data Summary

	Cow Creek	Summer				Fall-Winter-Spring			
RM	Station	Count	Log Mean	Maximum	Percent >406	Count	Log Mean	Maximum	Percent >406
0.1	Cow Creek at SE Edgewater Road	20	425	4400	53%	45	90	5900	16%
0.9	Cow Creek at SE Evelyn St	16	265	>6000	43%	44	43	6000	16%
1.2	Cow Creek at SE Last Road					3		>2419	33%
1.7	Cow Creek at SE 102nd Ave.	2		6000	50%	35	26	800	11%

Figure 6.16: Summer bacteria concentrations 1996 - 2001 in Cow Creek.

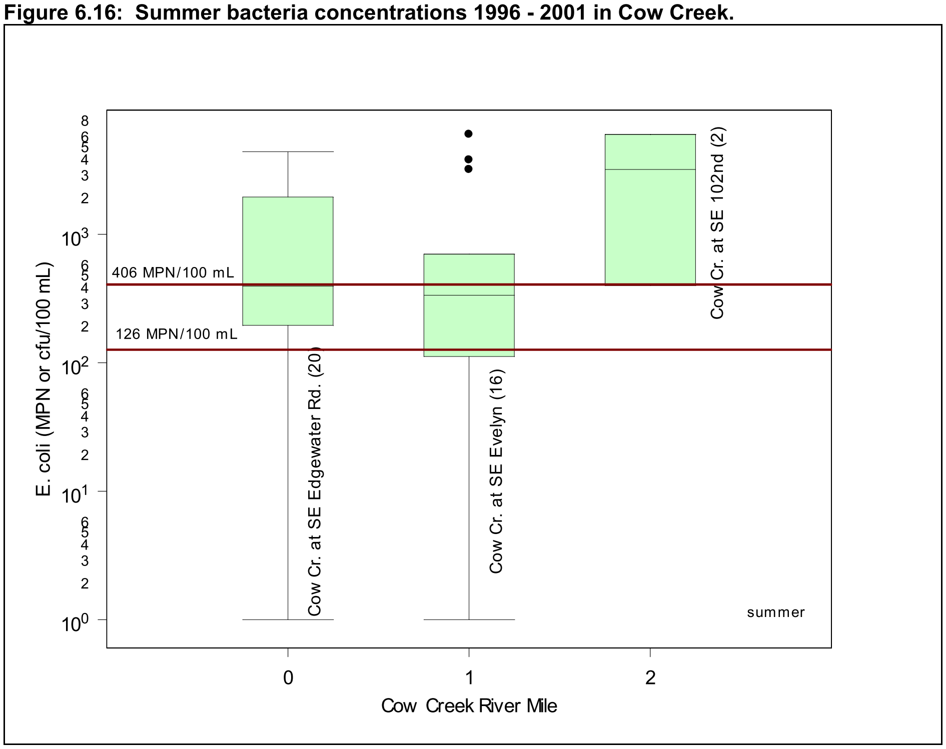
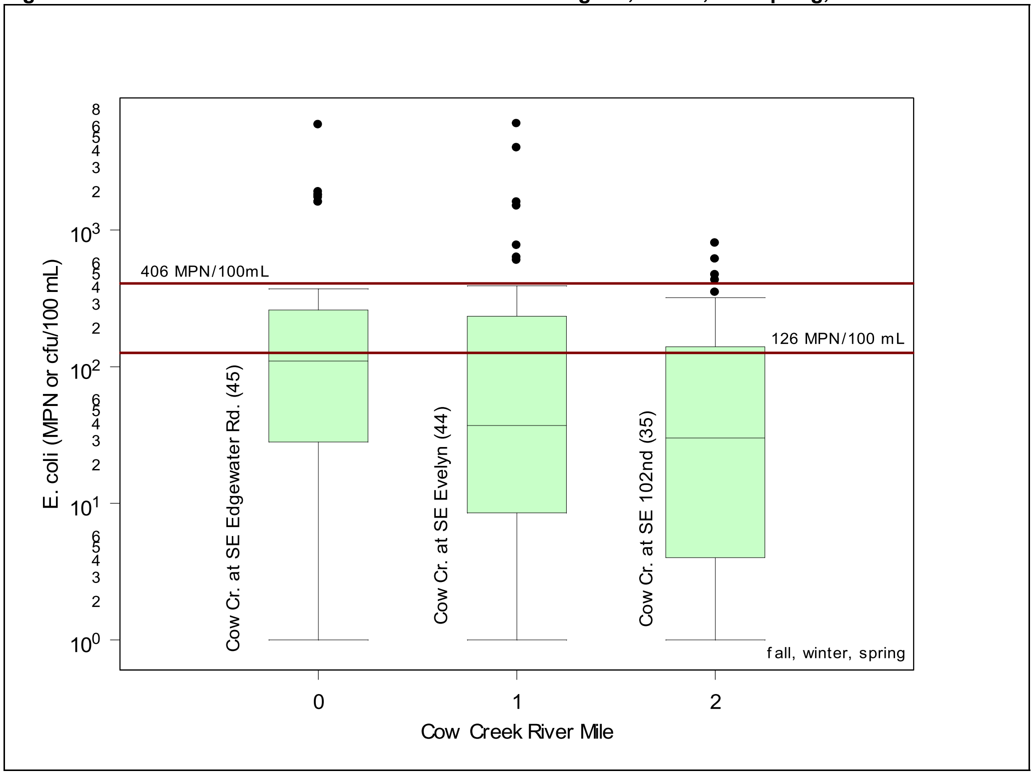


Figure 6.17: Bacteria concentrations in Cow Creek during fall, winter, and spring, 1996 - 2001.



Sieben Creek (Drainage Ditch)

Land use in most of the Sieben Creek watershed is urban residential. Parcels of industrial land are located near the confluence of Sieben Creek and the Clackamas River. Median summer concentrations exceed median wet-season concentrations, but, like the Cow Creek pattern, outliers occurred more frequently in the fall, winter, and spring (Table 6.19, Figures 6.18 and 6.19). Concentrations in samples collected from the upstream site on Sieben Creek exceed those detected in downstream samples during both summer and winter months.

Sieben Creek Bacteria Data Summary

	Sieben Cr. (drainage ditch)	Summer				Fall-Winter-Spring			
RM	Station	Count	Log Mean	Maximum	Percent >406	Count	Log Mean	Maximum	Percent >406
0.9	Sieben Creek at SE Sunnyside Rd.	11	800	6000	70%	47	171	2300	36%
0.1	Sieben Creek at Hwy 212	23	191	6000	24%	49	100	6300	16%

Figure 6.18: Bacteria concentrations in Sieben Creek during summers 1996 - 2001.

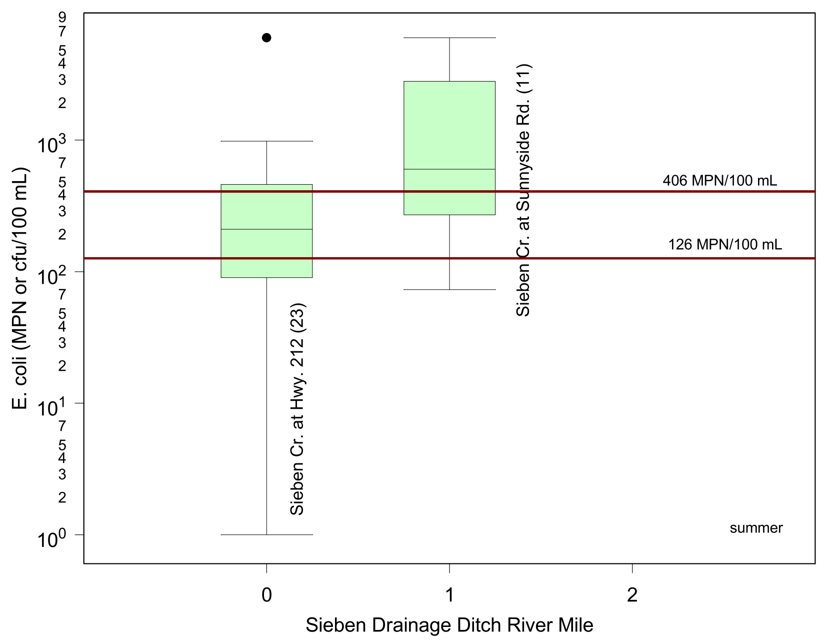
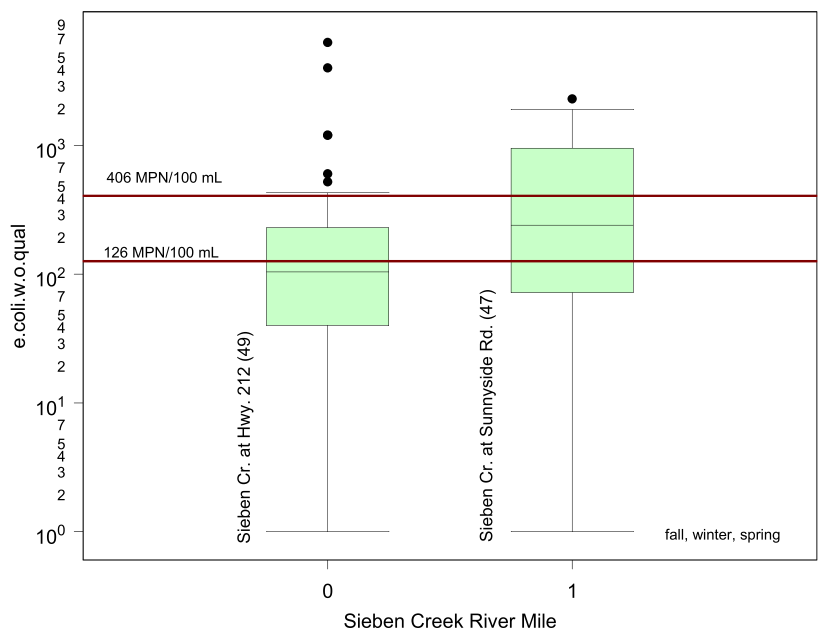


Figure 6.19: Bacteria concentrations in Sieben Creek during fall, winter, and spring, 1996 - 2001.



Rock Creek Watershed

Land use in the Rock Creek Watershed is mainly rural residential and agricultural, although urban land use exerts increasing influence near the mouth of the watershed (Rick Gruen, Clackamas SWCD, personal communication, June 2004). Rock Creek violates the bacteria standard in the wet months based on outliers exceeding the 406 MPN/100 mL standard at the most downstream site (Table 6.20). The remaining sites do not have sufficient winter data to evaluate the longitudinal variation along Rock Creek. Only two or eight samples represent summer concentrations at upstream sites, so the statistical evaluations (Figures 6.20 and 6.21) carry significant uncertainty. Except for the occurrence of more outliers in the winter, based on data from the most downstream site, Rock Creek bacterial distribution is not significantly different from summer to winter.

Rock Creek Bacteria Data Summary

	Rock Creek	Summer				Fall-Winter-Spring			
RM	Station	Count	Log Mean	Maximum	Percent >406	Count	Log Mean	Maximum	Percent >406
2.5	Rock Creek at Troge Rd.	8	77	461	13%	4	151	980	25%
1.8	Rock Creek at SE Sunnyside Road	2		1120	50%	4	243	548	50%
0.4	Rock Creek at Hwy 212-224	8	182	2419	13%	4	167	1733	25%
0.3	Rock Creek near Hwy 212-224 Junction	15	128	2400	33%	26	101	4200	19%

Figure 6.20: Bacteria concentrations in Rock Creek during summer, 1998 - 2001.

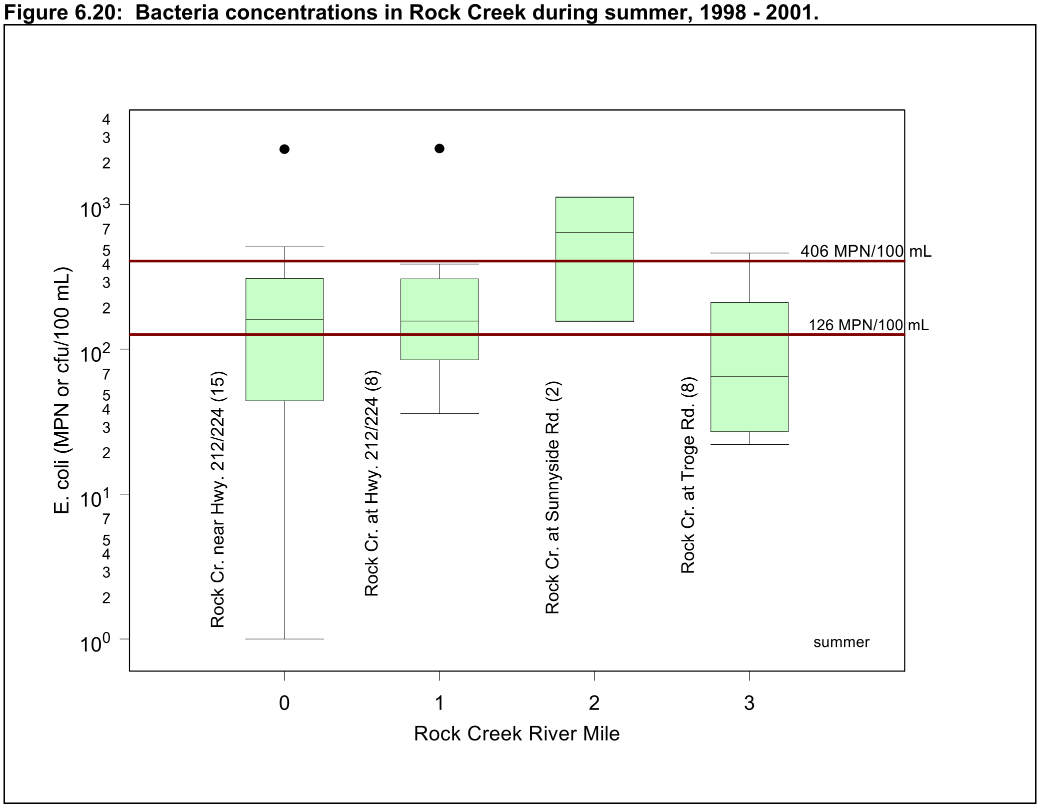
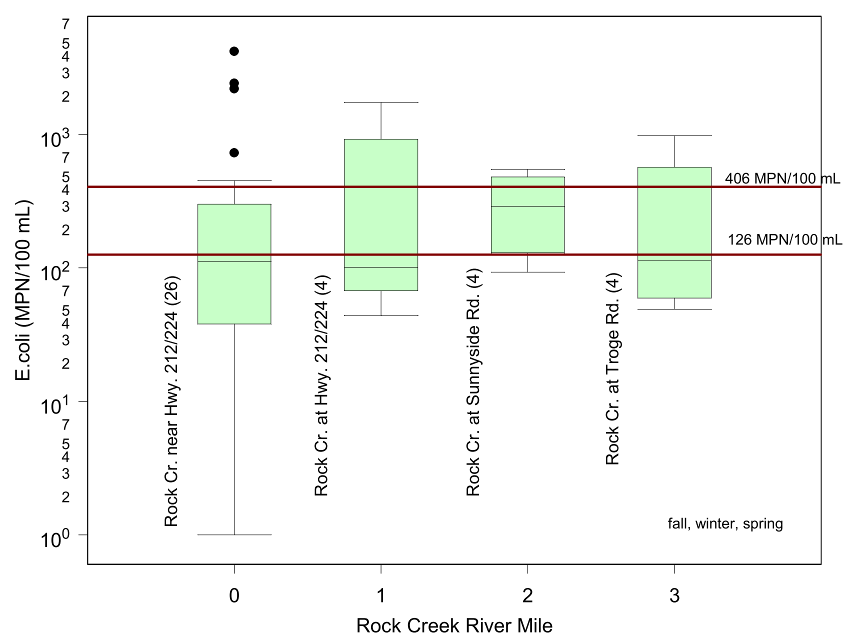


Figure 6.21: Bacteria concentrations in Rock Creek during fall, winter, spring, 1998 - 2002.



Deep Creek, North Fork Deep Creek, Tickle Creek

Land use in the Deep Creek watershed is mixed rural residential, forestry, and agriculture. Deep Creek tributaries (North Fork and Tickle Creek) receive discharge from two waste water treatment plants (WWTPs): Boring WWTP on North Fork Deep Creek and Sandy WWTP on Tickle Creek. Based on eight samples, Deep Creek violates water quality standards in the summer months (Table 6.21., Figure 6.22), but concentrations at the two stations (at RM 6.7 and 1.5) do not differ significantly. Insufficient data (four samples) are available to evaluate the wetter month bacterial concentrations (Figure 6.23) in Deep Creek, but available data indicate bacteria violations of the 406 MPN/100 mL criteria in the winter.

Deep Creek Bacteria Data Summary

	Deep Creek	Summer				Fall-Winter-Spring			
RM	Station	Count	Log Mean	Maximum	Percent >406	Count	Log Mean	Maximum	Percent >406
6.7	Deep Cr. at Hwy. 211	8	234	1413	38%	4	11	99	0%
1.5	Deep Cr. at Camp Kuratli	8	201	1414	13%	4	71	649	25%
5	N. Fk. Deep Cr. at Hwy 26	8	457	1733	63%	4	381	1986	25%
0.01	N. Fk. Deep Cr. at Camp Kuratli (trib. to Deep Cr. at RM 1.4)	8	129	517	13%	4	71	194	0%
7.3	Tickle Cr. at Langensand Rd.	8	41	1046	13%	4	27	131	0%
1.1	Tickle Cr. at Tickle Cr. Rd. (trib to Deep Cr. at RM 3.6)	8	286	2419	38%	4	98	345	0%

Figure 6.22: Bacteria concentrations in Deep Creek during summer 2001.

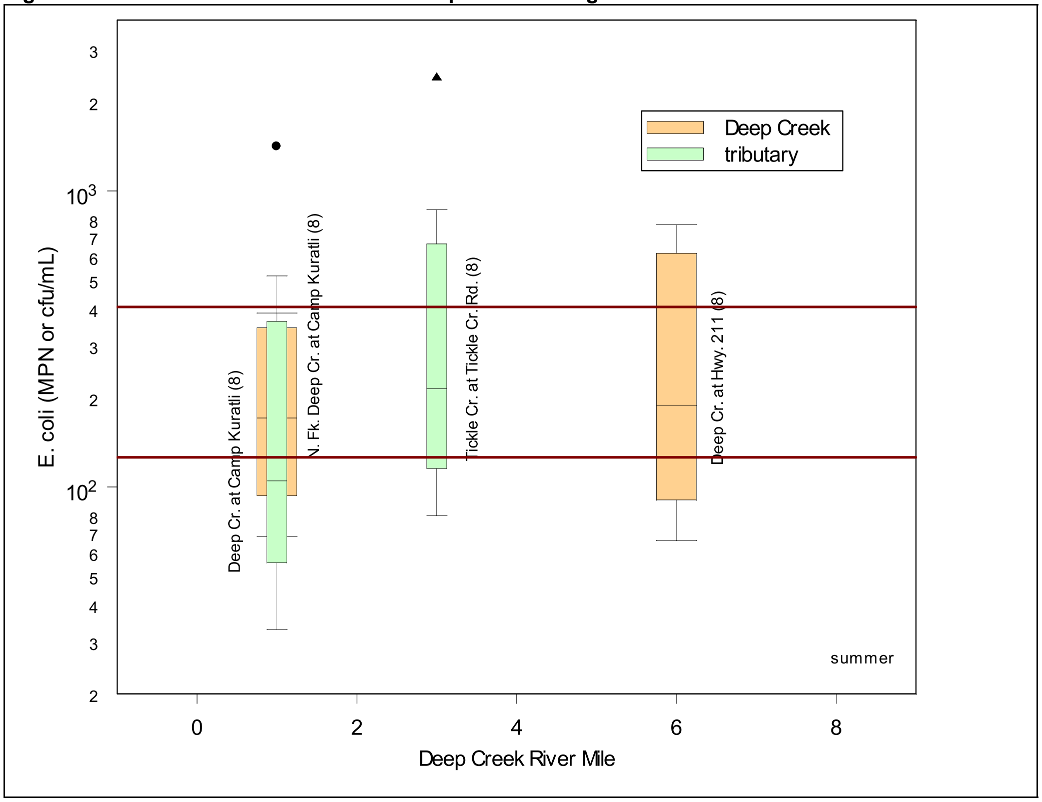
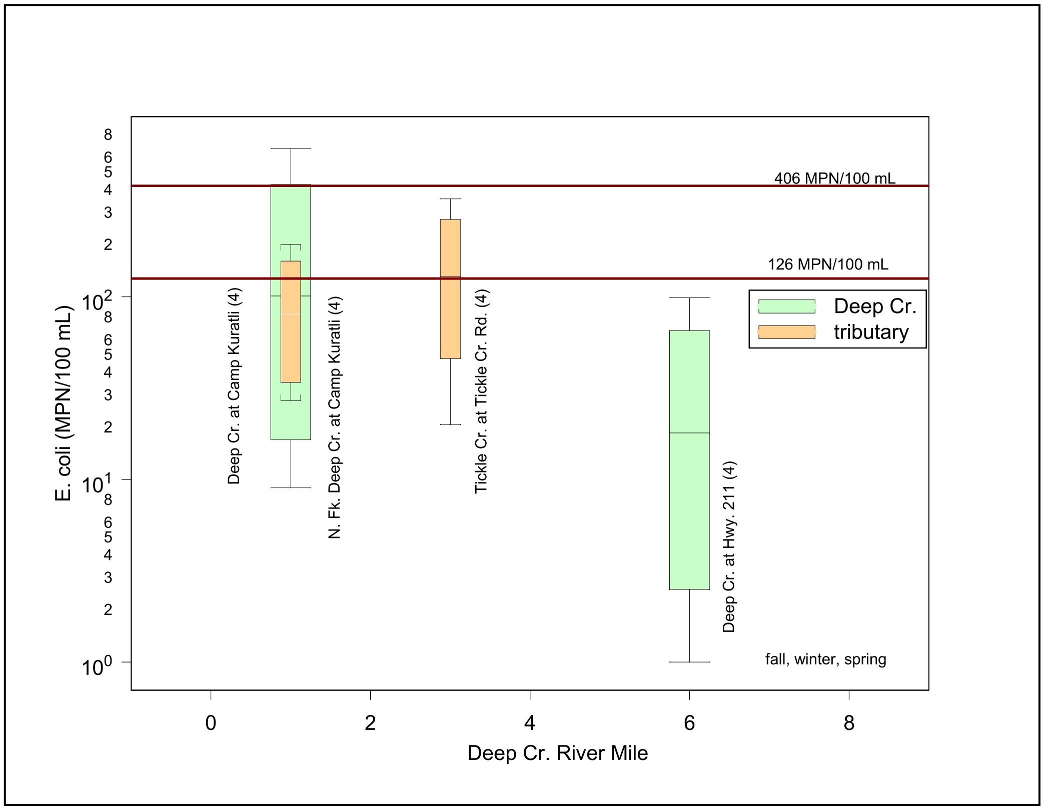


Figure 6.23: Bacteria concentrations in Deep Cr. during fall, winter, spring 2001.



Land uses in the North Fork Deep Creek watershed are mainly rural residential and agricultural. Parcels of land in the town of Boring and around the Highway 26 entrance are zoned industrial or commercial. The Boring WWTP discharges to North Fork Deep Creek at RM 3. Only one year of data is available to evaluate the bacterial concentrations in North Fork Deep Creek (Figure 6.24 and 6.25). Median upstream bacteria concentrations exceeded downstream concentrations during both summer and winter months, but this observation is based on a small sample set (eight and four samples, respectively).

Figure 6.24: Bacteria concentrations in North Fork Deep Creek during summer 2001.

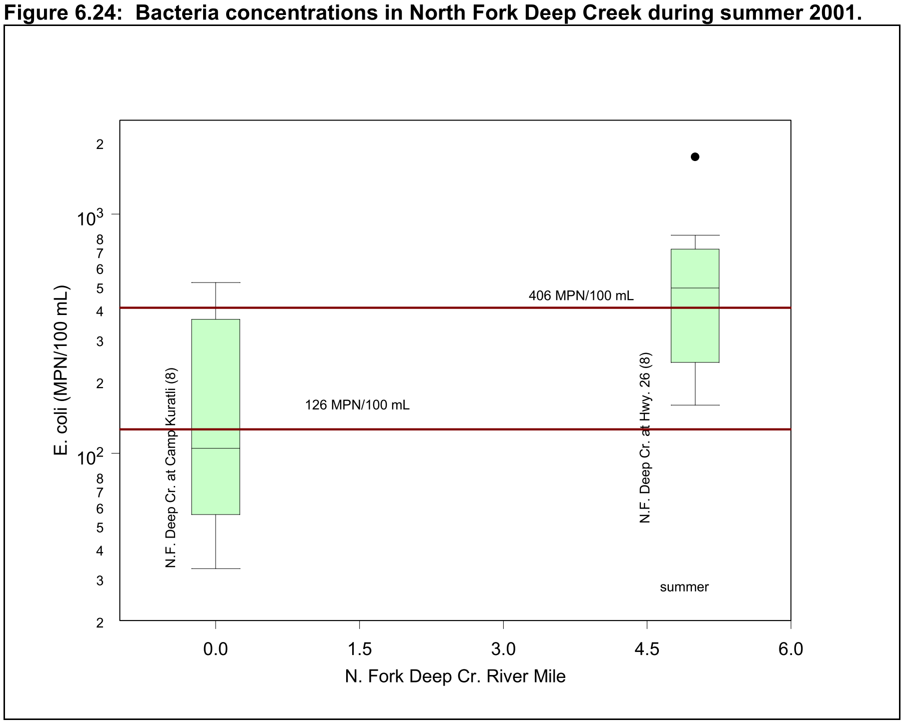
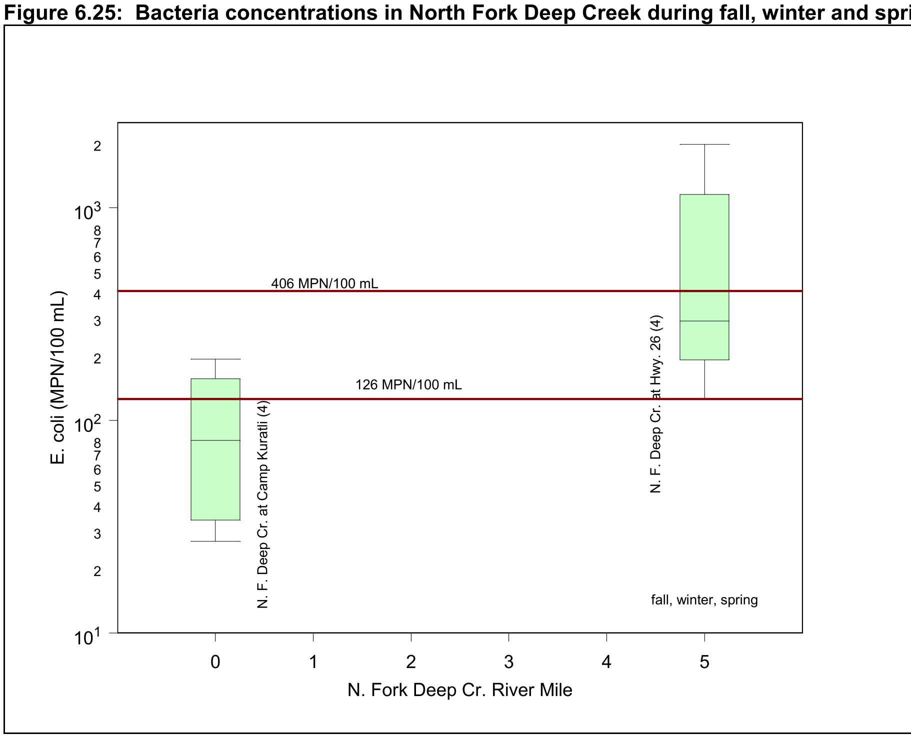


Figure 6.25: Bacteria concentrations in North Fork Deep Creek during fall, winter and spring 2001.



The lower portion of Tickle Creek is surrounded by forestry and agricultural land uses. Land use further upstream is rural residential and industrial/commercial in the town of Sandy. The Sandy WWTP discharges during winter months only at approximately at RM 3. Upstream of Sandy, land use is primarily for agriculture and forestry. Based on eight samples collected in summer 2001, Tickle Creek violates the bacteria standard during those months (Figure 6.26) and bacteria concentrations increase downstream. Sampling during winter months does not indicate wet-weather exceedances, but the data still show an upstream to downstream increase in bacterial concentrations (Figure 6.27).

Figure 6.26: Bacteria concentrations in Tickle Creek during summer 2001.

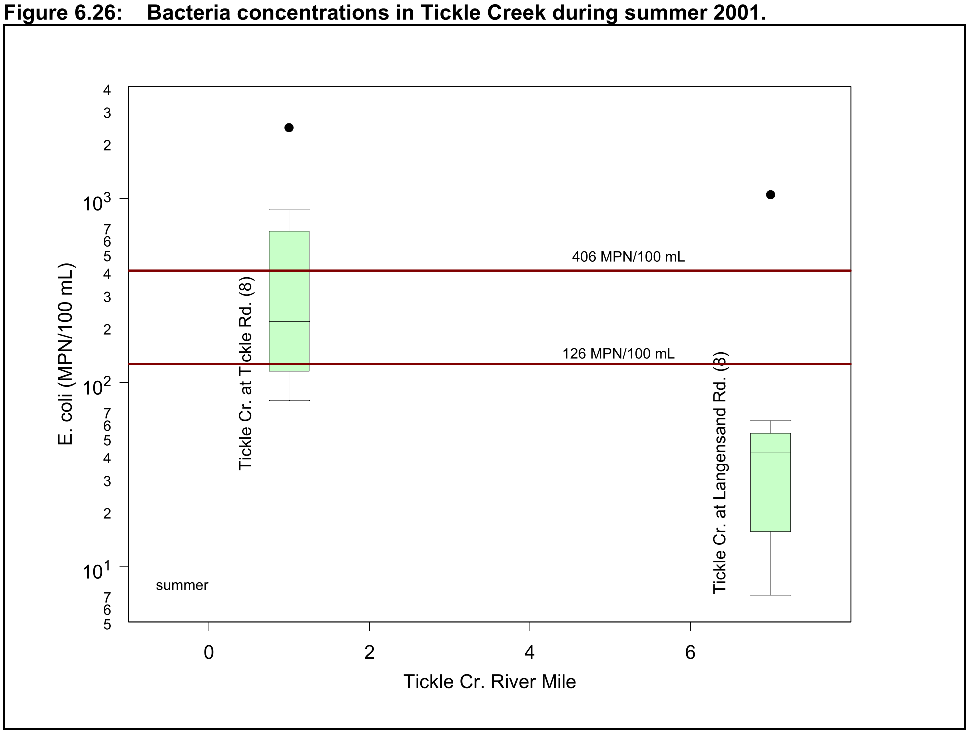
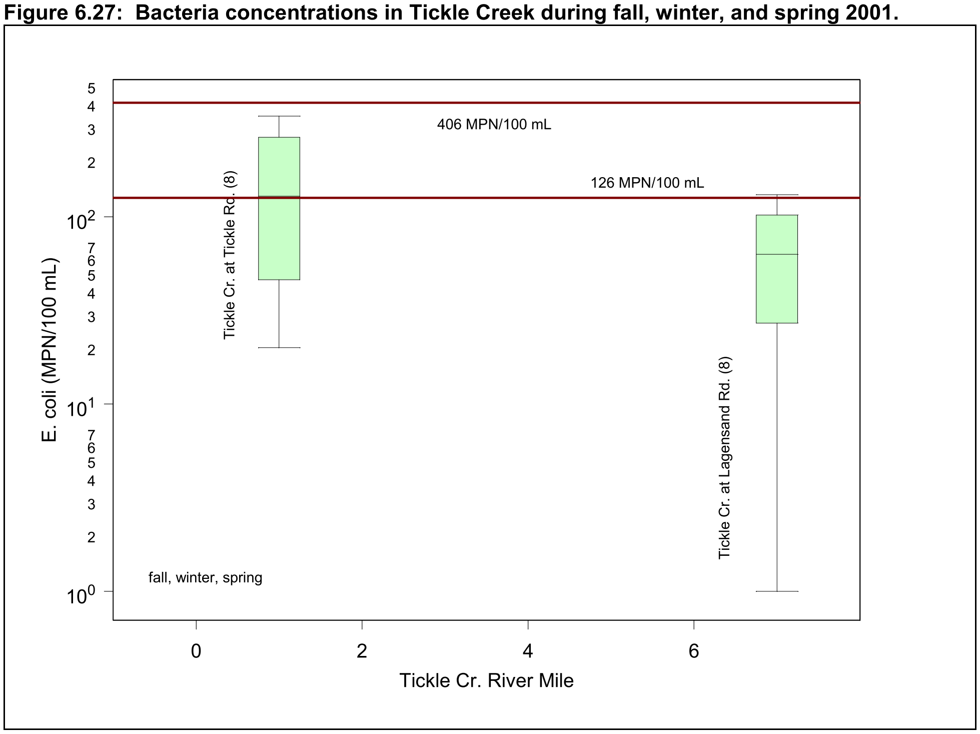


Figure 6.27: Bacteria concentrations in Tickle Creek during fall, winter, and spring 2001.



Bargfeld Creek

Bargfeld Creek is a tributary to Clear Creek, which enters the Clackamas River at RM 8. Land use in the lower portion of Clear Creek (including Bargfeld Creek) is primarily agricultural and rural residential. The data set for Bargfeld Creek (Table 6.22) includes only eight samples collected during the summer (Figure 6.28) and four samples collected in the winter months (Figure 6.29), at one site. The available data for Bargfeld Creek show water quality impairment in both summer and winter months, although the summer violations are more pronounced. Delano Creek enters Clear Creek approximately three miles downstream of Bargfeld Creek; limited Delano Creek sampling indicates both summer and winter water quality impairment. Data collected from Clear Creek does not indicate persistent water quality impairment from bacterial pollution, although one out of eight summer samples at two sites did violate the 406 MPN/100 mL criteria. The data do not indicate water quality violations in Clear Creek downstream of Bargfeld and Delano Creeks.

Bacteria data summary for Clear Creek and tributaries.

	Bargfeld Creek	Summer				Fall-Winter-Spring			
RM	Station	Count	Log Mean	Maximum	Percent >406	Count	Log Mean	Maximum	Percent >406
0.2	Clear Creek at Carver Park	8	27	158	0%	4	17	166	0%
7.2	Clear Creek at Fishers Mill Rd	8	148	1046	13%	4	31	276	0%
18	Clear Cr. at Metzler Park	8	57	435	13%	4	16	249	0%
3.6	Delano Cr. A t RM 3.6 (trib to Clear Creek)	8	1115	2419	63%	3		2419	33%
0.1	Bargfeld Cr. at Fishers Mill Rd (tributary to Clear Cr.)	8	713	2419	63%	4	65	816	50%

Figure 6.28: Bacteria data collected from Clear, Delano, and Bargfeld Creeks during summer 2001. Both Bargfeld and Delano Creeks are tributaries to Clear Creek.

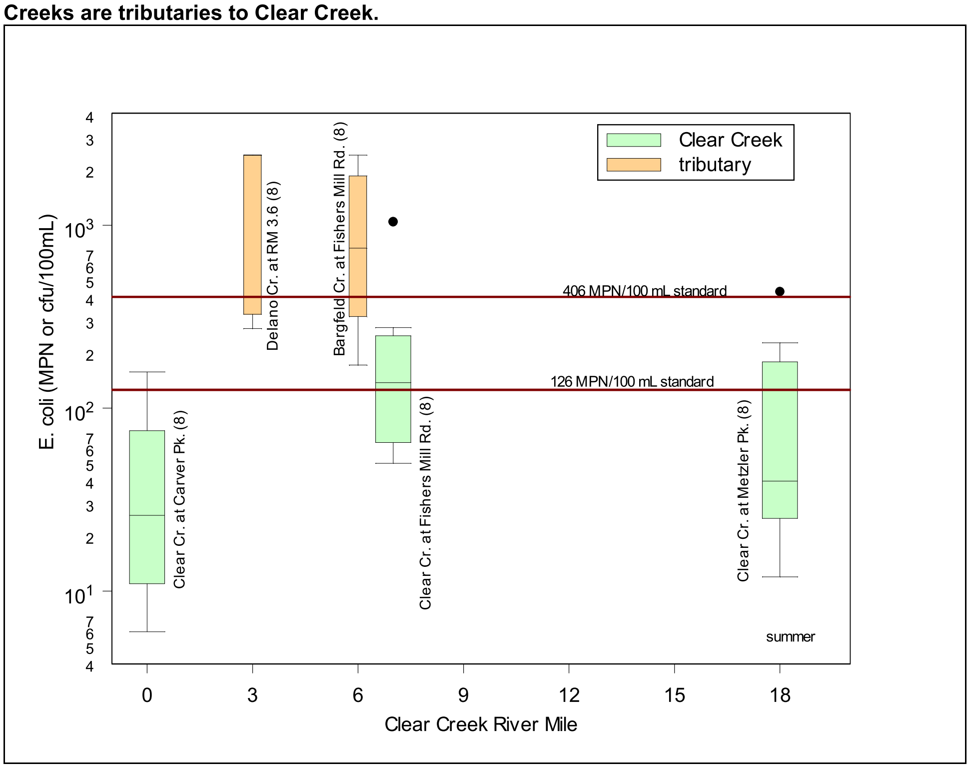
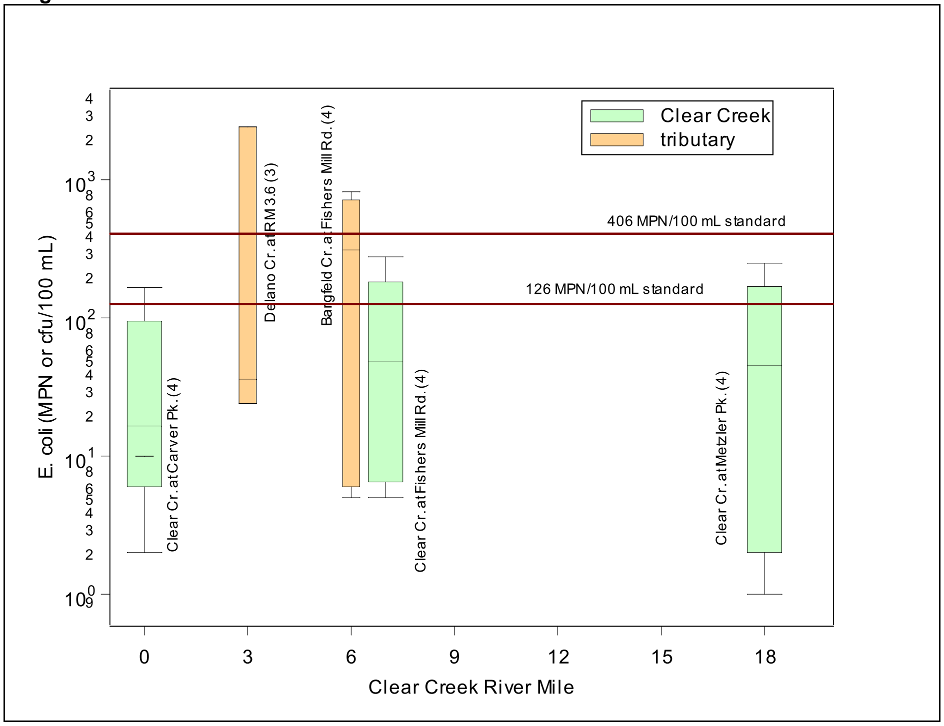


Figure 6.29: Bacteria data collected from Clear, Delano, and Bargfeld Creeks during fall, winter, and spring 2001. Both Bargfeld and Delano Creeks are tributaries to Clear Creek.



Load Duration Curve

ODEQ also reviewed the Clackamas data on a load duration curve. Load duration curves plot the flow exceedance probability versus bacteria load. The exceedance probability is the flow rank over the period of record divided by the total flow records. Low exceedance probabilities (unlikely events) represent high flows and high exceedance probabilities (likely events) represent low flow conditions.

The load duration curve for the Clackamas Subbasin (Figure 6.30) was developed using ODEQ data (High Rocks) combined with Clackamas County data (Highway 99) and flow data from two USGS flow gages (gage# 14211010 at Oregon City and 14210000 at Estacada). Because only one year of daily flow data were available for the Oregon City station, ODEQ first examined the correlation between the Oregon City flow and Estacada flow (where the record exceeds 30 years of data). Correlation between the two stations was better than 97% so ODEQ used the Estacada flow data and the equations that related the Estacada data to the Oregon City data to calculate flows at Oregon City for a period beginning in 1970.

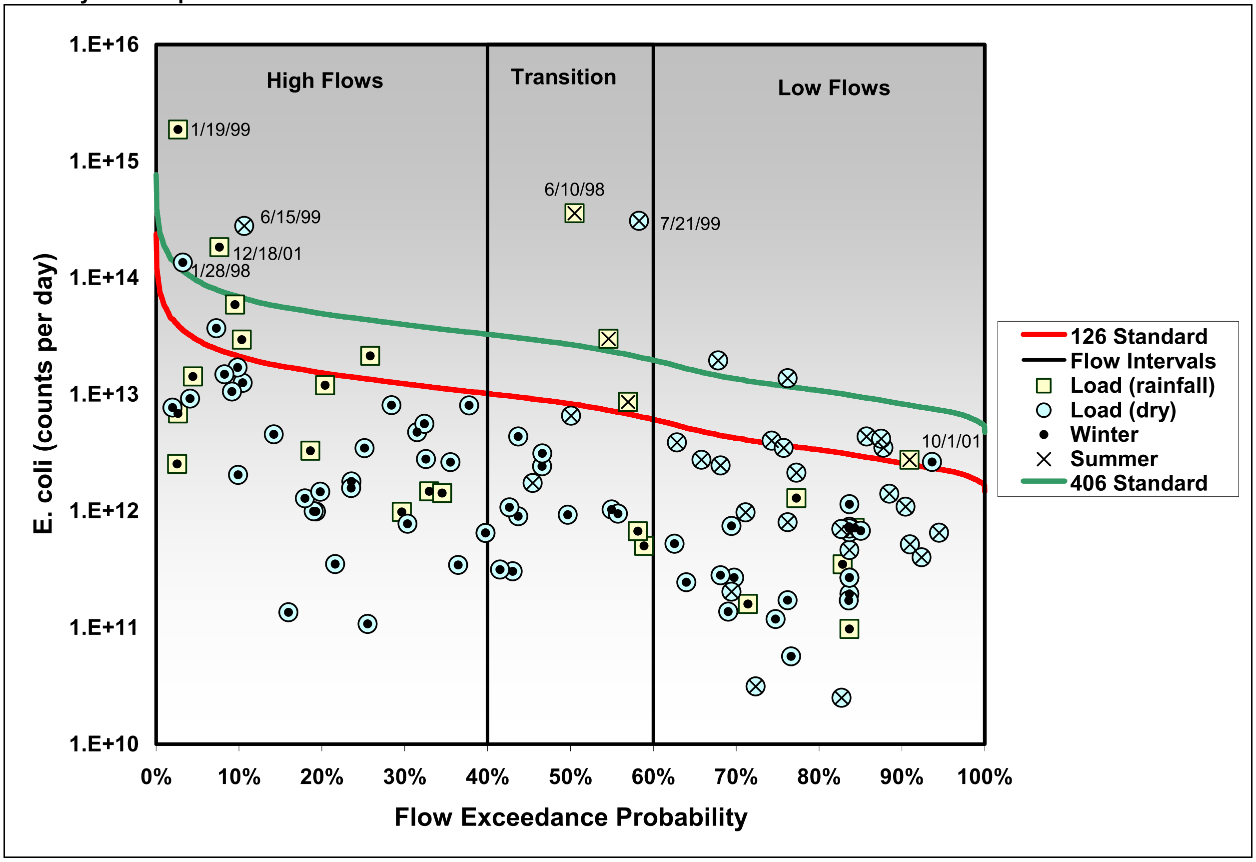
Load Duration Curves

The two plotted lines on the load duration curves indicate the bacteria loads associated with recreational contact standards criteria, and represent the loading capacity of the stream (Figure 6.30). The upper line represents the load of bacteria (y-axis) associated with a flow exceedance probability (x-axis) at an instream concentration of 406 *E. coli* organisms/100 ml. The lower line similarly represents the load for an instream concentration of 126 *E. coli* organisms /100 ml. Bacteria loads that are plotted above these curves indicate loads in excess of the criteria. The curve also illustrates the types of flow regimes associated with violations. The flow exceedance probability is expressed as a percent likelihood that flow rates will exceed a given magnitude. For example, flows that occur at the 10% level are only exceeded 10% of the time. Flow rates are divided into flow regimes representing high, transitional, and low flows. Violations on the right side of the graph occur during low flows, not associated with runoff. Those on the left side of the graph occur during high flows generally associated with rainfall and runoff events.

Approximately 20% of the mainstem Clackamas River calculated bacterial loads exceed the 126 MPN/100 mL loading capacity. Violations occur in all flow regimes, although slightly more violations occur in the summer months (12) than fall/winter/spring months (7). Fall/winter/spring violations, with one exception (on October 1, 2001) are associated with high flow regimes and high rainfall. The greatest calculated load occurred on 1/19/99 when stream flow was twice the long-term daily average and rainfall was more than three times the long-term daily average.

Loads represented by two samples (6/15/99 and 7/21/99) violate the 406 MPN/100 mL despite being collected during a dry period. The June 1999 sample, however, was collected during a period of unusually high flow, especially for late spring. On this day, flow at Estacada was 5170 cfs, more than twice the average flow of 2469 cfs (based on 95 years of record). Flow on 7/21/99 (1740 cfs) was somewhat higher than average (1118 cfs). The greatest summer load was calculated for a sample collected on June 10, 1998, a day when rainfall (0.41 in.) exceeded the average by approximately seven times. Figure 6.34 shows that two winter samples (12/18/01 and 1/28/98) were collected during dry periods, based on rainfall the day of sampling; however, these two samples were collected within two days of high rainfall periods (1.2 to 2.3 inches in preceding five days).

Figure 6.30: Load duration curve for the mainstem Clackamas River with bacteria data collected from High Rocks (old Hwy. 213) and Hwy. 99 bridge sites plotted. Dry and rainfall loads were distinguished as less than or greater than 0.15 inches of rain on the day the sample was collected.



ODEQ typically calculates the load reduction necessary to eliminate log mean violations on the load duration curve. ODEQ did not use that technique in developing the Clackamas bacteria TMDL for two reasons. First, ODEQ did not have sufficient flow data from the tributaries to build load duration curves at the tributary scale. Second, data indicate that the 75th percentile and the logarithmic mean of the mainstem Clackamas bacterial loads are already below the log mean criterion (126 MPN/100 mL), while outliers violate the 406 MPN/100 mL standard. A reduction target to bring all outliers into compliance would not be an appropriate allocation for the purposes of minimizing risk of disease. Moreover, ODEQ has typically applied targets that would meet the log-mean criterion in other TMDLs.

Loading Capacity

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

The loading capacity for the Clackamas Subbasin is in terms of concentrations of *E. coli* bacteria that meet the water quality criteria. The loading capacity is defined as the bacteria water quality criteria as stated in OAR 340-41-0009: a 30-day log mean of 126 *E. coli* organisms / 100 mL, based on a minimum of 5 samples. The loading capacity is applied to all the water bodies in the Clackamas Subbasin. Application of the loading capacity to the subbasin scale reduces bacteria concentrations in water quality limited streams and their tributaries, and protects water contact recreation throughout the Clackamas Subbasin.

Table 6.23 shows the loading capacity to achieve the 126 cfu/100 ml criteria under several flow scenarios. The same information is presented graphically in Figure 6.30, above.

Table 6.23: Flow Based Load Capacity to meet 126 cfu/100 ml *E. coli* criteria

Flow (cfs)	Flow Exceedance Probability	Load to meet geometric mean of 126 cfu/100 ml
719	95%	2.21E+12
1194	75%	3.68E+12
2660	50%	8.20E+12
4398	25%	1.35E+13
9084	5%	2.80E+13

Allocations

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

Allocations are applied year-round because violations occur during both summer and winter periods and in all flow regimes. The allocations are designed to protect the sensitive beneficial use, water contact recreation.

Wasteload Allocations

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

A Waste Load Allocation (WLA) is the amount of pollutant that a point source can contribute to the stream without exceeding water quality standards. The WLAs for wastewater treatment facilities included in Table 6.23 require effluent to comply with the bacteria standard. The current NPDES permit limits are based on the *E.coli* water quality standard and the allocations will remain at that level. Any new, expanded, or unlisted point source would be required to comply with this concentration limit. The WLAs for CAFOs would remain at 0. The following table (Table 6.24) outlines the NPDES permit requirements.

Table 6.24: Wasteload Allocations for Wastewater Treatment Plants (WWTP) and Confined Animal Feeding Operations (CAFO). CAFO loads are limited by existing permit requirements.

Facility	Receiving Water	River Mile	Geometric Mean Limit MPN/100 ml *E. coli*	Instantaneous Limit MPN/100 ml *E. coli*
Boring WWTP	North Fork Deep Cr.	3	126	406
Sandy WWTP	Tickle Cr.	3.1	126	406
Estacada WWTP	Clackamas R.	23.3	126	406
Timberlake WWTP	Clackamas R.	51.1	126	406
Confined Animal Feeding Operations (CAFO)[a]	Various	NA	0	0

a= CAFOs are allowed zero discharge from confinement, storage, or concentration areas under terms of NPDES permit.

Load Allocations

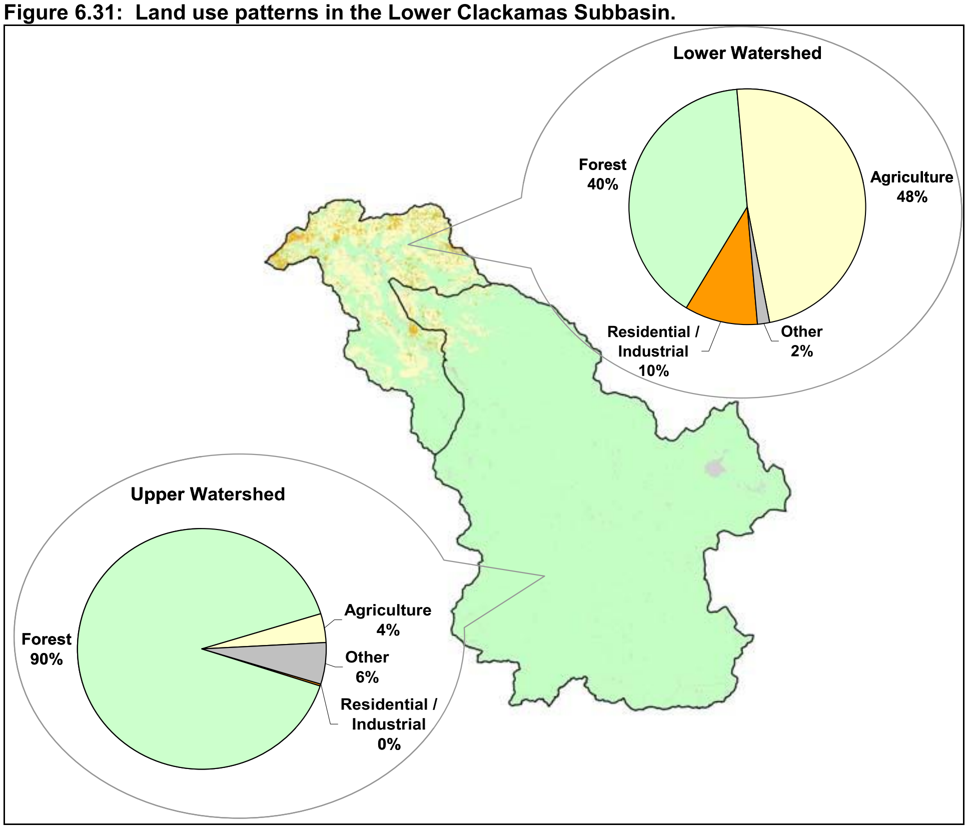
OAR 340-042-0040(4)(h)

A Clackamas Subbasin percent reduction has been allocated for all urban and agricultural land uses. The subbasin percent reductions are based on the percent reductions applied in the adjacent Johnson Creek watershed (Lower Willamette TMDL, Chapter 5). This regional application was justified by similar land use mixtures (rural residential/agriculture blending into dense urban) and because patterns and timing of violations in the lower Clackamas and its tributaries did not suggest that one source or weather condition was primarily responsible for violations.

Predominant land uses in the lower Clackamas that are likely to contribute bacterial contamination (Figure 6.31) are urban (Cow Creek, Sieben Creek, lower Rock Creek) and mixed rural residential and agriculture

(Rock, Deep, North Fork Deep, Bargfeld, and Tickle Creeks). Violations occur in each of these land uses as well as in areas of mixed use, and ODEQ did not observe a pattern to distinguish violations in mostly urban areas from rural and agricultural. Bacterial concentrations in the urban tributaries were greater than those measured in the rural/mixed use tributaries, but that may reflect more intensive and longer-term data collection in the urban tributaries.

Figure 6.31: Land use patterns in the Lower Clackamas Subbasin.



Without sufficient flow data for the tributaries to build specific load duration curves, bacterial loading responses to flows are unknown. In general, the creeks receiving urban runoff (Cow and Sieben Creeks, and to a lesser extent Rock Creek) show lower mean bacterial concentrations in winter, but more outliers that exceed the 406 MPN/100 mL criterion (the basis for the listing). Creeks in predominantly agricultural/rural areas show slightly greater mean bacterial concentrations in the summer, but this interpretation is based on eight or fewer samples at each site, all collected during the same year. While highest tributary bacterial concentrations tend to coincide with low flow, dry periods, on at least two dates (6/11/01 and 7/30/01) when multiple tributary violations were measured, precipitation fell at several times the long-term average (0.24 and 0.62 inches, respectively). Those limited data suggest that surface runoff may be responsible for bacterial contamination in tributary streams, even during summer months.

Similar to the Johnson Creek analysis, data indicate that there are multiple sources of bacteria that enter the Clackamas River and its tributaries via a variety of pathways. For example, if violations were only occurring during summertime, low-flow conditions, likely sources would include failing septic systems and livestock (or pets) in or near the stream and/or cross connections between sanitary and storm sewer systems. Conversely, a majority of violations during higher flows and rainfall events would suggest sources such as urban stormwater and poor manure management. Since violations occur under all flow conditions, year round, and in the presence and lack of rainfall, many or all of the sources listed above are likely contributing to the bacteria problem in the Clackamas River and its tributaries.

The analysis completed for the Clackamas Subbasin TMDL does not indicate the need for different bacteria reduction targets for urban and agricultural land uses. Unless and until additional source assessment work clearly distinguishes between urban and agricultural bacteria loads, a single percent reduction that applies to both urban and agricultural land uses will be applied with two exceptions: ODEQ will apply more stringent reductions in two tributaries because a limited data set indicates such reductions are necessary to bring those streams into compliance. ODEQ does not apply the reduction targets to forestry land uses because the data locally and from around the state indicate forestry land uses are not significant sources of fecal bacterial contamination.

With exceptions of Bargfeld and Delano Creeks (Table 6.25), ODEQ will apply the Johnson Creek percent reduction in load (78%) subbasin-wide to agricultural and urban land uses as a conservative assumption to meet the log-mean criterion. This reduction was based on a rigorous analysis in the Johnson Creek watershed of bacterial concentrations in a number of sites representing urban and agricultural land uses. ODEQ believes that this approach is protective of beneficial uses and will aid in implementation of the TMDL because it sets a tangible goal for nonpoint source management practices and programs.

Table 6.25: Sample populations after applying 78% reduction. Higher reductions were applied if necessary to bring the log mean concentrations into compliance. Statistics were not calculated on sample sets containing fewer than four samples.

Station	% reduction	Summer		Fall-Winter-Spring	
		Count	Log Mean	Count	Log Mean
Clackamas River d/s RM 15	78	47	14	107	4
Sieben Creek	78	34	67	96	29
Cow Creek	78	38	82	127	11
Rock Creek	78	33	29	38	27
Deep Creek and tributaries					
Deep Cr.	78	16	48	8	6
N. Fk. Deep Cr.	78	16	53	8	36
Tickle Cr.	78	16	24	8	11
Clear Cr. and tributaries					
Clear Cr.	78	24	13	12	4
Bargfeld Cr. *	83	8	126	4	14
Delano Cr. *	89	8	126	3	

* Required greater than 78% reduction to attain standard.

Applying a 78% reduction to the mainstem Clackamas samples downstream of RM 15 (data do not indicate violations further upstream) will bring the stream into compliance (Table 6.25). Applying a 78% reduction to data collected from the tributary streams brings all log mean concentrations into compliance except those measured in Bargfeld and Delano Creeks in the summer. In these cases, 83% and 89% reductions, respectively, are necessary to bring log mean concentrations into compliance. It is unclear whether there is a true difference in conditions in Bargfeld and Delano Creeks that would require a separate allocation. There were very few samples on which to base assessment, and further monitoring may indicate these creeks are similar to the others in the subbasin. The application of more stringent allocations reflects this need to both better assess and possibly further reduce bacterial concentrations in Bargfeld and Delano Creeks.

With the noted exceptions, the 78% reduction applies to urban and agricultural land use subbasin-wide, regardless of water quality limited status (i.e., whether on a 303(d) listed reach or not). This application of the allocation allows newly discovered sources of bacteria to be addressed by the current TMDL rather than requiring additional future TMDL development.

Several of the mainstem samples that would require more than a 78% reduction were collected during periods of unusually high rainfall or stream flow for the season (6/10/98, 9/17/96, 7/21/99, and 6/25/96). ODEQ does not believe that the conditions under which these samples were collected are representative of expected summer conditions and assumes the 78% reduction (and 83 – 89% reductions on Bargfeld and Delano Creeks) will sufficiently protect water quality. In the case of Delano Creek, Bargfeld Creek, and North Fork Deep Creek, few data (eight samples each, all collected the same summer or winter) were available. A monitoring strategy to more fully characterize mainstem and tributary water quality will be set up as part of implementation.

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

The Clackamas Subbasin bacteria TMDL incorporates measures other than "*daily loads*" to fulfill requirements of §303(d). Allocations are in terms of percent reduction in instream concentrations needed to achieve the numeric criterion for protection of recreational contact; a log-mean of 126 *E. coli* organisms/100 mL. Percent reductions are applied to each water quality limited stream and for other areas of the subbasin. The percent reduction translates load allocations into more applicable measures of performance, a percent reduction of in-stream bacteria counts. This TMDL allocates "*other appropriate measures*" (or surrogates measures) as provided under USEPA regulations [40 CFR 130.2(i)].

Margins of Safety
OAR 340-042-0040(4)(i), CWA §303(d)(1)

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS). The statutory requirement that TMDLs incorporate a MOS is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A MOS 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 MOS may be implicit, as in conservative assumptions used in calculating the loading capacity, Waste Load Allocation, and Load Allocations. The MOS may also be explicitly stated as an added, separate quantity in the TMDL calculation. In either case, assumptions should be stated and the basis behind the MOS documented. The MOS is not meant to compensate for a failure to consider known sources. Table 6.26 presents six approaches for incorporating a MOS into TMDLs.

Table 6.26: 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 MOS.
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.

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 MOS, which results in an overall allocation, represents the best estimate of what pollutant levels can be without violating water quality criteria. The selection of the MOS 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.

The margin of safety applied to the bacteria TMDL for the Clackamas Subbasin is implicit in assumptions made about the surrogate measure and percent reduction. In calculating the necessary Johnson Creek bacteria reduction (on which the Clackamas Subbasin reduction is based), ODEQ applied the margin of safety through the conservative calculation of the 75^{th} percentile to compare to the 126 *E. coli* counts/100 mL log mean criteria. 75^{th} percentile values were generally equal to or greater than the log mean values of the same data sets. The use of this “overestimation” of the log mean for purposes of defining percent reductions results in a slight overestimation of the needed reduction, giving an appropriate margin of safety to protect against underestimation of the mean.

Reserve Capacity

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

No reserve capacity is allotted at this time for bacteria in the Clackamas Subbasin water bodies. Future permitted sources of bacteria will be required to meet the water quality criteria of 126 *E. coli* organisms/100 ml as a geometric mean and no sample greater than 406 *E. coli* organisms/100ml.

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