Wenatchee River Basin Fecal Coliform Bacteria Total Maximum Daily Load Study

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Wenatchee River Basin Fecal Coliform Bacteria Total Maximum Daily Load Study

by
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Abstract

As part of the Wenatchee River Total Maximum Daily Load (TMDL) study, the Washington State Department of Ecology conducted a water quality monitoring assessment in 2003-2004. This report summarizes the data quality assurance and the findings of the monitoring study.

Washington State water quality criteria for fecal coliform bacteria were not met throughout the Mission, Brender, and Chumstick creek watersheds. Simple mass-balance load analyses of each creek identified specific reaches with the highest fecal coliform loading. Load allocations for 26 sites are recommended in this report.

Acknowledgements

The Wenatchee River Basin TMDL study is the result of a partnership between the Department of Ecology and the Water Resource Inventory Area (WRIA) 45 Water Quality Technical Subcommittee (consisting of Ecology TMDL staff and the WRIA 45 Watershed Planning Unit's Water Quality Subcommittee). Ecology authored this TMDL technical report for fecal coliform bacteria, and the Water Quality Technical Subcommittee reviewed, discussed, and commented on the report.

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- The WRIA 45 Water Quality Subcommittee for review and comments.
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Executive Summary

Introduction

Three tributaries to the Wenatchee River – Mission, Brender, and Chumstick creeks – are included on Washington State's list of water-quality-impaired waters because of high fecal coliform (FC) bacteria counts.

As part of the Wenatchee River basin total maximum daily load (TMDL) study for FC bacteria, the Washington State Department of Ecology collected stream water quality data during 2003-2004. Spatial and temporal FC bacteria patterns were analyzed based on dry-season sampling (July – October 2003) and wet-season sampling (March – May 2004).

Wenatchee River basin

The Wenatchee River basin (Water Resources Inventory Area 45) is located in the central part of Washington State (Figure ES1).

The Wenatchee River drains an area of about 1371 square miles, and flows southeast until it meets the Columbia River. The creeks with FC bacteria pollution (Mission, Brender, and Chumstick) enter the lower Wenatchee River below the city of Leavenworth.

Annual average precipitation in the lower Wenatchee River ranges from 25.5 inches at the city of Leavenworth to 8.5 inches at the city of Wenatchee.

Water quality standards

Washington State water quality standards have two-part criteria for FC bacteria for each water classification.

- For Class A "excellent" water, the FC bacteria geometric mean of samples may not exceed 100 colony forming units (cfu)/100mL, and no more than 10% of all samples may exceed 200 cfu/mL.
- For Class AA "extraordinary" water, the FC bacteria geometric mean of samples may not exceed 50 cfu/mL, and no more than 10% of the samples may exceed 100 cfu/mL.

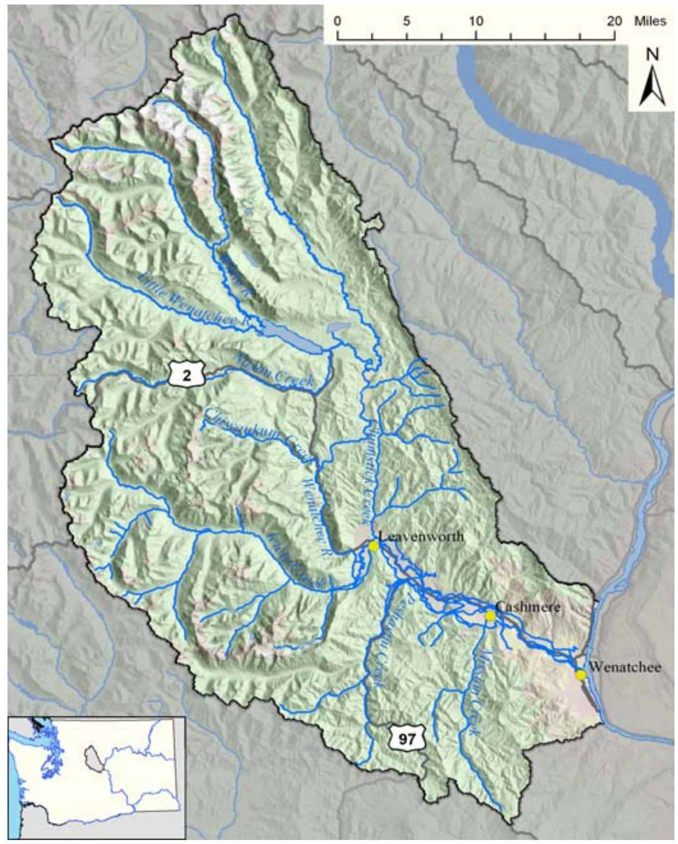

Figure ES1 – Study area map for the Wenatchee River Basin Fecal Coliform Bacteria TMDL.

Stream water quality assessment

Screening surveys were conducted bimonthly (twice a month) at the mouths of all tributaries to the Wenatchee River and Icicle Creek during 2002.

These surveys confirmed high FC bacteria counts exceeding standards only in the Mission, Brender, and Chumstick creek watersheds.

Bimonthly synoptic surveys were conducted throughout the Mission, Brender, and Chumstick creek watersheds during a dry season (July – October 2003) and a wet season (March – May 2004).

The dry season was characterized by low-streamflow conditions (parts of Mission Creek and Chumstick Creek went dry in 2003) with irrigation management return flows providing much of the streamflow in some creeks. Non-runoff sources (i.e., no rainfall runoff) predominated during this season. The wet season was characterized primarily by snowmelt runoff from higher elevations, with some local runoff as well.

Conclusions

FC bacteria data show all three creeks had higher FC concentrations and loads during the low-flow (dry season) when there was less dilution, indicating non-runoff sources of pollution.

The following are potential FC bacteria non-runoff sources:

- *Potential leakage from wastewater treatment plants and sanitary sewer systems.* There are no wastewater point source discharges in the creek subbasins; however, the City of Cashmere sewer collection system is located in the lower Mission/Brender Creek subbasin.
- *Direct deposition.* Bacteria may be directly deposited into surface waters by birds and other animals.
- *Illegal dumping.* The illegal dumping of wastes either to storm sewer systems or directly to surface waters is a potential bacteria source (for example, portable toilet wastes, recreational vehicle wastes).
- *Potentially contaminated non-stormwater discharges.* During non-runoff periods, water from springs, irrigation management return flows, irrigation runoff, and other sources flow into streams. This water could be contaminated with bacteria at the source or within the conveyance system.
- *Septic systems.* Failing septic systems have the potential to contribute bacteria during non-runoff and runoff periods.

The upper reaches of most of the three creeks originate in the Wenatchee National Forest. These reaches met the Class A FC bacteria water quality criteria. However, several sites in the upper-most reaches are in Class AA water and failed to meet the Class AA FC bacteria criteria.

Moving downstream in all the tributaries, FC bacteria concentrations increased, and Class A exceedances began to occur. A mass-balance evaluation showed certain reaches contributing larger FC bacteria loads than others, in some cases contributing to exceedances at downstream stations (i.e., the bacteria were transported downstream with the streamflow). For example, 85% of the dry-season FC bacteria loading in Brender Creek originated between river mile 1.2 (where Brender Creek first crosses Pioneer Road) and river mile 2.5. (See Figure ES2).

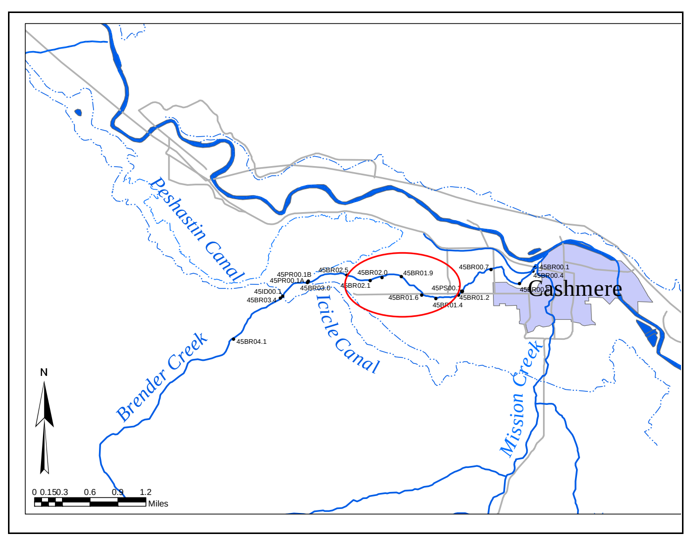

Figure ES2 – Brender Creek sampling stations and reach (highlighted) where 85% of the observed FC bacteria loading in 2003 originated.

In **Mission Creek**, there were significant increases in FC concentrations and loads between Binder Road (RM 1.2) and Creekside Place (RM 0.9). This reach is partly within Cashmere city limits, but most of this reach is within the un-sewered part of the City of Cashmere Urban Growth Area.

Brender Creek had nearly four times the average FC loads compared to Mission and Chumstick creeks, indicating a high source of pollution and a more immediate health concern.

In No Name Creek, a tributary to Brender Creek, the pond area on the side of Mill Road appears to be the major source of FC concentrations and load.

Nearly 50% of the net FC load entered upper **Chumstick Creek** between RM 9.1 and 7.7, an area of primarily rural land use.

Ideally, the source of the FC bacteria in each creek could be determined to be from either human or non-human sources.

- Where FC bacteria are found to be from human sources, onsite septic systems should be evaluated for proper functioning, and inspections for illegal discharges should be made.
- Where FC bacteria are found to be from non-human sources, best management practices (BMPs) should be applied to keep non-human sources from contaminating the creek.

Target reductions

Target FC reductions are established for Mission, Brender, and Chumstick creek basins (Table ES1). Implementation of BMPs and follow-up monitoring programs are needed in each basin.

Table ES1 – Summary of target reductions needed in Wenatchee River basin tributaries to comply with water quality standards.

Site Description	Fecal Coliform Reduction (%)
Mission Creek and tributaries	
Mission Creek at Sunset Highway	89%
Mission Creek at Creekside Place	98%
Mission Creek at Binder Road	71%
Mission Creek at Tripp Canyon	79%
Mission Creek below Bear Gulch	41%
Peshastin Irrigation return at Pioneer Road	90%
Pipe discharge at Pioneer Road	63%
Yaksum Creek at Coates Road	61%
Pipe discharge downstream of Tripp Cyn bridge	87%
Sand Creek near mouth	6%
Brender Creek and tributaries	
Brender Creek at Sunset Highway Road	68%
Brender Creek at Pioneer Road	89%
Brender Creek at RM 1.9	94%
Brender Creek at RM 2.5	60%
No Name Creek at mouth	52%
No Name Creek below pond on Mill Road	92%
Chumstick Creek and tributaries	
Chumstick Creek near mouth	49%
Chumstick Creek at RM 4.9 on Hwy 209	71%
Chumstick Creek at Camp 12 Road	92%
Chumstick Creek above Second Creek	38%
Eagle Creek near mouth	57%
Eagle Creek above mouth	47%
Eagle Creek above Van Creek	13%
Van Creek near mouth	87%
Van Creek on USFS land	14%
Little Chumstick Creek near mouth	45%

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Introduction

Chumstick, Mission, and Brender creeks and their tributaries were included on Washington State's 1998 list of impaired waters because of fecal coliform (FC) bacteria, dissolved oxygen, and pH water quality standard violations (Table 1). This list, called the 303(d) list because it is required by section 303(d) of the federal Clean Water Act, contains waterbodies that are not meeting water quality standards.

The Clean Water Act mandates that the state establish Total Maximum Daily Loads (TMDLs) for surface waters that do not meet standards after application of technology-based pollution controls. The U.S. Environmental Protection Agency (EPA) has promulgated regulations (40 CFR 130) and developed guidance (EPA, 1991) for establishing TMDLs.

Under the Clean Water Act, every state has its own water quality standards designed to protect, restore, and preserve water quality. Standards consist of designated uses, such as fish spawning and drinking water supply, and criteria, usually numeric criteria, to achieve those uses. When a lake, river, or stream fails to meet water quality standards after application of required technology-based controls, the Clean Water Act requires the state to place the waterbody on a list of "impaired" waterbodies and to prepare an analysis called a TMDL.

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant that can be discharged to the waterbody and still meet standards (the loading capacity) and allocates that load among the various sources. If the pollutant comes from a discrete (point) source such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation*. If it comes from a set of diffuse (nonpoint) sources such as general urban, residential, or farm runoff, the cumulative share is called a *load allocation*.

The TMDL must also consider seasonal variations and include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A reserve capacity for future loads from growth pressures is sometimes included as well. The sum of the wasteload and load allocations, the margin of safety, and any reserve capacity must be equal to or less than the loading capacity.

Consequently, in June 2002, Ecology began two years of monitoring as part of a TMDL technical study of dissolved oxygen, pH, and FC bacteria in the Wenatchee River watershed. The first year of surveys focused on dissolved oxygen and pH in the mainstem Wenatchee River and Icicle Creek, while the second year focused on FC bacteria in the Chumstick, Mission, and Brender creek watersheds.

This report describes the FC bacteria TMDL for the Chumstick, Mission, and Brender creek watersheds. The study area is within the Wenatchee River watershed (Figure 1).

Table 1. Wenatchee River basin stream reaches on the 1998 303(d) list for impaired waterbodies.

Stream	WBID (segment)	Parameter	Section
Brender Creek	WA-45-1100*	Fecal Coliform Dissolved Oxygen	T23N, R19E, Section 5
Chiwaukum Creek	WA-45-1900*	Temperature	T25N, R17E, Section 9
Chumstick Creek	WA-45-1200*	Dissolved Oxygen pH Fecal Coliform	T24N, R17E, Section 1
	WA-45-1200*	Instream Flow	T26N, R18E, Section 30
Icicle Creek	WA-45-1017*	Dissolved Oxygen	T24N, R17E, Section 24
	WA-45-1015*	Instream Flow	T24N, R17E, Section 13
	WA-45-1017*	Temperature	T24N, R17E, Section 30
Icicle Creek	WA-45-1017*	Dissolved Oxygen	T24N, R16E, Section 24
Little Wenatchee River	WA-45-4000*	Temperature	T27N, R16E, Section 15
Mission Creek	WA-45-1011*	Instream Flow	T23N, R19E, Section 8
	WA-45-1011*	Fecal Coliform	T23N, R19E, Section 5
	WA-45-1011	4,4' –DDT 4,4' -DDE Guthion	T23N, R19E, Section 4
	WA-45-1011*	DDT	T23N, R19E, Section 9
Nason Creek	WA-45-3000*	Temperature	T26N, R17E, Section 9
	WA-45-3000*	Temperature	T27N, R17E, Section 27
Peshastin Creek	WA-45-1013*	Temperature Instream Flow	T24N, R18E, Section 21
	WA-45-1014*	Temperature	T24N, R18E, Section 32)
Wenatchee River	WA-45-1010*	Instream Flow	T24N, R18E, Section 17
	WA-45-1010*	pH Temperature	T23N, R20E, Section 28
	WA-45-1020*	Dissolved Oxygen	T25N, R17E, Section 9
	WA-45-1020*	Instream Flow	T26N, R17E, Section 12

WBID – Waterbody identification number

* Also listed on the 1996 303(d) list.

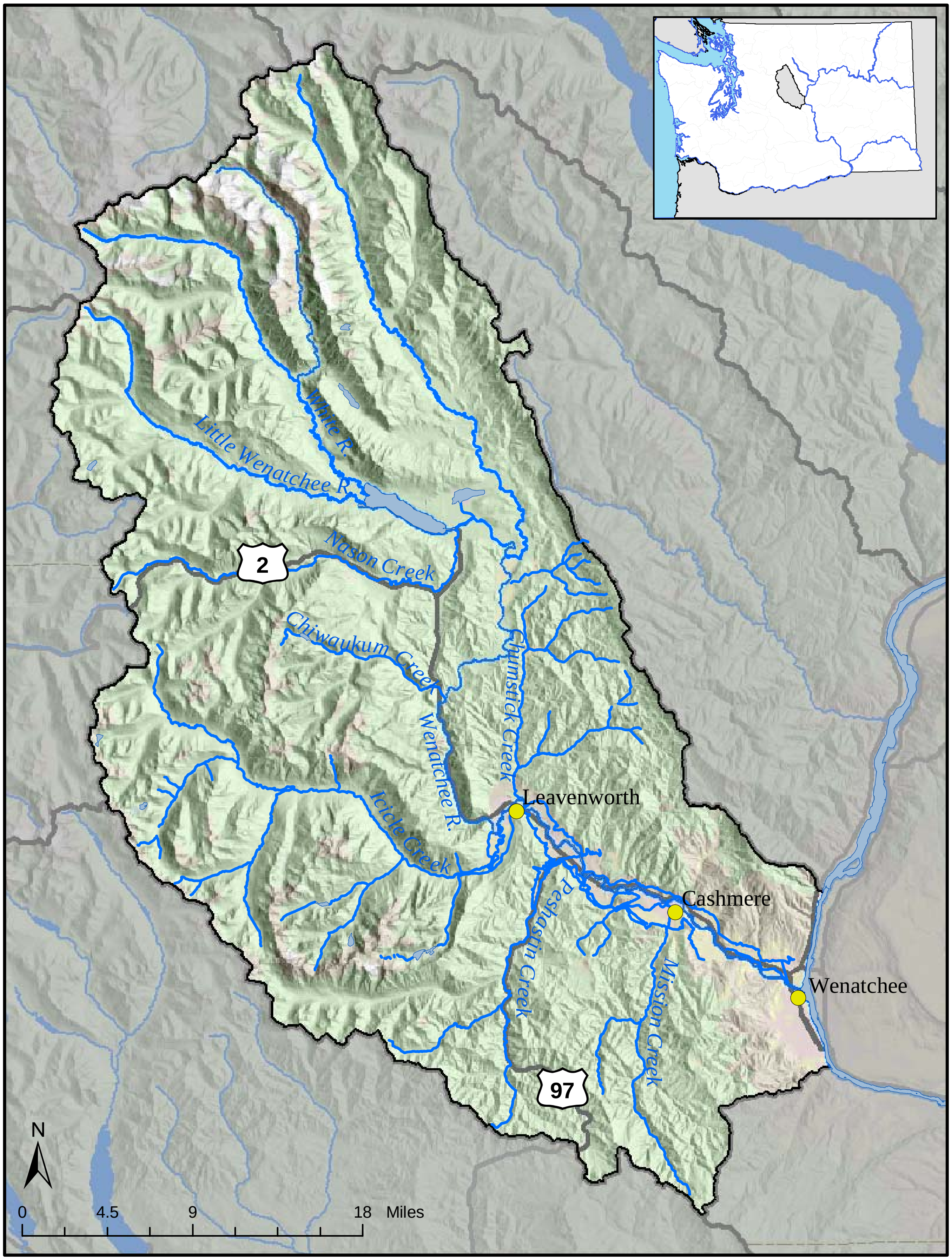


Figure 1. Study area for the Wenatchee River TMDL study.

Background

Study Area

The Wenatchee River subbasin (WRIA[1] 45), located in central Washington State, encompasses 878,423 acres. The subbasin is bounded on the west by the Cascade Mountians, on the north and east by the Entiat Mountains, and on the south by the Wenatchee Mountains. The Wenatchee is a subbasin to the Columbia River and enters that system at the city of Wenatchee 15 miles upstream of Rock Island Dam.

The geology of the upper subbasin consists of high and low relief landtypes associated with glaciation (e.g., cirque headwalls, glaciated ridges, and glacial/fluvial outwash). The middle part of the subbasin is a mixture of igneous and basalt rock formations and glacial/fluvial outwash terraces. Alluvial fans and terraces are predominant landtypes in the lower Wenatchee.

Annual average precipitation throughout the subbasin ranges from 150 inches at the crest of the Cascades to 8.5 inches in Wenatchee. Streamflow varies during the year, but mean monthly discharge peaks in the spring from combined effects of snowmelt and rain-on-snow events.

Most of the annual streamflow in the Wenatchee River originates from tributaries in the upper subbasin: the White River (25%), Icicle Creek (20%), Nason Creek (18%), the Chiwawa River (15%), and the Little Wenatchee River (15%) (Andonaegui, 2001). Both the White and the Little Wenatchee rivers enter Lake Wenatchee in the upper subbasin. The mouth of the lake is the head of the Wenatchee River, and Nason Creek enters the river just below the lake outlet.

There is a mixture of federal, state, county, and private land ownership throughout the subbasin. Most of the upper subbasin is designated federal wilderness area and is under the jurisdiction of the U.S. Forest Service Lake Wenatchee and Leavenworth ranger districts. State Highways 2 and 97 parallel much of the Wenatchee mainstem and Nason Creek and contain portions of their streambanks.

The incorporated cities designated in the 2000 census are Wenatchee (population 27,856), Cashmere (2,965), and Leavenworth (2,074). There are smaller unincorporated communities located along State Highways 2 and 97 (2000 census information).

Project Objectives

The objectives of the study were to:

1. Conduct water quality monitoring surveys for physical, chemical, and biological parameters to determine sources affecting FC bacteria, dissolved oxygen, and pH levels in Mission, Brender, and Chumstick creeks and their tributaries.

[1] Water Resource Inventory Area

2. Characterize FC bacteria concentrations and identify major bacterial loading sources along Mission, Brender, and Chumstick creeks.

3. Set FC bacteria TMDL target reduction allocations to address FC exceedances in Mission, Brender, and Chumstick creeks.

Methods

Study Design

Field personnel from Ecology and the Chelan County Conservation District collected water quality data during a series of surveys. Surveys were conducted on the dates shown in Table 2.

Table 2. Sampling dates, 2003-04.

Dry Season - 2003	Wet Season - 2004
July 7 – 9	March 1 – 3
July 21 – 23	March 15 – 16
August 4 – 6	March 29 – 30
August 18 – 20	April 5 -6
August 25 – 27	April 19 – 21
September 8	May 3 – 5
September 22 – 24	
September 29 – October 1	
October 6 – 8	
October 20 – 21	

Sampling events for July 2003 through May 2004 covered 22 stations in the Chumstick Creek drainage, 22 stations in the Mission Creek drainage, and 23 stations in the Brender Creek drainage. Hydrolab® meters were used to collect pH, conductivity, dissolved oxygen, and temperature measurements. Laboratory parameters for each site are described in the Quality Assurance Project Plan (Bilhimer et al., 2003), and methods are shown in Tables 3 and 4.

Table 3. Summary of field measurements and methods.

Parameter	Method
Velocity	Marsh-McBirney current meter
Specific Conductivity	Hydrolab meter
pH	Hydrolab meter
Temperature	Hydrolab meter
Dissolved Oxygen	Hydrolab meter Winkler modified azide (EPA 360.20)

Table 4. Summary of laboratory measurements and methods.

Parameter	EPA Method
Chloride	300.0
Total Suspended Solids	SM2540D
Turbidity	SM2130
Fecal Coliform	SM MF 9222D[1]

[1] SM indicates Standard Methods rather than EPA method.

Data Quality Objectives

Target precision, bias, accuracy, and required reporting limits are listed in Table 5.

Table 5. Targets for accuracy, precision, bias, and reporting limits for the sample measurement.

Analysis	*Accuracy* % deviation from true value	*Precision* Relative Standard Deviation (%)	*Bias* % deviation from true value	*Required Reporting Limits* Concentration units
Field				
Velocity*	± 2% of reading; 0.1 f/s	N/A	N/A	0.05 f/s
pH*	0.20 s.u.	N/A	0.10 s.u.	N/A
Water Temperature*	± 0.2°C	N/A	N/A	N/A
Dissolved Oxygen	N/A	N/A	5	1 mg/L
Specific Conductivity	N/A	N/A	5	1 umhos/cm
Laboratory				
Chloride	15	< 5	5	0.1 mg/L
Fecal Coliform (MF)	N/A	<25	N/A	1 cfu/100 mL
Total Suspended Solids	30	<10	10	1 mg/L
Turbidity	30	<10	10	1 NTU

* As units of measurement, not percentages
cfu – colony forming units

Sample Collection and Field Measurements

Ecology field personnel collected water quality data during surveys conducted in 2003-04. The methods used in these surveys were initially described in the Quality Assurance Project Plan (Bilhimer et al., 2003). However, several stations changed according to logistical needs and information acquired from sampling. Additionally, winter and spring runoff sampling were added to the Mission, Brender, and Chumstick creeks sampling regime to obtain a more complete picture of bacterial contamination in those watersheds (Carroll, 2003). Figures 2 through 5 show all sampling locations divided by sub-watershed. Tables 6 through 9 list the sampling station identification (which includes the river mile), description, and latitude and longitude of the sampling sites, as well as the general type of data collected at each site.

All water quality samples collected for laboratory analysis were grab samples taken just below the water surface from the main body of flow, unless there was not enough depth to submerse the sample container. Samples were collected either by using an extension rod extended from the streambank or by wading into the creek. Generally, for half of the Mission, Brender and Chumstick creek surveys, grab samples were collected twice a day (morning and afternoon); for the remaining half, grab samples were collected once per day.

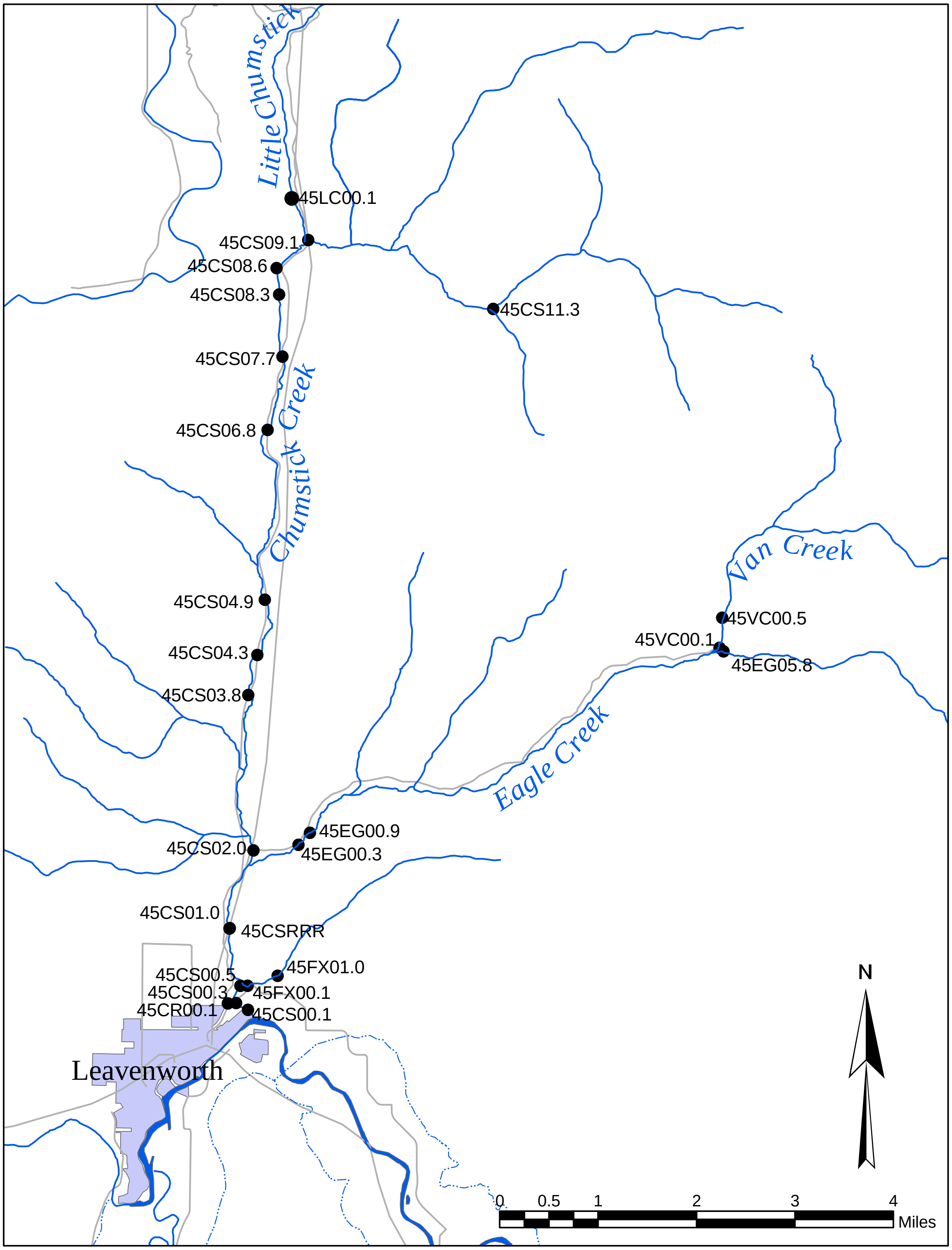


Figure 2. Chumstick Creek sampling stations for 2003-04 TMDL study.

Table 6. Chumstick Creek sample site identification, flow-type description, and location.

Station ID (includes RM)	Station Name	Type of Field Measurement	Longitude	Latitude
45CR00.1	Chumstick irrigation return nr mouth	Instantaneous flow	-120.6488	47.6047
45CS00.1	Chumstick Cr at mouth	Continuous flow station	-120.6470	47.6048
45CS00.3	Chumstick Cr nr mouth	Instantaneous flow	-120.6444	47.6038
45CS00.5	Chumstick Cr nr Leavenworth	Instantaneous flow	-120.6461	47.6073
45CS01.0	Chumstick Cr at RM 1.0	Instantaneous flow	-120.6484	47.6158
45CS02.0	Chumstick Cr abv Eagle Cr	Instantaneous flow	-120.6433	47.6272
45CS03.8	Chumstick Cr blw midstream	Instantaneous flow	-120.6445	47.6500
45CS04.3	Chumstick Cr midstream	Instantaneous flow	-120.6425	47.6559
45CS04.9	Chumstick Cr midstream at Hwy 209	Instantaneous flow	-120.6409	47.6640
45CS06.8	Chumstick Cr at bridge blw Camp 12 Rd	Instantaneous flow	-120.6404	47.6889
45CS07.7	Chumstick Cr at Camp 12 Rd	Instantaneous flow	-120.6372	47.6997
45CS08.3	Chumstick Cr at RM 8.3	Instantaneous flow	-120.6379	47.7088
45CS08.6	Chumstick Cr nr railroad bridge	Instantaneous flow	-120.6385	47.7127
45CS09.1	Chumstick Cr abv Little Chumstick Cr	Instantaneous flow	-120.6316	47.7168
45CS11.3	Chumstick Cr abv Second Cr	Instantaneous flow	-120.5913	47.7067
45CSRRR	Icicle irrigation return RM 1.0	Instantaneous flow	-120.6485	47.6157
45EG00.3	Eagle Cr nr mouth	Instantaneous flow	-120.6335	47.6280
45EG00.9	Eagle Cr abv mouth	Instantaneous flow	-120.6310	47.6298
45EG05.8	Eagle Cr abv Van Cr	Instantaneous flow	-120.5411	47.6565
45FX00.1	Fox irrigation return nr mouth	Instantaneous flow	-120.6445	47.6073
45FX01.0	Fox irrigation return at Fox Canyon	Instantaneous flow	-120.6380	47.6088
45LC00.1	Little Chumstick Cr nr mouth	Instantaneous flow	-120.6336	47.7205
45VC00.1	Van Cr at mouth	Instantaneous flow	-120.5420	47.6570
45VC00.5	Van Cr abv private property	Instantaneous flow	-120.5414	47.6614

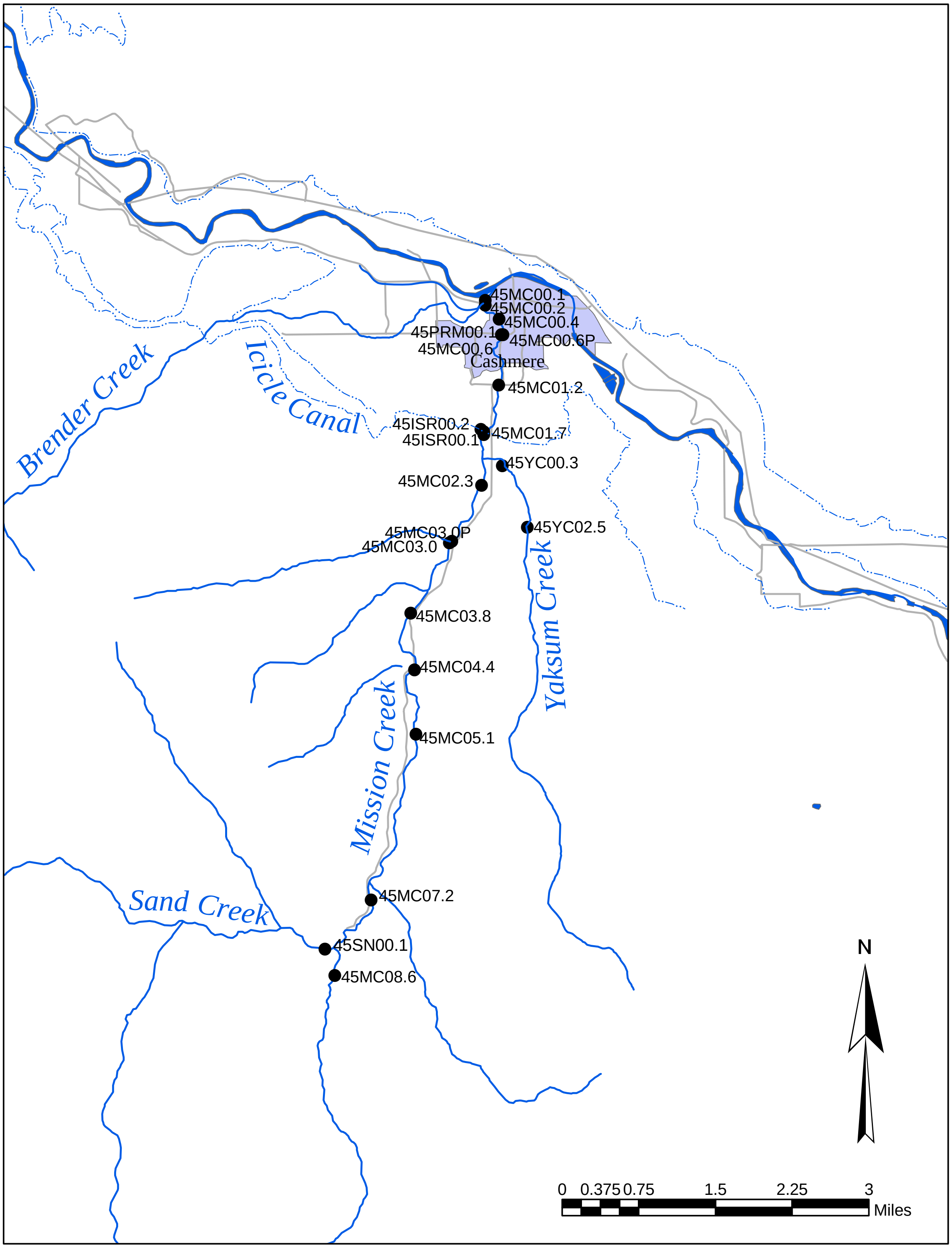


Figure 3. Mission Creek sampling stations for 2003-04 TMDL study.

Table 7. Mission Creek sample site identification, flow-type description, and location.

Station ID (RM included)	Station Name	Type of Field Measurement	Longitude	Latitude
45MC08.6	Mission Cr on USFS Land	Instantaneous flow	-120.5063	47.4263
45MC00.1	Mission Cr nr mouth blw Brender	Continuous flow station	-120.4748	47.5219
45MC00.2	Mission Cr nr Cashmere	Continuous flow station	-120.4748	47.5212
45ISR00.1	Icicle Irrigation District return (mouth of ditch)	Instantaneous flow	-120.4751	47.5033
45ISR00.2	Icicle Irrigation District return (top of ditch)	Instantaneous flow	-120.4757	47.5036
45MC00.4	Mission Cr at Angier Rd	Instantaneous flow	-120.4719	47.5192
45MC00.6	Mission Cr at Pioneer Ave	Instantaneous flow	-120.4711	47.5170
45MC00.6P	Pipe at Mission Cr at Pioneer Ave	Instantaneous flow	-120.4713	47.5170
45MC00.9	Mission Cr at Creekside Pl	Instantaneous flow	-120.4716	47.5136
45MC01.2	Mission Cr at Binder Rd	Continuous flow station	-120.4720	47.5099
45MC01.7	Mission Cr abv Icicle return	Instantaneous flow	-120.4751	47.5029
45MC02.3	Mission Cr abv Yaksum Cr	Instantaneous flow	-120.4756	47.4957
45MC03.0	Mission Cr at Tripp Canyon	Instantaneous flow	-120.4823	47.4876
45MC03.0P	Pipe at Mission Cr at Tripp Canyon	Instantaneous flow	-120.4818	47.4878
45MC03.8	Mission Cr blw Sherman Canyon	Instantaneous flow	-120.4904	47.4776
45MC04.4	Mission Cr at Sherman Canyon	Instantaneous flow	-120.4896	47.4696
45MC05.1	Mission Cr blw Bear Gulch	Instantaneous flow	-120.4893	47.4605
45MC07.2	Mission Cr abv Bear Gulch	Instantaneous flow	-120.4987	47.4370
45PRM00.1	Peshastin upstream irrigation return	Instantaneous flow	-120.4714	47.5170
45SN00.1	Sand Creek nr mouth	Instantaneous flow	-120.5072	47.4297
45YC02.5	Upper Yaksum Creek	Instantaneous flow	-120.4660	47.4898
45YC00.3	Yaksum Creek nr mouth	Instantaneous flow	-120.4712	47.4985

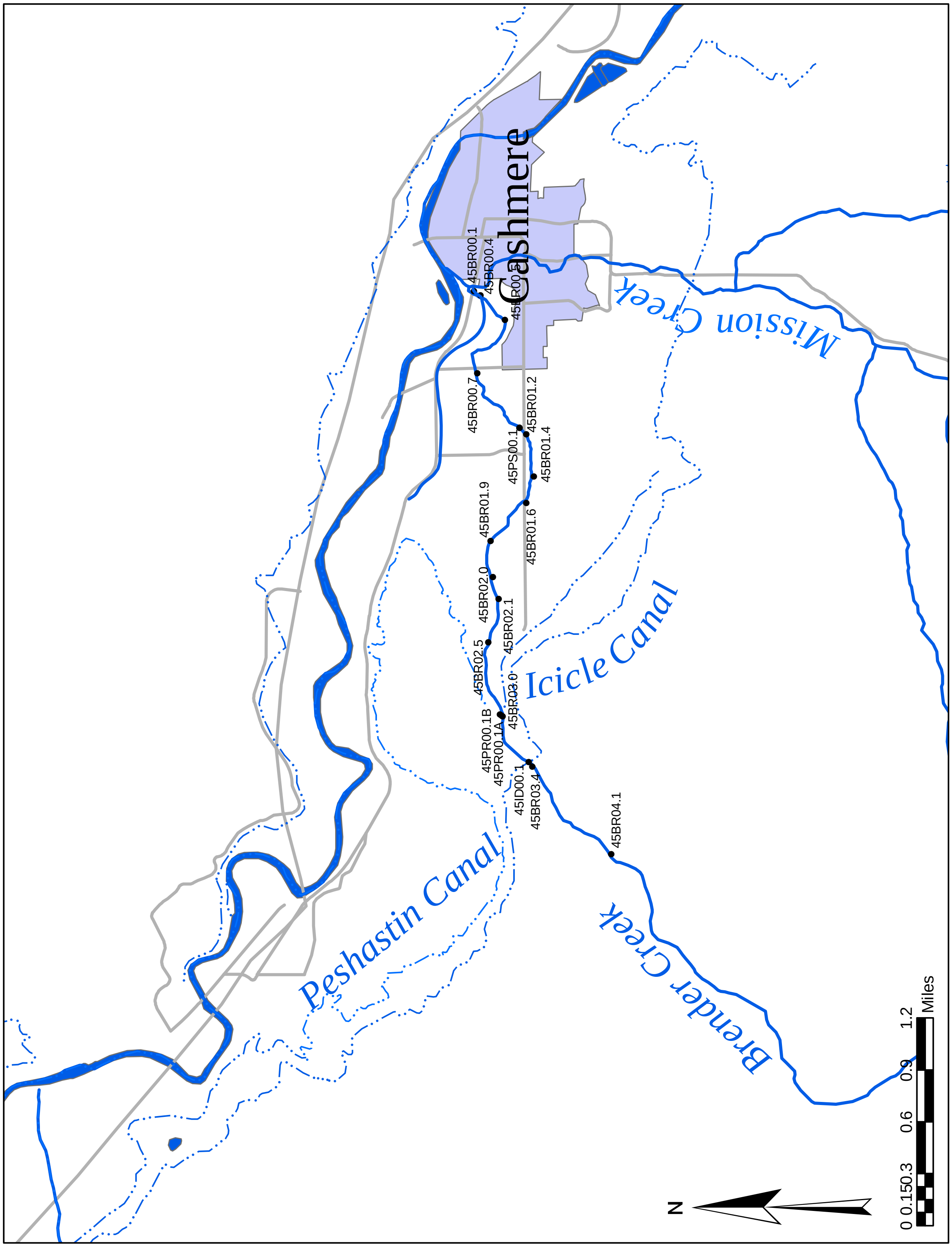


Figure 4. Brender Creek sampling stations for 2003-04 TMDL study.

Table 8. Brender Creek sample site identification, flow-type description, and location.

Station ID (RM included)	Station Name	Type of Field Measurement	Longitude	Latitude
45BR00.1	Brender Cr nr Cashmere	Instantaneous flow	-120.4754	47.5214
45BR00.4	Brender Cr abv mouth	Continuous flow station	-120.4759	47.5208
45BR00.5	Brender Cr blw sediment pond	Instantaneous flow	-120.4790	47.5188
45BR00.7	Brender Cr at Evergreen Dr	Instantaneous flow	-120.4856	47.5211
45BR01.2	Brender Cr at Pioneer Ave (downstream)	Continuous flow station	-120.4931	47.5170
45BR01.4	Brender Cr at Hinman Rd	Instantaneous flow	-120.4983	47.5164
45BR01.6	Brender Cr at Pioneer Ave (upstream)	Instantaneous flow	-120.5016	47.5170
45BR01.9	Brender Cr at RM 1.9	Instantaneous flow	-120.5063	47.5200
45BR02.0	Brender Cr at RM 2.0	Instantaneous flow	-120.5107	47.5198
45BR02.1	Brender Cr at RM 2.1	Continuous flow station	-120.5134	47.5193
45BR02.5	Brender Cr at RM 2.5	Instantaneous flow	-120.5188	47.5202
45BR03.0	Brender Cr abv Peshastin irrigation return	Instantaneous flow	-120.5279	47.5190
45BR03.4	Brender Cr abv (upstream) Icicle irrigation return	Instantaneous flow	-120.5341	47.5165
45BR04.1	Brender Cr at Brender Rd	Instantaneous flow	-120.5449	47.5099
45ID00.1	Icicle Irrigation District upstream return	Instantaneous flow	-120.5336	47.5168
45PS00.1	Peshastin Irrigation District return at Pioneer Rd.	Instantaneous flow	-120.4933	47.5171
45PR00.1A	Peshastin irrigation return (pipe)	Instantaneous flow	-120.5277	47.5192
45PR00.1B	Peshastin irrigation return (box)	Instantaneous flow	-120.5278	47.5191

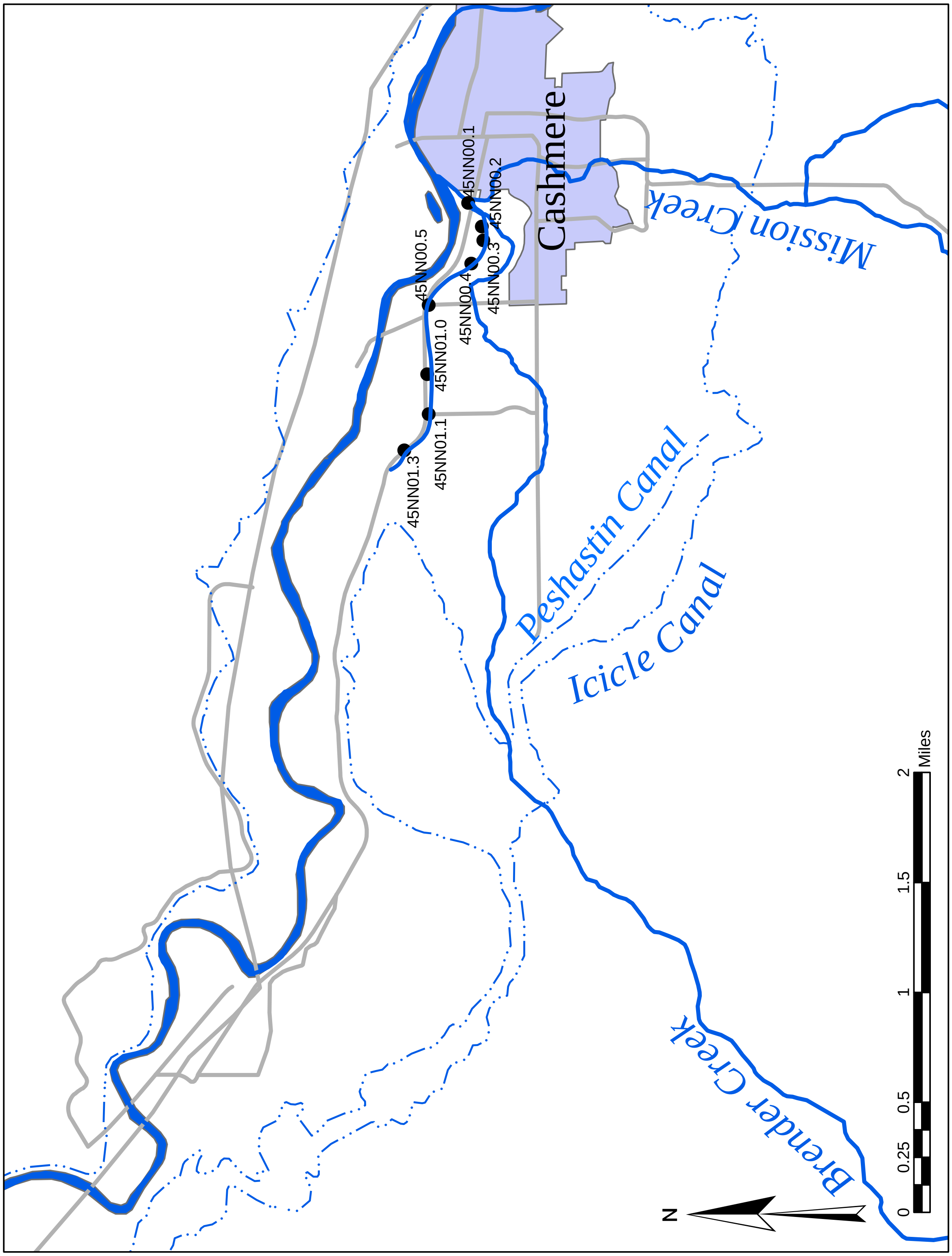


Figure 5. No Name Creek sampling stations for 2003-04 TMDL study.

Table 9. No Name Creek sample site identification, flow-type description, and location.

Station ID (RM included)	Station Name	Type of Field Measurement	Longitude	Latitude
45NN00.1	No Name Cr at mouth	Instantaneous flow	-120.4752	47.5217
45NN00.2	No Name Cr at Mill Rd	Instantaneous flow	-120.4775	47.5208
45NN00.3	No Name Cr blw duck pond	Instantaneous flow	-120.4788	47.5207
45NN00.4	No Name Cr abv duck pond	Instantaneous flow	-120.4811	47.5215
45NN00.5	No Name Cr at Sunset Hwy	Instantaneous flow	-120.4851	47.5243
45NN01.0	No Name Cr at Locust Ln	Instantaneous flow	-120.4918	47.5244
45NN01.1	No Name Cr at Wescott Dr	Instantaneous flow	-120.4957	47.5243
45NN01.3	No Name Cr at Turkey Shoot Rd	Instantaneous flow	-120.4992	47.5259

Sampling and Quality Control Procedures

All water samples for laboratory analysis were collected in pre-cleaned containers supplied by Ecology’s Manchester Environmental Laboratory (MEL). All samples for laboratory analysis were preserved as specified by MEL (2000) and delivered to MEL within 24 hours of collection. Laboratory analyses listed in Table 4 were performed in accordance with MEL (2000).

Field sampling and measurement protocols followed those specified in WAS (1993) for *in situ* temperature, dissolved oxygen, pH, and specific conductance (Hydrolab® multi-parameter meters) and for dissolved oxygen Winkler titrations. All meters were calibrated and post-calibrated per manufacturer's instructions.

Replicate samples were collected to assess total field and laboratory variation.

Data Quality Results

Quality Assurance Objectives

Data collected for this Wenatchee River TMDL Study were evaluated to determine whether data quality assurance/quality control (QA/QC) objectives for the project were met. Water quality data QA/QC objectives for precision, bias, and accuracy are described in Table 5.

Sample Quality Assurance

QA/QC for Samples

Field

Field sampling protocols followed those specified in WAS (1993). Field QC requirements include the use of field replicates and field blanks to assess total precision and field bias, respectively. Sample collection protocols were compromised at times because of low flow in the tributaries (see below).

Laboratory

Ecology's Manchester Environmental Laboratory (MEL) was used for all laboratory analyses. Laboratory data were generated according to QA/QC procedures described in MEL (2000). MEL prepared and submitted QA memos to Ecology's Environmental Assessment Program for each sampling survey. Each memo summarized the QC procedures and results for sample transport and storage, sample holding times, and instrument calibration. The memo also included a QA summary of check standards, matrix spikes, method blanks (used to check for analytical bias), and lab-split samples (used to check for analytical precision).

All samples were received in good condition and were properly preserved, as necessary. The temperature of the shipping coolers was between proper ranges of 2°C - 6°C for all sample shipments.

Holding times were violated at times throughout the project because of delayed transport problems or because the samples were held too long at MEL before analysis. MEL qualified as estimates all samples that were analyzed beyond holding times with a "J".

Instrument calibration and control checks were all within control limits for the project.

For the most part, data quality for this project met all laboratory QA/QC criteria as determined by MEL. Individual exceptions that caused the results to be qualified as an estimate were qualified by MEL with a "J" qualifier in the data tables. All qualifications will be taken into consideration for the purpose of data analysis. Data precision, bias, and accuracy for all parameters were compared to the project data quality objectives listed in Table 5.

Precision

Analytical Precision

Analytical laboratory precision was determined separately to account for its contribution to overall variability. Laboratory split samples were analyzed at least once per batch (or about 10% of the total) to assess analytical precision. A pooled relative standard deviation (%RSD) was calculated for each parameter using lab-split results greater than reporting limits.

%RSD was calculated by first calculating a pooled standard deviation as the square of the sum of the squared differences divided by two times the number of pairs. Then the pooled standard deviation was divided by the mean of the replicate measurements and then multiplied by 100 for the %RSD. Higher %RSD is expected for values that are close to their reporting limit (e.g., the %RSD for replicate samples with results of 1 and 2 is 47%, whereas the %RSD for replicate results of 100 and 101 is 0.7%, with each having a difference of 1).

Because higher %RSD is expected near the reporting limit, two tiers were also evaluated; lab-split results less than five times the reporting limit were considered separately from lab-splits results equal to or more than five times the reporting limit (for FC bacteria, the two tiers were less than 50 and greater than or equal to 50 cfu/100mL). The %RSD in the upper tier was compared to the target precision objective for each parameter. Results are listed in Table 10 and Table 11.

Table 10. Lab precision for dry-season results. Results at the detection limit were excluded from consideration.

Parameter	Target Precision %RSD	Average %RSD for samples <5X reporting limit (number of duplicate pairs)	Average %RSD for samples ≥5X reporting limit (number of duplicate pairs)
Chloride	<5	all samples >5X reporting limit	1.0 (24)
Fecal coliform[1]	<25	20.2 (20)	16.2 (39)
Total Suspended Solids	<10	6.9 (14)	5.2 (24)

[1]Bacteria duplicates are split into samples <50cfu/100mL and ≥50cfu/100 mL

Table 11. Lab precision for wet-season results. Results at the detection limit were excluded from consideration.

Parameter	Target Precision %RSD	Average %RSD for samples <5X reporting limit (number of duplicate pairs)	Average %RSD for samples ≥5X reporting limit (number of duplicate pairs)
Fecal coliform[1]	<25	34.7 (30)	all samples < 50 cfu/100 mL
Total Suspended Solids	<10	16.67 (4)	5.4 (31)

[1]Bacteria duplicates are split into samples <50cfu/100mL and ≥50cfu/100 mL

Total Precision

Field replicate samples were collected for at least 10% of the total number of general chemistry samples and at least 20% of the total number of microbiology samples in order to assess total precision (i.e., total variation) for field samples. As was done for the lab precision evaluation, two tiers were also evaluated for total precision; field-replicate results less than five times the reporting limit and field-replicate results equal to or more than five times the reporting limit (for FC bacteria, the two tiers were less than 50 and greater than or equal to 50 cfu/100mL). A pooled %RSD was calculated for each parameter using field replicate results greater than reporting limits. Results are listed in Tables 12 and 13.

Table 12. Total precision (field + lab) for dry-season results. Results at the detection limit were excluded from consideration.

Parameter	Target Precision %RSD	Average %RSD for samples <5X reporting limit (number of duplicate pairs)	Average %RSD for samples ≥5X reporting limit (number of duplicate pairs)
Chloride	<5	7.1 (1)	30.9 (37)
Fecal coliform[1]	<25	39.9 (22)	53.7 (88)
Total Suspended Solids	<10	55.0 (16)	44.0 (14)

[1]Bacteria duplicates are split into samples <50cfu/100mL and ≥50cfu/100 mL

Table 13. Total precision (field + lab) for wet-season results. Results at the detection limit were excluded from consideration.

Parameter	Target Precision %RSD	Average %RSD for samples <5X reporting limit (number of duplicate pairs)	Average %RSD for samples ≥5X reporting limit (number of duplicate pairs)
Fecal coliform[1]	<25	47.6 (22)	15.9 (11)
Total Suspended Solids	<10	27.4 (6)	8.49 (27)

[1]Bacteria duplicates are split into samples <50cfu/100mL and ≥50cfu/100 mL

Total precision %RSD in the upper tier was compared to the target precision. As expected, %RSD for field replicates was generally higher than that for lab-splits because it is a measurement of total variability, including both field and analytical variability.

The %RSD for FC bacteria and total suspended solids data did meet the target precision objectives during the wet-season sampling; however, the %RSD for chloride, FC bacteria, and total suspended solids data did not meet the target precision objectives during the dry-season sampling. The analytical precision for these parameters during the dry season was very good so most of the variability appears to be field variability. Bacterial populations, as well as suspended solid concentrations and turbidity, are inherently variable because of patchy distributions in the environment and intermittent discharge.

The dry-season sampling was conducted on Mission, Brender, No Name, and Chumstick creeks during low flow. Low flow conditions compromised sample collection protocols and may have increased variability. Standardized field sampling is employed to reduce variability of samples.

WAS (1993) sampling protocols caution against sampling the surface of the water because a micro-layer of bacteria tends to occur there; however, during the dry-season sampling, many grab samples unavoidably included the surface of the water because of a lack of water depth to submerse the collection bottle.

High variability was also present in replicate samples taken during higher flows in the dry season, so the lower precision data seems more indicative of generally high variability in the tributaries during the dry season. The target precision objective for the project may have been too low for the tributaries during the dry season. The dry-season data were not qualified for not meeting the target precision objectives; however the high variability of the data will be taken into consideration for analysis and interpreting results.

Field Measurement Quality Assurance

Field measurement protocols followed those specified in WAS (1993) for dissolved oxygen (Winkler titration), streamflow (Marsh-McBirney, 2000), and *in situ* temperature, dissolved oxygen, pH, and specific conductance (Hydrolab® multi-parameter meters).

Hydrolab® meters were used for taking instantaneous measurements and were also used to capture continuous measurements. Meters were pre- and post-calibrated for pH, dissolved oxygen (DO), and conductivity. The manufacturer’s instructions were followed for pH and conductivity calibration, using pH 7 and pH 10 low-ionic buffer solutions and 100 umhos/cm conductivity standard solution. The DO sensor was pre-calibrated to theoretical water-saturated air, in accordance with manufacturer’s instructions. Winkler field samples were collected daily for use as DO check standards. If necessary, Winkler DO measurements were used to adjust meter data (see below).

Precision

Replicate or duplicate measurements were not taken for instantaneous or continuous field measurements so there was not an assessment of precision for these measurements. All measurements made with meters were taken *in situ,* and the meter was allowed to equilibrate to a stable reading.

Bias

Instantaneous Measurement Bias

The average difference of post-calibration pH readings was 0.07 standard pH units (s.u.) with a standard deviation of 0.1 s.u. The pooled bias for all of the post-calibration instantaneous pH readings was 0.09 s.u. (the target bias was less than 0.1 s.u.). All instantaneous pH readings were considered acceptable except five pH readings from July 21, 2003 which were qualified as estimates due to a problem with the meter that morning.

Post-calibration checks for instantaneous conductivity measurements had a pooled %RSD bias of 3.4%, well under the target maximum bias of 5%. All instantaneous conductivity measurements were considered acceptable for use without qualification.

Hydrolab® instantaneous DO data was compared to Winkler check standards to assess bias. In most cases there was a slight adjustment (correction factor) applied to the meter DO data and there was no qualification designated.

The pooled standard deviation for the dry-season instantaneous DO data was 0.25 mg/L with a pooled %RSD of 2.5%, well below the target maximum bias of 5%. The pooled standard deviation for the wet-season instantaneous DO data was 0.20 mg/L with a pooled %RSD of 1.79%, well below the target maximum bias of 5%. For several sampling dates, instantaneous DO results were rejected or qualified due to poor correlation between Hydrolab and Winkler values, or malfunctioning equipment.

All of the Hydrolab instantaneous DO data was rejected for the following dates (although Winkler values were recorded):

- August 26, 2003 (22 values)
- March 16, 2004 (12 values)

In addition, for the following sampling dates, some or all of the instantaneous DO results were corrected but qualified as estimates (denoted with "J") due to poor correlation between Hydrolab and Winkler values:

- September 23, 2003 (2 values)
- October 21, 2003 (1 value)
- March 15, 2004 (5 values)

Other than the noted exceptions, all other DO data were considered acceptable for use.

Accuracy

For field measurements, target objectives for accuracy were set for velocity and temperature. Both accuracy targets are from the manufacturer's specifications for the respective instruments (velocity meter and thermometer). Instruments are factory calibrated and were considered to be performing within the specified published accuracies during the field season.

Conclusion

Overall, the data collected by Ecology for this project met the data quality objectives. There was high variability in the FC bacteria data; however, the QA and QC review suggests that the Ecology data are of good quality and are properly qualified.

Wenatchee River TMDL Data

All field and laboratory for the Wenatchee River basin FC bacteria TMDL are loaded into Ecology's Environmental Information Management (EIM) database and are available on-line from the Ecology website at: www.ecy.wa.gov/programs/eap/env-info.html. Several query options are available. The study identification (study ID) is "WENRTMDL," and the study name is "Wenatchee River TMDL".

Additional data collected by Ecology's Freshwater Monitoring Unit (FMU) are used in this TMDL analysis; these data also are available on-line at the above EIM website. The study ID is AMS001. Table 14 shows the FMU stations used in support of the Wenatchee River TMDL effort.

Table 14. Ecology's Freshwater Monitoring Unit stations used in the Wenatchee TMDL study and the project station equivalent.

FMU Station	Wenatchee TMDL Project station equivalent	Site Description
45D070	45BR00.4	Brender Creek above mouth
45C070	45CS00.5	Chumstick Creek near mouth
45C060	45CS00.1	Chumstick Creek above mouth
45Q060	45EG00.3	Eagle Creek above mouth
45E070	45MC00.2	Mission Creek near Cashmere
45R050	45NN00.2	No Name Creek at Mill Road
45A070	45WR00.5	Wenatchee River near mouth
45A110	45WR35.4	Wenatchee River near Leavenworth (Tumwater Canyon Hwy 2 bridge)

Fecal Coliform Bacteria TMDL

The presence of fecal coliform (FC) bacteria is an indicator of possible harmful, disease-causing pathogens (e.g., bacteria and viruses) associated with human and animal waste. Waterborne diseases include ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis, and hepatitis A.

This Wenatchee River Basin FC bacteria TMDL study focused on three tributaries to the Wenatchee River that were listed on the 1998 303(d) list for FC bacteria: Mission, Brender, and Chumstick creeks. The 1998 303(d) listings were the result of sampling by Ecology and the Chelan County Conservation District from 1992 through 1997.

To confirm that these were the only tributaries not meeting (exceeding) FC water quality standards, the mouths of all tributaries to the Wenatchee River were sampled during 2002. FC exceedances were found only in the listed streams; the sampling did not result in any additional listed streams. Single exceedances in the Cascade Orchard irrigation return (45CD00.1) to the Wenatchee River and the Icicle Irrigation District return (45FR00.1) in Fairview Canyon were not sufficient to list the irrigation returns.

Table 15 shows the 2004 303(d) listings for impaired waters in WRIA 45 due to FC bacteria contamination. A majority of the data used for the 2004 FC listings were generated by the TMDL surveys in 2003-04 discussed in this report. Therefore, all of the currently listed (i.e., impaired) waters for FC bacteria in WRIA 45 have been evaluated.

The 2003-04 sampling was conducted during two seasons: dry/irrigation (sampled July – October 2003) and wet/runoff (sampled March – May 2004). This sampling confirmed the 1998 303(d) listings for FC throughout the Mission, Brender, and Chumstick creek basins. Additional FC exceedances were observed in the following tributary creeks to these basins: Yaksum and Sand (Mission Creek basin), No Name (Brender Creek basin), and Little Chumstick, Eagle, and Van (Chumstick Creek basin).

Table 15. Stream reaches on the 2004 303(d) list for fecal coliform bacteria impaired waterbodies in the Wenatchee River basin (WRIA 45).

Stream	303 (d) listing ID#	Water Course #	Location
Brender Creek	8408*	FB41UG	T23N, R19E, Section 5
	41677	FB41UG	T23N, R19E, Section 6
	41682	FB41UG	T23N, R18E, Section 1
	41685	FB41UG	T23N, R18E, Section 11
Chumstick Creek	8412*	TX45RJ	T24N, R17E, Section 1
	41689	TX45RJ	T25N, R18E, Section 19
	41691	TX45RJ	T25N, R18E, Section 18
	41693	TX45RJ	T25N, R18E, Section 6
	41722	TX45RJ	T26N, R18E, Section 31
	41724	TX45RJ	T26N, R18E, Section 30
	41725	TX45RJ	T26N, R18E, Section 33
Eagle Creek	41696	ZW35YH	T25N, R18E, Section 30
	41727	ZW35YH	T26N, R18E, Section 24
Fox Creek irrigation return	41920	TX45RJ	T24N, R18E, Section 6
Icicle irrigation return	41925	DQ04NW	T23N, R19E, Section 14
Little Chumstick Creek	41731	FA38NK	T26N, R18E, Section 30
Mission Creek	16832*	DQ04NW	T23N, R19E, Section 5
	8423*	DQ04NW	T23N, R19E, Section 20
	8421**	FB41UG**	T23N, R19E, Section 5
	41557	DQ04NW	T23N, R19E, Section 4
	41559	DQ04NW	T23N, R19E, Section 9
	41561	DQ04NW	T23N, R19E, Section 8
	41562	DQ04NW	T23N, R19E, Section 17
No Name Creek	41928	UNK000	T23N, R19E, Section 5
	41929	UNK000	T23N, R19E, Section 5
	41930	UNK000	T23N, R19E, Section 5
	41932	UNK000	T23N, R19E, Section 5
	42537	UNK000	T23N, R19E, Section 5
Peshastin irrigation return	41938	DQ04NW	T23N, R19E, Section 4
Van Creek	41942	VF45OQ	T25N, R18E, Section 24
Yaksum Creek	41704	XL42OT	T23N, R19E, Section 8

* Also listed on the 1996 and 1998 303(d) list.

** Listing should have been included in Listing ID# 16832 because it is the same site (wrong Water Course # too).

Applicable Criteria

The Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code (WAC), include designated beneficial uses, waterbody classifications, and numeric and narrative water quality criteria for surface waters of the state.

Chumstick and Mission creeks discharge to the Class A portion of the Wenatchee River. These creeks and their tributaries are consequently considered Class A waterbodies, from their confluence with the mainstem Wenatchee River to any Wenatchee National Forest boundary. From the national forest boundary to their headwaters, Chumstick and Mission creeks and their tributaries are all considered Class AA, "extraordinary," waterbodies.

Characteristic uses for both Class A and AA waterbodies include water supply (domestic, industrial, agricultural), stock watering, fish and shellfish (salmonid and other fish migration, rearing, spawning, harvesting), wildlife habitat, recreation (primary contact recreation, sport fishing, boating, aesthetic enjoyment), and commerce and navigation.

Numeric criteria for specific water quality parameters are intended to protect designated uses. Criteria are more stringent in AA waters such that the class shall markedly and uniformly exceed the requirements for all, or substantially all, uses. Current bacteria standards are listed for each class of waters:

- For Class A Waters: "…*fecal coliform organism levels shall both not exceed a geometric mean*[2] *value of 100 colonies/100mL, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 mL."*
- For Class AA Waters: "…*fecal coliform organism levels shall both not exceed a geometric mean value of 50 colonies/100 mL and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 mL."*

These Washington State water quality standards are currently under revision. Changes have been adopted but are awaiting final EPA approval. Fresh waters will be classified by use (such as fish habitat, swimming, and water supply), rather than by class (AA, A, B, C and Lake classes), to allow the standards to be more tailored to specific waterbody uses.

In regards to freshwater FC bacteria standards, the revised standards will include the following language for recreational use designations:

- *Extraordinary Primary Contact* and *Secondary Contact* uses (formerly Class AA)
- *Primary Contact* and *Secondary Contact* uses (formerly Class A)
- *Secondary Contact* uses only (formerly Class B)

Examples of *Primary Contact* uses are swimming, snorkeling, and activities where the water and skin or body openings (e.g., eyes, ears, mouth, nose, and urogenital) come into direct and extended contact. *Secondary Contact* uses are boating, fishing, and activities where only brief incidental water contact would be expected.

[2] The geometric mean is calculated as the n^{th} root of the product of n numbers

The FC bacteria criteria for each of the new recreational use designations will remain the same as its corresponding class base criteria. Proposed new standards can be found on the Ecology website: www.ecy.wa.gov/programs/wq/swqs/index.html. The new standards are not expected to be completely approved by EPA before the completion of this TMDL study, therefore discussion in this report remains based on the class system. Post-TMDL assessments may be compared to the existing criteria and any new criteria that are adopted.

Technical Analysis

Although TMDL studies normally express allocations as pollutant loads (pollutant concentration multiplied by streamflow), this approach does not work well for bacteria TMDL studies. An allocation of fecal coliform (FC) pollutant loads in terms of "numbers of bacteria per day" is awkward and challenging to understand. Instead of managing FC pollution in terms of total load, Ecology has used the statistical rollback method (Ott, 1995) to manage the distribution of FC counts. The approach has proven successful in past bacteria TMDL assessments (Cusimano, 1997; Joy, 2000; Sargeant, 2002).

The technical analysis is based on 2003-04 FC data. Excel® spreadsheets were used to evaluate the data, including development of mass balances, statistical analyses, and plots. Simple spreadsheet mass-balance, reach-load analyses were used to calculate FC loads in Mission, Brender, No Name, and Chumstick creeks, treating FC as conservative (i.e., no losses from die-off or settling, plus no gain from re-suspension) and averaging by station for stations that were sampled on the same dates (n = 9 or 10).

The statistical roll-back method was used to establish FC reduction targets for the various segments of the mainstem and tributaries. The roll-back method assumes that the distribution of FC concentrations follows a log-normal distribution. The cumulative probability plot of the observed data gives an estimate of the geometric mean and 90th percentile which can then be compared to the FC bacteria standards. The roll-back procedure is as follows:

- A check was made to be sure the FC data fit a log-normal distribution.
- The geometric mean of the data was calculated using Excel.
- The 90th percentile of the data was estimated by using the following statistical equation (the 90th percentile value of samples was used in this TMDL evaluation as an estimate for the "no more than 10% samples exceeding …." criterion in the fecal coliform standard (WAC 173-201A)).

$$90^{th} \text{ percentile} = 10^{(\mu_{log} + 1.28 * \sigma_{log})}$$

where: μ_{log} = mean of the log transformed data

σ_{log} = standard deviation of the log transformed data

- The target percent reduction required was set as the highest of the following two resulting values:

  For Class A waters:

$$\text{Target percent reduction} = \left[\frac{observed\ 90th\ percentile - 200\ cfu/100mL}{observed\ 90th\ percentile}\right]x100$$

$$\text{Target percent reduction} = \left[\frac{observed\ geometric\ mean - 100\ cfu/100mL}{observed\ geometric\ mean}\right]x100$$

  For Class AA waters, the 100 cfu/100mL and 50 cfu/100mL criteria were used in the equations.

As "best management practices" for nonpoint sources are implemented, and the target reductions are achieved, a new but similar distribution (same coefficient of variation) of the data is assumed to be realized with the previous mean and standard deviation reduced by the target percent reductions. This assumption can be verified when TMDL-effectiveness-monitoring data are collected.

Source Assessment

An initial bacteria source assessment for each subbasin was carried out by first determining if sources were associated with runoff (i.e., were they wet-season or dry-season exceedances or both). This assessment was made by analyzing the available monthly data for seasonal patterns. Mission, Brender, and Chumstick subbasins have distinct spring runoff seasons from February through June, peaking in March or early April, and a dry season (roughly coinciding with the irrigation season) from July through October. There were no historical stormwater data for these subbasins available for review.

Source Identification

The following is a listing of potential bacteria sources in the three subbasins:

Non-Runoff Sources

- *Wastewater Treatment Plants and Sanitary Sewer Systems.* There are no wastewater point source discharges in the Mission/Brender and Chumstick creek subbasins; however, the City of Cashmere sewer collection system is located in the lower Mission/Brender Creek subbasin.
- *Direct Deposition.* Bacteria may be directly deposited into surface waters by birds and other animals.
- *Illegal Dumping.* The illegal dumping of wastes either to storm sewer systems or directly to surface waters (e.g., portable toilet wastes and recreational vehicle wastes are potential bacteria sources).

- *Contaminated Non-Stormwater Discharges.* During non-runoff periods, water from springs, irrigation-management return flow, irrigation runoff, and other sources may be discharged to streams. It is possible for this water to be contaminated with bacteria at the source or within the conveyance system.
- *Septic Systems.* Failing septic systems have the potential to contribute bacteria during non-runoff and runoff periods.

Runoff Sources

- *Urban Runoff.* Instream bacteria values in urban watersheds can be very high during runoff events. There are no available data from stormwater sampling in these watersheds to show if urban runoff is a significant source of bacteria. Bacteria sources in urban runoff would include:
  1. Pet and other animal waste
  2. Illegal dumping
  3. Failing septic systems
  4. Sanitary sewer cross-connections and overflows
- *Rural Runoff.* Rural runoff may contain bacteria from the same sources as urban runoff, with the possible exception of sanitary sewers. Additional potential sources are “hobby” farms, horse pastures, and ranchettes. In general, the density of onsite septic systems can be higher in rural areas; therefore, the number of failing septic systems may also be higher.
- *Agricultural Runoff.* The primary source of bacteria in agricultural runoff is most likely animal waste. Example sources are livestock grazing in pasture, inappropriate waste management practices, and faulty waste systems.
- *Forest Land Runoff.* The potential for bacteria sources leading to surface water contamination in forested areas is very low. Potential sources include wildlife, illegal dumping of wastewater in camping areas, and permitted livestock grazing on U.S. Forest Service lands.

Water-quality-impaired Tributaries

Mission Creek

The mainstem of Mission Creek is 9.4 miles long and drains an area of 58,899 acres (Figure 3). The elevation at the headwaters is 6,887 feet (2,099 meters), and the mouth of Mission Creek at its confluence with the Wenatchee River in the town of Cashmere is 783 feet (239 meters). Precipitation ranges from 25 inches per year in the headwaters to 10 inches per year at the mouth of Mission Creek.

There are several irrigation diversions in the lower six miles of the river which limit flow during the irrigation season. Additionally, there are three known irrigation-management returns operated by the Icicle-Peshastin Irrigation District. Above the Cashmere city limits and urban growth area (UGA), and below the USFS boundary, Mission Creek has primarily rural land-use with agriculture (primarily orchards), onsite septic systems, and wildlife potentially contributing as nonpoint FC bacteria sources.

Seasonal Variation

Mission Creek historical monthly data show a seasonal pattern of FC water quality exceedances for July through October at both the mouth and above the city of Cashmere. However, the monthly concentrations and loads were much higher at the mouth, indicating sources within the city limits or UGA (Figures 6 and 7). The FC water quality exceedances occurred during the low-flow, dry (irrigation) season. Historical FC monthly loads were elevated seasonally from April, during peak runoff, through October, the end of the dry season.

2003-04 Results

Figure 8 shows flows in Mission Creek for the 2003-04 sampling dates. During the dry-season, flows decreased in Mission Creek from the Forest Service boundary to Tripp Canyon (RM 3.0). Mission Creek was dry at Tripp Canyon (RM 3.0) and above Yaksum Creek (RM 2.3) for most of the sampling season, but downstream a small amount of flow (usually less than 1 cfs) returned by RM 1.2 (Binder Road), apparently from groundwater seepage and/or management return flows from irrigation ditches.

It was difficult to characterize net or cumulative FC load gains or losses in Mission Creek because FC loads were not transferred in the dry creek stretches. During the wet-season, flows were continuous throughout the creek corridor (survey flows ranged from 20 to 60 cfs), with flow gradually increasing downstream.

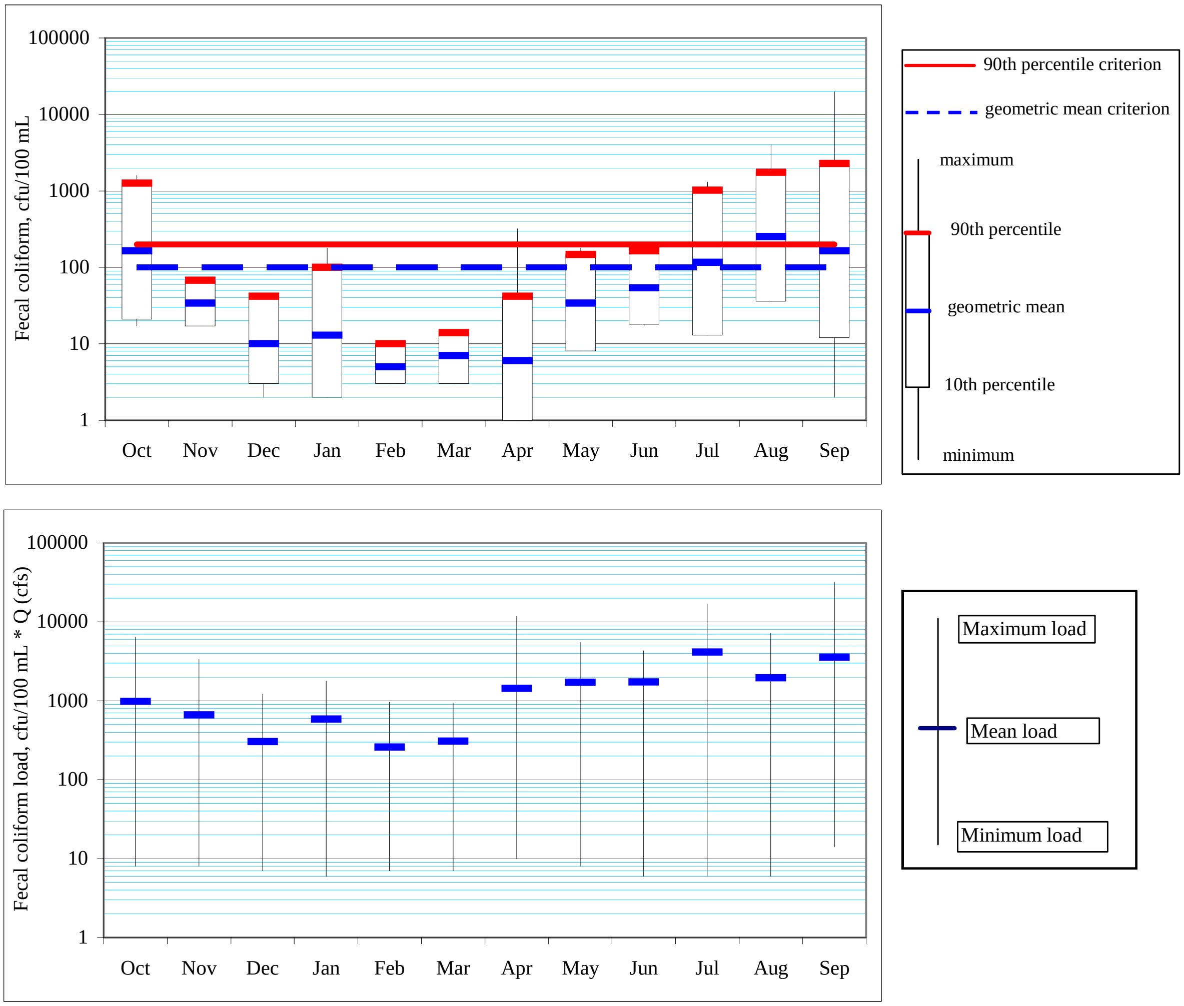
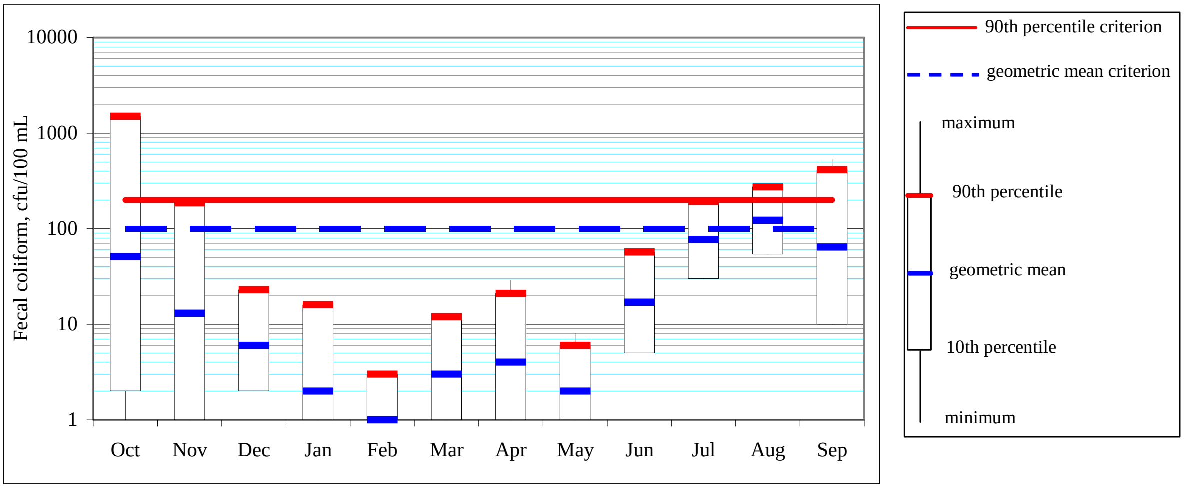


Figure 6. Historical fecal coliform bacteria monthly concentrations and loads in Mission Creek near the mouth (TMDL study station = 45MC00.2). Sampling conducted from 1993-2000 by Chelan County Conservation District and by Ecology (n = 6 to 14 per month).



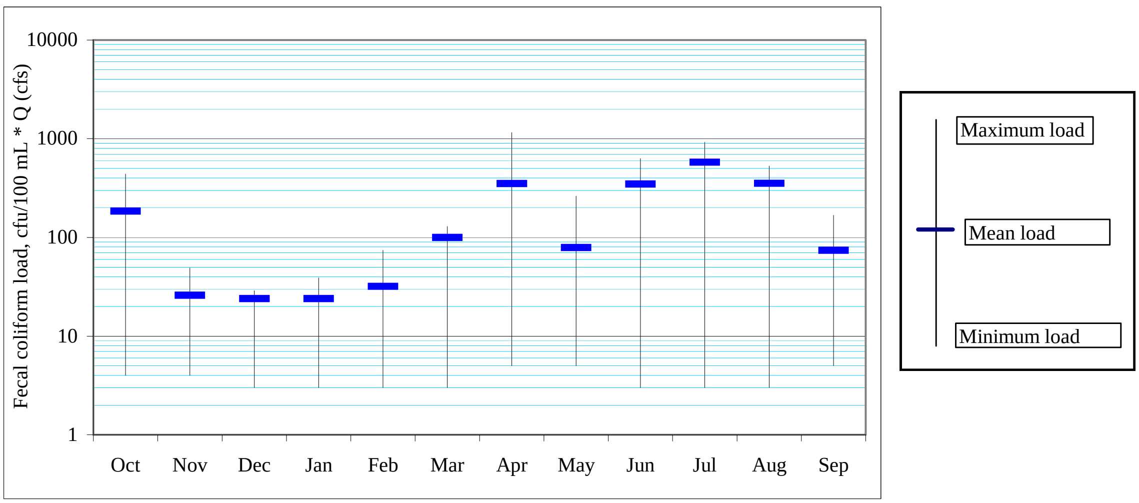
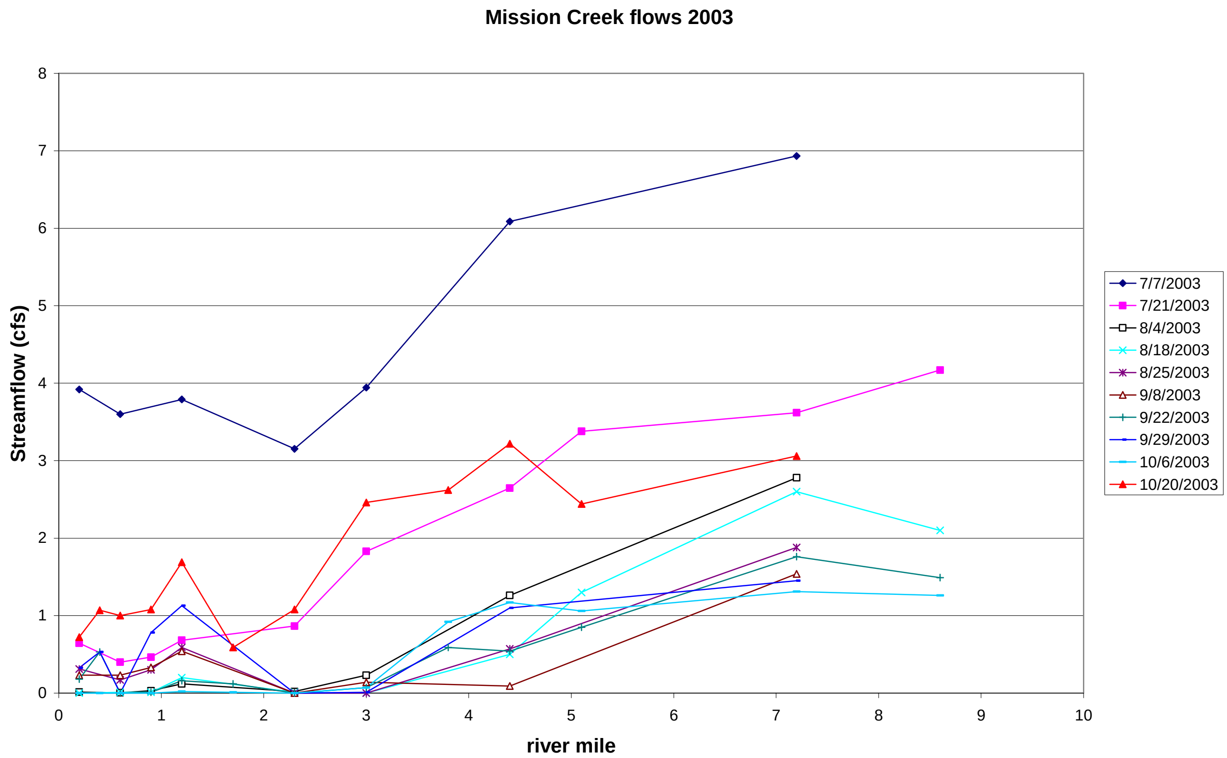


Figure 7. Historical fecal coliform bacteria monthly concentrations and loads in Mission Creek upstream of the City of Cashmere urban growth area (TMDL study station = 45MC02.3). Sampling conducted from 1993-2000 by Chelan County Conservation District (n = 3 to 5 per month).



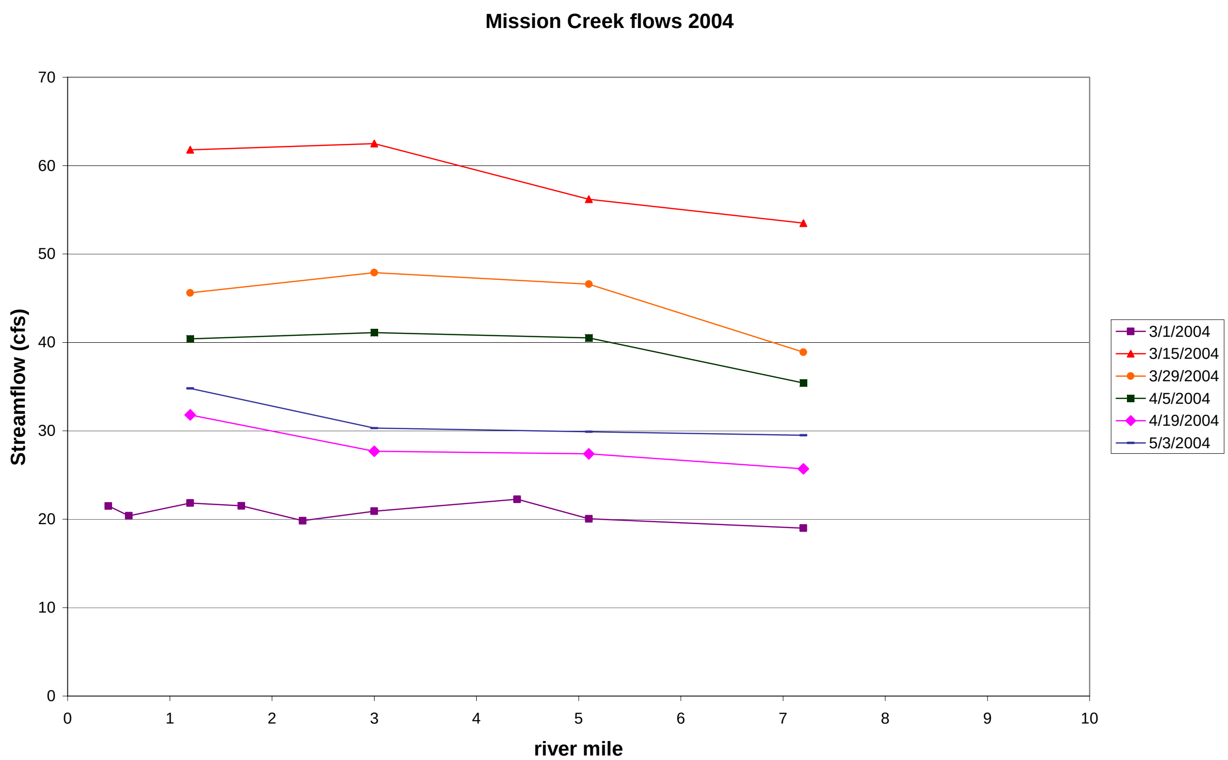


Figure 8. Mission Creek flows during the 2003-04 sampling surveys.

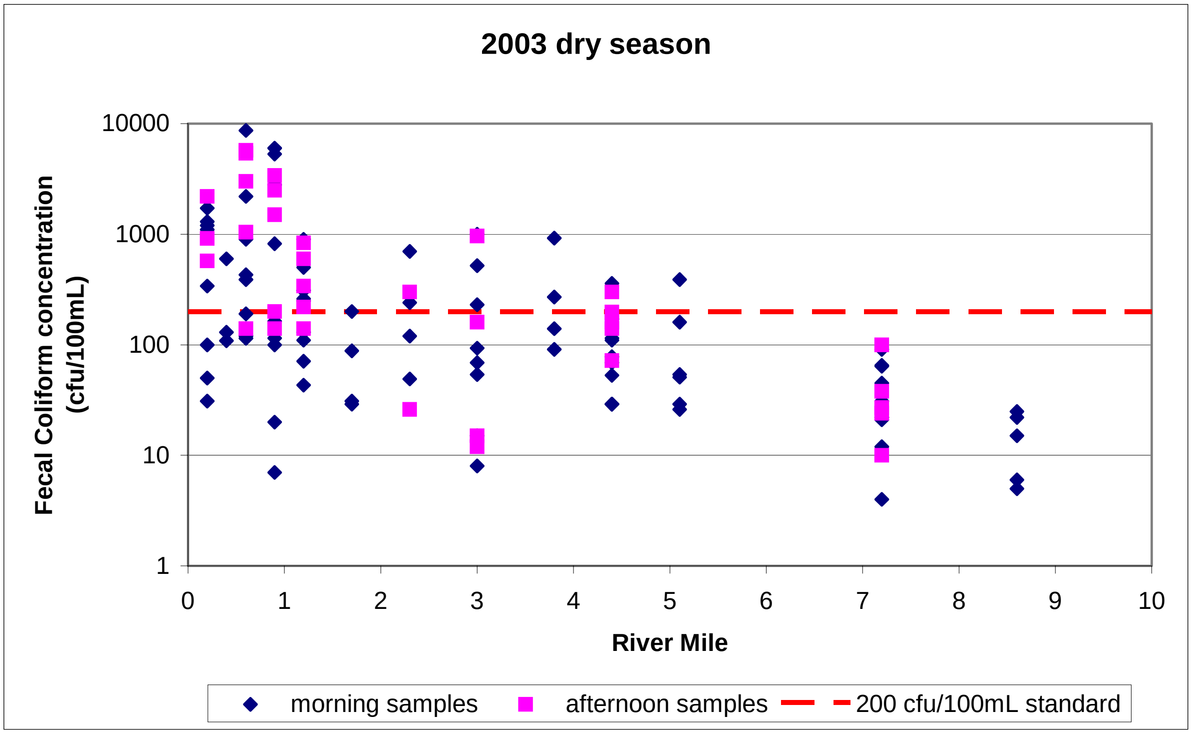
Figure 9 shows FC concentrations detected in Mission Creek for the 2003-04 surveys. There were no FC water quality exceedances during the 2004 wet-season surveys. There was high variability in the sample concentrations during the dry season (see *Data Quality Results* above), but concentrations increased greatly (notice log scale) between Binder Road (RM 1.2) and Creekside Place (RM 0.9).

The average dry-season FC load also increased greatly between RM 1.2 and RM 0.9 (Figure 10). The stretch between RM 1.2 and RM 0.9 is partly within Cashmere city limits, but most of this reach is within the un-sewered part of the City of Cashmere UGA.

Ideally, the source of the FC bacteria to Mission Creek could be determined to be either from human or non-human sources. If the FC bacteria are from human sources, the reach should be evaluated for properly functioning onsite septic systems and inspected for illegal discharges. If the FC bacteria are from non-human sources, best management practices (BMPs) should be implemented to keep non-human sources from contaminating the creek. There is likely to be some contamination from both human and non-human sources.

An initial assessment of FC sources to Mission and Brender creeks was conducted in 2003. Onsite septic system records were located for this reach and others outside of the UGA, but proper-functioning inspections were not completed (Burgoon and Rickel, 2003).

There were also moderate increases in concentrations at Mission Creek below Bear Gulch (RM 5.1), below Sherman Canyon (RM 3.8), and at Binder Road (RM 1.2) during the dry season. All of the reaches above these stations also should be checked for sources of nonpoint FC load contributions.



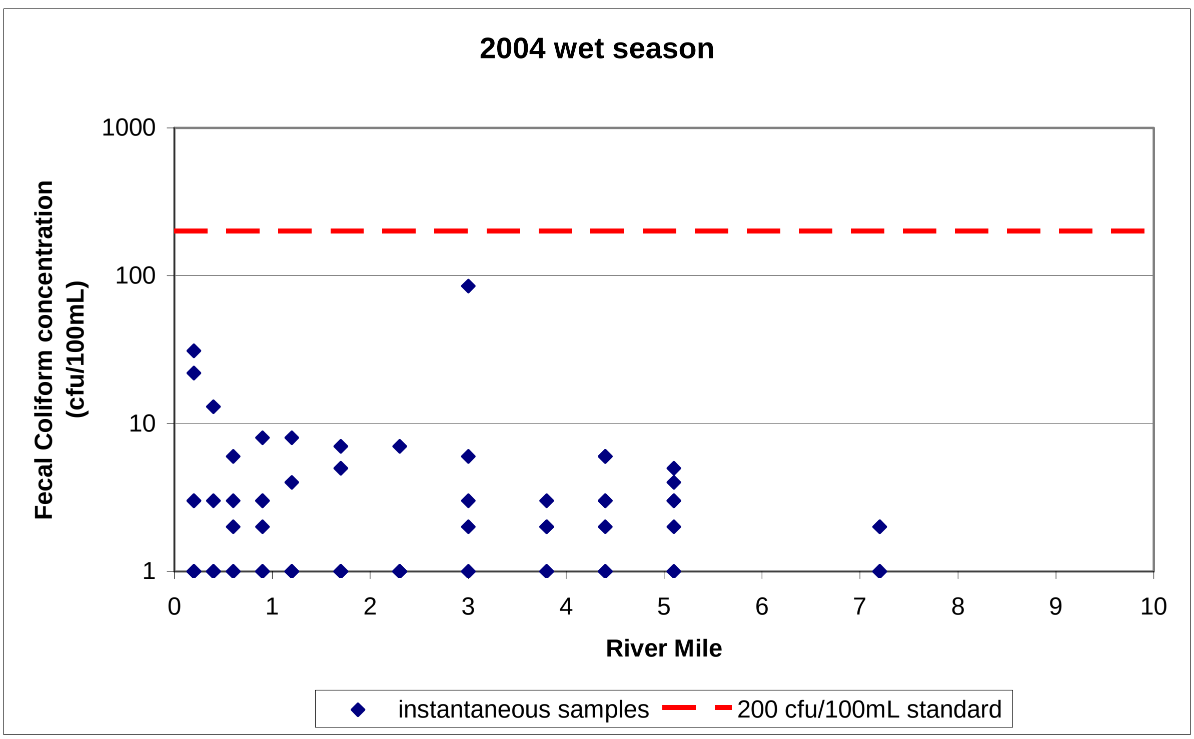


Figure 9. Fecal coliform bacteria concentrations in Mission Creek during the July through October 2003 (dry season) and the March through May 2004 (wet season) sampling surveys.

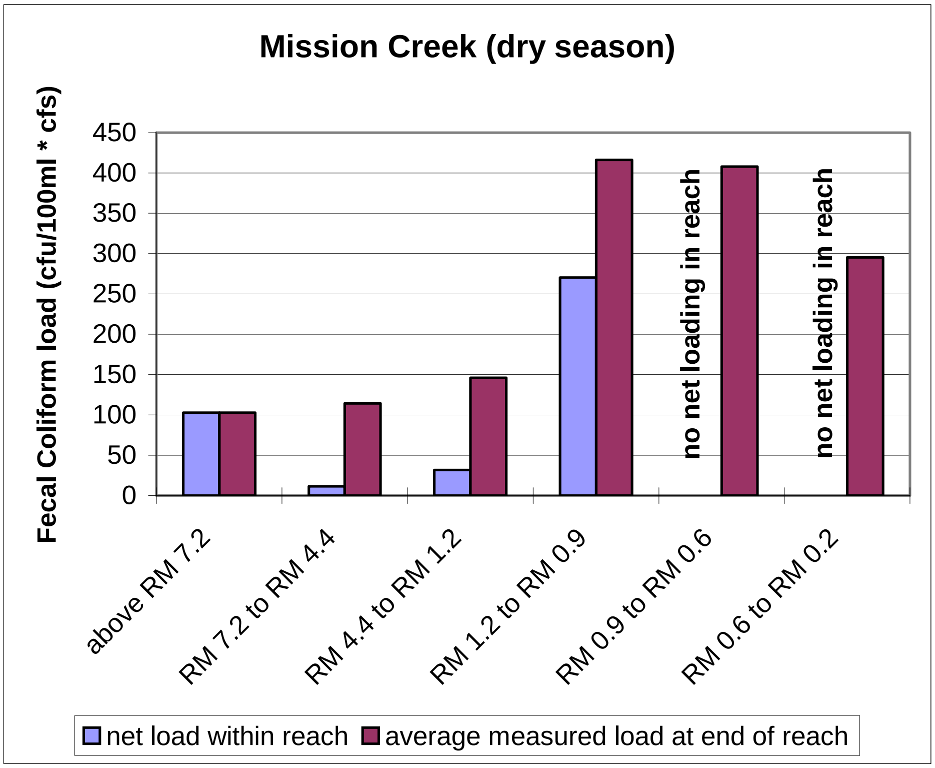


Figure 10. Average measured and net reach fecal coliform loads in Mission Creek for July through October 2003 (n=10).

Table 16 gives FC summary statistics for all sampling sites in the Mission Creek watershed. Exceedance of the standards occurred if either the geometric mean concentration exceeded 100 cfu/100mL or the 90th percentile statistic exceeded 200 cfu/100mL for Class A waters, or if either the geometric mean concentration exceeded 50 cfu/100mL or the 90th percentile concentration exceeded 100 cfu/100mL for Class AA waters.

Tributaries and other inputs to Mission Creek exceeded FC standards and added FC loads during the dry season but not during the wet season. These include a pipe discharge just below the Tripp Canyon Road crossing of Mission Creek (45MC03.0P), the ditch from the Icicle Creek Irrigation District management flow return (45ISR00.1), Yaksum Creek (45YC00.3 and 45YC02.5), and two culverts at the Pioneer Street bridge crossing (45PRM00.1 and 45MC00.6P). One culvert at Pioneer Street discharges from the City of Cashmere stormwater drain system, and apparently runs in the dry season due to nearby seepage infiltration. The other culvert at Pioneer Street diverts management return flows from the Peshastin Irrigation Canal to Mission Creek; however, the Peshastin Irrigation District also returns water to Brender Creek (at station PS00.1) and did not have FC exceedances there. This suggests there might be other nonpoint contributions to the water within the culvert, which is also part of the City of Cashmere stormwater collection system. The Peshastin Irrigation Canal water should be tested at the point of discharge to the stormwater collection system to confirm it is not a source to Mission Creek.

Table 16. Summary statistics for the 2003 (dry season) and 2004 (wet season) fecal coliform sampling in the Mission Creek basin. Exceedances of water quality standards are bolded.

Station	Class	Dry Season - July through October 2003				Wet season - March through May 2004			
		# of observations > 10% criterion*	# of days station was sampled	Geometric mean of daily samples (cfu/100mL)	90th percentile of daily samples (cfu/100mL)	# of observations > 10% criterion*	# of days station was sampled	Geometric mean of daily samples (cfu/100mL)	90th percentile of daily samples (cfu/100mL)
45MC00.2	A	10	23	91	**1799**	0	6	2	11
45MC00.4	A	1	3	**204**	**679**	0	6	2	7
45PRM00.1	A	4	9	**133**	**2097**	0	4	3	12
45MC00.6P	A	1	4	47	**544**	0	6	7	63
45MC00.6	A	6	8	**842**	**5746**	0	6	2	5
45MC00.9	A	6	10	**384**	**8180**	0	6	2	6
45MC01.2	A	7	10	**221**	**693**	0	6	2	6
45YC00.3	A	3	10	77	**519**	0	3	26	94
45YC02.5	A	1	3	**107**	**910**	0	1	2	NA
45ISR00.1	A	2	4	**205**	**801**	Not sampled	NA	NA	NA
45MC01.7	A	1	4	63	**206**	0	6	1	3
45MC02.3	A	3	4	**174**	**1017**	0	6	1	4
45MC03.0P	A	3	5	**208**	**1600**	0	5	19	95
45MC03.0	A	3	7	**107**	**952**	Not sampled	NA	NA	NA
45MC03.8	A	2	3	**326**	**1111**	0	6	4	32
45MC04.4	A	1	9	83	**256**	0	6	2	6
45MC05.1	A	1	5	76	**338**	0	6	2	5
45MC07.2	A	0	9	27	90	0	6	1	2
45SN00.1	AA	0	5	34	**106**	Not sampled	NA	NA	NA
45MC08.6	AA	0	5	12	31	Not sampled	NA	NA	NA

* The number of observations > 10% criterion is 200 cfu/100 mL for Class A water, and 100 cfu/100 mL for Class AA water

In addition to FC water quality exceedances, there were pH and dissolved oxygen (DO) water quality exceedances throughout the basin during the 2003 (dry season) sampling (Table 17). The pH and DO exceedances occurred during the same critical season of concern as for FC exceedances (i.e., the dry season). Low DO, high pH, and high FC levels are likely due to the same nonpoint sources. Control measures for FC will likely mitigate these other water quality concerns.

Table 17. Instantaneous pH and dissolved oxygen levels exceeding criteria in the Mission Creek basin, 2003-04 sampling.

Station	Date	Time	pH		Station	Date	Time	DO (mg/L)	
45MC00.6	8/18/2003	16:10:00	8.6		45ISR00.1	7/7/2003	12:35:00	7.75	
45MC00.6	3/1/2004	14:05:00	8.51		45MC00.6	8/18/2003	16:10:00	7.77	
45MC00.6	8/4/2003	15:20:00	8.55		45MC00.6P	10/20/2003	11:20:00	7.04	
45MC01.7	9/22/2003	12:50:00	8.72		45MC00.9	9/22/2003	13:30:00	7.19	
45MC01.7	10/6/2003	12:25:00	8.56		45MC00.9	8/18/2003	15:45:00	6.61	
45MC02.3	7/21/2003	14:05:00	8.66		45MC00.9	8/4/2003	15:10:00	7.77	
45MC02.3	7/7/2003	16:30:00	8.55		45MC02.3	8/4/2003	14:15:00	4.39	
45MC03.0	8/4/2003	13:50:00	9.09		45MC02.3	8/18/2003	13:35:00	6.68	
45MC03.0	7/21/2003	13:45:00	8.68		45MC02.3	8/4/2003	10:45:00	6.3	
45MC03.0	8/4/2003	10:25:00	8.72		45PRM00.1	10/20/2003	11:15:00	7.66	
45MC05.1	8/18/2003	11:55:00	8.51		**45SN00.1**	7/21/2003	12:30:00	9.25	
45MC07.2	7/21/2003	12:50:00	8.51	J	**45SN00.1**	8/18/2003	10:30:00	9.4	
45SN00.1	8/18/2003	10:30:00	8.55		45YC00.3	7/21/2003	14:25:00	7.96	
45SN00.1	7/21/2003	12:30:00	8.52	J					

Bold indicates station in Class AA water; J qualifier indicates estimate.
Washington State water quality criteria:
pH between 6.5 and 8.5;
DO not below 8.0 mg/L in Class A water, and not below 9.5 mg/L in Class AA water.

Sand Creek (45SN00.1) is a Class AA water, and the DO values below the 9.5 mg/L criterion may have been due to warm water temperatures as well. Implementation of the Wenatchee National Forest temperature TMDL and the upcoming Wenatchee River temperature TMDL will improve temperature (and therefore DO) as much as possible, and may bring DO into compliance with standards.

Brender Creek and No Name Creek

Brender Creek is approximately 6.8 miles long and drains an area of 6,489 acres (Figure 4). The headwater elevation is 2,666 feet, and the confluence with Mission Creek is at 789 feet. Precipitation ranges from 20 inches per year in the headwaters to 10 inches per year at the mouth.

There are two irrigation-management flow returns on Brender Creek at about RM 3.3 and one return at Pioneer Road (RM 1.2). The irrigation returns augment flow in Brender Creek throughout the dry season. There is a man-made pond (sediment trap) at about RM 0.6. Almost all land ownership in this watershed is private. Orchards and rural development are the dominant land use along lower Brender, outside of the Cashmere city limits and urban growth area (UGA).

No Name Creek, a tributary to Brender Creek, is approximately 0.5 miles long (Figure 5). No Name Creek probably did not exist historically. No Name Creek drains an old wetland in the lower Brender Creek watershed, but also conveys irrigation-management return flow coming down the Sunset Highway road-ditches throughout the irrigation (dry) season. No Name Creek is essentially a roadside ditch along Mill Road in what was once a large wetland, now occupied by the mill and wood waste fill but still containing a spring-fed roadside pond and various seeps. Much of No Name Creek runs through culverts before entering Brender Creek.

Seasonal Variation

Historical data at the mouth of Brender Creek show FC bacteria water quality exceedances throughout the year (with the exception of the November and March geometric mean); however, the historical FC concentrations and loads were seasonally elevated from May through October during the dry season (Figure 11).

There was very little historical data for No Name Creek. Sampling by the Chelan County Conservation District in the 1996 and 2000 water years showed an annual geometric mean FC count of 340 cfu/100mL (n=22 samplings) without any noticeable seasonal pattern (n = 2 per month).

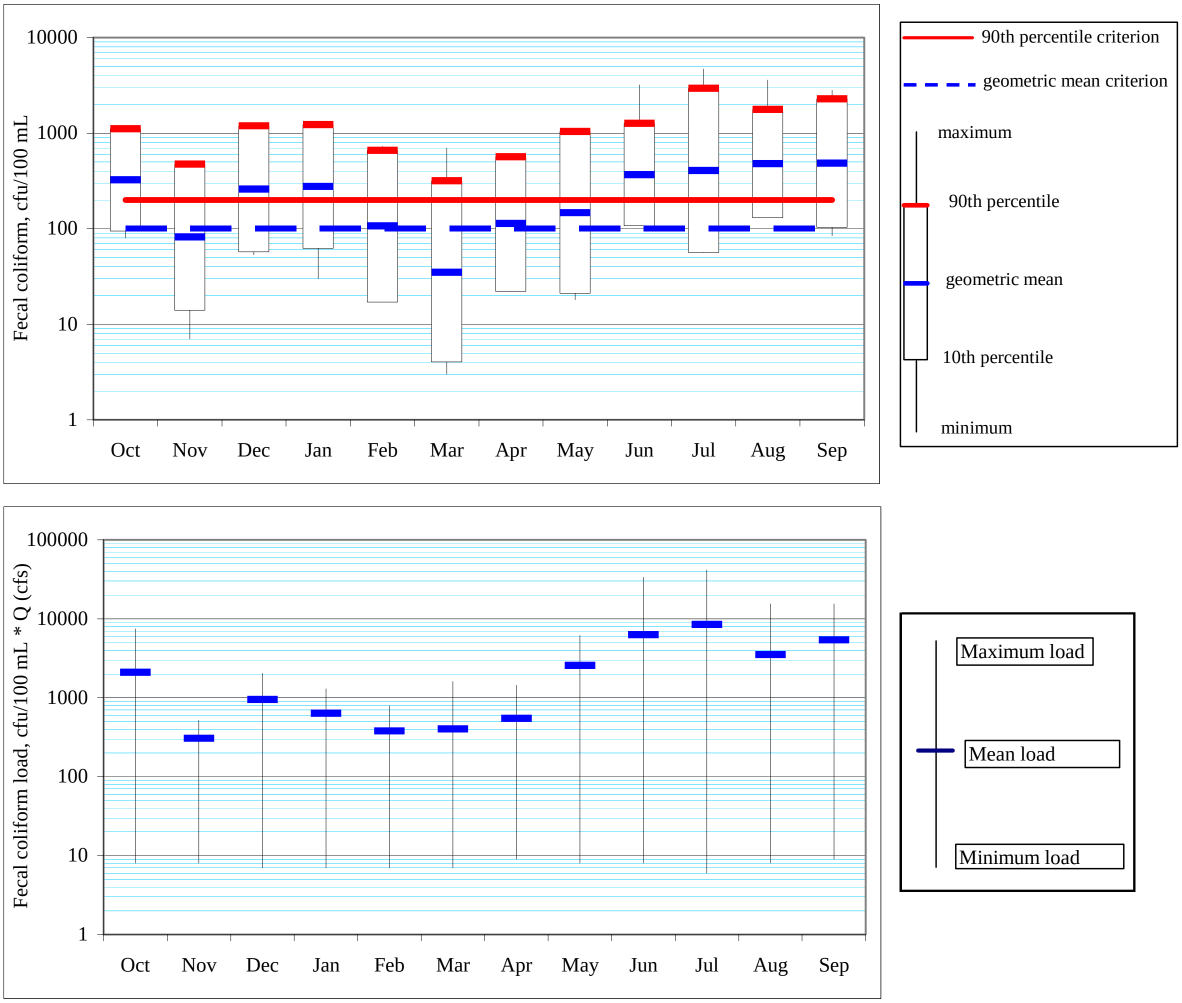


Figure 11. Historical fecal coliform bacteria monthly concentrations and loads in Brender Creek near the mouth (TMDL study station = 45BR00.1). Sampling conducted from 1993-2000 by Chelan County Conservation District and by Ecology (n = 6 to 9 per month).

2003-04 Results

Figures 12 and 13 show flows in Brender and No Name creeks for the 2003-04 sampling dates. Dry-season flows were generally higher than wet-season flows in both creeks due to flow augmentation from irrigation-management return flow during the irrigation season. The irrigation canals were open before the 4/20/04 sampling, evidenced by the increased flow in both creeks during the last two samplings of the wet season.

At times, management return flows apparently exceeded the hydraulic capacity of the natural channel, causing erosion and highly visible turbidity. Irrigation returns to Brender Creek were so great on 9/9/03 that turbidity jumped from a background level of 1 NTU at RM 4.1 (above the irrigation returns) to as high as 70 NTU at RM 1.4 (below the irrigation returns). This exceeds the turbidity water quality standard of only a 5 NTU allowable increase over background levels in streams with turbidity less than 50 NTU. This occurs whenever irrigation water is dumped from the canal, as opposed to just returning for balancing the canal siphon. The turbidity is not from the irrigation water, but instead from erosion in Brender Creek caused by the irrigation water flow addition.

Figure 14 shows FC concentrations detected in Brender Creek for the 2003-04 surveys. There were fewer FC water quality exceedances during the 2004 wet-season surveys; however, concentrations and exceedances increased beginning at RM 2.0 (above Pioneer Rd) in both seasons. Figure 15 shows FC concentrations detected in No Name Creek for the 2003-04 surveys. There was an increase in FC counts at RM 0.3 (at the outlet of the pond on Mill Road) for both seasons.

Table 18 gives FC summary statistics for all sampling sites in the Brender and No Name creek basins. Exceedance of the standards occurred if either the geometric mean concentration exceeded 100 cfu/100mL or the 90^{th} percentile concentration exceeded 200 cfu/100mL.

Brender Creek

Figure 16 shows the net and cumulative dry-season average FC loads observed in Brender Creek. Nearly 85% of the net average FC load entered between RM 2.5 and Pioneer Road (RM 1.2). The reach from RM 1.2 to RM 1.6 has moderate groundwater inflow with observed saturated soils and seepage along the streambanks. There was no FC in groundwater samples taken from piezometers in this reach (Sinclair, 2003; unpublished data). The reach from RM1.6 to RM 2.5 is generally orchard land with about a dozen houses along the creek corridor.

Ideally, the source of the FC bacteria to Bender Creek could be determined to be either from human or non-human sources. If the FC bacteria are from human sources, the reaches should be evaluated for properly functioning onsite septic systems (especially in the saturated soils) and inspected for illegal discharges. If the FC bacteria are from non-human sources, best management practices (BMPs) should be implemented to keep non-human sources from contaminating the creek. There is likely to be some contamination from both human and non-human sources.

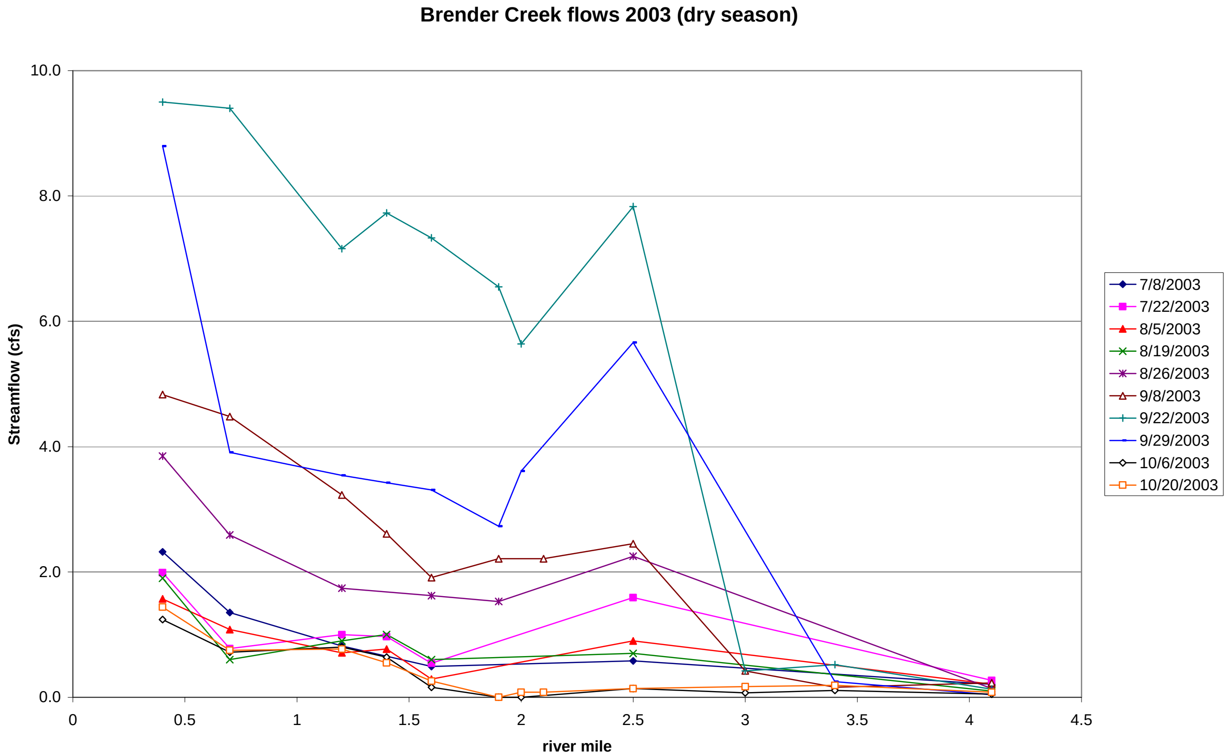
There was no net average FC loading from Pioneer Road (RM 1.2) to the Sunset Highway (RM 0.4). The cumulative average load loss in this reach could be explained by FC die-off or settling within the reach, but also by dilution from irrigation-management return flow at Pioneer Road and wetland drainage around Mill Road. Burgoon and Rickel (2003) found high FC counts in shallow wells adjacent to Brender Creek in the Mill Road area, but determined that groundwater levels in those wells were downgradient of the creek. Sampled irrigation-management return flow to Brender Creek from the Icicle and Peshastin irrigation district canals generally had FC concentrations well below FC standards. Even though there is no apparent loading in the lower part of Brender Creek, additional loading in this area could be masked by the high loading from above.

No Name Creek

Figure 17 shows the net and cumulative average dry-season FC loads observed in No Name Creek. No Name Creek had approximately 25% of the FC cumulative load as Brender Creek. Nearly 90% of the net FC load for No Name Creek entered between RM 0.5 and 0.2. This reach contains a ponded area of the creek used by ducks. There were generally five or six ducks counted during dry-season surveys. Using published manure production characteristics for ducks (ASAE, 1999), the five or six ducks using the pond could potentially account for a majority of the FC load in No Name Creek at such low flow (e.g., mean flow for the 2003 surveys was 0.8 cfs below the pond). However, this area is also in an un-sewered area of the City of Cashmere urban growth area with several businesses and residences using onsite septic systems, possibly in the filled wetland. Burgoon and Rickel (2003) found high FC counts in shallow wells adjacent to No Name Creek.

Ideally, the source of the FC bacteria to No Name Creek could be determined to be either from human or non-human sources. If the FC bacteria are from human sources, the reach between RM 0.5 and 0.2 should be evaluated for properly functioning onsite septic systems and inspected for illegal discharges. If the FC bacteria are from non-human sources, BMPs should be implemented to keep non-human sources from contaminating the creek. There is likely to be some contamination from both human and non-human sources.

The 10% of the FC load entering No Name Creek above the pond area (RM 0.4) is from nonpoint sources entering the roadside ditch. Several businesses and residences along Sunset Highway could be contributing. There was no net loading in the lowest reach of No Name Creek from RM 0.2 to the mouth (RM 0.1). The cumulative load loss in this reach could be explained by FC loss (die-off or settling within the reach) or dilution (there is an increase in flow at the mouth apparently from wetland drainage into the creek). Apparently, No Name Creek has been routed through an underground culvert from Sunset Highway to near the mouth; recent fill and grading work is evident.



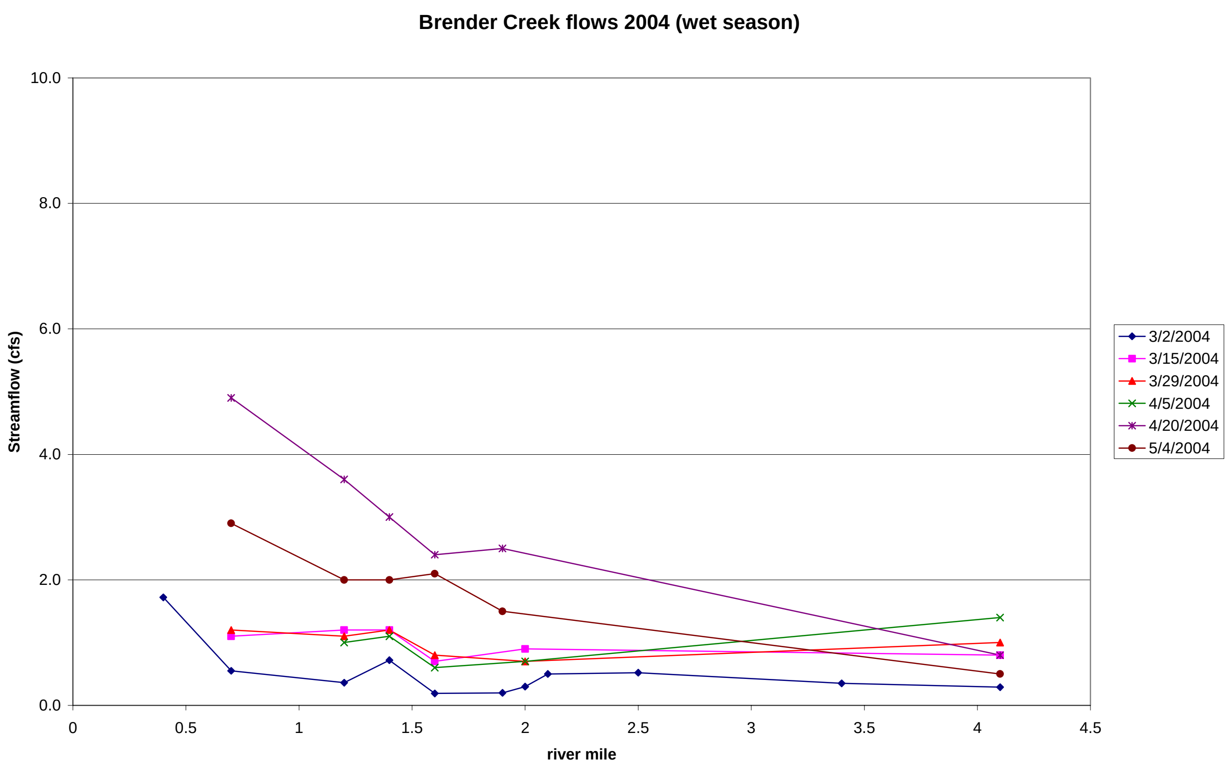
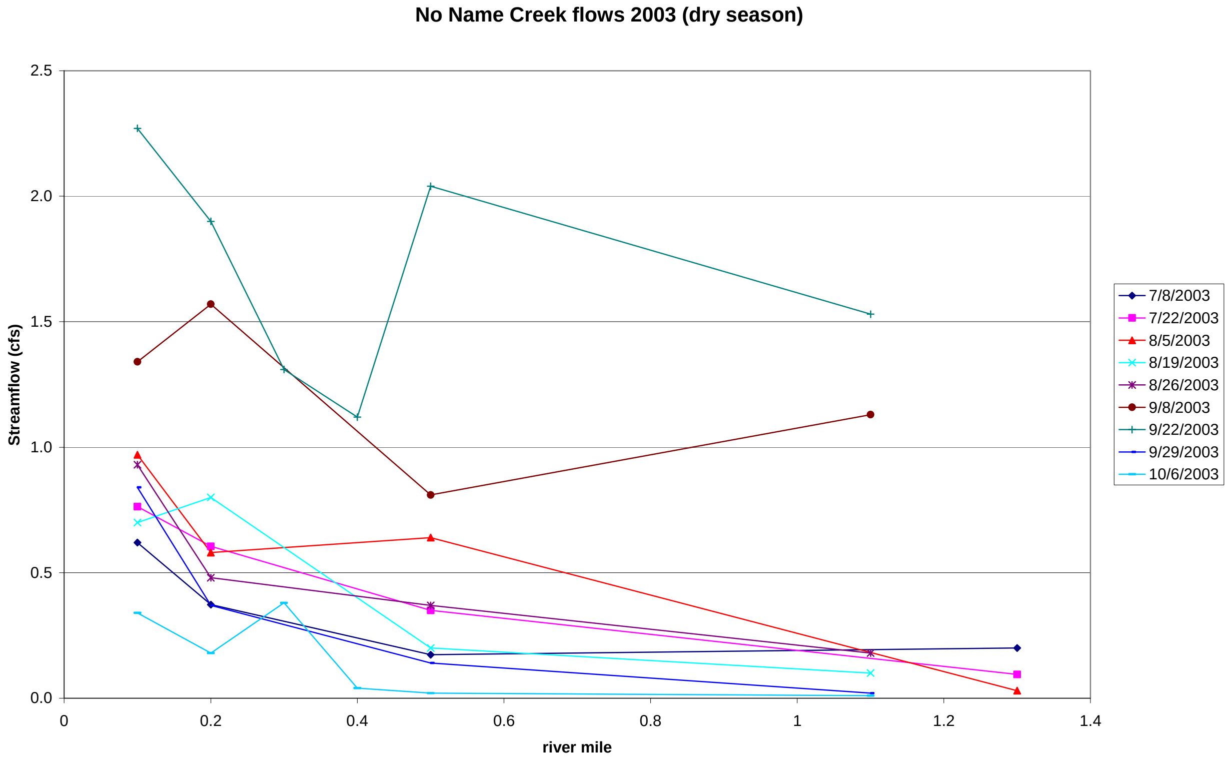


Figure 12. Brender Creek flows during the 2003-04 sampling surveys.



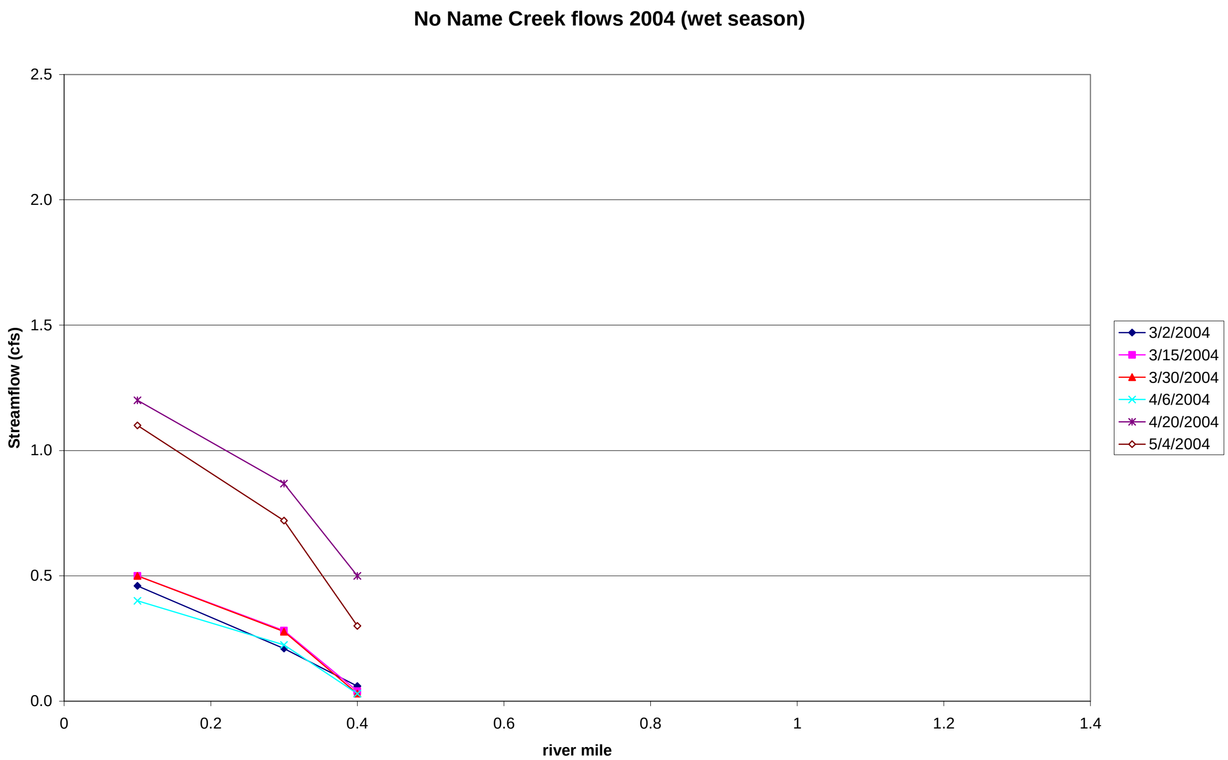


Figure 13. No Name Creek flows during the 2003-04 sampling surveys.

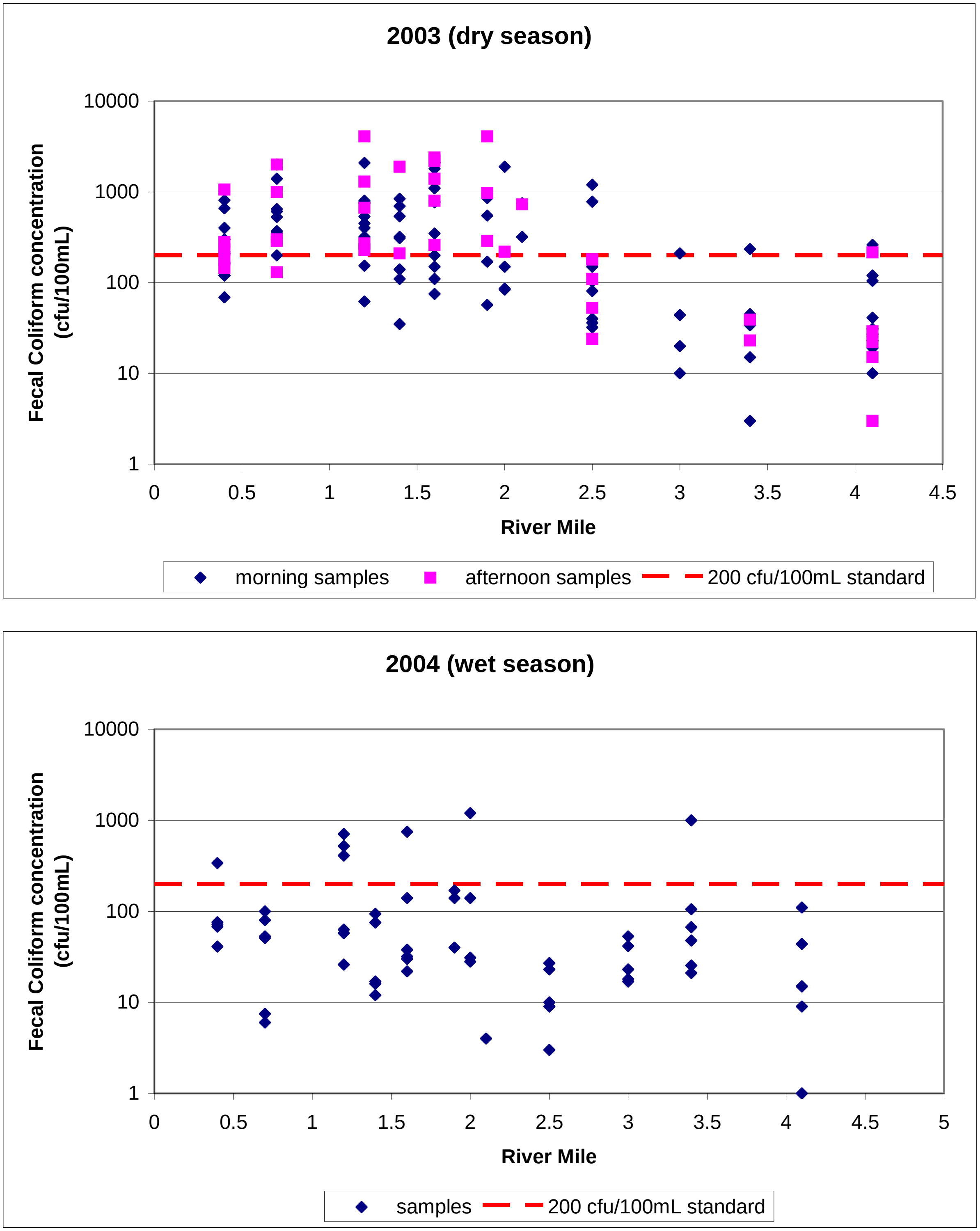


Figure 14. Fecal coliform bacteria concentrations in Brender Creek during the July through October 2003 (dry season) and the March through May 2004 (wet season) sampling surveys.

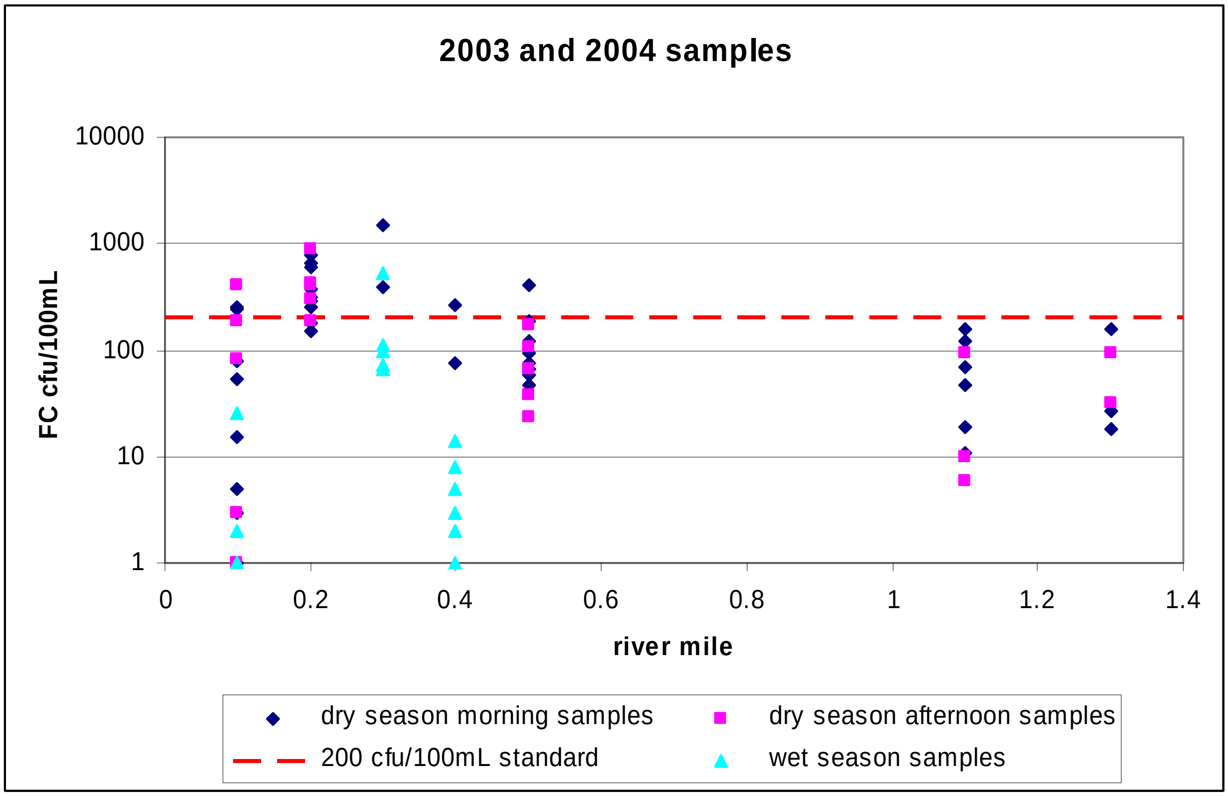
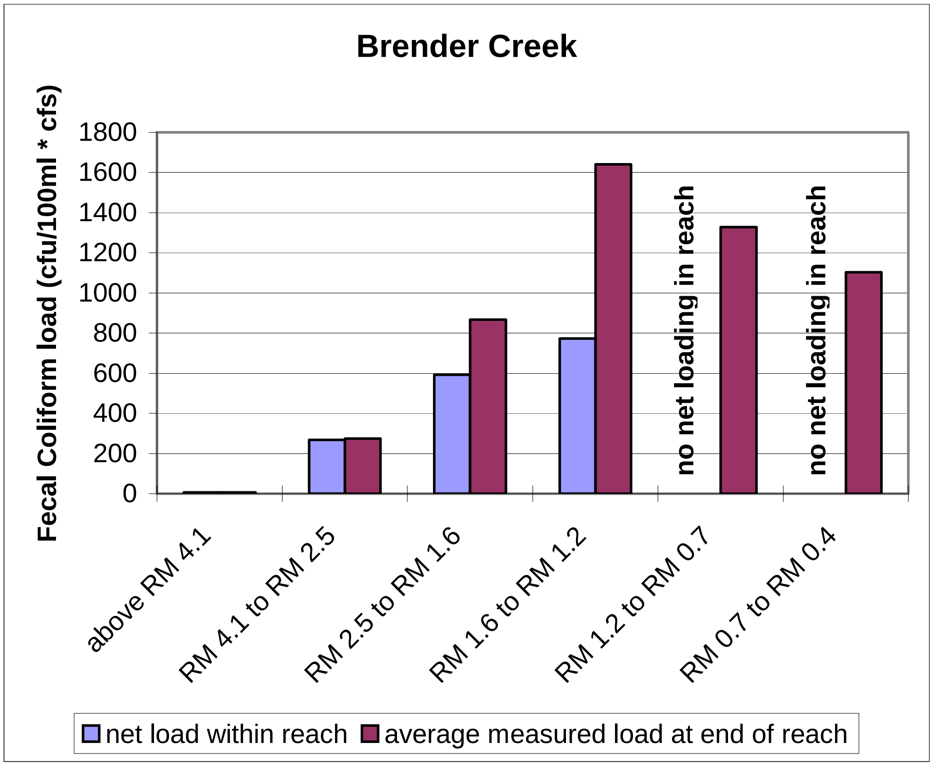


Figure 15. Fecal coliform bacteria concentrations in No Name Creek during the July through October 2003 (dry season) and the March through May 2004 (wet season) sampling surveys.

Table 18. Summary statistics for 2003 (dry season) and 2004 (wet season) fecal coliform sampling in Brender Creek and No Name Creek. Exceedances of water quality standard are bolded.

Station	Class	Dry Season - July through October 2003				Wet season - March through May 2004			
		# of observations over 200 cfu/100mL	# of days station was sampled	Geometric mean of daily samples (cfu/100mL)	90th percentile of daily samples (cfu/100mL)	# of observations over 200 cfu/100mL	# of days station was sampled	Geometric mean of daily samples (cfu/100mL)	90th percentile of daily samples (cfu/100mL)
45BR00.4	A	6	10	**231**	**632**	1	5	88	**243**
45BR00.7	A	10	10	**521**	**1394**	0	6	31	151
45PS00.1	A	0	6	30	191	0	2	6	24
45BR01.2	A	8	10	**454**	**1794**	3	6	**156**	**929**
45BR01.4	A	5	8	**263**	**1166**	0	5	30	102
45BR01.6	A	7	10	**453**	**2237**	1	6	66	**374**
45BR01.9	A	3	4	**396**	**3147**	0	3	98	**269**
45BR02.0	A	2	3	**309**	**2469**	1	4	**110**	**1042**
45BR02.1	A	2	2	**627**	**867**	0	1	4	NA
45BR02.5	A	2	10	**120**	**502**	0	6	11	29
45PR00.1A (B)	A	0	6	46	63	0	2	3	9
45BR03.0	A	1	4	37	197	0	5	27	53
45ID00.1	A	0	7	9	25	0	1	3	NA
45BR03.4	A	1	5	38	166	1	6	75	**454**
45BR04.1	A	1	10	39	167	0	6	15	113
45NN00.1	A	3	9	27	**413**	0	6	2	10
45R050	A	10	12	**497**	**1479**	Not sampled	NA	NA	NA
45NN00.2	A	8	9	**402**	**799**	Not sampled	NA	NA	NA
45NN00.3	A	2	2	**765**	**2593**	1	6	**111**	**311**
45NN00.4	A	1	2	**141**	**429**	0	6	4	13
45NN00.5	A	1	9	93	**242**	Not sampled	NA	NA	NA
45NN01.1 (1.3)	A	0	9	42	148	Not sampled	NA	NA	NA



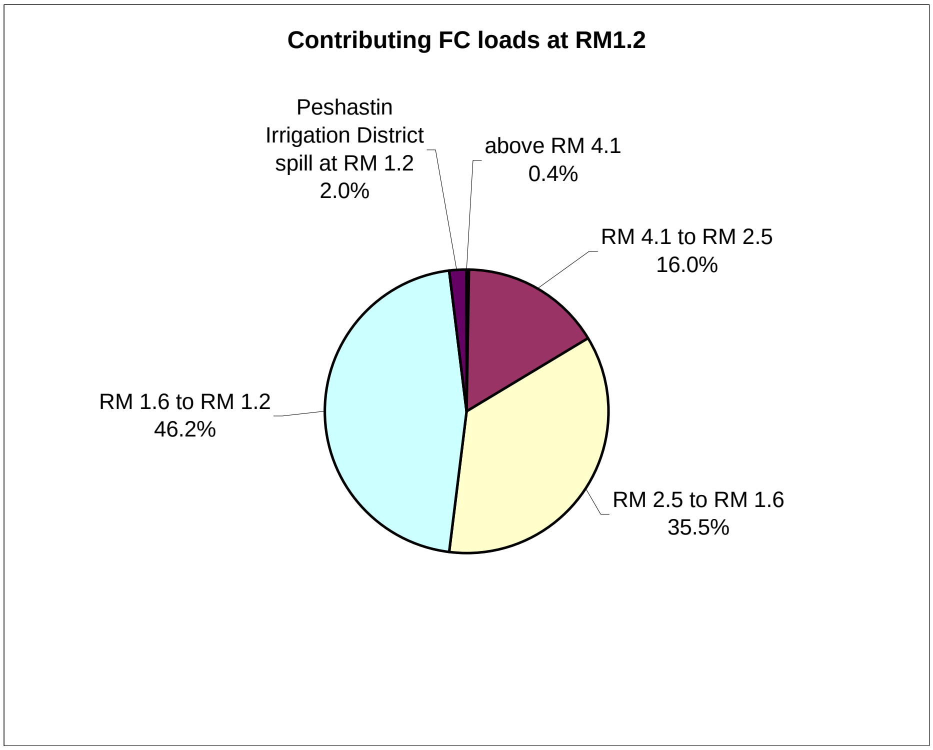
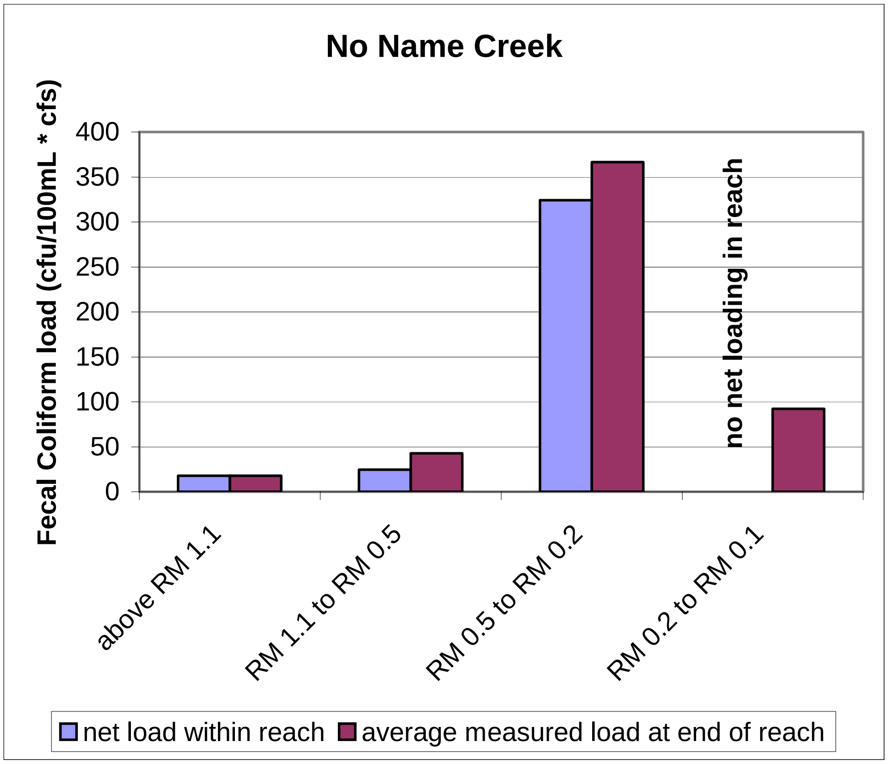


Figure 16. Average measured and net reach fecal coliform loads in Brender Creek with percent contributing loads for July through October 2003 (n=10).



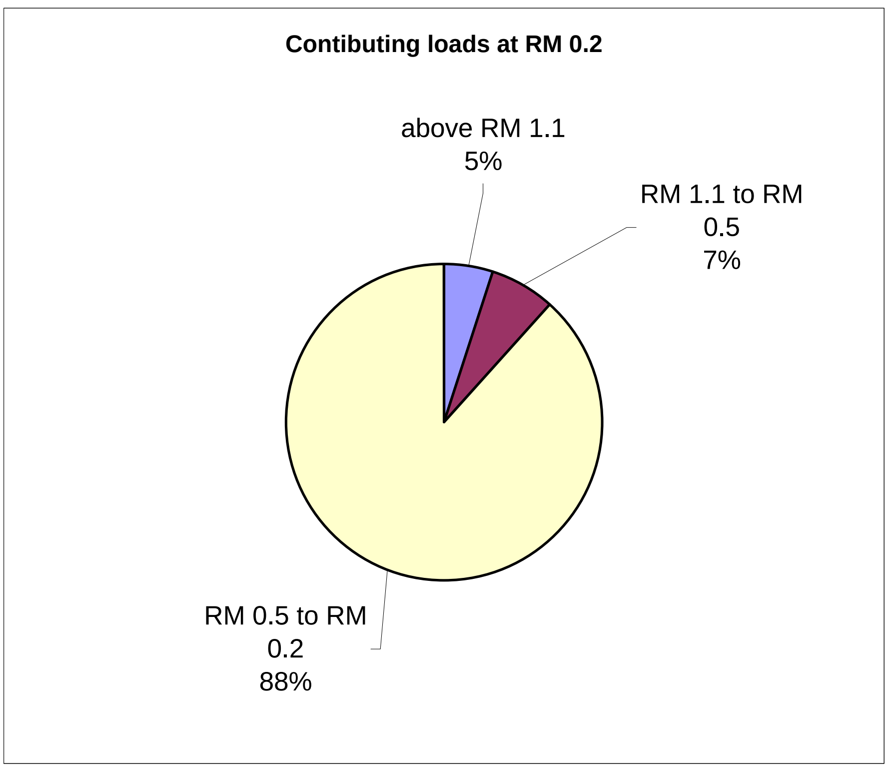


Figure 17. Average measured and net reach fecal coliform loads in No Name Creek with percent contributing loads for July through October 2003 (n=9).

In addition to FC water quality exceedances, there were pH and dissolved oxygen (DO) water quality exceedances throughout the Brender Creek basin (Table 19). The pH and DO exceedances were primarily observed during 2003 (dry season); however, several pH and DO exceedances were observed in March and April 2004 (wet-season) in Brender Creek. Low DO, high pH, and high FC levels are likely due to the same nonpoint sources. Control measures for FC will likely mitigate these other water quality concerns.

Table 19. Instantaneous pH and dissolved oxygen levels exceeding criteria in Brender and No Name creek basins, 2003-04 sampling.

Station	Date	Time	pH		Station	Date	Time	DO (mg/L)	
45BR00.7	4/5/2004	15:35:00	8.65		45BR00.4	10/20/2003	16:00:00	6.41	
45BR02.0	4/5/2004	14:20:00	8.54		45BR00.4	8/19/2003	12:10:00	7.59	
45NN01.1	8/19/2003	13:45:00	8.94		45BR00.4	7/22/2003	11:40:00	6.05	
45NN01.3	7/8/2003	15:30:00	8.53		45BR00.4	8/26/2003	10:10:00	7.15	
45NN01.3	7/22/2003	13:05:00	8.59		45BR00.4	8/5/2003	15:35:00	7.22	
45NN01.3	8/5/2003	15:45:00	8.68		45BR00.4	8/5/2003	11:10:00	6.89	
45PR00.1A	8/19/2003	10:05:00	8.63		45BR00.4	10/7/2003	9:40:00	7.03	
45PS00.1	9/30/2003	14:43:00	8.62		45BR00.5	10/20/2003	15:45:00	6.98	J
45PS00.1	7/8/2003	14:15:00	8.56		45BR00.5	10/7/2003	9:25:00	7.02	
45PS00.1	8/5/2003	14:40:00	8.54		45BR01.4	10/20/2003	15:00:00	7.87	
45PS00.1	8/26/2003	13:50:00	8.66		45BR02.0	3/2/2004	11:15:00	6.42	
					45ID00.1	9/23/2003	8:55:00	7.75	J
					45ID00.1	8/19/2003	9:45:00	7.91	
					45ID00.1	9/9/2003	8:30:00	6.89	
					45ID00.1	7/22/2003	9:10:00	7.94	
					45ID00.1	8/5/2003	9:25:00	6.59	
					45NN00.2	10/7/2003	10:45:00	7.08	
					45NN00.3	10/7/2003	10:30:00	7.05	
					45NN01.3	7/22/2003	13:05:00	7.96	
					45PRM00.1	10/20/2003	11:15:00	7.66	

J qualifier indicates estimate.

Washington State water quality criteria:

pH between 6.5 and 8.5;

DO not below 8.0 mg/L in Class A water, and not below 9.5 mg/L in Class AA water.

Chumstick Creek

Chumstick Creek has a total river mileage of 13.0 miles and drains a watershed area of 49,920 acres (Figure 2). The elevation at the headwaters is 2,400 feet (732 meters) and the mouth of Chumstick Creek at its confluence with the Wenatchee River is 1,068 feet (326 meters) above mean sea level. There are only minor surface water withdrawals in the watershed for limited agricultural uses and three known irrigation-management flow returns.

Anthropogenic (human-caused) impacts in the watershed include construction and maintenance for State Highway 209 and a utility corridor, railroad activities, and a significant amount of private ownership along the creek. There is a potential for additional development on steep hills near Chumstick Creek with a great potential for erosion and other impacts on the creek. Private lands consist of limited agriculture and farming with several small hobby farms as well as extensive Longview Fiber inholdings. U.S. Forest Service lands in the watershed are used largely for dispersed recreation. There are no wilderness or state forest lands in the subbasin.

Seasonal Variation

Limited historical fecal coliform (FC) bacteria data for Chumstick Creek near the mouth show a patchy pattern of FC water quality exceedances occurring during the drier months from July through October (Figure 18). Historical FC loads appear elevated seasonally from April through September, but the limited data (e.g., n = 3 for some months) may be influencing the historical summary data.

Likewise, the historical FC data for Chumstick Creek at RM 9.1 were limited but generally showed elevated FC concentrations and loads from May through October, encompassing the end of the spring runoff and the dry season (Figure 19).

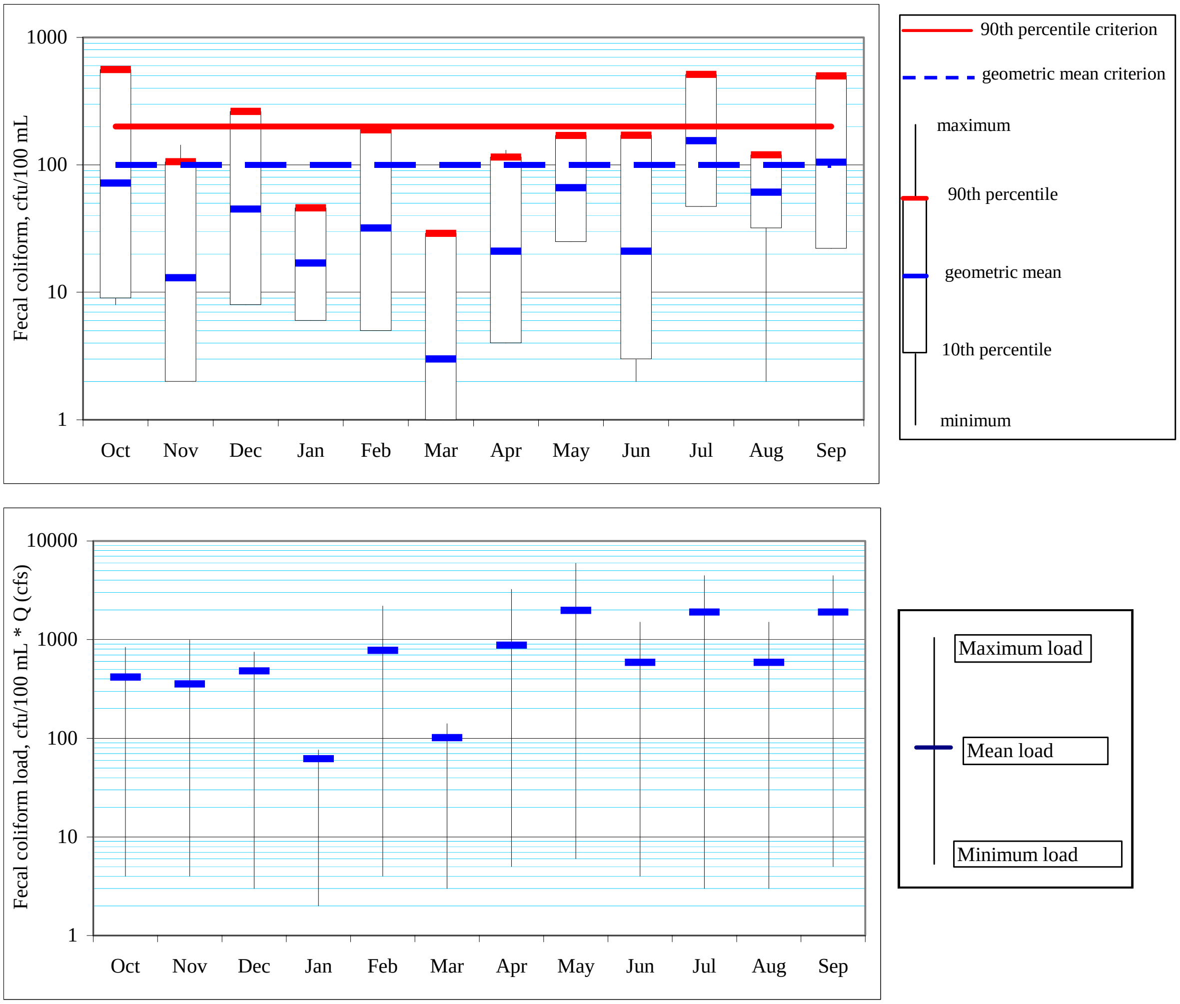


Figure 18. Historical fecal coliform bacteria monthly concentrations and loads in Chumstick Creek near the mouth (TMDL study station = 45CS00.3). Sampling conducted from 1993-2000 by the Chelan County Conservation District and by Ecology (n = 3 to 6 per month).

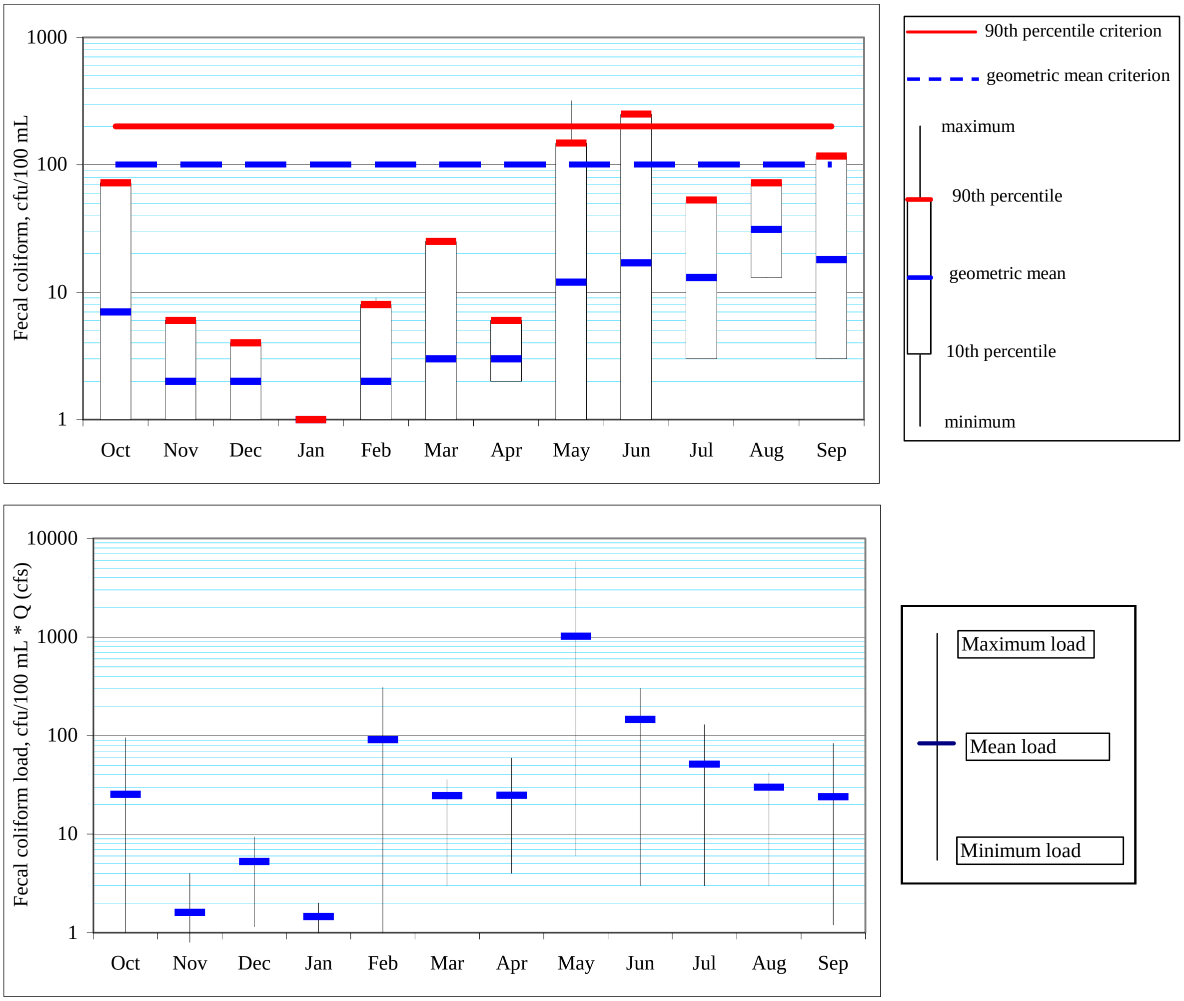


Figure 19. Historical fecal coliform bacteria monthly concentrations and loads in Chumstick Creek near the mouth (TMDL study station = 45CS09.1). Sampling conducted from 1993-2000 by the Chelan County Conservation District (n = 3 to 6 per month).

2003-04 Results

Figure 20 shows flows in Chumstick Creek for the 2003-04 sampling dates. Streamflow in Chumstick Creek was discontinuous below RM 3.8 (i.e., the creek went dry) from late August 2003 until late October 2003. Flow returned at the mouth of Chumstick Creek during the dry season, primarily from irrigation-management return flow, but also from upstream groundwater seepage starting near RM 1.0. The 2004 (wet-season) flows were much higher than the dry-season flows and generally increased moving downstream.

Figure 21 shows FC concentrations detected in Chumstick Creek for the 2003-04 surveys. There were essentially no FC water quality exceedances during the 2004 wet-season surveys; however, concentrations and exceedances increased beginning at RM 8.6 (below the Little Chumstick Creek mouth) in both seasons.

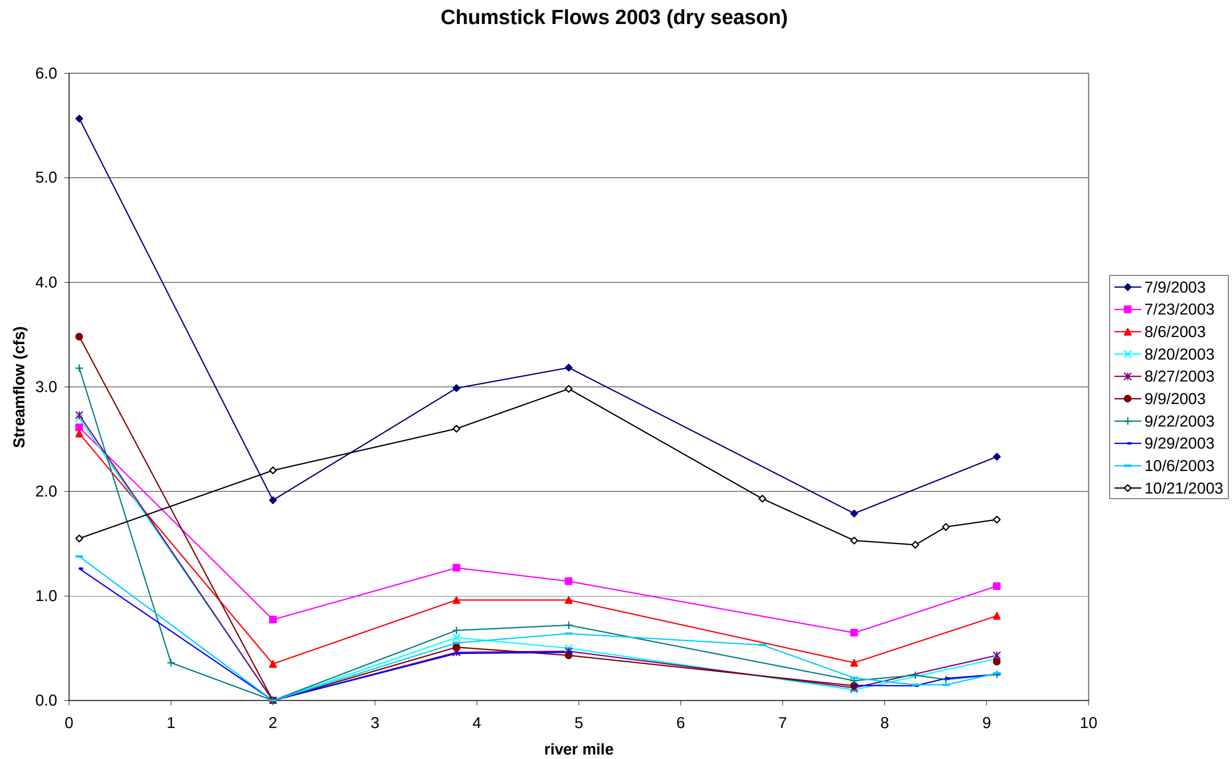
Table 20 gives FC summary statistics for all sampling sites in the Chumstick Creek watershed. Exceedances of the standards occurred if either the geometric mean concentration exceeded 100 cfu/100mL or the 90^{th} percentile concentration exceeded 200 cfu/100mL for Class A waters or if either the geometric mean concentration exceeded 50 cfu/100mL or the 90^{th} percentile concentration exceeded 100 cfu/100mL for Class AA waters. FC exceedances were observed in the following tributary creeks: Little Chumstick, Eagle, and Van.

During the dry season, the upper-most reach of Chumstick Creek (station 45CS11.3) did not meet (exceeded) the Class A FC water quality criteria; however, the next downstream site (45CS09.1) did meet criteria. Moving downstream, FC concentrations increased again, and Class A exceedances began to occur.

Tributaries and other inputs to Chumstick Creek exceeded FC standards, and some added FC loads. Little Chumstick Creek was dry in September and October 2003, and the mouth of Eagle Creek was dry from July 2003 throughout the rest of the dry-season sampling ending in October 2003. Several other sites in the upper-most reaches of the basin are in Class AA water and failed to meet the Class AA FC criteria (all sites on Van and upper Eagle creeks).

Figure 22 shows the net and cumulative dry-season average FC loads observed in upper Chumstick Creek. Cumulative FC loads in Chumstick Creek were slightly lower than those in No Name Creek. For most of the dry season, Chumstick was dry at RM 2.0, so only the upper portion of the creek (above RM 3.8) is evaluated in the reach load analysis. Nearly 50% of the net FC load entered upper Chumstick Creek between RM 9.1 and 7.7. This stretch of the creek is characterized as having primarily rural land use with agriculture, onsite septic systems, and wildlife potentially contributing as nonpoint sources.

Flow returned at the mouth of Chumstick Creek, primarily from nearby irrigation returns, but also from upstream groundwater seepage. Generally, the irrigation returns had very low FC concentrations, so the FC load at the mouth can be attributed to land-use and nonpoint sources in the reach above the mouth.



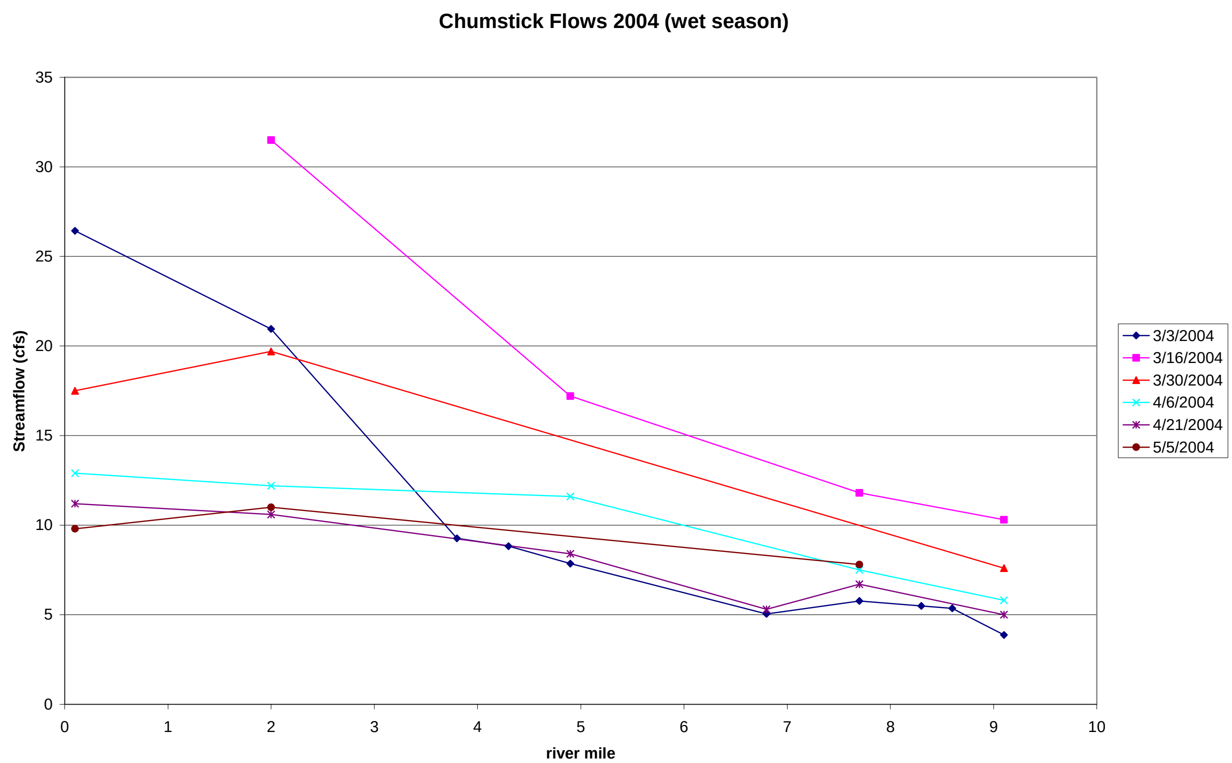
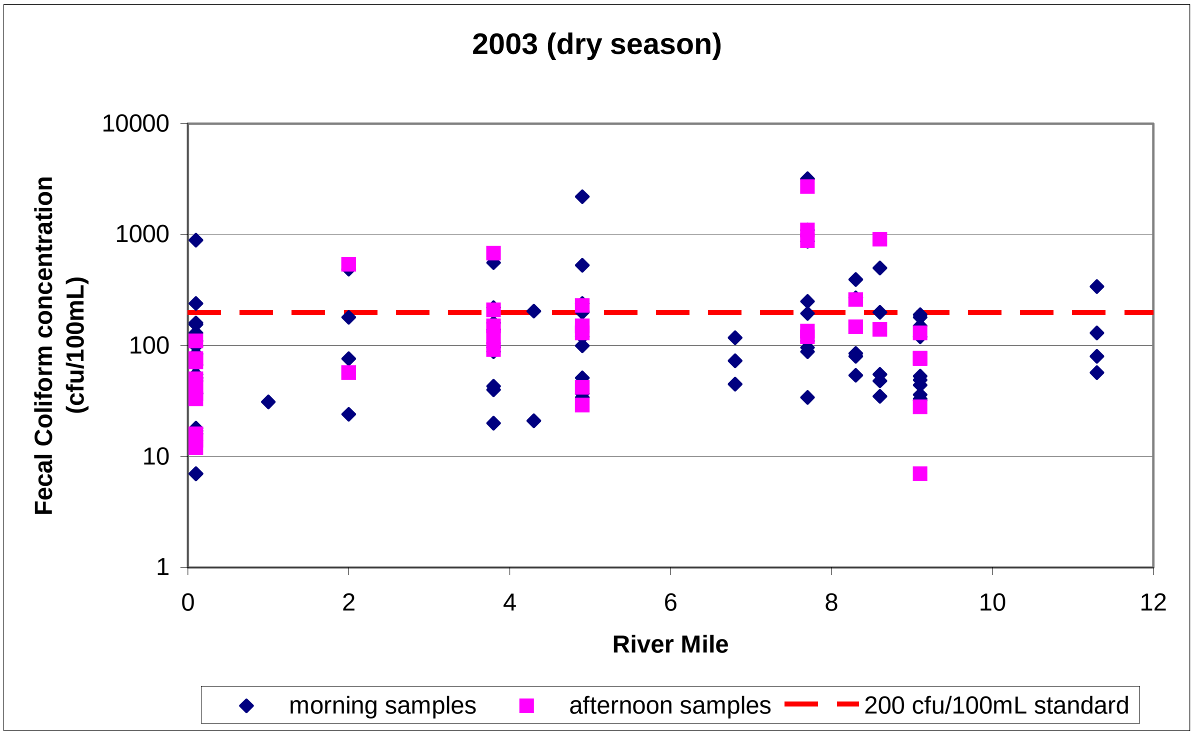


Figure 20. Chumstick Creek flows during the 2003-04 sampling surveys.



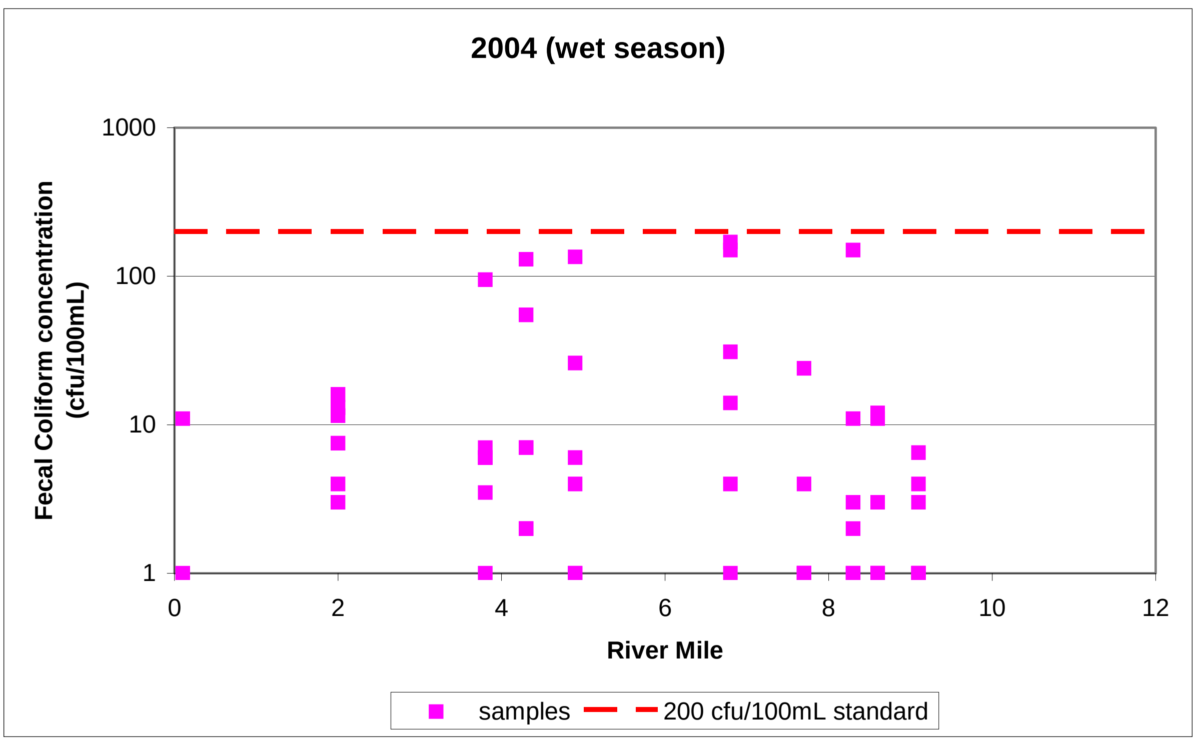
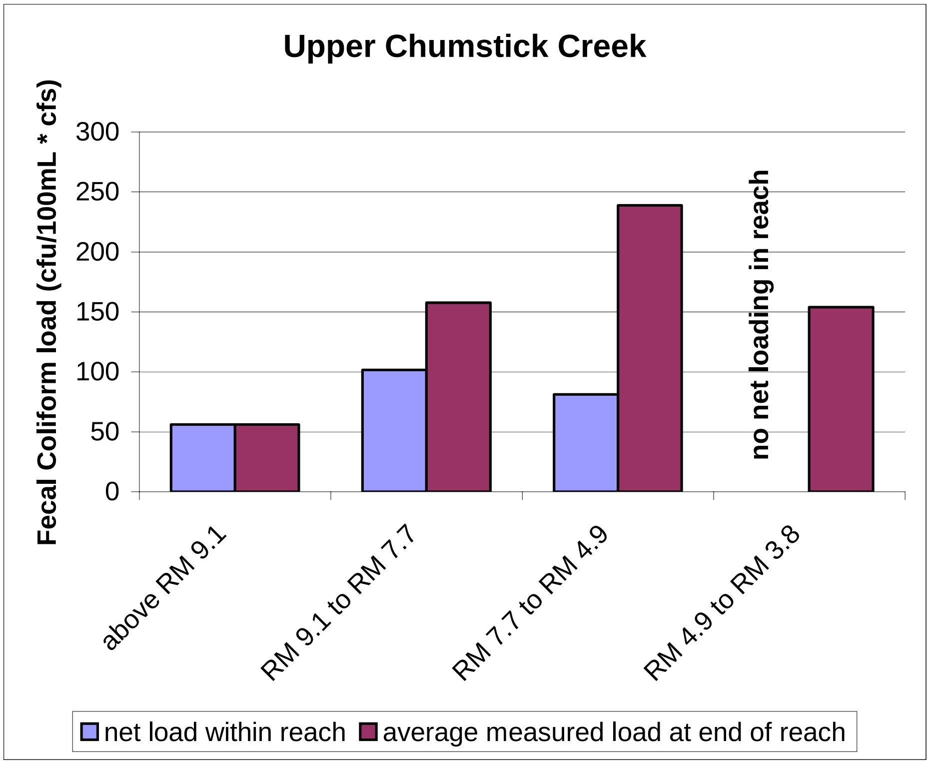


Figure 21. Fecal coliform bacteria concentrations in Chumstick Creek during the July through October 2003 (dry season) and the March through May 2004 (wet season) sampling surveys.

Table 20. Summary statistics for 2003 (dry season) and 2004 (wet season) fecal coliform sampling in the Chumstick Creek basin. Exceedances of water quality standards are bolded.

Station	Class	Dry Season - July through October 2003				Wet season - March through May 2004			
		# of observations > 10% criterion*	# of days station was sampled	Geometric mean of daily samples (cfu/100mL)	90th percentile of daily samples (cfu/100mL)	# of observations > 10% criterion*	# of days station was sampled	Geometric mean of daily samples (cfu/100mL)	90th percentile of daily samples (cfu/100mL)
45CR00.1	A	0	10	30	94	0	6	2	24
45FX00.1	A	2	10	14	156	0	2	1	1
45CS00.1	A	2	10	95	**391**	0	2	3	29
45CS02.0	A	1	4	**110**	**596**	0	6	8	18
45CS03.8	A	3	10	**106**	**368**	0	6	7	45
45CS04.3	A	1	2	66	**517**	0	6	11	97
45CS04.9	A	5	10	**138**	**684**	0	6	7	77
45CS06.8	A	0	3	73	135	0	6	19	**252**
45CS07.7	A	5	10	**339**	**2449**	0	6	2	11
45CS08.3	A	2	5	**121**	**315**	0	6	5	54
45CS08.6	A	2	5	**127**	**525**	0	6	3	13
45CS09.1	A	0	10	66	179	0	6	2	6
45CS11.3	A	1	4	**119**	**322**	Not sampled	NA	NA	NA
45LC00.1	A	1	5	63	**366**	0	6	10	77
45EG00.3	A	1	1	**235**	NA	0	6	2	3
45EG00.9	A	2	8	85	**378**	0	5	2	6
45EG05.8	AA	2	10	**54**	**115**	0	6	3	9
45VC00.1	AA	8	10	**190**	**781**	0	6	5	48
45VC00.5	AA	0	4	49	**117**	Not sampled	NA	NA	NA

* The number of observations > 10% criterion is 200 cfu/100 mL for Class A water, and 100 cfu/100 mL for Class AA water



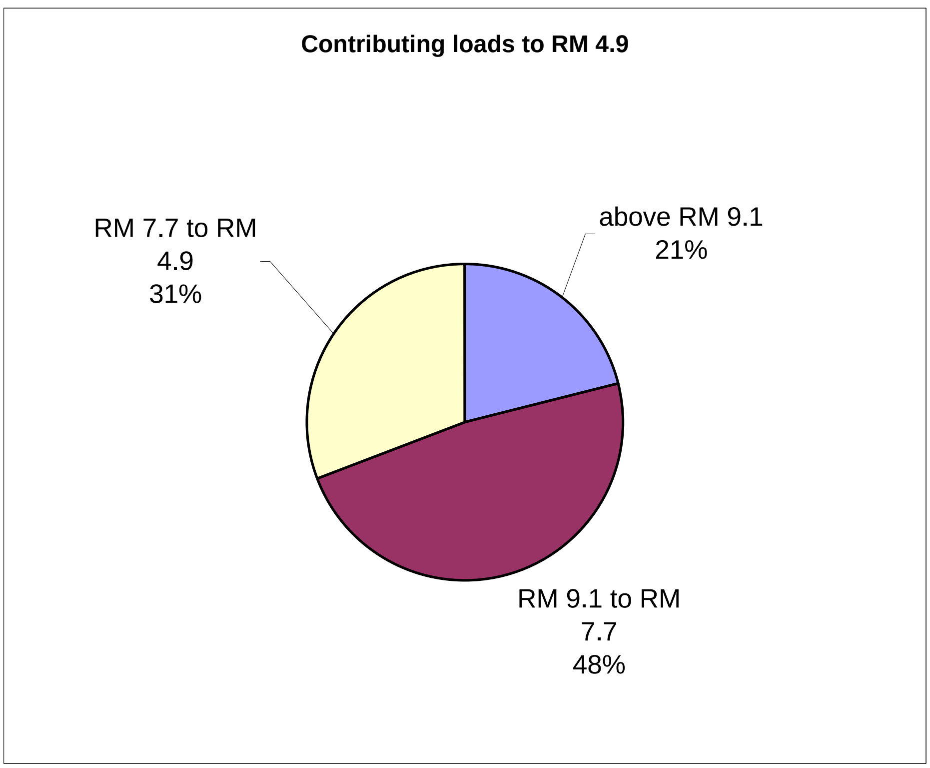


Figure 22. Average measured and net reach fecal coliform bacteria loads in upper Chumstick Creek with percent contributing loads for July through October 2003 (n=10).

In addition to FC water quality exceedances, there were pH and dissolved oxygen (DO) water quality exceedances throughout the Chumstick Creek basin (Table 21). All of the DO and most of the pH exceedances were observed during 2003 (dry season sampling); however, borderline pH exceedances were also observed May 5, 2004 (wet-season sampling) in Eagle and Van creeks and the Icicle Irrigation management return flow. Low DO, high pH, and high FC levels are likely due to the same nonpoint sources. Control measures for FC will likely mitigate these other water quality concerns.

Van Creek and upper Eagle Creek are in Class AA water, and the DO excursions below the 9.5 mg/L criterion may have been due to warm water temperatures. Implementation of the Wenatchee National Forest temperature TMDL and the upcoming Wenatchee River temperature TMDL will likely improve temperature (and therefore DO) as much as possible, and may bring DO into compliance with standards.

Table 21. Instantaneous pH and dissolved oxygen levels exceeding criteria in the Chumstick Creek basin, 2003-04 sampling.

Station	Date	Time	pH		Station	Date	Time	DO (mg/L)	
45CSRRR	5/5/2004	15:00:00	8.55		45CS01.0	10/1/2003	11:10:00	7.73	
45EG00.3	7/9/2003	16:05:00	8.53		45CS01.0	9/24/2003	15:00:00	5.62	J
45EG00.3	5/5/2004	13:50:00	8.55		45EG00.9	9/10/2003	13:05:00	7.93	
45EG00.9	5/5/2004	13:25:00	8.52		45EG00.9	8/20/2003	13:30:00	6.9	
45EG05.8	8/27/2003	11:00:00	8.55		**45EG05.8**	7/23/2003	12:10:00	9.2	
45EG05.8	8/20/2003	12:30:00	8.71		**45EG05.8**	10/21/2003	14:00:00	9.22	
45VC00.1	8/27/2003	15:30:00	8.62		**45EG05.8**	8/6/2003	16:00:00	9.24	
45VC00.1	8/20/2003	12:40:00	8.66		**45EG05.8**	8/27/2003	15:15:00	9.35	
45VC00.1	7/9/2003	15:40:00	8.63		**45EG05.8**	8/20/2003	12:30:00	9.05	
45VC00.1	8/27/2003	11:05:00	8.63		45LC00.1	8/6/2003	13:20:00	7.92	
45VC00.1	5/5/2004	12:45:00	8.52		**45VC00.1**	8/27/2003	15:30:00	9.21	
					45VC00.1	7/23/2003	12:40:00	8.94	
					45VC00.1	7/9/2003	15:40:00	9.39	
					45VC00.1	10/21/2003	13:48:00	9.37	
					45VC00.1	8/6/2003	16:20:00	8.77	
					45VC00.1	8/6/2003	10:45:00	9.26	
					45VC00.5	10/21/2003	13:30:00	9.24	

Bold indicates station in Class AA water; J qualifier indicates estimate.

Washington State water quality criteria:

pH between 6.5 and 8.5;

DO not below 8.0 mg/L in Class A water, and not below 9.5 mg/L in Class AA water.

Load Capacity and Allocations

The critical season of concern for the fecal coliform (FC) bacteria TMDL in the Mission, Brender, and Chumstick creek basins is the dry season, July through October. This period encompasses the irrigation season in the Wenatchee basin. In some instances, the creeks and tributary flows were augmented by irrigation-management return flow above wet-season flow levels (e.g., Brender and No Name creeks). In almost all cases, FC loads were greater during the dry season. The exceptions to this were the upper Brender Creek stations (45BR04.1 and 45BR03.4), Little Chumstick Creek (45LC00.1), and Chumstick Creek RM 4.3 (45CS04.3) which apparently experience some additional FC runoff loading during the wet season. In all cases except one, the 90th percentile was the most restrictive statistic not meeting criteria, so load reductions were based on the 90th percentile statistic.

Table 22 gives the target load reductions necessary to meet standards for each basin. The mouths of Mission, Brender, and Chumstick creeks, as well as additional key stations, were selected as compliance points to protect the creeks. The upstream stations were included because attaining compliance at the downstream site could still leave the upstream sites potentially out of compliance.

All tributaries, including point (discrete) sources such as culverts and irrigation-management flow returns, were given mouth or end-of-pipe compliance points for FC reductions. Eagle and Van creeks were also given upstream compliance points.

Margin of Safety

An implicit margin of safety (MOS) was applied to the FC bacteria TMDL as follows: Target reductions were based on a 90th percentile of a log-normal distribution. This is often more conservative than the water quality criterion which allows for 10% of the FC samples to exceed the criterion without considering the distribution of the data.

Table 22. Summary of target reductions needed in Wenatchee River basin tributaries to comply with the 90th percentile fecal coliform water quality criterion.

Station	Class	Site Description	Fecal Coliform Reduction (%)
Mission Creek and tributaries			
45MC00.2	A	Mission Creek at Sunset Highway	89%
45MC00.9	A	Mission Creek at Creekside Place	98%
45MC01.2	A	Mission Creek at Binder Road	71%
45MC03.0	A	Mission Creek at Tripp Canyon	79%
45MC05.1	A	Mission Creek below Bear Gulch	41%
45PRM00.1	A	Peshastin Irrigation return at Pioneer Road	90%
45MC00.6P	A	Pipe discharge at Pioneer Road	63%
45YC00.3	A	Yaksum Creek at Coates Road	61%
45MC03.0P	A	Pipe discharge downstream of Tripp Canyon bridge	87%
45SN00.3	AA	Sand Creek near mouth	6%
Brender Creek and tributaries			
45BR00.4	A	Brender Creek at Sunset Highway	68%
45BR01.2	A	Brender Creek at Pioneer Road	89%
45BR01.9	A	Brender Creek at RM 1.9	94%
45BR02.5	A	Brender Creek at RM 2.5	60%
45NN00.1	A	No Name Creek at mouth	52%
45NN00.3	A	No Name Creek below pond on Mill Road	92%
Chumstick Creek and tributaries			
45CS00.1	A	Chumstick Creek near mouth	49%
45CS04.9	A	Chumstick Creek at RM 4.9 on Hwy 209	71%
45CS07.7	A	Chumstick Creek at Camp 12 Road	92%
45CS11.3	A	Chumstick Creek above Second Creek	38%
45EG00.3	A	Eagle Creek near mouth	57% [1]
45EG00.9	A	Eagle Creek above mouth	47%
45EG05.8	AA	Eagle Creek above Van Creek	13%
45VC00.1	AA	Van Creek near mouth	87%
45VC00.5	AA	Van Creek on USFS land	14%
45LC00.1	A	Little Chumstick Creek near mouth	45%

[1] compliance basis is the geometric mean statistic

Conclusions

Dry-season and wet-season sampling was conducted in 2003-04 on tributaries to the Wenatchee River. Sampling confirmed that fecal coliform (FC) bacteria values did not meet (exceeded) the Washington State water quality standards in Mission, Brender, and Chumstick creeks and several of their tributaries.

In general, historical and recent FC data show that all the creeks had higher FC concentrations and loads during the low-flow (dry season) when there was less dilution, indicating non-runoff sources of pollution. The exceptions to this were the headwaters of Brender Creek and Little Chumstick Creek, where slightly higher loads were observed during the wet season.

Most of the upper reaches of the creeks in the study area originate within the Wenatchee National Forest boundaries. All sites in these reaches met the Class A FC water quality criteria, except for the upper Chumstick Creek site, 45CS11.3. However, several of the sites in the upper-most reaches are in Class AA water and failed to meet the Class AA FC criteria (i.e., all sites on Van Creek, upper Eagle Creek, and Sand Creek).

Moving downstream in all the creeks, FC concentrations increased, and Class A exceedances began to occur. A mass-balance evaluation showed certain reaches contributing larger loads than others, in some cases contributing to FC exceedances at downstream stations (i.e., the bacteria were transported downstream with the streamflow).

Target FC reductions are established for Mission, Brender, and Chumstick creek basins.

Mission Creek
There were significant increases in FC concentrations and loads between Binder Road (RM 1.2) and Creekside Place (RM 0.9). This reach of Mission Creek is partly within Cashmere city limits, but most of the reach is within the un-sewered part of the City of Cashmere urban growth area.

Brender Creek
Brender Creek had nearly four times the average FC loads of Mission and Chumstick creeks, indicating a high source of pollution and a more immediate health concern. Most of this FC load (85%) originates between the first crossing of Pioneer Road (RM 1.2) and RM 2.5.

In No Name Creek, a tributary to Brender Creek, the pond area on the side of Mill Road appears to be the major source of FC concentrations and load.

Chumstick Creek
Nearly 50% of the net FC load entered upper Chumstick Creek between RM 9.1 and 7.7. This stretch of the creek is characterized as having primarily rural land use, with agriculture, onsite septic systems, and wildlife potentially contributing as nonpoint (diffuse) FC sources.

Recommendations

Ideally, fecal coliform (FC) bacteria in each creek could be determined to be either from human or non-human sources. Wherever FC bacteria are found to be from human sources, onsite septic systems should be evaluated for proper functioning, and inspections for illegal discharges should be made. Wherever FC bacteria are found to be from non-human sources, best management practices (BMPs) should be applied to keep non-human sources from contaminating the creek.

Implementation of BMPs and follow-up monitoring programs are needed in order to evaluate target FC reductions in the Mission, Brender, and Chumstick creek basins.

Control measures to mitigate FC exceedances in these tributary basins will likely mitigate dissolved oxygen and pH exceedances within the basins as well.

Adaptive Management Process

The Wenatchee River Basin TMDL study is the result of a partnership between the Department of Ecology and the Water Resource Inventory Area (WRIA) 45 Water Quality Technical Subcommittee (WQTS). The WQTS consists of Ecology TMDL staff and the WRIA 45 Watershed Planning Unit's Water Quality Subcommittee.

Ecology authored this TMDL technical report for fecal coliform bacteria, and the WQTS reviewed, discussed, and commented on the report.

The data collection and literature review conducted for and presented in this technical report for the Wenatchee River basin represent the current state of knowledge for fecal coliform bacteria in the watershed. It is the understanding of the WQTS that additional studies will be performed to fill data gaps and address unanswered questions, as determined by the WQTS.

Conclusions and recommendations currently presented in this technical report may be revised based on new data as they become available. It is also the understanding of the WQTS that any new data gathered from further study can be incorporated in the TMDL process in the *Summary Implementation Strategy* (SIS) or *Detailed Implementation Plan* (DIP) wherein recommendations and management strategies may be refined. This adaptive management approach is acceptable to both Ecology staff and the WQTS. Ecology will partner with stakeholders (interested parties) in the watershed to conduct studies addressing information gaps (e.g., monitoring).

Further monitoring for purposes of TMDL assessment will be addressed in the TMDL SIS and DIP. Any new science available as a result of these studies will be integrated into the SIS and DIP as new conclusions and management recommendations. Management strategies addressing both point (discrete) and nonpoint (diffuse) pollution sources are subject to this adaptive management approach.

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