



Snohomish County

Swamp Creek Drainage Needs Report

APPENDIX D

Water Quality Analysis

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Appendix D. Water Quality Analysis

D.1 Introduction

The Swamp Creek Drainage Needs Report (DNR) Basin is defined as that area that includes the following subbasins: Scriber Creek, Martha Creek, North Swamp Creek, Middle Swamp Creek, South Swamp Creek, and Chase Lake. The Swamp Creek Urban Growth Area (UGA) includes all subbasins except Chase Lake.

This appendix documents existing water quality conditions and associated problems within the Swamp Creek DNR Basin. The Swamp Creek DNR Basin is located in south Snohomish County and comprises two geographically distinct areas. The study area described in this appendix consists of the Swamp Creek drainage basin area north of the King-Snohomish county line, and a small drainage area called the southwest urban growth area (Chase Lake) that lies outside the Swamp Creek DNR Basin. The majority of the Swamp Creek DNR Basin analyzed for this report encompasses approximately 16,000 acres within portions of the cities of Everett, Lynnwood, Brier, Bothell, Mountlake Terrace, and Kenmore, as well as unincorporated Snohomish County (see Figure 5-1 in Section 5.0 of this report). The Chase Lake Subbasin study area includes portions of the drainage basins for Hall Creek and an unnamed tributary that drains directly to Puget Sound, encompassing an area of approximately 400 acres of unincorporated Snohomish County that is bordered on all sides by the city of Edmonds (Figure 5-1).

The specific goal of the analyses presented in this appendix is to characterize existing water quality conditions within the Swamp Creek DNR Basin. General and specific water quality problems occurring within this study area are described in Section 5.0 of this report.

D.1.1 Available Water Quality Information

Information for this analysis was derived from field observations, a review of available data and reports, and contacts with Snohomish County Surface Water Management (SWM) staff. In comparison to other DNR study areas, extensive water quality information is available for the Swamp Creek DNR Basin, while no water quality information is available for the Chase Lake Subbasin.

King County has conducted baseline water quality monitoring at the mouth of Swamp Creek since 1976 (King County, 2002). Snohomish County has conducted baseline water quality monitoring at two long-term stations located in the upper watershed and at the King County boundary since 1992. From 1992 through 1993, Snohomish County conducted extensive water quality sampling at stations located upstream and downstream of various land uses within the Swamp Creek DNR Basin. In addition, the Washington State Department of Ecology (Ecology) monitored water quality in the stream at a sampling station located in the upper watershed from 1998 to 1999.

The following reports and data summaries provided particularly useful information on existing water quality problems in the study area:

- *Swamp Creek Watershed Management Plan and Technical Appendices* (Snohomish County, 1994). These documents contain a comprehensive summary of the watershed, including an analysis of water quality data, watershed biological and physical characteristics, water quality problem locations, and management plans and strategies.
- *City of Lynnwood Comprehensive Flood and Drainage Management Plan* (R.W. Beck, 1998). This document contains a comprehensive summary of the Scriber Creek watershed, including an analysis of water quality data, watershed biological and physical characteristics, water quality problem locations, and management plans and strategies.
- *Water Quality Monitoring of Northern Lake Washington Streams* (King County, 2002). This report contains a summary and an analysis of water and sediment quality data collected from 1979 to 1999.
- *Habitat Inventory and Assessment of Three Sammamish River Tributaries: North, Swamp, and Little Bear Creeks* (King County, 2001). This report contains a comprehensive stream survey and habitat assessment of Swamp Creek from its mouth to 380 meters (approximately one-quarter mile) north of 164th Street SE in Snohomish County.
- *The State of the Waters – Water Quality in Snohomish County’s Rivers, Streams, and Lakes* (Snohomish County, 2000). This report contains a summary and an analysis of water quality data collected from 1992 to 2000.

The water quality data collected for these and other studies are discussed in Sections D.2.1 and D.3.1. In addition, Snohomish County SWM performed dry-weather outfall screening visits at several drainage outfall locations in the Swamp Creek DNR Basin as part of a three-year countywide outfall assessment program. A summary report is not yet available, but field observations from the outfall screening study, as well as some water quality data gathered in that effort, are discussed in this appendix.

D.1.2 Land Use Patterns Affecting Water Quality

D.1.2.1 Swamp Creek

Swamp Creek originates in the Paine Field and West Casino Road area of south Everett, and flows south for approximately 14.7 miles before discharging into the Sammamish River approximately 0.7 mile upstream of Lake Washington (see Figure 5-1 in Section 5.0). The watershed includes Martha Lake, Scriber Lake, and Lake Stickney, as well as 19 tributaries, of which the largest are Martha Creek and Scriber Creek. The watershed is characterized by a broad lower region in the floodplain of the Sammamish River, a narrow valley middle region containing steep slopes in excess of 15 percent gradient south of the I-405 and I-5 crossing, and a gently sloping upper region in the intercity plateau area of south Snohomish County. Stream channel gradients generally range from zero to 2 percent throughout the watershed (King County, 2001).

As noted previously, Swamp Creek drains portions of unincorporated Snohomish County and the cities of Everett, Lynnwood, Brier, Bothell, Mountlake Terrace, and Kenmore. Approximate percentages of the drainage basin area within each jurisdiction are as follows: unincorporated Snohomish County (60 percent), Lynnwood (17 percent), Everett, Brier, Bothell, and Mountlake Terrace (total of 15 percent), and Kenmore (8 percent) (Snohomish County, 1994). The *Swamp Creek Watershed Management*

Plan (Snohomish County, 1994) notes that land use in the entire Swamp Creek DNR Basin consists of approximately 25 percent commercial land, 25 percent forest/wetland, 25 percent low-density residential land, 15 percent rural land, and 10 percent high-density residential land. The highest levels of urban development are generally located within unincorporated Snohomish County and south Everett along SR 99, and within the City of Lynnwood.

Water quality in these streams is affected by a combination of land uses. The segment of the SR 99 corridor located within the basin is a major source of runoff pollution, as is the Alderwood Mall area that lies within the Scriber Creek Subbasin. However, there are many other nonpoint sources of stormwater pollution in the basin, including Paine Field near the headwaters of Swamp Creek, sections of I-5 and I-405 in the North and Middle Swamp Creek subbasins, small non-commercial farm areas in middle reaches of the basin, and residential areas throughout the basin.

Longstanding land uses, as well as increased urbanization and land development activities, are affecting the water quality of Swamp Creek and its tributaries. Water quality impacts can result from a variety of land use activities, including increases in impervious surface area and associated stormwater runoff, conversion of forests to other land uses, increased pollution from small farms, increased pollution from roadways, insufficient retention/detention of stormwater from new impervious surfaces, ineffective stormwater treatment at construction sites, and reduction of vegetated buffer areas between developed land and surface waters. To provide a general indication of the types of pollutants that may be present in runoff from these land uses, Table 5-1 in Section 5.0 of this report lists potential sources of pollutants in stormwater runoff associated with various land use categories.

Finally, some residential developments, outside of the incorporated areas where sewer systems prevail, treat wastewater using onsite septic systems. Inadequately managed septic systems, combined with generally high groundwater levels can contribute nutrient and organic waste loadings and bacterial contamination to both surface water and groundwater systems.

D.1.2.2 Chase Lake

The Chase Lake portion of the study area is located in south Snohomish County and is bordered on all sides by the city of Edmonds. The topography of this area is characterized by a small rise at the south end of the area that slopes down toward the northeast. Much of the subbasin as defined for this DNR study does not drain to Chase Lake. Land uses and the associated drainage from this subbasin affects the water quality of several receiving waters, including Chase Lake, Lake Ballinger, McAleer Creek, and Shell Creek. The majority of the Chase Lake Subbasin consists of older suburban neighborhoods with drainage features comprised of ditches, swales, and culverts. Land use is dominated by medium-density, single-family residences, with a few small areas of high-density, single-family residential, and commercial land uses. Thus, runoff from residential land uses is the primary factor affecting water quality in drainage from this area. Typical water quality problems associated with residential and commercial development are listed in Table 5-1 in Section 5.0.

D.2 Analysis Methods

The analysis of water quality conditions in the Swamp Creek DNR Basin relied upon available water quality data, existing stream surveys, and data analyses performed by others and cited in published reports. No new water quality sampling was conducted specifically for this DNR, although a field reconnaissance of the Swamp Creek DNR Basin was performed. Therefore, the identification of water quality problems is based on a qualitative evaluation of existing data and a consolidation of the associated findings.

D.2.1 Existing Data

As noted in Section D.1.1, there are no known water quality data sources for the Chase Lake study area. For Swamp Creek, many of the historical data were collected and interpreted by Snohomish County SWM, King County, and Ecology. King County has conducted monthly baseline water quality monitoring at the mouth of Swamp Creek since 1979 (King County, 2002). Trace metals have been analyzed in stormwater samples collected at this site three to six times per year since 1992. Sediment metals have been collected annually from sites near the mouth of Swamp Creek since 1987 (King County, 2002). From August to November 1999, King County conducted an extensive habitat assessment of Swamp Creek from the mouth to 380 meters (approximately one-quarter mile) north of 164th Street SE in Snohomish County to document salmon habitat quality, adjacent land use, stream riparian areas, and potential nonpoint sources of pollution (King County, 2001). Figure 5-1 in Section 5.0 of this report shows the location of King County's baseline water quality monitoring site.

Snohomish County SWM began routine water quality monitoring of Swamp Creek in 1992 as part of its ambient water quality program. The County selected two sites in the watershed for long-term water quality assessment, an upstream site (identified as SWLU) and a downstream site (SCLD). The monitoring was designed to establish baseline water quality data and to test for spatial and temporal trends in water quality parameters. Monthly grab samples have been collected since May 1992, and sampling at these sites is ongoing. Figure 5-1 in Section 5.0 shows the locations of these long-term ambient water quality monitoring sites.

SWM's ambient water quality program was extended between May 1992 and April 1993 to provide a more intensive assessment of nonpoint source pollution generated from various land uses. This intensive monitoring program included the addition of six stations that were sampled with a higher frequency than the long-term stations (approximately 18 times during the year; 10 times during the wet season and 8 times during the dry season). The analytical parameters were the same as for the long-term stations. The six sites added were:

- Swamp Creek residential upstream (SCRU)
- Swamp Creek residential downstream (SCRD)
- Swamp Creek mixed-use upstream (SCMU)
- Swamp Creek mixed-use downstream (SCMD)
- Swamp Creek hobby farm upstream (SCHU)
- Swamp Creek hobby farm downstream (SCHD).

Figure 5-1 in Section 5.0 shows the locations of these short-term ambient water-quality monitoring sites. The residential, mixed-use, and hobby farm monitoring station locations focused on characterizing a reach of the stream directly affected by the corresponding land uses. For instance, the SCRU and SCRD monitoring station locations were selected to characterize the differences in water quality occurring in a reach of the stream bordered by, and receiving runoff from, a primarily residential area. Similarly, the SCMU and SCMD station locations were selected to characterize the differences in water quality occurring in a reach of the stream bordered by, and receiving runoff from, a mix of commercial, arterial roadway, and residential land uses. The hobby farm monitoring reach of Swamp Creek received runoff from several small, non-commercial farms at the time of the sampling effort.

Snohomish County SWM staff collected continuous temperature data at the long-term downstream location (SCLD) from May through October 1997. These data are presented and evaluated for compliance with state water quality standards in this appendix.

Due to concerns over urban development and surface water degradation in the Swamp Creek watershed, Ecology performed a general water quality study from 1998 to 1999 (Ecology, 2002). One upstream site (08J100) was selected to establish baseline water quality data and to test for spatial and temporal trends in water quality parameters. Figure 5-1 in Section 5.0 shows the location of this short-term monitoring site. Additionally, Ecology monitored pesticide concentrations in Swamp Creek at a location near its mouth in 1996 as part of the Washington State pesticide monitoring program (Ecology, 1998).

In addition to water quality monitoring efforts, Snohomish County SWM staff also evaluated several drainage outfall locations in the Swamp Creek DNR Basin during the summers of 1998, 1999, 2000, and 2001. These outfall evaluations were part of the County's outfall screening program focusing on observations of pollution problems in dry weather. A final report on the outfall screening program is not yet available, but the results of data collection in the Swamp Creek DNR Basin are discussed later in this appendix.

From 1997 to 1999, Morley (2000) collected 13 benthic invertebrate samples at 10 sites along 14 kilometers of Swamp Creek between the mouth and Lake Stickney. In addition, Snohomish County SWM staff collected two benthic invertebrate samples from one site located near the Swamp Creek long-term downstream water quality sampling location (SCLD) in 1997 and 1999 (see Figure 5-1). Data from these samples were used to calculate benthic index of biotic integrity (B-IBI) scores for each sampling location. The B-IBI scores provide an overall measure of human impact resulting from various habitat perturbations, including water quality problems (Fore et al., 1996). Additional information regarding the benthic invertebrate sampling and associated B-IBI scores is provided in Appendix C.

D.2.2 Field Reconnaissance

A field reconnaissance was conducted in the Swamp Creek DNR Basin on March 12, 2002, to evaluate existing water quality conditions, confirm previous accounts of water quality conditions, and identify potential sources of stormwater runoff contamination. The findings of the field reconnaissance are included in the discussion of water quality conditions in Section D.3.

D.2.3 Coordination With County Staff and Other Analyses

Evaluation of water quality within the study area also included coordination with Snohomish County SWM staff. During a meeting in April 2001, County staff provided an overview of available data, suggestions for other data sources, and observations of past water quality problems.

As noted above, benthic invertebrate data collected in the Swamp Creek DNR Basin by Snohomish County and Morley (2000) also provide a general understanding of water quality conditions in sampled stream reaches. A detailed analysis of these benthic invertebrate data is provided in Appendix C and summarized later in this appendix.

Land use data compiled for hydrologic modeling of the Swamp Creek DNR Basin and the Chase Lake Subbasin were evaluated to assess the spatial characteristics of land uses that are of concern for water quality impairment. Geographic information system (GIS) maps were produced indicating locations of land uses classified by their potential to generate contaminated runoff. These maps visually indicate where stormwater pollution and nonpoint source runoff contamination are likely to originate.

D.3 Water Quality Characterization

D.3.1 Water Quality Data

Streams in the Swamp Creek DNR Basin must meet Class AA water quality standards as set forth in the Washington Administrative Code (WAC 173-201A) and as listed in Table D-1. Under section 303(d) of the federal Clean Water Act, Ecology issues its 303(d) list identifying water bodies that do not meet water quality standards. Swamp Creek appearances on the 1998 303(d) list are identified throughout this section by water quality parameter.

As noted previously, no water quality data for the Chase Lake Subbasin are available. As described in Section D.2.1, there are five main sources of water quality data for the Swamp Creek DNR Basin:

- Snohomish County SWM ambient water quality monitoring program (1992 through 2001)
- Snohomish County SWM extended water quality monitoring program for the subbasins (1993–1994)
- Snohomish County SWM temperature study (1997)
- King County baseline water quality monitoring program (1979 to the present)
- Ecology baseline water quality monitoring program (1998–1999).

The majority of the available water quality data come from the SWM and King County long-term and special study monitoring programs. The associated water quality monitoring stations are shown in Figure 5-1 in Section 5.0 of this report. Water samples were collected and tested for the following parameters:

- total suspended solids
- total phosphorus
- ammonia nitrogen
- nitrate+nitrite nitrogen

- hardness
- fecal coliform bacteria
- total copper
- total lead
- total zinc

Table D-1 Water Quality Criteria for Class AA Freshwaters in the State of Washington (WAC 173-201)	
Fecal Coliform Bacteria	
Shall not exceed a geometric mean value of:	50 colonies/100 milliliters (mL)
With not more than 10% of samples exceeding:	100 colonies/100 mL
Dissolved Oxygen	
Shall exceed:	9.5 milligrams per liter (mg/L)
Temperature	
Shall not exceed:	16°C
Turbidity	
When background turbidity is 50 NTU or less, shall not exceed background turbidity by:	5 NTU (nephelometric turbidity units)
When background turbidity is more than 50 NTU, shall not have more than an increase of:	10%
pH	
Shall be within the range of:	6.5 to 8.5
Copper, total and dissolved	
Shall not exceed an acute criterion for a 1-hour average concentration or a chronic criterion for a 4-day average concentration. Toxicity criteria increase with total hardness. For a typical Snohomish County stream hardness range of 50 to 100 mg/L as CaCO ₃ .	Total metal acute criterion ranges from 9.2 to 17.7 micrograms per liter (µg/L), and chronic criterion ranges from 6.5 to 11.8 µg/L. Dissolved metal acute criterion ranges from 8.7 to 17.0 µg/L, and chronic criterion ranges from 6.3 to 11.4 µg/L.
Lead, total and dissolved	
Shall not exceed an acute criterion for a 1-hour average concentration or a chronic criterion for a 4-day average concentration. Toxicity criteria increase with total hardness. For a typical Snohomish County stream hardness range of 50 to 100 mg/L as CaCO ₃ .	Total metal acute criterion ranges from 33.8 to 81.6 µg/L, and chronic criterion ranges from 1.3 to 3.2 µg/L. Dissolved metal acute criterion ranges from 30.1 to 64.6 µg/L, and chronic criterion ranges from 1.2 to 2.5 µg/L.
Zinc, total and dissolved	
Shall not exceed an acute criterion for a 1-hour average concentration or a chronic criterion for a 4-day average concentration. Toxicity criteria increase with total hardness. For a typical Snohomish County stream hardness range of 50 to 100 mg/L as CaCO ₃ .	Total metal acute criterion ranges from 65.0 to 117 µg/L, and chronic criterion ranges from 58.9 to 106 µg/L. Dissolved metal acute criterion ranges from 63.6 to 114 µg/L, and chronic criterion ranges from 58.1 to 104 µg/L.

In addition, *in situ* field measurements of temperature, pH, DO, conductivity, and turbidity were recorded during some or all of the monitoring visits. Table D-2 provides a summary of relevant water quality data for Swamp Creek. The following paragraphs summarize the results for individual pollutants.

D.3.1.1 Fecal Coliform Bacteria

Snohomish County SWM data from 1992 through 2001 report violations of state standards for fecal coliform bacteria concentrations at both of the long-term monitoring stations and at five of the six short-term intensive study sites (Table D-2). Forty percent of the samples collected by SWM at the long-term upstream site (SCLU) and 72 percent of the samples collected at the long-term downstream site (SCLD) revealed fecal coliform bacteria concentrations in excess of the state standard. At the short-term sites, exceedances of the state fecal coliform standard ranged from 28 percent of the time at the hobby farm downstream site (SCHD) to 61 percent of the time at the residential downstream site (SCRD).

At several sites in the watershed, samples exceeded 1,000 colonies/100 mL (10 times the state standard) multiple times, with the highest concentrations measured at the long-term upstream (SCLU) and hobby farm downstream (SCHD) sampling locations, which are located downstream of Lake Stickney and several small farms. It is likely that the high fecal coliform concentrations are attributable to runoff that carries wastes generated by farm animals into the stream.

In general, concentrations increased from upstream to downstream stations, with the greatest values recorded at SWM's long-term downstream sampling location (SCLD; 216 colonies/100 mL) and at the King County sampling location (180 colonies/100 mL).

Exceedance of the state standard for fecal coliform bacteria is not in itself a threat to the health of the aquatic ecosystem. However, elevated fecal coliform concentrations can be an indication of a human health risk associated with direct contact exposure to animal or human waste contamination in the aquatic ecosystem. Swamp Creek was included on Ecology's 303(d) list of impaired waters in 1998 for violations of the state fecal coliform bacteria standard (Ecology, 2001).

**Table D-2
Summary of Swamp Creek Water Quality Data**

Location	Temp (°C)	DO (mg/L)	pH	Conduct (µmhos/cm)	Turbidity (NTU)	Fecal Coliform (colonies/100 mL)	Nitrate+ Nitrite (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)	Total Copper (mg/L)	Total Lead (mg/L)	Total Zinc (mg/L)
Snohomish County SWM Long-Term Monitoring Sites (1992–2001)												
Upstream (SCLU)												
Number	94	94	93	90	35	94	94	93	94	93	91	69
Minimum	2	2.46	5.83	17.4	0.54	1	0.012	0.0047	0	0.00007	0	0
Maximum	18	13.87	8.40	606	19.9	48000	3.2	0.237	65	0.073	0.0120	0.1200
Mean	9.8	9.1	7.22	119.16	2.74	114	0.56	0.03	4.47	0.0033	0.0014	0.0119
Median	9.7	9.54	7.01	111.25	1.56	77.5	0.41	0.022	2	0.0018	0.00086	0.00822
% not meeting state criteria	8.5	50	10.8			40.4				acute-4.3 chronic-4.3	acute-0 chronic-35.1	acute-4.3 chronic-4.3
Downstream (SCLD)												
Number	111	110	110	106	44	110	110	110	110	110	110	88
Minimum	2.3	5.34	6.38	37.1	0.7	4	0	0.0185	0	0.00007	0	0
Maximum	19.1	14.78	8.88	231	23.6	7300	2.5	0.12	540	0.073	0.017	0.100
Mean	10.77	10.81	7.87	147.12	3.43	216.54	0.95	0.05	14.15	0.003	0.0015	0.0084
Median	10.7	10.76	7.51	150.3	1.76	210	0.91	0.05	3	0.001475	0.000713	0.00471
% not meeting state criteria	9.9	15.5	2.7		0	71.8				acute-3.6 chronic-3.6	acute-0 chronic-21.8	acute-1.1 chronic-1.1

**Table D-2 (continued)
Summary of Swamp Creek Water Quality Data**

Location	Temp (°C)	DO (mg/L)	pH	Conduct (µmhos/cm)	Turbidity (NTU)	Fecal Coliform (colonies/100 mL)	Nitrate+ Nitrite (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)	Total Copper (mg/L)	Total Lead (mg/L)	Total Zinc (mg/L)
Snohomish County SWM Short-Term Assessment Sites (1992–1993)												
Residential Upstream (SCRU)												
Number	17	17	18	18	0	18	18	18	2	18	1	0
Minimum	2.6	6.47	6.8	77.6		37	0.55	0	3	0.0010	0.0030	
Maximum	17.4	9.89	7.9	333		1900	1.7	0.16	4	0.0990	0.0030	
Mean	10.12	8.53	7.60	136.31		172.65	1.11	0.06	3.50	0.0136	0.0030	
Median	8.9	8.63	7.55	125.6		121	1.2	0.05	3.5	0.0010	0.0030	
% not meeting state criteria	11.8	70.5	0			55.6				acute-22.2 chronic-33.3	acute-0 chronic-100	
Residential Downstream (SCRD)												
Number	18	18	17	18	0	18	18	18	2	18	1	0
Minimum	2.6	6.42	6.8	77.3		20	0.62	0	2	0.0010	0.0030	
Maximum	20.1	10.48	8.4	522		1000	1.9	0.25	6	0.1200	0.0030	
Mean	10.23	8.75	7.89	150.47		146.13	1.18	0.06	4.00	0.0100	0.0030	
Median	8.95	8.85	7.9	134.85		126	1.2	0.05	4	0.0010	0.0030	
% not meeting state criteria	16.7	55.6	0			61.1				acute-5.6 chronic-16.7	acute-0 chronic-100	
Mixed Use Upstream (SCMU)												
Number	18	18	18	18	0	0	18	18	18	18	18	0
Minimum	2.4	4.85	6.5	74.4			0.19	0.016	0	0.0010	0.0005	
Maximum	16	9.23	7.2	203			6.2	0.14	38	0.1400	0.0180	
Mean	8.99	6.83	6.94	124.59			0.96	0.05	6.94	0.0106	0.0032	
Median	8	7.135	6.95	119.55			0.66	0.04	4	0.0010	0.0020	
% not meeting state criteria	0	100	0							acute-11.1 chronic-11.1	acute-0 chronic-50	

**Table D-2 (continued)
Summary of Swamp Creek Water Quality Data**

Location	Temp (°C)	DO (mg/L)	pH	Conduct (µmhos/cm)	Turbidity (NTU)	Fecal Coliform (colonies/100 mL)	Nitrate+ Nitrite (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)	Total Copper (mg/L)	Total Lead (mg/L)	Total Zinc (mg/L)
Snohomish County SWM Short-Term Assessment Sites (1992–1993)												
Mixed Use Downstream (SCMD)												
Number	42	42	42	41	24	21	39	38	39	38	36	19
Minimum	2.6	0.67	6.2	21.1	0.9	7	0	0.007	0	0.001	0	0
Maximum	16.5	12.52	7.63	234	19.1	1800	2.3	0.21	73	0.1100	0.0240	0.0319
Mean	9.32	8.42	7.21	129.40	3.93	121.40	0.56	0.05	7.67	0.0055	0.0035	0.0115
Median	9.3	8.41	7.2	128.9	2.835	100	0.52	0.033	4	0.0018	0.0009	0.0101
% not meeting state criteria	4.7	66.7	7.1			47.6				acute-2.6 chronic-10.5	acute-0 chronic-33.3	acute-0 chronic-0
Hobby Farm Upstream (SCHU)												
Number	16	16	16	16	0	16	16	16	16	0	0	0
Minimum	1.9	3.54	6.3	55.7		6	0	0	0			
Maximum	22.2	8.61	7.8	171.1		820	0.95	0.13	6			
Mean	10.30	6.41	7.12	92.51		57.67	0.41	0.03	2.31			
Median	9.4	6.61	6.95	89.65		56.5	0.37	0.02	1			
% not meeting state criteria	25	100	18.8			37.5						
Hobby Farm Downstream (SCHD)												
Number	18	18	18	18	0	18	18	18	18	0	0	0
Minimum	1.6	0.82	6.4	57.2		6	0	0	0			
Maximum	17.9	9.17	7.8	252		15500	1.5	0.17	190			
Mean	10.17	5.61	7.16	110.99		69.67	0.62	0.05	14.89			
Median	9.75	6.435	7.05	87.9		44	0.715	0.023	3			
% not meeting state criteria	22.2	100	11.1			27.8						

**Table D-2 (continued)
Summary of Swamp Creek Water Quality Data**

Location	Temp (°C)	DO (mg/L)	pH	Conduct (µmhos/cm)	Turbidity (NTU)	Fecal Coliform (colonies/100 mL)	Nitrate+ Nitrite (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)	Total Copper (mg/L)	Total Lead (mg/L)	Total Zinc (mg/L)
Snohomish County SWM Continuous Temperature Monitoring (5/21/97 to 10/15/97)												
Station SCLD												
Number (hours)	3522											
Minimum	9.49											
Maximum	19.56											
Mean	15.1											
Median	15.4											
% not meeting state criteria	31.1											
King County Water Quality Monitoring Site (1979–1999)¹												
Station 0470												
Number (hours)	249	231	231	234	236	237	232	235	236	32	28	28
Minimum	0.1	6.5	6.1	85	0.2	0	0.014	0.0067	0.5			
Maximum	19	15	8.1	231	52	24000	2.32	0.347	136			
Mean	10.14	10.27	7.31	163.1	3.97	180	0.9968	0.0638	7.28			
% not meeting state criteria	6.4	31.4	0.9			67.9				acute-0	acute-0	acute-0
Ecology Water Quality Monitoring Site (1998–1999)												
Station 08J100												
Number (hours)	11	11	10	11	11	11	11	10	11	0	0	0
Minimum	3.3	6.2	6.5	68	0.7	11	0.022	0.014	1			
Maximum	15.9	11.3	7.5	120	6.1	1700	1.53	0.029	5			
Mean	9.12	9.11	7.12	101.91	2.04	245.18	0.53	0.02	2.36			
Median	8	9.5	7.15	104	1.3	57	0.162	0.023	2			
% not meeting state criteria	0	45.5	0			36.4						

Notes:

¹ Metals collected during storm events between 1995 and 2000.

C=Celsius, mg/L=milligrams per liter, µmhos/cm = micromhos per centimeter (conductivity), mL=milliliter, µg/L=micrograms per liter, NTU = nephelometric turbidity units.

D.3.1.2 Dissolved Oxygen

Low dissolved oxygen (DO) concentrations have been recorded throughout the Swamp Creek study area. Fifty percent of samples collected by SWM between 1992 and 2001 at the long-term upstream site (SCLU) and 16 percent of the samples collected at the long-term downstream site (SCLD) did not meet the state standard for DO (see Tables D-1 and D-2). At the short-term assessment sites monitored by SWM between 1992 and 1993, the state standard was exceeded between 56 and 100 percent of the time. Dissolved oxygen concentrations at the Swamp Creek mouth have not met standards 31 percent of the time since 1979 (King County, 2002). In addition, long-term trend analysis indicates a significant decline in DO concentrations at the mouth since 1990 (King County, 2002). In general, DO concentrations are lowest in the North and Middle Swamp Creek subbasins and highest in the South Swamp Creek Subbasin.

In monitoring conducted between 1992 and 2001, SWM has measured DO concentrations below 2.5 mg/L at multiple locations in Swamp Creek. These very low levels of DO—well below the state Class AA standard—are harmful and potentially lethal to fishes and other aquatic life. The DO levels appear to be lowest at the hobby farm downstream and long-term upstream sampling locations (SCHD and SCLU, respectively), which are located downstream of Lake Stickney and several small farms. It is possible that the low concentrations are attributable to (1) low DO outflow from Lake Stickney (due to excessive aquatic plant growth and decay), and (2) small farm land use practices that reduce DO (i.e., low aeration and inputs of oxygen-demanding substances). Swamp Creek was included on Ecology's 303(d) list of impaired waters in 1998 for violations of the state DO standard (Ecology, 2001).

D.3.1.3 Temperature and pH

Violations of the state standard for temperature were recorded throughout the study area, except at the mixed-use upstream sampling location (SCMU) in the North Swamp Creek Subbasin near the headwaters (Table D-2). The greatest number of excursions beyond the upper temperature standard (25 percent of the time) occurred at the SWM hobby farm upstream sampling location (SCHU). Continuous temperature data collected at the long-term downstream location (SCLD), from May through October 1997, show temperatures exceeding the state standard 31.1 percent of the time, with a maximum recorded temperature of 19.56 degrees Celsius.

Long-term trend analysis indicates a significant increase in stream temperatures at the mouth of Swamp Creek since 1979 (King County, 2002).

Baseline pH values along Swamp Creek are typically within the acceptable range of 6.5 to 8.5, with low measurements recorded on occasion (Table D-2). In general, baseline samples collected during the dry season have higher pH values than samples collected during the wet season. Long-term trend analysis indicates a significant decrease in pH values at the mouth of Swamp Creek since 1979. Increasing urbanization and the resulting increase in runoff flows may be causing the decrease in pH (King County, 2002).

D.3.1.4 Nutrients

The impacts of increased nutrient concentrations on water quality are well-documented (Edmondson and Lehman, 1981). In aquatic environments, the nutrients of primary concern are phosphorus and nitrogen. Increased concentrations of these nutrients in surface waters may result in excessive plant growth, loss of species diversity, dominance

by undesirable species, and depressed DO concentrations as aquatic plants decay (Jeffries and Mills, 1990).

Snohomish County SWM data from 1992 through 2001 show that total phosphorus and nitrate+nitrite nitrogen concentrations are moderate in Swamp Creek, although periodic high concentrations have been detected throughout the watershed (Table D-2). Nutrient concentrations increase with distance downstream (i.e., they are generally higher at station SCLD than at SCLU), and the highest mean total phosphorus and nitrate+nitrite nitrogen concentrations were measured at stations located in the South Swamp Creek Subbasin (SCRD and SCLD). These data suggest that sources of nutrients exist throughout the watershed.

Nutrient data collected at the mouth of Swamp Creek since 1979 (King County station 0470) suggest that downstream concentrations of total phosphorus and nitrate+nitrite nitrogen are moderate and are similar to most of the urban streams in King County (Metro, 1994; King County, 2002). Additionally, King County (2002) detected a statistically significant decline in total phosphorus concentrations at the mouth of Swamp Creek between 1979 and 1999. No trend for nitrogen was detected. The cause of the total phosphorus decrease was not determined, although improved best management practices (BMPs) and greater public education in the watershed may have contributed.

Water quality data collected at Martha Lake indicate nutrient levels are not problematic. Martha Lake is classified as an oligo-mesotrophic lake with low to moderate productivity of algae and aquatic plants (Snohomish County, 2000). Water clarity is high, ranging from 4.1 meters to 5.2 meters (13.4 feet to 17.1 feet), and phosphorus levels measured in the last 10 years have been relatively low (Snohomish County, 2000). The highest average total phosphorus concentrations observed at Martha Lake were 9 µg/L in 1999 in the epilimnion and 24 µg/L in 1990 in the hypolimnion (Snohomish County, 2000).

Although there are no Washington State standards for nutrient concentrations in streams, the United States Environmental Protection Agency (U.S. EPA) has published recommended water quality criteria for specific geographic regions or ecoregions around the country based on geographic and land use features (U.S. EPA, 2000). These recommended criteria represent water quality conditions in each ecoregion that are minimally influenced by human activity and provide for the protection and propagation of aquatic life. For the ecoregion encompassing the Swamp Creek DNR Basin (Aggregate Ecoregion II, Level III Subecoregion 2 – Puget Lowlands), the recommended water quality criteria for total phosphorus and nitrate+nitrite nitrogen are 0.020 mg/L and 0.26 mg/L, respectively. As illustrated in Table D-2, the monitoring data from throughout the Swamp Creek DNR Basin show concentrations of nitrates and phosphorus that exceed these recommended limits.

D.3.1.5 Total Suspended Solids and Turbidity

Elevated turbidity levels and total suspended solids (TSS) concentrations have been periodically measured in water samples from Swamp Creek; however, they do not appear to be a chronic problem. In general, turbidity and TSS concentrations in Swamp Creek are moderate throughout the watershed. Turbidity and TSS data collected at the mouth of Swamp Creek since 1979 are rated low to moderate and similar to most of the urban streams in King County (King County, 2002). Long-term trend analysis identifies no significant trend for TSS at the mouth of Swamp Creek since 1979 (King County, 2002). Trend analysis for turbidity was not performed because of the natural variability of the parameter. The periodic high turbidity and TSS concentrations measured in the

watershed are likely the results of land clearing and grading, farming practices, animal access to streams, and removal of streamside vegetation in residential areas bordering Swamp Creek and its tributaries.

D.3.1.6 Metals

Concentrations of copper, lead, and zinc exceeded the state chronic or acute toxicity criteria at most Snohomish County SWM sampling locations from 1992 through 2001 (Table D-2).

Thirty-five percent of the samples collected at the long-term upstream site (SCLU) and 22 percent of the samples collected at the long-term downstream site (SCLD) reveal total lead concentrations in excess of the state chronic toxicity criterion. The highest total lead concentrations were measured at the mixed-use upstream (SCMU) and downstream (SCMD) sites, where the chronic criterion was exceeded 50 and 33 percent of the time, respectively.

Copper concentrations have periodically exceeded the acute and chronic criteria at a majority of sites in the watershed. Total copper concentrations measured at SWM's residential upstream and downstream sites (SCRU and SCR D, respectively) exceeded the acute criterion 22 and 6 percent of the time, respectively, and exceeded the chronic criterion 33 and 17 percent of the time, respectively.

Zinc concentrations measured at the long-term upstream site (SCLU) exceeded the acute criterion and the chronic criterion 4 percent of the time. The downstream site exceeded the acute criterion and the chronic criterion 1 percent of the time.

King County analyzed total copper, lead, and zinc in storm flow samples collected at the mouth of the stream. No exceedances of the acute criteria were recorded (King County, 2002).

In monitoring conducted between 1992 and 2001, SWM has measured total copper concentrations above 100 µg/L at multiple locations in Swamp Creek. These are extremely high copper concentrations—well above the state Class AA standard—that are harmful and potentially lethal to fishes and other aquatic life. The highest concentrations were measured at the mixed-use upstream (SCMU) and downstream (SCMD) sampling locations, which are located in the North Swamp Creek Subbasin along SR 99, and at the residential upstream (SCRU) and downstream (SCR D) sites, which are located in the South Swamp Creek Subbasin downstream of the confluence with Scriber Creek.

Data from the first three years of Snohomish County's ambient water quality monitoring program showed elevated concentrations of copper, lead, and zinc in the watershed (Thornburgh, 1996). As a result, Ecology considered placing Swamp Creek on the 1998 update to its Clean Water Act section 303(d) list as being water quality limited for these metals. However, Ecology determined that the quality assurance plan was not adequate and that the metals monitoring data were suspect. In addition, the sampling data reported total recoverable metals, while the state water quality standards for fish and aquatic life are established for dissolved metals, so that the data could not be directly compared. Thus, Swamp Creek is not currently listed on the Ecology 303(d) list of impaired waters for violations of the state copper, lead, and zinc standards (Ecology, 2001). Nonetheless, it is apparent that high metals concentrations are a serious toxicity issue in Swamp Creek.

D.3.1.7 Sediment Metals

Since 1987, metals concentrations in streambed sediments have been measured by King County at the mouth of Swamp Creek. Those concentrations have varied from year to year. In general, compared to 20 other urban streams surveyed by King County, sediment metals concentrations in Swamp Creek were in the middle range, except for chromium, which was ranked the highest (i.e., worst) (King County, 2002). However, data collected since 1995 show Swamp Creek sediment metals to be in the low-to-middle range compared to other urban streams monitored by King County.

D.3.1.8 Pesticides

Ecology (1998) detected nine pesticides in Swamp Creek at a sampling location near the mouth, of which eight were herbicides and one was a fungicide. The herbicides 2,4-D, bromacil, dichlobenil, 2,6-dichlorobenzamide, MCPP, prometon, simazine and triclopyr, as well as the fungicide pentachlorophenol, were detected in low concentrations. No pesticide exceeded water quality standards. Additionally, PTI (1991) collected six grab samples in Swamp Creek between NE 175th Street and the mouth of Swamp Creek in King County. The pesticides diazinon, 2,4-D, and dicamba were detected in low concentrations.

D.3.1.9 Biological Monitoring

Morley (2000) collected 13 benthic invertebrate samples from 10 locations along 14 kilometers (8.7 miles) of Swamp Creek between 1997 and 1999, and Snohomish County SWM collected two samples from one location near the long-term downstream water quality monitoring station (SCLD) in 1997 and 1999 (see Figure 5-1 in Section 5.0 of this report). Data from these samples were used to calculate B-IBI scores that provide an overall measure of human impact from various habitat perturbations, including riparian zone alterations, substrate changes (e.g., silt deposition), and water quality issues. The B-IBI scores calculated by Morley (2000) vary slightly along the length of stream sampled, ranging from a high of 32 (fair) to a low of 22 (poor). Results from the Snohomish County SWM sampling program show B-IBI scores ranging from 20 to 22, with overall habitat quality rated as poor. Additional information regarding the benthic invertebrate sampling and associated B-IBI scores is provided in Appendix C.

D.3.2 Summary of Existing Water Quality Data Findings

In summary, the existing data show that water quality in the Swamp Creek DNR Basin is likely being degraded by commercial and industrial activities in the North Swamp Creek Subbasin and by commercial, residential, and agricultural activities in the Middle and South Swamp Creek subbasins. The water quality problems induced by runoff from the urbanized upstream areas include elevated concentrations of fecal coliform bacteria and toxic metals. High fecal coliform bacteria concentrations may result from a variety of factors including failing septic systems, fertilizer application, and animal wastes (from small farms and pets). Commercial, industrial, and roadway runoff are likely sources of toxic metals in the North Swamp Creek Subbasin.

Water quality in the Middle and South Swamp Creek subbasins is being affected by commercial, agricultural, and residential land uses, as evidenced by measurements of low DO levels, elevated concentrations of fecal coliform bacteria and metals, and elevated water temperatures. Low DO concentrations may be caused by a combination of factors including stagnant water conditions, elevated water temperatures, and nutrient inputs from

farm lands that lead to excessive plant growth and decay (i.e., eutrophication). Oxygen depletion can be extremely harmful for fish populations and other biological communities. Small farm waste management practices are a likely source of fecal coliform bacteria contamination in the downstream reaches of Swamp Creek. In addition, fertilizer applications, pet wastes, and failing septic systems in residential developments are other likely sources for the high fecal coliform bacteria concentrations reported. The elevated water temperatures stem from stagnant water conditions in small farm areas and a lack of shade in riparian areas due to encroachment of residential landscaping on the stream banks. The elevated metals concentrations may result from runoff from commercial developments and roads.

D.3.2.1 Outfall Screening Results

As noted previously, Snohomish County SWM performed dry-weather outfall screening surveys throughout the Swamp Creek DNR Basin in recent years. Although a final report on the outfall screening efforts is not yet available, the preliminary results were made available for this study (Snohomish County SWM, 2001) and are discussed below.

The outfall screening locations in the Swamp Creek watershed were selected based on evidence of existing water quality problems, or proximity to land uses that might be contributing to water quality degradation in Swamp Creek. The outfall screening focused on a total of 16 qualitative and quantitative water quality parameters. County staff who performed the field work recorded physical conditions and water quality field monitoring results measured at each outfall. Outfall screening was conducted in 1998, 1999, 2000, and 2001. However, not all stations were monitored each year. In addition, only a fraction of the site visits included water quality sample collection. Most field visits focused on qualitative observations only.

The results of the outfall screenings in this watershed are presented below. Table D-3 presents outfalls where problems were noted in the qualitative observations made during the outfall screening process. Table D-4 presents outfalls where quantitative water quality monitoring results identified problems. Approximately 69 of the 170 outfalls monitored in the Swamp Creek DNR Basin had identified qualitative or quantitative water quality problems. The majority of these problem outfalls are located along SR 99 in the North Swamp Creek Subbasin in unincorporated Snohomish County and south Everett (see Figure 5-1 in Section 5.0).

Qualitative observations were made at all outfalls visited. As shown in Table D-3, qualitative conditions at the outfalls were variable, with a high occurrence of extraneous material at the outfalls. The types of extraneous material observed included trash, sediment, yard waste, foam, and scum. Other qualitative observations included the presence of odor, abnormal vegetation, and outfall damage.

Water quality monitoring performed during the outfall screening indicated that numerous outfalls had water quality problems. Table D-4 presents the parameters evaluated and the monitoring results for those drainage outfalls where water quality problems were identified. Information presented in parentheses in Table D-4 represents Snohomish County SWM's threshold criteria for problem conditions in outfall water quality.

**Table D-3
Qualitative Outfall Screening Results for the Swamp Creek DNR Basin**

Site No¹	Date	Structure	Land Use	Odor	Oily Sheen	Extraneous Material	Vegetation	Outfall Damage
98-2	8/4/98	Pipe	Commercial/Industry	None	None	Some	Inhibited	Metal Corrosion
98-5	8/4/98	Pipe	Residential	None	None	None	Abnormal	None
98-11	8/6/98	Pipe	Residential/Rural	Extensive	None	Some	No veg	None
98-15	8/8/98	Pipe	N/A	Extensive	None	None	Excessive	None
98-30	8/25/98	Pipe	Parking lot	None	None	Some	No veg	Spalling
98-37	8/26/98	Pipe	Commercial/Industry	None	None	Some	No veg	Filled
98-38	8/26/98	Pipe	Commercial/Industry	None	None	None	Abnormal	None
98-41	8/26/98	Pipe	N/A	None	None	None	Normal	Metal Corrosion
98-78	9/9/98	Pipe	Residential	None	None	Some	Normal	Spalling
98-99	9/30/98	Pipe	Residential/Rural	None	None	Some	No veg	Metal Corrosion
98-100	9/30/98	Pipe	Residential/Rural	Extensive	None	Some	No veg	Metal Corrosion
99-4	8/26/98	Pipe	Commercial/Industrial	Extensive	None	Some	Abnormal	None
99-6	8/27/98	Pipe	Commercial/Industrial	None	None	None	Abnormal	None
99-7	8/25/98	Pipe	Residential	Extensive	None	Some	Normal	None
99-8	5/24/01	CB	Commercial/Industrial	None	None	Some	Abnormal	None
99-16	8/25/98	Pipe	Commercial/Industrial	Extensive	None	Extensive	Normal	None
99-18	8/20/98	Pipe	Commercial/Industrial	None	Some	Extensive	Normal	None
99-24	9/29/98	Pipe	Residential	None	None	Extensive	Normal	None
99-31	8/25/98	Pipe	Residential	Extensive	Some	Extensive	Abnormal	None
99-32	8/25/98	Pipe	Commercial/Industrial	None	None	Extensive	Abnormal	None
99-59	8/19/98	Pipe	Residential	None	Some	Extensive	Normal	None
99-62	8/18/99	Pipe	Residential	Extensive	Extensive	Extensive	Abnormal	None
00-95	9/19/00	Pipe	Commercial/Industrial	Some	None	Some	Normal	Erosion
99-97	5/24/01	Pipe	Residential	None	None	Extensive	Normal	None
00-2	6/21/00	Pipe	Residential/Urban	Extensive	None	Extensive	Normal	None

Table D-3 (continued)
Qualitative Outfall Screening Results for the Swamp Creek DNR Basin

Site No¹	Date	Structure	Land Use	Odor	Oily Sheen	Extraneous Material	Vegetation	Outfall Damage
00-4	6/27/00	Pipe	Commercial/Industrial	Extensive	Extensive	Extensive	Normal	None
00-10	6/29/00	Pipe	Commercial/Industrial	None	None	Extensive	Normal	None
00-15	7/17/00	Pipe	Residential/Urban	None	None	Some	Normal	Metal Corrosion
00-34	7/26/00	Pipe	Commercial/Industrial	None	None	Extensive	Normal	None
00-99	9/19/00	Pipe	Commercial/Industrial	None	None	Extensive	Normal	None
01-16	7/3/01	Pipe	Residential/Urban	None	None	Extensive	Normal	N/A
01 - 29	7/11/01	Pipe	Commercial/Industry	Extensive	Some	None	Normal	N/A

¹ Site locations presented in Figure 5-1.

Boldface text indicates that a significant problem was observed at the outfall.

**Table D-4
Outfall Screening Water Quality Monitoring Results for the Swamp Creek DNR Basin**

Site No. ¹	Date	Dissolved Oxygen (mg/L)	Temp (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)	Nitrate/Nitrite (µg/L)	Ammonia (mg/L)	Fluoride (mg/L)	Surfactants (mg/L as MBAS)	Fecals (colonies/100 mL)	Potassium (mg/L)	Microtox
Snohomish County SWM Criteria		(<10 mg/L)	(>20 °C)	(6.5 - 8.5)	(>250 µS/cm)	(>30 NTU)	(>1 mg/L)	(>1 mg/L)	(>1 mg/L)	(> 0.06 mg/L)	(>5000)	NM	(Moderate and Toxic)
98-7	8/6/98	NM	19.3	6.72	180	9.99	22.9	2.37	0.26	0.196	NM	NM	NM
98-11	8/6/98	8.9	17.4	6.8	243	11	272	0.0195	0.26	0.039	NM	NM	NonToxic
98-13	8/19/98	NM	19.4	7.7	214	NM	270	0.00886	0.437	0.205	NM	NM	Moderate
98-14	8/20/98	NM	20.2	7.9	179	5.8	123	0.0117	0.245	0.136	NM	NM	NonToxic
98-15	8/20/98	NM	20.3	7.1	17	11	801	0.009	0.119	0.092	NM	NM	NonToxic
98-22	8/25/98	NM	NM	NM	NM	NM	149	0.794	0.151	0.248	NM	NM	NonToxic
98-30	8/25/98	NM	21.5	8.06	181	4.3	54	0	0.56	0.106	NM	NM	NonToxic
98-31	8/25/98	NM	20.1	7.85	138	7.5	46.4	0	0.66	0.086	NM	NM	NonToxic
98-38	8/26/98	NM	16.8	11.32	38.3	75	482	0.272	2.5	0.283	NM	NM	Toxic
98-85	9/22/98	NM	18.1	7.8	151	0.99	280	0	0.716	0.0279	NM	NM	NonToxic
98-94	9/29/98	NM	15.6	8.5	241	1.9	1270	0.00349	0	0.0294	NM	NM	NonToxic
98-100	9/30/98	NM	15	7.7	213	3.8	44.4	0.33	0	0.101	NM	NM	NonToxic
99-4	8/26/98	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	Moderate
99-7	8/25/98	NM	15.6	6.85	197.4	3	3210	3.94	0.132	0.38	NM	3.35	NonToxic
99-8	5/24/01	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NonToxic
99-16	8/25/98	NM	16.6	6.8	140	5.56	109	0.148	0.0716	0.0623	NM	1.73	NonToxic
99-19	8/4/98	NM	17.2	6.6	112	20.1	118	0.155	0.0471	0.252	NM	1.61	NonToxic
99-24	9/29/98	NM	18.6	7.96	335	3.86	682	0.0157	0.0427	0.041	NM	2.36	Moderate
99-30	8/27/98	NM	16.6	7.64	192	1.6	572	0.0618	0.0641	0.104	NM	4.27	Moderate
99-31	8/25/98	NM	18	5.86	392	34.6	28.6	5.63	0.105	0.444	NM	5.71	Moderate
99-32	8/25/98	NM	19.6	6.95	240	2.57	252	0.0381	0.344	0.0737	NM	2.13	Moderate
99-59	8/19/98	NM	26.9	6.19	39.9	6.7	112	1.46	0.0519	0.408	NM	1.32	NonToxic
99-60	8/4/98	NM	26.9	6.05	174.4	4.39	833	0.59	0.0225	0.164	NM	4.68	NonToxic
99-62	8/18/99	NM	26.9	6.98	189.4	14.24	199	0.697	0.139	0.16	NM	2.02	NonToxic
99-95	9/29/98	NM	13.7	6.31	170	1.67	753	0.0453	0.028	0.0635	NM	1.94	NonToxic
99-97	5/24/01	NM	15.1	6.55	164	51.8	139	0.0498	0.0505	0.16	NM	3.13	NonToxic

Table D-4 (continued)
Outfall Screening Water Quality Monitoring Results for the Swamp Creek DNR Basin

Site No. ¹	Date	Dissolved Oxygen (mg/L)	Temp (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)	Nitrate+ Nitrite (µg/L)	Ammonia (mg/L)	Fluoride (mg/L)	Surfactants (mg/L as MBAS)	Fecals (colonies/ 100 mL)	Potassium (mg/L)	Microtox
Snohomish County SWM Criteria		(<10 mg/L)	(>20 °C)	(6.5 - 8.5)	(>250 µS/cm)	(>30 NTU)	(>1 mg/L)	(>1 mg/L)	(>1 mg/L)	(> 0.06 mg/L)	(>5000)	NM	(Moderate and Toxic)
00-1	6/21/00	6.03	17.2	7.14	143.5	12.4	225	0.113	NM	NM	470	0.757	NonToxic
00-2	6/21/00	4.38	13.6	7.68	407	21.3	317	40.3	0.514	2.77	36000	10.3	NonToxic
00-3	6/21/00	8.34	15.2	7.5	134.7	13.9	287	NM	NM	NM	28	1.82	NonToxic
00-4	6/27/00	7.8	16.1	12.4	2.66	1000	128	0.871	0.209	0.376	NM	13.3	Toxic
00-10	6/29/00	0.8	18.8	6.57	416	110	119	1.29	0.058	0.294	1300	2.05	NonToxic
00-15	7/17/00	5.78	14.8	6.83	238	3.12	208	0.125	0.149	0.065	2600	2.97	NonToxic
00-23	7/17/00	8.68	15.7	7.12	60.6	1.54	78.8	0.04	0.937	0.00118	1700	0.822	NonToxic
00-24	7/17/00	10.12	13.8	8.16	221	1.8	722	0.032	0.086	0.0143	150	3.29	NonToxic
00-27	7/24/00	7.6	17.9	7.28	243	4.85	534	0.038	0.24	0.231	6200	2.47	NonToxic
00-31	7/26/00	1.22	17	6.71	138.6	7.77	92.1	1.03	0.181	0.275	340	2.64	NonToxic
00-32	7/26/00	2.43	20	6.94	99.4	5.4	30.9	0.392	0.103	0.0702	2200	1.36	NonToxic
00-33	7/26/00	2.65	18.6	6.68	111.7	5	6.67	0.615	0.0968	0.408	38000	2.02	NonToxic
00-34	7/26/00	2.55	16.4	6.32	211	25.9	128	0.545	0.186	0.0418	240	2.31	NonToxic
00-38	8/14/00	5.35	14.7	7.09	254	48.5	NM	NM	0.0944	0.049	21000	3.39	NonToxic
00-76	9/12/00	4.54	15.6	6.37	219	17.4	178	0.625	0.325	0.062	91	1.98	NonToxic
00-77	9/12/00	9.32	15.9	7.75	184.5	2.51	68.9	0.086	0.243	0.029	1000	2.35	NonToxic
00-80	9/12/00	9.68	16.1	7.43	167.4	3.02	727	0.075	0.108	0.0135	75	1.9	NonToxic
00-82	9/12/00	9.65	15.9	6.74	92.2	5.97	42	0.093	0.441	0.0143	91	1.28	NonToxic
00-92	9/18/00	1.39	14.9	7.05	183.6	3.84	29.8	0.234	0.143	0.0203	35000	1.79	NonToxic
01-1	6/20/01	1.66	14.1	6.6	195.9	7.7	216	0.116	0.112	0.11	18	1.96	NonToxic
01-2	6/20/01	10.68	12.8	7.38	172	0.7	216	0.116	0.066	0.11	480	2.29	NonToxic
01-3	6/20/01	10.2	14.1	7.61	166.9	0.5	1620	0.051	0.03	0.0445	200	2.49	NonToxic
01-5	6/21/01	10.33	14.2	7.48	264	7.4	548	0.141	0.224	0.067	3	2.16	NonToxic
01-6	6/21/01	8.93	17.3	6.86	177.6	6	299	0.205	0.189	0.065	81	2.56	NonToxic
01-29	7/11/01	8.43	14.5	8.02	303	9.3	608	0.312	0.0793	0.0688	NM	3.38	NM

Table D-4 (continued)
Outfall Screening Water Quality Monitoring Results for the Swamp Creek DNR Basin

Site No. ¹	Date	Dissolved Oxygen (mg/L)	Temp (°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)	Nitrate/Nitrite (µg/L)	Ammonia (mg/L)	Fluoride (mg/L)	Surfactants (mg/L as MBAS)	Fecals (colonies/100 mL)	Potassium (mg/L)	Microtox
Snohomish County SWM Criteria		(<10 mg/L)	(>20 °C)	(6.5 - 8.5)	(>250 µS/cm)	(>30 NTU)	(>1 mg/L)	(>1 mg/L)	(>1 mg/L)	(> 0.06 mg/L)	(>5000)	NM	(Moderate and Toxic)
01-31	7/11/01	2.69	15.7	6.86	181	9.4	8.02	0.144	0.308	0.0739	600	1.68	NonToxic
01-69	8/13/01	3.91	19.6	6.98	253	21.5	1000	0.422	0.0776	0.108	NM	2.58	NonToxic
01-71	8/14/01	1.32	17.2	6.97	247	29.4	15.2	0.482	0.157	0.0534	9	2.39	NonToxic
01-72	8/14/01	1.86	17.7	7.14	258	9.4	657	0.321	0.111	0.105	NM	2.31	NonToxic
01-91	8/28/01	7.35	16.3	7.22	177.3	6.4	263	0.259	0.246	0.11	360	1.58	NonToxic
01-92	8/28/01	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NonToxic
01-93	8/29/01	2.41	9.8	7.48	149.9	0.3	NM	NM	NM	NM	NM	NM	NonToxic

Source: Snohomish County SWM (2001). Data quality has not been verified.

¹Site locations presented in Figure 5-1.

mg/L=milligrams per liter, µS/cm=microseimens per centimeter, mL=milliliter, C=Celsius, NTU=nephelometric turbidity units, MBAS = methylene blue active substance

"NM" indicates not measured, or not reported.

Boldface text represents exceedance of SWM criteria.

The majority of the parameters measured during the outfall screening are typical water quality monitoring parameters. However, ammonia, fluoride, surfactants, potassium, and Microtox are less common in water quality monitoring studies. Ammonia is produced by the decay of organic nitrogen compounds and is typically used as a chemical indicator for inputs of sanitary wastewater and septic tank effluent (U.S. EPA, 1993). Fluoride is typically measured as an indicator of inputs from residential or other potable water sources. The presence of fluoride in freshwater can indicate discharges from potable water sources, which in turn may suggest other water contamination associated with residential or commercial discharges. Surfactants, commonly measured as methylene blue active substance (MBAS), are an indicator of residential or commercial discharges. Surfactants are typically associated with household or industrial laundering or cleaning processes, and their presence in surface waters can indicate contamination from these types of discharges (U.S. EPA, 1993). Potassium is an element found in low concentrations in surface, ground, and potable waters, and typically is measured as an indicator of inputs of sanitary wastewater or septic tank effluent (U.S. EPA, 1993). Microtox is a biological monitoring tool (bioassay) that measures the decrease in respiration of bacteria in response to the presence of toxic substances in a sample. As shown in Table D-4, the majority of water quality exceedances of the SWM criteria occurred for DO and surfactants.

With regard to both the qualitative and quantitative observations, follow-up action has not yet been taken by SWM to ascertain the causes of these problems or to implement corrective measures.

D.3.2.2 Land Use Evaluation

To evaluate the potential effects of land use patterns on water quality in the Swamp Creek DNR, specific land use designations within each basin were analyzed and grouped into eight categories based on their relative potential to cause water quality problems. Water quality (WQ) categories 1 through 7 (high to low) were grouped in sequential order of their potential to generate pollution. WQ category 8 comprises agricultural and farming land uses, which tend to have unique water quality issues. A more detailed description of each of the eight land use categories follows:

- WQ category 1: Heavy industrial and commercial uses, freeways, service stations
- WQ category 2: Light industrial uses, arterial streets, lumber yards, miscellaneous manufacturing
- WQ category 3: Office parks, commercial uses, apartments, car washes, schools
- WQ category 4: Single-family residential (high, medium, and low densities), duplexes, mobile home parks
- WQ category 5: Parks, recreation areas, grasslands, rural residential uses
- WQ category 6: Undeveloped land, right-of-way, vacant lots
- WQ category 7: Forest, water, pasture
- WQ category 8: Farms, agriculture

Table D-5 summarizes the areal coverage within the Swamp Creek DNR Basin for each water quality land use category described above, by percentage. These data show that the majority (i.e., 78 percent) of the land use in this region is in WQ categories 1 through 4, which have a relatively high potential to cause water quality problems. Table D-5 also

shows coverage data in the Chase Lake Subbasin for the eight water quality land use categories. Similar to Swamp Creek, these data show that the majority (i.e., 93 percent) of the land use is in WQ categories 1 through 4.

Water Quality Category^a	Swamp Creek Study Area (% coverage)	Chase Lake Study Area (% coverage)
1	2.6	0.0
2	17.3	17.2
3	13.6	8.4
4	44.6	67.4
5	2.9	0.8
6	15.2	6.1
7	3.7	0.0
8	0.2	0.0

^a See text for definitions of categories.

D.3.3 Expectations for Future Water Quality

Planning for future land use in Snohomish County is now occurring under the state Growth Management Act. Key findings in the *Swamp Creek Watershed Management Plan* (Snohomish County, 1994) indicate that population increases will occur in the Swamp Creek watershed, resulting in more residential construction and a need for additional commercial development.

Overall, these projected land use changes are expected to increase several types of pollutants in stormwater runoff. Higher volumes of roadway traffic and commercial activity would likely increase loadings of heavy metals, and thus are cause for concern for increasing metals contamination in Swamp Creek. Similarly, the expected increase in residential development could result in associated loadings of nutrients (from lawn maintenance and automobile washing), pesticides, and fecal coliform bacteria (from pet wastes).

In addition, increased impervious surface areas and associated losses of infiltration areas will also decrease summer streamflows. To accommodate new development, existing wetland, forest, and pasture areas will inevitably be lost. Thus, stream temperatures in urbanized areas will likely rise due to reduced base flows and the potential loss of riparian vegetation. These concerns emphasize the importance of strengthening water quality protection requirements in all new development, and maintaining riparian habitat to shade the stream and to filter pollutants.

Overall, it is likely that the current water quality problems will remain, and potentially increase along with increasing development in the Swamp Creek DNR Basin.

D.4 References

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