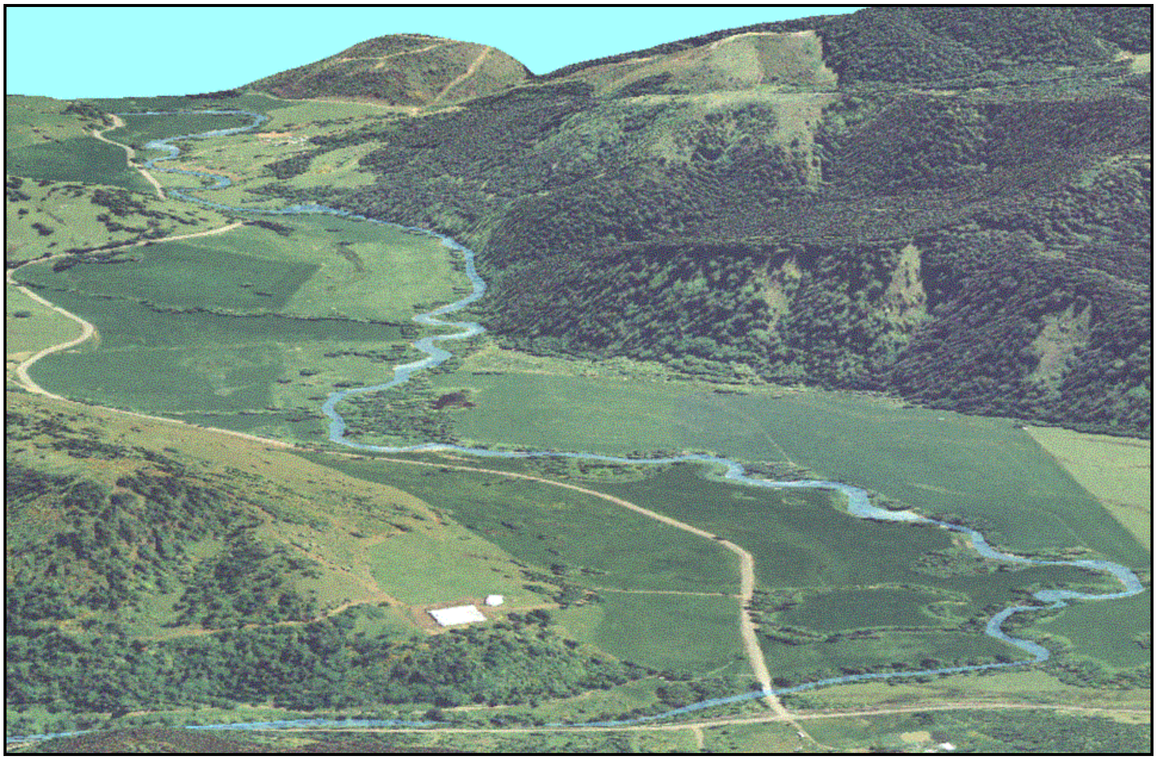
CHAPTER 2
UMPQUA BASIN BACTERIA TMDL



Prepared by

State of Oregon
Department of Environmental Quality

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TMDL COMPONENTS

Table 2.1. Umpqua Basin Bacteria TMDL Components

Waterbodies **OAR 340-042-0040(4)(a)**	Streams providing recreational contact or shellfish harvesting beneficial uses as defined in OAR 340-041-0320(1), Table 320A within the 4th field HUCs (hydrologic unit codes) 17100301, 17100302, and 17100303 (North Umpqua, South Umpqua and mainstem Umpqua Subbasins).
Pollutant Identification **OAR 340-042-0040(4)(b)**	Human pathogens associated with fecal contamination.
Beneficial Uses **OAR 340-042-0040(4)(c)** **OAR 340-041-0320(1)**	The most sensitive beneficial uses in the Umpqua Basin are water contact recreation, and commercial and recreational shellfish harvest where applicable.
Target Criteria Identification **OAR 340-042-0040(4)(c)** **OAR 340-041-0009(1)(a)(A)** **OAR 340-041-0009(1)(a)(B)** **OAR 603-100-0010** **CWA §303(d)(1)**	*E. coli* is used as an indicator of human pathogens for water recreational contact: (A) A 30-day log mean of 126 *E. coli* organisms per 100 milliliters, based on a minimum of five samples; (B) No single sample may exceed 406 *E. coli* organisms per 100 milliliters. In estuarine shellfish growing waters fecal coliform bacteria is used as an indicator of human pathogens for shellfish harvest in estuarine areas: (A) median concentration of 14 organisms per 100 ml. (B) not more than 10% of the samples exceeding 43 organisms per 100 ml.
Existing Sources **OAR 340-042-0040(4)(f)** **CWA §303(d)(1)**	Fecal bacteria sources may include wildlife, livestock waste, failing residential septic systems, wastewater treatment plant malfunctions, rural residential runoff and urban runoff.
Seasonal Variation **OAR 340-041-0040(4)(j)** **CWA §303(d)(1)**	Data is segregated into the summer period (June 1 – September 30) and the fall-winter-spring period (October 1 – May 31). Seasonal variation is also implicitly addressed using load duration curves because they incorporate all observed flows which are seasonally dependent. Allocations apply year round and are based on stream flow.
TMDL Loading Capacity **CWA §303(d)(1)**	The loading capacity was determined using load duration curves which account for the range of observed flows and the applicable water quality standard (126 *E. coli* organisms per 100 ml for water contact recreation or 14 fecal coliform organisms per 100 ml for shellfish protection). In some cases, the loading capacity has also been calculated to meet the applicable maximum criteria.
Allocations **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)**	The TMDL is divided into allocations to point sources (waste load allocations), nonpoint sources (load allocations), and a margin of safety (MOS) for each flow regime. Allocations apply year round and are based on stream flow. *Waste Load Allocations (Point Sources)*: Waste load allocations for waste water treatment plants are expressed as the effluent concentration equal to the target criteria. *Load Allocations (Nonpoint Sources)*: A reach specific load was allocated to nonpoint sources. *Excess Load:* The difference between the actual pollutant load and the loading capacity of the waterbody.
Surrogate Measures **OAR 340-041-0040(5)(b)** **40 CFR 130.2(i)**	Where appropriate, concentration or percent reduction in loading was used as a surrogate measure for loading.
Margins of Safety **OAR 340-042-0040(4)(i)** **CWA §303(d)(1)**	Either an implicit (using conservative assumptions during analysis) or an explicate (numeric) margin of safety was used where appropriate.
Reserve Capacity **OAR 340-042-0040(4)(k)**	New sources of fecal bacteria may discharge into receiving waters at the applicable target criteria.
Water Quality **Standard Attainment** **Analysis** **CWA §303(d)(1)**	Load duration curves indicate the loading at all observed flows. The implementation of flow-based reductions will result in water quality standard attainment. This is discussed further in the Water Quality Management Plan chapter of this document.
Water Quality Management Plan **OAR 340-041-0040(4)(l)** **CWA §303(d)(1)**	The Water Quality Management Plan (see Chapter 7) 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.

OVERVIEW

Waterbodies in the Umpqua Basin are water quality limited due to fecal bacteria affecting water contact recreation and shellfish harvest. The Umpqua River (including the estuary), South Umpqua River, Scholfield Creek, Deer Creek, North Fork Deer Creek, North Myrtle Creek, Elk Creek, Calapooya Creek, Smith River, Winchester Creek and Yoncalla Creek have violated water quality standards for fecal bacteria. Fecal bacteria sources may include wildlife, livestock waste, failing residential septic systems, wastewater treatment plant malfunctions, rural residential runoff and urban runoff. The TMDL includes descriptions of watersheds, the pollutants responsible for impairments, standards being applied, sources of the pollutants, a description of data collected, loading capacity and allocations of loads for various direct loads on a watershed scale, and a margin of safety, see Table 2.1.

In general, for the Umpqua Basin, fecal bacteria loading appears to be dominated by nonpoint sources, although point sources impact the estuary on occasion. Nonpoint source pollution comes from diffuse sources such as agricultural and urban runoff as opposed to point source pollution which is discharged by individual facilities through a pipe into a waterbody. Non-domestic animals (wildlife) are also nonpoint sources of bacteria; however, human controlled sources can be managed to reduce fecal bacteria loading. Stream flow based allocations have been developed for point and nonpoint sources and apply year round.

The allocations apply to all anthropogenic sources of bacteria in the Umpqua and South Umpqua Subbasins and will lead to attainment of criteria in all perennial streams.

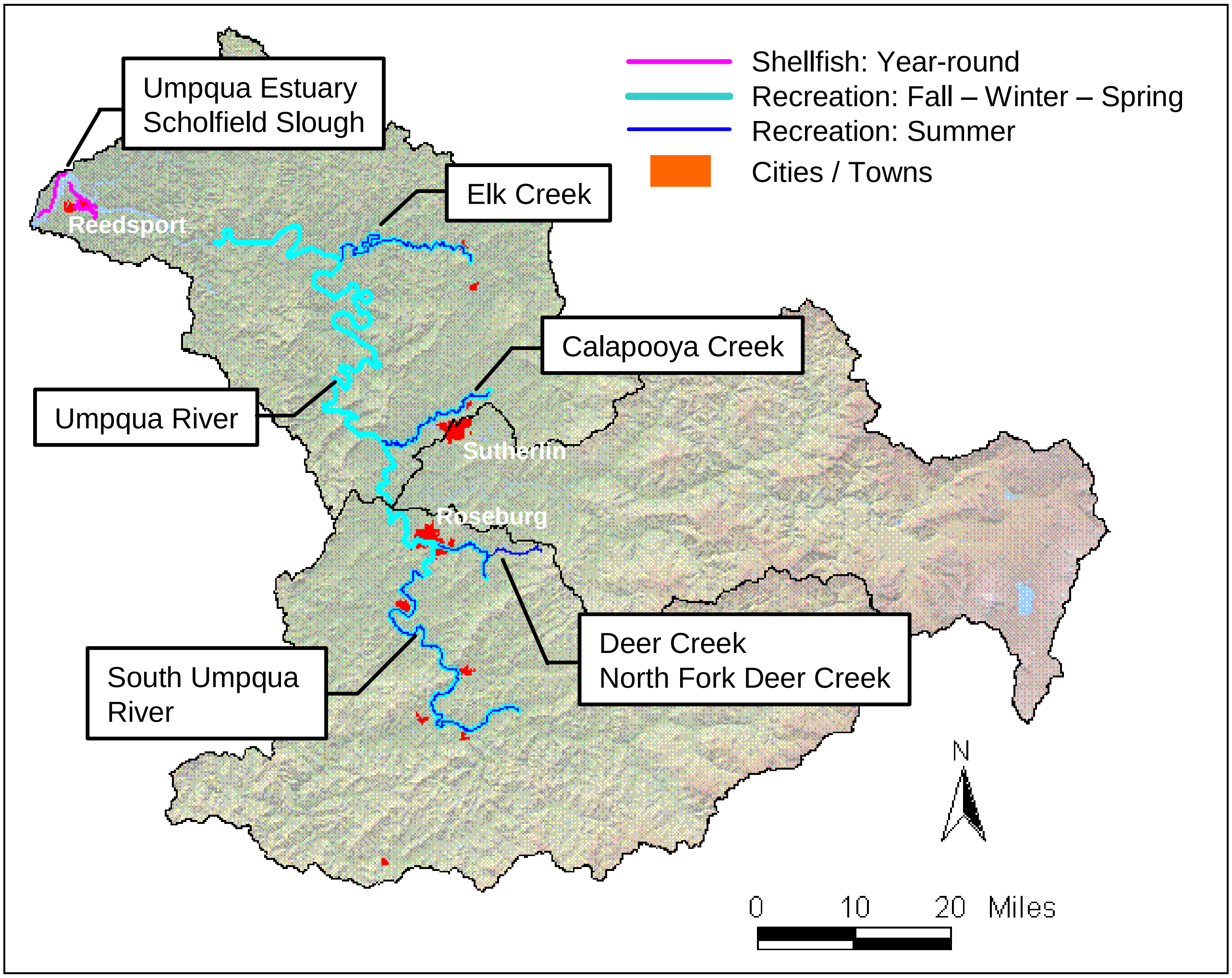
WATER QUALITY LIMITED WATERBODIES

The Umpqua Basin includes waterbodies in which concentrations of fecal bacteria have been measured greater than the water quality standard. DEQ is required by the federal Clean Water Act to maintain a list of stream segments that do not meet water quality standards and have not had a TMDL completed. This list is called the 303(d) List because it is required by Section 303(d) of the Clean Water Act. The U.S. Environmental Protection Agency received DEQ's 2004-06 303(d) list on May 23, 2006. Table 2.2 below lists the Umpqua Basin streams on the 303(d) list for bacteria, and Map 2.1 shows their location in the Umpqua Basin.

Table 2.2. Fecal Bacteria Water Quality Limited Streams in the Umpqua Basin, 2004-06 303(d) List

Record ID	Waterbody Name	River Mile	Parameter	Season	Beneficial Use
5429	Calapooya Creek	0 to 18.7	Fecal Coliform	Winter/Spring/Fall	Water contact
18307	Calapooya Creek	0 to 18.7	*E. coli*	Winter/Spring/Fall	Water contact
18308	Calapooya Creek	18.7 to 25.3	*E. coli*	Winter/Spring/Fall	Water contact
18033	Deer Creek	0 to 9.6	*E. coli*	Winter/Spring/Fall	Water contact
5425	Deer Creek	0 to 9.6	Fecal Coliform	Winter/Spring/Fall	Water contact
5657	Deer Creek	0 to 9.6	Fecal Coliform	Summer	Water contact
17636	North Fork Deer Creek	0 to 6.7	*E. coli*	Winter/Spring/Fall	Water contact
8091	North Fork Deer Creek	0 to 6.7	*E. coli*	Summer	Water contact
18521	Elk Creek	0 to 25.9	*E. coli*	Winter/Spring/Fall	Water contact
18522	Elk Creek	25.9 to 45.6	*E. coli*	Winter/Spring/Fall	Water contact
5430	Elk Creek	0 to 25.9	Fecal Coliform	Winter/Spring/Fall	Water contact
17877	North Myrtle Creek	0 to 18.3	*E. coli*	Summer	Water Contact
5652	Scholfield Creek	0 to 5.0	Fecal Coliform	Year Around	Shellfish
20144	Smith River	0 to 3.3	Fecal coliform	Year Around	Shellfish
18181	South Umpqua River	15.9 to 57.7	*E. coli*	Summer	Water contact
5427	South Umpqua River	15.9 to 57.7	Fecal Coliform	Summer	Water contact
20486	Umpqua River	25.9 to 109.3	*E. coli*	Winter/Spring/Fall	Water contact
5433	Umpqua River	25.9 to 109.3	Fecal Coliform	Winter/Spring/Fall	Water contact

Record ID	Waterbody Name	River Mile	Parameter	Season	Beneficial Use
5651	Umpqua River	0 to 1.0	Fecal Coliform	Year Around	Shellfish
5650	Umpqua River	1.0 to 6.7	Fecal Coliform	Year Around	Shellfish
5649	Umpqua River	7.7 to 11.8	Fecal Coliform	Year Around	Shellfish
20491	Umpqua River	10.7 to 25.9	Fecal Coliform	Year Around	Shellfish
20492	Umpqua River	25.9 to 109.3	Fecal Coliform	Year Around	Shellfish
20436	Winchester Creek	0 – 5.4	Fecal Coliform	Year Around	Shellfish
17888	Yoncalla Creek	0 – 8.3	*E. coli*	Winter/Spring/Fall	Water contact



Map 2.1 Impaired waterbodies in the Umpqua Basin for exceedances in bacteria criteria as identified on the 2002 303(d) list.

The Umpqua River (including the estuary), South Umpqua River, Scholfield Creek, Deer Creek, North Fork Deer Creek, North Myrtle Creek, Elk Creek, Calapooya Creek, Smith River, Winchester Creek and Yoncalla Creek have violated the fecal bacteria water quality standard, and are considered water quality limited (Table 2.2 and Map 2.1). Water quality limitations are separated into two seasons: summer (June 1 through September 30) and fall-winter-spring (October 1 through May 31).

POLLUTANT IDENTIFICATION

The pollutant of concern is fecal-related microorganisms which cause disease in humans. Fecal coliform and *Escherichia coli* (*E. coli*) bacteria are produced in the guts of warm-blooded vertebrate animals, and indicate the presence of pathogens. Fecal coliform and *E. coli* have been measured in water bodies in the Umpqua Basin.

BENEFICIAL USE IDENTIFICATION

The beneficial uses affected by elevated bacteria levels are primary water contact recreation (e.g., swimming) and shellfish harvesting, which is a subset of fishing. The criteria for "bacteria in shellfish waters" apply to the Umpqua River Estuary and beaches where shellfish are harvested commercially or recreationally for human consumption. The criteria for "recreational contact in water" apply to all other waters in the basin. Beneficial uses in the Umpqua Basin are defined in the Oregon Administrative Rules, *OAR 340–041–0320(1), Table 320A*, and are shown in Table 2.3 below.

Table 2.3. Beneficial uses occurring in the Umpqua Basin

(OAR 340–041–0320(1), Table 320A)
Bacteria-sensitive Beneficial Uses are marked in gray

Beneficial Use	Occurring	Beneficial Use	Occurring
Public Domestic Water Supply	✓	Anadromous Fish Passage	✓
Private Domestic Water Supply	✓	Salmonid Fish Spawning	✓
Industrial Water Supply	✓	Salmonid Fish Rearing	✓
Irrigation	✓	Resident Fish and Aquatic Life	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing [1]	✓
Aesthetic Quality	✓	Water Contact Recreation	✓
Commercial Nav. & Trans.	✓	Hydro Power	✓

[1] Fishing beneficial use includes shellfish harvest.

The bacteria TMDL is designed to protect two sensitive beneficial uses in two different landscape situations: 1) Bacteria impair the recreational use of rivers if concentrations exceed those determined through epidemiological studies to cause illness through body contact at a rate of 8 or more cases per 1,000 swimmers. 2) Bacterial levels in estuarine shellfish harvesting waters must be lower than those used for body contact, as shellfish filter large volumes of water and accumulate bacteria and pathogens at concentrations higher than found in ambient water.

TARGET CRITERIA IDENTIFICATION

The indicator bacterium used by DEQ for assessing bacterial contamination for recreational waters changed in 1996 from the general class of fecal coliform bacteria to *E. coli* (Table 2.4). In general, *E. coli* are a subset of fecal coliform bacteria. This change was made in part because *E. coli* is a more direct reflection of contamination from sources that also carry pathogens harmful to humans and is correlated more closely with human disease. There are some fecal coliform listings based on data gathered before the standard changed in 1996. In addition, fecal coliform bacteria are still used in the standard as the indicator for protection of human health in assessing water quality in commercial and recreational shellfish harvesting areas (Table 2.4). These shellfish harvesting areas, and monitoring of water quality associated with them, are under the jurisdiction of the Oregon Department of Agriculture (ODA). Bacterial criteria for the waters of the Umpqua Basin are contained in the Oregon Administrative Rules (OAR).

Table 2.4. Water quality standards summary for bacteria in the Umpqua Basin

Use	Description
Freshwaters and Estuarine Waters Other than Shellfish Growing Waters (Water Contact Recreation): OAR 340-041-0009(1)(a)	(A) A 30-day log mean of 126 *E. coli* organisms per 100 milliliters, based on a minimum of five samples; (B) No single sample may exceed 406 *E. coli* organisms per 100 milliliters.
Marine and Estuarine Shellfish Growing Waters: OAR 340-041-0009(1)(b)	A fecal coliform median concentration of 14 organisms per 100 milliliters, with not more than ten percent of the samples exceeding 43 organisms per 100 milliliters

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.
>
> (b) Marine Waters and Estuarine Shellfish Growing Waters: A fecal coliform median concentration of 14 organisms per 100 milliliters, with not more than ten percent of the samples exceeding 43 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 sewer or treatment plant overflows are not an apparent source of violations in the Umpqua Basin, similar language in Oregon Administrative Rules (340-041-0009(7)) regulates these sources.

Average vs. Extreme Concentration Target

In both standards, there is an average concentration target and an extreme concentration target. The TMDL target, in both cases, is the average concentration target. This target was chosen because it most directly relates to illness rates[1], is a more stable indicator of fecal contamination, and can be addressed through available analytical methods. The flow-based reductions necessary to meet the median shellfish criteria will likely result in compliance with the extreme concentration target (see Umpqua River and Estuary).

For the recreational contact standard, single sample maximum (406 *E. coli* organisms/100ml) was intended as a screening tool for determining whether swimming beaches should be closed on a short-term basis. This screening criterion is commonly used for listing purposes under Section 303(d) of the federal Clean Water Act. The TMDL does not envision that there will never be a violation of the single sample maximum, but that the geometric mean criterion will be met under all foreseeable conditions. discussion of the utility of these two criteria is in the recent document: Water Quality Standards for Coastal and Great Lakes Recreation Waters; Final Rule Federal Register / Vol. 69, No. 220 / Tuesday, November 16, 2004 / Rules and Regulation. In this document, USEPA stated:

> "using the single sample maximums as values not to be surpassed for all Clean Water Act applications, even when the data set is large, could impart a level of protection much more stringent than intended by the 1986 bacteria criteria document"

Therefore, the geometric mean criterion is identified as the ultimate goal of the TMDL. Future, post-TMDL compliance assessments of the basin will compare instream concentrations to the geometric mean criterion. In situations with limited data, maximum values are used to indicate that the mean concentration would likely be exceeded.

The management practices that control fecal bacteria to achieve the average concentration target will also control loading associated with the peak concentrations. If during future monitoring it is shown that peak concentrations are consistently exceeding the extreme sample criteria, DMAs will be asked to modify their management plans to address these peak loads, see Water Quality Management Plan (Chapter 7). Source or waterbody concentrations exceeding the extreme target concentration should trigger additional monitoring to determine compliance with the average target.

[1] From Implementation Guidance for Ambient Water Quality Criteria for Bacteria (USEPA, EPA-823-B-02-003, May 2002 Draft, p. 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.

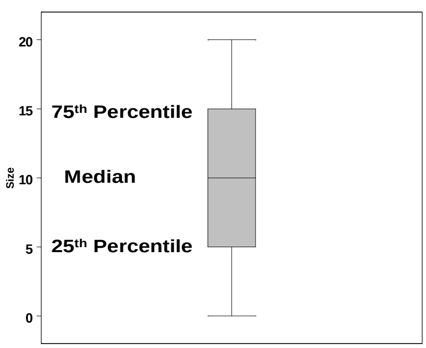
Part of the DEQ water quality standard for bacteria is expressed as a 30-day log mean. A log mean is also called a geometric mean, and is a type of average. A log mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the result if a straight average were used.

Measurements of bacteria can range from 0 to over 10,000 organisms in a 100 milliliter water sample. When data varies so much over a wide range, the numbers are often transposed into logarithms. This makes many of the calculations easier and allows the data to be displayed more clearly on graphs.

Some of the graphs in this document use a “log scale” for bacteria. See Figure 2.1 for an example. This means that values on the scale go from 1, to 10 (10^1), to 100 (10^2), to 1,000 (10^3), to 10,000 (10^4) and so forth.

Box Plots are used to illustrate the distribution of samples through time or among places. The percentile indicates the percentage of sample values less than the value at that point in the distribution. In example 1 (top), 75%of sample values are lower than 15 and 25% are lower than 5. By definition, the median is the 50th percentile, with 50% of values lower and 50% of values higher than the median.

Box and Whisker Plot Example 1

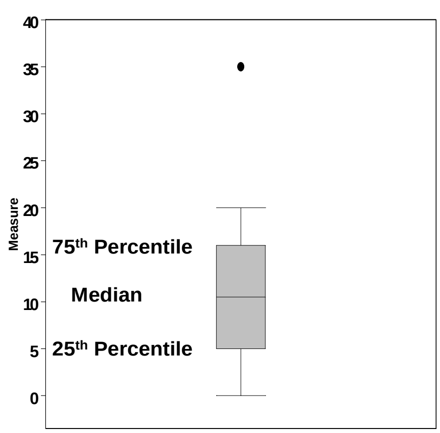


In the Box Plot at left, the numbers 0 through 20 are plotted based on their distribution as a percent of the total.

The median = 10
75th Percentile = 15
25th Percentile = 5

Ends of the “whiskers” are the extreme values in the data excluding “outliers”

Box and Whisker Plot Example 2



In the Box Plot at left, the numbers 0 through 20 are plotted based on their distribution as a percent of the total. An additional number,35, is plotted as an “outlier”

Outliers are greater than 1.5 times the range between the 25th and 75th Percentiles

The measurement of bacteria concentrations can vary considerably. Samples taken at the same time and place will probably not yield exactly the same result. Analysis of 227 duplicate fecal coliform samples collected in Oregon during 1996 and 1997 showed that samples varied more at higher concentrations, see Table 2.5. See Appendix A for a complete discussion of the results of this analysis.

Table 2.5. Results of 1996/1997 sample analysis

Average Value	Average Difference	Percent Difference
16	8	± 50%
318	97	± 28%

Umpqua Estuary

Fecal coliform concentrations in the estuary are typically less than the *E. coli* concentrations upstream (Figure 2.1). However, in the estuary, a stricter standard applies because of the use of shellfish for consumption. In Figure 2.1, the standards to protect shellfish harvesting are shown by the dotted lines at 43 org. /100ml and 14 org. /100 ml. The standards for water contact recreation are shown by the dotted lines at 406 org. /100 ml and 126 org. /100 ml. See Table 2.4 for the specific standards.

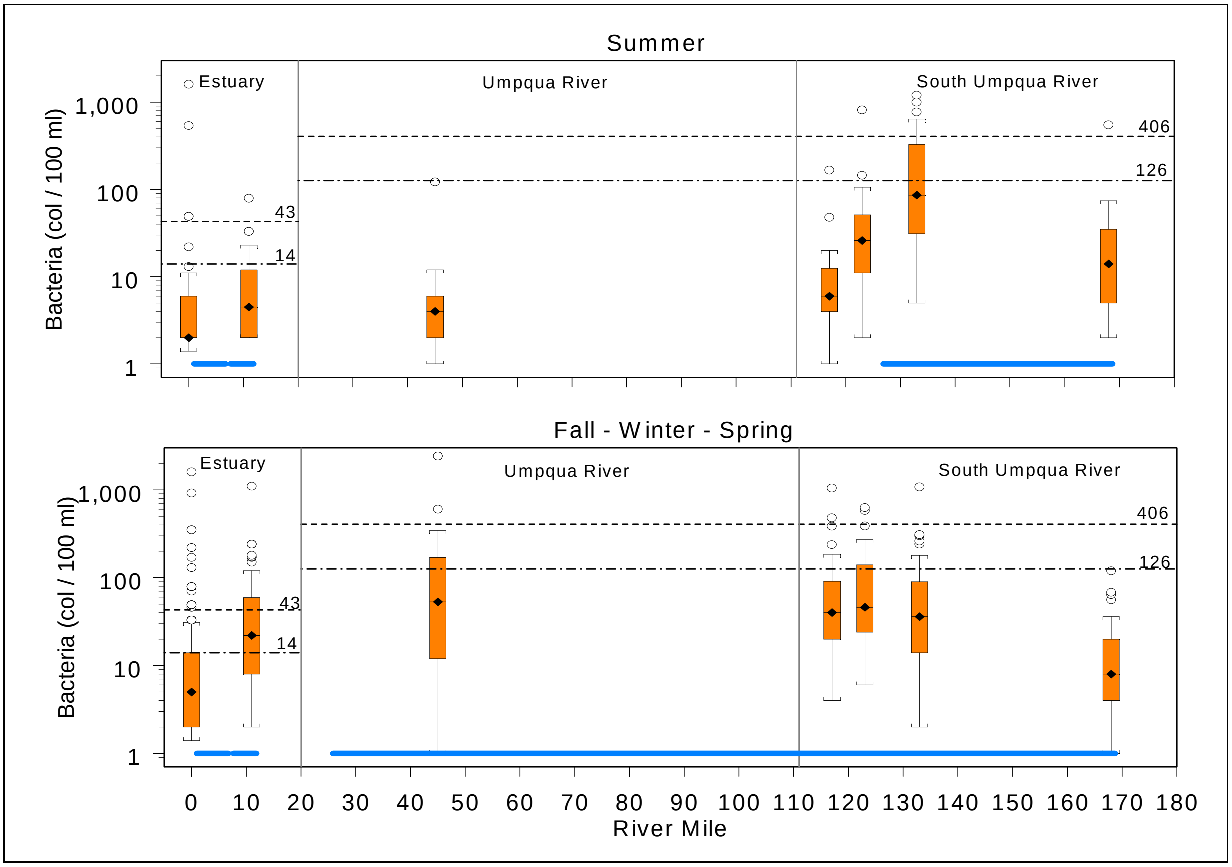


Figure 2.1 Summary of bacteria concentrations in the Umpqua Estuary (fecal coliform, river mile 0 to 20), Umpqua River (*E. coli*, river mile 20 to 111), and the South Umpqua River (*E. coli*, river mile 111 to 175). Reaches on the 2002 303(d) list are marked by the thick blue line. Data was collected between December 1995 and September 2003.

BASIN WIDE BACTERIA SOURCE ASSESSMENT AND ALLOCATIONS

Existing Sources

Point Sources

There are 18 facilities that treat domestic sewage and discharge effluent to water bodies in the Umpqua Basin and require NPDES[2] permits. The NPDES permits for these facilities require the effluent to meet the water quality standard for bacteria prior to discharge, with no allowance for mixing. The Discharge Monitoring Reports (DMRs) for these waste water treatment plants (WWTPs) show that they have generally been in compliance with this requirement and therefore do not cause or contribute to violations of the bacteria water quality standard. The permits also prohibit discharge of untreated sewage except during certain storm events. By rule, overflows of untreated sewage are prohibited in the summer months except during the 1-in-10 year 24 hour storm. In the winter months, all municipalities are expected to convey and treat all sewage up to the 1-in-5 year 24 hour storm. Some facilities in the basin are operating beyond their designed capacity and several occasionally release partially treated or diluted sewage during storm events. These exceptions appear to be contributing to exceedances of the bacteria standard and are discussed in the sections to follow. When operating in compliance with the requirements of the NPDES permits, waste water treatment facilities do not cause or contribute to bacteria water quality standard violations in the Umpqua Basin at this time. Therefore, the waste load allocation for the WWTPs is that their effluent meets the water quality criteria for bacteria (the shellfish growing waters bacteria water quality standard for those facilities that discharge into shellfish growing water and the recreational contact bacteria water quality standard for the other facilities).

There are two landfills in the Umpqua Basin operated by Douglas County with permits to discharge treated leachate into Umpqua Basin drainages. Neither landfill is a significant source of fecal bacteria. The landfill allocations will be that their effluent meets the *E. coli* water quality standard.

Several wastewater treatment facilities and landfills have general stormwater (1200Z) permits and are monitoring for *E. coli*. The benchmark in these permits is 406 E. coli/100 ml. Because these facilities only discharge during significant rainfall events, they are not expected to cause or contribute to exceedances of the bacteria standard.

None of the municipalities in the Umpqua Basin are required to have a stormwater permit. Therefore, urban runoff is treated as a nonpoint source and assigned a load allocation.

There are currently seven confined animal feeding operations (CAFOs) that have an NPDES permit. Oregon Department of Agriculture issues and insures compliance with the CAFO NPDES permits. CAFOs are only allowed to discharge during extreme rainfall events greater than the 25-year, 24-hour rainfall. The general permit also stipulates that during such a discharge, effluent cannot cause or contribute to a violation of state water quality standards. Because the TMDL only addresses the time period when the CAFO discharge is prohibited, the CAFO is allocated zero load. However, discharges during extreme rainfall events (i.e., the 25-year, 24-hour rainfall) remain permitted.

There are many other NPDES permitted facilities in the basin discharging effluent from industrial facilities and storm water. These facilities are not likely causing or contributing to fecal bacteria standards violations. These sources are allocated a load which is equivalent to the fecal bacteria concentrations at or below the water quality standard.

[2] NPDES stands for National Pollutant Discharge Elimination System, and is the name of the Clean Water Act permit program which applies to wastewater treatment plants and other facilities which discharge directly to state waters. It also applies to certain stormwater permits.

Nonpoint Sources

Nonpoint source pollution comes from diffuse sources as opposed to point source pollution which is discharged by individual facilities. Potential nonpoint fecal bacteria sources include wildlife, livestock waste, failing residential septic systems, pets, and illegal discharges. Fecal bacteria can be deposited directly into a water body or transported into water bodies by runoff or subsurface flow. Many of these sources overlap in space and time; for instance, a rural residential area may have failing septic tanks, livestock, pets, and wildlife. Therefore, the sources of the fecal bacteria are not obvious. Watershed councils in the Umpqua basin are pursuing bacteria source tracking using DNA analysis. Because management agencies are generally designated by land use (e.g., ODA), the following is a discussion of bacteria sources by land use. However, in this TMDL, distinction between nonpoint sources, such as wildlife, livestock, and failing septic systems, was not possible because of the re-suspension of bacteria from sediment and spatially overlapping sources. Load allocations apply to all nonpoint sources of fecal bacteria in the Umpqua, South Umpqua, and North Umpqua Subbasins.

Forest Managed Lands

76% of the Umpqua Basin is classified as forested (based on zoning maps, Oregon State Service Center, 1998). Samples collected from streams draining only forest lands during intensive storm surveys were well below the bacteria standard with a combined log mean concentration of 5 *E. coli* org./100 ml. Similar results were observed during a summer synoptic survey on Jackson Creek which drains forest-only lands. Assuming that these samples are representative of forest managed lands throughout the basin, these lands do not appear to cause or contribute to bacteria water quality violations. These results are consistent with similar TMDL studies in the Willamette and North Coast Basins.

Agricultural Lands

According to the 2002 Census of Agriculture (USDA 2004), in Douglas County, which covers approximately the same land area as the Umpqua Basin; livestock inventories included 47,031 cattle and calves and 36,302 sheep and lambs. Approximately 20% of the land in the Umpqua Basin is *zoned* for agriculture (based on zoning maps, Oregon State Service Center, 1998).

Bacteria from livestock waste can be transported to the stream during rainfall / runoff events, and bacteria in livestock waste can be directly deposited to streams while livestock are watering. Septic systems, pets, and wildlife are also commonly associated with agricultural land. Differing management practices and landscape properties control the delivery of fecal bacteria to water bodies. During intensive storm sampling events on Elk, Calapooya, and Deer Creeks, concentrations of *E. coli* increased as the percentage of agriculturally zoned areas increased upstream of the sampling point. However, this pattern was not evident during winter storm sampling on the South Umpqua River or during summer sampling on the South Umpqua River and Deer Creek.

Rural Residential and Urban Lands

Rural residential and urban areas together compose approximately 3% of the Umpqua Basin. Bacteria from developed land is known to come from pets, hobby farms, failing on-site wastewater treatment systems (i.e., septic systems), and wildlife. Residential areas are often inter-mixed with agricultural areas and therefore it is difficult to separate their contributions to bacteria loading.

Failing and/or poorly situated on-site sewage systems can produce significant loads of *E. coli*. An on-site system may not be visibly failing but be located too close to streams to properly treat sewage. If failing or poorly situated on-site systems were the dominant source of bacteria loading, bacteria concentrations would likely remain constant in the winter between rainfall events when soil is saturated due to constant loading. This is not the pattern observed during storm sampling events where concentrations tended to follow the same pattern as the hydrograph. Thus, while there may be some contribution from failing on-site sewage systems, this does not appear to be the dominant source of bacteria in the Umpqua Basin. There are regulatory programs in place at DEQ to insure on-site systems do not cause or contribute to water quality violations. Complaints and concerns should be directed to the Roseburg DEQ office.

The high percentage of impervious surface and efficient storm water delivery systems of urbanized areas can lead to significant loading from urban areas. Summer concentrations of *E. coli* increase in Deer

Creek as it flows through the Roseburg area confirming the existence of urban / residential sources of fecal bacteria.

Future Sources

Future sources may discharge effluent containing fecal bacteria at concentrations *less than* 14 fecal coliforms / 100 ml in the estuary and 126 *E. coli* / 100 ml in the remainder of the basin.

Die-off

Fecal coliforms, of which *E. coli* is a subset, are found in the intestines of warm blooded animals. This environment provides warm constant temperatures and nutrients which are conducive to bacterial growth. Once excreted from an animal host, however, these organisms encounter limited nutrient availability, osmotic stress, large variations in temperature and pH, and predation (Winfield and Groisman, 2003). However, bottom sediment can serve as a reservoir for fecal indicator bacteria, complicating the link between sources and bacteria concentrations in the water column.

Once excreted from their host, fecal bacteria typically have a limited ability to survive in the water column (EPA 2001). Death rates can be influenced by temperature, salinity, predation and sunlight. However, it is usually considered sufficient to approximate the die-off rate with an exponential decay which is dependent on concentration and temperature. Low survival rates of *E. coli* in waterbodies have been well-documented with an approximate half life of 1 day (Winfield and Groisman 2003). Anecdotal evidence suggests that coliform exposed to polluted waters may survive for longer periods of time and reproduce (Witbeck, personal communication, 2005). The fate of *E. coli* in sediment, though, is not clear and has been the topic of many studies.

Re-suspension

Fecal indicator bacteria can adhere to suspended particles in water which then settle, causing an accumulation of bacteria in the bottom sediment (Davies et al., 1995). Numerous studies have found fecal indicator bacteria at greater concentrations in the sediment than in the overlying water in rivers, estuaries and beaches (Stephenson and Rychert, 1982; Struck 1988; Obiri-Danso and Jones, 1999; Byappanahalli, et al. 2003; Whitman and Nevers, 2003). Concentrations in the sediment can range from 10 to 100 times greater than in the overlying water. Re-suspension of bottom sediment has been shown to increase fecal indicator bacteria concentrations in the water column. (Sherer et.al., 1988, and Le Fever and Lewis, 2003).

The higher concentrations of fecal indicator bacteria in sediment are attributed to much slower die-off rates when compared to overlying water (Gerba and MeLeod, 1976, LaLiberte and Grimes, 1982, Burton et. al., 1986, Sherer et. al., 1992, Davies et. al. 1995). Davies et al. (1995) found that the usual exponential decay model is not appropriate for fecal coliforms in sediment. Particle size distribution, nutrients and predation were hypothesized to influence survival rates; however, no quantitative correlation of survival rates with environmental factors was presented.

Two recent field studies have indicated the possibility that fecal indicator bacteria can form a stable, dividing population in sediment in a temperate environment (Whitman R.L and M.B. Nevers, 2003 and Byappanahalli, et al. 2003). Whitman and Nevers (2003) concluded that “more research into the environmental requirements and potential for in situ growth is necessary before *E. coli* multiplication in temperate environments can be confirmed, but this study provides initial data supporting that hypothesis.”

Flow-Based Source Assessment

Fecal bacteria concentrations generally increased with stream flow. However, no simple, predictive relationship exists. Given the complexity of the sources and transportation pathways, the TMDL is based on only a basic relationship between bacteria loading and separated by five flow ranges which cover all the observed flows. Fecal bacteria sources contribute to loading at during different flow regimes. Table 2.6 can be used as a general guide for flow-based source assessment.

Table 2.6. Generalized flow-based source assessment.

	Range of Flows				
Possible Sources	High Flow	Wet	Mid-Range	Dry	Low Flow
Direct Delivery (i.e. swimmers, wildlife, pets, livestock in-stream, illegal dumping)			M	H	H
Failing or poorly situated on-site wastewater systems		H	H	M	
Re-suspension	H	H	M		
Overland Flow	H	H	M		
WWTP overflow	H	M			

Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium)

Bacteria Source Tracking

ODEQ recognizes that, in the long term, it may be difficult to address bacteria water quality impairments without a reliable method to determine the source of contamination. However, given the known bacterial sources and the severity of bacterial water quality standards violations in the Umpqua Basin, considerable progress can be made toward achieving water quality standards simply by targeting known sources with appropriate Best Management Practices and currently accepted source tracking techniques.

Bacterial Source Tracking (BST) methods are potentially powerful tools that are increasingly being utilized to identify the animal source of bacteria in surface waters. The central premise of BST is that bacteria exhibit some degree of host specificity – that is, bacteria from different host organisms (livestock, humans, wildlife, etc.) can be differentiated and used to identify the sources of bacterial pollution in surface waters (Harwood 2002, Samadpour 2002).

BST techniques fall into two broad categories, molecular and non-molecular. Non-molecular techniques such as Antibiotic Resistance Analysis (ARA) and Carbon Utilization Profile (CUP) use non-genetic characteristics to differentiate the sources of fecal bacteria, while molecular techniques, which are commonly referred to as “DNA fingerprinting”, are based on the unique genetic makeup of different strains of fecal bacteria (EPA 2002). BST may use one of several methods to differentiate between bacterial sources, all of which follow a common sequence of analysis. First, a distinguishing characteristic (such as antibiotic resistance or differences in DNA), must be selected to identify various strains of bacteria. A representative library of bacterial strains and their fingerprints must then be generated from the human and animal sources that may impact the water body in question. Bacteria samples from the water body are then compared to those in the library and assigned to the appropriate source category based on fingerprint similarity (EPA 2002).

Several BST methodologies are currently being developed and tested, including Pulse Field Electrophoresis (PFGE), Ribotyping (RT), Amplified Fragment Length Polymorphism (AFLP) and ARA. There are several important considerations for choosing BST methods, namely their relevance to appropriate regulations, geographic areas and the ability to allocate loadings to particular source categories. Obviously, the association accuracy of the method and geographic range of the genetic library used are extremely important, as is the overall experimental design.

Lastly, for BST analyses to be truly useful, they must be conducted over a variety of flow and precipitation regimes over the course of a year and at multiple land use-based locations within a watershed. For the results to be used to indicate relative bacteria contributions causing violations samples should also be collected for BST during times when bacteria water quality standards are not being achieved. Concurrent stream flow measurements and bacteria counts should also be reported.

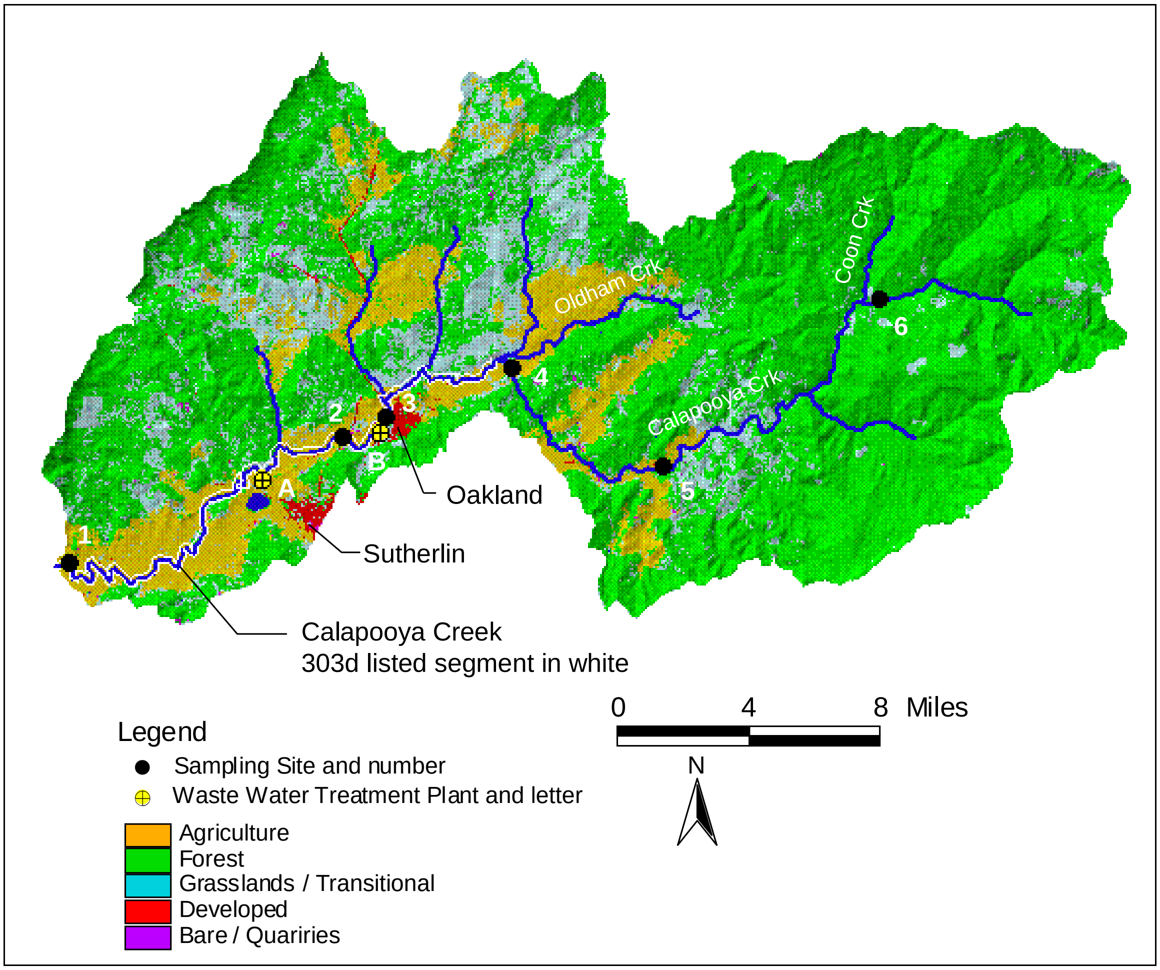
The Smith River Watershed Council, with financial assistance from DEQ, the Umpqua National Forest and the Bureau of Land Management, conducted a bacteria source tracking study in the lower Umpqua River, lower Smith River, and the Umpqua estuary during 2004 and 2005. Unfortunately, the study took place during a time of unusually low precipitation and flows. The vast majority of DNA samples that were analyzed came from times and places when the *E. coli* and fecal coliform numbers were below the level of concern for shellfish. This study concluded that during times of low flows, low runoff and low instream bacteria concentrations, wildlife, particularly birds, were the most frequent sources of *E. coli* organisms. Contributions from livestock showed an increase during times when bacteria levels were higher; however, the small number of samples is inadequate to form the basis for specific load allocations to various land uses. Until more data is available to identify sources during the times when a TMDL would apply, no conclusions about sources at higher flows can be drawn from the study

Several other groups in the Umpqua Basin are exploring the possibility of genetic Bacteria Source Tracking in their watersheds. Future use of this technique will help quantify the various sources of bacteria so resources can be focused on the most severe problems. However, because of the high cost of DNA analysis, samples should be focused on times and places where bacteria levels are high enough to cause concern.

Even without genetic Bacteria Source Tracking, however, watershed groups can use existing technologies such as the Colilert system to do more refined testing to identify specific sources of bacteria. These methods, together with implementation of Best Management Practices and further testing, are expected to result in a significant decrease in fecal bacteria in Umpqua Basin streams.

CALAPOOYA CREEK WATERSHED

Calapooya Creek drains into the Umpqua River and its 245 square mile drainage area is composed of 70% forest lands, 27% agricultural lands, and 3% urban/residential land use (based on zoning maps, Oregon State Service Center, 1998).



Map 2.2 Calapooya Creek Watershed with land use, monitoring locations, and wastewater treatment plants. Land use from U.S. Geological Survey, 1999, National Land Cover Data, Oregon, Version 07-30-99, EROS Data Center (EDC), Sioux Falls, SD.

Seasonal Variation

Calapooya Creek was determined to be water quality limited for bacteria during the fall-winter-spring periods from its mouth to river mile 25.3 (downstream of the Sutherlin Water Treatment plant intake, Table 2.7 and Map 2.2, site 5). This determination was based on fecal coliform data collected on Calapooya Creek at Umpqua (Map 2.2, site #1, river mile 0.4), and *E.Coli* data collected from various sites along the creek.. Between water years 1986 and 1995, 21% (5 of 24) of summer values and 18% (9 of 49) of the fall-winter-spring values at site #1 exceeded the fecal coliform standard (400 org./100 ml.), with maximum values of 2,400 and 1,600 org./100 ml. respectively.

Historical Data

Calapooya Creek at Umpqua has been sampled for *E. coli* bimonthly since 1996 (Table 2.7 and Map 2.2, site #1). The water quality standard for recreational contact is a 30-day log mean of 126 *E. coli* organisms per 100 ml, based on a minimum of five samples, with no single sample exceeding 406 *E. coli* organisms per 100 ml. Since five *E. coli* samples are rarely collected within 30-days by DEQ at long term monitoring sites, values over an entire season are used a surrogate for the 30-day period in determining the log mean.

Table 2.7. Summary of Calapooya Creek *E. coli* data (org./100 ml), December 1995 through September 2003. Exceedances of the standard are shown in the blue cells. This data includes results from the storm sampling event.

					Summer				Fall-Winter-Spring			
Map Key	Station Name and ID	Lat.	Lon.	River Mile	Number of Samples	Log Mean	Max.	% > 406	Number of samples	Log Mean	Max.	% > 406
1	Calapooya Creek At Umpqua 10996	43.3664	-123.4595	0.4	23	75	770	9	49	157	3080	22
2	Calapooya Creek @ I-5 Bridge 13245	43.4163	-123.3244	13.0	5	21	136	0	9	143	4185	22
3	Calapooya Cr @ Oakland Drinking Wtr. Intak12800	43.4211	-123.3075	14.7	5	42	100	0	14	149	1954	21
4	Calapooya Creek At Driver Valley Rd.(Medley Br.) 12796	43.4433	-123.2408	22.2	2	65	84	0	9	43	1379	22
5	Calapooya Creek @ Sutherlin Drinking H2O Intake 12803	43.4090	-123.1639	25.8	5	66	310	0	11	95	2419	18
6	Calapooya Creek above upper Coon Creek 25177	43.4730	-123.0577	35.2	2	36	44	0	9	4	8	0

During the fall-winter-spring period, the log mean of *E. coli* concentrations at the Calapooya Creek at Umpqua site was 157 org./100 ml, with 22% (11 of 49) exceeding 406 org./100 ml (Table 2.7 and Figure 2.3). These *E. coli* data indicate that Calapooya Creek at Umpqua is water quality limited for bacteria during the fall-winter-spring period. During the summer period, the log mean of *E. coli* samples at the same site was 75 org./100 ml, with 9% (2 of 23) exceeding 406 org./100 ml. The data indicate that there are occasional violations of the water quality standard during the summer period when water contact recreation is at its peak.

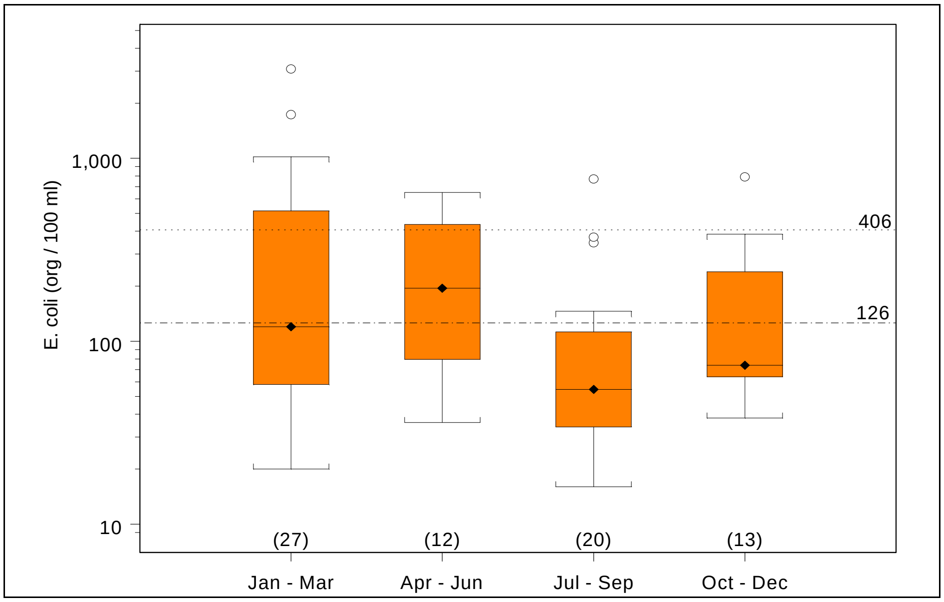


Figure 2.2 Calapooya Creek at Umpqua seasonal box plots including storm sampling data. The number of samples is in parentheses. For explanation of box plots, see Bacteria TMDL Overview.

Storm Sampling

In addition to bimonthly sampling at the mouth of Calapooya Creek, DEQ conducted intensive sampling bracketing a rainfall event the week of February 5 – 12, 2002, (Figure 2.3). The rain gage in Oakland recorded 0.67 inches of rain on February 6 and 1.22 inches on February 7. At each of the six different sites in Calapooya Creek, six *E. coli* samples were collected. *E. coli* concentrations tracked with the rainfall patterns, with concentrations peaking at all sites on February 7th (Figure 2.4). The lowest concentrations were recorded in Calapooya Creek above Coon Creek (Site #6), which drains only forestland. The median *E. coli* concentration increased in the downstream direction in proportion to the portion of the cumulative watershed which is zoned for agriculture (based on Oregon State Service Center, 1998) (Figure 2.5). The only two sites that did not violate the bacteria standard during the storm sampling were Calapooya Creek above Coon Creek (Site #6) and Calapooya Creek at the Sutherlin Drinking Water Intake (Site #5).

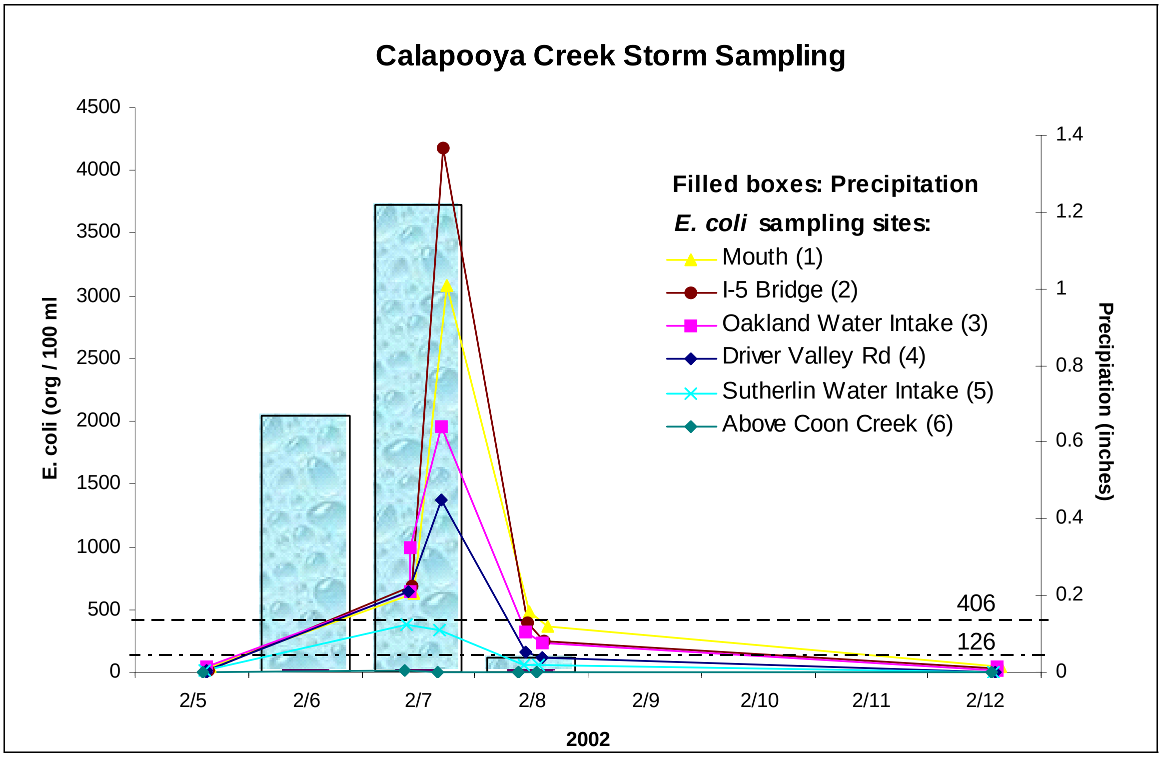


Figure 2.3 **Results of February 2002 storm sampling for sites in Calapooya Creek with daily precipitation measured in Oakland. See Map 2.2 for site locations.**

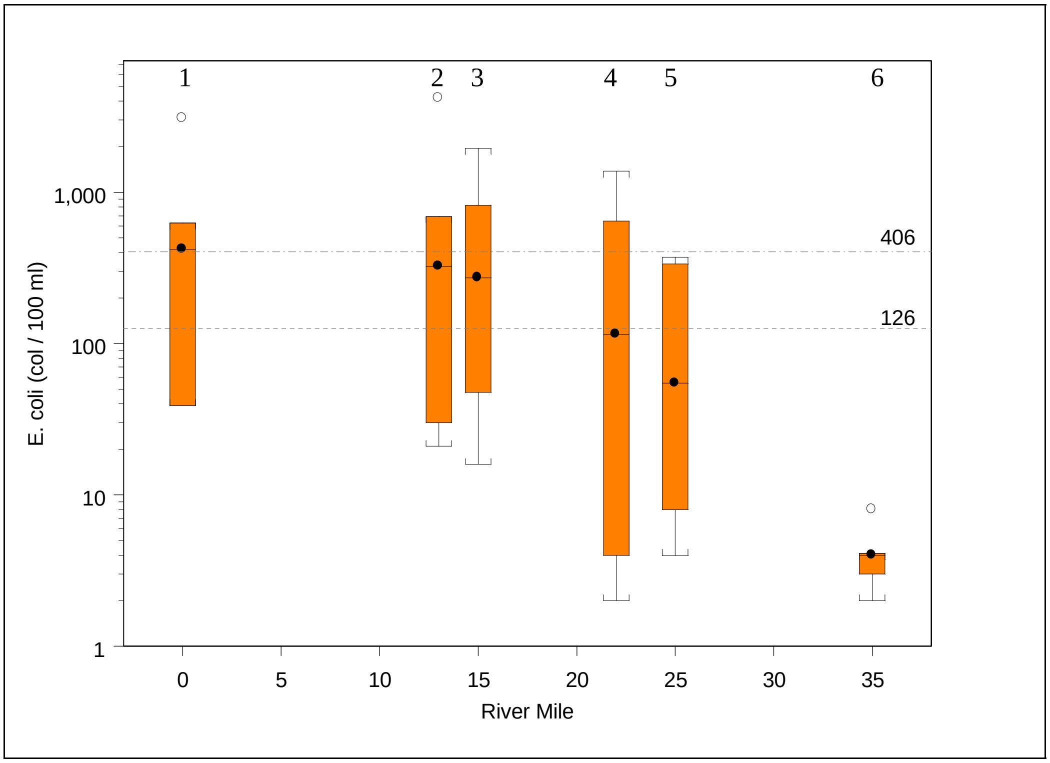


Figure 2.4 **Longitudinal profile of *E. coli* concentrations in Calapooya Creek during the February 2002 storm survey. See Map 2.2 for site locations. For an explanation of box plots, see Bacteria TMDL Overview.**

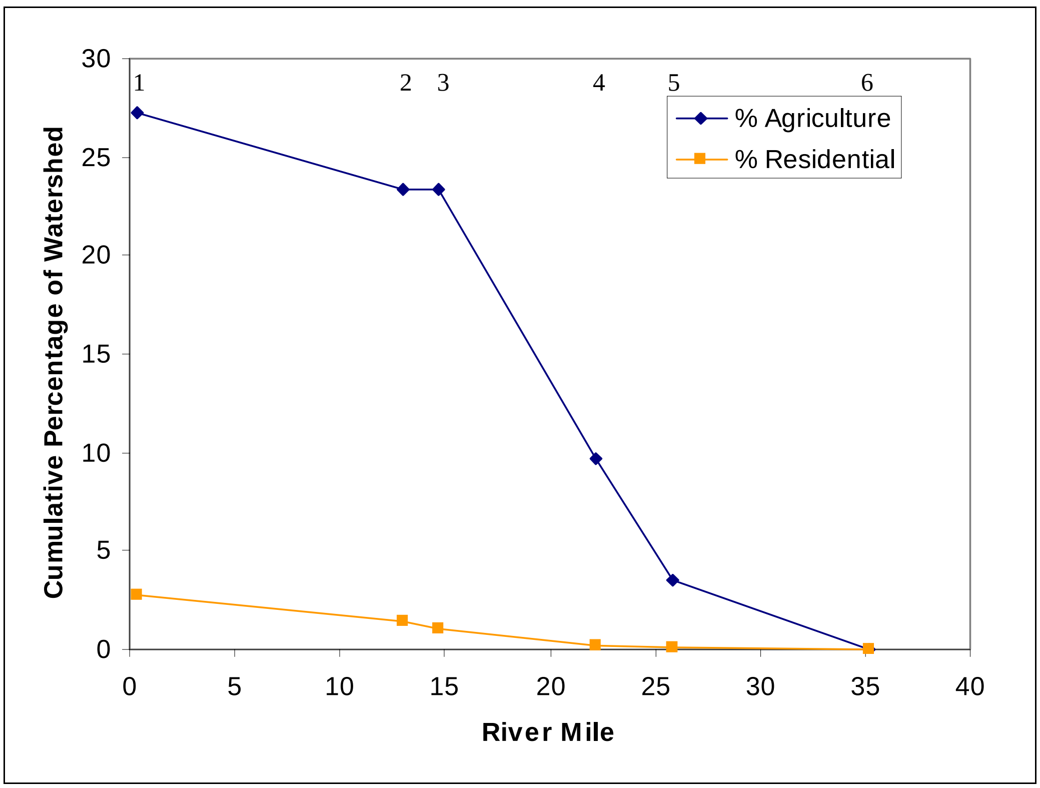


Figure 2.5 **Longitudinal profile of the land use in the Calapooya Creek Watershed. See Map 2.2 for site locations. Percentage of agricultural and urban / residential land was computed for the area upstream of each point. Forest land represents the balance of the watershed.**

Loading Capacity and Allocations

Flow-based loading capacity and allocations were determined using a load duration curve. This method segregates data by flow, allowing for flow-based source assessment, graphical display of the range of data, and the determination of the critical period for water quality. See Appendix B for a technical explanation of load duration curves.

E. coli data collected at Calapooya Creek at Umpqua (Map 2.2, site #1) was used to create the load duration curve because the highest median *E. coli* concentration was recorded at this site during the storm monitoring and because the most number of samples have been collected at this site. If water quality standards for bacteria are achieved at this site, it is likely water quality will be achieved along the length of the creek. Seventy-two *E. coli* samples were collected between December 1995 and September 2003.

Stream gage #14320700, Calapooya Creek near Oakland, is located at river mile 10 and drains 86% of the entire Calapooya Creek Watershed. Data from 1955 until 2001 was used as an estimate of flow discharge for the Calapooya Creek at the Umpqua *E. coli* sampling site. A hydrologic model provided flow discharge estimates for sample dates without flow measurements. Please see Appendix C for a technical discussion of the hydrologic model used to estimate flows.

The daily flow-based loading capacity of Calapooya Creek was determined for each day with a flow record by multiplying the standard (126 org./100 ml) by the flow and converting the units into organisms per day (Figure 2.6). The range of observed flows was separated into five categories: low, dry, mid-range, wet and high flows. A generalized loading capacity for each of the five flow periods was computed by taking the log-mean of calculated loading capacity for each day within that period (Table 2.8). The log-mean of the observed *E. coli* loading within each of the flow periods was compared with the loading capacity of that flow period.

A 73% reduction in load is necessary to meet the TMDL during high flows. Smaller reductions are needed during wet (7%) and mid-range (21%) flows. No reduction in loading is necessary to meet the average concentration criteria during the dry and low flow periods when water contact recreation is at its peak. Occasional exceedances of the peak criteria during the dry flow period are related to rainfall events and management practices that are implemented to achieve the average criteria during the High and Wet Flow periods will also address rainfall related loading during the dry flow period. If peak concentrations continue to exceed the extreme target, DMAs will be required to change their management plans to reduce peak loading.

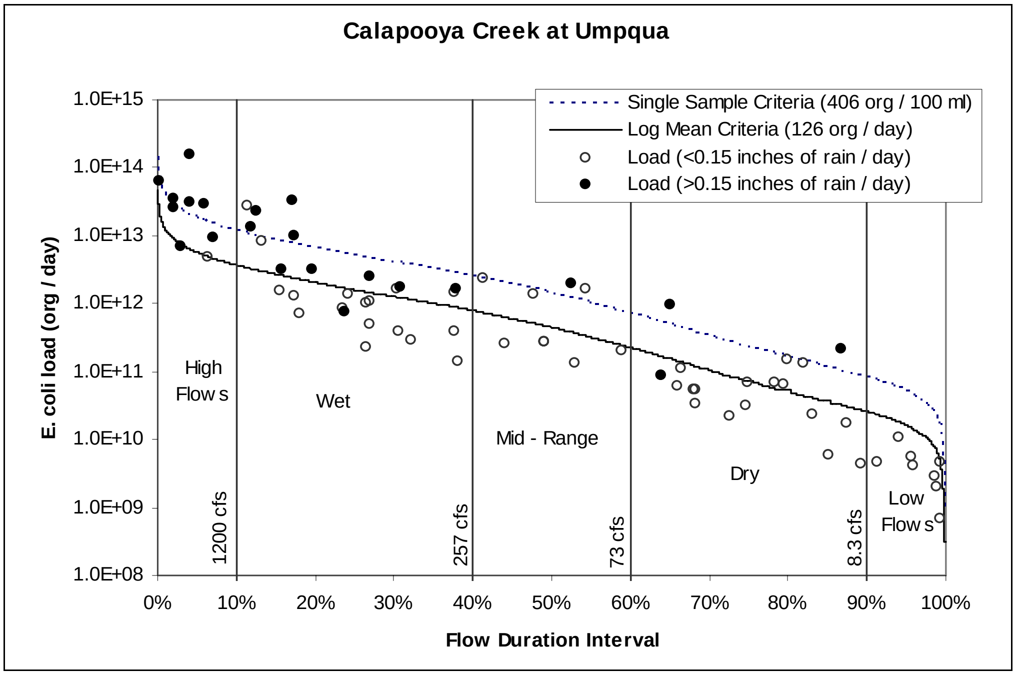


Figure 2.6 **Load duration curve for Calapooya Creek at river mile 0.4 (Map 2.2, site 1). Precipitation is the average rainfall accumulation for the day a sample was collected and the previous day at Oakland. The notation "1.0E+15" means 10^{15}.**

Table 2.8. TMDL by Range of Flows

	Range of Flows				
	High Flow (Above 1,200 cfs)	**Wet** (257 to 1,200 cfs)	**Mid-Range** (73 to 257 cfs)	**Dry** (8.3 to 73 cfs)	**Low Flow** (Below 8.3 cfs)
Loading Capacity (Org./day)	6.44×10^{12}	1.64×10^{12}	4.36×10^{11}	7.40×10^{10}	1.31×10^{10}
Current Load (Org./day)	2.39×10^{13}	1.76×10^{12}	5.55×10^{11}	5.27×10^{10}	3.45×10^{9}
Reduction	73%	7%	21%	0%	0%
Allocated Permitted Effluent Limits (*E.coli* organisms/100 ml) (average / extreme)	126 / 406	126 / 406	126 / 406	126 / 406	126 / 406
Estimate Point Source Loading (Org./day)	1.43×10^{10}	1.43×10^{10}	1.43×10^{10}	0*	0*
Load Allocation (Org./day)	6.11×10^{12}	1.54×10^{12}	4.00×10^{11}	5.27×10^{10}	3.45×10^{9}
Margin of Safety (Org./day)	3.22×10^{11}	8.19×10^{10}	2.18×10^{10}	2.12×10^{10}	9.62×10^{9}
TMDL (Org./day)	6.44×10^{12}	1.64×10^{12}	4.36×10^{11}	7.40×10^{10}	1.31×10^{10}

*Wastewater treatment plants are not permitted to discharge from June through October (see text).

Waste load allocations are expressed as the effluent concentration allowed by the bacteria standard: 126 *E. coli* org./100 ml as a log-mean based on a minimum of 5 samples in a 30-day period and no single sample exceeding 406 *E. coli* org./100 ml (Table 2.8). NPDES permits use a concentration target for *E. coli* rather than a load. Maximum waste load figures are derived from the maximum permitted daily flow for a facility (Table 2.9) and the average bacteria standard. Maximum waste load figures are used in the computations but are not allocations. The two wastewater treatment plants in the basin are not permitted to discharge between June and October because of other water quality concerns. This time period roughly corresponds with the dry and low flow periods. Therefore, in Table 2.8, the maximum waste load is presented as zero during these ranges of flows. However, if the wastewater treatment plants discharge effluent that is at or below the bacteria standard they will not cause or contribute to bacteria violations and, hence, will be meeting the bacteria TMDL. The treatment plants in the basin have requested a waste load allocation throughout the year whether they discharge or not. Therefore, they are given the same concentration waste load allocations for all ranges of flows. The two treatment plants in the watershed currently meet their waste load allocations (Table 2.10).

Table 2.9. Waste load allocations for Wastewater Treatment Plants (WWTPs).

Map Site ID	Facility Name	Receiving Stream	River Mile	Maximum Permit Flow (MGD)	Allocated Permitted Effluent Limits (*E.coli* org/100 ml)	(a) Estimate of Loading (organisms/day)
A	Sutherlin WWTP	Calapooya Creek	10.0	2	Log mean of 126 Not to exceed 406	$9.54x10^{9}$
B	Oakland WWTP	Calapooya Creek	13.3	1	Log mean of 126 Not to exceed 406	$4.77\ x10^{9}$

a=estimate assumes effluent meeting log-mean criterion prior to discharge at design flow

Table 2.10. Operation summary of WWTPs based on Discharge Monitoring Reports from September 2000 through September 2002

Facility Name	Average Flow (MGD)	Maximum Flow (MGD)	Average *E. coli* (org./100ml)	Maximum *E. coli* (org./100ml)
Sutherlin WWTP	0.9	3.8	8	157
Oakland WWTP	0.13	0.41	14	111

By rule, overflows of untreated sewage are prohibited in the summer months except during the 1-in-10 year 24 hour storm. In the winter months, all municipalities are expected to convey and treat all sewage up to the 1-in-5 year 24 hour storm. For the Calapooya Creek drainage, these events are about 4.0 and 3.5 inches, respectively.

An explicit margin of safety of 5% was incorporated into the TMDL for high, wet and mid-range flows. Because water quality compliance is based on the log mean of 5 samples, and high, wet and mid-range flows do not generally occur during the period associated with high amounts of water contact recreation, a relatively low margin of safety was deemed appropriate. The margin of safety for dry and low flows was set at the loading capacity minus the current load.

The load allocation is assigned to nonpoint sources of bacteria collectively, including wildlife and agriculture, forest, urban and residential land uses. The load allocation is the difference between the loading capacity and the waste load allocations plus the margin of safety for each range of flows (LA = LC – (WLA + MOS)).

Watershed Specific Source Assessment

This section expands on the discussion in the Basin Wide Bacteria Source Assessment section.

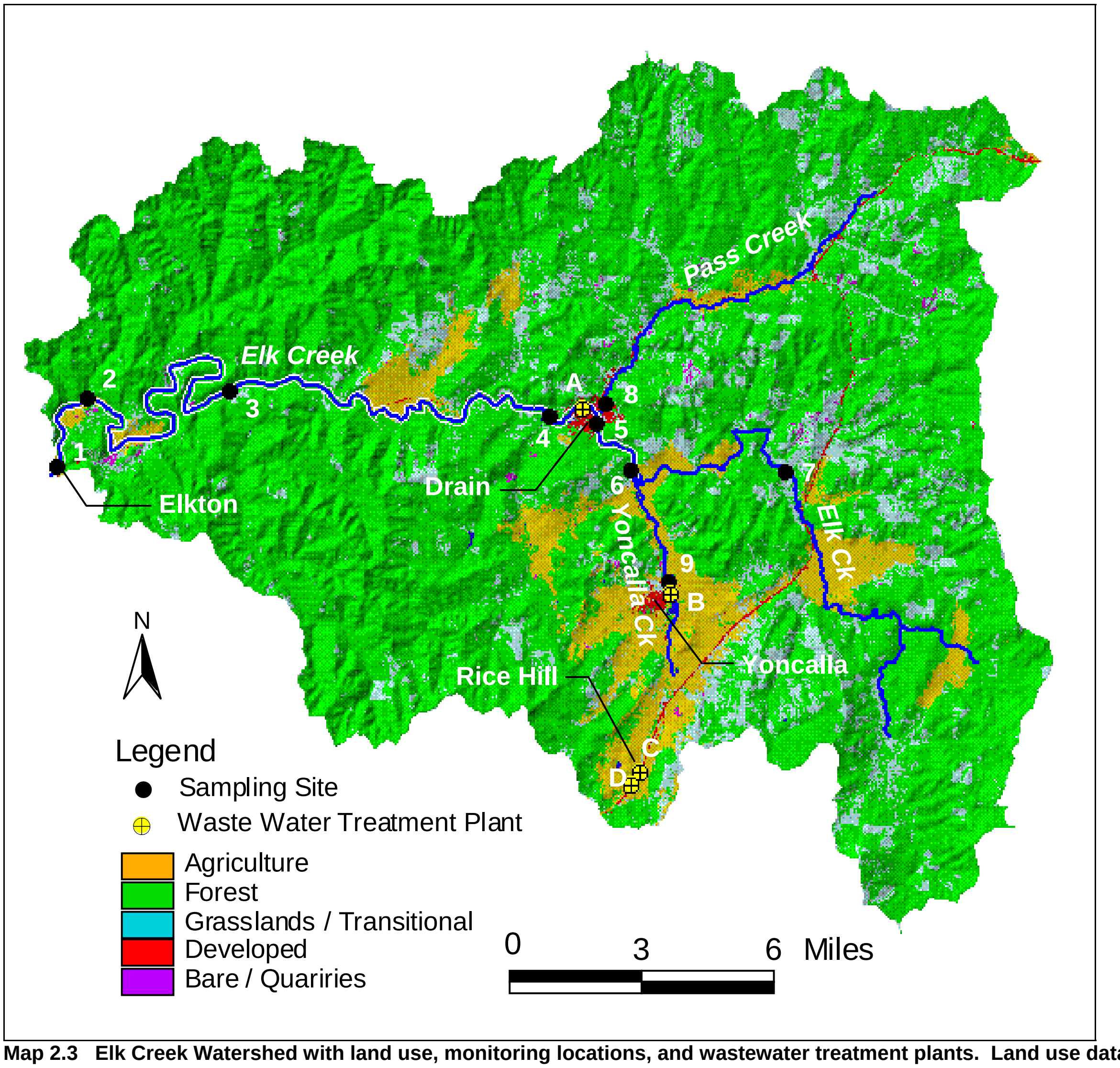
Since the two wastewater treatment plants in the Calapooya Creek Watershed are not contributing to bacteria water quality violations (Table 2.10), loading must be from nonpoint sources. The load duration curve indicates that most of the water quality violations occur during high and wet flows and are associated with rainfall. Overland flow and re-suspension of bacteria are likely contributing to the increased loading (see Table 2.2). Storm survey sampling also indicated a relationship between increased *E. coli* concentrations and rainfall. The data, however, do not reveal whether the increased concentrations are due to overland flow transporting bacteria to the stream or increased stream flow causing the re-suspension of bacteria from the bottom sediment. Storm survey data indicated an increase in *E. coli* concentrations as the proportion of watershed area zoned for agriculture increased (Figure 2.5). This information can guide implementation; however, due to spatial overlap, the load allocation does not make a distinction between nonpoint sources.

ELK CREEK WATERSHED

Elk Creek, from its mouth to river mile 45.6 (the entire length of the creek), was designated as water quality limited during the fall-winter-spring periods for bacteria using both fecal coliform and *E. coli* as indicator organisms.

Seasonal Variation

The determination to include Elk Creek on Oregon's 2002 303(d) list was based on fecal coliform data collected on Elk Creek at Elkton (Map 2.3, site #1, RM 0.4) and Elk Creek at Hayhurst Road (Map 2.3, site #4, RM 22.8) between water years 1986 and 1995. During the fall-winter-spring period, 18% (2 of 11) and 22% (8 of 37) of the measured concentrations exceeded the fecal coliform standard (400 org./100 ml), respectively. During the summer period, 0% (0 of 9) and 24% (4 of 17) exceeded the standard.



Map 2.3 Elk Creek Watershed with land use, monitoring locations, and wastewater treatment plants. Land use data is from USGS, 1999.

Historical Data

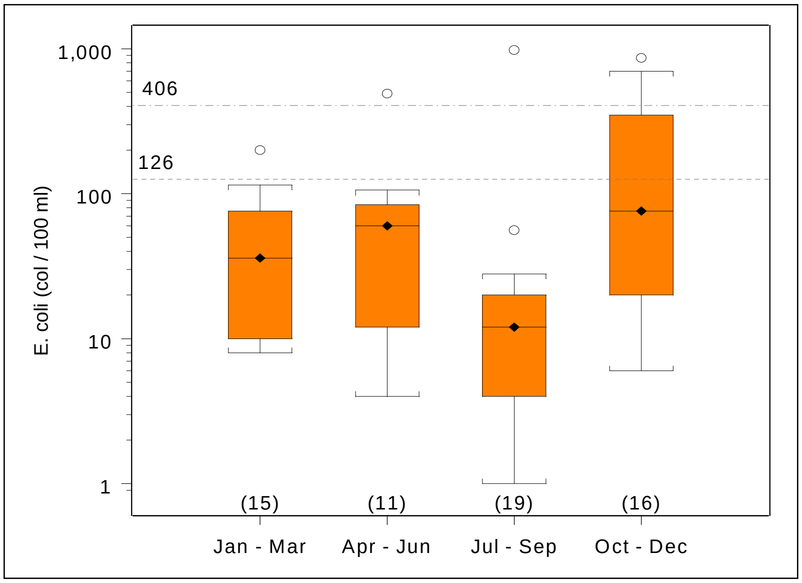


Figure 2.7 Seasonal distribution of E. coli concentrations at Elk Creek at Elkton, water years 1996 – 2003, including results from the storm survey (Map 2.3, site # 1). Number of samples for each period is labeled in parentheses. For explanation of box plots, see Bacteria TMDL Overview.

Since 1995, DEQ has collected bi-monthly *E. coli* samples from Elk Creek at Elkton and has performed synoptic surveys through out the basin (Figure 2.7 and Table 2.11). DEQ no longer performs regular sampling at Elk Creek at Hayhurst Road. *E. coli* concentrations at Elk Creek at Elkton are seasonally dependent, with water quality violations occurring during the fall-winter-spring period, specifically from October through December (Figure 2.7 and Table 2.11). One sample collected during the summer period exceeded the *E. coli* criteria.

Table 2.11. Summary of E. coli data for Elk Creek Watershed (org. /100 ml), December 1995 through September 2003, including results from storm survey. Exceedances of the water quality standard are shown in the blue cells.

						Summer				Fall-Winter-Spring			
Map Key	**Station Name**	**Station ID**	**Lat.**	**Lon.**	**River Mile**	**Number of Samples**	**Log Mean**	**Max.**	**% > 406**	**Number of Samples**	**Log Mean**	**Max.**	**% > 406**
1	Elk Ck. @ Elkton	10441	43.6351	-123.5634	0.2	21	14	980	5	40	50	866	10
2	Elk Ck. above Elkton	29286	43.6585	-123.5502	3.0	1	51	51	0	-	-	-	-
3	Elk Ck. @ Harold Wooley Bridge	25172	43.6638	-123.7011	12.9	4	6	11	0	9	186	1046	44
4	Elk Ck. @ Hayhurst Rd. (Drain)	11304	43.6583	-123.3373	22.8	3	51	131	0	7	413	1553	57
5	Elk Ck. above Pass Ck. (Drain)	28998	43.6565	-123.3155	24.5	2	22	35	0	1	12	12	0
6	Elk Ck. below Yoncalla Ck.	25173	43.6378	-123.2983	25.9	4	103	613	25	7	373	1733	57
7	Elk Ck. below Cox Ck.	25174	43.6419	-123.2278	32.9	3	89	98	0	7	301	1986	29
8	Pass Ck. above Drain	11305	43.6604	-123.3161	2.1	2	36	43	0	8	111	435	13
9	Yoncalla Ck. near Yoncalla	11306	43.6042	-123.2793	2.6	2	152	579	50	6	845	2419	67

Storm Sampling

DEQ monitored water quality over a 3-day period bracketing a storm event. Five samples were collected at seven sites in the Elk Creek Watershed November 27 - 29, 2001. A daily rain gage in Elkton reported a 0.33 inch rainfall accumulation while a rain gage in Oakland reported a 1.73 inch rainfall accumulation. The southeastern portion of the watershed (including Yoncalla Creek and Elk Creek above Yoncalla Creek) are closer to the Oakland rain gage hence likely had a greater accumulation of rainfall during this period.

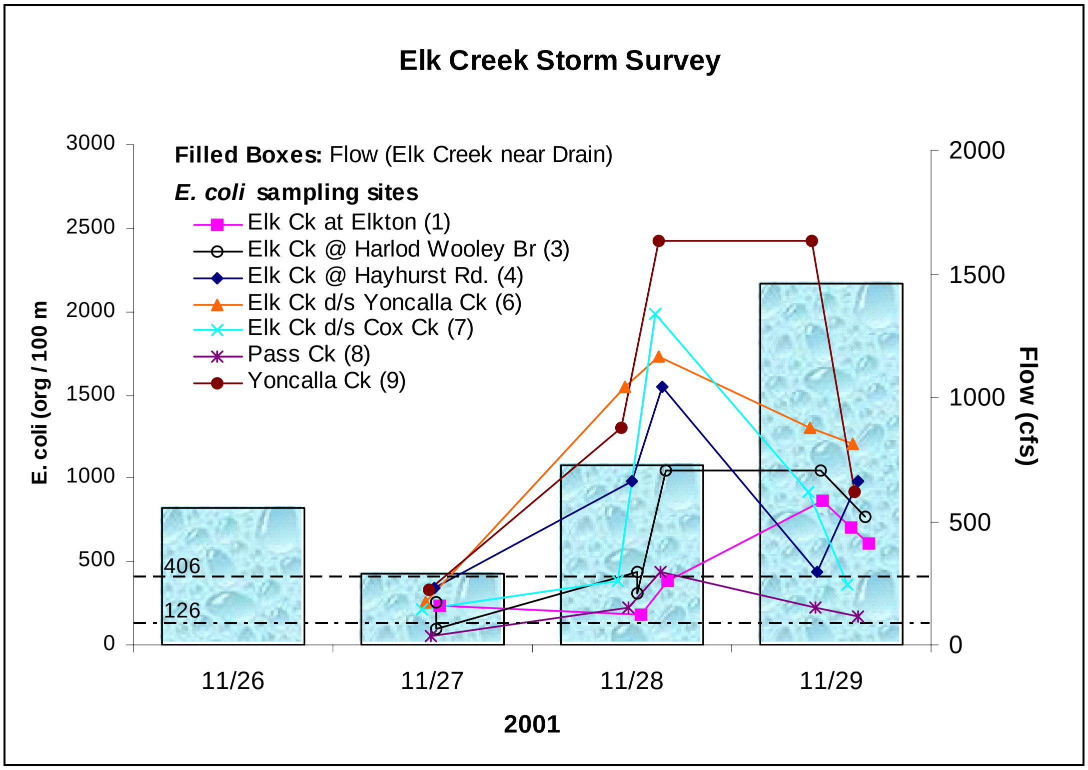


Figure 2.8 ***E.Coli*** **concentrations at monitoring locations during the storm survey**

All the monitoring locations sampled during the November storm exceeded water quality criteria for bacteria (Figure 2.8). The bacteria concentrations at each site followed a pattern similar to the rainfall and stream flow patterns. For most sites, the greatest *E. coli* concentrations occurred on the day with the most rainfall (based on the average of the Elkton and Oakland rain gages). The median concentrations along Elk Creek increased from RM 32.9 to 25.9, then decreased to RM 12.9, and then remained constant to the mouth (Figure 2.9). The spatial pattern of median concentrations corresponds with the proportion of cumulative watershed area zoned for agriculture (based on Oregon State Service Center, 1998). Yoncalla Creek near Yoncalla had the highest log mean concentration (1,181 org./100 ml), while Pass Creek had the lowest (179 org./100 ml). The highest concentrations were detected in Yoncalla Creek where one sample was at the 2,419 org./100 ml upper detection limit. The actual concentration may have been higher.

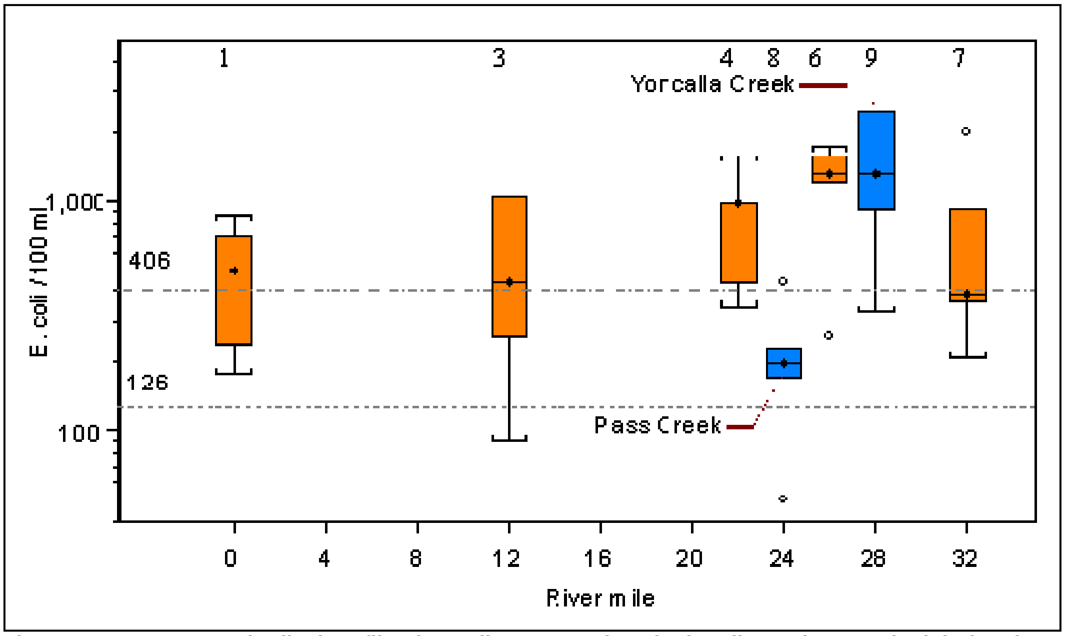


Figure 2.9 **Longitudinal profile of *E. coli* concentrations in the Elk Creek Watershed during the November 2001 storm survey. See Map 2.3 for site locations. Data from Yoncalla and Pass Creeks were collected near their mouths.**

The three wastewater treatment plants that are permitted to discharge into Yoncalla Creek were not discharging during this storm event, but the City of Drain wastewater treatment plant, which discharges treated effluent into Elk Creek at RM 23.5, reported a sewage overflow that lasted 4.25 hours in the early morning hours of November 29, 2001. This may be the reason that the bacteria concentration for the station at Elk Creek at Hayhurst Road showed an increase for the afternoon sample on November 29 while all other sample sites continued to decrease.

Loading Capacity and Allocations

Flow-based loading capacity and allocations were determined using a load duration curve. This method segregates data by flow, allowing for flow-based source assessment, graphical display of the range of data, and the determination of the critical period for water quality (Appendix B). Elk Creek at Hayhurst Road (Map 2.3, site #4) at RM 22.8 was chosen as the load duration curve site because of the availability of long term bacteria data, its location downstream of the wastewater treatment plants, and the fact that it had one of the highest median *E. coli* concentrations during the storm survey. If water quality standards for bacteria are achieved at this site, it is likely water quality will be achieved along the length of the creek. DEQ has collected ten *E. coli* samples and 53 fecal coliform samples at this site between 1974 and 2002. Douglas County has collected 20 fecal coliform samples at this site between 1999 and 2001. Both the *E. coli* and fecal coliform datasets were used to assess current loading (assuming a one to one relationship between the two).

Stream gage #14322000, Elk Creek near Drain, is operated by Douglas County and is located at approximately RM 26.3, upstream of the confluence with Pass Creek while downstream of the confluence with Yoncalla Creek. A ratio between the drainage areas was used to estimate flow at the bacteria sampling site, Elk Creek at Hayhurst Road. The drainage area for the flow gage is 103.1 square miles while the drainage area for the bacteria sampling site is 169.7 square miles. Therefore, to estimate flows at the bacteria sampling site, observed flows were multiplied by 1.65. Flows from 1978 to 2002 were used to compute the flow-based loading capacity.

Flow-Based Calculations

The daily flow-based loading capacity of Elk Creek was determined for each day with a flow record by multiplying the standard (126 org./100 ml) by the flow and converting the units into organisms per day (Figure 2.10). The range of observed flows was separated into five categories: low, dry, mid-range, wet and high flows. A generalized loading capacity for each of the five flow periods was computed by taking the log-mean of calculated loading capacity for each day within that period. The log-mean of the observed *E. coli* loading within each of the flow periods was compared with the loading capacity of that flow period (Table 2.12)

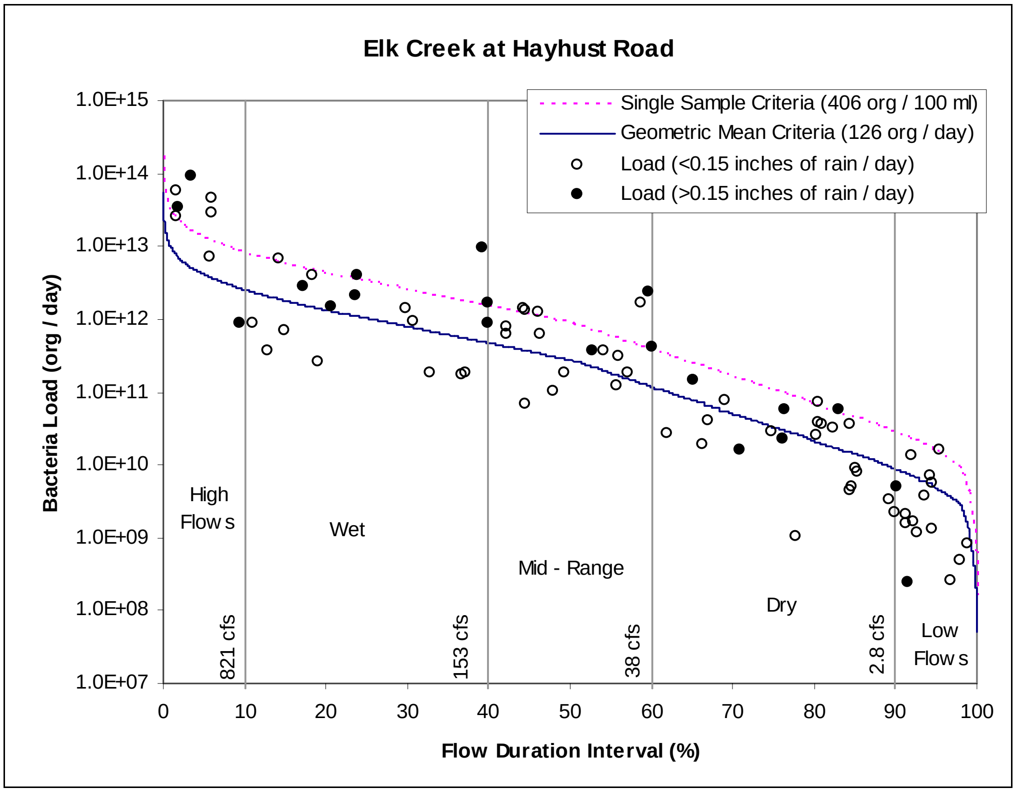


Figure 2.10 Load duration curve for Elk Creek at Hayhurst Road just downstream of Drain. The notation "1.0E+15" means 10^{15}.

Table 2.12. TMDL by Range of Flows.

	Range of Flows				
	High Flow (Above 821 cfs)	Wet (152 to 821 cfs	Mid-Range (38 to 152 cfs)	Dry (2.8 to 38 cfs)	Low Flow (Below 2.8 cfs)
Loading Capacity (Org./day)	4.65×10^{12}	1.04×10^{12}	2.57×10^{11}	3.29×10^{10}	3.85×10^{9}
Current Load (Org./day)	2.12×10^{13}	1.13×10^{12}	4.74×10^{11}	2.17×10^{10}	2.02×10^{9}
Reduction	78%	7%	46%	0%	0%
Allocated Permitted Effluent Limits (*E.coli* organisms/100 ml) (average / extreme)	126 / 406	126 / 406	126 / 406	126 / 406	126 / 406
Estimate Point Source Loading (Org./day)	1.91×10^{10}	1.91×10^{10}	1.91×10^{10}	0	0
Load Allocation (Org./day)	4.40×10^{12}	9.73×10^{11}	2.25×10^{11}	2.17×10^{10}	2.02×10^{9}
Margin of Safety (Org./day)	2.33×10^{11}	5.22×10^{10}	1.28×10^{10}	1.12×10^{10}	1.83×10^{9}
TMDL (Org./day)	4.65×10^{12}	1.04×10^{12}	2.57×10^{11}	3.29×10^{10}	3.85×10^{9}

*wastewater treatment plants are not permitted to discharge between May and October (see text).

A **78%** reduction in load is necessary to meet the TMDL during high flows, **7%** during wet flows, and **46%** during mid-range flows. No reduction in loading is necessary to meet the average criteria during the dry and low flow periods when water contact recreation is at its peak. Management practices that are implemented to achieve the average criteria during the high and wet flows periods will also address occasional exceedances during the dry and low flow period. If peak concentrations continue to exceed the peak target, DMAs will be required to change their management plans to reduce peak loading.

There are four facilities in the Elk Creek Watershed which are permitted to discharge treated sewage (Table 2.13). Waste load allocations are expressed as the effluent concentration allowed by the bacteria standard: 126 *E. coli* org./100 ml as a log-mean based on a minimum of 5 samples in a 30-day period and no single sample exceeding 406 *E. coli* org./100 ml (Table 2.8). Loading estimates are derived from the maximum permitted flow for a facility and the average bacteria standard. The total waste load allocation is the sum of the loads from the four facilities (Table 2.13). None of the facilities is permitted to discharge from May through October because of other water quality concerns. This time period roughly corresponds with the dry and low flow periods. Therefore, the plants are shown as contributing no bacteria load during these periods. In terms of bacteria, if the wastewater treatment plants discharge effluent that is at or below the bacteria standard, they will not cause or contribute to water quality violations and, hence, will be meeting the TMDL. By rule, overflows of untreated sewage are prohibited in the summer months except during the 1-in-10 year 24 hour storm. In the winter months, all municipalities are expected to convey and treat all sewage up to the 1-in-5 year 24 hour storm

Table 2.13. Waste load allocations for Wastewater Treatment Plants (WWTPs).

Figure 1 ID	Facility Name	Receiving Stream	River Mile	Permit Type	Maximum Permitted Flow (MGD)	Allocated Permitted Effluent Limits (*E.coli* org/100 ml)	(a) Estimate of Loading (organisms/day)
A	City of Drain WWTP	Elk Creek	23.5	NPDES-DOM-Da	1	Log mean of 126 Not to exceed 406	$4.77x10^9$
B	City of Yoncalla WWTP	Yoncalla Creek	4	NPDES-DOM-Db	1	Log mean of 126 Not to exceed 406	$4.77\ x10^9$
C	Rice Hill West WWTP	Yoncalla Creek	7.5	NPDES-DOM-Db	1	Log mean of 126 Not to exceed 406	$4.77\ x10^9$
D	Rice Hill East WWTP	Unnamed tributary to Yoncalla Creek	7.8	NPDES-DOM-Db	1	Log mean of 126 Not to exceed 406	$4.77\ x10^9$

a=estimate assumes effluent meeting log-mean criterion prior to discharge at design flow

There are currently two CAFOs that have an NPDES permit in the Elk Creek watershed: Broken Oak Bull Mastiffs (Elkton) and Wuergler (Drain). CAFOs are only allowed to discharge during extreme rainfall events greater than the 25-year, 24-hour rainfall. The general permit also stipulates that during such a discharge, effluent cannot cause or contribute to a violation of state water quality standards. Because the TMDL only addresses the time period when the CAFO discharge is prohibited, the CAFO is allocated zero load. However, discharges during extreme rainfall events (i.e., the 25-year, 24-hour rainfall) remain permitted.

The load allocation is assigned to nonpoint sources of bacteria including wildlife and agriculture, forest, urban and residential land use. The load allocation is the difference between the TMDL and the waste load allocation and the margin of safety for each flow regime.

Yoncalla Creek, a tributary to Elk Creek, was also determined to be water quality limited for *E. coli* during the Fall-Winter-Spring. Point source waste load allocations are discussed above. The log mean of the 6 samples is 845 *E. coli* / 100 ml. A simple percent reduction in the log mean *E. coli* concentration will serve as a surrogate measure for load allocations:

$$\%\ \text{reduction} = \left(1 - \frac{126\ (\text{E.coli org} / 100\ \text{ml})}{\text{Log Mean (E.coli org} / 100\ \text{ml})}\right) * 100$$

An 85% reduction in *E. coli* loading is necessary for Yoncalla Creek.

Margin of Safety

An explicit margin of safety of 5 % was incorporated into the TMDL for high, wet and mid-range flows. Because water quality compliance is based on the log mean of 5 samples and high, wet and mid-range flows do not occur during the period associated with most water contact recreation, a relatively low margin of safety was deemed appropriate. The Margin of Safety for dry and low flows is set at the remaining capacity.

Watershed Specific Source Assessment

This section expands on the discussion in the Basin Wide Bacteria Source Assessment section.

Review of the available discharge monitoring reports (DMRs) between September 2000 and September 2002 from the City of Yoncalla, Rice Hill East and Rice Hill West WWTPs indicates that their effluent is meeting the bacteria standards outlined in the permits. The City of Drain WWTP reported 12 sewage overflows into Elk Creek between September 2000 and September 2002. These overflows occurred during heavy rainfalls. Volume of the spills and the bacteria concentration of the spills are difficult to estimate. Raw sewage has been measured with a concentration of 3,300,000 *E. coli* org./100 ml (City of Portland, personal communication). An estimate of the *E. coli* concentration of diluted raw sewage during a storm event is 400,000 to 500,000 *E. coli* org. / 100 ml (Witbeck, 2005). Assuming an average of the diluted concentration and the best estimate of flow volumes, spill loading to Elk Creek ranged between 4.3×10^{11} to 4.1×10^{12} organisms. DEQ is working with the City of Drain treatment plant to insure compliance with their water quality permit. Based on this spill analysis, upgrades to the Drain treatment plant will result in a large reduction in *E. coli* loading. However, water quality standards are also not being met upstream of this point source discharge (Elk Creek above Cox Creek, Map 2.3, site #7 and Figure 2.9, river mile 32.9).

Since point sources are not the sole contributors to bacteria water quality violations, loading must also occur from nonpoint sources. The load duration curve indicates that most of the water quality violations occur during high and wet flows and are associated with rainfall (Figure 2.10). Overland flow and re-suspension of bacteria are likely contributing to the increased loading (see Table 2.12). Storm survey sampling also indicated increased *E. coli* concentrations with rainfall (Figure 2.8). The data, however, do not reveal whether the increased concentrations are due to overland flow transporting bacteria to the stream or increased stream flow causing the suspension of bacteria in the bottom sediment. Storm survey data indicated an increase in *E. coli* concentrations as the proportion of watershed area zoned for agriculture increases (Figure 2.9 and 2.11). Forested land does not appear to cause or contribute to bacteria water quality violations in the Elk Creek Watershed. This information can guide implementation; however, due to spatial overlap, the nonpoint source load allocation does not make a distinction between the various nonpoint sources.

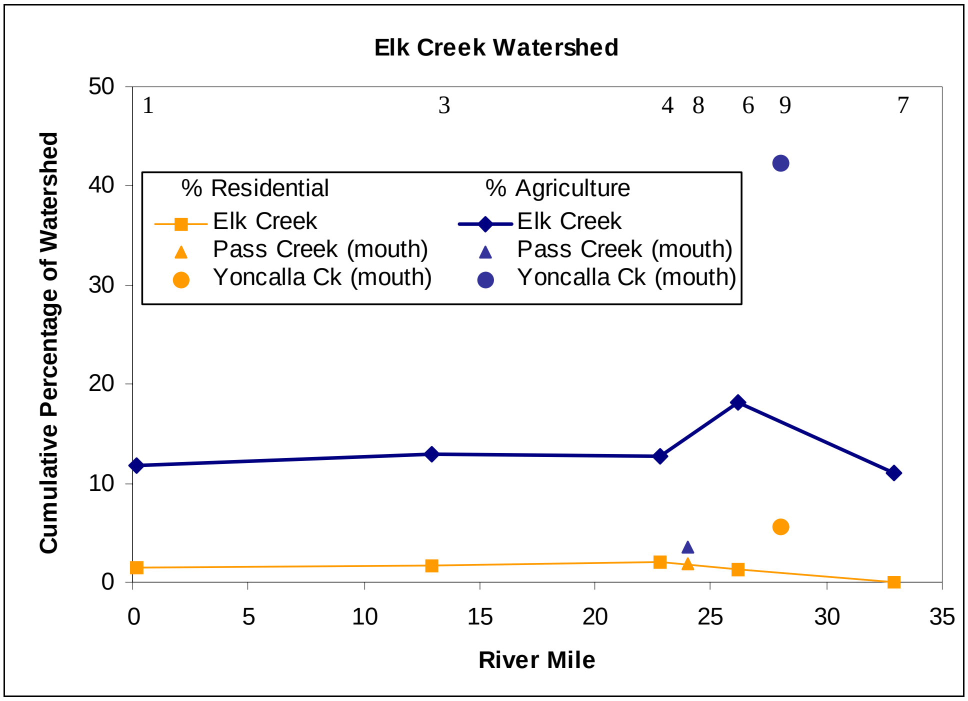


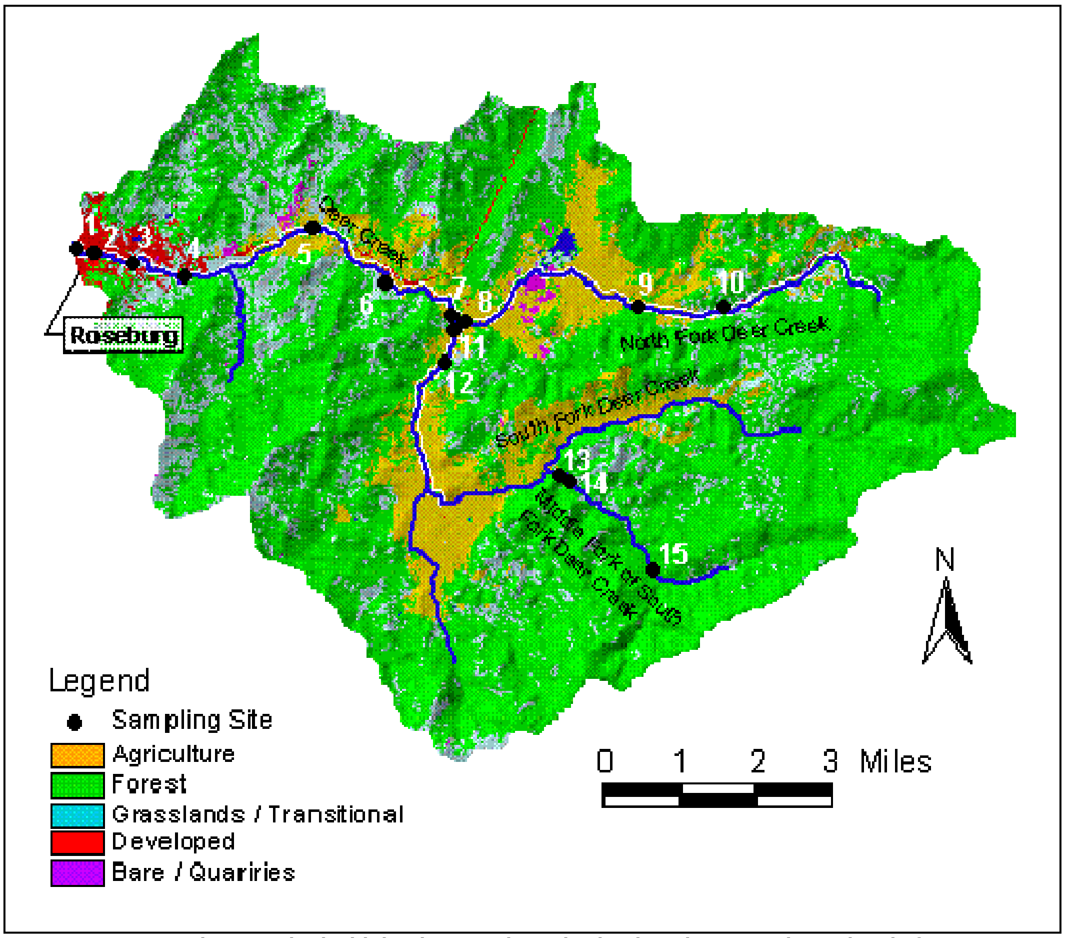
Figure 2.11 Longitudinal profile of the land use in Elk Creek Watershed. See Map 2.3 for site locations. Percent of agricultural and urban/residential land was computed for the area upstream of each point. The balance of the watershed is forest land. Land use for the Yoncalla and Pass Creeks was based on the outlets into Elk Creek.

DEER CREEK WATERSHED

Seasonal Variation

Long-Term Data

Deer Creek was determined to be water quality limited for bacteria during the Summer and Fall-Winter-Spring periods from its mouth to river mile 9.6, at the confluence with South Fork of Deer Creek (DEQ 2002 303(d) List) (Map 2.4). The determination was made based on fecal coliform data collected on Deer Creek at Highway 138 in Roseburg (river mile 0.2). Between water year 1986 and 1995, 64% (14 of 22) of Summer values and 42% (18 of 43) of the Fall-Winter-Spring values exceeded fecal coliform standard (400) each with a maximum value of 2400 org./100 ml. The North Fork of Deer Creek was also determined to be water quality limited for bacteria during the Summer and Fall-Winter-Spring periods from its mouth to river mile 6.7, at its headwaters. *E. coli* data submitted to DEQ from river mile 2.9 showed that 6 of 6 samples exceeded 406 org./100 ml. A large portion of the *E. coli* data for the Deer Creek Watershed was collected by the Douglas Soil and Water Conservation District with assistance from the Umpqua Basin Watershed Council and local citizens who allowed access to their property and is aggregated in this report with data collected by DEQ. This data met quality assurance objectives identified by DEQ and is available on DEQ's database.



Map 2.4 Deer Creek Watershed with land use and monitoring locations. Land use data is from USGS, 1999.

The recreational contact standard is a 30-day log mean of 126 *E. coli* organisms per 100 ml, based on a minimum of five samples, with no single sample exceeding 406 *E. coli* organisms per 100 ml. Five *E. coli* samples are rarely collected within 30-days, therefore samples aggregated by season are used as a surrogate for the 30-day period in determining the log means in Table 2.14.

Table 2.14. E. coli data for the Deer Creek Watershed including storm sample results. Duplicate samples taken for quality assurance purposes are not included in the summary. Exceedances of the standards are shown in blue.

				Summer				Fall-Winter-Spring			
Map Key	Station Name	Station ID	RM	# of Samples	Log Mean	Max.	% > 406	# of Samples	Log Mean	Max.	% > 406
1	Deer Creek At Hwy 138	11310	0.2	8	930	2419	75%	18	343	4480	39%
2	Deer Creek @ Fowler Bridge,	25950	0.4	-	-	-	-	7	213	649	29%
3	Deer Creek @ 1974 SE Douglas Ave.	25953	1	-	-	-	-	7	219	816	29%
4	Deer Creek u/s of Pearce Rd. bridge	25951	1.6	6	69	178	0%	7	185	727	43%
5	Deer Creek above Roseburg	25178	3.4	2	168	430	50%	8	182	1374	13%
6	Deer Creek d/s Bell Ranch Lane	25952	4.9	6	529	1986	67%	6	173	411	17%
7	Deer Creek d/s N. Fk./S. Fk. confluence	28492	6.1	6	310	649	33%	5	166	488	20%
8	North Fork Deer Creek near mouth	25188	0.1	8	141	276	0%	13	185	933	23%
9	North Fork Deer Creek above unnamed tributary	30214	2.9	6	1773	2419	100%	-	-	-	-
10	North Fork Deer Creek at RM 4.2	28496	4.2	6	317	1120	17%	5	106	2419	20%
11	South Fork Deer Creek, at mouth	28494	0.1	5	566	1733	80%	5	186	579	40%
12	South Fork Deer Creek near mouth	25187	0.6	8	194	488	13%	13	145	1334	23%
13	Middle Fork of South Fork Deer Creek near mouth	28493	0.3	7	207	378	0%	5	76	866	20%
14	Middle Fork of South Fork Deer Creek near mouth	30213	0.4	-	-	-	-	5	55	727	20%
15	Middle Fork of South Fork Deer Creek forest boundary site	25179	2.6	2	6	13	0%	8	6	40	0%

During the summer period, the bacteria water quality standard is violated along most of the mainstem of Deer Creek, North Fork Deer Creek and South Fork Deer Creek (Table 2.14 and Figure 2.12). The only site which had a consistently low concentration of *E. coli* was on the Middle Fork of South Fork of Deer Creek at the forest boundary. No agricultural or residential uses are located upstream of the site. There is a large increase in *E. coli* concentration near the mouth of Deer Creek, located in Roseburg and surrounded by urban and residential land. Another large increase is located in the North Fork of Deer Creek upstream of RM 2.9, with both agricultural and low density residential areas upstream.

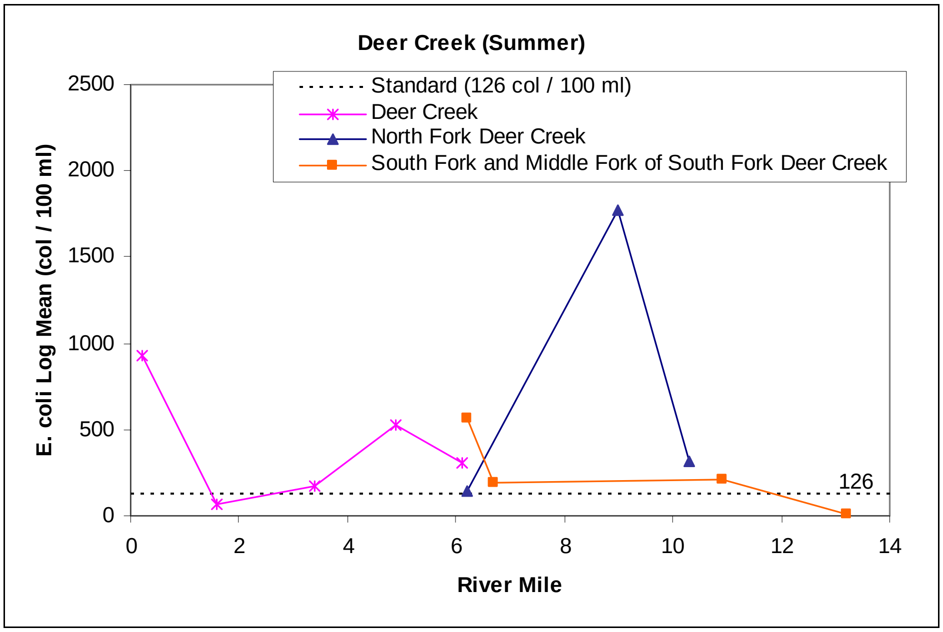


Figure 2.12 **Log mean concentrations of E. coli samples collected during the summer period. The river mile is the distance from the mouth of Deer Creek.**

Storm Sampling

DEQ monitored water quality over a 5-day period bracketing a storm event. Six samples were collected at five sites in the Deer Creek Watershed between January 23 and 28, 2002 (Figure 2.13). A daily rain gage in Roseburg reported a three-day rainfall accumulation of 1.0 inch.

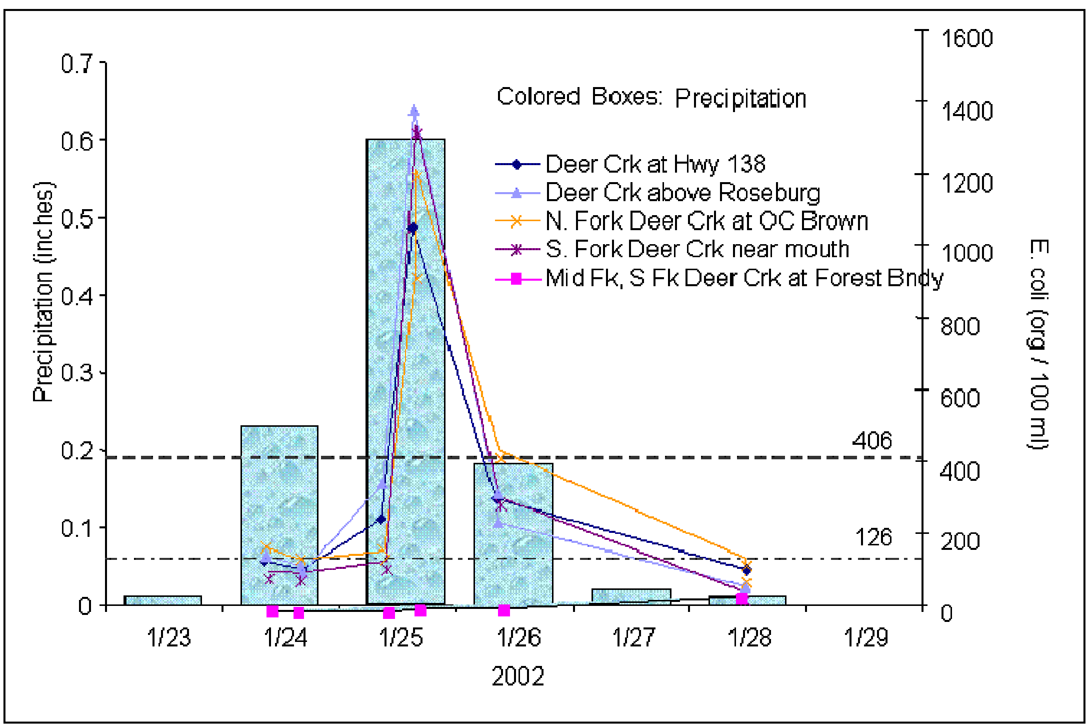


Figure 2.13 **E.coli concentrations at monitoring locations during 2002 storm survey.**

All the monitoring locations sampled during the November storm violated water quality standards for bacteria except the furthest upstream site, Middle Fork of the South Fork of Deer Creek, which drains only forested land (Figure 2.13). The bacteria concentrations at the other sites followed a similar pattern, with the bacteria rates with the highest concentrations occurring on the day of the heaviest rainfall.

Loading Capacity and Allocations

Flow-based loading capacity and allocations were determined using a load duration curve. This method segregates data by flow, allowing for flow-based source assessment, graphical display of the range of data, and the determination of critical period for water quality (Appendix B). Deer Creek at Highway 138 (Map 2.4, site #1) was chosen as the load duration curve site because of the availability of long term bacteria data, its location near the mouth of Deer Creek, and the fact that it had the highest log mean concentration during the fall-winter-spring period and the second highest during the summer period. If water quality standards for bacteria are achieved at this site it is likely water quality will be achieved along the length of the creek. DEQ, the Umpqua Basin Watershed Council and the Douglas Soil and Water Conservation District collected 26 *E. coli* samples and 67 fecal coliform samples between 1985 and 2002. Both the *E. coli* and fecal coliform datasets were used to assess current loading assuming a one to one relationship between the two. This allowed for a larger dataset to analyze and is a conservative assumption because *E. coli* is a subset of fecal coliform.

A regression was used to determine stream flow for Deer Creek near the sampling site between 1985 and 2001. A relationship was determined between stream gage #1431220, Deer Creek near Roseburg, which operated from 1955 until 1975, and stream gage #14320700, Calapooya Creek at Umpqua, which operated from 1955 until 2001. After 2001, stream flows were estimated using the hydrologic model described in Appendix C. Climate data for the model was measured in Roseburg.

Flow Based Calculations

The daily flow-based loading capacity of Deer Creek was determined for each day with a flow record by multiplying the standard (126 org./100 ml) by the flow and converting the units into organisms per day (Figure 2.14). The range of observed flows was separated into five categories: low, dry, mid-range, wet and high flows. A generalized loading capacity for each of the five flow periods was computed by taking the log-mean of calculated loading capacity for each day within that period. The log-mean of the observed *E. coli* loading within each of the flow periods was compared with the loading capacity of that flow period (Table 2.15). Reductions in loads are necessary to meet the TMDL during all ranges of flows with an 86% reduction necessary during low flows. Management practices that are implemented to achieve the average criteria will also address exceedances of the extreme criteria. If peak concentrations continue to exceed the extreme target, DMAs will be required to change their management plans to reduce peak loading.

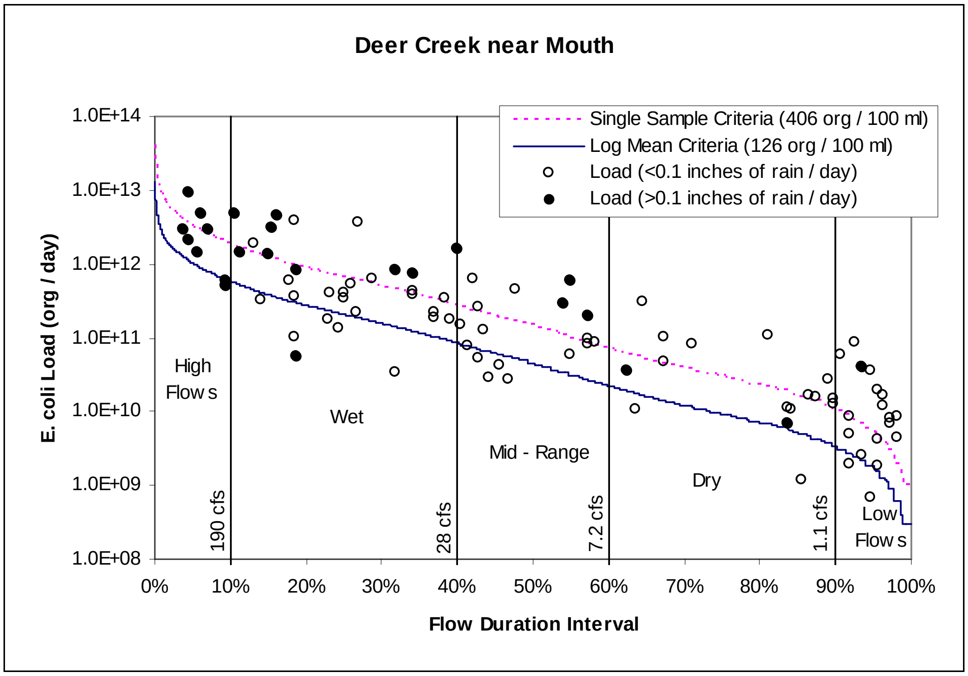


Figure 2.14 Load duration curve for Deer Creek at Highway 138 (Map 2.4, site #1). Precipitation is the average rainfall accumulation for the day a sample was collected and the previous day, measured at Roseburg.

Table 2.15. **Flow-based TMDLs for Deer Creek**

	Range of Flows				
	High Flow (Greater than 190 cfs)	Wet (28 to 190 cfs)	**Mid-Range** (7.2 to 28 cfs)	Dry (1.1 to 7.2 cfs)	**Low Flow** (Below 1.1 cfs)
Loading Capacity (Org./day)	1.18×10^{12}	2.12×10^{11}	4.41×10^{10}	9.16×10^{9}	1.35×10^{9}
Current Load(Org./day)	2.09×10^{12}	5.53×10^{11}	1.22×10^{11}	2.16×10^{10}	9.40×10^{9}
% Reduction	44%	62%	64%	58%	86%
Allocated Permitted Effluent Limits (*E.coli* organisms/100 ml) (average / extreme)	126 / 406	126 / 406	126 / 406	126 / 406	126 / 406
Estimate Point Source Loading (Org./day)	0	0	0	0	0
Load Allocation (Org./day)	1.12×10^{12}	2.01×10^{11}	4.19×10^{10}	8.24×10^{9}	1.22×10^{9}
MOS (Org./day)	5.90×10^{10}	1.06×10^{10}	2.21×10^{9}	9.16×10^{8}	1.35×10^{8}
TMDL	1.18×10^{12}	2.12×10^{11}	4.41×10^{10}	9.16×10^{9}	1.35×10^{9}

Allocations and Margin of Safety

Waste load allocations are expressed as the effluent concentration allowed by the bacteria standard: 126 *E. coli* org./100 ml as a log-mean based on a minimum of 5 samples in a 30-day period and no single sample exceeding 406 *E. coli* org./100 ml. However, there are no facilities which are likely to discharge fecal bacteria in the Deer Creek Watershed; therefore, their estimated load is zero. An explicit margin of safety was incorporated in the TMDL. When use is more likely to occur, during dry and low flows, a 10% margin of safety was incorporated and when use was less likely, during high, wet and mid-range flows, a 5% margin was used. The load allocation is assigned to nonpoint sources of bacteria including wildlife and agriculture, forest, urban and residential land uses. The load allocation is the difference between the TMDL and the margin of safety for each range of flows.

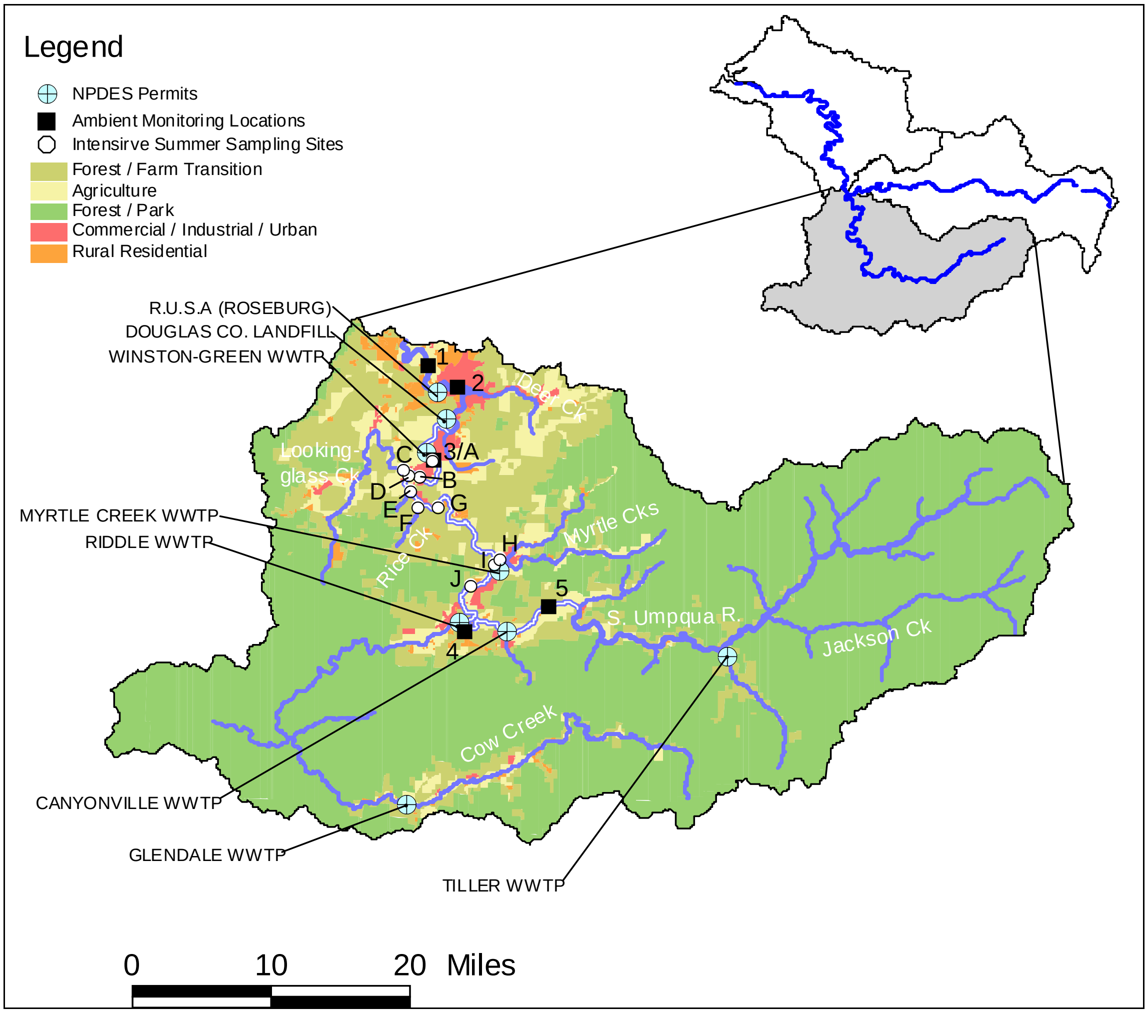
Percentage reductions apply to loading throughout the Deer Creek Watershed including the North and South Forks which exceed the *E. coli* standard. There is not enough *E. coli* or flow data to compute a load duration curve for sites other than the mouth of Deer Creek. The load reductions presented in Table 2.15 are overall reductions and are believed to be representative of conditions throughout the watershed. Certain reaches and tributaries may require larger or smaller reductions to meet water quality standards. As management practices are adopted and additional data is collected, more detailed allocations may become appropriate.

Watershed Specific Source Assessment

This section expands on the discussion in the Basin Wide Bacteria Source Assessment section. There are no known facilities which discharge fecal bacteria into Deer Creek. Therefore, the loading must be attributed to nonpoint sources. Because water quality violations are seen throughout most of the watershed and throughout the entire year, there are likely a number of different sources. The water quality violations are associated with agricultural, residential, and urban land uses. During the summer period, two sampling sites showed large increases in *E. coli* concentrations: Deer Creek near Roseburg and North Fork Deer Creek upstream of river mile 2.9. The former is likely due to urban sources like storm drains and the later to agricultural sources such as livestock. These sites should receive emphasis during implementation. Forested land does not appear to cause or contribute to bacteria water quality violations in the Deer Creek Watershed.

SOUTH UMPQUA RIVER AND TRIBUTARIES

The South Umpqua River was determined to be water quality limited for bacteria during the summer period (river mile 15.9 to 57.7) (Map 2.5). The water quality limited determination was first based on fecal coliform data collected between water years 1986 – 1996 at four sites. More recent *E. coli* data also supports the listing.



Map 2.5 South Umpqua River Watershed with land use, monitoring locations, and wastewater treatment plants. Land use data is from USGS, 1999.

Seasonal Variation

Historical Data

The Umpqua River has been sampled for *E. coli* bimonthly from December 1995 until September 2003 at the same 4 sites that were used to make the water quality limited determination (Table 2.16 and Figure 2.15, below). Based on these data, the South Umpqua River appears to be attaining the average bacteria water quality standard during the fall-winter-spring period with less than 10% exceeding the extreme criteria. However, 25% of the ambient monitoring samples during the summer period are above 406 org./100 ml at South Umpqua at Highway 42 (RM 21.2, Map 2.5, Site #3), so a TMDL remains necessary, especially because the summer period is when water contact recreation is most likely. Cow Creek, a major tributary to the South Umpqua, meets bacteria water quality standards year round.

Table 2.16. Ambient Monitoring, *E. coli* org./100 ml, December 1995 – September 2003* Exceedances of the standard are shown in the blue cells.

						Summer				Fall-Winter-Spring			
Map Key	Station Name	Station ID	Lat.	Lon.	River Mile	Number of Samples	Log Mean	Max.	% > 406	Number of Samples	Log Mean	Max.	% > 406
1	South Umpqua At Melrose Road	10442	43.2418	-123.4111	5.1	20	7	166	0	38	41	1046	5
2	South Umpqua At Stewart Park Road (Roseburg)	11522	43.2178	-123.3656	10.7	20	27	816	5	50*	53	626	4
3	South Umpqua at Hwy 42 (Winston)	10443	43.1339	-123.3979	21.2	20	131	1203	25	39	36	1080	3
4	Cow Creek At Mouth	10997	42.9439	-123.3358	0.3	21	8	313	0	38	11	106	0
5	South Umpqua At Days Cr Cutoff Rd (Canyonville)	11484	42.9709	-123.2158	55.5	20	16	548	5	38	9	120	0

*includes intensive storm sampling

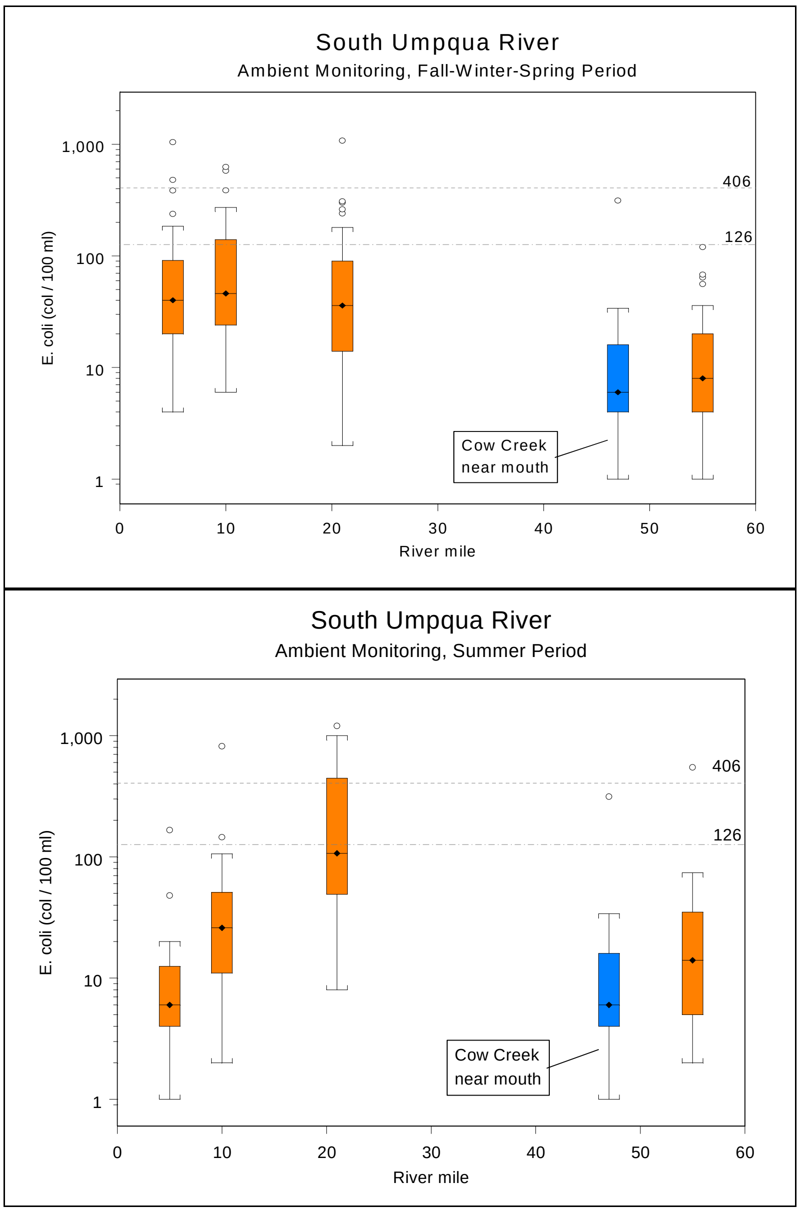


Figure 2.15 Longitudinal box plot of *E. coli* data collected during ambient monitoring between December 1995 and September 2003, segregated by Fall-Winter-Spring and Summer Period. Corresponds to data in Table 2.16.

Summer 2003 Intensive Sampling

DEQ and local stakeholders attempted to characterize the source of *E. coli* loading of the South Umpqua River by collecting 5 samples within 30 days at 10 sites during the summer of 2003. Samples were analyzed by Neilson Research Corporation of Medford, Oregon, an accredited Oregon environmental laboratory and met ODEQ quality assurance / quality control procedures. The results are shown in Figure 2.16 and Table 2.17 below.

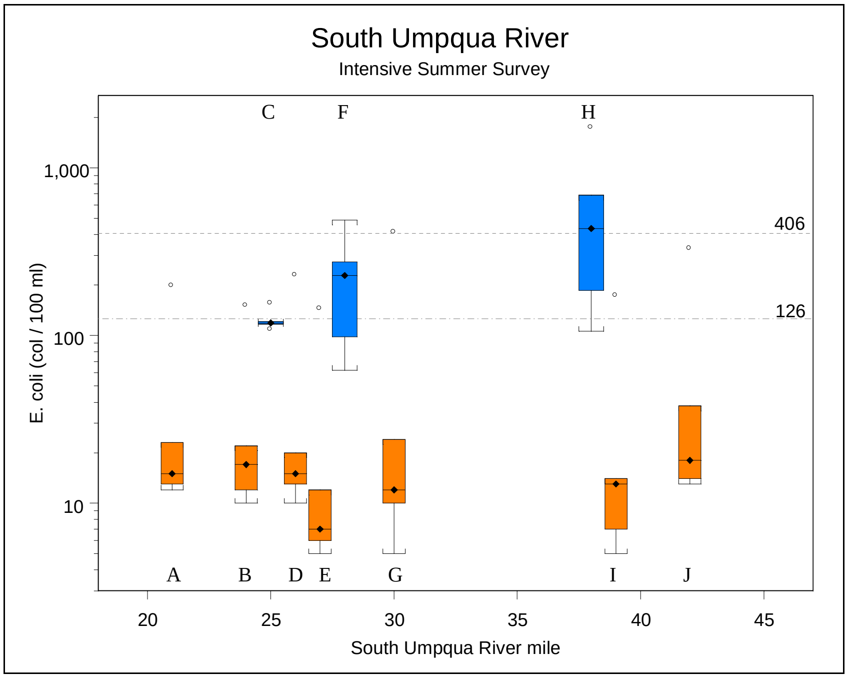


Figure 2.16 Longitudinal box plot of E. coli data collected during August and September 2003. Each site was sampled 5 times. Tributary sites were sampled near their confluences with the South Umpqua River. Each site is labelled with a letter that corresponds to Table 2.17.

Table 2.17. *E. coli* (org / 100 ml) results from the summer 2003 intensive survey. Exceedances of the standard are shown in the blue cells.

Map Key	Station Name	LASAR	River mile	Number of Samples	Log Mean	Maximum	% > 406
A	South Umpqua @ Hwy 42	10443	21.2	5	25	197	0%
B	South Umpqua @ Hwy 99	30696	24.6	5	23	150	0%
C	Lookingglass Creek @ Mouth	12248	0.1	5	123	155	0%
D	South Umpqua u/s of Lookingglass	30145	25.4	5	25	228	0%
E	South Umpqua River @ Dillard Bridge	25182	26.9	5	13	144	0%
F	Rice Creek @ Mouth	30694	0.1	5	179	488	20%
G	South Umpqua @ RM 30	12251	29.9	5	23	411	20%
H	Myrtle Creek @ Mouth	11316	0.1	5	400	1733	60%
I	South Umpqua u/s of Myrtle Creek	12245	39.2	5	16	172	0%
J	South Umpqua @ Tri City Intake	30726	41.8	5	33	328	0%

None of the South Umpqua River summer 2003 samples violated the log mean standard. One site, South Umpqua River at RM 30, had one value over the 406 org./100 ml standard. The highest concentration for all the South Umpqua River sites occurred on September 10, 2003. On September 9, Roseburg received 0.72 inches of rain. Mean daily discharge in the South Umpqua River at Brockway (USGS gage # 14312000 at RM 21.2) increased from 84 cfs on September 9 to 428 cfs on September 11. September 9 was also the scheduled day for bi-monthly ambient monitoring. *E. coli* concentrations from the ambient monitoring locations at river miles 10.7 (South Umpqua at Melrose Road, Site #1), 21.2 (South Umpqua at Highway 42, Site #3), and 55.5 (South Umpqua at Days Creek Cutoff Road, Site #4) all exceeded 406 org./100 ml.

Lookingglass, Rice, and Myrtle Creeks were also sampled during the summer 2003 survey. During this period, Myrtle Creeks violated the bacteria water quality standard with the log mean greater than 126 org./ 100 ml and concentrations in Myrtle and Rice Creeks exceeding 406 org. / 100 ml. However, none of the creeks appeared to increase *E. coli* concentrations in the South Umpqua River (Figure 2.16).

Other Tributaries

As part of other water quality studies, *E. coli* data has also been collected from other tributaries to the South Umpqua River. Deer Creek was also determined to be water quality limited for bacteria and has been addressed in a previous section. Since the mouth of Deer Creek (at South Umpqua river mile 11.2) is downstream of the monitoring site on the South Umpqua River, which has the elevated summer *E. coli* concentrations (river mile 21.2), the loading from Deer Creek is not the cause of the summer water quality limitation in the South Umpqua River. Of the other tributaries that have been sampled, Roberts Creek, and an unnamed creek near Douglas County Landfill also had samples with concentrations greater than 406 org./100ml.

Loading Capacity and Allocations

Flow-based Calculations

Flow-based loading capacity and allocations were determined using a load duration curve. This method segregates data by flow, allowing for flow-based source assessment, graphical display of the range of data, and determination of the critical period for water quality (Appendix B). The South Umpqua River at Highway 42 at RM 21.2 (Map 2.5, site 3/A) was chosen for the load curve because it has the highest log mean *E. coli* of the ambient monitoring sites and there is a flow gage at the site. If water quality standards for bacteria are achieved at this site, it is likely water quality standards will be achieved along the length of the river. Between DEQ and local stakeholders, 64 *E. coli* samples have been collected between December 1995 and September 2003. Data from USGS gage #14312000, South Umpqua near Brockway, between 1905 and 2003 was used to compute the flow-based loading capacity.

The daily flow-based loading capacity of the South Umpqua River was determined for each day with a flow record by multiplying the standard (126 org./100 ml) by the flow and converting the units into organisms per day (Figure 2.17). The range of observed flows was separated into five categories: low, dry, mid-range, wet and high flows. A generalized loading capacity was computed for each of the five flow periods. High, wet and mid-range flow loading capacity was computed by taking the log-mean of calculated loading capacity for each day within that period. When water contact recreation is at its peak, during dry and low flows, a more conservative approach was applied.

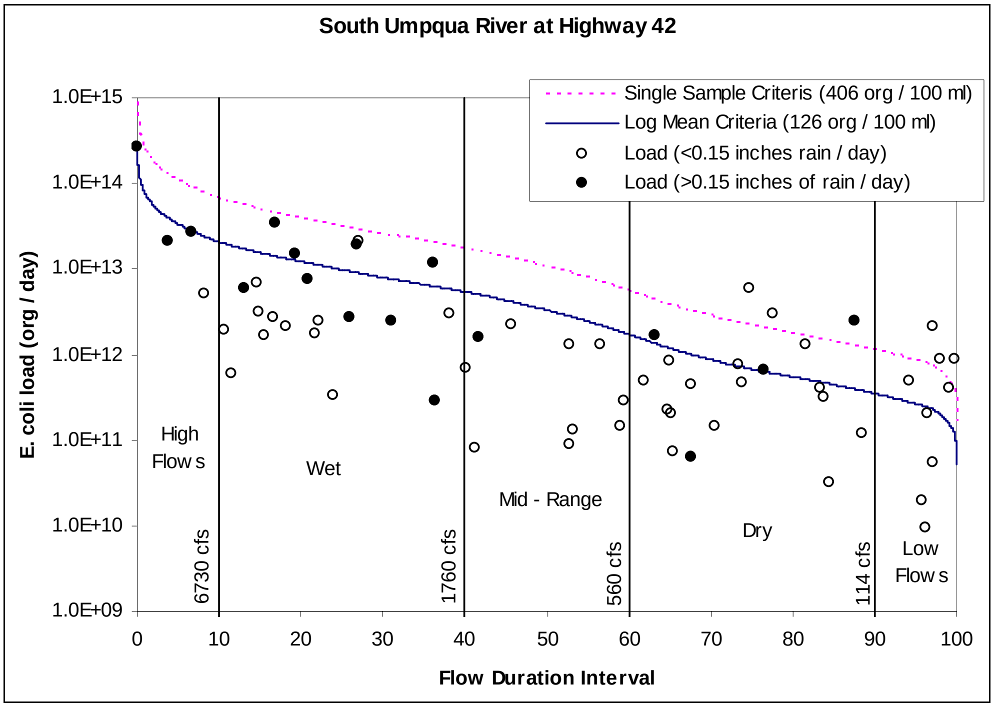


Figure 2.17 Load duration curve for South Umpqua River at river mile 21.2 (Map 2.5, site #3). Precipitation is the average rainfall accumulation for the day a sample was collected and the previous day, measured at Roseburg.

The lowest loading capacity from sampled days within each range of flows becomes the target. This alternative approach is more conservative than a 10% margin of safety and is justified because the observed water quality violations are occurring during a high use period near high use areas.

The log-mean of the observed *E. coli* loading within each of the flow periods was compared with the loading capacity for that flow period (Table 2.18). A 45 % reduction in load is necessary to meet the TMDL during low flows (less than 114 cfs), and a 13% load reduction during dry flow periods (114 to 560 cfs). No reduction in loading is necessary during the high, wet, or mid-range flow periods upstream of this site (i.e., neither the average nor the extreme criteria was exceeded during these periods). There are occasional (5% or less) exceedances of the extreme criteria downstream of this site. Management practices that are implemented to achieve the average criteria will also address occasional exceedances. If peak concentrations continue to exceed the extreme target, DMAs will be required to change their management plans to reduce peak loading.

Table 2.18. South Umpqua River Bacteria TMDL by Range of Flows

	Range of Flows				
	High Flow (Above 6,730 cfs)	Wet (1,760 to 6,730 cfs)	**Mid-Range** (560 to 1,760 cfs)	Dry (114 to 560 cfs)	**Low Flow** (Below 114 cfs)
Loading Capacity (Org./day)	3.77×10^{13}	1.00×10^{13}	3.22×10^{12}	3.79×10^{11}	1.14×10^{11}
Current Loading (Org./day)	2.97×10^{13}	3.47×10^{12}	4.19×10^{11}	4.38×10^{11}	2.09×10^{11}
% reduction	0	0	0	13	45
Allocated Permitted Effluent Limits (*E.coli* organisms/100 ml) (average / extreme)	126 / 406	126 / 406	126 / 406	126 / 406	126 / 406
Estimate Point Source Loading (Org./day)	5.77×10^{10}	5.77×10^{10}	5.77×10^{10}	5.77×10^{10}	5.77×10^{10}
Load Allocation	2.96×10^{13}	3.41×10^{12}	3.61×10^{11}	3.22×10^{11}	5.64×10^{10}
MOS	8.02×10^{12}	6.57×10^{12}	2.80×10^{12}	conservative assumptions	conservative assumptions
TMDL	3.77×10^{13}	1.00×10^{13}	3.22×10^{12}	3.79×10^{11}	1.14×10^{11}

Point Source Calculations

There are eight facilities in the South Umpqua River watershed which are permitted to discharge treated sewage (Table 2.19). Waste load allocations are expressed as the effluent concentration allowed by the bacteria standard: 126 *E. coli* org./100 ml as a log-mean based on a minimum of 5 samples in a 30-day period and no single sample exceeding 406 *E. coli* org./100 ml (Table 2.19). Maximum waste load figures are derived from the maximum permitted flow for a facility and the bacteria standard, 126 *E. coli* org / 100 ml. Maximum waste loads are used in the computations but are not allocations. The maximum waste load is the sum of the maximum waste loads from the five facilities upstream of the load duration curve site. By rule, overflows of untreated sewage are prohibited in the summer months except during the 1-in-10 year 24 hour storm. In the winter months, all municipalities are expected to convey and treat all sewage up to the 1-in-5 year 24 hour storm

Table 2.19. Waste load allocations.

Facility Name	Receiving Stream	River Mile	Permit Type	Max. Flow (MGD)	Allocated Permitted Effluent Limits (*E.coli* org/100 ml)
R.U.S.A. ROSEBURG WWTP	South Umpqua River	7.6	NPDES-DOM-Ba	10	Log mean of 126 Not to exceed 406
WINSTON-GREEN WWTP	South Umpqua River	20.6	NPDES-DOM-C2a	2	Log mean of 126 Not to exceed 406
CANYONVILLE WWTP	South Umpqua River	50.6	NPDES-DOM-Da	1	Log mean of 126 Not to exceed 406
MYRTLE CREEK WWTP	South Umpqua River	39.5	NPDES-DOM-Da	1	Log mean of 126 Not to exceed 406
RIDDLE WWTP	Cow Creek	1.9	NPDES-DOM-Da	1	Log mean of 126 Not to exceed 406
GLENDALE WWTP	Cow Creek	40.0	NPDES-DOM-Da	1	Log mean of 126 Not to exceed 406
TILLER RANGER STATION WWTP	South Umpqua River	74.7	NPDES-DOM-Da	1	Log mean of 126 Not to exceed 406
Roseburg Landfill	Unnamed Creek	Unk.	NPDES-IW-N	0.09 (1)	Log mean of 126 Not to exceed 406
Wildlife Safari (Winston)	Not applicable	Unk.	NPDES-CAFO	0 (2)	0
Bever Livestock Auction (Roseburg)	Not applicable	Unk.	NPDES-CAFO	0 (2)	0
Phillips (Myrtle Creek)	Not applicable	Unk.	NPDES-CAFO	0 (2)	0
Evans (Roseburg)	Not applicable	Unk.	NPDES-CAFO	0 (2)	0
Michaels Ranch (Days Creek)	Not applicable	Unk.	NPDES-CAFO	0 (2)	0

(1) Effluent flow based on rainfall, used maximum daily flow recorded between May and October 2004 to estimate load contributed to South Umpqua.
(2) CAFOs may only discharge during extreme rainfall event (greater than the 25-year, 24-hour event). During these events they may not cause or contribute to violations of the water quality standards.

Myrtle Creek treatment plant does not currently discharge between June and October because of other water quality concerns. This time period roughly corresponds with the dry and low flow periods. However, if Myrtle Creek discharges at or below the bacteria standard, the plant will not cause or contribute to water quality violations and, hence, will be meeting the TMDL. Therefore, Myrtle Creek is given the same concentration waste load allocation for all ranges of flows.

In addition, the Cow Creek Band of Umpqua Indians operates a wastewater treatment plant near Canyonville. The plant is regulated by the U.S. Environmental Protection Agency, which has issued an NPDES permit for its operation. Oregon does not have regulatory authority to address tribal waters. While not provided a WLA or LA in the state TMDL, the TMDL has assumed the facility and any tribal nonpoint sources to be discharging at or below the state *E. coli* criteria of 126 org. / 100 ml.

Roseburg Landfill, Winston-Green WWTP and RUSA have general industrial stormwater permits (GEN12Z). The benchmark in the stormwater permits is 406 counts/100 ml. Because these facilities only discharge during significant rainfall events, they are not expected to cause or contribute to exceedances of the bacteria standard when in compliance with their permit. Roseburg Landfill also has an individual permit for the treatment and discharge of leachate. There is a stormwater like quality to the landfill leachate system and appropriate *E. coli* benchmarks could be used to assess compliance with the WLA.

CAFOs are only allowed to discharge during extreme rainfall events greater than the 25-year, 24-hour rainfall (Table 2.19). The general permit also stipulates that during such a discharge, effluent cannot cause or contribute to a violation of state water quality standards. Because the TMDL only addresses the time period when the CAFO discharge is prohibited, the CAFO is allocated zero load. However, discharges during extreme rainfall events (i.e., the 25-year, 24-hour rainfall) remain permitted.

The load allocation is assigned to nonpoint sources of bacteria including wildlife and agriculture, forest, urban and residential land uses. The load allocation is the difference between the loading capacity and the waste load allocations. The summer 2003 sampling indicated that elevated concentrations were associated with a rainfall event large enough to influence flow. However, previous exceedances of the standard were not related to rainfall events.

Myrtle Creek and Rice Creek

Two tributaries besides Deer Creek were determined to be water quality limited: Rice Creek and Myrtle Creek. No point sources discharge into these creeks. A simple percent reduction in the log mean *E. coli* concentration will serve as a surrogate measure for load allocations:

$$\%\,\text{reduction} = \left(1 - \frac{126\,(\text{E.coli org}/100\,\text{ml})}{\text{Log Mean}\,(\text{E.coli org}/100\,\text{ml})}\right) * 100$$

Myrtle Creek needs a 69% reduction and Rice Creek needs a 30% reduction in loading to meet bacteria water quality standards. The 303(d) misidentifies Myrtle Creek as North Fork Myrtle Creek (LLID 1232963430229).

Watershed Specific Source Assessment

This section expands on the discussion in the Basin Wide Bacteria Source Assessment section.

Review of the available discharge monitoring reports (DMRs) between September 2000 and September 2002 from the facilities upstream of the impacted reach indicates that generally, during the summer period, the wastewater treatment plants met their permit limits. The Myrtle Creek wastewater treatment plant effluent occasionally exceeded the fecal coliform target; however, the impact to water quality downstream would have been minimal due to dilution with the increased flows of the South Umpqua River just downstream of the discharge point.

Since point sources do not cause or contribute to bacteria water quality violations, loading must be occurring from nonpoint sources. *E. coli* concentrations appear to increase with summer rainfall events; however, most of the dry and low flow standard violations were not associated with rainfall. Failing septic systems, direct delivery of bacteria from swimmers and watering animals to the river, or illegal discharges are possible sources of bacteria during low and dry flows (Table 2.2). The Orchard R-V Park that had failing septic systems and direct discharges into the South Umpqua River has now been connected to the Winston-Green wastewater treatment plant, beginning in 2003. During the intensive summer survey, no water quality violations were observed in the South Umpqua River, so source areas could not be determined. Despite the high concentrations observed in some of the tributaries, they do not appear to impact concentrations in the South Umpqua River.

UMPQUA RIVER AND ESTUARY

The Umpqua River has been determined to be water quality limited for bacteria from river miles 0 to 6.7, and 7.7 to 25.9 in the lower estuary, and 25.9 to 109.3, primarily in the freshwater portion of the river. The Umpqua Estuary refers to the tidally influenced portion of the Umpqua River, from its mouth to approximately river mile 27 (Scottsburg). The Umpqua Estuary supports commercial and recreational shellfish harvest and therefore must meet the shellfish standard, which is a median concentration of fecal coliform of 14 org./100 ml with no more than 10 % of the samples exceeding 43 org. / 100 ml. The shellfish standard is more restrictive than the recreational contact standard, which is a 5-sample *E. coli* log mean of 126 org. / 100 ml with no sample exceeding 406 org./100 ml. The Umpqua River from river mile 25.9 to 109.3 must meet the recreational contact standard.

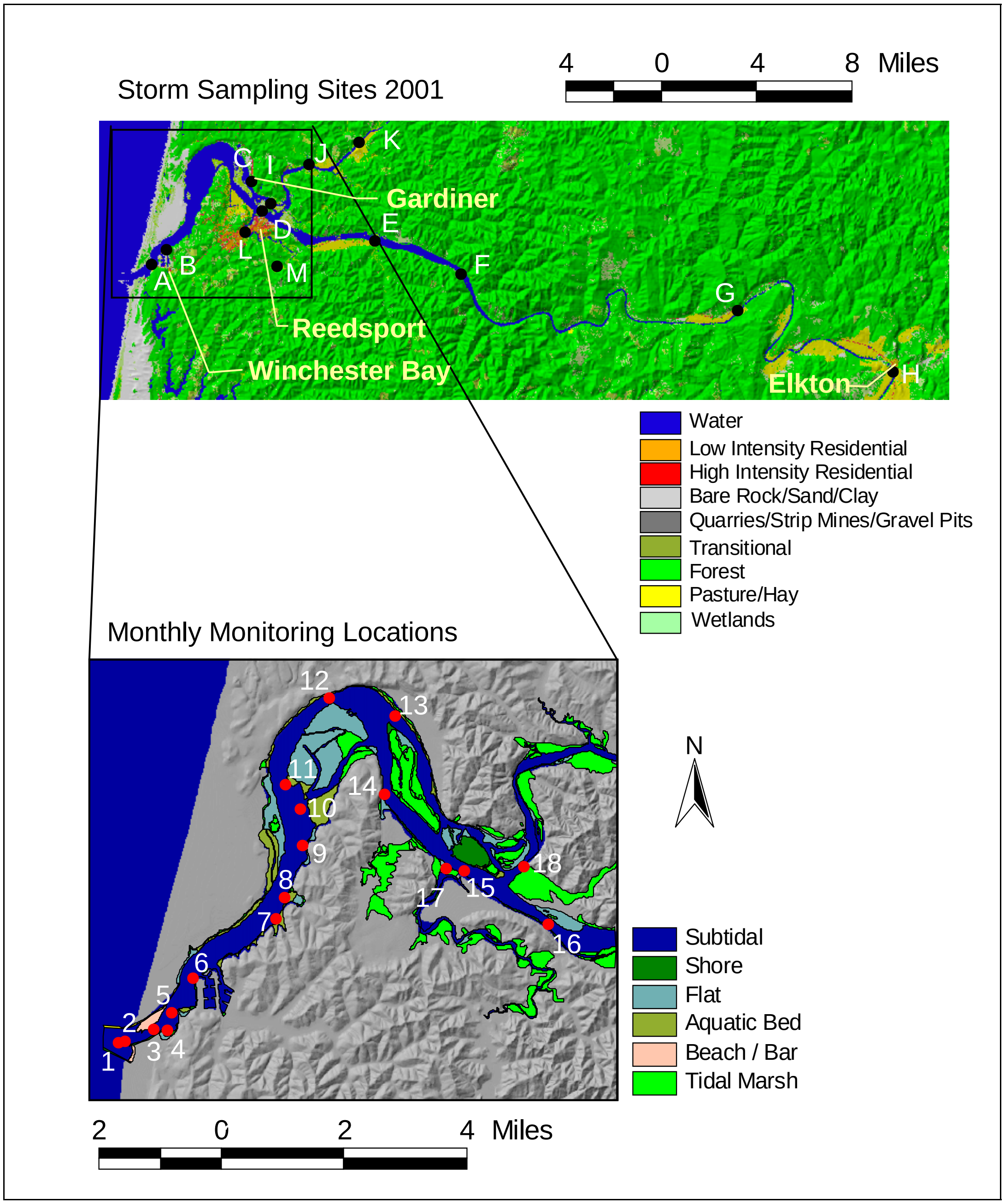


Figure 2.18 Water quality monitoring locations. In the upper map, land cover is based on National Land Cover Data for Oregon (Vogelmann et. al, 1999). In the lower map, estuary habitat is based on Cortright et. al., 1989. See Tables 2.20 and 2.21 for monitoring station information

Seasonal Variation

DEQ and the Oregon Department of Agriculture (ODA) have collected monthly fecal coliform samples from 18 sites in the Umpqua Estuary since 1988, with intermittent sampling back to 1967 (Figure 2.18, previous page, and Table 2.20). During a storm event in November 2001, DEQ also collected samples at nine sites over an eight day period. Because of tidal reversals, bacteria concentrations measured at the mouths of Smith River and Scholfield Slough were likely impacted by the Umpqua River (see discussion below).

Table 2.20. Water Quality Monitoring Locations – Umpqua Estuary

Ref	Lasar Number	Station Name	Begin	End	# of Samples	River Mile	Lat.	Long.
9	13369	Umpqua River At Marker #12 (Double Cove Point)	1967	2002	218	4.0	43.714	-124.153
15 / D	13372	Umpqua River At Hwy 101	1967	2002	178	11.0	43.710	-124.100
16	13374	Umpqua River 1 Mile U/S Of Reedsport	1967	2002	175	12.6	43.698	-124.072
3	13696	Umpqua River At Marker #6	1967	2002	210	0.4	43.670	-124.199
4	13697	Umpqua River At Half Moon Bay	1986	2002	195	0.6	43.670	-124.194
5	13698	Umpqua River At Marker #6A	1986	2002	192	0.8	43.674	-124.193
6	13699	Umpqua River At Marker #8 (Entrance To Win. Bay)	1986	2002	198	1.3	43.683	-124.187
7	13700	Umpqua River At Jerden Cove	1986	2002	202	2.8	43.697	-124.161
8	13701	Umpqua River At Macey Cove	1986	2002	202	3.1	43.702	-124.158
10	13702	Umpqua River At Big Bend-Inside	1986	2002	200	4.6	43.722	-124.154
11	13703	Umpqua River At Big Bend-Outside	1988	2002	183	5.1	43.727	-124.160
12	13704	Umpqua River At Marker #19	1986	2002	206	6.7	43.748	-124.146
13	13705	Umpqua River At Ip Mill Site (Gardiner)	1986	2002	197	7.9	43.744	-124.125
14	13706	Umpqua River At Leeds Island	1986	2002	189	9.0	43.726	-124.127
17 / L	13707	Scholfield Slough At Mouth	1986	2002	171	0.1	43.706	-124.108
18	13708	Smith River At Butler Creek	1986	2002	157	0.6	43.711	-124.082
2	13709	Umpqua Bay At East Jetty Tiangle	1986	2002	208	-0.1	43.667	-124.208
1	13710	Umpqua River At West Jetty Tiangle	1986	2002	172	-0.2	43.667	-124.210
G	25170	Umpqua River at Scott Creek Boat Ramp	2001	2001	2	22.3	43.664	-123.700
F	26452	Umpqua River @ Umpqua Wayside Park	2001	2001	7	19.3	43.678	-123.933
M	26454	Scholfield at Thorton Oar Lane	2001	2001	6	5.6	43.678	-124.087
A	26455	Umpqua R. at Douglas Co. Pier	2001	2001	6	0.8	43.676	-124.192
K	26456	Smith River at USFS Boat Ramp	2001	2001	8	6.0	43.752	-124.023

Ref	Lasar Number	Station Name	Begin	End	# of Samples	River Mile	Lat.	Long.
J	26457	Smith R. at South side Rd.	2001	2001	6	3.4	43.738	-124.064
C	26458	Umpqua at Gardiner Ramp	2001	2001	6	9.3	43.727	-124.111
E	26460	Umpqua R. at Dean Cr. Viewing Area	2001	2001	6	14.2	43.696	-124.006
I	26461	Smith R. at Bolon Island	2001	2001	6	0.8	43.715	-124.095
B	26462	Winchester Bay at Ork Rock Park	2001	2001	6	2.7	43.685	-124.181

Long-Term Data

All the long-term monitoring locations violated the shellfish water quality standard between January and March (Table 2.21). Only the Smith River site and the Umpqua River at Hwy 101 site exceeded the criteria during July through September.

Table 2.21. Long Term Monitoring Stations – Fecal Coliform (org. / 100 ml). Exceedances of the standards are shown in the blue cells.

Station Name	River Mile	All Data		Jan - Mar		Apr - Jun		Jul - Sep		Oct - Dec	
		Med	90th	Med	90th	Med	90th	Med	90th	Med	90th
Umpqua River At West Jetty Tiangle	-0.2	4	49	8	65	2	36	2	8	8	79
Umpqua Bay At East Jetty Tiangle	-0.1	4	93	9	150	2	27	2	5	8	79
Umpqua River At Marker #6	0.4	4	44	13	107	3	73	2	8	4	37
Umpqua River At Half Moon Bay	0.6	4	43	10	94	4	38	2	9	4	32
Umpqua River At Marker #6A	0.8	5	49	17	102	4	47	2	13	4	24
Umpqua River At Marker #8	1.3	4	49	16	89	5	33	2	13	4	41
Umpqua River At Jerden Cove	2.8	7	79	23	150	8	88	2	8	4	46
Umpqua River At Macey Cove	3.1	8	49	33	104	8	72	2	9	7	49
Umpqua River At Marker #12	4.0	8	79	23	143	8	49	3	11	8	43
Umpqua River At Big Bend-Inside	4.6	8	75	23	126	8	36	2	8	7	60
Umpqua River At Big Bend-Outside	5.1	9	91	30	240	9	70	2	8	11	89
Umpqua River At Marker #19	6.7	9	70	23	130	10	70	4	8	9	45
Umpqua River At Ip Mill Site (Gardiner)	7.9	9	57	17	87	17	79	2	17	9	48
Umpqua River At Leeds Island	9.0	13	79	23	131	16	60	6	33	13	55
Umpqua River At Hwy 101	11.0	17	93	23	168	12	42	5	48	23	111
Umpqua River 1 Mile U/S Of Reedsport	12.6	9	79	17	79	9	79	7	25	14	86
Scholfield Slough At Mouth	0.1	17	93	33	93	17	82	7	39	23	126
Smith River At Butler Creek	0.6	13	57	12	58	13	55	7	45	23	89

The sites at the Umpqua River at Hwy 101 and at Scholfield Slough at the mouth have the highest overall median and 90th percentile bacteria concentrations. When examining data from the 58 sampling events with results from all sites, bacteria concentrations generally decrease from Umpqua River at Leeds Island (site 14) to the mouth (site 1) (Figure 2.19).

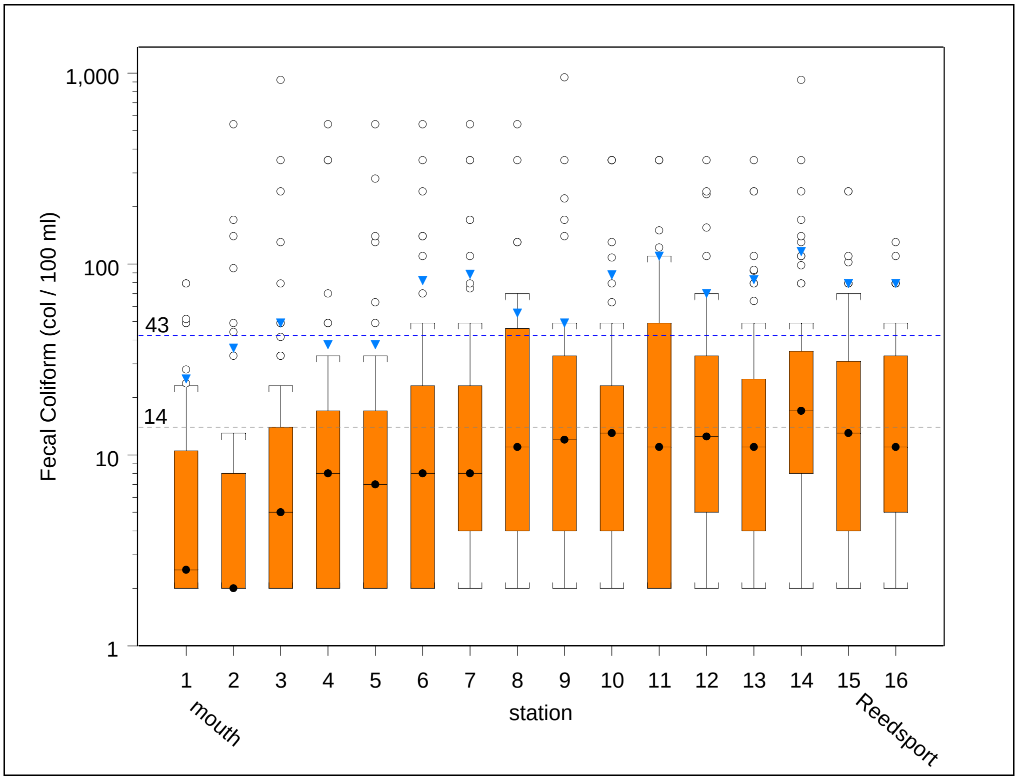


Figure 2.19 Longitudinal box plots of fecal coliform results. See Figure 2.18 for locations. Triangles represent the 90th percentile of the sample results. Results are presented for the 58 sampling events in which every site was sampled. For explanation of box plots, see Bacteria TMDL Overview.

Data from the site at the Umpqua River at Leeds Island warrants further investigation because of its high concentrations and because it is located downstream of Reedsport and the confluences of the Umpqua River with Scholfield Slough and Smith River. Leeds Island is also located near recreational shellfish beds. The fecal coliform concentrations at Umpqua River at Leeds Island have been slowly increasing from 1986 to 2002, for a total raise of about 7 fecal coliform org./100 ml (based on a Seasonal Kendal test with significance greater than 90%). Because the increase is so slight, it is appropriate to use older data together with the more recent data in conducting the analysis.

At Umpqua River at Leeds Island, fecal coliform concentrations vary by month (Figure 2.20). From August through October, fecal coliform concentrations are below both the median and 90th percentile standard. However, from December through March, monthly concentrations exceed both the median and 90th percentile values. In April through July and November, values are below or near either the median or 90th percentile standards. The median of measured salinities also varies seasonally: August through October has a median of 14 parts per thousand (ppt), April through July and November 4 ppt, and December through March less than 1 ppt indicating that high winter flows are dominating at this portion inthe estuary.

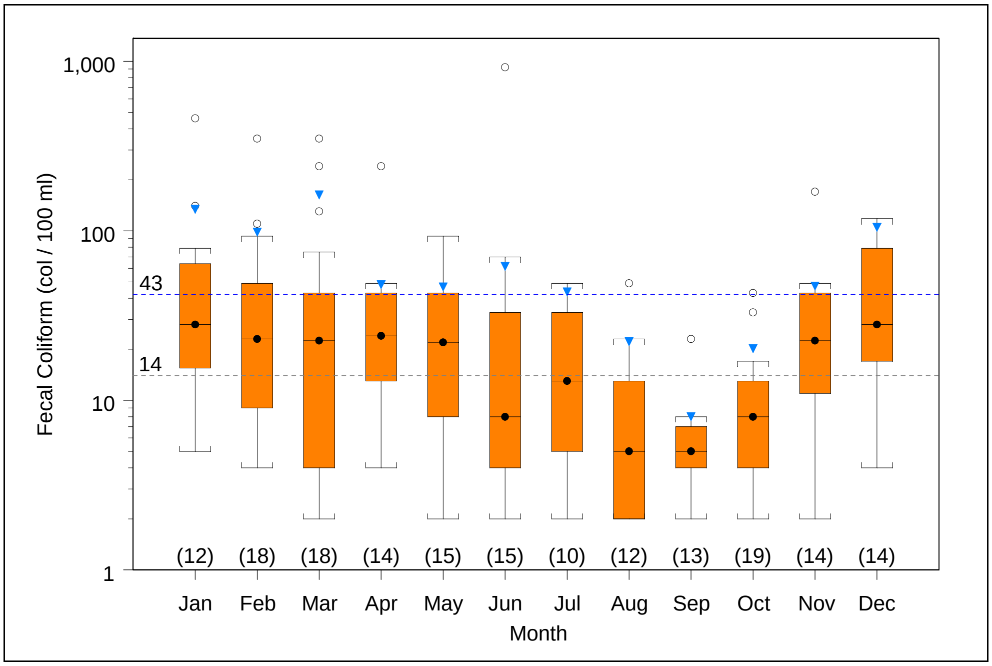


Figure 2.20 Monthly box plots of bacteria concentration at Umpqua River at Leeds Island. Triangles represent the 90th percentile of the sample results. Sample count is in parenthesis.

Similarly, stream flows at the Umpqua River near Elkton gage are seasonally dependent, with August through October ranges from 1,180-1,876 cfs, April through July and November with 1,728-9,525 cfs, and December through March with 12,178-15,839 cfs. Paired flow and fecal coliform data show an apparent but weak relationship with an R^2 value of 0.35 and a standard error of 0.46 (in log scale) (not shown). There appears to be a dramatic increase in bacteria concentrations when the Elkton Gage is > 5,200 cfs (Figure 2.21). Salinity measurements decrease with increased freshwater flow ($R^2 = 0.78$), with most flows above 8,000 cfs resulting in < 1 ppt salinity (similar to Appendix B, Figure B-5).

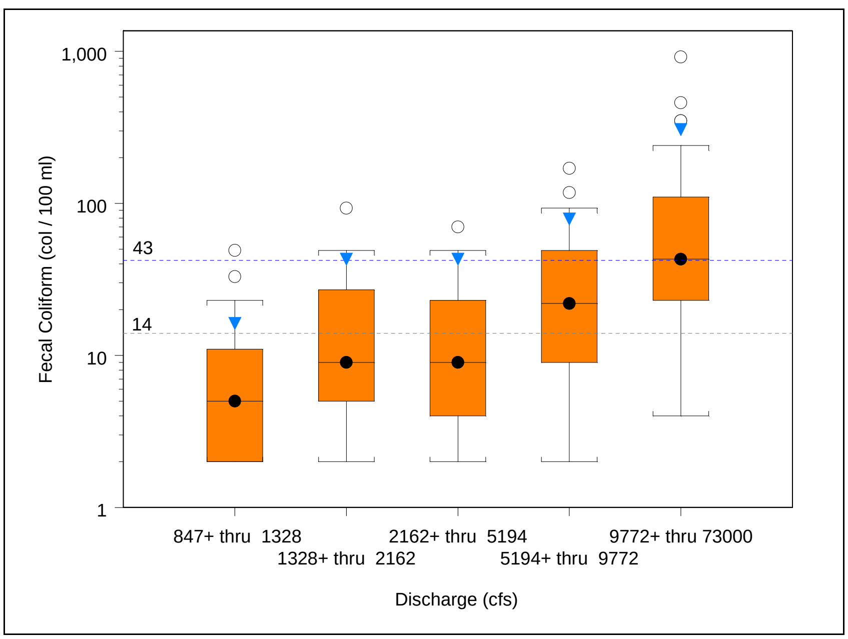


Figure 2.21 Box plots of bacteria concentration at Umpqua River at Leeds Island versus flow at Umpqua River at Elkton. Triangles represent the 90th percentile of the sample results. Each box contains an equal number of sampling events.

The determination that the Umpqua River is water quality limited from river mile 25.9 to 109.3 was based on fecal coliform concentrations measured in the Umpqua River at Umpqua (river mile 102.7) between October 1986 and October 1992, with 17% (7 of 42) of the values exceeding the fecal coliform standard (400). Since 1992, DEQ has not routinely collected bacteria samples at this site. *E. coli* data collected from the Umpqua River at Elkton (river mile 48.7) and results of the storm survey support the determination of water quality limitation for fecal bacteria (see table below).

Table 2.22. Ambient *E. coli* (org. / 100 ml) monitoring on the Umpqua River December 1995 through September 2002

		Summer: *E. coli*				Fall-Winter-Spring: *E. coli*			
Umpqua River Site	River mile	Number of Samples	Log mean (org. / 100 ml)	Max-imum (org. / 100 ml)	Percent > 406	Number of Samples	Log mean (org. / 100 ml)	Max-imum (org. / 100 ml)	Percent > 406
Elkton	48.7	16	3	12	0	42	28	2,419	2
Umpqua	102.7	1	1	1	0	4	32	135	0

Storm Sampling

DEQ conducted intensive storm sampling in the Umpqua Estuary and tributaries between November 27 and December 4, 2001 (Figure 2.22). At Reedsport, the accumulation of rainfall during the previous seven days was 2.95 inches. Daily accumulated rainfall from November 28 through December 2 ranged from 0.78 to 1.24 inches. The temporal patterns of rainfall at Reedsport and Roseburg do not match closely.

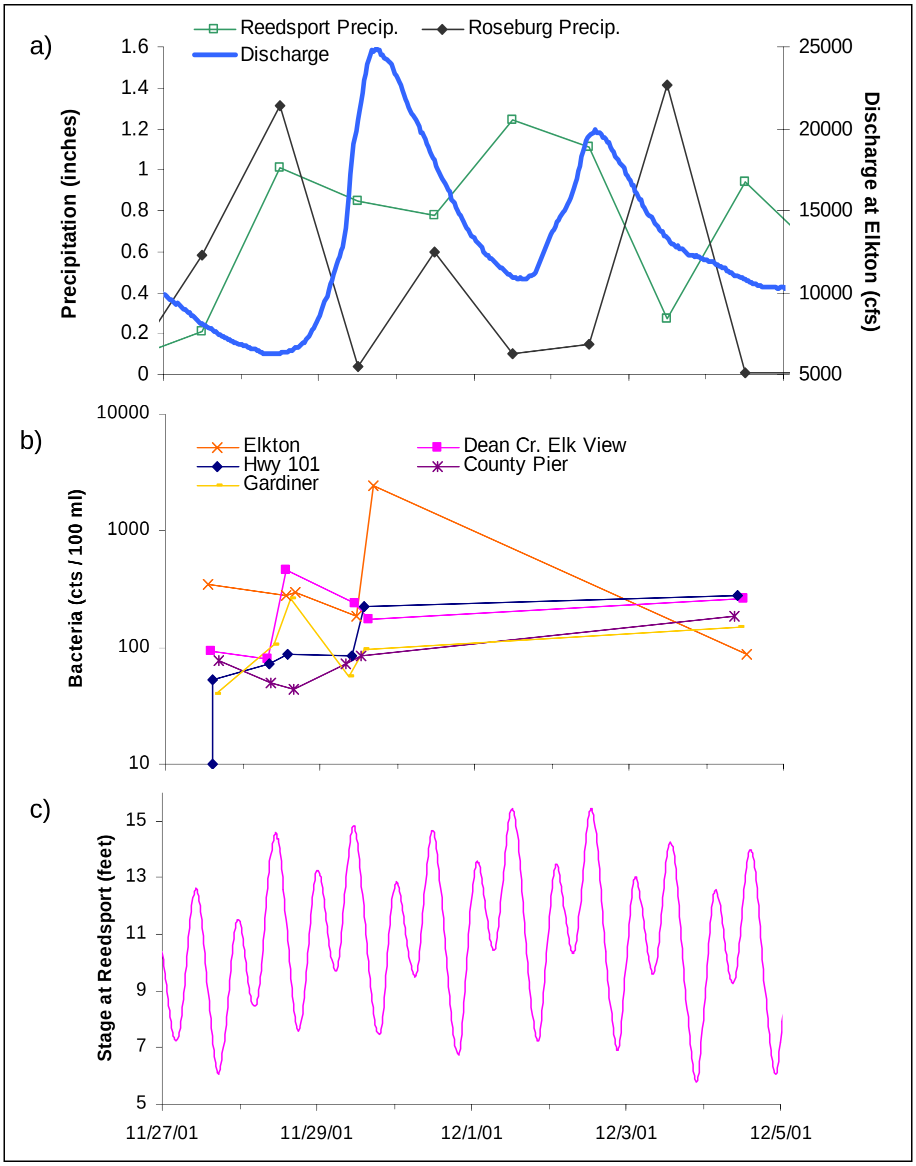


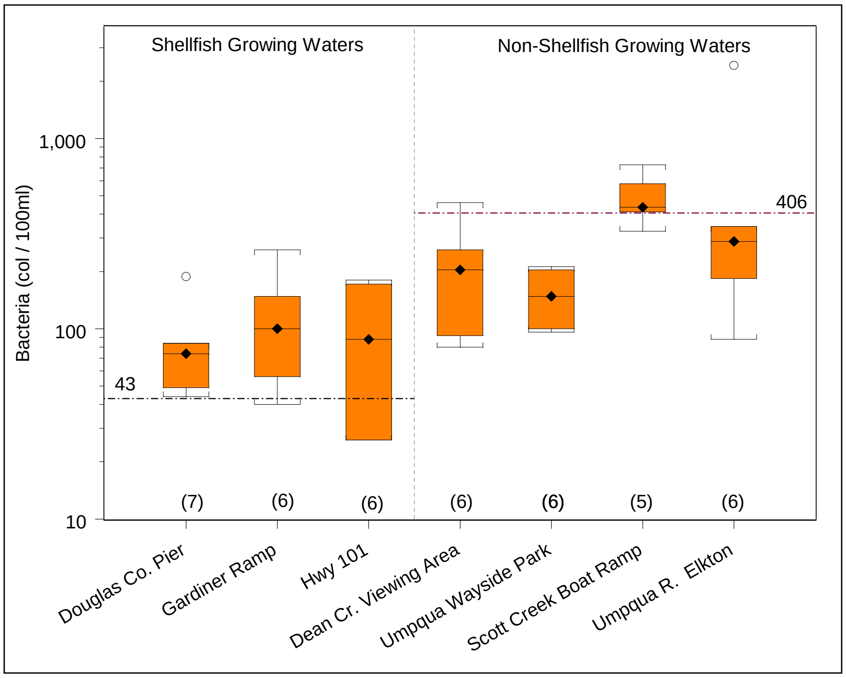
Figure 2.22 Hydrology and bacteria concentrations during storm sampling event. Date is at the beginning of each day.

The streamflow at Umpqua River at Elkton rose from 6,200 to 24,800 cfs during the event with a distinct peak. However, the storm was closely bracketed by other events (Figure 2.22a). The time series of fecal coliform results at each station do not follow a clear and consistent pattern (Figure 2.22b). Fecal coliform concentrations at Umpqua River at Elkton seem to correspond well with flows, while the Umpqua River at Gardiner seems to mimic rainfall and the Douglas County Pier site resulted in relatively consistent results. The lack of discernable pattern is likely due to a number of different factors including preceding and following storms, variability of rainfall, tidal influence (Figure 2.22c), and a reported sewage overflow at the Reedsport wastewater treatment plant.

Reedsport WWTP reported a release of partially treated sewage into the Umpqua River on November 28 through December 4, 2002 due to wet weather conditions (Oregon Emergency Response System 2001-0311 and -3220). On December 1, plant flows exceeded 7 million gallons for 1.5 hours and a concentration of 6,000 fecal coliforms per 100 ml was measured.

Concentrations generally decreased in the downstream direction on the Umpqua River with the highest median concentrations at the Scott Creek Boat Ramp (site G) and the lowest at Douglas County Pier, site A, Figure 2.23 (see Figure 2.18 for site locations).

Figure 2.23 Number of samples in parenthesis. Scott Creek and at Elkton are *E. coli* measurements while the remainder are fecal coliform. Samples collected between 11/27/01 and 12/4/01. Downstream flow is from right to left.



On the Umpqua River, the Elkton, Scott Creek Boat Ramp, and Dean Creek Viewing Area sites had values above the standard for contact recreation (406 org./100 ml). All sites that were sampled had median concentrations at or above the shellfish standard of 43 fecal coliform org./100 ml.

Fecal coliform concentrations near the mouths of Smith River and Scholfield Slough are not statistically different (Wilcoxon Signed Rank < 80%) from concentrations just downstream on the Umpqua and probably reflect mixing with Umpqua River waters (Figure 2.24). Higher concentrations upstream, though, show that both tributaries discharge into the Umpqua estuary at concentrations greater than the shellfish standard. The Smith River site is at RM 6.0 and the Scholfield Slough site is at RM 5.6. Salinity measurements were 0 ppt at these upstream locations throughout the storm survey, indicating that it was primarily freshwater that was being sampled.

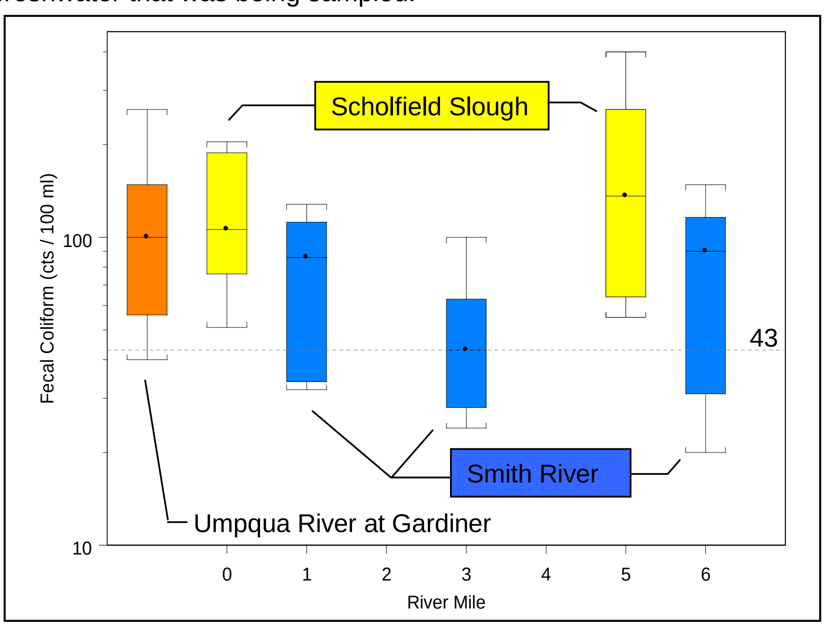


Figure 2.24 Fecal coliform concentration versus river mile on Scholfield Slough and Smith River during storm sampling (11/27/01 to 12/4/01). For explanation of box plots, see Bacteria TMDL Overview.

Loading Capacity

Flow-based Calculations

The loading capacities of the Umpqua River, Smith River, and Scholfield Slough were determined by using a modified Load Duration curve which incorporates dilution with seawater (see Appendix C for documentation). This method segregates data by flow, allowing for flow-based source assessment, graphical display of the range of data, and determination of the critical period for water quality.

The loading capacity for the Umpqua River was determined 1 mile upstream of Reedsport (river mile 12.6), which is the approximate upstream boundary of shellfish beds. The loading capacities for Smith River and Scholfield Slough were determined near their mouths which empty into shellfish growing waters. For these three waterbodies, the shellfish standard was used to determine the loading capacity. Upstream of these locations, the less restrictive water contact recreation standard applies. Therefore, if the shellfish water quality standard is achieved at these locations, it is likely water quality will be achieved upstream. Therefore, these allocations address the fecal bacteria limitation in the Umpqua River. In the estuary, the assimilative capacity increases closer to the mouth because of dilution with seawater and assumed increased die-off rate due to salinity.

The daily volume of freshwater was determined for each site using a hydrologic model (Appendix A). Salinity, which is used as an indication of sea water dilution, is related to the flow in the Umpqua River (Appendix B). Dilution of river water with seawater, although important during the low-flow summer months, is not significant near Gardiner and Reedsport during the more impacted winter months with greater river flow.

The daily flow-based loading capacity is determined by multiplying the standard (14 fecal coliform org./100 ml) by the volume of water (Figure 2.25, next page). The range of observed flows was separated into five categories: low, dry, mid-range, wet and high flows. A generalized loading capacity for each of the five flow periods was computed by taking the median of calculated loading capacity for each day within that period. The median of the observed fecal coliform loading within each of the flow periods was compared with the loading capacity of that flow period (Table 2.23). For the Umpqua River, Smith River and Scholfield Slough, the greatest load reductions (54%, 50%, and 86%, respectively) are necessary during the “wet flow” period. No reduction in loading is necessary to meet the median criteria during the mid-range, dry and low flow periods. Management practices to address loading during the “wet flow” period will also reduce loading during the drier periods.

The percent reductions necessary to meet the median targets in the different flow regimes also appear to be protective of the extreme target. The 90th percentile concentration for the Umpqua River upstream of Reedsport is 79 fecal coliform / 100 ml (Table 2.21). Most of these values occur during the high-flow and wet periods (Figure 2.25). Reductions during these periods are 54% and 50%, repectively. Applying these reductions to the 90th percentiles concentration results in concentrations lower than the criteria of 43 fecal coliforms / 100 ml. Likewise, the 90th percentile concentrations for Scholfield Slough and Smith River are 93 and 57 fecal coliforms / 100 ml, respectively. The reductions called for are 86% and 64% for Scholfield Slough and 50% and 39% for Smith River. These reductions result in the 90th percentile concentrations meeting the criteria of 43 fecal coliforms / 100 ml. Therefore, it is anticipated that the extreme criteria will also be achieved. If peak concentrations continue to exceed the extreme target, DMAs will be required to change their management plans to reduce peak loading. Although presenting the same data, the load duration curves and the seasonal analysis (Table 2.21) are not directly comparable because the former is a flow-based analysis and the later a seasonal analysis.

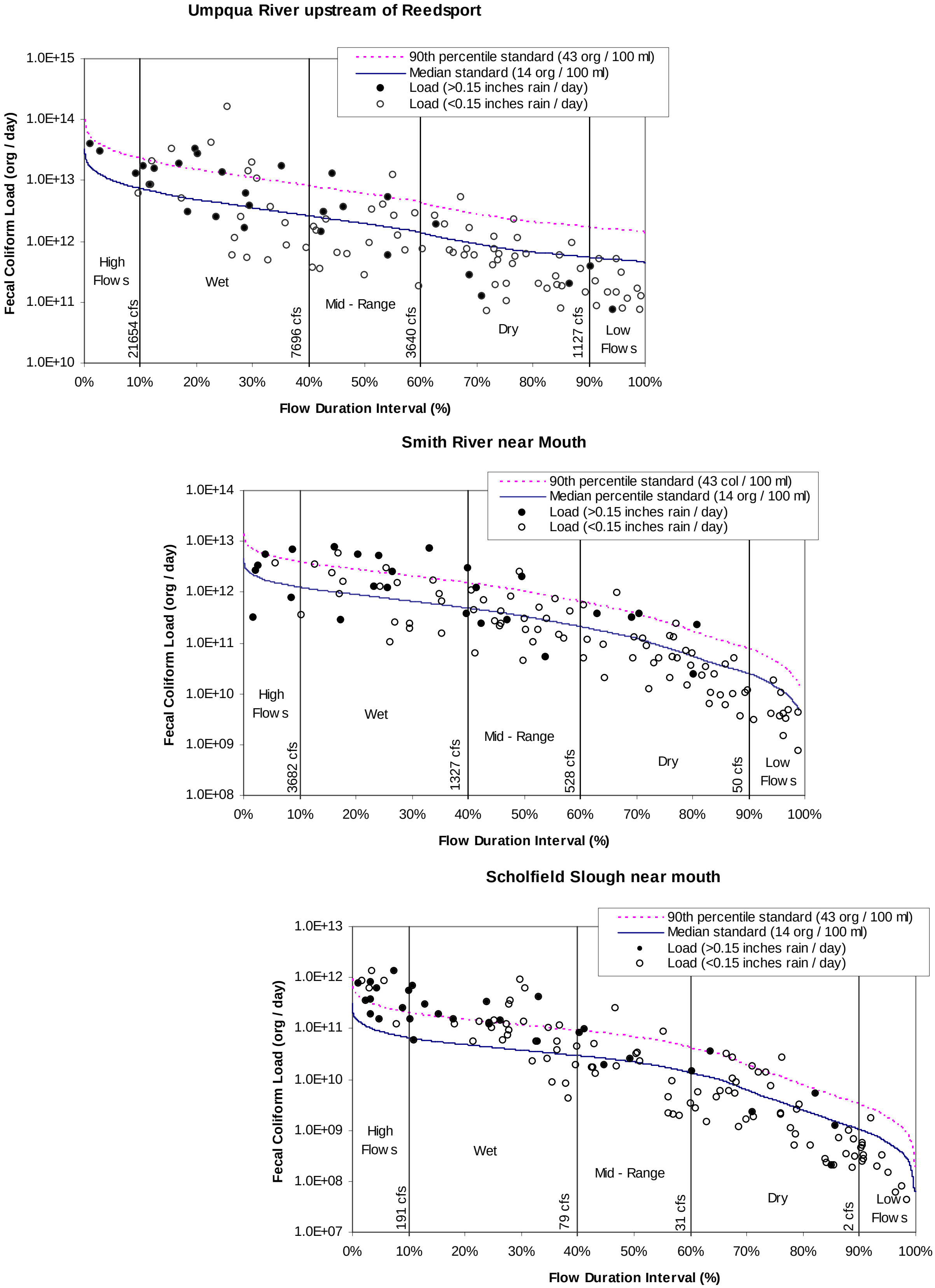


Figure 2.25 **Load duration curves for Umpqua River 1 mile upstream of Reedsport, Smith River, and Scholfield Slough. Rainfall is the average of the day the sample was collected and the previous day at Elkton.**

Table 2.23.	**(a) Umpqua River flow-based TMDL, upstream of Reedsport expressed in *E. coli* organisms per 100 ml.**				
	Range of Flows				
	High Flow (Above 21,654 cfs)	Wet (From 7,696 to 21,654 cfs)	Mid-Range (From 3,640 to 7,696 cfs)	Dry (From 1,127 to 3,640 cfs)	Low Flow (Below 1,127 cfs)
Loading Capacity (LC)	1.01×10^{13}	4.21×10^{12}	1.88×10^{12}	5.90×10^{11}	3.44×10^{11}
Current	2.17×10^{13}	8.51×10^{12}	1.61×10^{12}	5.71×10^{11}	1.42×10^{11}
% reduction	54%	50%	0%	0%	0%
Allocated Permitted Effluent Limits	See table 2.25				
Estimate Local Point Source Loading (Org./day)	6.36×10^{9}	6.36×10^{9}	6.36×10^{9}	6.36×10^{9}	6.36×10^{9}
Estimated Upstream Point Source Load (org. / day)	9.11×10^{10}	9.11×10^{10}	9.11×10^{10}	5.77×10^{10}	5.77×10^{10}
Load Allocation	9.49×10^{12}	3.90×10^{12}	1.52×10^{12}	5.06×10^{11}	7.70×10^{10}
MOS	5.05×10^{11}	2.11×10^{11}	2.71×10^{11}	1.90×10^{10}	2.03×10^{11}
TMDL	1.01×10^{13}	4.21×10^{12}	1.88×10^{12}	5.90×10^{11}	3.44×10^{11}

Table 2.23 (b) Smith River flow-based TMDL expressed in *E. coli* organisms per 100 ml.					
	Range of Flows				
	High Flow (Above 3,682 cfs)	Wet (From 1,327 to 3,682 cfs)	Mid-Range (From 528 to 1,327 cfs)	Dry (From 50 to 528 cfs)	Low Flow (Below 50 cfs)
Loading Capacity	1.61×10^{12}	7.71×10^{11}	3.35×10^{11}	8.34×10^{10}	1.34×10^{10}
Current Loading	3.25×10^{12}	1.27×10^{12}	2.88×10^{11}	4.92×10^{10}	3.94×10^{9}
% reduction	50%	39%	0%	0%	0%
Estimate Point Source Loading (Org./day)	0	0	0	0	0
Load Allocations	1.53×10^{12}	7.32×10^{11}	2.88×10^{11}	4.92×10^{10}	3.94×10^{9}
MOS	8.06×10^{10}	3.85×10^{10}	4.71×10^{10}	3.42×10^{10}	9.49×10^{9}
TMDL	1.61×10^{12}	7.71×10^{11}	3.35×10^{11}	8.34×10^{10}	1.34×10^{10}

Table 2.23 (c) Scholfield Slough flow-based TMDL expressed in *E. coli* organisms per 100 ml.					
	Range of Flows				
	High Flow (Above 191 cfs)	Wet (From 79 to 191 cfs)	Mid-Range (From 31 to 79 cfs)	Dry (From 2 to 31cfs)	Low Flow (Below 2 cfs)
Loading Capacity (LC)	8.73×10^{10}	4.25×10^{10}	2.20×10^{10}	3.95×10^{9}	5.71×10^{8}
Current Loading	6.03×10^{11}	1.18×10^{11}	2.11×10^{10}	2.23×10^{9}	2.73×10^{8}
% reduction	86%	64%	0%	0%	0%
Estimate Point Source Loading (Org./day)	6.68×10^{8}	6.68×10^{8}	6.68×10^{8}	0	0
LA	8.23×10^{10}	3.97×10^{10}	2.04×10^{10}	2.23×10^{9}	2.73×10^{8}
MOS	4.37×10^{9}	2.13×10^{9}	9.24×10^{8}	1.72×10^{9}	2.98×10^{8}
TMDL	8.73×10^{10}	4.25×10^{10}	2.20×10^{10}	3.95×10^{9}	5.71×10^{8}

Watershed Specific Source Assessment

Tidal reversals in the estuary and long travel times in the Umpqua Basin make source assessment for the estuary difficult. Observed values near the mouth of Smith River and Scholfield Slough are likely influenced by fecal coliform concentrations in the Umpqua River. However, greater concentrations upstream of their mouths (Figure 2.26) indicate that these tributaries are contributing fecal coliform loads. There was no clear relationship between rainfall and fecal coliform concentrations, as there was in the smaller, upland watersheds of Elk, Calapooya, and Deer Creeks.

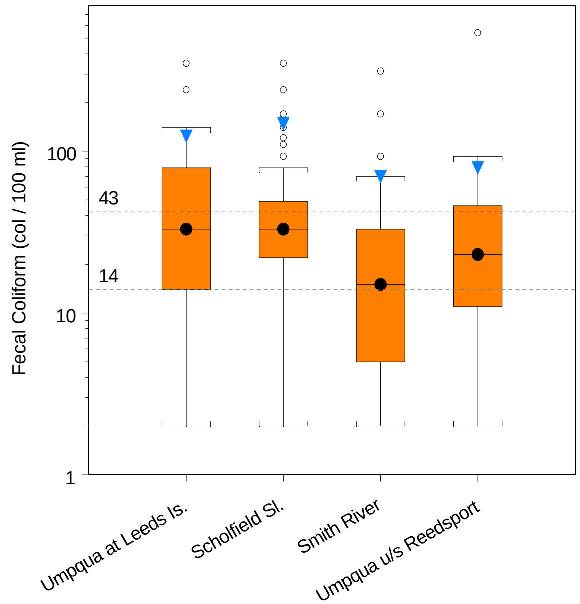
There are no point sources in the Smith River watershed, so all observed loading must be caused by nonpoint sources. The Reedsport Landfill is the only point source in Scholfied Slough which could be a source of bacteria. However, the discharge monitoring report indicates that the average wet weather flow is 0.14 MGD with an average effluent concentration of 6 fecal coliforms / 100 ml (winters of 2002 and 2003). Therefore, nonpoint sources dominate loading to Scholfield Slough. The data do not support further identification of nonpoint sources in the Smith River or Scholfield Slough during the times the TMDL will apply. (The Smith River Bacteria Source Tracking Project sampled DNA from *E. coli* samples, which showed that at lower flows, wildlife, particularly birds, are the dominant contributors of bacteria. However, the small amount of data collected during higher flows suggested an increasing contribution by livestock and other human-controlled sources. There was insufficient data to support more specific load allocations.)

Fecal coliform concentrations in the Umpqua River upstream of Reedsport exceed the water quality standard. The *E. coli* concentrations measured at Elkton, upstream of tidal influences, indicate that fecal bacteria loading from the upper part of the watershed likely has some impact on the estuary (Figure 2.26). Source assessment from the smaller watersheds of Elk, Calapooya, and Deer Creeks indicate an increase over time in fecal bacteria concentrations with rainfall and a spatial increase with the proportion of the watershed zoned as agriculture and urban / residential. Distinction between nonpoint sources, such as wildlife, livestock, and failing septic systems, was not possible because of the re-suspension of bacteria from sediment and spatially overlapping sources.

Brandy Bar wastewater treatment plant (river mile 19.8) discharges effluent into the Umpqua River approximately 7.5 miles upstream of shellfish growing waters at an average rate of 3,000 gallons per day, with a median concentration of 48 fecal coliform org./100 ml. Its loading accounts for much less than 1% of the total load.

Reedsport wastewater treatment plant releases partially treated or diluted sewage when its capacity is exceeded due to inflow and infiltration caused by heavy rainfall. The average daily flow from November and December 2001 and January 2002 was 1.9 MGD (million gallons per day) with a daily maximum of 3.7 MGD. Median concentrations during this period were 200, 90th percentile of 20,000, and maximum of 60,000 fecal coliforms/100 ml (Figure 2.26). During one reported spill, the Reedsport plant released more than 7 million gallons in 1.5 hours. Daily loads regularly exceed 1.3×10^{12} fecal coliforms per day (average winter flow of 1.59 MGD and the 90th percentile concentration of 20,000 fecal coliforms/100 ml). Likely, daily loads exceeded 1.0×10^{13} fecal coliforms per day on at least one occasion (3.66 MGD on March 7, 2002, and 60,000 fecal coliforms/100 ml on March 6, 2002).

There is a statistically significant increase in median concentration from 23 to 33 fecal coliforms / 100 ml from upstream to downstream of the Reedsport treatment plant (Table 2.24, next page). Analysis was done on 43 paired samples collected from December through March using the Rank Sum Wilcoxon test and it was significant at 95%. Ninetieth percentile values increased from 79 to 126 fecal coliform org./100 ml. When averaged by range of flows, there is a 4.15×10^{12} fecal coliform per day increase when comparing the sums of loads from Scholfield Slough, Smith River, and the Umpqua River upstream of Reedsport to loads downstream of Reedsport. Based on the discharge monitoring reports from the Reedsport treatment plant, it seems likely that a large portion of this load increase is due to the release of partially treated or diluted sewage.



Site	Median	90th Percentile
Umpqua u/s Reedsport	23	79
Smith River	15	70
Schofield Sl.	33	148
Umpqua at Leeds Is.	33	126

Figure 2.26 Summary of fecal coliform concentrations near Reedsport. The 43 paired samples were collected between December and March. For explanation of box plots, see Bacteria TMDL Overview.

Winchester Bay wastewater treatment plant releases partially treated sewage during summer months because of increased use. The outfall is on the Douglas County Pier and is approximately one mile from the jetty triangle commercial oyster beds. Median and 90th percentile concentrations increase tenfold from the October through June period to the July through September period. Observed concentrations between the upstream and downstream monitoring locations (Marker #6 and Marker #8, respectively) tend to decrease during July through September and for the entire year. Despite releases from the Winchester Bay treatment plant, surrounding monitoring sites did not violate the shellfish standard during the third quarter. Median salinity concentration during the third quarter is 28.9 ppt.

Table 2.24. Change in fecal coliform load (organisms per day) due to sources near Reedsport.

	Range of Flows				
	High Flow	Wet	Mid-Range	Dry	Low Flow
Load downstream of Reedsport (Leeds Is.)	2.49×10^{13}	1.40×10^{13}	2.83×10^{12}	6.40×10^{11}	2.84×10^{11}
Loading from Umpqua R., Smith R. and Scholfield Sl.	2.56×10^{13}	9.90×10^{12}	1.92×10^{12}	6.22×10^{11}	1.46×10^{11}
Difference	-6.16×10^{11}	4.15×10^{12}	9.07×10^{11}	1.81×10^{11}	1.38×10^{11}
% Change	-2.5%	29.5%	32.1%	2.8%	48.5%

The impact of loading from point sources upstream of estuary area is difficult to estimate because of the die-off of bacteria. Most of these sources of bacteria are addressed in the previous chapters. Two point-sources not addressed previously are the Glide-Idleyld Park WWTP which discharges to the North Umpqua River and the Wolf Creek Civilian Conservation Center WWTP operated by the USFS which discharges into Little River. Neither WWTP discharges greater than 1 MGD of effluent nor is likely to cause or contribute the bacteria water quality standard violations in the Umpqua Estuary due to dilution and die-off. The maximum load from upstream point sources was estimated by adding the estimated maximum daily loads. This method does not account for die-off between the source and the estuary which is a conservative assumption. The impact from other point sources is likely negligible.

Allocations

Point Source Wasteload Allocations

Wasteload allocations are dependent on whether the waterbody is classified as shellfish growing waters. By rule, overflows of untreated sewage are prohibited in the summer months except during the 1-in-10 year 24 hour storm. In the winter months, all municipalities are expected to convey and treat all sewage up to the 1-in-5 year 24 hour storm

Table 2.25. Point Sources Wasteload Allocations

Common Name	Stream Name	River Mile	Shellfish Growing Waters	Indicator organism	Allocated Permitted Effluent Limits (organisms / 100ml)	Max Permitted Flow (MGD)	(a) Estimate of Loading (org. / day)
Winchester Bay WWTP	Umpqua River	0.6	Yes	Fecal coliform	Median of 14 Less than 10% exceeding 43	1	5.30×10^{8}
Reedsport WWTP	Umpqua River	11.5	Yes	Fecal coliform	Median of 14 Less than 10% exceeding 43	2	1.06×10^{9}
Brandy Bar Landing WWTP	Umpqua River	19.8	No	*E. coli*	Log mean of 126 Not to exceed 406	1	4.77×10^{9}
Reedsport Landfill	Scholfield Creek	6.0	No	*E. coli*	Log mean of 126 Not to exceed 406	0.14 *	6.68×10^{8}

*Flow based on rainfall. Average wet weather flow rate reported winters of 2002 and 2003.
a=estimate assumes effluent meeting log-mean criterion prior to discharge at design flow

Brandy Bar wastewater treatment plant does not discharge into shellfish growing waters. Its waste load allocations is expressed as the effluent concentration allowed by the bacteria standard: 126 *E. coli* org./100 ml as a log-mean based on a minimum of 5 samples in a 30-day period and no single sample exceeding 406 *E. coli* org./100 ml. Estimates of the daily maximum bacteria waste loads were used in the TMDL calculations but are not allocations. Because of the large assimilative capacity of the Umpqua River, Brandy Bar WWTP would not cause or contribute to water quality standard violations in the Umpqua estuary.

Reedsport Landfill has a general permit and does not discharge directly into shellfish growing waters. Dilution is sufficient in Scholfield Creek to insure that effluent concentrations at the recreational contact standard do not cause or contribute to violation of the shellfish standard in the estuary. Therefore its WLA is that its effluent must meet the recreation contact, *E. coli* standard. The benchmark in the general industrial stormwater permit is 406 counts/100 ml. There is a stormwater like quality to the landfill leachate system and appropriate *E. coli* benchmarks could be used to assess compliance with the WLA. Because the facility only discharges during significant rainfall events, it is not expected to cause or contribute to exceedances of the bacteria standard when in compliance with this permit.

Reedsport and Winchester Bay wastewater treatment plants discharge into shellfish growing waters. To protect the beneficial use, bacteria concentrations of the water immediately surrounding the outfalls need to meet the shellfish harvest standard. Therefore, their waste load allocation is expressed as the concentration allowed by the shellfish harvest standard: median concentration of 14 fecal coliform org./100 ml. with no more than 10% of the samples exceeding 43 org./100ml. Changes to the outfall locations or design may allow for increased effluent concentrations if it is shown to protect the beneficial use. Reedsport WWTP also has a general stormwater permit (1200Z). Fecal coliform concentrations of the stormwater discharge should not exceed 43 col / 100 ml more than 10% of the time.

Most point sources upstream of the estuary are allocated bacteria loading in the previous chapters by geographic area. If point sources are not in areas not addressed in the previous chapters, then their WLA is the recreational contact bacteria standard. Due to dilution and die-off, these WLAs will not likely cause or contribute to water quality standards violations in the Umpqua Estuary.

Winchester stream (LLID 1241812436868) which flows into the Umpqua estuary was also determined to be water quality limited for fecal coliform as it impact the shellfish beneficial use (2004-06 303(d) list). The median concentration of six samples is 98 fecal coliforms / 100 ml. No point sources discharge into this creek. A simple percent reduction in the median fecal coliform concentration will serve as a surrogate measure for load allocations:

$$\%\ \text{reduction} = \left(1 - \frac{14\ (\text{fecal coliforms} / 100\ \text{ml})}{\text{Median}\ (\text{fecal coliforms} / 100\ \text{ml})}\right) * 100$$

Winchester stream requires an 86% reduction in fecal coliform loading to meet the shellfish criteria.

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