Skagit County Monitoring Program

Annual Report - 2009 Water Year (October 2008 – September 2009)

Samish Bay

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Table of Contents

List of Figures

List of Table

Skagit County Water Quality Monitoring Program – 2009 Water Year Annual Report

Executive Summary

Skagit County has completed the sixth year of water quality monitoring under the Skagit County Water Quality Monitoring Program. This program was established to help determine if the Skagit County Critical Areas Ordinance for Ongoing Agriculture (SCC 14.24.120) was sufficient to protect water quality in areas of ongoing agriculture. Forty monitoring stations were established in agricultural areas as well as reference locations outside of the agricultural zones. Monitoring began in October 2003 and is continuing. Reports are published after each water year (October 1- September 30). This report is the sixth annual report, for the 2009 water year.

Data collected during this project indicates that many Skagit County streams, within and outside of the agricultural areas, do not meet state water quality standards for fecal coliform, temperature, and/or dissolved oxygen. Only Site 45, the North Fork Skagit River, met all three standards. The standards are developed to protect salmonid populations, recreation, and downstream shellfish resources, so streams not meeting the standards represent less-than-ideal conditions for those uses. Conditions in Skagit County streams range from watercourses with occasional failures to a pattern of continual inability to meet the standards. Most of the substandard water quality occurs in tributaries to the Skagit River and in the Samish Basin, while the Skagit River itself meets most standards on most occasions. Further investigation will be necessary to determine the causes of poor water quality in each case. Some cases may represent natural conditions rather than human-caused problems.

A major focus of the program is the determination of trends in water quality both within and outside of the agricultural zones. Based on court decisions that the Growth Management Act requires protection of critical areas, but not restoration, the county uses trends monitoring as a method to determine whether water quality conditions are deteriorating in the county. Trends analysis for the first six years of the program reveals a mixed pattern of beneficial and deleterious trends both inside and outside of the agricultural areas, although by the fifth and sixth years, improving trends outnumbered deteriorating trends. It is apparent from this mixed pattern that water quality problems in Skagit County need to be addressed by individual watershed.

Skagit County data has also proved useful to Ecology in their water cleanup (TMDL) efforts, especially the Samish Bay Watershed Fecal Coliform TMDL. Skagit County, in cooperation with many local and state partners through the Clean Samish Initiative, has begun to comprehensively address pollution in the Samish Bay Watershed. County data, supplemented by volunteer data, has shown severe fecal coliform contamination in many areas of the watershed. The County has increased its sampling program and cooperated with the Washington State Department of Ecology, the Skagit Conservation District, and others in locating properties with possible pollution sources and seeking cooperative solutions to those problems.

The Washington State Department of Ecology used Skagit County data from the South Fork Skagit River to determine that additional monitoring for the County's NPDES Phase II Stormwater Permit was not necessary. In most cases, water bodies with TMDLs require additional monitoring in association with the stormwater permits, but County data showed that

the South Fork Skagit had improved substantially since the TMDL went into effect, and that additional stormwater monitoring was not necessary at the time of permit issuance.

County staff participate in local and regional technical groups and in training of volunteer monitoring groups. Staff also give numerous presentations throughout the year to interested organizations.

The program was supported through 2008 by a Centennial Clean Water grant from the Department of Ecology. Grant match and all current funding is provided by Skagit County's Clean Water Program. All monitoring is governed by an Ecology-approved Quality Assurance Project Plan. Skagit County data is submitted to the state Environmental Information Management database.

The Skagit County Water Quality Monitoring Program has collected six years of high-quality data. The program is scheduled to continue at least through the 2010 water year. Questions on the program can be addressed to Rick Haley at rickh@co.skagit.wa.us or 360-336-9400.

Skagit County Monitoring Program Annual Report

2009 Water Year
(October 2008-September 2009)

Introduction

The Skagit County Monitoring Program started in October 2003, as part of Skagit County's program to assess the effectiveness of Skagit County Code Chapter 14.24.120, Critical Areas Ordinance for Areas of Ongoing Agriculture. The revised ordinance (Skagit County Ordinance O20030020) was passed by the Skagit County Board of Commissioners in June 2003 in response to a Compliance Order from the Western Washington Growth Hearings Board.

The ordinance requires farmers to "do no harm" to adjacent watercourses, and relies on specific Watercourse Protection Measures and more generalized Best Management Practices to protect the watercourses instead of requiring buffers on the streams. The associated Skagit County Resolution R20030210 committed the County to conduct water quality monitoring in the agricultural areas as one method of assessing if the County's ordinance was sufficient to protect the aquatic resources in agricultural areas. The resolution was subsequently amended in June 2004 as Resolution R20040211 in response to additional Compliance Orders from the Western Washington Growth Hearings Board. This second resolution provided details about the water quality monitoring program in addition to other topics not associated with water quality. Included in R20040211 is the requirement for annual reporting on the water quality monitoring program. This document is intended to satisfy that requirement for the 2009 Water Year.

R20040211 also required the County to conduct a triennial review of the Critical Areas Ordinance for Areas of Ongoing Agriculture, including the water quality monitoring program, to seek public comment on the regulations and monitoring program, and to make changes if necessary. However, the State of Washington passed SSB 5248 in 2007, which placed a "time out" on changes to critical areas regulations impacting agriculture until 2010 while the statewide issues regarding agricultural regulation are studied.

In 2007, the Skagit County Commissioners passed Resolution R20070499. This resolution reiterated the need to conduct the triennial review despite the County's inability to make changes to the Ongoing Agriculture portion of the Critical Areas Ordinance because of SSB 5248. Another portion of the resolution required Skagit County Public Works to seek an outside review of the water quality monitoring program by a "credentialed academic." Skagit County contracted with the Washington State Water Research Center to conduct the review and produce a report in the spring of 2008. This report covered data collection, analysis, next steps to be taken, and responses to comments generated by the triennial review.

Sampling Locations

Figure 1 is a map with the sampling sites in the Skagit County Monitoring Program marked. Tables 1 and 2 list the sampling sites and site descriptions for the Skagit County Monitoring Program. Forty sites are currently included in the Program. These sites are located primarily in the agricultural zones (Agriculture-Natural Resource and Rural Resource). Other sites are located to provide context to, and comparisons with, the sites in the agricultural zones. These include sites located just upstream or downstream of agricultural areas or in streams draining suburban watersheds.

The monitoring program was designed to determine current conditions and long-term trends in water quality at the sampling locations. While it was not specifically designed to determine compliance of the watercourses with state water quality standards, the data is suitable for such determinations.

A secondary purpose for some of the sites included in the monitoring program is to provide data to the Washington State Department of Ecology in support of their Total Maximum Daily Load (TMDL, or Water Cleanup) programs in Skagit County. The sites that provide TMDL data are also in the agricultural zones and are integral to the determination of trends and conditions in those areas. Active Water Cleanup plans in Skagit County include the Lower Skagit Tributaries Temperature TMDL, the Samish Bay Watershed Fecal Coliform TMDL, and the Lower Skagit River Fecal Coliform TMDL. Improvements made as a result of the latter program indicate that the Lower Skagit River is a candidate for removal from Ecology's Impaired Waters list.

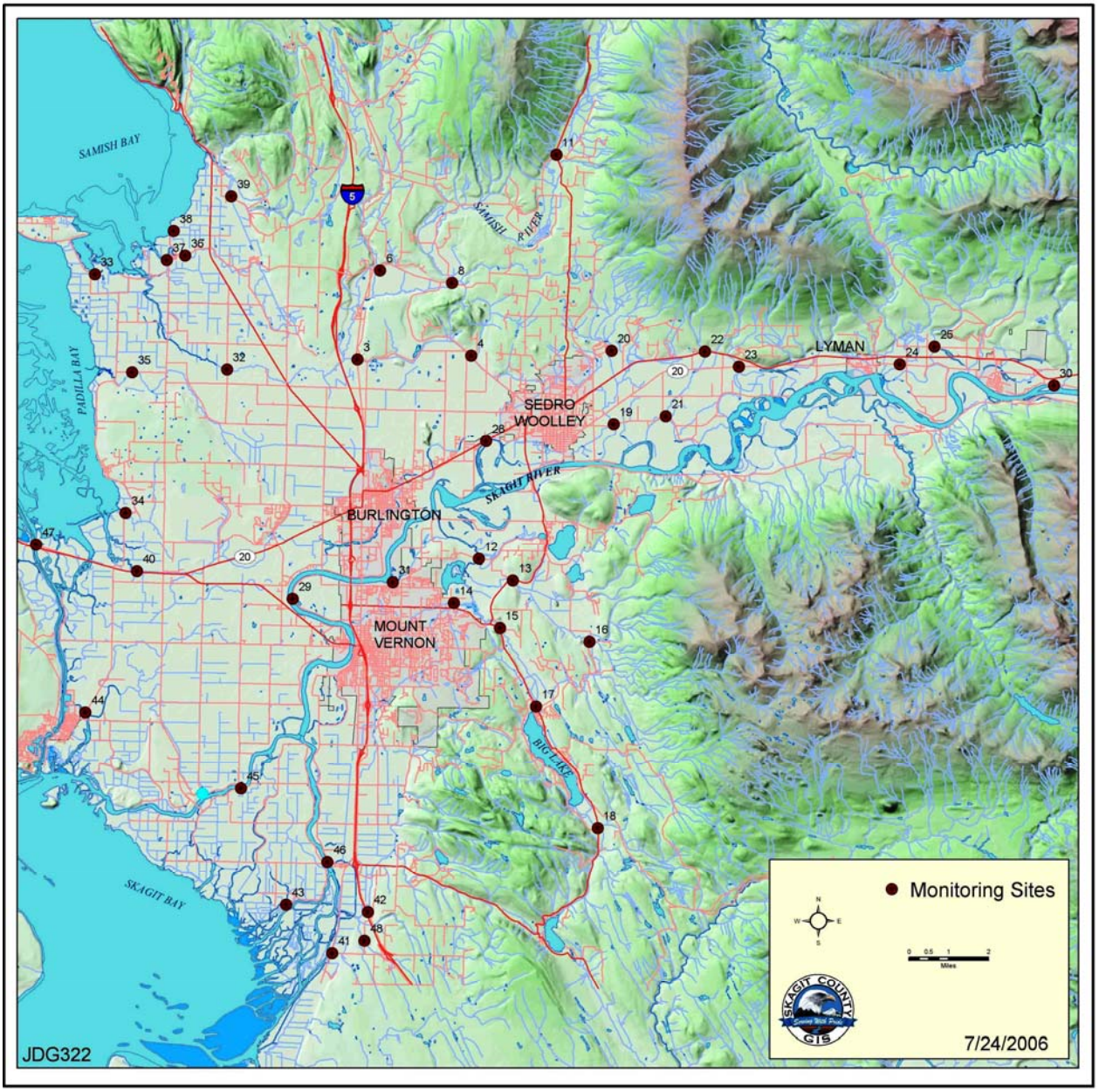


Figure 1. Sample Sites in the Skagit County Monitoring Program
Refer to Tables 1 and 2 for site locations and descriptions.

Table 1. Sample Sites for Skagit County Monitoring Program

Site Number	Watercourse	Location	Latitude	Longitude	Site Type[1]
3	Thomas Ck	Old Hwy 99 N	48.526	-122.339	3
4	Thomas Ck	F&S Grade	48.528	-122.276	2
6	Friday Ck	Prairie Rd	48.559	-122.327	4
8	Swede Ck	Grip Rd	48.555	-122.287	3
11	Samish R	State Route 9	48.602	-122.231	1
12	Nookachamps Ck	Swan Rd	48.454	-122.270	3,6
13	E.F. Nookachamps Ck	State Route 9	48.446	-122.251	3,6
14	College Way Ck	College Way	48.436	-122.286	4
15	Nookachamps Ck	Knapp	48.429	-122.258	2,6
16	E.F. Nookachamps Ck	Beaver Lake Rd	48.424	-122.208	1,6
17	Nookachamps Ck	Big Lake Outlet	48.400	-122.237	1,6
18	Lake Ck	State Route 9	48.356	-122.202	1,6
19	Hansen Ck	Hoehn Rd	48.504	-122.197	3,6
20	Hansen Ck	Northern State	48.531	-122.199	1,6
21	Coal Ck	Hoehn Rd	48.507	-122.169	3
22	Coal Ck	Hwy 20	48.531	-122.149	1
23	Wiseman Ck	Minkler Rd	48.526	-122.130	2
24	Mannser Ck	Lyman Hamilton Hwy	48.528	-122.041	2
25	Red Cabin Ck	Hamilton Cem Rd	48.534	-122.023	2
28	Brickyard Ck	Hwy 20	48.497	-122.268	4
29	Skagit R	River Bend Rd	48.439	-122.372	5,6
30	Skagit R	Cape Horn Rd	48.521	-121.960	5
31	Drain Dist 20 floodgate	Francis Rd	48.445	-122.317	3
32	Samish R	Thomas Rd	48.521	-122.410	3
33	Alice Bay Pump Station	Samish Island Rd	48.555	-122.483	3
34	Noname Slough	Bayview-Edison Rd	48.468	-122.464	3
35	Joe Leary Slough	D'Arcy Rd	48.520	-122.462	3
36	Edison Slough at school	W. Bow Hill Rd	48.562	-122.435	3
37	Edison Pump Station	Farm to Market Rd	48.561	-122.444	3
38	North Edison Pump Station	North Edison Rd	48.572	-122.441	3
39	Colony Ck	Colony Rd	48.581	-122.401	2
40	Big Indian Slough	Bayview-Edison Rd	48.447	-122.457	3
41	Maddox Slough/Big Ditch	Milltown Rd	48.309	-122.346	3
42	Hill Ditch	Cedardale Rd	48.324	-122.327	3
43	Wiley Slough	Wylie Rd	48.326	-122.372	3
44	Rexville Pump Station	Summers Drive	48.366	-122.419	3
	Sullivan Slough[2]	La Conner-Whitney Rd	48.395	-122.485	3
45	Skagit R – North Fork	Moore Rd	48.364	-122.416	5,6
46	Skagit R – South Fork	Fir Island Rd	48.342	-122.349	5,6
47	Swinomish Channel	County Boat Launch	48.455	-122.512	7
48	Fisher Ck	Franklin Rd	48.320	-122.328	3,6

[1]See Table 2 for site type descriptions

[2]Site 44 was moved in June, 2005. See text for details

Table 2. Sample Site Type Descriptions for Skagit County Monitoring Program

Site Type Number	Description	Number of Sites[1]
1	Ag-upstream: Located to determine status/trends at upstream end of agricultural areas.	6
2	Ag-midstream: Located to determine status/trends in the middle of agricultural areas.	6
3	Ag-downstream: Located to determine status/trends at downstream end of a watercourse in agricultural areas.	20
4	Reference: Located to determine status/trends in a non-agricultural area, such as urban/suburban or rural reserve, for comparison with ag area results.	3
5	Skagit River: Located to determine status/trends in the mainstem Skagit River or the forks. The Skagit may show effects from a wide variety of sources.	4
6	TMDL: Located to provide information for the Department of Ecology's TMDL efforts.	12
7	Swinomish Channel: Located to provide a water quality baseline for Swinomish Channel	1

1Some sites have more than one type designation

Nineteen of the 40 sites (sites 3-25) are continued from the Skagit County Baseline Monitoring Project (Skagit County 2004a). The Baseline Project used nearly identical methods to monitor water quality at 27 sites. Five additional sites were part of the Samish Bay Watershed Water Quality Monitoring Program (Skagit County 2003). The data from the Baseline and Samish Projects will be used to help interpret trends in water quality for sites continued in the Skagit County Monitoring Program. Not all of the Baseline sites could be continued into the current program due to limited resources and the need to expand the current program into the Skagit Delta, where there were no Baseline sites. In particular, several intermediate sites on the Samish River were discontinued, leaving one upstream and one downstream site on the Samish.

A proposal was submitted in February 2003 to the Department of Ecology for consideration in their FY 2004 Centennial Clean Water Grants program. The proposal was accepted and a grant of nearly $500,000 was awarded to support five years of the monitoring program, FY 2004 through FY 2008.

Results from the first five years of this program have been reported previously (Skagit County 2004c, Skagit County 2006, Skagit County 2007, Skagit County 2008, Skagit County 2009). This report contains data and analysis from water years 2004 - 2009.

Methods

Standard water quality monitoring methods are used in the Skagit County Monitoring Program. The methods are derived from several sources, including the Department of Ecology and the U.S. Environmental Protection Agency. A brief description of monitoring procedures follows, and detailed monitoring procedures can be found in the Quality Assurance Project Plan developed for the program (Skagit County 2004b).

Each site in the monitoring program is visited every two weeks. At each visit, dissolved oxygen, temperature, pH, turbidity, conductivity, and salinity are measured and samples are obtained for fecal coliform determinations. Additional water samples are obtained for quantifying plant nutrients (total nitrogen, ammonia, nitrate, nitrite, total phosphorus and orthophosphate) and total suspended solids on a quarterly basis. Stream discharge was measured at selected sites as time and staffing permitted through 2008.

The sample routes are designed so that each station is visited at approximately the same time of day on each visit, to minimize the effects of diurnal variation in water quality parameters on overall data variability.

Data collected is entered into a custom database, and then is checked for accuracy against the original data sheets. Output from the database is exported into Excel® spreadsheets for data summary and analysis. These spreadsheets are also published on the County's web site:

http://www.skagitcounty.net/SCMP

Activity Summary

Weekly Sampling - All weekly sampling trips were conducted on schedule during the 2009 water year, beginning on October 7, 2008. Sampling normally took place on Tuesdays, but occasionally took place on Mondays or Wednesdays to accommodate holiday and laboratory schedules. Occasionally samples are taken on different days because of flooding or other acts of nature. Sampling activities are illustrated in Figure 2.

Funding – The Centennial Clean Water Grant that funded the program at 75% ended in December 2008, with the remaining 25% coming from County funds. The 2009 water year work was funded by Skagit County's Clean Water Program. Skagit County has applied for EPA funding to address Samish Bay Watershed fecal coliform issues, but the core activities of the Skagit County Monitoring Program will continue to be funded out of the Clean Water Program.

Figure 2. Tracy Alker obtains dissolved oxygen readings from No Name Slough (Site 34).

Sample Site Revisions - Three sample sites were moved from the original location as delineated in the QAPP. Site 35 on Joe Leary Slough was moved approximately 3,500 feet upstream from Bayview-Edison Road to D'Arcy Road to solve right-of-entry problems. Site 40 on Big Indian Slough was moved approximately 2,800 feet upstream to solve right-of-entry problems and to move away from the tidegate and associated saltwater intrusion. These two changes were made prior to any sampling. Site 42 on Hill Ditch/Carpenter Creek was moved approximately 4,300 feet upstream because the original site at Pioneer Highway was subject to backwater from the Skagit River, and in early samples it was determined that primarily Skagit River water was being sampled instead of Hill Ditch/Carpenter Creek water. These changes were approved by the Department of Ecology as revisions to the QAPP in 2003 and 2004.

In June 2005, the sample site at Rexville Pump Station (Site 44), at the east end of the Sullivan Slough watershed, was moved to the west end of Sullivan Slough, at La Conner-Whitney Road. This move was made in consultation with the Department of Ecology and the Western Washington Agricultural Association. The majority of flow from that system discharges through the west end into Swinomish Channel. The Rexville Pump Station site was initially chosen because it was cited as a possible fecal coliform source in the Lower Skagit Fecal Coliform TMDL (Pickett 1997). However, fecal coliform readings at the site during this study were

generally low, and coupled with the infrequent discharges from the pump station, it was determined that sampling efforts would be better spent nearer the outlet of the slough.

Review of Skagit County Water Quality Program by State of Washington Water Research Center

Skagit County contracted with the State of Washington Water Research Center (WRC) for a review of its water quality program. The WRC Review Report draft was received in March, 2008, and the final report was received in June 2008. The report is available on the Skagit County web site at www.skagitcounty.net/SCMP.

Details of the review can be found in the review report, available online at www.skagitcounty.net/SCMP. Skagit County is implementing the report recommendations as the budget allows. Recommendations that have already been incorporated into the program include expansion of the sampling program to better identify pollution source locations (through the County's Pollution Identification and Correction program) and some of the statistical recommendations.

Data Summary

Graphs and tables on the following pages report results from the Skagit County Monitoring Program for dissolved oxygen, temperature, and fecal coliform. Please note that each graph within a series may have a different scale due to differences between sample sites. Full data listings for each sampling event at each sample site are included in Appendix A. A summary of water quality results for each sample site is included in Appendix B.

The graphs are meant to give an overall picture of the water quality at a given site over time. They are not intended to fully describe the conditions at that site, only to give an "at a glance" indication of the conditions over the course of the project. Detailed descriptive statistics are included in the summary tables and in Appendix B. Results of the Trends Analysis are described in the Data Analysis section that follows the Data Summary.

Temperature

Water temperature governs the metabolic rate of aquatic organisms. Excessive temperature can serve as a stress on fish and other cold-water organisms, and extreme temperatures can be lethal.

For the water years 2004-2007 and 2009, temperatures were measured with Stowaway Tidbit® dataloggers from Onset Computer Company. These devices were set to measure water temperature every half hour. They are normally deployed in June and retrieved in late August or early September. During those years, several of the dataloggers were missing at the end of each monitoring period. Some had apparently been lost due to channel changes associated with heavy rains in late summer, while others may have been vandalized. For the 2008 water year, a computer programming error resulted in the dataloggers measuring temperature for only two

weeks in late June and early July. Since annual peak temperatures occur later in the summer, the 2008 datalogger data was not very useful. However, temperatures are also measured at each sampling visit, and this data is displayed in the tables and graphs on the following pages for all years of the program. Readers interested in the continuous temperature data collected in 2004-2007 can access those graphs in the 2007 Water Year Annual Report at this web address: www.skagitcounty.net/scmp. Continuous temperature data summaries for those years are also included as separate files on the web page. Continuous temperature data for the 2009 water year will be posted on the web site when available.

Table 3 shows the daily maximum temperatures for the six years of the study, based on data collected at biweekly samplings. Because the state water quality standards are based on 7-day average maximums (7-DAMs), the maximums reported on Table 3 are not directly comparable to the state temperature standard, but are displayed here as an indication of the relative condition of each stream and for comparison of the temperature conditions from year to year.

Table 4 contains the 7-day average maximums for those sample sites where continuous temperature data is available. These data are directly comparable to the state water quality standards as described on the table and in the next paragraph.

In the fall of 2006, the Washington State Department of Ecology revised its water quality standards (WAC 173-201a) to comply with a request from the U.S. Environmental Protection Agency. Included in this revision were several changes to temperature and dissolved oxygen standards for Skagit County watercourses. In particular, the lower Skagit River, Hansen, Nookachamps, Fisher, and Carpenter Creeks, and the upper Samish River and tributaries were placed in the "Core salmonid spawning and rearing" use category. This change had the effect of imposing more stringent temperature and dissolved oxygen standards on these streams. Formerly, each of these streams was held to a 7-DAM standard of 17.5ºC, but with the revised standards these streams must now meet a 7-DAM standard of 16ºC. There were no changes to other streams in the county. Currently, Sites 3-4, 28, and 31-44 are held to the 17.5 ºC standard, while all other sites are held to the 16ºC standard.

In addition to changes in the general standard, the revisions to the state temperature standards in 2006 also added spawning period temperature standards to some streams in the county. Portions of the Samish River, Friday Creek, Hansen Creek, Lake Creek, and East Fork Nookachamps Creek have a 13ºC limit from February 15 to June 15 to protect steelhead spawning and egg incubation. The Skagit River upstream from Sedro-Woolley has a 13ºC limit from September 1 through May 15 to protect spawning and egg incubation for several salmonids.

Maximum summer water temperatures had been declining at most sites from 2004-2008, but were usually higher in 2009 than 2008. Record heat in late July brought many of the smaller streams to the highest temperatures recorded during this study.

Trends Analysis revealed many sites with significant declines in temperature over the course of the study, as will be discussed in the Statistics section below. However, many salmonid-bearing streams in Skagit County exceed temperature standards each summer. Ecology has developed

temperature remediation cleanup plans (TMDLs) for Fisher, Carpenter, Nookachamps, and Hansen Creeks, but many other Skagit County streams also exceed temperature standards.

Table 3. Temperature Results
Maximum temperature recorded during biweekly sampling for watercourses in the Skagit County Monitoring Program

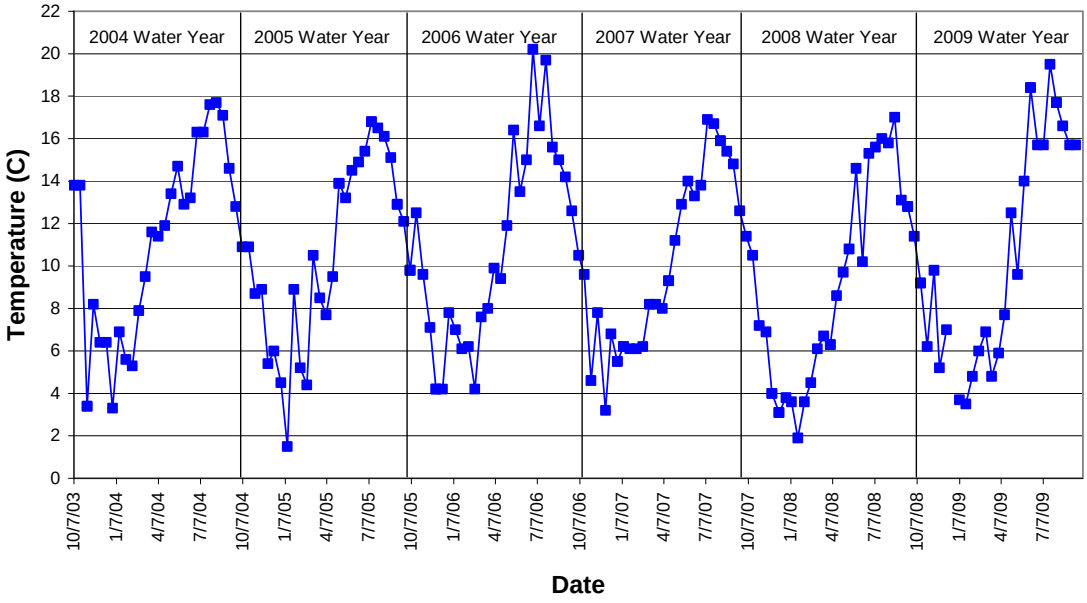
Site Number	Watercourse	Location	Highest daily temperature (°C)					
			2004	2005	2006	2007	2008	2009
3	Thomas Ck	Old Hwy 99 North	17.7	16.8	20.2	16.9	17.0	19.5
4	Thomas Ck	F&S Grade	15.4	14.1	15.9	14.2	14.0	15.7
6	Friday Ck	Prairie Rd	17.6	16.3	19.3	16.9	16.1	18.4
8	Swede Ck	Grip Rd	16.8	15.7	16.9	15.2	15.7	17.3
11	Samish R	State Route 9	13.4	14.6	14.6	13.5	12.8	14.2
12	Nookachamps Ck	Swan Rd	20.9	20.9	19.4	21.3	19.8	24.8
13	E.F. Nookachamps Ck	State Route 9	20.0	18.7	17.7	18.6	16.6	23.4
14	College Way Ck	College Way	18.5	16.1	15.4	15.9	15.9	20.8
15	Nookachamps Ck	Knapp	21.3	20.9	20.6	21.2	20.6	23.1
16	E.F. Nookachamps Ck	Beaver Lake Rd	18.6	17.0	15.8	17.3	15.5	20.5
17	Nookachamps Ck	Big Lake Outlet	22.2	23.1	20.9	22.8	21.7	24.4
18	Lake Ck	State Route 9	16.4	15.8	14.4	15.9	16.2	18.7
19	Hansen Ck	Hoehn Rd	18.4	16.0	17.7	15.4	15.4	16.8
20	Hansen Ck	Northern State	15.8	14.7	16.2	14.6	14.4	15.8
21	Coal Ck	Hoehn Rd	15.6	14.6	16.4	15.3	15.3	17.5
22	Coal Ck	Hwy 20	15.4	14.2	15.6	14.5	12.8	14.9
23	Wiseman Ck	Minkler Rd	15.8	14.7	16.2	15.1	14.7	12.7
24	Mannser Ck	Lyman Hamilton Hwy	13.9	12.5	13.3	12.3	12.7	13.2
25	Red Cabin Ck	Hamilton Cem Rd	11.8	11.3	12.5	11.5	11.2	10.6
28	Brickyard Ck	Hwy 20	14.2	16.1	16.4	12.8	15.6	16.3
29	Skagit R	R Bend Rd	16.6	16.4	15.7	14.8	15.0	16.2
30	Skagit R	Cape Horn Rd	14.9	15.1	15.3	15.1	13.3	14.4
31	Drain Dist 20 near floodgate	Francis Rd	16.0	14.4	13.2	15.5	15.4	17.0
32	Samish R	Thomas Rd	19.5	17.7	19.4	18.2	16.8	20.0
33	Alice Bay Pump Station	Samish Island Rd	25.8	22.8	27.0	23.1	21.9	25.4
34	Noname Slough	Bayview-Edison Rd	21.5	21.5	18.7	21.2	19.5	21.6
35	Joe Leary Slough	D'Arcy Rd	20.0	19.8	18.8	17.9	15.9	20.6
36	Edison Slough at school	W. Bow Hill Rd	29.9	24.7	27.8	24.6	23.8	31.3
37	Edison Pump Station	Farm to Market Rd	26.1	22.9	24.6	24.5	20.4	24.7
38	North Edison Pump Station	North Edison Rd	24.3	22.3	24.4	22.4	21.6	22.8
39	Colony Ck	Colony Rd	17.6	16.0	17.4	16.5	15.1	17.9
40	Big Indian Slough	Bayview-Edison Rd	19.3	18.8	17.3	18.6	17.5	22.1
41	Maddox Slough/Big Ditch	Milltown Rd	20.5	20.4	18.9	19.9	19.3	23.7
42	Hill Ditch	Cedardale Rd	21.6	21.1	19.8	20.8	19.4	23.1
43	Wiley Slough	Wylie Rd	21.9	19.3	18.4	20.4	19.1	17.6
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	18.1	18.7	18.4	17.4	18.7	20.8
45	Skagit R – North Fork	Moore Rd	17.2	17.0	16.4	15.3	14.0	17.0
46	Skagit R – South Fork	Fir Island Rd	17.4	17.6	16.6	16.0	14.6	17.0
47	Swinomish Channel	County Boat Launch	16.0	17.2	15.7	15.0	15.9	16.0
48	Fisher Ck	Franklin Rd	13.8	13.6	12.5	13.1	13.3	14.4

Table 4. Five-Year Temperature Results Summary
Maximum 7-day average maximum temperatures for 2004-2007 and 2009 of the Skagit County Monitoring Program

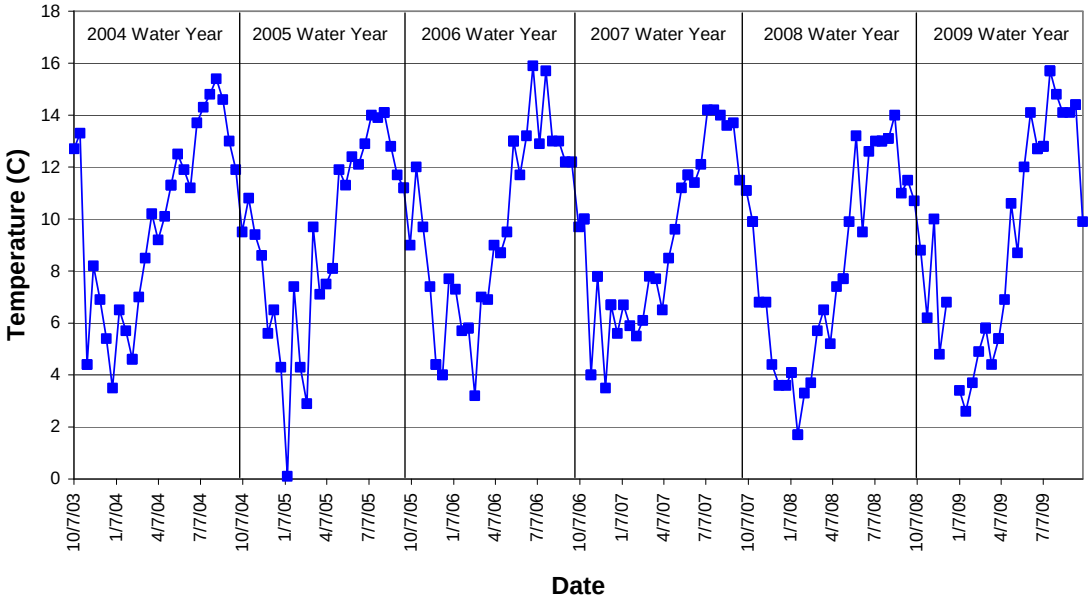
Site Number	Watercourse	Location	Max. 7DAM (°C) 2004	2005	2006	2007	2009
3	Thomas Ck	Old Hwy 99 North	20.3	19.7	N/A	N/A	24.4
4	Thomas Ck	F&S Grade	17.5	16.1	17.3	18.9	19.2
6	Friday Ck	Prairie Rd	21.0	19.6	21.3	20.8	22.7
8	Swede Ck	Grip Rd	19.1	17.5	19.3	18.6	21.8
11	Samish R	State Route 9	16.0	16.4	15.8	14.6	15.2
12	Nookachamps Ck	Swan Rd	24.2	N/A	20.6	N/A	17.3
13	E.F. Nookachamps Ck	State Route 9	21.5	19.8	21.6	20.1	N/A
14	College Way Ck	College Way	N/A	17.2	18.4	18.1	20.6
15	Nookachamps Ck	Knapp	22.4	21.6	23.2	22.9	24.9
16	E.F. Nookachamps Ck	Beaver Lake Rd	21.3	19.8	20.6	20.1	22.1
17	Nookachamps Ck	Big Lake Outlet	24.9	24.6	25.1	25.1	20.8
18	Lake Ck	State Route 9	18.8	17.6	18.4	18.4	22.4
19	Hansen Ck	Hoehn Rd	21.0	19.7	20.7	20.6	20.3
20	Hansen Ck	Northern State	19.6	18.9	19.0	18.0	20.7
21	Coal Ck	Hoehn Rd	18.6	17.3	18.2	18.2	N/A
22	Coal Ck	Hwy 20	N/A	N/A	17.5	17.3	N/A
23	Wiseman Ck	Minkler Rd	16.6	20.1	21.3	N/A	N/A
24	Mannser Ck	Lyman Hamilton Hwy	15.9	14.6	14.3	13.9	15.0
25	Red Cabin Ck	Hamilton Cem Rd	16.0	N/A	17.6	16.0	N/A
28	Brickyard Ck	Hwy 20	N/A	N/A	N/A	N/A	N/A
29	Skagit R	R Bend Rd	N/A	N/A	N/A	N/A	N/A
30	Skagit R	Cape Horn Rd	N/A	N/A	14.9	15.3	N/A
31	Drain Dist 20 near floodgate	Francis Rd	N/A	N/A	N/A	N/A	N/A
32	Samish R	Thomas Rd	20.5	19.1	20.7	19.9	22.7
33	Alice Bay Pump Station	Samish Island Rd	21.4	26.2	27.1	N/A	N/A
34	Noname Slough	Bayview-Edison Rd	N/A	22.4	22.8	22.9	N/A
35	Joe Leary Slough	D'Arcy Rd	22.8	19.5	24.1	18.9	N/A
36	Edison Slough at school	W. Bow Hill Rd	30.1	29.8	29.3	27.6	N/A
37	Edison Pump Station	Farm to Market Rd	27.4	27.1	26.8	27.9	N/A
38	North Edison Pump Station	North Edison Rd	15.9	N/A	28.1	N/A	N/A
39	Colony Ck	Colony Rd	20.4	19.0	19.7	N/A	21.1
40	Big Indian Slough	Bayview-Edison Rd	N/A	20.2	24.2	22.0	N/A
41	Maddox Slough/Big Ditch	Milltown Rd	25.7	N/A	25.7	22.7	25.4
42	Hill Ditch	Cedardale Rd	N/A	23.8	24.6	20.2	27.0
43	Wiley Slough	Wylie Rd	22.6	N/A	N/A	N/A	N/A
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	25.4	22.6	22.3	26.6	23.6
45	Skagit R – North Fork	Moore Rd	17.5	18.3	17.6	16.4	16.9
46	Skagit R – South Fork	Fir Island Rd	19.1	N/A	N/A	N/A	N/A
47	Swinomish Channel	County Boat Launch	N/A	N/A	N/A	N/A	N/A
48	Fisher Ck	Franklin Rd	15.7	14.5	15.0	14.7	N/A

Graphs on the following pages show the temperature data collected during biweekly visits. Gaps in the data represent streams that were either dry or flooded at sampling time.

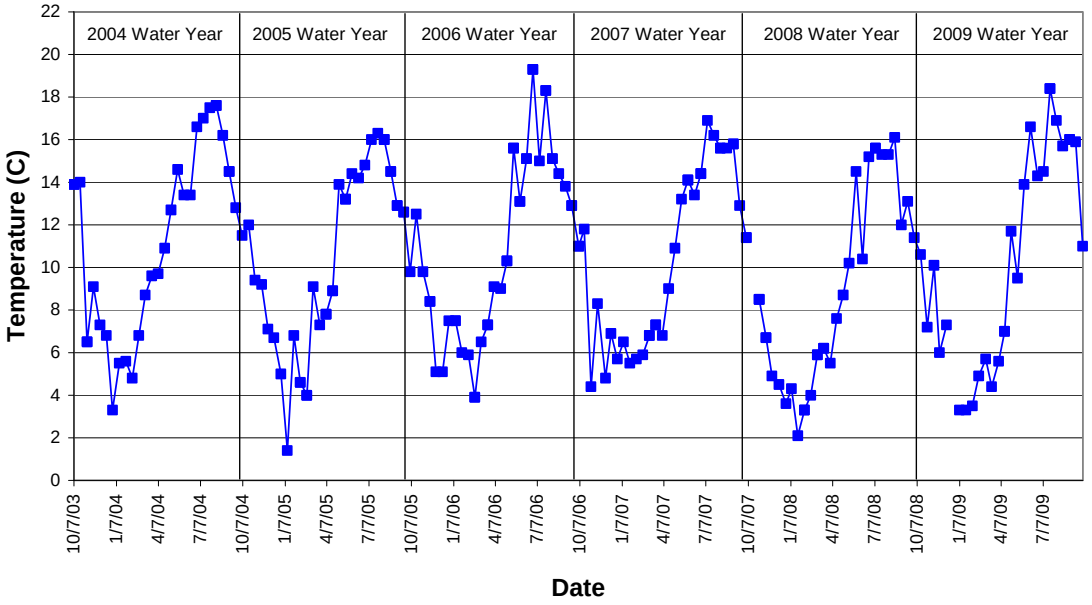
Thomas Creek at Hwy 99 - Site 3
Temperature from biweekly sampling



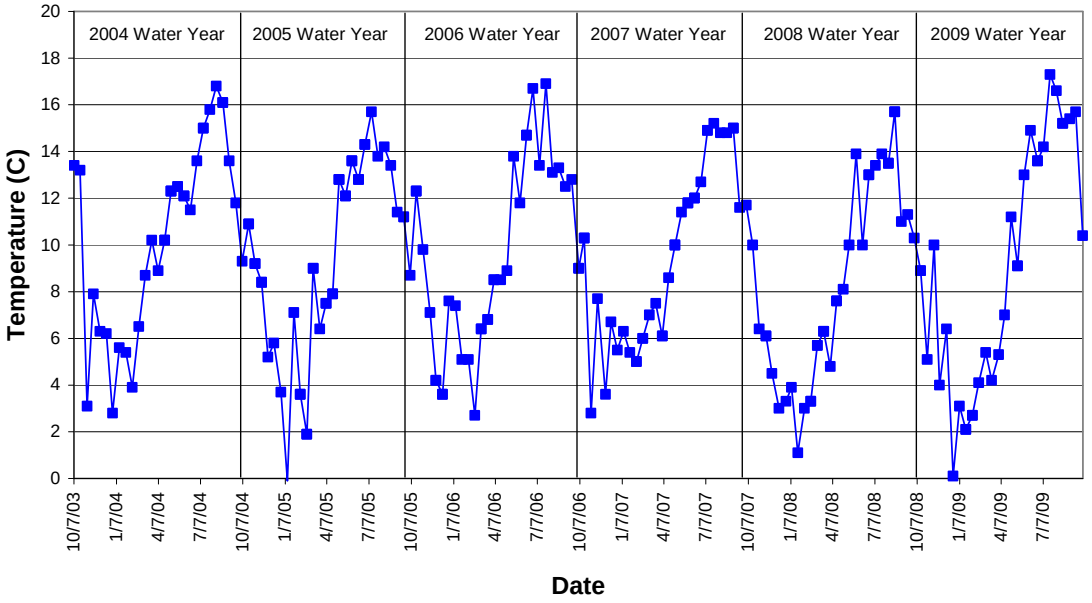
Thomas Creek at F&S Grade Rd - Site 4
Temperature from biweekly sampling



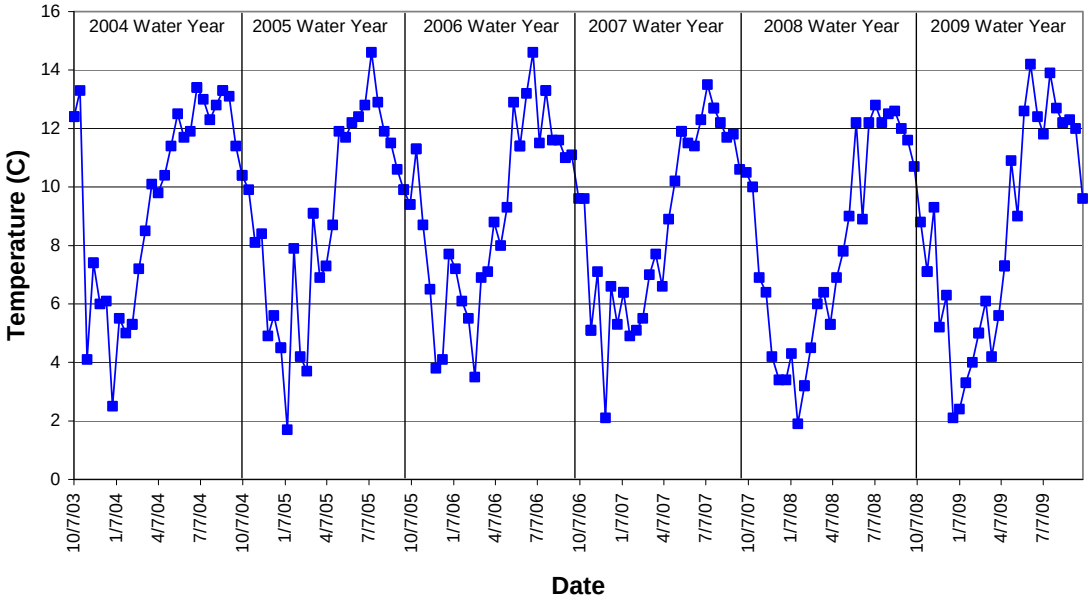
Friday Creek at Prairie Rd - Site 6
Temperature from biweekly sampling



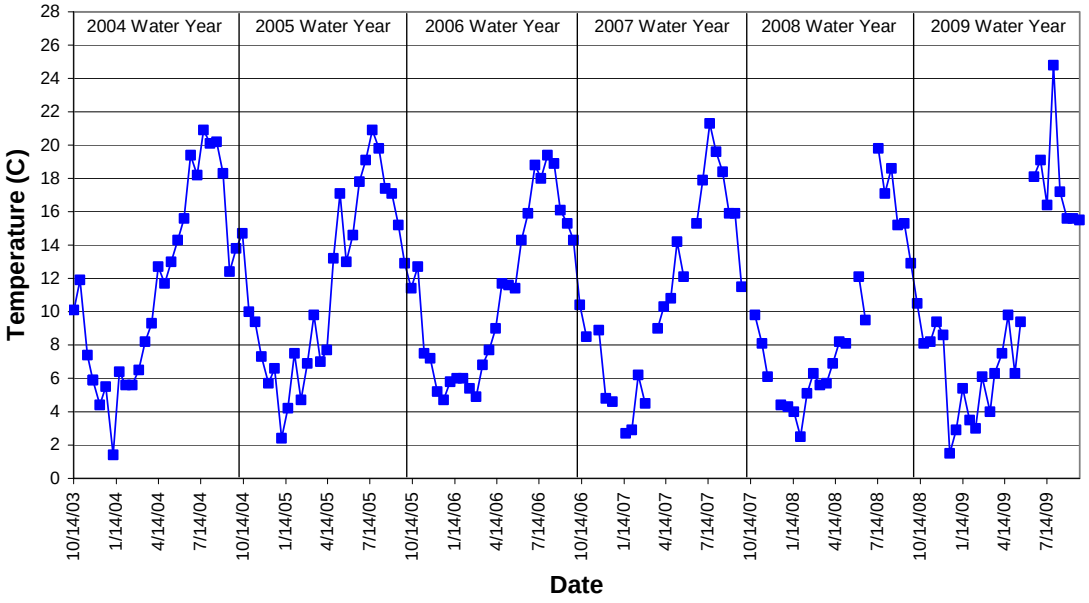
Swede Creek at Grip Rd - Site 8
Temperature from biweekly sampling



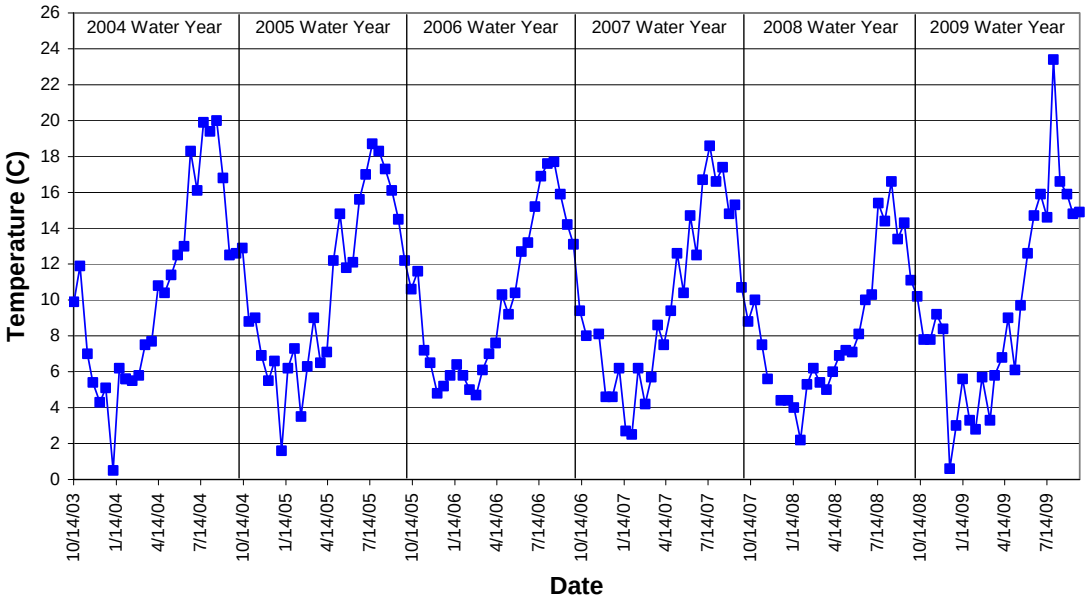
Samish River at Hwy 9 - Site 11
Temperature from biweekly sampling



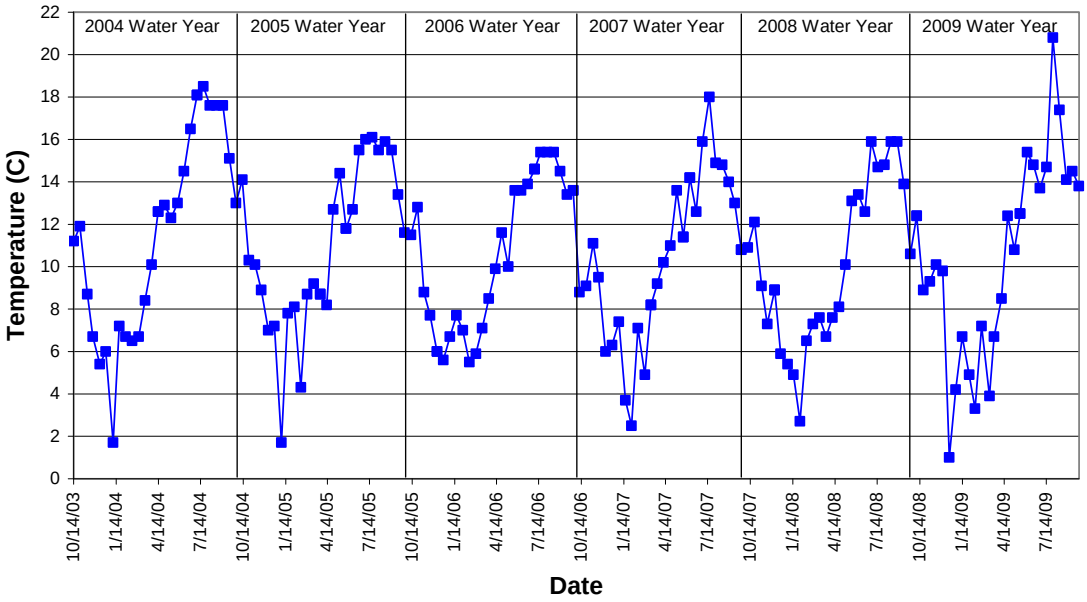
Nookachamps Creek at Swan Rd - Site 12
Temperature from biweekly sampling



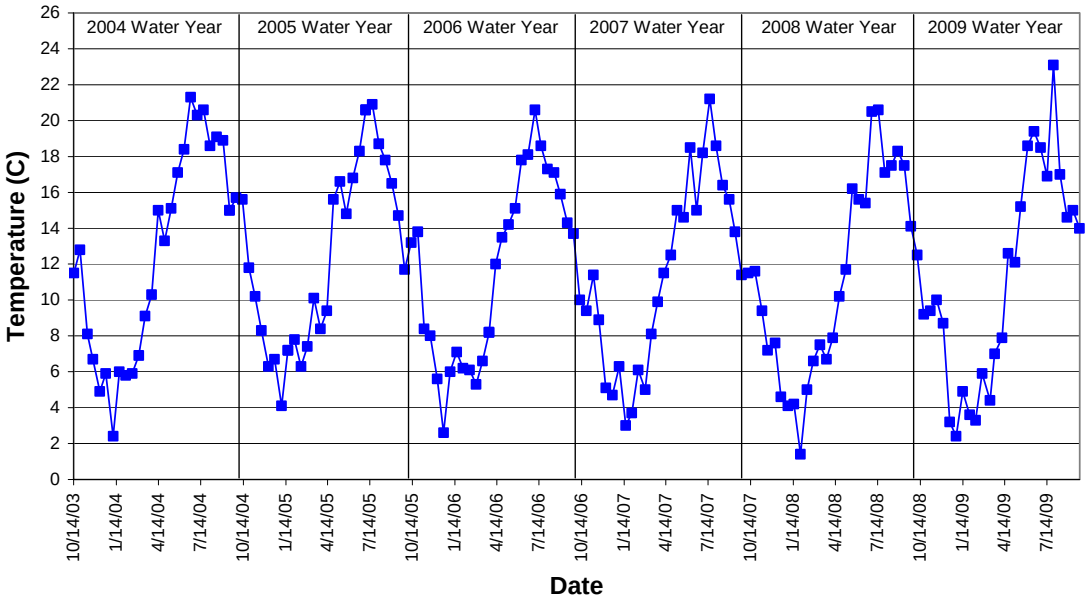
E.F. Nookachamps Creek at Hwy 9 - Site 13
Temperature from biweekly sampling



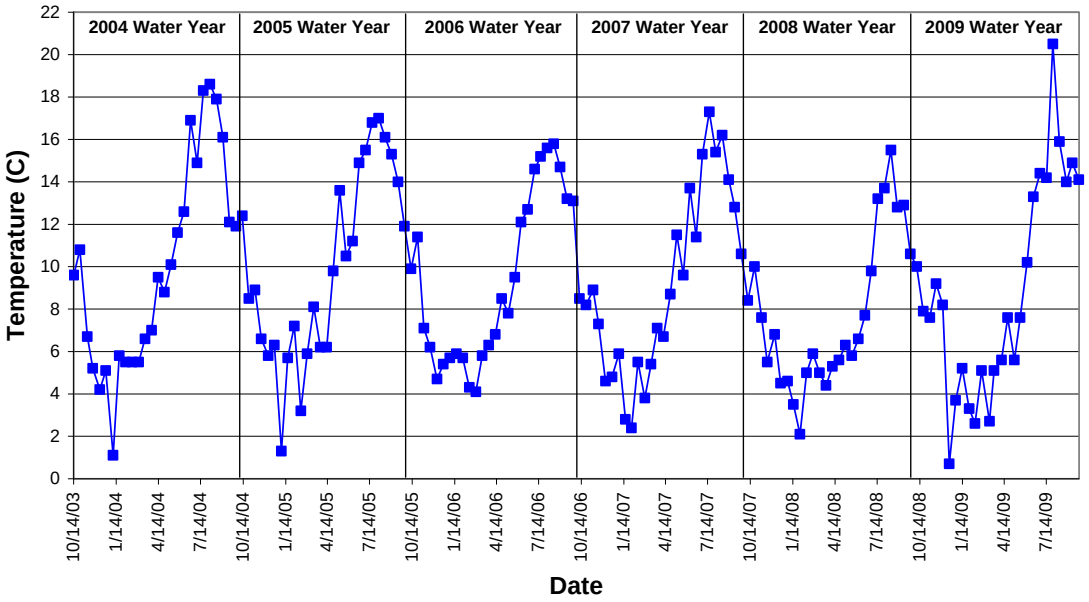
College Way Creek at College Way - Site 14
Temperature from biweekly sampling



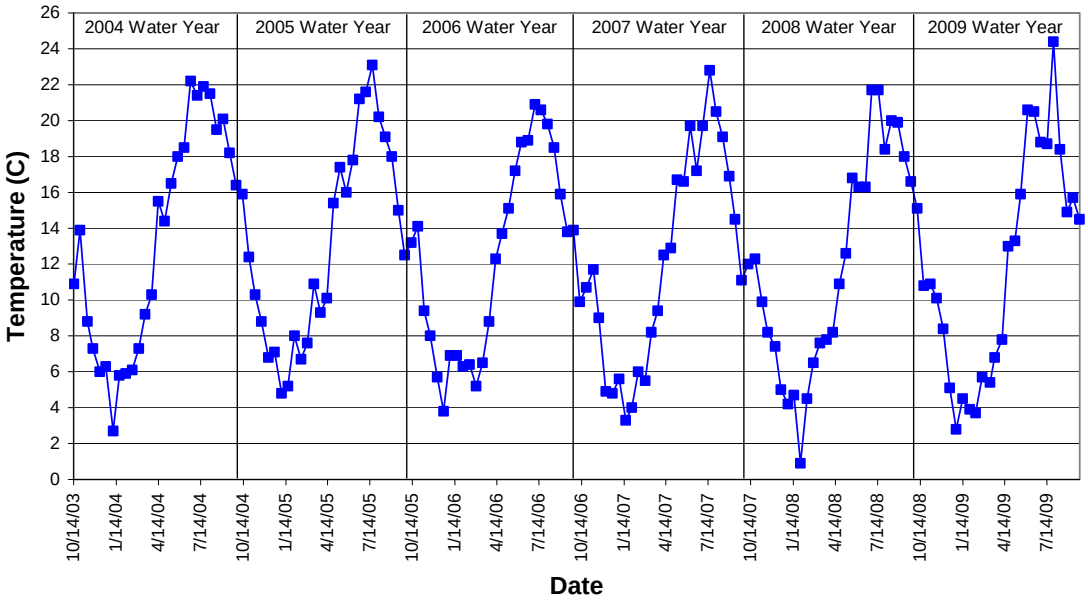
Nookachamps Creek at Knapp Rd - Site 15
Temperature from biweekly sampling



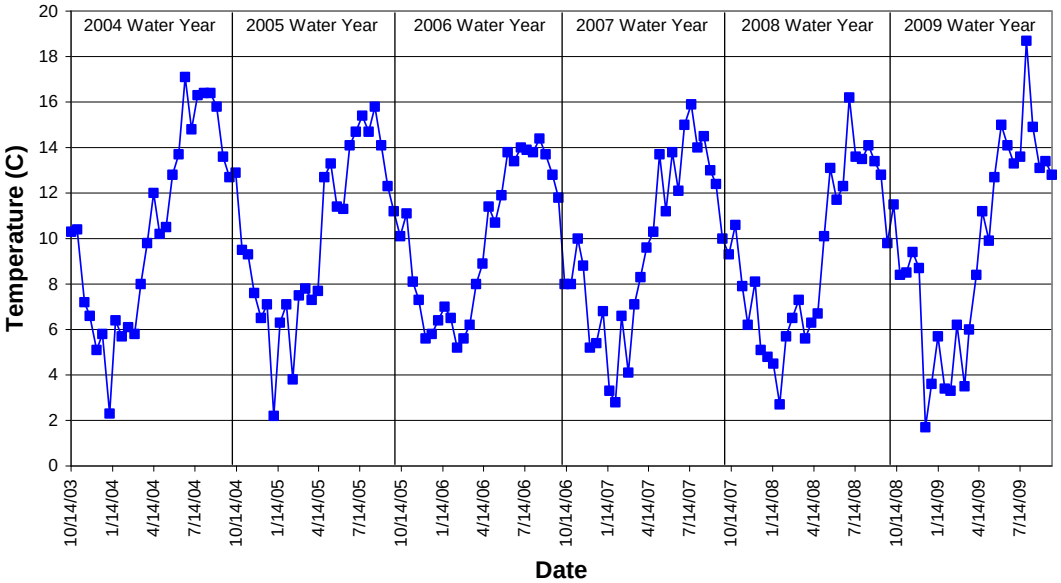
E.F. Nookachamps Creek at Beaver Lake Rd - Site 16
Temperature from biweekly sampling



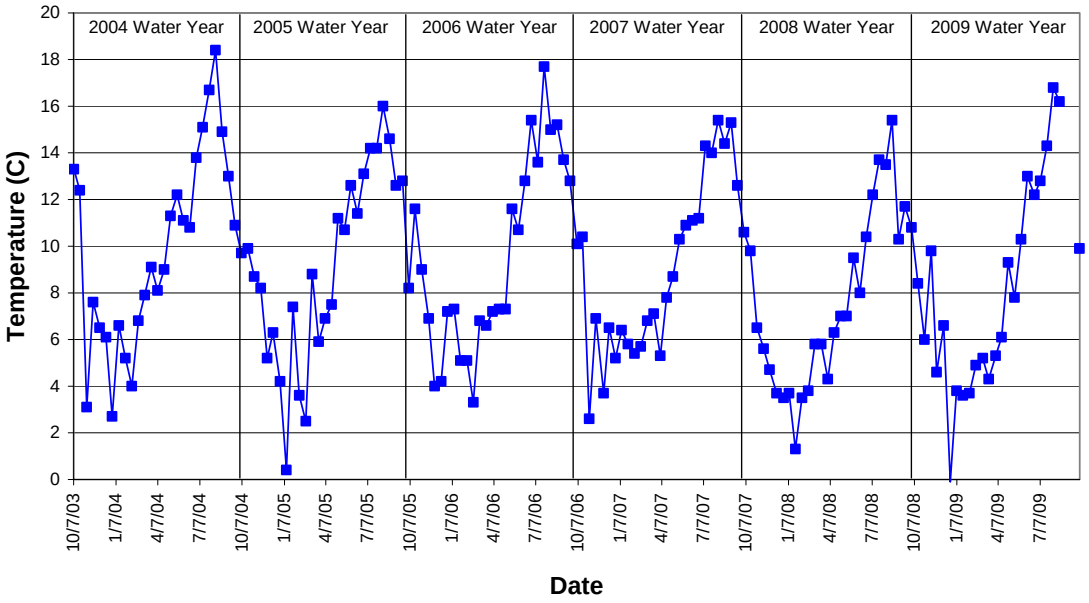
Nookachamps Creek at Big Lake Outlet - Site 17
Temperature from biweekly sampling



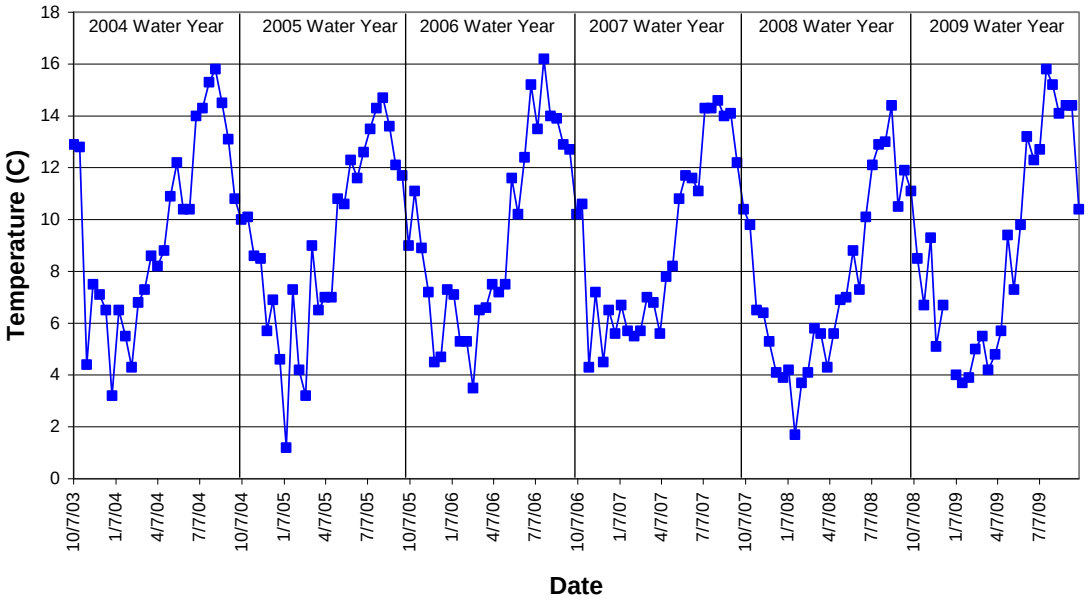
Lake Creek at Hwy 9 - Site 18
Temperature from biweekly sampling



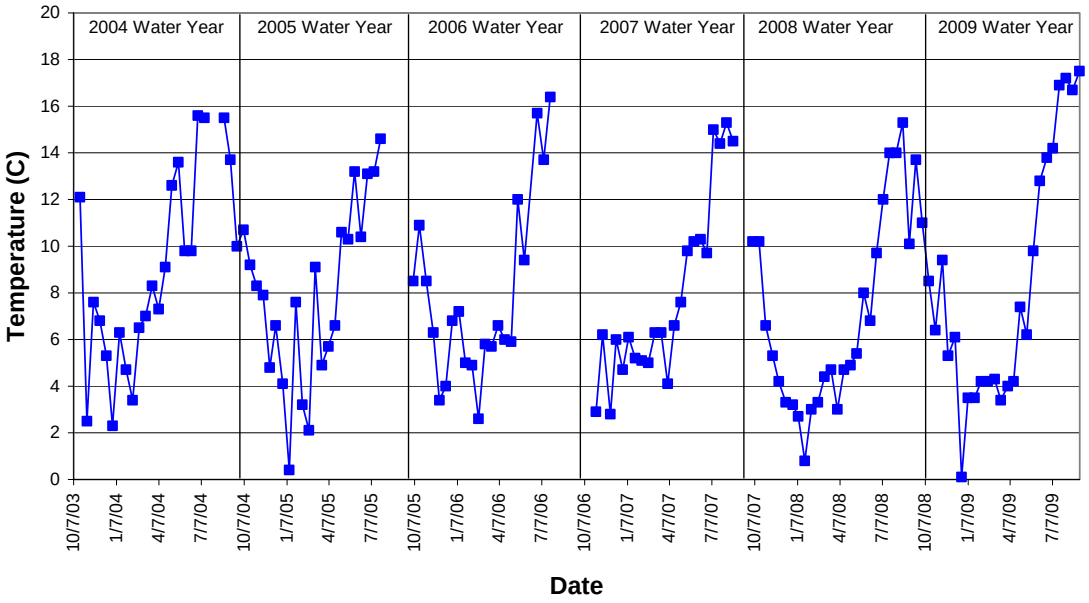
Hansen Creek at Hoehn Rd - Site 19
Temperature from biweekly sampling



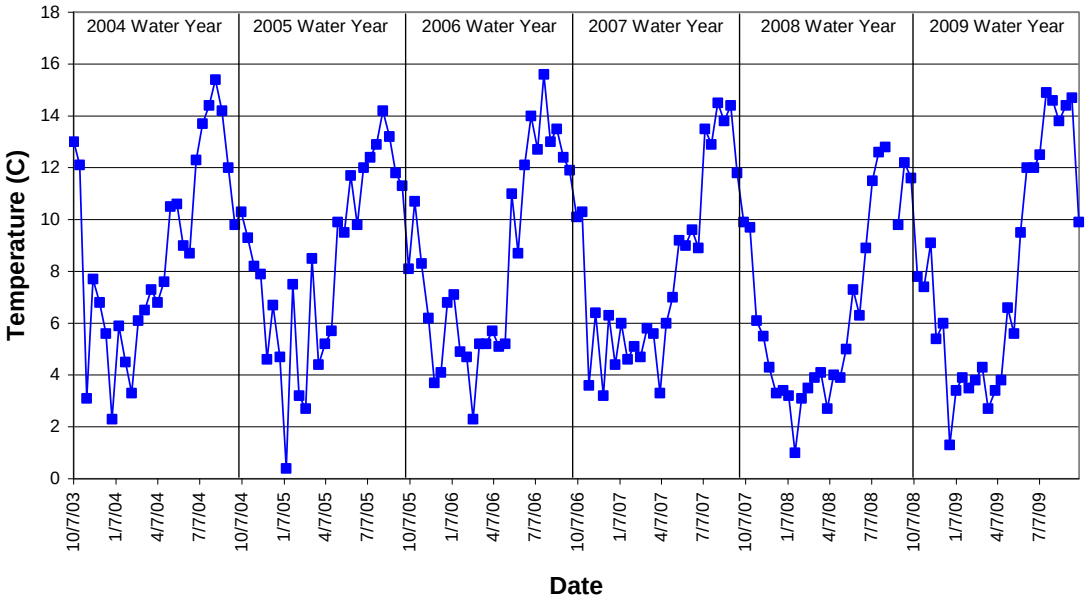
Hansen Creek at Northern State Hospital - Site 20
Temperature from biweekly sampling



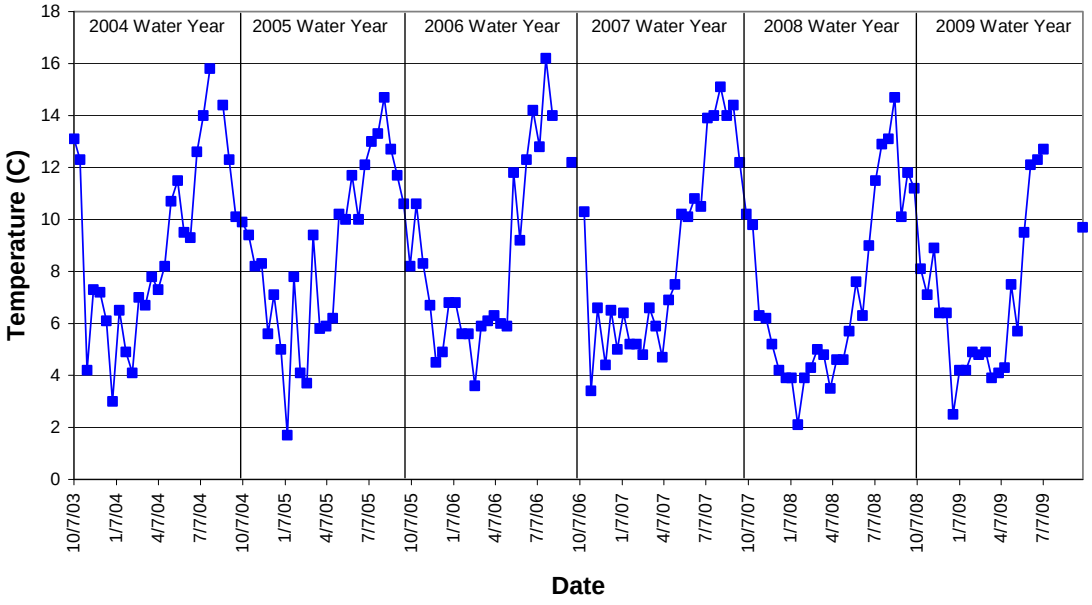
Coal Creek at Hoehn Rd - Site 21
Temperature from biweekly sampling



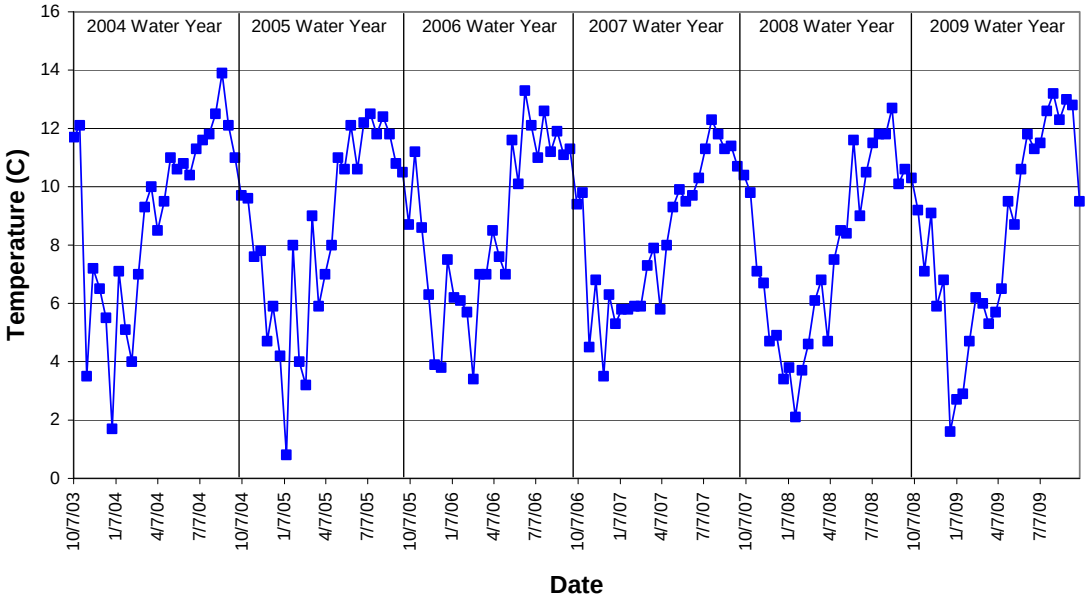
Coal Creek at Hwy 20 - Site 22
Temperature from biweekly sampling



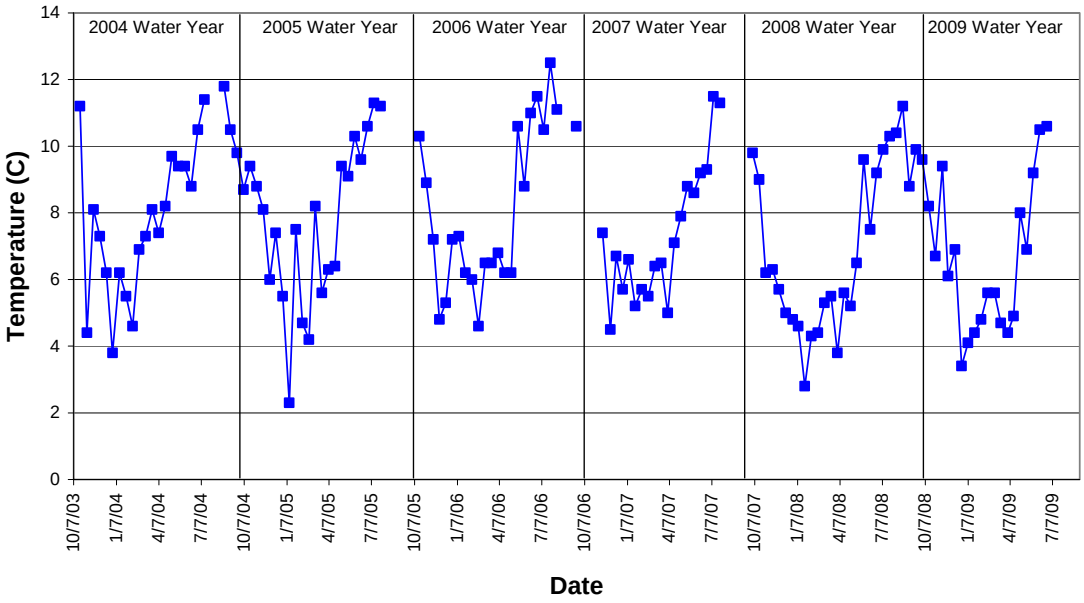
Wiseman Creek at Minkler Rd - Site 23
Temperature from biweekly sampling



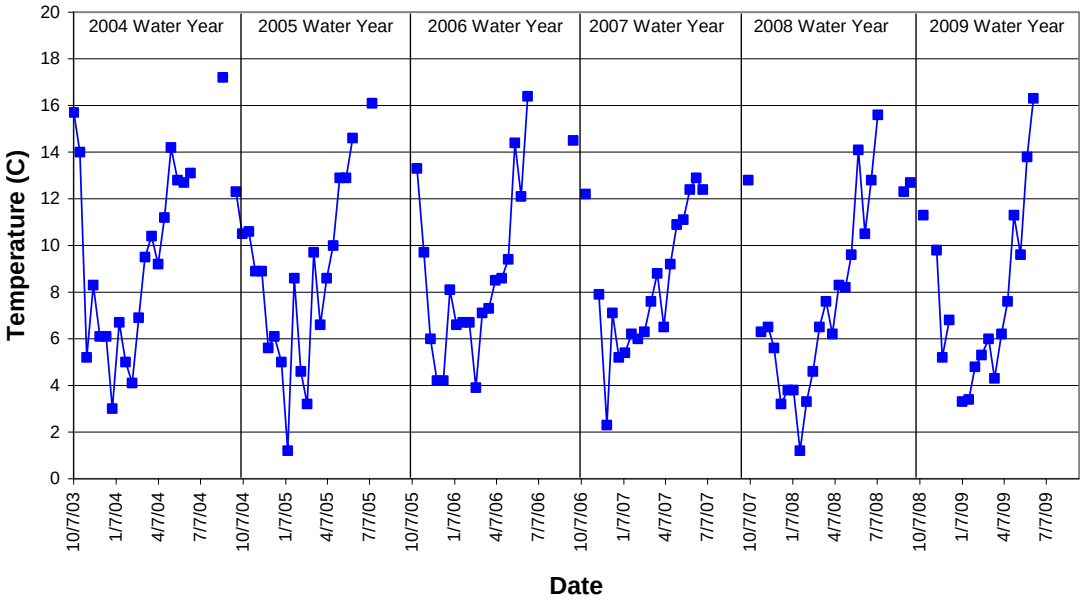
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Temperature from biweekly sampling



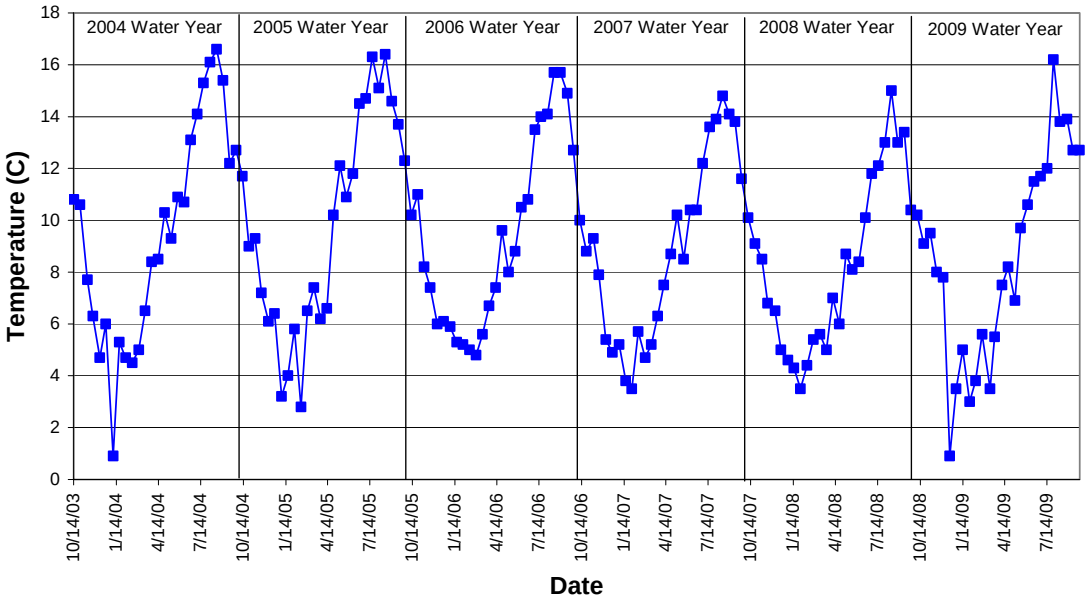
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Temperature from biweekly sampling



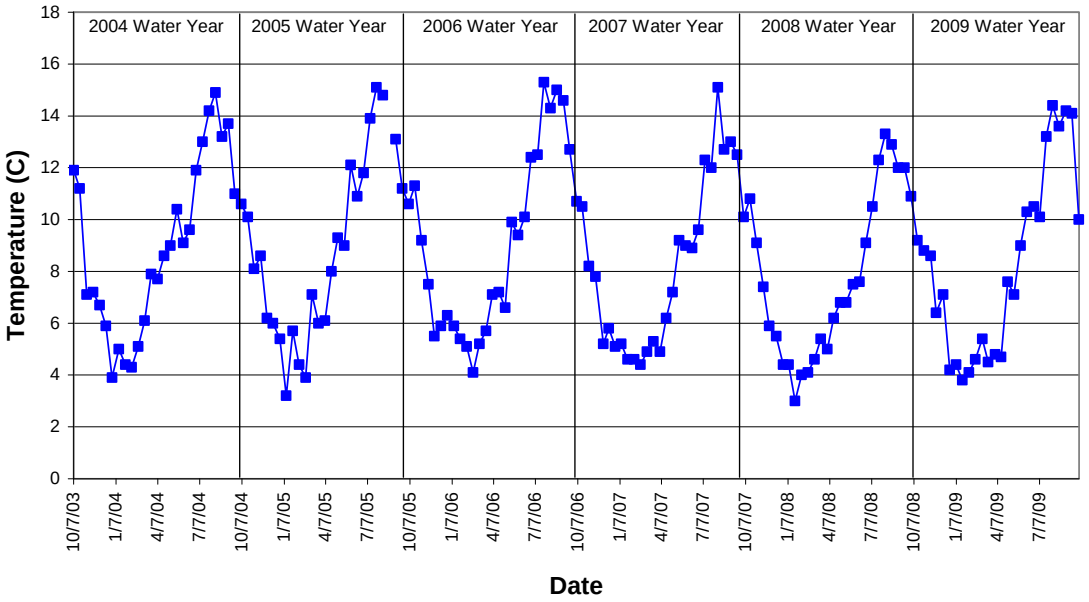
Brickyard Creek at Hwy 20 - Site 28
Temperature from biweekly sampling



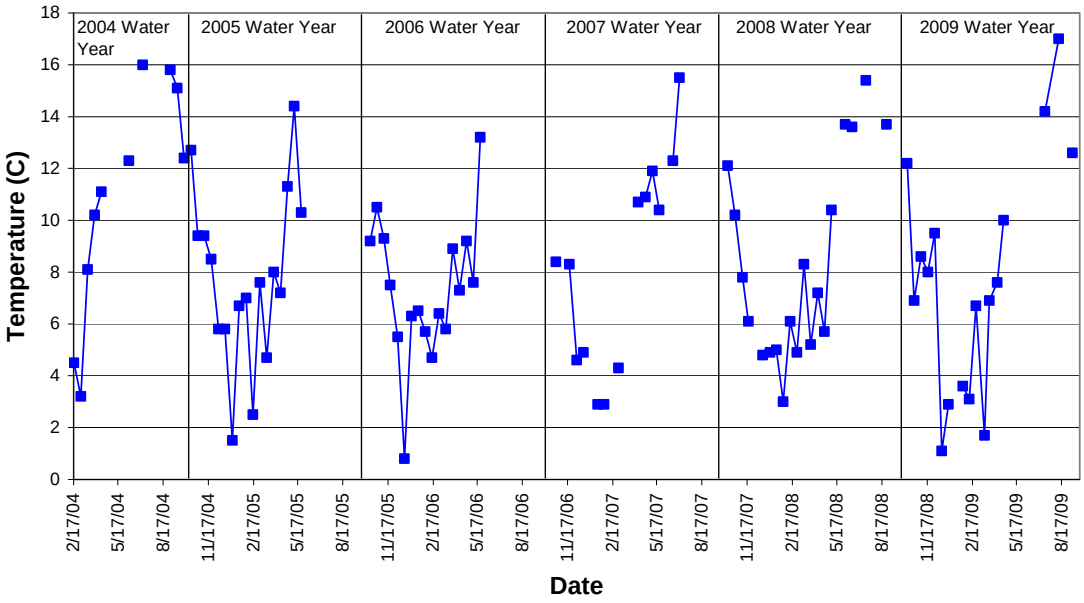
Skagit River at River Bend - Site 29
Temperature from biweekly sampling



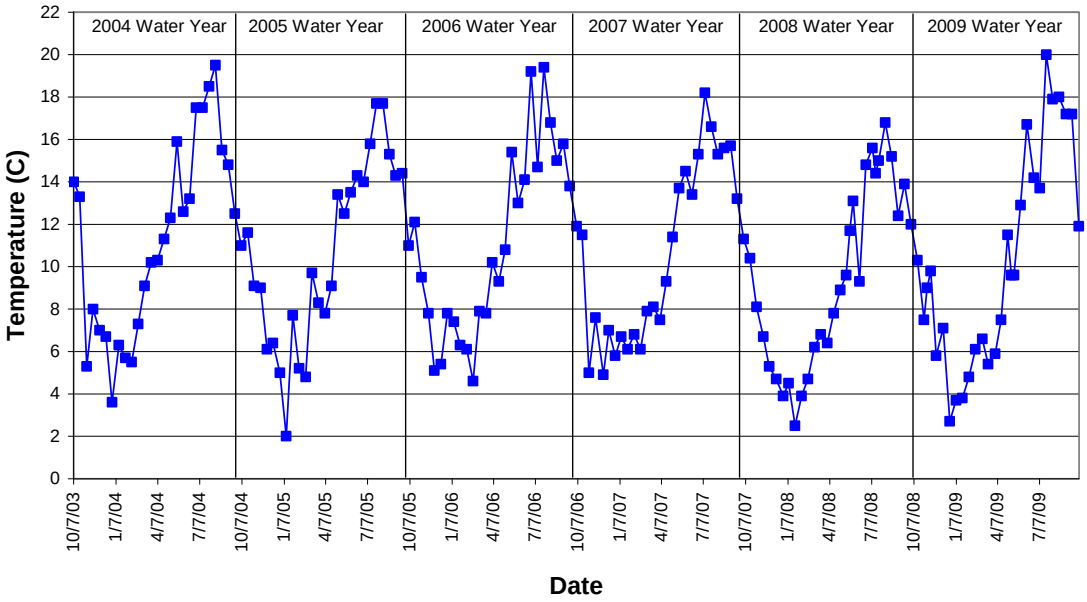
Skagit River at Cape Horn Rd - Site 30
Temperature from biweekly sampling



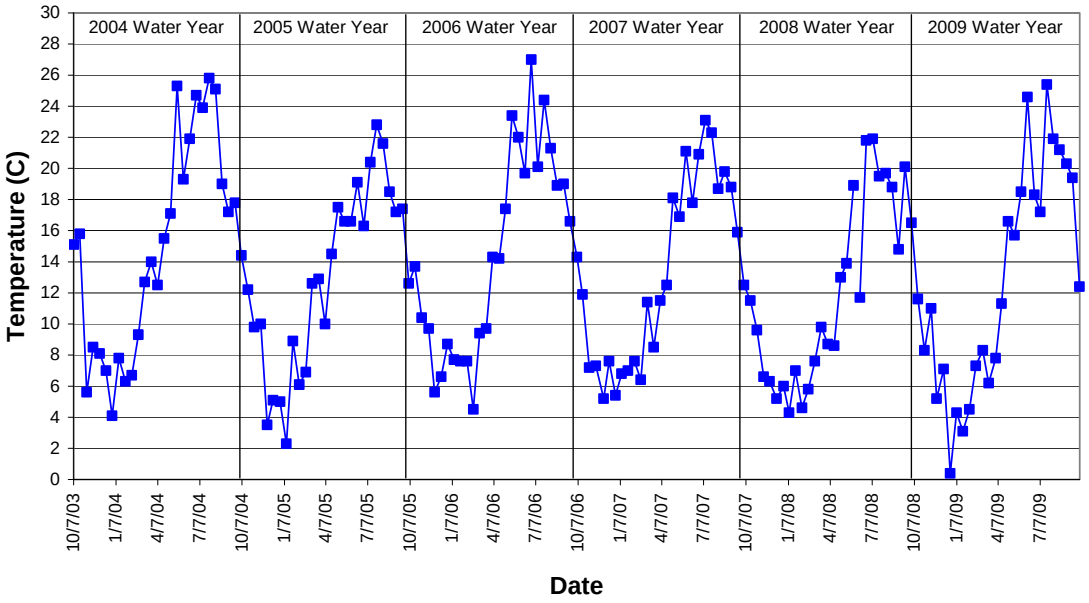
Drainage District 20 Ditch at Floodgate - Site 31
Temperature from biweekly sampling



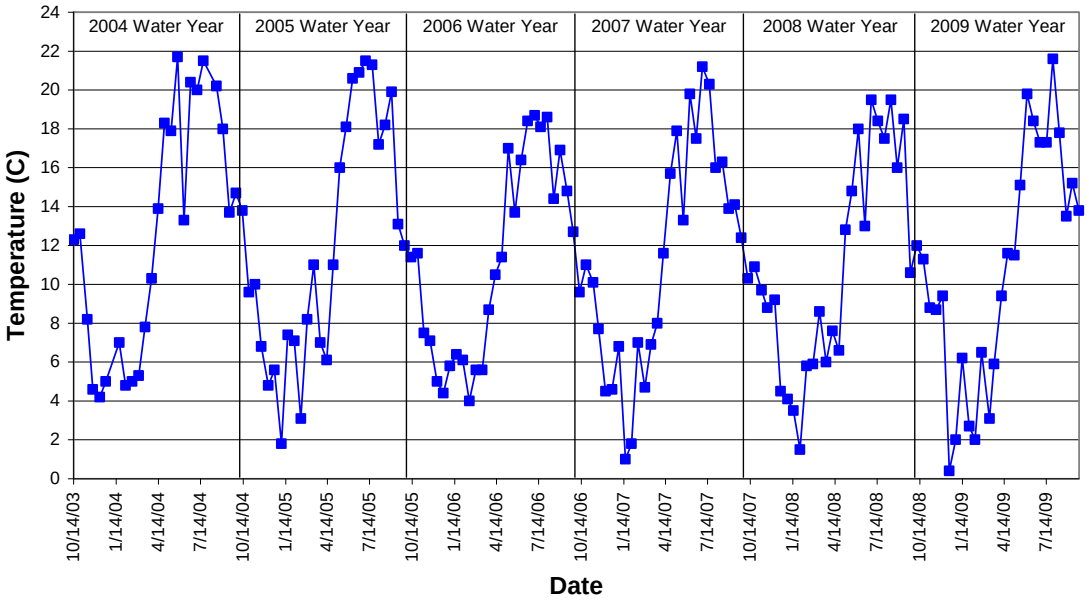
Samish River at Thomas Rd - Site 32
Temperature from biweekly sampling



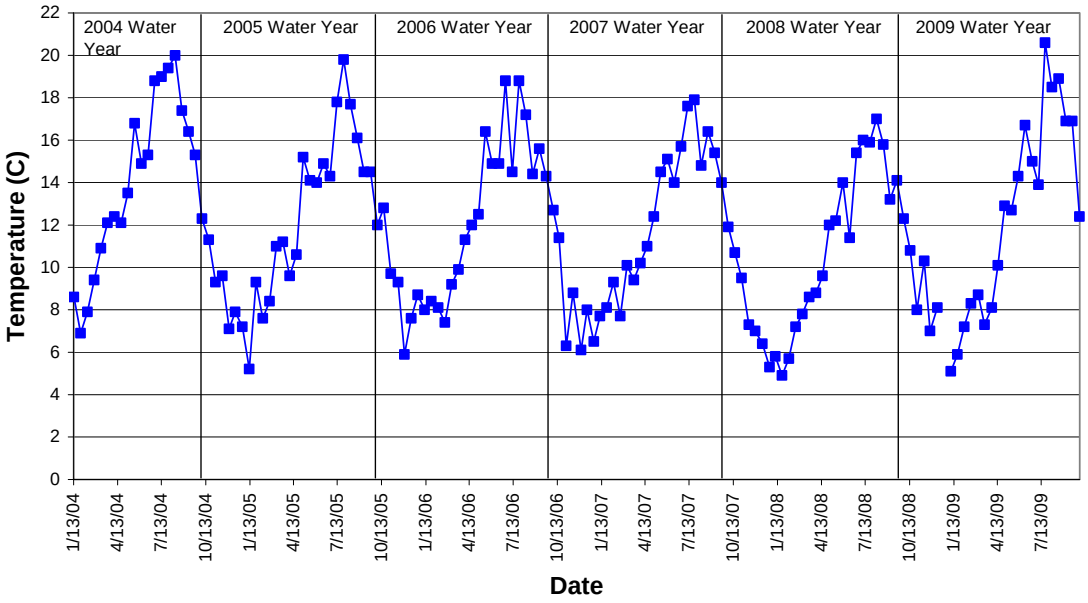
Alice Bay Pump Station - Site 33
Temperature from biweekly sampling



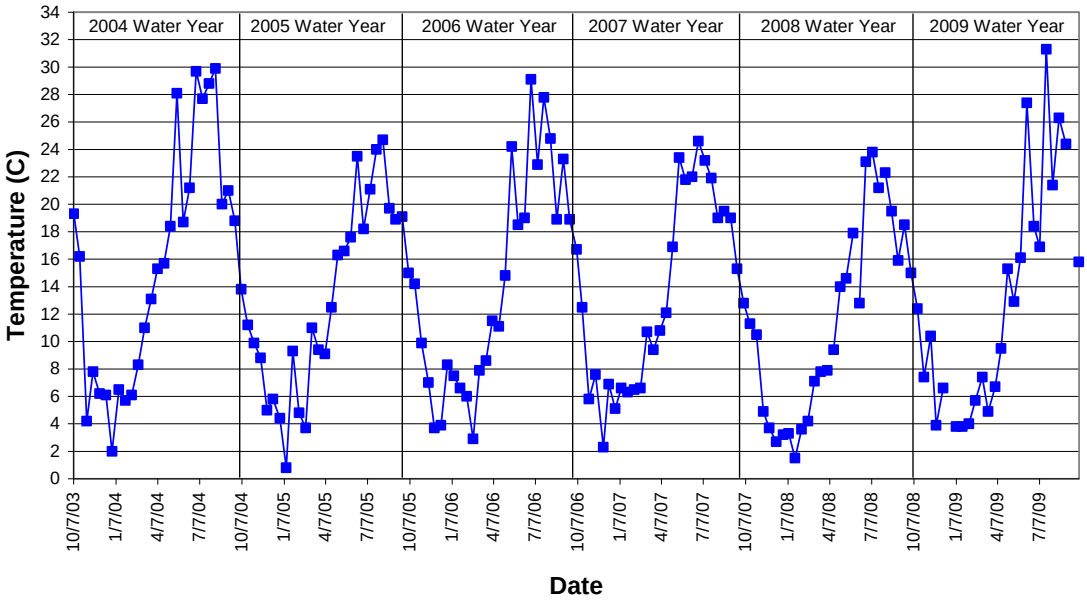
No Name Slough at Bayview-Edison Rd - Site 34
Temperature from biweekly sampling



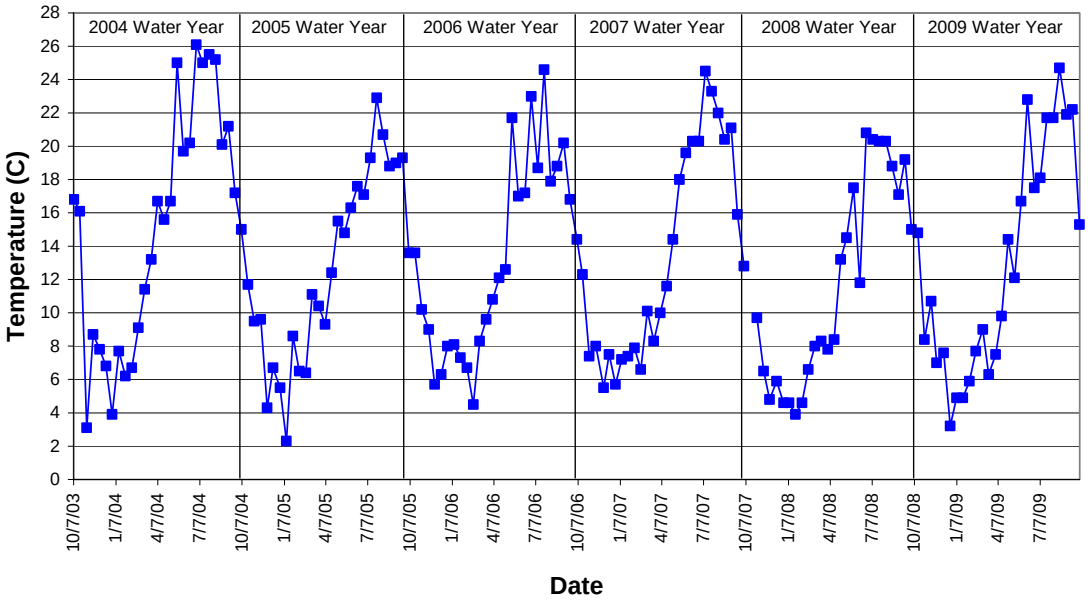
Joe Leary Slough at D'Arcy Rd - Site 35
Temperature from biweekly sampling



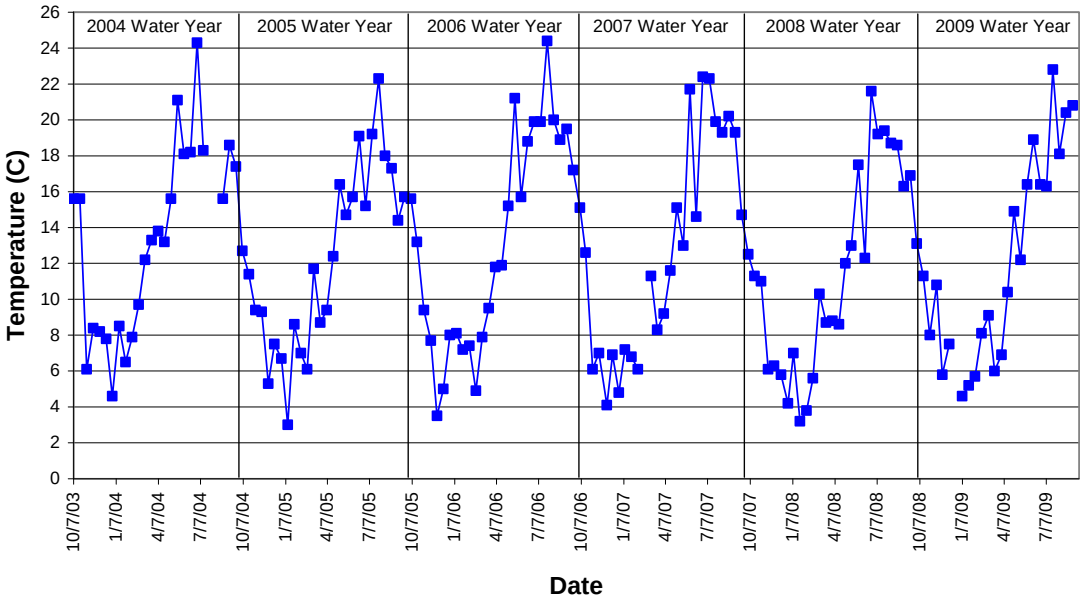
Edison Slough at Edison School - Site 36
Temperature from biweekly sampling



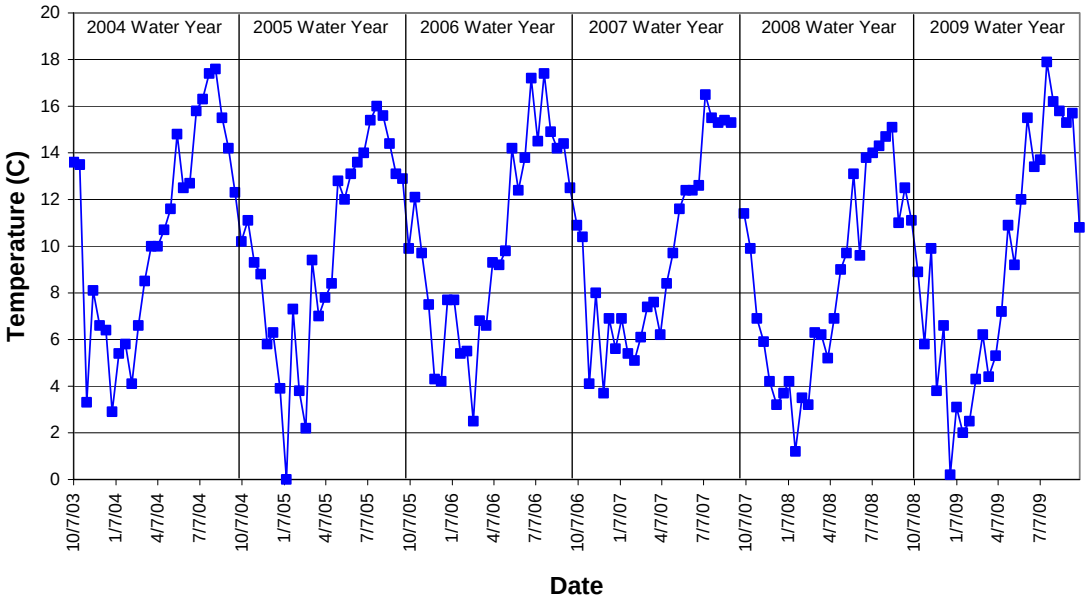
Edison Pump Station - Site 37
Temperature from biweekly sampling



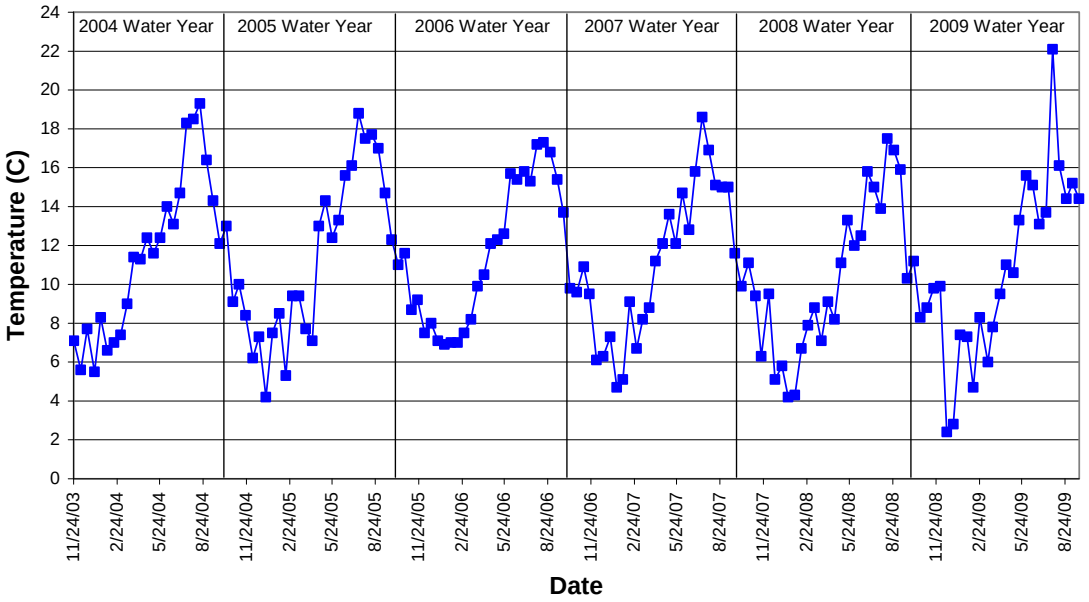
North Edison Pump Station - Site 38
Temperature from biweekly sampling



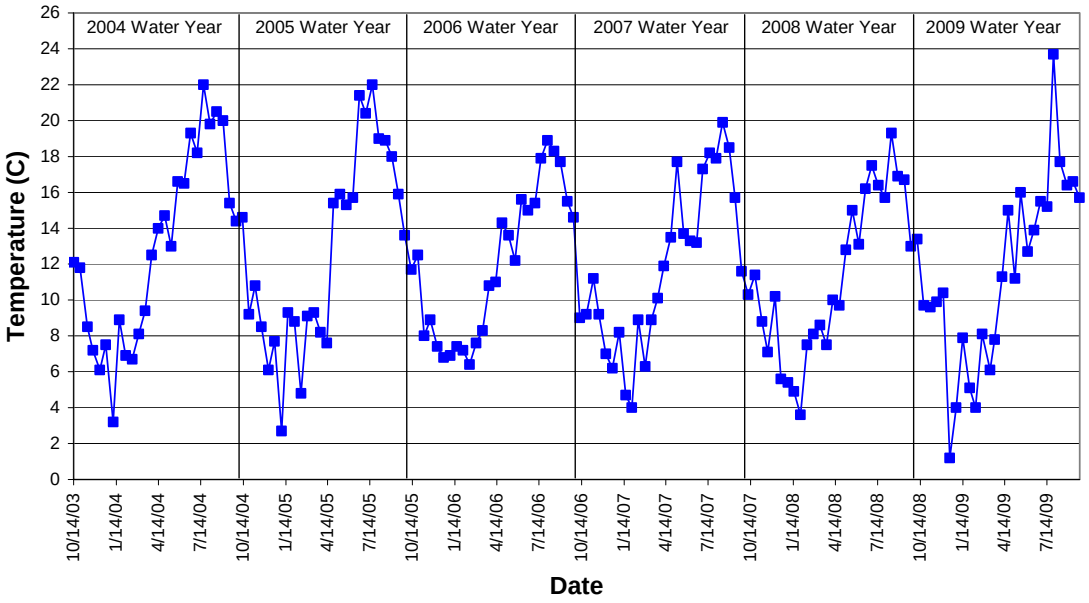
Colony Creek at Colony Rd - Site 39
Temperature from biweekly sampling



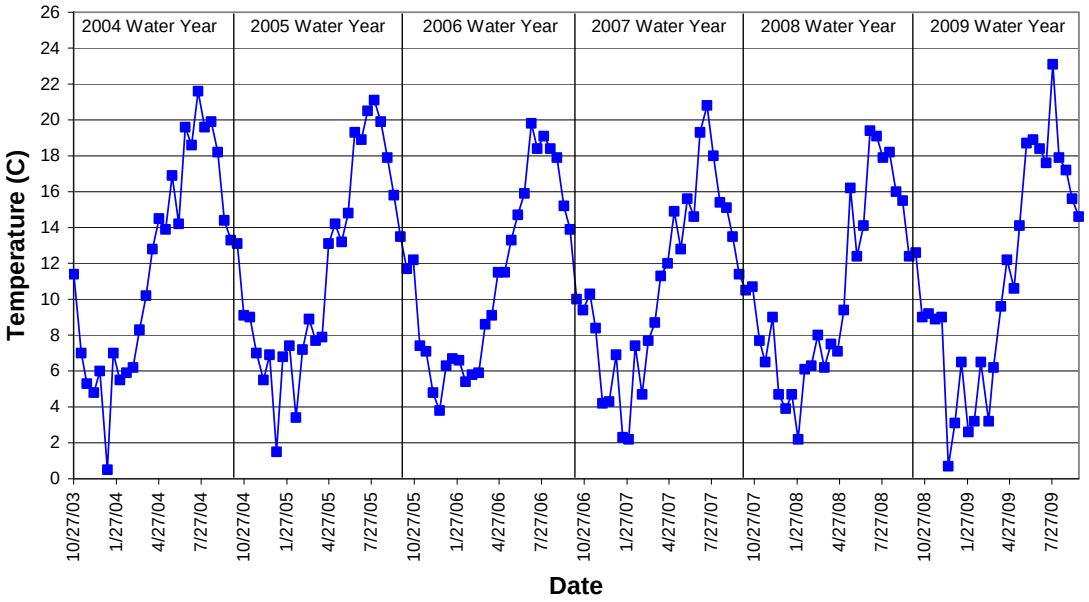
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Temperature from biweekly sampling



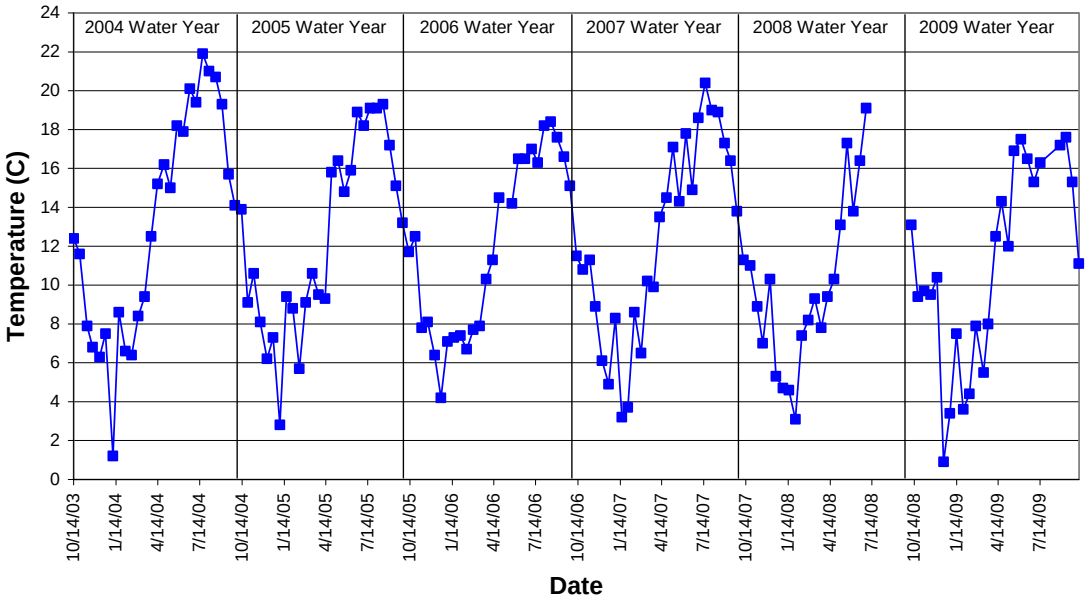
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Temperature from biweekly sampling



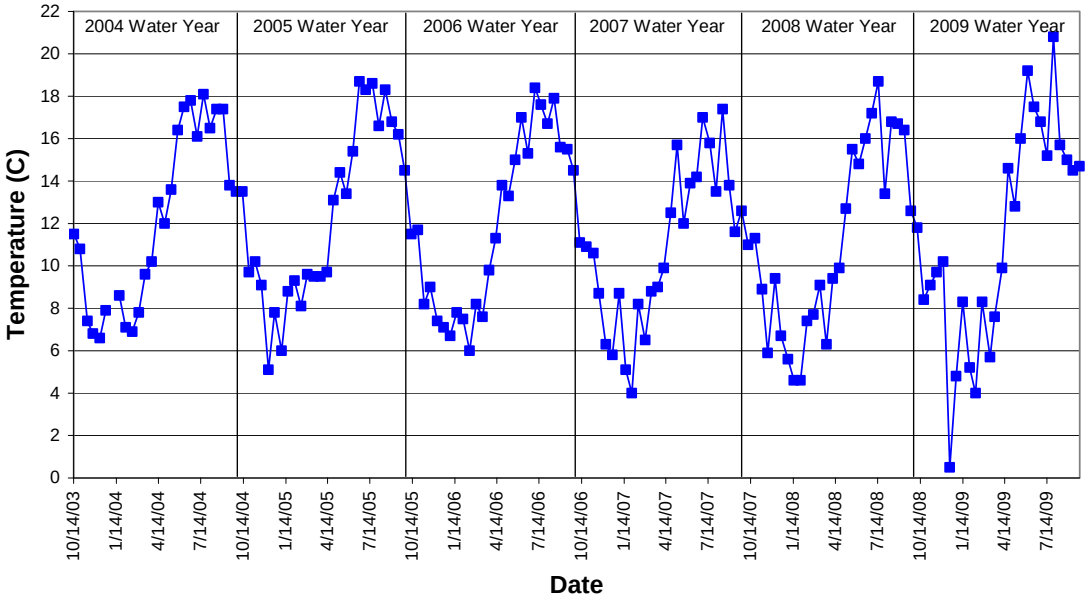
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Temperature from biweekly sampling



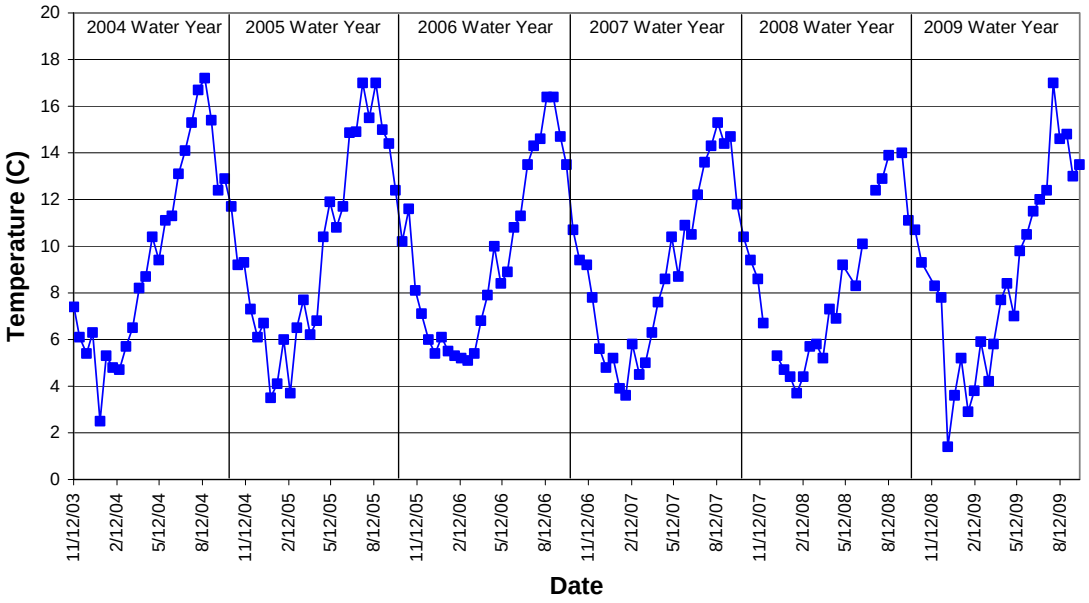
Wiley Slough at Wylie Rd - Site 43
Temperature from biweekly sampling



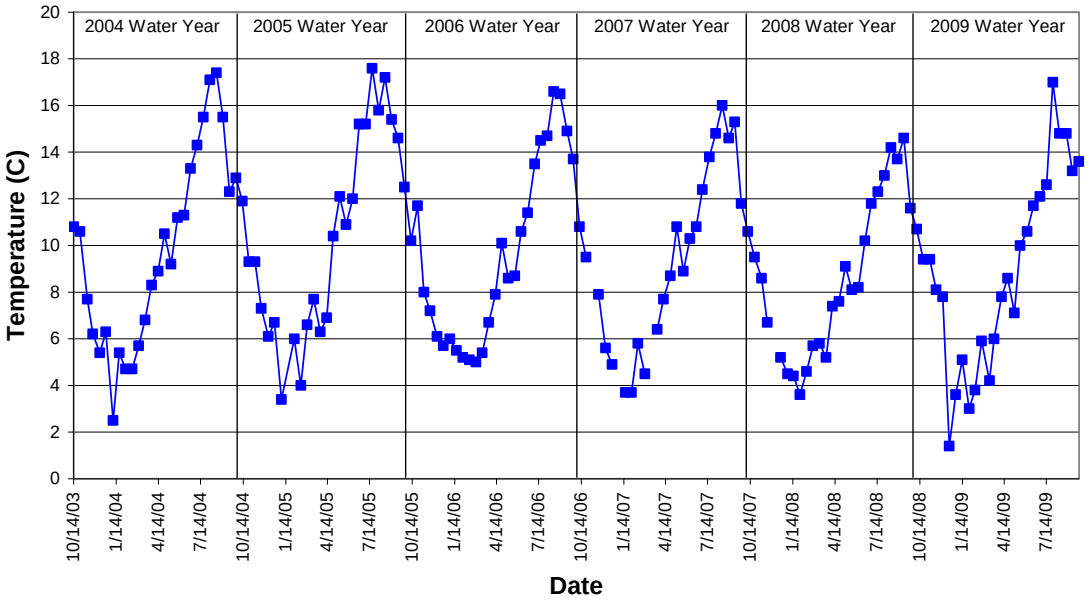
Sullivan Slough at La Conner-Whitney Rd - Site 44
Temperature from biweekly sampling



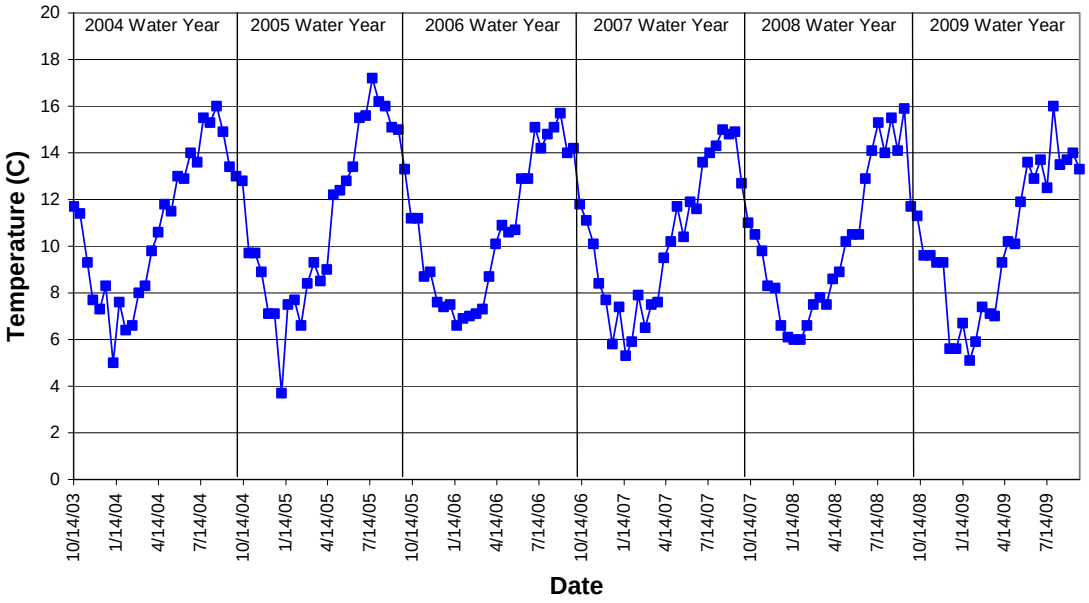
Skagit River near Moore Rd - Site 45
Temperature from biweekly sampling



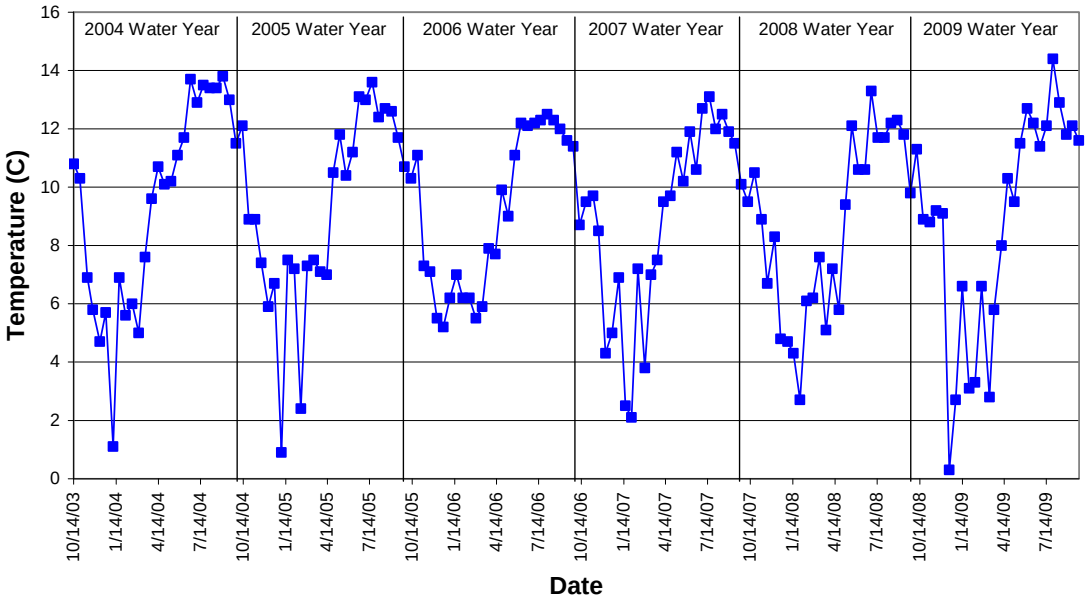
Skagit River at Conway - Site 46
Temperature from biweekly sampling



Swinomish Channel at County Boat Ramp - Site 47
Temperature from biweekly sampling



Fisher Creek at Franklin Rd - Site 48
Temperature from biweekly sampling



Dissolved Oxygen

Dissolved oxygen (DO) measurements determine how much oxygen is available in the water for fish and other organisms. DO measurements were taken with a meter at each site during each visit, except in rare instances of equipment malfunction. A summary of DO readings (in mg/L) obtained during the 2009 water year is provided in Table 5. Table 6 summarizes data from the five years of the study. The pages following Table 6 contain graphs illustrating dissolved oxygen levels at all sample sites for the 2004-2009 water years. Gaps in the data represent streams that were either flooded or dry at sampling time, or may represent equipment malfunctions.

The state water quality standards for dissolved oxygen are based on single-day minimum measurements. For some lowland watercourses in the Skagit County Monitoring Program (sites 3-4, 28, 31-44), the minimum standard is 8.0 mg/L. For the marine site (site 47), the standard is 6.0 mg/L. For all other sites, the standard is 9.5 mg/L. This represents a change from previous years, as the Department of Ecology reviewed fish usage in the Skagit and Samish Basins and redesignated several watercourses for the stricter standard. The solubility of oxygen in water is inversely related to temperature, so that higher temperatures frequently result in lower dissolved oxygen values.

Many streams in the Skagit County Monitoring Program meet oxygen standards all or most of the year. In a few streams, oxygen levels show steep declines in summer. These declines are usually associated with very low flows.

In the drainage infrastructure and lower sloughs, dissolved oxygen levels can be greatly influenced by algal activity. During large algae blooms, the oxygen produced during photosynthesis can lead to very high oxygen levels during the day. However, at those same times, nighttime oxygen levels can be very low as the large populations of algae turn from producing oxygen to consuming it. Because our oxygen readings are taken during the day, the monitoring program does not account for these nighttime oxygen reductions. During times when algae blooms are dying off, the decomposition of the dying algae can lead to very low oxygen levels both day and night. The results, as can be seen in the graphs of the drainage sites, are widely fluctuating dissolved oxygen levels depending on the state of the algal blooms at sampling time.

Table 5. Dissolved Oxygen Results
Summary of Dissolved Oxygen (DO) measurements in the Skagit County Monitoring Program 2009 Water Year

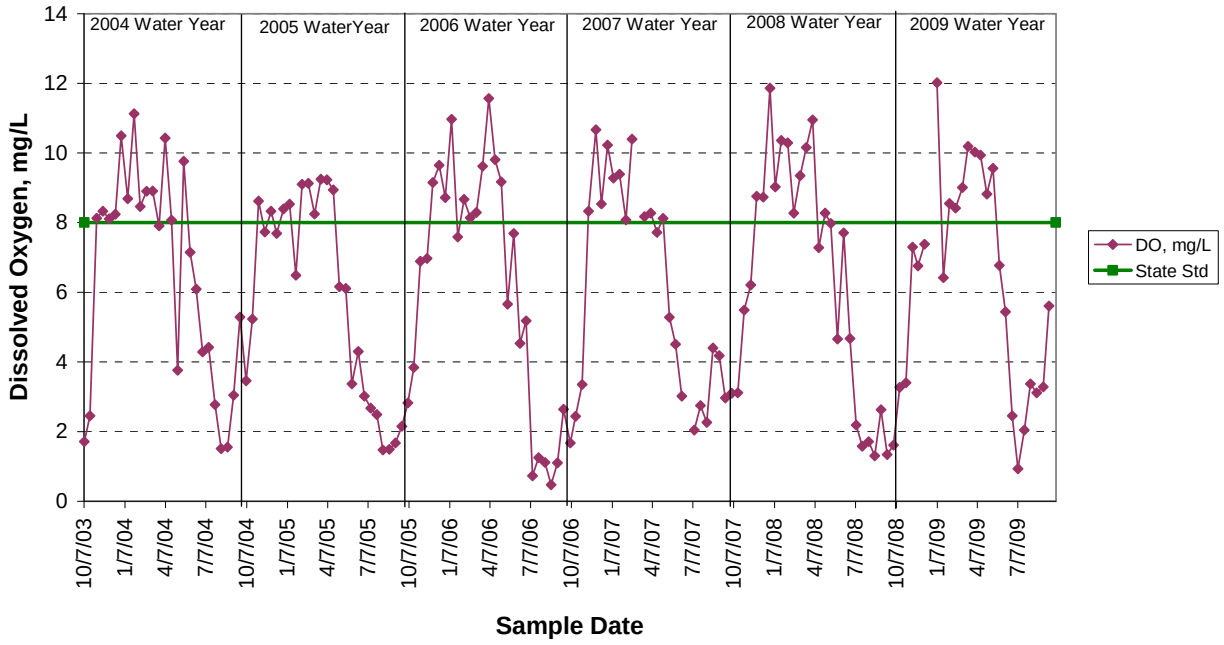
Site Number	Watercourse	Location	Mean DO (mg/L)	Minimum DO (mg/L)	St. Std[1]
3	Thomas Ck	Old Hwy 99 N	6.4	0.9	8.0
4	Thomas Ck	F&S Grade	11.2	9.1	8.0
6	Friday Ck	Prairie Rd	11.3	9.3	9.5
8	Swede Ck	Grip Rd	10.9	7.0	9.5
11	Samish R	State Route 9	9.0	6.5	9.5
12	Nookachamps Ck	Swan Rd	9.7	6.1	9.5
13	E.F. Nookachamps Ck	State Route 9	10.0	6.9	9.5
14	College Way Ck	College Way	9.3	4.1	9.5
15	Nookachamps Ck	Knapp	7.3	0.3	9.5
16	E.F. Nookachamps Ck	Beaver Lake Rd	11.5	8.8	9.5
17	Nookachamps Ck	Big Lake Outlet	10.1	7.0	9.5
18	Lake Ck	State Route 9	11.2	8.2	9.5
19	Hansen Ck	Hoehn Rd	10.7	6.6	9.5
20	Hansen Ck	Northern State	11.1	9.3	9.5
21	Coal Ck	Hoehn Rd	11.1	8.2	9.5
22	Coal Ck	Hwy 20	12.1	10.1	9.5
23	Wiseman Ck	Minkler Rd	12.1	10.2	9.5
24	Mannser Ck	Lyman Hamilton Hwy	7.0	4.9	9.5
25	Red Cabin Ck	Hamilton Cem Rd	12.5	11.0	9.5
28	Brickyard Ck	Hwy 20	9.7	4.4	8.0
29	Skagit R	River Bend Rd	11.2	9.5	9.5
30	Skagit R	Cape Horn Rd	11.4	9.4	9.5
31	Drain Dist 20 floodgate	Francis Rd	8.2	3.4	8.0
32	Samish R	Thomas Rd	10.9	9.1	8.0
33	Alice Bay Pump Station	Samish Island Rd	9.6	4.2	8.0
34	Noname Slough	Bayview-Edison Rd	6.7	1.4	8.0
35	Joe Leary Slough	D'Arcy Rd	5.7	2.6	8.0
36	Edison Slough at school	W. Bow Hill Rd	9.7	3.7	8.0
37	Edison Pump Station	Farm to Market Rd	7.7	2.4	8.0
38	North Edison Pump Station	North Edison Rd	8.9	1.6	8.0
39	Colony Ck	Colony Rd	11.1	8.3	8.0
40	Big Indian Slough	Bayview-Edison Rd	5.5	2.1	8.0
41	Maddox Slough/Big Ditch	Milltown Rd	6.6	3.1	8.0
42	Hill Ditch	Cedardale Rd	7.9	3.4	9.5
43	Wiley Slough	Wylie Rd	5.1	1.2	8.0
44	Rexville PS/Sullivan Slough	La Conner-Bayview Rd	7.4	2.7	8.0
45	Skagit R – North Fork	Moore Rd	11.5	9.6	9.5
46	Skagit R – South Fork	Fir Island Rd	11.4	9.0	9.5
47	Swinomish Channel	County Boat Launch	8.5	6.6	6.0
48	Fisher Ck	Franklin Rd	11.1	9.4	9.5

[1]Washington State Water Quality Standard per WAC 173-201A

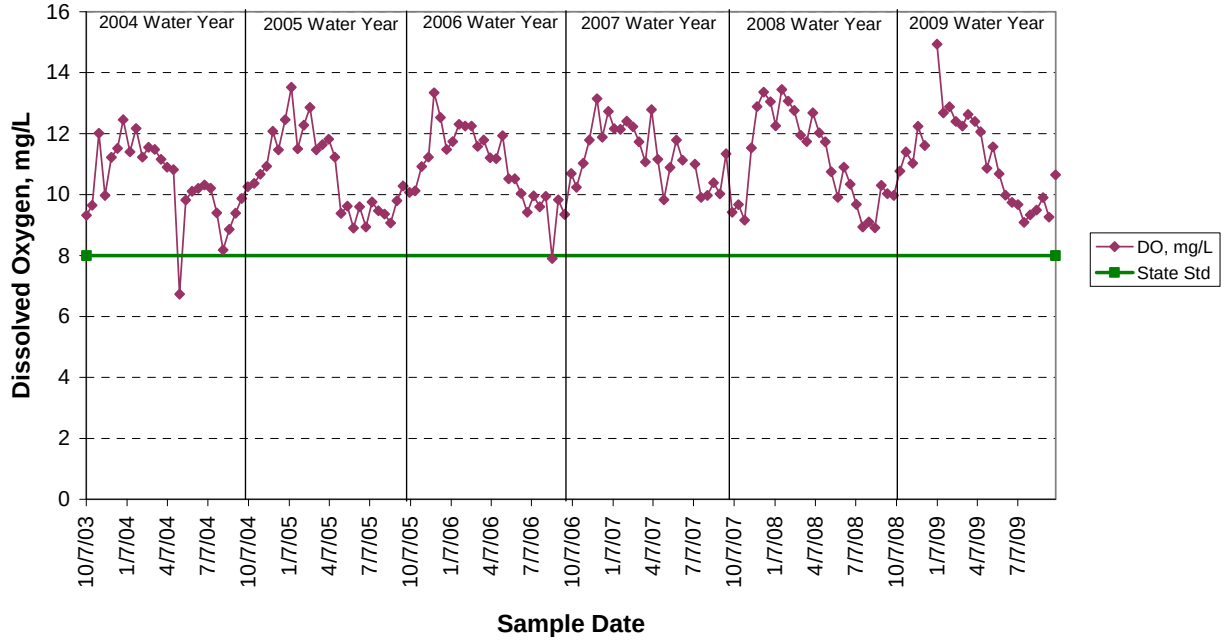
Table 6. Six-Year Dissolved Oxygen Results Summary
Mean Dissolved Oxygen levels for the five years of the Skagit County Monitoring Program

Site Number	Watercourse	Location	Mean Dissolved Oxygen (mg/L)					
			2004	2005	2006	2007	2008	2009
3	Thomas Ck	Old Hwy 99 North	6.5	5.9	6.2	6.1	6.2	6.4
4	Thomas Ck	F&S Grade	10.4	10.7	10.9	11.3	11.1	11.2
6	Friday Ck	Prairie Rd	10.5	11.2	11.1	11.6	11.5	11.3
8	Swede Ck	Grip Rd	10.4	11.1	11.2	11.5	11.3	10.9
11	Samish R	State Route 9	8.2	8.2	8.4	9.0	8.5	9.0
12	Nookachamps Ck	Swan Rd	9.0	9.4	9.5	9.1	10.0	9.7
13	E.F. Nookachamps Ck	State Route 9	9.3	9.8	10.3	10.4	10.3	10.0
14	College Way Ck	College Way	9.0	9.1	9.0	9.1	9.5	9.3
15	Nookachamps Ck	Knapp	7.8	7.8	8.2	7.8	8.6	7.3
16	E.F. Nookachamps Ck	Beaver Lake Rd	11.2	11.4	11.4	11.6	12.0	11.5
17	Nookachamps Ck	Big Lake Outlet	9.7	9.7	10.0	10.1	10.4	10.1
18	Lake Ck	State Route 9	10.7	11.1	11.2	11.5	11.3	11.2
19	Hansen Ck	Hoehn Rd	10	10.1	10.5	10.9	11.0	10.7
20	Hansen Ck	Northern State	10.5	11	11.2	11.4	11.4	11.1
21	Coal Ck	Hoehn Rd	10.7	11.1	11.4	11.4	11.5	11.1
22	Coal Ck	Hwy 20	11.7	11.8	11.9	12.2	12.2	12.1
23	Wiseman Ck	Minkler Rd	11.6	11.6	11.8	12.1	11.9	12.1
24	Mannser Ck	Lyman Hamilton Hwy	6.1	6.2	6.8	7.6	6.9	7.0
25	Red Cabin Ck	Hamilton Cem Rd	11.6	11.5	11.9	12.2	11.8	12.5
28	Brickyard Ck	Hwy 20	8.6	9.2	9.2	9.9	9.7	9.7
29	Skagit R	R Bend Rd	11.2	10.8	11.3	11.2	10.9	11.2
30	Skagit R	Cape Horn Rd	11.0	11.1	11.3	11.7	11.3	11.4
31	DD20 near floodgate	Francis Rd	8.7	8.1	9.0	7.6	7.8	8.2
32	Samish R	Thomas Rd	10.3	10.8	10.8	11.1	10.9	10.9
33	Alice Bay Pump Station	Samish Island Rd	10.4	7.6	9.5	11.7	8.4	9.6
34	Noname Slough	Bayview-Edison Rd	5.9	6.6	6.6	6.1	6.9	6.7
35	Joe Leary Slough	D'Arcy Rd	5.2	4.0	5.0	6.3	5.7	5.7
36	Edison Slough at school	W. Bow Hill Rd	9.3	7.6	8.4	9.3	8.4	9.7
37	Edison Pump Station	Farm to Market Rd	7.6	5.5	5.8	7.6	7.3	7.7
38	North Edison Pump Station	North Edison Rd	6.5	7.0	6.4	9.1	7.6	8.9
39	Colony Ck	Colony Rd	10.1	10.8	10.8	11.1	11.3	11.1
40	Big Indian Slough	Bayview-Edison Rd	4.0	4.6	4.8	5.4	7.5	5.5
41	Maddox Slough/Big Ditch	Milltown Rd	5.2	5.2	5.9	7.0	6.3	6.6
42	Hill Ditch	Cedardale Rd	6.7	7.1	7.6	8.0	6.9	7.9
43	Wiley Slough	Wylie Rd	4.9	4.2	4.6	6.2	6.5	5.1
44	Rexville PS/Sullivan Slough	La Conner-Whit Rd	4.2	10.4	8.6	8.0	7.4	7.4
45	Skagit R – North Fork	Moore Rd	11.2	11.1	11.4	11.2	11.2	11.5
46	Skagit R – South Fork	Fir Island Rd	11	11	11.3	11.1	11.3	11.4
47	Swinomish Channel	County Boat Launch	8.4	8.7	8.8	9.2	8.9	8.5
48	Fisher Ck	Franklin Rd	10.8	10.9	11	11.3	11.0	11.1

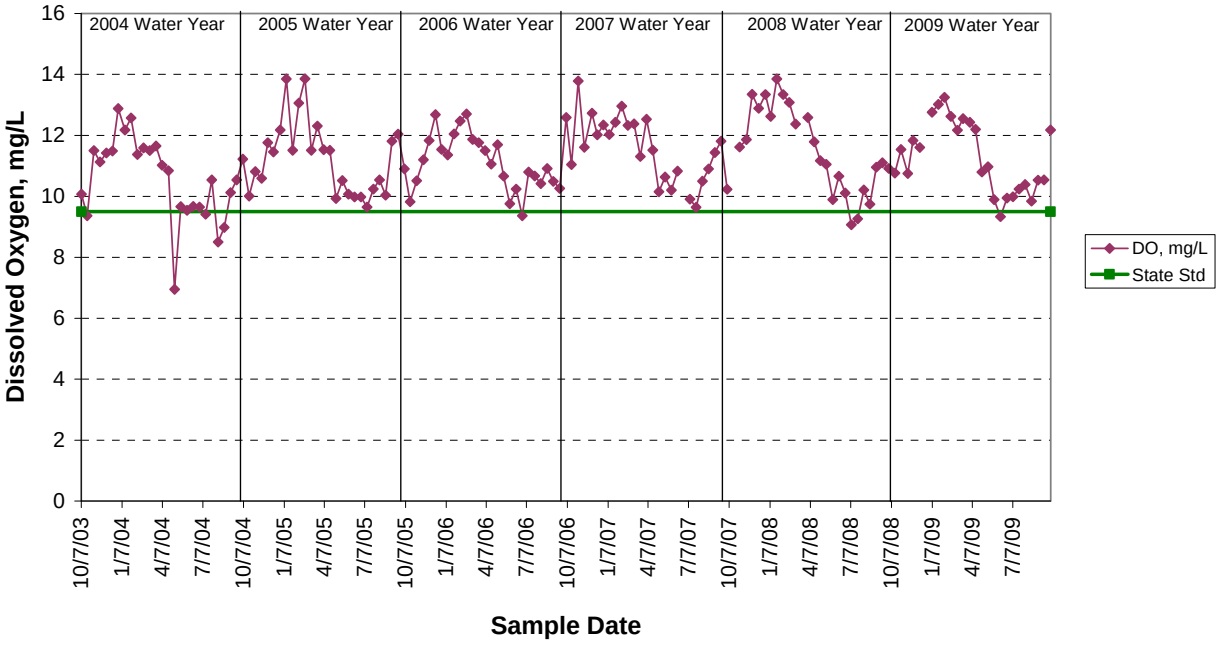
Thomas Creek at Hwy 99 - Site 3
Dissolved Oxygen



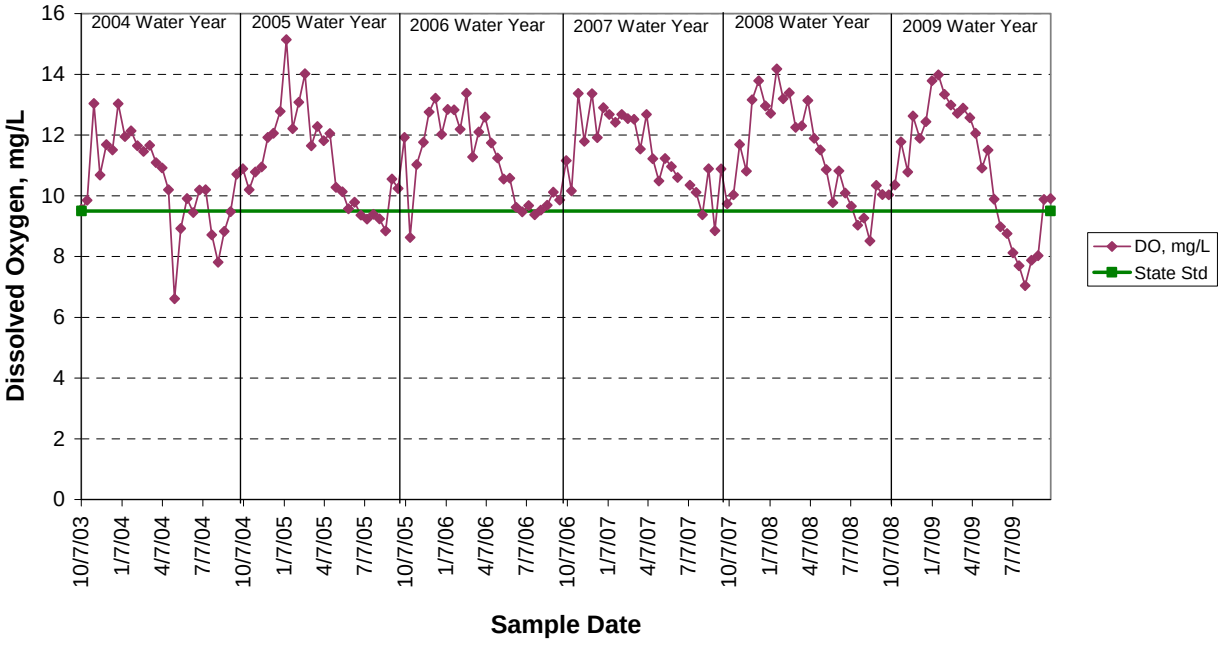
Thomas Creek at F&S Grade Rd - Site 4
Dissolved Oxygen



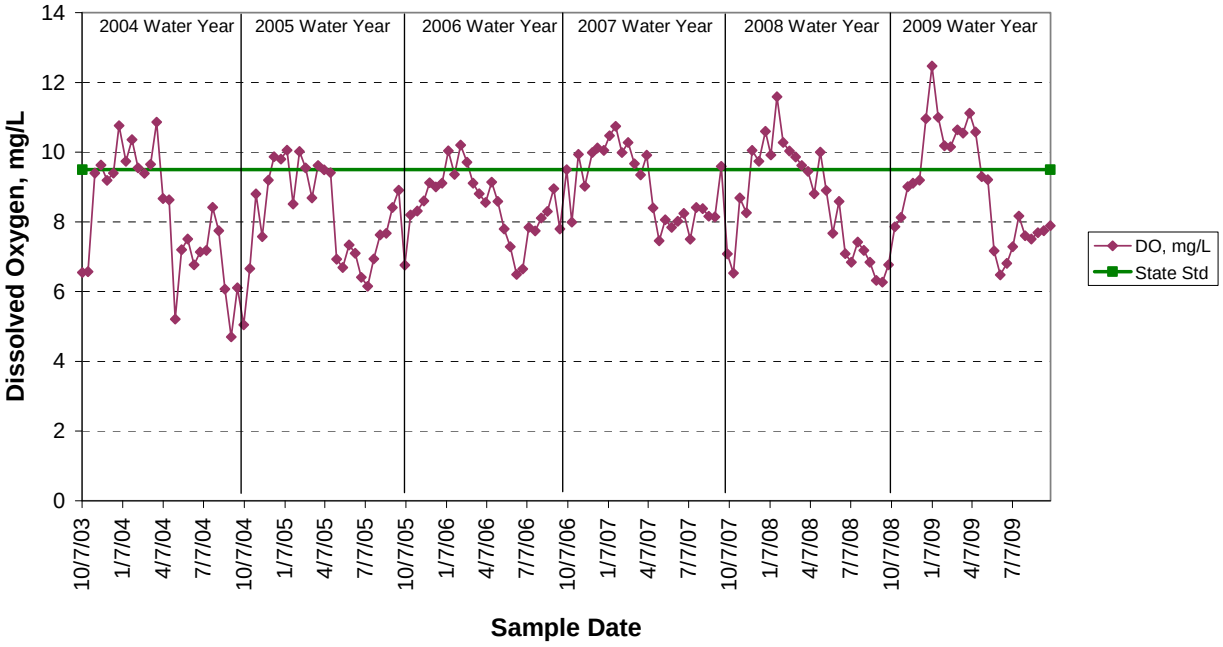
Friday Creek at Prairie Rd - Site 6
Dissolved Oxygen



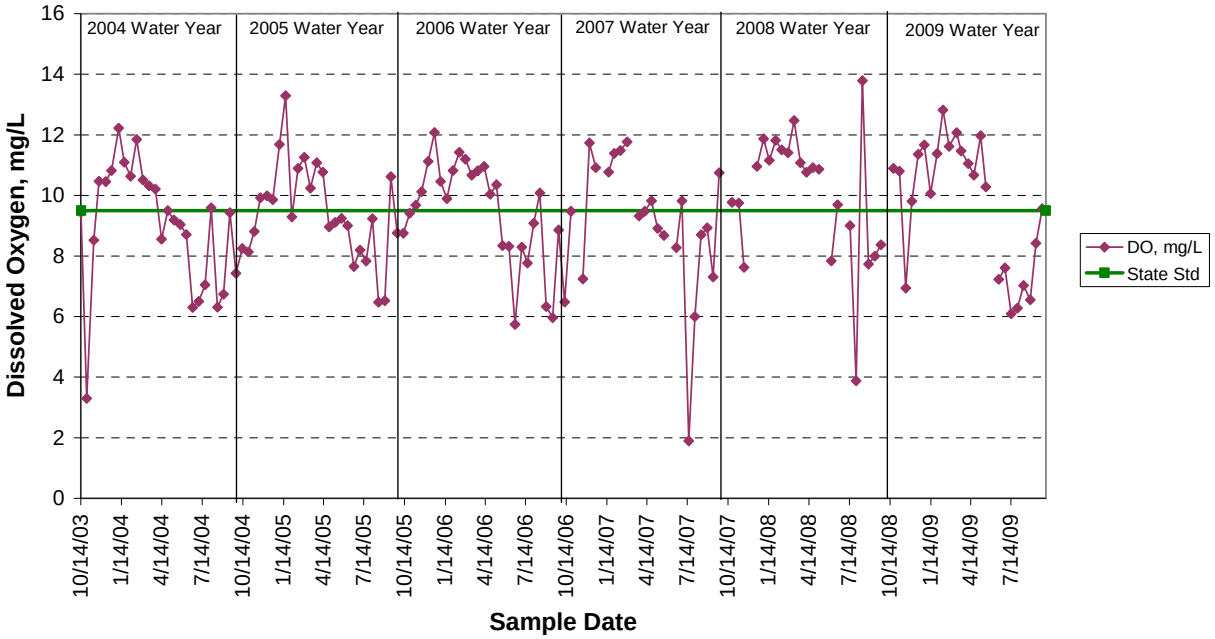
Swede Creek at Grip Rd - Site 8
Dissolved Oxygen



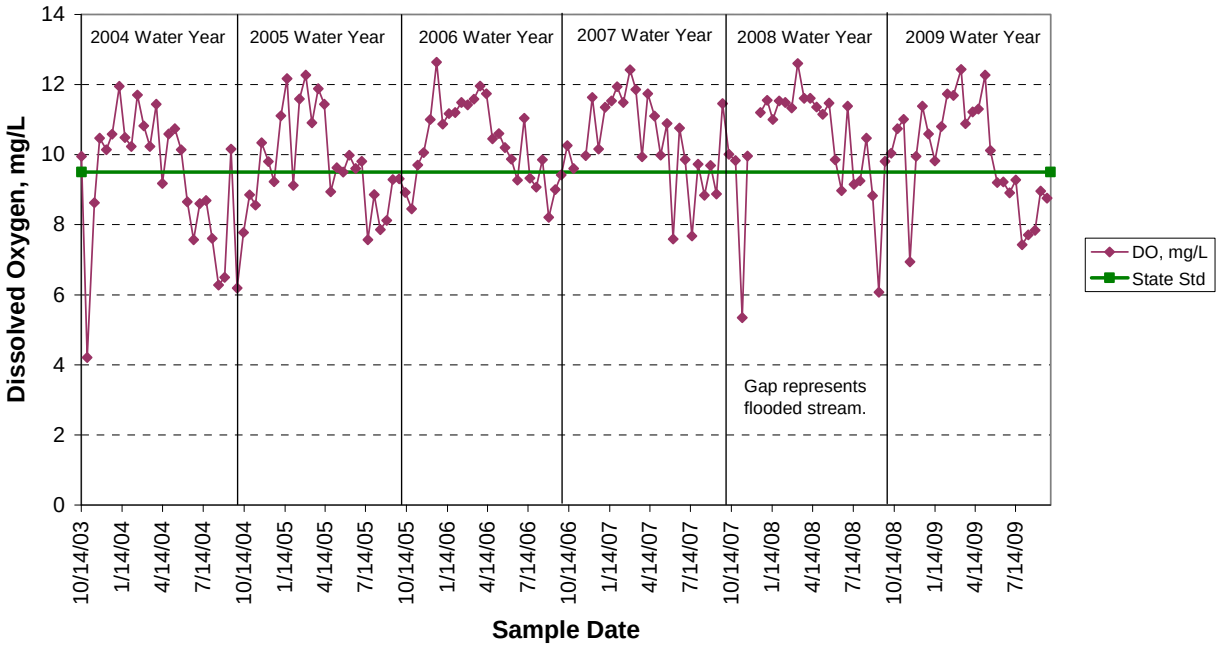
Samish River at Hwy 9 - Site 11
Dissolved Oxygen



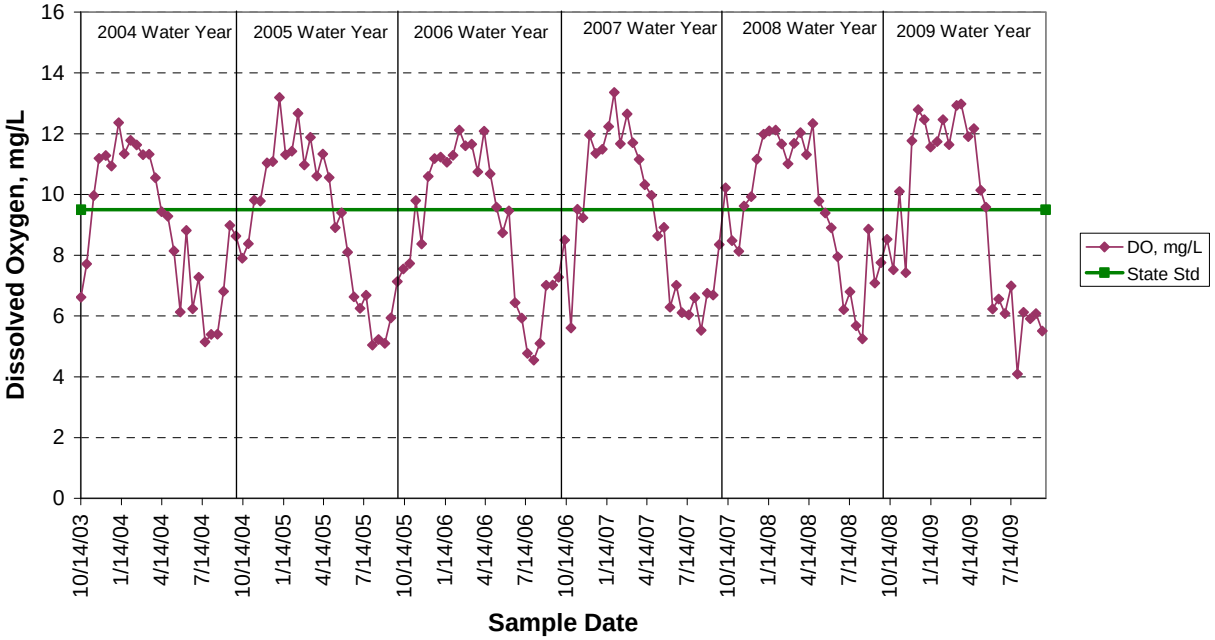
Nookachamps Creek at Swan Rd - Site 12
Dissolved Oxygen



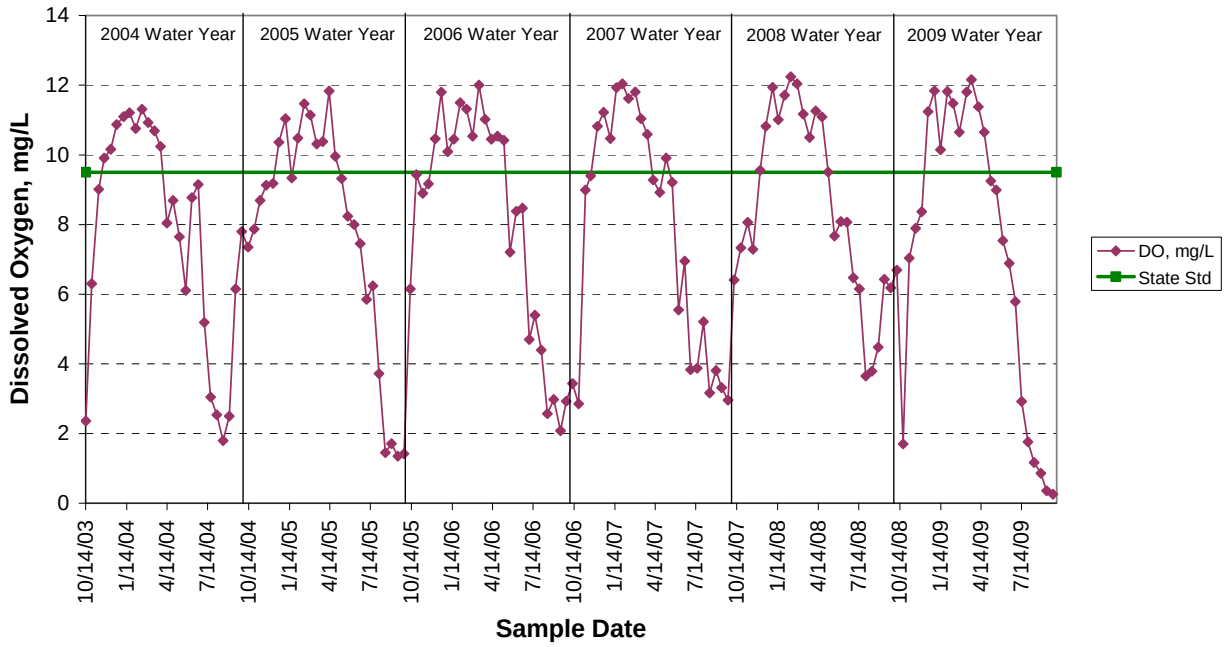
E.F. Nookachamps Creek at Hwy 9 - Site 13
Dissolved Oxygen



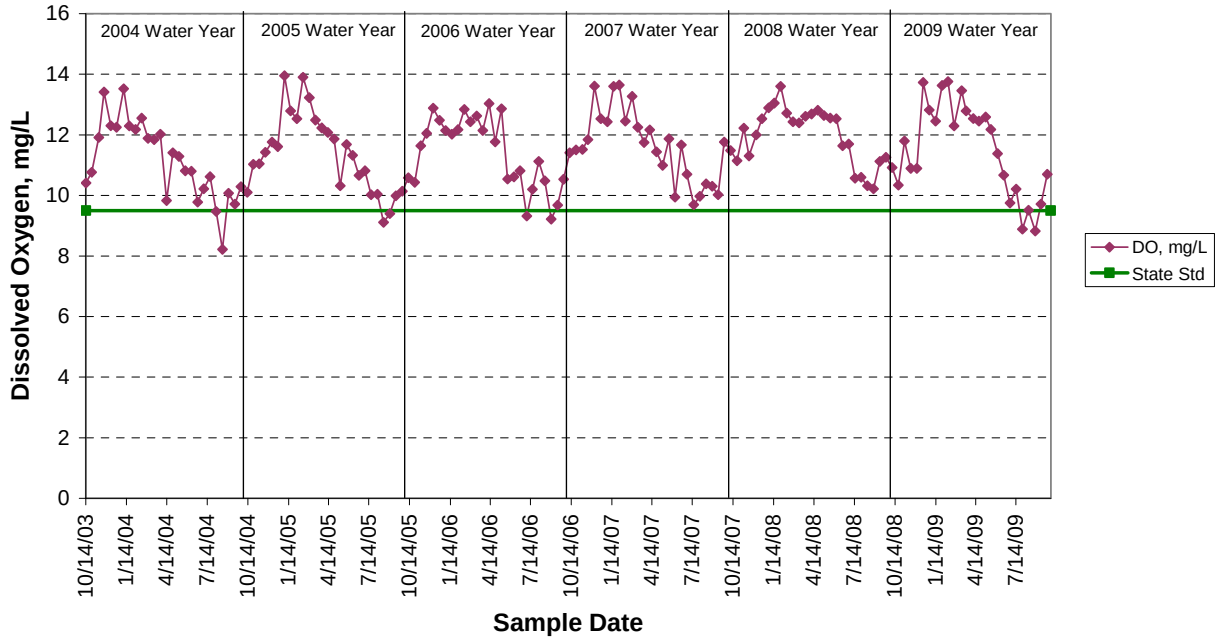
College Way Creek at College Way - Site 14
Dissolved Oxygen



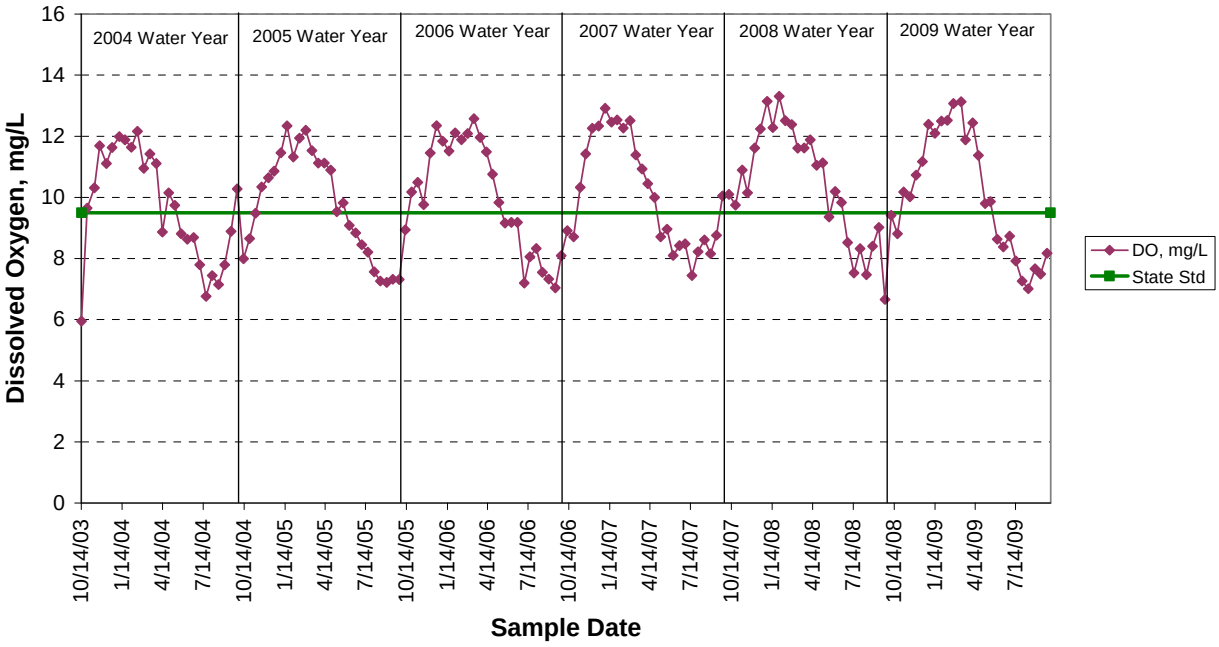
Nookachamps Creek at Knapp Rd - Site 15
Dissolved Oxygen



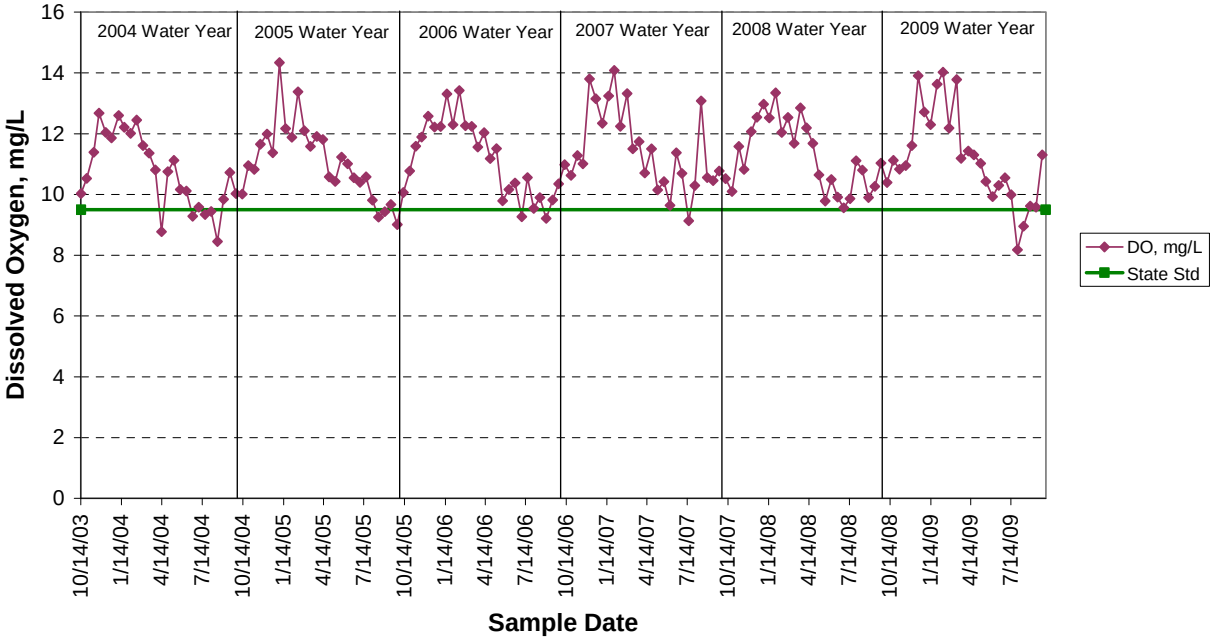
E.F. Nookachamps Creek at Beaver Lake Rd - Site 16
Dissolved Oxygen



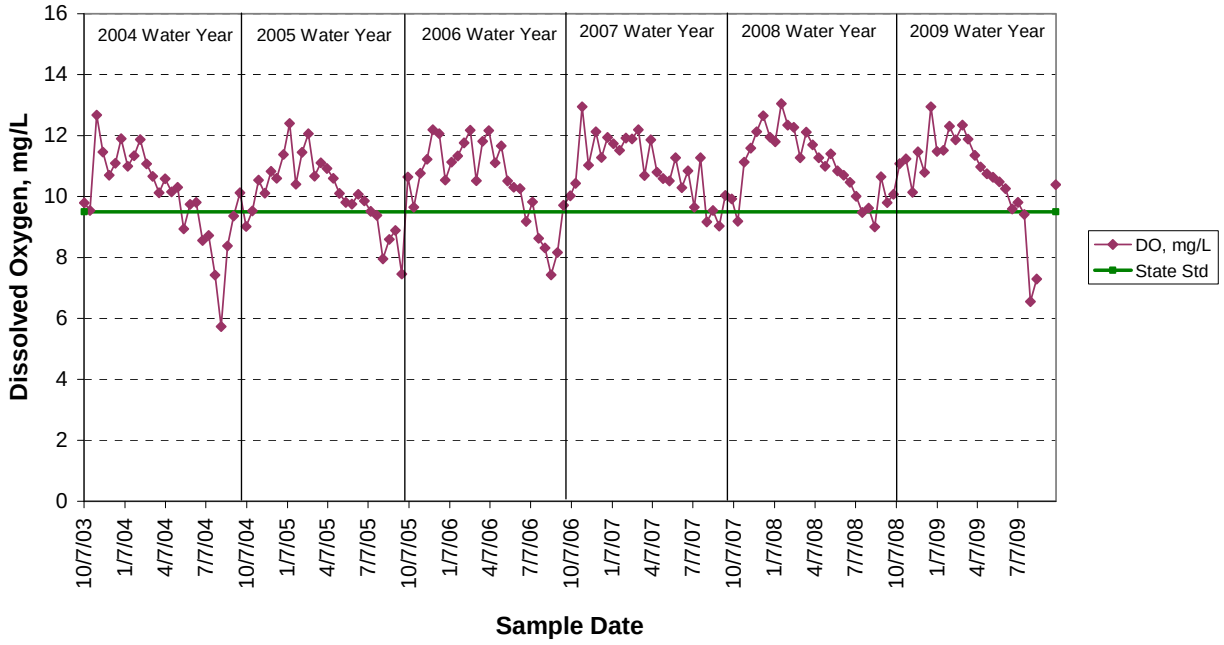
Nookachamps Creek at Big Lake Outlet - Site 17
Dissolved Oxygen



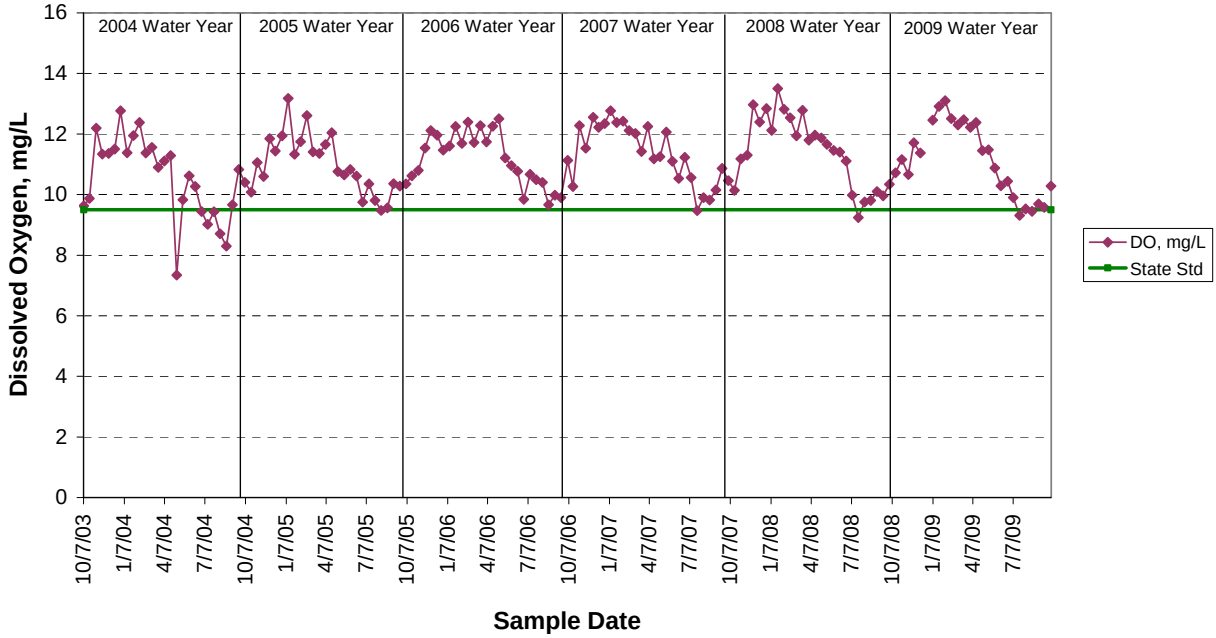
Lake Creek at Hwy 9 - Site 18
Dissolved Oxygen



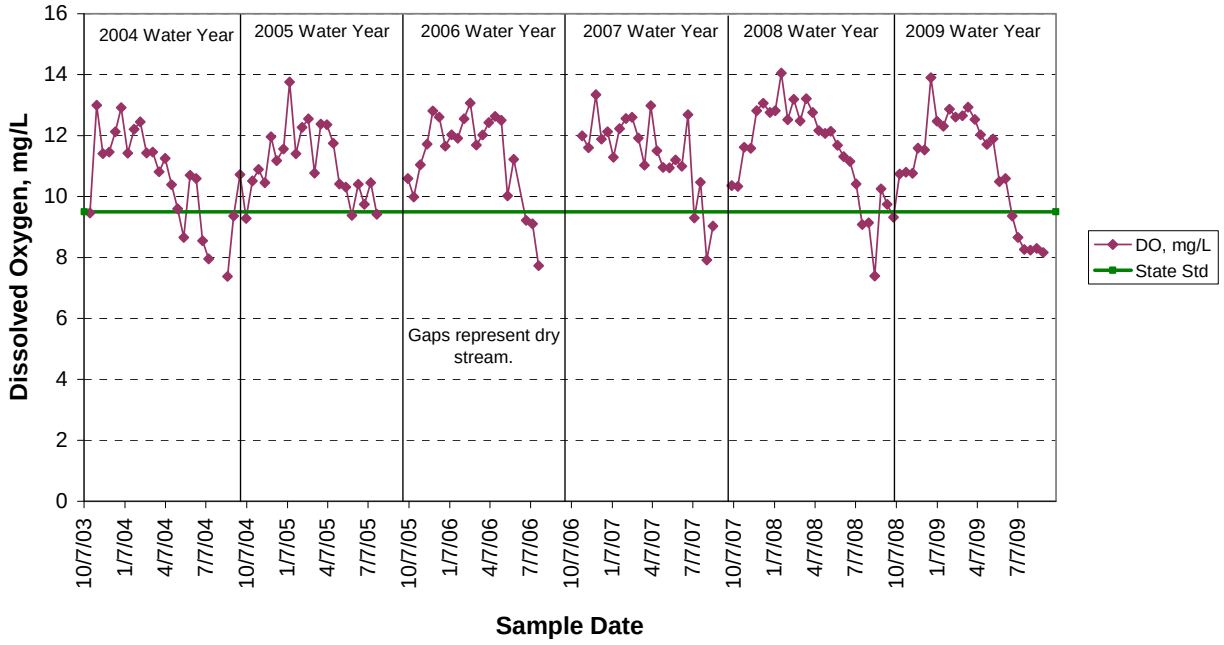
Hansen Creek at Hoehn Rd - Site 19
Dissolved Oxygen



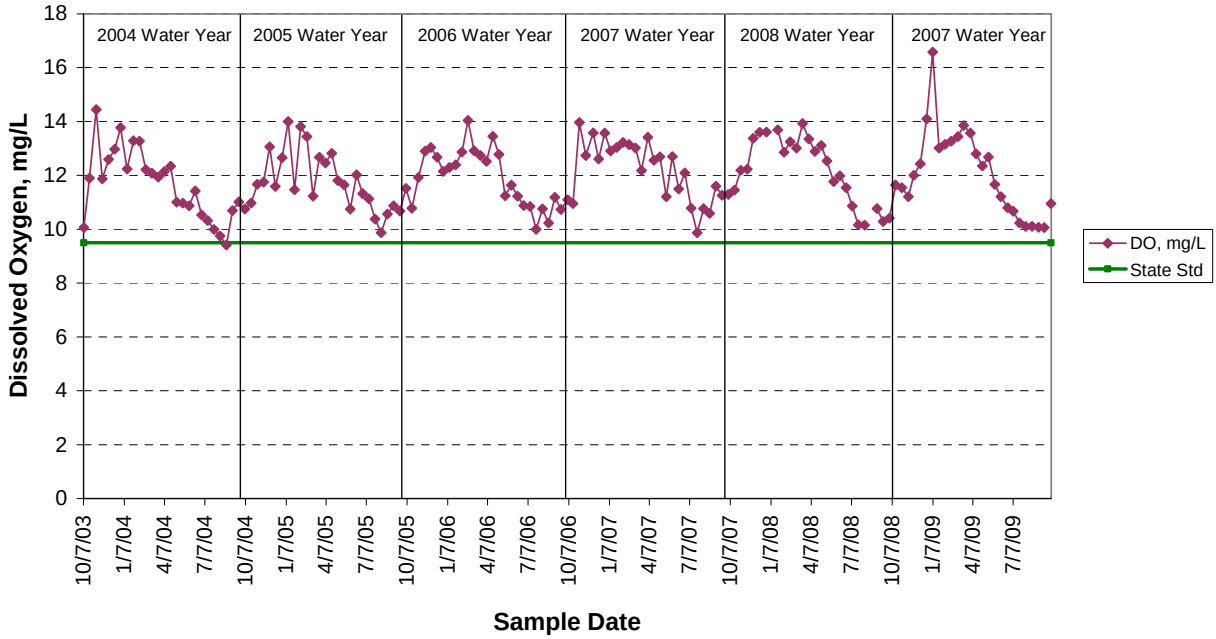
Hansen Creek at Northern State Hospital - Site 20
Dissolved Oxygen



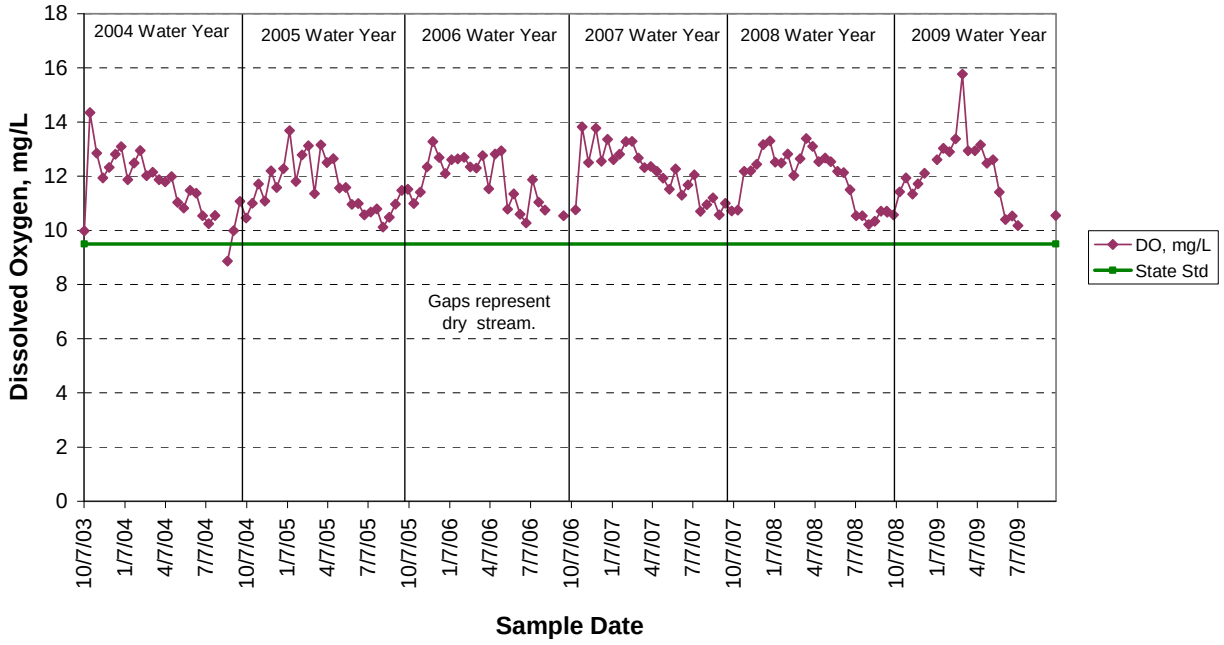
Coal Creek at Hoehn Rd - Site 21
Dissolved Oxygen



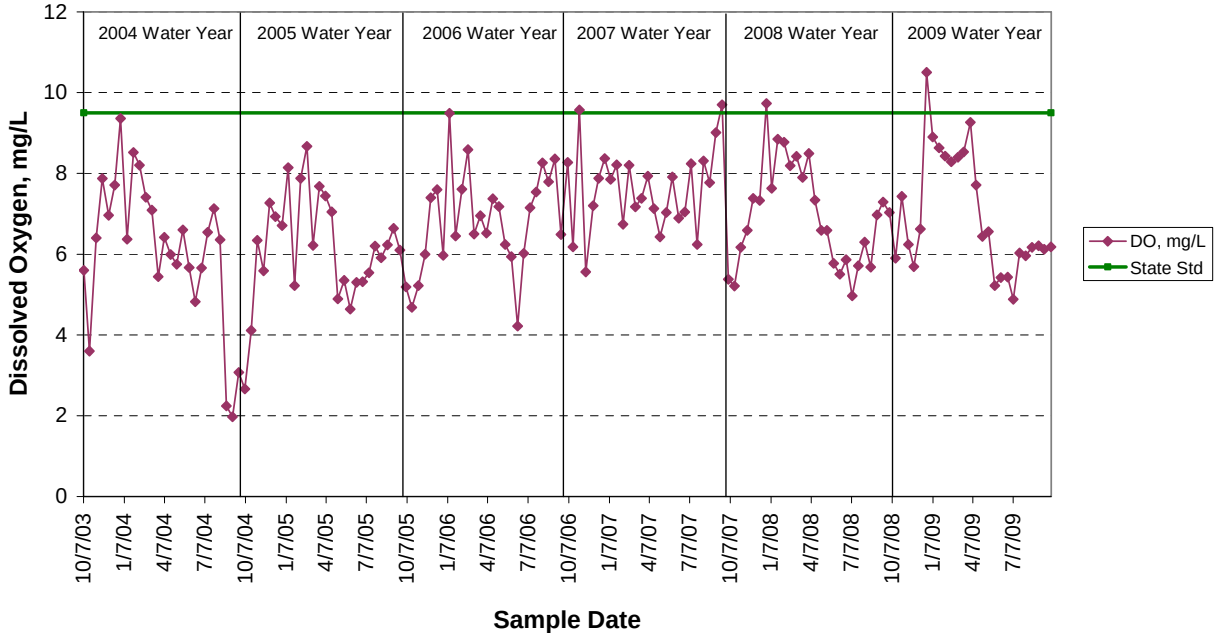
Coal Creek at Hwy 20 - Site 22
Dissolved Oxygen



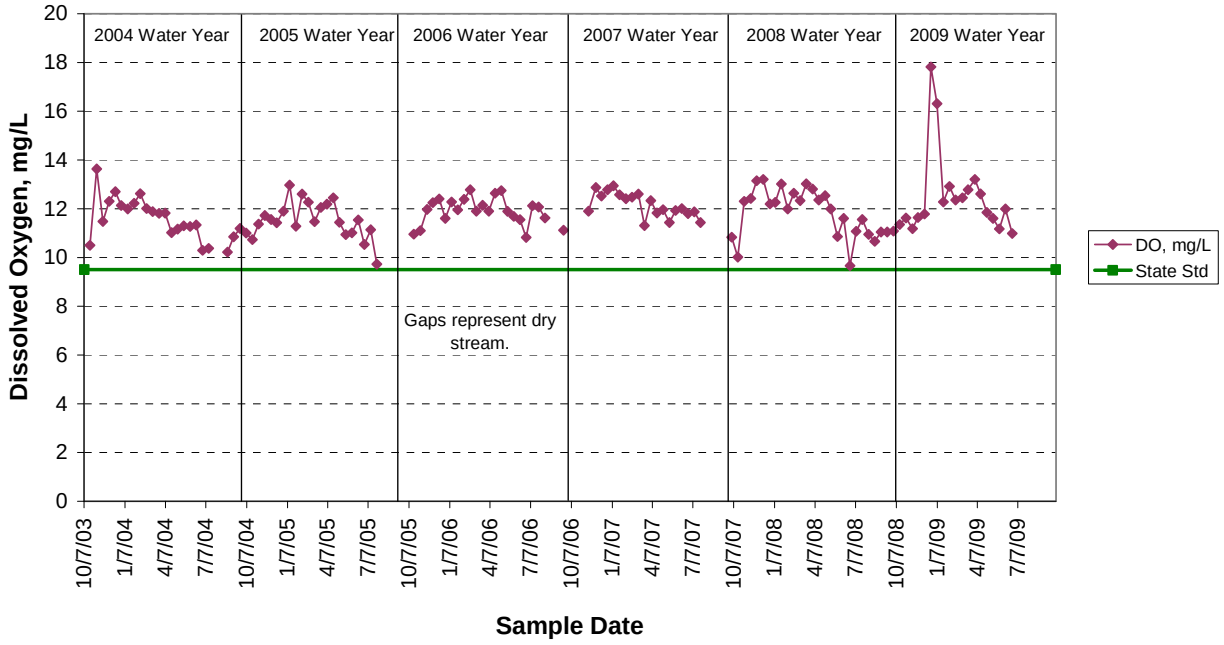
Wiseman Creek at Minkler Rd - Site 23
Dissolved Oxygen



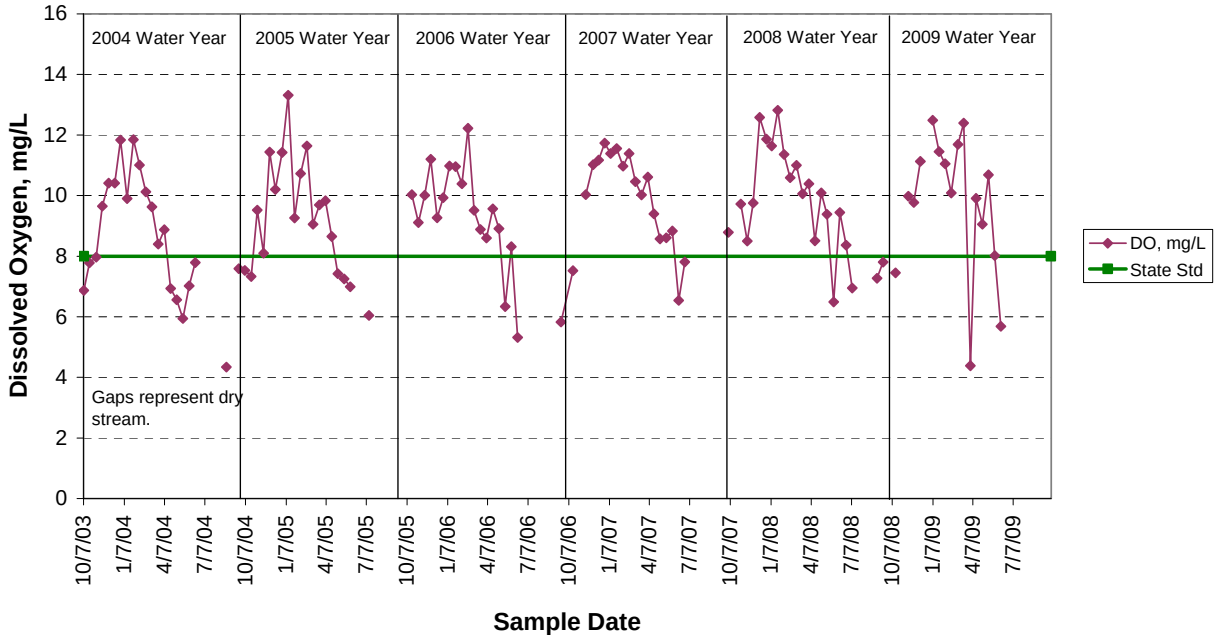
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Dissolved Oxygen



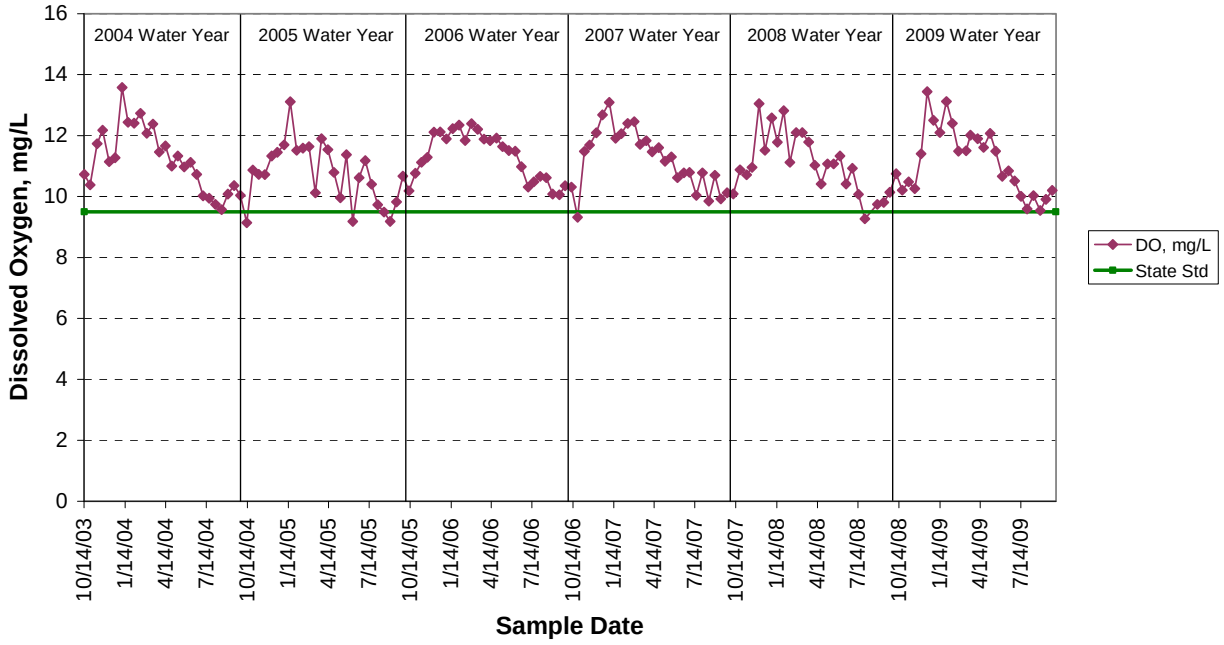
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Dissolved Oxygen



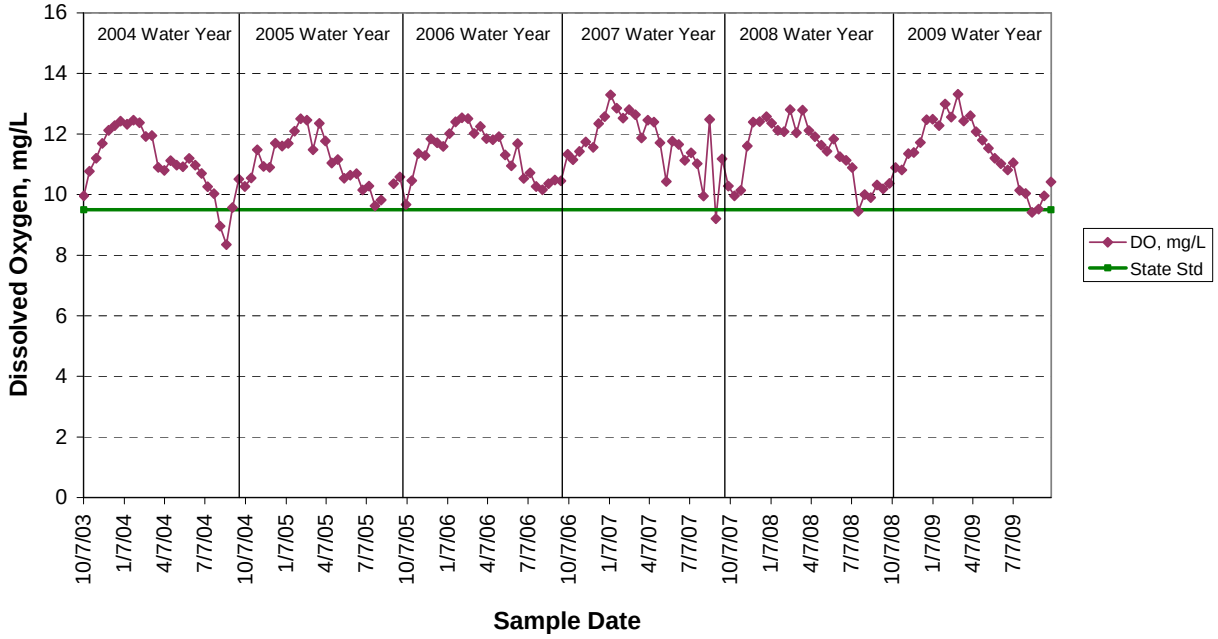
Brickyard Creek at Hwy 20 - Site 28
Dissolved Oxygen



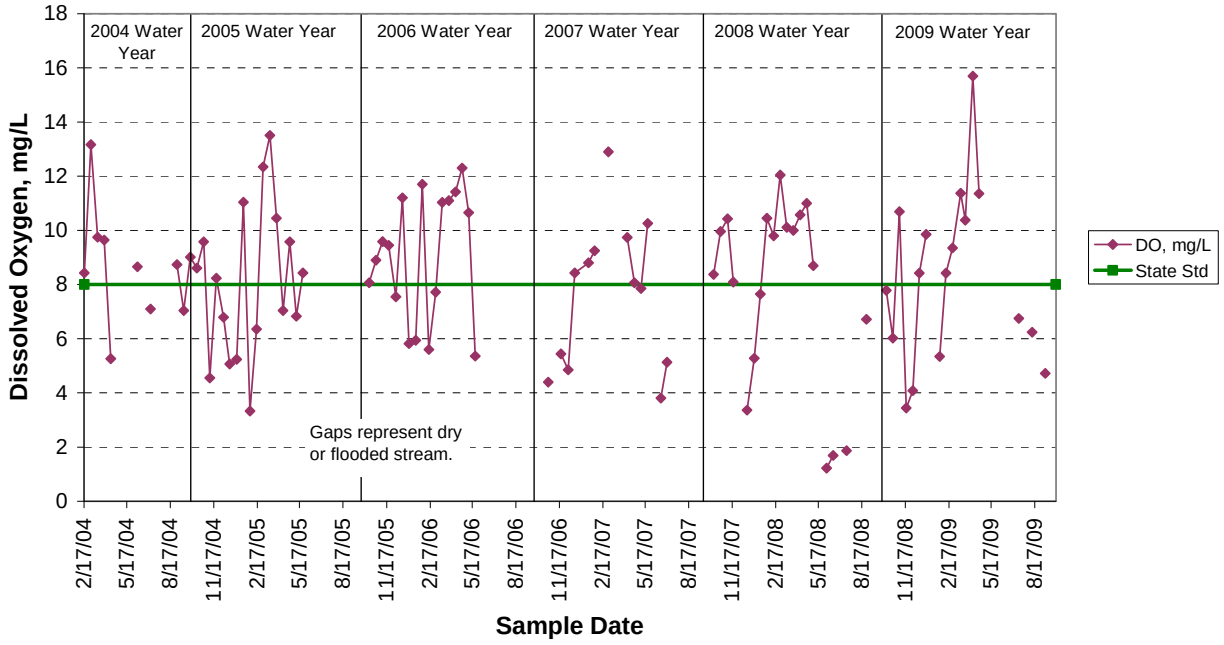
Skagit River at River Bend - Site 29
Dissolved Oxygen



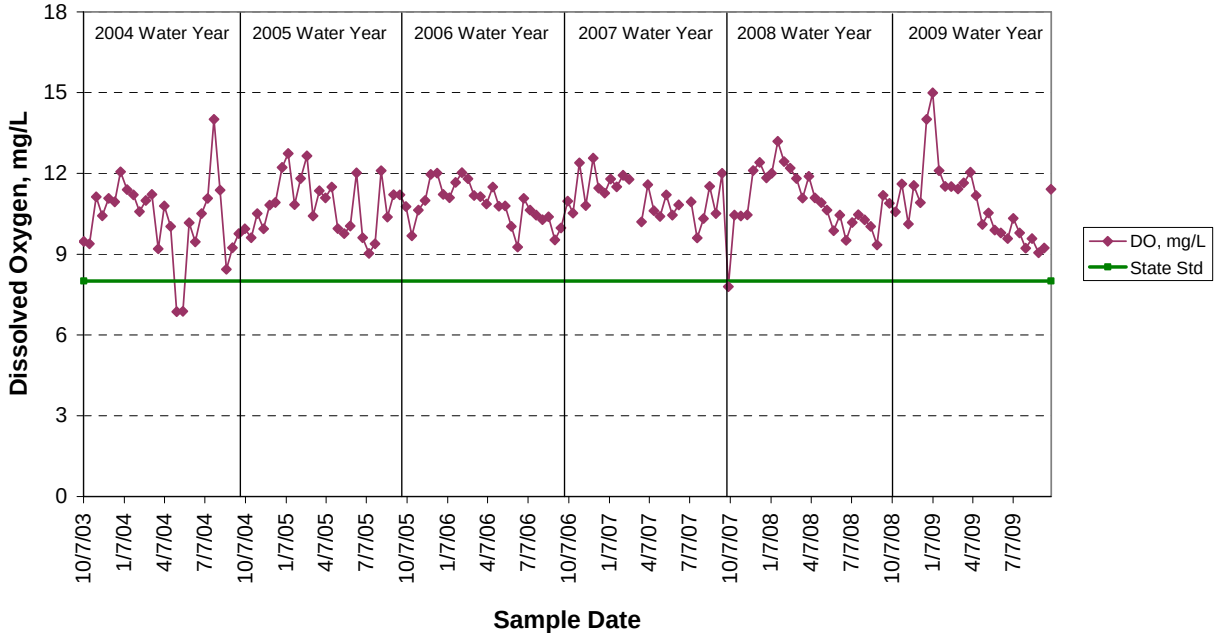
Skagit River at Cape Horn Rd - Site 30
Dissolved Oxygen



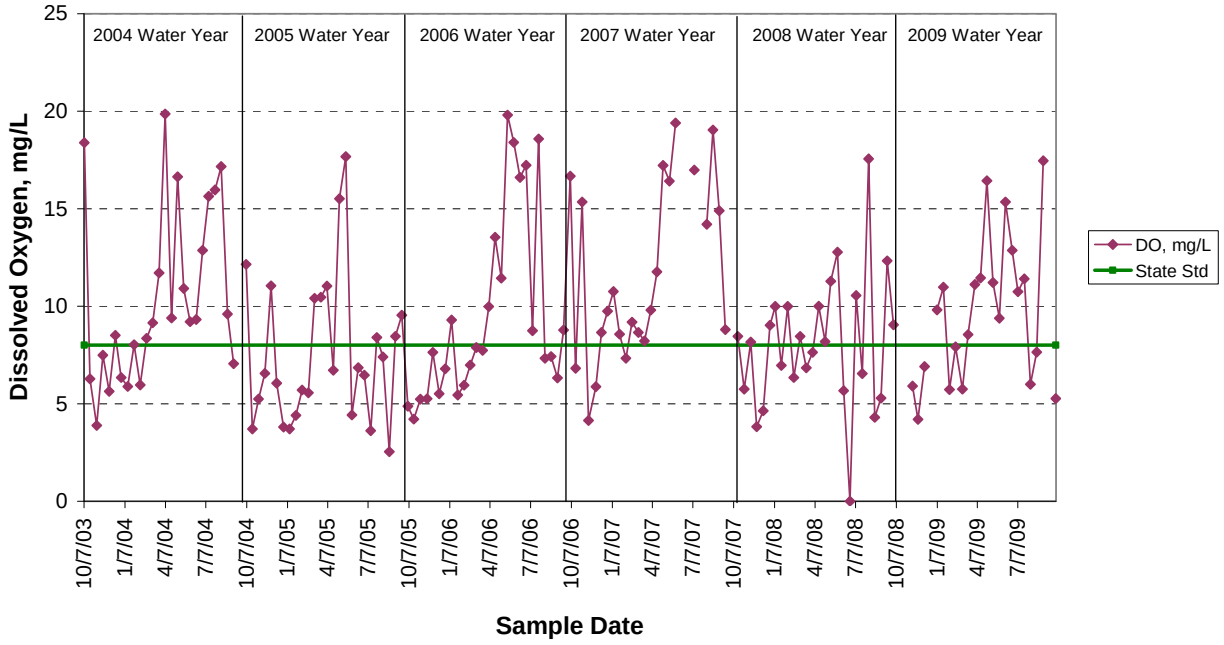
Drainage District 20 Ditch at Floodgate - Site 31
Dissolved Oxygen



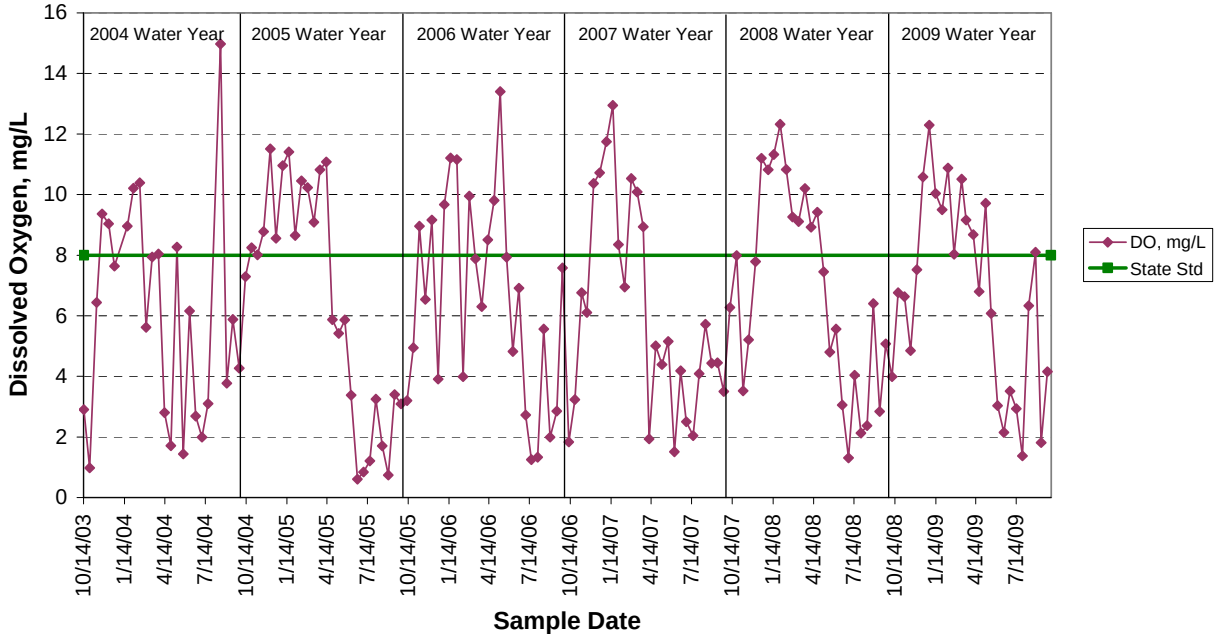
Samish River at Thomas Rd - Site 32
Dissolved Oxygen



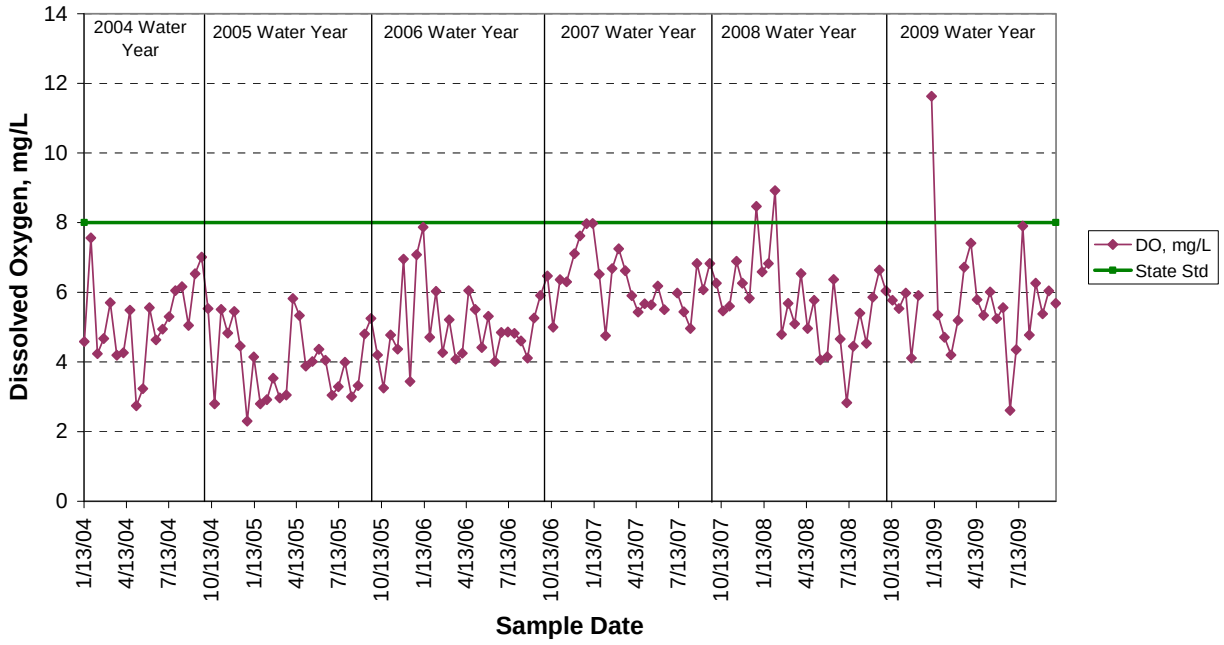
Alice Bay Pump Station - Site 33
Dissolved Oxygen



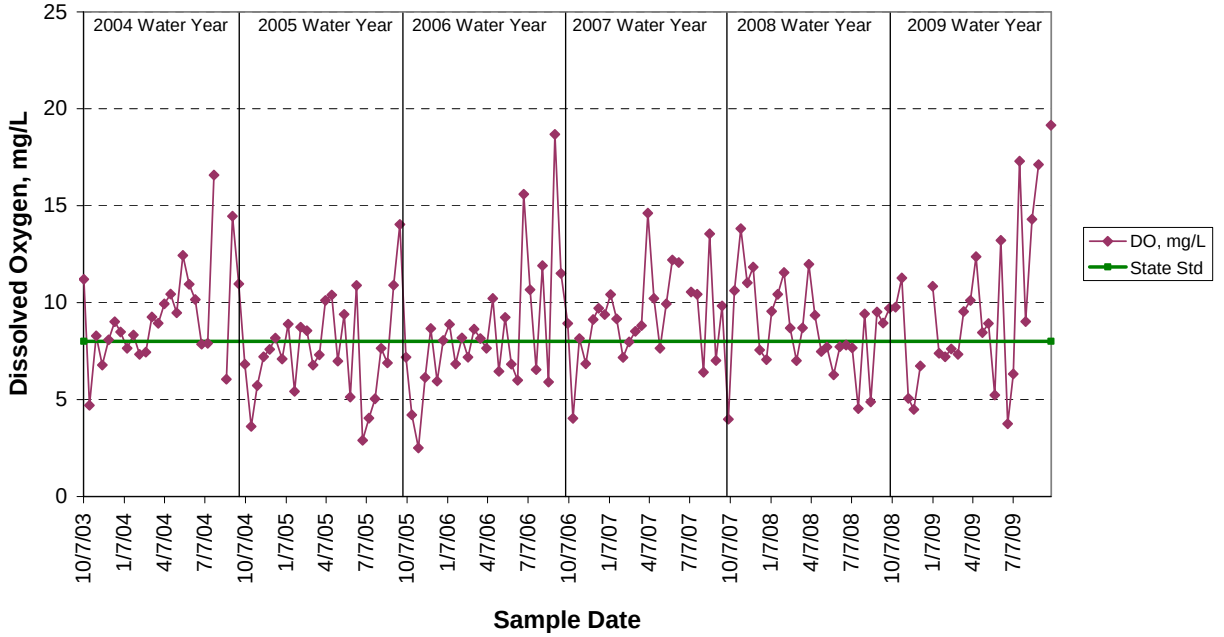
No Name Slough at Bayview-Edison Rd - Site 34
Dissolved Oxygen



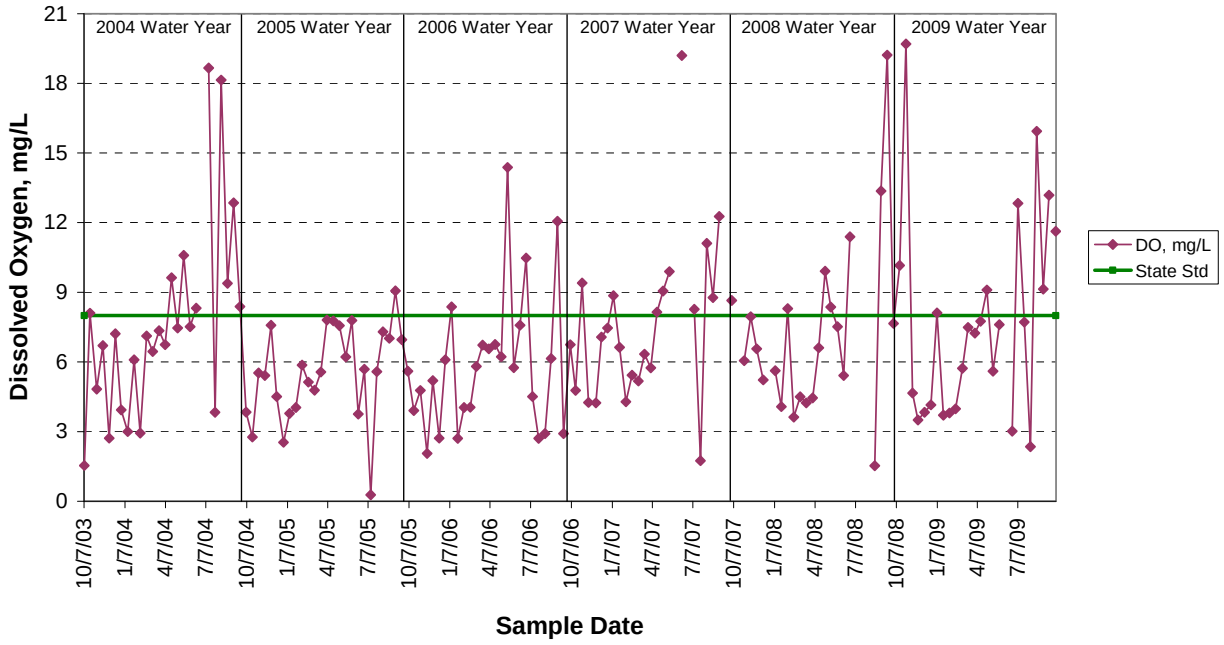
Joe Leary Slough at D'Arcy Rd - Site 35
Dissolved Oxygen



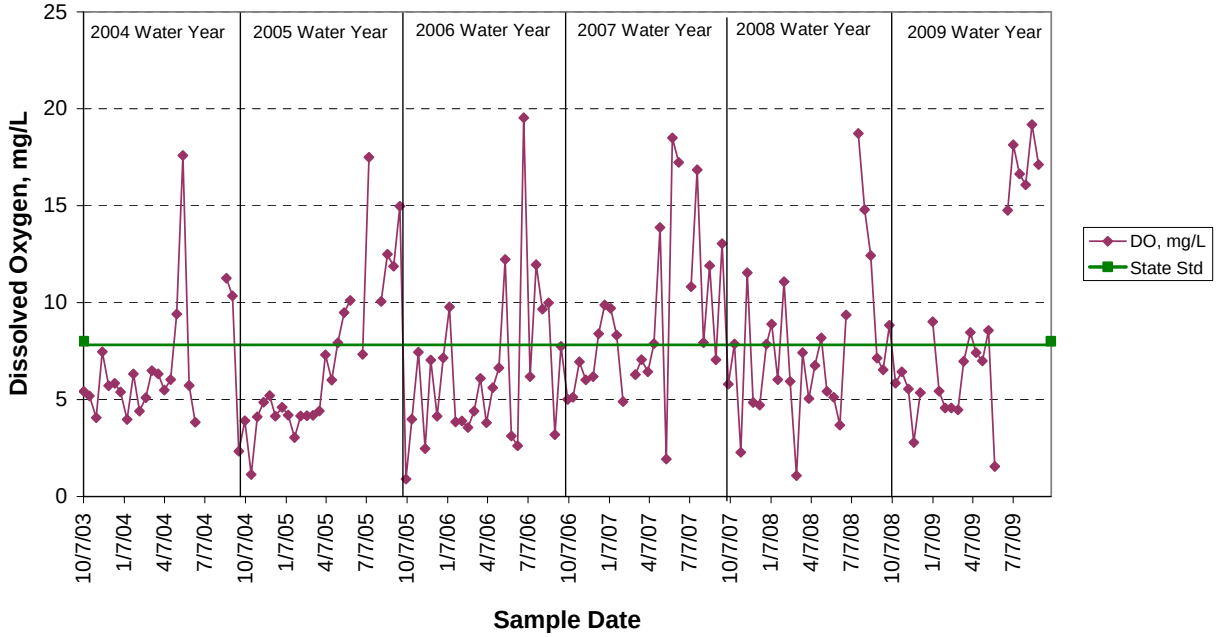
Edison Slough at Edison School - Site 36
Dissolved Oxygen



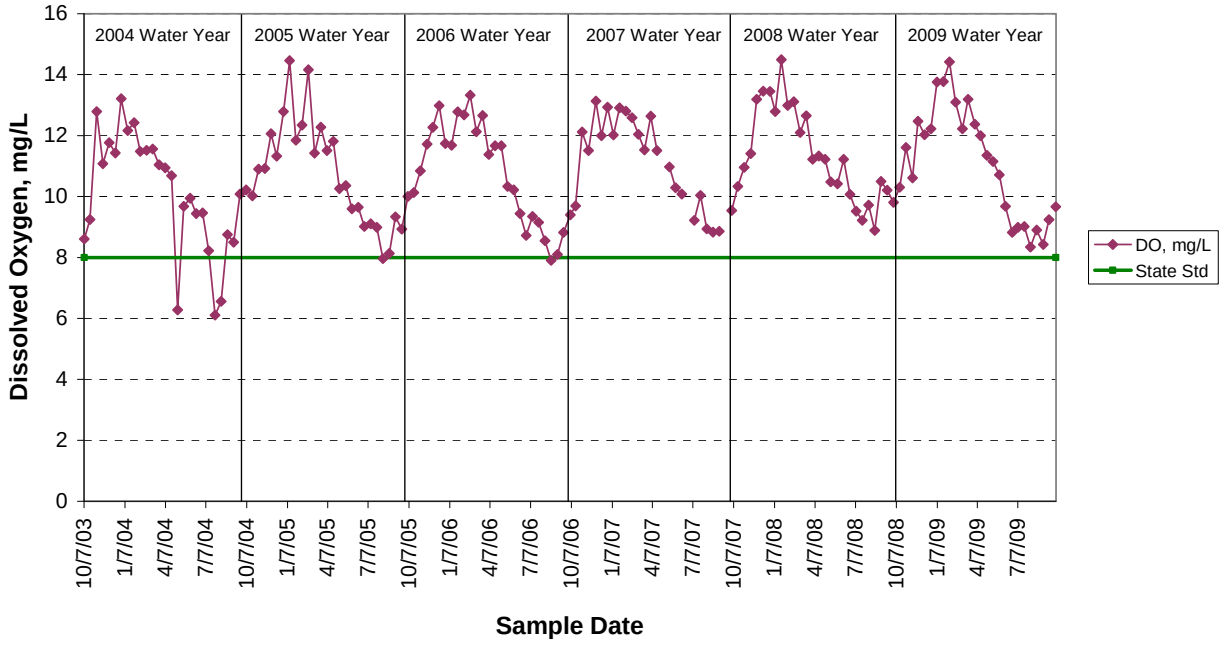
Edison Pump Station - Site 37
Dissolved Oxygen



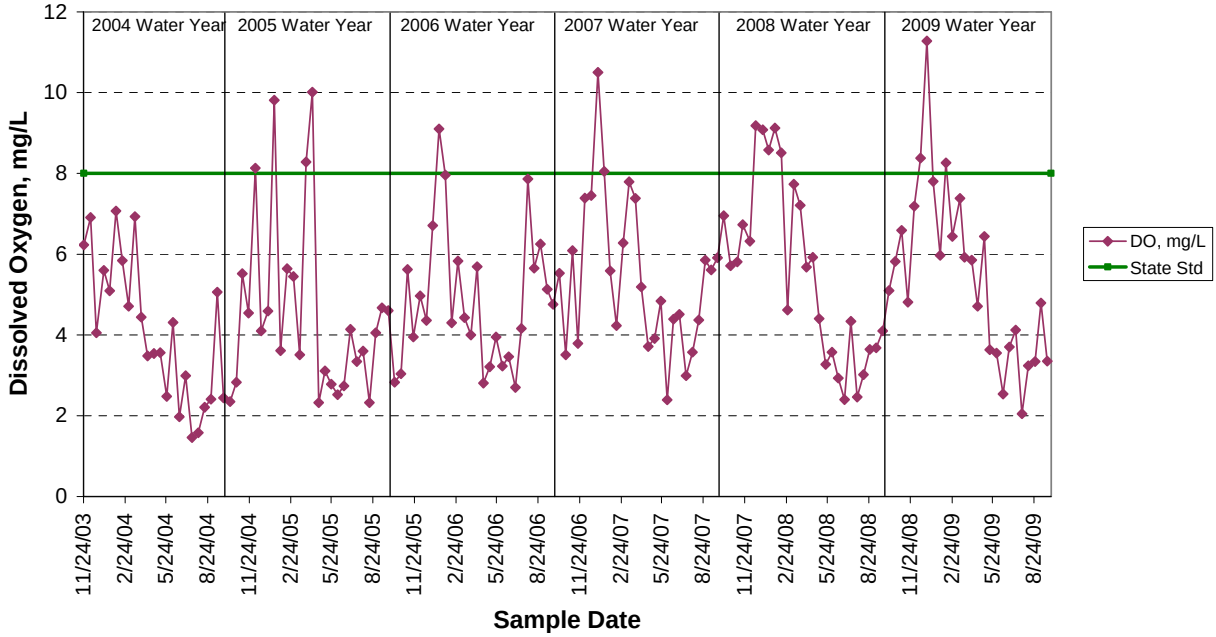
North Edison Pump Station - Site 38
Dissolved Oxygen



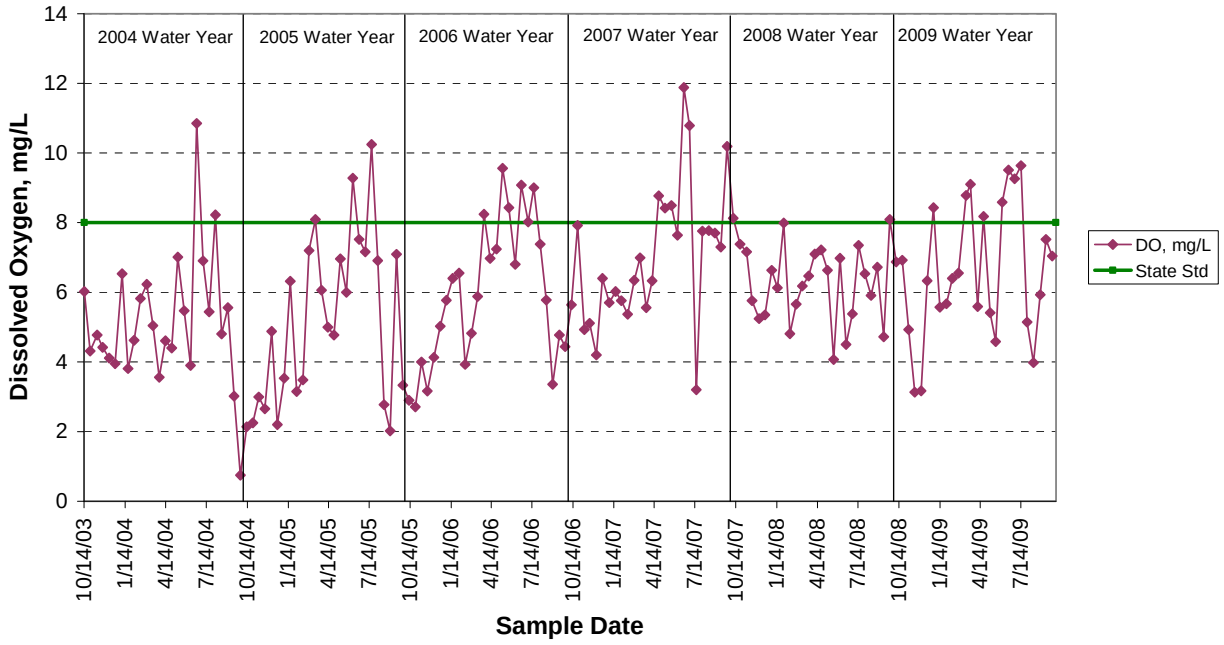
Colony Creek at Colony Rd - Site 39
Dissolved Oxygen



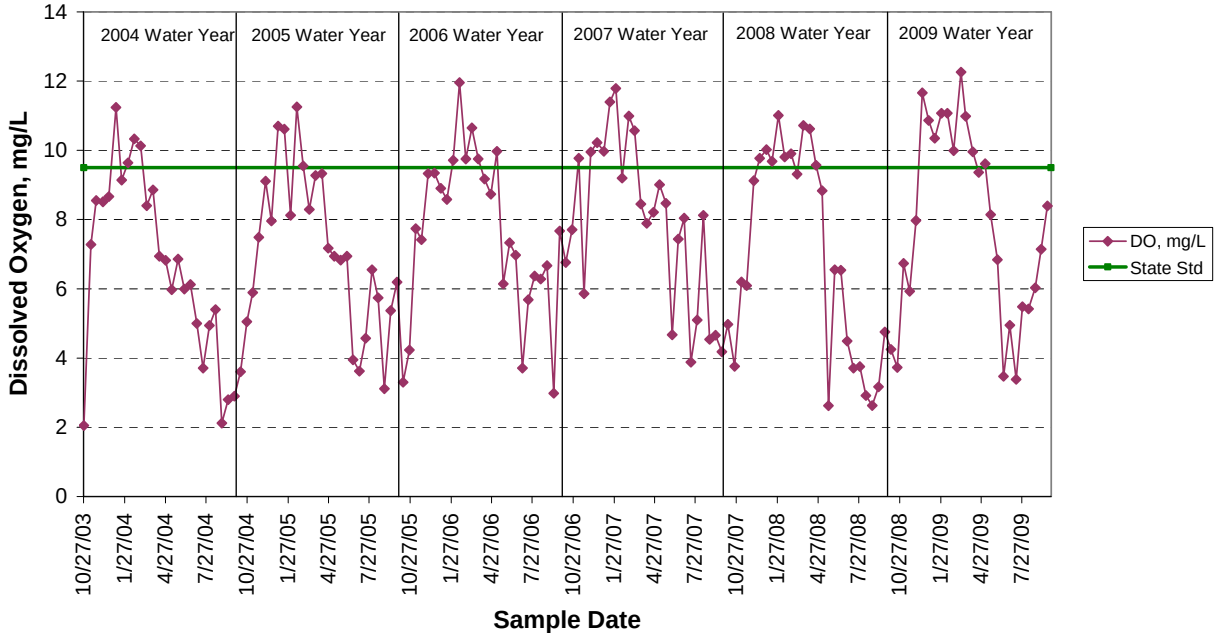
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Dissolved Oxygen



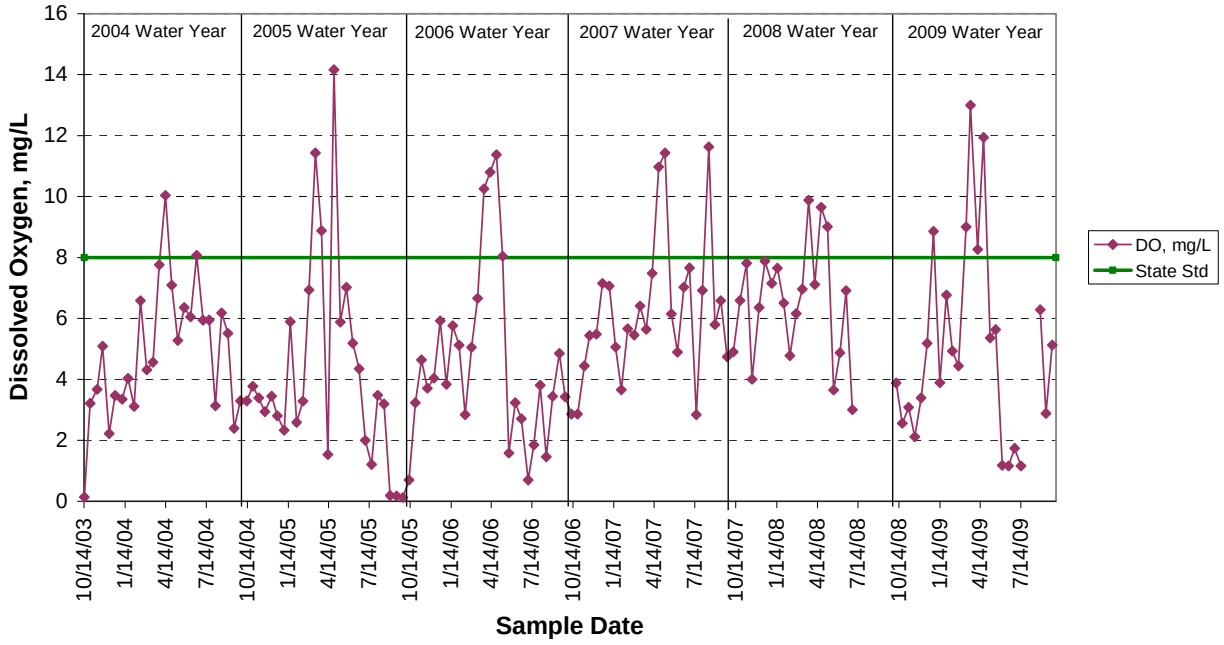
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Dissolved Oxygen



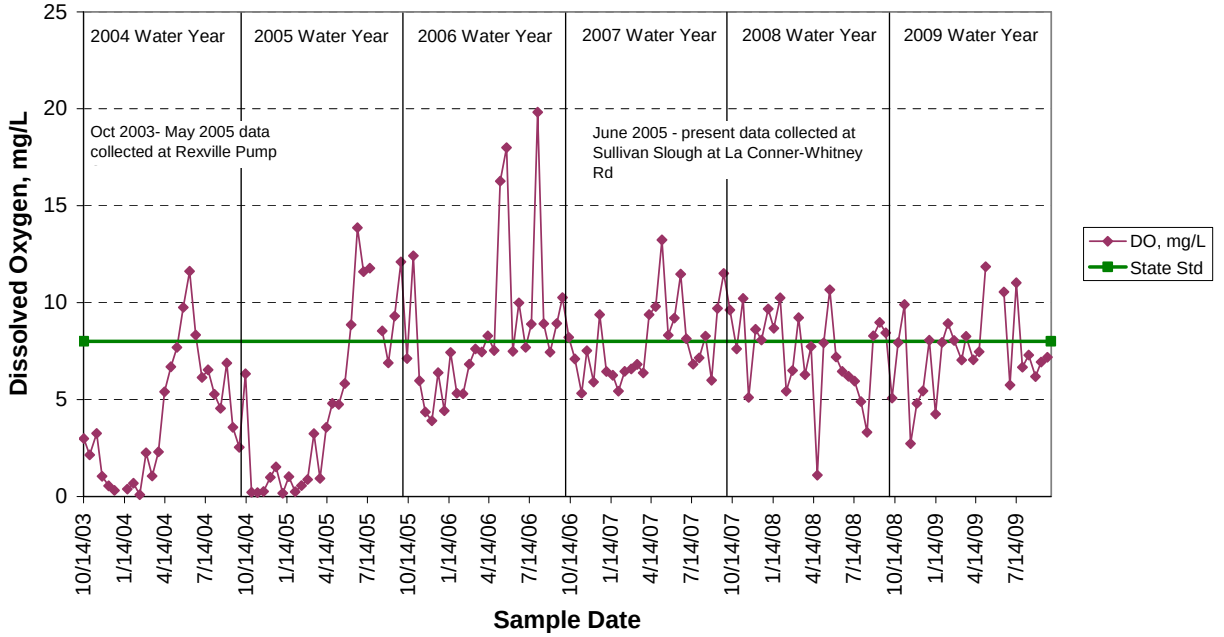
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Dissolved Oxygen



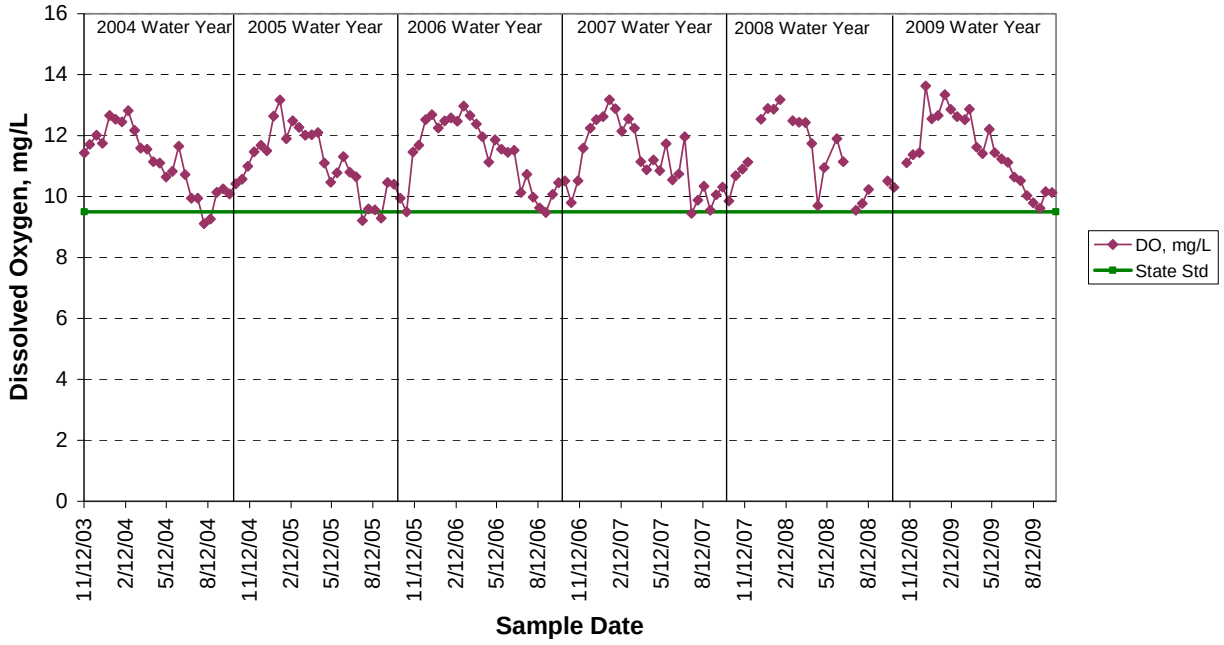
Wiley Slough at Wylie Rd - Site 43
Dissolved Oxygen



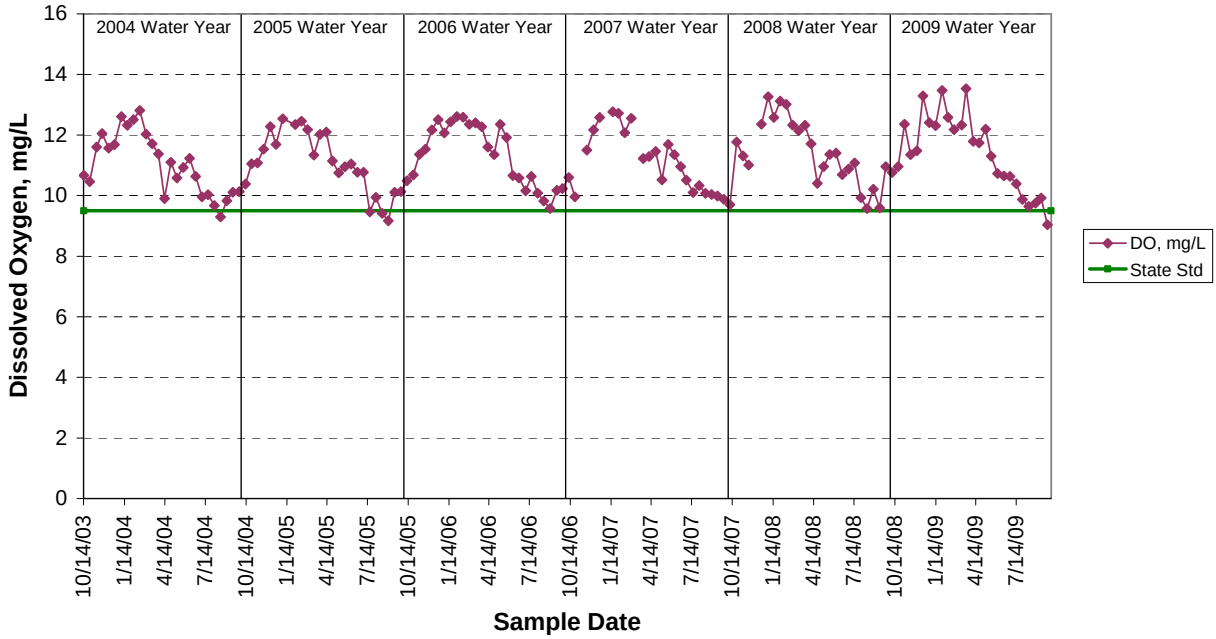
Sullivan Slough at La Conner-Whitney Rd - Site 44
Dissolved Oxygen



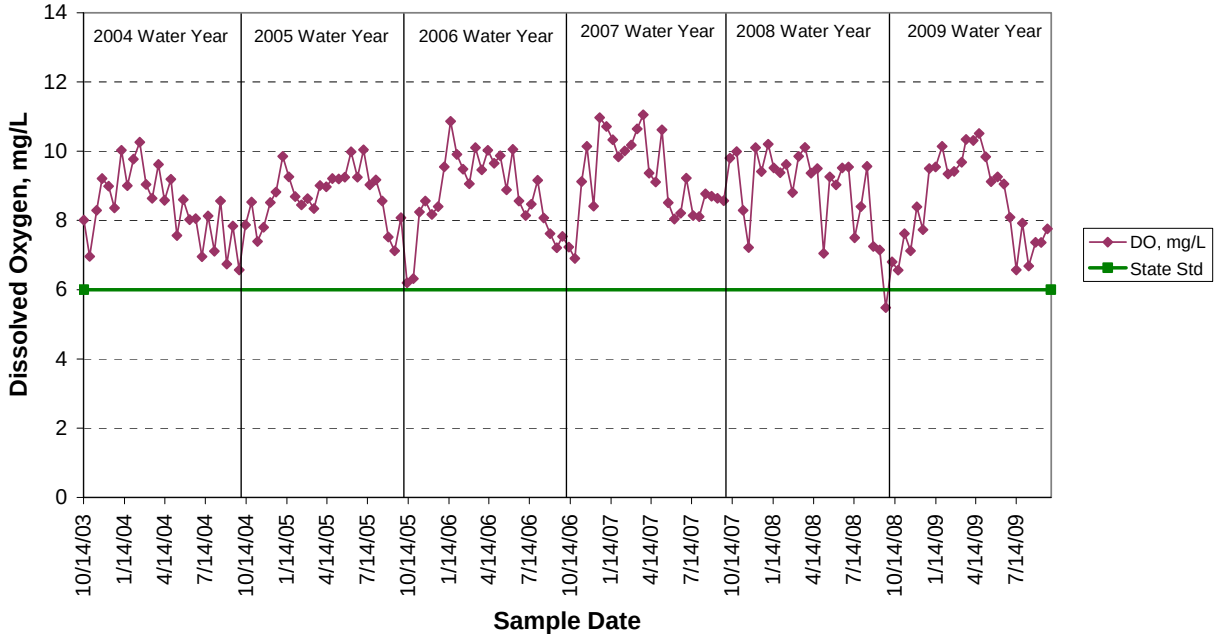
N.F. Skagit near Moore Rd - Site 45
Dissolved Oxygen



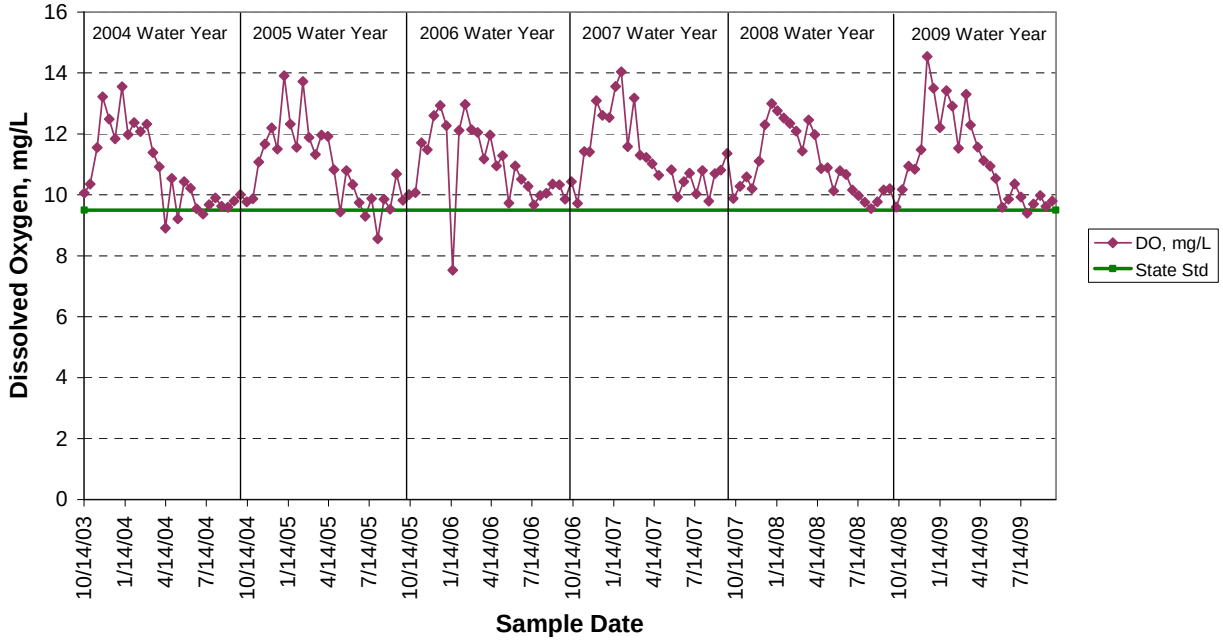
S.F. Skagit at Conway Boat Ramp - Site 46
Dissolved Oxygen



Swinomish Channel at County Boat Ramp - Site 47
Dissolved Oxygen



Fisher Creek at Franklin Rd - Site 48
Dissolved Oxygen



Fecal Coliform

Fecal coliform is a measurement of the amount of enteric bacteria from warm-blooded animals present in a watercourse. Although fecal coliform measurements do not directly quantify disease-causing organisms, they serve as an indicator of the possible presence of such bacteria. Samples for fecal coliform measurements are taken at each site during each visit and submitted to the Skagit County Health Department Water Lab (2003-2008) or Edge Analytical (2009) for analysis by the Most Probable Number method.

Fecal coliform measurements for the 2009 water year, in colony-forming units per 100 ml (cfu), are summarized in Table 7. Six-year results are summarized in Table 8. State standards for fecal coliform are based on the geometric mean of the samples as well as the percent of the samples that exceed given criteria. For most of the watercourses in the Skagit County Monitoring Program (sites 3-20, 28-29, 31-46, 48), fecal coliform is not to exceed a geometric mean of 100 cfu, with no more than 10% of the measurements exceeding 200 cfu. For the upriver sites (sites 21-25, 30), the standard is a geometric mean of 50 cfu, with no more than 10% of the measurements exceeding 100 cfu. For the marine site (site 47), a more stringent standard of 14 cfu with no more than 10% exceeding 41 cfu is enforced to protect shellfish beds.
Table 8 gives the geometric mean fecal coliform at each site for all five years of the study. All Skagit River sites (sites 29, 30, 45, and 46) and Swinomish Channel (site 47) met the state standard for fecal coliform for all six years of this project. Most other watercourses in the Skagit County Monitoring Program did not meet the standard.

The 2008 water year was marked by several incidents of high fecal coliform counts at County monitoring stations in the Samish Bay Watershed. Each incident was triggered by moderate to heavy rainfall. These high counts resulted in at least four closures of the Samish Bay shellfish beds to commercial harvest. Three of these closures were voluntary, where the Washington State Office of Shellfish and Water Protection contacted growers and asked them to hold off harvesting until river levels declined or further sampling indicated fecal coliform levels had dropped. The fourth incident resulted in a mandatory closure of Samish Bay in response to a sample count of 17,000 colony-forming units/100 mL from the Samish River at Thomas Road on April 29, 2008.

The 2009 water year saw continued high fecal coliform counts in the Samish River and elsewhere in the Samish Bay Watershed. County and Storm Team volunteer monitoring continued to document the relationship between high rainfall events and excess fecal coliform. This continuing situation prompted the Washington State Department of Ecology to initiate the Clean Samish Initiative, a partnership of over 20 Federal, State, and County governmental organizations as well as shellfish industry and non-profit groups. This effort is aimed at making immediate improvements in the Samish Bay Watershed fecal coliform situation.

The sources of fecal coliform organisms reaching the watercourses of Skagit County could include runoff from failing septic tanks, livestock operations, wildlife, and pets. Methods to identify bacterial sources are under development but are expensive and not necessarily ready for widespread application. Skagit County has again applied for grant funding to support a program

to identify sources of fecal coliform pollution in the Samish Basin through a Pollution Identification and Correction program similar to Kitsap County's.

Graphs on the pages following Table 8 illustrate fecal coliform levels for water years 2004-2009 at each of the sample sites. The scale on each graph differs in order to fully illustrate the variability at each site. The blue lines on the graphs indicate the geometric mean portion of the state water quality standards.

Table 7. 2009 Fecal Coliform Results
Summary of Fecal Coliform Readings in Skagit County Monitoring Program
2009 Water Year

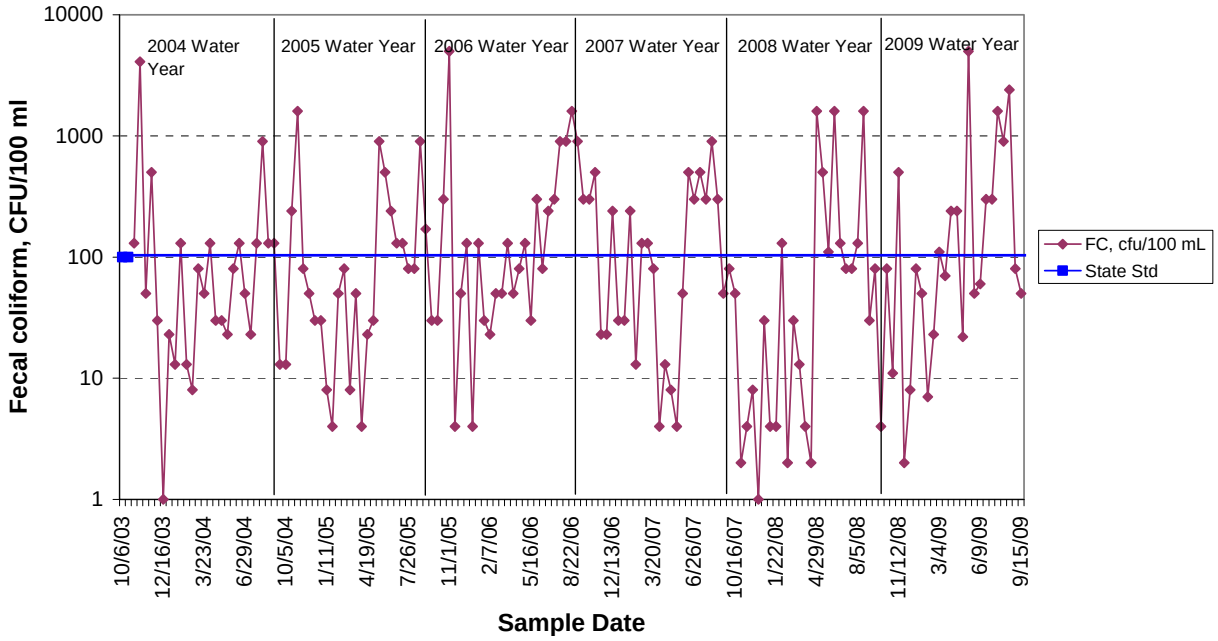
Site Number	Watercourse	Location	N	Geometric mean (cfu)[1]	% > 100 or 200[1]	Max
3	Thomas Ck	Old Hwy 99 North	24	99	38	5000
4	Thomas Ck	F&S Grade	25	234	52	23,000
6	Friday Ck	Prairie Rd	25	35	12	900
8	Swede Ck	Grip Rd	26	91	27	2400
11	Samish R	State Route 9	25	19	4	500
12	Nookachamps Ck	Swan Rd	24	87	25	900
13	E.F. Nookachamps Ck	State Route 9	25	84	36	3000
14	College Way Ck	College Way	25	140	36	3000
15	Nookachamps Ck	Knapp	25	80	20	3000
16	E.F. Nookachamps Ck	Beaver Lake Rd	25	33	24	2400
17	Nookachamps Ck	Big Lake Outlet	23	17	9	500
18	Lake Ck	State Route 9	25	44	32	900
19	Hansen Ck	Hoehn Rd	24	82	21	1600
20	Hansen Ck	Northern State	25	49	24	500
21	Coal Ck	Hoehn Rd	22	37	14	2400
22	Coal Ck	Hwy 20	20	21	15	300
23	Wiseman Ck	Minkler Rd	17	19	6	240
24	Mannser Ck	Lyman Hamilton Hwy	26	23	12	900
25	Red Cabin Ck	Hamilton Cem Rd	13	13	8	500
28	Brickyard Ck	Hwy 20	16	55	13	1600
29	Skagit R	R Bend Rd	23	15	4	220
30	Skagit R	Cape Horn Rd	23	6	0	50
31	Drain Dist 20 near floodgate	Francis Rd	15	57	27	1600
32	Samish R	Thomas Rd	26	81	15	5000
33	Alice Bay Pump Station	Samish Island Rd	26	64	23	1600
34	Noname Slough	Bayview-Edison Rd	24	198	50	3000
35	Joe Leary Slough	D'Arcy Rd	25	103	28	1600
36	Edison Slough at school	W. Bow Hill Rd	24	53	25	900
37	Edison Pump Station	Farm to Market Rd	25	109	36	1600
38	North Edison Pump Station	North Edison Rd	22	125	27	30,000
39	Colony Ck	Colony Rd	25	68	36	3000
40	Big Indian Slough	Bayview-Edison Rd	25	132	40	9000
41	Maddox Slough/Big Ditch	Milltown Rd	25	58	12	500
42	Hill Ditch	Cedardale Rd	24	82	33	1600
43	Wiley Slough	Wylie Rd	22	39	14	300
44	Sullivan Slough	La Conner-Whitney Rd	25	148	44	1700
45	Skagit R – North Fork	Moore Rd	24	10	0	80
46	Skagit R – South Fork	Fir Island Rd	25	9	4	300
47	Swinomish Channel	County Boat Launch	22	7	2	110
48	Fisher Ck	Franklin Rd	24	78	33	500

[1]State water quality standard for fecal coliform requires water bodies to have a geometric mean of less than 50 (sites 21-25, 30) or 100 (sites 3-20, 28-29, 31-46, 48) colony forming units (cfu) per 100 ml and less than 10% of the samples > 100 (sites 21-25, 30) or > 200 cfu (sites 3-20, 28-29, 31-46, 48). Marine locations (site 47) are required to be < 14 cfu with no more than 10% > 41 cfu.

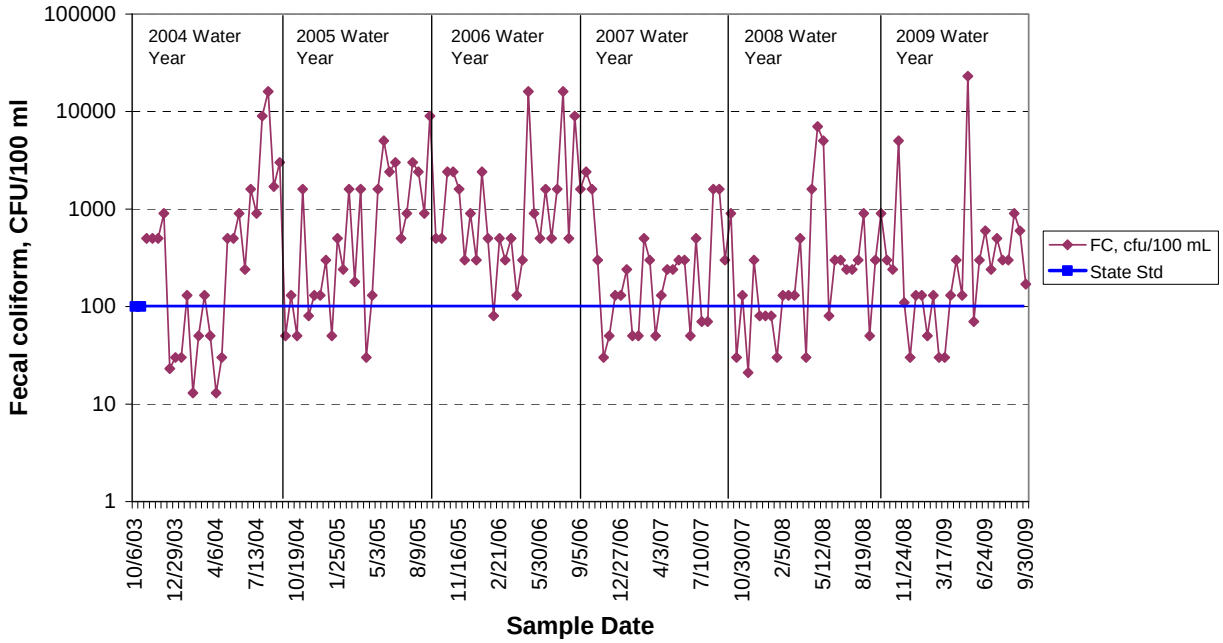
Table 8. Six-Year Fecal Coliform Results Summary
Geometric mean fecal coliform levels for the five water years of the Skagit County Monitoring Program

			2004	2005	2006	2007	2008	2009
3	Thomas Ck	Old Hwy 99 North	57	65	121	77	36	99
4	Thomas Ck	F&S Grade	255	516	950	187	215	234
6	Friday Ck	Prairie Rd	43	24	55	39	35	35
8	Swede Ck	Grip Rd	95	83	113	66	70	91
11	Samish R	State Route 9	22	15	22	14	20	19
12	Nookachamps Ck	Swan Rd	90	64	75	49	43	87
13	E.F. Nookachamps Ck	State Route 9	44	44	57	65	38	84
14	College Way Ck	College Way	171	143	157	193	252	140
15	Nookachamps Ck	Knapp	78	71	78	84	65	80
16	E.F. Nookachamps Ck	Beaver Lake Rd	54	28	20	24	19	33
17	Nookachamps Ck	Big Lake Outlet	15	11	16	16	12	17
18	Lake Ck	State Route 9	68	50	45	61	40	44
19	Hansen Ck	Hoehn Rd	75	54	107	126	71	82
20	Hansen Ck	Northern State	37	43	77	49	31	49
21	Coal Ck	Hoehn Rd	110	112	115	168	117	37
22	Coal Ck	Hwy 20	15	8	11	12	8	21
23	Wiseman Ck	Minkler Rd	14	13	23	21	13	19
24	Mannser Ck	Lyman Hamilton Hwy	43	21	17	16	15	23
25	Red Cabin Ck	Hamilton Cem Rd	14	8	9	7	17	13
28	Brickyard Ck	Hwy 20	53	41	55	58	49	55
29	Skagit R	R Bend Rd	14	10	7	7	13	15
30	Skagit R	Cape Horn Rd	3	3	5	6	5	6
31	Drain Dist 20 near floodgt	Francis Rd	88	46	89	24	36	57
32	Samish R	Thomas Rd	64	86	85	42	47	81
33	Alice Bay Pump Station	Samish Island Rd	96	92	62	28	44	64
34	Noname Slough	Bayview-Edison Rd	79	214	204	118	102	198
35	Joe Leary Slough	D'Arcy Rd	115	108	143	192	55	103
36	Edison Slough at school	W. Bow Hill Rd	83	42	71	41	43	53
37	Edison Pump Station	Farm to Market Rd	102	162	197	135	94	109
38	N Edison Pump Station	North Edison Rd	180	70	120	57	157	125
39	Colony Ck	Colony Rd	95	100	156	77	46	68
40	Big Indian Slough	Bayview-Edison Rd	48	43	51	11	56	132
41	Maddox Slough/Big Ditch	Milltown Rd	25	30	73	71	44	58
42	Hill Ditch	Cedardale Rd	22	18	27	61	27	82
43	Wiley Slough	Wylie Rd	55	80	56	75	47	39
44	Rexville PS/Sullivan Sl	La Conner-Whitney Rd	14	20	44	76	128	148
45	Skagit R – North Fork	Moore Rd	6	9	6	5	7	10
46	Skagit R – South Fork	Fir Island Rd	13	13	8	7	8	9
47	Swinomish Channel	County Boat Launch	6	3	4	3	5	7
48	Fisher Ck	Franklin Rd	77	96	76	106	74	78

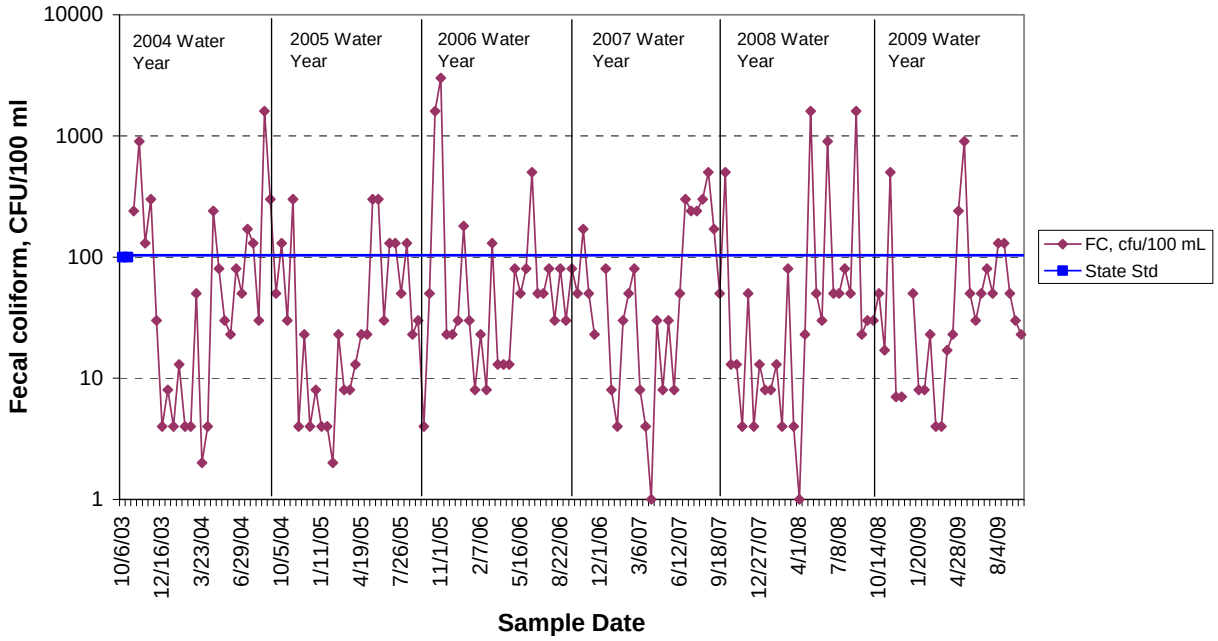
Thomas Creek at Hwy 99 - Site 3
Fecal coliform



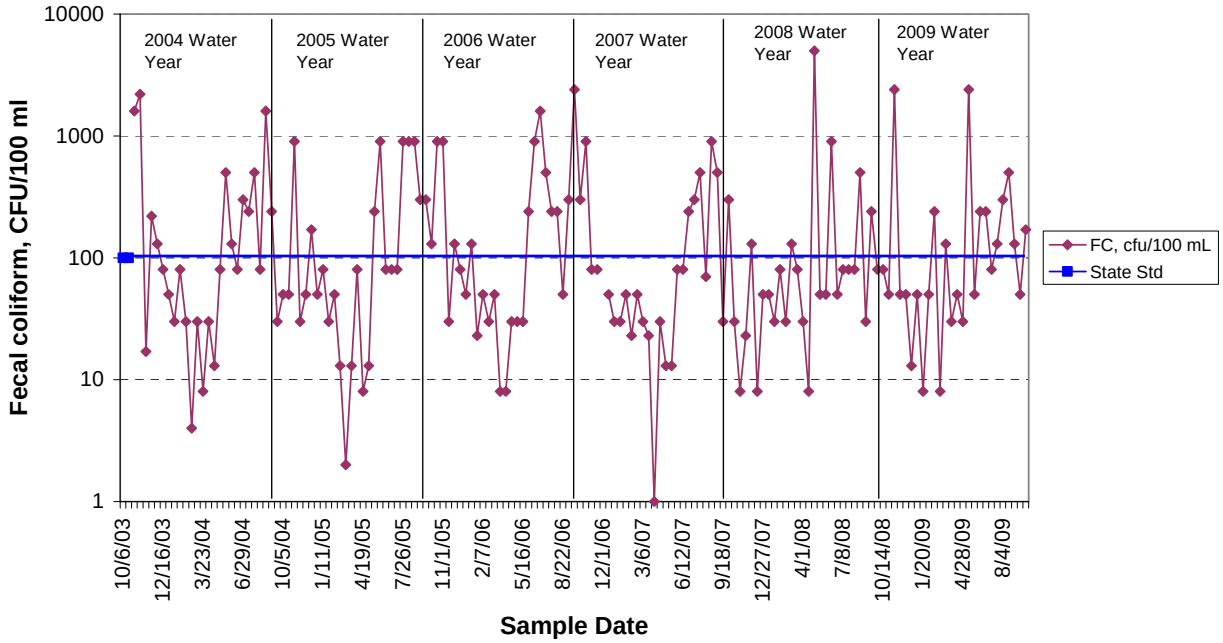
Thomas Creek at F&S Grade Rd - Site 4
Fecal coliform



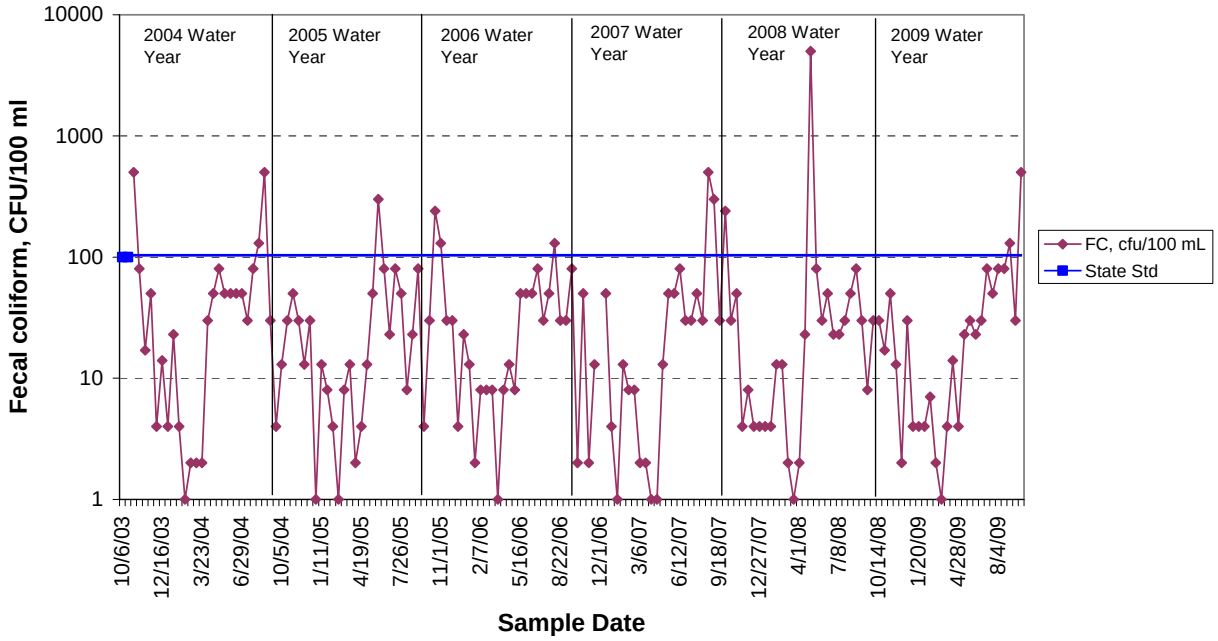
Friday Creek at Prairie Rd - Site 6
Fecal coliform



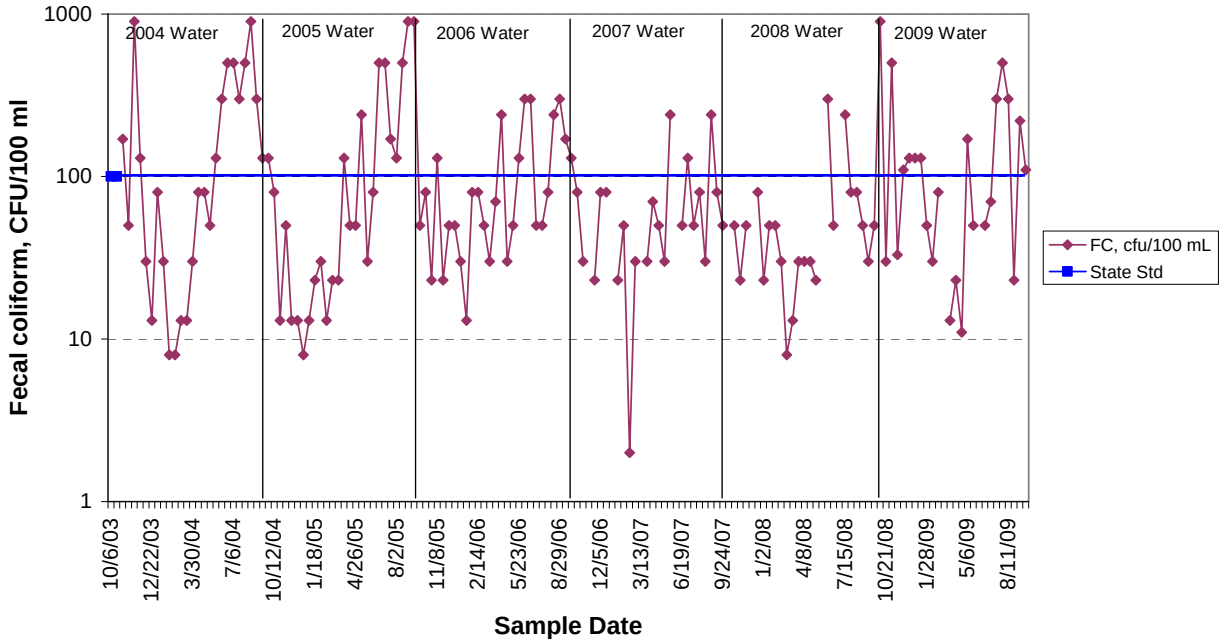
Swede Creek at Grip Rd - Site 8
Fecal coliform



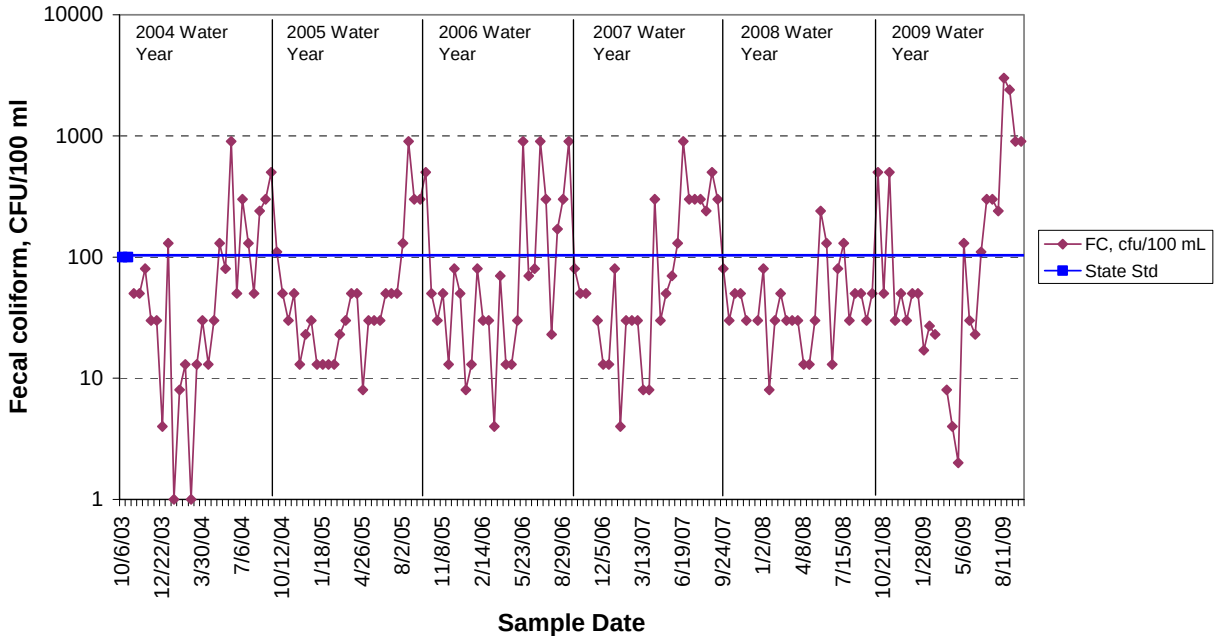
Samish River at Hwy 9 - Site 11
Fecal coliform



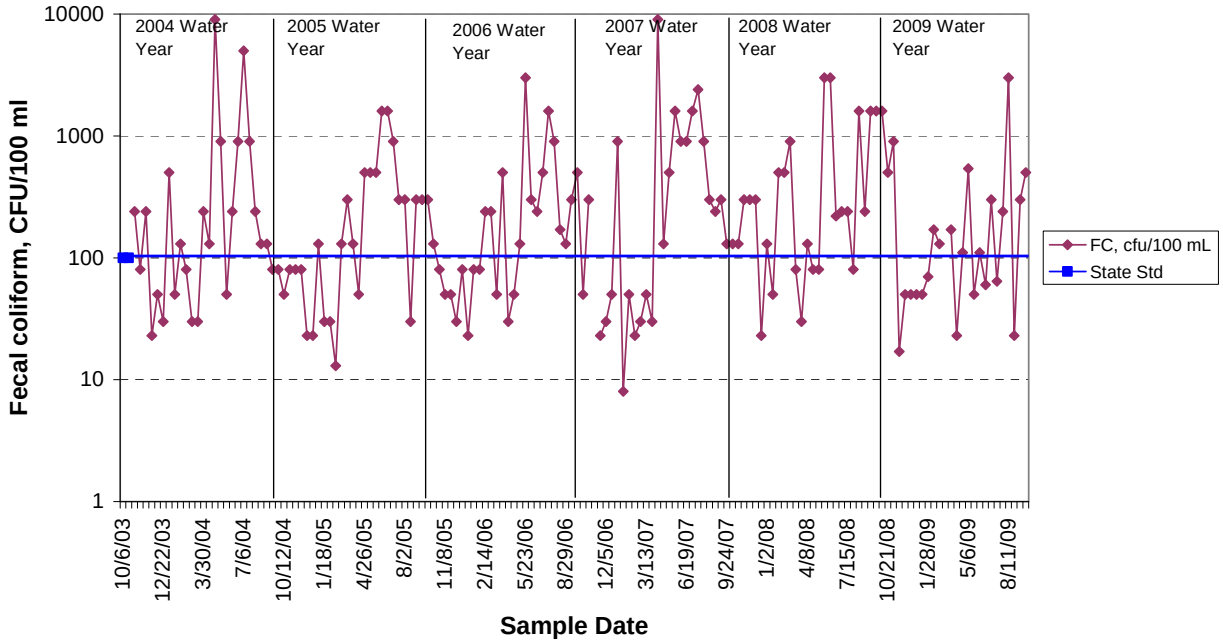
Nookachamps Creek at Swan Rd - Site 12
Fecal coliform



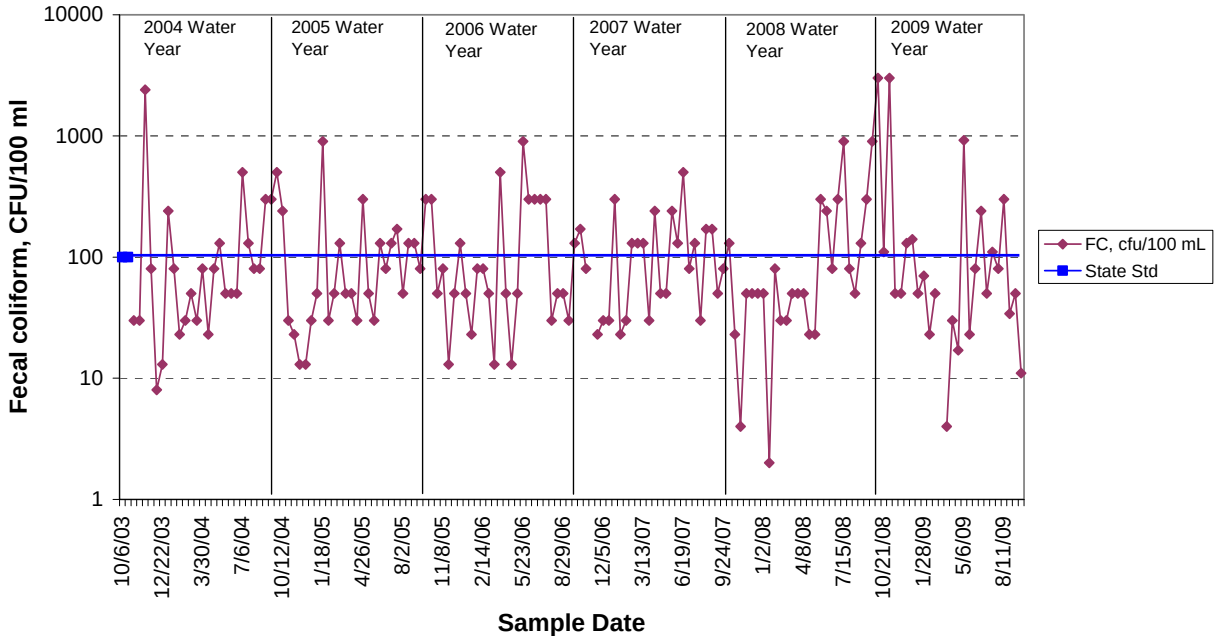
E.F. Nookachamps Creek at Hwy 9 - Site 13
Fecal coliform



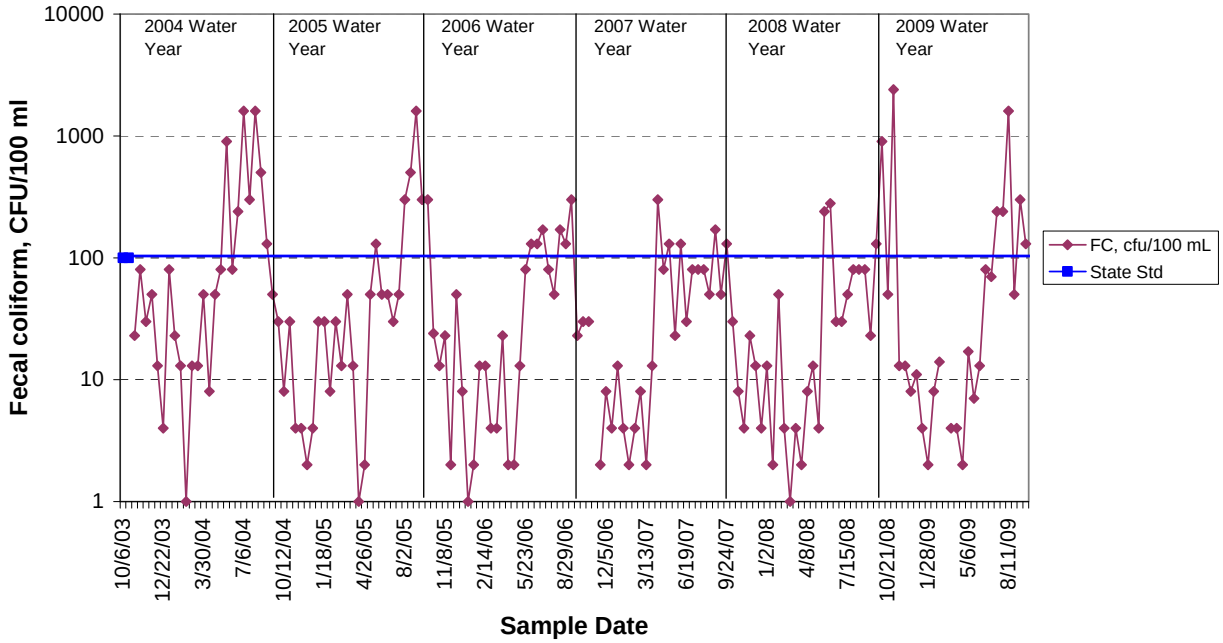
College Way Creek at College Way - Site 14
Fecal coliform



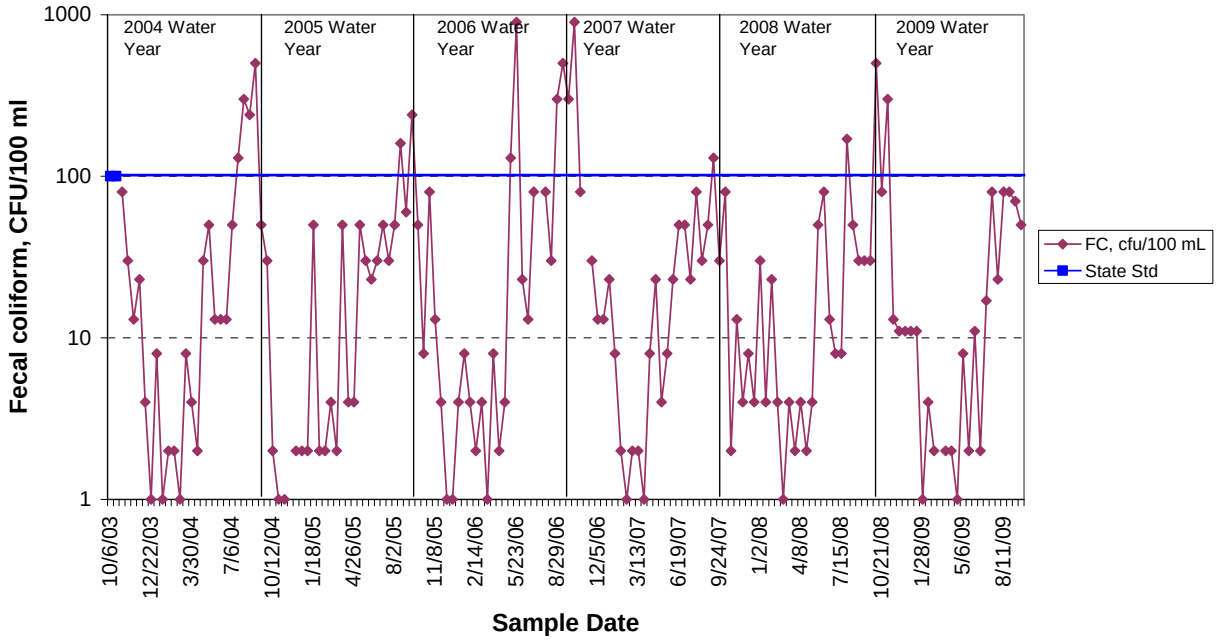
Nookachamps Creek at Knapp Rd - Site 15
Fecal coliform



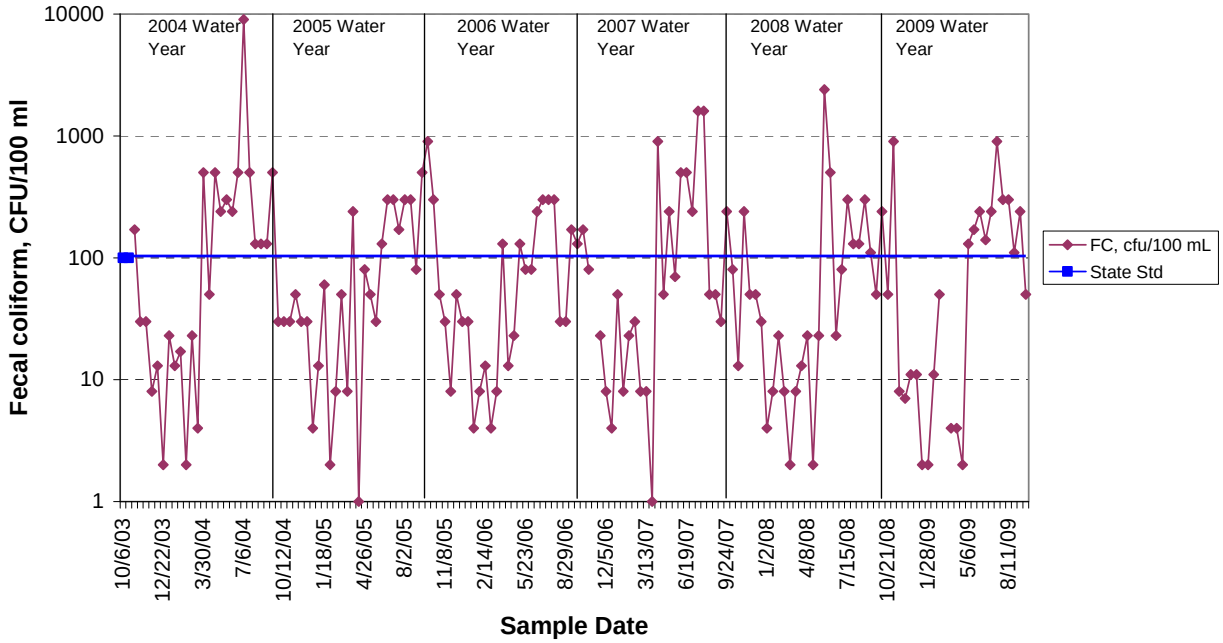
E.F. Nookachamps Creek at Beaver Lk Rd - Site 16
Fecal coliform



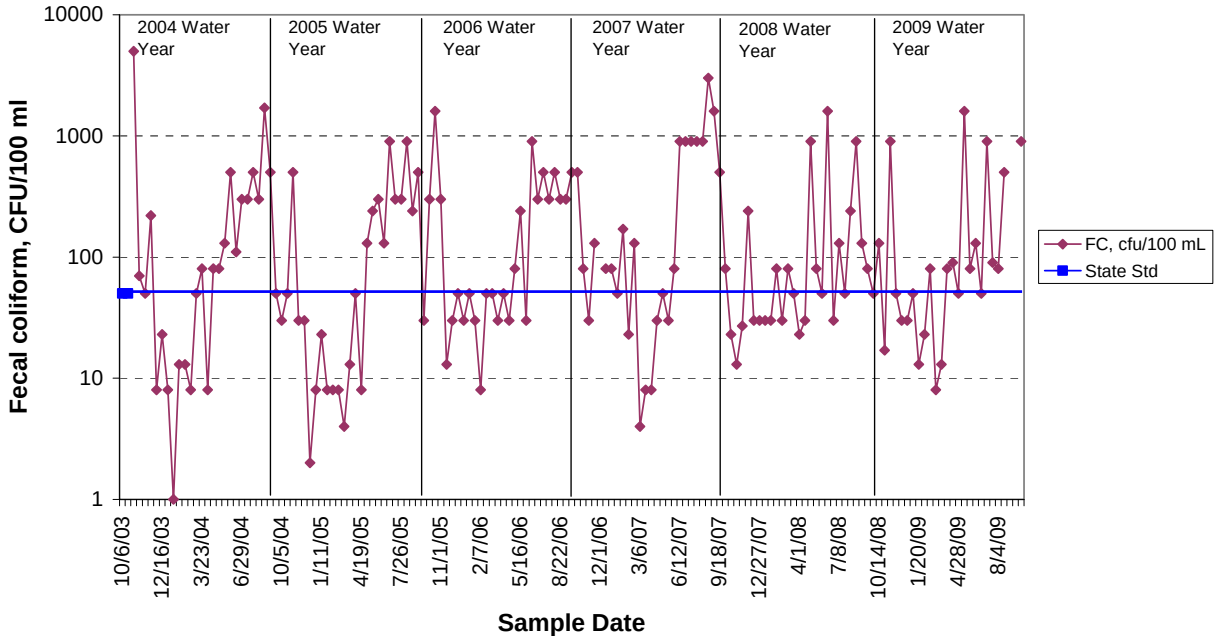
Nookachamps Creek at Big Lake Outlet - Site 17
Fecal coliform



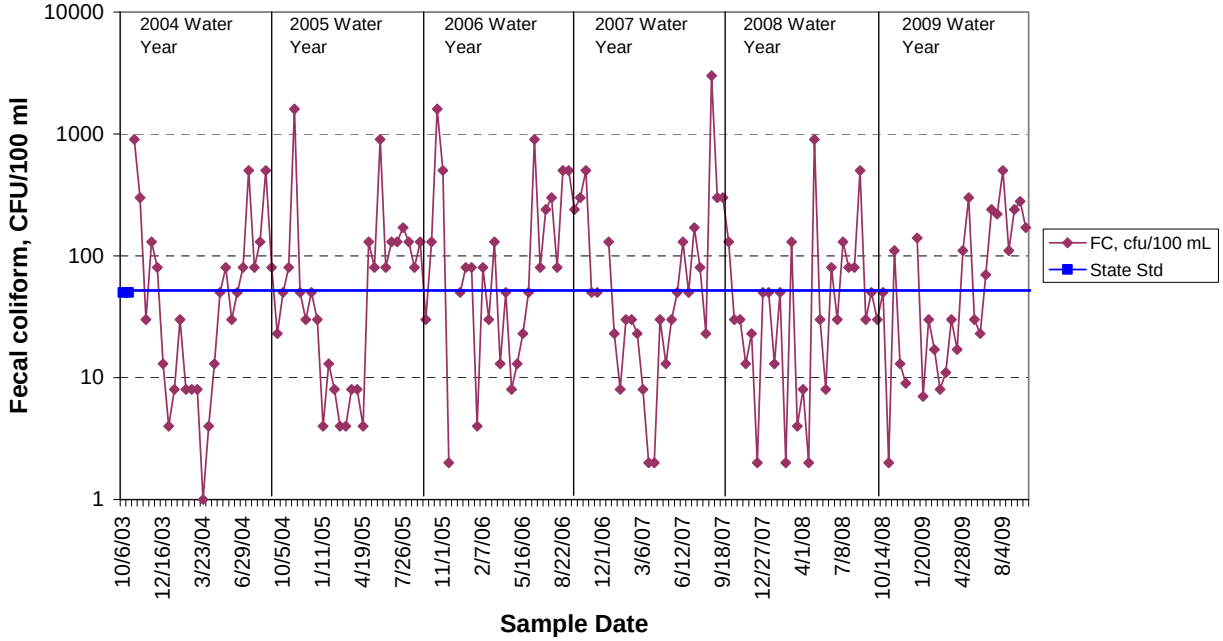
Lake Creek at Hwy 9 - Site 18
Fecal coliform



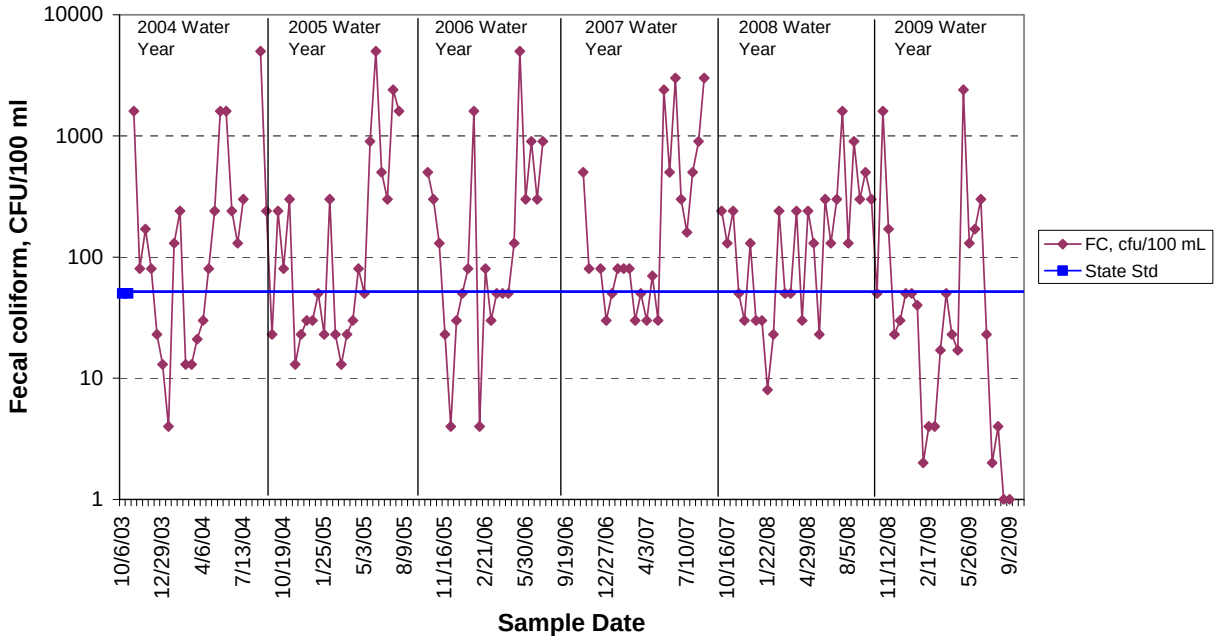
Hansen Creek at Hoehn Rd - Site 19
Fecal coliform



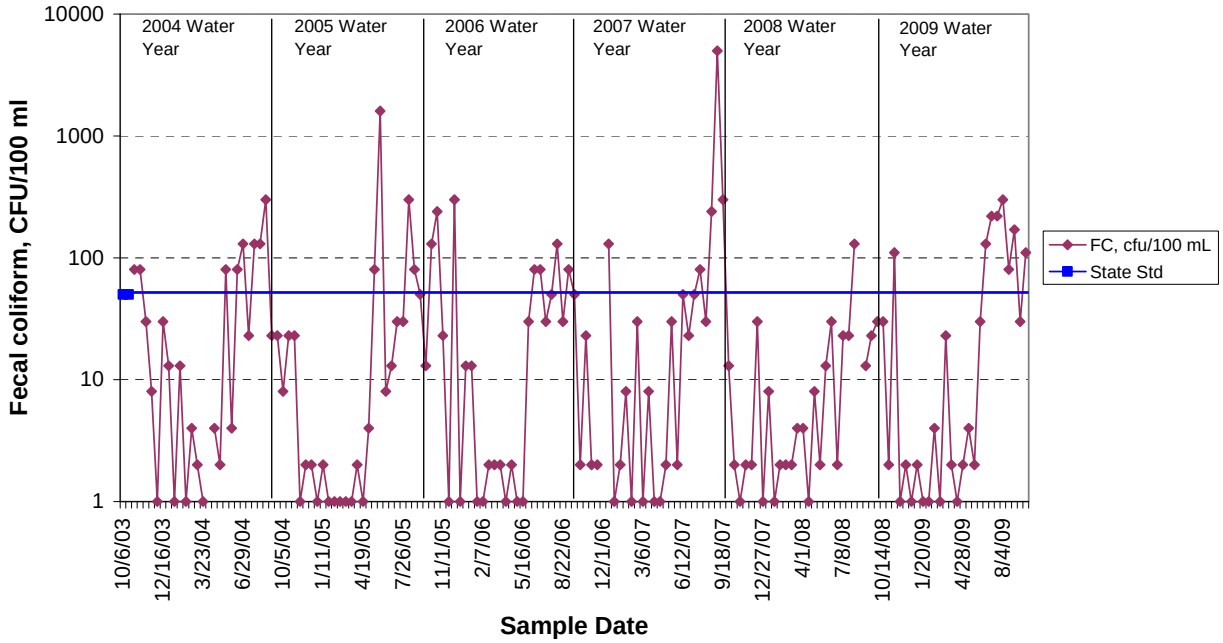
Hansen Creek at Northern State Hospital - Site 20
Fecal coliform



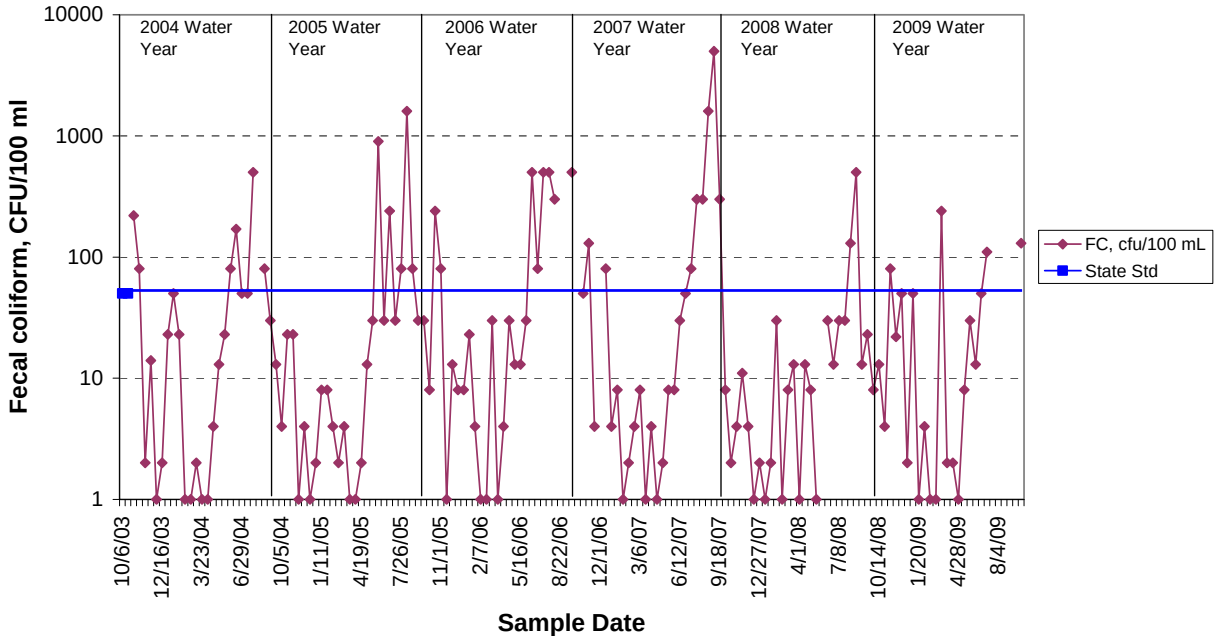
Coal Creek at Hoehn Rd - Site 21
Fecal coliform



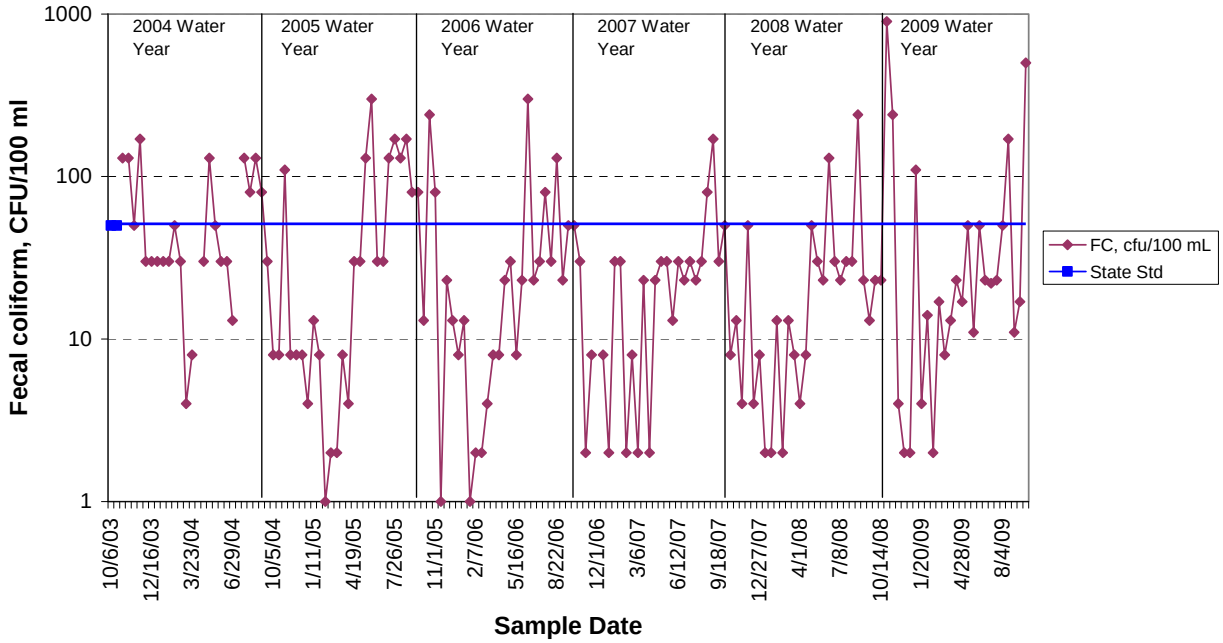
Coal Creek at Hwy 20 - Site 22
Fecal coliform



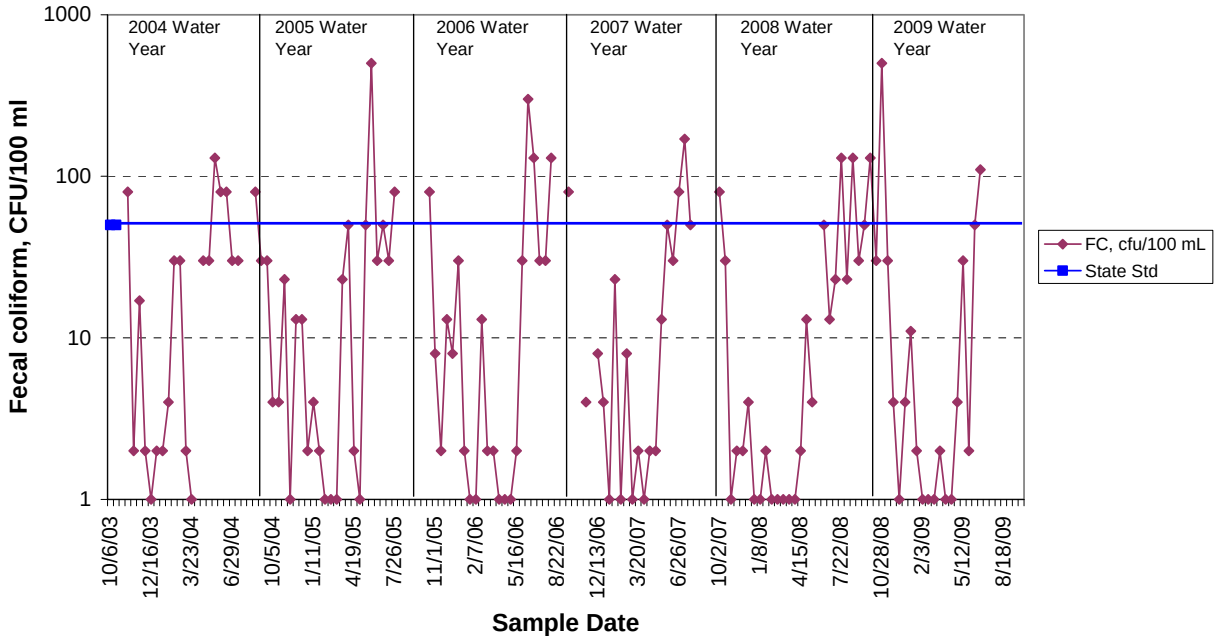
Wiseman Creek at Minkler Rd - Site 23
Fecal coliform



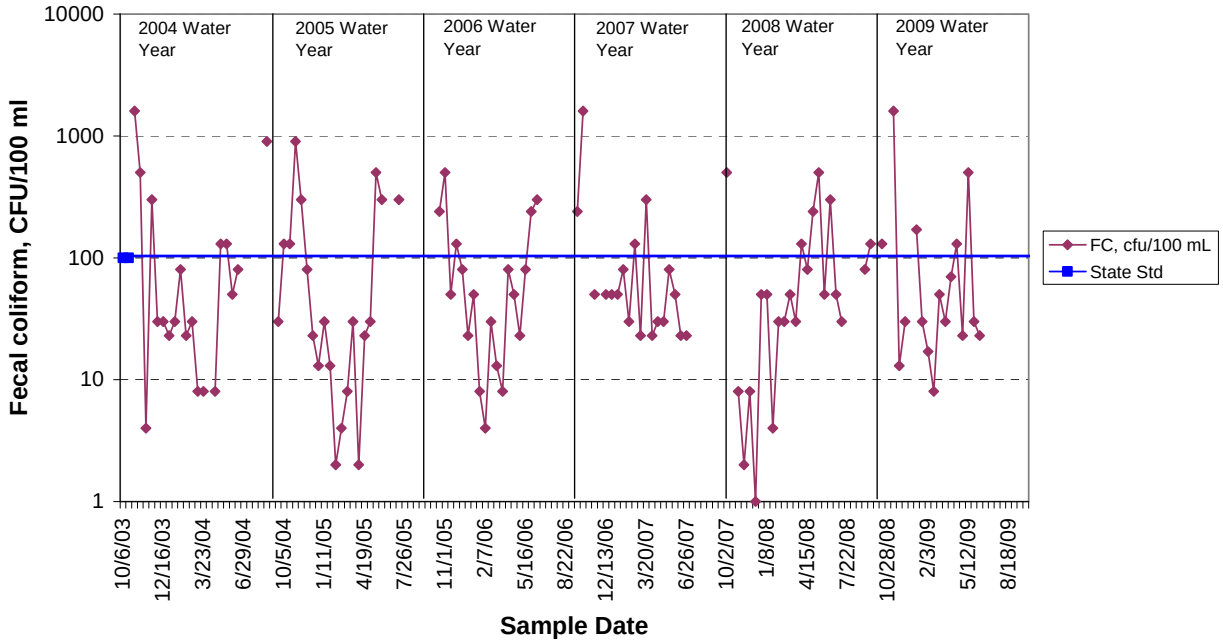
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Fecal coliform



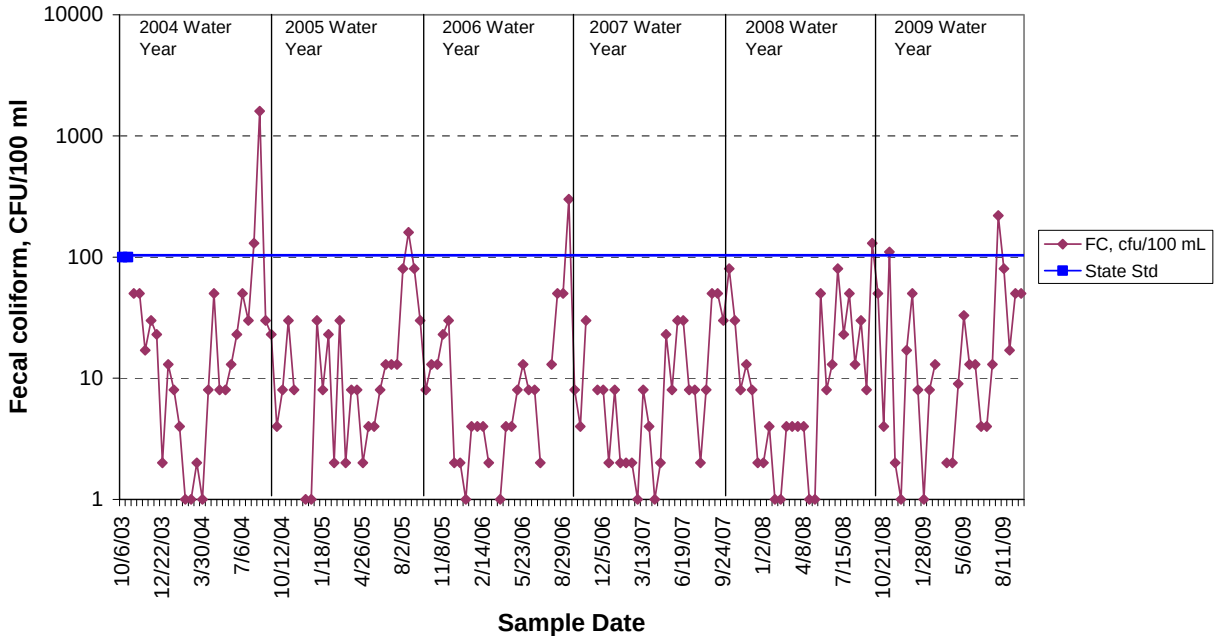
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Fecal coliform



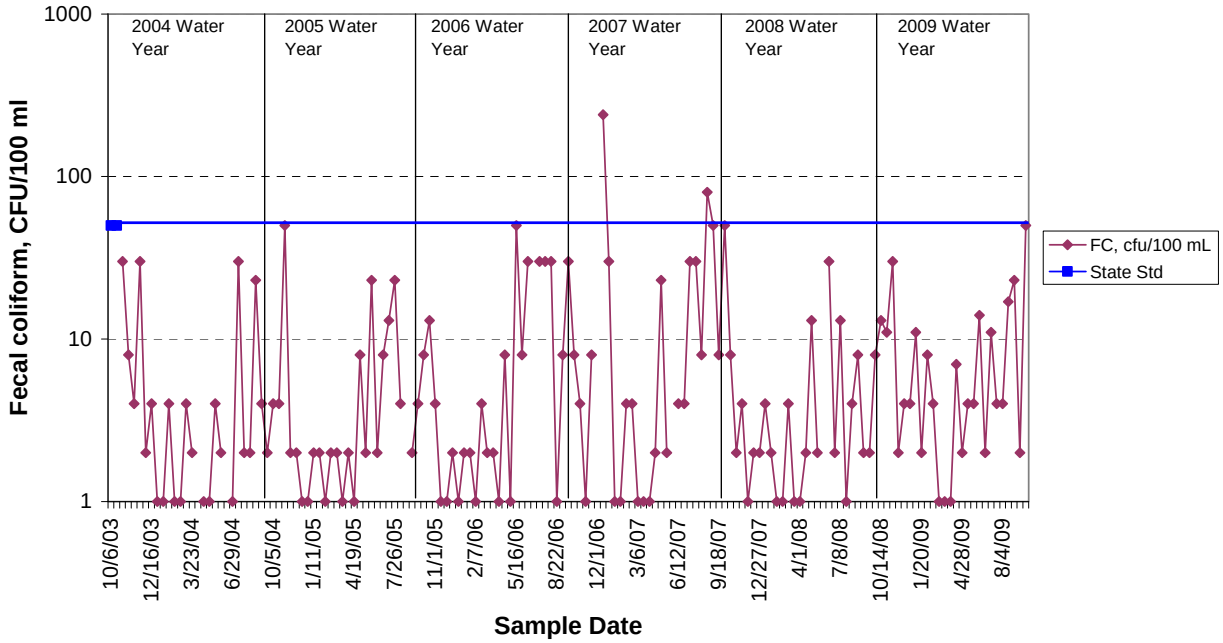
Brickyard Creek at Hwy 20 - Site 28
Fecal coliform



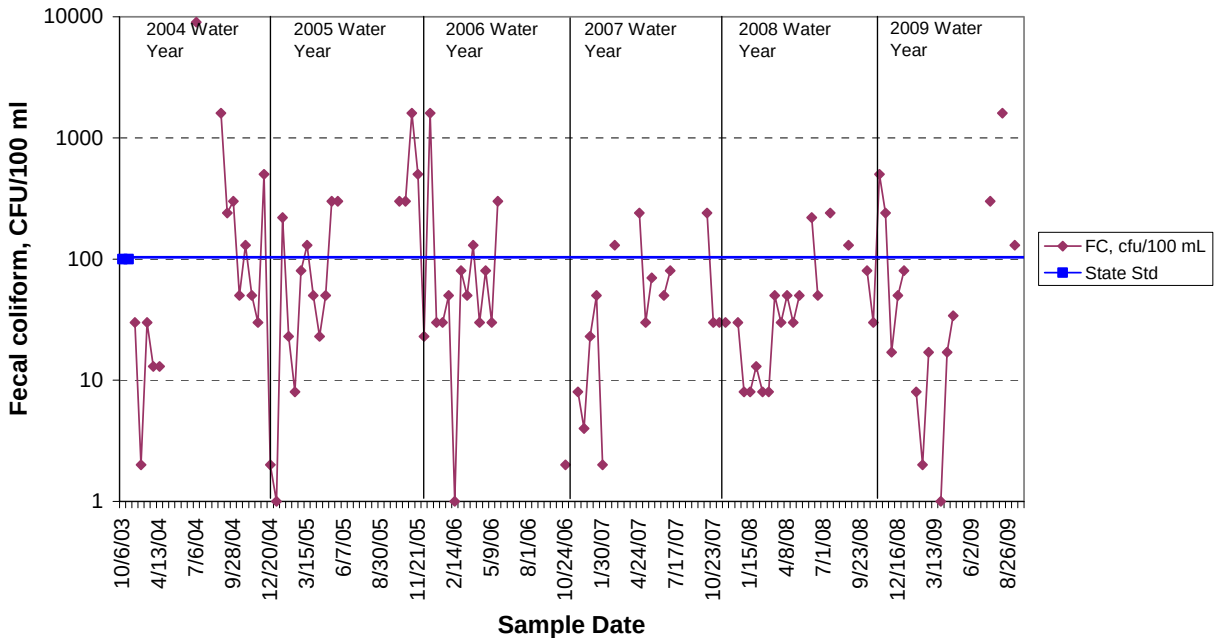
Skagit River at River Bend - Site 29
Fecal coliform



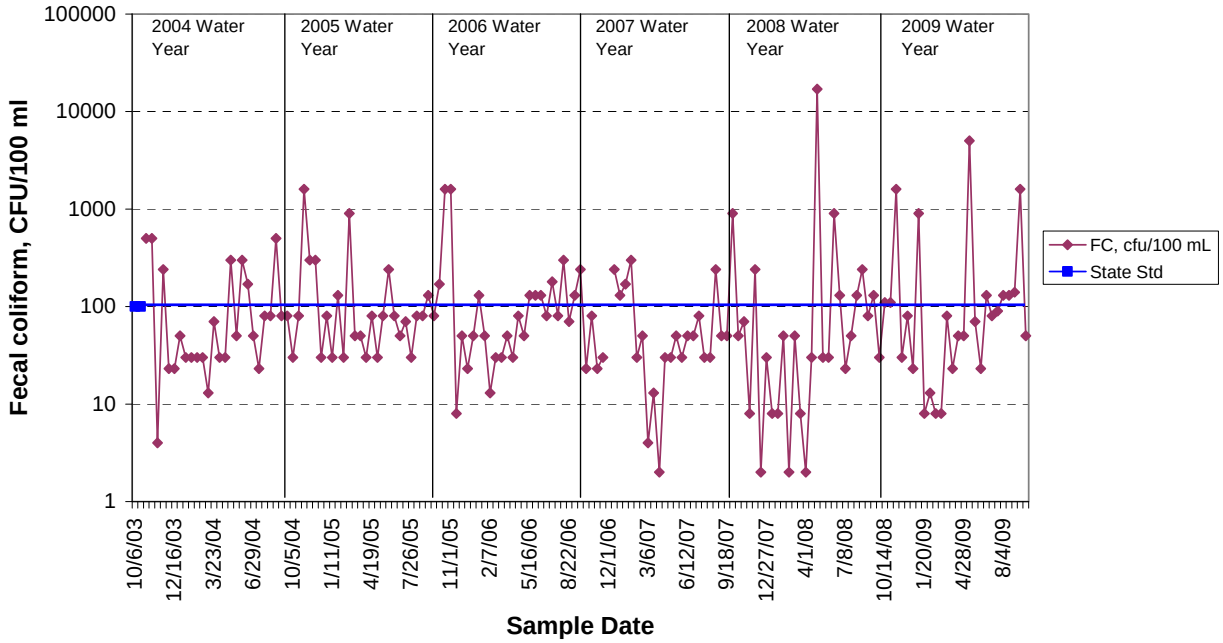
Skagit River at Cape Horn Rd - Site 30
Fecal coliform



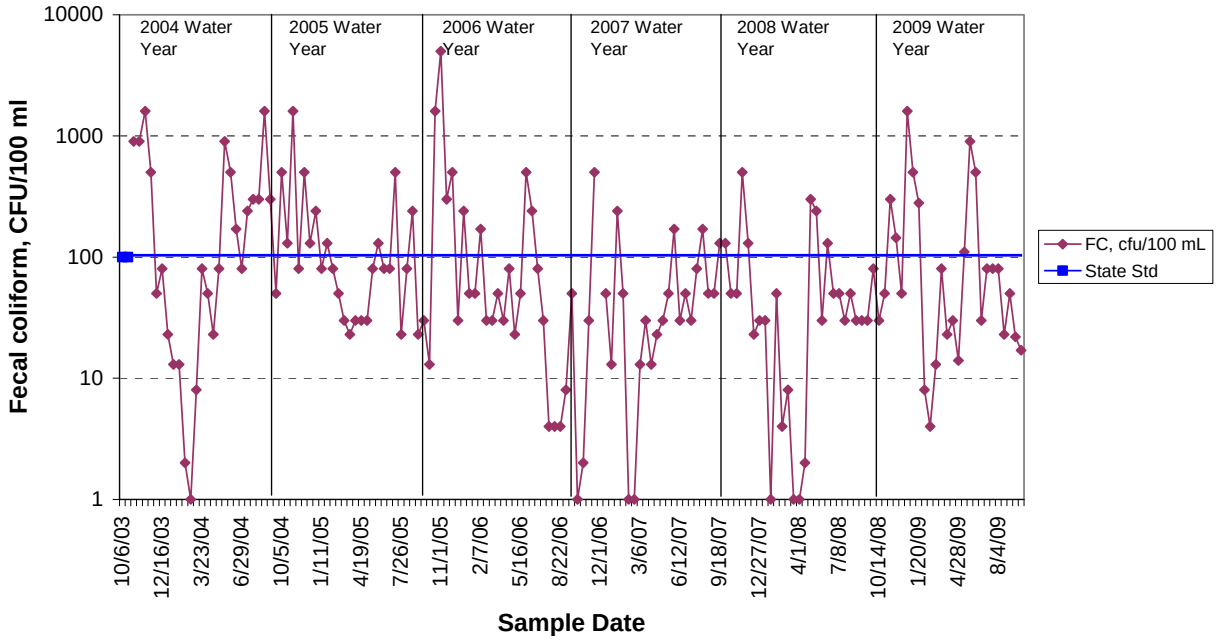
Drainage District 20 Ditch at Floodgate - Site 31
Fecal coliform



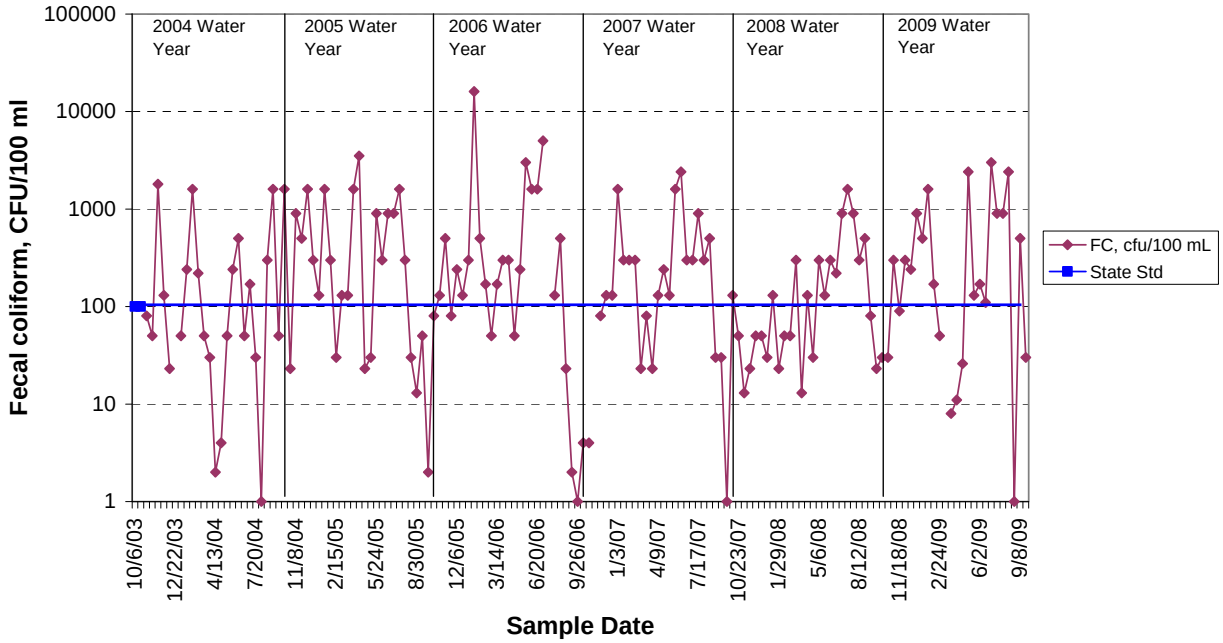
Samish River at Thomas Rd - Site 32
Fecal coliform



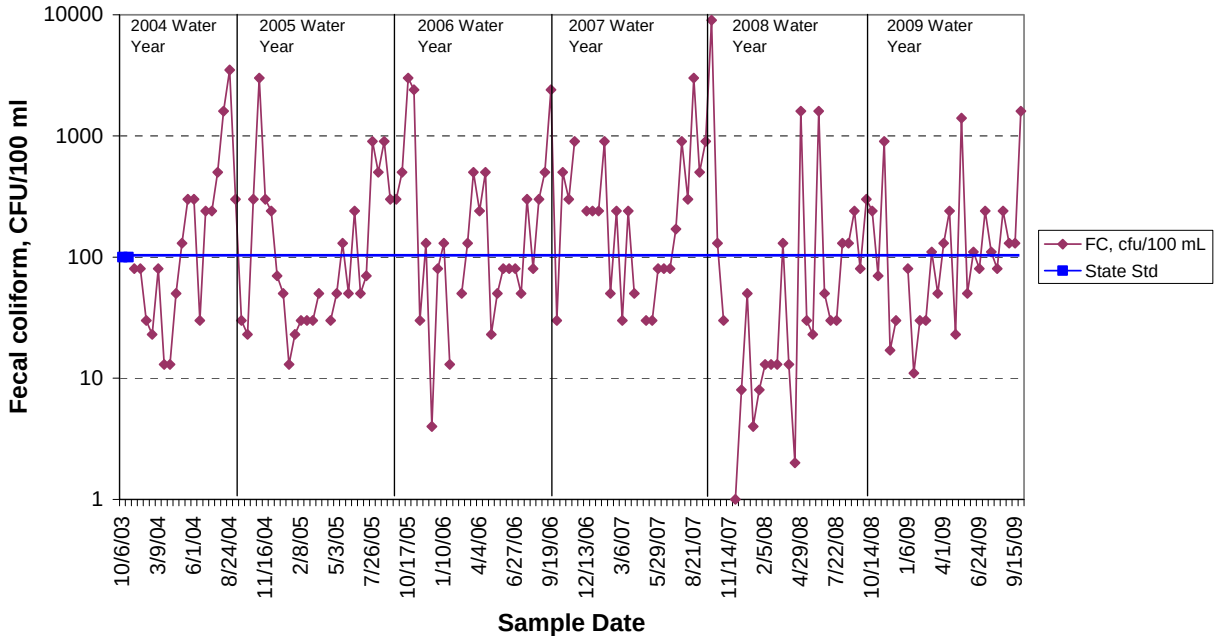
Alice Bay Pump Station - Site 33
Fecal coliform



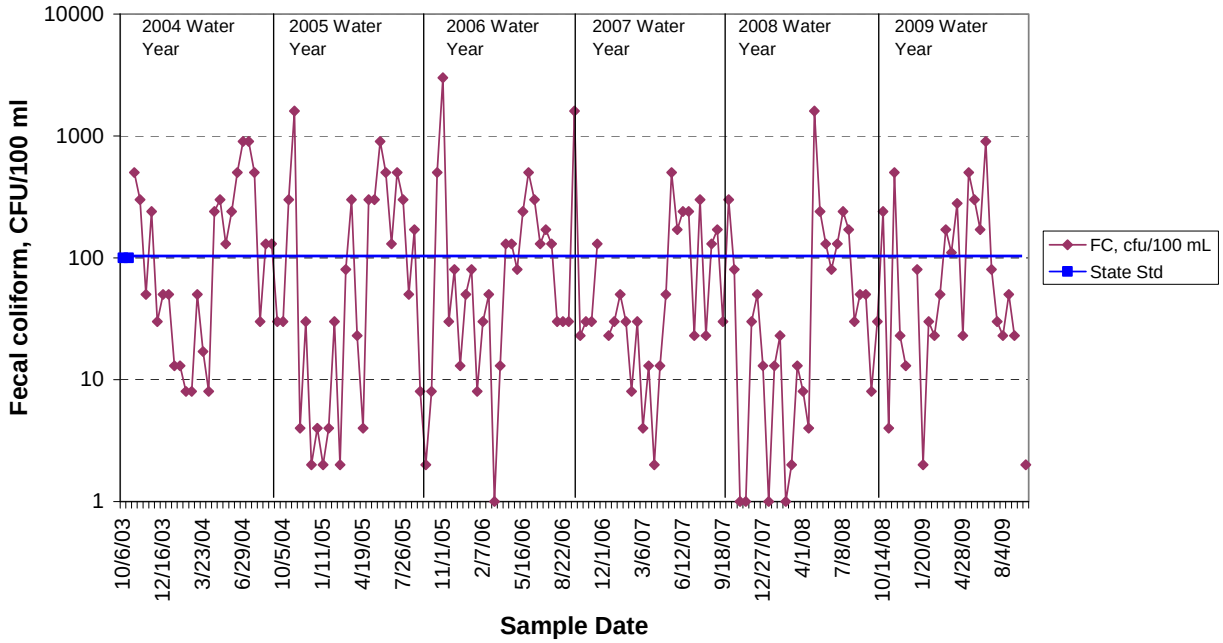
No Name Slough at Bayview-Edison Rd - Site 34
Fecal coliform



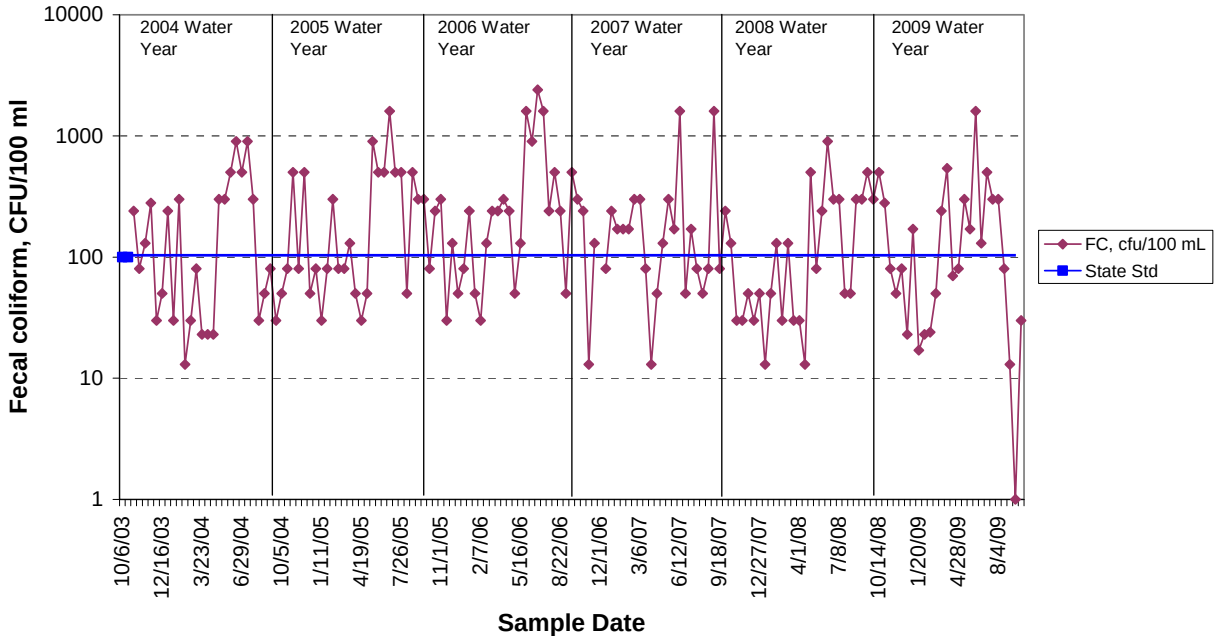
Joe Leary Slough at D'Arcy Rd - Site 35
Fecal coliform



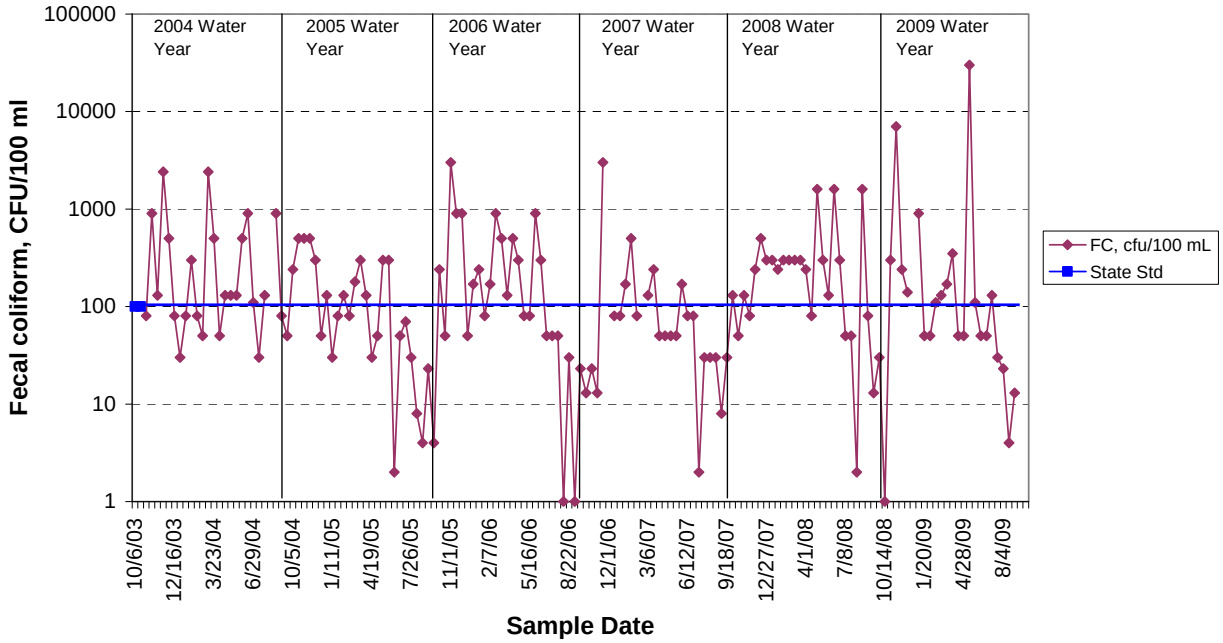
Edison Slough at Edison School - Site 36
Fecal coliform



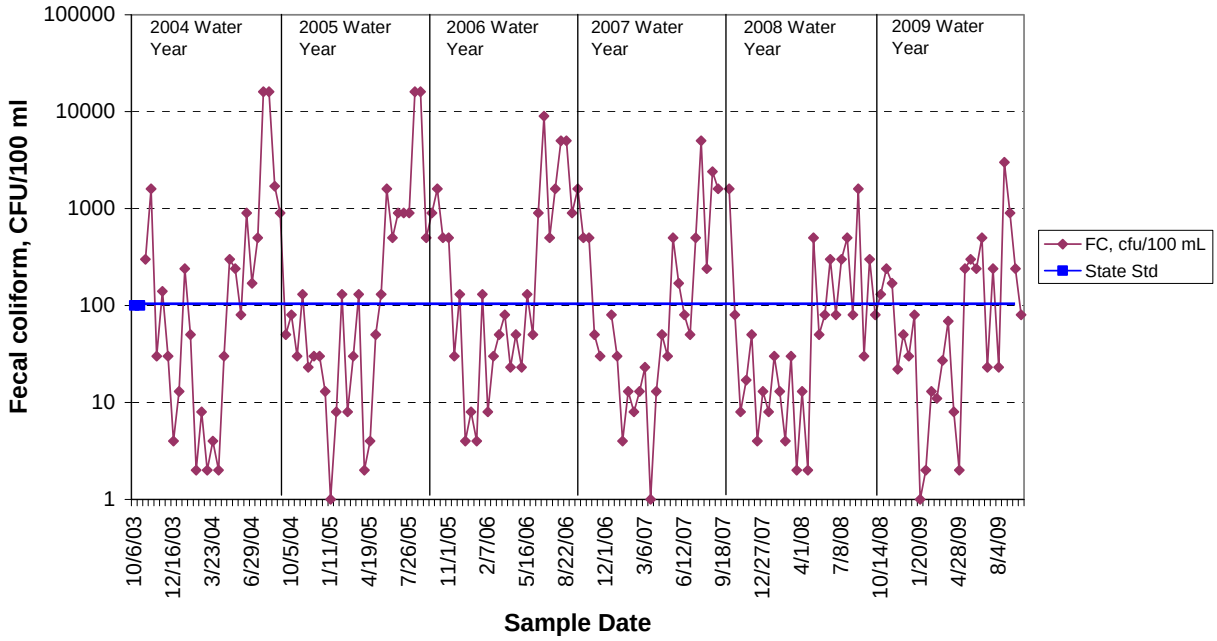
Edison Pump Station - Site 37
Fecal coliform



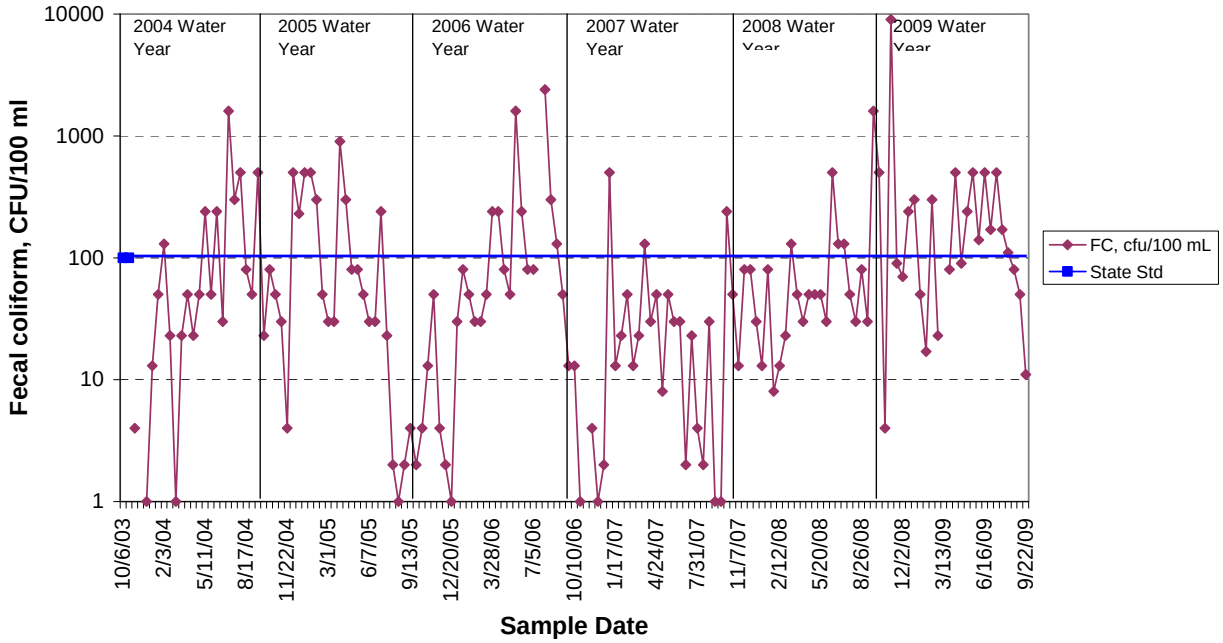
North Edison Pump Station - Site 38
Fecal coliform



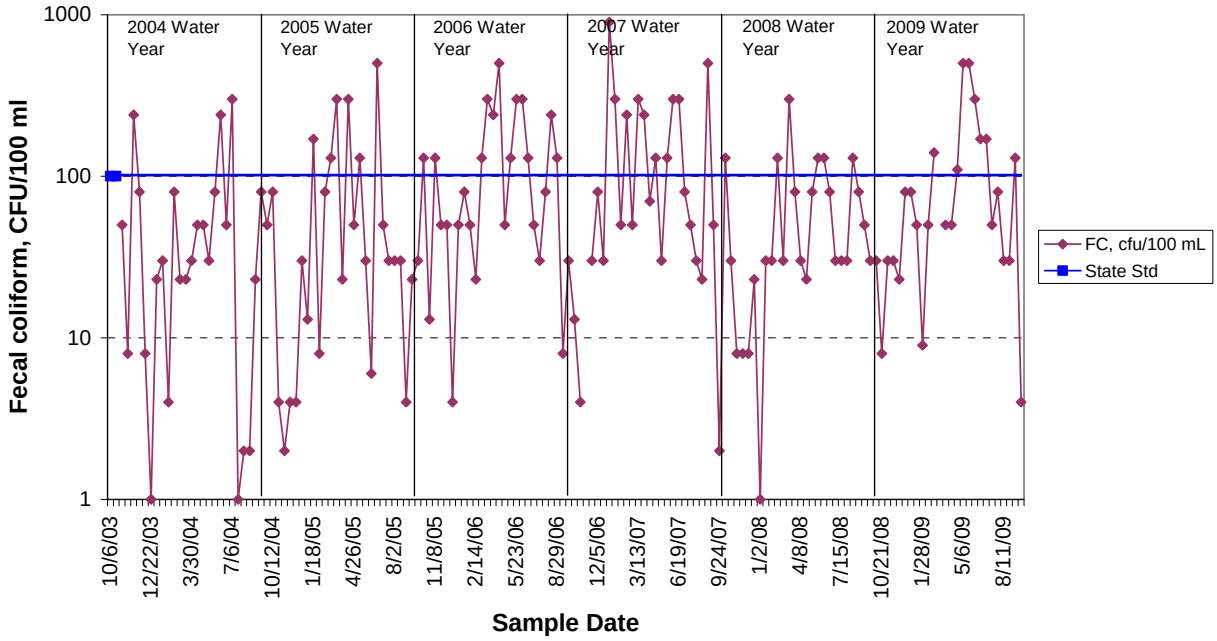
Colony Creek at Colony Rd - Site 39
Fecal coliform



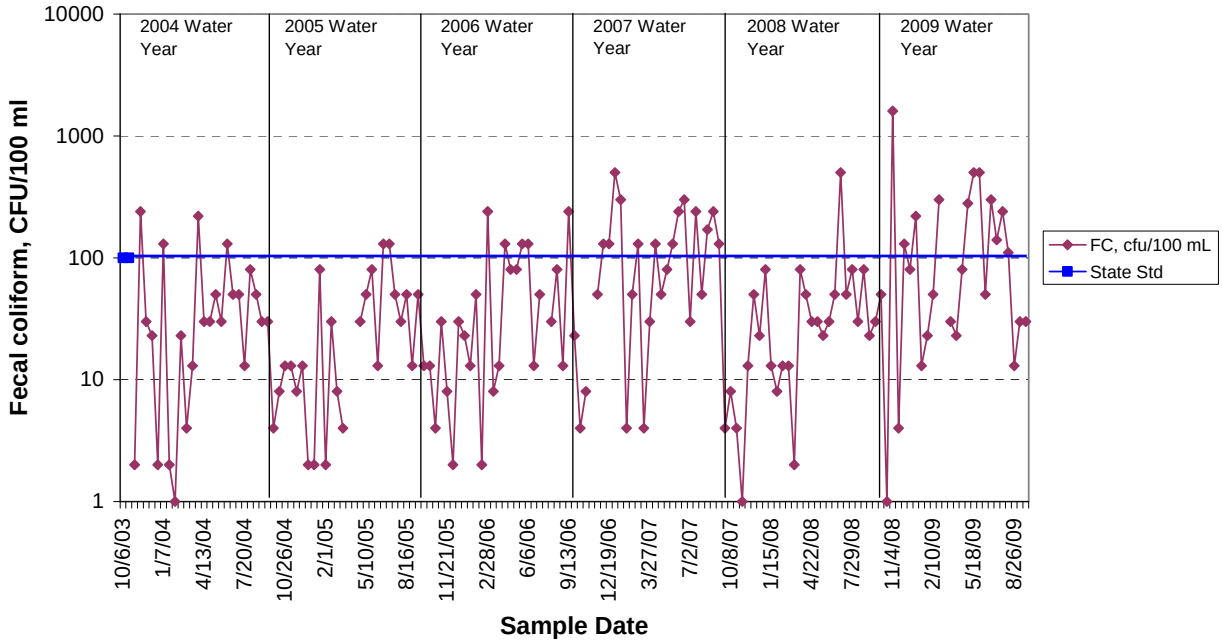
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Fecal coliform



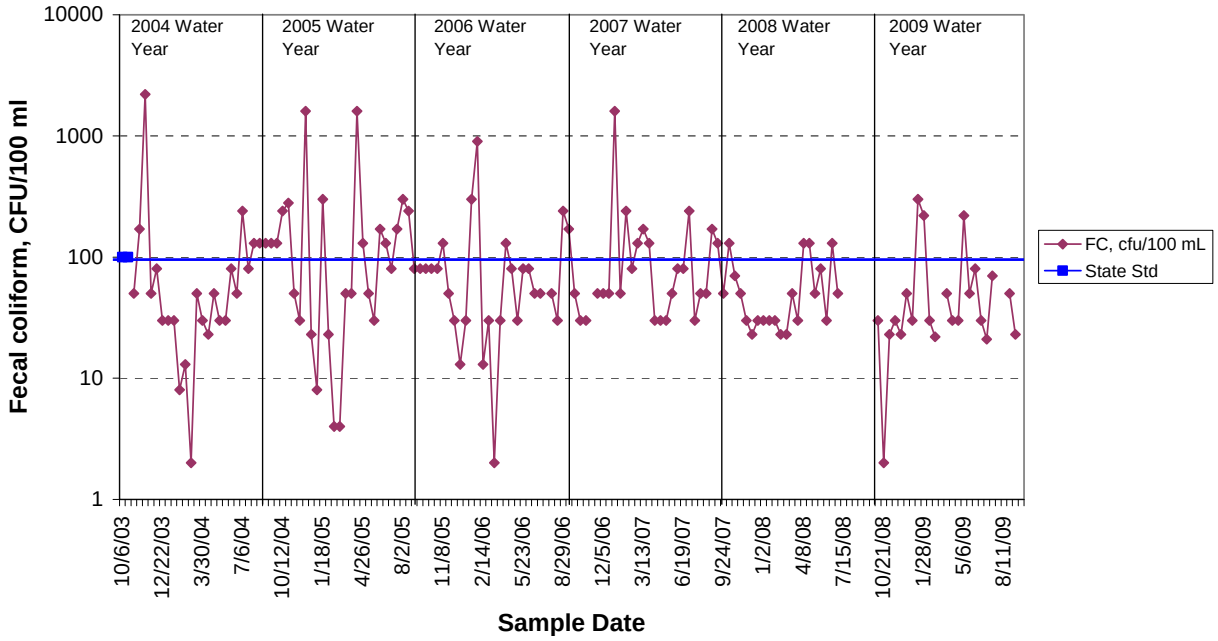
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Fecal coliform



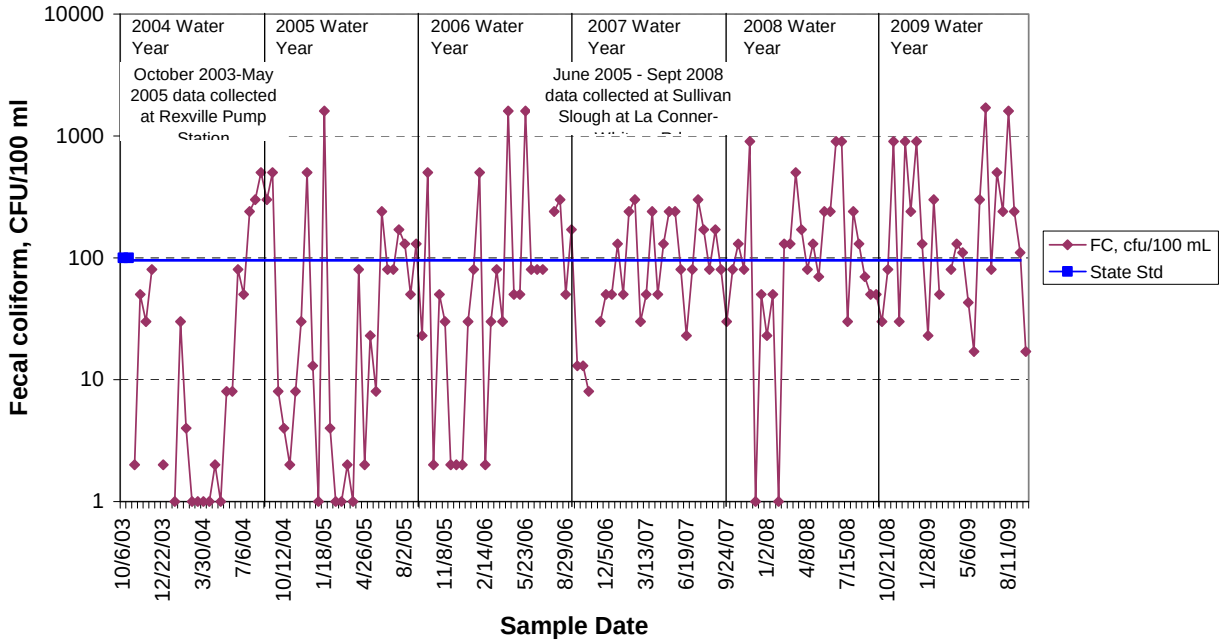
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Fecal coliform



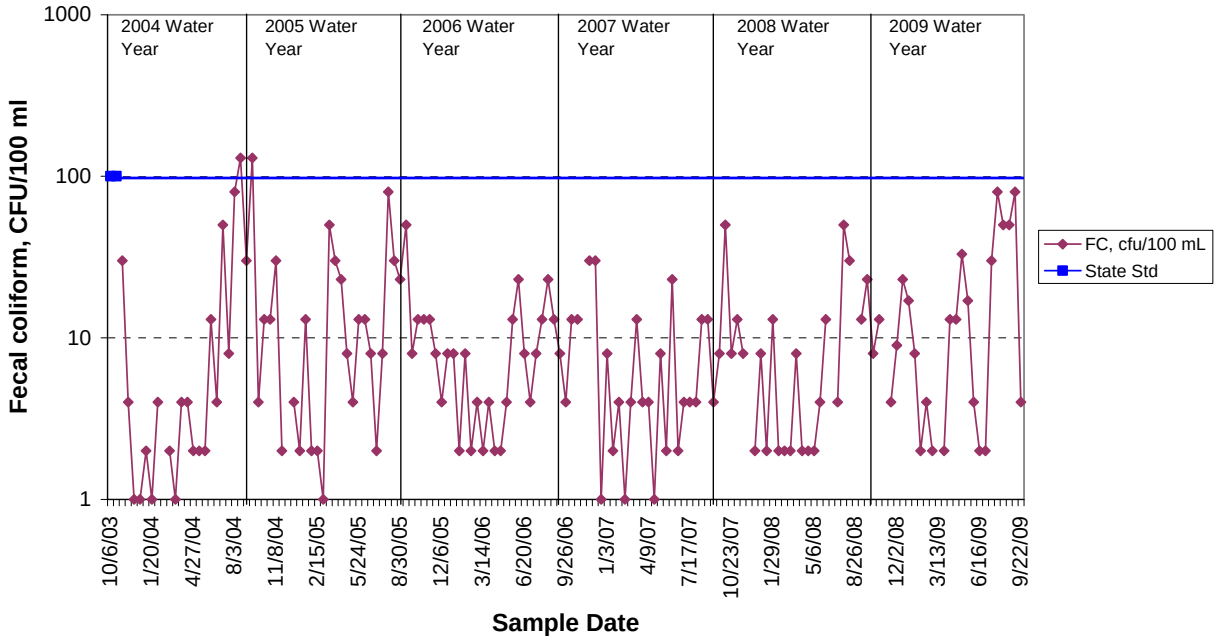
Wiley Slough at Wylie Rd - Site 43
Fecal coliform



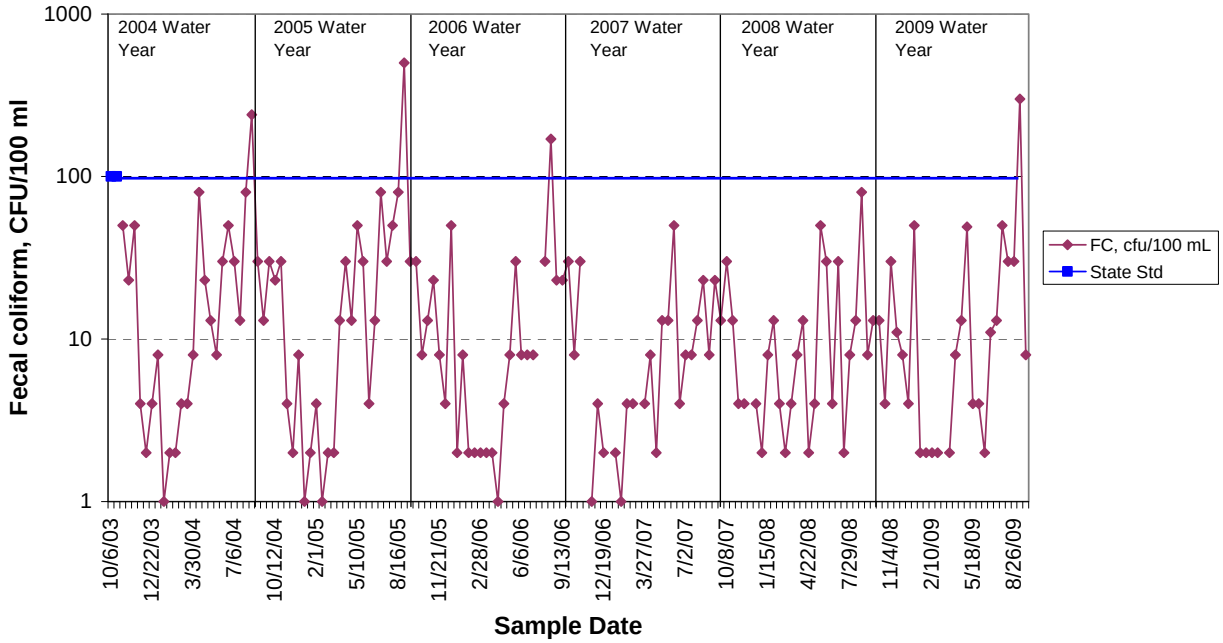
Sullivan Slough at La Conner-Whitney Rd - Site 44
Fecal coliform



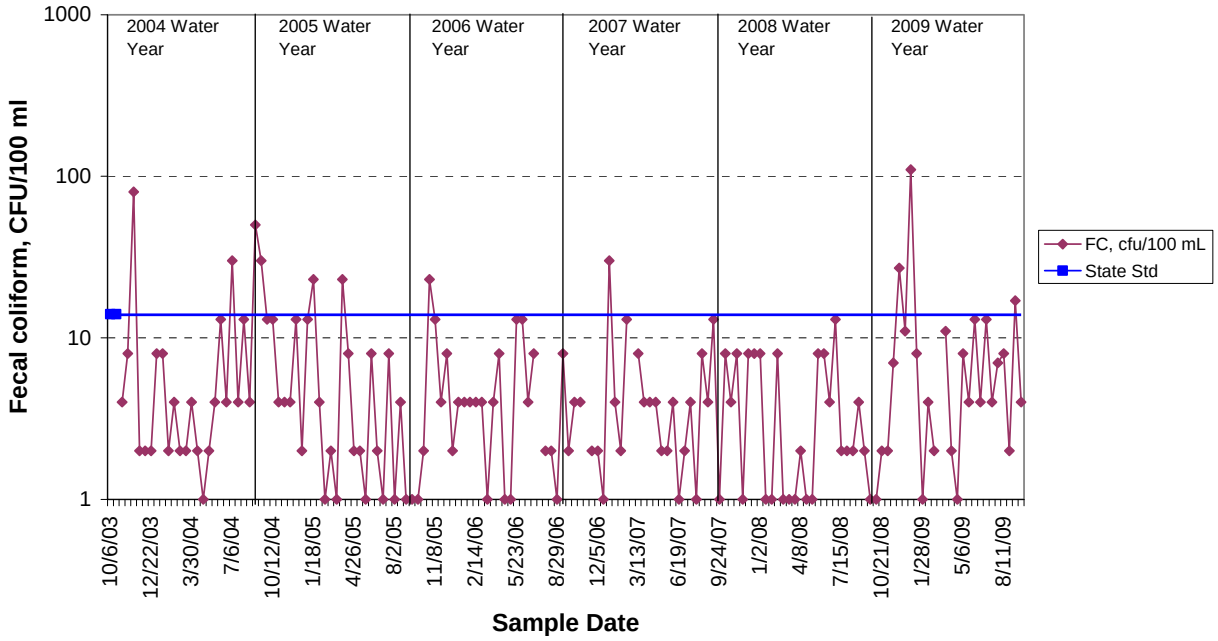
N.F. Skagit River at Moore Rd - Site 45
Fecal coliform



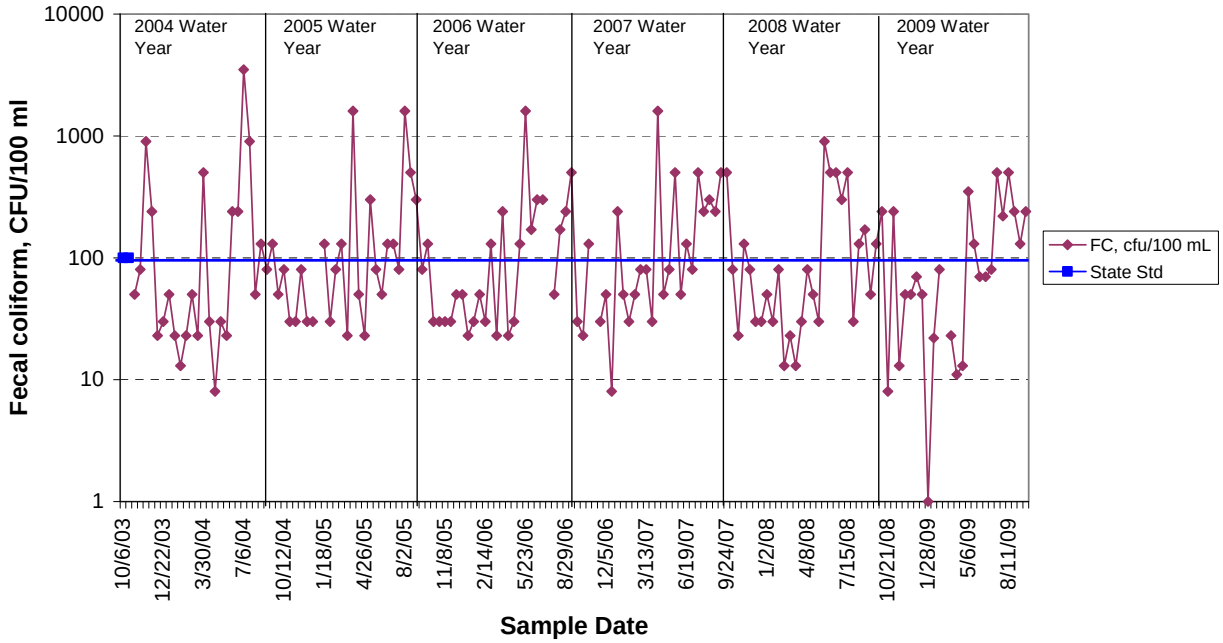
S.F. Skagit River at Conway - Site 46
Fecal coliform



Swinomish Channel at County Boat Ramp - Site 47
Fecal coliform



Fisher Creek at Franklin Rd - Site 48
Fecal coliform



Nutrients

Water samples for measurement of plant nutrients were taken at each station quarterly. Samples were analyzed by Edge Analytical of Burlington, WA. Table 9 gives mean nutrient values for selected parameters for the 2009 water year. All nutrient values are included in Appendix A, with summary statistics found in Appendix B.

Nutrient levels in watercourses determine the potential for algal activity. Excessive nutrient levels can lead to large blooms of algae, which can increase dissolved oxygen levels during the day but lead to large decreases in dissolved oxygen at night when the algae are respiring, and also when the algae die and decompose.

Most of the streams in the program showed moderate levels of total nitrogen, ammonia, and total phosphorus. The drainage infrastructure sampling sites generally had similar total phosphorus values and higher levels of total nitrogen and ammonia compared to the stream stations.

There are no numeric state standards for nutrients as factors in algal blooms. However, the state has both acute and chronic water quality standards for ammonia toxicity that are calculated from the ammonia level combined with the water temperature and pH for each individual ammonia measurement. Calculation of ammonia standards for a few individual readings suggests that some Skagit County watercourses would exceed the state standards on rare occasions.

Table 9. 2009 Nutrient Results
Mean Nutrient Values (Mg/L) For Watercourses In The Skagit County Monitoring Program, 2009 Water Year.

Site Number	Watercourse	Location	Total Nitrogen[1]	Total Phosphorus	Ammonia
3	Thomas Ck	Old Hwy 99 N	0.79	0.07	0.13
4	Thomas Ck	F&S Grade	0.57	0.07	0.06
6	Friday Ck	Prairie Rd	0.43	0.07	0.04
8	Swede Ck	Grip Rd	0.50	0.06	0.06
11	Samish R	State Route 9	0.31	0.06	0.04
12	Nookachamps Ck	Swan Rd	0.54	0.06	0.09
13	E.F. Nookachamps Ck	State Route 9	0.42	0.05	0.06
14	College Way Ck	College Way	0.55	0.07	0.09
15	Nookachamps Ck	Knapp	0.64	0.07	0.11
16	E.F. Nookachamps Ck	Beaver Lake Rd	0.31	0.05	0.03
17	Nookachamps Ck	Big Lake Outlet	0.45	0.05	0.05
18	Lake Ck	State Route 9	0.42	0.05	0.04
19	Hansen Ck	Hoehn Rd	0.50	0.11	0.05
20	Hansen Ck	Northern State	0.46	0.17	0.04
21	Coal Ck	Hoehn Rd	0.36	0.08	0.04
22	Coal Ck	Hwy 20	0.37	0.09	0.03
23	Wiseman Ck	Minkler Rd	0.38	0.10	0.02
24	Mannser Ck	Lyman Hamilton Hwy	0.40	0.05	0.03
25	Red Cabin Ck	Hamilton Cem Rd	0.33	0.06	0.02
28	Brickyard Ck	Hwy 20	0.64	0.05	0.10
29	Skagit R	River Bend Rd	2.33	0.07	0.07
30	Skagit R	Cape Horn Rd	0.29	0.07	0.02
31	Drain Dist 20 floodgate	Francis Rd	1.14	0.09	0.15
32	Samish R	Thomas Rd	0.44	0.08	0.08
33	Alice Bay Pump Station	Samish Island Rd	2.83	0.43	1.29
34	Noname Slough	Bayview-Edison Rd	1.54	0.61	0.35
35	Joe Leary Slough	D'Arcy Rd	1.25	0.20	0.63
36	Edison Slough at school	W. Bow Hill Rd	1.30	0.50	0.30
37	Edison Pump Station	Farm to Market Rd	2.97	0.77	1.60
38	North Edison Pump Station	North Edison Rd	2.90	0.78	1.19
39	Colony Ck	Colony Rd	0.72	0.12	0.07
40	Big Indian Slough	Bayview-Edison Rd	1.02	0.11	0.36
41	Maddox Slough/Big Ditch	Milltown Rd	1.29	0.13	0.43
42	Hill Ditch	Cedardale Rd	0.59	0.08	0.09
43	Wiley Slough	Wylie Rd	1.51	0.26	0.51
44	Sullivan Slough	Summers Dr/La Conner	1.38	0.28	0.61
45	Skagit R – North Fork	Moore Rd	0.34	0.08	0.03
46	Skagit R – South Fork	Fir Island Rd	0.32	0.06	0.02
47	Swinomish Channel	County Boat Launch	0.37	0.07	0.07
48	Fisher Ck	Franklin Rd	0.69	0.19	0.10

[1]Total Kjeldahl nitrogen

Other Parameters

The Skagit County Monitoring Program also measures pH, conductivity, and salinity during each visit to each site. Conductivity and salinity are measured to help interpret other water quality parameters. Measurement of pH shows whether a watercourse is within the range that supports aquatic life. In general, pHs in the Skagit program have been within state standards.

Discharge measurements are made in selected locations, usually on a four-week basis. Discharge measurements are intended to provide a general indication of the flow regime for that watercourse and as an aid in interpreting other water quality parameters. As the Department of Ecology has added several stream gauges in our area, Skagit County has de-emphasized discharge measurement.

Although results for these parameters are not discussed in detail in the main report, all measurements are available in Appendix A and are summarized in Appendix B.

Water Quality Index

The Water Quality Index (WQI) is an indicator developed by the Washington State Department of Ecology as an overall indicator of water quality at a given site. The Index compares typical water quality parameters with established standards and yields a single, unitless number between 1 and 100 to describe the overall water quality of a site at the time of sampling. The Index can then be summarized in a number of ways to give a site an overall score for a water year. The parameters included in the WQI are dissolved oxygen, temperature, pH, turbidity, suspended solids, fecal coliform, and nutrients.

The WQI is best used to answer general questions about the condition of watercourses, such as "What is the general condition of this stream," or "How does this stream compare to others in the area?" (Hallock 2002). Because the index is a distillation of many parameters, it is unsuitable for answering detailed questions concerning the water quality of an individual stream.

Ecology rates streams with WQI Overall Score of 80 or greater "of lowest concern." Streams with ratings of 40-80 are considered "of marginal concern," while scores less than 40 are considered "of highest concern."

Water Quality Index calculations for the sample sites in the Skagit County Monitoring Program during the 2009 water year are summarized in Table 10. Note that although the WQI was designed for freshwater bodies, we have applied the index to the Swinomish Channel monitoring site (Site 47), which is primarily marine. This allows trend detection over time at this station, but the WQI for Site 47 should not be compared to the freshwater sites.

The WQI results show that several watercourses in the study area fall into the "highest concern" category. Most, but not all, are agricultural drainages with little summer flow.

Table 10. 2009 Water Quality Index Results
Water Quality Index (WQI) determinations for watercourses in the Skagit County Monitoring Program, 2009 Water Year

Site Number	Watercourse	Location	Mean WQI	Overall Score*	Max	Min
3	Thomas Ck	Old Hwy 99 N	42	31	73	18
4	Thomas Ck	F&S Grade	72	66	90	50
6	Friday Ck	Prairie Rd	89	86	97	79
8	Swede Ck	Grip Rd	78	72	95	68
11	Samish R	State Route 9	85	81	98	76
12	Nookachamps Ck	Swan Rd	78	72	95	58
13	E.F. Nookachamps Ck	State Route 9	88	85	98	70
14	College Way Ck	College Way	57	46	87	24
15	Nookachamps Ck	Knapp	36	15	96	1
16	E.F. Nookachamps Ck	Beaver Lake Rd	93	91	100	89
17	Nookachamps Ck	Big Lake Outlet	88	84	99	77
18	Lake Ck	State Route 9	94	93	99	87
19	Hansen Ck	Hoehn Rd	91	91	97	86
20	Hansen Ck	Northern State	91	89	98	79
21	Coal Ck	Hoehn Rd	89	87	98	77
22	Coal Ck	Hwy 20	97	96	98	95
23	Wiseman Ck	Minkler Rd	98	98	99	97
24	Mannser Ck	Lyman Hamilton Hwy	75	69	95	65
25	Red Cabin Ck	Hamilton Cem Rd	97	97	98	97
28	Brickyard Ck	Hwy 20	71	71	92	51
29	Skagit R	River Bend Rd	96	94	99	92
30	Skagit R	Cape Horn Rd	92	89	99	81
31	Drain Dist 20 floodgate	Francis Rd	72	56	88	56
32	Samish R	Thomas Rd	80	75	94	53
33	Alice Bay Pump Station	Samish Island Rd	21	15	40	1
34	Noname Slough	Bayview-Edison Rd	26	14	63	1
35	Joe Leary Slough	D'Arcy Rd	20	15	33	12
36	Edison Slough at school	W. Bow Hill Rd	30	30	54	1
37	Edison Pump Station	Farm to Market Rd	21	18	31	1
38	North Edison PS	North Edison Rd	13	13	20	1
39	Colony Ck	Colony Rd	74	67	94	57
40	Big Indian Slough	Bayview-Edison Rd	17	11	34	1
41	Maddox Sl/Big Ditch	Milltown Rd	63	56	83	47
42	Hill Ditch	Cedardale Rd	52	39	91	13
43	Wiley Slough	Wylie Rd	22	10	58	5
44	Sullivan Slough	La Conner-Bayview Rd	43	33	72	17
45	Skagit R – North Fork	Moore Rd	96	95	99	94
46	Skagit R – South Fork	Fir Island Rd	94	93	98	92
47	Swinomish Channel	County Boat Launch	74	67	95	59
48	Fisher Ck	Franklin Rd	81	81	85	76

*Note: Overall score is the mean of the three lowest monthly scores (Hallock 2002)
Color code: Lowest Concern (80+ Overall Score), Marginal Concern (40-80), Highest Concern (<40)

Data Analysis

Summary statistics for all measured parameters at each sampling site can be found in Appendix B. These statistics can be used as a general indication of water quality conditions at each station. However, water quality conditions vary greatly at each station over time and the summary statistics should not be used as a sole indicator of water quality.

A primary goal of the Skagit County Monitoring Program is to detect trends in water quality over time. The purpose of the trends analysis is to provide indications of whether water quality in agricultural areas is improving, staying the same, or deteriorating. Once trends are detected, efforts could be undertaken to determine if the trends are caused by local activities or by regional conditions such as changes in climate. By comparing trends at stations inside and outside of the agricultural areas and by monitoring climate conditions, it should be possible to determine those conditions that seem to be caused by local circumstances.

One important statistical tool in trends monitoring is the Seasonal Kendall's Test. This test is designed to determine overall trends in water quality for parameters that vary seasonally, such as temperature and dissolved oxygen. The Seasonal Kendall's Test has been widely employed for similar purposes in Washington, Oregon, and throughout the country (e.g. Cude 2002, Ehinger 1993, Holdeman et al 2003). Most parameters measured in the Skagit County Monitoring Program have seasonal variation, caused by our local climate which produces comparatively high water flows and low temperatures in the winter and spring, and lower flows with higher temperatures in the summer and early fall.

The Seasonal Kendall's Test was computed using WQStat Plus software (Intelligent Design Technologies, 1998). For most analyses, twelve seasons were designated, starting with the beginning of each month. This approach was recommended in the review of Skagit County's water quality monitoring program by the WRC. Exceptions are noted below. Observations below detection limits were replaced with one-half of the detection limit per the software user manual. The software was able to ignore missing data, so no accommodation for missing data was necessary.

Skagit County has completed trends analysis via the Seasonal Kendall's Test for 17 key parameters or calculated factors at each sampling location. The parameters tested include pH, dissolved oxygen, temperature, turbidity, fecal coliform, ammonia, nitrate+nitrite, total phosphorus, orthophosphate, total Kjeldahl nitrogen (TKN, an estimate of the total available nitrogen), total suspended solids, and water quality index. Temperature data from biweekly sampling visits were used for this analysis instead of continuous data collected during the summer months because the Seasonal Kendall's Test is not designed for summer-only data. Skagit County continues to examine methods for determining trends in the continuous temperature data. Since the temperature data from biweekly visits was collected at the same time of day for any individual station, the trends analysis should not be biased by differences caused by time of day.

The period used for trends analysis was the six full years of Skagit County Monitoring Program data. This period was chosen to coincide with the implementation of the Critical Areas Ordinance for Areas of Ongoing Agriculture (Skagit County Ordinance O20030020).

Sites 21, 25, 28, and 31 have extended dry periods during most summers. The WQStat trends analysis program was unable to compute trends based on 12 seasons for those sites due to the lack of data for the dry periods. For those four sites, trends were calculated based on four seasons, starting with January, April, July, and October.

Data used for the Seasonal Kendall's Test can be subject to "autocorrelation," where each successive data point is correlated with the previous point (Dave Hallock, Washington Department of Ecology). This situation usually occurs when samples are collected more frequently than monthly. For the Skagit County Monitoring Program, dissolved oxygen, temperature, and fecal coliform data are collected biweekly. Tests are available to detect autocorrelation but in some cases may be confounded by the very seasonality we are trying to accommodate (Dave Hallock, Washington Department of Ecology). Our approach for these parameters has been to conduct the analysis using all data, and repeat the analysis using monthly averages to avoid autocorrelation (Mike Barber, Washington State Water Research Center). There were very few differences between these two calculations. In the cases where there are differences, it would probably be prudent to use the monthly averages.

A summary of Seasonal Kendall's Test results for those parameters showing a significant trend is provided in Table 11. Complete trends analysis results can be found in Appendix C.

Table 11. Trends Analysis Results
Summary of Significant Trends Detected in Skagit County Monitoring Program
2004-2009 Water Years

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
3	pH	130	0.061	4.683		
	MpH	65	0.070	4.108		
	Temp	131	-0.445	-4.105	Decreasing temperature	
	MT	65	-0.384	-2.457	Decreasing temperature	
	NH3	65	-0.010	-2.072	Decreasing ammonia	
4	DO	130	0.200	4.817	Increasing oxygen	
	MDO	65	0.201	3.495	Increasing oxygen	
	Temp	131	-0.351	-3.950	Decreasing temperature	
	MT	65	-0.283	-2.759	Decreasing temperature	
	NO3+NO2	65	-0.044	-2.399	Decreasing nitrate	
	NH3	65	0.003	1.995		Increasing ammonia
6	DO	128	0.224	4.446	Increasing oxygen	
	MDO	65	0.206	3.249	Increasing oxygen	
	Temp	130	-0.416	-4.327	Decreasing temperature	
	MT	65	-0.351	-3.004	Decreasing temperature	
	TP	65	0.000	-3.850	Decreasing phosphorus	
8	pH	130	0.055	4.156		
	MpH	65	0.055	3.439		
	DO	130	0.216	4.140	Increasing oxygen	
	MDO	65	0.219	2.570	Increasing oxygen	
	Temp	131	-0.379	-3.712	Decreasing temperature	
	MT	65	-0.301	-2.326	Decreasing temperature	
	TP	65	0.000	-2.104	Decreasing phosphorus	
11	pH	130	0.106	7.692		
	MpH	65	0.103	6.387		
	DO	131	0.165	3.270	Increasing oxygen	
	MDO	65	0.150	2.146	Increasing oxygen	
	Temp	131	-0.303	-3.390	Decreasing temperature	
	MT	65	-0.351	-2.326	Decreasing temperature	
	Turb	131	-0.256	-3.891	Decreasing turbidity	
	MTB	65	-0.277	-2.326	Decreasing turbidity	
	TP	65	0.000	-2.838	Decreasing phosphorus	
	NH3	65	0.007	3.232		Increasing ammonia
	TSS	64	0.000	-2.727	Decreasing solids	
	WQI	62	0.931	2.733	Increasing WQI	
12	pH	122	0.100	7.588		
	MpH	65	0.085	5.039		
	DO	122	0.189	2.044	Increasing oxygen	
	MDO	65	0.252	2.246	Increasing oxygen	
	Temp	122	-0.396	-3.388	Decreasing temperature	
	MT	65	-0.435	-3.540	Decreasing temperature	
	FC	122	-6.687	-2.537	Decreasing coliform	

Table 11. Trends Analysis Results (con't.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
13	pH	128	0.087	5.368		
	MpH	65	0.080	4.013		
	DO	128	0.261	3.717	Increasing oxygen	
	MDO	65	0.307	3.825	Increasing oxygen	
	Temp	128	-0.456	-4.496	Decreasing temperature	
	MT	65	-0.539	-3.406	Decreasing temperature	
	TP	65	0.000	-3.559	Decreasing phosphorus	
	WQI	62	0.669	2.793	Increasing WQI	
14	pH	129	-0.035	-2.696		
	Temp	130	-0.368	-3.412	Decreasing temperature	
	MT	65	-0.368	-2.566	Decreasing temperature	
	Turb	130	0.355	2.219		Increasing turbidity
	MTB	65	0.346	2.246		Increasing turbidity
15	pH	130	0.110	8.627		
	MpH	65	0.096	5.595		
	DO	130	0.164	2.910	Increasing oxygen	
	Temp	130	-0.379	-3.708	Decreasing temperature	
	MT	65	-0.493	-2.853	Decreasing temperature	
	MFC	65	-8.207	-2.864	Decreasing coliform	
	NO3+NO2	65	0.019	2.329		Increasing nitrate
	TP	65	0.000	2.013	Decreasing phosphorus	
16	pH	130	0.084	4.443		
	MpH	65	0.076	3.163		
	DO	130	0.176	3.835	Increasing oxygen	
	MDO	65	0.201	2.853	Increasing oxygen	
	Temp	130	-0.434	-4.146	Decreasing temperature	
	MT	65	-0.503	-3.582	Decreasing temperature	
	FC	129	-3.550	-3.371	Decreasing coliform	
	MFC	65	-8.207	-2.864	Decreasing coliform	
	TP	65	0.000	-3.027	Decreasing phosphorus	
	NH3	65	0.000	1.998		Increasing ammonia
	WQI	62	0.484	2.182	Increasing WQI	
17	pH	130	0.062	4.445		
	MpH	65	0.053	2.489		
	DO	130	0.185	4.389	Increasing oxygen	
	MDO	65	0.208	3.460	Increasing oxygen	
	Temp	130	-0.395	-3.144	Decreasing temperature	
	MT	65	-0.432	-2.376	Decreasing temperature	
18	pH	130	0.097	6.112		
	MpH	65	0.099	4.189		
	DO	130	0.120	2.887	Increasing oxygen	
	MDO	65	0.122	2.676	Increasing oxygen	
	Temp	130	-0.301	-3.242	Decreasing temperature	
	MT	65	-0.401	-3.661	Decreasing temperature	
	NO3+NO2	65	0.020	2.140		Increasing nitrate
	TP	65	0.000	-3.338	Decreasing phosphorus	

Table 11. Trends Analysis Results (con't.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
19	pH	130	0.065	4.586		
	MpH	65	0.065	3.740		
	DO	131	0.281	6.792	Increasing oxygen	
	MDO	65	0.273	4.406	Increasing oxygen	
	Temp	131	-0.506	-4.870	Decreasing temperature	
	MT	65	-0.451	-3.126	Decreasing temperature	
	TP	65	0.000	-2.249	Decreasing phosphorus	
	NH3	64	0.010	2.393		Increasing ammonia
20	pH	129	0.045	3.109		
	MpH	65	0.060	2.084		
	DO	131	0.212	5.777	Increasing oxygen	
	MDO	65	0.226	4.406	Increasing oxygen	
	Temp	131	-0.408	-4.531	Decreasing temperature	
	MT	65	-0.384	-2.882	Decreasing temperature	
	TP	65	0.000	-2.966	Decreasing phosphorus	
	NH3	65	0.000	2.135		Increasing ammonia
21	pH	115	0.055	4.479		
	MpH	60	0.063	3.876		
	DO	116	0.279	4.017	Increasing oxygen	
	MDO	60	0.326	3.754	Increasing oxygen	
	Temp	116	-0.651	-3.607	Decreasing temperature	
	MT	60	-0.652	-3.268	Decreasing temperature	
	TP	58	0.000	-2.113	Decreasing phosphorus	
	NH3	58	0.000	2.232		Increasing ammonia
	TSS	58	0.948	2.395		Increasing solids
22	DO	129	0.176	4.144	Increasing oxygen	
	MDO	65	0.169	3.672	Increasing oxygen	
	Temp	130	-0.531	-4.560	Decreasing temperature	
	MT	65	-0.502	-3.250	Decreasing temperature	
23	DO	127	0.154	3.306	Increasing oxygen	
	MDO	65	0.126	2.326	Increasing oxygen	
	Temp	127	-0.492	-4.463	Decreasing temperature	
	MT	65	-0.384	-3.127	Decreasing temperature	
	NO3+NO2	64	-0.053	-2.553	Decreasing nitrate	
	TP	64	0.000	-2.444	Decreasing phosphorus	
	NH3	64	0.000	2.476		Increasing ammonia
24	pH	130	0.083	8.042		
	MpH	65	0.088	6.020		
	DO	131	0.261	3.591	Increasing oxygen	
	MDO	65	0.196	3.794	Increasing oxygen	
	Temp	131	-0.312	-3.770	Decreasing temperature	
	MT	65	-0.228	-2.457	Decreasing temperature	
	FC	128	-3.476	-3.474	Decreasing coliform	
	TKN	65	0.000	-2.071	Decreasing nitrogen	
	TP	65	0.000	-3.085	Decreasing phosphorus	
	NH3	65	0.003	3.694		Increasing ammonia

Table 11. Trends Analysis Results (con't.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
25	DO	114	0.164	3.417	Increasing oxygen	
	MDO	60	0.152	2.827	Increasing oxygen	
	Temp	113	-0.359	-3.211	Decreasing temperature	
	FC	110	-0.254	-2.321	Decreasing coliform	
	WQI	59	0.501	2.143	Increasing WQI	
28	pH	98	0.089	3.615		
	MpH	55	0.070	2.813		
	DO	99	0.356	2.954	Increasing oxygen	
	MDO	55	0.316	2.891	Increasing oxygen	
	Temp	99	-0.501	-2.631	Decreasing temperature	
	MTB	55	0.502	2.311		Increasing turbidity
	NO3+NO2	50	-0.090	-2.997	Decreasing nitrate	
29	pH	129	0.089	3.170		
	MpH	65	0.075	2.676		
	Temp	130	-0.320	-4.217	Decreasing temperature	
	MT	65	-0.313	-3.488	Decreasing temperature	
	Turb	130	-0.766	-2.517	Decreasing turbidity	
	NO3+NO2	63	0.009	3.292		Increasing nitrate
	TKN	63	0.000	-2.057	Decreasing nitrogen	
	TP	62	0.000	-2.148	Decreasing phosphorus	
30	pH	129	0.051	4.487		
	MpH	65	0.052	4.107		
	DO	130	0.129	3.787	Increasing oxygen	
	MDO	65	0.115	3.060	Increasing oxygen	
	Temp	130	-0.368	-4.963	Decreasing temperature	
	MT	65	-0.267	-3.262	Decreasing temperature	
	Turb	130	-0.893	-3.668	Decreasing turbidity	
	MTB	65	-1.150	-2.448	Decreasing turbidity	
	TP	64	0.000	-2.031	Decreasing phosphorus	
31	Turb	76	-1.975	-2.831	Decreasing turbidity	
	MTB	45	-1.825	-2.395	Decreasing turbidity	
32	pH	131	0.070	3.413		
	MpH	66	0.090	3.001		
	DO	131	0.169	2.857	Increasing oxygen	
	MDO	66	0.213	2.585	Increasing oxygen	
	Temp	133	-0.502	-4.586	Decreasing temperature	
	MT	66	-0.417	-3.066	Decreasing temperature	
	TP	66	0.000	-1.986	Decreasing phosphorus	
	WQI	62	0.724	2.724	Increasing WQI	
33	Temp	131	-0.596	-3.942	Decreasing temperature	
	MT	66	-0.535	-3.579	Decreasing temperature	
	Turb	131	-1.460	-2.232	Decreasing turbidity	
	MTB	66	-1.569	-2.203	Decreasing turbidity	
	FC	132	-11.31	-3.612	Decreasing coliform	
	MFC	66	-16.67	-2.569	Decreasing coliform	

Table 11. Trends Analysis Results (con't.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
34	pH	128	0.065	2.954		
	Temp	128	-0.396	-3.001	Decreasing temperature	
	MT	64	-0.426	-2.824	Decreasing temperature	
	NH3	64	-0.022	-2.352	Decreasing ammonia	
35	pH	122	0.127	5.530		
	MpH	62	0.138	3.866		
	DO	129	0.385	3.857	Increasing oxygen	
	MDO	62	0.375	3.459	Increasing oxygen	
	Temp	124	-0.552	-5.843	Decreasing temperature	
	MT	62	-0.602	-5.303	Decreasing temperature	
	FC	119	-9.837	-2.341	Decreasing coliform	
	WQI	60	3.862	2.842	Increasing WQI	
36	Temp	131	-0.802	-4.242	Decreasing temperature	
	MT	67	-0.741	-3.343	Decreasing temperature	
	Turb	131	-0.508	-2.094	Decreasing turbidity	
	MTB	67	-0.757	-2.397	Decreasing turbidity	
	FC	133	-5.904	-2.939	Decreasing coliform	
37	Temp	130	-0.610	-3.995	Decreasing temperature	
	MT	66	-0.537	-3.373	Decreasing temperature	
	TKN	65	0.311	3.809		Increasing Nitrogen
	TP	65	0.042	2.146		Increasing phosphorus
38	Temp	128	-0.528	-3.769	Decreasing temperature	
	TP	65	0.055	2.334		Increasing phosphorus
39	MpH	65	0.046	2.268		
	DO	128	0.224	5.015	Increasing oxygen	
	MDO	65	0.267	3.060	Increasing oxygen	
	Temp	130	-0.486	-4.456	Decreasing temperature	
	MT	65	-0.414	-2.716	Decreasing temperature	
	FC	128	-2.774	-2.021	Decreasing coliform	
	TKN	64	0.030	2.350		Increasing Nitrogen
40	pH	127	0.081	6.448		
	MpH	63	0.090	4.568		
	DO	127	0.400	4.096	Increasing oxygen	
	Temp	127	-0.246	-2.327	Decreasing temperature	
	NO3+NO2	63	0.080	2.675		Increasing nitrate
	TKN	64	0.034	2.233		Increasing Nitrogen
	OP	34	0.024	2.390		Increasing phosphate
	WQI	62	6.015	2.338	Increasing WQI	
41	pH	130	0.074	5.594		
	MpH	65	0.069	3.770		
	DO	130	0.425	3.948	Increasing oxygen	
	MDO	130	3.290	3.603	Increasing oxygen	
	Temp	130	-0.394	-3.191	Decreasing temperature	
	MT	65	-0.299	-2.567	Decreasing temperature	

Table 11. Trends Analysis Results (con't.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
42	pH	129	0.075	6.024		
	MpH	64	0.079	5.186		
	DO	129	0.197	2.610	Increasing oxygen	
	Temp	129	-0.301	-2.824	Decreasing temperature	
	NO3+NO2	65	0.018	2.038		Increasing nitrate
	TKN	65	0.060	2.383		Increasing Nitrogen
	NH3	65	0.007	2.346		Increasing ammonia
43	pH	124	0.038	2.482		
	DO	124	0.582	3.641	Increasing oxygen	
	MDO	62	0.687	2.852	Increasing oxygen	
	Temp	123	-0.299	-2.731	Decreasing temperature	
	MT	62	-0.299	-2.475	Decreasing temperature	
	TP	62	0.000	-2.492	Decreasing phosphorus	
	WQI	59	6.015	2.105	Increasing WQI	
44	pH	129	0.090	3.705		
	MpH	65	0.071	2.489		
	DO	128	1.091	4.091	Increasing oxygen	
	MDO	65	1.024	2.732	Increasing oxygen	
	Temp	129	-0.251	-2.962	Decreasing temperature	
	MT	65	-0.293	-3.553	Decreasing temperature	
	FC	129	12.360	3.197		Increasing coliform
	NO3+NO2	64	0.039	4.541		Increasing nitrate
	TKN	65	0.132	3.419		Increasing Nitrogen
	OP	33	0.031	2.908		Increasing phosphate
	NH3	65	0.060	2.559		Increasing ammonia
45	pH	126	0.178	8.103		
	MpH	65	0.182	6.294		
	DO	122	0.057	2.236	Increasing oxygen	
	Temp	124	-0.302	-4.093	Decreasing temperature	
	MT	64	-0.359	-3.036	Decreasing temperature	
	Turb	124	-1.155	-3.592	Decreasing turbidity	
	MTB	64	-0.976	-2.719	Decreasing turbidity	
	NO3+NO2	62	0.010	3.340		Increasing nitrate
	NH3	62	0.000	1.986		Increasing ammonia
46	pH	125	0.129	8.122		
	MpH	64	0.141	5.750		
	DO	125	0.067	2.503	Increasing oxygen	
	Temp	125	-0.321	-4.615	Decreasing temperature	
	Turb	125	-1.212	-3.553	Decreasing turbidity	
	FC	124	-0.660	-2.432	Decreasing coliform	
	NO3+NO2	63	0.010	3.277		Increasing nitrate
47	pH	129	-0.022	-1.968		
	DO	130	0.139	2.658	Increasing oxygen	
	Temp	130	-0.204	-3.599	Decreasing temperature	
	MT	65	-0.175	-3.107	Decreasing temperature	
	NO3+NO2	65	0.030	3.430		Increasing nitrate

Table 11. Trends Analysis Results (con't.)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
48	DO	129	0.078	2.352	Increasing oxygen	
	MDO	65	0.063	2.189	Increasing oxygen	
	Temp	130	-0.251	-3.387	Decreasing temperature	
	MT	65	-0.251	-2.919	Decreasing temperature	

Notes: N = Number of data points
Slope = Magnitude and direction of trend in original units per year
Z = Calculated Kendall's statistic, Z > 1.960 or < -1.960 means statistically significant trend at 95% confidence level
M = Monthly, e.g. MDO represents the Kendall's statistic calculated on monthly means instead of individual biweekly data, in order to control for autocorrelation

Trends analysis results and discussion – Trends were calculated for 17 parameters or calculated parameters (such as monthly averages) at each site, for a total of 680 tests. Of those, 306 tests showed a statistically significant trend at the 95% confidence level. Trends judged as improving (e.g. increased dissolved oxygen, reduced temperature) made up 173 of the significant trends. Deleterious trends (e.g. reduced dissolved oxygen, increased nutrients) made up 82 of the significant trends. The remaining 51 trends were increasing pH or monthly pH, and a value judgment was not made for those trends as their implications are not clear at this point.

Because the overall list of significant trends included many redundant items (e.g. biweekly dissolved oxygen and monthly average dissolved oxygen), the list was reduced to unique trends involving the monthly averages (for pH, dissolved oxygen, temperature, and turbidity) plus the nutrient data which was already monthly. For this data set, there were 187 significant trends, with 91 trends identified as representing improved conditions and 73 identified as deleterious. The remaining 23 were increasing pH trends.

By either accounting method, the improving trends outnumber the deleterious trends. Most of the positive trends were either reduced temperature or increased dissolved oxygen. Since dissolved oxygen levels are inversely related to the temperature, at least some of the improvements in dissolved oxygen could be due to the temperature declines.

Thirty-three of the 40 stations showed a significant declining trend in monthly mean water temperature over the life of the study. In most cases this would represent an improvement in salmonid rearing conditions. Weather data collected at the Washington State University Extension Service Field Station in West Mount Vernon also shows a declining trend in air temperature for 2003-2008, as assessed by the Seasonal Kendall's Test. This effect was highly dependent on the warm 2004 water year data and the cool 2008 water year data, and with the warmer 2009 air temperature data added, the trend in air temperature became non-significant.

Twenty-five of the 40 sites showed a significant increasing trend in mean monthly dissolved oxygen over the life of the study. As mentioned above, this likely stems at least in part from the declining temperatures. However, 12 of the 40 sites showed a significant increasing trend in oxygen percent saturation, which takes temperature into account. This indicates that dissolved oxygen improved at some sites independent of the temperature reduction (this analysis was

completed after the tables and appendices were completed and is not included in them). There were no declining trends in dissolved oxygen or percent saturation.

Eight sites showed a significant increasing trend in Water Quality Index (WQI). This can be seen as a general indicator of improving water quality, although the previously discussed temperature and dissolved oxygen trends could explain the increases in WQI.

Most of the deleterious trends were increases in nutrient values. Increased nutrients can lead to excessive blooms of algae, which can upset food webs and lead to dissolved oxygen depletion. In extreme cases, ammonia levels can be high enough to produce direct toxicity. Ammonia toxicity is tied to pH and temperature, so the toxicity of a particular reading must be assessed individually. A spot check of Skagit County ammonia data indicates that observed levels in the drainage infrastructure may occasionally approach chronically toxic levels.

Trend statistics are tools to help us understand changing conditions in our watercourses, but do not completely describe the condition of a watercourse. Many of the sites with no significant trends or improving trends in water quality parameters still do not meet state water quality standards, and therefore still qualify as areas of concern. Many Skagit County sites remain on Ecology's Impaired Waters list. As previously discussed, high fecal coliform levels in the Samish Bay watershed have led to closures of shellfish beds and loss of revenue. Dissolved oxygen and temperature conditions are still substandard in many watercourses, resulting in poor rearing conditions for salmonids and other aquatic life.

Data Quality

This section details the steps taken to ensure high quality data in the Skagit County Monitoring Program, and the results of quality control checks.

Sampling Plan (Quality Assurance Project Plan, or QAPP)

The Skagit County Monitoring Program operates under a QAPP approved by Ecology in 2003. This plan details sampling strategies, equipment to be used, and all other aspects of the sampling program, and Ecology approval was required in order for Skagit County to access grant funds. The plan forms the basis for all sampling activities. The plan may be viewed at www.skagitcounty.net/scmp.

Quality Control Measures

Field Meter calibration

Field meters are calibrated according to manufacturer's recommendations, or more often as needed.

The turbidity meter (Lamotte 2020) is calibrated the afternoon before or the morning of each sampling trip, and the reading before calibration is recorded. For 44 recorded calibrations during

this period, the average deviation from the calibration standard was 10.6%. This reflects meter drift between the calibration the afternoon before the sampling trip and the next calibration a week later. It is likely that meter drift during the sampling day is substantially less than 10%.

The pH meter (Hanna Instruments 8314) is calibrated on the morning of each sampling trip, then left on throughout the sampling trip. The pH meter is recalibrated during the trip if the meter was turned off or if questionable results were obtained. The meter rarely deviated more than 0.02 pH units from the calibration standard.

The dissolved oxygen/temperature/conductivity meter (YSI 85) is calibrated for dissolved oxygen using the built-in calibration chamber (water-saturated air). The meter is recalibrated to local elevation at each sample site. For several weeks during the 2005 water year, Skagit County recorded the meter deviation from the calibration target for those occasions when the deviation exceeded 1%. During that period, meter deviation exceeded that value 89 times out of 180 sample sites (49%). Average deviation for those 89 calibrations was 2.6%. Since the meter was recalibrated at each sample site, the actual meter drift before use was something less than 1%.

The dissolved oxygen meter probe is deployed in areas with sufficient current (> 1 fps) to produce reliable results, or the probe is stirred to produce adequate velocity across the membrane. Samples for pH and turbidity are obtained from the thalweg of the stream with sample containers rinsed at least twice with sample water, and are analyzed immediately.

Lab samples

Laboratory samples are collected using clean equipment and proper procedures. Samples for nutrient and suspended solids analysis are collected with a sampling wand from the thalweg of the watercourse, and care is taken to prevent oversampling of the surface film or disturbing the bottom. The sampling container is rinsed twice with the water to be sampled. The sample is then obtained and poured into the bottles provided by the contract lab, Edge Analytical of Burlington, WA, an Ecology-certified laboratory. Samples are capped and placed in a cooler with water ice until they are picked up by the lab on the same day.

Samples for fecal coliform are collected and stored in an identical manner and transported to the laboratory within eight hours of collection.

Quality Control Review

Data from field sheets and lab reports is entered into the Skagit County Water Quality Database. Once all the data for a given date is entered, a printout from the database is produced and compared to the original field and lab data sheets. Any data entry errors are then corrected in the database.

Personnel

The Project Manager has over 25 years of experience monitoring water quality in the freshwater environment. The Project Manager is present on over 80% of the sampling trips and personally trained all other personnel involved.

Duplicate Analysis

Because water quality is constantly changing in streams, duplicate analysis is not attempted for parameters determined in the field – dissolved oxygen, temperature, conductivity, salinity, and turbidity. Instead, we rely on maintenance and calibration of the field meters according to manufacturer's recommendations and experienced field staff to produce reliable field data.

Duplicate samples are collected for fecal coliform at a 20% rate and for two selected nutrients at a 10% rate. Selected nutrient duplicates (total phosphorus, orthophosphate, nitrate, and/or ammonia) are intended to provide a precision estimate for all the nutrient analyses.

Table 12 summarizes the results of the duplicate analyses for the 2009 water year.

Variability in fecal coliform, total phosphorus, and ammonia were above target levels. The fecal coliform data showed particularly high variability. These results are similar to what was found in the first five years of the Skagit County Monitoring Program and in Skagit County's previous work in the Baseline and Samish Bay Tributaries studies.

Table 12. 2009 Data Quality Results
Coefficients of Variation for parameters with duplicate samples in the Skagit County Monitoring Program – 2009 Water Year

		Coefficient of Variation[1]	
Parameter	N	2009 Results	Target CV (%)[2]
Fecal coliform		47	33
Total phosphorus		15	10 [3]
Nitrate		4	10 [3]
Ortho-phosphate		1	10 [3]
Ammonia		25	10 [3]

[2] Target precision as listed in QAPP
[3] 10% CV target was listed for all nutrients

Fecal coliform duplicates are collected as follows: A 200-ml sample collection bottle is filled and emptied twice with water from the sampling site to serve as rinses. The bottle is then filled again, capped, and homogenized. Care is taken to prevent oversampling of the surface film and disturbance of bottom sediments. Two 100-ml samples are then poured from the sample collection bottle, alternating approximately 50-ml aliquots into each sample container, with the sample collection bottle swirled in between aliquots to maintain homogenization. Once both sample bottles are filled, they are capped (leaving air space) and immediately placed in a cooler with ice.

This method of collection should minimize the variability due to changing water quality and uneven distribution of coliform organisms in the water column. What remains should be an estimate of laboratory variability, assuming that the samples are handled the same between the site and the laboratory.

The high variability of the fecal coliform results is at least partially due to the use of the Most Probable Number (MPN) analysis technique (Don Lennartson, Washington State Department of Health (retired), personal communication). This method was chosen for the Skagit County Monitoring Program because the Skagit County Health Department laboratory is certified for the method, and because it is reportedly more reliable for samples with high turbidity, which are often encountered in the Skagit County Monitoring Program (Michaud 1991). We continued using MPN when we switched to Edge Analytical in 2009 to maintain data comparability. Fecal coliform variability in the Skagit County Monitoring Program, although higher than the initial target level, is similar to that seen in other studies in Washington (Paul Pickett, Washington State Department of Ecology, personal communication). The reasons for the higher nutrient variability are unknown at this point.

Data Quality Summary

The Skagit County Monitoring Program produces reliable data that is suitable for inclusion in Ecology's Environmental Information Management system. Data is collected according to an Ecology-approved Quality Assurance Project Plan. Field parameters are analyzed using calibrated meters and consistent sampling methods. Laboratory samples are handled correctly and analyzed in Ecology-certified laboratories. The database is rechecked for data entry errors. Experienced personnel are involved with every aspect of data collection and analysis. The information collected in the Skagit County Monitoring Program should be considered high quality data.

Annual Report Summary

The Skagit County Monitoring Program completed a sixth water year of sampling in September 2009. Standard water quality parameters were collected biweekly at 40 sites in watercourses in both agricultural and non-agricultural areas. Results indicated that many watercourses did not meet state water quality standards for one or more parameters. Trend analysis revealed a pattern of both improving and deteriorating trends, with a plurality of improving trends. Skagit County continues to seek resources to address the water quality problems identified here.

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References

Cichosz, Tom and Michael E. Barber. 2008. Review of Skagit County Water Quality Monitoring Program. State of Washington Water Research Center.

Cude, Curtis. 2002. McKenzie Watershed Water Quality Report: Water Years 1992-2001. Oregon Department of Environmental Quality, Portland, OR.

Ehinger, Bill. 1993. Water Quality Data Summary and Linear Trend Analysis of the Wenatchee River Basin. Washington State Department of Ecology Report 93-e16.

Hallock, Dave. 2002. A Water Quality Index for Ecology's Stream Monitoring Program. Washington State Department of Ecology Publication No. 02-03-052.

Holdeman, Mark A., Gibson, Sammy C, and Carl Christensen. 2003. Trend Analysis of Fixed Station Water Quality Monitoring Data in the Upper Wabash River Basin 1998. Indiana Department of Environmental Management, Office of Water Quality, Assessment Branch, Surveys Section, Indianapolis, Indiana. IDEM 032/02/023/2003.

Intelligent Design Technologies. 1998. WQStat Plus statistics software and user's manual. Longmont, CO.

Michaud, J.P., 1991. A Citizen's Guide to Understanding and Monitoring Lakes and Streams. Washington State Centennial Clean Water, Puget Sound Water Quality Authority.

Pickett, Paul J. 1997. Lower Skagit River Total Maximum Daily Load Water Quality Study. Washington State Department of Ecology Publication No. 97-326a.

Skagit County. 2003. Samish Bay Watershed Water Quality Monitoring Project Final Report. Skagit County Public Works, Mount Vernon, WA.

Skagit County. 2004a. Baseline Water Quality Monitoring Project Final Report. Skagit County Public Works, Mount Vernon, WA.

Skagit County. 2004b. Skagit County Water Quality Monitoring Program Quality Assurance Project Plan, Update 5-13-04. Skagit County Public Works, Mount Vernon, WA.

Skagit County. 2004c. Skagit County Monitoring Program Annual Report, 2004 Water Year. Skagit County Public Works, Mount Vernon, WA.

Skagit County. 2006. Skagit County Monitoring Program Annual Report, 2005 Water Year. Skagit County Public Works, Mount Vernon, WA.

Skagit County. 2007. Skagit County Monitoring Program Annual Report, 2006 Water Year. Skagit County Public Works, Mount Vernon, WA.

Skagit County. 2008. Skagit County Monitoring Program Annual Report, 2007 Water Year. Skagit County Public Works, Mount Vernon, WA.

Skagit County. 2009. Skagit County Monitoring Program Annual Report, 2008 Water Year. Skagit County Public Works, Mount Vernon, WA.