WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

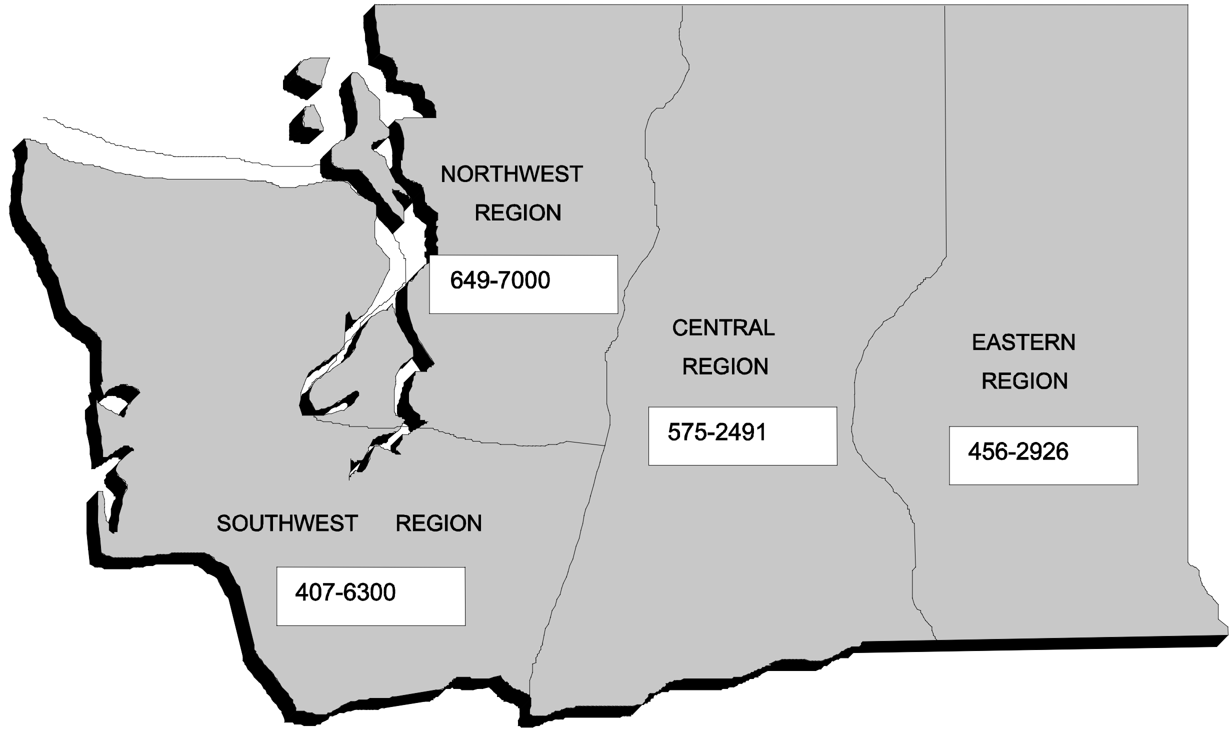
Salmon Creek
Nonpoint Source Pollution TMDL

Publication No. 95-355
October 1995

Printed on Recycled Paper

For additional copies of this report, contact:

Department of Ecology
Publications
P.O. Box 47600
Olympia, WA 98504-7600
Telephone: (360) 407-7472



For more information or if you have special accommodation needs, please contact Barbara Tovrea at (206) 407-6696. Ecology Headquarters telecommunications device for the deaf (TDD) number is (206) 407-6006. Ecology Regional Office TDD numbers are as follows:

SWRO (TDD) (360) 407-6306
NWRO (TDD) (206) 649-4259
CRO (TDD) (509) 454-7673
ERO (TDD) (509) 458-2055

Salmon Creek
Nonpoint Source Pollution TMDL

---

by
Robert F. Cusimano and David Giglio

Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Watershed Assessments Section
Olympia, Washington 98504-7710

Water Body No. WA-28-1020, WA-28-1023
WA-28-1025, WA-28-1026, and WA-28-1027

Publication No. 95-355
October 1995

Printed on Recycled Paper

Table of Contents

APPENDIX A.

APPENDIX B.

APPENDIX C.

APPENDIX D.

List of Figures

List of Tables

Abstract

The Salmon Creek Watershed Management Plan identifies degradation of beneficial uses in the Salmon Creek drainage that include primary contact recreation due to fecal waste contamination, and loss of wildlife and salmonid rearing/spawning habitat due to a number of instream and watershed disturbances. Water quality in the Salmon Creek drainage violates water quality standards for fecal coliform, turbidity, temperature, and dissolved oxygen due to nonpoint source pollution. In addition, the system has high levels of nutrients. Factors contributing to the degradation of beneficial uses and poor water quality include devegetation of the upland forests and grasslands, construction projects (road, parking lot, and home construction), reduction of the number and size of natural wetlands, poor agriculture practices, failing or improperly maintained septic systems, and alteration of the stream channels and riparian zones.

Using data collected by local government agencies during 1988-1994, phased TMDLs are recommended for fecal coliform and turbidity to help control nonpoint source pollution in the Salmon Creek drainage. Currently there are a number of local agencies and organizations that have interest in or are working to improve water quality in the Salmon Creek Drainage. In order to facilitate the efforts of local groups to mitigate nonpoint source pollution, Ecology should target grant funds and personnel resources to help with implementing controls and organizing watershed management activities in the basin. Follow-up monitoring is recommended to assess changes in water quality.

Acknowledgements

We would like to thank John Tooley, Gordon Franklin, Steven Keirn, Carl Addy, and Philip Gaddis for providing information and contributing to the development of this document. Comments on the draft report were provided by Will Kendra, Nora Jewett, Bill Ehinger, and Steve Butkus. Word processing and final report preparation were done by Barbara Tovrea.

Introduction

Problem Statement

The Southwest Regional Office (SWRO) of the Washington State Department of Ecology (Ecology) is concerned about nonpoint pollutant loading to Salmon Creek, a Class A waterbody, due to anthropogenic activities in the watershed. They requested that the Watershed Assessments Section (WAS) assess the water quality of the drainage system and recommend appropriate Total Maximum Daily Loads (TMDLs) for problem pollutants. WAS submitted a Quality Assurance Project Plan (QAPP) for undertaking a nonpoint source pollutant TMDL study on January 30, 1995 (Cusimano and Giglio 1995). Figure 1 is a map of the study area.

The Salmon Creek basin's growth has led to environmental stresses that have reduced water quality. State water quality standards (WAC 173-201A), regulated in part under Section 303(d) of the Federal Clean Water Act, have been violated in Salmon Creek basin for fecal coliform, dissolved oxygen, and temperature. Criteria exceedences for turbidity and pH have also been found. The current 303(d) list of waterbodies and parameters not attaining water quality standards is provided in Table 1. Nutrient levels, while not specifically regulated by numeric criteria, are also high relative to other streams and rivers in southwestern Washington. These impacts threaten both human and natural stream uses, from recreational swimming to fish habitat. Degraded water quality is often the result of adjacent land uses: pasture, sewage treatment, lawns, impervious surfaces, farming, and industry.

Table 1. 1994 §303(d) List for the Salmon Creek Drainage

Parameter:	**Fecal Coliform**	**Temperature**	**Dissolved Oxygen**
Salmon Creek	X	X	
Cougar Canyon Creek	X		X
Mill Creek	X		
Curtin Creek	X		
Woodin Creek	X		

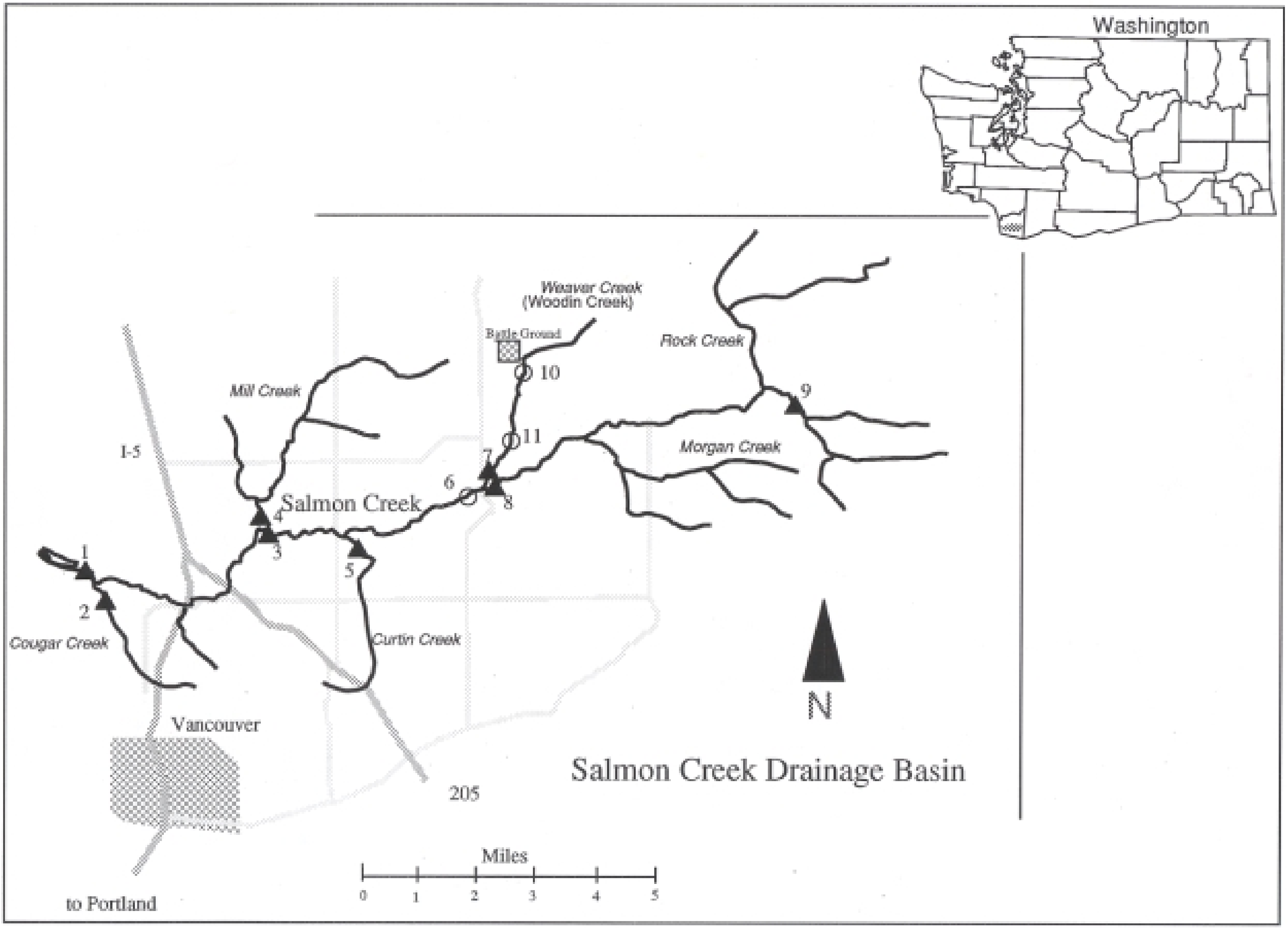


Figure 1. Salmon Creek study area and sampling locations

Background Information

Salmon Creek, located entirely within Clark County, flows from the foothills of the Cascade Mountains west to Lake River, which flows into the Columbia River. The Cascade foothills are generally forested, while the lower drainage is primarily urban. The city of Vancouver lies just south of lower Salmon Creek, and several small towns lie along the tributaries and central plains of the basin. These middle reaches contain a mixture of small towns, large and small scale farms, pasture, and homes. Six major tributaries flow into Salmon Creek: Rock Creek and Morgan Creek to the east, Weaver (also called Woodin) Creek and Curtin Creek (also called Glenwood) in the middle, and Mill Creek and Cougar Creek to the west (Figure 1). Salmon Creek, and the lower portions of Mill, Curtin, Morgan and Rock Creeks, and their associated wetlands are under shoreline jurisdiction of the Clark County Shoreline Master Program.

Characterized by gently rolling hills and alluvial flood plains, the Salmon Creek basin is primarily rural-residential. Urban areas also comprise a considerable proportion of the basin's land area, mostly along its southwest reaches. Forestry, agriculture, and commercial and industrial activities are significant uses within the basin (Wille 1990). The basin is highly urbanized near Vancouver, with many small subbasins already heavily developed. The Suds Creek, Tenny Creek, 114th Street tributary, and 119th Street tributary subbasins typify the urbanization within this portion of the Salmon Creek drainage. Cougar Creek and Curtin Creek, the larger tributaries of lower Salmon Creek, are also developing rapidly. These basins often experience problems with flooding, undersized culverts, inadequate buffer vegetation, erosion, and sedimentation (CCDCD 1989). Rapid and diverse development within the basin has also led to water quality degradation of Salmon Creek and its tributaries, resulting in non-attainment of state water quality standards.

Weaver Creek is a well-studied example of a Salmon Creek tributary suffering human-induced degradation. Flowing through Battle Ground, Weaver Creek received the town's treated wastewater, which resulted in violations of state water quality standards, most notably dissolved oxygen and ammonia. A 1978 Ecology study found that total ammonia in the wastewater treatment plant's (WWTP) outflow severely depleted the creek's dissolved oxygen levels, threatening aquatic life in the stream (Moore and Anderson 1978). The average dissolved oxygen concentration downstream of the outfall was 3.7 mg/L while the standard is a minimum of 8 mg/L for a Class A waterbody.

A further investigation of Battle Ground WWTP's impacts on Weaver Creek found that although streamflow responded quickly to rain events, it was insufficient to dilute WWTP inputs (Crawford 1985). The plant was designed to use natural stream flow to dilute effluent at a 20:1 ratio, but flow from the facility was typically half that of the stream. In 1993, a TMDL was approved by the United States Environmental Protection Agency for 5-day biochemical oxygen demand and ammonia for Weaver Creek. Subsequent to the approved TMDL, discharge from the treatment plant was rerouted to the regional wastewater treatment plant and discharged to the Columbia River.

Fecal coliform levels on Weaver Creek, a problem throughout the basin, never met water quality standards; values both upstream and downstream of the WWTP discharge exceeded standards (Crawford 1985). Upstream values were often higher, implying the WWTP discharge was diluting fecal coliform concentrations. Other point sources, including plywood manufacturing and dairy production, had been reported to contribute less than one percent of the coliform loading, suggesting that the fecal contamination was from nonpoint pollution (Crawford 1985).

Fecal coliform contamination is a major concern because it indicates that biological waste is entering the water. A 1981 study investigated the basin's septic systems, which were believed to contribute to nonpoint fecal coliform contamination. The study found that 3% of surveyed septic systems along the Salmon Creek drainage were presently leaking, and 10% had failed previously and been fixed. One finding was that 47% of failures were preventable: the result of a lack of maintenance, undersized systems, poor siting, or physical damage (SWHD 1981).

A follow-up survey in 1989 of septic systems within Salmon Creek studied all parcels adjacent to the creek, and randomly sampled all systems within 1,000 feet of the creek and its tributaries. In this study, 5.6% of the systems were failing, sub-standard, or absent. The vast majority (92%) of systems were at least 15 years old; 58.7% of the systems had either never been pumped or were not known to have been pumped. Calculations from this study attribute from one to five percent of Salmon Creek's fecal coliform loading to failing septic systems (Newman 1989). The 1989 survey results are similar to the 1981 results, implying that septic systems contribute to but are not the major source of coliform contamination.

A 1990 study by Southwest Washington Health District (SWHD) on Salmon Creek basin found fecal coliform to be the most consistent and most severe violator of state water quality standards. This study isolated dairies as the primary source of contamination, with the regions around lower Morgan Creek, central Salmon Creek and Mill Creek having the highest concentrations of both dairies and coliform contamination (SWHD 1990). In response to this agriculturally-based water quality degradation, the Clark County Conservation District (CCCD) undertook a review of basin farming practices, recommending implementation of appropriate Best Management Practices (BMPs) for agriculture (CCCD 1990). The document outlines BMPs for erosion and animal waste control, pastureland and cropland management, and stream corridor protection. It concludes with strong recommendations for stream fencing, streambank revegetation, and animal waste and sediment education programs to counter the negative impacts of dairy production.

Negative impacts from human land uses are not strictly recent events, however. Euro-Americans settled along Salmon Creek beginning in 1852. In 1864, A.S. Marble built the first mill on the creek. A woolen factory, which failed, also attempted to run a mill on the stream in 1867. The draining and ditching of Fourth Plain swamp (now the town of

Orchards) began in 1863, which may mark the beginning of wetland losses in the area. About 1880 Isaac Dietderich built a millpond on the creek, perhaps the first man-made obstruction to salmon passage. Dairy farming in the basin goes back at least to 1882, when the Honorable H.D. Rissell owned 30 milk cows (Parsons 1983). Pasture, small-scale farms, forestry and increasing development have all contributed to impaired water quality, which has gradually reduced habitat quantity and quality for salmon and other fish and aquatic organisms.

The earliest impediments to salmonid reproduction occurred in the late 19th century, when logging dams were first constructed along Salmon Creek. Today, however, it is sedimentation from widespread development that impairs stream habitat quality. While no historical data exist, current coho, steelhead, and cutthroat trout populations are between three and five percent of what an intact habitat might support (Wille 1989). The highest quality existing habitat presently lies within the basin's less-developed headwaters: upper Salmon Creek, upper Morgan Creek, and Rock Creek. Direct cattle access along lower Salmon Creek and many tributaries increases turbidity and ammonia levels, lessening habitat quality. As a low-gradient creek (averaging slope 0.24% over first 35 km), Salmon Creek has a limited ability to flush sediment deposits (Wille 1989). In addition to covering pool habitat for salmon, sediment buildup over time decreases the channel capacity, which increases the potential for flooding and can lead to increases in water temperature due to greater solar heating of the shallower waters.

Wetlands, which provide flood control and contribute to summer flow levels, have been estimated to constitute 3.4% of the basin (Wille 1990). Roughly half of Salmon Creek basin's wetlands are emergent (usually seasonal and adjacent to the stream), while forested and scrub-shrub wetlands are also fairly common. The greatest numbers of wetlands are within Mill Creek and Curtin Creek subbasins, but the greatest acreage lies along lower and central Salmon Creek itself. However, one fifth of recent county developments involve wetlands. Threats to wetlands include channelization and draining, as well as indiscriminate filling of privately owned wetlands (Wille 1990). Loss of remaining wetlands could contribute to further water quality degradation by removing ecologically important water detention and filtering systems.

Project Objectives

Objectives for the Salmon Creek basin TMDL study include:

1. Determine the quality of existing data used for listing parameters on Salmon Creek and its tributaries.
2. Establish wet and dry season load allocations for fecal coliform and turbidity.
3. Relate load allocations and reduction targets to land-use.
4. Propose a nonpoint source pollution reduction strategy that incorporates use of Best Management Practices in the drainage.
5. Propose a follow-up monitoring program to evaluate the effectiveness of the pollution reduction strategy(s).

Quality Assurance/Quality Control

Water quality data have been collected as part of monthly monitoring programs, as well as special studies such as stormwater sampling. The SWHD contracted with the CCCD and Clark County Department of Community Development (CCDCD) to conduct monthly water quality sampling in the Salmon Creek drainage. They collected data from four sites on mainstem Salmon Creek from October 1988 through September 1989 as part of a Centennial Clean Water Fund grant (SWHD 1990). This study also included storm event sampling from 26 sites within the basin on November 2, 1988. From May 1991 through February 1994, the SWHD also sampled water quality monthly at up to 10 sites on the mainstem and major tributaries of Salmon Creek, including the four 1988-89 mainstem sites (as annotated on Figure 1). Additionally, several diurnal samples were collected during this period.

A Quality Assurance Project Plan (QAPP) for the 1991-94 study was approved by Ecology (Gaddis 1991). All field measurements followed manufacturer's recommendations and all laboratory tests were performed at Clark County Water Quality Laboratory, accredited by Ecology. Although a QAPP was not prepared for the 1988-89 data, the same methods and procedures used in the 1991-94 study were followed. Because these studies have all been under the direction of Carl Addy of the SWHD, using acceptable quality assurance, the information is being treated as one body of data. The monthly data from both sampling efforts were entered from hard copy data into a spreadsheet data base by Ecology. Stormwater and diurnal samples were not included.

Replicate results demonstrate acceptable precision with the exception of fecal coliform data, which are usually less precise. A pooled precision estimate was made by taking the root mean square (RMS) of the coefficient of variation (CV) for each replicate pair (Table 2). To compensate for possible differences in variation over the analytical range, coliform and turbidity replicates were divided into categories (above or below Water Quality Standards).

Given the quantity and quality of the existing data, WAS proposed using the 1988-94 monitoring data to develop appropriate TMDLs for the Salmon Creek watershed (Cusimano and Giglio 1995). Additional field sampling was not needed to establish TMDL targets, but follow-up monitoring will be needed to evaluate the effectiveness of the pollution control measures employed in the drainage.

The historical data are presented in Appendix A. Sample station numbering was modified to accommodate differences in the 1988-89 and 1991-94 surveys. All data analyses and presentations in this report were performed using the arithmetic average of replicate values and half the reporting limit for all undetected variables.

Table 2. Field Replicate Pooled Precision Estimates

Parameter	# of Replicates	Root Mean Square of the Coefficient of Variation (%)
Fecal Coliform, Mean MPN < 100	10	49.9
Fecal Coliform, Mean MPN ≥ 100	13	42.8
Temperature	22	1.6
Dissolved Oxygen	22	0.8
Turbidity, Mean NTU < 5.0	16	5.4
Turbidity, Mean NTU ≥ 5.0	7	3.0
Ammonia	23	22.6
Nitrates-Nitrites	23	4.5
Total Phosphorus	22[a]	7.5
pH	23	0.8

[a] One pair of phosphorus samples was excluded because of a suspected error. Were it included, the pooled precision would be 25.2.

Water Quality Data Results

The following is a summary of the existing data. In order to better show temporal and spatial differences, and to define seasonal allocation targets, the raw data were separated into dry (May-October) and wet (November-April) seasons. The seasons were established by simply grouping the highest and lowest 6 contiguous months average flows. Table 3 shows the monthly average, minimum, and maximum flows from data collected from 1943-94 at the USGS station on the mainstem near Battle Ground and from data collected from 1991-94 by CCDCD on the mainstem near Klineline Park (near site 1).

Table 3. Salmon Creek average, minimum, and maximum flows based on USGS station data, 1943-1994, collected near Battleground, and average and minimum flows based on 1991-94 data collected by CCDCD at a station near Klineline Park. All units in cfs.

	USGS Station (#1421200) near Battleground			**CCDCD Station near Klineline Park**		
Month	**Average**	**Minimum**	**Maximum**	**Average**	**Minimum**	**Maximum**
January	150	12.0	1010	268	73	787
February	116	13.0	1440	241	54	1500
March	95	18.0	502	209	61	1373
April	65	13.0	380	305	56	1840
May	38	7.4	390	114	33	697
June	20	1.2	285	62	26	445
July	7.9	0.9	71	37	20	110
August	4.4	0.6	38	27	19	43
September	5.1	0.6	104	26	19	56
October	21	1.0	760	43	19	1500
November	89	1.3	974	191	23	1500
December	134	5.4	978	308	51	1620

Figures 2-8 show box plots of water quality variable concentrations by sampling station for both wet and dry seasons. (Each box represents the interquartile range or the 50% of the data between the 25th and 75th percentiles, the line in the box is the median, the end of the whiskers are the minimum and maximum data point within 1.5 times the interquartile range, an "*" is an outlier between 1.5 and 3 times the interquartile range, and a "o" is an outlier greater than 3 times the interquartile range.) Figures 2-8 include data on Weaver Creek from both before and after the WWTP discharge was removed in April 1993. A discussion of the effect of removing the WWTP follows the general water quality review. Data for each variable were examined for normality using normal probability plots, and if needed, they were normalized by logarithmic transformation.

Fecal Coliform

While not directly harmful themselves, fecal coliform bacteria are indicators of animal wastes (and associated pathogens) entering waterbodies. Cattle, failing septic systems, pets, and wildlife can all contribute to elevated levels. High counts of fecal coliform make waters unsuitable for human consumption and recreation.

The existing data indicate regular exceedences of the state water quality standard of 100 colonies / 100 mL at all sites downstream of Salmon Creek headwaters (Figure 2). Fecal coliform levels vary little between dry and wet seasons. The possible influence of flow on fecal coliform concentrations was examined using flow data collected by CCDCD near Klineline Park. Correlation analysis of logarithmic transformed flow and fecal coliform data indicates no significant relationship ($\propto = 0.05$) at any of the sampling sites, except site #1, which shows a positive relationship due to one high flow and high fecal coliform value.

The 1988 storm event data reported by SWHD (1990) showed that every site exceeded the water quality standard for fecal coliform. Twenty-one of the 26 sites had values exceeding 1,000 colonies / 100 mL, and eight sites had values beyond 10,000 colonies / 100 mL. Again, the lowest values occurred in the less developed headwaters.

Turbidity

Turbidity measures the ability of light to penetrate water, and is an indicator of suspended particles such as clay, silt, organic matter, and small biological organisms. High turbidity can reflect erosion, and the sedimentation of suspended particles associated with erosion impairs salmonid rearing by reducing clean gravel spawning habitat and aquatic insect habitat (a key food source for salmonids).

Five violations of the state water quality criterion for turbidity occurred on mainstem Salmon Creek between 1991 and 1993, all during November, December, and January. A violation was indicated when an individual turbidity measurement exceeded the natural background turbidity level, represented by headwater site #9, by greater than 5 NTU on the day of sample collection. All sites experience occasional (wet-season) high turbidity levels. With the exceptions of Curtin Creek and Salmon Creek headwaters, turbidity appears to be a problem throughout the basin (Figure 3).

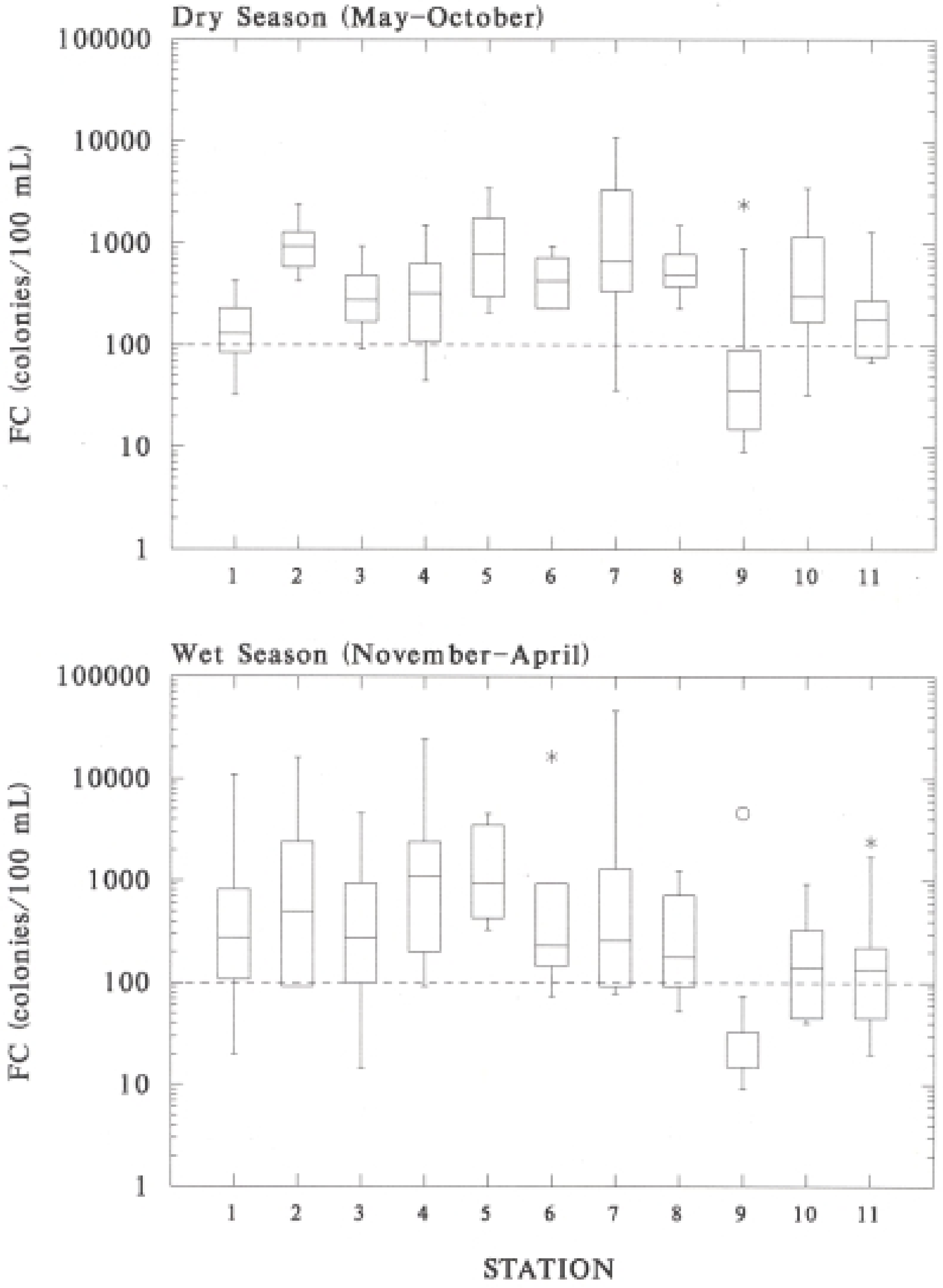


Figure 2. Salmon Creek dry and wet season fecal coliform data; dashed line denotes water quality standard: geometric mean not to exceed 100 colonies/100 mL.

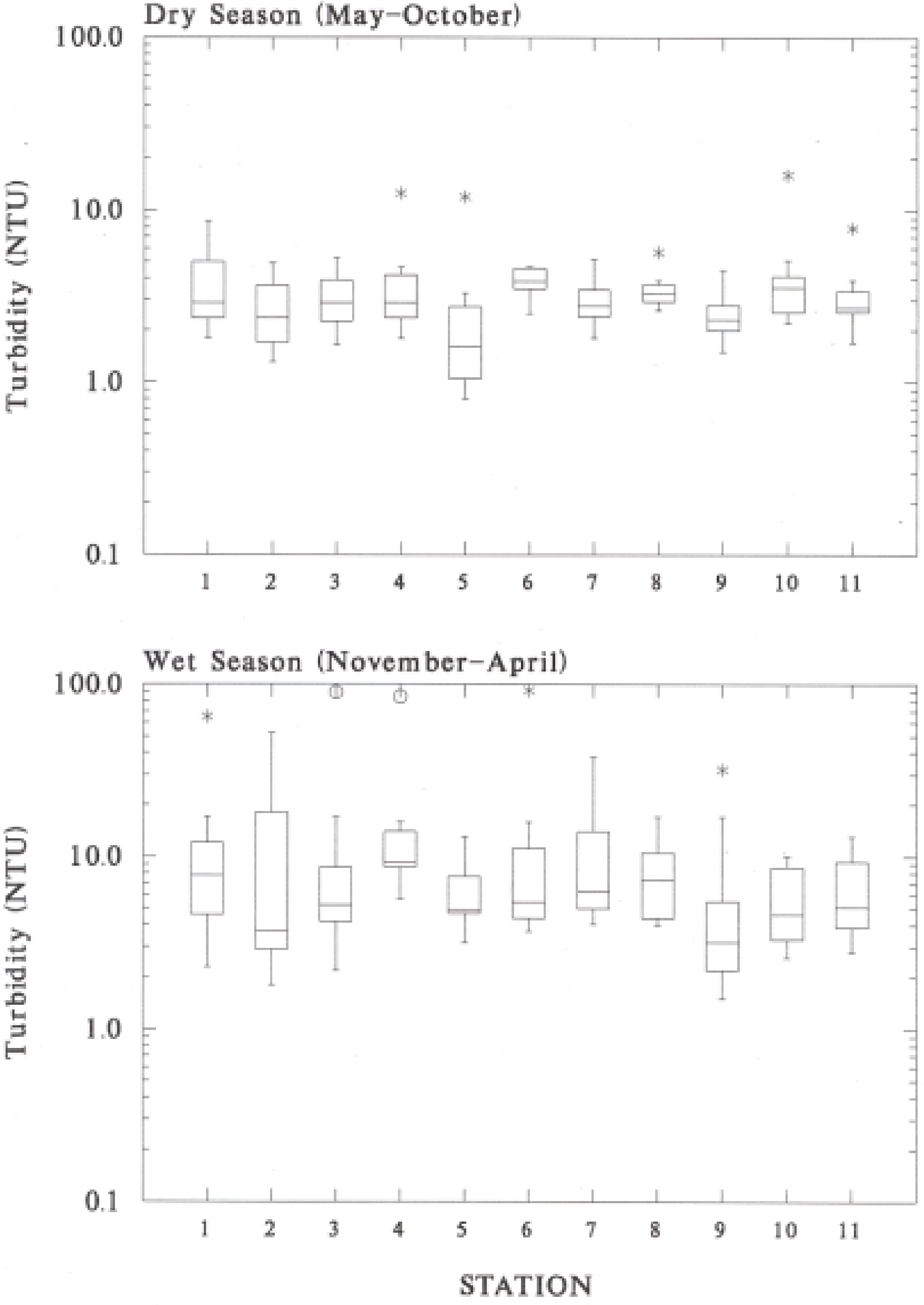


Figure 3. Salmon Creek dry and wet season turbidity data

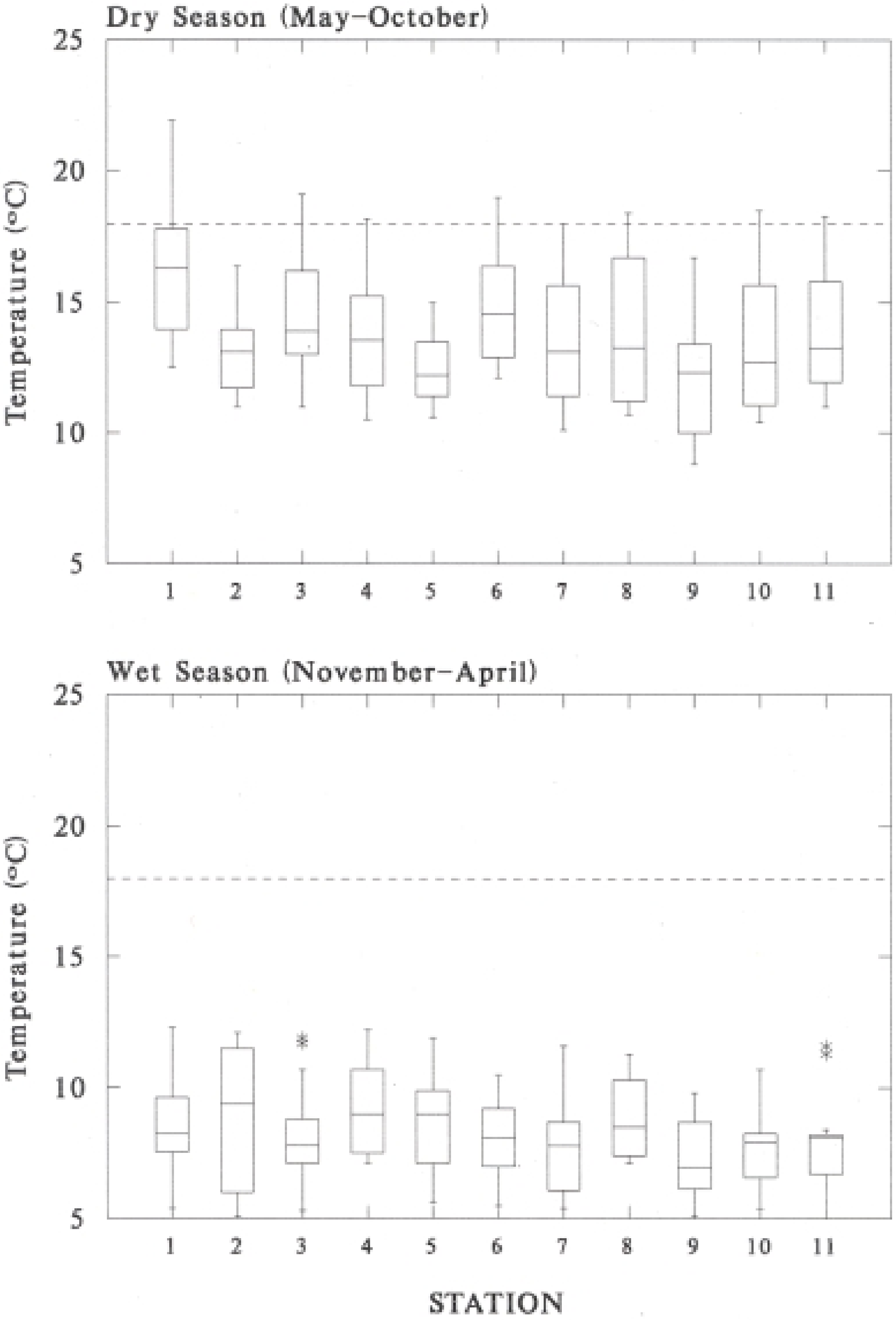


Figure 4. Salmon Creek dry and wet season temperature data; dashed line denotes water quality standard: 16 degrees C.

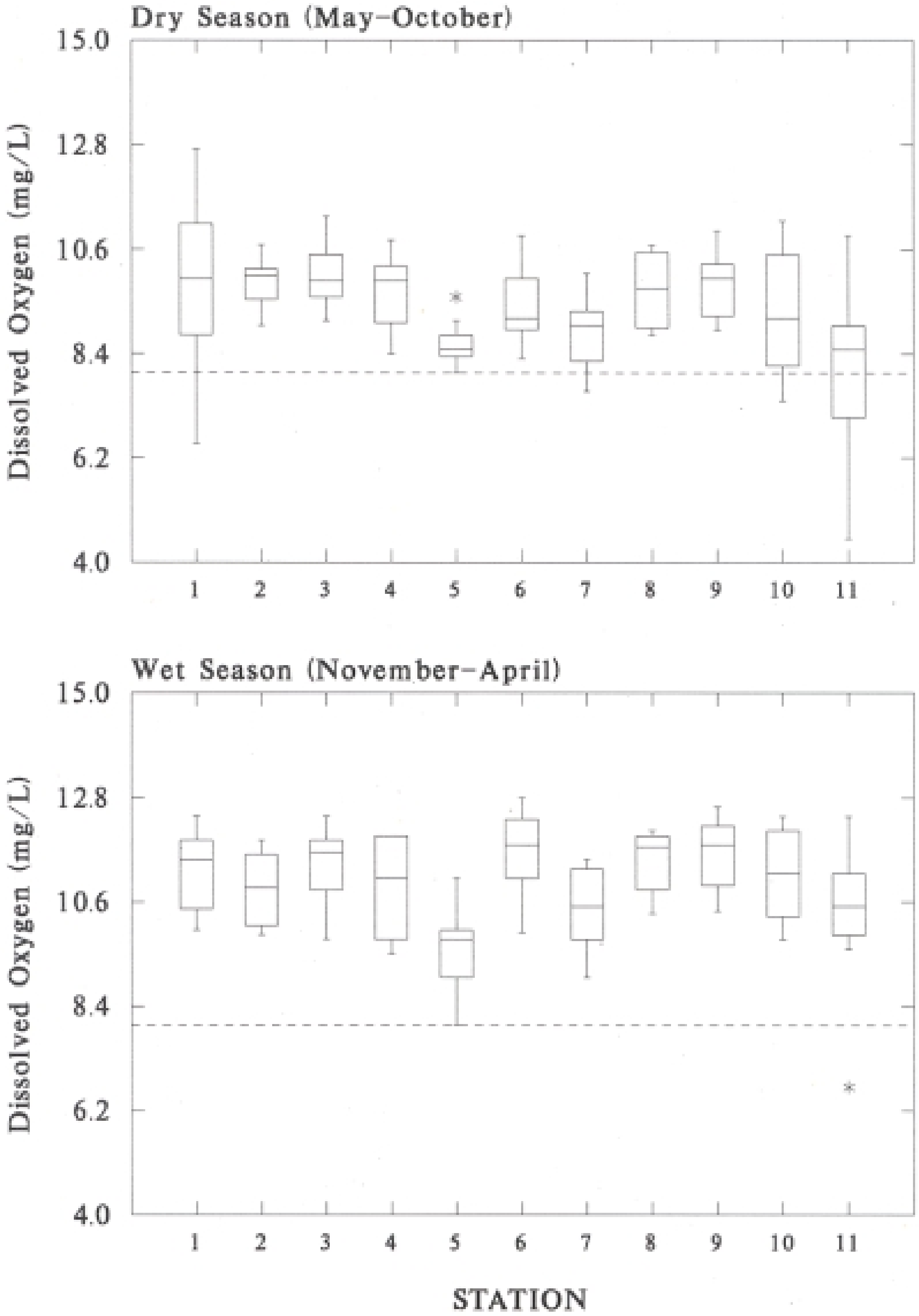


Figure 5. Salmon Creek dry and wet season dissolved oxygen data; dashed line denotes Class A criterion of 8 mg/L.

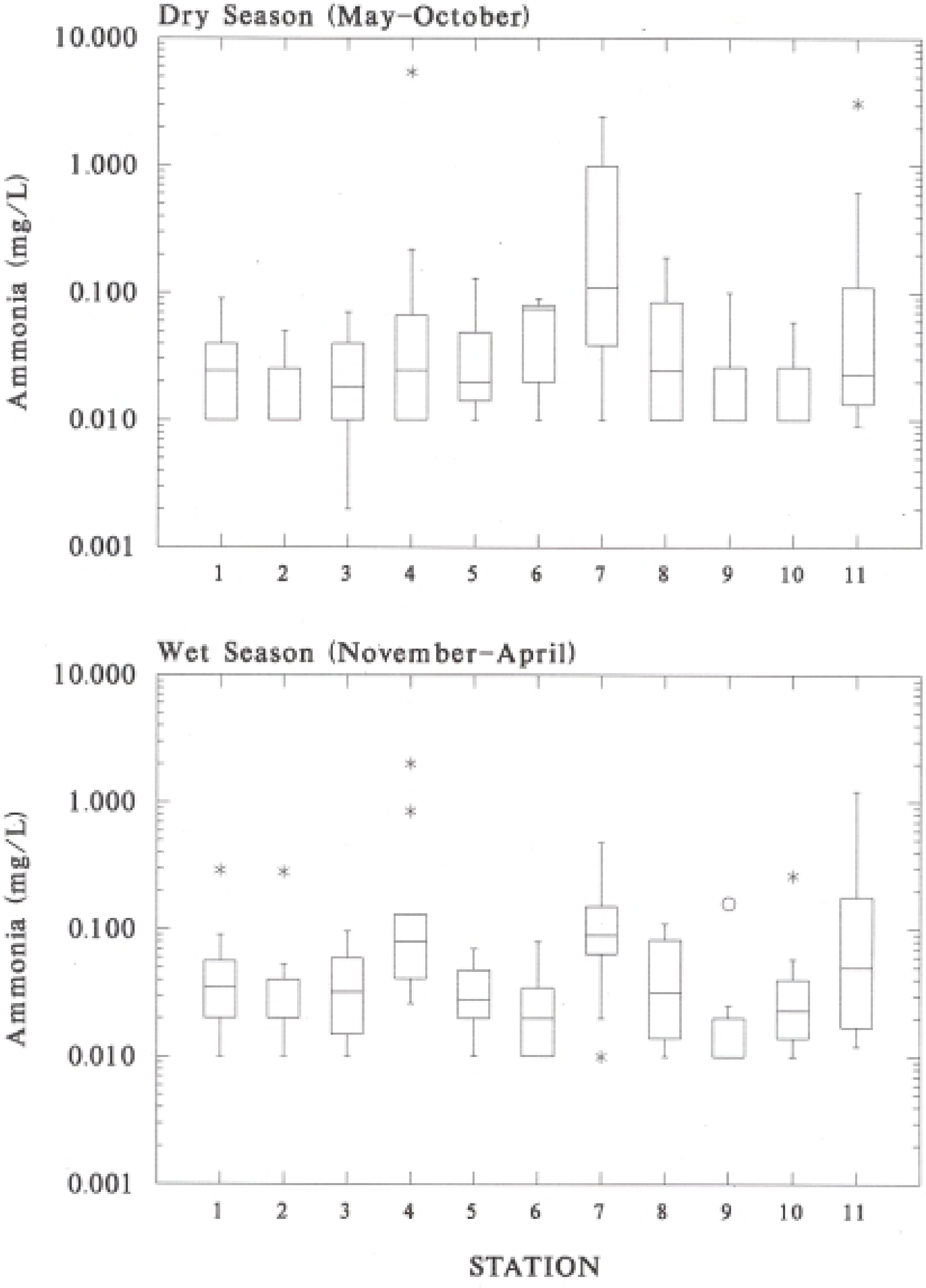


Figure 6. Salmon Creek dry and wet season ammonia data.

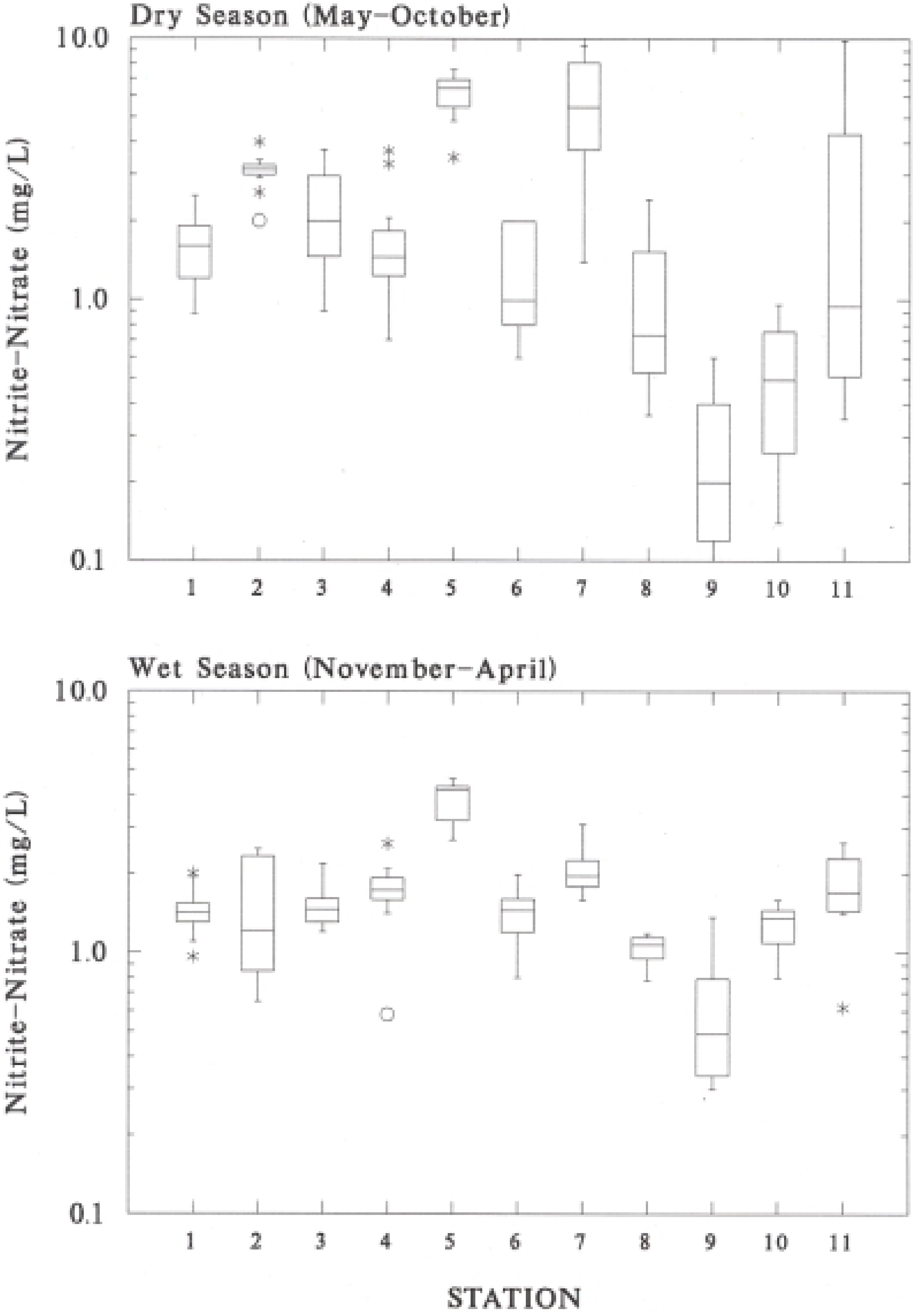
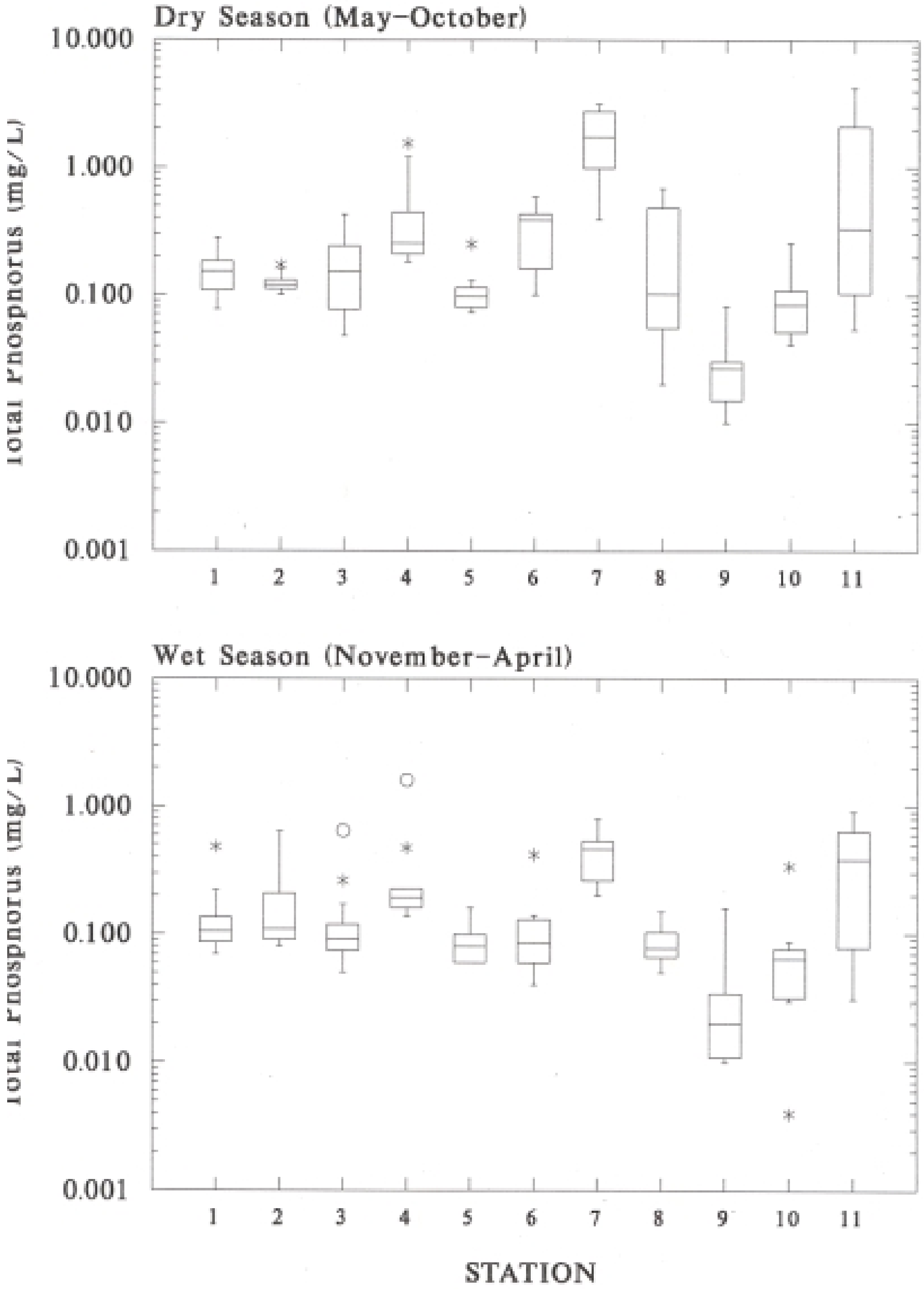


Figure 7. Salmon Creek dry and wet season nitrite-nitrate data



Dry Season (May-October)

Wet Season (November-April)

Figure 8. Salmon Creek dry and wet season total phosphorus data.

The 1988 storm event data reported by SWHD (1990) showed that turbidity was generally lowest in the headwaters and central mainstem of Salmon Creek (usually below or about 10 NTU). A small tributary of Mill Creek was the most turbid (almost 70 NTU), and the lower Salmon Creek and Cougar Creek sites were also high (between 20 and 30 NTU). Nine of 25 storm event sampling sites violated water quality standards by exceeding natural background levels by greater than 5 NTU.

Temperature

Temperature is a water quality concern because most aquatic organisms are "cold-blooded," and are strongly influenced by water temperature. The temperature of water regulates the respiration, distribution, behavior, movement, feeding rate, growth, and reproduction of aquatic organisms. Temperature also can change the rate of biodegradation of organic matter; increased temperature accelerates biodegradation, which increases the demand for dissolved oxygen. As temperature increases, oxygen also becomes less soluble in water, which can lead to low oxygen concentrations.

Stream temperatures may be altered by land use. For example, clearing stream banks eliminates shading and deforesting lands often results in decreased summer flows, both of which can increase stream temperatures. The state water quality standards require Class A streams to maintain temperatures below 18°C. Salmon Creek and some of its major tributaries, however, violate this standard during the summer months (Figure 4). Mainstem temperatures exceeded 18°C at some stations every summer. The highest values occurred near the mouth of Salmon Creek, with temperatures nearing 22°C.

Dissolved Oxygen

Dissolved oxygen (DO) is one of the most important gases dissolved in water and is essential to aquatic life. The amount of oxygen dissolved in water varies with atmospheric pressure, reaeration rate, photosynthesis, plant and animal respiration, sediment oxygen demand, biochemical oxygen demand, nitrification, and temperature.

Although Cougar Creek is on the 303(d) list for historical violations of the DO standard (8 mg/L), DO levels were above 9 mg/L during the 1988-1994 study period (Figure 5). However, violations did occur in the basin. Lower Salmon Creek occasionally dipped below 8 mg/L as did Weaver Creek. Weaver Creek had values near toxic levels for salmonids (below 5 mg/L) just below the WWTP outfall before the discharge was diverted. The low DO levels in Weaver Creek were caused by high biochemical oxygen demand (BOD) stemming from the Battle Ground WWTP. While Curtin Creek does not violate standards, it demonstrates low oxygen saturation levels. Lower Salmon Creek exhibited oxygen supersaturation of up to 140% in the summer, probably reflecting eutrophication influences due to nonpoint source loading of nutrients.

Ammonia

The un-ionized fraction of ammonia is toxic to fish and is dependent on pH, temperature, and the total ammonia concentration. Ammonia is usually present at natural levels below 0.1 mg/L. However, human activities can increase total ammonia concentration to toxic levels, which may be as low as 0.3 mg/L for some salmonids (Goldman and Horne 1983). Ammonia can also promote the growth of unwanted algae and plants.

The data show that ammonia concentrations were quite low throughout the year (generally below 0.1 mg/L), but that concentrations occasionally exceeded 1.0 mg/L during low flows (Figure 6). Concentrations were consistently highest in the Weaver Creek basin before the WWTP discharge was diverted, and were also high within Mill Creek basin, which had one measurement of 5.41 mg/L that violated the applicable ammonia chronic criterion of 1.44 mg/L for a pH of 7.8 and temperature of 18.2° C.

Nitrate-Nitrite

Most surface waters contain some nitrates, however, there is usually less than 1 mg/L. The presence of nitrates in concentrations greater than 4-5 mg/L may reflect unsanitary conditions, since one major source of nitrates is human and animal wastes. Plants are capable of converting nitrates to organic nitrogen such that excessive amounts can stimulate plant growth. High concentrations of nitrates can also be a human health concern (*i.e.,* drinking water levels should be less than 10 mg/L nitrate plus nitrite).

Nitrate-nitrite levels were high year-round; only the headwaters typically had concentrations below 1 mg/L (Figure 7). The dry season had some of the highest values recorded, with Weaver Creek and Curtin Creek exceeding 5.0 mg/L.

Phosphorus

Phosphorus, normally the most growth limiting nutrient in aquatic environments, is often present in large amounts in streams because of its use in detergents and its presence in human and livestock wastes. Mean phosphorus concentrations in southwestern Washington for all the stream/river Ecology ambient monitoring stations are less than 0.060 mg/L.

Like nitrate-nitrite and ammonia, the highest phosphorous values were recorded during the dry season (Figure 8). Values were generally high throughout the basin. Weaver Creek and Mill Creek were the only sites to exceed 1.0 mg/L.

Battle Ground WWTP Discharge

Weaver Creek had some of the highest concentrations of nutrients and bacteria prior to the removal of the Battle Ground WWTP discharge in April 1993. During the dry season, before the WWTP discharge was removed, Weaver Creek typically had phosphorus concentrations that ranged between 1.0 and 4.5 mg/L. However, after the Battle Ground waste treatment facility outflow was diverted to the Columbia River, Weaver Creek water quality changed. Nutrient concentrations all dropped dramatically in the spring of 1993, maintaining low values from that point on (Figure 9). Fecal coliform levels, however, did not show a clear reduction after the diversion, implying that they are primarily caused by nonpoint sources (Figure 10).

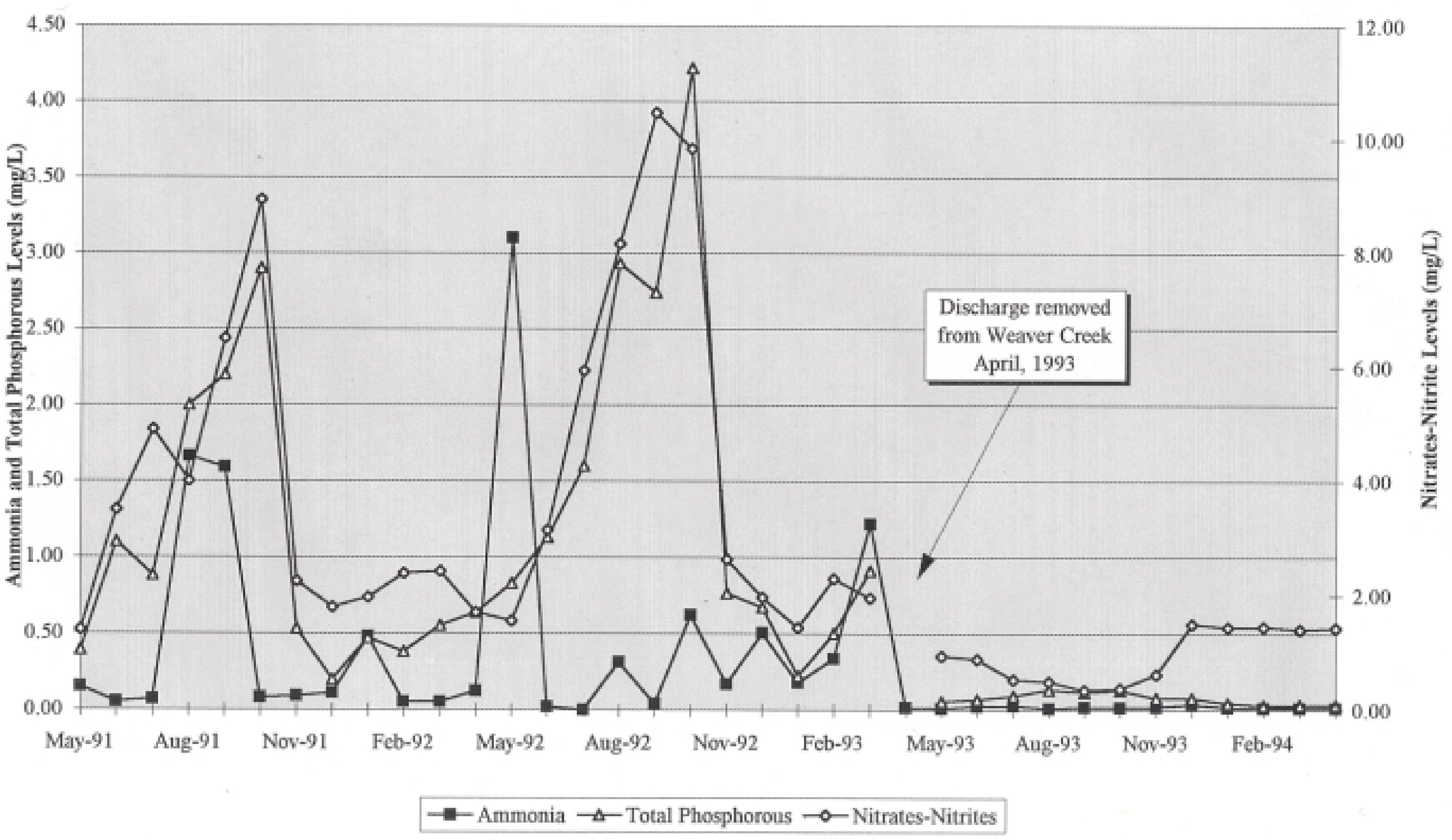


Figure 9. Nutrient concentrations in Weaver Creek, 1991-1994

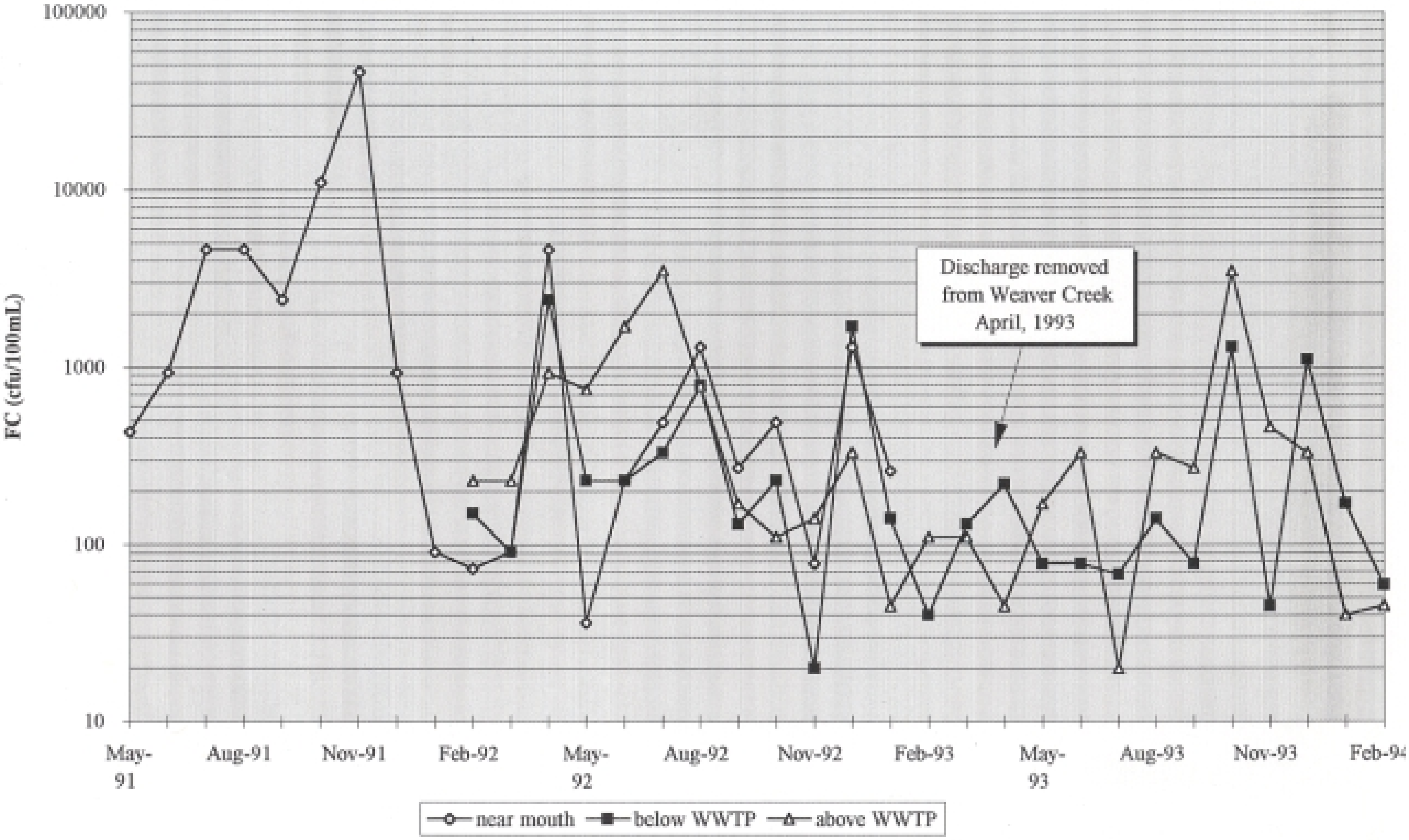


Figure 10. Fecal coliform concentrations in Weaver Creek, 1991-1994

Nonpoint TMDLs

The Clean Water Act (CWA) Section 303(d) requires states to effect pollution controls on waterbody segments where technology-based controls are insufficient to reach water quality standards. To meet this requirement, a total daily maximum load (TMDL) must be established for each pollutant violating water quality criteria. The TMDL is the sum of point and nonpoint sources as wasteload (WLA) and load (LA) allocations, respectively. Allocations are implemented through NPDES permits, grant projects, and nonpoint source controls. Thus, the TMDL process helps bring problem waterbodies into compliance with water quality standards.

The TMDL evaluation uses monitoring data and models to estimate pollutant loads that a waterbody can receive and still meet water quality standards. EPA's regulations [40 CFR 130.2(i)] state that ". . .TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. . ." EPA specified **other appropriate measure** as a key concept for establishing nonpoint pollutant source controls.

Where a large nonpoint source component is included in the TMDL, as in the Salmon Creek drainage, or where data contain a high degree of uncertainty, a phased TMDL approach is appropriate (EPA 1991). The LAs under a phased TMDL are refined as specific nonpoint problems undergo control measures, and as additional data are obtained. Ecology has recently clarified key steps of phased TMDLs as follows:

1. Define the beneficial uses affected
2. Determine the factors/causes
3. Determine the targets and priorities
4. Develop the pollution controls and identify resources
5. Monitor the results
6. Adjust the controls
7. Involve the public at all steps

The following is a discussion of the Salmon Creek phased TMDL with respect to these aspects.

Beneficial Uses Affected

The beneficial uses affected in the Salmon Creek drainage have been documented in the watershed management plan entitled, "The Legacy, The Salmon Creek Watershed Management Plan" (Salmon Creek Citizen Advisory Committee *et al.* 1993). Overall, the document supports a comprehensive multiple-use approach to watershed management where purposes of flood control, stormwater treatment, wildlife and fisheries, forest management, agriculture, recreation, and other uses can all be met jointly to protect natural resources for both the assurance of sustainable economic prosperity and quality of life. Specific degradation of beneficial uses identified in the basin include primary contact recreation due to waste contamination, and loss of wildlife and salmonid rearing/spawning habitat due to a host of instream and watershed disturbances.

Factors/Causes

The 303(d) list identifies fecal coliform as the most pervasive problem in the Salmon Creek drainage (Table 1). The data reviewed in this report support the listing, but also indicate nonpoint pollution problems with turbidity, dissolved oxygen, nutrients, and temperature. It is likely that these problems are all related to the land-use and stream corridor problems discussed in the Introduction. It is also likely that targeting one or two of these parameters for TMDLs will help manage the others as control measures are implemented in the drainage. Fecal coliform and turbidity have been targeted as nonpoint TMDL parameters for Salmon Creek (Cusimano and Giglio 1995). These two parameters have state water quality criteria and suitably reflect land-use practices and stream corridor disturbances.

Land uses in the drainage, as defined by two geographic information system (GIS) data layers called "parcels" (based on assessed land use for tax purposes) and "land use" (based on interpretation of 1990 aerial photographs), are listed in Table 4 and 5, respectively. Drainage maps representing these two data layers are in Appendix B. The data layers used to calculate areas and percentages of land-use by subbasins were provided by the Clark County Department of Assessment and GIS Office, Clark County, Washington. The GIS spatial analysis was conducted by John Tooley of Ecology (Tooley 1995).

The disparate percentages of land use by subbasin between data layers demonstrates the difficulty in using GIS spatial data to help explain variability in water-quality samples. Aggregating the data into mapping and analysis classes to meet water quality spatial analysis classes contributes to the variance between data layers, but most of the differences are due to different definitions under which the data were collected. For purposes of this report the land use data layer may provide the most information since it is based on photo-interpretation of land use rather than assessed land use.

The land use information is useful for comparing and contrasting characteristics of the subbasins. For example, examining the size and overall characteristics of the major subbasins (which account ≈75% of land area) shows that Curtin, Mill, Morgan, Weaver, and Upper Salmon have drainage sizes of similar magnitude but contrasting land use. Upper Salmon Creek is mostly forested, while Cougar Creek is mostly developed. Other major subbasins are mostly agricultural, rural, and rural residential.

Table 4. Salmon Creek Watershed, Parcel Land Use

Total Acres by Subbasin

Subbasin Name[a]	Forest	Vacant/ Mixed/ Open	Agricul-ture	Pasture	Rural	Rural Residen-tial	Residen-tial	Parks/ Schools/ Recr.	Public Facilities	Institu-tional	Commer-cial	Light Industry	Heavy Industry	Roads	Total
I-5 North	16.4	643.9	119.2	0.0	150.9	395.8	533.1	48.2	7.4	11.9	87.9	10.2	27.3	1.5	2053.5
I-5 South	33.2	158.5	34.4	0.0	79.5	139.5	208.8	27.4	17.3	8.9	0.0	0.0	0.0	0.3	707.7
114th St. trib.	1.1	30.8	6.0	0.0	23.8	44.0	135.5	18.2	0.3	5.2	11.1	0.5	0.6	0.0	277.1
119th St. trib.	0.9	152.3	8.3	0.0	44.9	216.6	303.6	0.0	3.1	7.2	1.7	0.0	1.5	2.6	742.6
Mainstem Salmon	16.0	354.0	11.3	0.0	24.9	53.3	105.3	19.7	10.8	2.5	21.2	1.7	0.8	0.0	621.6
Pleasant Valley	4.0	270.9	20.8	9.5	230.5	408.0	250.3	27.2	0.0	38.4	0.3	0.0	6.5	0.8	1267.2
Suds	2.3	57.0	0.0	0.0	0.0	41.6	243.8	15.5	5.0	3.7	6.9	0.0	0.0	0.5	376.3
Tenny	7.2	164.3	0.3	0.0	52.3	169.2	323.0	12.7	0.0	3.8	68.5	0.6	20.6	5.4	827.9
Cougar	0.0	288.3	0.0	0.0	81.2	166.0	713.0	119.9	14.4	25.1	168.8	4.9	16.1	0.4	1598.0
Mill	303.3	3014.9	1140.7	40.5	3407.5	1919.7	535.9	71.4	12.7	27.4	107.8	5.6	2.8	0.8	10590.9
Curtin	38.3	1179.3	406.8	40.5	1480.3	1129.7	1367.9	242.5	167.8	43.6	58.2	70.8	79.3	7.7	6312.8
Morgan	32.8	1287.8	238.4	0.0	301.7	791.5	1066.1	96.3	14.8	23.7	175.8	20.4	54.5	3.0	4107.0
Weaver	465.0	2212.1	456.9	60.3	2084.6	1897.4	567.8	285.5	67.0	25.1	47.4	17.2	48.5	2.7	8237.6
Rock	1737.6	896.9	92.0	2.2	1026.2	770.4	130.9	0.0	1.0	1.1	0.0	0.0	1.2	9.0	4668.6
Upper Salmon	4057.4	1047.6	8.4	0.0	614.8	872.7	64.4	62.3	0.7	2.2	3.9	8.1	38.5	0.7	6781.7
Total	6715.3	11758.5	2543.6	153.1	9603.2	9015.5	6549.5	1046.8	322.4	229.8	759.3	140.0	298.2	35.2	49170.3

Percentage Land Use by Subbasin

Subbasin Name[a]	Forest	Vacant/ Mixed/ Open	Agricul-ture	Pasture	Rural	Rural Residen-tial	Residen-tial	Parks/ Schools/ Recr.	Public Facilities	Institu-tional	Commer-cial	Light Industry	Heavy Industry	Roads	Total
I-5 North	0.7	26.4	4.9	0.0	6.2	16.2	21.8	2.0	0.3	0.5	3.6	0.4	1.1	0.1	84.1
I-5 South	3.9	18.4	4.0	0.0	9.2	16.2	24.3	3.2	2.0	1.0	0.0	0.0	0.0	0.0	82.3
114th St. trib.	0.3	9.3	1.8	0.0	7.2	13.2	40.7	5.5	0.1	1.6	3.3	0.1	0.2	0.0	83.3
119th St. trib.	0.1	16.1	0.9	0.0	4.7	22.8	32.0	0.0	0.3	0.8	0.2	0.0	0.2	0.3	78.3
Mainstem Salmon	2.0	44.4	1.4	0.0	3.1	6.7	13.2	2.5	1.4	0.3	2.7	0.2	0.1	0.0	78.0
Pleasant Valley	0.3	19.1	1.5	0.7	16.2	28.8	17.6	1.9	0.0	2.7	0.0	0.0	0.5	0.1	89.3
Suds	0.5	12.0	0.0	0.0	0.0	8.7	51.2	3.3	1.0	0.8	1.4	0.0	0.0	0.1	79.0
Tenny	0.7	16.6	0.0	0.0	5.3	17.1	32.7	1.3	0.0	0.4	6.9	0.1	2.1	0.6	83.7
Cougar	0.0	15.0	0.0	0.0	4.2	8.6	37.0	6.2	0.7	1.3	8.8	0.3	0.8	0.0	82.9
Mill	2.7	27.3	10.3	0.4	30.8	17.4	4.8	0.6	0.1	0.2	1.0	0.1	0.0	0.0	95.8
Curtin	0.5	16.8	5.8	0.6	21.0	16.1	19.4	3.4	2.4	0.6	0.8	1.0	1.1	0.1	89.7
Morgan	0.7	26.4	4.9	0.0	6.2	16.2	21.8	2.0	0.3	0.5	3.6	0.4	1.1	0.1	84.0
Weaver	5.3	25.3	5.2	0.7	23.8	21.7	6.5	3.3	0.8	0.3	0.5	0.2	0.6	0.0	94.1
Rock	36.6	18.9	1.9	0.0	21.6	16.2	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.2	98.3
Upper Salmon	58.5	15.1	0.1	0.0	8.9	12.6	0.9	0.9	0.0	0.0	0.1	0.1	0.6	0.0	97.8
Total	13.1	21.7	4.7	0.3	18.5	16.8	11.8	2.0	0.6	0.4	1.3	0.3	0.5	0.1	92.1

[a] Minor tributaries appear in italic. Tributaries are listed roughly sequentially from mouth to headwaters

Table 5. Salmon Creek Watershed, Existing Land Use.

Total Acres by Subbasin

Subbasin Name[a]	Forest	Vacant	Agriculture	Residential	Parks/ Schools	Public Facilities	Commercial	Industry	Roads	Unknown	Water	Total
I-5 North	323.1	182.0	641.1	1002.7	202.5	2.2	22.9	22.9	23.5	12.8	7.0	2443.0
I-5 South	113.1	70.8	232.5	281.1	79.0	1.5	0.0	0.0	74.4	1.1	6.4	860.l0
114th St. trib.	45.0	18.9	29.4	151.5	26.1	1.4	8.4	1.4	46.5	3.5	0.4	332.5
119th St. trib.	112.6	95.0	121.9	377.7	22.9	0.4	2.8	1.7	206.6	0.4	6.6	948.6
Mainstem Salmon	84.2	38.3	40.5	112.9	345.6	3.9	5.1	2.5	54.6	0.3	108.8	796.7
Pleasant Valley	242.6	141.7	281.2	487.7	93.7	0.0	0.0	9.5	148.4	0.9	13.2	1418.9
Suds	13.9	58.7	22.7	257.4	21.1	5.0	8.8	0.0	88.4	0.4	0.0	476.4
Tenny	117.6	114.5	91.7	370.2	21.5	1.3	31.3	21.9	217.5	0.5	1.1	989.2
Cougar	128.3	162.8	181.0	759.8	188.4	13.5	116.3	18.1	356.0	3.1	0.8	1928.2
Mill	2212.7	656.7	5760.7	1596.7	112.1	8.7	92.3	7.9	573.8	11.3	22.3	11055.0
Curtin	653.5	603.5	2336.9	1992.7	293.0	192.6	55.1	135.9	763.5	7.1	4.5	7038.2
Morgan	646.3	364.6	1282.4	1317.1	405.1	4.5	45.8	45.7	735.7	25.6	14.0	4886.7
Weaver	2742.5	382.6	3056.2	1596.9	377.5	67.1	28.1	30.8	453.5	15.7	7.3	8758.3
Rock	3436.9	181.3	506.3	536.4	1.1	1.0	2.0	1.2	77.1	0.4	4.0	4747.7
Upper Salmon	5853.4	76.6	237.8	532.3	64.5	0.7	3.9	29.3	126.9	2.7	4.7	6932.7
Total	16725.5	3147.8	14822.3	11373.1	2253.9	303.8	422.9	328.9	3946.5	85.8	201.0	53612.0

Percentage Land Use by Basin

Subbasin Name[a]	Forest	Vacant	Agriculture	Residential	Parks/ Schools	Public Facilities	Commercial	Industry	Roads	Unknown	Water	Total
I-5 North	13.2	7.4	26.2	41.0	8.3	0.1	0.9	0.9	1.0	0.5	0.3	100.0
I-5 South	13.1	8.2	27.0	32.7	9.2	0.2	0.0	0.0	8.7	0.1	0.7	100.0
114th St. trib.	13.5	5.7	8.8	45.6	7.8	0.4	2.5	0.4	14.0	1.0	0.1	100.0
119th St. trib.	11.9	10.0	12.9	39.8	2.4	0.0	0.3	0.2	21.8	0.0	0.7	100.0
Mainstem Salmon	10.6	4.8	5.1	14.2	43.4	0.5	0.6	0.3	6.9	0.0	13.7	100.0
Pleasant Valley	17.1	10.0	19.8	34.4	6.6	0.0	0.0	0.7	10.5	0.1	0.9	100.0
Suds	2.9	12.3	4.8	54.0	4.4	1.0	1.9	0.0	18.6	0.1	0.0	100.0
Tenny	11.9	11.6	9.3	37.4	2.2	0.1	3.2	2.2	22.0	0.1	0.1	100.0
Cougar	6.7	8.4	9.4	39.4	9.8	0.7	6.0	0.9	18.5	0.2	0.0	100.0
Mill	20.0	5.9	52.1	14.4	1.0	0.1	0.8	0.1	5.2	0.1	0.2	100.0
Curtin	9.3	8.6	33.2	28.3	4.2	2.7	0.8	1.9	10.8	0.1	0.1	100.0
Morgan	13.2	7.5	26.2	27.0	8.3	0.1	0.9	0.9	15.1	0.5	0.3	100.0
Weaver	31.3	4.4	34.9	18.2	4.3	0.8	0.3	0.4	5.2	0.2	0.1	100.0
Rock	72.4	3.8	10.7	11.3	0.0	0.0	0.0	0.0	1.6	0.0	0.1	100.0
Upper Salmon	84.4	1.1	3.4	7.7	0.9	0.0	0.1	0.4	1.8	0.0	0.1	100.0
Total	32.1	5.8	27.7	20.3	4.0	0.6	0.8	0.6	7.7	0.1	0.4	100.0

[a] Minor tributaries appear in italic. Tributaries are listed roughly sequentially from mouth to headwaters

In general, the land use data layer helps explain why Upper Salmon meets water quality standards but the other subbasins do not (*i.e.*, it is mostly forested and less developed). Rock Creek is the only major subbasin without an associated monitoring station, but it can probably be assumed to have similar water quality as Upper Salmon because of the similarity in land-use and drainage size.

Targets and Priorities

The following targets and priorities for water quality improvement are based on Washington State's numeric standards for fecal coliform and turbidity.

Fecal Coliform

The fecal coliform concentration-based nonpoint TMDL is simply the Freshwater Class A fecal coliform standard (WAC 173-201A-030-2):

> Fecal coliform organism levels shall both not exceed a geometric mean (GM) value of 100 colonies/100 mL and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 mL.

To meet the TMDL, concentration-based LAs were established for monitoring stations 1-9 annotated in Figure 1. Table 6 lists the dry and wet season levels for both the geometric means and the 90th percentiles for each site based on the 1988-94 data. Table 6 also lists the percent reduction required to meet the standard at each site for both parts of the criteria. The percent reductions required by each part of the criteria were then compared, and the most restrictive criterion was used to establish the recommended target level, or LA. The allocations and percent reductions were calculated as follows:

1. Partition monthly data into a wet and dry season.
2. Calculate the GM of the data for each of the major mainstem and subbasin sampling sites for each season.
3. Determine the (log) distribution statistics for each season at each site and calculate the 90th percentile based on the mean, standard deviation, and Z-score. Adjust the distribution such that no more than 10% of the values exceed 200 colonies/100 mL. Then calculate the GM of the adjusted data. If the adjusted GM for a site is <100 colonies/mL, it will be the site LA. If the GM is >100 colonies/100 mL, the LA will then be 100 colonies/100 mL.

Table 6. Salmon Creek drainage wet and dry season fecal coliform geometric means, 90th percentiles, and recommended reductions.

Salmon Creek and its Major Tributaries **Station Name**	Site #	**First Criterion: Geometric Mean < 100**				**Second Criterion: 90% of Samples < 200**				**Recommended Target Levels**			
		Existing Geometric Mean		Percent Reduction needed (mean < 100)		Existing Upper Tenth Percentile		Percent Reduction needed (90% < 200)		Target Geometric Mean		Target Percent Reduction	
		Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
Salmon Creek (mouth)	1	313	129	68	23	1917	301	89	34	33	86	89	34
Cougar Creek	2	722	899	86	89	9243	1803	98	89	16	100	98	89
Salmon Creek (lower)	3	182	281	45	64	1261	806	84	75	29	70	84	75
Mill Creek	4	839	282	88	65	8763	1121	98	82	19	50	98	82
Curtin Creek	5	1155	743	91	87	4409	2608	96	92	52	57	96	92
Salmon Creek (middle)	6	257	453	61	78	1162	869	83	77	44	100	83	78
Weaver Creek	7	534	857	81	88	9204	6509	98	97	12	26	98	97
Salmon Creek (upper)	8	234	751	57	87	1125	1404	82	86	42	100	82	87
Salmon (headwaters)	9	28	54	0	0	200	318	0	37	28	34	0	37

4. Subtract the LA for each site established in step 3 from the GM calculated in step 2. Divide by the GM from step 2 and multiply times 100 to obtain the percent reduction required to meet the site specific LAs.

Figure 11 shows how the estimated sample distribution was adjusted to the target distribution based on the above procedure for wet season data at site 1. The adjusted frequency distribution has a 90th percentile of 200 colonies/100 mL, and a GM of 33 colonies/100 mL. The percent reduction in this case is 89%.

In summary, the fecal coliform TMDL is simply the concentration-based freshwater Class A water quality criteria. Load allocations are the site-specific geometric means needed to meet both parts of the water quality criteria. These site-specific LAs can be used as control points to monitor the success of management measures taken in the subbasins or along the mainstem of the Salmon Creek drainage. Figures 12 and 13 are graphical representations of the data presented in Table 6.

Turbidity

The turbidity nonpoint TMDL is the numeric freshwater Class A turbidity standard (Chapter 173-201A-030-2 WAC):

> Turbidity shall not exceed 5 NTU over background turbidity when background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

To meet the TMDL, numeric LAs were established for monitoring stations 1-9 annotated in Figure 1. Background turbidity was assumed to be equal to turbidity at the headwater sampling site, which was always less than 50 NTU. LAs were established such that turbidity levels would not exceed 5 NTU over background 90% of the time. The 90th percentile was chosen as a control level for turbidity because allowing 10% of the values to exceed water quality standards for conventional parameters is supported by EPA (EPA 1995). The turbidity LA for each site is the background level plus 5 NTU, and the target percent reduction is the percent reduction required for the 90th percentile of the data to meet the LA. Table 7 lists the 90th percentile of background adjusted data (as discussed below) and target percent reductions to meet the LA. The allocations and percent reductions were calculated as follows:

1. Partitioned monthly data into a wet and dry season.
2. Set background turbidity equal to the turbidity level at the headwater sampling site #9. For each sampling event, subtract background turbidity from downstream site values, including tributaries. Because the criterion applies only to positive differences between background and downstream sites, all remainders <0 were set to 0 NTU.

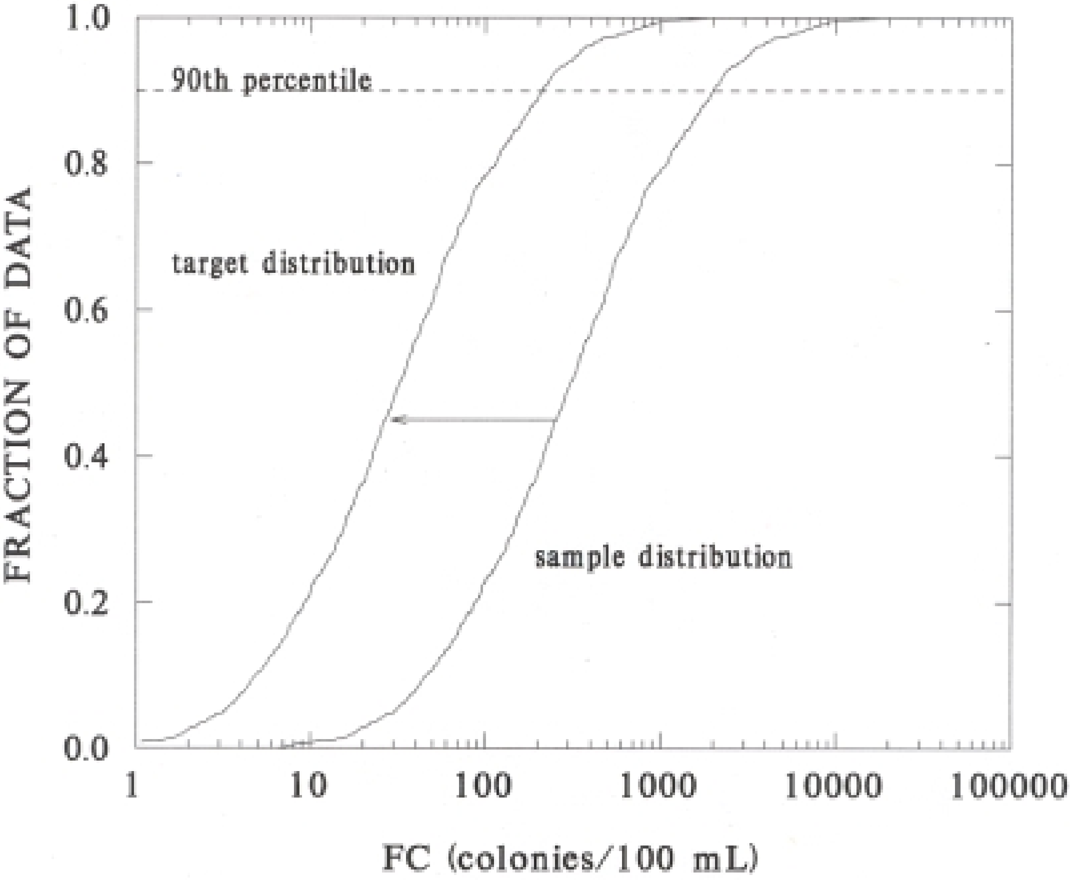


Figure 11. Frequency plot of estimated sample and target fecal coliform distributions for site 1 during the wet season.

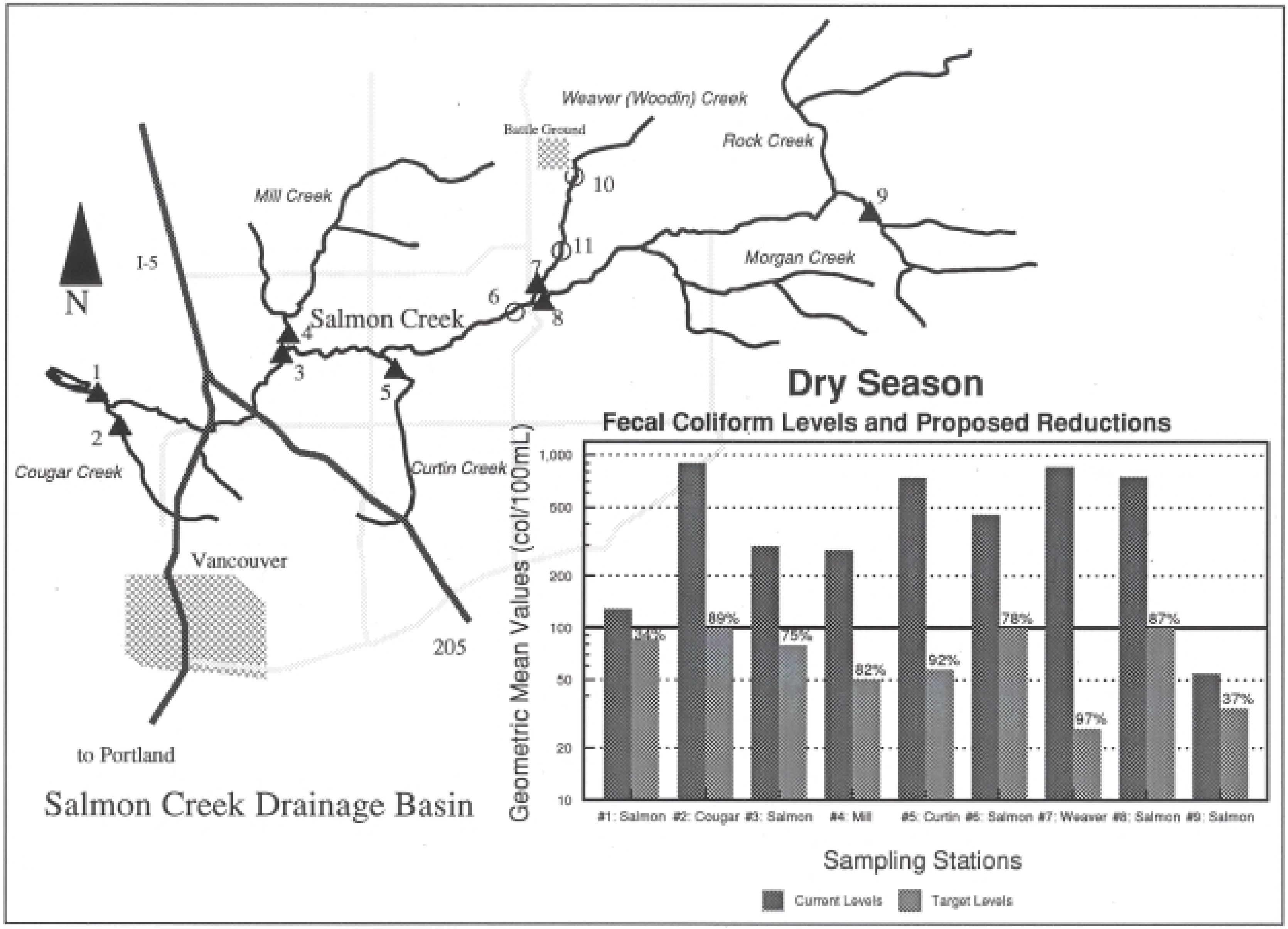


Figure 12. Dry season fecal coliform geometric means and proposed percent reductions.

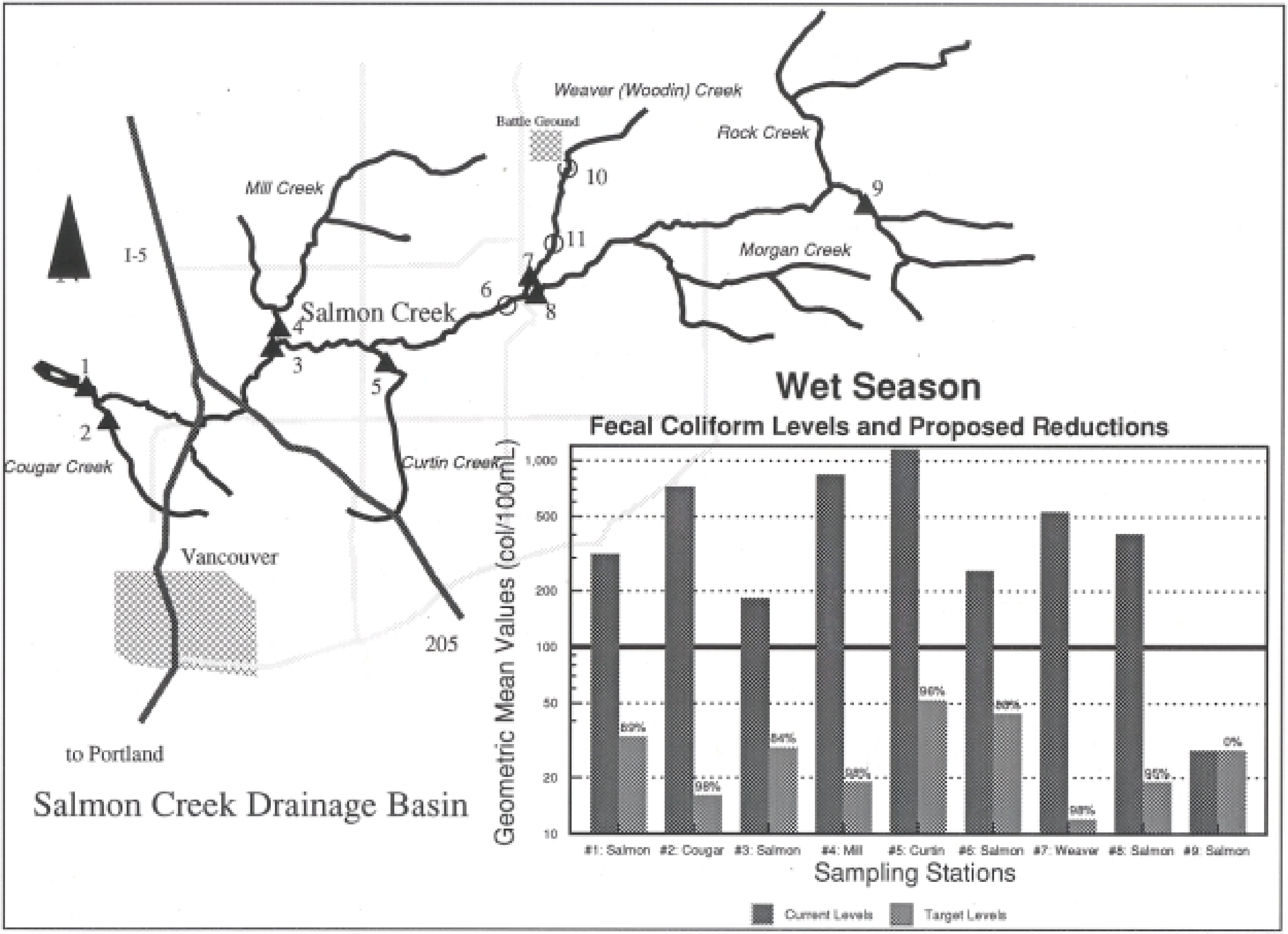


Figure 13. Wet season fecal coliform geometric means and proposed percent reductions.

Table 7. Salmon Creek drainage wet and dry season average turbidity, 90th percentiles, and recommended reductions.

Salmon Creek and its Major Tributaries	**Site #**	**90th %tile of Adjusted Data[a]**		**90th %tile of Adjusted Data minus LA of 5 NTU**		**Target Percent Reduction[b]**	
Station Name		**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**	**Wet Season**	**Dry Season**
Salmon Creek (mouth)	1	13.4	3.7	8.4	-1.3	63	0
Cougar Creek	2	20.1	1.9	15.1	-3.1	75	0
Salmon Creek (lower)	3	12.8	1.8	7.8	-3.2	61	0
Mill Creek	4	21.1	3.5	16.1	-1.5	76	0
Curtin Creek	5	5.9	2.8	0..9	-2.2	16	0
Salmon Creek (middle)	6	17.9	2.8	12.9	-2.2	72	0
Weaver Creek	7	10.1	2.0	5.1	-3.0	51	0
Salmon Creek (upper)	8	8.2	3.2	3.2	-1.8	39	0
Salmon Creek (headwaters)	9	NA	NA	NA	NA	NA	NA

[a] Adjusted data equals each site value minus background (site 9) value for each sampling event.
[b] Target reduction is the percent reduction required to reduce the 90th percentile of the adjusted data to 5 above background.

3. LAs for each site are 5 NTU.

4. Determine the (log) distribution statistics for each site during each season for the adjusted data calculated in step 2. Calculate the 90th percentile based on the mean, standard deviation, and Z-score. Subtract 5 NTU (LA) from the 90th percentile. If the remainder is ≤0 NTU, no reduction is necessary. If the remainder is >0, then divide the remainder by the 90th percentile value of the adjusted data and multiply by 100 to establish the percent reduction necessary to meet the LA.

Pollution Controls and Identifying Resources

Developing the pollution control measures or best management practices (BMPs) is an important part of a phased nonpoint TMDL, because they are the mechanism by which target pollution reductions can be met. The target reductions listed in Tables 6 and 7 can only be achieved if resources are allocated to address specific sources of impairment in the drainage. Fortunately, there has been an ongoing effort to implement BMPs in the Salmon Creek drainage.

The National Resources Conservation Service (NRCS) in Brush Prairie, Washington, has been implementing over 50 different types of BMPs in the Salmon Creek drainage since early 1990, and is currently compiling a computer inventory of these BMPs (CCCD 1990). The BMPs that have been and are currently being pursued by the NRCS have focused on: erosion and sediment control, stream corridor enhancement, animal waste control, and pastureland and cropland management. The 1993 watershed management plan described earlier also recommended BMPs that range from adopting land-use ordinances, providing developer incentives, minimizing impervious surfaces, stormwater management, public education, as well as many of those currently being implemented by the NRCS. In addition, SWHD has designed a BMP for maintaining septic systems that can be implemented in the Salmon Creek drainage. The BMP specifies methods for the maintenance of on-site sewage treatment systems. A copy of the septic BMP is in Appendix C.

Although all of the subbasins and mainstem control sites have high concentrations of fecal coliform and elevated turbidity, it would be logical to focus efforts in the drainage from upstream to downstream. Since the historical data show little degradation in the upper basin, enhancement BMPs should be implemented below this point. However, maintaining good water quality in the upper basin should also be a priority since it may experience growth pressures and timber harvest. Preventative BMPs such as erosion control for new developments should be instituted and attention should be paid to changes in land use in the "healthy" parts of the basin.

Currently there are a number of local agencies and organizations that have interest in or are working to improve water quality in the Salmon Creek Drainage. They include:

Clark County Department of Community Development
Clark County Parks and Recreation Division
Southwest Washington Health District
Clark County Conservation District
Natural Resources Conservation Service
Clark Public Utilities
Pacific Groundwater Group (Consultant for Clark Public Utilities)
Salmon Creek Citizen Advisory Committee

In order to facilitate these local efforts, Ecology should endorse the funding of projects in the Salmon Creek basin which support the goals of the fecal coliform and turbidity TMDLs. In addition, Ecology should designate personnel resources to help organize watershed management activities and maintain coordination and communication among the above groups.

Monitoring the Results

Once BMPs have been implemented, evaluating the effectiveness of the controls relative to the target LAs is important. Clark Public Utilities recently contracted with the Pacific Groundwater Group (PGG) to prepare a sampling plan for the Salmon Creek drainage. PGG submitted a sampling plan to Clark Public Utilities on February 28, 1995, that includes continued sampling at the control points used to establish LAs for fecal coliform and turbidity. Sampling began in summer 1995. In order to effectively evaluate the target indicators, sampling methods and water quality variables should correspond to those followed during the 1988-1994 sampling programs. Ecology should seek to ensure that this sampling effort will meet TMDL monitoring requirements, and work with Clark Public Utilities to secure adequate funding to maintain the monitoring program over time.

Adjusting the Controls

A phased TMDL requires that the BMP strategy be amended if targets are not being met. Although BMPs have been implemented since early 1990, a significant level of BMPs must be installed before significant pollution reductions will be realized. Monitoring results should be periodically examined to determine the effectiveness of BMPs at reducing nonpoint pollutants.

Involving the Public at All Steps

Control measures in a nonpoint TMDL are dependent on individual land management activity. Consequently, public participation in identifying where and how to focus on areas that contribute to nonpoint pollution will be critical. Public education is also important in controlling nonpoint pollution.

Water Resources

In addition to water quality, another component of the Salmon Creek drainage water resources is water quantity. Table 3 shows that the lowest monthly average and minimum flows occur during August and September. Water withdrawals due to water right/claim use could result in further decreases in summer low flows, with potentially and probable deleterious effects on water quality.

Appendix D contains an Ecology memorandum which summarizes some of the water right/claim use issues in Salmon and Burnt Bridge Creeks. Evaluating water right/claim use is an ongoing project in the drainage. Currently there are 132 water rights and 238 claims in Salmon Creek. Water rights in Salmon Creek are reported to total 31.4 cfs (personal communication, Chris Anderson). Ecology, Clark County, and Clark Public Utility have agreed to use a stream flow of 12 cfs at Klineline Park to initiate action on water use in the basin (Memorandum of Agreement 1995). It will be important to monitor stream water quantity and water use allocations so that a safe level of minimum flows can be maintained for all beneficial uses in the Salmon Creek basin.

Conclusions and Recommendations

- Historical water quality data support the 303(d) listing of fecal coliform as one of the most significant water quality problems in the Salmon Creek drainage. However, the data also point to other basin-wide water quality problems such as high turbidity, nutrients, temperature, and low dissolved oxygen. It is likely that these problems are all related to land-use and stream corridor disturbances.

- Increasing stream shading, especially in the lower reaches of Salmon Creek, is recommended to help reduce water temperatures during the summer. In addition, revegetating stream banks can be done in conjunction with bank stabilization to help reduce instream turbidity.

- Using data collected during 1988-1994, phased TMDLs are recommended for fecal coliform and turbidity to help control nonpoint source pollution in the Salmon Creek drainage. TMDLs for these parameters were based on meeting the water quality standard at site-specific control points in the Salmon Creek drainage during both wet (November-April) and dry (May-October) seasons. Implementing control measures for these parameters will probably also mitigate problems with nutrients and low dissolved oxygen in the basin.

- Currently there are a number of local agencies and organizations that have interest in or are working to improve water quality in the Salmon Creek drainage. In order to facilitate the efforts of local groups, Ecology should target grant funds and personnel resources to help with implementing BMPs and organizing watershed management activities in the basin.

- Follow-up monitoring is needed to evaluate the effectiveness of pollution control measures in the Salmon Creek drainage. Clark Public Utilities has recently begun an ambient monitoring program. Ecology should work with the Utility to ensure that the sampling design is appropriate to evaluate the fecal coliform and turbidity TMDLs and LAs.

- Water quantity in Salmon Creek and water use allocations should be closely monitored to make sure that a safe level of minimum flows can be maintained for all beneficial uses in the Salmon Creek basin.

References

CCCD (Clark County Conservation District), 1990. *Agriculture's Contribution to Non-Point Pollution in the Salmon Creek Basin*.

CCDCD (Clark County Department of Community Development), 1989. *Salmon Drainage Master Plan*. Clark County Department of Community Development. P.O. Box 5000, Vancouver, WA.

Crawford, P., 1985. *Weaver (Woodin) Creek Low-Flow, Point-Source Reconnaissance*, memorandum to Jon Neel. Washington State Department of Ecology, Olympia WA.

Cusimano, R.F. and D. Giglio, 1995. *Salmon Creek Nonpoint Source Pollution TMDL-Final Quality Assurance Project Plan*. Washington State Department of Ecology. Olympia, WA.

EPA, 1991. *Guidance for Water Quality-based Decisions: The TMDL Process*. United States Environmental Protection Agency, Office of Water, Washington, D.C. EPA 440/4-91-001.

EPA, 1995. *Guidelines for Preparation of the 1996 State Water Quality Assessments (305(b) Reports)*. United States Environmental Protection Agency, Office of Water, Washington, D.C. 20460. EPA 841 B-95-001.

Gaddis, Philip, 1991. *Clark County Water Quality Monitoring Program*. Clark County Department of Public Works (now Community Development). P.O. Box 5000, Vancouver, WA.

Goldman, Charles R. and Alexander J. Horne, 1983. *Limnology*. McGraw-Hill Publishing Company, New York.

Moore, A. and D. Anderson, 1978. *Weaver (Woodin) Creek-Battleground Sewage Treatment Plant Impact Study*. Project Report PR-4, Washington State Department of Ecology, Olympia, WA.

Newman, T., 1989. *Septic Systems in the Salmon Creek Basin: A Sanitary Survey*. Southwest Washington Health District, Vancouver, WA.

Parsons, M. E, 1983. *Clarke County, Washington Territory 1885*. Post Publishing Company, Camas, WA.

Salmon Creek Citizen Advisory Committee, Clark County Community Development, and Clark County Parks and Recreation Division, 1993. *The Legacy, The Salmon Creek Watershed Management Plan.*

SWHD (Southwest Washington Health District), 1981. *Non-Point Source Water Pollution from Septic Tank Systems in the Salmon Creek Basin*. Vancouver, WA.

SWHD (Southwest Washington Health District), 1990. *Salmon Creek Water Quality Monitoring Report: Final Report*. Vancouver, WA.

Tooley, J. 1995. Description of Spatial Analysis in support of Columbia Gorge TMDL Projects. Memorandum to Larry Goldstein, Washington State Department of Ecology, Olympia, WA.

Wille, S. A., 1989. *An Adult and Juvenile Salmonid Population Estimate and Habitat Evaluation in the Salmon Creek Basin*. Clark County Conservation District, Vancouver, WA.

Wille, S. A., 1990. *Wetland Resources of the Salmon Creek Basin*. Clark County Conservation District, Vancouver, WA.

Appendix A

Raw Data from 1988-89 and 1991-1994

Appendix A. Salmon Creek Watershed Monthly Ambient Water Quality Data, 1988-1989, 1991-1994.

Site	Year	Month	Day	Time	Temp (°C)	DO (mg/L)	DO Sat'n (%)	NH3 (mg/L)	NO2-NO3 (mg/L)	TN (mg/L)	NO3 (mg/L)	TKN (mg/L)	TP (mg/L)	OP (mg/L)	Turb (NTU)	NFR (mg/L)	5d BOD (mg/L)	FC /100m	pH (S.U.)	Cond (umhos/cm)	Alk (mg/L)	Hard (mg/L)
1	1988	10	10	1050	14.2	10.1	98.5	<0.01	1.6			0.05	0.20		2.5			230	7.3	198		
3	1988	10	10	1030	12.8	11.3	106.8	<0.01	1.5			0.02	0.25		2.5			230	7.3	181		
6	1988	10	10	1010	12.9	10.0	94.7	<0.01	0.8			0.29	0.43		3.5			430	7.2	148		
9	1988	10	10	0940	11.9	10.3	95.4	<0.01	0.1			0.03	<0.01		1.5			150	7.2	61		
1	1988	11	3	1545				<0.01	2.0				0.22		17					99		
3	1988	11	3	1607				<0.01	1.3				0.17		17					98		
6	1988	11	3	1628				<0.01	1.5				0.12		16					84		
9	1988	11	3	1651				0.16	1.3				0.02		8.2					61		
1	1988	11	21		9.3	10.0	87.2	0.07	1.3				0.16		13			930	6.9	92		
3	1988	11	21		9.2	10.3	89.5	<0.01	1.6				0.26		14			4,600	6.9	91		
6	1988	11	21	1045	9.2	10.6	92.1	<0.01	1.4				0.14		6.2			930	7.1	67		
9	1988	11	21	1030	8.7	10.6	91.0	<0.01	0.7				0.03		4.2			30	6.8	38		
1	1988	12	5	1130	5.4	11.9	94.1	<0.01	1.4				0.07		4.6			730	7.2	92		
3	1988	12	5	1035	5.5	12.2	96.8	<0.01	1.5				0.08		3.6			430	7.0	86		
6	1988	12	5	1015	5.5	12.7	100.7	0.03	1.3				0.06		3.7			91	7.1	81		
9	1988	12	5	1000	6.4	12.6	102.2	<0.01	0.5				0.02		2.1			30	6.7	33		
1	1989	1	24	1140	4.6	11.9	92.2	<0.01	1.4				0.08		5.5			230	6.3	76		
3	1989	1	24	1120	4.6	11.4	88.3	<0.01	1.6				0.05		4.9			430	6.5	68		
6	1989	1	24	1100	4.8	12.0	93.5	0.02	1.6				0.04		4.7			230	6.8	51		
9	1989	1	24	1045	5.1	11.8	92.6	<0.01	0.9				0.03		1.9			<30	6.7	32		
1	1989	2	14	1030	4.2	12.2	93.6	0.29	1.3				0.11		6.9			230	6.6	129		
3	1989	2	14	1000	3.7	12.4	93.9	0.06	1.3				0.08		5.2			430	6.6	103		
6	1989	2	14	0925	3.3	12.8	95.9	0.08	1.6				0.09		4.8			73	6.6	74		
9	1989	2	14	0900	3.2	12.4	92.6	<0.01	0.5				<0.01		1.5			<30	6.7	37		
1	1989	3	14	1030	7.4	11.3	94.0	<0.01	1.1				0.10		9.8			1,500	6.6	73		
3	1989	3	14	1000	7.1	11.8	97.4	<0.01	1.2				0.09		9.4			1,500	6.7	68		
6	1989	3	14	0945	7.0	11.8	97.2	<0.01	1.1				0.06		7.8			930	6.9	52		
9	1989	3	14	0915	6.8	12.5	102.5	<0.01	1.1				0.01		3.3			<30	6.9	32		
1	1989	4	11	1140	12.0	10.4	96.5	0.02	1.9				0.11		4.5			430	7.7	94		
3	1989	4	11	1115	11.9	11.7	108.3	0.05	1.6				0.12		3.9			930	7.5	80		
6	1989	4	11	1100	10.5	11.6	104.0	0.02	0.8				0.08		4.1			230	7.6	54		
9	1989	4	11	1030	8.7	11.5	98.8	0.02	0.4				0.01		2.5			<30	7.7	31		
1	1989	5	2	1130	13.4	10.0	95.8	0.05	0.9				0.12		4.2			230	6.7	115		
3	1989	5	2	1115	13.1	10.8	102.8	0.02	0.9				0.10		4.5			430	6.5	109		
6	1989	5	2	1045	12.1	10.9	101.4	0.08	0.6				0.10		4.6			230	6.5	73		
9	1989	5	2	1030	9.9	10.8	95.5	0.07	0.6				<0.01		2.1			<30	7.3	40		
1	1989	6	6		17.9	6.5	68.5	<0.01	1.2				0.16		7.1			230	7.0	148		
3	1989	6	6		16.4	9.1	93.0	0.04	1.5				0.13		4.2			230	7.0	121		
6	1989	6	6		16.4	8.3	84.8	0.08	1.1				0.16		4.7			230	6.7	88		
9	1989	6	6		13.4	9.2	88.1	<0.01	0.6				0.03		2.8			30	7.0	43		
1	1989	7	10	1215	16.6	10.0	102.6	0.09	1.8				0.28		3.2			230	7.5	182		

D- The sample is a duplicate (field replicate)
B- Blank

Site	Year	Month	Day	Time	Temp (°C)	DO (mg/L)	DO Sat'n (%)	NH3 (mg/L)	NO2-NO3 (mg/L)	TN (mg/L)	NO3 (mg/L)	TKN (mg/L)	TP (mg/L)	OP (mg/L)	Turb (NTU)	NFR (mg/L)	5d BOD (mg/L)	FC /100m	pH (S.U.)	Cond (umhos/cm)	Alk (mg/L)	Hard (mg/L)
3	1989	7	10	1140	15.6	10.4	104.5	<0.01	2.0				0.34		4.8			430	7.3	157		
6	1989	7	10	1115	15.5	9.3	93.3	0.09	2.0				0.59		2.5			430	7.2	125		
9	1989	7	10	0930	13.3	10.1	96.5	<0.01	0.4				0.03		4.5			140	6.9	50		
1	1989	8	7	1230	20.7	9.5	106.0	0.03	1.2				0.17		3.0			210	7.0	173		
3	1989	8	7	1200	19.1	9.8	105.9	0.06	1.0				0.23		3.0			430	6.8	162		
6	1989	8	7	1135	19.0	8.9	96.0	0.07	0.9				0.35		3.7			930	6.4	121		
9	1989	8	7	1100	15.5	9.0	90.2	0.02	0.2				0.03		1.6			36	7.2	59		
1	1989	9	11	1145	16.5	10.0	102.4	0.04	1.5				0.13		2.6			150	7.4	198		
3	1989	9	11	1120	14.2	10.4	101.4	0.06	3.0				0.21		2.8			430	7.2	184		
6	1989	9	11	1050	13.6	9.0	86.6	0.02	2.0				0.43		4.0			720	6.6	154		
9	1989	9	11	1030	12.6	9.3	87.5	0.06	0.6				0.02		2.0			91	7.3	59		
1	1991	5	16	1453	13.7	11.0	106.0	<0.01	0.9			0.32	0.11	0.05	3.2	4.0	1.2	430	7.3	106	38	
2	1991	5	16	1430	13.7	9.5	91.0	<0.01	2.0			0.04	0.13	0.07	2.8	6.0	1.2	930	7.5	234	82	
3	1991	5	16	1404	13.6	10.7	103.0	<0.01	0.9			0.20	0.08	0.04	3.6	2.0	0.6	930	7.3	87	31	
4	1991	5	16	1348	13.6	10.0	96.0	0.22	0.7			0.48	0.21	0.09	4.3	2.0	1.4	91	7.4	145	53	
5	1991	5	16	1338	15.0	9.1	89.0	0.13	3.5			0.73	0.11	0.07	3.3	6.0	2.0	2,400	7.3	165	69	
7	1991	5	16	1100	11.8	10.1	94.0	0.15	1.4			0.40	0.39	0.33	3.4	11	1.1	430		115	35	
8	1991	5	16	1110	11.4	10.6	96.0	0.19	0.5			0.16	0.08	0.02	3.6	3.0	1.3	430		70	18	
9	1991	5	16	1025	9.6	10.6	94.0	0.10	0.3			0.17	0.03	0.02	2.0	8.0	0.6	<30		39	65	
1	1991	6	18	1205	16.8	7.6	78.3	0.05	1.2			0.13	0.21	0.12	8.6	20	1.2	91	7.4	149		
2	1991	6	18	1140	12.7	10.1	95.2	0.03	2.9			0.06	0.11	0.08	1.8	1.0	1.6	430	7.6	234		
3	1991	6	18	1030	13.6	9.9	95.2	0.03	2.0			0.33	0.16	0.09	3.1	4.0	1.0	230	7.3	128		
4	1991	6	18	1045	13.5	9.9	95.0	0.09	1.1			0.50	0.18	0.15	4.7	<1	0.5	390	7.2	150		
5	1991	6	18	1000	11.7	8.7	80.2	0.04	4.9			<0.01	0.08	0.06	1.1	<1	0.4	2,400	6.9	229		
7	1991	6	18	0850	12.3	9.4	87.8	0.05	3.5			0.46	1.1	1.05	2.6	1.0	1.1	930	7.4	200		
8	1991	6	18	0915	13.0	9.9	94.0	0.04	0.4			0.11	0.02	<0.01	3.3	<1	0.7	750	7.6	61		
9	1991	6	18	0815	10.0	10.7	94.8	0.02	0.2			0.08	0.03	<0.01	2.4	1.0	0.5	36	6.7	46		
1	1991	7	9	1230	17.7	7.8	82.0	0.01				0.86	0.17		5.3	8.0	0.8	91	7.5	140		
2	1991	7	9	1200	13.0	9.0	85.0	0.01	3.1			<0.01	0.12	0.11	4.9	7.0	0.9	1,500	7.9	229		
3	1991	7	9	1110	16.0	9.2	92.0	0.01				0.05	0.16	0.11	3.2	<1	0.9	930	7.7	110		
4	1991	7	9	1130	14.6	8.7	85.0	0.04	3.3			0.75	0.56	0.45	2.4	<1	1.9	91	7.8	210		
5	1991	7	9	1033	12.5	8.4	79.0	0.02				<0.01	0.11	0.08	1.6	<1	1.0	390	7.1	214		
7	1991	7	9	0930	15.0	8.7	85.0	0.07	4.9			0.35	0.88	0.98	3.2	<1	2.4	4,600	7.5	202		
8	1991	7	9	1000	16.2	9.2	92.0	0.01				0.18	0.04	0.03	3.5	8.0	0.7	1,500	7.4	62		
9	1991	7	9	0845	13.0	9.9	93.0	0.01				0.08	0.07		2.4	4.0	0.4	30	7.2	44		
1	1991	8	6	1130	19.4	8.9	95.0	0.03	2.1			0.42	0.16	0.12	4.5	10.4	1.2	230	7.4	168		
2	1991	8	6	1113	14.2	9.7	93.0	0.02	4.0			<0.05	0.12	0.11	3.8	7.2	0.5	2,400	8.0	233		
3	1991	8	6	1030	17.0	9.1	94.0	0.03	3.5			0.22	0.14	0.13	2.1	3.0	0.8	930	7.8	142		
4	1991	8	6	1049	15.9	8.5	85.0	0.03	3.7			1.24	1.2	0.77	4.0	3.6	2.2	1,500	7.8	249		
5	1991	8	6	1015	12.8	8.3	78.0	0.02	6.1			0.03	0.10	0.07	1.0	2.2	0.2	230	7.0	227		
7	1991	8	6	0915	16.3	7.6	76.0	1.66	4.0			2.10	2.0	1.8	3.0	2.8	5.1	4,600	7.7	372		
8	1991	8	6	0935	17.2	8.9	92.0	0.02	0.6			0.06	0.05	0.03	3.2	<0.2	0.5	930	7.7	80		
9	1991	8	6	0830	14.4	9.1	87.5	<0.01	0.1			0.06	0.02	<0.01	2.6	3.0	0.8	<30	7.3	50		
B	1991	8	6	0847	19.4			0.03	<0.01			0.19	<0.01	0.01	<0.1	0.2	0	<30	7.3	2.6		

D- The sample is a duplicate (field replicate)

B- Blank

Site		Year	Month	Day	Time	Temp (°C)	DO (mg/L)	DO Sat'n (%)	NH3 (mg/L)	NO2-NO3 (mg/L)	TN (mg/L)	NO3 (mg/L)	TKN (mg/L)	TP (mg/L)	OP (mg/L)	Turb (NTU)	NFR (mg/L)	5d BOD (mg/L)	FC /100m	pH (S.U.)	Cond (umhos/cm)	Alk (mg/L)	Hard (mg/L)
1		1991	9	10	1204	16.9	10.3	106.0	0.06	2.22			0.20	0.15	0.13	2.2	6.8	0.9	430	7.8	186		
2		1991	9	10	1148	13.3	10.0	94.0	0.05	3.1			0.05	0.13	0.11	3.5	7.6	1.0	430	7.9	239		
3		1991	9	10	1105	14.5	9.6	94.0	0.07	3.1			0.52	0.21	0.20	1.8	3.4	0.9	91	7.6	165		
4		1991	9	10	1120	13.9	9.4	90.0	0.05	1.5			0.49	0.35	0.26	2.6	1.4	0.9	430	7.8	191		
5	D	1991	9	10	1043	11.9	8.1	75.0	0.06	6.47			<0.05	0.08	0.07	0.8	1.4	0.7	430	6.9	218		
5		1991	9	10	1043	11.9	8.2	76.0	0.08	6.45			<0.05	0.08	0.07	1.0	1.2	0.5	430	7.0	221		
7		1991	9	10	0945	13.9	8.3	80.0	1.59	6.50			1.70	2.2	1.9	1.8	2.0	1.7	2,400	7.6	329		
8		1991	9	10	1005	14.4	9.0	87.0	0.06	0.76			0.21	0.06	0.04	3.0	1.6	1.0	430	7.7	90		
9		1991	9	10	0900	12.5	9.6	90.0	0.08	0.12			<0.05	0.05	0.01	3.0	3.0	0.7	36	7.2	58		
1		1991	10	2	1215	15.0	10.1	99.0	0.01	2.48			0.20	0.19	0.16	2.1	2.6		91	7.1	200		
2		1991	10	2	1155	12.0	10.2	94.0	0.01	3.25			0.02	0.17	0.22	4.4	13.4		930	7.5	247		
3		1991	10	2	1118	12.9	10.0	94.0	0.01	3.75			0.23	0.26	0.22	2.3	2.2		91	7.0	184		
4		1991	10	2	1133	12.3	10.2	94.0	0.01	1.62			0.34	0.27	0.23	2.4	1.0		430	7.1	182		
5		1991	10	2	1055	11.2	8.4	76.0	0.02	7.06			0.13	0.13	0.08	1.3	4.4		230	6.6	228		
7		1991	10	2	0950	12.3	9.0	83.0	0.08	8.94			0.02	2.9	1.95	2.1	1.6		11,000	7.2	345		
8		1991	10	2	1015	12.9	9.6	91.0	0.01	0.64			0.11	0.73	0.05	3.5	2.8		930	7.1	95		
9	D	1991	10	2	0915	12.1	9.7	90.0	<0.01	0.08			0.08	0.05	<0.01	1.7	1.4		91	6.7	55		
9		1991	10	2	0915	12.1	9.7	90.0	<0.01	0.10			0.01	0.04	<0.01	1.7	1.0		36	6.8	58		
1		1991	11	5	1332	9.8	10.0	89.0	0.05	1.63			1.0	0.48	0.114	65	130		11,000	6.7	99		
2		1991	11	5	1308	12.1	10.0	93.0	0.02	0.97			0.30	0.32	0.058	50	144		11,000	6.6	70		
3		1991	11	5	1210	5.9	9.8	78.0	0.03	2.01			2.4	0.64	0.014	90	212		4,600	6.5	72		
4		1991	11	5	1230	9.5	9.5	84.0	2.01	2.60			5.65	1.6	0.466	85	64		24,000	6.8	217		
5		1991	11	5	1140	6.6	8.1	64.0	<0.01	3.00			0.1	0.16	0.092	7.7	7.0		4,600	6.4	152		
7		1991	11	5	0950	6.6	9.0	74.0	0.09	2.25			2.1	0.53	0.258	38	114		46,000	6.4	107		
8	D	1991	11	5	1020		9.9		0.04	1.99			1.95	0.38	0.103	95	202		21,000	6.2	58		
8		1991	11	5	1020	8.1	10.0	84.0	0.04	1.99			2.35	0.45	0.088	90	224		12,000	6.1	63		
9		1991	11	5	0910	6.1	10.5	84.0	<0.01	1.36			1.3	0.16	0.063	32	91		4,600	6.4	38		
B		1991	11	5	1105	15.6			0.07	0.08			0.11	0.04	<0.01	0.2	0.1		<30	6.4	1.7		
1		1991	12	3	1245	8.4	11.2	94.0	0.05	1.31	1.72	0.41		0.13	0.05	14	49		91	6.8	70		
2		1991	12	3	1155	9.4	10.9	94.0	0.02	0.85	2.6	1.75		0.08	0.06	3.0	2.4		91	7.1	219		
3		1991	12	3	1107	8.4	11.1	93.0	0.04	1.28	1.58	0.3		0.06	0.04	5.8	8.0		36	6.7	60		
4		1991	12	3	1123	7.5	10.6	89.0	0.13	1.76	2.94	1.18		0.19	0.13	9.1	7.3		200	6.6	114		
5		1991	12	3	1045	9.5	9.0	80.0	0.05	4.08	4.54	0.46		0.06	0.05	4.7	5.6		930	6.6	190		
7		1991	12	3	0930	8.7	10.4	90.0	0.11	1.79	2.13	0.34		0.20	0.15	5.2	5.8		930	6.7	80		
8		1991	12	3	1010	8.5	11.1	96.0	<0.01	1.18	1.56	0.38		0.05	0.05	6.5	9.0		91	6.8	57		
9	D	1991	12	3	0850	8.1	11.2	94.0	0.02	0.48	0.52	0.04		0.05	0.02	3.0	4.4		<30	6.6	32		
9		1991	12	3	0840	8.1	11.4	96.0	0.03	0.50	0.56	0.06		<0.01	0.01	3.2	4.2		<30	6.6	31		
1		1992	1	7	1245	5.8	11.9	95.0	0.09	1.52	1.79	0.27		0.14	0.12	5.5	5.7		91	6.9	89		
2		1992	1	7	1213	6.0	11.8	94.0	0.04	2.49	2.49	<0.01		0.12		2.7	3.3		91	7.1	219		
3		1992	1	7	1135	5.3	11.9	93.0	0.09	1.48	1.68	0.20		0.10	0.13	4.8	2.4		91	6.7	70		
4		1992	1	7	1151	4.3	12.0	92.0	0.12	1.59	2.32	0.73		0.16	0.16	5.7	4.0		91	6.7	103		
5		1992	1	7	1119	7.1	10.0	82.0	0.07	4.18	4.92	0.74		0.07	0.05	4.8	7.3		4,600	6.7	184		
7		1992	1	7	0953	5.8	11.1	89.0	0.48	1.96	3.42	1.46		0.47	0.53	5.0	6.4		91	6.8	100		
8	D	1992	1	7	1033	4.9	11.9	93.0	0.11	1.14	1.43	0.29		0.10	0.11	4.8	4.0		91	6.7	60		

D- The sample is a duplicate (field replicate)
B- Blank

Site		Year	Month	Day	Time	Temp (°C)	DO (mg/L)	DO Sat'n (%)	NH3 (mg/L)	NO2- NO3 (mg/L)	TN (mg/L)	NO3 (mg/L)	TKN (mg/L)	TP (mg/L)	OP (mg/L)	Turb (NTU)	NFR (mg/L)	5d BOD (mg/L)	FC /100m	pH (S.U.)	Cond (umhos/cm)	Alk (mg/L)	Hard (mg/L)
8		1992	1	7	1019	4.9	11.9	93.0	0.11	1.16	1.31	0.15		0.10	0.10	4.7	3.3		<30	6.7	63		
9		1992	1	7	0850	4.6	12.0	94.0	0.02	0.36	0.37	0.01		0.01	0.01	2.3	5.6		36	6.7	36		
1		1992	2	10	1309	7.9	11.4	96.0	0.02	1.47	1.55	0.08		0.09	0.07	4.6	5.4		91	7.0	105		
2		1992	2	10	1239	8.7	10.8	92.0	0.02	2.33	2.36	0.03		0.08	0.09	2.9	5.7		91	7.2	214		
3		1992	2	10	1204	7.7	11.2	94.0	0.02	1.42	1.47	0.05		0.07	0.06	4.5	7.3		73	6.9	82		
4		1992	2	10	1220	7.1	11.5	94.0	0.08	1.41	1.83	0.42		0.16	0.12	5.8	7.3		230	6.9	125		
5		1992	2	10	1145	9.0	9.8	84.0	<0.01	4.18	4.53	0.35		0.06	0.05	4.3	10.0		430	6.7	198		
7	D	1992	2	10	1046	7.8	11.4	96.0	0.01	2.07	2.4	0.33		0.27	0.23	3.9	5.4		91	7.1	105		
7		1992	2	10	1040	7.8	11.3	96.0	<0.01	2.07	2.22	0.15		0.25	0.21	4.2	7.3		73	6.9	105		
8		1992	2	10	1115	7.1	11.6	96.0	0.03	1.00	1	<0.01		0.07	0.08	4.1	5.3		91	6.8	65		
9		1992	2	10	0900	7.1	11.4	95.0	<0.01	0.32	0.35	0.03		0.04	<0.01	2.4	4.2		<30	6.6	52		
10		1992	2	10	0945	7.7	11.5	97.0	<0.01	1.45	1.73	0.28		0.08	0.03	3.6	3.0		230	6.6	80		
11		1992	2	10	1005	8.1	10.6	90.0	0.05	2.38	2.8	0.42		0.38	0.33	3.9	5.0		150	6.7	113		
1	D	1992	3	9	1320	9.5	11.8	104.0	0.04	1.47	1.77	0.30		0.09	0.08	4.3	2.7		430	7.0	113		
1		1992	3	9	1310	9.4	12.0	105.0	0.04	1.46	1.8	0.34		0.11	0.07	4.4	5.0		230	6.9	113		
2		1992	3	9	1240	10.0	11.2	100.0	0.01	2.42	2.61	0.19		0.09	0.08	1.8	3.7		430	7.2	224		
3		1992	3	9	1200	8.2	11.9	100.0	0.02	1.49	1.69	0.20		0.08	0.06	4.2	6.3		73	6.8	93		
4		1992	3	9	1218	8.5	11.1	95.0	0.85	1.73	2.78	1.04		0.47	0.29	8.7	5.0		2,400	6.9	148		
5		1992	3	9	1139	9.9	11.1	99.0	0.02	4.60	4.75	0.15	0.25	0.06	0.04	3.2	5.4		430	6.7	206		
7		1992	3	9	1030	7.9	11.3	97.0	0.02	2.30	2.33	0.03		0.29	0.22	4.3	5.7		91	6.8	111		
8		1992	3	9	1053	7.4	12.0	100.0	0.03	1.03	1.67	0.64		0.08	0.06	4.0	5.0		91	6.7	80		
9		1992	3	9	0900	6.2	12.0	98.0	<0.01	0.31	0.34	0.03		0.01	<0.01	2.1	3.2		<30	6.7	37		
10		1992	3	9	0941	7.6	12.2	102.0	<0.01	1.31	1.49	0.18		0.03	0.02	2.6	4.6		230	6.7	96		
11		1992	3	9	1005	8.1	11.2	96.0	0.05	2.42	2.78	0.36		0.55	0.45	3.9	4.8		91	6.7	127		
B		1992	3	9	1348	19.3			<0.01	0.05	0.02	0.03		<0.01	0.01	<0.1	<0.1		<30	6.6	1.2		
1		1992	4	13	1310	12.3	10.4	97.0	0.036	0.96	1.24			0.161	0.07	9.8	18.7		930	7.0	109		
2		1992	4	13	1240	11.7	10.1	93.0	0.038	0.82	1.14			0.207	0.06	18	43.5		2,400	7.0	110		
3		1992	4	13	1200	11.7	10.6	98.0	0.032	1.23	1.48			0.120	0.08	6.0	8.0		1,500	7.0	93		
4		1992	4	13	1212	12.2	9.8	92.0	0.041	0.58	1.15			0.212	0.09	16	12.3		2,400	7.0	116		
5	D	1992	4	13	1130	11.9	10.0	93.0	0.025	3.29				0.098	0.05	5.3	10.4		4,600	6.9	180		
5		1992	4	13	1130	11.9	10.0	93.0	0.031	3.09	3.65			0.096	0.08	5.2	9.3		2,400	6.9	182		
7		1992	4	13	1027	11.6	9.8	91.0	0.075	1.68	2.83			0.639	0.31	14	35.0		4,600	6.9	123		
8		1992	4	13	1055	11.3	10.6	97.0	0.034	0.78	1.10			0.149	0.09	8.3	13.7		930	6.9	73		
9		1992	4	13	0845	9.7	10.6	93.0	0.023	0.31	0.38			0.066	<0.01	17	19.2		73	6.8	41		
10		1992	4	13	0930	10.7	10.1	92.0	0.043	0.82	1.02			0.087	0.03	6.4	14.0		930	6.6	82		
11		1992	4	13	1000	11.6	9.6	88.0	0.122	1.70	2.13			0.636	0.46	8.8	21.6		2,400	6.7	115		
B		1992	4	13	1330	18.9			<0.02	0.09	0.02			0.020	<0.01	<0.1	<0.1		<30	6.4	0.99		
1		1992	5	11	1340	13.1	10.9	104.0	0.021	1.34	1.19			0.110	0.072	4.8	5.0		150	7.3	124		
2		1992	5	11	1312	11.2	10.2	94.0	<0.02	2.56	2.97			0.108	0.051	2.3	0.7		930	7.5	232		
3	D	1992	5	11	1150	11.6			0.056	1.40	1.72			0.099	0.063	3.7	0.6		150	7.2	100		
3		1992	5	11	1150	11.6	10.8	100.0	0.043	1.46	1.73			0.098	0.071	3.6	2.3		230	7.3	108		
4		1992	5	11	1215	11.3	10.3	95.0	<0.02	1.18	1.76			0.221	0.141	4.1	1.3		930	7.4	163		
5		1992	5	11	1115	11.6	9.6	89.0	<0.02	4.82	5.68			0.073	0.059	2.9	5.0		930	6.9	214		
7		1992	5	11	1010	10.9	9.0	95.0	2.44	2.31	4.34			0.640	0.481	5.2	6.3		36	7.0	141		

D- The sample is a duplicate (field replicate)
B- Blank

Site		Year	Month	Day	Time	Temp (°C)	DO (mg/L)	DO Sat'n (%)	NH3 (mg/L)	NO2-NO3 (mg/L)	TN (mg/L)	NO3 (mg/L)	TKN (mg/L)	TP (mg/L)	OP (mg/L)	Turb (NTU)	NFR (mg/L)	5d BOD (mg/L)	FC /100m	pH (S.U.)	Cond (umhos/cm)	Alk (mg/L)	Hard (mg/L)
8		1992	5	11	1032	11.0	10.7	98.0	0.138	0.73	1.04			0.104	0.085	3.8	3.0		230	7.2	71		
9		1992	5	11	0840	8.8	11.0	95.0	<0.02	0.21	0.25			0.015	0.007	2.2	2.6		<30	6.9	40		
10		1992	5	11	0920	10.4	11.0	98.0	<0.02	0.85	1.03			0.047	0.025	3.6	3.6		750	7.0	106		
11		1992	5	11	0945	11.0	7.3	66.0	3.1	1.55	5.00			0.830	0.556	7.9	10.0		230	6.8	139		
B		1992	5	11	1158				<0.02	<0.01	<0.07			<0.01	0.008	0.1	<0.1		<30	6.8	3.6		
1		1992	6	15	1457	17.0	11.5	120.0	0.04	1.68	2.07			0.106	0.086	2.8	5.8		78	7.5	164		68
2		1992	6	15	1420	13.2	10.1	96.0	<0.02	3.14	3.24			0.113	0.103	2.4	5.2		700	7.5	239		102
3		1992	6	15	1344	14.8	10.2	101.0	<0.03	2.18	2.53			0.144	0.122	2.2	1.8		170	7.1	140		68
4		1992	6	15	1358	13.5	10.2	98.0	0.02	1.29	1.80			0.189	0.145	1.8	3.2		45	7.4	189		85
5		1992	6	15	1332	12.9	8.5	81.0	0.02	6.14	7.80			0.093	0.070	2.6	6.0		3,500	6.9	224		102
7		1992	6	15	1157	14.2	9.2	90.0	0.02	5.84	7.80			1.42	1.31	3.5	2.0		230	7.3	278		102
8		1992	6	15	1235	15.0	10.1	100.0	<0.02	0.99	1.31			0.178	0.154	3.1	2.0		490	7.4	108		34
9	D	1992	6	15	0930	12.0	10.2	95.0	<0.02	0.11	0.17			0.020	0.003	2.6	2.4		170	7.0	45		17
9		1992	6	15	0930	11.6	10.2	94.0	<0.02	0.13	0.22			0.024	0.004	2.8	2.2		40	7.0	47		17
10		1992	6	15	1058	14.4	9.3	91.0	<0.02	0.14	0.70			0.081	0.048	5.1	5.2		1,700	7.1	175		68
11		1992	6	15	1130	14.5	8.5	83.0	0.02	3.14	3.88			1.13	0.929	3.9	2.4		230	7.2	233		85
B		1992	6	15	1504				<0.02	0.01	0.02			0.016	<0.002	0.1	<0.5		<18	6.8	1.35		<17
1		1992	7	13	1350	21.4	11.7	108.0	<0.02	1.73	1.86			0.122	0.071	1.8	1.8		130	7.7	182		
2	D	1992	7	13	1330	15.0	9.6	96.0	<0.02	3.15	4.11			0.130	0.100	1.8	3.6		1,300	7.7	240		
2		1992	7	13	1330	15.2	9.6	97.0	<0.02	3.18	3.49			0.120	0.120	1.6	2.6		2,200	7.5	242		
3		1992	7	13	1220	18.6	9.6	102.0	<0.02	2.39	2.25			0.175	0.154	1.7	1.2		170	7.7	163		
4		1992	7	13	1240	16.7	9.5	98.0	<0.02	1.43	1.62			0.207	0.174	1.9	0.8		270	7.5	195		
5		1992	7	13	1205	14.1	8.5	82.0	<0.02	6.85	6.06			0.120	0.068	1.6	3.2		790	7.0	231		
7		1992	7	13	1050	17.6	8.2	85.0	<0.02	5.13	5.16			1.476	1.42	2.4	0.8		490	7.6	327		
8		1992	7	13	1115	18.4	8.9	95.0	<0.02	1.14	1.34			0.319	0.242	2.7	1.8		790	7.4	130		
9		1992	7	13	0939	16.2	8.9	92.0	<0.02	0.18	0.26			<0.015	0.015	2.2	0.8		2,400	7.1	52		
10		1992	7	13	1000	18.1	8.3	88.0	<0.02	0.32	1.17			0.108	0.059	4.7	3.8		3,500	7.2	203		
11		1992	7	13	1025	18.3	6.8	73.0	<0.02	5.94	5.59			1.60	1.58	2.7	1.6		330	7.3	312		
B		1992	7	13	1400	24.1			<0.02	0.05	0.12			0.067	0.020	<0.1	<0.1		<18	6.9	1.17		
1		1992	8	10	1315	21.9	12.7	143.0	0.028	1.81	2.05			0.177	0.156	2.8	2.8		78	7.8	186		
2		1992	8	10	1445	16.4	9.1	93.0	0.021	3.14	3.43			0.160	0.109	1.7	3.8		1,100	7.5	242		
3		1992	8	10	1405	18.6	9.5	102.0	0.044	2.92	3.43			0.300	0.286	2.3	2.2		130	7.4	177		
4		1992	8	10	1420	18.2	8.4	90.0	5.41	2.06	10.36			1.530	0.580	12.6	12.5		950	7.8	429		
5		1992	8	10	1311	14.6	8.0	78.0	0.06	6.85	7.54			0.080	0.082	1.8	3.8		790	6.9	238		
7		1992	8	10	1210	18.0	8.1	85.0	0.62	9.36	11.1			2.97	2.86	2.5	1.8		1,300	7.5	390		
8		1992	8	10	1230	17.9	8.8	94.0	0.12	2.41	2.93			0.656	0.635	3.0	2.6		330	7.5	171		
9		1992	8	10	0950	14.9	9.2	92.0	<0.02	0.13	0.25			0.012	0.005	2.6	1.8		490	7.1	57		
10	D	1992	8	10	1045	18.5	9.0	97.0	0.042	0.22	0.48			0.152	0.054	3.7	3.0		1,300	7.4	213		
10		1992	8	10	1045	18.5	9.0	97.0	<0.02	0.21	0.48			0.177	0.072	3.5	3.4		790	7.4	214		
11		1992	8	10	1140	18.0	4.6	49.0	0.31	8.16	10.16			2.93	2.99	2.7	2.2		790	7.2	369		
B		1992	8	10	1320	29.2			0.03	<0.01	<0.07			<0.015	0.003	<0.1	<0.05		<18	7.1	0.88		
1		1992	9	14	1315	13.6	12.4	119.0	0.03	2.23	2.36			0.209	0.127	2.0	1.4		45	7.6	199		
2		1992	9	14	1259	11.0	10.7	97.0	0.03	3.41	3.24			0.111	0.106	1.3	2.6		790	7.5	232		
3		1992	9	14	1150	11.2	10.8	99.0	0.04	3.35	3.47			0.426	0.266	2.3	2.4		790	6.8	184		

D- The sample is a duplicate (field replicate)
B- Blank

Site		Year	Month	Day	Time	Temp (°C)	DO (mg/L)	DO Sat'n (%)	NH3 (mg/L)	NO2-NO3 (mg/L)	TN (mg/L)	NO3 (mg/L)	TKN (mg/L)	TP (mg/L)	OP (mg/L)	Turb (NTU)	NFR (mg/L)	5d BOD (mg/L)	FC /100m	pH (S.U.)	Cond (umhos/cm)	Alk (mg/L)	Hard (mg/L)
4	D	1992	9	14	1210	10.5	10.6	95.0	<0.02	1.47	1.75			0.305	0.271	2.3	1.6		230	7.5	200		
4		1992	9	14	1210	10.5	10.4	93.0	<0.02	1.49	1.59			0.320	0.276	2.3	1.6		170	7.5	200		
5		1992	9	14	1130	10.6	8.9	79.0	0.04	7.59	8.16			0.250	0.067	12	7.8		1,300	6.9	219		
7		1992	9	14	1030	10.1	10.1	90.0	0.03	7.34	7.58			2.60	2.26	2.4	1.8		270	7.3	346		
8		1992	9	14	1100	11.0	10.6	97.0	0.03	2.04	2.26			0.605	0.528	3.9	3.4		790	7.4	126		
9		1992	9	14	0905	10.3	10.3	91.0	<0.02	0.10	0.25			0.017	0.008	1.6	1.6		45	7.1	60		
10		1992	9	14	0945	10.6	10.5	95.0	<0.02	0.195	0.39			0.086	0.048	3.6	2.6		170	7.3	228		
11		1992	9	14	1005	12.2	7.4	69.0	0.04	10.47	10.77			2.74	2.43	1.8	1.4		130	7.2	383		
B		1992	9	14	1328	18.8			<0.02	0.015	<0.07			0.002	0.004	<0.1	0.1		<18	7.1	1.36		
1	D	1992	10	12	1330	13.0	12.1	114.0	<0.02	2.33	2.50			0.210	0.176	6.7	2.4		20	7.5	199		
1		1992	10	12	1330	12.6	12.0	113.0	<0.02	2.29	2.47			0.213	0.170	6.6	4.6		45	7.5	196		
2		1992	10	12	1304	11.4	10.5	96.0	<0.02	3.29	3.76			0.100	0.091	1.4	2.0		490	7.6	235		
3		1992	10	12	1220	11.0	10.6	97.0	<0.02	3.25	3.68			0.400	0.366	4.2	3.6		120	7.4	183		
4		1992	10	12	1240	10.6	10.8	98.0	<0.02	1.39	1.49			0.240	0.229	3.2	0.8		130	7.4	192		
5		1992	10	12	1200	11.2	8.7	79.0	<0.02	7.26	7.85			0.080	0.067	0.8	2.0		210	6.9	227		
7		1992	10	12	1045	11.0	9.0	81.0	0.18	9.33	11.86			3.11	2.95	4.3	1.6		490	7.5	397		
8		1992	10	12	1110	10.7	10.5	95.0	0.02	2.04	2.37			0.690	0.610	5.7	4.2		490	7.4	161		
9		1992	10	12	0930	9.5	10.1	89.0	<0.02	0.43	0.13			<0.015	0.004	2.7	1.0		<18	7.0	65		
10		1992	10	12	1000	10.5	10.5	95.0	<0.02	0.40	0.53			0.081	0.057	2.8	1.0		110	7.4	230		
11		1992	10	12	1018	13.0	4.5	43.0	0.62	9.84	13.17			4.22	3.46	3.5	1.2		230	7.1	411		
B		1992	10	12	1355	19.7			<0.02	0.02	0.06			<0.015	0.002	<0.1	<0.5		<18	6.7	1.01		
1		1992	11	2	1424	11.2	10.3	95.0	0.034	1.56	1.90			0.124	0.080	11.4	10.7		490	7.1	114		
2		1992	11	2	1350	11.5	9.9	91.0	<0.02	1.85	1.80			0.096	0.078	3.7	3.3		790	7.1	173		
3		1992	11	2	1300	10.7	10.3	94.0	0.035	1.72	2.03			0.112	0.067	3.8	6.7		330	6.8	93		
4		1992	11	2	1315	10.7	9.6	86.0	0.026	2.09	2.69			0.225	0.176	9.3	2.3		130	7.2	210		
5		1992	11	2	1230	11.1	8.0	73.0	0.032	4.66	5.30			0.099	0.063	4.9	4.3		790	6.8	192		
7		1992	11	2	1125	11.3	9.5	87.0	0.064	3.09	4.06			0.792	0.732	6.3	3.7		78	7.2	188		
8		1992	11	2	1145	10.6	10.4	94.0	0.029	1.32	1.70			0.105	0.062	13	8.3		1,100	7.0	76		
9	D	1992	11	2	0945	10.0	10.3	92.0	<0.02	0.49	0.61			0.018	0.002	7.2	4.3		20	6.9	45		
9		1992	11	2	0945	9.8	10.4	93.0	<0.02	0.49	0.61			0.020	<0.001	7.2	4.3		68	6.8	44		
10		1992	11	2	1030	10.6	9.8	89.0	0.038	0.99	1.20			0.072	0.045	4.6	3.7		140	7.0	166		
11		1992	11	2	1055	11.3	6.7	61.0	0.169	2.63	3.39			0.764	0.688	5.4	4.0		20	6.9	192		
B		1992	11	2	1430	17.9			<0.02	0.004	<0.007			<0.015	<0.001	<0.1	<0.1		<18	6.7	1.09		
1		1992	12	8	1430	4.9	12.0	94.0	0.054	1.34	2.66			0.106	0.052	12	19.0		1,300	7.1	98		
2		1992	12	8	1400	5.6	11.6	92.0	0.282	0.65	1.81			0.634	0.061	52	122.0		16,000	6.9	84		
3		1992	12	8	1320	4.8	11.9	93.0	0.081	1.44	1.61			0.098	0.065	8	10.5		230	6.9	77		
4		1992	12	8	1340	4.1	12.0	92.0	0.029	1.92	2.58			0.137	0.09	12	12.5		2,500	7.1	127		
5		1992	12	8	1300	7.6	9.4	80.0	0.048	4.32	5.01			0.105	0.057	12	14.0		1,100	6.9	199		
7		1992	12	8	1200	6.1	10.5	86.0	0.304	1.92	2.50			0.459	0.32	22	33.0		1,300	7.0	113		
8		1992	12	8	1220	4.8	12.0	94.0	0.074	1.12	1.41			0.106	0.051	17	22.0		350	6.8	75		
9		1992	12	8	1000	5.2	12.0	98.0	0.013	0.30	0.39			0.012	0.004	3.8	5.0		<18	6.9	37		
10		1992	12	8	1050	6.4	10.8	88.0	0.024	1.32	1.46			0.063	0.025	6.3	7.0		330	6.7	79		
11	D	1992	12	8	1115	6.5	9.9	81.0	0.502	1.84	3.30			0.613	0.556	11	11.5		1,300	7.0	122		
11		1992	12	8	1115	6.7	9.9	81.0	0.505	1.96	2.99			0.670	0.570	10	11.0		1,700	7.0	122		

D- The sample is a duplicate (field replicate)
B- Blank

Site	Year	Month	Day	Time	Temp (°C)	DO (mg/L)	DO Sat'n (%)	NH3 (mg/L)	NO2-NO3 (mg/L)	TN (mg/L)	NO3 (mg/L)	TKN (mg/L)	TP (mg/L)	OP (mg/L)	Turb (NTU)	NFR (mg/L)	5d BOD (mg/L)	FC /100m	pH (S.U.)	Cond (umhos/cm)	Alk (mg/L)	Hard (mg/L)
B	1992	12	8	1440	13.9			<0.02	0.002	0.035			<0.015	0.003	<0.1	<0.5		<18	7.1	1.29		
1	1993	1	4	1430	4.7	12.2	95.0	0.059	1.26	1.61			0.104	0.071	13	11.1		490	7.05	85		
2	1993	1	4	1400	5.1	11.9	94.0	0.053	1.21	1.46			0.109	0.042	18	16.0		490	7.16	123		
3	1993	1	4	1320	4.7	12.3	97.0	0.059	1.20	1.49			0.094	0.040	11	13.6		950	6.95	68.1		
4	1993	1	4	1340	3.8	12.0	51.0	0.066	1.59	3.08			0.166	0.090	14	8.4		1,100	6.84	90.3		
5	1993	1	4	1300	5.6	10.5	83.0	0.026	2.70	3.20			0.080	0.028	13	10.4		330	6.79	150		
7	1993	1	4	1150	5.4	11.5	91.0	0.151	1.58	2.22			0.249	0.157	13	16.0		260	6.79	80		
8 D	1993	1	4	1215	4.8	12.0	96.0	0.092	1.13	1.60			0.103	0.051	11	11.2		1,400	6.96	60.8		
8	1993	1	4	1215	4.5	12.2	95.0	0.092	1.14	1.49			0.094	0.049	11	11.6		1,100	6.89	61.5		
9	1993	1	4	1030	4.3	12.5	97.0	0.01	0.36	0.40			0.061	0.003	3.8	3.2		<18	6.76	32.6		
10	1993	1	4	1100	5.4	11.4	90.0	0.033	1.38	1.54			0.004	0.002	10	10.0		45	6.73	62.8		
11	1993	1	4	1130	5.5	11.1	87.0	0.178	1.43	2.18			0.224	0.147	12	10.8		140	6.69	76.4		
B	1993	1	4	1450				0.007	0.001	0.022			0.006	0.002	<0.1	0.1		<18	6.97	1.03		
1	1993	2	9	1245	7.7	11.6	98.0	0.024	1.47	1.67			0.080	0.058	3.8	2.2		45	7.09	109		
3	1993	2	9	1030	7.1	11.6	96.0	0.051	1.49	1.63			0.078	0.054	3.7	2.2		110	7.08	88		
10	1993	2	9	0930	8.2	11.2	96.0	0.011	1.53	1.58			0.031	0.016	3.1	2.0		110	6.75	82		
11	1993	2	9	1000	8.4	9.6	82.0	0.335	2.29	2.84			0.500	0.454	3.4	2.2		40	6.93	127		
B	1993	2	9	1210	17.2			<0.004	0.014	0.01			0.002	0.001	<0.1	<0.1		<18	6.83	0.9		
1	1993	3	9	1055	8.1	11.6	100.0	0.03	1.35	1.60			0.080	0.055	5.0	3.8		130	7.28	102.9		
3 D	1993	3	9	1005	7.3	11.9	99.0	0.089	1.35	1.67			0.126	0.071	5.2	4.6		<18	7.14	85.1		
3	1993	3	9	1005	7.2	11.9	99.0	0.089	1.37	1.69			0.106	0.071	5.3	5.0		20	7.24	82.3		
10	1993	3	9	0910	6.7	12.4	101.0	0.04	1.20	1.31			0.073	0.022	4.8	2.8		110	7.01	75.4		
11	1993	3	9	0935	7.4	10.0	83.0	1.22	1.95	4.49			0.910	0.627	8.5	14.5		130	6.92	148.6		
B	1993	3	9	1115	17.3			0.008	<0.01	<0.01			0.007	0.005	0.1	0.0		<18	6.95	0.97		
1	1993	4	13	1100	8.7	10.5		0.02						0.029	7.8			220	6.97	70		
3	1993	4	13	1015	8.1	11.0		0.016						0.016	7.4			110	6.85	60.0		
10	1993	4	13	0900	8.2	10.3		0.019						0.015	3.3			45	6.56	59.2		
11	1993	4	13	0930	8.2	10.4		0.016						0.023	4.8			220	6.77	64.2		
B	1993	4	13	1230	15.9			0.009						0.003	0.1			<18	6.84	1.02		
1	1993	5	11	1300	14.5	9.6	96.0	0.019	0.88	1.05			0.077	0.036	5.2	6.6		110	6.90	83.4		
3	1993	5	11	1200	13.1	10.1	97.0	0.004	0.90	1.02			0.048	0.021	5.3	9.8		230	7.13	67.5		
10	1993	5	11	1130	11.5	11.2	103.0	<0.02	0.954	1.05			0.041	0.018	2.2	2.8		170	6.82	64.6		
11	1993	5	11	1148	11.7	10.9	101.0	0.009	0.945	1.02			0.054	0.030	2.7	3.5		78	6.81	67.6		
1	1993	6	8	1045	15.2	8.3	82.0	0.046	1.01	1.32			0.152	0.075	6.7	8.4		45	7.07	116.6		
3	1993	6	8	0945	13.2	9.9	95.0	0.027	1.14	1.32			0.048	0.035	4.3	5.2		490	7.26	95.6		
10	1993	6	8	0930	12.0	10.1	94.0	0.021	0.952	1.03			0.043	0.023	2.7	2.7		330	7.05	91.0		
11	1993	6	8	0950	12.5	9.5	89.0	0.024	0.888	1.02			0.069	0.053	3.3	3.8		78	6.99	92.4		
B	1993	6	8	1200	21.2			<0.02	<0.01	<0.01			<0.01	0.003	<0.1	0.4		<18	6.81	0.99		
1	1993	7	13	1230	16.1	11.3	115.0	0.019	1.45	1.57			0.091	0.036	2.8	3.8		140	7.61	153		
3	1993	7	13	1200	14.9	10.0	100.0	0.035	1.62	1.78			0.052	0.034	3.1	2.4		490	7.49	117		
10 D	1993	7	13	1030	14.8	7.8	77.0	0.032	0.665	0.883			0.057	0.039	2.4	2.2		45	7.08	149.5		
10	1993	7	13	1030	14.6	7.8	77.0	0.032	0.682	0.818			0.056	0.045	2.4	2.6		20	7.09	149		
11	1993	7	13	1100	14.9	8.9	90.0	0.029	0.529	0.722			0.091	0.075	1.7	0.8		68	7.10	150		
B	1993	7	13	1345	21.4			<0.02	0.001	<0.01			0.004	0.014	<0.1	0.0		<18	6.44	1.33		

D- The sample is a duplicate (field replicate)
B- Blank

Site		Year	Month	Day	Time	Temp (°C)	DO (mg/L)	DO Sat'n (%)	NH3 (mg/L)	NO2-NO3 (mg/L)	TN (mg/L)	NO3 (mg/L)	TKN (mg/L)	TP (mg/L)	OP (mg/L)	Turb (NTU)	NFR (mg/L)	5d BOD (mg/L)	FC /100m	pH (S.U.)	Cond (umhos/cm)	Alk (mg/L)	Hard (mg/L)
1		1993	8	10	1120	18.1	9.5	100.0	0.019	1.46	1.61			0.085	0.061	2.6	3.6		78	7.58	164		
3		1993	8	10	1030	16.5	9.4	96.0	0.002	1.70	1.85			0.074	0.051	2.5	2.6		130	7.47	132		
10		1993	8	10	0900	15.8	8.0	81.0	0.033	0.584	0.769			0.091	0.059	2.1	2.0		330	7.01	166		
11	D	1993	8	10	0930	17.5	8.8		0.009	0.49	0.568			0.129	0.086	2.5	1.4		220	7.22			
11		1993	8	10	0930	16.7	8.6	88.0	0.009	0.49	0.609			0.132	0.093	2.4	1.2		140	7.18	167		
B		1993	8	10	1240	24.3			<0.02	<0.01	<0.01			0.002	0.003	0.2	0.0		<18	7.04	0.87		
1		1993	9	14	1130	14.9	8.7	87.0	0.028	1.89	2.11			0.081	0.068	2.2	2.0		130	7.33	188		
3	D	1993	9	14	1055	13.3	9.7	93.0	0.018	2.35	2.62			0.069	0.063	1.6	1.2		170	7.38	154		
3		1993	9	14	1040	13.6	9.7	94.0	0.015	2.35	2.55			0.067	0.060	1.7	1.2		490	7.38	156		
10		1993	9	14	0945	13.4	8.0	77.0	0.053	0.457	0.69			0.102	0.072	3.6	1.8		270	7.23	207		
11		1993	9	14	1010	13.5	9.1	88.0	0.022	0.35	0.40			0.116	0.092	2.7	2.8		78	7.19	204		
B		1993	9	14	1300	20.1			0.005	<0.01	<0.01			0.005	<0.01	0.1	<0.1		<18	6.60	1.5		
1	D	1993	10	12	1120	12.5	8.6	81.0	0.017	1.92	1.92			0.092	0.063	2.1	4.3		170	7.12			
1		1993	10	12	1113	12.5	8.5	80.0	0.017	1.93	1.91			0.092	0.061	2	2.4		78	7.12	188		
3		1993	10	12	1030	11.8	9.6	90.0	0.007	2.18	2.17			0.060	0.050	1.9	1.6		490	7.14	154		
10		1993	10	12	0915	12.0	7.4	69.0	0.059	0.53	0.911			0.255	0.083	16	47.5		3,500	7.08	226		
11		1993	10	12	0945	11.5	8.5	78.0	0.018	0.37	0.60			0.130	0.088	3.2	1.4		1,300	7.12	213		
B		1993	10	12	1245	14.6			<0.02	0.01	<0.01			0.022	0.005	0.2	0.0		<18	6.73			
1		1993	11	9	1115	5.5	12.4	100.0	<0.02	1.94	2.18			0.084	0.052	2.3	2.7		20	7.02	175		
3		1993	11	9	1030	4.8	12.1	95.0	0.015	2.18	2.41			0.056	0.044	2.2	3.6		170	6.98	147		
10		1993	11	9	0930	4.2	12.2	95.0	0.021	0.80	0.932			0.070	0.043	3.3	9.0		460	7.22	222		
11		1993	11	9	1000	3.8	12.4	96.0	0.021	0.617	0.76			0.079	0.051	2.8	2.6		45	6.99	216		
B		1993	11	9	1230	15.8			<0.02	<0.01	0.021			0.010	0.003	0	0.8		<18	6.66	0.98		
1		1993	12	14	1115	7.8	10.6	90.0	0.089	1.43	1.89			0.087	0.036	11	12.8		170	6.87	88		
3		1993	12	14	1045	7.8	10.7	91.0	0.096	1.40	1.91			0.054	0.024	8.6	10.3		170	6.79	74.1		
10		1993	12	14	0930	8.1	9.9	84.0	0.058	1.33	2.16			0.058	0.026	9.0	8.6		330	6.23	65.9		
11		1993	12	14	1000	8.0	10.3	87.0	0.036	1.50	1.68			0.078	0.035	13	13.2		1,100	6.43	75.2		
B		1993	12	14	1245	14.8			0.002	<0.01	<0.01			0.001	0.009	0.1	<0.1		<18	6.32	1.17		
10		1994	1	10	1000	8.3	10.5	90.0	0.023	1.42	1.74			0.041	0.020	9.0	14.8		40	6.96	67		
11		1994	1	10	1030	8.2	10.8	93.0	0.017	1.44	1.67			0.045	0.023	9.3	10.0		170	7.21	70		
10		1994	2	7	0915	5.5	12.1	98.0	0.014	1.46	1.63			0.031	0.013	3.7	3.0		45	7.04	89.4		
10		1994	2	7	1245	5.3	12.1	97.0	0.014	1.43	1.56			0.035	0.016	4.4	3.8		45	7.04	92.1		
11		1994	2	7	0945	5.0	11.9	94.0	0.012	1.45	1.56			0.031	0.017	4.3	4.0		40	7.00	92.2		
11		1994	2	7	1215	5.3	12.0	96.0	0.014	1.41	1.56			0.035	0.015	4.2	3.4		78	6.97	92.4		

Site Definition:
1: Salmon Creek (mouth) at 36th Ave.
2: Cougar Creek at 119th St.
3: Lower Salmon Creek at 52nd Ave.
4: Mill Creek at Salmon Creek Road
5: Curtin Creek at 139th St.
6: Middle Salmon Creek at 112th Ave.
7: Weaver (Woodin) Creek at 122nd Ave.
8: Upper Salmon Creek at 122nd Ave.
9: Salmon Creek Headwaters at 199th St.
10: Weaver Creek at L St.
11: Weaver Creek at 189th St.

D- The sample is a duplicate (field replicate)
B- Blank

Appendix B

Salmon Creek land use maps based on existing and assessed (parcels) land use

See hard copy of the report for this map.

See hard copy of report for this map.

Appendix C

Southwest Health District's septic best management practice

Best Management Practices
Maintenance of Septic System

I Introduction / Background

On-site sewage systems are necessary to serve dwellings and some non-residential buildings where sewer is not available and density is low. In past decades, septic systems failed due to placement, design, installation or lack maintenance, causing potential public health hazards and/or pollution of surface and ground water. In recent years, technology has advanced to the level where modern on-site sewage systems can be expected to provide a high degree of treatment and public health protection as well as protection of the environment.

The proper placement, design and installation of on-site sewage treatment systems provides a high degree of quality assurance for resource protection. However, proper maintenance of septic systems is an essential component protecting public health and water quality. Most often, septic system failure is due to lack of maintenance by the property owner. Without monitoring the condition of the septic tank, the potential for discharging excessive solids/scum into the drainfield exists. This can lead clogging of the drainfield lines. With the addition of assured maintenance, the on-site sewage treatment and disposal system can be considered a more reliable facility.

Best Management Practices (BMP) protect the public health and environment from potential adverse affects of sewage from failing on-site sewage treatment systems. This BMP is intended to do so by diminishing the possibility of sewage system failures by requiring periodic owner maintenance.

II Purpose and Scope

This BMP sets forth methods for the maintenance of on-site sewage treatment systems; Maintaining septic system records; Regular inspection every 4 years; Regular septic tank pumping every 8 years or justification if not needed. This BMP would be applicable to Southwest Washington Health Distrist REGULATION NO. 92-01 On-Site Sewage Treatment System Maintenance

III Septic System Maintenance

A. Records and identification of septic system.

Developing and acquiring septic system records is essential to septic system maintenance for determining the location and capacity of the septic system. To accomplish this, two sources of records are available.

1. Health Agency Records

Installed septic systems can be identified by reviewing records (if available) of permitted septic system. Identification may be accomplished through on-site sewage treatment system identification numbers, tax serial numbers, permit holders name, location or date issuance of permit. Records may include septic system permits, design requirements, construction as-built sketches and soil logs.

2. Operator (Owner) Records

The operator (owner) records should include:

a) A record (plot plan) showing the location of the septic tank and drainfield. This should include distance from house, property lines, etc.

b) A record (if applicable) of the design of the septic system. These records have been developed for permitted pressurized or pretreatment septic systems.

c) A record of dates when owner inspected all components of the septic system. This will include (if applicable) inspection dates of septic tank effluent pump, pump chamber, distribution box and drainfield. This record should contain inspection findings.

d) A record of dates the septic tank was pumped.

e) The inspection and pumping record should be posted on the premises to provide a maintenance record and reminder to current and future tenants. (Recommended location: on the electrical service fuse box).

B. Inspection of septic system components every f our (4) years.

Owners of a septic system (including gravity, pressurized and pre-treatment septic systems) for residential or non-residential use would be required to provide proof that inspection has occurred at least once every four (4) year. These inspections can be conducted by the homeowner, a licensed pumper, a Registered Sanitarian, qualified Sewer Utility Technician or the health authority's Environmental Health Specialist.

Inspecting a septic system requires removing soil over the tank (usually located 5-10 feet from house) so all manholes and inspection ports to the tank can be opened. The top of septic tank is usually 6 inches to 2 feet below the ground surface. Once the top of septic tank is exposed, the septic tank and contents can be inspected, measured and pumped (if needed). **NEVER ENTER AN EMPTY OR PARTIALLY FILLED SEPTIC TANK.** Gases produced in the tank can be explosive and can cause death. **Personal protection is very important: wear gloves during inspection and wash hands after inspection to reduce risk of contamination.**

Inspections consist of:

1. Observe the septic system area for surfacing sewage and physical damage.

2. Measuring septage levels in the septic tank, including the floating "scum" layer and the settled "sludge" layer to determine whether this material will remain in the septic tank. (Refer to section C. Pumping septic tank every 8 years, if needed for techniques for measuring septage)

   a) If scum layer is within 6 inches from the bottom of the outlet baffle, pumping would be recommended.

   b) If sludge layer is within 12 inches from the bottom of the outlet baffle pumping would be recommended.

   c) If the scum layer or septage levels are noticeably below the outlet then consider the septic tank to be leaking.

3. Inspecting the inside of the septic tank for the condition of the inlets, outlets, baffles.

   a) For concrete baffles only a minimal amount of corrosion is allowed on surfaces. If concrete edges are noticeably pitted and uneven, condition would be considered poor.

   b) Plastic baffles having loose joints to septic tank outlet are considered a poor condition.

4. Inspection (if applicable) the pump systems. This includes screens, floats and alarm systems to ensure proper operation (recommend addition of screen and alarm if none is present). Be cautious of potential sewer gas.

   a) Test the pump f or proper operation. Observe the pumping cycle f or proper operation (this would include the area over the transport line for pressure leaks).

   b) Inspect all mechanical and electrical components for corrosion (this includes electrical connections and wiring). **Unplug electricity before handling electrical components.**

   c) If water or scum marks are higher than pump float(s) then consider the screen to be restricting flow and requires cleaning.

   d) If noticeable scum or sludge is observed removal of material is required.

5. Uncover and inspect the distribution box (if present) to ensure proper operation.

   a) Inspect distribution box for cracks and corrosion.

   b) Water test distribution box for equal distribution to outlets pipes. This is done by pouring water into distribution box and watching it's drainage for equal distribution.

   c) If septage levels are above outlet pipes then consider drainfield to restrict flow for usage and this requires corrective measures. **Contact the local health agency for assistance.**

6. Inspect the drainfield to ensure proper operation.

    a) Inspect for surfacing sewage.

    b) Inspect condition of ground cover of drainfield area. If the drainfield area is used for a driveway, landscaping, corral, etc., the drainfield will not work properly. This condition would tend to compact the soils, reduce the assistance from evaporation and transpiration in the disposal of the effluent, and reduce the accessibility to the system.

    c) Inspect for surface water diversions over tank and drainfield. All surface water diversions such as roof, road, patio, etc... drains should be diverted away from the septic tank, pump chamber, and drainfield area.

    d) Inspect drainfield area for height of tree. Trees surrounding the drainfield should be half the projected height in distance from the drainfield. This distance will minimize roots in the drainfield for most tree species.

    e) Evaluation and placement of barriers, where needed, to protect the system from traffic.

<u>C.   Pumping septic tank every 8 years, if needed.</u>

Every septic tank subject to this BMP must be pumped not less than once every eight (8) years. To avoid pumping in eight years, the owner shall provide to the health authority an inspection report that is certified by a Registered Sanitarian, qualified Sewer Utility Technician or Health District Environmental Health Specialist that the contents the septic tank have not reached levels necessary for pumping, and providing a calculated estimate as to when pumping will be needed. At the preference of the on-site system owner, the required inspection report may be generated and signed by licensed pumper.

1. Pumping a septic system requires removing soil cover over the tank (usually located 5-10 feet from house) so the manholes to the tank can be opened. The manhole is usually 6 inches to 2 feet below the ground surf ace. Once the manhole is opened, the contents of the tank can be checked and/or pumped into a truck for disposal at an approved site. **NEVER ENTER AN EMPTY OR PARTIALLY FILLED SEPTIC TANK.** Gases produced in the tank can be explosive and can cause death. **Personal protection is very important, wear gloves during pumping inspection and wash hands after inspection to reduce risk of contamination.**

   Scum layer: The layer which float on top of the septage.

   Sludge layer: The layer which settles at the bottom of the septic tank:

2. The following are steps to take to check your septic tank to see if it needs to be pumped.

   a) Wrap a strip of toweling around the bottom 3 feet of a 6 foot probing stick and mark the length of the stick in half foot increments. Then attach a "foot" to the stick (this would involve tacking a small piece of wood to the end of the stick having the towel).

   b) With the towel end down, lower the stick to the bottom of the tank (if available lowering the stick behind the baffle or through the sanitary tee, this will prevent the scum layer from adhering to stick). Once the stick has stopped measure the depth of the septage in the tank and let the stick remain for a few minutes.

   c) Carefully remove the stick. The toweling should reveal the sludge line and measure it's thickness from the bottom of the stick.

   d) Lower the stick along the outlet baffle/tee. With the use of the foot determine the length of the outlet baffle/tee by rotating and raising the stick so the foot is caught by the bottom of the outlet baffle/tee. Measure length of outlet baffle/tee and remove stick.

e) Slowly lower the stick into the scum layer (the stick will have resistance through the scum layer). Once through the scum layer with the use of the foot, determine the thickness of the scum layer. This is done by rotating and rasing the stick so the foot is caught by the bottom of the sum layer. Measure the thickness of the scum layer. Remove stick and wash it to remove contamination.

f) Sketch all measurements on a piece of paper comparing the depth of the septage, the thickness of the scum and sludge layers and the length of the outlet baffle/tee.

g) The thickness of the scum layer should be no less than 6 inches above the bottom of the outlet baffle/tee. The top of the sludge layer should be greater than 12 inches below the outlet baffle/tee (see figure 10). **Note: most septic tanks have two compartments that require checking.**

h) If your measurements reveal sludge levels not within these perimeters, you should have your tank pumped.

i) Discharge of excessive solids/scum into the drainfield can lead to clogging of the drainfield lines. The tank should be pumped <u>before</u> experiencing problems.

j) The inspection and pumping record should be posted on the premises to provide a maintenance record and reminder to current and future tenants.v (Recommended location: on the electrical service fuse box).

k) <u>PUMPER TO NOTIFY OWNER AND THE HEALTH AUTHORITY IF REPAIRS ARE NEEDED.</u> Repair Permit & Inspection would be required where serious problems are encountered. **Contact the local health agency for assistance.**

Appendix D
Memorandum on water right/claim use

MEMORANDUM

November 18, 1994

TO: Gale Blomstrom

FROM: Chris Anderson

SUBJECT: Recommendation for Metering Existing Surface Water Withdrawals in the Salmon Creek and Burnt Bridge Creek Basins in Clark County

This is my recommendation for metering of diversions for existing surface Water Rights and Claimed water uses to meet the requirements of HB1309 (Chapter 506-64 WAC). Both Salmon Creek and Burnt Bridge Creek in our region and the Snake River in the Eastern Region, have been chosen as the first basins in the state that our program will initiate mandatory metering in.

Salmon Creek and Burnt Bridge Creek have been chosen for metering based on the following:

1) An existing, on-going water right enforcement project dealing with surface water rights, claims, and unauthorized uses. This is part of a cooperative effort (MOU) between Ecology, Clark County and Clark Public Utilities;

2) Salmon Creek was ranked in the SASSI report for Coho Salmon;

3) Our need for data collection, to verify use, to assist us in updating our records, and as a continued effort to educate the public.

I will be sending letters, followed by administrative orders, to 48 property owners who have water rights or claims as follows:

	Water Rights	Claims
Salmon Creek	29	16
Burnt Bridge Creek	2	0
Total	32	16

The property owners of permitted or claimed use in the basins, the 48 chosen to receive the first mailing, will be sent a letter explaining the metering requirements, metering information and guidance, Chapter 508-64 WAC, reporting criteria, and a copy of their water right or claim. This first mailing does not include all issued surface water rights or claims, but will be sent to those with diversions that equal or exceed 0.20 cfs (90 gpm). A month later an order requiring installation of the metering device will be issued. If it is deemed necessary and/or appropriate, the owners of water rights and claims under 0.20 cfs will be sent the same letter/order at some future date.

ANALYSIS OF WATER RIGHT/CLAIMED USE IN BOTH BASINS

Below is the total of water rights and claims. These totals were used in calculating metering requirements for both basins.

	Water Rights	Claims
Salmon Creek	132	238
Burnt Bridge Creek	30	23
Total	162	261

WATER RIGHTS

I used Linton Wildricks 90/10 theory that suggests, by a statistical approach, that 90% of the water in a given basin is used by 10% of the water rights. I am basing my choice on this statistical analysis because it appears to be both logical and defendable.

When I ran this calculation on the water rights issued in these basins, I found that 20% of the water rights use 87% of the water. I also found that a cut-off point of 0.20 cfs would result in the same 87%. Thus, any water right that equals or exceeds 0.20 cfs will receive a letter and order.

Water rights in both basins total 38.1 cfs. This approach will require metering of 32 water rights for 32.4 cfs. Some of the water rights are issued for non-consumptive uses. Non-consumptive rights, one for 15 cfs, are included and the owners will be required to measure the water supply into the storage facility at the point of diversion, and the water returned to the creek at the point of return. This data can be used to determine if it is truly a non-consumptive use.

CLAIMS

There are 261 claims for surface water in both basins. Claims offer the greatest challenge for this project. Data is limited, unreliable, and each claim must be considered at face value.

After analysis of the claims database, I calculated an estimated quantity that could be withdrawn based on the available data. There are four reported uses on the claim forms; Domestic, Stockwater, Irrigation, and Other. For an estimated quantity, I used these assumptions in my calculation:

1) Domestic and Stockwater = 0.02 cfs;
2) Irrigation = 0.02 cfs per acre;
3) Other = 0.02 cfs.

Of the 261 claims it is possible that approximately 16 cfs could be in use. Most claims reported Domestic and Stockwater as the primary use of water. Of the 261 claims, 68 reported Irrigation of more than 1 acre. Based on the information available, the remaining claims for irrigation are estimated to be for less than one acre. The acres in claims that reported the number of acres irrigated were used to calculate a quantity needed for irrigation. Because Other is not defined, I assumed an additional 0.02 cfs could be used.

Using the same cut-off as I used for the Water Rights, 0.20 cfs, I calculated the claims that would require metering. There are 16 claimed uses that equal or exceed 0.20 cfs. Of the approximate 16 cfs in claimed use, over 8 cfs would be metered.