WASHINGTON STATE DEPARTMENT OF ECOLOGY

Fishtrap Creek Total Maximum Daily Load Study

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or

Barbara Tovrea, EILS Program
Washington State Department of Ecology
P.O. Box 47710
Olympia, WA 98504-7710
(360) 407-6696

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Fishtrap Creek
Total Maximum Daily Load Study

by
Karol Erickson

Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Watershed Assessments Section
P.O. Box 47710
Olympia, Washington 98504-7710

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Abstract

The Fishtrap Creek watershed, tributary to the Nooksack River in northwestern Washington, is dominated by dairy farming. Fifteen sites in mainstem Fishtrap Creek and its tributaries were surveyed for conventional water quality parameters six times between September 1993 and January 1994. The water quality investigation results showed high to very high levels of fecal coliform bacteria throughout the watershed (as high as 880,000 organisms/100 mL), low levels of dissolved oxygen in the small tributaries (as low as 2.2 mg/L), and one instance of very high ammonia levels (19.2 mg/L NH_3-N).

A total maximum daily load (TMDL) for fecal coliform was allocated as follows: the geometric mean of all samples at all sites is not to exceed 100 organisms/100 mL, with no more than 10 percent of all samples exceeding 200 organisms/100 mL. To achieve this load allocation, dairy farm "best management practices" are recommended to be implemented at dairy farms throughout the watershed. The highest priority areas are immediately upgradient of the intersection of Depot and Visser roads and near the mouth of the Benson Road Ditch. Because this is a phased TMDL, continued monitoring of progress will be necessary for successful implementation of the TMDL.

1.0 Introduction

Background

The Fishtrap Creek watershed has been of continuing interest to water quality managers over the last several years, as evidenced by studies conducted by the Department of Ecology, Whatcom Conservation District, and Whatcom County Health Department (Dickes, 1992; WCCD, 1988; WCCD and WCHD, 1990). This northern Whatcom County watershed, tributary to the Nooksack River, has long been dominated by dairy farming, allowing water quality effects from dairy waste to be isolated from other nonpoint sources. This study evaluates conventional water quality parameters for the Fishtrap Creek watershed, with an emphasis on fecal coliform bacteria contamination.

This study coincides with several new initiatives within the Department of Ecology. Perhaps the most significant for the Fishtrap Creek area was the issuance of a new dairy waste permitting program in September 1994, designed to reduce water quality impacts from dairy waste. The permit targets those farms known to be polluting, regardless of size, and involves close coordination between the Department of Ecology (Ecology) and local Conservation Districts.

The second initiative is a pilot project to test a geographic-based approach to conducting Ecology's business. The Nooksack Watershed Initiative is a geographically-targeted, community-driven process for addressing environmental priorities, including water quality and availability, flooding, land use, Indian water rights, and declining fisheries. A 21-member Nooksack Watershed Initiative Task Force has been convened to guide the process for setting and taking action on environmental priorities. The task force will be considering recommendations for water quality and habitat improvements from studies conducted within the Nooksack watershed, including those contained in this report.

In addition to the Nooksack Watershed Team project, Ecology's Water Quality Program has recently restructured its Program activities to work on a watershed basis with a five-year cycle of activities. Fishtrap Creek is part of the larger Nooksack/San Juan Watershed, which is scheduled for permit action in fiscal year 1995 (July 1994 through June 1995). The watershed will then start a new five-year cycle, starting with basin scoping in fiscal year 1996, collecting and analyzing data and drafting a water quality management strategy in years 1997 through 1999, and implementing the strategy in 2000 and beyond.

The recommendations of this total maximum daily load (TMDL) study for Fishtrap Creek will be implemented within the framework of these three Ecology initiatives.

Project Goals and Objectives

The project goals and objectives, as stated in the Fishtrap Creek Agricultural Waste Study Quality Assurance Project Plan (Erickson, 1993) were:

A. Determine instantaneous pollutant loadings in Fishtrap Creek and its tributaries for three seasons: summer low flow (mid-September), fall (November), and winter (January). Three sites describe the pollutant loading entering the basin from Canada, and one site describes the loading from Fishtrap Creek into the Nooksack River. The remaining 11 sites describe pollutant loads of the tributaries and Fishtrap Creek.

B. To the extent possible, determine the seasonal patterns and critical periods for pollutant concentrations and loadings.

C. Make recommendations concerning a Total Maximum Daily Load (TMDL) assessment of the basin and subsequent allocations or management plans. Recommend other follow-up actions and studies.

Basin Overview

Fishtrap Creek watershed is located in northwest Whatcom County and drains into the Nooksack River (Figure 1). Fishtrap Creek drains 30.6 square miles, of which slightly more than half is in Canada (WCCD, 1988).

The majority of the Fishtrap Creek basin lies within the Lynden Terrace, a flat lowland with elevations ranging from 150 feet near the Canadian border to about 50 feet where it meets the Nooksack lowlands. The northwestern quarter of the basin (entirely in Canada) is in the Boundary Uplands, a hilly area with elevations ranging from about 500 to 150 feet. The southern edge of the basin, downstream from Lynden, lies within the Nooksack lowlands, less than 50 feet in elevation (WCCD, 1988).

Precipitation in the basin ranges from over 60 inches per year in the northern uplands to about 40 inches in the lowlands. Seventy percent of the precipitation falls between October and March; June, July, and August receive about 12 percent of the yearly average (WCCD, 1988).

In Canada most of the tributaries to Fishtrap Creek flow in natural channels, but in the United States the drainage network has been highly modified to form a system of north/south ditches at half-mile intervals adjacent to roads. Mean annual runoff for the Fishtrap Creek basin has been estimated to be 43,000 acre-feet (Walker, 1960). The streamflow pattern of Fishtrap Creek is typical of western Washington basins

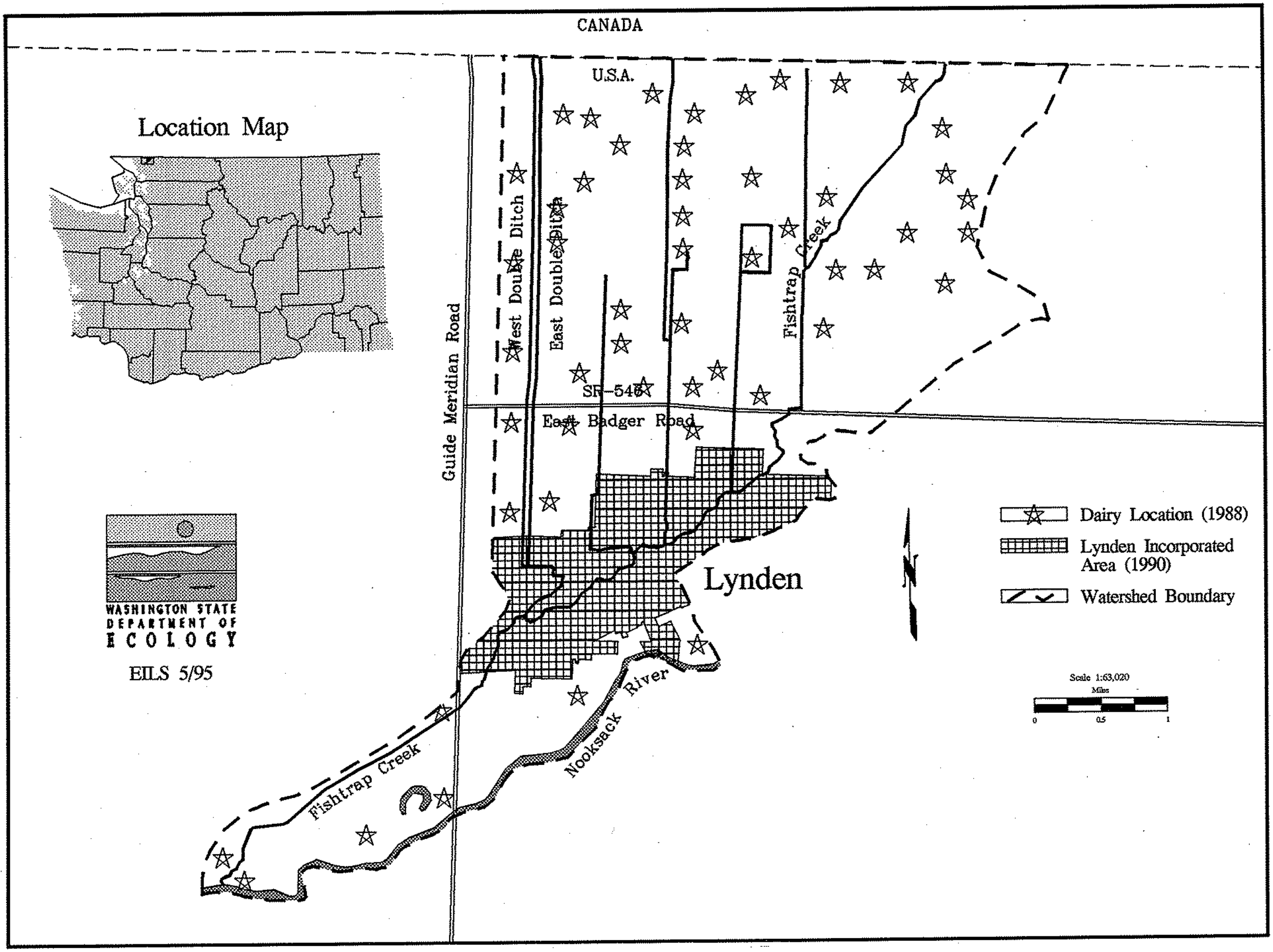


Figure 1. Reference location and land use of Fishtrap Creek watershed

without significant snow contributions: low flows occur in July through September and high flows from November through March. Figure 2 shows a plot of monthly streamflow near Lynden based on a USGS gage operated between 1948 and 1971.

Fishtrap Creek provides spawning and rearing habitat for a variety of anadromous fish species, including chum, silver, and king salmon; and steelhead, sea-run cutthroat, and resident trout. The historically high fish runs have been greatly reduced due to diversions, impoundments, obstructions, and pollution (WCCD, 1988).

There is wading and swimming in Fishtrap Creek at a local park in northeast Lynden during summer months.

Water supplies for irrigation, domestic, and municipal use are generally obtained from shallow aquifers in the watershed. The limited number of surface water rights on record are for irrigation; domestic use, stock watering, and garden irrigation; and fire protection and manufacturing. It is not known if these rights are being exercised. New surface water diversions have been prohibited since prior to 1960. Ground water supply concerns due to elevated levels of nitrate, pesticides, chloride, and iron were a target of a recent study by Whatcom County and the U.S. Geological Survey (Whatcom County, 1993; Cox and Kahle, 1994).

Water Quality Standards

Fishtrap Creek and its tributaries are classified as Class A Waters in Washington State's water quality standards (WAC 173-201A). For Class A waters, "fecal coliform organism levels shall both not exceed a geometric mean value of 100 colonies/100 mL, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 mL." A full listing of water quality criteria for Class A waters is given in Appendix A.

2.0 Pollution Sources

Pollution Sources

There are no known point source pollution sources in the United States' portion of the Fishtrap Creek watershed. The City of Lynden wastewater treatment plant discharges directly to the Nooksack River.

Land use in the Fishtrap Creek basin varies considerably between Canada and the United States. In Canada, the land use is largely residential, and has been affected by

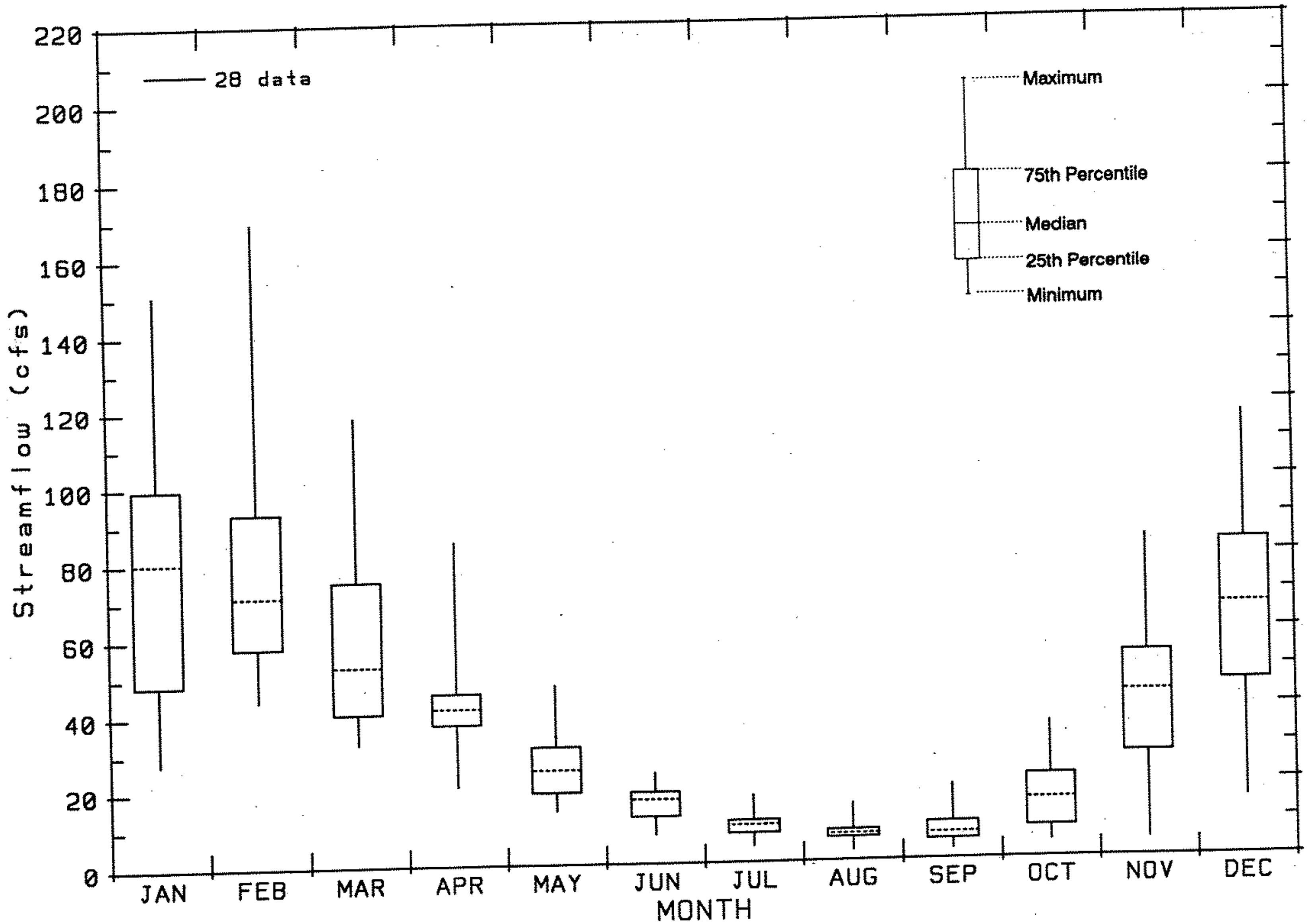


Figure 2. Monthly streamflow for Fishtrap Creek near Lynden.
Based on average daily streamflow measurements at USGS gage 12-212000 operated from 1948 through 1971.

an influx of population over the last several decades. Non-residential land use on the Canadian side consists of agriculture, woodlands, and small tracts of wetlands.

In the United States, the land use is predominantly agricultural and is dominated by dairy farming (Figure 1). The basin supported about 55 commercial dairies in 1994, or about 15 percent of all dairies in the county. Dairy farming in the Fishtrap Creek area is following a trend similar to the rest of the state: a decreasing number of dairies but an increasing number of cows. Most of the land is used to produce forage, either as pasture or to produce hay, silage, or greenfeed. A variety of other crops are produced on the remaining land, including small fruit crops (raspberries, strawberries, and blueberries), row crops (potatoes, corn, carrots, and green beans) and field crops (peas, wheat, barley, oats, and rye). Woodland and urban land uses also cover smaller portions of the basin.

The town of Lynden is experiencing considerable residential growth, as Lynden becomes less of a dairy farming town and more of a bedroom community for Bellingham. The sewered area in the watershed coincides with Lynden city limits.

The largest sources of pollution in the United States' portion of the basin are related to agricultural practices, and dairy farms in particular. In addition to dairy waste, potential agricultural-related pollutants include sediment from fields and devegetated streambanks, fertilizers, pesticides (including herbicides), and silage leachate.

Potential non-agricultural sources of pollution in the watershed include failing septic tanks and stormwater runoff from urban land (e.g., construction sites, roads, and yards). Several construction projects were underway during the course of the study, including new golf course construction, housing development, and bridge repair. Wildlife can also potentially contribute significant quantities of fecal coliform to a watershed if large numbers of animals congregate in an area (birds or elk, for example); however, this is not the case in the Fishtrap Creek area and wildlife contributions are far out-weighed by farm animals.

Ground water and field drainage through tiles also periodically contribute water and associated pollutants to the surface waters of Fishtrap Creek.

Status of Pollution Prevention Activities

The status of dairy waste management in five counties in the northeast Puget Sound area was inventoried in 1993 by the Soil Conservation Service (Bachert, 1993). The inventory assessed each dairy farm in terms of whether a Dairy Waste Management Plan had been written, was up-to-date, and was being implemented. The inventory also included the number of animals and number of acres that dairy wastes were being applied to.

The results for Fishtrap Creek showed a total of 54 farms inventoried, with an average of 196 animals. Most waste management plans in the Fishtrap Creek area are in the form of a "long-term agreement" with the Whatcom Conservation District in which a farmer commits to implementing a farm plan over the course of several years. The level of plan development in the Fishtrap Creek basin compared to the five-county total is shown in Table 1 below and graphically in Figure 3. The Fishtrap Creek watershed lags slightly behind the rest of the NE Puget Sound area in terms of percent of farms with plans (41 percent vs. 50 percent).

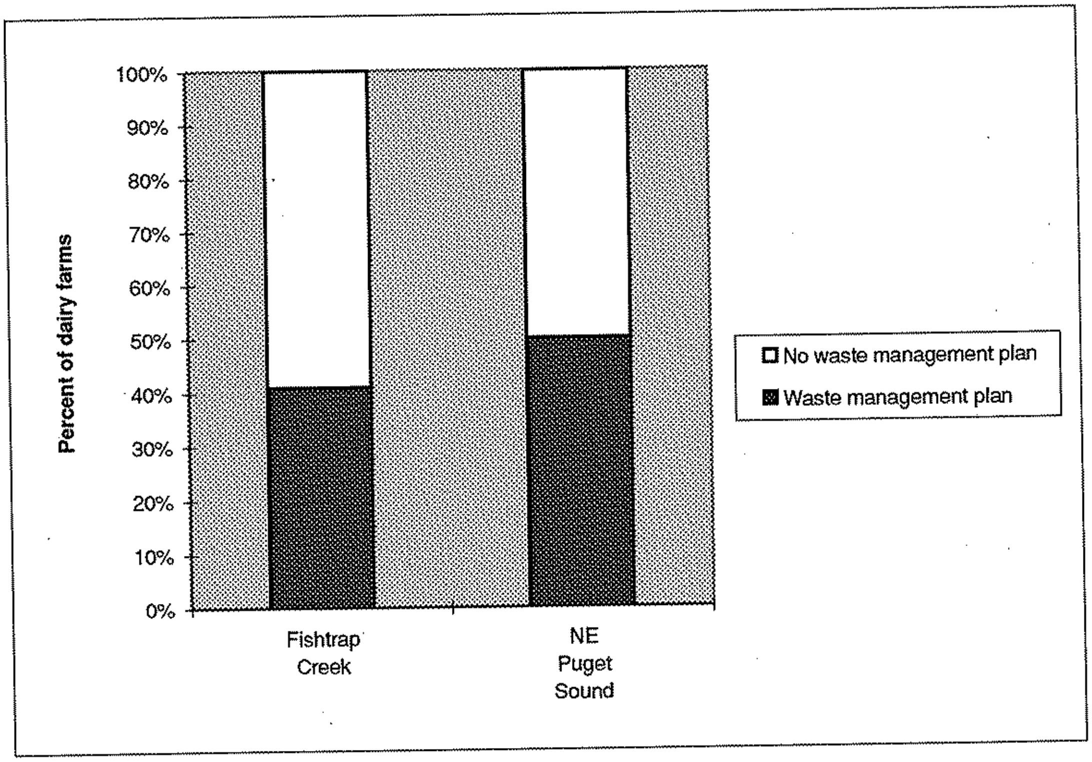
Table 1. Status of dairy waste plans in the Fishtrap Creek watershed and five-county area in NE Puget Sound.

Plan Status	Fishtrap Creek Watershed		Five-County Area	
	Number	%	Number	%
Farms with waste management plans	22	41	336	50
Farms with no plan	32	59	339	50
Total farms	**54**	**100**	**675**	**100**

The percent of farms that have fully or partially implemented waste management plans is shown in Table 2 below and in Figure 3. In this respect the Fishtrap Creek basin is similar to the rest of the NE Puget Sound area. The number of farms with implemented waste management systems is slightly greater than the number of farms with plans, because a few farms do not have a plan but nevertheless have a fully or partially implemented system.

Table 2. Status of dairy waste plan implementation in the Fishtrap Creek watershed and five-county area in NE Puget Sound.

Implementation Status	Fishtrap Creek Watershed		NE Puget Sound	
	Number	%	Number	%
Farms with fully implemented waste management system	12	22	167	23
Farms with partially implemented waste management system	13	24	197	27
Farms without an implemented waste management system	29	53	359	50
Total farms	**54**	**100**	**723**	**100**



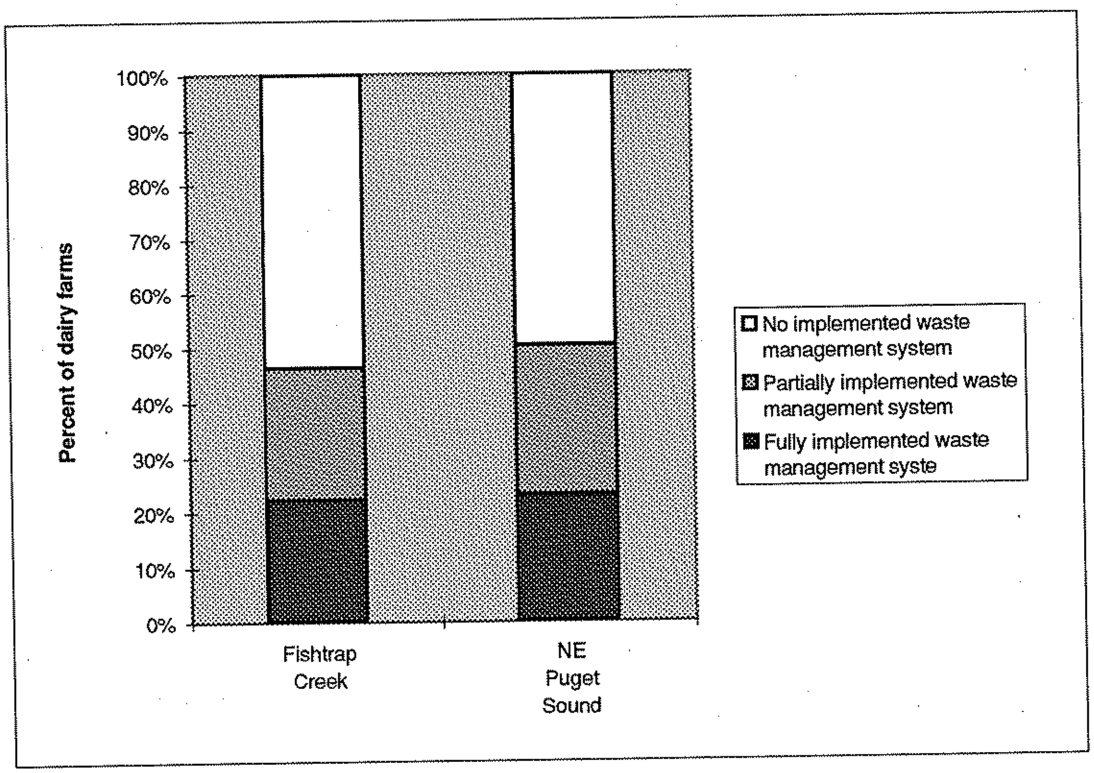


Figure 3. Status of dairy waste management plans in the Fishtrap Creek watershed and five-county area in NE Puget Sound

The Whatcom Conservation District has been actively working with farmers in the Fishtrap Creek watershed. In recent years, work has concentrated on fencing animals away from streams, installing rainfall diversion structures to keep uncontaminated runoff away from contaminated areas, construction of concrete slabs and curbing in livestock confinement areas, and construction of storage lagoons sufficiently large for six-months storage. Nevertheless, much work remains to have fully implemented waste management systems on each farm in the watershed.

Ecology's dairy waste inspector for Whatcom County has also been working with farmers in the Fishtrap Creek watershed in implementing the dairy waste permit. Contacts have been made with 12 farm owners in the Fishtrap watershed related to dairy waste management (Hovde, 1994). For those 12 farms, there have been a total of 26 inspections for compliance, 9 referrals to the Whatcom Conservation District, and 6 sets of water quality samples taken.

3.0 Water Quality Investigation

Methods

Six water quality surveys were conducted on the following dates: September 13, 30, November 8, December 14 (1993), January 12 and 25 (1994). The sampling network consisted of 15 sites along the mainstem Fishtrap Creek and all significant tributaries: both sides of Double Ditch Road, Benson Road, Depot Road, and Bender Road (Figure 4).

Streamflow measurements were collected at key sites: all mainstem Fishtrap Creek sites, the mouths of each tributary, and at all sites along the Canadian border. Streamflow records of Fishtrap Creek just north of the Canadian border were obtained from Environment Canada in Vancouver, British Columbia.

Although the emphasis of the study was on fecal coliform, the water quality at each site was tested for additional general chemistry parameters to characterize the stream system. Parameters tested in addition to fecal coliform were temperature, pH, conductivity, nutrients (ammonia, nitrate+nitrite, total nitrogen, ortho-phosphorus, and total phosphorus), dissolved oxygen, biological oxygen demand, total suspended solids, and chloride. See Appendix B for a full discussion of analytical methods.

Results and Discussion

The results of the water quality surveys are presented in Appendix C. A quality assurance evaluation showed that the data collected were of good quality and adequate

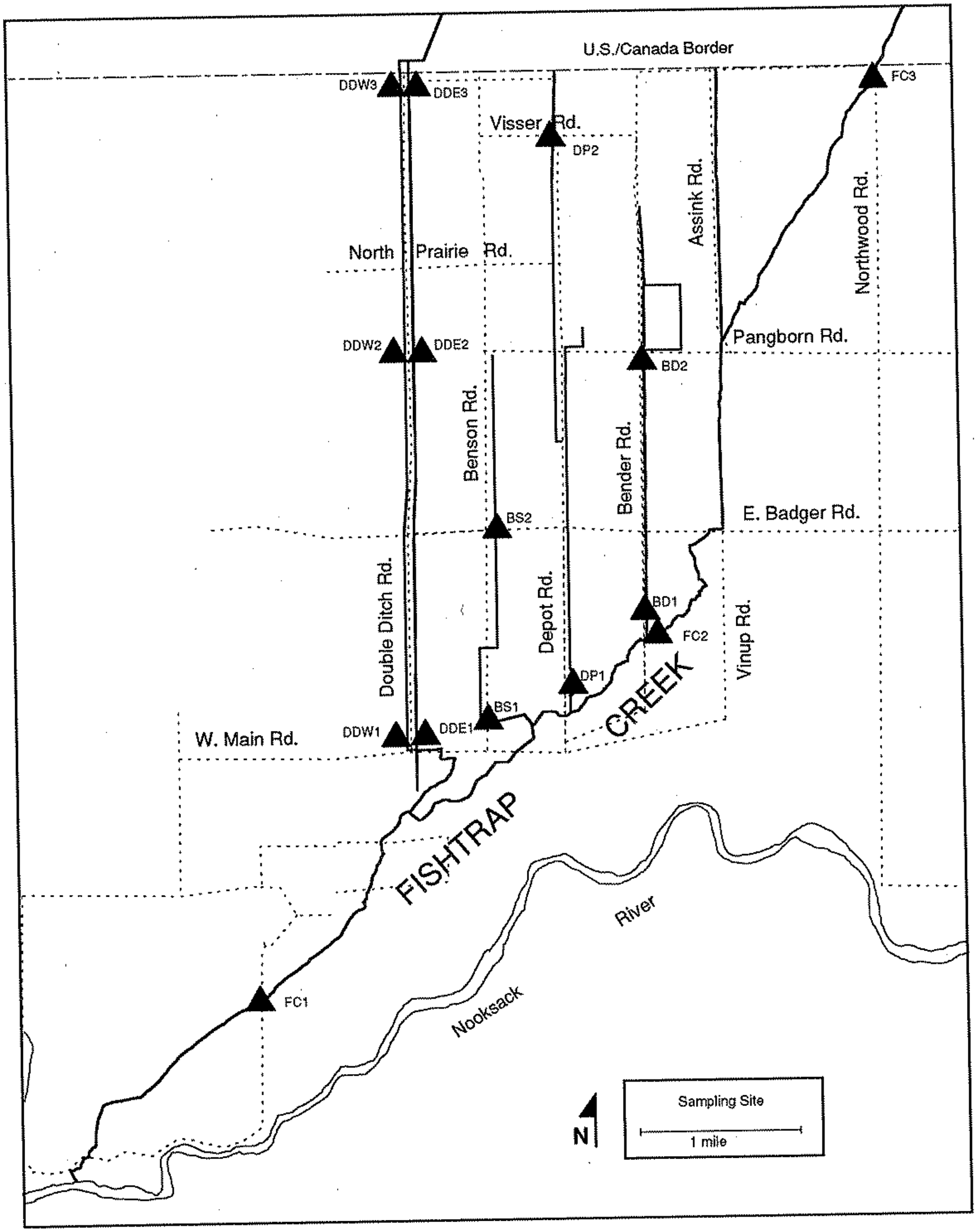


Figure 4. Location of sampling sites.

for the use intended (Appendix B). The mean coefficient of variation (the standard deviation divided by the mean, expressed as percent) was 21 percent for fecal coliform, which was consistent with that found in similar studies (Dickes, 1992; Coots, 1994).

Sampling dates represented a variety of weather conditions. Figure 5 shows precipitation and streamflow at the Canadian border over the study period. The antecedent precipitation and streamflow for each sampling event are summarized in Table 3. Coots (1994) showed that highest concentrations of fecal coliform in the Black River watershed occurred during the rising limb of the hydrograph following a significant rain event. Although the January 12 survey fell very close to the peak of the hydrograph, none of the sampling dates occurred when streamflow was rising.

Table 3. Antecedent precipitation and streamflow for sampling events.

Survey Number	Date	Precip. in 24 hours preceding start of sampling (inches)	Streamflow at FC1 (cfs)	Comment
1	9/13/93	0.00	10	
2	9/20/93	0.41	14	Rain was preceded by a long dry period.
3	11/8/93	0.00	13	No precipitation in previous 6 days.
4	12/14/93	0.26	200	Previous 2 weeks were generally rainy.
5	1/12/94	0.34	190	Previous 2 weeks were generally rainy.
6	1/25/94	0.00	54	Previous 2 weeks were fairly dry.

Fecal Coliform

Fecal coliform concentrations varied tremendously throughout the study area and over the course of the study period, with concentrations varying over five orders of magnitude (from 3 to 880,000 organisms/100 mL). In general, concentrations were high throughout the study area and the period of study. The geometric mean for each site (Figure 6), ranged from 78 to 14,000 organisms/100 mL. The lowest concentrations were found in Fishtrap Creek where it crosses into the U.S. from

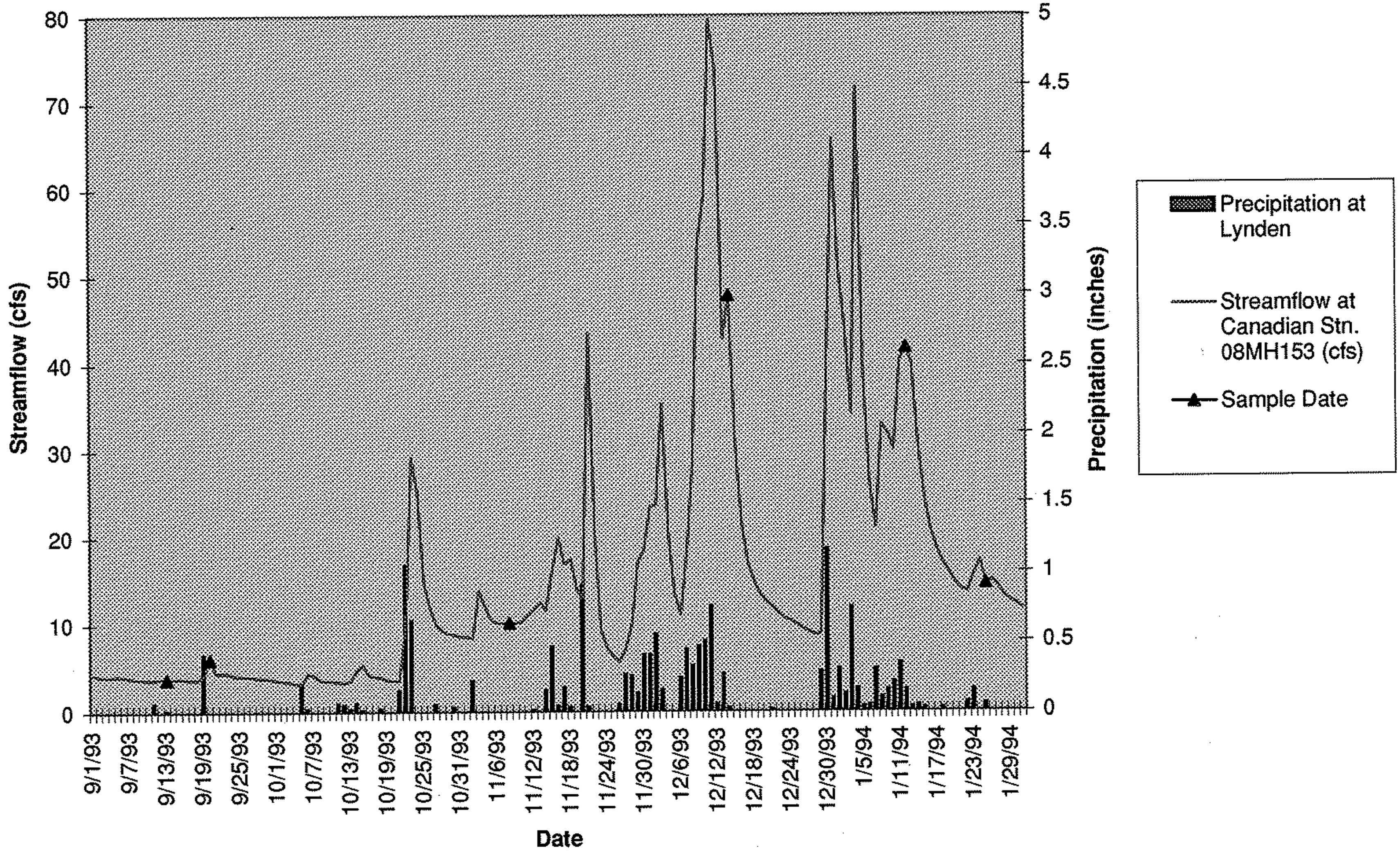


Figure 5. Streamflow near the Canadian border, precipitation at Lynden, and sampling dates at Fishtrap Creek, September 1, 1993 to January 31, 1994.

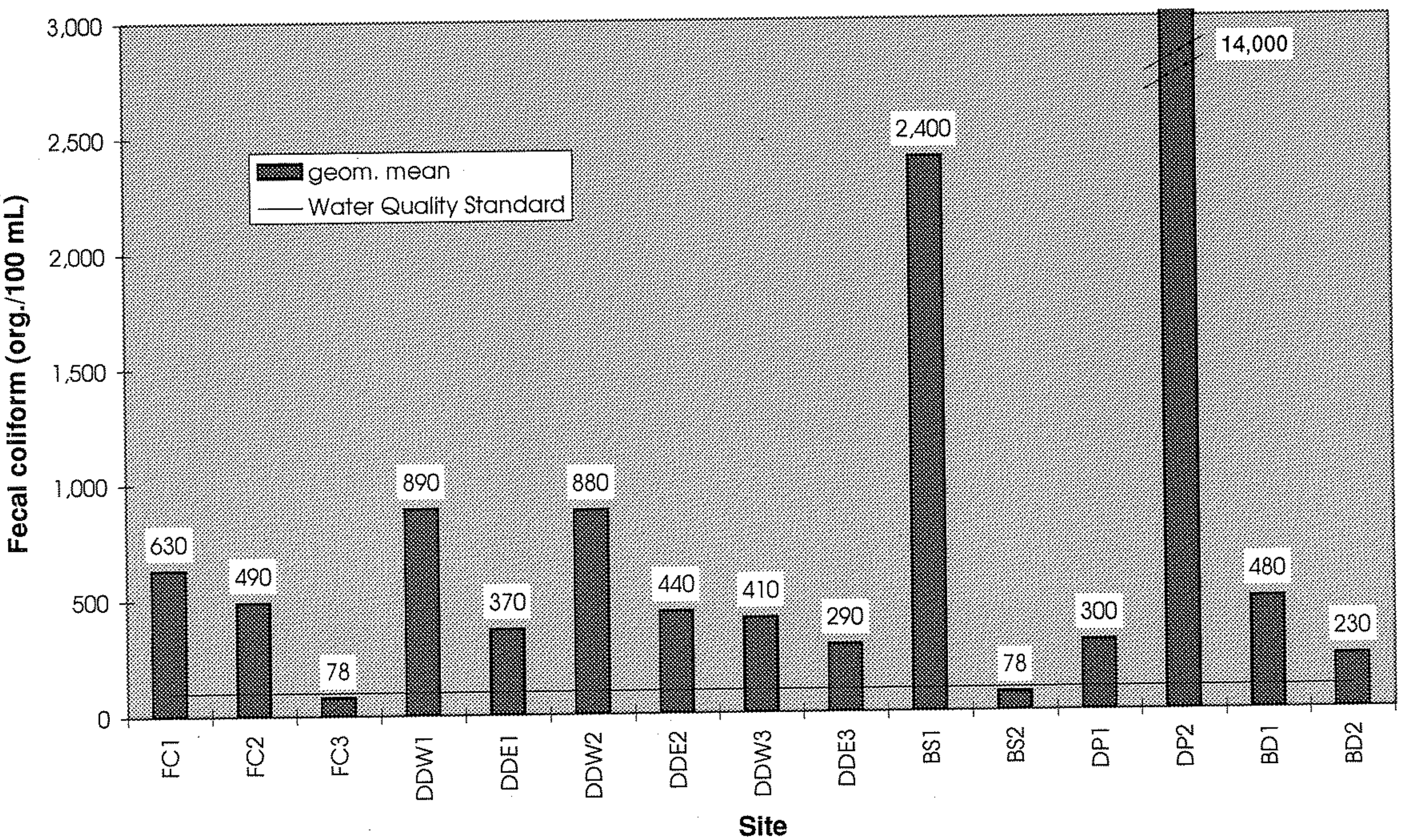


Figure 6. Fecal coliform geometric mean values for each site.

Canada (FC3) and in the Benson Road ditch at the Badger Road intersection (BS2). The highest concentrations were found at the intersection of Depot and Visser roads (DP2).

As is often the case with fecal coliform, the pattern of fecal coliform levels over the study area was generally not consistent from one date to another. This is a reflection of the variable loading characteristics associated with fecal coliform. The fecal coliform concentration at any given time may be a function of local manure spreading (timing, amount, location, and characteristics), cows (proximity to waterbody and number of animals), precipitation (rainfall timing, intensity, duration, and runoff routes), and suspension and deposition of bacteria in the stream sediments. These factors can vary widely from day to day and are difficult to monitor.

Although the pattern of fecal coliform levels was not consistent from one date to another, the geometric mean for each site was fairly consistent with that found by the Whatcom Conservation District (WCCD and WCHD, 1990) and Dickes (1992) where sampling sites coincided (Figure 7).

The water quality criterion for fecal coliform was violated at every site sampled. Thirteen of the sites had geometric means greater than 100 organisms/100 mL. The remaining two sites, FC3 and BS2, had more than 10 percent of their samples exceed 200 organisms/100 mL.

Fecal coliform concentrations were not well correlated with flow and in some cases were negatively correlated with flow (Figure 8). Fecal coliform concentrations were also not correlated to total suspended solids values. Concentrations were high at the mainstem sites on September 20 in comparison to other dates. This sampling date coincided with a rainfall event after a prolonged dry period when manure was being widely applied to the fields throughout the watershed.

Concentrations were low at the Canadian border in comparison to the mouths of the streams. The geometric mean was 710, 29, and 120 percent higher at the mouth than at the Canadian border for Fishtrap Creek, East Double Ditch, and West Double Ditch respectively.

For several sites in the study area, the land use of the contributing drainage area is nearly exclusively dairy farming (BS2, DP2, and BD2). In other cases, a pair of sites bracket land use that is essentially all dairy farming (DDW1/DDW3 and DDE1/DDE3). For these areas, elevated fecal coliform levels can be directly related to dairy farming practices (failing septic tanks would represent a minuscule volume of waste in comparison to that produced by dairy cows). At the remaining sites (FC1, FC2, BS1, DP2, and BD2), dairy farming is the predominant land use, but the drainage area also includes urban areas.

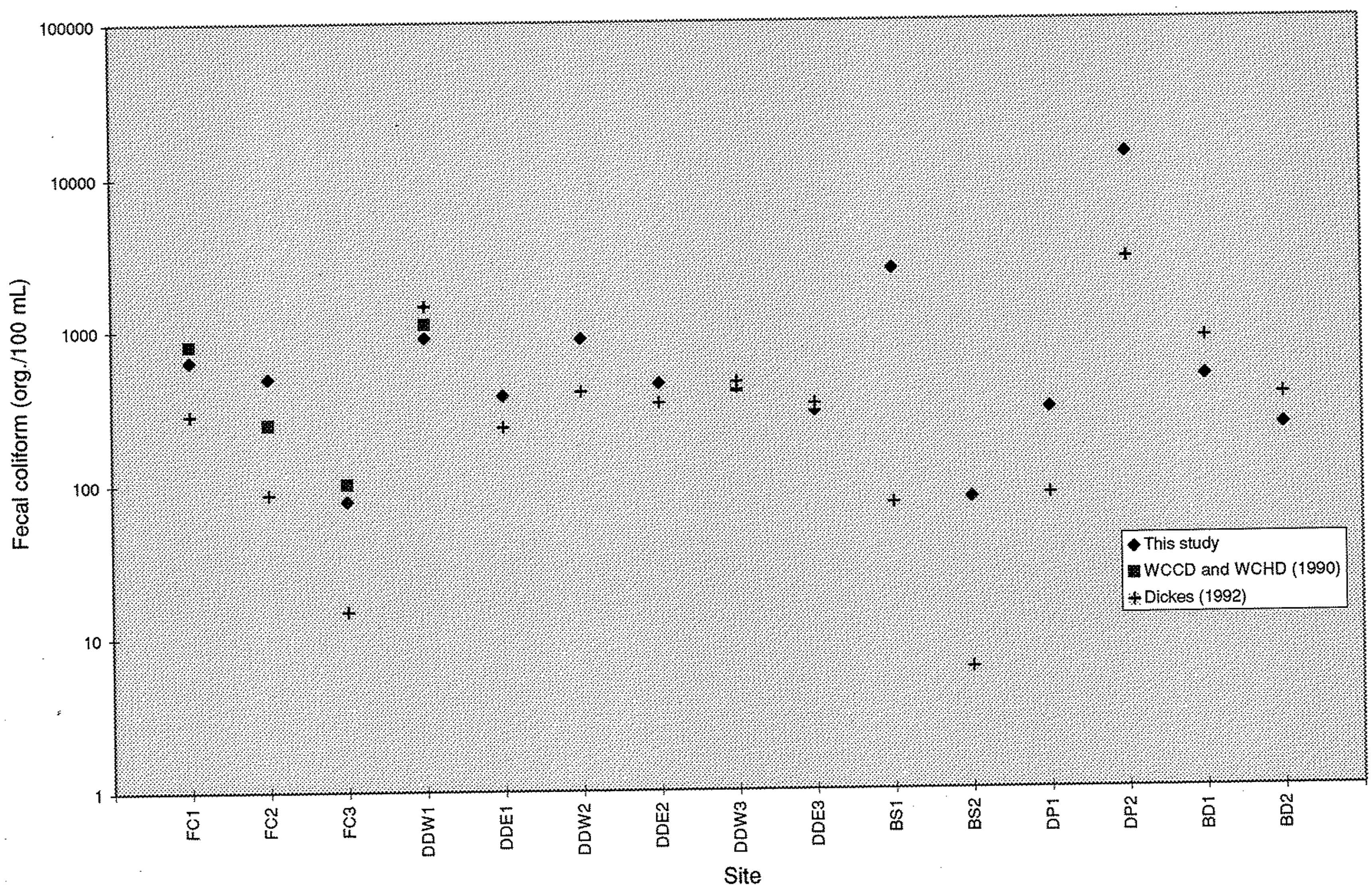


Figure 7. Fecal coliform geometric mean values from WCCD and WCHD (1990), Dickes (1992), and this study.

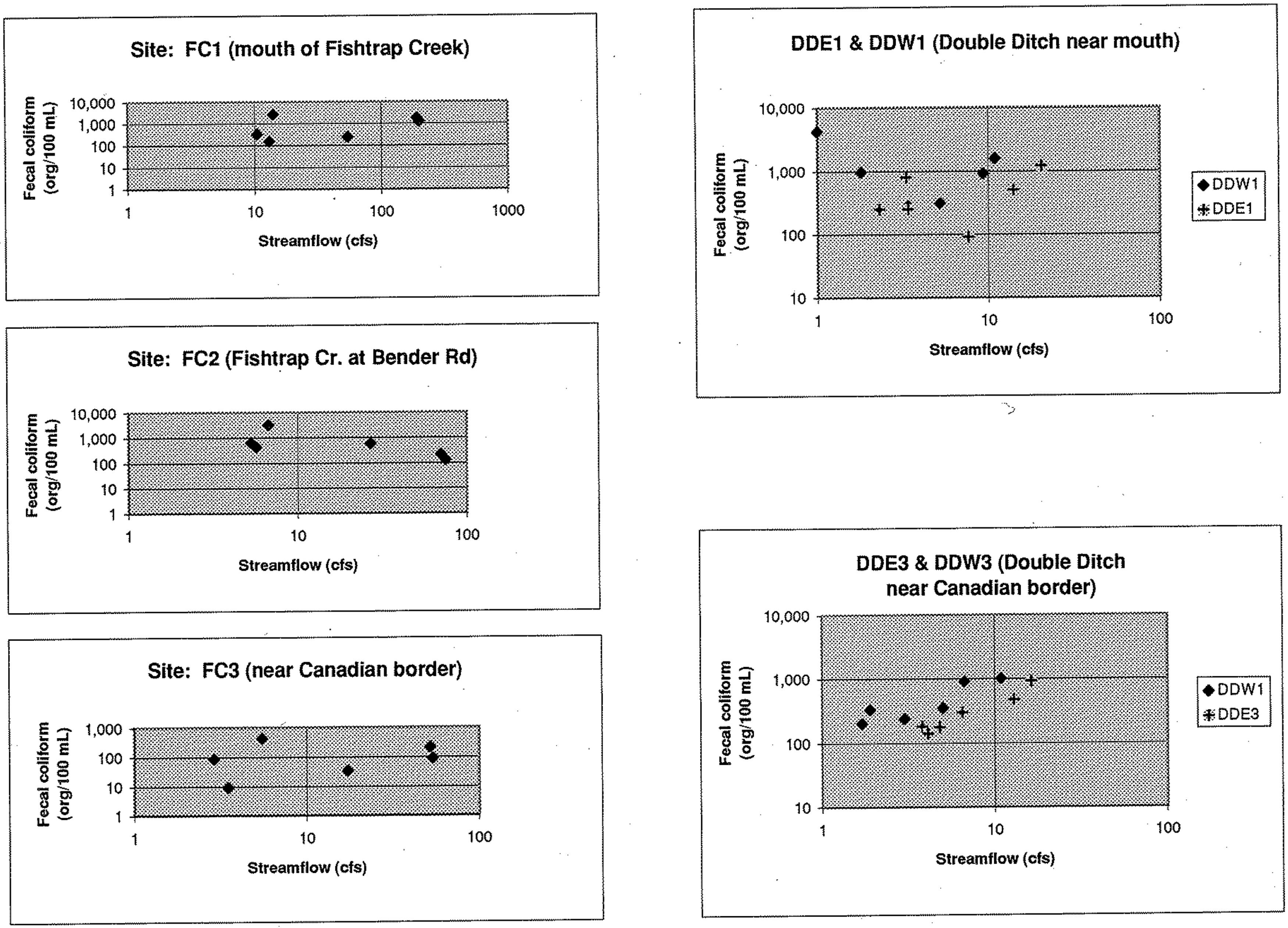


Figure 8. Fecal coliform concentrations vs. streamflow.

The results clearly indicate problem areas that require attention. The site with the highest concentrations recorded is DP2, at the intersection of Depot Road and Visser Road. The reading of 810,000 organisms/100 mL on December 14, 1993, is indicative of direct contamination of dairy waste with little dilution. This site had a geometric mean of 14,000 organisms/100 mL. In addition, site BS1, near the mouth of the Benson Road ditch, had a geometric mean of 2,400 organisms/100 mL. The farms immediately upgradient of these sites should be high priority candidates for inclusion in the dairy waste permitting system.

One objective of the study was to identify the "critical period" of fecal coliform loading to the watershed. "Worst-case" conditions for fecal coliform have often been found to correspond to high flow events in previous studies (Coots, 1994; Dickes and Patterson, 1994); however, as discussed above, this was not the case for the Fishtrap Creek data. Instead, the data suggest that critical conditions in the Fishtrap Creek watershed may occur in the late summer or fall after a significant rainfall event following a prolonged dry period. This is consistent with previous studies in the area (WCCD and WCHD, 1990), which found the highest concentrations to be in October when rainfall resumed after a dry period. Since about half of the farms do not apply manure in the winter (Timblin, personal communication), the supply of fecal coliform may be less in the winter than in the summer when manure is being widely applied throughout the watershed. However, additional data would be needed, ideally throughout the year and over the course of several storm events, to definitively establish the critical period.

Other Parameters

Dissolved oxygen levels were consistently above the Class A criterion of 8.0 mg/L on mainstem Fishtrap Creek and both sides of Double Ditch. In the smaller tributaries, however, the dissolved oxygen criterion was violated at every site. At site BS2, dissolved oxygen levels were below the criterion for all six sampling events; the remaining small tributaries showed violations at least 40 percent of the time.

Ammonia criteria were violated only once, at DP2 on December 14, 1993. The total NH_3-N reading of 19.2 mg/L at that site violated both the 4-day chronic (2.3 mg/L) and 1-hour acute (17.8 mg/L) criteria. Ammonia inputs to the streams were probably rapidly oxidized to nitrate. Levels of nitrate+nitrite were relatively high throughout the watershed. Average values per site ranged from 0.65 mg/L at BS2 to 7.83 mg/L at DP2.

In summary, the water quality investigation results showed high to very high levels of fecal coliform bacteria throughout the watershed, low levels of dissolved oxygen in the small tributaries, and one instance of very high ammonia levels.

4.0 TMDL Allocations

Load Allocations

Section 303(d) of the federal Clean Water Act requires states to identify water bodies that are water quality-limited (*i.e.* water bodies that do not meet, or are not expected to meet applicable water quality standards after sources have undergone technology-based controls).

Fishtrap Creek and its tributaries appear on Ecology's 1994 303(d) list for fecal coliform and dissolved oxygen, as shown in Table 4.

Table 4. Ecology's 1994 Section 303(d) listing for Fishtrap Creek waterbodies.

Waterbody Segment Number	Waterbody Name	Parameters Exceeding Standards
WA-01-1115	Fishtrap Creek	Fecal Coliform
WA-01-1116	Double Ditch Drain	Fecal Coliform
WA-01-1117	Benson Road Ditch	Dissolved Oxygen
WA-01-1118	Depot Road Ditch	Dissolved Oxygen
		Fecal Coliform
WA-01-1119	Bender Road Ditch	Dissolved Oxygen
		Fecal Coliform

The Clean Water Act also requires that Total Maximum Daily Load (TMDL) allocations be made for pollutants on the 303(d) list. These allocations represent the amount of pollution the watershed can assimilate without violating water quality criteria. For nonpoint sources, these are termed "load allocations." This TMDL establishes load allocations for fecal coliform, with the assumption that if fecal coliform levels are brought into compliance with water quality standards, dissolved oxygen will also be in compliance.

A phased approach is recommended for the Fishtrap Creek TMDL. A phased approach is appropriate for basins with large nonpoint source contributions. With a phased approach, load allocations are defined, control measures are implemented, and the basin continues to be monitored to assess the effectiveness of the nonpoint source controls. If the controls are less effective than initially estimated in the first load allocations, the allocations may need to be adjusted or other nonpoint management techniques explored.

Load allocations are usually expressed in units of mass/time, such as pounds/day. In the case of fecal coliform, however, units of mass, such as pounds, or even numbers of colonies/time, are not particularly meaningful. The Clean Water Act specifies that TMDLs can be expressed in terms of either mass per time (*i.e.*, load), toxicity, **or other appropriate measure** (emphasis added) (40 CFR 130.2(i)). The TMDL goals for fecal coliform are often expressed in the form of a concentration, and in this TMDL will be given in units of organisms/100 mL of water.

TMDL allocations are generally defined for a set of "critical conditions." For point sources, critical conditions are usually defined to be when the diluting streamflow is at a 7-day, 10-year low flow level. For nonpoint sources, there is no standard set of criteria that represent critical conditions. In the case of fecal coliform, the water quality criterion is based on a geometric mean of all samples, as long as such averaging "does not skew the data so as to mask noncompliance periods" (Ch. 173-WAC-201A-060 (3)). Data from throughout the study period were included for determining load allocations.

The following load allocation is recommended for each waterbody segment in the Fishtrap Creek watershed: the geometric mean of all samples at each site is not to exceed 100 organisms/100 mL, with no more than 10 percent of all samples exceeding 200 organisms/100 mL.

Based on the data collected during this study, the percent reductions in fecal coliform concentrations necessary to meet the first part of the water quality standard (geometric mean of less than 100 organisms/100 mL) are shown in Table 5. Because the data were not collected during the rising limb of the hydrograph, these numbers may underestimate the actual percent reductions necessary to meet water quality standards. In addition, even with this percent reduction, the second part of the water quality standard may not be satisfied (less than 20% of the samples to exceed 200 organisms/100 mL). Also, there is no "margin-of-safety" or future growth built in. However, because this is a phased TMDL that will take years to fully implement, the percent reductions listed here represent a good initial target that can be refined during later phases of TMDL implementation.

Controls should be initially targeted at the two sites with the highest percent reduction needed, DP2 and BS1.

Table 5. Fecal coliform geometric means and recommended percent reductions for each site.

Site	Fecal coliform geometric mean (organisms/100 mL)	Percent reduction needed to reach a geometric mean of 100 organisms/100 mL
FC1	630	84
FC2	490	80
FC3	78	*
DDE1	370	73
DDE2	440	77
DDE3	290	66
DDW1	890	89
DDW2	880	89
DDW3	410	76
DP1	300	67
DP2	14,000	99
BD1	480	79
BD2	230	57
BS1	2,400	96
BS2	78	*

* The geometric mean for these sites is less than 100 organisms/100 mL. However, reductions are still necessary to meet the second part of the fecal coliform criterion: less than 10 percent of the samples to exceed 200 organisms/mL. To estimate the percent reduction needed for these sites, more data are needed.

Implementation

The load allocations described above can largely be achieved by implementing "best management practices" (BMPs) on the dairy farms in the watershed. Table 6 lists some typical dairy waste BMP categories and their estimated effectiveness in reducing pollutant loading (EPA, 1993). These effectiveness estimates are summary literature values. For specific cases, a wide range of effectiveness can be expected depending on such site-specific variables as soil type; topography; precipitation characteristics; type of animal housing and waste storage facilities; method of waste collection, handling, and disposal; and seasonal variations.

Table 6. Estimated effectiveness of selected dairy waste Best Management Practices (EPA, 1993).

Practice Category (each category includes several specific types of practices)	Fecal Coliform (% Reduction)
Animal waste systems (includes methods for collecting, storing, and disposing of runoff and process-generated wastewater)	85
Filter strips (includes all practices that reduce contaminant losses using vegetative control measures)	55
Containment Structures (includes such practices as waste storage ponds, waste storage structures, waste treatment lagoons)	90

The most direct way to obtain the recommended reductions in fecal coliform loading is through continued, and preferably, accelerated, implementation of Ecology's dairy waste permitting program. Through this program, when there is a reliable indication that a water quality problem exists due to dairy farming, an Ecology inspector visits nearby farms and investigates potential dairy waste management problems. If determined to be justified, the inspector will refer the farmer to the local Conservation District who will help develop a dairy waste management plan for the farm. This plan will contain one or more BMPs that are designed to reduce pollutant loading to waterbodies.

The dairy waste permitting program is currently being adapted to Ecology's watershed approach with a five-year cycle of activities. Under this approach, the Nooksack/San Juan Watershed is scheduled for focused permit implementation in fiscal year 1995 and again in 2000. In the intervening years, work is to be focused on defining the problem, meeting with primary interest groups, and preparing a detailed plan for dairy permit implementation in the watershed.

Another avenue for implementation of this TMDL is the new Nooksack River Watershed Initiative. A 21-member task force is currently developing priorities for taking action on environmental problems in the watershed. This report will be evaluated by the Task Force for implementation of the recommendations.

5.0 Conclusions and Recommendations

Conclusions

This investigation shows that inadequate dairy waste management is degrading the water quality of the Fishtrap Creek watershed. Water quality criteria for fecal coliform were exceeded at all sites surveyed. The water quality criterion for dissolved oxygen was violated at each small tributary site (Benson, Depot, and Bender Road ditches).

Fecal coliform concentrations near the Canadian border were generally much lower than at the mouths of the tributaries and the mainstem. Therefore Canadian land use practices cannot be implicated for water quality problems in the United States' portion of the watershed.

Fecal coliform levels were not correlated with streamflow. The data suggest that the highest fecal coliform concentrations may occur in late summer or fall, during or after a significant rainfall event, and after a prolonged dry period when manure is being widely applied to the fields throughout the watershed.

Recommendations

A phased TMDL is recommended with the following load allocations: the geometric mean of all samples at each site is not to exceed 100 organisms/100 mL, with no more than 10 percent of all samples exceeding 200 organisms/100 mL. To achieve these load allocations, dairy farm BMPs are recommended to be implemented throughout the watershed. The highest priority areas are immediately upgradient of the intersection of Depot and Visser roads and near the mouth of the Benson Road Ditch.

Ecology's dairy waste permitting program is recommended to be focused in the Fishtrap Creek watershed. All farms without a long-term agreement or dairy waste management plan need to have a plan developed, and the plans implemented. Additional dairy waste inspectors and Conservation District staff will be necessary to accomplish this. It is recommended that there be at least one dairy waste inspector per 100 dairy farms, in contrast to the existing ratio of one inspector to well over 300 dairies.

The Nooksack Watershed Initiative Task Force can play a key role in implementing this TMDL. The Task Force can be instrumental in educating and informing local stakeholders, forging consensus to address the problem, identifying potential funding sources for assisting farmers and funding dairy waste inspectors, and seeing that progress is monitored.

It is recommended that risks to waders and swimmers in the local Lynden Park be assessed by monitoring for fecal coliform bacteria, or other indicators of human pathogens, during the summer months.

Because this is a phased TMDL, continued monitoring of the basin to assess progress toward reducing fecal coliform levels is essential. The highest priority areas to monitor initially are DP2 (near the intersection of Depot Road and Visser Road) and BS1 (near the mouth of Benson Ditch) to verify that the very high fecal coliform concentrations at this site are reduced. The area with the next highest average concentrations is the west side of Double Ditch, followed by the mouth of Fishtrap Creek.

Detecting statistically valid trends in fecal coliform levels is difficult due to the high variability in bacteria concentrations. It is recommended that a systematic and statistically-based monitoring system for fecal coliform be designed and implemented over a five-year time period. The TMDL allocations should then be reevaluated based on an analysis of the five years of data.

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Appendices

Appendix A. Class A (excellent) freshwater quality standards and characteristic uses (WAC 173-201A).

General Characteristic:	Shall meet or exceed the requirements for all or substantially all uses.
Characteristic Uses:	Shall include, but not be limited to, the following: domestic, industrial, and agricultural water supply; stock watering; salmonid and other fish, clam, oyster, mussel, crustacean and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing, spawning and harvesting; salmonid and other fish migration; wildlife habitat; primary contact recreation, sport fishing, boating, and aesthetic enjoyment; and commerce and navigation.

<u>Water Quality Criteria</u>

Fecal coliform:	Organism levels shall both not exceed a geometric mean value of 100 colonies/100 mL, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 mL.
Dissolved oxygen:	Shall exceed 8.0 mg/L.
Temperature:	Shall not exceed 18.0°C due to human activities. When natural conditions exceed 18.0°C, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C. Incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8°C.
pH:	Shall be within the range of 6.5 to 8.5 with a human-caused variation within a range of less than 0.5 units.
Ammonia:	Ammonia criteria for chronic (4-day average) and acute (1-hour average) are given in the following table.
Turbidity:	Shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

Toxic, radioactive, or deleterious material:	Concentrations shall be below those which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the Department of Ecology.
Aesthetic values:	Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.

4-Day Average Concentration for Ammonia[1]

Salmonids or Other Sensitive Coldwater Species Present

Un-ionized Ammonia (mg/liter NH_3)

		temperature 0^{c}						
		0	5	10	15	20	25	30
	6.50	0.0008	0.0011	0.0016	0.0022	0.0022	0.0022	0.0022
	6.75	0.0014	0.0020	0.0028	0.0039	0.0039	0.0039	0.0039
	7.00	0.0025	0.0035	0.0049	0.0070	0.0070	0.0070	0.0070
	7.25	0.0044	0.0062	0.0088	0.0124	0.0124	0.0124	0.0124
	7.50	0.0018	0.0111	0.0156	0.022	0.022	0.022	0.022
pH	7.75	0.0129	0.0182	0.026	0.036	0.036	0.036	0.036
	8.00	0.0149	0.021	0.030	0.042	0.042	0.042	0.042
	8.25	0.0149	0.021	0.030	0.042	0.042	0.042	0.042
	8.50	0.0149	0.021	0.030	0.042	0.042	0.042	0.042
	8.75	0.0149	0.021	0.030	0.042	0.042	0.042	0.042
	9.00	0.0149	0.021	0.030	0.042	0.042	0.042	0.042

Total Ammonia (mg/liter NH_3)

		temperature 0^{c}						
		0	5	10	15	20	25	30
	6.50	3.0	2.8	2.7	2.5	1.76	1.23	0.87
	6.75	3.0	2.8	2.7	2.6	1.76	1.23	0.87
	7.00	3.0	2.8	2.7	2.6	1.76	1.23	0.87
	7.25	3.0	2.8	2.7	2.6	1.77	1.24	0.88
	7.50	3.0	2.8	2.7	2.6	1.78	1.25	0.89
pH	7.75	2.8	2.6	2.5	2.4	1.66	1.17	0.84
	8.00	1.82	1.70	1.62	1.57	1.10	0.78	0.56
	8.25	1.03	0.97	0.93	0.90	0.64	0.46	0.33
	8.50	0.58	0.55	0.53	0.53	0.38	0.28	0.21
	8.75	0.34	0.32	0.31	0.31	0.23	0.173	0.135
	9.00	0.195	0.189	0.189	0.195	0.148	0.116	0.094

1 to convert these values to mg/liter N, multiply by 0.822

Appendix B. Methods and Quality Assurance

Methods

Grab samples were collected at each site in mid-channel, except for FC1 where deep water occasionally resulted in samples collected near the channel side. Replicates were taken at the identical site, generally within 15 minutes of each other. Blanks were deionized water. The method used for analyzing each water quality parameter is shown in Table B-1.

Table B-2 summarizes the sampling design and schedule. Samples were collected downstream to upstream, except Depot Road ditch where a calculation of travel time showed there could be no influence from upstream disturbances at the downstream site.

Samples collected for pH, temperature, and specific conductance were analyzed immediately in the field. Samples collected for dissolved oxygen were preserved and analyzed in the Ecology field lab in Olympia. Samples sent to Manchester Laboratory were stored on ice and arrived at the laboratory within 24 hours.

Precipitation records were received from the Lynden wastewater treatment plant. Streamflow records of Fishtrap Creek just north of the Canadian border were obtained from Environment Canada in Vancouver, British Columbia. A continuous data logger was also installed near the mouth of Fishtrap Creek to record water levels. Water levels were converted to streamflow values by the use of a rating curve. However, because there were few flow measurements at high flows, the accuracy of the rating curve at high flows is questionable, and the Canadian streamflow values were used whenever high flows were used for analysis.

Field work was conducted by the author, Betsy Dickes, and Barbara Patterson. Belinda Hovde and Robert Booth of Ecology's Northwest Regional Office also assisted with one sampling survey.

Quality Assurance

Field sampling and measurement quality assurance protocols followed those listed in the WAS protocols manual (Cusimano, 1994).

Total variation for field sampling and lab analysis was assessed by collecting replicate samples of at least ten percent of the total number of field and laboratory samples for each parameter. Fecal coliform samples, because of their high variability, were collected in replicate for about 25 percent of the samples.

TABLE B-1

Summary of field and laboratory measurements, target detection limits, and methods

Parameter	Measurement Limits	Method [1]
Field Measurements		
Velocity	± 0.05 fps	Current Meter
pH	± 0.1 SU	Field Meter/electrode
Temperature	± 0.1 degree C	Thermometer
Dissolved Oxygen	± 0.06 mg/L	Winkler Titration
Specific Conductance	± 20 μmho/cm	Field meter/cond. bridge
Laboratory Measurements	Reporting Limit	
Total Suspended Solids	1 mg/L	EPA 160.2
5-day BOD	2 mg/L	EPA 405.1
Nitrate and Nitrite Nitrogen	0.01 mg/L	EPA 353.1
Ammonia Nitrogen	0.01 mg/L	EPA 350.1
Total Persulfate Nitrogen	0.02 mg/L	Valderrama, 1981
Orthophosphate	0.01 mg/L	SM17 4500-P F
Total Phosphorus	0.01 mg/L	SM17 4500-P F
Fecal Coliform	2 cfu/100 mL	SM17 9222D
Chloride	0.01 mg/L	EPA 300.0

[1] Method references:
SM: APHA, 1989
EPA: EPA, 1983

The coefficient of variation (CV), defined as the standard deviation divided by the mean (expressed as percent), was calculated for each replicate pair. Precision was found to be acceptable for all data collected, with the mean CV less than one percent for conductivity, dissolved oxygen, and chloride; and less than five percent for nitrate + nitrite and total persulfate nitrogen. The mean CVs for total suspended solids (15%), ammonia (7%), ortho-phosphate (8%), and total phosphorus (10%) were somewhat higher but considered to be acceptable. The mean CV for fecal coliform was 21 percent, which is consistent with that found in similar studies (Dickes, 1992; Coots, 1994).

Blanks for ortho-phosphate were collected to assess potential contamination introduced in the filtering process. Two surveys had sample blanks showing elevated levels of ortho-phosphate, thereby making ortho-phosphate results for those days of questionable reliability. Ortho-phosphate levels were not discussed in the sample results.

The recommended maximum holding time (time elapsed between sample collection and analysis) for the total nitrogen samples from September 20, 1994, was exceeded by the laboratory by a few days. Therefore these results are not as reliable as those for other dates.

Data qualifiers are given in the table of results, Appendix C, where applicable.

Table B-2. Fishtrap Creek Site Sampling

	Description	Station ID	Flow	pH, cond, temp	DO	FC	TSS	BOD	NH3	NO3/ NO2	TPN	OP	TP	CL
1	Fishtrap Creek near mouth	FC1	X	X	X	X	X	X	X	X	X	X	X	X
2	Fishtrap Creek upstream of Bender Road	FC2	X	X	X	X	X	X	X	X	X	X	X	X
3	Fishtrap Creek near Canadian border	FC3	X	X	X	X	X	X	X	X	X	X	X	X
4	Double Ditch Drain near mouth - west side	DDW1	X	X	X	X	X	X	X	X	X	X	X	X
5	Double Ditch Drain near mouth - east side	DDE1	X	X	X	X	X	X	X	X	X	X	X	X
6	Double Ditch Drain 1 mile north of Badger Rd - east side	DDW2		X	X	X	X	X	X	X	X	X	X	X
7	Double Ditch Drain 1 mile north of Badger Rd - west side	DDE2		X	X	X	X	X	X	X	X	X	X	X
8	Double Ditch Drain near mouth - west side	DDW3	X	X	X	X	X	X	X	X	X	X	X	X
9	Double Ditch Drain near Canadian border - west side	DDE3	X	X	X	X	X	X	X	X	X	X	X	X
10	Benson Road near mouth	BS1	X	X	X	X	X	X	X	X	X	X	X	X
11	Benson Road and Badger Road	BS2		X	X	X	X		X	X	X	X	X	X
12	Depot Road near mouth	DP1	X	X	X	X	X	X	X	X	X	X	X	X
13	Depot Road and Visser Road	DP2		X	X	X	X		X	X	X	X	X	X
14	Bender Road near mouth	BD1	X	X	X	X	X	X	X	X	X	X	X	X
15	Bender Road and Pangborn	BD2		X	X	X	X		X	X	X	X	X	X
16	Replicate Site #1 - all parameters	DFC5	X	X	X	X	X	X	X	X	X	X	X	X
17	Replicate Site #2 - all parameters	DFC6	X	X	X	X	X	X	X	X	X	X	X	X
18	Replicate Site #3 - FC only	DFC7				X								
19	Replicate Site #4 - FC only	DFC8				X								
20	Blank - orthophosphate	BFC4										X		

Appendix C. Fishtrap Creek Water Quality Sampling Results

Stn ID	Date	Flow time	Flow	Sample time	pH	Cond	Temp.	DO	FC	TSS	BOD5	NH3	NO3+ NO2	TPN	OP	TP	Cl
(units)			(cfs)		(std. units)	(umhos/ cm)	(°C)	(mg/L)	(org./100 mL)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
FC1	8/16/93	12:00	18.7														
FC1	9/13/93	8:00	10.4	10:05	7.7	248	11.6	10.0	330	<1	<2	0.3	1.6	2.20	<0.010	0.02	12.5
FC1	9/20/93	7:22	13.6	7:47	7.4	218	11.1	9.0	2,500 J	6	<2	0.2	1.4	2.36 OHT	0.012	0.08	13.0
FC1	9/20/93	7:36	14.2	7:53	7.4	218	11.1	8.9	2,700 J,S	6	<2	<0.1	1.9	2.16	0.015	0.07	13.0
FC1	9/20/93	15:19	16.0														
FC1	11/8/93	7:00	13.0	7:30	7.6	230	5.7	11.5	170	2	<2	0.027	2.17	2.30	<0.010 B	0.170	11.8
FC1	11/8/93								130 S								
FC1	12/7/93	11:00	50.0														
FC1	12/13/93	14:50	168														
FC1	12/14/93			7:50	7.0	220	7.2	10.7	1,000 S	18	2	0.227	3.06	3.94	0.021	0.087	9.8
FC1	12/14/93								1,400 S								
FC1	1/11/94	15:30	182														
FC1	1/12/94			8:00	7.8	215	8.0	10.8	1,700 S	18	<2	0.200	3.15	4.11	0.018	0.076	9.6
FC1	1/24/94	14:20	63.1														
FC1	1/25/94			7:55	7.0	142	7.8	11.0	280 S	10	<2	0.053	3.32	3.54	<0.010 B	0.044	11.3
FC1	1/25/94				6.4				210 S								
FC2	9/13/93	11:00	5.3	11:10	7.6	268	11.9	9.9	640 J	1	<2	0.4	2.4	3.14	<0.010	0.02	11.7
FC2	9/20/93	12:41	6.7	13:10	7.6	260	11.1	10.2	3,200	2	<2	0.4	2.4	3.91 OHT	<0.010	0.02	11.4
FC2	11/8/93	12:50	5.7	13:00	7.6	252	6.4	11.7	330	2	<2	0.022	3.28	3.33	<0.010 B	0.011	10.5
FC2	11/8/93			13:15	7.6	248	6.4	11.6	520 S	1	<2	0.016	3.24	3.29	0.012 B	0.011	10.3
FC2	12/14/93	13:15	70.5	13:30	7.3	175	7.3	9.9	210 S	19		0.090	3.81	4.23	<0.010	0.071	7.4
FC2	1/12/94	13:45	74.8	14:00	7.2	200	8.2	10.0	58	19	<2	0.128	4.21	4.40	0.011	0.059	7.7
FC2	1/12/94								200								
FC2	1/25/94	13:40	27.1	13:50	7.3	235	8.5	10.5	630	6	<2	0.049	4.57	4.63	<0.010 B	0.029	10.7
FC2	1/25/94			14:00	7.3	233	8.4	10.7	530	6		0.052	4.43	4.40	<0.010 B	0.026	10.7
FC3	9/13/93	12:30	2.9	12:52	7.3	262	12.0	10.0	88	<1	<2	<0.1	4.2	5.68	<0.010	<0.02	10.4
FC3	9/20/93	14:28	5.5	14:35	7.3	225	11.9	10.5	370	1	<2	<0.1	3.2	3.37 OHT	<0.010	0.04	10.3
FC3	9/20/93								520								
FC3	11/8/93	14:15	3.5	14:30	7.5	228	6.8	11.3	9	4	<2	0.021	4.52	4.58	<0.010 B	0.014	9.2
FC3	12/14/93	15:00	54.1	14:40	7.4	156	7.0	10.1	110 S	15		0.083	3.89	4.10	0.012	0.067	6.5
FC3	12/14/93			14:55	7.4	156	7.0	10.1	69	12		0.084	3.83	3.91	<0.010	0.061	6.5
FC3	1/12/94	15:10	51.9	15:20	7.3	162	7.9	9.9	210	14	<2	0.122	3.86	4.29	0.014	0.052	6.2
FC3	1/12/94			15:20	7.3	168	7.9	9.8	220	13	<2	0.111	3.85	4.09	0.012	0.048	6.3
FC3	1/25/94	15:05	17.3	15:20	7.4	231	8.5	9.5	34	4	<2	0.024	4.87	5.20	<0.010 B	0.031	9.6
DDW1	9/13/93	14:50	3.4	14:40	9.1	210	17.4	15.4	280	3	<2	<0.1	0.8	1.57	0.019	0.03	12.9
DDW1	9/20/93	8:48	1.8	8:45	7.5	238	10.6	8.3	960 X	2	<2	<0.1	1.3	2.06 OHT	0.023	0.03	20.3
DDW1	11/8/93	8:20	1.0	8:30	7.8	212	3.8	12.4	4,200 S	3	<2	0.047	1.94	2.10	0.025 B	0.039	33.1
DDW1	12/14/93	8:45	9.3	9:00	7.3	188	6.5	10.0	930 S	8		0.243	3.22	3.97	0.051	0.093	10.0
DDW1	12/14/93			9:00	7.3	189	6.5	10.0	900 S	7		0.257	3.26	3.84	0.050	0.093	10.2
DDW1	1/12/94	9:00	10.9	9:10	7.4	180	7.5	10.1	1,700 S,BOF	17	<2	0.166	3.05	4.61	0.053	0.108	9.0
DDW1	1/12/94								1,400 S								
DDW1	1/25/94	8:07	5.2	9:20	7.3	195	6.9	10.9	310 S	9	<2	0.045	2.82	3.12	0.028 B	0.063	9.9

Appendix C. Fishtrap Creek Water Quality Sampling Results

Stn ID (units)	Date	Flow time	Flow (cfs)	Sample time	pH (std. units)	Cond (umhos/ cm)	Temp. (°C)	DO (mg/L)	FC (org./100 mL)	TSS (mg/L)	BOD5 (mg/L)	NH3 (mg/L)	NO3+ NO2 (mg/L)	TPN (mg/L)	OP (mg/L)	TP (mg/L)	Cl (mg/L)
DDE1	9/13/93	14:15	2.5	14:00	8.4	218	10.3	13.1	270	<1	<2	<0.1	0.9	1.40	0.018	0.03	13.0
DDE1	9/13/93	14:30	2.2	14:05	8.4	218	10.4	12.9	230	<1	<2	<0.1	0.9	1.47	0.016	0.07	13.1
DDE1	9/20/93	8:20	3.3	8:24	7.6	235	10.6	9.4	800 X,S	1	<2	<0.1	1.6	2.13 OHT	0.027	0.12	19.0
DDE1	11/8/93	7:45	3.4	8:10	7.8	202	4.4	12.2	250	1	<2	<0.010	1.95	2.04	<0.010 B	0.015	12.3
DDE1	12/14/93	8:20	14	8:30	7.2	188	6.7	9.6	500 S	10		0.253	2.42	3.82	0.042	0.095	9.6
DDE1	1/12/94	8:30	20.4	8:50	7.2	188	7.4	9.6	1,200 S	20	<2	0.263	2.59	4.10	0.038	0.109	9.2
DDE1	1/25/94	8:30	7.6	8:40	6.6	195	7.0	10.5	71 S	8	<2	0.051	2.47	2.80	0.015 B	0.051	10.6
DDE1	1/25/94			8:50	6.7	195	7.0	10.4	110 S	8	<2	0.059	2.37	2.64	0.013 B	0.052	10.1
DDW2	9/13/93	16:30	3.8	16:11	7.9	223	14.8	9.8	4,300 J	<1	<2	<0.1	1.1	1.56	0.045	0.08	12.9
DDW2	9/20/93	9:55	2.8	9:35	7.5	237	10.7	9.4	490 S	2	<2	<0.1	1.4	2.05 OHT	0.023	0.05	18.6
DDW2	9/20/93	10:05	2.5	9:40	7.5	235	10.7	9.4	490 S	2	<2	<0.1	1.5	1.85 OHT	0.021	0.05	18.6
DDW2	11/8/93			9:20	7.7	210	4.9	11.8	130 S	1		<0.010	2.03	2.09	0.011 B	0.017	12.4
DDW2	11/8/93								140 S								
DDW2	12/14/93			9:35	7.1	175	6.4	9.5	4,400 S	5		0.347	2.31	3.21	0.049	0.103	8.9
DDW2	12/14/93								2,300								
DDW2	1/12/94			10:00	7.4	165	7.2	9.7	1,000 X	16		0.221	2.61	3.54	0.038	0.092	7.8
DDW2	1/25/94			9:55	7.5	190	6.9	10.5	470 S	8		0.036	2.88	3.20	0.068 B	0.143	9.8
DDE2	9/13/93	16:50	3.4	16:15	8.0	188	10.5	10.4	480	3	<2	0.2	1.5	1.54	0.017	0.04	12.9
DDE2	9/20/93	9:20	4.8	9:05	7.6	212	10.6	10.0	470 S	5	<2	<0.1	1.2	2.43 OHT	0.028	0.06	18.6
DDE2	11/8/93			9:00	7.6	205	5.3	12.2	570 S	2		0.017	2.07	2.18	0.013 B	0.024	12.2
DDE2	11/8/93			9:15	7.8	197	5.3	12.2	400 S	1		<0.010	2.08	2.17	<0.010 B	0.017	12.1
DDE2	12/14/93			9:30	7.3	185	6.3	9.9	530 S	9		0.444	2.62	3.68	0.073	0.117	9.3
DDE2	1/12/94			9:50	7.4	175	7.1	9.8	730 X	19		0.289	2.74	4.71	0.086	0.135	8.4
DDE2	1/25/94			9:55	7.6	190	6.7	11.3	220 S	4		0.043	3.00	3.16	0.030 B	0.053	9.5
DDE2	1/25/94								140 S								
DDW3	9/13/93	17:00	1.7	17:00	7.9	220	13.3	10.0	200	1	<2	0.1	1.2	1.61	0.013	0.03	12.8
DDW3	9/20/93	10:44	3.0	10:35	7.6	230	10.8	9.6	240 S	4	<2	<0.1	1.1	2.05 OHT	0.020	0.05	17.8
DDW3	11/8/93	10:00	1.9	9:50	7.7	210	5.6	11.7	330 S	1	<2	<0.010	2.11	2.15	0.010 B	0.018	12.2
DDW3	12/14/93	10:20	6.7	10:30	7.1	168	6.4	9.6	900 S	3		0.407	2.36	3.27	0.068	0.099	8.4
DDW3	1/12/94	10:35	10.9	10:55	7.1	160	7.1	9.5	900 S	12	<2	0.395	2.71	4.17	0.098	0.128	7.6
DDW3	1/12/94			10:55	7.2	163		9.5	1,100 X,S	8	<2	0.384	2.69	3.53	0.093	0.131	7.7
DDW3	1/25/94	10:20	5.0	10:40	7.5	185	6.8	10.6	350 S	6	<2	0.056	3.03	3.24	0.026 B	0.050	9.2
DDE3	9/13/93	16:55	3.8	16:50	7.8	220	13.3	9.8	180	1	<2	<0.1	1.4	2.27	0.015	0.03	12.9
DDE3	9/20/93	10:30	4.8	10:20	7.6	233	10.8	9.5	150 S	4	<2	<0.1	1.1	2.17 OHT	0.018	0.05	18.0
DDE3	9/20/93								200 S								
DDE3	11/8/93	9:40	4.1	9:50	7.7	210	5.6	11.7	140 S	1	<2	<0.010	2.18	2.16	<0.010 B	0.017	12.3
DDE3	12/14/93	10:00	12.9	10:10	7.1	156	6.3	9.5	470 S	4		0.429	2.29	3.19	0.080	0.117	8.6
DDE3	1/12/94	10:12	16.3	10:25	7.4	160	7.1	9.6	930 S	13	<2	0.415	2.38	3.54	0.107	0.131	7.6
DDE3	1/25/94	10:15	6.5	10:40	7.5	185	6.7	11.1	300 S	4	<2	0.035	2.87	3.18	0.025 B	0.050	9.1

Appendix C. Fishtrap Creek Water Quality Sampling Results

Stn ID	Date	Flow time	Flow	Sample time	pH	Cond	Temp.	DO	FC	TSS	BOD5	NH3	NO3+ NO2	TPN	OP	TP	Cl
(units)			(cfs)		(std. units)	(umhos/ cm)	(°C)	(mg/L)	(org./100 mL)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
BS1	9/13/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
BS1	9/20/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
BS1	11/8/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
BS1	12/14/93	11:44	4.9	11:50	6.8	290	8.9	6.4	2,200 S	10		0.768	0.83	2.14	0.027	0.114	14.0
BS1	1/12/94	13:00	6.8	13:10	6.9	281	9.1	7.8	1,100 S	44	3	0.514	1.79	3.15	0.024	0.099	13.2
BS1	1/25/94	12:00	1.6	12:45	7.4	300	8.9	8.3	6,000	7	<2	0.403	0.59	1.34	<0.010 B	0.045	15.1
BS2	9/13/93	17:45	0.1	17:47	6.9	340	10.4	5.3	43	3	<2	0.5	0.2	1.01	<0.010	0.04	13.5
BS2	9/20/93	12:15	0.1	12:00	7.0	285	11.5	7.1	260	11		0.3	0.1	1.16 OHT	<0.010	0.05	14.1
BS2	11/8/93			12:20	7.0	275	9.6	6.2	3	4		0.516	0.06	0.88	0.015 B	0.033	13.3
BS2	12/14/93			12:15	6.6	305	9.2	4.9	700 S	8		0.721	0.83	2.12	0.044	0.072	14.3
BS2	1/12/94			13:25	6.7	290	9.2	6.2	700	30		0.514	2.17	4.20	0.032	0.083	13.7
BS2	1/25/94			13:15	6.8	300	9.6	5.5	14	3		0.443	0.57	1.25	0.016 B	0.033	15.4
DP1	9/13/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
DP1	9/20/93	11:15	0.1	11:15	6.6	136	12.8	4.8	360	4	<2	<0.1	0.9	1.67 OHT	<0.010	0.08	4.9
DP1	11/8/93	10:45	0.2	10:55	7.6	330	6.0	11.3	400	<1	<2	<0.010	0.34	0.69	0.019 B	0.036	19.6
DP1	12/14/93	12:30	7.0	12:40	7.0	338	8.7	7.9	370 S	13		0.370	2.43	3.34	0.015	0.077	16.2
DP1	1/12/94	11:45	10.5	11:55	6.5	320	8.8	8.6	460 S	63	3	0.356	2.66	5.15	0.023	0.087	15.5
DP1	1/25/94	11:30	2.8	11:40	7.2	327	8.6	9.4	92	13	<2	0.180	1.27	1.88	<0.010 B	0.043	19.0
DP2	9/13/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
DP2	9/20/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
DP2	11/8/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
DP2	12/14/93			10:45	7.2	810	6.0	2.2	740,000	49		19.200	7.41	35.50	2.48/2.45	4.390	22.3
DP2	12/14/93			10:45					880,000								
DP2	1/12/94			11:25	7.0	235	6.9	9.2	290 S	2		0.066	8.22	8.79	0.291	0.319	9.3
DP2	1/25/94			11:00	7.5	260	6.7	6.5	11,000 J	1		0.119	7.87	8.73	0.335 B	0.325	10.7
BD1	9/13/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
BD1	9/20/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
BD1	11/8/93	DRY	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
BD1	12/14/93	13:45	10.6	13:50	6.9	310	9.0	6.7	670	7		0.449	2.66	3.97	0.056 J	0.140	11.1
BD1	1/12/94	14:20	8.1	14:25	7.0	290	9.3	6.9	1,600	18		0.599	2.61	4.89	0.104	0.237	10.8
BD1	1/25/94	14:15	3.0	14:20	7.4	305	9.4	9.2	100	3	3	0.170	3.70	4.40	0.015 B	0.049	12.3
BD2	9/13/93	11:30	0.2	12:00	7.3	322	12.7	9.1	51 S	<1	<2	0.2	<0.2	0.87	0.020	0.07	15.2
BD2	9/20/93	14:04	0.1	13:30	7.5	340	12.4	8.9	340	2		0.1	0.4	1.03 OHT	0.011	0.05	16.3
BD2	11/8/93			13:45	7.3	335	8.8	9.1	69	2		0.085	0.40	0.84	0.011 B	0.028	15.2
BD2	12/14/93			14:15	7.0	275	8.7	5.2	410 S	4		0.409	3.33	4.75	0.127	0.229	11.1
BD2	1/12/94			14:45	7.0	260	9.0	5.8	420	8		0.563	2.95	5.58	0.168	0.296	9.8
BD2	1/25/94			14:40	7.1	275	9.6	7.2	650	4	<2	0.088	3.70	4.14	<0.010 B	0.029	11.1

Appendix C. Fishtrap Creek Water Quality Sampling Results

Stn ID (units)	Date	Flow time	Flow (cfs)	Sample time	pH (std. units)	Cond (umhos/cm)	Temp. (°C)	DO (mg/L)	FC (org./100 mL)	TSS (mg/L)	BOD5 (mg/L)	NH3 (mg/L)	NO3+ NO2 (mg/L)	TPN (mg/L)	OP (mg/L)	TP (mg/L)	Cl (mg/L)
Blanks	9/13/93														<0.010		
	9/20/93														<0.010		
	11/8/93														0.063 B		
	12/14/93														<0.010		
	1/12/94														<0.010		
	1/25/94														0.230 B		

Codes:
J The analyte was positively identified. The associated numerical result is an estimate.
B The survey blank showed elevated levels of O-PO4.
OHT Over holding time.
Microbiology:
X High background count.
S Spreader (non-fecal motile colonies covering a quarter of the plate or more that may be masking fecal colonies).
BOF Bottle overfull.