Skokomish River Basin Fecal Coliform Bacteria Total Maximum Daily Load Study

Water Quality Attainment Monitoring Report

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Cover photo: The Lower Skokomish River.
Photo courtesy of Shannon Kirby (Mason Conservation District).

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Water Quality Attainment Monitoring Report

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Abstract

The Washington State Department of Ecology is required, under section 303(d) of the federal Clean Water Act and U.S. Environmental Protection Agency regulations, to develop and implement Total Maximum Daily Loads (TMDLs) for impaired waters.

The lower Skokomish River and some of its tributaries exceeded Washington State fecal coliform bacteria freshwater quality standards. During January 1999 through January 2000, a TMDL Study was conducted to (1) determine the sources of fecal coliform loading, and (2) develop load allocations that would protect water quality and shellfish harvesting use in Annas Bay.

The TMDL Study identified percent reductions needed in fecal coliform concentration and loading at four compliance sites: Weaver Creek, Ten Acre Creek, Purdy Creek, and the lower Skokomish River.

Since the TMDL, several pollution reduction actions have been implemented, including decommissioning of high-risk, on-site sewage treatment systems and installation of riparian fencing and plantings. Subsequently, a water quality *Attainment Monitoring Study* was conducted during 2005-2006 to determine if TMDL fecal coliform water quality targets and standards were attained for the TMDL sites sampled during this study.

This *Attainment Monitoring Study* showed that water quality in the Skokomish River and tributaries has improved greatly since the 1999-2000 TMDL Study. All four TMDL compliance sites have lower fecal coliform levels. All sites also met fecal coliform water quality standards during the May through February critical period.

All sites, with the exception of Weaver Creek, met TMDL fecal coliform targets during the critical period. A 20% reduction in fecal coliform levels is needed in Weaver Creek to meet the TMDL target.

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Introduction

The Washington State Department of Ecology (Ecology), Skokomish Tribe, local government, and local citizens have concerns about the quality of water in the Skokomish River watershed. During 1999 and 2000, Ecology conducted a fecal coliform bacteria study of the lower Skokomish River and its tributaries and made recommendations on how to protect and improve water quality in the river (Seiders et al., 2001; Hempleman, 2002). This type of study is called a *Total Maximum Daily Load* (TMDL) *Study* or *Water Quality Improvement Plan*.

The 1999-2000 study showed that some of the tributaries and the Skokomish River mainstem had high levels of bacteria. High bacteria levels can be a human health concern and should be at levels where water quality is safe for recreational use. In addition, shellfish beds at the mouth of the Skokomish River in Annas Bay have been closed to shellfish harvest because of fecal coliform contamination. A reduction of bacteria levels in the river reduces bacteria inputs to the shellfish beds, allowing safe shellfish harvesting.

Since 1999 many restoration actions have been implemented to improve water quality in the Skokomish basin. Landowners, Mason Conservation District (CD), the Skokomish Tribe, and local government have worked to improve bacterial water quality. To check on the progress in making the Skokomish River watershed safer for people, Ecology and Mason CD conducted a water quality study on the mainstem and its tributaries in 2005-2006. The purpose of the study was to see how much water quality had improved and to see which areas needed additional work to ensure water quality improvement.

This report describes our current understanding of bacterial pollution in the Skokomish River basin. The report provides a picture of bacterial water quality in the Skokomish basin lowlands from the Middle Fork Skokomish to the mainstem at Highway 106. The good news is that bacteria levels are very low in most of the tributaries and the mainstem. All areas met fecal coliform water quality standards and, with the exception of Weaver Creek, all sites met fecal coliform TMDL targets. This report documents improvements that have occurred and recommends additional pollution clean-up work for Weaver Creek.

Background

Washington State's Water Quality Assessment [303(d)]

The federal Clean Water Act established a process to identify and clean up polluted waters. Under the Act, every state and most tribes have their own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses for protection, such as cold water biota and drinking water supply, as well as criteria, usually numeric criteria, to achieve those uses.

Every two years, states are required to prepare a list of waterbodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list or water quality assessment. To develop the list, Ecology compiles its own water quality data along with data submitted by local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before the data are used to develop the water quality assessment.

The Water Quality Assessment is a list that tells a more complete story about the condition of Washington's water. This list divides waterbodies into five categories:

- Category 1 – Meets tested standards for clean water.
- Category 2 – Waters of concern.
- Category 3 – No data available for these waters.
- Category 4 – Polluted waters that do not require a TMDL since the problems are being solved in one of three ways:
    - 4a – Has a TMDL approved and it is being implemented
    - 4b – Has a pollution control project in place that should solve the problem
    - 4c – Is impaired by a non-pollutant such as low water flow, dams, culverts
- Category 5 – Polluted waters that require a Total Maximum Daily Load – or the 303d list.

What is a Total Maximum Daily Load (TMDL)?

TMDL process overview

The federal Clean Water Act requires that a TMDL be developed for each of the waterbodies in Category 5 of the 303(d) list. A TMDL identifies how much pollution needs to be reduced or eliminated to achieve clean water. Then the local community works with Ecology to develop and implement a strategy to control the pollution and a monitoring plan to assess effectiveness of the water quality improvement activities.

Elements required in a TMDL

The goal of a TMDL is to ensure the impaired water will meet water quality standards or TMDL targets that are protecting beneficial uses. Beneficial uses are activities such as fishing, shellfish harvesting, and swimming among other things. 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 source (referred to as a 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 sources (referred to as a nonpoint source) 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.

TMDL analyses: Loading capacity

Identification of the contaminant loading capacity for a waterbody is an important step in developing a TMDL. EPA defines the loading capacity as "the greatest amount of loading that a waterbody can receive without violating water quality standards" (EPA, 2001). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a waterbody into compliance with standards. The portion of the receiving water's loading capacity assigned to a particular source is a load or wasteload allocation. By definition, a TMDL is the sum of the allocations, which must not exceed the loading capacity.

What is Attainment Monitoring?

An attainment monitoring study determines if the TMDL targets and water quality standards have been met. This is an essential component of any restoration or implementation activity since it measures to what extent the work performed or recommended has attained the watershed restoration objectives or goals.

The benefits of an attainment monitoring study include:

- Optimization in planning/decision-making (i.e., program benefits).
- Watershed recovery status (i.e., how much restoration has been achieved, how much more effort is required).
- Adaptive management or technical feedback to refine restoration treatment design and implementation.

The attainment monitoring study and evaluation of clean-up actions addresses two fundamental questions with respect to restoration or implementation activity:

1. Is the restoration or implementation work achieving the desired objectives or goals (significant improvement)?
2. How can restoration or implementation techniques be improved?

Because this report analyzes scientific data, the discussion of current water quality and pollution trends is technical. Ecology has attempted to write the report in a way that will help all readers learn more about the river's water quality. Appendix A includes a glossary of terms and acronyms. Readers needing more information or explanation are encouraged to call the Ecology Water Quality Specialist for the Skokomish Watershed at (360) 407-6000.

Study Area

The Skokomish River drains a basin of about 247 square miles (Seiders et al., 2001). The river discharges to Annas Bay in southern Hood Canal near Potlatch, Washington (Figure 1). Major sub-basins include the North Fork Skokomish River (118 square miles, including 99 square miles that are noncontributing most of the year) (Embrey and Frans, 2003), South Fork Skokomish River (104 square miles), and Vance Creek (25 square miles) (Seiders et al., 2001). The upper watershed has steep gradients, high-energy stream channels, and unstable alluvial streambeds (Embrey and Frans, 2003).

The lower ten miles of the river pass through a broad floodplain, which is the primary area of residential and agricultural land use in the basin. The streams and springs in the lower valley contribute to several large wetland areas which then drain to the mainstem of the Skokomish River mostly downstream of Highway 101 at river mile (RM) 5.3. The river then discharges to the tidal estuary of Annas Bay and Hood Canal. Tidal influence to the river is thought to extend up to about RM 3.9, about 1.8 miles upstream of the Highway 106 bridge (Seiders et al., 2001).

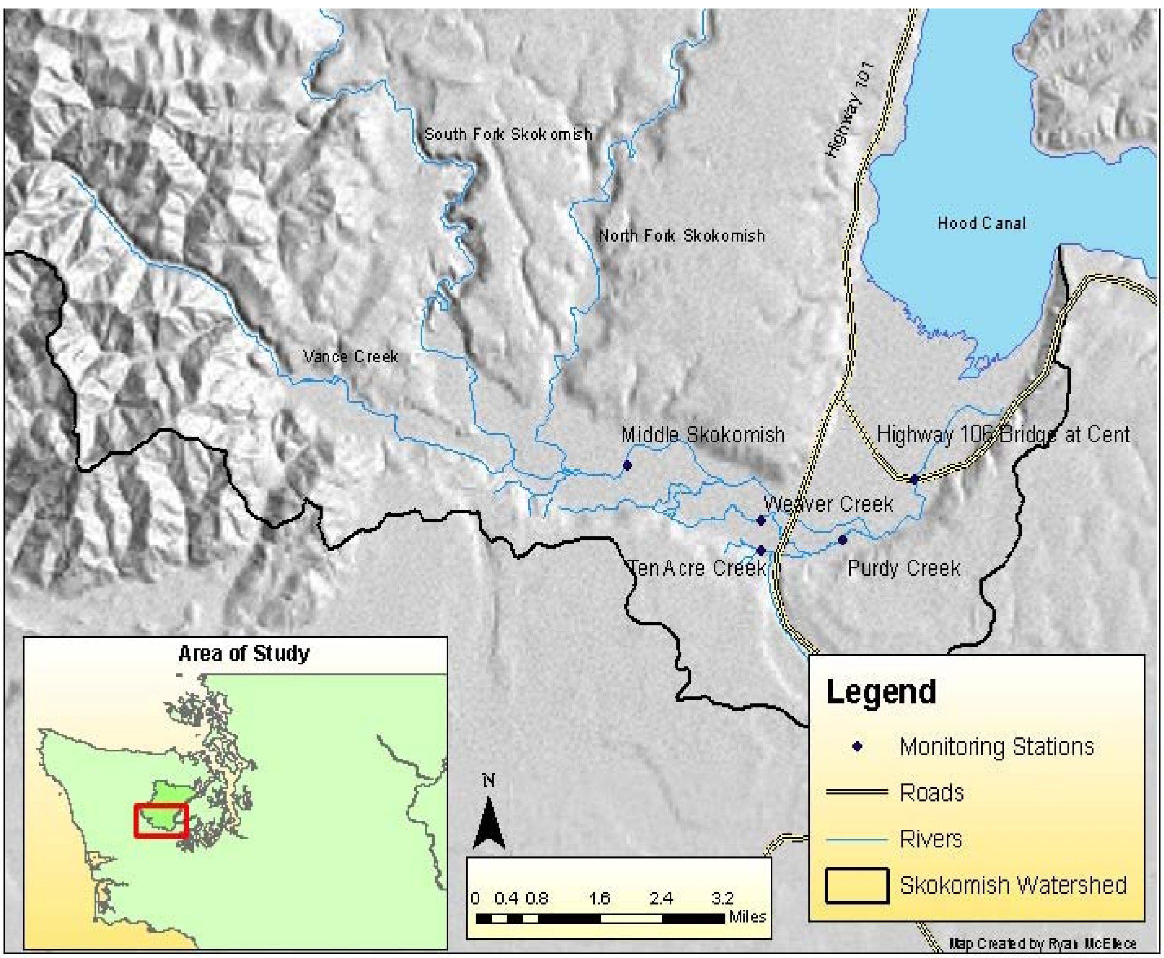

Figure 1. The Skokomish River basin sampling locations.

The mainstem Skokomish River flow ranges from a minimum of 99 cubic feet per second (cfs) seen in October and November 1987 to the highest recorded daily flow of 30,000 cfs (Embrey and Frans, 2003; USGS, 2006). Mean annual streamflow for the Skokomish for 63 years of record through 2006 is 1,219 cfs (USGS, 2006).

Rainfall levels in the basin range widely from 75 inches per year near the mouth to about 230 inches per year at the crest of the Olympic Mountains near 6,000 feet elevation (Phillips, 1968). Much of the winter precipitation in the mountains accumulates as snowpack that provides runoff in the North and South Forks through the spring and early summer. The dry season runs from July into September, which is followed by a wet season (October through March) in which more than 75% of the annual precipitation occurs. The U.S. Geological Survey (USGS) attributes this pattern mostly to dam-mediated flow regulation of the North Fork Skokomish, which captures much of the snowmelt in reservoirs.

The typical pattern for Puget Sound basin rivers with headwaters in the mountains includes two periods of high flows – one in the fall and winter with the arrival of the rainy season, and one during spring snow-melt – with a low-flow period in August-September (Embrey and Frans, 2003).

The Skokomish River basin is sparsely populated, rural in nature, and free of urban areas. The Skokomish Indian Reservation is located at the mouth of the basin. Land-use and many other regulations within the Reservation are under the jurisdiction of the Skokomish Tribe. Some of the land use is residential. Commercial and noncommercial agricultural activities occur in the lower river valley and include cattle and other livestock culture, hay and Christmas tree production, and some vegetable cropping. Silviculture within National Forest Service and privately owned lands dominate the upper basins. The upper reaches of the Skokomish River lie within the Olympic National Park. The North Fork basin includes Lake Cushman. The shores of Lake Cushman have some residential development, and the lake is used for recreation (Seiders et al., 2001).

There are both point and nonpoint sources of water pollution to the Skokomish River. Three fish hatchery operations constitute the only point sources of pollution in the watershed. All the facilities are located along the southern valley wall where nearby springs provide an ideal water supply for fish-rearing operations. Pollutant discharges from these facilities are managed under the Upland Fin-Fish Hatching and Rearing National Pollutant Discharge Elimination System (NPDES) Waste Discharge General Permit (Seiders et al., 2001). Pollutants monitored under this permit generally relate to settleable and suspended solids. Fecal coliform bacteria are not included in the permits since it has been documented that such operations are not a source of fecal coliform bacteria (Kendra, 1989).

Nonpoint sources of fecal coliform pollution in the Skokomish River watershed include agriculture, humans (on-site sewage treatment systems), recreation (uncontrolled human waste), domestic animals, and wild animals. The domestic livestock population in the lower valley is estimated to include about 500 cattle, and a smaller number of horses, llamas, goats, and chickens (MCD, 2001). Estimates of wild animal populations (e.g., elk, deer, beaver, waterfowl, and other warm-blooded animals) were not obtained. Based on the land-use assessment, agricultural practices are likely the primary source of bacteria in affected areas of the basin.

Livestock manure enters waterways when animals have direct access to streams and when stormwater runoff carries feces and feces-contaminated water into waterways.

Pollutants Addressed by the TMDL

The 1998 303(d) list included eight sites in five waterbody segments in the Skokomish River watershed for fecal coliform bacteria: Hunter Creek, Purdy Creek (2 listings), Ten Acre Creek, Weaver Creek, and the Skokomish River (3 listings).

The TMDL Study indicated fecal coliform concentrations and loads needed to be reduced at the four sites indicated in Table 1 (Seiders et al., 2001). One of the TMDL Study recommendations was to move Hunter Creek to Category 1 (clean water category) of the Clean Water Assessment due to improvements in fecal coliform water quality. Therefore Hunter Creek was not included in this study. A site on the Middle Fork Skokomish River was included in the *Attainment Monitoring Study* as a reference site (Table 1). Very little development occurs upstream of this site.

Table 1. Sampling locations for TMDL attainment monitoring.

Sample site	TMDL ID	Latitude north	Longitude west
Hwy 106 bridge at center*	Skok106c	47.319608	123.138539
Purdy Creek	PurBour	47.304238	123.159728
Weaver Creek	WeavrLow	47.308621	123.184393
Ten Acre Creek	TenAcre	47.303506	123.183914
Middle Skokomish **	MidSkok	47.317164	123.221303

* Furthest downstream point of attainment.
** Reference site.
Latitude and longitude are NAD27 coordinate system.

Reductions were not determined at five other sites, and the remaining sites were designated as requiring no change from the 1999-2000 TMDL study period. The TMDL Study assumed that the target levels at the Skokomish River at Highway 106 should be met if upstream sites met or improved their allocated loads. Purdy Creek at the mouth is assumed to meet water quality standards if Purdy Creek at East Bourgault Road meets target fecal coliform levels. The TMDL Study did not measure nonpoint pollution between the Highway 106 bridge and the mouth of the Skokomish River at Annas Bay.

The Skokomish River at the Bobby Allens site was not evaluated because of difficult access (Seiders, 2004), and is noted as needing monitoring to see if the site at least meets fecal coliform target values for the Skokomish River at Highway 106 (Seiders et al., 2001). This site location is approximately 1.25 miles north of the junction of Highway 106 and the Purdy Cutoff Road., on the right bank of the Skokomish River (Bullchild, 2007).

EPA approved the Skokomish bacteria TMDL in the fall of 2001 (EPA, 2001). The TMDL lists five stream segments with waterbody ID numbers and eight locations within these five segments. The eight locations appeared on the 1998 303(d) list. Excessive sediment runoff and flooding are listed as concerns for evaluation by Ecology, but there is no requirement stipulated for assessment.

Three other sites are not included in the requested scope of work, but are on the 303(d) list and are listed on EPA's TMDL Approval: Purdy Creek at mouth, Skokomish River at Highway 101, and Skokomish River at Bobby Allens. Purdy Creek at mouth and the Skokomish River at Highway 101 must meet the *Extraordinary Primary Contact* classification for recreation (formerly Class AA) water quality standard. Monitoring is needed to see if the Skokomish River at Bobby Allens at least meets the target geometric mean value (GMV) for the Skokomish River at Highway 106, which is 18.5 most probable number (MPN)/100 mL, and a 90th percentile not to exceed 67.7 MPN/100 mL (Seiders et al., 2001). The Skokomish Tribe obtains monthly fecal coliform samples at the TMDL sites, the mouth of Purdy Creek, and at the Bobby Allens site on the Skokomish River. A summary of their data is presented in Appendix D.

Water Quality Standards, Beneficial Uses, and TMDL Summary and Targets

Beneficial Uses of Water

While resources in the lower Skokomish River area are shared by many groups, protecting shellfish harvest required the most stringent improvements in water quality in the TMDL. The Annas Bay estuary area contains a rich shellfish resource that is used by Tribal, commercial, and recreational harvesters. Recreational shellfish beds are located within, and to the south of, Potlatch State Park. Potlatch State Park is also a center of primary contact recreation, being used by swimmers and scuba divers. The mainstem Skokomish River and lower Vance Creek are also used by swimmers and waders during the summer. The lower Skokomish River valley provides important habitat to a variety of terrestrial wildlife such as elk, deer, beaver, and waterfowl. The wildlife, shellfish, and fin-fish are important cultural and economic resources for the Skokomish Tribe (Seiders et al., 2001).

Water Quality Standards

The freshwaters of the Skokomish River and the marine receiving waters of Hood Canal are classified as *Extraordinary Primary Contact* for recreation (formerly Class AA) in Chapter 173-201A of the Washington Administrative Code: Water Quality Standards for the Surface Waters of the State of Washington. Freshwater standards apply to the entire Skokomish River basin where salinity is less than 10 parts per thousand (WAC 173-201A-060), and marine water standards apply where salinity is 10 parts per thousand or higher:

- *Fresh water - 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 (GM) value exceeding 100 colonies/100 mL.*
- *Marine water - fecal coliform organism levels shall both not exceed a geometric mean of 14 colonies/100 ml, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 43 colonies/100 mL.*

The estimated 90th percentile value is comparable to the 10% of all samples obtained (for calculating GM value) and should not exceed a maximum value part of the standard. The estimated 90th percentile value was used to calculate fecal coliform reductions needed in the 1999-2000 TMDL.

Fecal Coliform Bacteria: Freshwaters

Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. In the Washington State water quality standards, fecal coliform is used as an "indicator bacteria" for the state's freshwaters (e.g., lakes and streams). Fecal coliform in water "indicates" the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. The fecal coliform criteria are set at levels that have been shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

The *Extraordinary Primary Contact* use is intended for waters capable of "providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas." To protect this use category: Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100/colonies mL" [WAC 173-201A-200(2)(b), 2003 edition].

Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than ten total samples) limit. These two measures, used in combination, ensure that bacterial pollution in a waterbody will be maintained at levels that will not cause a greater risk to human health than intended. While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both monthly (if five or more samples exist) and seasonal (summer versus winter) data sets.

Fecal Coliform Bacteria: Marine Waters

Washington State Department of Ecology

In marine waters, bacteria criteria are set to protect shellfish consumption and people who work and play in and on the water. Two separate bacterial indicators are used in the state's marine waters. In waters protected for both primary contact recreation and shellfish harvesting, fecal coliform bacteria are used as indicator bacteria to gauge the risk of waterborne diseases. In waters protected only for secondary contact, enterococci bacteria are used as the indicator bacteria. The presence of these bacteria in the water indicates the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals.

To protect either *shellfish harvesting* or *primary contact recreation* (swimming or water play): "Fecal coliform organism levels must not exceed a geometric mean value of 14 colonies/100 mL, with not more than 10% of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 43 colonies/100 mL" [WAC 173-201A-210(3)(b), 2003 edition].

The criterion level set to protect shellfish harvesting and primary contact recreation is consistent with federal shellfish sanitation rules. Fecal coliform concentrations in Washington State marine waters that meet shellfish protection requirements also meet the federal recommendations for protecting people who engage in primary water contact activities. Thus the same criterion is used to protect both "shellfish harvesting" and "primary contact" uses in the state standards.

Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than ten total samples) limit. These two measures must be used in combination to ensure that the bacterial pollution in a waterbody will be maintained at levels that will not cause a greater risk to human health. While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both monthly (if five or more samples exist) and seasonal (summer versus winter) data sets.

Once the concentration of fecal coliform in the water reaches the numeric criterion, human activities that would increase the concentration above that criterion are not allowed. If the criterion is exceeded, the state will require that human activities be conducted in a manner that will bring bacterial concentrations back into compliance with the standards.

If natural levels of bacteria (from wildlife) cause criteria to be exceeded, no allowance exists for human sources to measurably increase bacterial pollution further. While the specific level of illness rates caused by animal versus human sources has not been quantitatively determined, warm-blooded animals are a common source of serious waterborne illness for humans. Of particular concern are animals managed by humans and thus exposed to human-derived pathogens as well as pathogens of animal origin.

Washington State Department of Health

The Washington State Department of Health classifies commercial shellfish beds in Washington State using the National Shellfish Sanitation Program (NSSP) criteria. To meet these criteria, bacteria concentrations in commercial shellfish harvesting areas can be no higher than 14 MPN/100 mL as a geometric mean, and the estimated 90^{th} percentile value must be less than 43 MPN/100 mL.

TMDL Summary and Targets

Ecology initiated a TMDL Study in 1999 (Seiders et al., 2001). Water quality sampling was conducted from January 1999 through January 2000 with the assistance of the Skokomish Tribe. The *Skokomish River Basin Fecal Coliform Bacteria Total Maximum Daily Load Study* was subsequently issued in April 2001 and approved by EPA in October 2001.

The TMDL was established to (1) address water quality impairments due to high fecal coliform levels in the lower Skokomish River basin and (2) help protect marine water quality standards and shellfish harvesting in Hood Canal.

The TMDL applies to areas upstream of the Highway 106 bridge and includes part of the Skokomish Indian Reservation and areas under state jurisdiction. The EPA and the Skokomish Tribe have Clean Water Act jurisdiction on all lands within the Reservation.

The 1998 Section 303(d) list included eight sites in five waterbody segments in the Skokomish River watershed for fecal coliform bacteria: Skokomish River (3 listings), Hunter Creek, Purdy Creek (2 listings), Weaver Creek, and Ten Acre Creek.

Since the Skokomish River empties into Annas Bay, the bacteria concentrations in the river affect water quality in Annas Bay. The TMDL Study calculated target concentrations and loads based on protection of shellfish harvests in the bay (Seiders et al., 2001). The TMDL Study recommended fecal coliform concentration and load reductions at the four sites indicated in Table 2.

Table 2. Skokomish basin TMDL recommended fecal coliform (FC) load allocations.

Sampling Site	On 1996 and 1998 303(d) lists	TMDL Study		Target		Required Change	Target Load Allocation FC/day
		GMV* FC/100mL	Geometric 90^{th} %tile FC/100mL	GMV* FC/100mL	Geometric 90^{th} %tile FC/100mL		
Weaver Creek	yes	55.0	314.6	17.5	100.0	- 68%	5.86E +10
TenAcre Creek	yes	34.1	133.2	25.6	100.0	- 25%	8.23E +09
Purdy Creek (E. Bourgault Rd)	yes	54.3	146.6	25.7	69.4	- 53%	1.16E +11
Skokomish River at Hwy 106	yes	32.8	120.3	18.5	67.7	- 44%	7.52E +11

* GMV: geometric mean value.

These four sites are referred to as the "points of compliance" because they are the critical places for determining that target reductions recommended in the TMDL have been achieved. The Skokomish TMDL recommended the Skokomish River at the Highway 106 bridge as the main site to monitor for compliance with the TMDL. Target levels at this location should be reached if upstream sites meet their allocated loads. The recommended fecal coliform concentrations and targets are presented in Table 2 as geometric mean values and 90th percentiles, including percent reduction requirements.

Watershed Clean-up Actions

During 2003, a workgroup including valley residents, the Skokomish Tribe, and Ecology representatives completed a cleanup plan. The management actions recommended in the *Skokomish River Detailed Implementation Plan for Fecal Coliform Bacteria* (Hempleman, 2002) suggested reasonable approaches to improving water quality within a realistic timeframe under difficult physical, political, and economic conditions. These approaches emphasized voluntary actions for achieving sustainable water quality improvement in the watershed.

The dominant land use in the Skokomish River watershed is rural/agricultural. Bacteria pollution comes from sources throughout the watershed. There are no bacterial sources with NPDES (National Pollution Discharge Elimination System) permits.

Since completion of the Detailed Implementation Plan, much cleanup work has taken place. Figure 2 and Table 3 present best management practices (BMPs) implemented, mostly through the Conservation Reserve Enhancement Program, since the completion of both the TMDL and Detailed Implementation Plan (Kirby, 2006).

From January 2005 through November 2006, the Mason Conservation District (CD), in partnership with Ecology, tracked progress towards TMDL targets by monitoring at the points of compliance identified in the 1999-2000 TMDL Study.

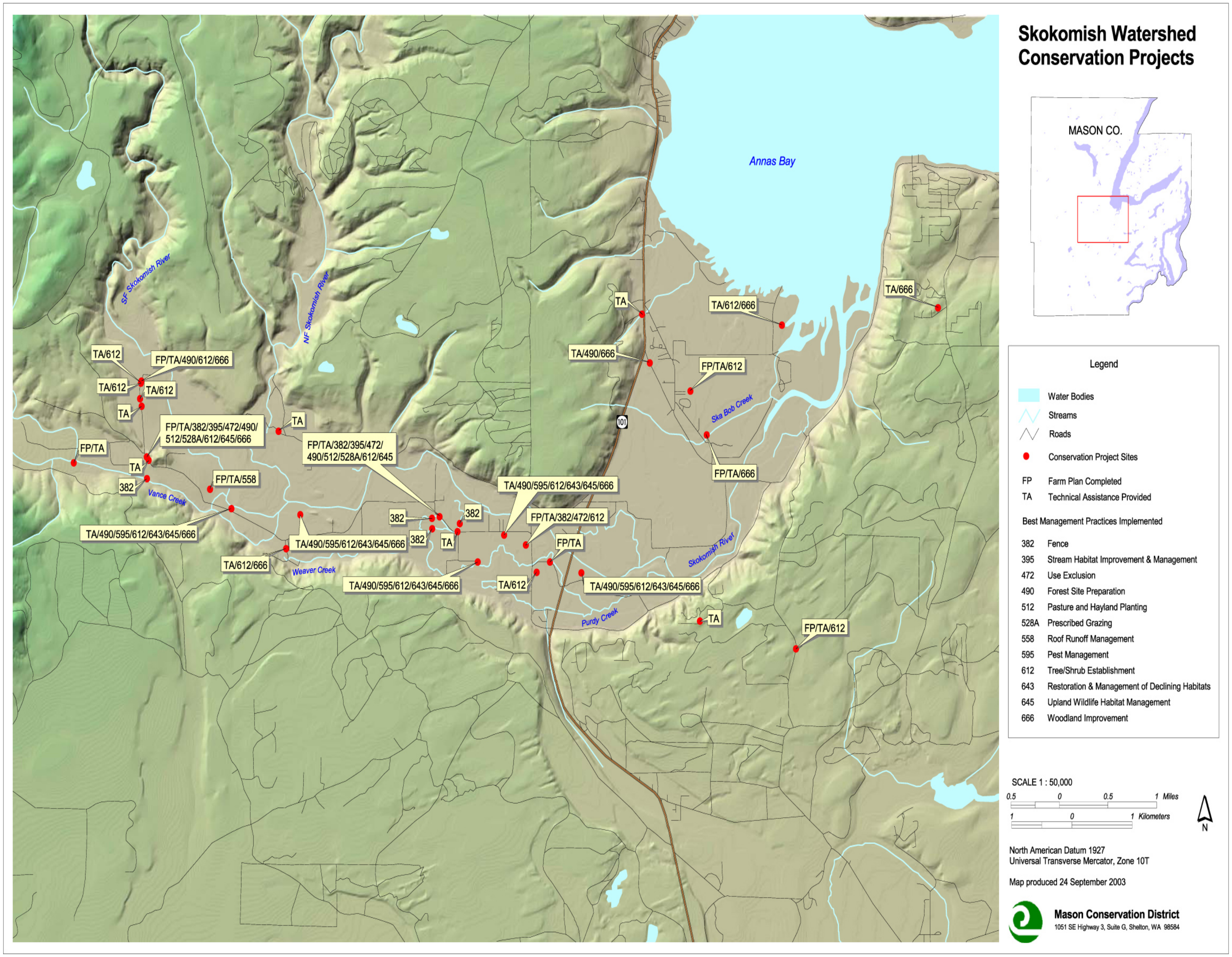

Figure 2. Skokomish River watershed conservation projects. (Map information from the Mason Conservation District.)

Table 3. Cleanup actions in the Skokomish River watershed.

Source Type	Who	Action
Agricultural Practices	Landowners, Mason Conservation District	Installed about 24,000 ft of riparian fencing ($3.50 per ft).
		Planted about 32,000 trees ($1.50 per tree).
		Enrolled 62 acres of land with a buffer of 150 ft.
		Provided technical assistance on proper manure handling and storage.
	Cascade Land Acquisition	Acquired 175 acres of land adjacent to prime fish habitat (total cost $350,000).
Septic Systems	Mason County	Purchased 19 frequently-flooded properties and decommissioned septic systems.
	Dept. of Fish and Wildlife	Inspected and repaired all fish hatchery septic systems.
	Skokomish Tribe	Evaluated and repaired septic systems on the Reservation.
Recreation	Taylor Shellfish, Simpson, Puget Sound Action Team	Added signage to reduce unauthorized partying and camping along the river ($200 fine).
	Hunter Stores, Dept. of Fish and Wildlife	Installed port-a-potties during fishing seasons.
	Valley residents, Skokomish Tribe, participating agencies	Posted flyers on proper waste management on fishermen's windshields and nearby toilet facilities.

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Water Quality Attainment Monitoring Study

The Quality Assurance (QA) Project Plan (Batts, 2005) for this 2005-06 *Attainment Monitoring Study* describes the study design and procedures that were followed for (1) measurements made in the field, and (2) collection and analysis of laboratory samples. Sample site locations are shown in Figure 1 and Table 1. The monitored field information was *flow*, and the laboratory parameter was *fecal coliform bacteria*.

Goals and Objectives

Project Goals

The primary goal of the *Attainment Monitoring Study* is to evaluate attainment of the percent reductions and load allocations at four compliance stations identified for bacteria concentrations and load reductions in the 1999-2000 Skokomish River Basin TMDL.

Study Objectives

To meet project goals, the following steps were taken.

1. Review historic documentation related to the TMDL.
2. Compile information and data generated after implementation of the TMDL (performed by the Mason CD).
3. Perform necessary additional monitoring.
4. Review data for representativeness, comparability, and usability.
5. Analyze and interpret data to determine if the TMDL water quality targets were met.
6. Determine if changes in water quality were significant.

Field and Laboratory Methods

The sampling effort was a coordinated multi-agency, multi-program project, involving EPA, the Washington state Department of Ecology (Ecology), the Mason Conservation District (CD), and Mason County. EPA approved the TMDL and funded Ecology's work on the project through a Clean Water Act Section 319 grant. Ecology funded Mason CD's work and Mason County's laboratory analysis through a Centennial Clean Water Fund grant. Mason CD conducted primary field sampling and monitoring, with quality checks by Ecology doing some side-by-side sampling.

The Mason CD conducted flow (whenever possible) and fecal coliform sampling every other week, from January 2005 through November 2006. Tandem sampling with Mason CD and Ecology occurred for the first four sampling events. Comparable results from both agencies resulted in tandem sampling reduced to once a month. Results of six months of examining data comparability were favorable. After that, tandem sampling was reduced to four times per year (quarterly). Monitoring dates and sampling entities are described in Appendix B.

Data Analysis Methods

Field and laboratory data were compiled and organized using Excel® spreadsheet software (Microsoft Corporation, 2001). Water quality results from field and laboratory work were also entered into the Ecology's Environmental Information Management (EIM) database. Statistical analyses, plots, and mass balance calculations were made using Excel®.

Analysis of the fecal coliform bacteria data included use of the statistical rollback method to determine if TMDL targets were being met. The statistical rollback method (Ott, 1995) has been used by Ecology to determine the necessary reduction for both the geometric mean (GM) and 90th percentile bacteria concentration (Roberts, 2003; Joy, 2000) to meet water quality standards or TMDL targets. Compliance with the most restrictive of the dual fecal coliform criteria determines the bacteria reduction needed.

To be consistent with the TMDL for rollback statistical analysis and to determine if TMDL targets were met, the data set used included one value for each month in the critical period (May through February). That value was the geometric mean of the values obtained for the month of sampling. For example, if there were four results for February, the geometric mean of those results would be used for February in the data analysis.

WQHYDRO software (Aroner, 2007) was used to conduct trend analysis. A non-parametric Seasonal-Kendall test with a correction for correlation was used to test trends where continuous data were available (Skokomish River at Highway 101). This test is a modification of the original Seasonal-Kendall test where an attempt was made to account for serial correlation between adjacent seasons (Aroner, 2007).

A Step Trend statistical test was used to determine if significant changes in water quality had occurred at sites where only pre- and post-implementation monitoring had occurred. For the pre-implementation period, TMDL data were used (January 1999 through January 2000). For the post-implementation period, data from the *Attainment Monitoring Study* were used (January 2005 through October 2006). Data were log-transformed for this parametric test. For both analyses, a two-tailed test with a significance level of $\alpha = 0.05$ was used.

For the purposes of trend data analysis and comparison to water quality standards, both laboratory and field duplicates were arithmetically averaged. Fecal coliform and flow discharge data obtained during Ecology and Mason CD tandem sample events were arithmetically averaged for data analysis and comparison to the water quality standards. For Ecology, data values below the detection limit were assumed to be the detection limit for analysis purposes. Mason CD data were used as they were downloaded from the Ecology's EIM system.

Quality Assurance and Quality Control Results

Field and laboratory quality assurance and quality control results are discussed in Appendix C. The Appendix also contains a discussion of the comparability between the Mason County Laboratory data and Ecology's Manchester Environmental Laboratory data.

Study Results and Discussion

Comparison of Environmental Conditions During the 1999-2000 TMDL Study and the 2005-06 TMDL Water Quality Attainment Monitoring Study

It is important to look at streamflow and weather patterns that occurred during both water quality studies to determine if a real improvement in water quality has occurred. Water quality may appear to improve during favorable environmental conditions. For some areas, such as the Skokomish River basin run-off events can carry fecal coliform bacteria to surface water causing degraded water quality. On the other hand, water quality may seem to improve during periods of less precipitation.

The U.S. Geological Survey (USGS) has a continuous flow monitoring station on the Skokomish River at Potlatch near Highway 101 (USGS station 12061500). Mean monthly flow discharge results for 63-64 years at this site were compared to mean monthly flow results during the TMDL Study and the *Attainment Monitoring Study* (Figure 3).

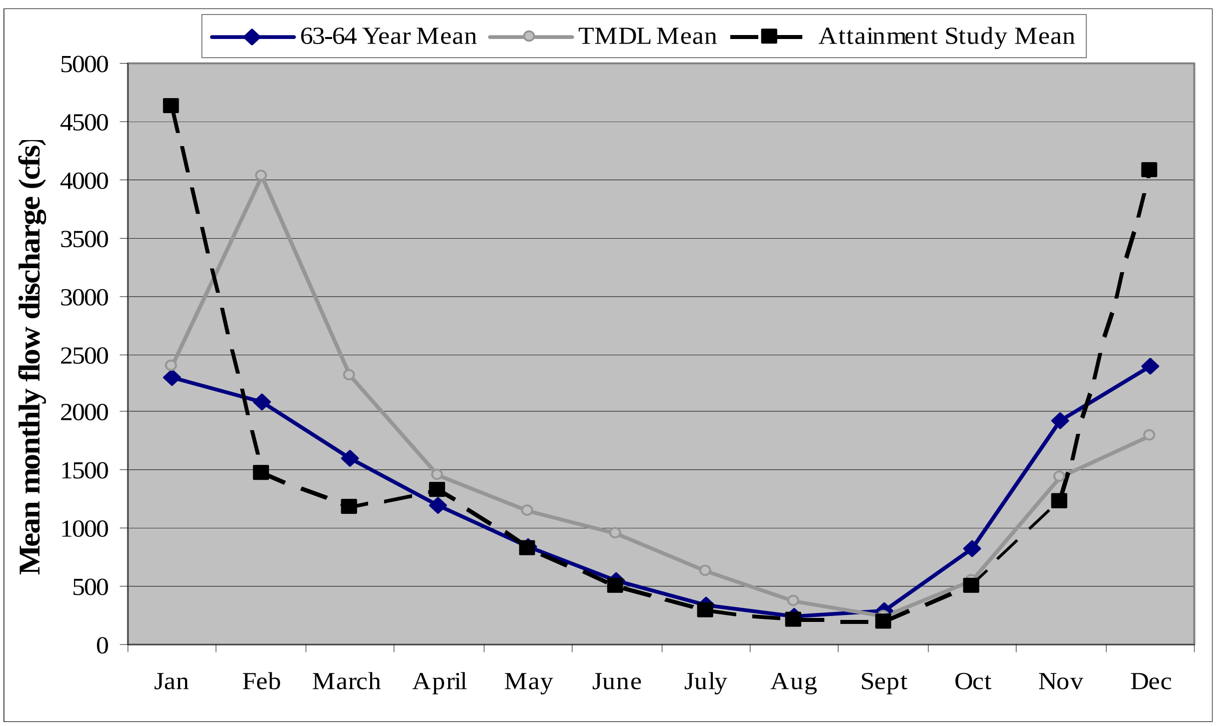

Figure 3. Monthly mean flow for the Skokomish River at Highway 101 for the historical record, the TMDL period, and the TMDL attainment monitoring period.

The historical record for flow in the Skokomish River at Highway 101 compares favorably with flow statistics from the 10-month averaging period for the TMDL and the *Attainment Monitoring Study*. The historical record mean flow discharge for the 10-month averaging period is 1181 cfs. During the TMDL Study, it was 1354 cfs, and during the *Attainment Monitoring Study* it was 1393 cfs.

The closest weather station to the Skokomish River is the National Oceanic and Atmospheric Administration (NOAA) weather station at the Cushman Powerhouse. Mean monthly precipitation results for 32-33 years at this site were compared to mean monthly precipitation results during the TMDL Study and the *Attainment Monitoring Study* (Figure 4). The historical record for precipitation at the Cushman Powerhouse compares favorably with flow statistics from the 10-month averaging period for the *Attainment Monitoring Study*. During the TMDL Study, precipitation was higher than the historical average. The historical record mean precipitation record for the 10-month averaging period is 89.30 inches. During the TMDL Study, precipitation was 117.46 inches, and during the *Attainment Monitoring Study*, it was 82.75 inches.

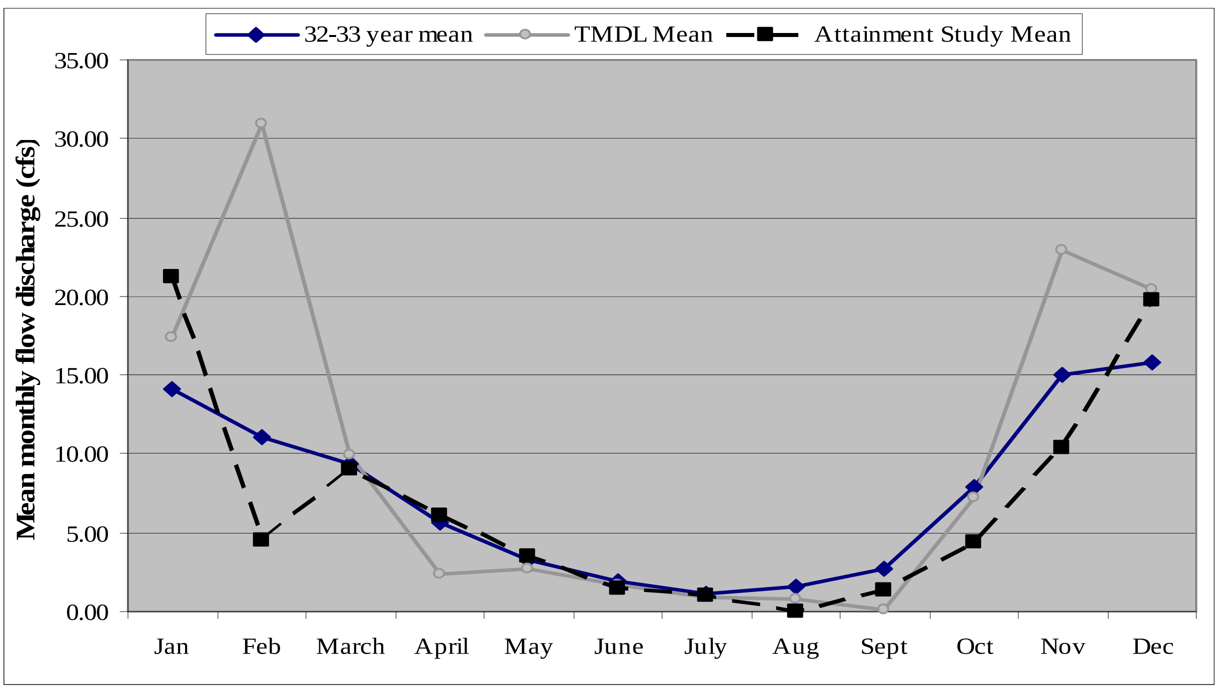

Figure 4. Monthly mean precipitation for the NOAA weather station at Cushman Powerhouse for the historical record, the TMDL period, and the TMDL attainment monitoring period.

Precipitation and flow discharge for the TMDL Study and *Attainment Monitoring Study* sample dates are compared in Table 4. Average precipitation for the sample day was higher for the TMDL Study, but a wider range of precipitation days were sampled for the *Attainment Monitoring Study*. The previous 24-hour rainfall was similar for both studies, with a wider range of events sampled in the *Attainment Monitoring Study*. While smaller creeks are generally more responsive to storm events, the effects of similar storm events would more likely be seen the day after sampling in a larger river like the Skokomish.

Table 4. Precipitation and flow discharge for the 1999-2000 TMDL Study and the 2005-06 *Attainment Monitoring Study* sample dates.

Study period	Precipitation for sample day	Precipitation 24 hours before sample day	Flow discharge for Skokomish at Hwy 101
TMDL Study			
Mean	0.58	0.18	1726
Maximum	3.35	1.12	8730
Minimum	0.00	0.00	218
Attainment Monitoring Study			
Mean	0.23	0.15	1370
Maximum	4.20	2.53	16400
Minimum	0.00	0.00	164

The average flow discharge was higher for the TMDL Study, but a greater range of flows (including more extreme flows) was sampled during the *Attainment Monitoring Study.*

Environmental conditions for both the TMDL Study and the *Attainment Monitoring Study* are similar. Conclusions drawn from the data are likely a result of actual water quality change and not favorable environmental or climate conditions.

Attainment Monitoring Study Results

Fecal coliform bacteria levels were low for all sites. All sites, with the exception of Weaver Creek, met TMDL targets for fecal coliform bacteria. Figure 5 presents fecal coliform statistics for each site sampled during the study and includes Ecology's ambient monitoring results for the Skokomish River at Highway 101. Table 5 presents Skokomish Basin TMDL Recommended Targets, TMDL Results, and TMDL Attainment Monitoring Results.

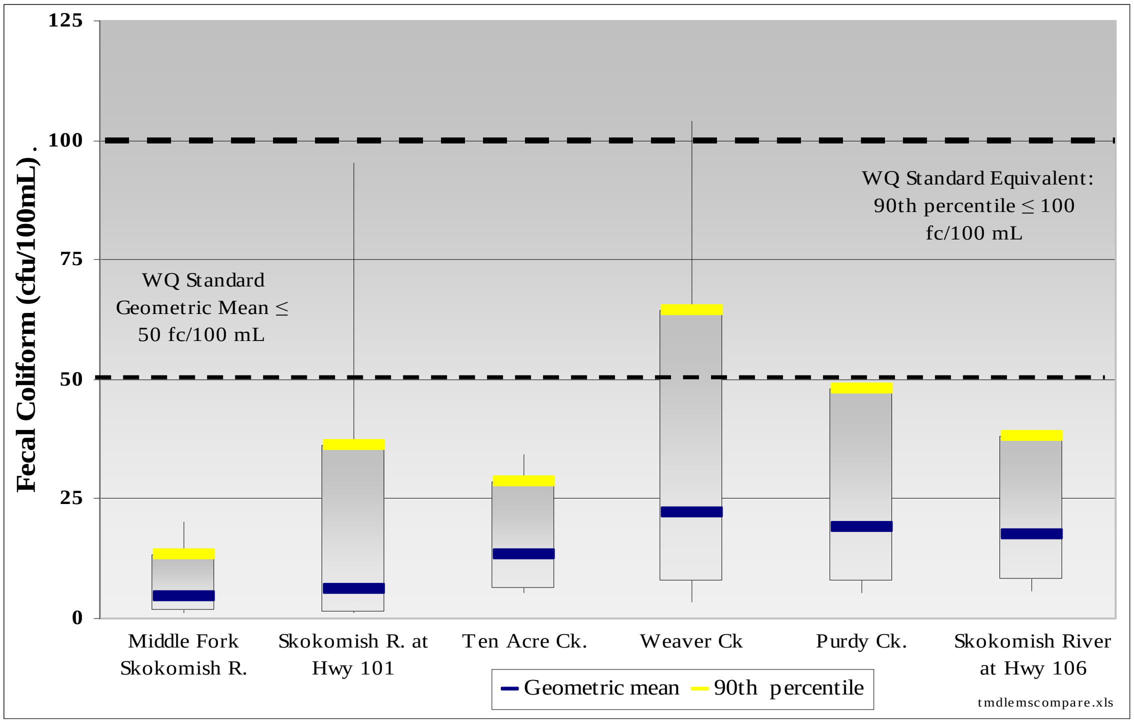

Figure 5. Skokomish River and tributaries fecal coliform statistics for 2005-06 attainment monitoring sampling.

Table 5. Skokomish River basin TMDL recommended fecal coliform (FC) targets, TMDL results, and TMDL attainment monitoring results for the critical period (May – February).

Sampling Site	Target		TMDL Study		Attainment Monitoring Study		Meets TMDL Targets?	Required Change
	GMV* FC/100mL	Geometric 90th %tile FC/100mL	GMV* FC/100mL	Geometric 90th %tile FC/100mL	GMV* FC/100mL	Geometric 90th %tile FC/100mL		
Weaver Creek	17.5	100.0	55.0	314.6	22.0	64.4	No	- 20%
Ten Acre Creek	25.6	100.0	34.1	133.2	13.4	28.7	YES	None
Purdy Creek (E Bourgault Rd)	25.7	69.4	54.3	146.6	19.0	48.2	YES	None
Skokomish River at Hwy 106	18.5	67.7	32.8	120.3	17.6	38.2	YES	None

* GMV: geometric mean value.

Middle Fork Skokomish River

The Middle Fork Skokomish River site was sampled as a reference site. Very little development occurs upstream of this site, and fecal coliform levels represent natural background conditions. During the late summer and early fall low-flow season, much of the Middle Fork Skokomish flows were underground. During this period at the monitoring site, there was no surface water to sample.

Sampling results for the middle fork are presented in Appendix B. Fecal coliform levels on the middle fork are very low (Figure 5). No TMDL targets were set for this site, but results are well within fecal coliform standards.

Skokomish River at Highway 101

Ecology has an ambient monitoring site on the Skokomish River at the Highway 101 bridge. Sampling for a variety of parameters including fecal coliform occurs monthly at this site. Ambient monitoring did not occur with the same sampling frequency or timing, or use the same analytical method, for fecal coliform analysis as the *Attainment Monitoring Study*. The membrane filter analysis method was used for ambient monitoring. It is worthwhile to look at the ambient results from this station for the same period as the attainment monitoring, but it is important to consider the differences in the two laboratory techniques for determining fecal coliform bacteria.

Standard Methods (APHA, 1998) states that the membrane filter (MF) technique is as effective as the most probable number (MPN) test for detecting bacteria in the coliform group. Modification of procedural details particularly of the culture medium has made the results comparable with those given by the MPN procedure. The MPN results have a wider confidence interval than MF, and a built-in positive statistical bias. Some researchers believe the MPN method is better at enumerating injured or stressed organisms. Therefore, MPN and MF databases are not usually mixed (Joy, 2002). Ecology's fecal coliform data for Highway 101 are MF data only.

Ambient fecal coliform results for this station can be found at Ecology's River and Stream Water Quality Monitoring web-site at (www.ecy.wa.gov/apps/watersheds/riv/station.asp?sta=16A070). Fecal coliform results were low and met water quality standards, with a geometric mean of 9.6 and a 90^{th} percentile of 38.5 cfu/100 mL (Figure 5).

Skokomish River at Highway 106

TMDL targets were set for the Skokomish River at Highway 106 (Table 2). Sampling results for the Skokomish River are presented in Appendix B. During the *Attainment Monitoring Study*, fecal coliform levels for the Skokomish River at Highway 106 site met TMDL targets and water quality standards (Figure 5, Table 5).

Ten Acre Creek

TMDL targets were set for Ten Acre Creek (Table 2). Sampling results for the Ten Acre Creek site are presented in Appendix B. During the *Attainment Monitoring Study*, fecal coliform levels at the Ten Acre Creek site were low, meeting TMDL targets and water quality standards (Figure 5, Table 5).

Ten Acre Creek was one of the few tributaries where flow was consistently measured. Figure 6 presents mean fecal coliform loading for each month. Consistent with the TMDL, individual daily loads were derived from the product of concentration, flow, and a conversion factor to express load in fecal coliform per day. Monthly averages are an arithmetic average of the daily load(s) for the month. The TMDL fecal coliform targets, based on concentration and load allocations, are extrapolated from these target concentrations. Therefore, TMDL target limit compliance is based on concentration, not load.

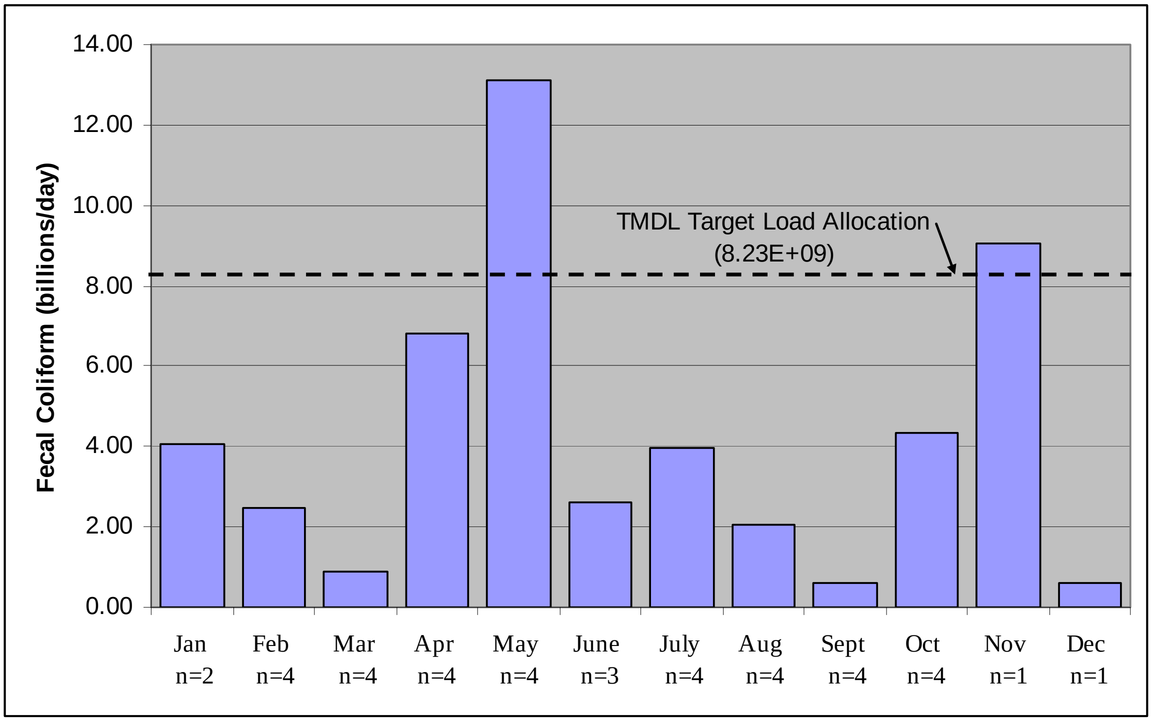

Figure 6. Ten Acre Creek estimated monthly fecal coliform loading for 2005-06.

Weaver Creek

TMDL targets were set for Weaver Creek (Table 2). Sampling results for Weaver Creek are presented in Appendix B. During the *Attainment Monitoring Study*, fecal coliform levels in Weaver Creek showed improvement since the TMDL Study but failed to meet TMDL targets for fecal coliform (Figure 5, Table 5). A 20% reduction in fecal coliform levels is still needed during the May – February critical period to meet TMDL targets. Weaver Creek did meet water quality standards for fecal coliform during the critical period with a geometric mean of 22 MPN/100 mL, and 9.8% of the samples used for calculating the geometric mean exceeded 100 MPN/100 mL (n=41).

Purdy Creek at East Bourgault Road

TMDL targets were set for Purdy Creek at East Bourgault Road (Table 2). Sampling results for Purdy Creek are presented in Appendix B. During the *Attainment Monitoring Study*, fecal coliform levels at this site were low, meeting TMDL targets and water quality standards (Figure 5, Table 5).

Comparison of Fecal Coliform Results During the TMDL Study and the Attainment Monitoring Study

Figure 7 presents box plots summarizing fecal coliform results for the TMDL Study and the *Attainment Monitoring Study*. To compare both data sets, the recent data were analyzed the same way as the TMDL data. The arithmetic mean of the fecal coliform laboratory replicate and result was used for analysis. Field duplicates were not used for this analysis. One value was obtained for each month during the critical period by taking the geometric mean value for the month.

Results show that fecal coliform levels for the Skokomish River at the Highway 106 bridge site and for the tributaries have improved.

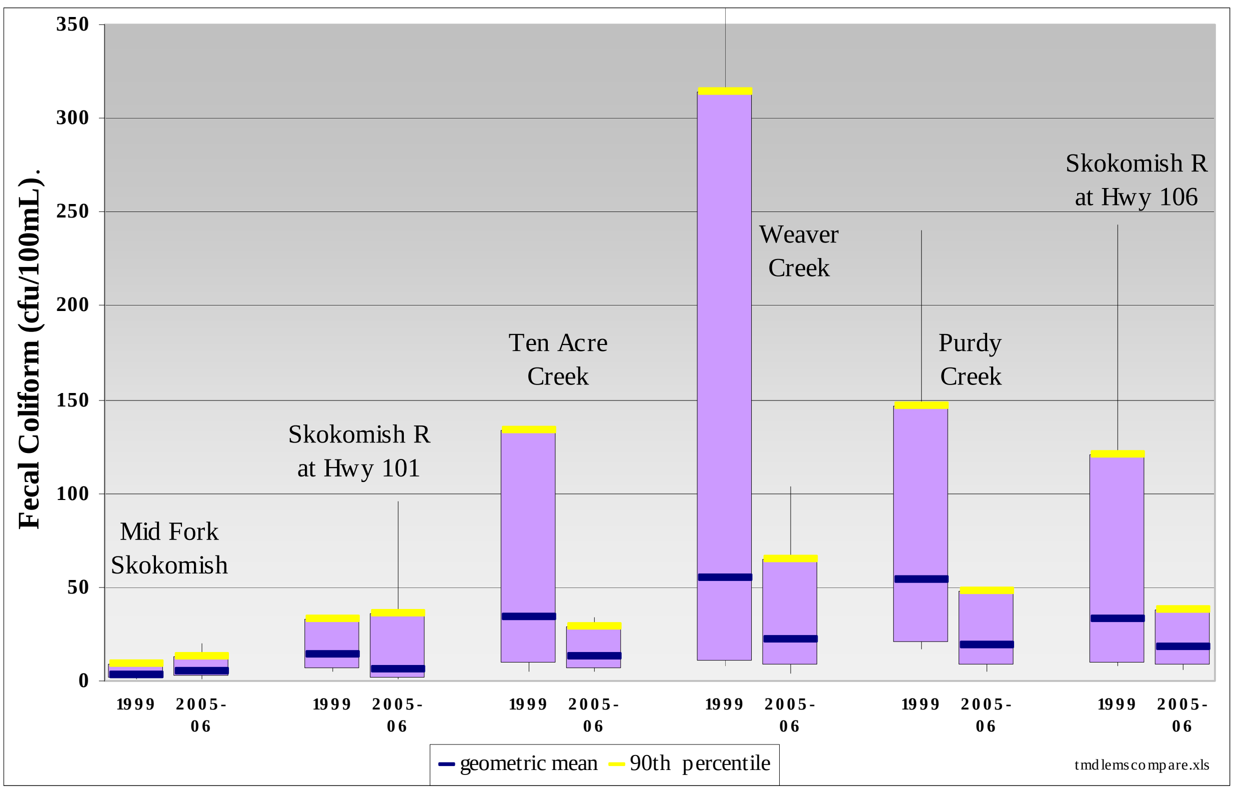

Figure 7. TMDL Study and *Attainment Monitoring Study* results comparison for fecal coliform bacteria.

To determine if there were any statistically significant trends in fecal coliform, a step trend statistical test was used for the tributary sites and for the Skokomish River site at Highway 106. The step trend test was used to determine if significant changes in water quality have occurred at sites where just pre- and post-implementation monitoring had occurred. For the Skokomish River at Highway 101, continuous monthly fecal coliform data were available so a Seasonal-Kendall trend test was done. Table 6 describes the results of the trend tests.

Table 6. Trend test results for attainment monitoring sites.

Ecology Monitoring Site	Statistical Trend Test Used	Seasonal Sen Slope	α = (2 tail)	Have fecal coliform levels changed significantly?
Skokomish River at Highway 101 bridge	Seasonal-Kendall	+ 0.20	0.12	No
Middle Fork Skokomish River	Step	n/a	0.82	No
Skokomish River at Highway 106 bridge	Step	n/a	<0.01	YES
Weaver Creek	Step	n/a	0.38	No
Ten Acre Creek	Step	n/a	0.85	No
Purdy Creek	Step	n/a	0.05	YES

For the sites on the three creeks sampled, Weaver, Purdy, and Ten Acre, there were decreasing levels of fecal coliform. However, only Purdy Creek had a statistically significant decreasing trend in fecal coliform levels ($p \leq 0.03$) (Figure 8).

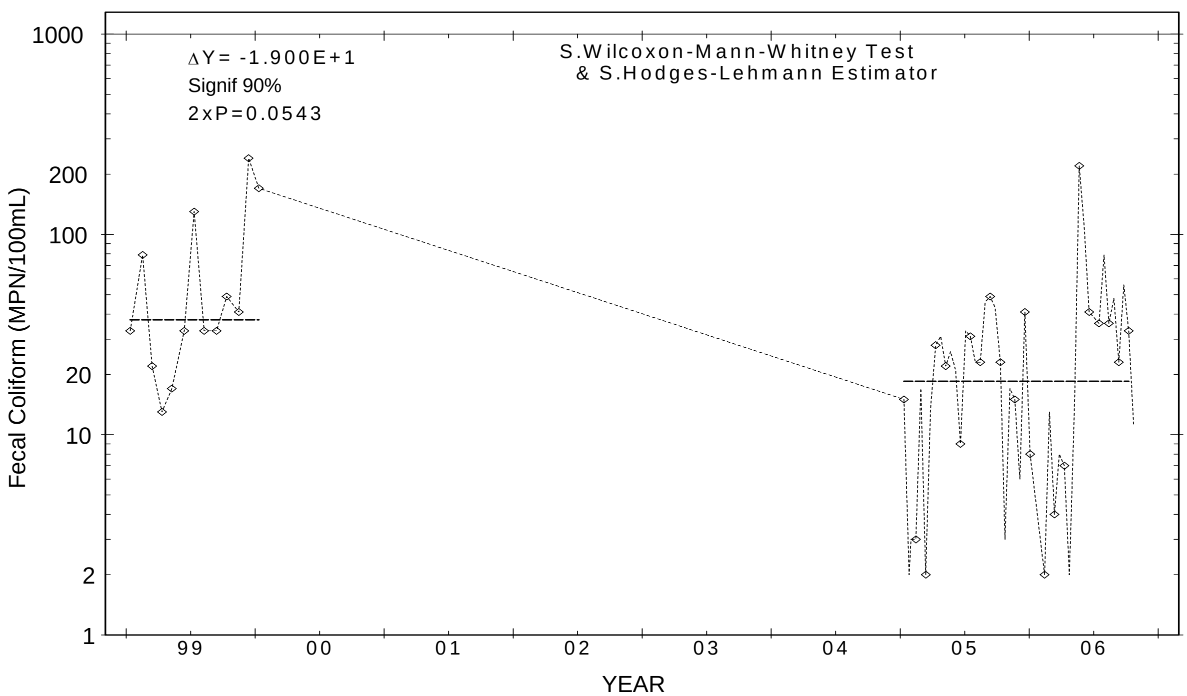

Figure 8. Step-trend analysis of Purdy Creek fecal coliform levels during the TMDL Study and the *Attainment Monitoring Study*.

Fecal coliform levels on the Middle Fork Skokomish River have not changed. At the Highway 106 bridge site, fecal coliform levels have decreased ($p \leq 0.02$) (Figure 9).

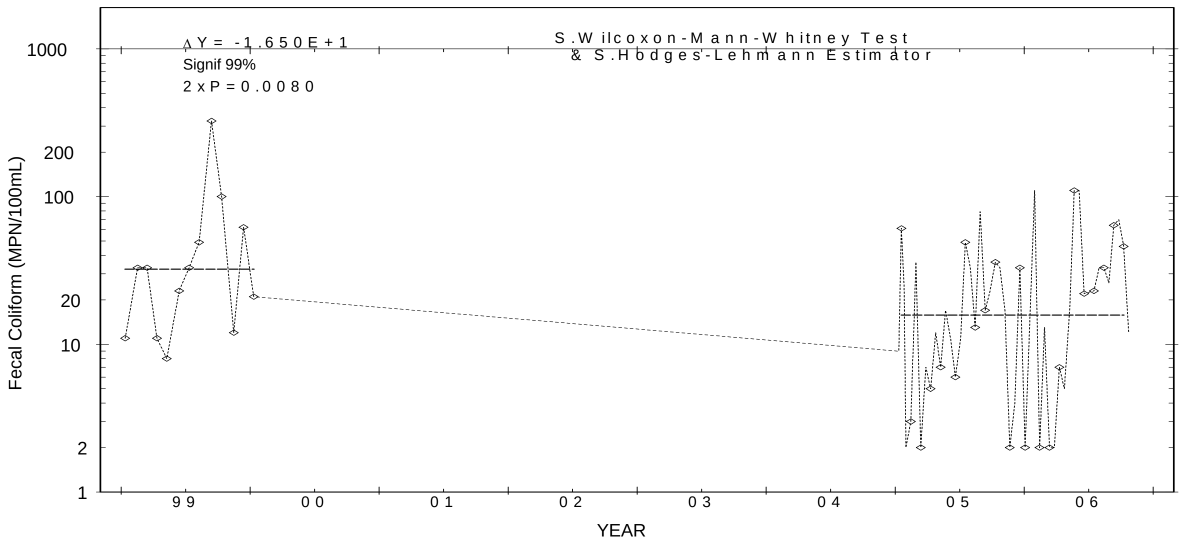

Figure 9. Skokomish River at Highway 106 bridge step-trend analysis of fecal coliform levels during the TMDL Study and the *Attainment Monitoring Study*.

Skokomish Tribe Ambient Surface Water Monitoring

The Skokomish Tribe has been collecting monthly fecal coliform data at a number of sites within the Skokomish River basin and the Tribal Reservation from December 1995 through the present (September 2007). Tribal monitoring did not occur with the same frequency or timing, or use the same laboratory or analytical method, for fecal coliform analysis as the *Attainment Monitoring Study*. Tribal monitoring used the membrane filter analysis method.

At the request of the Tribe, Ecology determined fecal coliform trends for sites the Tribe sampled within the Skokomish basin. A two-tailed Seasonal-Kendall non-parametric test was used to determine January 1999 through September 2007 trends in fecal coliform. Results of the trend analysis are presented in Appendix D. In addition, fecal coliform data from each site were compared with the water quality standard for the 2005-06 period of the *Attainment Monitoring Study*. When reviewing water quality and trend results, it is important to consider the differences in the sampling regime and the laboratory techniques for detecting fecal coliform bacteria.

Based on the Tribe's data, several sites in the Skokomish basin had improving fecal coliform levels from 1995 through September 2007 (Appendix D, Table D-1). The Skokomish River at the Highway 106 bridge and a site approximately 1.25 miles downstream showed decreasing fecal coliform levels. Decreasing levels were also seen on the following tributary sites:

- Weaver Creek at the Skokomish Valley Road bridge (a TMDL site)
- Ten Acre Creek (a TMDL site)
- Hunter Creek

Fecal coliform levels were compared to Washington State water quality standards for the January 2005 – October 2006 sampling period, excluding March and April (the non-critical period). All sites met fecal coliform water quality standards for that period, with the exception of the two Purdy Creek sites and a downstream site on Weaver Creek (Appendix D, Table D-2). The upstream site on Weaver Creek at the Skokomish Valley Road bridge met fecal coliform water quality standards.

Conclusions and Recommendations

Four sites were sampled for the 2005-06 *Attainment Monitoring Study:* Weaver Creek, Ten Acre Creek, Purdy Creek, and the lower Skokomish River. All four sites met fecal coliform water quality standards. All sites, with the exception of Weaver Creek, met TMDL fecal coliform targets (Table 5). Weaver Creek needs a 20% reduction in fecal coliform levels to meet the TMDL target value. Significant improvements in fecal coliform levels were seen in the Skokomish River at the Highway 106 bridge site and at the Purdy Creek site.

Due to Weaver Creek failing to meet fecal coliform targets during the *Attainment Monitoring Study,* Ecology's Southwest Regional Office is currently conducting additional monitoring in the Weaver Creek subwatershed. The purpose of this additional monitoring is to locate the sources of bacteria to the creek.

Water Quality Program Recommended Management Actions for the Skokomish River Basin

- Landowners in the watershed should maintain best management practices (BMPs). These BMPs should be inspected on a periodic basis to ensure that the BMPs continue to be properly operated and/or maintained.
- Bacteria sources to Weaver Creek should be addressed based on the findings of Ecology's current monitoring effort in the Weaver Creek subwatershed.
- Follow-up monitoring should be conducted on Weaver Creek after implementation of best management practices to confirm that Weaver Creek meets TMDL targets for fecal coliform bacteria.

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Appendices

Appendix A. Glossary and Acronyms

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years.

Best Management Practices (BMPs): Physical, structural, and/or operational practices that, when used singularly or in combination, prevent or reduce pollutant discharges.

Clean Water Act: Federal Act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Act establishes the TMDL program.

Designated Uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each waterbody or segment, regardless of whether or not the uses are currently attained.

Enterococci: A subgroup of the fecal streptococci that includes *S. faecalis, S. faecium, S. gallinarum* and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5% sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C.

Existing Uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Extraordinary Primary Contact: Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

Fecal Coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within twenty-four hours at 44.5 plus or minus 0.2 degrees Celsius. FC are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric Mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from ten to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Load Allocation: The portion of a receiving waters' loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading Capacity: The greatest amount of a substance that a waterbody can receive and still meet water quality standards.

Nonpoint Source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System Program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

Point Source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental, or injurious to the public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish, or other aquatic life.

Primary Contact Recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Riparian: Relating to the banks along a natural course of water.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Surface Waters of the State: Lakes, rivers, ponds, streams, inland waters, saltwaters, wetlands and all other surface waters and water courses within the jurisdiction of the state of Washington.

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Wasteload Allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Acronyms

Following are acronyms used frequently in this report. Also see acronyms included in the Glossary above.

Ecology	Washington State Department of Ecology
EIM	Environmental Information Management system (Ecology)
EPA	U.S. Environmental Protection Agency
MCD	Mason Conservation District (Mason CD)
MEL	Manchester Environmental Laboratory (Ecology)
MPN	Most probable number
NPDES	National Pollution Discharge Elimination System
USGS	U.S. Geological Survey

Appendix B. Mason Conservation District and Ecology's Laboratory and Field Results for the Skokomish River Basin

Table B-1. Mason CD and Ecology's laboratory and field results for the Skokomish River.

Date	Mason Conservation District Mason County Laboratory			Ecology Manchester Environmental Laboratory			Mason CD	Ecology
	Fecal Coliform MPN/100 mL						Flow Discharge cfs	
	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate
Middle Skokomish River								
01/11/2005	2			2			nd	
01/18/2005	nd			no access			nd	
01/26/2005	nd			2			nd	
01/31/2005				4.5			nd	
02/14/2005	1.8 U			1.8 U			nd	
02/28/2005	2			1.8 U			189.0	
03/14/2005	2			4.5			186.0	
03/28/2005	2	1.8	2				nd	
04/11/2005	2						nd	
04/25/2005	7.8	7.8	7.8	4.5	2	13	18.3	18.2
05/09/2005	7.8						289.9	
05/23/2005	2			1.8 U			nd	
06/06/2005	4						277.8	278.9
06/20/2005	1.8 U			7.8			158.0	
07/05/2005	4	4	23				68.0	
07/18/2005	2						92.9	94.3
08/01/2005	13						36.5	
08/15/2005	2	7.8	4.5				10.7	10.7
08/29/2005	33	33	33				nd	
09/12/2005	dry						0	
09/26/2005	dry						0	
10/11/2005	13			23			59.8	66.8
10/24/2005	23						121.6	126.4
11/07/2005	4.5						nd	
11/21/2005	4.5						nd	
12/05/2005	1.8 U	6.8	4.5	4.5 J	18 UJ	18UJ	121.6	
12/19/2005	2						nd	
01/03/2006	2						nd	
01/30/2006	no access						nd	
02/13/2006	2	4.5	2				nd	
02/27/2006	7.8			4.5			nd	
03/13/2006	1.8 U						nd	
03/27/2006	1.8 U						nd	

Date	Mason Conservation District Mason County Laboratory			Ecology Manchester Environmental Laboratory			Mason CD	Ecology
	Fecal Coliform MPN/100 mL						Flow Discharge cfs	
	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate
04/10/2006	1.8 U						nd	
04/24/2006	1.8 U						nd	
05/09/2006	4.5						nd	
05/22/2006	49						nd	
06/05/2006	23						nd	
06/19/2006	2						nd	
07/05/2006	4.5						nd	
07/17/2006	6.8			11			68.6	
07/31/2006	4.5	2	4				nd	
08/14/2006	4.5			11			6.2	
08/28/2006	dry						0	
09/11/2006	dry						0	
09/25/2006	dry						0	
10/09/2006	dry						0	
10/23/2006	dry			dry			0	
Skokomish River at Highway 106 bridge								
01/11/2005	11			7.8			nd	
01/18/2005	nd			70	79	23	nd	
01/26/2005	nd			4.5	79	11	nd	
01/31/2005	1.8 U			1.8 U			nd	
02/14/2005	1.8 U	6.8	7.8	2.0	4.0	2.0	nd	
02/28/2005	70			1.8 U			nd	
03/14/2005	2			1.8 U			nd	
03/28/2005	6.8						nd	
04/11/2005	4.5						nd	
04/25/2005	17			6.8			nd	
05/09/2005	7.8	6.8	13				nd	
05/23/2005	23			11			nd	
06/06/2005	11						nd	
06/20/2005	4.5			7.8			nd	
07/05/2005	11						nd	
07/18/2005	49	23	9				nd	
08/01/2005	33						nd	
08/15/2005	13						nd	
08/29/2005	79						nd	
09/12/2005	17						nd	
09/26/2005	23						nd	
10/11/2005	23			49			nd	
10/24/2005	33						nd	
11/07/2005	17						nd	
11/212005	2						nd	

Date	Mason Conservation District Mason County Laboratory			Ecology Manchester Environmental Laboratory			Mason CD	Ecology
	Fecal Coliform MPN/100 mL						Flow Discharge cfs	
	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate
12/05/2005	4.5			4			nd	
12/19/2005	33						nd	
01/03/2006	1.8 U						nd	
01/17/2006	17						nd	
01/30/2006	110						nd	
02/13/2006	1.8 U						nd	
02/27/2006	33	8	23	11	23	6.8	nd	
03/13/2006	2						nd	
03/27/2006	2						nd	
04/10/2006	6.8						nd	
04/24/2006	4.5						nd	
05/09/2006	17						nd	
05/22/2006	110						nd	
06/05/2006	110						nd	
06/19/2006	22						nd	
07/05/2006	49						nd	
07/17/2006	22			23			nd	
07/31/2006	33						nd	
08/14/2006	49			17			nd	
08/28/2006	26						nd	
09/11/2006	49	49					nd	
09/25/2006	70						nd	
10/09/2006	46						nd	
10/23/2006	7.8			17			nd	
Weaver Creek at Bourgault Road								
01/11/2005	95	49	130	350	170	33	nd	
01/18/2005	nd			330			nd	
01/26/2005	nd			1.8 U			nd	
01/31/2005	2			1.8			nd	
02/14/2005	1.8 U			13			nd	
02/28/2005	2	2	1.8 U	7.8	2	1.8 U	nd	
03/14/2005	2			3.7			46.3	
03/28/2005	6.8						46.1	
04/11/2005	79						nd	
04/25/2005	13			13			nd	
05/09/2005	79						nd	
05/23/2005	13	23	23	23			nd	
06/06/2005	23	33	33				nd	
06/20/2005	7.8	4.5	13	4	4.5	4.0	nd	
07/05/2005	33						nd	
07/18/2005	23						nd	

Date	Mason Conservation District Mason County Laboratory			Ecology Manchester Environmental Laboratory			Mason CD	Ecology
	Fecal Coliform MPN/100 mL						Flow Discharge cfs	
	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate
08/01/2005	23						nd	
08/15/2005	13						nd	
08/29/2005	33						nd	
09/12/2005	13	23	13				nd	
09/26/2005	79						nd	
10/11/2005	11	33	46	49	17	26	nd	
10/24/2005	17						nd	
11/07/2005	4.5	23	13				nd	
11/21/2005	17						nd	
12/05/2005	7.8			18 UJ			nd	
12/19/2005	79						nd	
01/03/2006	11						nd	
01/17/2006	22	79	33				nd	
01/30/2006	70						nd	
02/13/2006	2						nd	
02/27/2006	4.5			1.8 U			nd	
03/13/2006	1.8 U	1.8 U	3.6				nd	
03/27/2006	1.8 U	1.8	2				nd	
04/10/2006	2						nd	
04/24/2006	1.8 U	4	4.5				nd	
05/09/2006	79						nd	
05/22/2006	920						nd	
06/05/2006	170						nd	
06/19/2006	23						nd	
07/05/2006	27	22	17				nd	
07/17/2006	17			17			nd	
07/31/2006	7.8						nd	
08/14/2006	34			23			nd	
08/28/2006	23						nd	
09/11/2006	49						nd	
09/25/2006	13						nd	
10/09/2006	33						nd	
10/23/2006	4.5			6.8			nd	
Ten Acre Creek at Campbell Lane								
01/11/2005	4.5			6.8			4.5	
01/18/2005	nd			23			nd	
01/26/2005	nd			4.5			nd	
01/31/2005	6.1	1.8 U	2	7.8	4	2	nd	
02/14/2005	17			6.8			5.9	
02/28/2005	11			1.8			6.2	
03/14/2005	11			23			4.7	

Date	Mason Conservation District Mason County Laboratory			Ecology Manchester Environmental Laboratory			Mason CD	Ecology
	Fecal Coliform MPN/100 mL						Flow Discharge cfs	
	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate
03/28/2005	7.8						5.4	
04/11/2005	95						8.9	
04/25/2005	11			23			7.2	
05/09/2005	23						6.2	
05/23/2005	23			13			8.3	11.7
06/06/2005	33						nd	
06/20/2005	7.8			13			5.6	
07/05/2005	4.5						5.8	
07/18/2005	4.5						3.8	
08/01/2005	7.8		13				7.5	5.6
08/15/2005	23						4.5	
08/29/2005	11						nd	
09/12/2005	7.8						4.6	5.2
09/26/2005	7.8						4.4	4.6
10/11/2005	79			140			5.8	
10/24/2005	4.5						6.3	
11/07/2005	49						6.1	8.9
11/21/2005	1.8						nd	
12/05/2005	2			7.8 J			4.9	5.5
12/19/2005	240						nd	
01/03/2006	46	17	46				7.9	
01/30/2006	no access						nd	
02/13/2006	4.5						5.8	
02/27/2006	23			46			6.4	7.2
03/13/2006	1.8 U						8.3	6.9
03/27/2006	2						6.3	
04/10/2006	14	23	33				5.4	7.0
04/24/2006	1.8 U						7.8	7.0
05/09/2006	13						6.3	7.0
05/22/2006	130	240	110				10.4	12.3
06/05/2006	49	46	7.8				3.7	
06/19/2006	17						7.2	
07/05/2006	79						7.2	
07/17/2006	2	2		13	4.5	4.5	5.6	6.3
07/31/2006	46						nd	
08/14/2006	17			13			5.6	
08/28/2006	23						5.7	
09/11/2006	6.8						1.8	
09/25/2006	2						5.4	
10/09/2006	4.5						4.6	4.9
10/23/2006	4.5	2	1.8 U	4.5	7.8	2	5.9	3.9
Purdy Creek at East Bourgault Road								
01/11/2005	17			13			nd	nd
01/18/2005	nd			no access			nd	nd

Date	Mason Conservation District Mason County Laboratory			Ecology Manchester Environmental Laboratory			Mason CD	Ecology
	Fecal Coliform MPN/100 mL						Flow Discharge cfs	
	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate
01/26/2005	nd			2			nd	nd
01/31/2005	4.5			2			nd	nd
02/14/2005	4.5			1.8			nd	nd
02/28/2005	1.8 U			33			nd	nd
03/14/2005	1.8 U	1.8 U	1.8 U	1.8 J	4.5	2	nd	nd
03/28/2005	14						nd	nd
04/11/2005	23	33	23				nd	nd
04/25/2005	13			49			nd	nd
05/09/2005	22						nd	nd
05/23/2005	22			33	33	22	nd	nd
06/06/2005	21						nd	nd
06/20/2005	4.5			13			nd	nd
07/05/2005	33						nd	nd
07/18/2005	31						nd	nd
08/01/2005	23	21					nd	nd
08/15/2005	23						nd	nd
08/29/2005	46						nd	nd
09/12/2005	49						nd	nd
09/26/2005	23	49	31				nd	nd
10/11/2005	23			23			nd	nd
10/24/2005	2	4.5	11				nd	nd
11/07/2005	17						nd	nd
11/21/2005	17	17					nd	nd
12/05/2005	6.8			4.5			nd	nd
12/19/2005	49	33	49				nd	nd
01/03/2006	7.8						nd	nd
01/30/2006	no access						nd	nd
02/13/2006	1.8 U						nd	nd
02/27/2006	23			13			nd	nd
03/13/2006	3.7						nd	nd
03/27/2006	7.8						nd	nd
04/10/2006	6.8						nd	nd
04/24/2006	1.8 U						nd	nd
05/09/2006	7.8	22	13				nd	nd
05/22/2006	220						nd	nd
06/05/2006	110						nd	nd
06/19/2006	32	49	17				nd	nd
07/05/2006	33						nd	nd
07/17/2006	23			49			nd	nd
07/31/2006	79						nd	nd
08/14/2006	23	49	33	23	49	46	nd	nd
08/28/2006	46	49	49				nd	nd
09/11/2006	23						nd	nd

Date	Mason Conservation District Mason County Laboratory			Ecology Manchester Environmental Laboratory			Mason CD	Ecology
	Fecal Coliform MPN/100 mL						Flow Discharge cfs	
	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate	Lab Replicate	Sample	Field Duplicate
09/25/2006	33	79	49				nd	nd
10/09/2006	17	49	49				nd	nd
10/23/2006	11			11			nd	nd

nd: Sample not obtained or flow measurements not done.
U: Analyte was not detected at or above reported result.
J: Estimated count samples analyzed > 24 hours after collection.

Appendix C. Quality Assurance and Quality Control Results

Laboratory Data

Mason Conservation District (CD) fecal coliform samples were analyzed at the Mason County Public Health Laboratory in accordance with the quality assurance quality control (QA/QC) procedures followed by Mason County Laboratory (Spaulding, 1992). Ecology fecal coliform samples were analyzed at Ecology's Manchester Environmental Laboratory (MEL) in accordance with QA/QC procedures followed by Ecology's MEL (MEL, 2006). Both laboratories used the fecal coliform most probable number (MPN) method 9221 EW (APHA, 1998). The Food and Drug Administration most probable number (MPN) chart was used to determine the MPN and 95% confidence limits.

All fecal coliform samples met holding time requirements. At MEL the microbiological samples were analyzed within 30 hours, which is a standard procedure for MEL. MEL microbiological samples were not analyzed within the 6-hour window described in Standard Methods (APHA, 1998) because of the logistical challenges in collecting and transporting samples within the given timeframe.

Duplicate field samples were used to estimate total variation (field and laboratory). Duplicates are two field samples collected sequentially at the same site as close as possible in time. Laboratory replicates are samples that are split in the laboratory and run independently. The Quality Assurance (QA) Project Plan (Batts, 2005) specified acceptable precision for the total data set of each agency's duplicate pairs as a percent root mean square of the coefficient of variation (RMSCV%) equal to or less than 30%. For comparison of Ecology – Mason CD pairs, the precision target was RMSCV% equal to or less than 50%.

Table C-1 describes precision estimates for Mason CD and Ecology data. Neither entity met the data quality objectives specified in the QA Project Plan. The data quality objectives specified in the QA Project Plan were very stringent requiring a 30% RMSCV for the entire fecal coliform (MPN) data set, field duplicates, and laboratory splits. The QA Project Plan incorrectly cited a 30% RMSCV value as being consistent with the TMDL Study (Seiders et al., 2001). In the TMDL Study the RMSCV% for MPN field duplicates was 44%. Mason CD's RMSCV% was 45% for field duplicates and 48% for the laboratory replicates, well within precision values found during the TMDL Study. Ecology's RMSCV% was higher with 61% RMSCV for field duplicates and 63% for laboratory replicates. The precision between the Ecology and Mason CD sample set was 55% RMSCV, just higher than the QA Project Plan data quality objective of 50%.

Precision for Mason County CD fecal coliform data is considered adequate because it is similar to precision reported in the TMDL. Ecology's data is less precise. Ecology and Mason CD data will be averaged for data analysis purposes. Periods where both parties sampled and data are averaged will likely be more representative of true environmental conditions. Data variability will be taken into consideration during data analysis and result interpretations.

Table C-1. Precision estimates for Mason Conservation District and Ecology water quality data.

Parameter	No. of Replicate Pairs	No. of Analyses	Replicate Rate	Pooled Standard Deviation	RMSCV*	Units
Ecology Sampling						
Fecal Coliform (field duplicates)	16	92	17%	16.6	61%	MPN/ 100mL
Fecal Coliform (lab replicates)	16	92	17%	21.1	63%	MPN/ 100mL
Mason CD Sampling						
Fecal Coliform (field duplicates)	42	298	14%	10.0	47%	MPN/ 100mL
Fecal Coliform (lab replicates)	46	298	15%	9.6	45%	MPN/ 100mL
Flow (field)	22	80	28%	1.8	13%	cubic feet per second
Ecology – Mason CD Comparison Sampling						
Fecal Coliform (field duplicates)	66	390	17%	9.0	55%	MPN/ 100mL

* RMSCV: Root Mean Square of the Coefficient of Variation.

Field Data Quality

Mason CD obtained flow measurements during most of the sampling events at two sites. Duplicate flow measurements were obtained 28% of the time by Ecology. Table C-1 presents precision of flow measurements. Precision for flows was good with a RMSCV of 13%.

Establishing Comparability of Mason CD Data with Ecology Data

Mason CD conducted most of the monitoring for this project with funding from a Centennial Clean Water grant. Side-by-side sampling was conducted with Ecology's Environmental Assessment Program (EA Program) for the first five sample events and for nine more events during the rest of the 2005-06 sample period. Flows were measured as close together in time and location as possible. Samples collected by Mason CD were analyzed by the Mason County Laboratory for fecal coliform using the most probable number (MPN) method. Samples collected by Ecology were sent to Manchester Laboratory for MPN analysis. Both laboratories used the Federal Drug Administration (FDA) table to read MPN tubes.

As described in the QA Project Plan (Batts, 2005), Mason CD and Ecology data were assessed for comparability by determining if 95% confidence intervals overlapped for each paired instance. Standard Methods Table 9221.IV (APHA, 1998) was used to determine confidence limits around the closest available value at a particular tube series in the FDA table. Of 70 paired side-by-side sampling events, five results were not within the 95% confidence limits. The individual results of this assessment are described in Table C-2. These results are considered acceptable, and Mason CD and Ecology data are considered comparable.

Ecology and Mason CD obtained flow measurements as close together as possible in time. Table C-1 presents precision of flow measurements. Precision for flows was good with a RMSCV of 13%. Results are considered comparable.

Due to comparable results between the two agencies, Mason CD and Ecology results were both used in data analysis.

Table C-2. Results of Mason Conservation District (Mason County Water Quality Laboratory) and Ecology's (Manchester Environmental Laboratory) side-by-side sampling as compared to 95% confidence limits per Standard Methods Table 9221.IV.

Date	Mason County Lab		Manchester Lab		Sample 95% Confidence Limits*	QA (Field Duplicate) 95% Confidence Limits*	Within 95% Confidence Limits?*
	Lab Sample MPN/100mL	Field Duplicate MPN/100mL	Lab Sample MPN/100mL	Field Duplicate MPN/100mL			
Middle Skokomish River							
01/11/2005	2		2		0.1 - 10		Yes
01/31/2005	1.8 U		4.5		≤ 6.8		Yes
02/14/2005	1.8 U		1.8 U		≤ 6.8		Yes
02/28/2005	2		1.8 U		0.1 - 10		Yes
03/14/2005	2		4.5		0.1 - 10		Yes
04/25/2005	7.8	7.8	4.5	2	2.1 - 22	2.1 -22	Yes
05/23/2005	2		1.8 U		0.1 - 10		Yes
06/20/2005	1.8 U		7.8		≤ 6.8		NO
10/11/2005	13		23		4.1 - 35		Yes
12/05/2005	1.8 U	6.8	4.5	18 UJ**	≤ 6.8	1.8 - 15	Yes
02/27/2006	7.8		4.5		2.1 - 22		Yes
07/17/2006	6.8		11		1.8 - 17		Yes
08/14/2006	4.5		11		0.79 - 15		Yes
Skokomish River at Highway 106 bridge							
01/11/2005	11		7.8		3.5 - 26		Yes
01/31/2005	1.8 U		1.8 U		≤ 6.8		Yes
02/14/2005	1.8 U	6.8	2.0	4.0	≤ 6.8	1.8-17	Yes
02/28/2005	70		1.8 U		22 - 170		Yes
03/14/2005	2		1.8 U		0.1 - 10		Yes
04/25/2005	17		6.8		6.0 - 40		Yes
05/23/2005	23		11		6.8 - 70		Yes
06/20/2005	4.5		7.8		0.79 - 15		Yes
10/11/2005	23		49		6.8 - 70		Yes
12/05/2005	4.5		4		0.79 - 15		Yes
02/27/2006	33		11		10 - 100		Yes
07/17/2006	22		23		6.8 - 50		Yes
08/14/2006	49		17		15 - 150		Yes
10/23/2006	7.8		17		2.1 - 22		Yes
Weaver Creek at Bourgault Road							
01/11/2005	95	49	350	170	34-230	36-400	Yes
01/31/2005	2		1.8		0.1 - 10		Yes
02/14/2005	1.8 U		13		≤ 6.8		NO
02/28/2005	2	2	7.8	2	0.1 - 10	≤ 6.8	Yes
03/14/2005	2		3.7		≤ 6.8		Yes
04/25/2005	13		13		4.1 - 35		Yes
05/23/2005	13		23		4.1 - 35		Yes
06/20/2005	7.8	4.5	4	4.5	2.1 - 22	0.79 - 15	Yes

Date	Mason County Lab		Manchester Lab		Sample 95% Confidence Limits*	QA (Field Duplicate) 95% Confidence Limits*	Within 95% Confidence Limits?*
	Lab Sample MPN/100mL	Field Duplicate MPN/100mL	Lab Sample MPN/100mL	Field Duplicate MPN/100mL			
10/11/2005	11	33	49	17	3.5 - 26	10 - 100	NO/Yes
12/05/2005	7.8		18 UJ		2.1 - 22		Yes
02/27/2006	4.5		1.8 U		0.79 - 15		Yes
07/17/2006	17		17		6.0-40		Yes
08/14/2006	34		23		14 - 100		Yes
10/23/2006	4.5		6.8		0.79 - 15		Yes
Ten Acre Creek at Campbell Lane							
01/11/2005	4.5		6.8		0.79-15		Yes
01/31/2005	6.1	1.8 U	7.8	4	1.8-15	≤ 6.8	Yes
02/14/2005	17		6.8		6.0 - 40		Yes
02/28/2005	11		1.8		3.5 - 26		Yes
03/14/2005	11		23		3.5 - 26		Yes
04/25/2005	11		23		3.5 - 26		Yes
05/23/2005	23		13		6.8 - 70		Yes
06/20/2005	7.8		13		2.1 - 22		Yes
10/11/2005	79		140		22 -220		Yes
12/05/2005	2		7.8 J		0.1 - 10		Yes
02/27/2006	23		46		6.8 - 70		Yes
07/17/2006	2	2	13	4.5	0.1 - 10	0.79 - 15	Yes
08/14/2006	17		13		6.0 - 40		Yes
10/23/2006	4.5	2	4.5	7.8	0.79 - 15	0.1 - 10	Yes
Purdy Creek on East Bourgault Rd							
01/11/2005	17		13		5.9 - 36		Yes
01/31/2005	4.5		2		0.79 - 15		Yes
02/14/2005	4.5		1.8		0.79 - 15		Yes
02/28/2005	1.8 U		33		≤ 6.8		NO
03/14/2005	1.8 U	1.8 U	1.8 J	4.5	≤ 6.8	≤ 6.8	Yes
04/25/2005	13		49		4.1 - 35		NO
05/23/2005	22		33	33	6.8 - 50		Yes
06/20/2005	4.5		13		0.79 - 15		Yes
10/11/2005	23		23		6.8 - 70		Yes
12/05/2005	6.8		4.5		1.8 - 17		Yes
02/27/2006	23		13		6.8 - 70		Yes
07/17/2006	23		49		6.8 - 70		Yes
08/14/2006	23	49	23	49	6.8 - 70	15 - 150	Yes
10/23/2006	11		11		3.5 - 26		Yes

* 95% Confidence limits per Standard Methods Table 9221.IV.

** Ecology value was not within 95% confidence limits (CL) but lower detection limit used was high (18 MPN/100 mL). Value considered to meet intent of 95% CL. MPN = most probable number.

Appendix D. Skokomish Tribe Ambient Surface Water Monitoring: Trend Analysis for Select Sites in the Skokomish River Basin

The Skokomish Tribe has been collecting monthly fecal coliform data at a number of sites withing the Skokomish basin and Tribal Reservation from December 1995 through the present (September 2007). Their Standard Operating Procedures (SOPs) are described in Dublanica et al. (2005). The SOP also serves as the Tribe's Quality Assurance Project Plan. The Tribe contracts with the Thurston or Mason County Laboratory for fecal coliform analysis. Membrane filter analysis is done to determine fecal coliform count.

At the request of the Tribe, Ecology analyzed fecal coliform trends for sites the Tribe samples within the Skokomish basin. A two-tailed, non-parametric Seasonal-Kendall trend test was used to determine trends during January 1999 through September 2007. Data were missing for some months including no data for February through November 1998. The following sites were analyzed to determine trends:

- Skokomish River at Rocky Beach, upstream of confluence with Hunter Creek (Skok R. at Rocky Beach).
- Skokomish River at Chico's Eddy, just downstream of confluence with Purdy Creek (Skok R. at Chico's Eddy).
- Skokomish River at Highway 106 bridge (Skok R. at 106 bridge).
- Skokomish River at Bobby Allens, approximately 1.25 miles downstream of Highway 106 bridge (Skok R. at Bobby Allen).
- Purdy Creek at Bourgault Road.
- Purdy Creek at the mouth.
- Weaver Creek at Skokomish Valley Road bridge.
- Weaver Creek at the low bridge downstream of TMDL site.
- Hunter Creek.
- Ten Acre Creek.

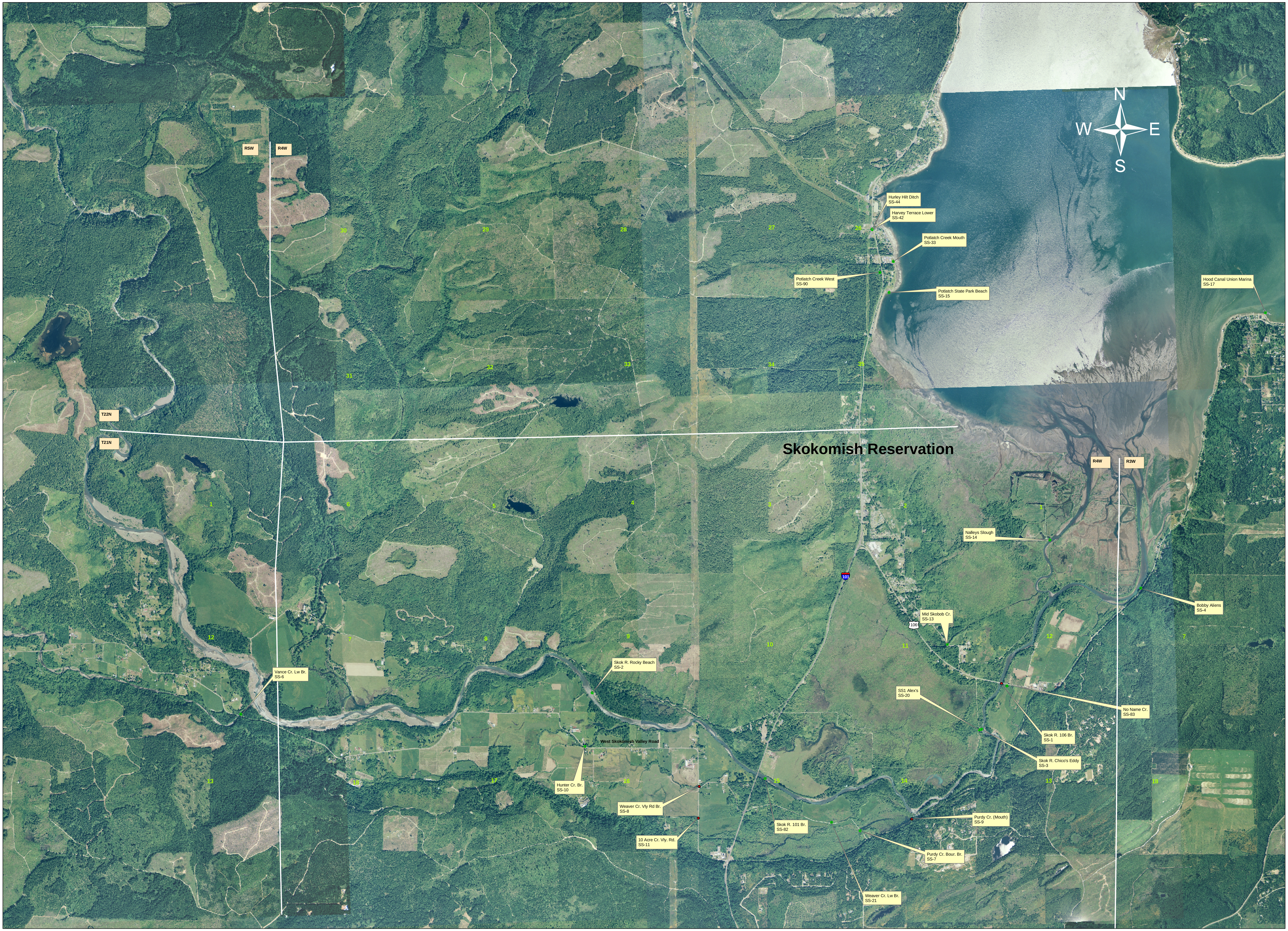
Figure D-1 presents the Tribe's monitoring sites in the Skokomish basin. Tribal data may be obtained by calling the Skokomish Tribe Natural Resources Department at (360) 877 5213.

The following Tribal sites are also TMDL compliance sites:

- Skokomish River at Highway 106 bridge.
- Purdy Creek at East Bourgault Road.
- Weaver Creek at Skokomish Valley Road bridge.
- Ten Acre Creek.

Results of the trend analysis are presented in Table D-1. Trends from January 1999 through September 2007 were determined in the table. Data were not available for all months; all available data were used in the trend analysis.

Figure D-1. Skokomish Tribe monitoring sites in the Skokomish River basin.



0 0.4 0.8 1.6 Miles

Control Sites

- PURDYMOUTH
- WERVERVLY
- SKOKR106BR
- 10ACREVYRD

Skokomish Natural Resources Composite Map 2005
USGS Quads--University of Washington
Datum D_ North_American _Nad 83 Source File
BIA Tribal Parcel Datum--Nad 27 --Shifted

Table D-1. Seasonal-Kendall fecal coliform trend analysis results for select Skokomish Tribal stations. Period tested January 1999 - September 2007.

Skokomish Tribal Site	Seasonal Sen Slope	P value (2 tail)	Have fecal coliform levels changed significantly?
Skok. R. at Rocky Beach	0.11	0.12	No
Skok. R. at Chico's Eddy	-0.29	0.34	No
Skok. R. at Hwy 106 bridge	-1.38	<0.01	Yes, fecal coliform levels have decreased at this site
Skok. R. at Bobby Allens	-1.60	<0.01	Yes, fecal coliform levels have decreased at this site
Purdy Ck. at Bourgault Rd.	-0.80	0.11	No
Purdy Ck. near the mouth	0.67	0.29	No
Weaver Ck. at Skok. Valley Rd.	-1.80	0.02	Yes, fecal coliform levels have decreased at this site
Weaver Ck. at the low bridge	0.29	0.44	No
Hunter Creek	-1.99	<0.01	Yes, fecal coliform levels have decreased at this site
Ten Acre Creek	-1.95	<0.01	Yes, fecal coliform levels have decreased at this site

Results of the trend analysis (January 1999 through September 2007) show that fecal coliform levels have decreased at the following sites:

- Skokomish River at the Highway 106 bridge (Figure D-2).
- Skokomish River at the Bobby Allens site (Figure D-3).
- Weaver Creek at the Skokomish Valley Road bridge (Figure D-4).
- Hunter Creek (the month of September showed increasing fecal coliform levels) (Figure D-5).
- Ten Acre Creek (Figure D-6).

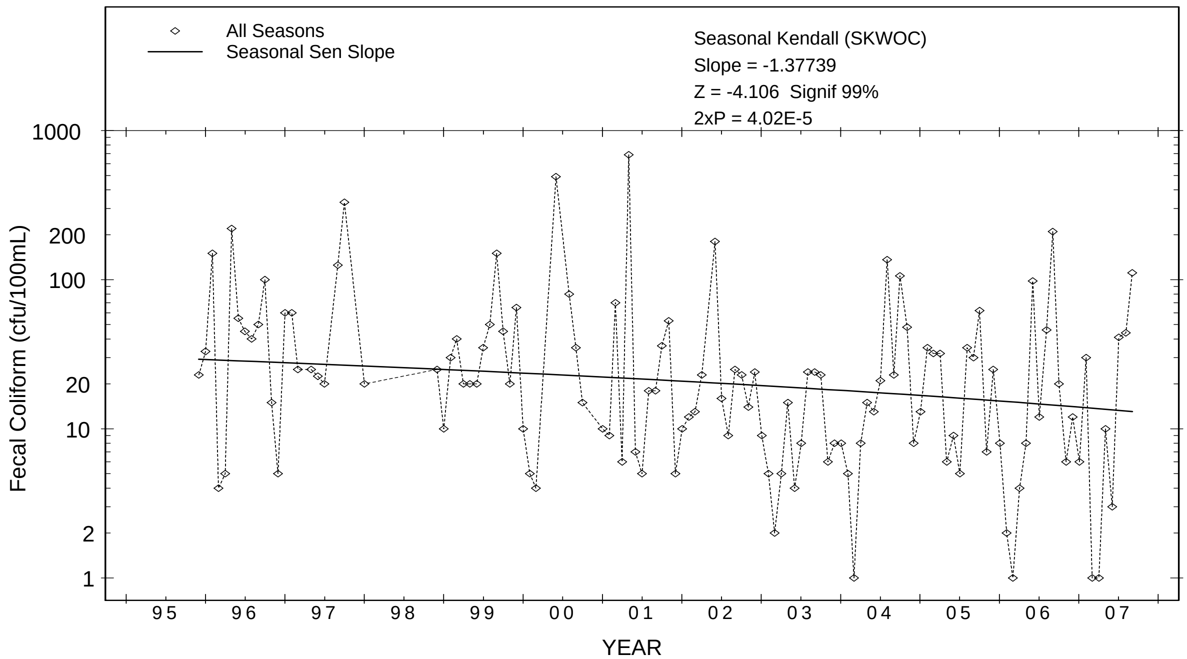


Figure D-2. Seasonal-Kendall trend test results for fecal coliform levels in the Skokomish River at Highway 106 bridge show improving fecal coliform levels.

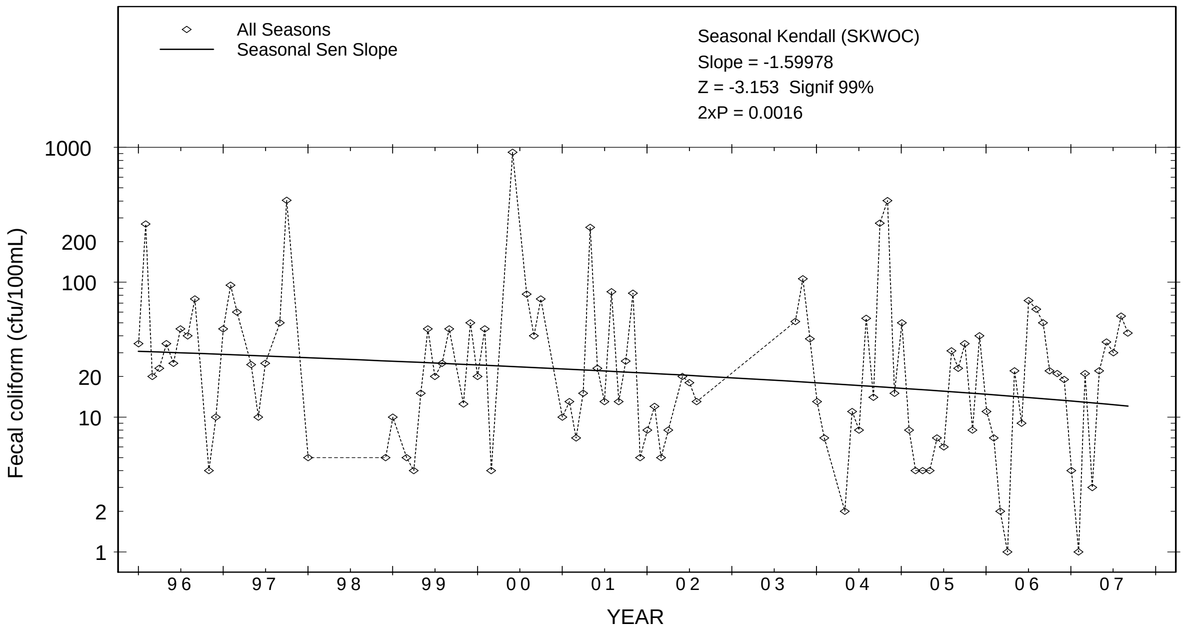


Figure D-3. Seasonal-Kendall trend test results for fecal coliform levels in the Skokomish River at the Bobby Allens site show improving fecal coliform levels.

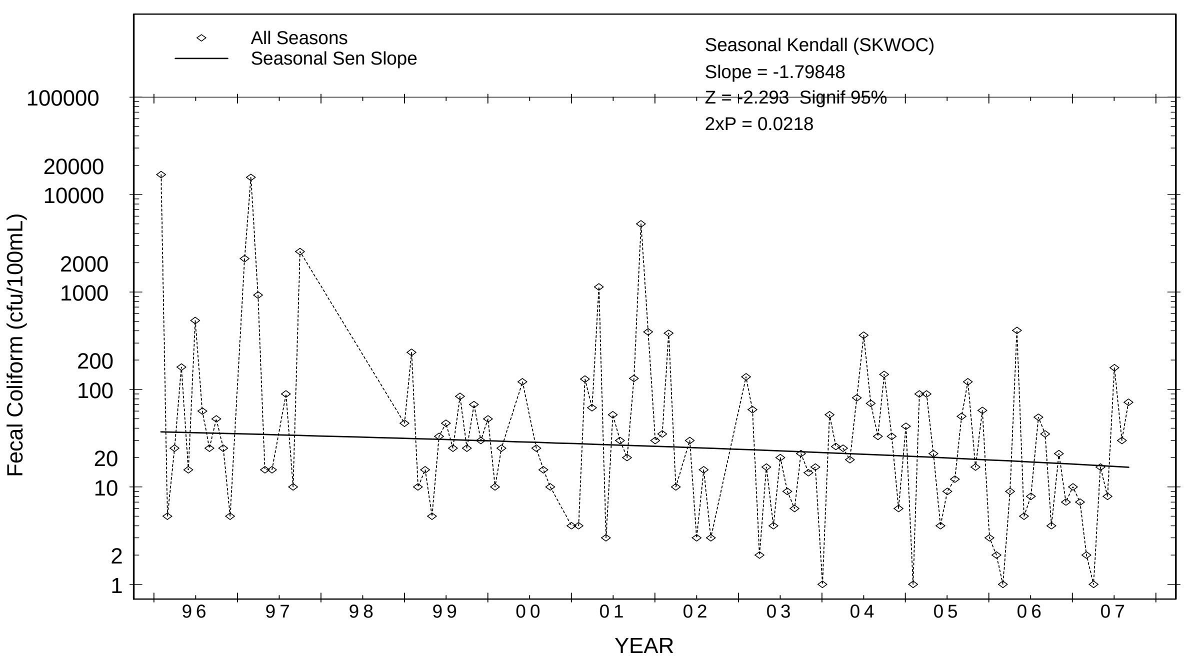


Figure D-4. Seasonal-Kendall trend test results for fecal coliform levels for Weaver Creek at the Skokomish Valley Road bridge site show improving fecal coliform levels.

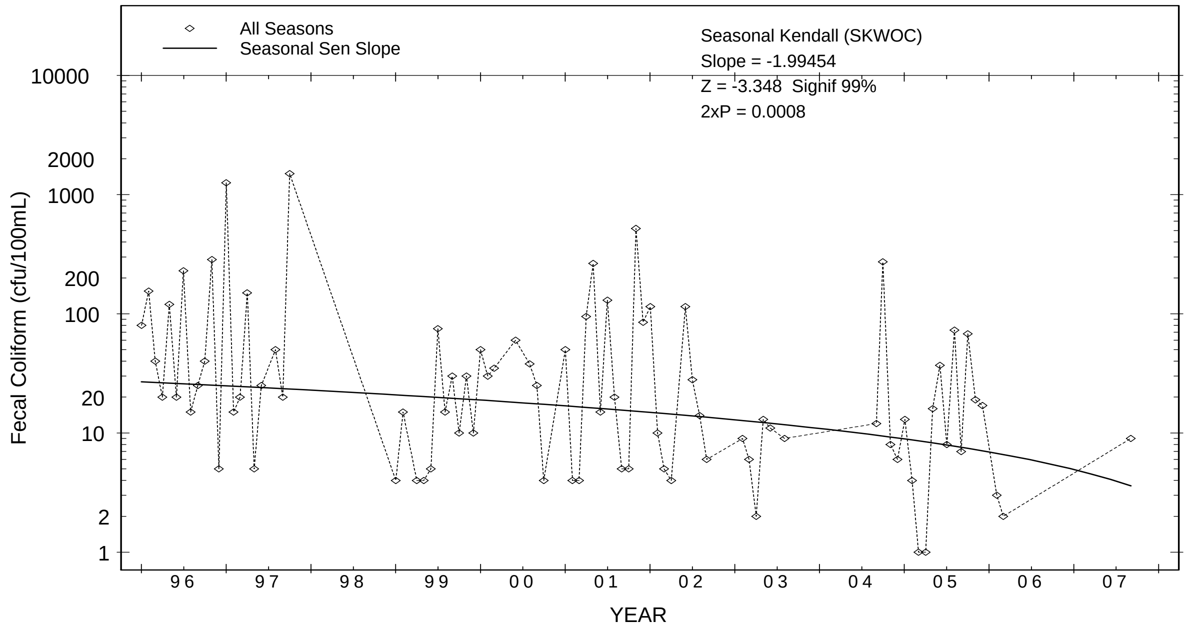


Figure D-5. Seasonal-Kendall trend test results for fecal coliform levels for Hunter Creek site show improving fecal coliform levels. Note: there were no cattle pastured in the Hunter Creek basin in 2005-2006 (Figlar-Barnes, 2007).

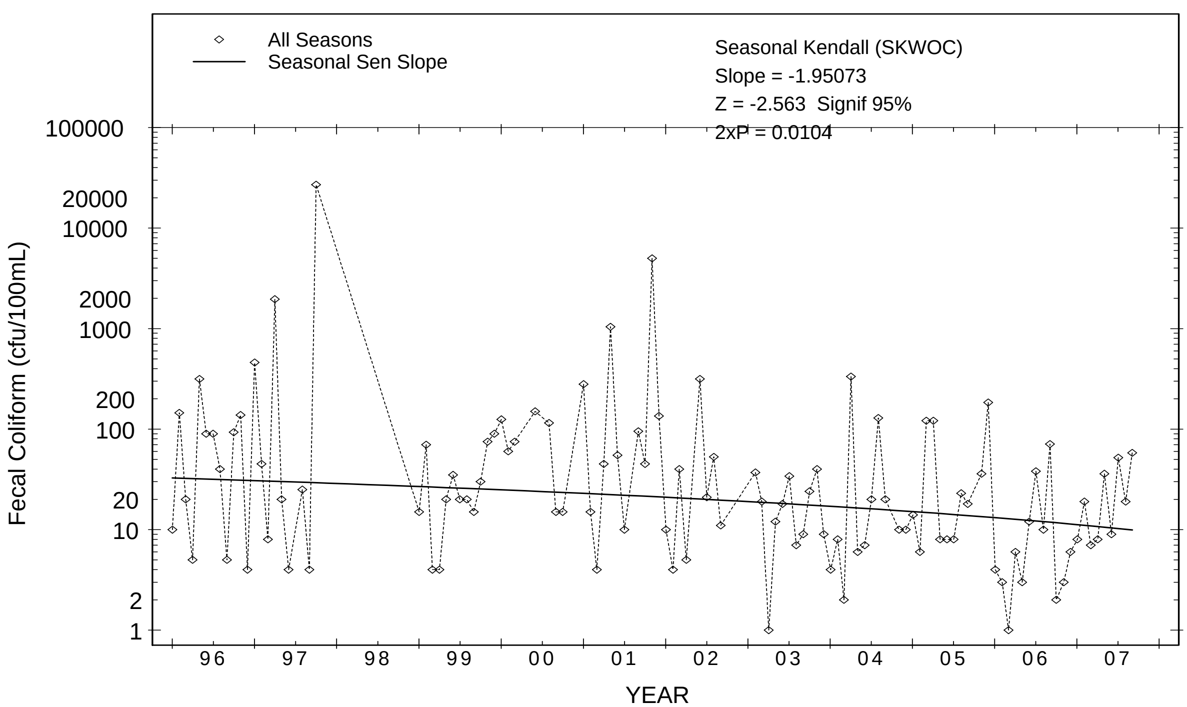


Figure D-6. Seasonal-Kendall trend test results for fecal coliform levels for Ten Acre Creek site show improving fecal coliform levels. Note that September fecal coliform values were not improving over time.

Fecal coliform levels were compared to Washington State water quality standards for the January 2005 – October 2006 sampling period, excluding March and April (the non-critical period). Results are presented in Table D-2. All sites met fecal coliform water quality standards for that period, with the exception of the two Purdy Creek sites and a downstream site on Weaver Creek. The upstream site on Weaver Creek at the Skokomish Valley Road bridge met fecal coliform water quality standards.

Table D-2. Comparison of Skokomish Tribal fecal coliform data to water quality standards for the January 2005 – October 2006 sampling period excluding March and April. This is the same period as the TMDL *Attainment Monitoring* which also excludes the non-critical two months.

Sampling Site	Number of Samples	Fecal Coliform Geometric Mean cfu/100mL*	Percent of Fecal Coliform Samples Exceeding 100 cfu/100mL*	Meets Fecal Coliform Water Quality Standards?
Skok. R. at Rocky Beach	18	8	0%	Yes
Skok. R. at Chico's Eddy	18	17	6%	Yes
Skok. R. at Hwy 106 bridge	18	18	6%	Yes
Skok. R. at Bobby Allens	18	18	0%	Yes
Purdy Ck. at Bourgault Rd.	18	23	17%	No
Purdy Ck. near the mouth	18	23	11%	No
Weaver Ck.at Skok. Valley Rd.	18	15	11%	No
Weaver Ck. at the low bridge	18	9	0%	Yes
Hunter Creek	14	9	0%	Yes
Ten Acre Creek	17	12	6%	Yes

* Both parts of the Fecal Coliform Water Quality Standard must be met: The geometric mean should not exceed 50 fc/100 mL, and no greater than 10% of samples used to calculate the geometric mean should exceed 100 fc/100 mL.