CHAPTER 2 :
WILLAMETTE BASIN BACTERIA TMDL

TABLE OF CONTENTS

OVERVIEW

The Willamette River receives water from tributary watersheds between the Cascade and Coast Ranges. The Willamette Valley, formed by these mountain ranges, their tributaries, and interaction with the Columbia River, covers 11,400 square miles (29,000 km^2) of western Oregon. Headwaters of the Willamette River are in several watersheds, including the Middle Fork and Coast Fork Subbasins. The mainstem of the Willamette River forms at the confluence of the Middle Fork Willamette River and the Coast Fork Willamette River. The river then travels almost 190 miles to drain to the Columbia River.

Major tributaries to the Willamette River include the Calapooia, McKenzie, Santiam, Molalla, Yamhill, Tualatin and Clackamas Rivers and Johnson Creek. Much of the Valley bottom is included within the Lower, Middle and Upper Willamette Subbasins that have connections to the surrounding subbasins, but also drain directly to the Willamette River through small creeks and overland flow. The land use in these subbasins is varied, but consists primarily of forestland, agricultural land, and urban development. Urban development is scattered throughout the basin, but the largest urban areas are within the Lower, Middle and Upper Willamette Subbasins.

Total Maximum Daily Loads (TMDLs) have been developed for the mainstem of the Willamette River which require reductions in loading from several land use sectors throughout the basin. This chapter details the current conditions, modeled sources, and reductions necessary for compliance with water quality standards in the mainstem of the Willamette River. The details of reductions in tributaries to the Willamette River are presented in Chapters 5-13 of this document which contain detailed subbasin analysis.

Water Quality Summary

Water quality impairments due to bacteria vary in scale throughout the Willamette Basin. Violations are common in creeks that drain urban and agricultural land and discharge to the Willamette River. These sources of bacteria are addressed in the individual subbasin TMDL documents following this chapter. The 2002 303(d) list identified river miles (RM) 0 to about 149 of the Willamette River as not attaining the applicable bacteria criteria to support water contact recreation during fall-winter-spring months. The river is not listed as water quality limited in summer and assessment of the available data confirms its compliance. Observed fall-winter-spring water quality violations in the Willamette River above Willamette Falls are very subtle, and are limited to rare violations of the single sample maximum concentration at a few sites. Below Willamette Falls, violations are more common and are consistent with known sources of bacteria from combined sewer overflows, spills from pump stations, and other sources of urban runoff.

BACTERIA TMDL

A total maximum daily load (TMDL) has been developed for the mainstem of the Willamette River including all reaches listed as water quality limited on the 2002 303(d) list. The TMDL includes an analysis of current conditions, loading capacity, excess loading due to anthropogenic sources, and wasteload and load allocations for controllable sources of bacteria (Table 2.1). Separate TMDL documents have been developed for some of the subbasins that discharge to the Willamette River and are included in Chapters 5-13. Load allocations have been developed specifically for land uses in some of these subbasins, and composite load allocations have been applied to other subbasins to allow for nonpoint source control planning to proceed ahead of development of additional subbasin-specific TMDLs.

Table 2. 1 TMDL Summary for Mainstem Reaches of the Willamette River.

Waterbodies **OAR 340-042-0040(4)(a)**	The Willamette River mainstem as it flows though, Hydrologic Unit Codes (HUCs) 17090001, 17090002, 17090003, 17090007, and 17090012, providing beneficial uses as defined in OAR 340-41, water contact recreation.
Pollutant Identification **OAR 340-042-0040(4)(b)**	Pollutants: Human pathogens from various sources. *E. coli* is currently used as an indicator of human pathogens to protect recreational contact. Prior to 1996, fecal coliform bacteria were used as an indicator of human pathogens.
Beneficial Uses **OAR 340-042-0040(4)(c)** **OAR 340-41**	Water contact recreation.
Target 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.
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.
Seasonal Variation **OAR 340-042-0040(4)(j)** ***CWA §303(d)(1)***	Violations of the bacteria criteria have occurred during the fall, winter and spring from the river mouth to approximately river mile 149.
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 loading rate that will achieve the 126 *E. coli* organisms per 100 ml water quality criteria under all flow conditions, thereby protecting beneficial uses. Waste Load Allocations (Point Sources): Waste load allocations for waste water treatment plants are expressed as the numeric criterion (126 *E.coli* organisms/100 ml) multiplied by the applicable flow. City of Portland Combined Sewer Overflows were given an allocation for only those times authorized under the Environmental Quality Commission Order which will meet the 126 *E. coli* organisms per 100 ml water quality criteria. Municipal stormwater waste loads (under a MS4 permit) were given a percent reduction. Load Allocations (Nonpoint Sources): Load allocations are expressed as a percent reduction necessary to meet the numeric criteria. 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 and MS4 Waste Load Allocations* Allocations are in terms of percent reduction needed to achieve the numeric criteria. This translates load and MS4 waste load allocations into more applicable measures of 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 conservative selection of percent reduction of current *E. coli* counts. No numeric margin of safety is developed.
Reserve Capacity **OAR 340-042-0040(4)(k)**	Future sources will be required to meet water quality criteria prior to 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.

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

ODEQ must establish a Total Maximum Daily Load (TMDL) for any waterbody designated on the 303(d) list as violating water quality criteria for bacteria. A TMDL is the total amount of a pollutant, from all sources, that can enter a specific waterbody without violating water quality criteria. The pollutant causing impairment is pathogenic microorganisms including bacteria, viruses, and protozoa that cause disease when ingested by people. The presence of these pathogens has traditionally been determined by their association with "indicator" bacteria that are more readily measured. In Oregon standards and this TMDL, *Escherichia coli* (*E. coli)*, a species within the category of fecal coliform bacteria is the indicator used for determining compliance and setting load allocations. These bacteria live in the gastrointestinal tract of warm-blooded vertebrate animals and are shed in their feces. The most typical *E. coli* strains do not cause illness; rather they indicate sources that are likely to include other pathogens that do cause human illness.

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

This bacteria TMDL is designed to protect beneficial uses. Beneficial uses of water are defined for each basin within Oregon in Oregon Administrative Rules (OAR) at OAR 340-41-340. Uses specifically affected by elevated fecal bacterial concentrations are recreational contact in freshwater and shellfish harvesting in estuarine and marine waters. This TMDL is only concerned with recreational contact as the Willamette Basin has no estuarine or marine waters.

Elevated concentrations of fecal bacteria can indicate an impairment of the recreational use of waters. USEPA determined through epidemiological studies that using the *E coli* bacteria as an indicator group at a geometric (or log mean) of 126 organisms per 100 ml would result in an estimated 8 illnesses per 1,000 swimmers. (USEPA 1986) Bacterial criteria for Oregon's waters are contained in the Oregon Administrative Rules, section 340-41-0009.

Target Identification
OAR 340-042-0040(4)(c), CWA § 303(d)(1)

Several reaches of the Willamette River and its tributaries are listed as water quality limited under section 303(d) of the federal Clean Water Act (DEQ 2003). The 303(d) listings are based on the bacteria standard in effect prior to 1996. The freshwater criteria were based on fecal coliform bacteria as indicator organisms as follows:

> A log mean of 200 fecal coliform per 100 ml based on a minimum of five samples in a 30-day period with no more than ten percent of the samples in the 30-day period exceeding 400 per 100 ml.

The present analysis and TMDL are based on the current bacteria standard, which was adopted in 1996 and is based on *E. coli* as an indicator organism. *E. coli* is a species contained within the larger group of fecal coliform bacteria. This standard was reorganized and revised as **OAR 340-41-0009** in 2003, though it is substantively identical to the language adopted in 1996. Applicable numeric and narrative criteria for this standard are:

> (1) Numeric Criteria: Organisms of the coliform 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 (a) and (b) of this paragraph.
> (a) Freshwaters and Estuarine Waters Other than Shellfish Growing Waters:
> (A) A 30-day log mean of 126 *E. coli* organisms per 100 ml, based on a minimum of five (5) samples;
> (B) No single sample shall exceed 406 *E. coli* organisms per 100 ml.

(2) Raw Sewage Prohibition: No sewage shall be discharged into or in any other manner be allowed to enter waters of the state unless such sewage has been treated in a manner approved by the Department or otherwise approved by these rules;

(4) Bacterial pollution or other conditions deleterious to waters used for domestic purposes, livestock watering, irrigation, bathing, or shellfish propagation, or otherwise injurious to public health shall not be allowed;

Additional language in the state water quality standards applies to sanitary sewer overflows and to facilities with combined sanitary and storm sewers:

(6) Sewer Overflows in Winter: Domestic Waste collection and treatment facilities are prohibited from discharging raw sewage to waters of the State during the period of November 1 through May 21, except during a storm event greater than the one-in-five year, 24-hour, duration storm. However, the following exceptions apply:
(a)The Commission may on a case-by-case basis approve a bacteria control management plan to be prepared by the permittee, for a basin or specified geographic area which describes hydrologic conditions under which the numeric bacteria criteria would be waived. These plans will identify the specific hydrologic conditions, identify the public notification and education processes that will be followed to inform the public about an event and the plan, describe the water quality assessment conducted to determine bacteria sources and loads associated with the specified hydrologic conditions, and describe the bacteria control program that is being implemented in the basin or specified geographic area for the identified sources;

Although summer overflows are not an apparent source of violations in the Willamette River, similar language in Oregon Administrative Rules (340-041-0009(7)) regulates these sources.

The 30-day log mean of 126 *E. coli* organisms per 100 milliliters criterion was used as the target concentration in the TMDL for determining the loading capacity of a waterbody. This criterion most directly relates to illness rates[1] and potential impacts on the beneficial use of water contact recreation.

Water Quality Limited Waterbodies

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

Waterbodies that do not meet one or more criteria of a water quality standard are considered water quality limited. The State of Oregon submits a list of waterbodies that do not meet standards to the US Environmental Protection Agency (USEPA) as required under Section 303(d) of the federal Clean Water Act. Currently, there are five reaches of the Willamette River considered as water quality limited during fall-winter-spring due to excessive concentrations of fecal coliform bacteria (Table 2.2, Map 2.1). Based on data used for the original listings, the frequency of exceedance decreased with distance from the Portland Metro Area. Violations near the mouth of the river occurred in approximately 30 to 40% of samples, while violations decreased to 12% of samples at river mile (RM) 131 near Corvallis. More recent data indicates much lower violation rates, with those in the upper reach near Corvallis essentially eliminated. There are also 13 other waterbodies that are tributary to the Willamette River and are listed as water quality limited at some time of the year. These latter waterbodies will be discussed briefly below, but are treated in detail in other chapters of this document.

[1] From Implementation Guidance for Ambient Water Quality Criteria for Bacteria (USEPA, EPA-823-B-02-003, May 2002 Draft, pg 7): "For the purpose of analysis, the data collected at each of these sites were grouped into one paired data point consisting of an averaged illness rate and a geometric mean of the observed water quality. These data points were plotted to determine the relationships between illness rates and average water quality (expressed as a geometric mean). The resulting linear regression equations were used to calculate recommended geometric mean values at specific levels of protection (e.g., 8 illnesses per thousand). Using a generalized standard deviation of the data collected to develop the relationships and assuming a log normal distribution, various percentiles of the upper ranges of these distributions were calculated and presented as single sample maximum values.

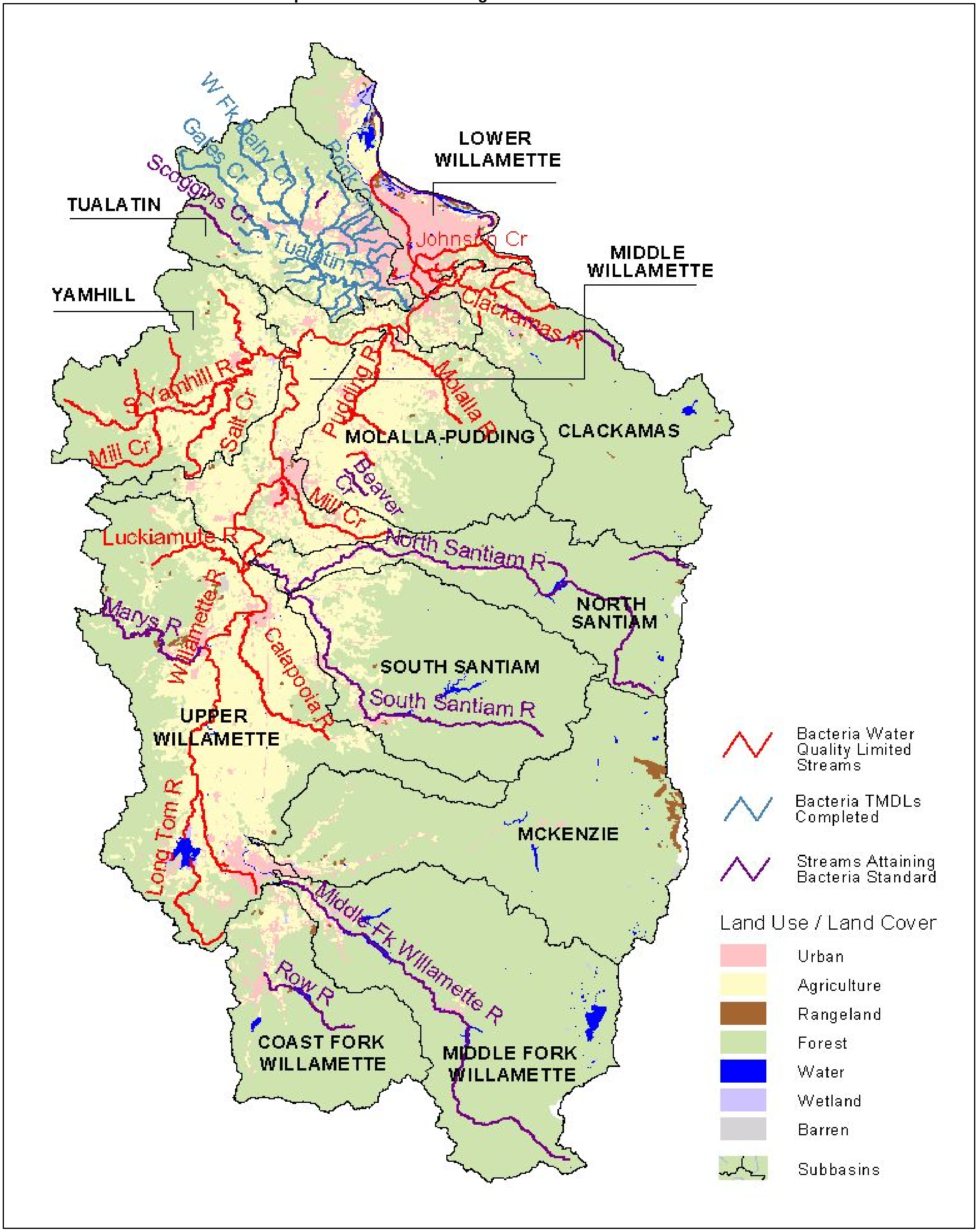
Current analysis and TMDL load allocations are based on *E. coli* data collected since 1996 and relative to the current water quality criteria. All listed waterbodies other than the Willamette River itself, are included in TMDLs for other subbasins. Listed waterbodies other than the Willamette River in the Lower, Middle, and Upper Willamette Subbasins were specifically analyzed and load allocations developed for tributary streams.

Table 2. 2 Waterbodies [a] in the Willamette Basin Listed as Water Quality Limited Due to Elevated Fecal Bacterial Concentrations.

Waterbody	Subbasin	Boundary	River Miles (RM)	Season
Willamette River	Lower Willamette	Mouth to Willamette Falls	0 to 25	Fall/Winter/Spring
Willamette River	Middle Willamette	Willamette Falls to Yamhill River	25 to 55	Fall/Winter/Spring
Willamette River	Middle Willamette	Yamhill River to Santiam River	55 to 108	Fall/Winter/Spring
Willamette River	Upper Willamette	Santiam River to Calapooia River	108 to 120	Fall/Winter/Spring
Willamette River	Upper Willamette	Calapooia River to Long Tom River	120 to 149	Fall/Winter/Spring
Bashaw Creek	Middle Willamette	Mouth to Headwaters	0 to 4.8	All Year
Clackamas River	Clackamas	Mouth to RM 15	0 to 15	Summer
Clark Creek	Middle Willamette	Mouth to Headwaters	0 to 1.9	All Year
Johnson Creek	Lower Willamette	Mouth to RM 23.7	0 to 23.7	All Year
Mill Creek	Middle Willamette	Mouth to Headwaters	0 to 25.7	All Year
Pringle Creek	Middle Willamette	Mouth to RM 6.2	0 to 6.2	All Year
A-3 Drain	Upper Willamette	Mouth to Headwaters		All Year
Amazon Creek	Upper Willamette	Mouth to RM 22.6	0 to 22.6	All Year
Amazon Diversion Canal	Upper Willamette	Mouth to Headwaters	0 to 1.8	All Year
Calapooia River	Upper Willamette	Mouth to Brush Creek	0 to 42.8	Fall/Winter/Spring
Coyote Creek	Upper Willamette	Mouth to Headwaters	0 to 26.6	All Year
Fern Ridge Reservoir	Upper Willamette		24.2 to 31.8	Fall/Winter/Spring
Long Tom River	Upper Willamette	Mouth to Fern Ridge Reservoir	0 to 24.2	Fall/Winter/Spring
Luckiamute River	Upper Willamette	Mouth to Pedee Creek	0 to 31.7	Fall/Winter/Spring
Marys River	Upper Willamette	Mouth to Greasy Creek	0 to 13.9	Fall/Winter/Spring

a = Additional listings for waterbodies in Columbia Slough and the Tualatin Subbasin were reclassified in the 2002 303(d) list following adoption of TMDLs in these subbasins. Current Listings in the Molalla-Pudding, and Yamhill subbasins will be addressed in future TMDLs.

Map 2.1 Bacteria listings in the Willamette Basin



Current Conditions

The analysis of Willamette River *E. coli* concentrations in the mainstem of the Willamette River was based on 10 ambient monitoring stations that have a long-term record of regular sampling (Map 2.2). Data from an additional 17 ambient monitoring stations on major tributaries to the Willamette River were used to estimate loading to the mainstem. The distribution of sample concentrations is the basis of determining whether water quality criteria are violated. *E. coli* sample distributions are presented in box and whisker plots, as described in Figure 2.1 Box-and-whisker plots are used to illustrate the distribution of data collected through time by comparing counts seasonally at the same site or among sites. The median, which is similar to a geometric mean for most bacteria datasets, is clearly indicated on the plots as the middle value among ranked samples. The fat portion of the bar represents 25% of the sample values above and below the median (for a total of 50% of the sample values). Under most circumstances, all values are within the "whisker" bars, though the natural variability in bacterial concentrations often results in "outlier" values beyond these limits. The examples in Figure 2.1 show two box-and-whisker plots and the method to interpret their data distributions. See also Appendix A.

Map 2.2 303(d) listings, river miles, and monitoring sites included in the Model of Loading for the Mainstem Willamette River.

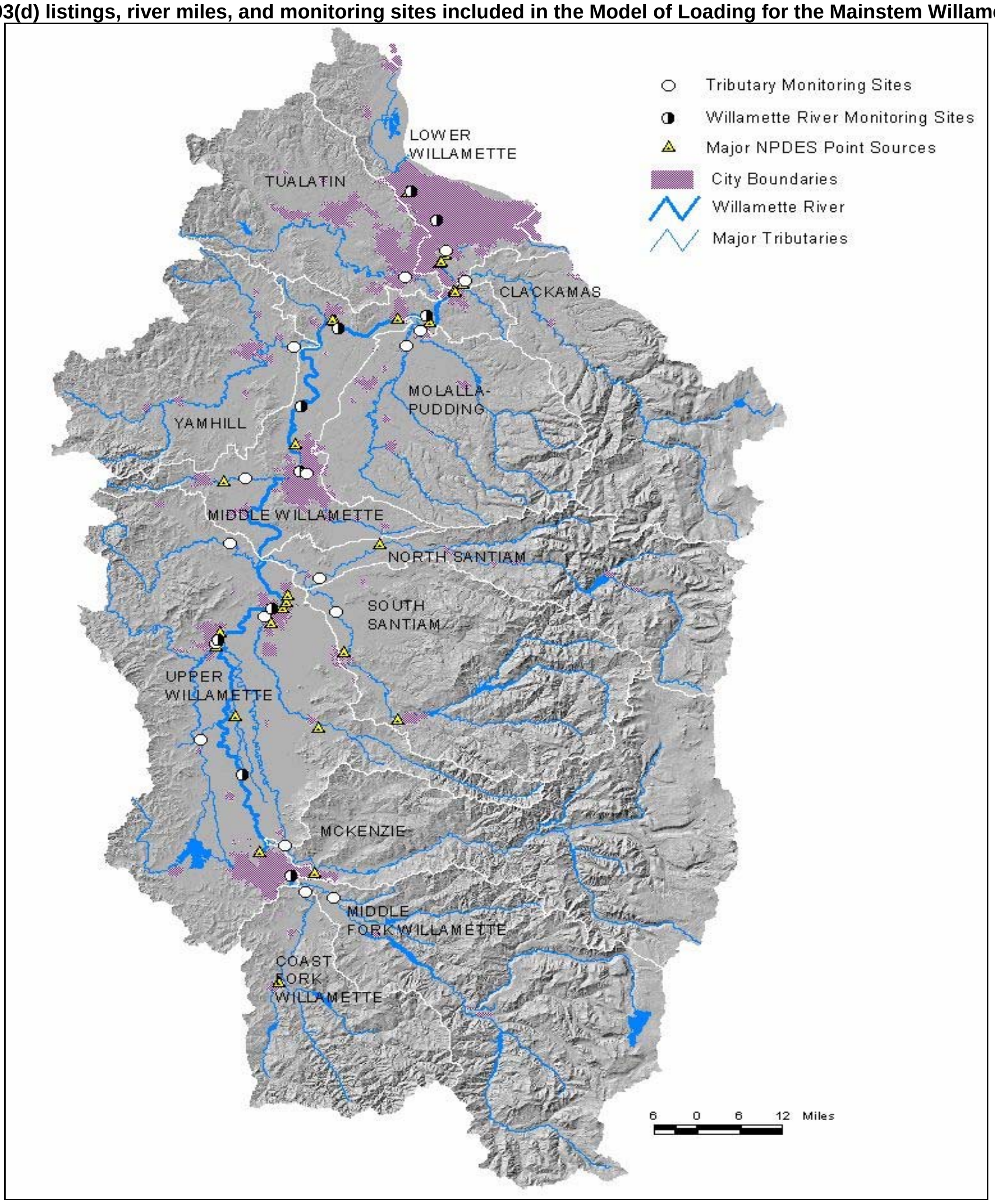
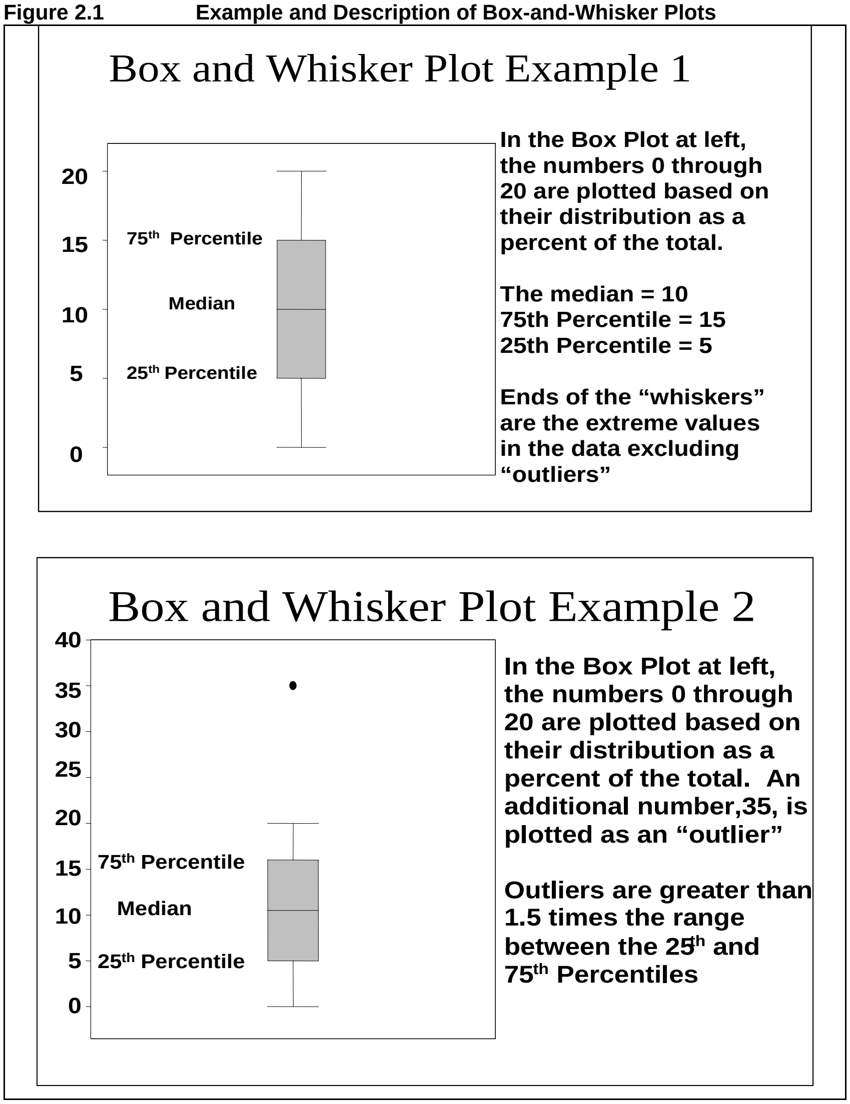


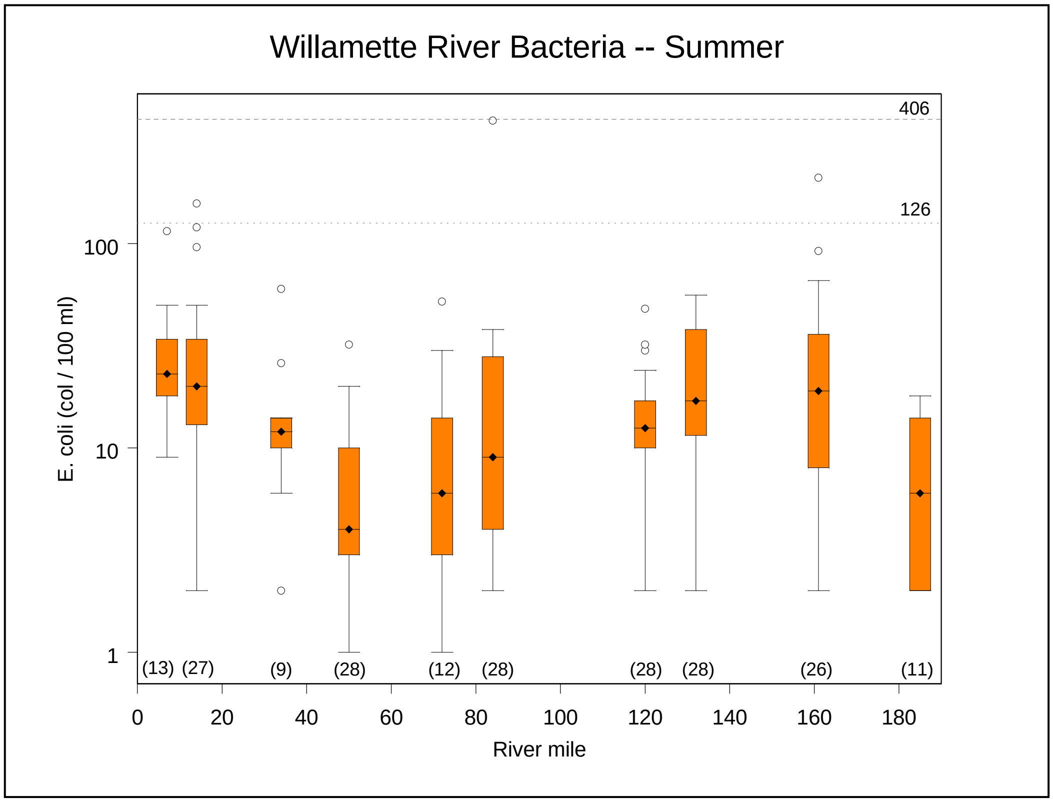
Figure 2.1 Example and Description of Box-and-Whisker Plots



Summer Data

E. coli data have been collected by ODEQ at ten stations in the Willamette River since 1996 (Figure 2.2). These data indicate that long-term geometric mean values at all stations during summer months are well below the recreational contact criterion of 126 *E. coli* organisms/100 ml. Further, only one summer sample approached the single sample maximum value of 406 *E. coli* organisms /100 ml. This analysis indicates the entire main stem of the Willamette River has met the *E. coli* criterion during the summer months (June 1 – September 30). These data indicate the Willamette River is not water quality limited due to excess bacterial concentrations during summer months.

Figure 2.2 Distribution of *E. coli* Data at Willamette River Stations during Summer from 1996-2003 (ODEQ data). Number of Samples in (parentheses).

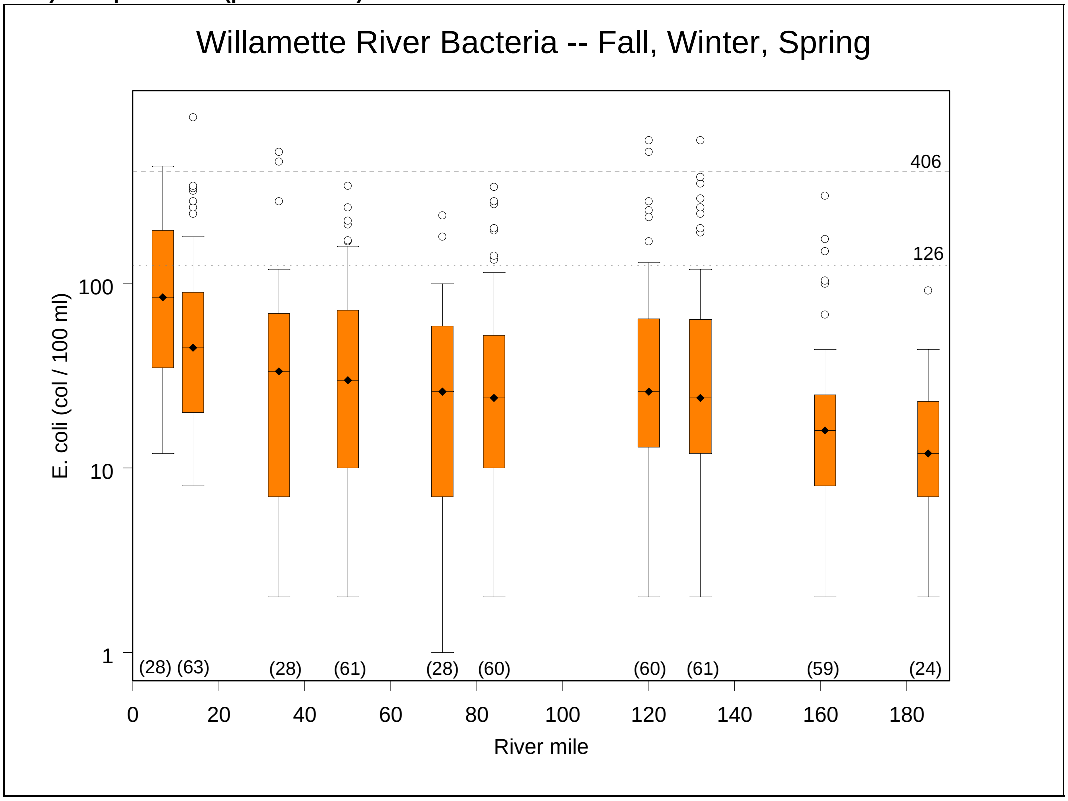


Fall-Winter-Spring Data

The ten stations analyzed for summer compliance were also analyzed for compliance with water quality criteria during the fall-winter-spring period. Recent data (1996-2003, Map 2.2, Figure 2.3) collected by ODEQ indicate outright attainment of the *E. coli* criterion in much of the Willamette River during the fall, winter and spring (October 1 – May 31). Moreover, the data suggest that the entire river is in compliance with both bacteria criteria most of the time, and violations are rare and only modestly exceed the single sample maximum criterion. However, ODEQ data have been collected monthly or bi-monthly and may not have been able to capture certain patterns in bacterial concentrations. For instance, data collected from these stations reflect instream concentrations of the river when it is well mixed, but likely would not capture localized violations at the mouths of significant tributaries that deliver substantial loads to the mainstem during storm events. Still, data from the mainstem indicate occasional exceedance of the "no single sample >406 *E. coli* organisms /100 ml" portion of the criterion at RM 34, 120 and 132, as well as lower in the river at RM 7 and 14.

Additional data collected by the City of Portland in the lower reach of the river impacted by combined sewer overflows (CSO) indicate a greater fall-winter-spring exceedance rate in the lower river than suggested by ODEQ data (below). CSOs occur at 55 separate locations from Sellwood to Swan Island. City of Portland data representing this region between RM 18 (Waverly Country Club, near the upstream edge of CSO discharge area) and RM 7 (St. John's Bridge, near the downstream edge of the CSO discharge area) of the Willamette River (Figure 2.4) were collected at a greater frequency (weekly for most of the period) than ODEQ data. These data demonstrate common exceedance of the geometric mean criterion in the lower river within the CSO region, and that violations were more common with distance downstream. These data also indicate that violations generally occur between October and March of any given year, and are associated with storm events of at least 0.15 inches per 24 hours, which typically result in overflows from the Portland CSOs. No violations of the geometric mean criteria were observed during the summer, supporting the conclusion that the river is generally not water quality limited during summer months.

Figure 2.3 Distribution of E. coli Data at Willamette River Stations during Fall-Winter-Spring from 1996-2003 (ODEQ Data). Sample Size in (parentheses).

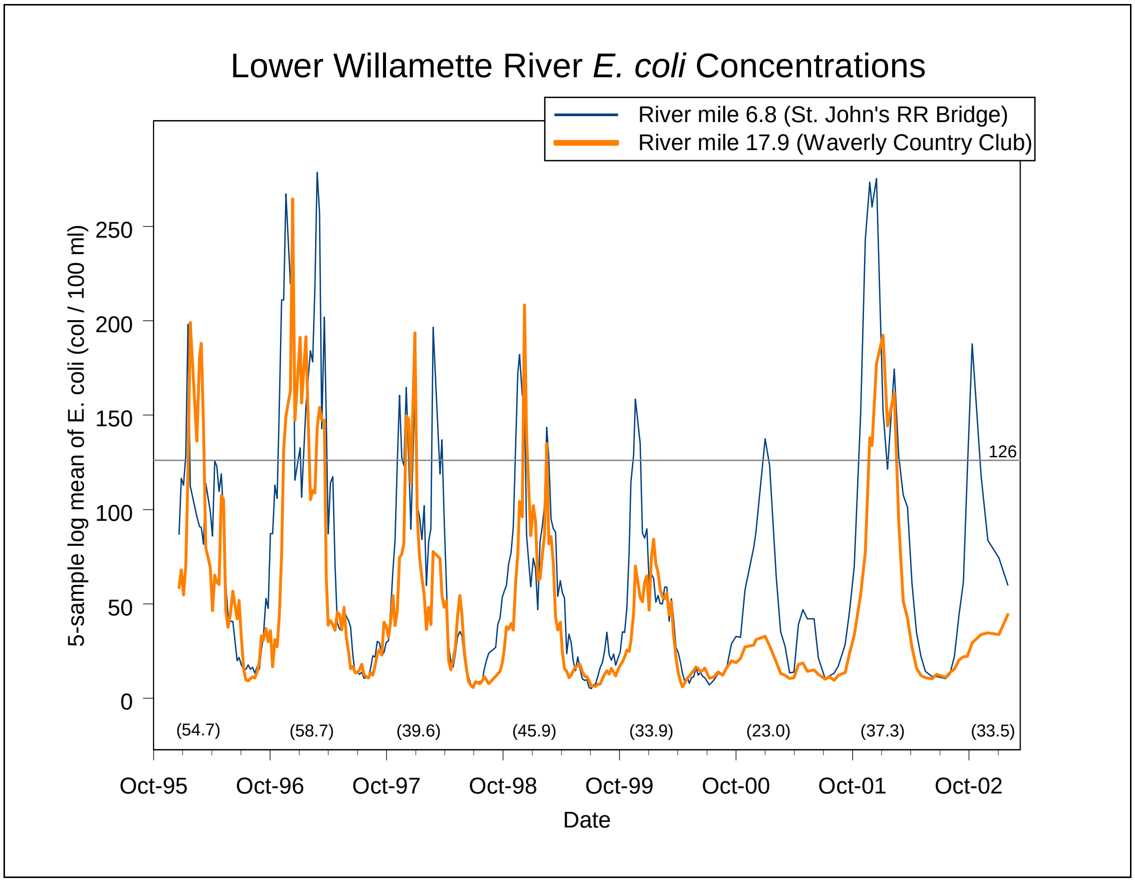


Tributaries to the Willamette River below RM 18 are small relative to volume of water in the River and have no significant effect on bacterial loading. As with larger tributaries, however, these smaller rivers may cause localized increases in bacterial concentration at their confluence with the Willamette River. The most significant sources of bacteria are from upstream accumulation and direct discharges to the River in this reach. The City of Portland has collected weekly bacteria samples on the lower Willamette River since 1995. A moving 5-sample log-mean of the dataset for two stations addresses the 30-day log mean criterion (126 organisms / 100 ml). Samples collected at midstream near the Waverly Country Club (RM 17.9) and the St. John's Bridge (RM 6.8) provide the upper and lower boundaries of the locations of the combined sewer overflows within the city of Portland. Data from these sites indicate that the log-mean criterion was exceeded 11% and 16% of the sample period at Waverly Country Club and St. John's Bridge, respectively. Violations of the log-mean criterion occurred in five of the eight fall-winter-spring periods at RM 17.9, and in all of the periods at RM 6.8 (Figure 2.4). The three fall-winter-spring periods without exceedances at RM 18 corresponded to the three lowest annual rainfall accumulations from water year 1995-2002 (rainfall data from Portland Airport, Oregon Climate Service). However, even during the relatively dry years, downstream concentrations violated the bacteria criteria.

Analysis of spill frequency and volume between the mouth and RM 50 of the Willamette River also indicates the likelihood of occasional standards violations due to relatively large spills of untreated sewage from treatment plants or their conveyance systems.

Combined sewers that transport sewage and runoff serve approximately 35 % of the area of Portland. During most rainfall events, a mixture of runoff and sewage is discharged into the Willamette River through 55 outfalls (City of Portland, 1999a). In 1991, the City of Portland entered into a legal agreement with ODEQ and the Environmental Quality Commission (EQC) to nearly eliminate CSOs. In the Amended Stipulation and Final Order (ASFO, 1994), parties agreed that the City of Portland would reduce the CSO volume by 94% with maximum overflow frequencies from May 1 through October 31 occurring during storms greater than or equal to a three year return frequency and from November 1 through April 31 occurring during storms with a four in one year return frequency.

Figure 2.4 **Moving 5-sample log-mean of *E. coli* concentrations in the lower Willamette River. Annual accumulation of precipitation by water year in inches is included in parentheses.**

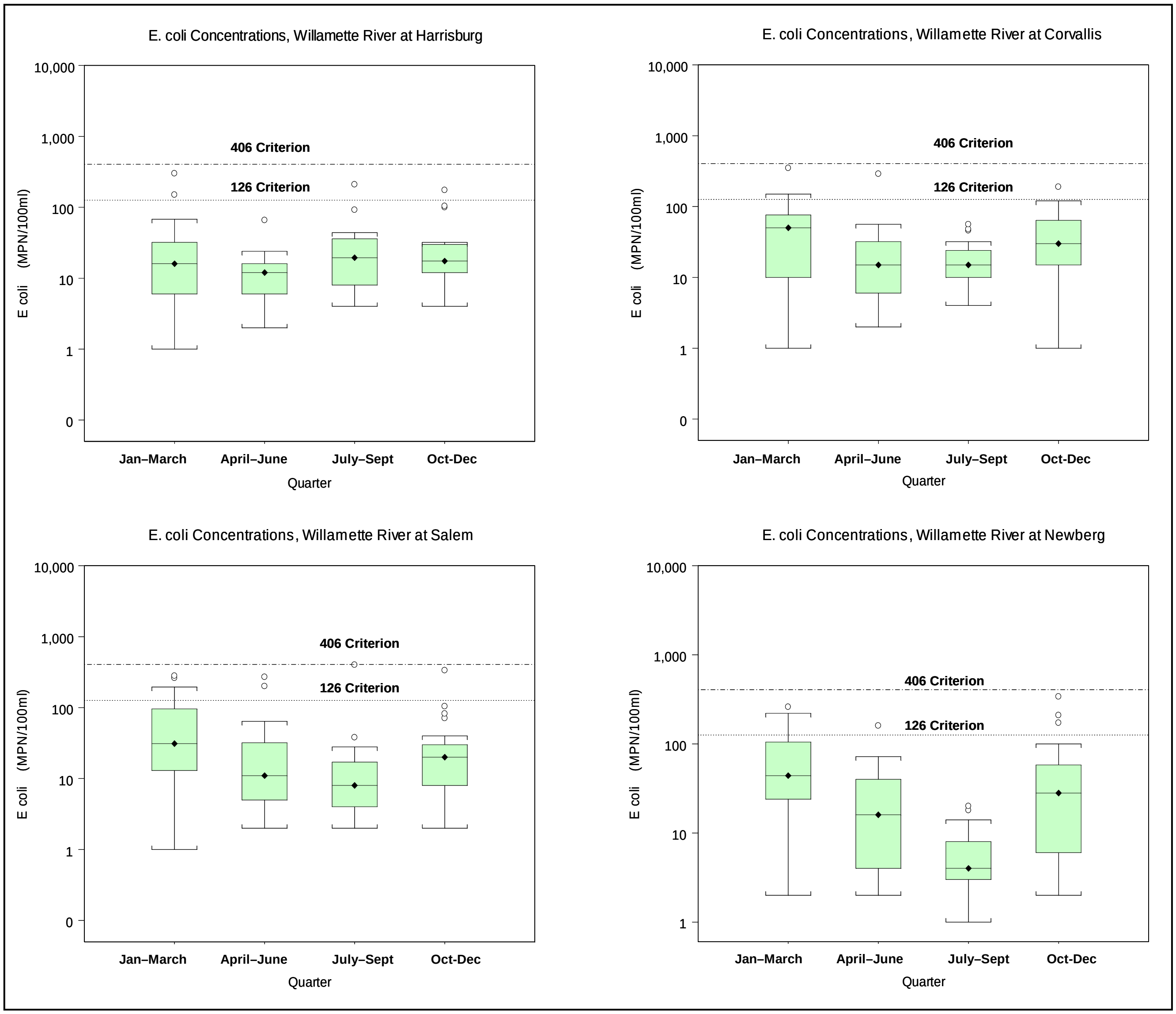


Seasonal Variation

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

Bacterial concentrations have generally met water quality criteria throughout the year and at most stations above Willamette Falls. Long-term median values at Newburg, Salem, Corvallis and Harrisburg were well below the monthly log-mean criterion (126 MPN/100 ml), suggesting compliance with the criterion (Figure 2.5). Though there was variation among seasons at some sites, there were no consistent patterns. Concentrations at the Newburg station were lower in summer than the rest of the year, but variation at other stations was more subtle. Individual sample values at these sites never exceeded the single-sample maximum criterion (406 MPN/100 ml).

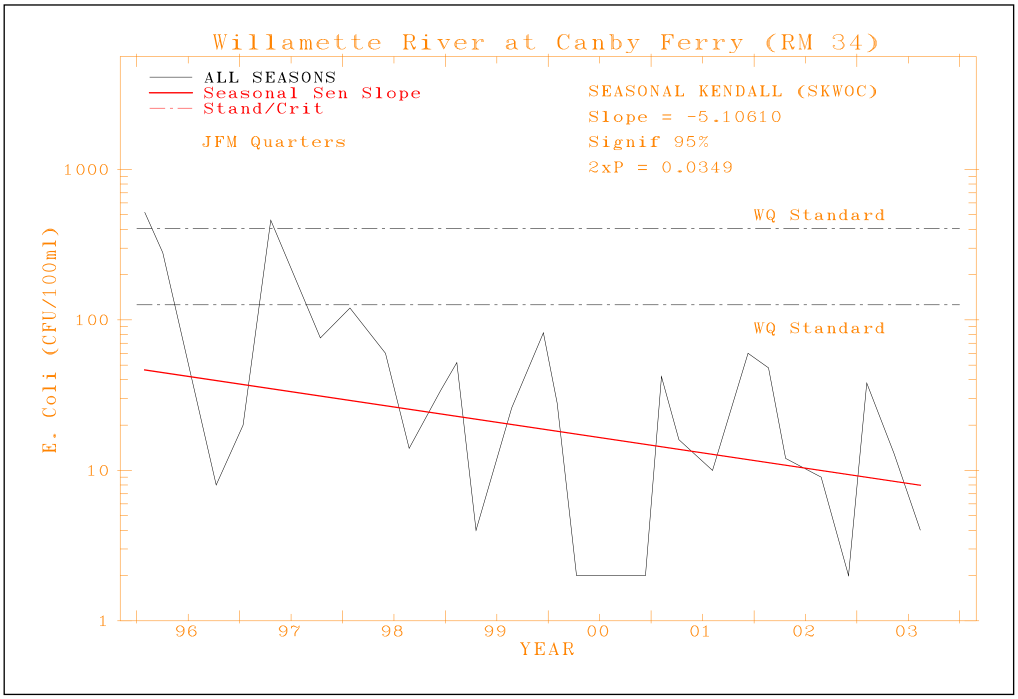
Figure 2.5 Bacterial concentrations at 4 stations on the Willamette River: Harrisburg (RM 161), Corvallis (RM 132), Salem (RM 84), and Newberg (RM 50).



Temporal Trends

Trend analysis (Figure 2.6) indicates that water quality has improved at RM 34 (Willamette River at Canby Ferry) in recent years (1996 to 2003) and water quality criteria have generally been met at this station. Concentrations from this station decreased significantly (p= 0.018) during the period from 1996 to 2003. There were several relatively dry winters during this period but the decline was also observed in normal winters.

Figure 2.6 Trend Analysis for E. coli Concentrations through time



Current Condition Summary

Data indicate that the mainstem of the Willamette River meets water quality standards most of the time above Willamette Falls, and violations are common but seasonal in the lower river. There were no reported violations in ODEQ data during summer in the entire river through the period beginning in 1996 to recent. ODEQ data demonstrate rare violations of the single sample maximum criterion (406 MPN/100ml) and no violations of the geometric mean criterion (126 MPN/100ml) in recent years in the fall-winter-spring season above Willamette Falls. However, data from the City of Portland demonstrates that violations were common in the lower reach of the river, largely owing to elevated concentrations during higher flow periods associated with urban runoff and combined sewer overflows. The violation rate was higher at the lower end (RM 7) of the Portland Metropolitan area than at the upper end of the reach at RM 18.

Loading Assessment

The Willamette River has been divided into three major segments for estimation of compliance rates, and analysis and allocation of loading. (1) sources and tributaries upstream of RM 48 (”upper reach”); (2) the transition zone from predominately rural/agricultural to urbanized land use, between RM 18 to 48 (“middle reach”); and (3) the zone impacted by City of Portland’s combined sewer overflow (CSO), river mile 0 to 18 (“lower reach”). Although there is some overlap in source types among these segments, there is a general increase in urbanization from the upper river downstream to the mouth in Portland. The concentration of bacteria in the Willamette River upstream of RM 48 is largely controlled by loading from tributaries to the mainstem of the River. The middle reach is impacted by a combination of loading from tributaries, agricultural operations, and increasing urbanization. The lower reach of the river is controlled by loading from its tributaries, urban runoff, and the upper watershed, but is also impacted by combined sewer overflows in the Portland Metropolitan area. (See Map 2.2). Though there are significant loads upstream, several factors, including dilution and temperature, influence the ultimate concentrations as water traverses these three segments. Bacteria die while being transported down stream, resulting in an ever-decreasing load unless additional loads are introduced.

Analytical Methods

The 30-day log mean of 126 *E. coli* organisms per 100 milliliters criterion was used as the target concentration in the TMDL for determining the loading capacity of a waterbody (see Loading Capacity discussion below) and hence is also used to assess current loading. Specific allocations were derived based on an analysis of the contribution of sources relative to the estimate of the current load. Those with similar loads received the calculated percent reduction. Those with minor loadings (e.g. treated waste water) received their current permitted loading, set at the water quality standard. Three methods were used to estimate loading to the Willamette River: (1) the steady-state water quality model QUAL2E, (2) a load duration curve, and (3) the hydro-dynamic water quality model PULSEQUAL.

QUAL2E

A model was developed to analyze tributary and direct loading for the entire Willamette River. The steady state, one-dimensional, first-order decay-rate model QUAL2E was used to estimate instream bacterial concentrations (Brown and Barnwell, 1987). This model is not well-suited to estimating concentrations under rapidly changing conditions (such as a storm event), so a scenario with fixed flow and bacterial source concentrations was developed to estimate reasonable worst-case conditions. This model provides an estimate of bacterial concentrations at any point on the river under the modeled conditions. The model approximated the 30-day period with the highest *E. coli* concentrations in the river. Therefore, model results should be compared to the 30-day log-mean criterion of 126 *E. coli* / 100 ml.

Reasonable Worst Case Scenario

The reasonable worst case scenario was defined as an event with average January flows and the 90th percentile concentration of *E. coli* based on data collected from the mainstem and tributaries during the Fall-Winter-Spring period. ODEQ ambient monitoring network provided *E. coli* data for tributaries and the main stem calibration sites (Map 2.2). Ambient monitoring sites are distributed throughout the state and provide the basis for long term assessment of water quality on the statewide scale. A subset of these sites that were located in the Willamette Valley, were used for assessing and modeling bacterial loading. Tributary monitoring sites were generally located near the mouths of rivers (Map 2.3, Table 2.3) and there were a sufficient number in the Willamette Basin to accommodate TMDL analysis. Most sites were sampled monthly or every other month between January 1996 and April 2003. The average January flows were derived from the entire periods of record of the USGS stream gage network.

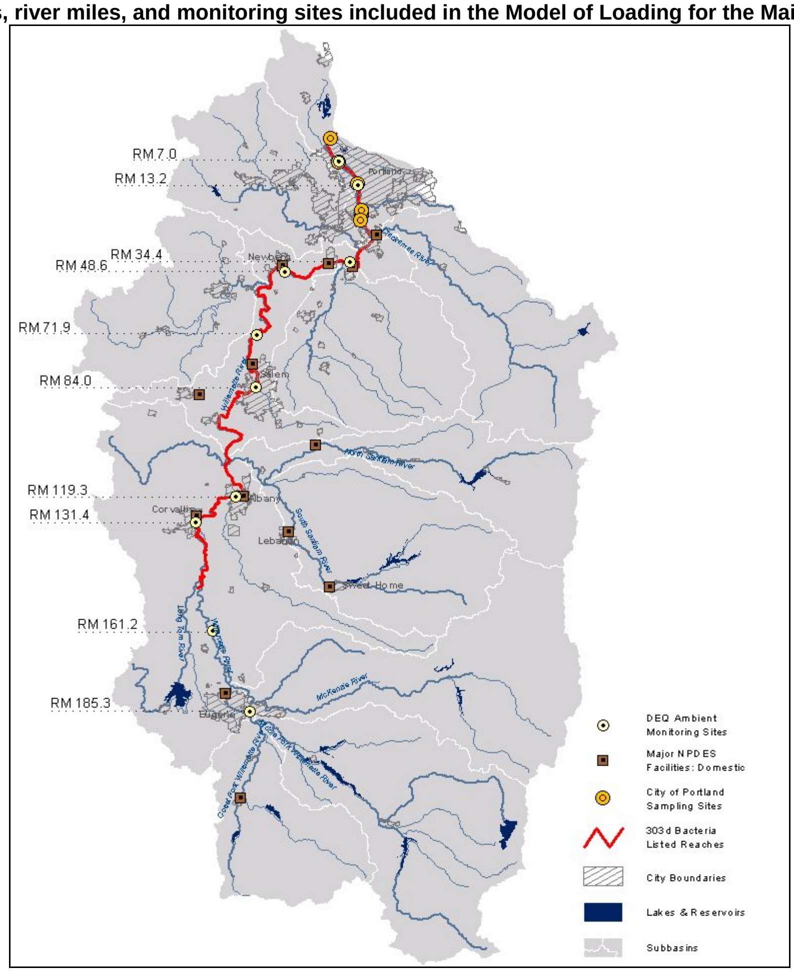
Further discussion of the QUAL2E model setup, rationale and limitations is included in the Bacteria Technical Appendix A. The results of this model are presented in the Loading Assessment and Standards Attainment Analysis sections.

Table 2. 3 Monitoring Stations on Tributaries to the Willamette River used in modeling load accumulation (QUAL2E). 90th percentile concentrations of E. coli were used to define reasonable-worst-case scenario for modeling.

Tributary	River Mile of Confluence	USGS Gage #	ODEQ Site #	Flow (cfs)	FWS *E. coli* samples (count)	FWS *E. coli* 90th percentile (org / 100 ml)
Coast Fork Mid Fork	187	14157500 14152000	11275 10386	10649	27 27	55[A]
McKenzie R	174.8	14163900 14165000	10376	6317	43	40
Long Tom R	145.9	14170000	11140	2100	31	540
Mary's R	132.1	14171000	10373	1192	79	215
Calapooia R	119.5	14173500	11180	2276	34	522
North Santiam R South Santiam R	108	14189000	17092 10366	14270	45 28	60[B]
Luckiamute R	107.5	14190500	10658	2236	7	427
Rickreall Cr	88.1	14907000	10364	392	8	357
Mill Cr[C]	83.6	14192000	28961	272	12	862
Yamhill R	54.9	14194150 14197000	10363	5510	40	908
Molalla R Pudding R.	35.7	14200000 14202000	10637 10363	5156	28 28	272[A]
Tualatin R	28.4	14207500	10456	3883	41	228
Clackamas R	24.8	14211000	11233	7019	43	96
Johnson Cr	18.5	14211550	11321	65	32	976

Notes: (A) concentrations were flow-averaged from two monitoring sites.
(B) concentrations averaged from two monitoring sites, weighting by drainage area
(C) *E. coli* sampled at Front St. Bridge, Salem; Data collected by City of Salem.
FWS = Fall-Winter-Spring, the period from October through May.

Map 2.3 303(d) listings, river miles, and monitoring sites included in the Model of Loading for the Mainstem Willamette River.



Load Duration Curve

The second method relied on measurements of flow and bacterial concentrations at a single station at RM 18 of the Willamette River. These data were used to develop a load-duration curve at this site to estimate the current load, the load capacity, and necessary load reductions to meet the load capacity. The load duration curve combines bacterial concentrations and associated flow rates at a given site to determine whether loads exceed water quality criteria, and what reduction is necessary to ensure the criteria are not violated. The results of this analysis are presented in the Loading Capacity and Load Allocation sections. See the bacteria technical appendix for further discussion.

PULSEQUAL

The third method accounted for loading from Portland CSO using PULSEQUAL, a hydro-dynamic water quality model developed by Limno-tech Inc (2001). The model simulates hourly *E. coli* concentrations over a six year period of diverse hydrologic conditions. The model output is compartmentalized into 0.4 mile segments. The results of this analysis are also presented in the Loading Capacity and Load Allocation sections. See the bacteria technical appendix for further discussion.

Existing Sources: Loading Contributions and Flow Analysis
OAR 340-042-0040(4)(f), CWA § 303(d)(1)

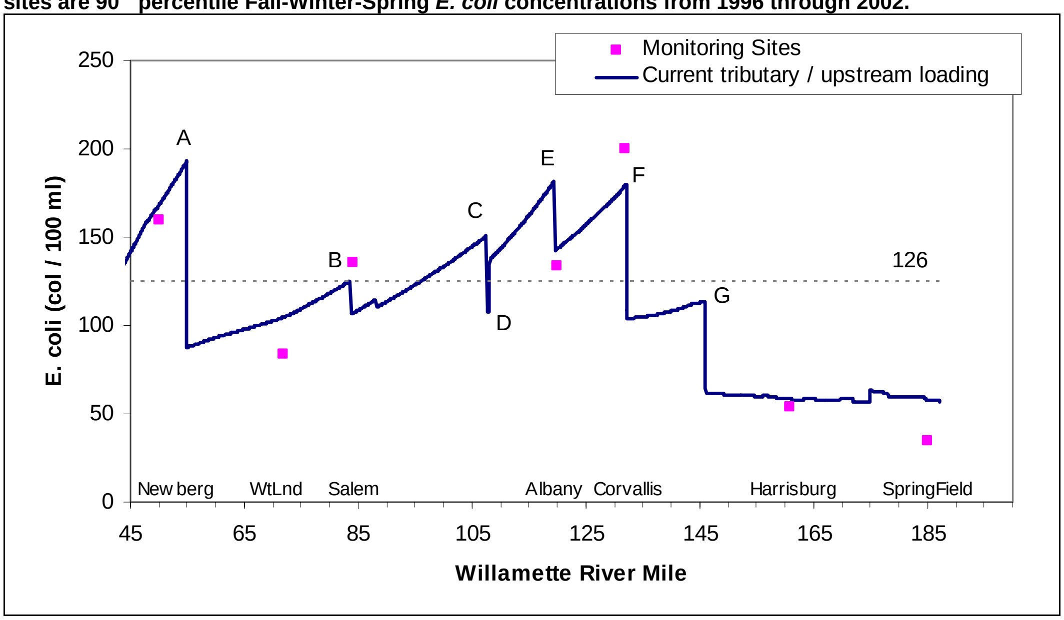
River Mile 48 to Headwaters (Upper Reach)

Most significant tributaries and volume of water enter the Willamette River above RM 48. These tributaries carry bacteria, but also contribute assimilative capacity where large volumes of relatively clean water enter the system. The tributaries are included separately in Chapters 5 through 13 of this document, but their influence on loading to the Willamette River was analyzed along with other direct sources to the river. Loading was modeled based on average annual flows for January and the 90^{th} percentile of *E. coli* concentrations in samples collected by ODEQ from 1996 to 2003.

Flow from the Coast Fork and Middle Fork Willamette, the McKenzie, and North and South Santiam Rivers account for approximately 70% of the flow in the upper reach of the Willamette River. Bacterial concentrations in these tributaries are well below the water quality criteria and generally much lower than the remaining tributaries in this reach. These “clean” tributaries provide assimilative capacity to the river. Some of the other tributaries carry excess loads of bacteria causing local elevations in concentration to occur when entering the Willamette River.

In addition to loading from the tributaries, additional loading directly to the river from point and nonpoint sources was added to the model (QUAL2E) to account for observed concentrations above RM 48. Loads of 3.3×10^{13} and 4.6×10^{12} *E. coli* organisms/ day were added at RM 132 and 84, respectively. These locations correspond approximately to the cities of Corvallis/Albany and Salem which have storm water discharges and have both reported the discharge of untreated sewage into the Willamette. Prior to 2001, the City of Corvallis had regular combined sewer overflows (CSOs) due to rainfall events. A new wastewater treatment facility has corrected the problem, and the City has had no CSO events even with large storm events since these improvements were made. The City of Salem has reported occasional sanitary sewer overflows to the Willamette River and tributaries. The City of Albany reported pump station failures with discharges into the Willamette River and the Calapooia River. These discharges are rare and unpredictable, but may be expected to occur during wet weather events similar to those being simulated by the model. A portion of these loads is likely attributable to nonpoint sources in the area. A nonpoint source *E. coli* load of 3.4×10^{13} organisms / day was simulated between RM 132 and 187.

Figure 2.7 *E. coli* concentrations during reasonable worst case scenario under current conditions above RM 45. Tributary confluences / sources: A. Yamhill River, B. City of Salem WWTP and Mill Creek, C. Luckiamute River, D. Santiam River, E. Calapooia River, F. City of Corvallis WWTP and Mary’s River, and G. Long Tom River. Values plotted at monitoring sites are 90^{th} percentile Fall-Winter-Spring *E. coli* concentrations from 1996 through 2002.



Modeling of the upper reach predicted that Long Tom, Yamhill and Luckiamute Rivers currently have the greatest tributary impact on *E. coli* concentration in the Willamette River increasing the concentration by approximately 77%, 120% and 40%, respectively (Figure 2.7). Conversely, the relatively uncontaminated Santiam River provided additional assimilative capacity, decreasing *E. coli* concentrations by 22 %. Increases in *E. coli* concentration are also apparent at Salem and Corvallis which may be attributed to sanitary sewer overflows. CSOs at Corvallis reflected in the data have ceased with improvements to sanitary facilities. Recent monitoring data have indicated improved water quality near Corvallis.

River Mile 18 to 48 (Middle Reach)

There is a transition from agricultural/urban to urban/residential land uses with distance from RM 48 to 18. While the transition zone is upstream of the influence of City of Portland CSO, it is impacted by runoff from rural residential and agricultural land, by ever-increasing urban uses and by occasional sanitary sewer spills and overflows.

The Middle Reach of the Willamette River is impacted by the bacteria load entering into the mainstem via its tributaries and from other sources above RM 48 (Tables 2.3 and 2.4). The effects of tributary loads in the middle reach of the Willamette River, while significant, are more subtle than in the upper reach. Flows from the Molalla/Pudding and Tualatin subbasins increase the average *E. coli* concentration in the mainstem slightly, but the relatively uncontaminated Clackamas River does not substantially change the concentration.

Modeled concentrations increase as a result of inflows, but decay to a relatively low concentration at RM 18 (Figure 2.8). Despite the local influence of the Molalla/Pudding Rivers, Tualatin River, Clackamas River and Johnson Creek (all determined to be water quality limited for bacteria), the QUAL2E model predicts that the middle reach would currently meet water quality criteria after recovering from relatively high loads entering the river from the upper reach, particularly from the Yamhill River. The model estimates that tributary and upstream loading accounts for 26% of the observed loading at RM 18. These tributaries add loading to the river above RM 18, but are not sufficient sources to cause observed violations that are common at RM 18 (symbols in Figure 2.8). The QUAL2E model estimates current loading from upstream sources and tributaries during the critical condition at RM 18 at 1.25×10^{14} *E. coli* organisms / day. A load duration curve analysis indicates that during high-flows (analogous to the reasonable worst case scenario) current loading at RM 18 is 4.09×10^{14} *E. coli* organisms/day (see Loading Capacity). Approximately a quarter of the loading at RM 18 can be attributed to sources upstream of RM 48 and tributaries entering the reach. Additional loading to the river could include nonpoint sources or waste water treatment plant upset (discussed below in Point Source Upsets).

A possible source of bacteria in the middle reach is nonpoint source pollution being delivered to the Willamette River directly or through unmonitored tributaries. Nonpoint source pollutant loading comes from diffuse sources as opposed to point source pollutant loading which is discharged by individual facilities. Nonpoint fecal bacteria sources may include wildlife, livestock waste, failing residential septic systems, and residential and urban runoff. Based on analysis in the individual subbasin bacteria TMDLs, forested landscape does not cause or contribute significantly to water quality violations for bacteria. A major transition in land use occurs in the middle reach which corresponds to an increase in bacteria concentration between monitoring stations at RM 34 and 18 (Figure 2.8 and 2.9). The land that drains into the Willamette River directly or through unmonitored tributaries between RM 48 and 34 is dominated by agriculture (79%) with only a minor residential and urban component (6%). Between RM 34 and 18, though, the landscape is more varied with forestry (37%), agricultural (29%), and residential / urban (26%). The residential and urban land use component includes Canby, Oregon City, West Linn, Lake Oswego, Gladstone, and Milwaukie as well as unincorporated parts of Clackamas County and the very southwestern portion of Portland. The increase in urbanization corresponds with the observed increase in *E. coli* concentrations in the Willamette River. Although the loading from urban runoff could not be quantified in this reach, other analyses in the Willamette Basin have shown that it can be a significant source of bacteria pollution (see Subbasin-wide Loading Allocations below). Generalized reductions will apply to these sources.

Figure 2.8 ***E. coli*** **concentrations during reasonable worst case scenario under current conditions from RM 0 to 50. Values plotted at monitoring sites are 90th percentile Fall-Winter-Spring *E. coli* concentrations from 1996 through 2002.**

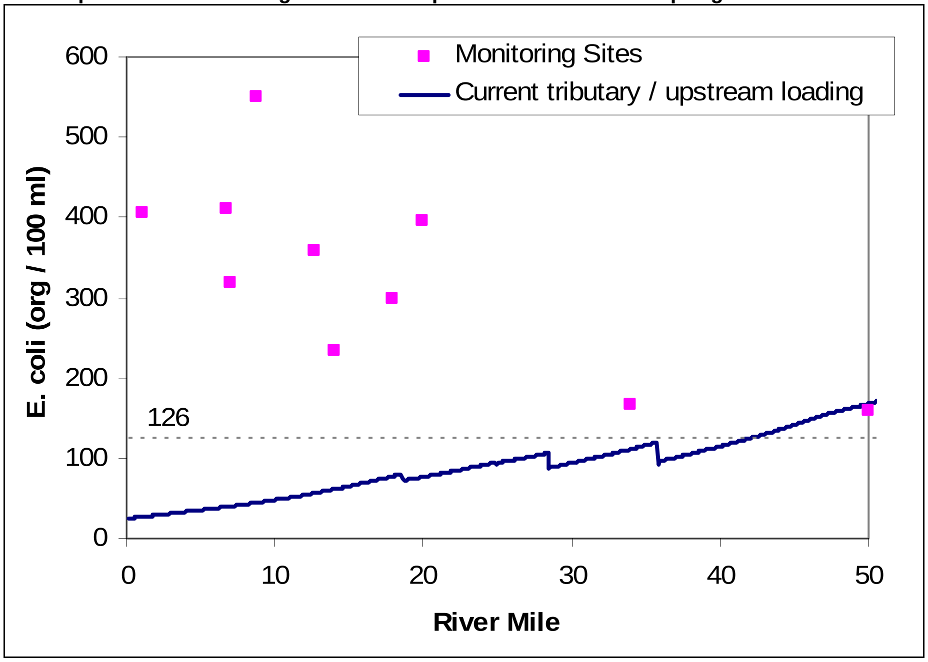
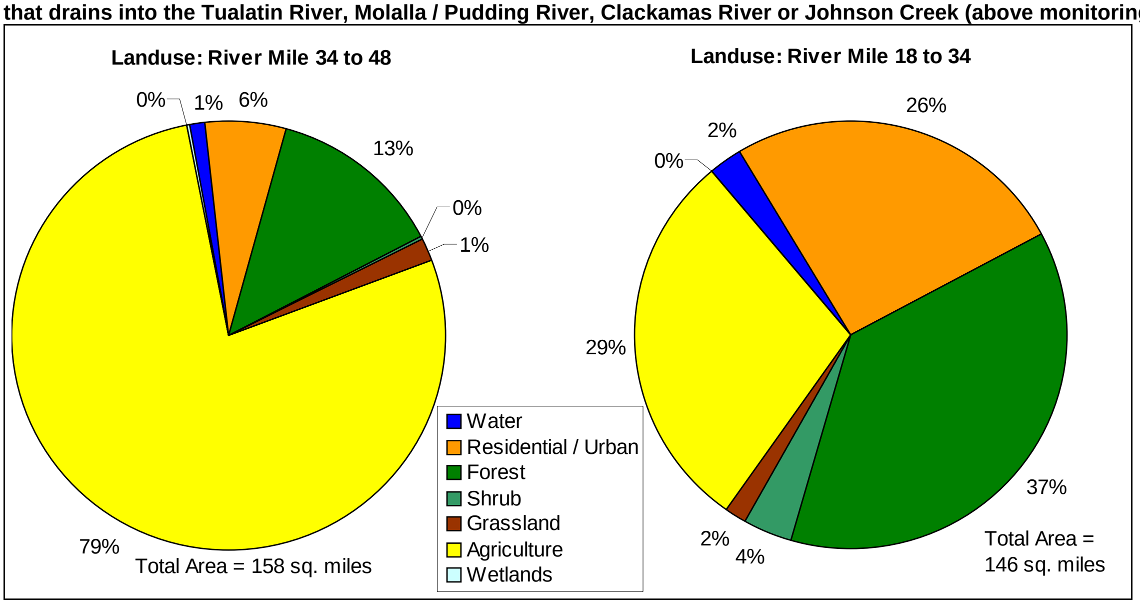


Figure 2.9 **Land use distribution for area draining into the Willamette River between RM 18 and 48 not including land that drains into the Tualatin River, Molalla / Pudding River, Clackamas River or Johnson Creek (above monitoring sites).**



River Mile 0-18 (Lower Reach)

The lower reach of the Willamette River is predominantly urbanized, and contains the largest urban population and highest population density in Oregon. There appear to be three major sources of bacteria loading to the lower Willamette River in this reach: combined sewer overflows (CSOs), upstream sources (upstream of RM 18), and urban runoff. Upstream sources were described in the previous sections. Tributaries to the lower reach of the Willamette River are generally quite small relative to the volume of the river and are only significant at a very local scale. The QUAL2E model indicates that, in the absence of additional loading beyond that in upstream flow, the lower reach would meet water quality criteria (refer to Figure 2.8). Some direct discharges may occur in the middle or upper reaches and still impact the lower reach, though known sources in the lower reach are certainly responsible for most bacterial criteria violations.

Combined sewers that transport sewage and runoff serve approximately 35 % of the area of Portland. During most rainfall events, a mixture of runoff and sewage is discharged into the Willamette River through 55 outfalls (City of Portland, 1999a). In 1991, the City of Portland entered into a legal agreement with ODEQ and the Environmental Quality Commission (EQC) to nearly eliminate all CSOs. This agreement was amended in 1994 (Amended Stipulation and Final Order [ASFO]). Under the Order, the City of Portland agreed to reduce the CSO volume by 94% with maximum overflow frequencies from May 1 through October 31 occurring during storms greater than or equal to a three year return frequency and from November 1 through April 31 occurring during storms with a four in one year return frequency.

E. coli concentrations in the Willamette River from the mouth to RM 17.6 were simulated with PULSEQUAL (City of Portland, 1999b and Limno-tech, Inc. 2001). The decay rate was determined by calibration to the weekly *E. coli* data collected from December 1995 through June 1997 at five sampling locations. In order to determine the effect of reducing the frequencies of CSOs, different loading scenarios were simulated with data from a six-year period from 1982 to 1987 in order to capture a range of hydrologic conditions. The model simulated hourly *E. coli* concentrations over this period. Simulating the pre-CSO control loads, Limno-tech, Inc. (2001) estimated that CSOs accounted for 54 % of the annual loading, upstream sources for 44 %, and stormwater runoff for 2 %. The current average wet-weather load from CSOs of 2.9×10^{14} *E. coli* organisms/day will be reduced to 2.0×10^{13} *E. coli* organisms/day following full compliance with the ASFO. Along with this overall reduction, the frequency of overflows will be comparatively rare. As of 2003, the City of Portland estimates that CSO volume has been reduced by 53% compared with the volume in 1990 (City of Portland, 2003).

Point Source Upsets

When operating properly, waste water treatment plants do not cause or contribute to water quality standards violations; however mechanical failures and sanitary sewer overflows (SSOs) are occasional sources of bacteria loading. Between January 1996 and April 2003, there were 158 reports of sanitary sewer spills from seven permittees into the Willamette River (or its tributaries) below RM 50 (Table 2.3). The precise impact of these spills cannot be determined, but it is likely that some of them may have caused short-term, localized violations of water quality standards.

Water samples for bacterial analysis were collected at frequencies ranging from weekly to every two months depending on the location and monitoring entity. Given the short duration of spills with the relatively infrequent monitoring, it is not possible to correlate spills with increases in bacteria concentrations. However, the number of spills documented and approximate volumes suggest an unpredictable but potentially significant source of water quality standards violations.

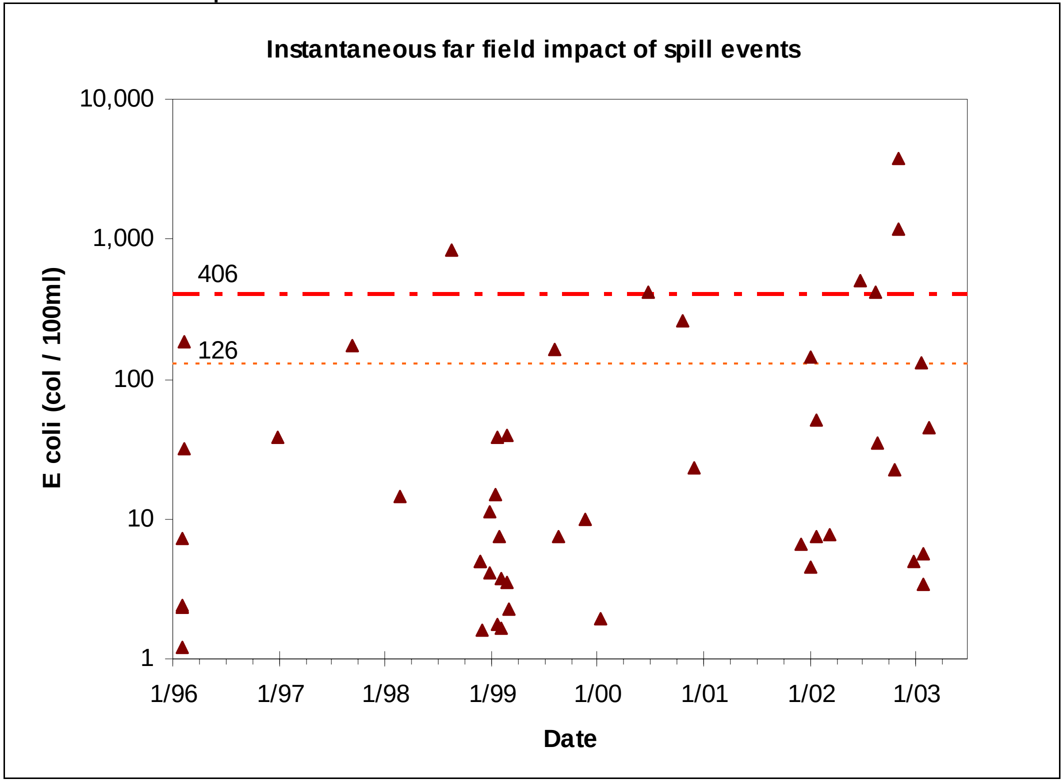
Most of the spill volumes were not reported, so the delivered bacteria load could not be calculated. Of the 52 spills with reported volumes, the downstream impact on water quality can be evaluated assuming: a concentration of 3,300,000 *E. coli* organisms / 100 ml for raw sewage (City of Portland, personal communication); using river flow measurements in Portland (Table 2.3); and assuming all of the bacteria load reached the Willamette in a short period of time. This is a very conservative set of assumptions. If there were no other bacteria sources, 12 of these spills could have resulted in concentrations above the log mean criterion (126 organisms / 100 ml) and 6 would have caused violations of the single sample criterion (406 organisms / 100 ml). Some of these spills were several days in duration and so the load received by the river would have been less than indicated. Even so, these spills were of short enough duration and rare enough that it is unlikely that the 30-day geometric mean criterion would have been violated. All of the spills that may have caused a violation of the single sample criterion, and most of the spills that might have caused concentrations greater than the log-mean criterion were during dry weather and low flows. A spill that resulted in concentrations only slightly higher than the geometric mean criterion occurred during the 100-year storm event in February 1996.

Although some of these may have been significant short-term events, control of sporadic overflows and spills is a function of the normal NPDES permitting process. Spills are allowed by rule under rare circumstances, and correction of conditions resulting in ongoing spills is planned by the permit holder and ODEQ through department orders that include schedules for completion.

Table 2. 4 Summary of documented spill events to the middle (RM 18-48) and lower (RM 0-18) reach of the Willamette River or its major tributaries (1996 to April 2003). The river mile is a general guide because some of the spills took place outside the treatment plant due to other system failures.

Permittee	Approximate River Mile	Number of Spill Events	Average Spill Volume (gallons)	Maximum Spill Volume (gallons)	Date of Maximum Spill Volume
City of Portland	0 - 17	36	264,040	2,880,000	1/26/1999
Gresham (through Johnson Creek)	18	16	1,007,867	3,000,000	1/25/2003
Clackamas Co. Service District	18.7	14	139,667	400,000	7/5/2000
Oak Lodge	20.1	17	146,231	1,000,000	1/16/2000
Portland: Tryon Creek WWTP	20.2	18	1,469,688	12,500,000	2/9/1996
Tri-Cities	25.5	12	460,667	1,763,000	11/6/2002
Wilsonville	39	1	100,000	100,000	8/25/1999
Newberg	49.7	44	100,196	980,000	1/9/2002

Figure 2.10 Estimated concentrations of *E. coli* resulting from known sewage spill events assuming flow rates measured in the Portland area and assuming no other bacterial sources. Concentrations shown assume no sources of bacteria other than spills.



Control of Sewer Overflows

Storm related over-flows of raw sewage are prohibited to waters of the State. However, the Environmental Quality Commission (EQC) recognized that it is impossible to design and construct a conveyance system that will prevent overflows under all storm conditions. Therefore, the State of Oregon has determined that all wastewater conveyance systems should be designed to transport sewage during storm events up to a specific size to the treatment facility. Therefore, such storm related overflows will not be considered a violation if the permitted facility has conveyance and treatment facilities adequate to prevent overflows except during a storm event greater than the one-in-five-year, 24-hour duration storm from November 1 through May 21 and except during a storm event greater than the one-in-ten-year, 24-hour duration storm from May 22 through October 31. The discharger still must provide the highest and best practicable treatment and/or control of wastes, activities, and flows and must have properly operated the conveyance and treatment facilities during these overflow events.

As these discharges are expected only under unusual conditions and do not reflect normal operating conditions for wastewater treatment plants, loads were not allocated in the TMDL to account for these "discharges." The proposed TMDL is targeting the 30-day log mean bacteria criterion. Allocations in the TMDL assume all controls are in place and operating according to permit limits for point sources, and at reduced loads for nonpoint sources. Spills or discharges of the type described above will be controlled through the normal NPDES permitting process and, where evidence exists that a particular facility requires enhanced or more stringent control, necessary improvements will be achieved through a Mutual Agreement and Order between ODEQ and the facility.

The ongoing agreements between municipalities and ODEQ regarding sanitary sewer or combined sewer overflows other than for the CSOs in the City of Portland are not described in the TMDL. In general, CSOs that have historically occurred in cities other than Portland have been controlled. Other than the CSOs in the City of Portland, no loads from these systems are included in the allocations for the Willamette Basin. The City of Portland has received an allocation for CSO discharges in the TMDL consistent with the terms of the Amended Stipulated and Final Order between the City and ODEQ. These allocations would only be expressed during storms with a return interval stipulated in the order.

OAR 340-041-0009 (11) gives ODEQ the discretion to require a Bacteria Management Plan from sources ODEQ concludes contribute to the problem. These plans will identify the technologies, best management practices and/or measures and approaches to be implemented to limit bacterial contamination. For point sources the NPDES permit is the bacteria management plan. Municipalities that discharge storm water to water-quality-limited surface waters and are under a phase I or II permit are responsible for controlling pollutants in those discharges to the maximum extent practicable. This is regardless of the condition of water upstream of the municipality. For nonpoint sources, the plan will be developed by the designated management agency for that source and this can include cities that do not fall under the permit requirements. As indicated in OAR 340-041-0009 (11), ODEQ may determine a plan is not necessary for these cities/sources based on an understanding of the contribution of bacteria to a given waterbody segment, so a plan may not be required in all cases.

Summary of Current Loads

Modeled estimates of loading in the Willamette River indicate that tributary loads upstream of river mile 18 on the Willamette River are important contributors to violations of bacteria water quality standards throughout the basin. These contributions are larger upstream of RM 48 than downstream of that point. Modeling also indicates that, although loads from upstream are important to the lower reach below RM 34, local loading from urban runoff, and combined sewer overflows are responsible for most bacteria violations. Point source discharges are included in modeling of loading, but generally are a small component of excess loading because point source wastewater flows are small relative to receiving waters, and are required by permit to meet water quality criteria prior to discharge. Despite this, point sources are important load contributors during treatment or conveyance failures that result in bypass or spills of under treated sewage. Current loading to the lower reach by upstream sources is estimated at **4.09×10^{14}** *E. coli* organisms/day during high flow conditions (see below). Under current conditions, modeling (PULSEQUAL) estimated that 54% of loading to the lower reach was from direct local discharges (CSOs, spills), 2% was from stormwater, and 44% was from upstream sources.

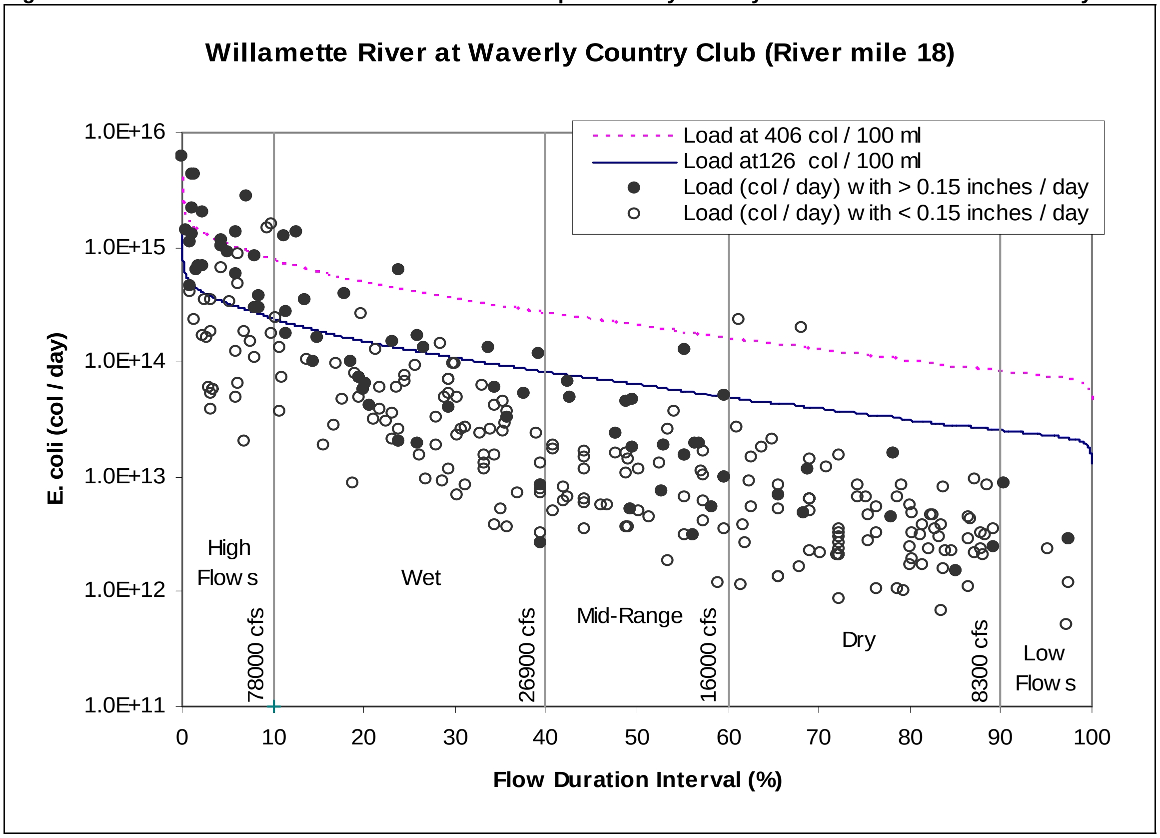
Loading Capacity
OAR 340-042-0040(4)(d)

The 30-day log mean of 126 *E. coli* organisms per 100 milliliters criterion was used as the target concentration in the TMDL for determining the loading capacity of a waterbody. This criterion most directly relates to illness rates and potential impacts on the beneficial use of water contact recreation. Modeling of the mainstem of the Willamette River targeted this criterion by estimating average conditions during a reasonable worst case scenario. Loading capacity in the river was determined with a load duration curve that provided an estimate of the reduction necessary to meet the log mean criterion. Where sufficient data was available in tributary subbasins, flow duration curves were developed, and current loading was estimated using the log-mean of the load of all samples in each flow interval. Other approaches for estimating the current conditions and percent reductions necessary to achieve the log mean criterion were used in several tributaries where there was not sufficient information (usually flow data) to develop a flow duration curve. These are described separately in other chapters of this document.

The loading capacity for bacteria is the number of organisms of *E. coli* that the river can receive without water quality standards being violated. Reduction of bacterial concentrations in tributaries along with the general absence of spills or CSOs will control loads and result in compliance throughout the river. Since there are no significant tributaries to the lower Willamette River below RM 18, the load capacity was assumed to be determined by loading from upstream sources and tributaries, and direct discharges to the lower reach. A flow-based loading capacity was determined through the development of load-duration curves (Cleland 2002 and Appendix A) at RM 18 (near Waverly Country Club) of the Willamette River to determine the limits appropriate for this upstream flow. The load-duration relationship is represented graphically by plotting bacteria loads associated with flow rate at the time of sampling. The geometric-mean criterion curve (solid line in Figure 2.11) indicates the bacteria load equivalent to the 126 *E. coli* organisms per 100 ml water quality criteria under the range of flow conditions for the site. Loads that are lower than this line meet the criterion, and therefore protect beneficial uses. As flow increases, so does the loading capacity of the river.

Current loads (Figure 2.11) were calculated using City of Portland data collected weekly to monthly between December 1995 and April 2003, and discharge data from the USGS gage number 14211720 (RM 12.8, “Willamette River at Portland”). The curve also indicates under which conditions of flow the greatest loads occur. Loads were calculated and separated into those that occurred when rainfall measured less than 0.15 inches per day and greater than 0.15 inches per day (threshold for a significant rain event). In the analysis of data collected on the Willamette River near the Waverly Country Club, loading was most likely to exceed the loading criterion in the highest flow regime (e.g., flows exceeding 78,000 cfs). Bacteria concentrations at this site represent cumulative loads in the river upstream of combined sewer overflows in the Portland area. Samples that exceeded the criteria were mostly associated with rainfall events greater than 0.15 inches. Of the samples collected when there was less than 0.15 inches of rain, only 4 exceeded the single sample maximum values of 406 MPN/100 ml. Loading was rarely higher than the criterion limit in the other flow regimes, indicating rare violations of water quality standards at these lower flows.

Figure 2.11 **Load duration curve. Bacteria data provided by the City of Portland and the flow data by USGS.**



This analysis indicates that loading at RM 18 exceeds the loading capacity of the river during some high to very high flow events. Moreover, the loading capacity is most likely to be exceeded during significant rain events. From this we determined that the critical condition, when loading exceeded capacity, was during high flows, generally during or following rainfall events. Modeling upstream of RM 18 indicated that the loading to this lower reach from all major tributaries and other sources upstream of RM 48 would not exceed the loading capacity under the reasonable, worst case scenario.

The loading capacity was calculated for each of the five flow intervals depicted in Table 2.4 by the following formula:

Criterion — Flow — Conversion factors

$$\text{Loading Capacity}\,\frac{col}{day} = 126\,\frac{col}{100\,ml} * Q\,\frac{ft^3}{s} * \overbrace{283.2\,\frac{100ml}{ft^3} * 86400\,\frac{s}{day}}$$

Loading capacity was calculated for each flow interval using the lowest flow rate in the interval to allow for the most conservative estimate of loading capacity (Table 2.5). Current loading was estimated with the log-mean of the load of all samples in each flow interval. Current loading rates were lower than the loading capacity in all but the highest flow regime, supporting the conclusion that violations are unlikely during all but the highest flow conditions. This is supported by analysis of bacteria concentrations that indicate violations occur during high flows and mostly associated with rainfall greater than 0.15 inches per day (Figure 2.11). The loading rate that would meet the log-mean criterion during high flows was 2.40×10^{14} *E. coli* organisms/day. Combined allocations that result in this loading rate during high flow conditions would be protective at all times of the year.

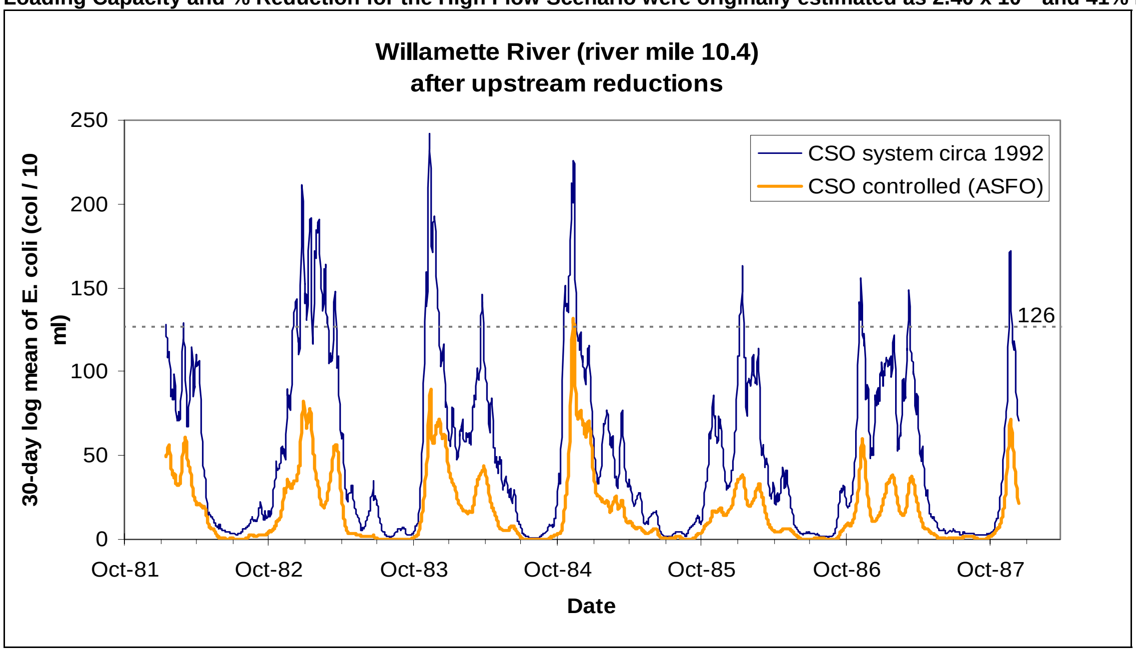
Table 2. 5 Flow based Load Capacity for the Willamette River at RM 18. Flow is in cubic feet per second and loads are in *E. coli* organisms per day.

	Range of Flows				
	High Flow	**Wet**	**Mid-Range**	**Dry**	**Low Flow**
Flow Rate (cfs)	78000	26900	16000	8300	<8300
Current Load	4.09×10^{14}	4.21×10^{13}	1.05×10^{13}	4.11×10^{12}	2.19×10^{12}
Preliminary Loading Capacity (a)	2.40×10^{14}	8.29×10^{13}	4.93×10^{13}	2.56×10^{13}	1.29×10^{13}

a = Loading capacity at river mile 18 prior to accounting for limited CSO discharges when AFSO fully implemented.

To determine the effect of these loads downstream of RM 18 under all conditions, ODEQ and City of Portland hired Limno-tech, Inc. to conduct additional PULSEQUAL modeling. The modeling was designed to predict bacteria concentration in the Willamette River from its mouth to RM 18 with reduced upstream loading based on TMDL load allocations and the City of Portland being in compliance with ASFO downstream of river mile 18 (Limno-tech, 2004, see bacteria technical appendix for further discussion). A flow-based loading capacity under high flow conditions of 2.40×10^{14} *E. Coli* organisms per day (a 41% reduction) was input to the PULSEQUAL model as upstream boundary condition. Based on daily average *E. coli* concentrations, the 30-day log mean criterion would be achieved 99.8 % of the six-year simulation period (Figure 2.12). The maximum log-mean concentration predicted by the model was 131.4 organisms / 100 ml at RM 10.4. The 30-day log mean was greater than 126 organisms / 100 ml for one simulated four-day period during November 1984, which encompassed four days of rainfall accumulations of greater or equal to 0.97 inches of rain per day (Portland Airport, reported by Oregon Climate Service). This type of hydrologic condition only occurred once during the six-year simulation.

Figure 2.12 Predicted 30-day moving log mean of *E. coli* concentration post-implementation of the upstream TMDLs for CSO conditions circa 1992 and CSO conditions after implementation of the ASFO. This scenario assumed a Flow-Based Loading Capacity and % Reduction for the High Flow Scenario were originally estimated as 2.40×10^{14} and 41% respectively.



The modeled loading associated with the extreme event that violated the criterion was approximately 3.67×10^{14} organisms per day, while the loading capacity for this high-flow event was 3.51×10^{14} organisms per day. The excess loading associated with this event was 1.6×10^{13} organisms per day. To ensure that the load allocations will result in meeting the log-mean water quality criterion at all times, the estimate of the loading capacity for the river was reduced by an additional 2.0×10^{13} organisms per day for a total loading capacity of $\mathbf{2.2 \times 10^{14}}$ organisms per day (Table 2.6).

To determine the percent reduction needed to achieve the loading capacity and thereby meet the 126 *E. coli* organisms/100 ml criterion, the estimate of the current load and the calculated loading capacity were used to calculate a percent reduction. The percent reduction necessary to meet the TMDL is calculated by:

% Reduction = (Current Load – Loading Capacity) / Current Load * 100

A **46%** reduction from current estimated bacteria loading will be required to meet the estimate of the Loading capacity of the Willamette River at all places and all times (Table 2.6). Reductions in load upstream of RM 18 will result in meeting the log-mean criterion at all times upstream of the area affected by the Portland CSO.

Table 2. 6 Flow based Load Capacity for the Willamette River modified to account for continuing CSO loading following full implementation of the AFSO and control of combined sewer overflows.

	Load (*E.coli* organisms/day)
Current Load	**4.09×10^{14}**
Flow-Based Loading Capacity at River Mile 18 (a)	**2.40×10^{14}**
Additional Load Subtracted for CSO	**2.0×10^{13}**
Final Loading Capacity	**2.20×10^{14}**
Reduction (a)	**46%**

(a) Flow-Based Loading Capacity and % Reduction for the High Flow Scenario were originally estimated as 2.40×10^{14} and 41% respectively. This reduction was used in the scenario shown in Figure 2.12. The Flow-Based Load Capacity and Reduction needed for the High Flow Scenario were further reduced to those listed above to insure that predicted 30-day moving log mean of *E. coli* would be in compliance with the 126 criterion after implementation of the AFSO.

Allocations

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

The loading capacity determined for the river is divided among sources of bacteria throughout the basin. Allocations are applied year around to all sources. The majority of the loads are allocated to nonpoint sources upstream of RM 18. Point sources throughout the basin will be required to meet effluent limits equaling water quality criteria in effluent prior to discharge. Combined sewer overflows in the Portland Metro area will receive an allocation reflecting significant reductions from existing loads and will only be allocated during those conditions specified under the 1994 ASFO.

Wasteload Allocations

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

Waste water treatment plants are allocated permitted effluent limits at the bacteria standard. When operating properly, they will not cause or contribute to water quality violations (Table 2.7) and are a relatively small proportion of the total loading to the Willamette River. The sum of all point source waste loads discharged directly to the Willamette River is approximately 9.3×10^{11} organisms per day; however the waste load will vary based on effluent flow rates. Most discharges operate well within their permit limits and discharge smaller loads than indicated below. New sources or increased discharges from existing sources to the Willamette River or its tributaries will be allowed however they will be required to meet bacteria standards prior to discharge. This ensures these additions of load will not cause violations of water quality standards.

Combined sewer overflows (CSOs) are allocated an average wet weather event load based on modeling of the lower reach of the Willamette River that will result in meeting the 30-day log mean of 126 *E. coli* organisms per 100 milliliters criterion. The average one-day wet weather loading event is calculated as the average of all wet weather daily loads (a wet weather event constitutes at least one CSO overflow) (Limno-tech, 2001). The load allocation is zero at all times except during the maximum overflow frequencies (from May 1 through October 31 occurring during storms greater than or equal to a three year return frequency and from November 1 through April 31 occurring during storms with a four in one year return frequency) allowed by the Amended Stipulation and Final Order (ASFO). The allocation that accounts for these overflow events allows average wet weather event loads of 2.0×10^{13} *E. coli* organisms/day. This loading rate represents a 93% decrease relative to current conditions.

Table 2. 7 Wasteload allocations for Wastewater Treatment Plants (WWTPs).

File Number	Legal Name	River Mile	Allocated Permitted Effluent Limits (*E.coli* organisms/100 ml)	(a) Estimate of Loading (organisms/day)
55999	MWMC Eugene/Springfield STP	178	126 *E. coli* organisms/100 ml as a log-mean based on a minimum of 5 samples in a 30-day period and Not to exceed 406 *E. coli* organisms/100 ml in any single sample	2.38×10^{11}
34040	Springfield Public Schools District No. 19	170.8		4.77×10^{9}
105415	City of Harrisburg	158.4		4.77×10^{9}
20151	City of Corvallis	130.8		4.77×10^{10}
500	City of Adair	122		4.77×10^{9}
1098	City of Albany	119		4.77×10^{10}
57871	City of Monmouth	95.5		4.77×10^{9}
41513	City of Independence	95.5		4.77×10^{9}
78140	City of Salem	78.1		2.38×10^{11}
100077	Brooks STP	71.7		4.77×10^{9}
25567	City of Dundee	51.7		4.77×10^{9}
102894	City of Newberg	49.7		2.38×10^{10}
96010	Century Meadows Sanitary System, Inc.	42		4.77×10^{9}
97952	City of Wilsonville	39		2.38×10^{10}
13691	City of Canby	33		2.38×10^{10}
97612	Regency of Oregon, Inc.	31.6		4.77×10^{9}
30554	Forest Park Mobile Village LLC	28.2		4.77×10^{9}
89700	Tri-City Service District	25.5		4.77×10^{10}
70735	City of Portland	20.2		4.77×10^{10}
62795	Oak Lodge Sanitary District	20.1		2.38×10^{10}
16590	Clackamas County Service District #1	18.7		1.19×10^{11}
Total				9.29×10^{11}

a=estimate based on sum of individual treatment plants assuming effluent meeting log-mean criterion prior to discharge at design flow.

As shown in Table 2.6, a **46%** reduction of bacterial loads would be needed from urban (including waste loads addressed under an MS-4 permit) and agricultural areas. Although this reduction was defined under high-flow conditions, the reductions would be in effect at all times since management practices that control bacterial accumulation must be maintained year around. Areas addressed under the various MS4 permits are contained in the Lower, Middle and Upper Willamette Subbasins. Urban storm water runoff in these subbasins also influences the quality of several tributaries as well as the Willamette River itself. Additional percent reductions were identified in the tributary chapters and are summarized in the following section (load allocations). Where subbasin TMDLs present load reductions for specific waterbodies that are covered by an MS4 permit, those reductions will also be applied to the portion of the MS4 area that drains directly to the Willamette River.

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

Load allocations have been developed for nonpoint sources throughout the basin and in the mainstem of the river to ensure water quality standards will be met. The QUAL2E model demonstrated that the mainstem of the river will meet WQS throughout if tributary loads are reduced to meet standards and point source spills and overflows are reduced to permitted levels. The load-duration curve analysis at RM 18 of the Willamette River and modeling of CSO contributions to the lower reach indicated that a reduction in loads of 46% would result in standards being met under all flow conditions given all sources upstream. Between these analyses, it is clear that reductions in nonpoint source loads in tributaries and those added to the mainstem must be significantly reduced. Load allocations in the subbasins with tributaries to the Willamette River were developed in terms of percent reductions and will result in each tributary meeting the criteria throughout the watershed and in the water delivered to the river.

Subbasin-wide Load Allocations-Percent Reductions

This document includes assessments of indicator bacterial concentrations in waterbodies in the Lower, Middle, and Upper Willamette subbasins. In general, these assessments were made for waterbodies that are listed as impaired under Section 303(d) of the Clean Water Act and are included on Oregon's "303(d) list." A result of analysis of concentrations of these indicators is the allocation of pollutant loads to various land use categories. These land use categories are urban development and agriculture (including rangeland). Forestry was generally not a significant contributor to bacterial loads and, although not specifically allocated, is included in the background load.

Although allocations are based on analysis of individual waterbodies or reaches of streams, they represent land uses throughout the subbasin in which they were developed. The samples collected were intended to be representative of not only the site, but also of the land use associated with them. Although the reductions included in individual subbasin TMDLs are appropriate for the specific waterbodies they were developed for, the land use allocations have been generalized to apply to other parts of the subbasin regardless of water quality limited status (i.e., whether on the 303(d) list or not). This application of allocations throughout the subbasins allows newly discovered sources of bacteria to be addressed by the current TMDL rather than requiring additional TMDL development efforts in the future.

Reductions required for urban areas were typically higher than for generic agricultural land use (Table 2.8). The highest urban reduction in the Upper Willamette was 84% (Amazon Creek); the Middle Willamette was 94% (Clark Creek); and the Lower Willamette was 80% (Springbrook Creek). The highest agricultural reduction required in the Upper Willamette was 66% (Coyote Creek); the Middle Willamette was 83% (Mill Creek); and the Lower Willamette was 78% (Johnson Creek). These reductions are appropriate as allocations for other agricultural and urban areas in each of the subbasins and are the allocated targets for permitting and planning purposes.

It is appropriate to combine the allocations above into ranges that may be applied outside of the subbasins analyzed for basin-wide planning purposes. The reduction estimates for the analyzed subbasins have been translated into ranges that should be used as planning targets by management agencies responsible for ensuring water quality. Therefore a range of 80-94% reductions are appropriate for urban planning and permitting and a range of 66% to 83% reductions are appropriate for agricultural management areas in other subbasins in the Willamette Valley that have not been listed as water quality limited. This would allow planning to proceed under the assumption that appropriate pollutant controls would be applied and water quality standards would be met throughout the Willamette Basin.

Table 2. 8 Allocated percentage reductions for waterbodies in the Upper, Middle, and Lower Willamette Subbasins. Allocations to Willamette River are for urban and agricultural runoff.

Subbasin/Waterbody		Land Use	Overall %Reduction	%Reduction Urban	% Reduction Agriculture
Upper Willamette (see Chapter 10)					
Lower Long Tom River		Agriculture	47%	47%	47%
Luckiamute River		Agriculture	61-63%	61%	63%
Calapooia River		Agriculture	65%	65%	65%
Coyote Creek		Agriculture	66%	66%	66%
Upper Long Tom River		Ag/Ur	77%	77%	77%
A-3 Drain		Ur/Ag	33%	33%	33%
Amazon Creek		Urban	84%	84%	
Fern Ridge Res		n/a	64%		
Willamette River [a]		n/a		65% [b]	58%
Middle Willamette (see Chapter 7)					
Bashaw		Agriculture	68%	n/a	68%
Overall	Summer Fall-Winter-Spring	Ur/Ag	90% 84%	90% 84%	90% 76%
Mill Creek	Summer Fall-Winter-Spring	Ur/Ag	89% 81%	89% 85%	89% 83%
Pringle Creek	Summer Fall-Winter-Spring	Urban	90% 79%	90% 79%	90% 79%
Clark Creek	Summer Fall-Winter-Spring	Urban	94% 89%	94% 89%	n/a
Willamette River [c]		n/a		75% [b]	61%
Lower Willamette (see Chapter 5)					
Johnson Creek		Ur/Ag	78%	78%	78%
Fairview Creek		Urban	66%	66%	
Springbrook Creek		Urban	80%	80%	
Willamette River [d]		n/a		78% [b]	78%

a = based on average of subbasin reductions by landuse. See Load Allocation Section in Chapter
b = appropriate for use in MS4 permits and other planning documents.
c = based on overall analysis of subbasin samples by landuse.
d = based on analysis of Johnson Creek as most urbanized waterbody, and only available agricultural reductions.

Each of the subbasins with listed water quality limited streams received load allocations or it was determined that they were meeting standards. Following are brief descriptions of the each of the waterbodies and the allocation method used, and the reductions necessary to achieve the log-mean criterion of 126 *E. coli* organisms/100ml.

Long Tom River

The load duration curve method was used to determine the percent reduction necessary in the current load for the Long Tom River to meet the bacteria criterion (see Chapter 10 for details). In order to meet the log-mean criterion the maximum log mean based reduction is 47%.

Mary's River

The Mary's River is on the 303(d) list for violating the bacteria criterion in fall/winter/spring. Although a load duration curve for the lower Mary's River indicates it generally has meet water quality criteria (see Chapter 10; Upper Willamette Subbasin), there have been minor violations. An individual percent reduction will not be calculated for the Marys River, but ODEQ will apply the Upper Willamette Subbasin generalized percent reductions to address the criterion violations related to the Mary's River and Willamette mainstem.

Calapooia River

The load duration curve method was used to determine the percent reduction necessary to meet the bacteria criterion. The log mean value of data within all flow zones (High, Transitional, Typical, and Low) would meet the log-mean criterion with 65% load reductions overall.

Luckiamute River
The load duration curve method was used to determine the percent reduction in the current load necessary for the Luckiamute River to meet the log-mean criterion (see Chapter 10 for details). The log mean value of data within all flow zones (High, Transitional, Typical, and Low) would meet the log-mean criterion with 61% load reductions.

Mill Creek
The percent reduction for Mill Creek was determined conservatively by using the 75th percentile of the measured samples, rather than the calculated log-mean of the data set and calculating the percent reduction necessary to meet the log-mean criterion. Percent reductions in the Mill Creek drainage ranged from 83 to 89% among urban and agricultural sources. The percent reduction necessary to achieve the 126 *E. coli* organisms / 100 ml log-mean criterion was calculated during summer and fall-winter-spring periods separately for various land uses.

Rickreall Creek
Recent data from Rickreall Creek suggest general compliance with standards. Modeling suggests there is no impact on the Willamette River during the “reasonable worst case scenario” because the flow contribution is relatively insignificant. Rickreall Creek is not on the 2002 303(d) list for bacteria and available data does not indicate violations of the *E. coli* log-mean criterion.

Yamhill River
The Yamhill River contributes to bacteria criterion violations in the Willamette River under the “reasonable worst case scenario.” ODEQ will develop a TMDL for the Yamhill River and subbasin in 2006. However, the assumed allocation for input to the Willamette River model was 126 *E. coli* organisms/100 ml at the average January flow. Between now and TMDL development, use of the generalized reductions for urban and agricultural land uses are appropriate for planning purposes.

Molalla River and Pudding River
The Molalla River contributes to bacteria criteria violations in the Willamette River under the “reasonable worst case scenario”. ODEQ will develop a TMDL for the Molalla River and Pudding River Subbasin in 2007. However, the allocation for the input to the Willamette River is set at 126 *E. coli* organisms/100 ml at the average January flow. A TMDL for this subbasin is scheduled for completion in 2007.

Tualatin River
The Tualatin River drains to the Willamette River mainstem at about RM 28. ODEQ completed a bacteria TMDL for the Tualatin basin in August of 2001. The Tualatin TMDL utilized an event based, unit load model. The model used storm volumes, runoff concentrations for various land uses and bacteria die-off rates to predict instream bacteria concentrations. Allocations were set for each land use to attain the 126 *E. coli* criterion at the mouth of each fifth field watershed.

Clackamas River
The Clackamas River is not water quality limited for bacteria in the fall/winter/spring and does not contribute to bacteria criterion violations in the Willamette River during this time period. However, the allocation for the input to the Willamette River is set at or below the 126 *E. coli* organisms/100 ml at the average January flow.

Johnson Creek
The load duration curve method was used to develop the bacteria TMDL for the Johnson Creek Watershed. To achieve the loading capacity equivalent to the 126 *E. coli* organisms/100 ml criterion, a 72% reduction of the current load is necessary for Johnson Creek at 17th Avenue.

Allocation Summary

The TMDL represents allocations of loading capacity to all sources as appropriate to ensure water quality standards are not violated (Table 2.9). These allocations were developed to control bacterial concentrations in fall-winter-spring most often, but the allocations are applicable throughout the year since bacteria accumulate year around and may be "discharged" at any time. Wasteload allocations are estimates of the loading from all point sources when discharging at the log-mean water quality criterion at facility design flow. Load allocations for nonpoint sources and for MS4 permits assume reductions in load or concentration specified in individual subbasin TMDLs or as specified in Subbasin-wide Loading Allocation section (above) throughout the Willamette Basin. In subbasins with no listings, generalized reductions will be used as planning targets by designated management agencies. The Margin of Safety (MOS) is based on the use of conservative assumptions in analysis and modeling. Reserve capacity was set at 1/10th of the Loading Capacity. Reserve capacity will not be used for future point sources, which, as with existing sources, will be required to meet water quality criteria prior to discharge.

Loading capacity = TMDL = LA + WLA + MOS + Reserve Capacity

Table 2. 9 Allocations for all sources during the critical condition. Loading capacity is based on highest reduction required to meet standard during reasonable worst case scenario as defined in Loading Assessment. Loads are in terms of *E. coli* organisms per day.

Sources	Allocations	Current Loads	Excess Load
Nonpoint Sources: Load Allocation (LA) (a)	1.77 x10^{14}	4.08x10^{14} (e)	2.31x10^{14}
Point Sources: Wasteload Allocation (WLA) (b)	9.3 x10^{11}	9.3 x10^{11}	0
Combined Sewer Overflow (c)	2.0 x10^{13}	2.90x10^{14}	2.70x10^{14}
Reserve Capacity (d)	2.2 x10^{13}	NA	(2.2 x 10^{13})
Margin of Safety (MOS)	Conservative Assumptions	NA	NA
Total Allocations/Loading Capacity	2.20x10^{14}	6.99x10^{14}	4.79x10^{14}

a=Includes MS4 waste loads and other stormwater load reductions
b=estimate assuming discharge meeting log-mean criterion (126 organisms/100ml) at design flow.
c=30-day average based on no load except during overflow events allowed under ASFO
d= reserve capacity =0.1*Loading Capacity
e= NPS current load = total current load – estimated permitted point source contribution. NPS current load does include non-permitted point source spills and upsets.

Excess Load

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

There is currently an excess bacterial load to the Willamette River that results in occasional violations of water quality standards in the upper basin, and frequent violations in the lower basin. This load results partly from nonpoint source urban and agricultural runoff and waste water treatment plant upsets in the middle and upper reaches of the river, and partly from direct discharges from CSOs in the lower reach. The total excess load to the lower reach is 4.6x10^{14} *E. coli* organisms per day (Table 2.9), although this excess loading seasonal and sporadic. Point source loading during normal operations accounts for 1/1000th of that from these other sources and plays little or no role in standards violations. However, as noted above, spills and other overflows may be locally significant though rare and unpredictable sources.

Water Quality Standards Attainment Analysis

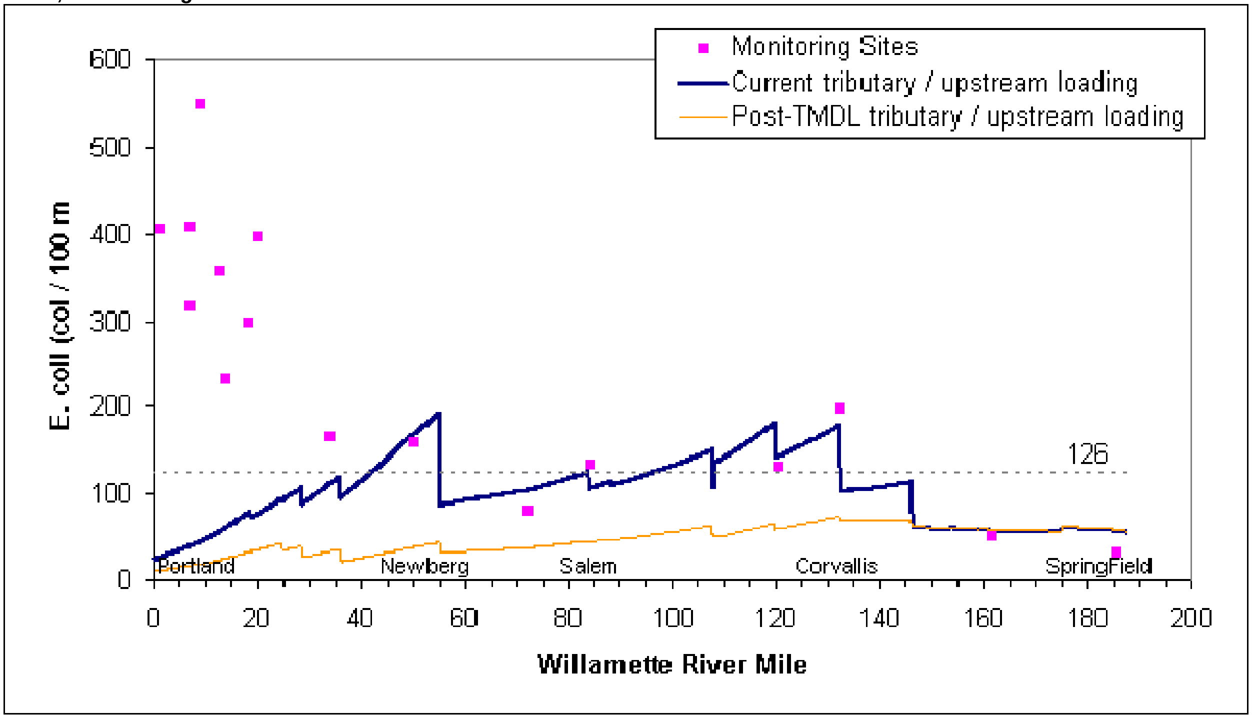
OAR 340-042-0040(4)(l)(e) & (j)

Upper Reach

The QUAL2E model was used to ensure that water quality standards would be attained if all allocations are met. A model scenario was run with tributary concentrations set at or below the log-mean *E. coli* criterion and where there were no loads from sewer overflows and spills. Where the current 90th percentile *E. coli* concentration for a tributary was greater than 126 organisms/100 ml, the concentration was reduced to 126 organisms/100 ml. Specific allocations/reductions assigned to individual subbasins or waterbodies were used as provided in the allocation section. All point sources discharging directly to the Willamette River were set at the permitted concentration of 126 organisms/100ml as specified in Table 2.6.

Modeling indicated that point sources discharging at the water quality criteria as indicated above cause less than a one-percent increase in *E. coli* concentrations over ambient concentrations. Further, the model predicted that, under these allocated conditions, the Upper Willamette River will meet water quality standards (Figure 2.13). Therefore, when all allocations have been implemented, the entire upper reach is expected to be in compliance with water quality standards.

Figure 2.13 *E. coli* concentrations during reasonable worst case scenario under current conditions and with post-TMDL loading reductions from tributaries and sources above RM 45. Values plotted at monitoring sites are 90th percentile Fall-Winter-Spring *E. coli* concentrations from 1996 through 2002.Tributary confluences / sources: A. Yamhill River, B. City of Salem WWTP and Mill Creek, C. Luckiamute River, D. Santiam River, E. Calapooia River, F. City of Corvallis WWTP and Mary's River, and G. Long Tom River.



Middle Reach

The load duration curve at the lower end of the reach (RM 18) and the QUAL2E model at the upper end of this reach (RM 48) indicates that the reach will be in compliance with the water quality standard after the TMDL is implemented.

Lower Reach

Allocations for the lower reach (river mile 0-18) assume the controls detailed in the Amended Stipulation and Final Order (ASFO) will be implemented and CSO and sewage spills will be mostly eliminated. As discussed previously, the tributary TMDLs and permit compliance will result in the reduction of bacteria concentrations at and above RM 18. The upstream boundary *E. coli* concentration of the PULSEQUAL model was reduced to meet the 126 *E. coli* organisms/100 ml log-mean criterion during the period of model simulation. Using this boundary condition and assuming all ASFO CSO controls are implemented, Limno-tech, Inc. (2003) ran scenarios predicting the log mean *E. coli* concentration (refer to Figure 2.12). With all load and wasteload allocations applied, the log-mean criterion will be met at all times.

Margin of Safety

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

A margin of safety is integral to the allocation process in TMDLs. The margin of safety may be an explicit reduction in the allocations to loads and wasteloads or it can be implicit in the procedures used for analysis and modeling. An implicit margin of safety presumes that conservative assumptions will result in less of the true available load being allocated to sources. The implicit margin of safety for this TMDL was based on the application of conservative assumptions in analysis and modeling. These assumptions include:

- Load capacity development from Load Duration Curve analysis used the lowest flow rate in each modeled flow regime, which overestimates actual loading prior to calculating percent reduction;
- Based overall reductions on worst case load analysis of extreme high-flow regime;
- Assessment of the current worst case scenario used 90th percentile concentrations rather than log-mean values to accentuate pattern of water quality criterion exceedences.

Reserve Capacity

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

The Reserve Capacity for the Willamette River was set at 1/10th of the Loading Capacity. This allows for future growth and expansion overall, though it is not provided to increase loading for point source discharges. Point source discharges are currently limited to meeting bacterial water quality criteria prior to discharge. In this way, point sources do not decrease loading capacity of the stream. New sources or increases to existing and point source discharges will also be required to meet these criteria prior to discharge to the Willamette River.

.

References

Brown C.L. and T.O. Barnwell. 1987. The Enhanced Stream Water Quality Models QUAL2E and QUAL2E-UNCAS: Documentation and User Manual, Environmental Protection Agency, EPA/600/3-87/007, Athens, Georgia.

City of Portland. 1999a. Willamette River Stakeholders Task Force, Recommendations To The Portland City Council, Portland's Predesign Project to Reduce Combined Sewer Overflows. http://www.cleanrivers-pdx.org/tech_resources/cso_stakeholders_report.htm

City of Portland. 1999b. Water Quality Assessment of Lower Willamette River, Willamette River CSO Predesign Project. September.

City of Portland. 2003. http://www.cleanrivers-pdx.org/what_we_do/ east_side_cso_tunnel.htm

DEQ. 2003. List of Water Quality Limited Waterbodies in Oregon ("303d List"). Submitted to USEPA in compliance with section 303(d). View at http://www.deq.state.or.us/wq/303dlist/303dpage.htm.

Limno-Tech, Inc. 2001. FINAL Forecasted Effects of CSO Control Alternatives on Water Quality in the Lower Willamette River, prepared for Montgomery Watson Portland, Oregon. Ann Arbor, Michigan.

Limno-Tech, Inc. 2004. PUSLEQUAL Modeling in Support of Bacteria TMDL Development for the Willamette River. Ann Arbor, Michigan. November 19th.

Tetra Tech. 1993. Willamette River Basin Bacteria Component Report, submitted to Oregon DEQ.

USEPA. 1986. Ambient Water Quality Criteria for Bacteria – 1986. Office of Water, Regulation and Standards, Criteria and Standards Division. EPA440/5-84-002

USEPA. 2001. Protocol for Developing Pathogen TMDLs. Office of Water. EPA 841-R-00-002.