Chehalis Best Management Practices Evaluation Project

Final Report for Water Quality Sites

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Chehalis Best Management Practices Evaluation Project

Final Report for Water Quality Sites

by
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Olympia, Washington 98504-7710

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Abstract

The Washington State Department of Ecology conducted water quality monitoring to document improvements in water quality associated with best management practices (BMPs) installed in the upper Chehalis basin. Monitoring was conducted in three sub-basins where BMPs were applied: Beaver and Allen creeks in Thurston County, Bunker and Deep creeks in Lewis County, and Berwick and Dillenbaugh creeks in Lewis County.

Monitoring design included pre- and post-BMP sampling, upstream and downstream. Types of BMPs evaluated included agricultural BMPs such as fencing riparian corridors (animal exclusion), implementation of dairy waste management plans, and revegetation of riparian areas. Several erosion control practices – such as bank stabilization, exclusion of off-road vehicles, and culvert removal or replacement – also were evaluated.

1. Monitoring on Beaver Creek and Allen Creek showed major improvements in fecal coliform and ammonia-nitrogen levels due to implementation of BMPs on a large dairy farm. Water quality in Beaver Creek improved such that progress was made toward meeting the load allocations required by the total maximum daily load (TMDL) study. Further reductions in fecal coliform levels at all Beaver and Allen creek sites are still needed to meet water quality standards and the load allocation required in the TMDL.

2. In Deep Creek and Bunker Creek, improvements in fecal coliform levels were detected at one site. However, increases in fecal coliform levels were seen the following year when BMPs were not maintained properly. No other water quality improvements due to BMP implementation were noted.

3. An improvement in fecal coliform levels occurred on Berwick Creek after agricultural fencing was maintained properly. However, improvements due to BMP implementation were not detected at the other sites. This may be due, in part, to differences in pre- and post-BMP sampling regimes.

In summary, agricultural BMPs are effective in improving water quality if the BMPs are maintained properly.

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- Joan LeTourneau formatted and edited the final report.

Introduction

The purpose of this study is to document improvements in surface water quality associated with best management practices (BMPs) installed in the Chehalis River basin. This report presents water quality monitoring results for three project areas where BMPs were evaluated: Beaver and Allen creeks, Bunker and Deep creeks, and Berwick and Dillenbaugh creeks.

Monitoring was conducted as part of the Chehalis Fisheries Restoration Program funded by the U.S. Fish & Wildlife Service (USFWS). Monitoring design included pre- and post-evaluation of sites, upstream and downstream, where BMPs where installed. Types of BMPs evaluated include agricultural BMPs such as fencing the riparian corridor (animal exclusion), implementation of dairy waste management plans, and revegetation of the riparian area. Several erosion control practices – such as bank stabilization, exclusion of off-road vehicles, and culvert removal or replacement – also were evaluated.

Background

In the Chehalis River basin, poor water quality has been identified as a threat to the fisheries resource (Hiss and Knudsen, 1993). A 1993 USFWS report (Wampler et al.) details stream reaches in the Chehalis basin where fish habitat degradation has occurred. In an effort to protect and enhance the fishery, the USFWS created the Chehalis Fisheries Restoration Program (CFRP), which provides funding for projects to restore anadromous fish to the Chehalis basin. Types of projects funded by CFRP include fisheries habitat restoration and installation of BMPs to improve or protect water quality. The Washington State Department of Ecology (Ecology) received CFRP funding from 1994-2000 to determine if habitat restoration projects and installed BMPs are effective in improving water quality.

While CFRP provides funding for numerous restoration projects, only a few project areas were selected to demonstrate results. Trying to monitor all project areas would result in too dispersed an effort. Detecting water quality improvements is more effective if monitoring focuses on collecting samples at a relatively high frequency and analyzing them for a small number of relevant variables. The restoration projects chosen for monitoring were selected in consultation with USFWS.

Several types of monitoring were conducted to evaluate the effectiveness of BMPs, including water quality monitoring, benthic macroinvertebrate sampling, and water temperature monitoring for shade tree restoration of riparian areas. Five BMP project areas were chosen for water quality monitoring to determine the effectiveness of BMPs. These project areas are:

- Black River from river mile (RM) 11.8 to 13.2
- Chehalis River around RM 70.6
- Beaver and Allen creeks
- Bunker and Deep creeks
- Berwick and Dillenbaugh creeks.

In 1996 a final report was completed on the post-BMP monitoring of the Black River (Sargeant, 1996a), and a report describing pre-BMP monitoring results on the Chehalis River was completed in 1995 (Sargeant, 1995a). Abstracts from these two reports are included in Appendix A. This report describes the results of the water quality monitoring for the other three project areas in the Chehalis basin that received BMPs to improve water quality: Beaver/Allen, Bunker/Deep, and Berwick/Dillenbaugh.

Several total maximum daily load (TMDL) technical studies have been completed for areas in the upper Chehalis basin. These studies included recommendations for pollutant loading reduction. In addition to evaluating the effectiveness of BMPs, where applicable data from this study were compared to loading levels proposed by the TMDL studies.

Water Quality Standards

Beaver, Allen, Bunker, Deep, Berwick, and Dillenbaugh creeks are all designated Class A waters according to surface water quality standards for Washington State. The beneficial uses of Class A waters include domestic, industrial, and agricultural water supply; stock watering; fish and shellfish migration, rearing, spawning, and harvesting; wildlife habitat; primary contact recreation; sport fishing, boating, and aesthetic enjoyment; and commerce and navigation. Water quality standards applicable to the study areas, as described in Chapter 173-201A WAC, are as follows:

- Fecal coliform organism levels shall both not exceed a geometric mean value of 100 colonies/100 mL and not have more than 10% of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 mL.
- Dissolved oxygen shall exceed 8.0 mg/L.
- Temperature shall not exceed 18.0°C due to human activities.
- pH shall be within the range of 6.5 to 8.5 standard units.
- Turbidity shall not exceed five nephlometric turbidity units (NTU) over background turbidity when background turbidity is 50 NTU or less.
- Acute and chronic toxicity criteria for ammonia are defined as a function of pH and temperature.

Quality Assurance and Quality Control Results

Appendix B discusses quality assurance procedures and results for precision, completeness, representativeness, and comparability of the data. Water quality data met data quality objectives in most cases. Data not meeting quality objectives were noted, and their quality considered for use in data analysis. For this report all laboratory data were reported and used for data analysis, and laboratory values qualified as estimates or as undetected at the reporting limit were used as reported. Data qualifiers are included in Appendix C.

Methods

Sample Collection

For Beaver/Allen and Bunker/Deep creeks all sampling was conducted in accordance with the quality assurance (QA) project plan and addenda (Sargeant, 1994, 1995b, 1996b, 1997a, 1998). For Berwick/Dillenbaugh creeks, sampling was conducted in accordance with the QA project plan and addenda (Sargeant, 1994, 1998; O'Neal, 1999). Pre-BMP data for Berwick/Dillenbaugh creeks were collected by the Lewis County Conservation District.

Monitoring design included pre- and post-BMP monitoring, upstream and downstream, depending on site conditions. Sites at the mouths of sub-basins corresponding to TMDL study sites were also monitored to determine if TMDL targets were met.

At each site field measurements for temperature, pH, and conductivity were made using the methods described in the QA project plan. For Beaver Creek, dissolved oxygen measurements were obtained during the 1994 dry season using a field meter. For Bunker/Deep and Berwick/Dillenbaugh creeks, dissolved oxygen samples were collected during the dry season. Samples were preserved on-site and were analyzed within 24 hours of collection using a modified Winkler titration at the Ecology headquarters.

Flow discharge measurements were obtained by instantaneous flow measurements using a velocity meter and top-set wading rod, or estimated using a flow curve developed from correlating flows with a staff gauge. Flow measurements were not obtained at Beaver creek mile (CM) 0.9 due to hazardous conditions. Flow measurements were obtained on November 18, 1997, and flow discharge was 75.5 cfs at CM 0.9 and 73.2 cfs at CM 0.1. There are no major surface water inputs between these two sites, so flows at CM 0.9 were assumed to be similar to flows at CM 0.1.

Flows were not measured at Beaver CM 2.5 due to hazardous conditions. Flow discharge at this site was estimated by totaling flows from Allen Creek (CM 2.6T) and Beaver Creek (CM 4.2). Flow measurements were not obtained for Bunker Creek and the mouth of Berwick Creek (CM 0.0) during the winter due to hazardous conditions. For Berwick CM 0.0, no tributaries or other inputs contribute to the creek between CM 0.0 and 0.6. CM 0.0 discharge was estimated to be equivalent to Berwick CM 0.6.

For Berwick Creek, two wet season flow measurements were not obtained at two separate sites due to hazardous high water conditions. Flow discharge for these dates is estimated by correlating flows from the upstream station. One dry season flow measurement was not taken at Berwick CM 1.7 due to time constraints. Flow discharge was estimated using the upstream station.

All laboratory samples were collected from flowing water by sub-surface grab. Immediately following collection, samples were placed on ice in the dark. Samples were shipped to

Ecology's Manchester Environmental Laboratory within 24 hours after collection where they were analyzed in accordance with the QA project plan.

Sample Timing

Sampling was conducted during the dry and wet seasons. The dry season is from June through September, and the wet season is from November though March.

For the wet season, storm-event sampling began in November after 10 or more inches of rain had fallen during the wet season. Daily precipitation at the Olympia Airport National Weather Service station was monitored throughout the study to determine when to initiate sampling. A storm-event sampling was triggered when 0.5 inches of rainfall fell within the previous 48 hours. Precipitation for the sample day and preceding 24-, 48-, and 72-hour rainfall (as of 12:00 a.m.) is shown in Appendix D.

For Beaver/Allen and Bunker/Deep creeks, rainfall information was obtained from the National Oceanic and Atmospheric Administration (NOAA) gauging station in Olympia, Washington. For Berwick and Dillenbaugh creeks rainfall information was obtained from the NOAA gauging station in Centralia, Washington.

Several sample dates show a preceding 48-hour rainfall of less than 0.5 inches. This is because previous rainfall information was obtained for the 24 hours preceding sampling as of 5:00 a.m. the day of sampling. The rainfall table in Appendix D represents a slightly different time period, from 12:00 a.m. to 12:00 p.m.

Sample Period and Parameters

1. Beaver and Allen Creeks

In 1994-95 Beaver and Allen creeks sampling was conducted during the dry and wet season. Wet season data from 1994-95 showed during the wet season water quality problems at the monitoring sites were primarily associated with storm events. Consequently, to conserve time and laboratory costs, sampling was focused on the critical time period of wet season storm events for the remainder of the study (Sargeant, 1995b). Sample timing, field measurements, and laboratory parameters collected for each site are described in Table 1.

Table 1. Beaver and Allen creeks sampling period, field measurements, and laboratory parameters for each site.

Creeks	Time period	Field measurements	Laboratory parameters
Beaver CM 4.2	1994 dry season	pH, conductivity, DO, temperature, flow discharge	FC, NH3, NO2/3, TPN
	1994-99 wet season	pH, conductivity, temperature, flow discharge	FC, NH3, NO2/3, TPN, turbidity
Allen CM 2.6T	1994 dry season	pH, conductivity, DO, temperature, flow discharge	FC, NH3, NO2/3, TPN
	1994-99 wet season	pH, conductivity, temperature, flow discharge	FC, NH3, NO2/3, TPN, turbidity
Beaver CM 2.5	1994 dry season	pH, conductivity, DO, temperature	FC, NH3, NO2/3, TPN
	1994-99 wet season	pH, conductivity, temperature	FC, NH3, NO2/3, TPN, turbidity
Beaver CM 0.9	1996-98 wet season	pH, conductivity, temperature	FC, NH3, NO2/3, TPN, turbidity
Beaver CM 0.1	1994 dry season	pH, conductivity, DO, temperature, flow discharge	FC, NH3, NO2/3, TPN
	1994-99 wet season	pH, conductivity, temperature, flow discharge	FC, NH3, NO2/3, TPN, turbidity

DO: dissolved oxygen
FC: fecal coliform
NH3: ammonia-nitrogen
NO2/3: nitrate nitrite nitrogen
TPN: total persulfate nitrogen

2. Bunker and Deep Creeks

For Bunker and Deep creeks, sampling was conducted during the dry and wet season from 1994-99. Data from 1994-95 showed that during the wet season sediment was the major water quality problem at the monitoring sites, and was primarily associated with storm events. To conserve time and laboratory costs, sampling during the wet season was focused on storm-event sampling and sediment related parameters for the remainder of the study (Sargeant, 1995b).
No sampling was conducted during the 1997-98 wet season and 1998 dry season due to funding constraints. Sample timing, field measurements, and laboratory parameters collected for each site are described in Table 2.

Table 2. Bunker and Deep creeks sampling period, field measurements, and laboratory parameters for each site.

Creeks	Time period	Field measurements	Laboratory parameters
Deep CM 4.5	1995-99 wet season	pH, conductivity, temperature, flow discharge	Turbidity, TSS
	1999 dry season	pH, conductivity, DO, temperature, flow discharge	FC, NH3, NO2/3, TPN, TP
Deep CM 3.9	1994-97, 1999 dry season	pH, conductivity, DO, temperature, flow discharge	FC, NH3, NO2/3, TPN, TP
	1994-95 wet season	pH, conductivity, temperature, flow discharge	FC, NH3, NO2/3, TPN, turbidity
	1995-99 wet season	pH, conductivity, temperature, flow discharge	Turbidity, TSS
Deep CM 3.6	1994-97, 1999 dry season	pH, conductivity, DO, temperature, flow discharge	FC, NH3, NO2/3, TPN
	1994-95 wet season	pH, conductivity, temperature, flow discharge	FC, NH3, NO2/3, TPN, turbidity
	1995-99 wet season	pH, conductivity, temperature, flow discharge	Turbidity, TSS
Deep CM 2.4	1994-97, 1999 dry season	pH, conductivity, DO, temperature, flow discharge	FC, NH3, NO2/3, TPN, turbidity
	1994-95 wet season	pH, conductivity, temperature, flow discharge	FC, NH3, NO2/3, TPN, turbidity
	1995-99 wet season	pH, conductivity, temperature, flow discharge	Turbidity, TSS
Bunker CM 0.5	1994-97, 1999 dry season	pH, conductivity, DO, temperature, flow discharge	FC, BOD5, NH3, NO2/3, TPN, TP
	1994-95 wet season	pH, conductivity, temperature	FC, NH3, NO2/3, TPN, turbidity
	1995-97 wet season	pH, conductivity, temperature	Turbidity, TSS
	1998-99 wet season	pH, conductivity, temperature	Turbidity, TSS, FC

DO: dissolved oxygen
TSS: total suspended solids
FC: fecal coliform
NH3: ammonia-nitrogen
NO2/3: nitrate nitrite nitrogen
TPN: total persulfate nitrogen
TP: total phosphorus
BOD5: 5-day biological oxygen demand

3. Berwick and Dillenbaugh Creeks

For the Berwick and Dillenbaugh creeks, wet-season storm-event sampling was conducted from November through March in 1998-2000. Dry-season sampling was conducted once each month from June through September in 1999 and 2000. Sample timing, field measurements, and laboratory parameters collected for each site are described in Table 3.

Table 3. Berwick and Dillenbaugh creeks sampling period, field measurements, and laboratory parameters for each site.

Creeks	Time period	Field measurements	Laboratory parameters
Berwick CM 4.2	1999 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, turbidity
	2000 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, NO2/3¸ TPN, TP turbidity
	1998-2000 wet season	pH, conductivity, temperature, flow discharge	FC, turbidity
Berwick CM 3.0	1999 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, turbidity
	2000 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, NO2/3¸ TPN, TP turbidity
	1998-2000 wet season	pH, conductivity, temperature, flow discharge	FC, turbidity
Berwick CM 2.0	1999 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, turbidity
	2000 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, NO2/3¸ TPN, TP turbidity
	1998-2000 wet season	pH, conductivity, temperature, flow discharge	FC, turbidity
Berwick CM 1.7	1999 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, turbidity
	2000 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, NO2/3¸ TPN, TP turbidity
	1998-2000 wet season	pH, conductivity, temperature, flow discharge	FC, turbidity
Berwick CM 0.6	1999 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, turbidity
	2000 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, NO2/3¸ TPN, TP turbidity
	1998-2000 wet season	pH, conductivity, temperature, flow discharge	FC, turbidity
Berwick CM 0.0	1999 dry season	pH, conductivity, DO, temperature	FC, NH3, turbidity
	2000 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, NO2/3¸ TPN, TP turbidity
	1998-2000 wet season	pH, conductivity, temperature	FC, turbidity
Dillenbaugh CM 3.5	1999 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, turbidity
	2000 dry season	pH, conductivity, DO, temperature, flow discharge,	FC, NH3, NO2/3¸ TPN, TP turbidity
	1998-2000 wet season	pH, conductivity, temperature, flow discharge	FC, turbidity

DO: dissolved oxygen
FC: fecal coliform
NH3: ammonia-nitrogen
NO2/3: nitrate nitrite nitrogen
TPN: total persulfate nitrogen
TP: total phosphorus

Data Analysis

Water Quality Standards

Sample results were compared to the Class A freshwater quality standards. Parameters with applicable water quality standards include fecal coliform bacteria, turbidity, dissolved oxygen, temperature, pH, and ammonia-nitrogen.

Total Maximum Daily Load Compliance

Ecology is required by the federal Clean Water Act to conduct a TMDL evaluation for impaired waterbodies on the Section 303(d) list. The evaluation begins with a water quality technical study. The technical study determines the capacity of the waterbody to absorb pollutants and still meet water quality standards. Several TMDL technical studies have been completed for areas in the upper Chehalis basin. These studies included recommendations for pollutant loading reduction. The *Black River Wet Season TMDL Study,* Coots (1994) determined that a 92% reduction of fecal coliform load was necessary to meet the proposed load allocation of 50 cfu/100mL at the mouth of Beaver Creek. The *Upper Chehalis River Dry Season TMDL Study,* Pickett (1994b) determined that in Bunker Creek a 91% reduction of ammonia-nitrogen (lb/day) and a 73% reduction in BOD_5 load (lb/day) were necessary. This study also determined that a 99% reduction of ammonia-nitrogen (lb/day) and an 89% reduction in BOD_5 load (lb/day) were necessary in Dillenbaugh Creek to meet the proposed load allocations in the TMDL. Where applicable, loading levels from this current study were compared to the load allocations proposed in the TMDL.

Pre- and Post-BMP Comparisons

Beaver/Allen Creeks

Samples collected during the initial assessment study (1994-95) were not included in the statistical analysis, because of differences in sampling strategies between that period and the rest of the study. The 1994-95 sampling was a characterization of water quality and, as such, did not target specific flow or weather conditions. The remainder of the study (1995-99) purposefully targeted periods within the wet season when antecedent rainfall exceeded a specified amount. Because of these differences, the winter 1995-96 sampling was used as the baseline.

Trend analysis was done on fecal coliform loading near the mouth of Beaver Creek (CM 0.1), Beaver Creek just below Allen Creek (CM 2.5), near the mouth of Allen Creek (CM 2.6), and Beaver Creek above the dairy (CM 4.2). Agricultural BMPs take time to install, and their impact on nonpoint source pollution is often delayed as the residual effects of past practices attenuate. Their gradual effect makes a comparison of pre- versus post-BMP conditions problematic. Instead, a regression analysis of $\log_{10}$-transformed instantaneous load (concentration multiplied by flow) over time was used, including linear and quadratic time functions to capture linear and curvilinear temporal patterns in load. Residuals were examined to ensure linearity and homoscedasticity.

A more direct way to test the effectiveness of the BMPs in reducing fecal coliform and nitrogen loads is by comparing measured values of loads entering and leaving the stream reach delineated by Beaver CM 4.2, the mouth of Allen (CM2.6T), and Beaver CM 2.5. The sum of the loads at Beaver CM 4.2 and Allen (BeCM 2.6T) represents an estimate of the load entering the reach. If there is no significant contribution from this reach (i.e., the dairy), then this estimate should approximate the outgoing load measured at Beaver CM 2.5. If the dairy contributed substantially to the load, and there was a significant reduction in load due to the BMPs, then the difference between our estimate (sum of Allen Creek and Beaver CM 4.2) and the load measured at Beaver CM 2.5 should decrease over time. A regression analysis, as described above, was used on the difference between the logs of the incoming and outgoing loads [$\log_{10}$-(load_{in})- $\log_{10}$-(load_{out})] to estimate changes over time.

Bunker/Deep Creeks

A nonparametric Kruskal-Wallis test was conducted to compare dry season data for fecal coliform and nitrogen concentrations from 1995, 1996, 1997, and 1999. If differences between years were seen, then a nonparametric Tukey-type multiple comparison test was done to determine which years were significantly different (Zar, 1984). A statistical significance level of $P \leq 0.05$ was used for all tests.

Trend analysis was conducted on turbidity, total suspended solids, nitrate/nitrite, ammonia-nitrogen, and total persulfate nitrogen for the Deep Creek stations at CM 2.4, 3.6, 3.9, and 4.5 for the entire study period. Ecology used regression analysis of $\log_{10}$-transformed data (concentration multiplied by flow), including linear and quadratic functions, and time to capture linear and curvilinear temporal patterns in concentration. Residuals were examined to ensure linearity and homoscedasticity. If time was a significant ($P<0.05$) factor in the regression, then a significant change over time was assumed.

Berwick/Dillenbaugh Creeks

Paired t-tests were used to compare water quality between upstream and downstream sites. Sites were evaluated for differences in fecal coliform and nitrogen concentrations, and turbidity, when data were available. A two-tailed test with a significance level of $\alpha = 0.05$ was used.

In order to compare results from this study to historical data collected by the Lewis County Conservation District (LCCD), flows were estimated. Flows had to be estimated for the sample date in order to calculate fecal coliform loading for those sites, because the LCCD collected flows one day after water quality data were collected. Flows were estimated by correlating Berwick Creek flows with nearby Newaukum River flows. The United States Geological Survey (USGS) has a permanent flow monitoring station on the Newaukum River near Chehalis. Historical stream flow daily values recorded by USGS were used for comparison with LCCD instantaneous flow measurements for Berwick Creek. The correlation was exceptionally high, with a regression coefficient of $r^2 = 0.94$.

In order to compare dry season fecal coliform data between years for the post-BMP study, a statistical test for the significance of variation was done using SYSTAT (1997) statistical software. Comparisons were made for fecal coliform concentration using a non-parametric test, the Kruskal-Wallis one-way analysis of variance. A two-tailed test with a significance level of $\alpha \leq 0.05$ was used. This analysis was performed only for the reach between Berwick CM 0.6 and 0.0, a stretch of the creek where BMPs changed over the course of post-BMP data collection.

Post-BMP data were compared to pre-BMP data collected by the LCCD. The tributary to Berwick CM 5.3 was added by Ecology as a background station; however, pre-BMP data are not available for comparison. Similarly, no historical data were available for Dillenbaugh Creek above the mouth of Berwick Creek. In order to compare pre- and post-BMP data, statistical analysis for the significance of variation was also done using SYSTAT (1997) box plots. Box plots required log transformations of both fecal coliform and turbidity data. Due to the difference in collection methods by Ecology and the LCCD, data collected on dates with exceptionally high flows was excluded from analysis. The highest flow occurring during pre-BMP data collection was 29.9 cubic feet per second (cfs) at Berwick CM 0.6. Consequently, all post-BMP data collected on dates with a flow higher than that value at CM 0.6 were disregarded to make data sets more comparable.

Additionally, all available flow data (pre- and post-BMP) were compared to fecal coliform data using SYSTAT (1997) scatter plots.

Results

1. Beaver Creek and Allen Creek BMP Evaluation

Site Description

Beaver Creek, in south Thurston County, drains 17, 300 acres (Lewis County Conservation District, 1992). The creek is 10.2 miles in length, draining to the Black River just south of the town of Littlerock. The largest tributary to Beaver Creek is Allen Creek which flows into Beaver Creek at creek mile (CM) 2.4. Allen Creek is 4.5 miles in length and drains Scott and Deep Lakes.

Beaver Creek was identified in the *Black River Wet Season Nonpoint Source TMDL Study* as having the most serious fecal coliform pollution problem in the Black River drainage (Coots, 1994).

The study area for this project includes the lower five miles of Beaver Creek (Figure 1). Primary land uses in the area of interest include residential homes near the town of Littlerock, and hobby farm and agricultural use in the mid-basin. There is a large dairy operation located between Beaver CM 4.2 and 2.7. Coho salmon and coastal cutthroat trout use both Beaver and Allen creeks for spawning and rearing (StreamNet, 1998; Blakley et al., 2000).

Historical Data

In 1991 and 1992, Ecology conducted a dry season TMDL of the Black River. Some sampling of tributaries was conducted during the study, including Beaver Creek. One of the findings of the study was that Beaver Creek appeared to have one or more pollutant loading sources in the stretch between Case Road (CM 4.2) and the junction with Allen Creek (CM 2.6). This was suggested by data for fecal coliform bacteria, total persulfate nitrogen, and nitrate/nitrite nitrogen (Pickett, 1994a).

A wet season TMDL was conducted on the Black River during the winter season in 1991-92 and 1992-93, including sampling on Beaver Creek. One of the conclusions of the study was that Beaver Creek had the most serious fecal coliform bacteria problems in the Black River basin and should be pursued as a first priority for corrective actions. The load from Beaver Creek dominated the upper basin, making it difficult to quantify contributions to the Black River from nearshore areas below the mouth of the creek (Coots, 1994).

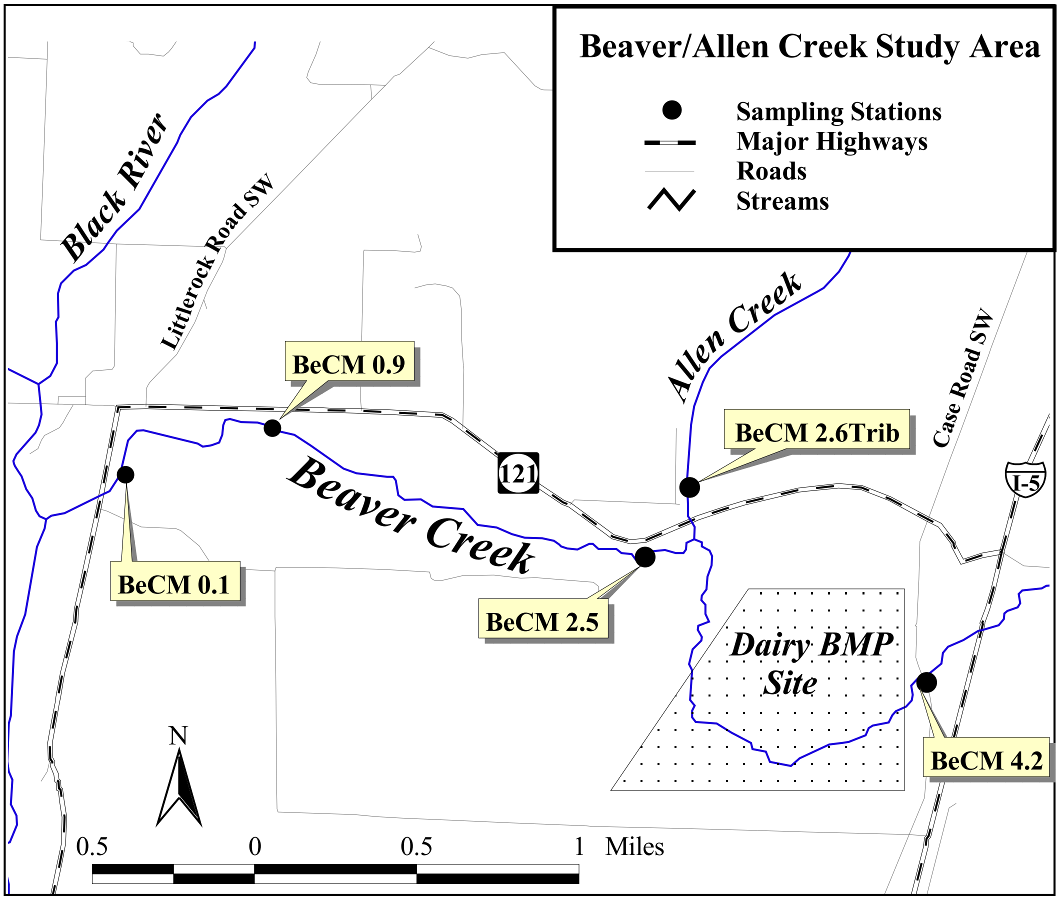

Figure 1. Sampling Sites for Beaver Creek and Allen Creek.

Best Management Practices

Two areas in the sub-basin received BMP treatment, a large dairy operation on Beaver Creek and an animal pasture near the mouth of Allen Creek.

Beaver CM 4.2 - 2.5

The major land use between Beaver CM 4.2 and 2.5 is a large dairy operation. Before 1995 the herd size ranged between about 500 to 550 animals. In 1995 the herd size was increased to about 900 milking cows and 150 dry cows. Manure and wastewater were applied to the field year-round, as there was very little manure storage capacity. In fall 1996, construction of an animal waste holding pond system was completed. The holding pond stores animal waste during the winter, so that application of manure should not occur during the wet season. The holding pond also affects the nutrient content of the manure and wastewater, in that there is dilution from captured rainfall and ammonia-nitrogen loss during storage (Erickson, 2002). A full description of the BMPs implemented on the dairy can be found in *Effects of Land Application of Dairy Manure and Wastewater on Groundwater Quality* (Erickson, 2002).

Allen Creek

The Chehalis Fisheries Restoration Program funded BMPs at four sites on Allen Creek between Allen CM 1.0 and 2.5. The BMPs included over a mile of stream fencing to exclude livestock, 130,000 square feet of stream corridor revegetation, placement of 11 large woody debris structures, and construction of limited access livestock watering sites. The BMPs were installed between 1994-97 by the Thurston Conservation District, the Chehalis Basin Task Force, and a private consultant (Kelly, 1998).

Water Quality Results

The field and laboratory results for the monitoring portion of this project are presented in Appendix E. In the data tables, some results are qualified with symbols or codes. These symbols, commonly referred to as qualifiers, contain important information about that result. A list of data qualifiers is included in Appendix C.

Comparison to water quality standards

The water quality standards classification for Beaver and Allen creeks is Class A Freshwater. Sample results were compared to all applicable water quality standards, including standards for pH, temperature, dissolved oxygen, turbidity, fecal coliform, and ammonia-nitrogen.

Field parameters

For the time periods monitored in this study, all sites met the temperature standard. Temperature and dissolved oxygen were only collected during the summer 1994. The only station to meet the dissolved oxygen standard in 1994 was Beaver CM 0.1 near the mouth (Table 4). Percent dissolved oxygen saturation was low for all sites except for Beaver CM 0.1. There were a number of stations where pH fell below the standard (Table 4). The two most downstream stations met pH standards.

Laboratory parameters

For the time periods monitored in this study, all sites met the ammonia-nitrogen and turbidity standards.

During the 1994 summer season sampling (two events), all sites met standards for fecal coliform. For the wet-season sampling, Beaver CM 4.2 met fecal coliform standards during two of five wet seasons sampled. Allen Creek at CM 2.6T met fecal coliform standards for one of five seasons. Beaver Creek at CM 2.5, 0.9, and 0.1 did not meet standards for any wet season sampled. Table 5 describes compliance with the fecal coliform standard for all sites and seasons sampled.

Table 4. Beaver Creek and Allen Creek sites not meeting pH or dissolved oxygen water quality standards.

Sites Not Meeting pH Standards				
Station name	Creek mile	Date	pH (SU)	pH standard (SU)
Beaver Creek at Case Road	BeCM 4.2	12/26/94 1/10/95 1/25/95 11/18/97 12/2/98	6.2 6.4 6.3 6.4 6.4	6.5-8.5
Allen Creek (mouth)	BeCM 2.6T	1/10/95	6.4	6.5-8.5
Beaver Creek below Allen Creek	BeCM 2.5	11/14/94 11/18/97 11/24/97 12/2/98	5.2 6.4 6.1 6.4	6.5-8.5
Sites Not Meeting Dissolved Oxygen Standards				
Station name	Creek mile	Date	DO (mg/L)	DO standard (mg/L)
Beaver Creek at Case Road	BeCM 4.2	8/31/94 9/13/94 9/14/94	4.4 and 4.2 7.6 5.4	> 8.0 mg/L
Allen Creek (mouth)	BeCM 2.6T	8/31/94 9/13/94 9/14/94	6.2 6.3 5.2	> 8.0 mg/L
Beaver Creek below Allen Creek	BeCM 2.5	8/31/94 9/13/94 9/14/94	5.6 and 6.1 5.8 5.2	> 8.0 mg/L

TMDL compliance

In the *Black River Wet Season TMDL Study,* Coots (1994) determined that a 92% reduction of fecal coliform load was necessary to meet the proposed load allocation of 50 cfu/100mL at the mouth of Beaver Creek.

Improvements in fecal coliform concentration and loading were seen at the BMP site and at the mouth of Beaver Creek. However, none of the sites met fecal coliform standards for all seasons sampled. Further reductions in fecal coliform levels are necessary.

Fecal coliform concentrations were log normally distributed; therefore, fecal coliform concentrations were log transformed ($\log_{10}$) for statistical analysis. The statistical rollback method was used to determine percent fecal coliform reductions necessary at each site to meet the fecal coliform water quality standard (Ott, 1995). The 1997-99 data set was used to determine how much reduction in fecal coliform is still necessary to meet the water quality standard (n=15).

Table 5. Beaver Creek and Allen Creek compliance with fecal coliform standards.

	BeCM 4.2			BeCM 2.6 Trib			BeCM 2.5			BeCM 0.9			BeCM 0.1		
	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard
Dry Season 1994	6	0 of 2 > 200	Yes	92	0 of 2 > 200	Yes	91	0 of 2 > 200	Yes				72	0 of 2 > 200	Yes
Wet Season 1994-95	33	1 of 10 > 200	Yes	47	1 of 10 > 200	Yes	1261	8 of 10 > 200	NO				843	8 of 10 >200	NO
Wet Season 1995-96	102	1 of 5 > 200	NO	236	2 of 5 > 200	NO	7445	5 of 5 > 200	NO				6157	5 of 5 > 200	NO
Wet Season 1996-97	31	1 of 10 > 200	Yes	78	2 of 10 > 200	NO	514	6 of 10 > 200	NO	288	4 of 9 > 200	NO	394	7 of 10 > 00	NO
Wet Season 1997-98	67	2 of 10 > 200	NO	97	3 of 10 > 200	NO	130	3 of 10 > 200	NO	129	3 of 10 > 200	NO	145	3 of 10 > 00	NO
Wet Season 1998-99	119	1 of 5 > 200	NO	167	4 of 5 > 200	NO	200	2 of 5 > 200	NO				227	2 of 5 > 200	NO

Sites not meeting water quality standards according to this table are not automatically placed on Ecology's 303(d) list. Listing criteria are currently being revised; draft guidance is available on Ecology's web site at http://www.ecy.wa.gov/programs/wq/wqhome.html. Generally one sample exceedance is not sufficient for 303(d) listing.

Table 6 presents recommended fecal coliform reductions for all of the Beaver and Allen creek sites. Necessary fecal coliform reductions at CM 2.5 and 1.0 were calculated as if fecal coliform standards were met in Allen Creek and upstream of CM 4.2. To do this the sum of the residual loading (measured load - sum of load) and the rolled back upstream loads were calculated. If the residual was a negative value, no loading was assumed. The fecal coliform loads were converted to concentrations. Roll-back analysis was performed on the concentrations to determine the percent loading reduction necessary if upstream sites met water quality standards.

Table 6. Beaver Creek and Allen Creek fecal coliform loading reductions necessary to meet wet season TMDL fecal coliform targets.

Tributary or creek stretch (1997-99 data)	n	Current geometric mean	Current 90^{th} percentile	Target geometric mean	Target 90^{th} percentile	Required reduction
Upstream CM 4.2	15	81	310	52	200	36%
Allen Creek	15	116	436	53	200	54%
Beaver CM 4.2 - 2.5	15	92	462	71	200	30%
Beaver Cm 2.5 - 1.0	15	134	581	43	200	57%
Reductions needed at Beaver CM 1.0 to meet TMDL requirements						
Beaver Creek CM 1.0 (1997-99)	15	169	735	46	200	73%
Beaver Creek CM 1.0 (1991-93)	21	400	5317	15	200	96%

The last two lines of the table show the total fecal coliform loading reduction necessary at Beaver CM 0.1 (near the mouth) and the reduction necessary in 1991-93 calculated using the rollback method. From 1993 to 1999, a 23% reduction in fecal coliform loading was seen at Beaver CM 0.1.

Data analysis

Figure 2 presents pie charts of average wet season fecal coliform loading from each creek segment, by sample year. The charts show that the creek reach between CM 4.2 and 2.5 (excluding Allen Creek loading) initially contributes the highest percentage of loading to the creek in the study area. In 1997-99 this reach contributes less fecal coliform loading than in previous years.

Figure 2. Average wet season fecal coliform loading contributions to Beaver Creek, 1994-99.

Figure 3 presents average seasonal fecal coliform loading contributions for Beaver CM 0.1. Fecal coliform loading data collected during the Black River Wet Season TMDL is included in the figure. All sampling, except the 1994-95 set, was storm-event sampling. The graph shows that fecal coliform loading at the mouth increased until 1995-96 and decreased after BMP implementation.

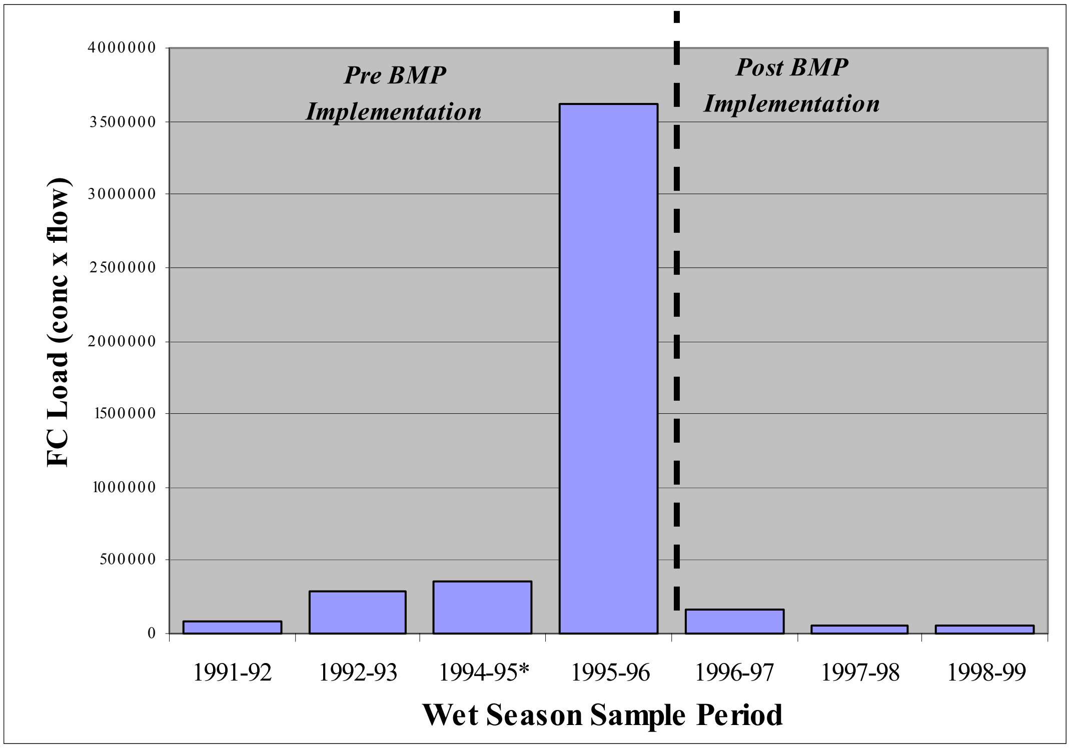

Figure 3. Average wet season fecal coliform loading for Beaver Creek (mouth).
*All years are storm-event sampling except 1994-5.

Pre- and post-BMP trend analysis

Trend analysis of the $\log_{10}$–transformed loading data from November 1995 through March 1999 showed significant decreases in fecal coliform load at the mouth of Beaver Creek and at Beaver CM 2.5 (Table 7). No significant changes in fecal coliform loads were detected in Allen Creek (CM 2.6) or upstream of the dairy at Beaver CM 4.2.

Table 7. Results of trend analyses of constituent loads, November 1995 through March 1999.

Site	Fecal coliform loads	Total persulfate nitrogen	Nitrate/nitrite	Ammonia nitrogen
Beaver CM 0.1	Decreasing	Decreasing	No change	Decreasing
Beaver CM 2.5	Decreasing	Decreasing	Decreasing	Decreasing
Allen Creek (mouth)	No change	No change	No change	No change
Beaver CM 4.2	No change	No change	No change	No change

Figure 4 presents fecal coliform concentration data (as opposed to loads) for the same sites. It shows the same pattern of decreasing fecal coliform concentrations seen at Beaver CM 0.1 and 2.5 and no significant changes in concentration seen in Allen Creek or at Beaver CM 4.2.

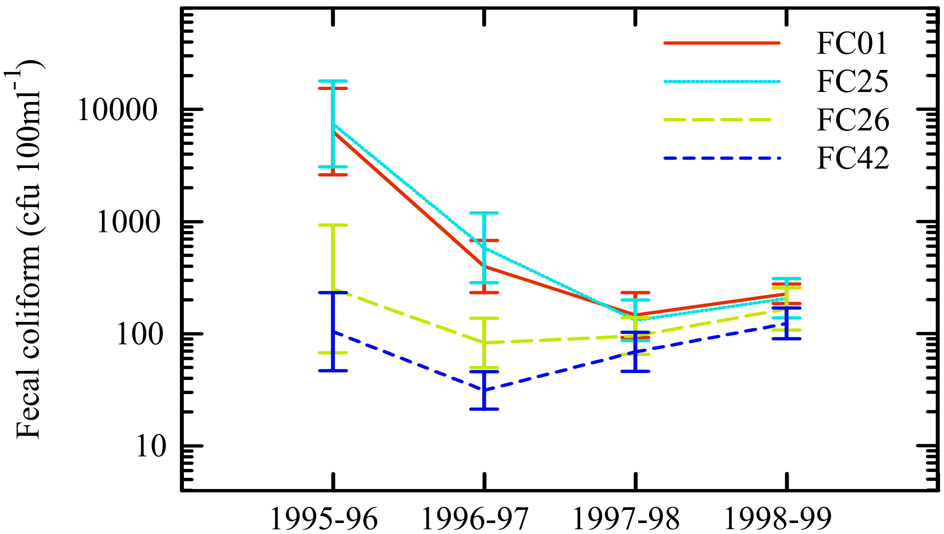

Figure 4. Fecal coliform loading for Beaver Creek and Allen Creek, 1995-99.

Significant decreases in ammonia-nitrogen loads and concentrations were also seen at Beaver CM 0.1 and CM 2.5, with no significant changes seen in Allen Creek CM 2.6 or at Beaver CM 4.2. Figure 5 presents 1995-99 ammonia-nitrogen loading for all sites.

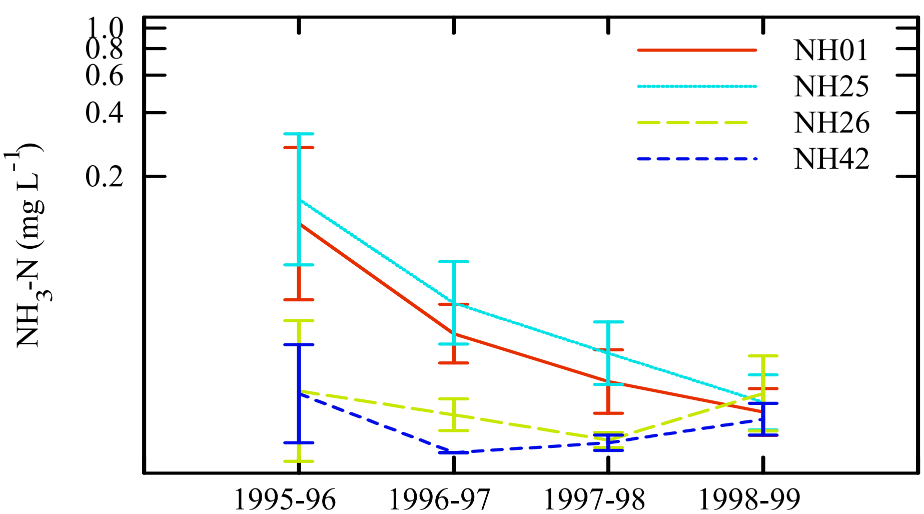

Figure 5. Ammonia-nitrogen loading for Beaver Creek and Allen Creek, 1995-99.

Total persulfate nitrogen and nitrate/nitrite loads did not change at Beaver CM 4.2 or in Allen Creek. Total persulfate nitrogen did decrease over the study at the two lower sites (CM 2.5 and 0.1) while nitrate/nitrite decreased only at Beaver CM 2.5. The significant decreases seen in total persulfate nitrogen and nitrate/nitrite loads were small in comparison with the decreases in ammonia-nitrogen and fecal coliform loads that occurred in the first three years of the study, and were offset by increases in the 1998-99 season. Total persulfate nitrogen and nitrate/nitrite concentration data showed similar patterns, with decreasing concentration over the first three years at the two lower Beaver Creek sites and no significant change at the Allen Creek and Beaver CM 4.2 sites (Table 8, Figures 6 and 7).

Table 8. Beaver Creek and Allen Creek results of trend analysis on loads originating in the stream reach occupied by the dairy.

Variable	Trend analysis results
Fecal coliform	Decrease
Total persulfate nitrogen	No change
Nitrate/nitrite	No change
Ammonia nitrogen	Decrease

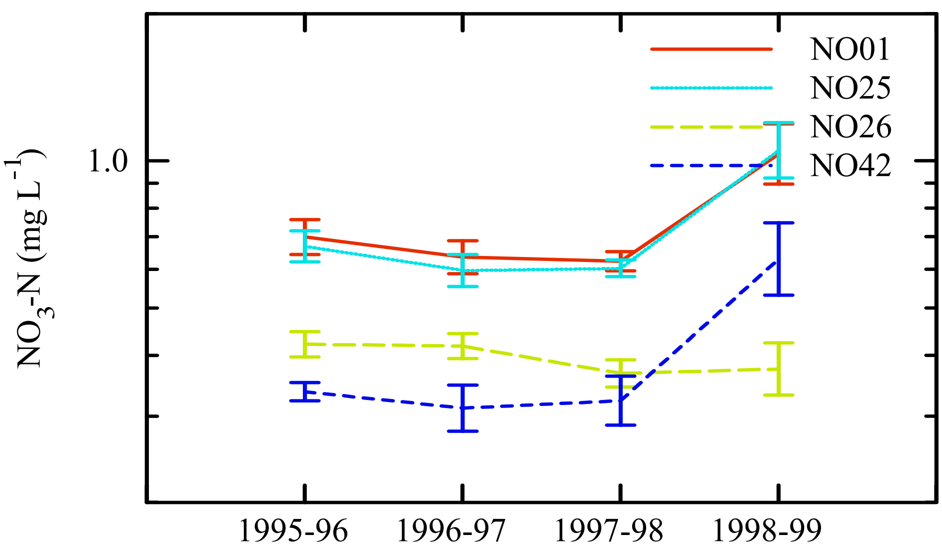

Figure 6. Nitrate-nitrite nitrogen concentrations for Beaver Creek and Allen Creek, 1995-99.

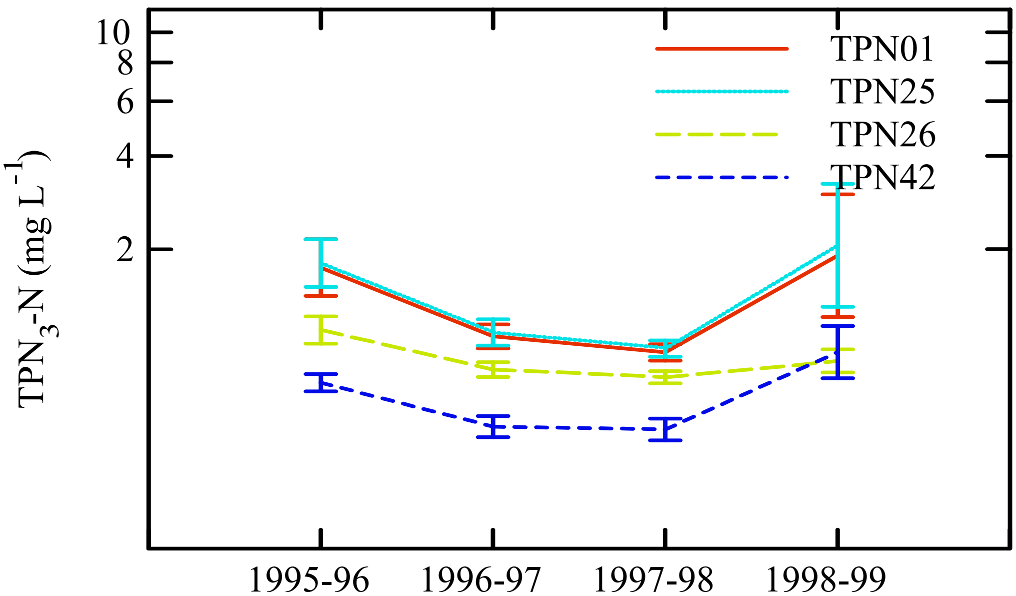

Figure 7. Total persulfate nitrogen concentrations for Beaver Creek and Allen Creek, 1995-99.

The trend analysis of the differences between measured loads leaving the stream reach where the dairy is located (Beaver CM 2.5) and the sum of loads entering this reach (Allen Creek plus Beaver CM 4.2) showed dramatic decreases in fecal coliform and ammonia-nitrogen from 1995-96 to 1998-99 (Table 5). Total persulfate nitrogen and nitrate/nitrite did not decline significantly over the study period. Although declines were seen over the first three years, the 1998-99 loads were equal to 1995-96 loads.

Discussion

There were a few pH violations at the upstream stations. Low pH levels at the two upstream stations could be caused by natural conditions such as decomposition of leaf/needle material in the creek or wetlands upstream. There are wetlands just upstream of Beaver CM 4.2 and 2.5.

Most sites had problems meeting water quality standards for fecal coliform during the wet season, but decreases in fecal coliform levels were seen over the course of the study.

The 1995-96 Beaver Creek data showed an increase in fecal coliform loading since the wet season TMDL study. This was most likely due to the increase in herd size at the dairy. In 1996 after BMPs were implemented, fecal coliform loading levels dropped.

Trend analyses done at each site with data from 1995-99 showed that upstream loads were stable, while loads of fecal coliform bacteria and ammonia-nitrogen measured downstream of the dairy decreased by 99% since the BMPs were initiated at the dairy. In addition, fecal coliform and ammonia-nitrogen loading attributable to the stream reach where the dairy is located (Beaver CM 4.2-2.7) also declined precipitously over the same period. Less change was seen in total persulfate nitrogen and nitrate/nitrite loading. The change was inconsistent with non-significant changes in nitrogen loading from the dairy reach. An increase in both total persulfate nitrogen and nitrate/nitrite was seen in the last year of sampling. This could be related to the somewhat higher than typical flows during sampling that year, or to changes in the operation of the BMPs, or to the fact that nitrate/nitrite (a large proportion of total persulfate nitrogen is comprised of nitrate-N) is very soluble and moves freely with groundwater. In contrast, fecal coliform tends to move with particulate matter in overland flow while ammonia-nitrogen can adsorb onto and be held by soil particles. These contrasting pathways into the stream would likely result in different responses to the BMPs.

Conclusions and Recommendations

- Implementation of BMPs at the dairy resulted in huge reductions in fecal coliform bacteria and ammonia-nitrogen loading to Beaver Creek.
- Further reductions in fecal coliform loading are needed at all sites to meet water quality standards.
- No changes in water quality were seen in Allen Creek due to BMP implementation.

2. Bunker Creek and Deep Creek BMP Evaluation

Site Description

Bunker and Deep creeks are located in Lewis County just northeast of the town of Adna. The focus of the BMP evaluation for this area was Deep Creek. Deep Creek is a tributary to Bunker Creek which drains to the upper Chehalis River at river mile (RM) 84.8. Deep Creek is 6.4 miles in length (Bucknell and Phinney, 1975). Figure 8 presents a map of the study area.

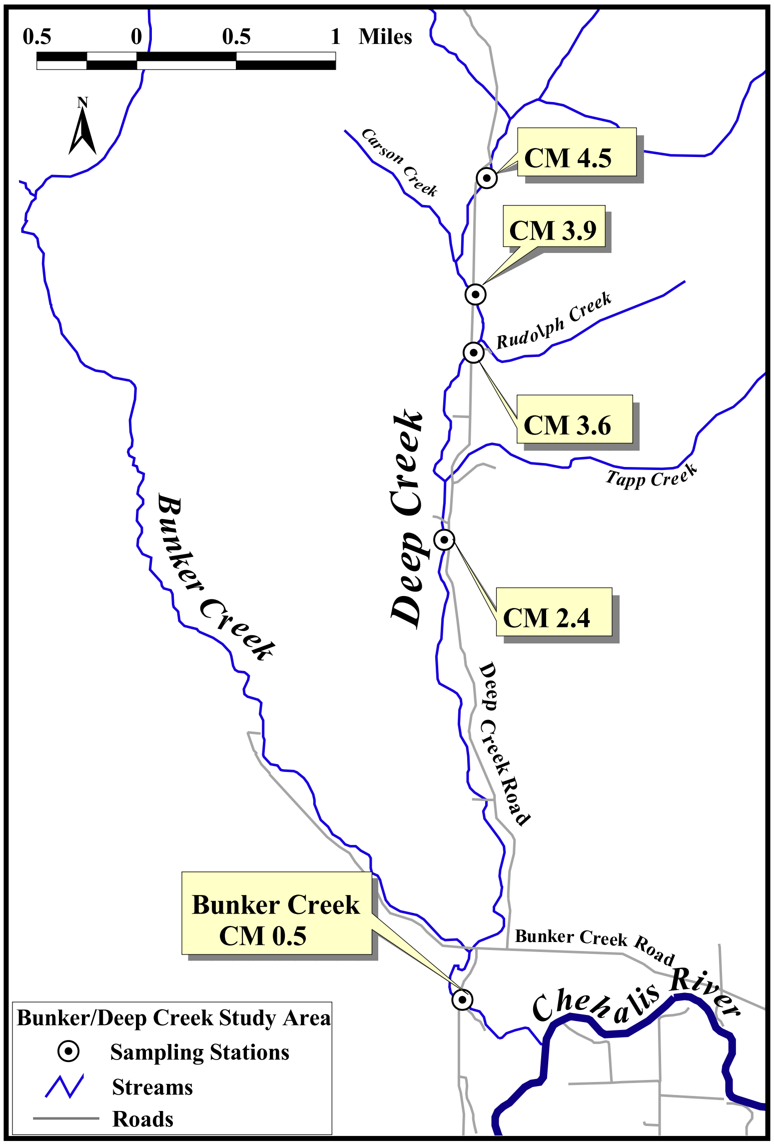

Figure 8. Sampling sites for Bunker Creek and Deep Creek.

Land use in the lower four miles of Deep Creek is rural residential with numerous small animal-keeping operations. Above CM 4.5, land use is primarily forestry and recreation. Coho salmon use the lower reaches of Bunker and Deep creeks for spawning and rearing (StreamNet, 1998).

Historical Data

In 1991 and 1992, Ecology conducted a dry season TMDL study of the Upper Chehalis River (Pickett, 1994b). Bunker Creek was sampled twice each year during the dry season study. Results for Bunker Creek showed good water quality in terms of temperature and pH, but dissolved oxygen was consistently depressed below the water quality criterion. Fecal coliform results were high, with two of four events greater than 500cfu/100mL. The USFWS identified livestock access and pollutant inputs on both Deep Creek and Bunker Creek (Wampler et al., 1993).

Best Management Practices

Several areas in the Deep Creek basin received BMP treatment. Specific BMPs and creek reaches affected are described below.

Upstream of Deep CM 4.5

Land use in this area is primarily forestry and off road vehicle recreation. In 1994-95 the Chehalis Fisheries Restoration Program (CFRP) and Washington Department of Natural Resources funded BMPs to target salmon restoration, including erosion control treatment and riparian restoration. The project included 3.2 miles of road abandonment, 12 new culverts and replacement of four culverts, correction of one fish blockage that opened up 1.5 miles of stream, installation of three fish weirs, and 59 acres of watershed/riparian replanting (Ireland, 1995).

Deep CM 4.5 - 3.9

The landowner immediately upstream of Deep CM 3.9 keeps a herd of cattle. The property alongside the creek has been fenced for many years. Upstream of this site, there is no known domestic animal access.

Deep CM 3.9 - 3.6

A large portion of the creek received BMP treatments in this stretch of creek. The site just upstream of Deep CM 3.6 received 1,300 feet of fencing and riparian planting along the south side of the creek, with no animal access points. This piece of property also includes Rundoph Creek. Fencing of Rundoph Creek was completed in January 1997 (Mendoza, 1998). Approximately 11 cow/calf pairs and one steer were kept at this site during the BMP study.

Aquatic Restoration Consultants did an independent review of the success of the CFRP projects in 1997 (Mendoza, 1998). At this site, fencing was in place and there was low mortality of riparian plantings.

Deep CM 3.6 - 2.4

One landowner keeps animals between these two stations; the number of animals varies. There were 20 cattle and a few horses in 1995; in early summer of 1996, the herd size was reduced to 12 cattle and a few horses; and in 1997, 20 cow/calf pairs and a horse were kept (Amrine, 1998). At this site, 4,552 feet of fencing was installed along 3,000 feet of the creek on both sides. Three pasture pumps were installed, and there is one animal access point.

Just upstream of Deep CM 2.4, a large culvert washed out during a flood event on February 6, 1996. This culvert has been identified as a cause of bank erosion immediately downstream of the culvert. The culvert was replaced in April 1996.

An independent review of this project in 1997 showed fencing was in excellent condition, but the livestock crossing was experiencing low levels of erosion. In addition, the crossing allowed livestock access to the riparian zone upstream. There was visible evidence of livestock access to the riparian zone, with some grazing of the riparian plantings (Mendoza, 1998).

Downstream of Deep CM 2.4

On a site with two horses and 10-12 cattle, 2,650 feet of fencing was installed on both sides of the creek. There are two animal crossings at the sites. Land use in this area is primarily rural homesteads with some animal keeping.

Water Quality Results

The field and laboratory results for the monitoring portion of this project are presented in Appendix F. In the data tables, some results are qualified with symbols or codes. These symbols, commonly referred to as qualifiers, contain important information about that result. A list of data qualifiers is included in Appendix C.

Comparison to water quality standards

The water quality standards classification for Bunker and Deep creeks is Class A Freshwater. Sample results were compared to all applicable water quality standards including standards for pH, temperature, dissolved oxygen, turbidity, fecal coliform, and ammonia-nitrogen.

Field parameters

For pH and temperature, there were a few isolated periods on Deep Creek where pH fell below the standard, and on Bunker Creek where temperature exceeded the criterion (Table 9).

All sites had numerous summer season violations of the dissolved oxygen standard, with none of the sites meeting the standard in August and September. Percent dissolved oxygen saturation values were low for most sites, especially Bunker Creek where in September the percent dissolved oxygen saturation values reached lows from 31-62%.

Table 9. Bunker Creek and Deep Creek sites not meeting pH or temperature water quality standards.

Sites Not Meeting pH Criterion				
Station name	Creek mile	Date	pH (SU)	pH standard (SU)
Deep Creek	CM 4.5	3/22/95 7/12/99	6.3 6.1	6.5-8.5
Deep Creek	CM 3.9	1/10/95	6.4	6.5-8.5
Deep Creek	CM 3.6	12/4/95	6.4	6.5-8.5
Sites Not Meeting Numeric Temperature Criterion				
Station name	Creek mile	Date	Temp (°C)	Temp. standard (°C)
Bunker Creek	CM 0.5	8/30/94	18.6	≤ 18

Laboratory parameters

For the time periods monitored in this study, all sites met the ammonia-nitrogen standards. To determine compliance with the water quality standard for turbidity, turbidity must be compared to a background site. For the purposes of this study, the station immediately upstream was used as background. Results for Deep CM 4.5 and Bunker CM 0.5 were excluded from comparison due to the lack of a background site for those stations. Deep CM 3.9, 3.6, and 2.4 had wet season turbidity violations. Turbidity violations are included in Table 10.

Table 10. Deep Creek sites not meeting the turbidity standard.

Creek station	Date	NTUs above background
Deep CM 3.9	2/9/96	20
	12/27/98	17
	1/28/99	20
Deep CM 3.6	1/29/95	7
	3/9/95	23
	2/6/96	60
	11/13/96	11
	12/1/98	7
	12/27/98	20
Deep CM 2.4	2/21/95	9
	11/7/95	25
	1/22/96	8
	11/13/96	17
	11/25/96	6
	1/7/97	6
	2/12/97	9
	2/19/97	7
	12/1/98	15
	12/27/98	30
	2/22/99	11

During the 1994-95 winter season sampling, all sites met fecal coliform standards. After the 1994-95 wet season, fecal coliform sampling in Deep Creek was confined to the dry season which is the most critical period for this parameter at these sites. None of the sites met the fecal coliform standard for all years sampled. Table 11 describes compliance with the fecal coliform standard for all sites and during each season sampled.

Table 11. Bunker Creek and Deep Creek compliance with fecal coliform standards.

	Deep CM 4.5			Deep CM 3.9			Deep CM 3.6			Deep CM 2.4			Bunker CM 0.5		
	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard	Geom. mean below 100cfu/ 100mL	10% or less of all samples do not exceed 200cfu/ 100mL	Meets water quality stan-dard
Wet Season 1994-95				8	0 of 10 > 200	Yes	11	0 of 10 > 200	Yes	31	0 of 10 > 200	Yes	59	1 of 10 > 200	Yes
Dry Season 1995				70	0 of 2 > 200	Yes	225	2 of 2 > 200	NO	1608	3 of 3 > 200	NO	79	0 of 2 >200	Yes
Dry Season 1996				55	0 of 3 > 200	Yes	87	0 of 3 > 200	Yes	69	0 of 3 > 200	Yes	83	1 of 3 > 200	NO*
Dry Season 1997				107	1 of 3 > 200	NO	61	0 of 3 > 200	Yes	318	2 of 3 > 200	NO	108	1 of 3 > 200	NO
Wet Season 1998-99													119	3 of 9 > 200	NO
Dry Season 1999	68	1 of 3 > 200	NO*	25	0 of 3 > 200	Yes	215	1 of 3 > 200	NO	614	3 of 3 > 200	NO	66	0 of 3 >200	Yes

* Sites not meeting water quality standards according to this table are not automatically placed on Ecology's 303(d) list. Listing criteria are currently being revised; draft guidance is available on Ecology's web site at http://www.ecy.wa.gov/programs/wq/wqhome.html. Generally one sample exceedance is not sufficient for 303(d) listing.

TMDL compliance

In the *Upper Chehalis River Dry Season TMDL Study*, Pickett (1994b) determined that a 91% reduction of ammonia-nitrogen (lb/day) and a 73% reduction in BOD_5 load (lb/day) were necessary in Bunker Creek to meet the proposed load allocations in the TMDL.

The dry season TMDL set the ammonia-nitrogen load allocation for Bunker Creek at 0.005 lb/day. Figure 9 presents the average dry season ammonia-nitrogen loading, where available, for Bunker and Deep creeks. Bunker Creek did not meet the ammonia-nitrogen load allocation set in the TMDL for any of the years sampled, with values an order or two in magnitude greater than the TMDL limit.

The dry season TMDL recommended BOD_5 limits to improve dissolved oxygen levels in Bunker Creek. Sampling was conducted for BOD_5 at Bunker Creek. All values were less than the detection limit of 2-4 mg/L. Detection limits for this parameter were not adequate to address whether or not the TMDL limit of 0.4 lb/day BOD_5 had been achieved.

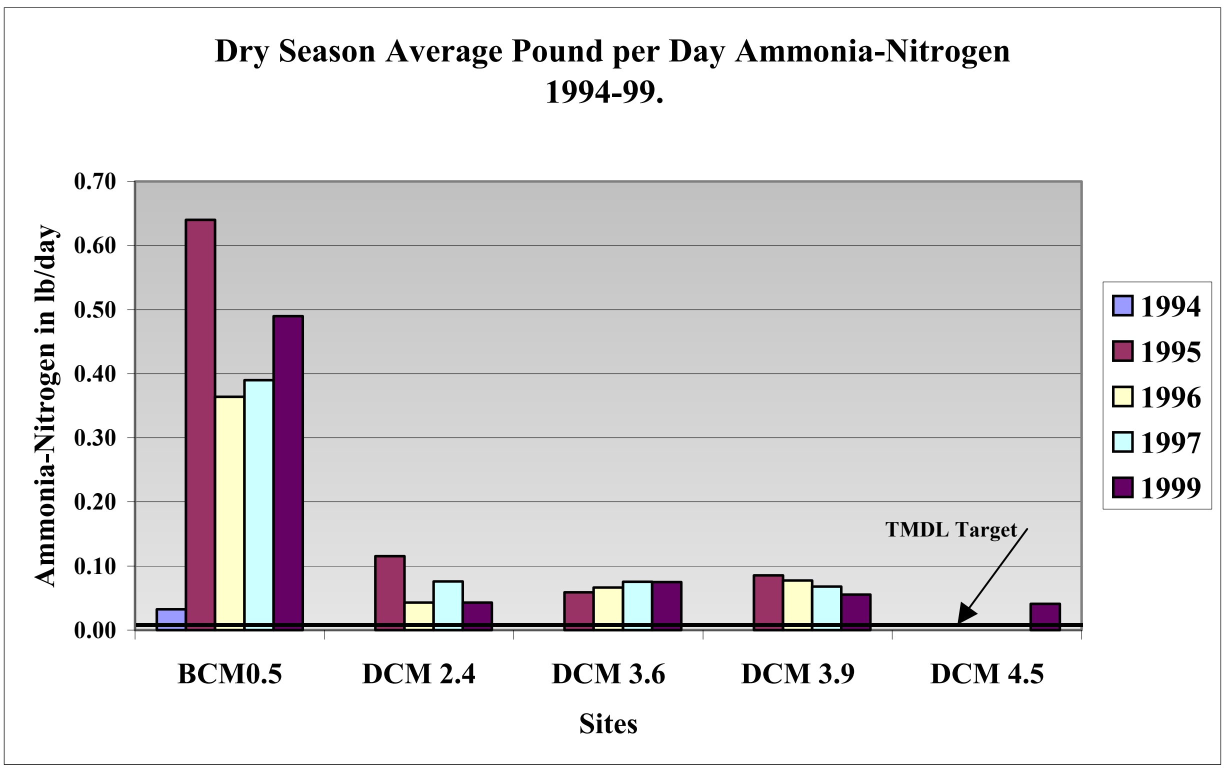

Figure 9. Average dry season ammonia-nitrogen loading for Bunker Creek and Deep Creek, 1994-99 (no sampling conducted in 1998).

Data analysis

A nonparametric Kruskal-Wallis test was done to compare dry season fecal coliform and nitrogen concentrations from 1995, 1996, 1997, and 1999. The only site to show significant differences in fecal coliform concentrations was Deep CM 2.4. Reductions in fecal coliform from 1995 were seen there in 1996. This improvement was probably due to fencing to exclude livestock and to a decrease in herd size that year (Sargeant, 1997b). After 1996 fecal coliform levels at Deep CM 2.4 increased (Figure 10). These increases may be due to poor management of the cattle crossing or to an increase in herd size at this site. It may also be due to increases in fecal coliform levels at upstream sites, not 1999 fecal coliform increases at Deep CM 3.6.

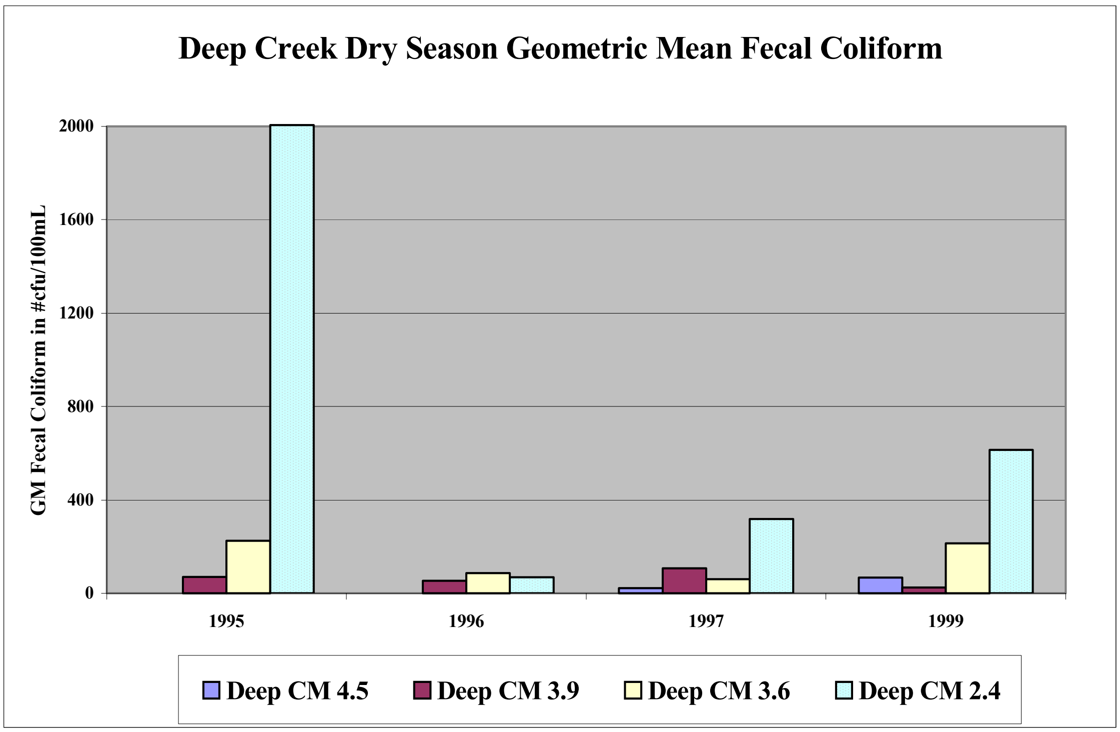

Figure 10. Dry season fecal coliform levels for Deep Creek.

Trend analysis was conducted on wet season turbidity, total suspended solids, and dry season nitrate/nitrite, ammonia-nitrogen, and total persulfate nitrogen for the stations at Deep CM 2.4, 3.6, 3.9, 4.5. No significant changes over time were detected in any of the variables at any station.

Discussion

The upstream sites had a few pH and dissolved oxygen violations. The Deep Creek watershed above CM 4.5 is primarily coniferous forest. Streams that drain coniferous forest are usually slightly acidic (Allan, 1995). Slightly depressed oxygen levels can be caused by natural conditions such as decomposition of leaf/needle material in the creek or wetlands upstream. However, in 1994 dissolved oxygen saturation levels were well below 90% at Beaver CM 4.2 and 2.5, and Allen Creek, indicating possible pollution sources upstream.

Most sites had problems meeting water quality standards for fecal coliform and dissolved oxygen during the dry season, and turbidity during the wet season. The TMDL targets for reductions in ammonia-nitrogen and increases in dissolved oxygen are not being met.

The BMPs installed at Deep CM 2.4 had some initial effect in reducing fecal coliform upstream. However, in the following years fecal coliform levels increased, probably due to lack of BMP maintenance and/or an increase in herd size. No other water quality improvements due to BMP implementation were seen.

The major wet season water quality problem on Deep Creek is high-suspended sediment levels during the winter season. At all Bunker and Deep creek sites, bank sloughing and bank erosion was observed. Bank erosion can occur when animals graze directly on streambanks. Mass wasting from trampling, hoof slide, and streambank collapse cause soil to move directly into the stream. Excessive grazing on streamside vegetation reduces the ability of vegetation to protect streambanks and trap sediments (EPA, 1993).

Other factors may also reduce streambank stability. High run-off flows can also contribute to bank erosion (EPA, 1993). In Bunker and Deep creeks, winter and summer flows are extremely variable with average summer flows <1.1 cfs and rain event flows averaging between 60-88 cfs at Deep CM 2.4. The streambank may be contributing sediment to the creek via high winter flows.

Upstream forest management practices could be the cause of higher winter and lower dry season flows by a variety of mechanisms. These include the following (MacDonald et al., 1991):

- Road-building (due to both the impervious surface and the interruption of subsurface lateral flow).
- Reduction of infiltration rates and soil moisture storage capacity by compaction.
- Reduced rain and snow interception due to removal of the forest canopy.
- Higher soil moisture levels due to the reduction of evapotranspiration.
- Any changes in the timing of flows that result in a synchronization of previously unsynchronized flows.

Conclusions and Recommendations

- Implementation of BMPs in the Deep Creek watershed did not have a measurable effect on improving water quality in Deep Creek or Bunker Creek.
- Ensure currently installed BMPs are being maintained.
- Evaluate the stream channel for causes of streambank erosion, and implement appropriate BMPs.

3. Berwick Creek and Dillenbaugh Creek BMP Evaluation

Site Description

Berwick Creek is located in Lewis County approximately two miles southeast of the town of Chehalis in the upper Chehalis basin. This 7.1 mile long creek is a tributary to Dillenbaugh Creek, which drains to the Chehalis River.

The study area for this project includes the lower five miles of Berwick Creek (Figure 11). Primary land uses in the area include industry in the lower basin, and agriculture, rural residential, and forestry in the upper basin. A number of dairies are adjacent to Berwick Creek as well as livestock rearing operations. Both Dillenbaugh and Berwick creeks have good facilities for spawning Coho salmon; however, agricultural pollution has caused kills of Coho fingerlings in both creeks (Lewis County Conservation District, 1995).

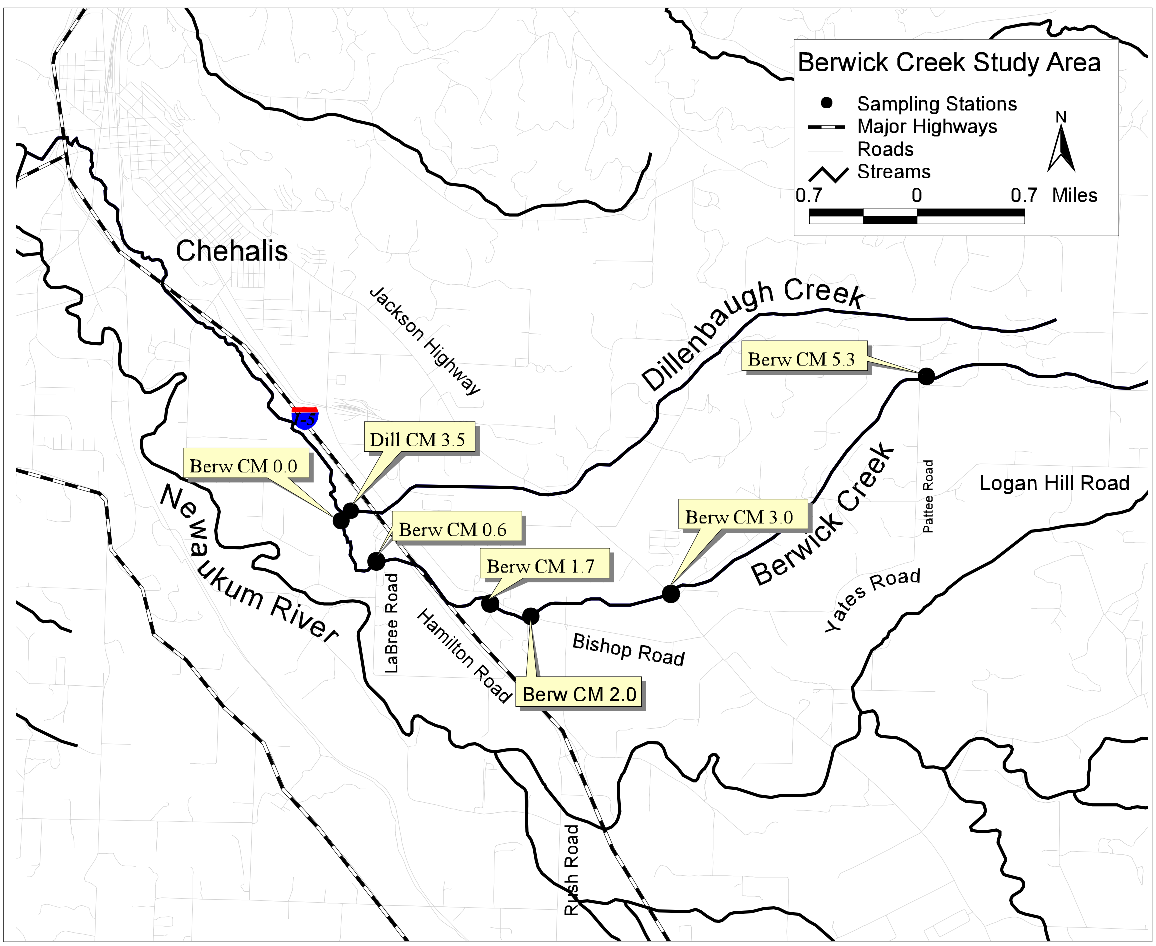

Figure 11. Sampling sites for Berwick Creek and Dillenbaugh Creek.

Historical Data

In 1991 and 1992, Ecology conducted a dry season TMDL study of the Upper Chehalis River (Pickett, 1994b). Dillenbaugh and Berwick creeks were sampled twice on July 7 and August 5, 1992. Dillenbaugh Creek near LaBree Road (CM 0.6) was sampled. This site had relatively good water quality, but high fecal coliform values of 220 and 250 cfu/100mL. Berwick Creek at Hamilton Road also was sampled. This site had poor water quality, with dissolved oxygen values below 8.0 mg/L, high total persulfate nitrogen values of 0.785 and 2.26 mg/L, and high fecal coliform values of 700 and 3100 cfu/100mL.

The Lewis County Conservation District (LCCD) collected weekly water quality data from May 1994 through April 1995 before Berwick Creek BMPs were implemented. The data were collected for 21 sites on three watercourses: Berwick Creek, Dillenbaugh Creek, and another tributary to Dillenbaugh Creek, the Dilly-Twig tributary. Weekly measurements for pH, conductivity, total dissolved solids, dissolved oxygen, and turbidity were obtained using field meters. Fecal coliform samples were collected and sent to the Lewis County Environmental Health Laboratory for analysis approximately once each month. Flows were collected at two Berwick Creek sites one day after water quality data were collected. Results are available in the *Dillenbaugh Creek Model Watershed Management Plan* (Brummer, 1995). It is important to note that data were collected once each week without regard to precipitation or weather events. Quality assurance measures for the LCCD are available in the QA project plan (Bordin, 1993).

Best Management Practices

From 1994 through 1996, the LCCD implemented BMPs on properties adjacent to Berwick Creek as part of the Chehalis Fisheries Restoration Program (CFRP). Land uses and BMPs are described below.

Upstream Berwick CM 5.3

The Berwick Creek station at CM 5.3 is the north tributary to Berwick Creek, joining the south tributary 0.4 miles downstream of this site. This station was chosen as a background station because conditions upstream represent the most natural conditions in this sub-basin, second or third growth coniferous forest. Between the August 12 and September 13, 1999 sampling, property on the right bank upstream of the monitoring station was logged with a 10-15 foot buffer left along the right bank. The LCCD did not implement any BMPs above this site.

Berwick CM 5.3 - 3.0

The area between CM 5.3 and 3.0 is largely rural. Just upstream of CM 3.0 is a sheep pasture. In 1995, 1000 feet of fence and an off-channel alcove were constructed along the creek (Amrine, 2000). Additionally, approximately one acre of native trees and shrubs were planted in the riparian area.

Berwick CM 3.0 - 2.0

The area between CM 3.0 and 2.0 is rural, but specific land uses are unknown. No BMPs were implemented under the CFRP in this area.

Berwick CM 2.0 - 1.7

A large dairy operation with a few horses is located between CM 2.0 and 1.7. While no new BMPs were implemented under the CFRP, the creek in this area is fenced and a pasture pump for watering animals is in place.

Berwick CM 1.7 - 0.6

The area between CM 1.7 and 0.6 is rural residential with some industrial facilities located at the downstream end. A number of BMPs were implemented in this stretch. In 1994, 1625 feet of fencing and two limited access livestock watering sites were constructed. Additionally, a pasture pump was installed, and approximately 1/3 acre of native trees and shrubs were planted in the riparian area. In 1996, 1040 feet of fencing, a limited access livestock watering site, and an off-channel alcove were constructed. Two-thirds of an acre of native trees and shrubs were planted in the riparian area.

Berwick CM 0.6 - 0.0

A large dairy operation occupies the creek stretch downstream of CM 0.6. No new BMPs were implemented under the CFRP; however, the owner of the dairy has an approved farm plan with the conservation district. The dairy has a waste storage pond, and the creek is fenced with a ten-foot buffer along both sides of the stream bank.

During the 1999 dry-season sampling, it was noted that fecal coliform levels increased dramatically between CM 0.6 and 0.0. In September 1999, an Ecology dairy waste inspector and field investigator conducted an inspection of the dairy including a more intensive sampling of the creek. The inspection showed that waste management practices were generally good, but animals had been accessing the creek through the fence. The fencing problems were subsequently corrected.

Water Quality Results

The field and laboratory results for the post-BMP monitoring portion of this project are presented in Appendix G. In the data tables, some results are qualified with symbols or codes. These symbols, commonly referred to as qualifiers, contain important information about that result. A list of data qualifiers is included in Appendix C.

Comparison to water quality standards

The water quality standards classification for Berwick and Dillenbaugh creeks is Class A Freshwater. Sample results were compared to all applicable water quality standards including standards for pH, temperature, dissolved oxygen, turbidity, fecal coliform, and ammonia-nitrogen.

Field parameters

During the wet season, all sites met water quality standards for temperature. However, during the dry season there were a few violations of the numeric temperature criterion described in Table 12.

During wet-season sampling, there were a few isolated pH readings that fell below the standards (Table 12). pH at the uppermost site fell below pH standards several times during the wet and dry-season sampling.

Table 12. Berwick Creek and Dillenbaugh Creek sites not meeting pH, temperature, or dissolved oxygen water quality standards.

Sites Not Meeting pH Standards				
Station name	Site code	Date	pH (SU)	pH standard (SU)
Berwick Cr at Pattee Road	CM 5.3	1/10/00	6.3	6.5-8.5
Berwick Cr at Pattee Road	CM 5.3	2/01/00	5.3	6.5-8.5
Berwick Cr at Pattee Road	CM 5.3	2/08/00	5.7	6.5-8.5
Berwick Cr at Pattee Road	CM 5.3	2/15/00	6.1	6.5-8.5
Berwick Cr at Pattee Road	CM 5.3	3/15/00	6.4	6.5-8.5
Berwick Cr at Pattee Road	CM 5.3	7/5/00	6.3	6.5-8.5
Berwick Cr at Pattee Road	CM 5.3	8/7/00	5.9	6.5-8.5
Berwick Cr at Borovec Road	CM 1.7	2/8/00	6.0	6.5-8.5
Berwick Cr at LaBree Road	CM 0.6	12/28/98	6.4	6.5-8.5
Berwick Cr (mouth)	CM 0.0	3/30/99	6.4	6.5-8.5
Dillenbaugh Cr (above Berwick)	CM 3.5	12/1/98	6.2	6.5-8.5
Sites Not Meeting Numeric Temperature Criterion				
Station name	Site code	Date	Temp (°C)	Temp standard (°C)
Berwick Cr at Jackson Hwy	CM 3.0	6/14/99	18.3	≤ 18°C
Berwick Cr at Bishop Road	CM 2.0	6/14/99 7/12/99	18.6°C 18.9°C	≤ 18°C
Dillenbaugh Cr above Berwick	CM 3.5	8/7/00	18.5°C	≤ 18°C
Sites Not Meeting Dissolved Oxygen Standards				
Station name	Site code	Date	DO (mg/L)	DO standard (mg/L)
Berwick Cr at LaBree Road	CM 0.6	8/7/00	7.9	> 8.0
Berwick Cr (mouth)	CM 0.0	7/12/99 8/11/99 9/13/99 8/7/00	7.3 6.6 6.5 7.5	> 8.0

Dissolved oxygen sampling was conducted during the dry season. For Berwick and Dillenbaugh creeks, dissolved oxygen should be greater than 8.0 mg/L. The four upstream sites on Berwick Creek and Dillenbaugh Creek met standards during all sample events. Berwick CM 0.6 did not meet standards one time on August 7, 2000 with dissolved oxygen of 7.9 mg/L. The mouth of Berwick had the most dissolved oxygen violations, with dissolved oxygen concentrations below 8 mg/L during four of eight sampling events. Three of eight dissolved oxygen violations occurred in 1999 when fecal coliform levels were higher. Table 9 includes dissolved oxygen violations.

Figure 12 presents dissolved oxygen mean percent saturation by site and year. Percent dissolved oxygen saturation generally decreases downstream. A 13% increase in dissolved oxygen saturation is seen at Berwick CM 0.0 from 1999 to 2000, again with a corresponding decrease in fecal coliform.

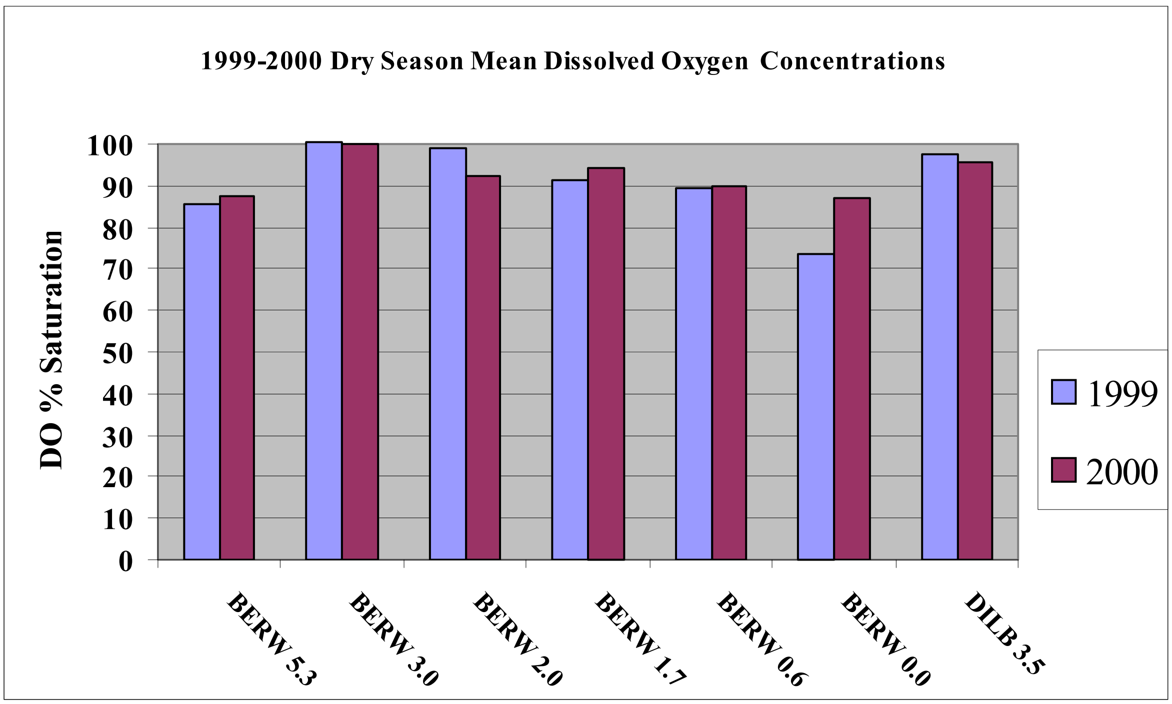

Figure 12. Dissolved oxygen average percent saturation by site for Berwick Creek and Dillenbaugh Creek, 1999-2000.

Laboratory parameters

For the time periods monitored in this study, all sites met the ammonia-nitrogen standard.

To determine compliance with the water quality standard for turbidity, turbidity must be compared to a background site. For the purposes of this study, the station immediately upstream was used as background. Results for Berwick Creek at CM 5.3 and 3.0, and Dillenbaugh Creek, were excluded from comparison due to the lack of a background site for those stations. Berwick Creek at CM 2.0 had numerous turbidity violations during the dry and wet season. It is unusual that five of the 11 turbidity violations seen at CM 2.0, and two of the three at CM 0.0, were during the dry season. Usually higher turbidity levels are triggered by run-off events, but for the dry-season sampling where violations were seen, little or no rainfall occurred within the previous 24 hours. Turbidity violations are included in Table 13.

Table 13. Berwick Creek sites not meeting the turbidity standard.

Station name	Site code	Date	NTUs above background
Berwick Creek at Bishop Road	CM 2.0	12/01/98	6
		12/28/98	13
		03/03/99	6
		6/14/99	15
		7/12/99	11
		9/13/99	9
		11/30/99	6
		01/04/00	6
		02/01/00	6
		6/20/00	13
		7/5/00	12
Berwick Creek at Borovec Road	CM 1.7	8/11/99	7
Berwick Creek (mouth)	CM 0.0	8/11/99	10
		9/13/99	11
		11/30/99	6

For fecal coliform, Berwick CM 5.3 was the only site to meet water quality standards for both years and seasons. Table 14 presents a comparison of all sites to the fecal coliform standard during the wet and dry seasons, for both the 1998-99 and 1999-2000 sampling periods.

TMDL compliance

In the *Upper Chehalis River Dry Season TMDL Study,* Pickett (1994b) determined that a 99% reduction of ammonia-nitrogen (lb/day) and an 89% reduction in BOD_5 load (lb/day) were necessary in Dillenbaugh Creek to meet the proposed load allocations in the TMDL. Dry season Dillenbaugh Creek ammonia-nitrogen data obtained were compared to the TMDL target of 0.01 lb/day of ammonia-nitrogen. Dillenbaugh Creek did not meet the ammonia-nitrogen load allocation set in the TMDL for either year sampled. No 5-day biological oxygen demand data were obtained for this study.

Table 14. Berwick Creek and Dillenbaugh Creek compliance with fecal coliform standards.

Site	Geometric mean below 100cfu/ 100 mL	10% or less of all samples do not exceed 200cfu/100 mL	Meets water quality standards	Geometric mean below 100cfu/ 100 mL	10% or less of all samples do not exceed 200cfu/100 mL	Meets water quality standards	Geometric mean below 100cfu/ 100 mL	10% or less of all samples do not exceed 200cfu/100 mL	Meets water quality standards
	Annual Results November 1998 - September 1999			Wet Season Results November 1998 - March 1999			Wet Season Results June-September 1999		
BerCM 5.3	12	0 of 11 > 200	Yes	14	0 of 7 > 200	Yes	10	0 of 4 > 200	Yes
BerCM 3.0	104	6 of 11 > 200	NO	57	2 of 7 > 200	NO	294	4 of 4 > 200	NO
BerCM 2.0	213	4 of 11 > 200	NO	84	0 of 7 > 200	Yes	1088	4 of 4 > 200	NO
BerCM 1.7	333	6 of 11 > 200	NO	125	2 of 7 > 200	NO	1855	4 of 4 > 200	NO
BerCM 0.6	200	5 of 11 > 200	NO	165	3 of 7 > 200	NO	279	2 of 4 > 200	NO
BerCM 0.0	1003	6 of 10 > 200	NO	163	2 of 6 > 200	NO	15367	4 of 4 > 200	NO
DilCM 3.5	93	1 of 11> 200	Yes	98	1 of 7 > 200	NO*	85	0 of 4> 200	Yes
	Annual Results November 1999 - September 2000			Wet Season Results November 1999 - March 2000			Dry Season Results June-September 2000		
BerCM 5.3	13	1 of 14 > 200	Yes	12	1 of 10 > 200	Yes	17	0 of 4 > 200	Yes
BerCM 3.0	81	7 of 14 > 200	NO	50	3 of 10 > 200	NO	272	4 of 4 > 200	NO
BerCM 2.0	194	8 of 14 > 200	NO	128	5 of 10 > 200	NO	548	3 of 4 > 200	NO
BerCM 1.7	195	7 of 14 > 200	NO	157	5 of 10 > 200	NO	339	2 of 4 > 200	NO
BerCM 0.6	240	10 of 14 > 200	NO	195	6 of 10 > 200	NO	404	4 of 4 > 200	NO
BerCM 0.0	327	9 of 14 > 200	NO	384	7 of 10 > 200	NO	219	2 of 4 > 200	NO
DilCM 3.5	86	2 of 14> 200	NO	87	2 of 10 > 200	NO	83	0 of 4> 200	Yes

* Sites not meeting water quality standards according to this table are not automatically placed on Ecology's 303(d) list. Listing criteria are currently being revised; draft guidance is available on Ecology's web site at http://www.ecy.wa.gov/programs/wq/wqhome.html. Generally one sample exceedance is not sufficient for 303(d) listing.

Data analysis

Paired t-tests for dry season nitrogen data showed statistically significant increases downstream in ammonia-nitrogen between Berwick CM 3.0 and 2.0, and Berwick CM 0.6 and 0.0. Berwick CM 0.6 to 0.0 also had significant increases in total persulfate nitrogen. Results of the t-tests are included in Table 15. Bolded areas indicate a significant difference between sites.

Table 15. Berwick Creek results of paired t-test for ammonia-nitrogen and persulfate nitrogen concentrations.

Monitoring sites	Ammonia-nitrogen (P(T<=t) two-tailed)		Total persulfate nitrogen (P(T<=t) two-tailed)	
Berwick CM 5.3 and 3.0	0.13 (CM 3.0 higher)	n=8	0.47	n=7
Berwick CM 3.0 and 2.0	**0.00 (CM 2.0 higher)**	**n=8**	0.06 (CM 2.0 higher)	n=7
Berwick CM 2.0 and 1.7	0.45	n=8	0.88	n=7
Berwick CM 1.7 and 0.6	0.43	n=8	0.32	n=7
Berwick CM 0.6 and 0.0	**0.03 (CM 0.0 higher)**	**n=8**	**0.00 (CM 0.0 higher)**	**n=10**

For the 1998-2000 data set, paired t-tests (n=24) showed a significant increase in turbidity from Berwick CM 3.0 to 2.0, with an average turbidity of 9.6 and 15.4 NTUs respectively. There was also a significant increase in turbidity between Berwick CM 0.6 and 0.0, with a mean turbidity of 14.3 and 17.3 NTU respectively.

Comparisons were made of both wet and dry season fecal coliform concentrations for upstream to downstream stations using paired t-tests. Results of the t-tests are included in Table 16. Bolded areas indicate a significant difference in fecal coliform concentrations.

Table 16. Berwick Creek results of paired t-test for fecal coliform concentration.

Monitoring sites	Fecal coliform concentration Wet season (P(T<=t) two-tailed)		Fecal coliform concentration Dry season (P(T<=t) two-tailed)	
Berwick CM 5.3 and 3.0	**0.00 (CM 3.0 higher)**	**n=17**	**0.00 (CM 3.0 higher)**	**n=8**
Berwick CM 3.0 and 2.0	**0.05 (CM 2.0 higher)**	**n=17**	0.07 (CM 2.0 higher)	n=8
Berwick CM 2.0 and 1.7	**0.03 (CM 1.7 higher)**	**n=17**	0.45	n=8
Berwick CM 1.7 and 0.6	0.30	n=17	0.15	n=8
Berwick CM 0.6 and 0.0	0.22	n=16	0.08 (CM 0.0 higher)	n=8

Fecal coliform loading levels for the wet and dry seasons are presented in Figures 13 and 14. As expected, loading was much lower in the dry season, except for the 1999 dry season loading at the mouth of Berwick Creek. During the wet season, fecal coliform loading generally increases from upstream to downstream. For 1999-2000, both wet and dry seasons, Berwick Creek contributed more fecal coliform loading to Dillenbaugh Creek than the upstream loading contributions from Dillenbaugh Creek. Conversely, flow from Dillenbaugh Creek upstream was from 65% (wet season) to 200% (dry season) greater than flows from Berwick Creek

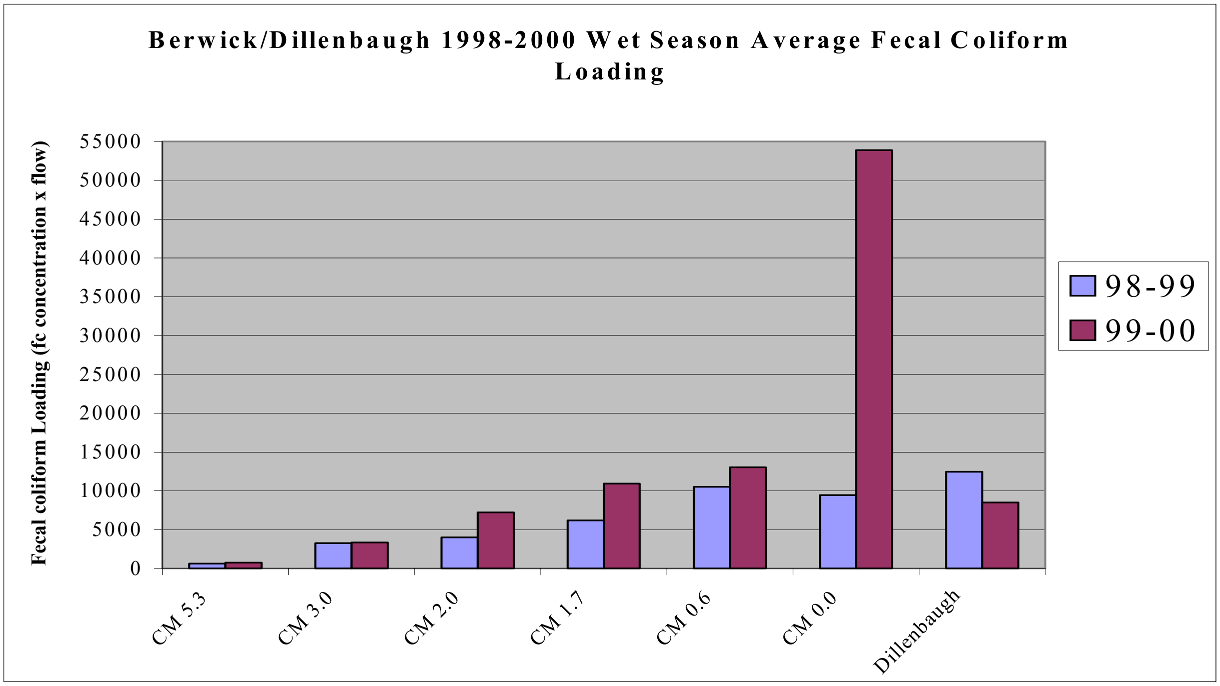

Figure 13. Wet season average fecal coliform loading for Berwick Creek and Dillenbaugh Creek, 1998-2000.

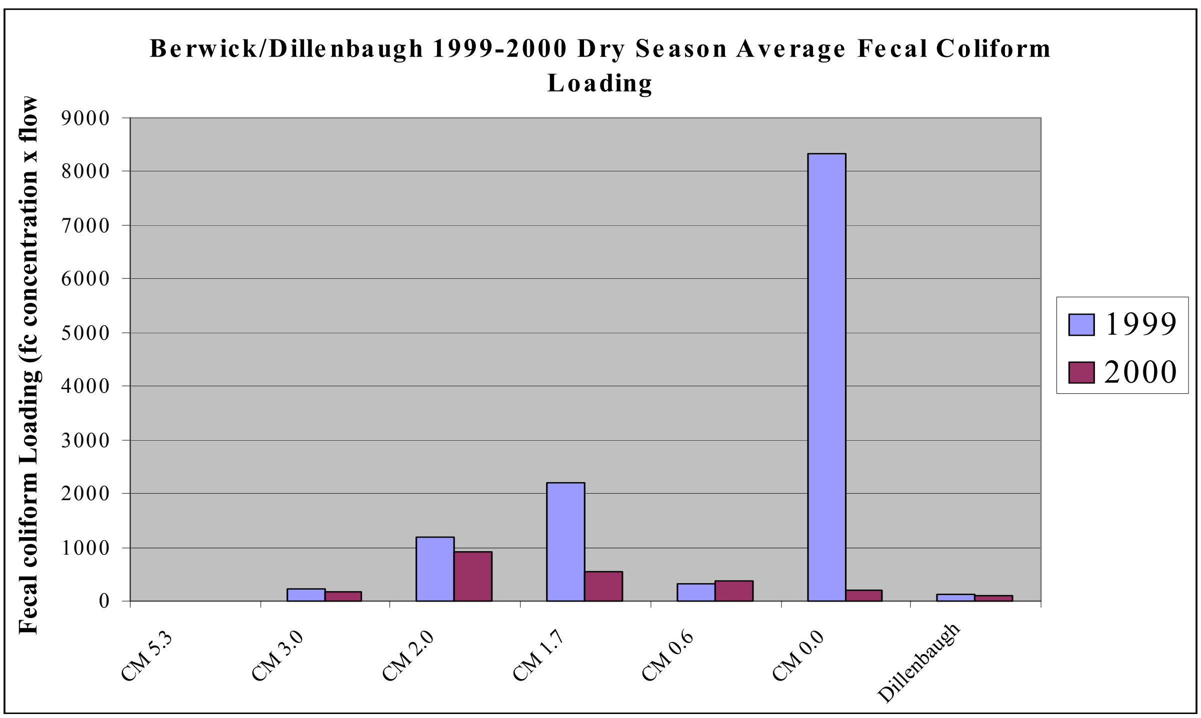

Figure 14. Dry season average fecal coliform loading for Berwick Creek and Dillenbaugh Creek, 1999-2000.

The Berwick Creek sites at CM 5.3, 3.0, 2.0, 1.7, 0.6, and 0.0 were compared to historical water quality data collected by the Lewis County Conservation District (LCCD). No statistically significant improvements occurred in either fecal coliform concentrations or turbidity levels between the Ecology and the LCCD studies. However, at Berwick CM 0.0, statistically significant improvements in fecal coliform levels were seen between 1999 and 2000 (Figure 15).

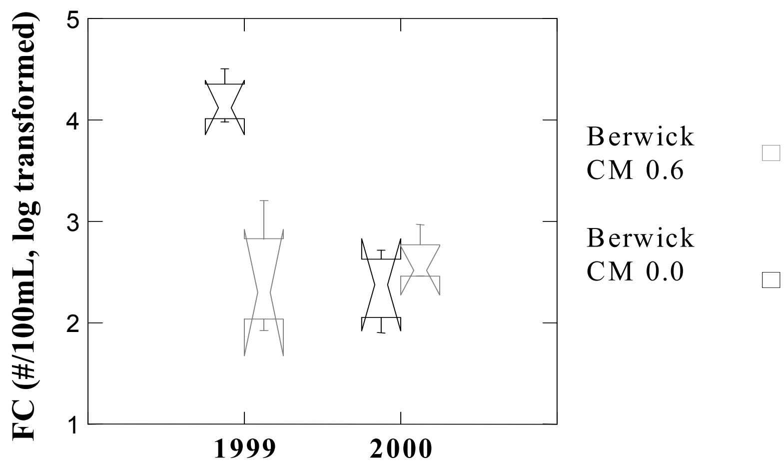

Figure 15. Dry season fecal coliform results between CM 0.6 and CM 0.0 of Berwick Creek, 1999-2000.

Discussion

Water quality at Berwick CM 5.3 was generally good, despite a number of pH violations. Streams that drain coniferous forest are slightly acidic (Allan, 1995). While dissolved oxygen levels met standards at this site, the dissolved oxygen percent saturation levels were below 90%. Slightly depressed oxygen levels can be caused by natural conditions such as decomposition of leaf/needle material in the creek or wetlands upstream. During 1999, elevated ammonia-nitrogen levels were noted while 2000 levels were below detection limits. In 2000, the percent dissolved oxygen saturation level increased slightly.

All sites except Berwick CM 5.3 had problems meeting the fecal coliform bacteria standard. Increases in fecal coliform and nitrogen seen at Berwick CM 3.0 and 2.0 indicate possible waste sources upstream. Turbidity violations were frequent at Berwick CM 2.0 even during the dry season, indicating possible bank erosion problems upstream.

Numerous water quality problems were noted at Berwick CM 0.0 including fecal coliform, ammonia-nitrogen, and total persulfate nitrogen increases from upstream. Fecal coliform increases were not seen during the 1998-99 wet season, but in 1999-2000 levels increased from upstream to downstream.

The dry season was the opposite, with increases in bacteria seen from upstream to downstream in 1999 and significant improvements seen in the 2000 dry season. With improvements in fecal coliform levels, higher dissolved oxygen levels were also seen. There was a statistically significant decrease in fecal coliform concentration between the 1999 dry season and the 2000 dry season after a cattle exclusion gate was repaired to eliminate access to the creek.

While wet season fecal coliform violations were seen at the Dillenbaugh Creek site, water quality was generally better than in Berwick Creek for the parameters sampled. Higher fecal coliform, total persulfate nitrogen, and ammonia-nitrogen concentrations were seen in Berwick Creek. Water quality improvements in Berwick Creek would greatly enhance water quality in Dillenbaugh Creek.

Conclusions and Recommendations

- Evaluate bacterial sources at all sites because of the high frequency of fecal coliform violations, focusing on the season of concern.

- Investigate high turbidity levels between Berwick CM 3.0 and 2.0, possibly due to animal access to the creek.

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Summary Conclusions and Recommendations

Conclusions

All three project areas showed some water quality improvement due to implementation of best management practices (BMPs). At the Beaver Creek dairy, BMP implementation was most effective, with drastic reductions in fecal coliform bacteria and nutrients. In Deep Creek, reductions in fecal coliform levels were detected when cows were fenced out of the creek, and increases in fecal coliform were seen when fencing was not maintained properly. A similar reduction in fecal coliform levels occurred on Berwick Creek when fencing was maintained properly. Therefore, it can be concluded that agricultural BMPs are effective in improving water quality if the BMPs are maintained properly.

While improvements in water quality were detected at BMP sites, other areas within the basin showed degraded water quality. This could be due to changes in land ownership or use.

The very different pre- and post-sampling strategies in Berwick Creek made it difficult to detect water quality changes in this basin. The pre-BMP sampling strategy focused on collecting monthly water quality data, while the post-BMP strategy focused on collecting data during critical water quality periods.

Recommendations

- BMP projects funded by the Chehalis Fisheries Restoration Program should contain a maintenance component.
- BMPs should be implemented on a sub-basin basis.
- A landowner outreach program is needed to inform landowners about BMPs necessary to maintain water quality in their sub-basins.
- A consistent pre- and post-BMP evaluation monitoring strategy is needed to detect changes due to BMP implementation.

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Appendices

Appendix A

Abstracts from Chehalis Best Management Practices Evaluation Project Reports

Chehalis Best Management Practices Evaluation Project Report on the Black River Project Area, Ecology Publication Number 96-325 (Sargeant, 1996a)

This report describes surface water monitoring results for best management practices (BMP) implementation at the Black River Ranch, located in southwestern Thurston County. Sampling was done from river mile (RM) 11.8 to 13.2. Implementation of BMPs occurred from 1991 to 1995, including installation of a waste management system with a solids separator and over-winter storage pond; application of waste at agronomic rates; herd-size reduction; and water conservation practices. The overall study design includes dry season pre\post monitoring and dry and wet season upstream\downstream water quality monitoring. In comparing 1994 dry season results to data collected in 1991 and 1992, the downstream deep water station showed continued improvements in water quality over 1991 conditions, confirming improvements seen in 1992. Dry season levels of conductivity, turbidity, ammonia, total persulfate nitrogen, and total phosphorus have dramatically declined since 1991. The 1994-95 wet season sampling showed higher levels of ammonia, turbidity, and conductivity at a tributary draining the Black River Ranch, in comparison to the two Black River stations. All three sites did not meet fecal coliform criteria. Additional post-BMP monitoring is recommended after BMPs have been implemented long enough to be effective, and on-site soils have recovered.

1995-96 Water Quality Data Report for the Chehalis River Project Area, Ecology Publication Number 96-353 (Sargeant, 1996)

This interim report describes the second year's water quality monitoring results for a site where nonpoint source best management practices (BMPs) will be installed. The site is a dairy located on the east bank of the mainstem Chehalis River at river mile 70.6. The overall study design includes pre- and post-BMP water quality monitoring during the wet season. The Chehalis River upstream and downstream of the BMP site, and one tributary in the vicinity of the BMP site, were monitored. Monitoring results for all stations exceeded water quality standards for fecal coliform. The tributary adjacent to the BMP site had statistically significant higher levels of conductivity, ammonia nitrogen, organic nitrogen, total persulfate nitrogen, and fecal coliform than the two river stations, and significantly lower nitrite/nitrate nitrogen levels. The report recommends that pre-BMP monitoring be concluded and post-BMP monitoring begin after installation of BMPs.

Appendix B

Quality Assurance and Quality Control

Laboratory Data

Laboratory data were generated according to quality assurance/quality control procedures followed by Ecology's Manchester Environmental Laboratory (Ecology, 1994). Manchester Laboratory was used for all laboratory analysis. All general chemistry samples met holding time requirements. Microbiology samples were analyzed within 30 hours, which is standard procedure for Manchester Laboratory. Microbiology samples were not analyzed within the 6-hour window described in Standard Methods (APHA, 1992) because of logistical challenges in collecting and transporting samples within the given timeframe.

Duplicate field samples were used to estimate sampling precision, expressed as the percent coefficient of variation (% CV). Duplicates are two field samples collected at the same site as close as possible in time. The % CV is calculated by dividing the standard deviation by the mean and multiplying by 100. Values below the detection limit were assumed to be the detection limit value.

At levels close to the method detection limit, small differences in duplicate results can generate a large standard deviation and thus a higher % CV. Consequently, it is acceptable for the % CV to be greater at levels close to the method detection limit. Laboratory replicates were arithmetically averaged for quality assurance calculations.

The duplicate results for all three Chehalis BMP evaluation areas were pooled to determine precision. The results for mean % CV for all parameters are shown in Table 1. Sampling for all parameters did not occur at all BMP evaluation areas.

Table 1. Field precision for sampling parameters.

	Number of samples	Average % CV for values
Fecal Coliform	108	13 %
Fecal Coliform (<50cfu/100mL)	36	18 %
Turbidity	54	3 %
Total Suspended Solids	16	9 %
Ammonia-Nitrogen	41	4 %
Nitrite/Nitrate-Nitrogen	41	1 %
Total Persulfate Nitrogen	39	4 %
Total Phosphorus	12	4 %
Dissolved Oxygen (meter)	4	3 %
Dissolved Oxygen (Winkler)	60	< 1 %

Precision for fecal coliform duplicate results should not exceed 50% CV. Of 108 duplicate fecal coliform samples, all duplicates had a CV less than 50%. Considering the variability in bacteria parameters, precision for fecal coliform was very good.

For all other parameters, precision for field duplicate measurement should not exceed 20% CV for results above the reporting limit. For results close to the reporting limit, a higher % CV may be acceptable. All duplicates met the 20% CV requirement except two of 16 total suspended solids samples. Both of these sets of duplicates were close to the reporting limit and were below a CV of 50%. Data quality for all nutrient and turbidity parameters was excellent, and of good quality for total suspended solids.

Data qualifiers were reported with some data as indicated in the appendices. A list of data qualifiers is included in Appendix C. All laboratory data are considered usable, subject to the qualification provided.

Field Data

Field instruments were used to collect pH, conductivity, dissolved oxygen, and temperature measurements. Instruments were calibrated according to the manufacturer's instructions. The pH meters were pre- and post-checked against known standards. The dissolved oxygen meter was checked using the Winkler titration method at Ecology's field laboratory in Lacey. For Berwick Creek, conductivity readings were compared with laboratory conductivity values. For Beaver/Allen and Bunker/Deep creeks, conductivity readings were pre- or post-checked against known standards.

The pH meter did not meet either pre- or post-check requirements (± 0.2 standard pH units), or was not functioning properly, for Berwick Creek on the following dates: March 3, 1999, and February 1, 2000. On December 13, 1999, the meter was recalibrated and functioning after the second sampling station.

The pH meter did not meet either pre- or post-check requirements, or was not functioning properly, for Bunker and Deep creeks on the following dates: November 14, 1994 at the Bunker Creek site; December 27, 1994; February 21, July 12, and November 7, 1995; April 1, July 8, November 25, and December 3, 1996; July 1, 1997; November 16, 1998; and January 28, 1999 at the Deep Creek site.

For Beaver and Allen creeks, pH meter readings did not meet pre- or post-checks, or was not functioning, on the following dates: February 21, November 8, December 10 and 19, 1995; November 25 and December 3, 1996; January 13, March 1, and November 16, 1998.

For Berwick Creek, approximately 10% of conductivity meter readings were compared with laboratory conductivity values. The average CV is 24% with values ranging from 6 to 97%. Conductivity data are considered invalid for the entire sample event when the % CV exceeds 20%. Consequently, conductivity data for the following dates are invalid due to lab checks: March 20, June 12, July 5, and August 7, 2000.

In addition to comparing meter to lab data, calibration data were used to determine the acceptability of field conductivity data. Conductivity meter readings did not meet pre- and/or post-calibration checks (± 20%), or was not functioning for Berwick Creek on March 3 and December 13, 1999, and January 10, 2000, and for Bunker/Allen creeks on August 6, 1996.

During the 1994 dry season, a field meter was used to measure dissolved oxygen on Beaver and Allen creeks and Bunker and Deep creeks. Winkler titrations were used to check the quality of the field data. Field results compared favorably to the Winkler titrations (Table 1), but a more precise measurement was needed. After 1994, Winkler titrations were used to measure dissolved oxygen at all sites. Duplicate field samples were used to estimate sampling precision for the Winkler analysis; results were excellent with the highest CV at 1.8%.

Flow discharge was estimated either by instantaneous flow measurements using a velocity meter and top-set wading rod, or from a flow discharge-rating curve.

Appendix C

Data Qualifiers

Laboratory Data Qualifiers	
U	This analyte was not detected at or above the reporting limit
E	This result is an estimate.
J	This result is an estimate. For bacteria, true value may be greater than or equal to the reported results.
Field Data Qualifiers	
**	For pH and conductivity, meter did not meet quality control requirements or was not functioning.
e	Flows were estimated using a flow discharge-rating curve.
Ee	Flows were estimated by extrapolating the flow value from a flow discharge-rating curve.
E	Flows were estimated using flow-discharge values obtained at the nearest upstream or downstream station. There were no major sources of surface water between the sites.
Ea	Flows were estimated as the sum of flows from Allen Creek and Beaver Creek at Case Road.

Appendix D

Previous Rainfall for Sample Events

Beaver/Allen Creek and Bunker/Deep Creek Previous Rainfall Data.

Rainfall information was obtained from the National Oceanic and Atmospheric Administration (NOAA) gauging station in Olympia, Washington.

Sample Date	Sample Area	Precipitation day of sampling in inches	Preceding 24 hour rainfall in inches	Preceding 48 hour rainfall in inches	Preceding 72 hour rainfall in inches
8/30/94	Bunker/Deep	0	0	0.04	0.04
8/31/94	Bunker/Deep Beaver/Allen	0	0	0	0.04
9/13/94	Beaver/Allen	Trace	0	0	0
9/14/94	Bunker/Deep Beaver/Allen	0.28	Trace	0	0
11/14/94	Bunker/Deep Beaver/Allen	0.10	0.04	0.04	0.05
12/26/94	Beaver/Allen	2.45	0.46	0.47	0.47
12/27/94	Bunker/Deep	1.11	2.45	2.91	2.92
1/10/95	Bunker/Deep Beaver/Allen	0.19	0.38	0.46	0.77
	Beaver/Allen	0.02	0	0	0
1/29/95	Bunker/Deep Beaver/Allen	0.41	0.53	0.53	0.76
2/16/95	Bunker/Deep Beaver/Allen	0.45	0.38	0.39	0.39
2/21/95	Bunker/Deep Beaver/Allen	0	0.07	1.71	3.79
3/9/95	Bunker/Deep Beaver/Allen	1.05	0.72	0.72	0.72
3/14/95	Bunker/Deep Beaver/Allen	0.45	0.32	0.47	0.94
3/22/95	Bunker/Deep Beaver/Allen	0.01	0.49	1.06	1.46
7/12/95	Bunker/Deep	0	0	Trace	1.34
8/14/95	Bunker/Deep	Trace	0	0.02	0.02
11/7/95	Bunker/Deep	1.17	0.86	1.36	1.47
11/8/95	Beaver/Allen	1.13	1.17	2.03	2.53
11/28/95	Beaver/Allen	0.55	1.07	1.18	1.58
12/4/95	Bunker/Deep	Trace	0.37	0.65	1.21
12/10/95	Beaver/Allen	0.76	0.61	0.61	0.61
12/11/95	Bunker/Deep	0.58	0.76	1.37	1.37
12/19/95	Beaver/Allen	0.13	0.13	0.48	0.49
1/3/96	Bunker/Deep	0.11	0.41	0.44	0.45
1/22/96	Bunker/Deep	0.22	0.12	1.12	1.32
2/5/96	Beaver/Allen	1.32	0.06	0.34	0.34
2/6/96	Bunker/Deep	1.95	1.32	1.38	1.66
2/20/96	Bunker/Deep	0.35	0.24	0.66	1.32

Sample Date	Sample Area	Precipitation day of sampling in inches	Preceding 24 hour rainfall in inches	Preceding 48 hour rainfall in inches	Preceding 72 hour rainfall in inches
3/4/96	Bunker/Deep	0.33	0.49	0.49	0.49
3/11/96	Bunker/Deep	0.07	0.24	0.48	0.5
4/1/96	Bunker/Deep	0.32	0.21	0.21	0.35
7/8/96	Bunker/Deep	0	0	0	0
8/6/96	Bunker/Deep	0	0.03	0.09	0.09
9/11/96	Bunker/Deep	0	0	0	0.03
11/13/96	Bunker/Deep Beaver/Allen	0.17	0.39	0.56	0.56
11/25/96	Bunker/Deep Beaver/Allen	0.25	0.28	0.95	0.95
12/3/96	Bunker/Deep Beaver/Allen	0	0.56	0.82	1.05
12/9/96	Bunker/Deep Beaver/Allen	0.09	0.34	0.73	0.96
1/7/97	Bunker/Deep Beaver/Allen	0.04	1.01	1.01	1.25
1/28/97	Bunker/Deep Beaver/Allen	0.17	0.51	0.51	0.51
2/12/97	Bunker/Deep Beaver/Allen	0.37	0.64	0.64	0.64
2/19/97	Bunker/Deep Beaver/Allen	0.65	1.06	1.31	1.42
3/3/97	Bunker/Deep Beaver/Allen	0.17	0.82	2.05	2.21
3/10/97	Bunker/Deep Beaver/Allen	Trace	0.67	0.85	1.31
7/1/97	Bunker/Deep	0	0.02	0.04	0.28
8/5/97	Bunker/Deep	Trace	0	Trace	0
9/8/97	Bunker/Deep	0	0	0	0
11/16/97	Bunker/Deep	0.21	0.01	0.01	0.01
11/18/97	Beaver/Allen	0.04	0.99	1.20	1.21
11/30/97	Beaver/Allen	0.18	0.53	1.05	1.06
12/16/97	Beaver/Allen	2.57	0.5	0.50	0.50
1/6/98	Beaver/Allen	0.66	1.46	1.61	1.70
1/13/98	Beaver/Allen	0.54	0.06	0.34	0.34
2/22/98	Beaver/Allen	0.2	0.58	0.79	0.89
3/1/98	Beaver/Allen	0.72	0.63	0.63	0.63
3/9/98	Beaver/Allen	1.02	0.46	0.48	0.48
3/23/98	Beaver/Allen	1.09	0.32	0.63	0.63
11/16/98	Bunker/Deep Beaver/Allen	0	0.56	0.90	3.49
12/1/98	Bunker/Deep	1.76	0.52	0.86	0.86
12/2/98	Beaver/Allen	0.33	1.76	2.28	2.62
12/8/98	Bunker/Deep	0.13	1.13	1.18	1.27
12/27/98	Bunker/Deep Beaver/Allen	2.58	0.31	1.53	2.01

Sample Date	Sample Area	Precipitation day of sampling in inches	Preceding 24 hour rainfall in inches	Preceding 48 hour rainfall in inches	Preceding 72 hour rainfall in inches
1/28/99	Bunker/Deep Beaver/Allen	2.25	1.32	1.35	1.35
2/16/99	Beaver/Allen	0.76	0.14	0.14	0.25
2/17/99	Bunker/Deep	0.27	0.76	0.90	0.90
2/22/99	Bunker/Deep	1.17	0.25	0.44	0.57
3/14/99	Bunker/Deep	0.19	0.45	1.34	1.34
3/30/99	Bunker/Deep	0.02	0.51	1.13	1.29
7/12/99	Bunker/Deep	0	0	0	0
8/11/99	Bunker/Deep	0	0	0	0
9/13/99	Bunker/Deep	0	Trace	0	0

Berwick/Dillenbaugh Creek Previous Rainfall Data.

Rainfall information was obtained from the National Oceanic and Atmospheric Administration (NOAA) gauging station in Chehalis, Washington.

Sample Date	Precipitation day of sampling in inches	Preceding 24 hour rainfall in inches	Preceding 48 hour rainfall in inches	Preceding 72 hour rainfall in inches
12/01/98	1.46	0.58	0.64	0.64
12/08/98	0.34	0.64	0.88	1.24
12/28/98	0.1	1.97	2.17	2.77
02/16/99	0.72	0.2	0.2	0.23
03/03/99	0.66	0.44	1.09	1.68
03/14/99	0.1	0.34	0.85	0.85
03/30/99	0.05	0.48	0.95	1.22
06/14/99	0	0.02	0.02	0.02
07/12/99	0	0	0	0
08/11/99	0	0	0	trace
09/13/99	0	0	0	0
11/22/99	0.31	0.1	0.25	0.51
11/30/99	0.16	0.16	0.16	0.31
12/13/99	0.4	0.9	1.32	1.37
01/04/00	0.56	0.22	0.78	1.42
01/10/00	0.58	0.94	1.23	1.3
02/01/00	0.92	0.31	0.31	0.31
02/08/00	0.26	0.33	0.33	0.39
02/15/00	0.09	0.39	0.39	0.52
03/15/00	0.01	0.2	0.53	0.53
03/20/00	Trace	0.2	0.55	0.6
06/20/00	0	0	0	0
07/05/00	0	0	0.41	0.47
08/07/00	0	0	0	0

Appendix E

Beaver Creek and Allen Creek

Field Data, 1994-99
Laboratory Data, 1994-99

Appendix E. 1994-1999 Field Data for Beaver Creek and Allen Creek.
(paired results indicate field duplicate)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Dissolved Oxygen mg/L Winkler	Dissolved Oxygen % Saturation	Flow Discharge cfs
BeCM 4.2	8/31/94	07:50	14.4	7.1	125	4.4		43%	1.3
BeCM 4.2	8/31/94	13:21	14.7		123	4.2		42%	0.8
BeCM 4.2	9/13/94	14:16	13.3	7.1	155	7.6		73%	0.5
BeCM 4.2	9/14/94	10:10	13.7	6.8	149	5.4		52%	0.4
BeCM 4.2	11/14/94	10:14	7.1	6.8	128				5.6
BeCM 4.2	12/26/94	13:01	6.8	6.2	62				79.5 Ee
BeCM 4.2	1/10/95	13:55	5.0	6.4	64				45.5 e
BeCM 4.2	1/25/95	9:55	3.0	6.3	68				25.3
BeCM 4.2	1/29/95	8:05	6.2	7.5	65				31.1
BeCM 4.2	2/16/95	9:00	3.9	7.3	64				28.0
BeCM 4.2	2/21/95	14:55	9.8	**	49				91.9 Ee
BeCM 4.2	3/9/95	8:20	7.0	7.8	57				48.1
BeCM 4.2	3/14/95	9:20	9.1	7.1	50				77.9
BeCM 4.2	3/22/95	12:12	7.3	7.2	52				79.7
BeCM 4.2	11/8/95	9:50	9.6	**	69				80.2 e
BeCM 4.2	11/28/95	13:25	9.8	6.5	45				96.9 Ee
BeCM 4.2	12/10/95	14:05	5.4	**	63				58.8
BeCM 4.2	12/19/95	13:05	7.3	**	61				80.3
BeCM 4.2	2/6/96	9:55	3.0	6.5	55				82.2 Ee
BeCM 4.2	11/13/96	13:15	9.6	6.5	87				13.8
BeCM 4.2	11/25/96	12:30	5.7	**	54				90.5
BeCM 4.2	12/3/96	9:55	4.4	**	57				58.8
BeCM 4.2	12/9/96	8:06	6.4	6.7	57				76.2
BeCM 4.2	1/7/97	9:30	6.0	7.3	51				143.6 Ee
BeCM 4.2	1/28/97	9:40	3.4	6.6	64				62.0
BeCM 4.2	2/12/97	8:50	5.2	6.7	59				50.3
BeCM 4.2	2/19/97	8:45	7.1	6.7	54				107.5
BeCM 4.2	3/3/97	9:55	5.7	6.7	54				81.2 e
BeCM 4.2	3/10/97	10:45	6.8	6.8	54				88.3 e
BeCM 4.2	11/18/97	10:15	7.0	6.4	79				27.0
BeCM 4.2	11/24/97	11:24	8.0	7.1	57				84.8
BeCM 4.2	11/30/97	11:20	7.9	6.7	76				62.1
BeCM 4.2	12/16/97	11:41	6.8	6.7	70				81.6
BeCM 4.2	1/6/98	9:59	5.5	6.7	78				116.4 Ee
BeCM 4.2	1/13/98	13:20	1.5	**	60				72.1
BeCM 4.2	2/22/98	10:14	6.7	7.0	71				47.1
BeCM 4.2	3/1/98	13:35	7.3	**	72				50.1 e
BeCM 4.2	3/9/98	10:15	7.0	6.9	72				43.2
BeCM 4.2	3/23/98	11:20	9.3	6.7	82				51.1
BeCM 4.2	11/16/98	12:00	9.4	**	125				9.3
BeCM 4.2	12/2/98	12:30	6.9	6.4	55				260.0
BeCM 4.2	12/27/98	13:37	4.5	7.0	57				82.4
BeCM 4.2	1/28/99	9:58	4.7	6.7	95				103.1 Ee
BeCM 4.2	2/16/99	9:30	5.6	6.5	66				70.3

** Meter did not meet quality control requirements or was not functioning.

e Flows were estimated using a flow discharge rating curve.

Ee Flows estimated by extrapolating the flow value from a flow discharge rating curve.

Appendix E. 1994-1999 Field Data for Beaver Creek and Allen Creek.
(paired results indicate field duplicate)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Dissolved Oxygen mg/L Winkler	Dissolved Oxygen % Saturation	Flow Discharge cfs
BeCM 2.6T	8/31/94	14:06	14.2	7.2	105	6.2		61%	1.8
BeCM 2.6T	8/31/94	8:06	15.8		110		6.2	63%	1.8
BeCM 2.6T	9/13/94	13:53	13.9	6.8	104	6.3		61%	2.1
BeCM 2.6T	9/14/94	10:43	15.1	6.6	108	5.2		52%	2.0
BeCM 2.6T	11/14/94	11:10	7.5	6.7	112				8.5
BeCM 2.6T	12/26/94	13:40	7.3	6.7	70				69.3 Ee
BeCM 2.6T	1/10/95	14:00	5.7	6.4	75				41.1 e
BeCM 2.6T	1/25/95	10:40	4.3	6.8	79				24.5
BeCM 2.6T	1/29/95	8:45	6.8	7.7	75				28.2
BeCM 2.6T	2/16/95	9:40	4.4	7.4	74				27.4
BeCM 2.6T	2/21/95	15:20	10.1	**	64				64.7 Ee
BeCM 2.6T	3/9/95	9:15	8.3	7.7	71				33.8
BeCM 2.6T	3/14/95	10:05	9.6	7.1	54				45.9
BeCM 2.6T	3/22/95	12:50	8.1	7.1	70				49.0
BeCM 2.6T	11/8/95	10:30	10.6	**	70				38.8
BeCM 2.6T	11/28/95	13:45	10.5	6.7	66				91.5 e
BeCM 2.6T	12/10/95	14:55	6.2	**	71				53.4
BeCM 2.6T	12/19/95	13:50	7.3	**	80				55.6
BeCM 2.6T	2/6/96	10:15	4.7	6.5	74				59.9
BeCM 2.6T	11/13/96	14:45	10.2	6.7	87				14.5
BeCM 2.6T	11/25/96	13:05	6.7	**	80				49.9
BeCM 2.6T	12/3/96	9:30	4.5	**	77				51.6
BeCM 2.6T	12/9/96	8:45	6.4	6.9	70				52.9
BeCM 2.6T	1/7/97	9:50	6.0	7.0	57				113.0 e
BeCM 2.6T	1/28/97	10:05	4.0	7.1	78				45.2
BeCM 2.6T	2/12/97	9:15	5.6	6.7	68				45.9
BeCM 2.6T	2/19/97	9:25	7.1	6.8	68				74.9
BeCM 2.6T	3/3/97	10:15	6.2	6.8	55				52.4 e
BeCM 2.6T	3/10/97	10:50	6.9	6.9	60				57.4 e
BeCM 2.6T	11/18/97	10:56	8.1	6.5	96				26.5
BeCM 2.6T	11/24/97	12:09	8.7	7.0	77				47.1
BeCM 2.6T	11/30/97	12:05	8.2	6.8	80				53.3
BeCM 2.6T	12/16/97	12:38	7.4	6.9	93				64.6 e
BeCM 2.6T	1/6/98	10:14	5.8	6.8	74				79.7
BeCM 2.6T	1/13/98	12:50	2.2	**	76				49.2
BeCM 2.6T	2/22/98	10:49	6.9	7.1	86				43.0
BeCM 2.6T	3/1/98	13:55	8.1	**	78				35.9 e
BeCM 2.6T	3/9/98	10:45	7.7	6.9	88				33.4
BeCM 2.6T	3/23/98	12:08	10.2	6.8	105				32.5
BeCM 2.6T	11/16/98	12:35	9.4	**	109				13.3
BeCM 2.6T	12/2/98	13:00	7.2	6.5	64				133.5
BeCM 2.6T	12/27/98	14:10	5.1	6.7	69				69.0
BeCM 2.6T	1/28/99	10:29	4.6	6.9	55				126.6
BeCM 2.6T	2/16/99	10:00	5.7	6.9	62				58.0

** Meter did not meet quality control requirements or was not functioning.

e Flows were estimated using a flow discharge rating curve.

Ee Flows estimated by extrapolating the flow value from a flow discharge rating curve.

Appendix E. 1994-1999 Field Data for Beaver Creek and Allen Creek.
(paired results indicate field duplicate)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Dissolved Oxygen mg/L Winkler	% Saturation	Flow Discharge cfs
BeCM 2.5	8/31/94	14:32	14.8		116		5.6	56%	3.1
BeCM 2.5	8/31/94	8:48	15.5		115		6.1	61%	2.0
BeCM 2.5	9/13/94	13:30	13.7	6.8	122	5.8		56%	2.1
BeCM 2.5	9/14/94	11:14	14.9	6.6	122	5.2	5.1	51%	1.9
BeCM 2.5	11/14/94	11:43	7.4	5.2	145				22.1
BeCM 2.5	12/26/94	14:00	7.3	7.0	70				148.8 Ea
BeCM 2.5	1/10/95	14:20	5.4	6.5	79				86.6 Ea
BeCM 2.5	1/25/95	11:10	4.1	6.9	81				49.8 Ea
BeCM 2.5	1/29/95	9:10	6.5	7.3	85				59.3 Ea
BeCM 2.5	2/16/95	10:07	4.5	7.3	75				55.4 Ea
BeCM 2.5	2/21/95	15:50	10.1	**	55				156.6 Ea
BeCM 2.5	3/9/95	9:40	7.7	7.7	83				81.9 Ea
BeCM 2.5	3/14/95	10:35	9.4	7.2	70				123.8 Ea
BeCM 2.5	3/22/95	13:18	7.8	7.4	63				128.7 Ea
BeCM 2.5	11/8/95	11:20	10.4	**	90				118.9 Ea
BeCM 2.5	11/28/95	14:20	10.2	6.5	53				188.4 Ea
BeCM 2.5	12/10/95	15:30	6.0	**	65				112.2 Ea
BeCM 2.5	12/19/95	14:30	7.4	**	69				135.9 Ea
BeCM 2.5	2/6/96	10:50	3.9	6.6	73				142.1 Ea
BeCM 2.5	11/13/96	13:50	9.8	6.6	110				28.3 Ea
BeCM 2.5	11/25/96	13:35	6.2	**	64				140.4 Ea
BeCM 2.5	12/3/96	9:15	4.8	**	65				110.4 Ea
BeCM 2.5	12/9/96	9:06	6.4	6.8	66				129.1 Ea
BeCM 2.5	1/7/97	10:10	6.0	6.9	55				256.6 Ea
BeCM 2.5	1/28/97	10:25	3.9	7.2	74				107.2 Ea
BeCM 2.5	2/12/97	9:30	5.5	6.7	72				96.1 Ea
BeCM 2.5	2/19/97	9:55	7.2	6.9	63				182.3 Ea
BeCM 2.5	3/3/97	10:25	5.9	6.8	58				133.6 Ea
BeCM 2.5	3/10/97	11:05	6.9	6.8	61				145.7 Ea
BeCM 2.5	11/18/97	11:33	7.7	6.4	138				53.5 Ea
BeCM 2.5	11/24/97	12:35	8.2	6.1	86				131.9 Ea
BeCM 2.5	11/30/97	12:35	8.1	6.7	81				115.4 Ea
BeCM 2.5	12/16/97	13:20	7.3	6.7	84				146.2 Ea
BeCM 2.5	1/6/98	10:40	5.7	6.8	55				196.1 Ea
BeCM 2.5	1/13/98	12:30	1.6	**	70				121.2 Ea
BeCM 2.5	2/22/98	11:13	6.9	7.0	82				90.1 Ea
BeCM 2.5	3/1/98	14:05	7.7	**	70				86.0 Ea
BeCM 2.5	3/9/98	11:10	7.3	6.8	75				76.6 Ea
BeCM 2.5	3/23/98	12:36	9.6	6.8	82				83.6 Ea
BeCM 2.5	11/16/98	13:00	9.4	**	132				22.6 Ea
BeCM 2.5	12/2/98	13:30	7.1	6.4	54				393.5 Ea
BeCM 2.5	12/27/98	14:40	4.9	6.7	64				151.4 Ea
BeCM 2.5	1/28/99	11:05	4.7	6.8	51				229.7 Ea
BeCM 2.5	2/16/99	10:30	5.7	6.8	66				128.4 Ea

** Meter did not meet quality control requirements or was not functioning.

Ea Flows were estimated as the sum of flows from Allen Creek and Beaver Creek at Case Rd.

Appendix E. 1994-1999 Field Data for Beaver Creek and Allen Creek.

(paired results indicate field duplicate)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Dissolved Oxygen mg/L Winkler	Dissolved Oxygen % Saturation	Flow Discharge cfs
BeCM 0.9	11/25/96	13:45	6.1	**	63				163 E
BeCM 0.9	12/3/96	9:05	4.9	**	67				156 E
BeCM 0.9	12/9/96	9:17	6.5	6.8	67				162 E
BeCM 0.9	1/7/97	10:30	6.1	7.0	53				384 E
BeCM 0.9	1/28/97	10:35	3.8	7.2	79				131 E
BeCM 0.9	2/12/97	9:40	5.5	6.8	70				118 E
BeCM 0.9	2/19/97	10:10	7.3	6.9	61				228 E
BeCM 0.9	3/3/97	10:45	6.1	6.7	58				176 E
BeCM 0.9	3/10/97	11:10	6.7	6.8	57				200 E
BeCM 0.9	11/18/97	12:30	7.8	6.6	75				75.2
BeCM 0.9	11/24/97	13:17	8.4	6.8	96				172 E
BeCM 0.9	11/30/97	13:00	8.2	6.7	76				150 E
BeCM 0.9	12/16/97	13:40	7.3	6.7	76				182 E
BeCM 0.9	1/6/98	10:57	5.7	6.7	54				301 E
BeCM 0.9	1/13/98	12:15	1.9	**	71				133 E
BeCM 0.9	2/22/98	11:30	7.1	7.2	81				129 E
BeCM 0.9	3/1/98	14:20	7.7	**	71				115 E
BeCM 0.9	3/9/98	11:20	7.4	7.0	75				98 E
BeCM 0.9	3/23/98	12:54	9.9	6.9	83				110 E

** Meter did not meet quality control requirements or was not functioning.

E Flows were estimated using flow discharge values obtained at the nearest station, no major surface water inputs occur between the sites.

Appendix E. 1994-1999 Field Data for Beaver Creek and Allen Creek.
(paired results indicate field duplicate)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Dissolved Oxygen mg/L Winkler	Dissolved Oxygen % Saturation	Flow Discharge cfs
BeCM 0.1	8/31/94	9:20	14.0		112		9.3	91%	2.2
BeCM 0.1	8/31/94	15:15	16.3		111		9.5	97%	2.3
BeCM 0.1	9/13/94	12:57	13.7	7.3	113	10.3		100%	3.0
BeCM 0.1	9/14/94	11:41	14.9	7.2	104	9.7		96%	3.0
BeCM 0.1	11/14/94	13:10	7.7	8.0	142				17.9
BeCM 0.1	12/26/94	14:30	7.3	6.9	74				207.1 Ee
BeCM 0.1	1/10/95	14:35	5.5	6.7	70				92.8 e
BeCM 0.1	1/25/95	11:30	4.4	7.0	78				63.8
BeCM 0.1	1/29/95	9:40	6.7	7.7	80				79.6
BeCM 0.1	2/16/95	10:33	4.7	7.3	69				75.1
BeCM 0.1	2/21/95	16:10	10.1	**	55				273.2 Ee
BeCM 0.1	3/9/95	10:15	7.8	7.7	85				104.0
BeCM 0.1	3/14/95	10:55	9.5	7.3	74				160.2
BeCM 0.1	3/22/95	13:35	7.7	7.2	60				161.0
BeCM 0.1	11/8/95	11:45	10.1	**	110				186.8 e
BeCM 0.1	11/28/95	14:40	10.2	6.7	57				247.8 Ee
BeCM 0.1	12/10/95	15:50	6.0	**	66				132.0
BeCM 0.1	12/19/95	14:45	7.6	**	65				158.2
BeCM 0.1	2/6/96	11:10	4.0	6.5	65				189.4 Ee
BeCM 0.1	11/13/96	14:05	10.0	7.0	109				42.8
BeCM 0.1	11/25/96	14:05	6.2	**	80				162.8
BeCM 0.1	12/3/96	8:32	5.0	**	66				155.9
BeCM 0.1	12/9/96	9:32	6.5	6.9	67				162.4
BeCM 0.1	1/7/97	10:50	6.2	7.1	54				384.0 Ee
BeCM 0.1	1/28/97	10:50	3.9	7.4	79				130.6
BeCM 0.1	2/12/97	9:55	5.6	6.9	68				118.0
BeCM 0.1	2/19/97	10:30	7.2	6.9	60				228.0
BeCM 0.1	3/3/97	10:55	6.3	6.8	60				176.4 e
BeCM 0.1	3/10/97	11:25	7.4	6.8	51				200.0 e
BeCM 0.1	11/18/97	13:00	8.0	6.8	74				73.2
BeCM 0.1	11/24/97	13:35	8.4	6.7	69				171.5
BeCM 0.1	11/30/97	13:20	8.2	6.9	79				150.3
BeCM 0.1	1/6/98	11:37	5.8	6.8	60				301.1 e
BeCM 0.1	1/13/98	11:35	1.9	**	64				132.8
BeCM 0.1	2/22/98	11:54	7.1	7.1	76				128.6
BeCM 0.1	3/1/98	14:40	7.7	**	71				115.1 e
BeCM 0.1	3/9/98	11:35	7.5	7.0	74				97.7
BeCM 0.1	3/23/98	13:25	9.9	6.9	92				109.9
BeCM 0.1	11/16/98	13:30	9.6	**	138				29.5
BeCM 0.1	12/2/98	13:45	7.2	6.5	52				402.0
BeCM 0.1	12/27/98	14:55	5.0	6.7	63				188.1
BeCM 0.1	1/28/99	11:17	4.8	6.9	47				278.8 e
BeCM 0.1	2/16/99	10:55	5.9	6.8	67				149.0

** Meter did not meet quality control requirements or was not functioning.

e Flows were estimated using a flow discharge rating curve.

Ee Flows estimated by extrapolating the flow value from a flow discharge rating curve.

Appendix E. 1994-99 Laboratory Data for Beaver Creek and Allen Creek.

(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total* Organic Nitrogen mg/L	Total Persulfate Nitrogen mg/L		Fecal Coliform #/100 mL	
BeCM 4.2	8/31/94	07:50			0.029		0.284		0.253	0.566		4	
BeCM 4.2	8/31/94	13:21			0.033	0.035	0.284	0.285	0.217	0.528	0.544		
BeCM 4.2	9/13/94	14:16			0.042		0.275		0.197	0.514		9	
BeCM 4.2	9/14/94	10:10			0.022		0.301		0.184	0.507			
BeCM 4.2	11/14/94	10:14	3.9		0.017		0.173		0.298	0.488		43	66
BeCM 4.2	12/26/94	13:01	2.3		0.010 U		0.385		0.308	0.703		228	
BeCM 4.2	1/10/95	13:55	1.7		0.011		0.405		0.141	0.557		27	29
BeCM 4.2	1/25/95	9:55	1.0		0.010 U		0.010 U		0.419	0.439		8	9
BeCM 4.2	1/29/95	8:05	2.0		0.010 U		0.286		0.195	0.491		31	
BeCM 4.2	2/16/95	9:00	1.4		0.010 U		0.271		0.143	0.424		36	31
BeCM 4.2	2/21/95	14:55	2.2		0.010 U		0.422		0.222	0.654		16 J	
BeCM 4.2	3/9/95	8:20	2.2		0.010 U		0.199		0.228	0.437		61	35
BeCM 4.2	3/14/95	9:20	2.1		0.018		0.166		0.223	0.407		52	
BeCM 4.2	3/22/95	12:12	1.6		0.019		0.124		0.266	0.409		11	11
BeCM 4.2	11/8/95	9:50	11		0.010 U		0.379		0.459	0.848		1200 J	
BeCM 4.2	11/28/95	13:25	3.1		0.111		0.301		0.41	0.822		140	120
BeCM 4.2	12/10/95	14:05	1.1		0.010 U		0.347		0.355	0.712		20	
BeCM 4.2	12/19/95	13:05	1.1		0.010 U		0.336		0.38	0.726		36	
BeCM 4.2	2/6/96	9:55	3.3		0.022		0.325		0.269	0.616		100	
BeCM 4.2	11/13/96	13:15	3.5		0.010 U		0.150		0.349	0.509		320	
BeCM 4.2	11/25/96	12:30	4.0		0.010 U	0.010 U	0.470	0.475	0.365	0.848	0.901	110	99
BeCM 4.2	12/3/96	9:55	1.4		0.010 U		0.404		0.312	0.726 J		9	
BeCM 4.2	12/9/96	8:06	1.2		0.010 U		0.422		0.172	0.604		23	
BeCM 4.2	1/7/97	9:30	1.6		0.010 U		0.397		0.162	0.569		13	
BeCM 4.2	1/28/97	9:40	1.5	1.3	0.010 U		0.303		0.159	0.472		11	
BeCM 4.2	2/12/97	8:50	3.8		0.010 U		0.230		0.193	0.433		44	
BeCM 4.2	2/19/97	8:45	2.3		0.010 U		0.231		0.185	0.426		65	64
BeCM 4.2	3/3/97	9:55	1.4		0.010 U		0.237		0.206	0.453		20	
BeCM 4.2	3/10/97	10:45	1.7		0.010 U	0.010 U	0.229	0.233	0.204	0.441	0.448	14	14
BeCM 4.2	11/18/97	10:15	2.4		0.010 U		0.210	0.202	0.286	0.502		28	
BeCM 4.2	11/24/97	11:24	3.4		0.011		0.400		0.346	0.757		160	140
BeCM 4.2	11/30/97	11:20	1.9	1.8	0.010		0.394		0.109	0.513		60	
BeCM 4.2	12/16/97	11:41	9.4	9.3	0.012	0.010 U	0.371	0.368	0.208	0.592	0.586	720	
BeCM 4.2	1/6/98	9:59	3.1	3.3	0.010 U		0.493		0.214	0.717		44	
BeCM 4.2	1/13/98	13:20	2.6		0.022	0.019	0.451	0.454	0.108	0.591	0.572	48	
BeCM 4.2	2/22/98	10:14	2.0		0.010 U		0.256		0.214	0.480		37	33
BeCM 4.2	3/1/98	13:35	2.4		0.010 U		0.231		0.226	0.467		40	
BeCM 4.2	3/9/98	10:15	1.8		0.010 U		0.237		0.115	0.362		13	12
BeCM 4.2	3/23/98	11:20	6.1		0.010 U		0.153		0.220	0.383		290	230
BeCM 4.2	11/16/98	12:00	3.0		0.018		0.831		0.541	1.39		130	
BeCM 4.2	12/2/98	12:30	2.3	2.2	0.020	0	0.906	0.926	0.430	1.36	1.37	140	130
BeCM 4.2	12/27/98	13:37	3.6		0.017		0.651		0.175	0.843		260	
BeCM 4.2	1/28/99	9:58	3.2	3.1	0.010 U	0.010 U	0.480	0.464	0.249	0.745	0.716	130	102
BeCM 4.2	2/16/99	9:30	1.6		0.010 U		0.420		0.154	0.584		46	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria true value may be greater than or equal to the reported result

Appendix E. 1994-99 Laboratory Data for Beaver Creek and Allen Creek.

(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total* Organic Nitrogen mg/L	Total Persulfate Nitrogen mg/L		Fecal Coliform #/100 mL	
BeCM 2.6T	8/31/94	14:06			0.010 U	0.013	0.102	0.099	0.171	0.253	0.314	130	170
BeCM 2.6T	8/31/94	8:06			0.011		0.105		0.170	0.286			
BeCM 2.6T	9/13/94	13:53			0.024		0.080		0.213	0.317		57	
BeCM 2.6T	9/14/94	10:43			0.035		0.099		0.238	0.372			
BeCM 2.6T	11/14/94	11:10	1.9		0.012		0.235		0.293	0.540		26	
BeCM 2.6T	12/26/94	13:40	5.5		0.010 U		0.339		0.401	0.750		210	225
BeCM 2.6T	1/10/95	14:00	1.8		0.010 U		0.398		0.253	0.661		60 J	
BeCM 2.6T	1/25/95	10:40	1.8		0.010 U		0.483		0.252	0.745		29	
BeCM 2.6T	1/29/95	8:45	2.3		0.010 U	0.010 U	0.426	0.431	0.327	0.780	0.751	61	71
BeCM 2.6T	2/16/95	9:40	2.5		0.010 U		0.415		0.206	0.631		35	
BeCM 2.6T	2/21/95	15:20	2.1		0.010 U		0.407		0.281	0.698		14 J	21
BeCM 2.6T	3/9/95	9:15	2.7		0.010 U		0.356		0.370	0.736		79	
BeCM 2.6T	3/14/95	10:05	2		0.010 U		0.350		0.384	0.744		29	22
BeCM 2.6T	3/22/95	12:50	2.3		0.029		0.319		0.461	0.809		59	
BeCM 2.6T	11/8/95	10:30	5.9		0.010 U		0.347		0.615	0.972		760	
BeCM 2.6T	11/28/95	13:45	3.6		0.010 U		0.464		0.536	1.01		170	
BeCM 2.6T	12/10/95	14:55	1.7		0.010 U	0.010 U	0.413	0.417	0.581	0.961	1.05	110	
BeCM 2.6T	12/19/95	13:50	1.6	1.5	0.010 U		0.437		0.633	1.08		6	6
BeCM 2.6T	2/6/96	10:15	5.3		0.283		0.456		0.811	1.55		8600 J	
BeCM 2.6T	11/13/96	14:45	3.0		0.010 U	0.010 U	0.181	0.182	0.552	0.755	0.732	89	96
BeCM 2.6T	11/25/96	13:05	4.2		0.013		0.601		0.616	1.23		1000 J	
BeCM 2.6T	12/3/96	9:30	2.6		0.015		0.417		0.464	0.896 J		40	
BeCM 2.6T	12/9/96	8:45	1.9		0.027		0.426		0.330	0.783		10	
BeCM 2.6T	1/7/97	9:50	2.4		0.010 U		0.346		0.315	0.671		320 J	
BeCM 2.6T	1/28/97	10:05	2.5		0.026		0.473		0.328	0.827		17	
BeCM 2.6T	2/12/97	9:15	4.8		0.011		0.412		0.303	0.726		71	
BeCM 2.6T	2/19/97	9:25	4.4		0.040	0.045	0.359	0.363	0.425	0.830	0.828	67	89
BeCM 2.6T	3/3/97	10:15	3.4		0.010 U	0.010 U	0.388	0.387	0.426	0.786	0.862	190	180
BeCM 2.6T	3/10/97	10:50	2.5		0.010 U		0.384		0.376	0.770		43 J	
BeCM 2.6T	11/18/97	10:56	6.1		0.010 U		0.330		0.499	0.839		430	470
BeCM 2.6T	11/24/97	12:09	4.8		0.010 U		0.395		0.521	0.926		80 J	
BeCM 2.6T	11/30/97	12:05	3.7		0.010 U	0.010 U	0.379	0.379	0.378	0.762	0.772	43	
BeCM 2.6T	12/16/97	12:38	11	11	0.010		0.371		0.305	0.686		520	
BeCM 2.6T	1/6/98	10:14	6.1		0.010 U		0.515		0.375	0.900		310	
BeCM 2.6T	1/13/98	12:50	2.3		0.020		0.491		0.166	0.677		18	23
BeCM 2.6T	2/22/98	10:49	4.8		0.010 U		0.315		0.537	0.862		64	
BeCM 2.6T	3/1/98	13:55	4.5		0.011		0.319		0.454	0.784		43	
BeCM 2.6T	3/9/98	10:45	3.5		0.011		0.325		0.281	0.617		43	
BeCM 2.6T	3/23/98	12:08	29		0.016		0.294		0.413	0.723		120	
BeCM 2.6T	11/16/98	12:35	3.5		0.012		0.255		0.584	0.851		290	
BeCM 2.6T	12/2/98	13:00	3.9		0.044		0.495		0.601	1.14		240	
BeCM 2.6T	12/27/98	14:10	2.4		0.047		0.396		0.445	0.888		220	
BeCM 2.6T	1/28/99	10:29	4.7		0.010 U		0.373		0.399	0.782		220	
BeCM 2.6T	2/16/99	10:00	2.5		0.010 U		0.397		0.331	0.738		37	40

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria true value may be greater than or equal to the reported result

Appendix E. 1994-99 Laboratory Data for Beaver Creek and Allen Creek.

(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total* Organic Nitrogen mg/L	Total Persulfate Nitrogen mg/L		Fecal Coliform #/100 mL	
BeCM 2.5	8/31/94	14:32			0.010 JU		0.656		0.227	0.893		120	
BeCM 2.5	8/31/94	8:48			0.018 J		0.709		0.283	1.01			
BeCM 2.5	9/13/94	13:30			0.06		0.498		0.373	0.931		69	
BeCM 2.5	9/14/94	11:14			0.032		0.605		0.284	0.921			
BeCM 2.5	11/14/94	11:43	2.9		0.486	0.491	1.19	1.20	0.394	1.93	2.22	5600 J	
BeCM 2.5	12/26/94	14:00	4.6		0.171		0.658		0.781	1.61		5800	
BeCM 2.5	1/10/95	14:20	1.7		0.057	0.060	0.838	0.841	0.247	1.08	1.21	660	630
BeCM 2.5	1/25/95	11:10	2.8		0.023		0.977		0.390	1.39		100 J	97
BeCM 2.5	1/29/95	9:10	2.7		0.182		0.819		0.339	1.34		4700 J	4800 J
BeCM 2.5	2/16/95	10:07	2.9		0.052	0.052	0.793	0.795	0.194	1.05	1.03	230	230
BeCM 2.5	2/21/95	15:50	2.0		0.012		0.601		0.290	0.903		34 J	
BeCM 2.5	3/9/95	9:40	4.3		0.139	0.120	0.667	0.653	0.791	1.68	1.48	11000 J	10000 J
BeCM 2.5	3/14/95	10:35	4.1		0.409		0.514		0.687	1.61		14000	
BeCM 2.5	3/22/95	13:18	2.1		0.055	0.055	0.492	0.493	0.497	0.911	0.957	830 J	970 J
BeCM 2.5	11/8/95	11:20	11		0.781		0.795		1.384	2.96		64000 J	66000 J
BeCM 2.5	11/28/95	14:20	2.9	2.8	0.055		0.579		0.636	1.27		2000 J	
BeCM 2.5	12/10/95	15:30	1.9		0.088		0.737		0.785	1.61		4100 J	
BeCM 2.5	12/19/95	14:30	1.4		0.040		0.681		0.699	1.42		1300	
BeCM 2.5	2/6/96	10:50	6.0		0.616	0.620	0.576	0.582	1.028	2.21	2.24	33000	
BeCM 2.5	11/13/96	13:50	4.6		0.564		0.840		0.676	2.08		1300	
BeCM 2.5	11/25/96	13:35	3.2		0.035		0.717		0.498	1.25		480 J	
BeCM 2.5	12/3/96	9:15	2.1	2.3	0.026		0.667		0.407	1.10 J		120	65
BeCM 2.5	12/9/96	9:06	1.6		0.020		0.669		0.246	0.935		46	
BeCM 2.5	1/7/97	10:10	2.4		0.014		0.588		0.229	0.831		220 J	
BeCM 2.5	1/28/97	10:25	2.4		0.028	0.026	0.667	0.677	0.285	0.984	0.974	84	
BeCM 2.5	2/12/97	9:30	5.2		0.216		0.612		0.432	1.26		5600 J	
BeCM 2.5	2/19/97	9:55	4.7		0.202		0.448		0.470	1.12		11000	
BeCM 2.5	3/3/97	10:25	3.4		0.065		0.467		0.392	0.924		3300	
BeCM 2.5	3/10/97	11:05	1.7		0.010 U		0.419		**0.297**	0.726		130	
BeCM 2.5	11/18/97	11:33	4.1		0.010 U		0.519	0.525	0.340	0.938	0.805	240	
BeCM 2.5	11/24/97	12:35	3.5		0.027		0.583		0.440	1.05		140 J	
BeCM 2.5	11/30/97	12:35	2.6		0.017		0.589		0.176	0.782		57	36
BeCM 2.5	12/16/97	13:20	10		0.181		0.745		0.524	1.45		660 J	
BeCM 2.5	1/6/98	10:40	3.7		0.010 U		0.595		0.149	0.754		88 J	
BeCM 2.5	1/13/98	12:30	2.4	2.3	0.030		0.713		0.167	0.910		36	
BeCM 2.5	2/22/98	11:13	3.2		0.010 U		0.543		0.393	0.946		64	79
BeCM 2.5	3/1/98	14:05	3.9		0.107		0.563		0.325	0.995		110	
BeCM 2.5	3/9/98	11:10	3.3		0.032	0.040	0.644	0.661	0.195	0.893	0.874	33	
BeCM 2.5	3/23/98	12:36	14		0.057		0.568		0.341	0.966		1600 J	
BeCM 2.5	11/16/98	13:00	3.6		0.015	0.015	1.51	1.53	8.845	9.86	10.9	210	160
BeCM 2.5	12/2/98	13:30	3.1		0.030		0.999		0.601	1.63		180	
BeCM 2.5	12/27/98	14:40	2.4		0.034		1.17		0.506	1.710 J		560	530
BeCM 2.5	1/28/99	11:05	3.7		0.010 U		0.761		0.359	1.13		280	
BeCM 2.5	2/16/99	10:30	3.6		0.010 U		0.953		0.217	1.18		63	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria true value may be greater than or equal to the reported resul

Appendix E. 1994-99 Laboratory Data for Beaver Creek and Allen Creek.
(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total* Organic Nitrogen mg/L	Total Persulfate Nitrogen mg/L		Fecal Coliform #/100 mL	
BeCM 0.9	11/25/96	13:45	4.5		0.035		0.734		0.194	0.963		570 J	
BeCM 0.9	12/3/96	9:05	2.4		0.020		0.650		0.370	1.04 J		71	
BeCM 0.9	12/9/96	9:17	1.8	1.8	0.016		0.667		0.261	0.944		25	
BeCM 0.9	1/7/97	10:30	2.2		0.025	0.027	0.584	0.586	0.312	0.942	0.903	120 J	195 J
BeCM 0.9	1/28/97	10:35	2.2		0.026		0.694		0.266	0.986		47	52
BeCM 0.9	2/12/97	9:40	3.4		0.075		0.673		0.262	1.01		2000 J	
BeCM 0.9	2/19/97	10:10	3.5		0.047		0.471		0.341	0.859		2900	
BeCM 0.9	3/3/97	10:45	2.8		0.074		1.00		0.496	1.57		2100	
BeCM 0.9	3/10/97	11:10	1.7		0.010 U		0.464		0.277	0.751		140	
BeCM 0.9	11/18/97	12:30	4.5		0.010 U		0.534		0.349	0.893		250 J	
BeCM 0.9	11/24/97	13:17	5.2		0.010 U		0.577		0.373	0.960		100 J	
BeCM 0.9	11/30/97	13:00	2.9		0.010 U		0.586		0.280	0.876		26	
BeCM 0.9	12/16/97	13:40	15		0.188		0.764		0.448	1.40		1300 J	1200 J
BeCM 0.9	1/6/98	10:57	5.5		0.010 U		0.611		0.301	0.922		120	
BeCM 0.9	1/13/98	12:15	2.4		0.024		0.747		0.119	0.890		44	
BeCM 0.9	2/22/98	11:30	3.4	3.4	0.010 U		0.540		0.401	0.951		56 J	
BeCM 0.9	3/1/98	14:20	3.9		0.081	0.085	0.580	0.571	0.367	1.01	1.04	120	130
BeCM 0.9	3/9/98	11:20	2.7		0.015		0.645		0.136	0.796		27	
BeCM 0.9	3/23/98	12:54	8.2		0.039		0.608		0.325	0.972		1400 J	1750 J

U Indicates that the analyte was not detected at or above the reporting limit.

J   This result is an estimate. For bacteria true value may be greater than or equal to the reported result.

Appendix E. 1994-99 Laboratory Data for Beaver Creek and Allen Creek.

(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total* Organic Nitrogen mg/L	Total Persulfate Nitrogen mg/L		Fecal Coliform #/100 mL	
BeCM 0.1	8/31/94	9:20			0.010 U		0.853		0.217	1.08			
BeCM 0.1	8/31/94	15:15			0.033		0.834		0.213	1.08		84	35
BeCM 0.1	9/13/94	12:57			0.011		0.502		0.345	0.858		88	
BeCM 0.1	9/14/94	11:41			0.011		0.558		0.348	0.917			
BeCM 0.1	11/14/94	13:10	2.6		0.379		1.29		0.391	2.06		1000 J	910 J
BeCM 0.1	12/26/94	14:30	5.8		0.190		0.700		0.710	1.60		6800	6400
BeCM 0.1	1/10/95	14:35	1.6		0.034		0.873		0.213	1.12		460	
BeCM 0.1	1/25/95	11:30	1.5		0.010 U		0.994		0.106	1.11		80	55
BeCM 0.1	1/29/95	9:40	3.0		0.101		0.878		0.141	1.12		2800 J	
BeCM 0.1	2/16/95	10:33	2.7		0.043		0.859		0.138	1.04		270	
BeCM 0.1	2/21/95	16:10	3.1		0.010 U	0.010 U	0.594	0.600	0.295	0.885	0.919	53 J	58 J
BeCM 0.1	3/9/95	10:15	4.5		0.011		0.735		0.844	1.59		5300 J	
BeCM 0.1	3/14/95	10:55	3.4		0.188	0.235	0.567	0.556	0.467	1.36	1.12	7700	8300
BeCM 0.1	3/22/95	13:35	2.3		0.071		0.521		0.352	0.944		520	
BeCM 0.1	11/8/95	11:45	23		0.938		0.875		1.77	3.58		77000 J	78500 J
BeCM 0.1	11/28/95	14:40	4.1		0.048		0.586		0.656	1.29		3100 J	3000 J
BeCM 0.1	12/10/95	15:50	2.2		0.110		0.753		0.757	1.62		7100	
BeCM 0.1	12/19/95	14:45	1.4		0.015		0.700		0.655	1.37		650	480
BeCM 0.1	2/6/96	11:10	5.1		0.335		0.615		0.620	1.57		9300	
BeCM 0.1	11/13/96	14:05	5.0		0.355		1.03		0.605	1.99		930	
BeCM 0.1	11/25/96	14:05	6.0		0.030		0.746		0.534	1.31		530 J	
BeCM 0.1	12/3/96	8:32	2.6		0.020		0.650		0.400	1.07 J		170	
BeCM 0.1	12/9/96	9:32	1.8		0.017		0.647		0.257	0.921		26	27
BeCM 0.1	1/7/97	10:50	2.6		0.012		0.586		0.291	0.889		240 J	
BeCM 0.1	1/28/97	10:50	2.2		0.028		0.702		0.257	0.987		57	
BeCM 0.1	2/12/97	9:55	4.1		0.049		0.679		0.270	0.998		2300 J	
BeCM 0.1	2/19/97	10:30	3.4		0.039		0.510		0.359	0.908		2800	
BeCM 0.1	3/3/97	10:55	2.8		0.070		0.496		0.444	1.01		2100	
BeCM 0.1	3/10/97	11:25	1.7		0.025		0.467		0.260	0.752		220	
BeCM 0.1	11/18/97	13:00	4.5		0.010 U		0.531		0.346	0.887		270	
BeCM 0.1	11/24/97	13:35	5.1		0.011		0.580		0.449	1.04		120	110 J
BeCM 0.1	11/30/97	13:20	3.0		0.010 U		0.603		0.310	0.923		43	
BeCM 0.1	12/16/97	14:00	15		0.189		0.791		0.450	1.43		900 J	
BeCM 0.1	1/6/98	11:37	5.7	5.8	0.010 U	0.010 U	0.620	0.640	0.153	0.747	0.839	120	120 J
BeCM 0.1	1/13/98	11:35	1.9		0.026		0.758		0.153	0.937		49	
BeCM 0.1	2/22/98	11:54	3.3		0.010 U		0.540		0.268	0.818		71 J	
BeCM 0.1	3/1/98	14:40	3.7		0.077		0.580		0.343	1.00		140	
BeCM 0.1	3/9/98	11:35	3.1	3.0	0.015		0.676		0.109	0.800		27	27
BeCM 0.1	3/23/98	13:25	8.8		0.036		0.601		0.207	0.844		2200 J	
BeCM 0.1	11/16/98	13:30	3.7		0.013		1.63		7.52	9.16		180	
BeCM 0.1	12/2/98	13:45	4.6		0.024		0.933		0.653	1.61		190	200
BeCM 0.1	12/27/98	14:55	4.2	4.2	0.029	0.033	0.982	0.978	0.314	1.30	1.35	430	
BeCM 0.1	1/28/99	11:17	4.9		0.010 U		0.770		0.280	1.06		250	
BeCM 0.1	2/16/99	10:55	2.1		0.010 U		1.02		0.200	1.23		160 J	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria true value may be greater than or equal to the reported result.

Appendix F

Bunker Creek and Deep Creek

Field Data, 1994-99
Laboratory Data, 1994-99

Appendix F. 1994-99 Field Data for Bunker Creek and Deep Creek.

(paired results indicate field duplicates)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Dissolved Oxygen mg/L Winkler	Dissolved Oxygen % Saturation	Flow Discharge cfs
DCM 4.5	3/9/95	13:35	7.9	6.8	57				17.2
DCM 4.5	3/14/95	12:45	8.4	7.7	53				52.0
DCM 4.5	3/22/95	9:54	6.8	6.3	52				43.5
DCM 4.5	11/7/95	14:00	8.3	**	72				22.8
DCM 4.5	12/4/95	13:25	8.0	6.6	57				34.2
DCM 4.5	12/11/95	9:25	8.5	6.5	56				44.9
DCM 4.5	1/3/96	13:30	8.4	7.5	64				24.5
DCM 4.5	1/22/96	9:45	6.8	7.8	57				52.9
DCM 4.5	2/6/96	12:30	5.8	7.5	49				80.4
DCM 4.5	2/20/96	13:30	7.6	7.6	55				32.9
DCM 4.5	3/4/96	11:40	6.5	6.6	60				7.5
DCM 4.5	3/11/96	12:35	8.8	6.7	58				13.1
DCM 4.5	4/1/96	10:40	7.4	**	65				4.5
DCM 4.5	11/13/96	10:05	8.5	7.2	90				5.7
DCM 4.5	11/25/96	8:55	6.9	**	58				43.7
DCM 4.5	12/3/96	11:23	6.7	**	61				34.6
DCM 4.5	12/9/96	11:04	7.7	7.0	74				30.9
DCM 4.5	1/7/97	12:00	7.7	7.0	53				54.8 e
DCM 4.5	1/28/97	12:00	5.5	7.4	59				14.9
DCM 4.5	2/12/97	10:50	5.8	6.9	58				24.0
DCM 4.5	2/19/97	11:45	7.4	6.8	57				44.9
DCM 4.5	3/3/97	11:45	6.2	6.8	56				24.5 e
DCM 4.5	3/10/97	12:05	6.9	6.8	40				40.2 e
DCM 4.5	7/1/97	12:25	12.8	**	87		9.2	87.9%	2.1
DCM 4.5	11/16/98	9:17	9.0	**	93				9.1
DCM 4.5	12/1/98	15:15	8.1	6.7	51				62.6
DCM 4.5	12/8/98	10:10	7.0	7.3	74				52.9
DCM 4.5	12/27/99	10:35	5.6	6.9	89				27.7
DCM 4.5	1/28/99	12:19	6.6	**	42				153.6
DCM 4.5	2/17/99	9:50	6.1	6.5	68				34.8
DCM 4.5	2/22/99	9:35	6.5	7.1	60				37.5
DCM 4.5	3/14/99	11:05	7.4	6.5	57				14.2
DCM 4.5	3/30/99	14:00	7.3	6.7	49				40.4
DCM 4.5	7/12/99	9:10	13.8	6.1	94		8.4	81.5%	0.5
DCM 4.5	8/11/99	11:00	15.1	7.0	97		7.3	73.4%	0.2
DCM 4.5	9/13/99	8:20	11.2	6.5	107		7.9	72.7%	0.01

** Meter did not meet quality control requirements or was not functioning.

e Flows were estimated using a flow discharge rating curve.

Appendix F. 1994-99 Field Data for Bunker Creek and Deep Creek.

(paired results indicate field duplicates)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Dissolved Oxygen mg/L Winkler	Dissolved Oxygen % Saturation	Flow Discharge cfs
DCM 3.9	11/14/94	14:26	7.0	7.5	97				2.6
DCM 3.9	12/27/94	12:30	8.7	**	55				250 Ee
DCM 3.9	1/10/95	12:35	6.4	6.4	60				13.1
DCM 3.9	1/25/95	15:15	5.4	7.1	65				11.5
DCM 3.9	1/29/95	11:24	7.3	7.8	62				9.9 e
DCM 3.9	2/16/95	12:20	4.2	7.6	65				7.9
DCM 3.9	2/21/95	10:45	7.9	**	60				67.7
DCM 3.9	3/9/95	13:10	8.0	6.9	55				22.3
DCM 3.9	3/14/95	13:25	8.5	7.4	62				61.2
DCM 3.9	3/22/95	10:33	6.8	6.7	52				55.6 e
DCM 3.9	7/12/95	12:55	14.2	**	103		8.2	80.5%	0.3
DCM 3.9	8/14/95	10:40	12.5	7.4	114		6.6	62.4%	0.1
DCM 3.9	11/7/95	13:20	8.2	**	70				30.6
DCM 3.9	12/4/95	12:50	8.2	6.5	56				47.8
DCM 3.9	12/11/95	10:10	8.5	6.9	56				59.4 e
DCM 3.9	1/3/96	12:45	8.4	7.4	63				28.3
DCM 3.9	1/22/96	10:25	6.7	7.8	58				70.7
DCM 3.9	2/6/96	13:00	5.9	7.6	51				117.3
DCM 3.9	2/20/96	14:05	7.4	7.7	55				41.2
DCM 3.9	3/4/96	12:10	6.8	6.6	56				8.5 e
DCM 3.9	3/11/96	13:00	8.9	6.7	62				14.8
DCM 3.9	4/1/96	11:05	7.6	**	62				5.1
DCM 3.9	7/8/96	12:00	15.0	**	60		7.7	76.9%	0.3
DCM 3.9	8/6/96	11:30	14.4	7.2	**		5.7	56.6%	0.8
DCM 3.9	9/11/96	12:22	12.7	7.3	110		5.8	55.1%	0.1
DCM 3.9	11/13/96	10:45	8.7	7.2	80				6.5
DCM 3.9	11/25/96	9:45	7.0	**	68				50.8
DCM 3.9	12/3/96	12:00	6.7	**	61				45.2
DCM 3.9	12/9/96	11:26	7.8	7.1	60				37.0
DCM 3.9	1/7/97	12:30	7.8	7.1	54				72.4 e
DCM 3.9	1/28/97	12:20	5.6	7.5	62				16.3
DCM 3.9	2/12/97	11:10	5.9	6.9	58				27.0
DCM 3.9	2/19/97	12:00	7.4	6.8	58				51.9
DCM 3.9	3/3/97	11:55	6.2	6.8	56				34.1 e
DCM 3.9	3/10/97	12:15	7.0	6.8	46				52.2 e
DCM 3.9	7/1/97	12:55	12.9	**	83		9.0	85.4%	1.9
DCM 3.9	8/5/97	10:30	15.4	7.7	86		6.2	62.9%	0.3
DCM 3.9	9/8/97	11:10	13.0	7.3	112		5.5	52.2%	0.1
DCM 3.9	11/16/98	9:48	9.2	**	90				7.8
DCM 3.9	12/1/98	15:35	8.0	6.6	47				77.6
DCM 3.9	12/8/98	10:35	7.0	7.5	63				60.3
DCM 3.9	12/27/98	11:06	5.7	7.3	55				40.7
DCM 3.9	1/28/99	12:52	6.6	**	41				159.8 Ee
DCM 3.9	2/17/99	10:25	6.1	7.1	59				42.1
DCM 3.9	2/22/99	10:00	6.5	7.0	45				43.9
DCM 3.9	3/14/99	11:30	7.5	7.0	48				16.8
DCM 3.9	3/30/99	14:25	7.3	6.9	49				46.2 e
DCM 3.9	7/12/99	9:40	14.4	6.5	104		7.1	69.7%	0.5
DCM 3.9	8/11/99	11:15	15.7	6.8	97		5.5	55.8%	0.1
DCM 3.9	9/13/99	8:40	11.0	6.5	115		4.9	44.8%	<0.01

** Meter did not meet quality control requirements or was not functioning.

e Flows were estimated using a flow discharge rating curve.

Ee Flows were estimated by extrapolating the flow from a flow discharge rating curve.

Appendix F. 1994-99 Field Data for Bunker Creek and Deep Creek.

(paired results indicate field duplicates)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Dissolved Oxygen mg/L Winkler	Dissolved Oxygen % Saturation	Flow Discharge cfs
DCM 3.6	11/14/94	14:55	7.2	7.2	100				2.2
DCM 3.6	12/27/94	12:55	8.7	**	55				260 Ee
DCM 3.6	1/10/95	12:05	6.4	6.5	54				13.9
DCM 3.6	1/25/95	14:47	5.3	7.1	67				10.8
DCM 3.6	1/29/95	11:30	7.4	8.0	64				10.2 e
DCM 3.6	2/16/95	12:55	4.3	7.6	68				8.3
DCM 3.6	2/21/95	11:40	8.0	**	56				78.7
DCM 3.6	3/9/95	12:35	8.0	7.1	58				25.6
DCM 3.6	3/14/95	14:00	8.7	7.5	56				67.4
DCM 3.6	3/22/95	10:43	6.9	6.9	56				62.1 e
DCM 3.6	7/12/95	12:20	13.8	**	110		9.1	88.5%	0.3
DCM 3.6	8/14/95	11:30	12.4	7.7	117		7.5	70.3%	0.1
DCM 3.6	11/7/95	12:45	8.2	**	71				34.3
DCM 3.6	12/4/95	12:10	8.2	6.4	56				51.4
DCM 3.6	12/11/95	10:35	8.5	6.7	65				60.3
DCM 3.6	1/3/96	12:15	8.4	7.4	64				28.3
DCM 3.6	1/22/96	10:55	6.8	7.9	62				77.3
DCM 3.6	2/6/96	13:30	6.0	7.7	50				132.2 Ee
DCM 3.6	2/20/96	14:30	7.5	7.8	55				41.6
DCM 3.6	3/4/96	12:22	6.8	6.6	60				10.2
DCM 3.6	3/11/96	13:21	9.2	6.7	60				17.5
DCM 3.6	4/1/96	11:25	7.8	**	65				5.7
DCM 3.6	7/8/96	12:45	15.1	**	61		8.8	87.6%	0.7
DCM 3.6	8/6/96	11:00	14.4	7.4	**		7.7	76.1%	0.5
DCM 3.6	9/11/96	12:56	13.0	7.2	123		5.9	56.7%	0.0
DCM 3.6	11/13/96	11:20	8.8	7.3	83				9.8
DCM 3.6	11/25/96	10:20	7.0	**	65				52.8
DCM 3.6	12/3/96	12:25	6.8	**	63				42.9
DCM 3.6	12/9/96	11:50	7.8	7.1	60				38.8
DCM 3.6	1/7/97	12:40	7.8	7.1	55				81.2 e
DCM 3.6	1/28/97	12:40	5.7	7.5	64				16.1
DCM 3.6	2/12/97	11:25	5.9	6.9	60				27.9
DCM 3.6	2/19/97	12:20	7.5	6.8	59				58.6
DCM 3.6	3/3/97	12:00		6.8	57				37.6 e
DCM 3.6	3/10/97	12:25	7.1	6.8	56				58.3 e
DCM 3.6	7/1/97	13:30	13.1	**	86		9.4	90.1%	2.6
DCM 3.6	8/5/97	11:30	15.6	7.49	88		7.9	80.1%	0.3
DCM 3.6	9/8/97	11:50	13.4	7.76	119		7.5	72.3%	0.8
DCM 3.6	11/16/98	10:05	9.3	**	90				9.0
DCM 3.6	12/1/98	15:55	8.0	6.67	47				94.7
DCM 3.6	12/8/98	10:55	7.1	7.2	68				66.6
DCM 3.6	12/27/98	11:34	5.7	7.16	66				53.1
DCM 3.6	1/28/99	13:04	6.5	**	41				180.5 Ee
DCM 3.6	2/17/99	10:40	6.1	6.75	57.3				44.6
DCM 3.6	2/22/99	10:15	6.5	6.86	42.9				51.3
DCM 3.6	3/14/99	11:51	7.5	6.96	48				18.4
DCM 3.6	3/30/99	14:35	7.5	6.83	47				50.8
DCM 3.6	7/12/99	10:25	14.1	6.62	114		8.5	83.3%	0.7
DCM 3.6	8/11/99	11:40	15.5	6.92	104		7.2	72.7%	0.2
DCM 3.6	9/13/99	9:05	11.4	6.87	117		6.0	55.3%	0.0

** Meter did not meet quality control requirements or was not functioning.

e Flows were estimated using a flow discharge rating curve.

Ee Flows were estimated by extrapolating the flow from a flow discharge rating curve.

Appendix F. 1994-99 Field Data for Bunker Creek and Deep Creek.

(paired results indicate field duplicates)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Winkler	% Saturation	Flow Discharge cfs
DCM 2.4	11/14/94	15:40	7.4	7.0	125				4.5
DCM 2.4	12/27/94	13:10	8.7	**	60				>260 Ee
DCM 2.4	1/10/95	11:30	6.3	6.5	66				19.0
DCM 2.4	1/25/95	14:10	5.2	7.1	67				12.6
DCM 2.4	1/29/95	11:47	7.4	7.9	68				16.4 e
DCM 2.4	2/16/95	13:39	4.4	7.7	70				11.8
DCM 2.4	2/21/95	13:00	8.3	**	60				97.0
DCM 2.4	3/9/95	12:02	7.8	7.9	61				35.4
DCM 2.4	3/14/95	14:40	8.8	7.8	58				86.3
DCM 2.4	3/22/95	11:00	6.9	7.1	55				84.6 e
DCM 2.4	7/12/95	11:45	13.7	**	118		9.1	88.3%	0.8
DCM 2.4	8/14/95	12:15	13.1	7.7	141		7.2	69.0%	0.1
DCM 2.4	11/7/95	11:50	8.2	**	73				56.0
DCM 2.4	12/4/95	11:20	8.1	6.7	59				59.8
DCM 2.4	12/11/95	11:15	8.6	6.9	79				81.9
DCM 2.4	1/3/96	11:35	8.4	7.3	63				38.8
DCM 2.4	1/22/96	11:35	6.8	8.1	59				97.2
DCM 2.4	2/6/96	13:45	6.0	7.7	51				176.7 Ee
DCM 2.4	2/20/96	15:05	7.5	7.6	58				59.1
DCM 2.4	3/4/96	12:50	6.8	6.6	60				15.9
DCM 2.4	3/11/96	13:50	9.2	6.8	66				22.9
DCM 2.4	4/1/96	11:50	7.9	**	70				7.4
DCM 2.4	7/8/96	13:25	15.6	**	73		8.6	87.0%	0.6
DCM 2.4	8/6/96	9:55	14.5	7.2	**		6.8	67.5%	0.8
DCM 2.4	9/11/96	13:15	13.4	7.3	155		6.4	61.2%	0.1
DCM 2.4	11/13/96	11:55	8.9	7.3	94				19.5
DCM 2.4	11/25/96	10:55	7.1	**	66				82.9
DCM 2.4	12/3/96	13:00	6.9	**	62				66.2
DCM 2.4	12/9/96	12:37	7.8	7.2	63				57.2
DCM 2.4	1/7/97	12:50	7.8	7.2	55				109.7 Ee
DCM 2.4	1/28/97	13:00	5.7	7.5	71				23.3
DCM 2.4	2/12/97	11:45	6.0	6.9	60				44.2
DCM 2.4	2/19/97	12:40	7.5	6.8	60				71.7
DCM 2.4	3/3/97	12:10	6.2	6.8	59				52.4 e
DCM 2.4	3/10/97	12:50	7.3	6.7	44				79.6 e
DCM 2.4	7/1/97	14:00	13.6	**	94		9.6	93.1%	2.5
DCM 2.4	8/5/97	12:20	16.3	7.6	100		7.8	80.3%	0.5
DCM 2.4	9/8/97	12:30	13.5	7.7	143		7.5	72.4%	0.2
DCM 2.4	11/16/98	10:44	8.8	**	99				12.2
DCM 2.4	12/1/98	16:15	7.9	6.7	46				127.4 Ee
DCM 2.4	12/8/98	11:25	7.1	7.1	64				95.3
DCM 2.4	12/27/98	12:00	5.4	7.1	63				83.4
DCM 2.4	1/28/99	13:20	6.5	**	41				240.2 Ee
DCM 2.4	2/17/99	11:10	6.1	6.8	63				64.1
DCM 2.4	2/22/99	10:45	6.5	6.8	40				73.5
DCM 2.4	3/14/99	12:10	7.6	7.0	49				23.3
DCM 2.4	3/30/99	15:00	7.6	6.8	50				78.3
DCM 2.4	7/12/99	10:45	14.6	6.5	121		7.8	77.0%	0.4
DCM 2.4	8/11/99	12:00	15.8	6.9	107		6.4	64.5%	0.2
DCM 2.4	9/13/99	9:30	11.2	6.8	128		5.6	51.3%	0.1

** Meter did not meet quality control requirements or was not functioning.

e Flows were estimated using a flow discharge rating curve.

Ee Flows were estimated by extrapolating the flow from a flow discharge rating curve.

Appendix F. 1994-99 Field Data for Bunker Creek and Deep Creek.

(paired results indicate field duplicates)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm	Dissolved Oxygen mg/L Meter	Dissolved Oxygen mg/L Winkler	Dissolved Oxygen % Saturation	Flow Discharge cfs
BCM 0.5	8/30/94	16:50	18.6	7.0	145	4.2		45.2%	0.1
BCM 0.5	8/31/94	10:45	16.3		147		4.5	46.4%	0.0
BCM 0.5	9/14/94	8:27	14.9	7.0	137	3.2	3.1	30.9%	0.2
BCM 0.5	9/14/94	13:35	15.9	6.9	136	3.7	4.0	40.7%	0.2
BCM 0.5	11/14/94	16:18	7.2	**	95				29.6
BCM 0.5	12/27/94	13:37	8.9	**	45				
BCM 0.5	1/10/95	10:35	5.8	6.7	60				85.7
BCM 0.5	1/25/95	13:32	4.5	7.1	60				66.5
BCM 0.5	1/29/95	12:05	7.3	8.0	56				69.1
BCM 0.5	2/16/95	14:20	3.9	7.7	55				60.2
BCM 0.5	2/21/95	14:00	8.4	**	49				
BCM 0.5	3/9/95	11:20	7.5	7.9	54				145.9
BCM 0.5	3/14/95	15:25	8.7	7.7	47				
BCM 0.5	3/22/95	11:19	6.7	7.4	50				
BCM 0.5	7/12/95	10:45	14.8	**	115		7.5	74.5%	2.9
BCM 0.5	8/14/95	9:15	14.8	7.3	118		5.2	51.7%	0.7
BCM 0.5	11/7/95	11:10	7.7	**	60				
BCM 0.5	12/4/95	10:50	7.9	7.0	51				
BCM 0.5	12/11/95	12:00	8.4	6.8	72				
BCM 0.5	1/3/96	11:00	8.5	6.8	76				
BCM 0.5	1/22/96	12:15	6.4	7.9	52				
BCM 0.5	2/6/96	14:10	5.4	7.7	46				
BCM 0.5	2/20/96	15:45	7.3	7.7	60				
BCM 0.5	3/4/96	13:25	6.8	6.6	54				
BCM 0.5	3/11/96	14:30	9.4	6.8	55				
BCM 0.5	4/1/96	12:20	8.2	**	63				
BCM 0.5	7/8/96	11:40	15.9	**	85		7.4	75.3%	2.8
BCM 0.5	8/6/96	9:00	15.8	6.8	**		5.5	55.8%	2.3
BCM 0.5	9/11/96	13:35	15.4	7.3	110		4.8	48.8%	0.5
BCM 0.5	11/13/96	12:25	8.9	6.6	76				
BCM 0.5	11/25/96	11:35	6.9	**	61				
BCM 0.5	12/3/96	13:30	6.4	**	55				
BCM 0.5	12/9/96	13:04	7.7	7.1	54				
BCM 0.5	1/7/97	13:10	7.5	7.1	46				
BCM 0.5	1/28/97	13:25	5.3	7.5	59				
BCM 0.5	2/12/97	12:10	5.8	6.9	54				
BCM 0.5	2/19/97	13:15	7.2	6.9	55				
BCM 0.5	3/3/97	12:20	6.1	6.8	51				
BCM 0.5	3/10/97	13:00	7.3	6.8	49				
BCM 0.5	7/1/97	14:35	14.7	**	92		9.0	89.4%	11.1
BCM 0.5	8/5/97	13:15	18.3	7.5	103		5.8	62.5%	1.3
BCM 0.5	9/8/97	13:15	15.4	7.5	131		6.1	61.5%	0.9
BCM 0.5	11/16/98	11:05	9.1	**	88				
BCM 0.5	12/1/98	16:40	7.4	6.9	41				
BCM 0.5	12/8/98	12:00	6.5	7.2	51				
BCM 0.5	12/27/98	12:40	5.0	7.2	63				
BCM 0.5	1/28/99	13:39	5.8	**	36				
BCM 0.5	2/17/99	11:55	6.0	6.8	48				
BCM 0.5	2/22/99	11:20	6.4	6.9	35				
BCM 0.5	3/14/99	12:45	7.9	7.1	42				
BCM 0.5	3/30/99	15:40	7.3	6.9	42				
BCM 0.5	7/12/99	11:30	16.2	6.5	106		6.8	69.4%	3.1
BCM 0.5	8/11/99	12:30	17.4	6.9	101		5.9	61.5%	0.7
BCM 0.5	9/13/99	10:05	13.3	6.8	106		5.4	51.5%	0.6

** Meter did not meet quality control requirements or was not functioning.

Appendix F. 1994-99 Laboratory Data for Bunker Creek and Deep Creek.
(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		TSS mg/L		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total N mg/L		Total Phosphorus mg/L		Fecal Coliform #/100 mL		BOD5 mg/L	
BCM 0.5	8/30/94	16:50					0.043		0.036		0.318		0.131		125		2 U	
BCM 0.5	8/31/94	10:45					0.042		0.043		0.435						2 U	2U
BCM 0.5	9/14/94	8:27					0.096		0.031		0.511		0.129				2 U	
BCM 0.5	9/14/94	13:35					0.049		0.029		0.364		0.129		88	61	2 U	
BCM 0.5	11/14/94	16:15	6.5	6.5			0.010 U		0.209		0.332				27			
BCM 0.5	12/27/94	13:35	80				0.021		0.694		1.04				195			
BCM 0.5	1/10/95	10:35	11				0.010 U		0.453		0.596				94			
BCM 0.5	1/25/95	13:00	6.9				0.031		0.518		0.612				14			
BCM 0.5	1/29/95	12:03	10	10			0.041		0.379		0.495				40			
BCM 0.5	2/16/95	14:18	9.8				0.010 U		0.357		0.536				89			
BCM 0.5	2/21/95	14:00	27				0.010 U		0.677		0.903				20	19		
BCM 0.5	3/9/95	11:20	31				0.010 U		0.389		0.583				540			
BCM 0.5	3/14/95	15:25	28	27			0.017		0.603		0.780				88			
BCM 0.5	3/22/95	11:19	15				0.027		0.620		0.781				23			
BCM 0.5	7/12/95	10:45					0.058		0.201		0.507				130		3 U	3U
BCM 0.5	8/14/95	9:15					0.102	0.097	0.054		0.342				57	39	3 U	3U
BCM 0.5	11/7/95	11:10	85		138													
BCM 0.5	12/4/95	10:50	16	17	22													
BCM 0.5	12/11/95	12:00	25		34													
BCM 0.5	1/3/96	11:00	13		16													
BCM 0.5	1/22/96	12:15	21		32													
BCM 0.5	2/6/96	14:10	80		130													
BCM 0.5	2/20/96	15:45	35		39													
BCM 0.5	3/4/96	13:25	12	12	7													
BCM 0.5	3/11/96	14:30	13		10													
BCM 0.5	4/1/96	12:20	12		6	6												
BCM 0.5	7/8/96	11:40					0.035		0.116		0.496		0.031		200		3 U	
BCM 0.5	8/6/96	9:00					0.036		0.078		0.436		0.052		69		3 U	3U
BCM 0.5	9/11/96	13:35					0.044	0.046	0.055	0.056	*	*	0.083	0.088	33	48	3 U	
BCM 0.5	11/13/96	12:25	21		22													
BCM 0.5	11/25/96	11:35	37		56													
BCM 0.5	12/3/96	13:30	16		16													
BCM 0.5	12/9/96	13:04	11		11													
BCM 0.5	1/7/97	13:10	21		33													
BCM 0.5	1/28/97	13:25	8.9		6													
BCM 0.5	2/12/97	12:10	24		30													
BCM 0.5	2/19/97	13:15	28		34													
BCM 0.5	3/3/97	12:20	14		11													
BCM 0.5	3/10/97	13:00	13		23													
BCM 0.5	7/1/97	14:35					0.013		0.183		0.405		0.070		75		4 U	
BCM 0.5	8/5/97	13:15					0.030		0.091		0.234		0.077		64		4 U	4U
BCM 0.5	9/8/97	13:15					0.038		0.081		0.267		0.106		260		4 U	
BCM 0.5	11/16/98	11:05	13		8	8									99			
BCM 0.5	12/1/98	16:40	32		57										87			
BCM 0.5	12/8/98	12:00	21		30										110	79		
BCM 0.5	12/27/98	12:40	39		72										410			
BCM 0.5	1/28/99	13:39	80		140										240			
BCM 0.5	2/17/99	11:55	18		22										240	225		
BCM 0.5	2/22/99	11:20	21		29										180			
BCM 0.5	3/14/99	12:45	11		7										46			
BCM 0.5	3/30/99	15:40	18	18	21										30			
BCM 0.5	7/12/99	11:30					0.063		0.101		0.417		0.071		88			
BCM 0.5	8/11/99	12:30					0.067		0.058		0.368		0.088		75	51		
BCM 0.5	9/13/99	10:05					0.050	0.052	0.043	0.042	0.320	0.341	0.093	0.094	51			

U Indicates that the analyte was not detected at or above the reporting limit.
J This result is an estimate. For bacteria, true value may be greater than or equal to the reported result.
*: Laboratory did not analyze sample for total persulfate nitrogen (total N).

Appendix F. 1994-99 Laboratory Data for Bunker Creek and Deep Creek.

(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		TSS mg/L		NH3 mg/L		NO2/3 mg/L		TPN mg/L		Total Phosphorus mg/L		Fecal Coliform #/100 mL	
DCM 4.5	3/22/95	9:54	15													
DCM 4.5	11/7/95	14:00	28		16											
DCM 4.5	12/4/95	13:25	12 J	13	14	15										
DCM 4.5	12/11/95	9:25	23		24											
DCM 4.5	1/3/96	13:30	10		6											
DCM 4.5	1/22/96	9:45	17		16											
DCM 4.5	2/6/96	12:30	110		191											
DCM 4.5	2/20/96	13:30	60		52											
DCM 4.5	3/4/96	11:40	12		5											
DCM 4.5	3/11/96	12:35	16		10											
DCM 4.5	4/1/96	10:40	8.3		3											
DCM 4.5	11/13/96	10:05	11	11	5	7										
DCM 4.5	11/25/96	8:55	27		26											
DCM 4.5	12/3/96	11:23	12		7											
DCM 4.5	12/9/96	11:04	9.2		5											
DCM 4.5	1/7/97	12:00	15		15											
DCM 4.5	1/28/97	12:00	7.4		3											
DCM 4.5	2/12/97	10:50	17		14											
DCM 4.5	2/19/97	11:45	25		38											
DCM 4.5	3/3/97	11:45	11		6											
DCM 4.5	3/10/97	12:05	11		14											
DCM 4.5	7/1/97	12:25					0.010 U	0.010U	0.198	0.188	0.318	0.328	0.065	0.063	23	
DCM 4.5	11/16/98	9:17	10	10	4											
DCM 4.5	12/1/98	15:15	33		56											
DCM 4.5	12/8/98	10:10	17		19											
DCM 4.5	12/27/99	10:35	33		60											
DCM 4.5	1/28/99	12:19	110		220											
DCM 4.5	2/17/99	9:50	12		11											
DCM 4.5	2/22/99	9:35	15		19											
DCM 4.5	3/14/99	11:05	11		4											
DCM 4.5	3/30/99	14:00	15		12	6										
DCM 4.5	7/12/99	9:10					0.029		0.126		0.287		0.059		23	
DCM 4.5	8/11/99	11:00					0.038		0.115		0.263		0.076		49 J	
DCM 4.5	9/13/99	8:20					0.018		0.084		0.201		0.067		280 J	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria, true value may be greater than or equal to the reported result.

Appendix F. 1994-99 Laboratory Data for Bunker Creek and Deep Creek.

(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		TSS mg/L		NH3 mg/L		NO2/3 mg/L		TPN mg/L		Total Phosphorus mg/L		Fecal Coliform cfu/100 m/L	
DCM 3.9	11/14/94	14:24	5.9				0.010 U		0.352		0.494				4	
DCM 3.9	12/27/94	12:25	160				0.022		0.970		1.450				150	
DCM 3.9	1/10/95	12:35	9.5				0.010 U		0.690		0.774				5	
DCM 3.9	1/25/95	14:55	5.6				0.010 U		0.718		0.713				2	
DCM 3.9	1/29/95	11:22	8.3				0.044		0.564		0.621				13	8
DCM 3.9	2/16/95	12:18	6.8				0.010 U		0.552		0.618				7	4
DCM 3.9	2/21/95	10:45	26				0.010 U		0.880		1.020				4	
DCM 3.9	3/9/95	13:10	22	22			0.010 U		0.609		0.801				5	5
DCM 3.9	3/14/95	13:25	22				0.010 U		0.789		0.903				8	8
DCM 3.9	3/22/95	10:33	14				0.022		0.815		0.958				15	11
DCM 3.9	7/12/95	12:55					0.069		0.182		0.463				55	61
DCM 3.9	8/14/95	10:40					0.074		0.022		0.224				85	
DCM 3.9	11/7/95	13:20	32	32	17											
DCM 3.9	12/4/95	12:50	14		16											
DCM 3.9	12/11/95	10:10	23		23											
DCM 3.9	1/3/96	12:45	10		6											
DCM 3.9	1/22/96	10:25	17		18	19										
DCM 3.9	2/6/96	13:00	130		240											
DCM 3.9	2/20/96	14:05	50		38											
DCM 3.9	3/4/96	12:10	12	11	4											
DCM 3.9	3/11/96	13:00	15		9											
DCM 3.9	4/1/96	11:05	7.4		2											
DCM 3.9	7/8/96	12:00					0.028		0.084		0.256		0.022		36	
DCM 3.9	8/6/96	10:30					0.035		0.054		0.257		0.063		88	86
DCM 3.9	9/11/96	12:22					0.062		0.042		*		0.090		48	57
DCM 3.9	11/13/96	10:45	9.2		5											
DCM 3.9	11/25/96	9:45	24		20											
DCM 3.9	12/3/96	12:00	12		6											
DCM 3.9	12/9/96	11:26	9.1		4											
DCM 3.9	1/7/97	12:30	17	17	18	18										
DCM 3.9	1/28/97	12:20	7.1		3											
DCM 3.9	2/12/97	11:10	15	17	14	14										
DCM 3.9	2/19/97	12:00	27		39											
DCM 3.9	3/3/97	11:55	10		7											
DCM 3.9	3/10/97	12:15	11	12	13	14										
DCM 3.9	7/1/97	12:55					0.010 U		0.206		0.368		0.057		25	26
DCM 3.9	8/5/97	10:30					0.050		0.161		0.312		0.078		180	
DCM 3.9	9/8/97	11:10					0.034		0.040		0.164		0.101		270	
DCM 3.9	11/16/98	9:48	9.6		2											
DCM 3.9	12/1/98	15:35	37	39	61	78										
DCM 3.9	12/8/98	10:35	21		24											
DCM 3.9	12/27/98	11:06	50		111											
DCM 3.9	1/28/99	12:52	130		257											
DCM 3.9	2/17/99	10:25	14		15											
DCM 3.9	2/22/99	10:00	14		16											
DCM 3.9	3/14/99	11:30	11		4											
DCM 3.9	3/30/99	14:25	16		16											
DCM 3.9	7/12/99	9:40					0.044		0.091		0.289		0.063		6	
DCM 3.9	8/11/99	11:15					0.060		0.058		0.268		0.089		29	
DCM 3.9	9/13/99	8:40					0.050		0.021		0.221		0.092		93	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria, true value may be greater than or equal to the reported result.

*: Laboratory did not analyze sample for TPN.

Appendix F. 1994-99 Laboratory Data for Bunker Creek and Deep Creek.

(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		TSS mg/L		NH3 mg/L		NO2/3 mg/L		TPN mg/L		Total Phosphorus mg/L		Fecal Coliform cfu/100 m/L	
DCM 3.6	11/14/94	14:57	5.9				0.010 U		0.415		0.510				13 X	19
DCM 3.6	12/27/94	12:50	150				0.022		1.16		1.610				70	
DCM 3.6	1/10/95	12:05	9.5				0.010 U		0.811		0.891				21	
DCM 3.6	1/25/95	14:20	5.9				0.010 U		0.858		0.884				6	1 U
DCM 3.6	1/29/95	11:30	15				0.014		0.677		0.746				19	
DCM 3.6	2/16/95	12:50	6.9				0.010 U		0.672		0.747				4	
DCM 3.6	2/21/95	11:40	28	26			0.010 U		1.05		1.340				3	3 U
DCM 3.6	3/9/95	12:35	45				0.010 U		0.813		0.983				15	
DCM 3.6	3/14/95	14:00	23				0.049		0.914		1.09				10	7
DCM 3.6	3/22/95	10:43	14	13			0.036		0.934		1.09				15	11
DCM 3.6	7/12/95	12:20					0.038	0.047	0.250	0.25	0.521				240	
DCM 3.6	8/14/95	11:30					0.079		0.020		0.317				210	
DCM 3.6	11/7/95	12:45	35		28											
DCM 3.6	12/4/95	12:10	16		24											
DCM 3.6	12/11/95	10:35	27		31											
DCM 3.6	1/3/96	12:15	11	11	8											
DCM 3.6	1/22/96	10:55	18		24											
DCM 3.6	2/6/96	13:30	190		360	332										
DCM 3.6	2/20/96	14:30	50		42											
DCM 3.6	3/4/96	12:22	11		5											
DCM 3.6	3/11/96	13:21	15		9											
DCM 3.6	4/1/96	11:25	8.0		3											
DCM 3.6	7/8/96	12:45					0.048		0.104		0.262		0.026		24	21
DCM 3.6	8/6/96	11:00					0.010 U		0.078		0.273		0.054		170	
DCM 3.6	9/11/96	12:56					0.010 U		0.037		*		0.069		170	
DCM 3.6	11/13/96	11:20	20		21											
DCM 3.6	11/25/96	10:20	26	25	25	25										
DCM 3.6	12/3/96	12:25	12		7											
DCM 3.6	12/9/96	11:50	9.7		5											
DCM 3.6	1/7/97	12:40	20		25											
DCM 3.6	1/28/97	12:40	7.7		4											
DCM 3.6	2/12/97	11:25	19		19											
DCM 3.6	2/19/97	12:20	27		41											
DCM 3.6	3/3/97	12:00	12		11	9										
DCM 3.6	3/10/97	12:25	12		16											
DCM 3.6	7/1/97	13:30					0.012		0.222		0.353		0.072		43	
DCM 3.6	8/5/97	11:30					0.010 U		0.110		0.225		0.066		61	
DCM 3.6	9/8/97	11:50					0.010 U	0.011	0.126	0.11	0.234	0.22	0.098	0.102	92	85
DCM 3.6	11/16/98	10:05	10		3											
DCM 3.6	12/1/98	15:55	45		97											
DCM 3.6	12/8/98	10:55	23		27											
DCM 3.6	12/27/98	11:34	70	70	163	160										
DCM 3.6	1/28/99	13:04	140		274											
DCM 3.6	2/17/99	10:40	16		18											
DCM 3.6	2/22/99	10:15	18		20											
DCM 3.6	3/14/99	11:51	11		5											
DCM 3.6	3/30/99	14:35	17		17											
DCM 3.6	7/12/99	10:25					0.049		0.126		0.338		0.068		26	
DCM 3.6	8/11/99	11:40					0.043		0.102		0.274		0.089		91	
DCM 3.6	9/13/99	9:05					0.022		0.046		0.288		0.100		4200 J	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria, true value may be greater than or equal to the reported result.

*: Laboratory did not analyze sample for TPN.

Appendix F. 1994-99 Laboratory Data for Bunker Creek and Deep Creek.

(Paired sample results indicate field duplicate)

Station Creek Mile	Date	Time	Turbidity NTU		TSS mg/L		NH3 mg/L		NO2/3 mg/L		TPN mg/L		Total Phosphorus mg/L		Fecal Coliform cfu/100 m/L	
DCM 2.4	11/14/94	15:38	11				0.010 U		0.392		0.516				120	
DCM 2.4	12/27/94	13:10	150				0.047		1.19		2.060				125	125
DCM 2.4	1/10/95	11:30	12	11			0.010 U		0.783		0.876				31	18
DCM 2.4	1/25/95	13:45	6.2				0.010 U		0.840		0.824				8	
DCM 2.4	1/29/95	11:45	12				0.010 U		0.667		0.748				31	
DCM 2.4	2/16/95	13:35	8.7	8.6			0.010 U		0.647		0.708				31	40
DCM 2.4	2/21/95	13:00	36				0.010 U		1.06		1.340				11	
DCM 2.4	3/9/95	12:05	32				0.010 U		0.694		0.890				83	
DCM 2.4	3/14/95	14:40	28				0.021		0.894		1.04				14	
DCM 2.4	3/22/95	11:00	19				0.026		0.932		1.07				18	
DCM 2.4	7/12/95	11:45					0.051		0.326		0.644				5600 J	
DCM 2.4	8/14/95	12:15					0.028	0.027	0.037	0.04	0.306	0.33			1200	1500
DCM 2.4	9/13/95	10:20													1200	930
DCM 2.4	11/7/95	11:50	60		69										830	
DCM 2.4	12/4/95	11:20	22		36											
DCM 2.4	12/11/95	11:15	30		41											
DCM 2.4	1/3/96	11:35	15		14	11										
DCM 2.4	1/22/96	11:35	26		39											
DCM 2.4	2/6/96	13:45	190		335											
DCM 2.4	2/20/96	15:05	55		55											
DCM 2.4	3/4/96	12:50	13		7											
DCM 2.4	3/11/96	13:50	16	17	12											
DCM 2.4	4/1/96	11:50	9.1		4											
DCM 2.4	7/8/96	13:25					0.021	0.020	0.125	0.13	0.370	0.31	0.031	0.037	84	
DCM 2.4	8/6/96	9:55					0.010 U		0.052		0.293		0.053		55	
DCM 2.4	9/11/96	13:15					0.057		0.026		*		0.079		72	
DCM 2.4	11/13/96	11:55	37		39											
DCM 2.4	11/25/96	10:55	32		38											
DCM 2.4	12/3/96	13:00	15		12											
DCM 2.4	12/9/96	12:37	11		9										12 J	
DCM 2.4	1/7/97	12:50	26		36											
DCM 2.4	1/28/97	13:00	9.2		6											
DCM 2.4	2/12/97	11:45	28		26											
DCM 2.4	2/19/97	12:40	34		50											
DCM 2.4	3/3/97	12:10	13		12											
DCM 2.4	3/10/97	12:50	14		21											
DCM 2.4	7/1/97	14:00					0.013		0.264		0.450		0.068		100	
DCM 2.4	8/5/97	12:20					0.012		0.146		0.236		0.095		420	430
DCM 2.4	9/8/97	12:30					0.016		0.081		0.211		0.100		760 J	
DCM 2.4	11/16/98	10:44	11		4											
DCM 2.4	12/1/98	16:15	60		121											
DCM 2.4	12/8/98	11:25	27		39											
DCM 2.4	12/27/98	12:00	100		230											
DCM 2.4	1/28/99	13:20	150		293											
DCM 2.4	2/17/99	11:10	21	20	29	28										
DCM 2.4	2/22/99	10:45	29		45											
DCM 2.4	3/14/99	12:10	13		11											
DCM 2.4	3/30/99	15:00	22		26											
DCM 2.4	7/12/99	10:45					0.041		0.115		0.353		0.067		880	800
DCM 2.4	8/11/99	12:00					0.051		0.083		0.310		0.087		400	
DCM 2.4	9/13/99	9:30					0.023		0.028		0.325		0.083		690	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria, true value may be greater than or equal to the reported result.

*: Laboratory did not analyze sample for TPN.

Appendix G

Berwick Creek and Dillenbaugh Creek

Field Data, 1998-2000
Laboratory Data, 1998-2000

Appendix G. 1998-2000 Field Data for Berwick Creek and Dillenbaugh Creek.
(paired results indicate field duplicate)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm Field	Conductivity umhos/cm Lab	Dissolved Oxygen mg/L		Dissolved Oxygen % Saturation	Flow cfs
Berw CM 5.3	12/1/98	14:45	6.3	6.7	33					17.1
Berw CM 5.3	12/8/98	12:45	5.3	7.4	31					12.2
Berw CM 5.3	12/28/98	12:18	5.2	6.7	42					17.7
Berw CM 5.3	2/16/99	12:00	5.1	7.1	26					8.0
Berw CM 5.3	3/3/99	14:30	5.6	**	**					22.9
Berw CM 5.3	3/14/99	15:20	7.9	7.2	23					9.0
Berw CM 5.3	3/30/99	11:49	6.0	6.9	21					9.9
Berw CM 5.3	6/14/99	13:35	15.5	7.6	65		8.5		86%	0.2
Berw CM 5.3	7/12/99	12:25	13.4	6.6	79		9.1		89%	0.1
Berw CM 5.3	8/11/99	13:30	13.7	6.9	73		8.6		84%	0.1
Berw CM 5.3	9/13/99	14:15	11.9	6.9	66		9.2		86%	0.1
Berw CM 5.3	11/22/99	12:10	6.8	7.8	38					3.9
Berw CM 5.3	11/30/99	10:30	7.5	6.5	26					13.8
Berw CM 5.3	12/13/99	10:03	5.6	**	**					20.6
Berw CM 5.3	1/4/00	9:22	4.9	8.0	26					17.3
Berw CM 5.3	1/10/00	10:40	3.6	6.3	**					11.5
Berw CM 5.3	2/1/00	10:32	4.3	**	33					6.0
Berw CM 5.3	2/8/00	10:45	6.0	5.7	24					6.2
Berw CM 5.3	2/15/00	9:30	4.4	6.1	22					4.3
Berw CM 5.3	3/15/00	9:20	5.8	6.4	32					1.7
Berw CM 5.3	3/20/00	10:15	5.8	7.4	**					4.8
Berw CM 5.3	6/12/00	11:05	12.5	6.8	**	71	9.7		92%	0.2
Berw CM 5.3	7/5/00	10:45	12.4	6.3	**	77	9.1		86%	0.1
Berw CM 5.3	8/7/00	11:00	13.8	5.9	**		8.7		85%	0.0
Berw CM 5.3	9/11/00	10:30	11.2	6.6	90		9.6		89%	0.1
Berw CM 3.0	12/1/98	13:30	7.0	6.7	39					40.4
Berw CM 3.0	12/8/98	13:05	5.9	7.4	36					24.4
Berw CM 3.0	12/28/98	12:53	6.1	6.6	33					43.2
Berw CM 3.0	2/16/99	12:30	5.9	6.8	38					17.2
Berw CM 3.0	3/3/99	14:00	6.4	**	**					51.6
Berw CM 3.0	3/14/99	14:58	8.3	7.2	27					19.6
Berw CM 3.0	3/30/99	11:30	6.2	6.9	31					24.8
Berw CM 3.0	6/14/99	13:00	18.3	7.6	67		9.5		10%	0.9
Berw CM 3.0	7/12/99	12:45	17.3	7.2	103		10.0		10%	0.8
Berw CM 3.0	8/11/99	14:00	15.6	7.4	72		9.5	9.5	96%	0.8
Berw CM 3.0	9/13/99	14:45	16.1	7.2	68		9.8		100%	0.3
Berw CM 3.0	11/22/99	12:39	7.3	8.0	65					8.1
Berw CM 3.0	11/30/99	10:55	8.1	6.4	31					30.2
Berw CM 3.0	12/13/99	10:20	5.7	**	**					43.7
Berw CM 3.0	1/4/00	9:52	5.7	8.0	52					39.8
Berw CM 3.0	1/10/00	11:10	4.2	7.1	**					28.4
Berw CM 3.0	2/1/00	11:00	5.6	**	48					15.0
Berw CM 3.0	2/8/00	11:15	6.6	7.9	42					15.1
Berw CM 3.0	2/15/00	9:55	4.8	6.5	31					9.2
Berw CM 3.0	3/15/00	9:50	5.4	7.5	44					5.2
Berw CM 3.0	3/20/00	10:35	5.9	7.7	**					11.8
Berw CM 3.0	6/12/00	11:50	14.1	7.3	**	70.7	10.3		10%	0.8
Berw CM 3.0	7/5/00	11:30	14.4	6.8	**		10.4		10%	0.7
Berw CM 3.0	8/7/00	11:30	15.7	6.5	**		9.6	9.6	97%	0.4
Berw CM 3.0	9/11/00	11:00	12.6	6.9	93		10.5	10.6	10%	0.7

** Meter did not meet quality control requirements or was not functioning.

Appendix G. 1998-2000 Field Data for Berwick Creek and Dillenbaugh Creek.
(paired results indicate field duplicate)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm		Dissolved Oxygen mg/L		%	Flow cfs
					Field	Lab	Conc.		Saturation	
Berw CM 2.0	12/1/98	13:00	7.0	6.7	41					41.0
Berw CM 2.0	12/8/98	13:30	6.0	7.5	37					26.5
Berw CM 2.0	12/28/98	13:16	6.2	6.6	33					49.9
Berw CM 2.0	2/16/99	12:50	6.1	6.8	35					19.3
Berw CM 2.0	3/3/99	13:36	6.6	**	**					56.7 e
Berw CM 2.0	3/14/99	14:42	8.3	7.2	28					18.7
Berw CM 2.0	3/30/99	11:10	6.2	6.9	31					26.6
Berw CM 2.0	6/14/99	12:30	18.6	7.6	71		9.1		98%	0.6
Berw CM 2.0	7/12/99	13:21	18.9	6.6	89		9.2		100%	0.7
Berw CM 2.0	8/11/99	14:30	16.7	7.3	71		10.0		10%	0.6
Berw CM 2.0	9/13/99	15:00	17.1	7.0	72		9.2		96%	0.4
Berw CM 2.0	11/22/99	12:58	7.3	8.0	66					8.6
Berw CM 2.0	11/30/99	11:20	8.2	6.4	34					38.1
Berw CM 2.0	12/13/99	10:48	5.7	7.7	**					45.9
Berw CM 2.0	1/4/00	10:13	5.8	8.0	34					42.5
Berw CM 2.0	1/10/00	11:25	4.2	7.4	**					25.2
Berw CM 2.0	2/1/00	11:16	5.7	**	53					17.8
Berw CM 2.0	2/8/00	11:40	6.7	7.7	40					16.9
Berw CM 2.0	2/15/00	10:10	4.8	6.8	31					9.4
Berw CM 2.0	3/15/00	10:05	5.4	7.6	40					4.1
Berw CM 2.0	3/20/00	10:55	5.9	7.7	**	38				11.5
Berw CM 2.0	6/12/00	12:20	14.7	7.3	**		9.8		98%	0.8
Berw CM 2.0	7/5/00	12:00	15.1	6.8	**		9.3		93%	0.6
Berw CM 2.0	8/7/00	11:50	17.0	7.0	**	89	8.5		88%	0.3
Berw CM 2.0	9/11/00	11:30	13.1	6.7	95	87	9.6		92%	0.8
Berw CM 1.7	12/1/98	12:20	6.8	6.8	51					39.3
Berw CM 1.7	12/8/98	13:45	6.0	7.3	37					29.4
Berw CM 1.7	12/28/98	13:40	6.6	6.5	36					50.7
Berw CM 1.7	2/16/99	13:10	6.2	6.8	36					24.5
Berw CM 1.7	3/3/99	13:10	6.8	**	**					67.4
Berw CM 1.7	3/14/99	14:22	8.3	7.1	31					21.4
Berw CM 1.7	3/30/99	10:54	6.1	6.8	35					29.5
Berw CM 1.7	6/14/99	12:12	17.4	7.7	67		8.8	8.8	92%	0.6 e
Berw CM 1.7	7/12/99	13:40	17.8	6.6	82		8.7		92%	0.5
Berw CM 1.7	8/11/99	14:45	16.7	7.3	71		8.8		91%	0.5
Berw CM 1.7	9/13/99	15:30	16.2	7.1	72		8.8		90%	0.4
Berw CM 1.7	11/22/99	13:15	7.5	7.9	81					9.2
Berw CM 1.7	11/30/99	11:40	8.3	6.5	37					37.6
Berw CM 1.7	12/13/99	11:07	5.7	6.9	**					53.2
Berw CM 1.7	1/4/00	10:40	5.9	7.9	57					47.1
Berw CM 1.7	1/10/00	11:50	4.2	7.3	**					27.1
Berw CM 1.7	2/1/00	11:35	5.8	**	54					19.6
Berw CM 1.7	2/8/00	12:05	6.9	6.0	38					16.4
Berw CM 1.7	2/15/00	10:25	4.9	6.8	31					9.6
Berw CM 1.7	3/15/00	10:25	5.5	7.6	49					5.2
Berw CM 1.7	3/20/00	11:15	6.0	7.7	**	41				12.8
Berw CM 1.7	6/12/00	12:50	14.6	7.3	**		9.9		98%	0.8
Berw CM 1.7	7/5/00	12:30	15.1	6.9	**		9.2		92%	0.7
Berw CM 1.7	8/7/00	12:05	16.8	7.4	**		8.9		92%	0.4
Berw CM 1.7	9/11/00	11:50	13.1	6.9	93		9.9		95%	0.7

** Meter did not meet quality control requirements or was not functioning.

e Flows were estimated using a flow discharge rating curve.

Appendix G. 1998-2000 Field Data for Berwick Creek and Dillenbaugh Creek.
(paired results indicate field duplicate)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm Field	Conductivity umhos/cm Lab	Dissolved Oxygen mg/L Conc.		Dissolved Oxygen % Saturation	Flow cfs	
Berw CM 0.6	12/1/98	11:50	6.8	6.6	48					43.4	
Berw CM 0.6	12/8/98	14:15	6.0	7.4	43					30.3	
Berw CM 0.6	12/28/98	14:06	6.5	6.4	39					55.9	
Berw CM 0.6	2/16/99	13:30	6.3	6.7	40					27.4	
Berw CM 0.6	3/3/99	12:50	6.5	**	**					69.0	e
Berw CM 0.6	3/14/99	14:00	8.2	7.1	32					24.2	
Berw CM 0.6	3/30/99	10:23	5.9	6.8	34					33.2	
Berw CM 0.6	6/14/99	11:40	16.5	7.5	110		8.5		88%	0.6	
Berw CM 0.6	7/12/99	14:05	17.5	6.6	87		8.8	8.9	93%	0.5	
Berw CM 0.6	8/11/99	15:15	16.6	7.1	74		8.4		87%	0.4	
Berw CM 0.6	9/13/99	15:50	14.8	7.0	76		9.0	9.0	89%	0.5	
Berw CM 0.6	11/22/99	13:33	7.5	7.8	70					10.8	
Berw CM 0.6	11/30/99	12:40	8.4	6.4	41					42.5	
Berw CM 0.6	12/13/99	11:35	5.6	7.5	**					49.1	
Berw CM 0.6	1/4/00	11:10	5.9	7.0	57					54.4	
Berw CM 0.6	1/10/00	12:05	4.2	7.0	**					33.9	
Berw CM 0.6	2/1/00	11:55	5.9	**	76					26.1	
Berw CM 0.6	2/8/00	12:30	6.9	7.9	50					21.3	
Berw CM 0.6	2/15/00	10:45	4.9	6.9	35					10.9	
Berw CM 0.6	3/15/00	10:45	5.6	7.7	44					5.5	
Berw CM 0.6	3/20/00	11:30	6.1	7.8	**	45				15.1	
Berw CM 0.6	6/12/00	13:15	14.0	7.3	**		9.7	9.7	95%	1.0	
Berw CM 0.6	7/5/00	12:40	14.2	7.0	**	80	9.4		92%	0.7	
Berw CM 0.6	8/7/00	12:30	16.8	7.4	**		7.9		82%	0.4	
Berw CM 0.6	9/11/00	12:15	12.4	6.8	95		9.7		92%	0.7	
Berw CM 0.0	12/1/98	11:10	6.6	6.5	53					43.4	E
Berw CM 0.0	12/8/98	14:45	6.0	7.5	54					30.3	E
Berw CM 0.0	12/28/99	No data--water too high to access station									
Berw CM 0.0	2/16/99	14:15	6.4	6.8	52					27.4	E
Berw CM 0.0	3/3/99	12:30	6.1	**	**					69.0	E
Berw CM 0.0	3/14/99	13:40	7.9	7.0	39					24.2	E
Berw CM 0.0	3/30/99	10:05	5.7	6.4	40					33.2	E
Berw CM 0.0	6/14/99	10:45	16.3	7.3	80		8.1		83%	0.6	E
Berw CM 0.0	7/12/99	14:40	17.6	6.6	88		7.3		77%	0.5	E
Berw CM 0.0	8/11/99	15:55	16.8	7.1	84		6.6		68%	0.4	E
Berw CM 0.0	9/13/99	16:40	14.9	6.8	91		6.5		65%	0.5	E
Berw CM 0.0	11/22/99	14:11	7.5	7.8	69					10.8	E
Berw CM 0.0	11/30/99	13:20	8.5	6.4	50					42.5	E
Berw CM 0.0	12/13/99	12:13	5.7	7.4	**					49.1	E
Berw CM 0.0	1/4/00	12:15		7.8	58					54.4	E
Berw CM 0.0	1/10/00	12:45	4.2	6.8	**					33.9	E
Berw CM 0.0	2/1/00	12:22	6.0	**	68					26.1	E
Berw CM 0.0	2/8/00	13:00	7.1	7.9	62					21.3	E
Berw CM 0.0	2/15/00	11:05	5.0	7.8	40					10.9	E
Berw CM 0.0	3/15/00	11:07	5.7	7.7	48					5.5	E
Berw CM 0.0	3/20/00	11:57	6.1	7.7	**	46				15.1	E
Berw CM 0.0	6/12/00	14:00	14.2	7.2	**	90	9.1		89%	1.0	E
Berw CM 0.0	7/5/00	13:15	14.8	6.9	**		9.5		94%	0.7	E
Berw CM 0.0	8/7/00	12:50	17.0	7.1	**	99	7.5		78%	0.4	E
Berw CM 0.0	9/11/00	12:55	13.1	6.9	105		9.0		86%	0.7	E

** Meter did not meet quality control requirements or was not functioning.

e Flows were estimated using a flow discharge rating curve.

E Flows were estimated to be the same as Berwick CM 0.6.

Appendix G. 1998-2000 Field Data for Berwick Creek and Dillenbaugh Creek.

(paired results indicate field duplicate)

Station Creek Mile	Date	Time	Temp °C	pH std units	Conductivity umhos/cm		Dissolved Oxygen mg/L		%	Flow cfs
					Field	Lab	Conc.		Saturation	
Dill CM 3.5	12/1/98	10:35	6.9	6.2	56					58.8
Dill CM 3.5	12/8/98	14:40	6.4	7.3	44					47.5
Dill CM 3.5	12/28/98	14:49	6.8	6.6	41					*
Dill CM 3.5	2/16/99	14:00	6.5	6.8	42					39.3
Dill CM 3.5	3/3/99	12:00	6.0	**	**					*
Dill CM 3.5	3/14/99	13:20	8.0	6.9	33					35.6
Dill CM 3.5	3/30/99	9:45	5.7	6.3	38					54.3
Dill CM 3.5	6/14/99	10:38	15.9	7.2	69		9.2	9.2	94%	1.8
Dill CM 3.5	7/12/99	14:15	17.5	6.8	89		9.3	9.4	98%	1.1
Dill CM 3.5	8/11/99	15:40	16.7	7.3	73		9.9		103%	1.2
Dill CM 3.5	9/13/99	16:20	14.7	7.2	83		9.6		95%	0.9
Dill CM 3.5	11/22/99	13:56	7.5	8.0	88					17.9
Dill CM 3.5	11/30/99	12:50	8.8	6.4	39					80.7
Dill CM 3.5	12/13/99	12:05	5.9	7.6	**					94.6
Dill CM 3.5	1/4/00	11:52	6.3	7.6	35					87.6
Dill CM 3.5	1/10/00	12:30	4.3	6.9	**					66.0
Dill CM 3.5	2/1/00	12:20	6.1	**	41					39.7
Dill CM 3.5	2/8/00	13:10	7.1	7.8	38					37.0
Dill CM 3.5	2/15/00	11:04	5.3	7.6	39					18.8
Dill CM 3.5	3/15/00	11:05	6.2	7.7	38					12.2
Dill CM 3.5	3/20/00	11:55	6.5	7.7	**	45				24.7
Dill CM 3.5	6/12/00	13:45	15.1	7.3	**		9.9		99%	1.7
Dill CM 3.5	7/5/00	13:00	15.1	7.1	**	80	9.4		94%	1.4
Dill CM 3.5	8/7/00	12:50	18.5	7.6	**		8.7		93%	0.9
Dill CM 3.5	9/11/00	12:50	13.5	7.0	100	88	10.0		97%	1.4

* Flows not done due to high water volume.

** Meter did not meet quality control requirements or was not functioning.

Appendix G. 1998-2000 Laboratory Data for Berwick Creek and Dillenbaugh Creek.

(paired results indicate field duplicate)

Station Name	Date	Time	Turbidity NTU		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total Persulfate Nitrogen mg/L		Total Phosphorus mg/L		FC-mf #/100 mL	
Berw CM 5.3	12/1/98	14:45	4.9		0.023		0.165		0.400				13	
Berw CM 5.3	12/8/98	12:45	3.2										8	
Berw CM 5.3	12/28/98	12:18	7										200 J	170 J
Berw CM 5.3	2/16/99	12:00	18										34	
Berw CM 5.3	3/3/99	14:30	6.1										9	6
Berw CM 5.3	3/14/99	15:20	3.8										2	
Berw CM 5.3	3/30/99	11:49	5.1	5.1									10	
Berw CM 5.3	6/14/99	13:35	2.4		0.049								17	
Berw CM 5.3	7/12/99	12:25	1.5		0.029		0.237		0.428		0.063		6	
Berw CM 5.3	8/11/99	13:30	1.3		0.032								16	
Berw CM 5.3	9/13/99	14:15	1		0.029								5	
Berw CM 5.3	11/22/99	12:10	3.9	3.7									6	
Berw CM 5.3	11/30/99	10:30	4.0										62	
Berw CM 5.3	12/13/99	10:03	4.8										280 J	
Berw CM 5.3	1/4/00	9:22	5.5										23	
Berw CM 5.3	1/10/00	10:40	4.0										4	
Berw CM 5.3	2/1/00	10:32	4.3										40	23
Berw CM 5.3	2/8/00	10:45	4.2										19	
Berw CM 5.3	2/15/00	9:30	4.0										5	
Berw CM 5.3	3/15/00	9:20	4.2										1 U	
Berw CM 5.3	3/20/00	10:15	4.7		0.010 U		0.073		0.196		0.018		1	3
Berw CM 5.3	6/20/00	11:05	3		0.010 U		0.102		0.339		0.059		7	12
Berw CM 5.3	7/5/00	10:45	2.1		0.010 U		0.170		0.354		0.055		19	
Berw CM 5.3	8/7/00	11:00	1.4		0.010 U		0.262		0.360		0.089		21	
Berw CM 5.3	9/11/00	10:30	1.6		0.010 U		0.167		0.305		0.082		23	
Berw CM 3.0	12/1/98	13:30	23		0.029		0.678		1.05				210	
Berw CM 3.0	12/8/98	13:05	6.7	6.8									69	92
Berw CM 3.0	12/28/98	12:53	20										210	
Berw CM 3.0	2/16/99	12:30	9.6										49	
Berw CM 3.0	3/3/99	14:00	14										17	
Berw CM 3.0	3/14/99	14:58	9.3										15	
Berw CM 3.0	3/30/99	11:30	10										48	39
Berw CM 3.0	6/14/99	13:00	7.1		0.053								230	
Berw CM 3.0	7/12/99	12:45	6.6		0.041		0.121		0.402		0.099		550	
Berw CM 3.0	8/11/99	14:00	8.2		0.037								280	
Berw CM 3.0	9/13/99	14:45	4.5		0.025								210	
Berw CM 3.0	11/22/99	12:39	5.8										26	
Berw CM 3.0	11/30/99	10:55	12										360 J	
Berw CM 3.0	12/13/99	10:20	11										290 J	270 J
Berw CM 3.0	1/4/00	9:52	17										86	
Berw CM 3.0	1/10/00	11:10	8.1										49	
Berw CM 3.0	2/1/00	11:00	18										230	
Berw CM 3.0	2/8/00	11:15	13										76	75
Berw CM 3.0	2/15/00	9:55	6.0										14	
Berw CM 3.0	3/15/00	9:50	6.1										5	
Berw CM 3.0	3/20/00	10:35	7.3		0.010 U		0.315		0.424		0.028		7	
Berw CM 3.0	6/20/00	11:50	4.5		0.010 U		0.121		0.294		0.093		250	
Berw CM 3.0	7/5/00	11:30	4		0.010 U		0.105		0.256		0.083		260	220
Berw CM 3.0	8/7/00	11:30	4.3		0.018		0.097		0.270		0.116		220	
Berw CM 3.0	9/11/00	11:00	4.7		0.010 U		0.062		0.244		0.107		410	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria, true value may be ≥ to the reported result.

Appendix G. 1998-2000 Laboratory Data for Berwick Creek and Dillenbaugh Creek.
(paired results indicate field duplicate)

Station Name	Date	Time	Turbidity NTU		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total Persulfate Nitrogen mg/L		Total Phosphorus mg/L		FC-mf #/100 mL	
Berw CM 2.0	12/1/98	13:00	29		0.031		0.687		1.05				180	
Berw CM 2.0	12/8/98	13:30	10										180	
Berw CM 2.0	12/28/98	13:16	33	31									200	190
Berw CM 2.0	2/16/99	12:50	13										49	
Berw CM 2.0	3/3/99	13:36	20										51	
Berw CM 2.0	3/14/99	14:42	12										20	27
Berw CM 2.0	3/30/99	11:10	14										76	
Berw CM 2.0	6/14/99	12:30	22		0.075								2900 J	
Berw CM 2.0	7/12/99	13:21	18	18	0.066		0.135		0.711		0.105		3800	
Berw CM 2.0	8/11/99	14:30	13		0.050								410	
Berw CM 2.0	9/13/99	15:00	13		0.038								310	
Berw CM 2.0	11/22/99	12:58	7.8										77	
Berw CM 2.0	11/30/99	11:20	18										240	220
Berw CM 2.0	12/13/99	10:48	15										440	
Berw CM 2.0	1/4/00	10:13	23										350	
Berw CM 2.0	1/10/00	11:25	10										54	
Berw CM 2.0	2/1/00	11:16	24										1100 J	730 J
Berw CM 2.0	2/8/00	11:40	17										490	
Berw CM 2.0	2/15/00	10:10	8.3										92	
Berw CM 2.0	3/15/00	10:05	6.8										11	14
Berw CM 2.0	3/20/00	10:55	8.8		0.010 U		0.296		0.408		0.030		16	
Berw CM 2.0	6/20/00	12:20	17		0.035		0.119		0.611		0.104		4000 J	
Berw CM 2.0	7/5/00	12:00	16		0.019		0.101		0.438		0.087		670	
Berw CM 2.0	8/7/00	11:50	8.3	8.2	0.025		0.095		0.337		0.124		170	92
Berw CM 2.0	9/11/00	11:30	8.8		0.013		0.043		0.259		0.106		230	
Berw CM 1.7	12/1/98	12:20	20		0.050		0.887		1.34				250	
Berw CM 1.7	12/8/98	13:45	10										160	
Berw CM 1.7	12/28/98	13:40	30										300	
Berw CM 1.7	2/16/99	13:10	15										200	190
Berw CM 1.7	3/3/99	13:10	21										74	
Berw CM 1.7	3/14/99	14:22	13	13									21	29
Berw CM 1.7	3/30/99	10:54	14										110	
Berw CM 1.7	6/14/99	12:12	18		0.086								11000 J	12000 J
Berw CM 1.7	7/12/99	13:40	17		0.174		0.166		0.754		0.119		3500	
Berw CM 1.7	8/11/99	14:45	20	20	0.050								210	
Berw CM 1.7	9/13/99	15:30	15		0.040								1400	
Berw CM 1.7	11/22/99	13:15	7.6										75	
Berw CM 1.7	11/30/99	11:40	18										540	
Berw CM 1.7	12/13/99	11:07	15										420	530
Berw CM 1.7	1/4/00	10:40	24										440	
Berw CM 1.7	1/10/00	11:50	11										92	
Berw CM 1.7	2/1/00	11:35	25										1500 J	
Berw CM 1.7	2/8/00	12:05	18										600	
Berw CM 1.7	2/15/00	10:25	7.5										66	31
Berw CM 1.7	3/15/00	10:25	9.1										13	
Berw CM 1.7	3/20/00	11:15	9.8	10	0.010 U	0.011	0.296	0.311	0.439	0.462	0.037	0.034	18	
Berw CM 1.7	6/20/00	12:50	12		0.013		0.116		0.324		0.100		2400 J	
Berw CM 1.7	7/5/00	12:30	9.8		0.010 U		0.103		0.302		0.092		350	
Berw CM 1.7	8/7/00	12:05	10		0.030	0.026	0.161	0.162	0.466	0.495	0.126	0.124	110	100
Berw CM 1.7	9/11/00	11:50	9.4		0.011		0.044		0.241		0.103		150	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria, true value may be ≥ to the reported result.

Appendix G. 1998-2000 Laboratory Data for Berwick Creek and Dillenbaugh Creek.

(paired results indicate field duplicate)

Station Name	Date	Time	Turbidity NTU		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total Persulfate Nitrogen mg/L		Total Phosphorus mg/L		FC-mf #/100 mL	
Berw CM 0.6	12/1/98	11:50	22		0.048		0.820		1.31				180	
Berw CM 0.6	12/8/98	14:15	12										54	
Berw CM 0.6	12/28/98	14:06	34										430	
Berw CM 0.6	2/16/99	13:30	18										250	240
Berw CM 0.6	3/3/99	12:50	26	24	0.106		0.326		0.775				370	450
Berw CM 0.6	3/14/99	14:00	17		0.024		0.331		0.652		0.054		83	
Berw CM 0.6	3/30/99	10:23	17		0.018		0.462		0.832		0.066		96	
Berw CM 0.6	6/14/99	11:40	13		0.078								1600 J	
Berw CM 0.6	7/12/99	14:05	11		0.054	0.052	0.217	0.223	0.582	0.621	0.114	0.111	140 J	180
Berw CM 0.6	8/11/99	15:15	9.1		0.053								84	
Berw CM 0.6	9/13/99	15:50	8.8		0.036								280	
Berw CM 0.6	11/22/99	13:33	8.3										180	150
Berw CM 0.6	11/30/99	12:40	21										570	
Berw CM 0.6	12/13/99	11:35	15										620	
Berw CM 0.6	1/4/00	11:10	24										300	
Berw CM 0.6	1/10/00	12:05	12										210	210
Berw CM 0.6	2/1/00	11:55	24										1500	
Berw CM 0.6	2/8/00	12:30	19	18									450	
Berw CM 0.6	2/15/00	10:45	8.8										57	
Berw CM 0.6	3/15/00	10:45	8.1										11	
Berw CM 0.6	3/20/00	11:30	11		0.010 U		0.288		0.441		0.038		51	
Berw CM 0.6	6/20/00	13:15	8.7		0.018		0.130		0.345		0.099		930 J	
Berw CM 0.6	7/5/00	12:40	10		0.013	0.012	0.129	0.128	0.343	0.332	0.091	0.092	370	310
Berw CM 0.6	8/7/00	12:30	11		0.036		0.171		0.396		0.138		290	
Berw CM 0.6	9/11/00	12:15	10		0.022		0.056		0.264		0.105		290	
Berw CM 0.0	12/1/98	11:10	18	20	0.046	0.048	0.973	0.983	1.41	1.54			100	120
Berw CM 0.0	12/8/98	14:45	14										69	
Berw CM 0.0	12/28/99	No data--water too high to access station												
Berw CM 0.0	2/16/99	14:15	21										280	
Berw CM 0.0	3/3/99	12:30	29		0.175		0.334		1.03				500	
Berw CM 0.0	3/14/99	13:40	20		0.121		0.366		0.873		0.101		120	
Berw CM 0.0	3/30/99	10:05	21		0.083		0.503		1.03		0.095		140	
Berw CM 0.0	6/14/99	10:45	17		0.106								9600 J	
Berw CM 0.0	7/12/99	14:40	15		0.091		0.307		0.988		0.155		16000	
Berw CM 0.0	8/11/99	15:55	19		0.102								11000	
Berw CM 0.0	9/13/99	16:40	20		0.168	0.168							32000	34000
Berw CM 0.0	11/22/99	14:11	8.7										250	
Berw CM 0.0	11/30/99	13:20	27										1000	
Berw CM 0.0	12/13/99	12:13	18										7700	
Berw CM 0.0	1/4/00	12:15	27										390	500
Berw CM 0.0	1/10/00	12:45	14										1100	
Berw CM 0.0	2/1/00	12:22	28	28									1500	
Berw CM 0.0	2/8/00	13:00	22										650	
Berw CM 0.0	2/15/00	11:05	10										84	
Berw CM 0.0	3/15/00	11:07	12										27	
Berw CM 0.0	3/20/00	11:57	12		0.015		0.326		0.518		0.059		35	33
Berw CM 0.0	6/20/00	14:00	11	10	0.082		0.171		0.532		0.117		520 J	500
Berw CM 0.0	7/5/00	13:15	10		0.020		0.165		0.383		0.102		160	
Berw CM 0.0	8/7/00	12:50	12		0.058		0.194		0.470		0.155		350	
Berw CM 0.0	9/11/00	12:55	9.2		0.018		0.067		0.304		0.113		80	

U Indicates that the analyte was not detected at or above the reporting limit.

J This result is an estimate. For bacteria, true value may be ≥ to the reported result.

Appendix G. 1998-2000 Laboratory Data for Berwick Creek and Dillenbaugh Creek.
(paired results indicate field duplicate)

Station Name	Date	Time	Turbidity NTU		Ammonia Nitrogen mg/L		Nitrate/Nitrite mg/L		Total Persulfate Nitrogen mg/L		Total Phosphorus mg/L		FC-mf #/100 mL	
Dill CM 3.5	12/1/98	10:35	14		0.033	0.029	1.10	1.07	1.56	1.52			870 J	710 J
Dill CM 3.5	12/8/98	14:40	8.6										15	
Dill CM 3.5	12/28/98	14:49	28										110	
Dill CM 3.5	2/16/99	14:00	15										100 J	
Dill CM 3.5	3/3/99	12:00	24										170	
Dill CM 3.5	3/14/99	13:20	13										49	
Dill CM 3.5	3/30/99	9:45	13										72	91
Dill CM 3.5	6/14/99	10:38	4.6		0.057								170	160
Dill CM 3.5	7/12/99	14:15	4.6		0.022		0.030		0.281		0.081		71 J	
Dill CM 3.5	8/11/99	15:40	4.9		0.043								140	
Dill CM 3.5	9/13/99	16:20	5.3		0.025								92	
Dill CM 3.5	11/22/99	13:56	8.4										57	69
Dill CM 3.5	11/30/99	12:50	18										220	300
Dill CM 3.5	12/13/99	12:05	14										110	
Dill CM 3.5	1/4/00	11:52	21	21									170	
Dill CM 3.5	1/10/00	12:30	14										170	
Dill CM 3.5	2/1/00	12:20	25										480	
Dill CM 3.5	2/8/00	13:10	19										200	150
Dill CM 3.5	2/15/00	11:04	9.1										26	
Dill CM 3.5	3/15/00	11:05	8.6										21	
Dill CM 3.5	3/20/00	11:55	9.6		0.010 U	0.011	0.463	0.464	0.603	0.592	0.041	0.044	12	
Dill CM 3.5	6/20/00	13:45	5.2		0.013		0.069		0.249		0.097		57	
Dill CM 3.5	7/5/00	13:00	4.4		0.010 U		0.029		0.195		0.078		91	
Dill CM 3.5	8/7/00	12:50	5.7		0.021		0.030		0.200		0.112		120	
Dill CM 3.5	9/11/00	12:50	6.1		0.015		0.015		0.192		0.105		80	80