Skagit County Monitoring Program

Annual Report - 2010 Water Year (October 2009 – September 2010)

Colony Creek

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

Executive Summary

Skagit County has completed the seventh 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 seventh annual report, for the 2010 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. None of the 40 sites has met all water quality standards for the entire project, although some sites meet the standards most of the time. 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 received EPA funding to address Samish Bay Watershed pollution issues and is working in partnership with the Washington State Department of Ecology, the Skagit Conservation District, local tribes, 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 2011 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

2010 Water Year
(October 2009-September 2010)

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 Management 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 Management 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 2010 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. The legislature subsequently passed additional legislation to extend the "time out" to 2011.

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.

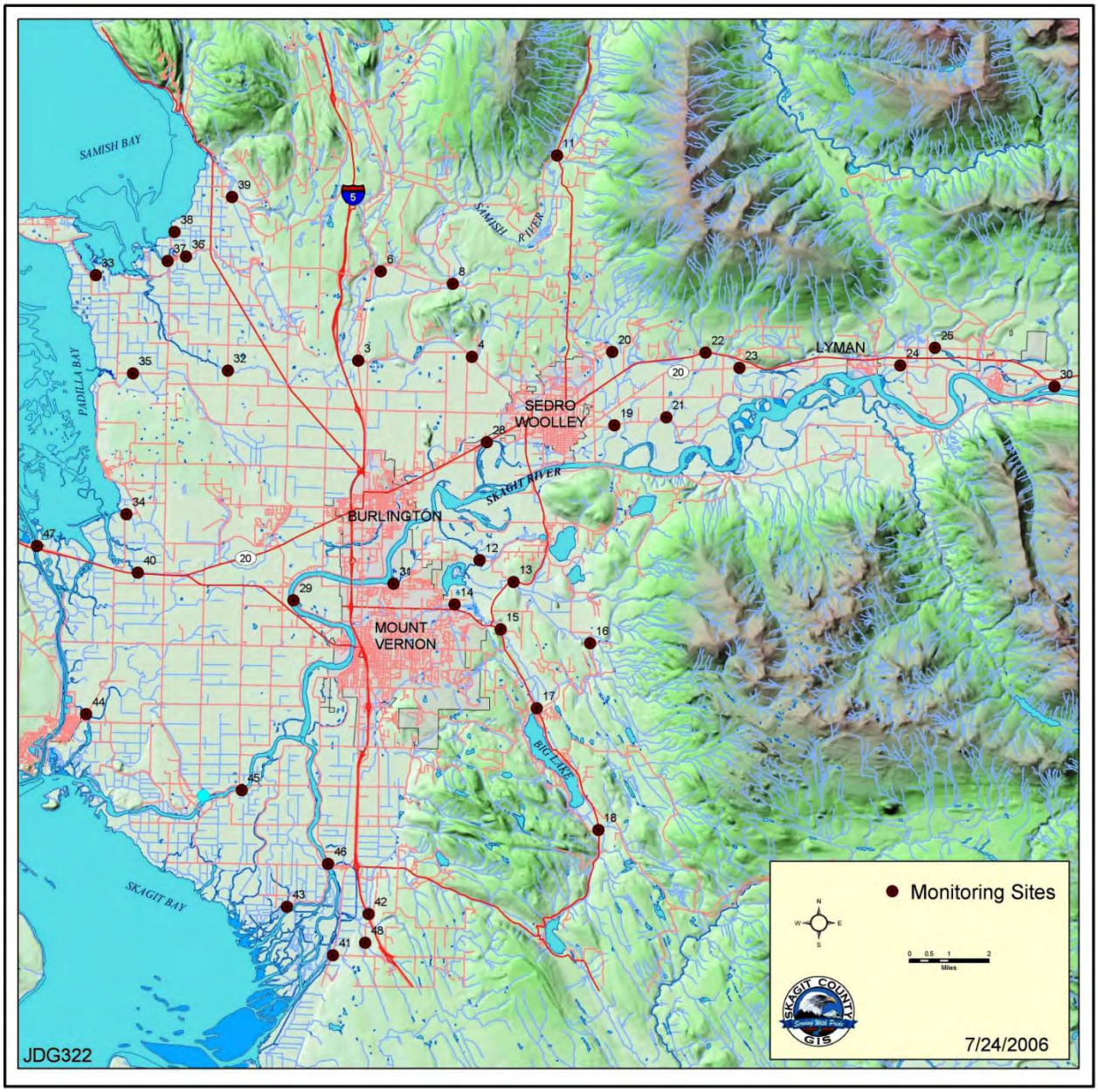


Figure 1. Sample Sites in the Skagit County Monitoring Program
Refer to Tables 1 and 2 for site locations and descriptions.

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 agricultural 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

[1]Some 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 six years of this program have been reported previously (Skagit County 2004c, Skagit County 2006, Skagit County 2007, Skagit County 2008, Skagit County 2009, Skagit County 2010). This report contains data and analysis from water years 2004 - 2010.

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 - Weekly sampling on a regular schedule is often referred to as "ambient sampling" to distinguish it from storm sampling that occurs in response to rain events. All weekly sampling trips were conducted on schedule during the 2010 water year, beginning on October 6, 2009. 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.

Storm sampling – As part of the Clean Samish Initiative, Skagit County conducts additional water quality sampling in the Samish Basin during significant rain events. Data collected during these rain events is not included in the tabulation of regular sampling events to preclude undue influence of storm events on Trends Analysis. Storm event sampling is summarized in a separate section of this report.

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 2010 water year work was funded by Skagit County's Clean Water Program. Skagit County has received 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. Margo Gillaspy and Emily Derenne take readings at Coal Creek

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 2009-2010, 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.

For the 2010 water year, many of the deployed dataloggers were either lost to vandalism or high water, or else reached the end of their battery life during deployment. Others were not retrieved before late summer rains brought the streams up earlier than usual. Consequently, many locations do not have continuous water temperature data for the 2010 water year. Continuous temperature data for the 2010 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, including marine Site 47.

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.

Trends Analysis had revealed many sites with significant declines in temperature between 2004 and 2009. Warmer water temperatures during the 2010 water year eliminated that trend in many cases. 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 last six years of the Skagit County Monitoring Program

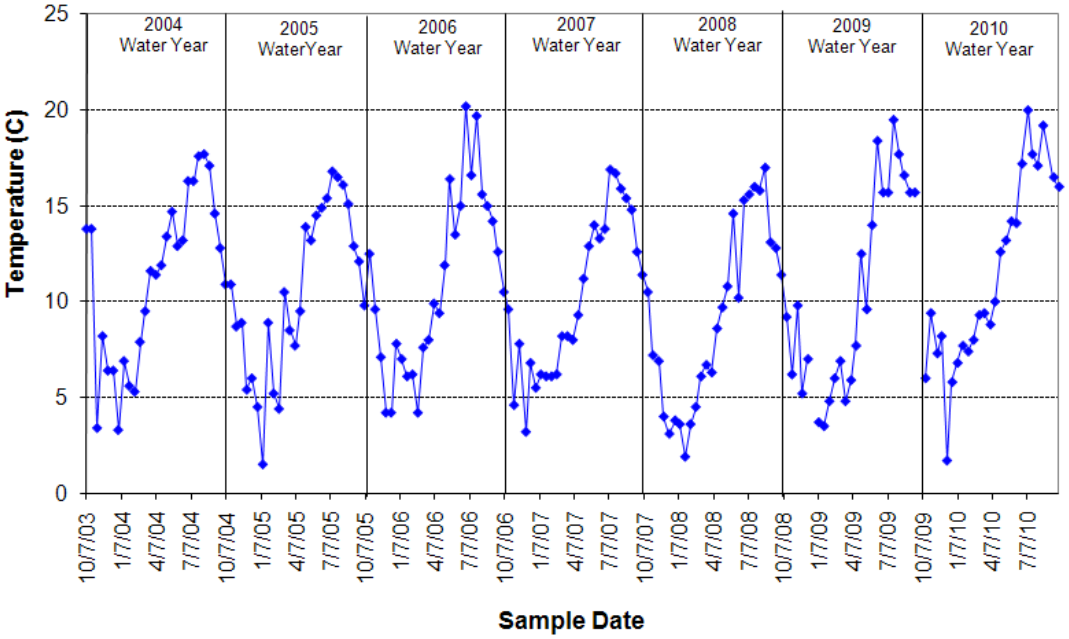
Site Number	Watercourse	Location	Highest daily temperature (°C)					
			2005	2006	2007	2008	2009	2010
3	Thomas Ck	Old Hwy 99 North	16.8	20.2	16.9	17.0	19.5	20.0
4	Thomas Ck	F&S Grade	14.1	15.9	14.2	14.0	15.7	16.3
6	Friday Ck	Prairie Rd	16.3	19.3	16.9	16.1	18.4	18.7
8	Swede Ck	Grip Rd	15.7	16.9	15.2	15.7	17.3	18.1
11	Samish R	State Route 9	14.6	14.6	13.5	12.8	14.2	15.6
12	Nookachamps Ck	Swan Rd	20.9	19.4	21.3	19.8	24.8	21.5
13	E.F. Nookachamps Ck	State Route 9	18.7	17.7	18.6	16.6	23.4	19.0
14	College Way Ck	College Way	16.1	15.4	15.9	15.9	20.8	16.1
15	Nookachamps Ck	Knapp	20.9	20.6	21.2	20.6	23.1	20.5
16	E.F. Nookachamps Ck	Beaver Lake Rd	17.0	15.8	17.3	15.5	20.5	17.7
17	Nookachamps Ck	Big Lake Outlet	23.1	20.9	22.8	21.7	24.4	22.1
18	Lake Ck	State Route 9	15.8	14.4	15.9	16.2	18.7	15.8
19	Hansen Ck	Hoehn Rd	16.0	17.7	15.4	15.4	16.8	17.4
20	Hansen Ck	Northern State	14.7	16.2	14.6	14.4	15.8	15.5
21	Coal Ck	Hoehn Rd	14.6	16.4	15.3	15.3	17.5	16.8
22	Coal Ck	Hwy 20	14.2	15.6	14.5	12.8	14.9	15.5
23	Wiseman Ck	Minkler Rd	14.7	16.2	15.1	14.7	12.7	14.1
24	Mannser Ck	Lyman Hamilton Hwy	12.5	13.3	12.3	12.7	13.2	13.5
25	Red Cabin Ck	Hamilton Cem Rd	11.3	12.5	11.5	11.2	10.6	11.7
28	Brickyard Ck	Hwy 20	16.1	16.4	12.8	15.6	16.3	17.5
29	Skagit R	R Bend Rd	16.4	15.7	14.8	15.0	16.2	14.8
30	Skagit R	Cape Horn Rd	15.1	15.3	15.1	13.3	14.4	14.7
31	Drain Dist 20 near floodgate	Francis Rd	14.4	13.2	15.5	15.4	17.0	14.6
32	Samish R	Thomas Rd	17.7	19.4	18.2	16.8	20.0	19.1
33	Alice Bay Pump Station	Samish Island Rd	22.8	27.0	23.1	21.9	25.4	26.9
34	Noname Slough	Bayview-Edison Rd	21.5	18.7	21.2	19.5	21.6	19.6
35	Joe Leary Slough	D'Arcy Rd	19.8	18.8	17.9	15.9	20.6	18.4
36	Edison Slough at school	W. Bow Hill Rd	24.7	27.8	24.6	23.8	31.3	32.4
37	Edison Pump Station	Farm to Market Rd	22.9	24.6	24.5	20.4	24.7	26.5
38	North Edison Pump Station	North Edison Rd	22.3	24.4	22.4	21.6	22.8	25.4
39	Colony Ck	Colony Rd	16.0	17.4	16.5	15.1	17.9	17.0
40	Big Indian Slough	Bayview-Edison Rd	18.8	17.3	18.6	17.5	22.1	14.9
41	Maddox Slough/Big Ditch	Milltown Rd	20.4	18.9	19.9	19.3	23.7	19.4
42	Hill Ditch	Cedardale Rd	21.1	19.8	20.8	19.4	23.1	19.9
43	Wiley Slough	Wylie Rd	19.3	18.4	20.4	19.1	17.6	20.2
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	18.7	18.4	17.4	18.7	20.8	16.8
45	Skagit R – North Fork	Moore Rd	17.0	16.4	15.3	14.0	17.0	14.8
46	Skagit R – South Fork	Fir Island Rd	17.6	16.6	16.0	14.6	17.0	14.9
47	Swinomish Channel	County Boat Launch	17.2	15.7	15.0	15.9	16.0	15.7
48	Fisher Ck	Franklin Rd	13.6	12.5	13.1	13.3	14.4	12.7

Table 4. Five-Year Temperature Results Summary
Maximum 7-day average maximum temperatures for 2004-2007 and 2009-2010 of the Skagit County Monitoring Program

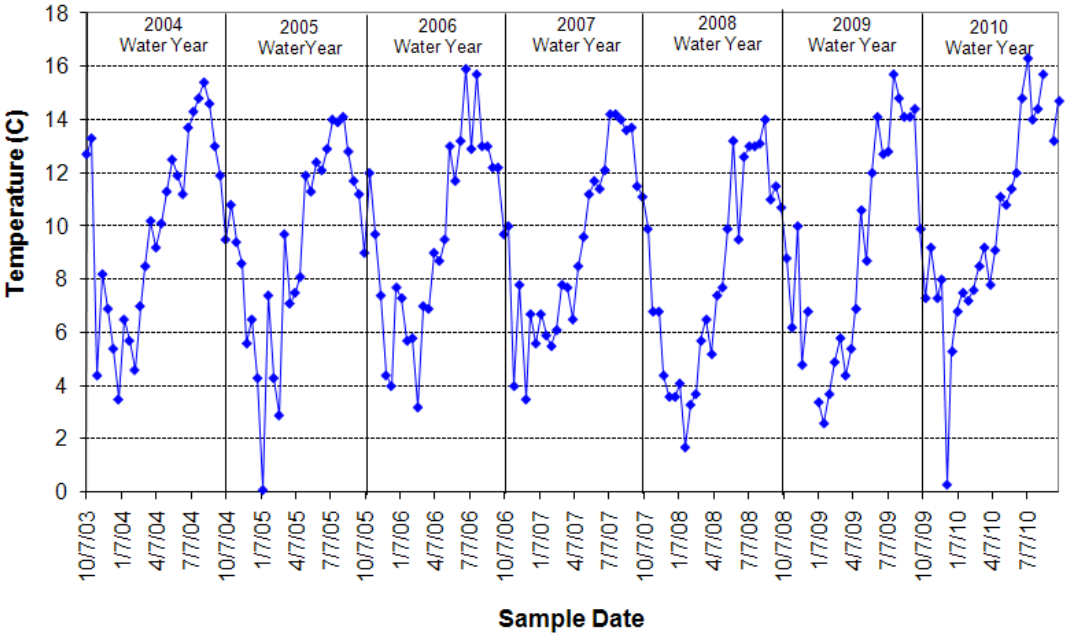
Site Number	Watercourse	Location	Standard	Max 7DAM (°C) 2004	2005	2006	2007	2009	2010
3	Thomas Ck	Old Hwy 99 North	17.5	20.3	19.7	N/A	N/A	24.4	21.9
4	Thomas Ck	F&S Grade	17.5	17.5	16.1	17.3	18.9	19.2	N/A
6	Friday Ck	Prairie Rd	16.0	21.0	19.6	21.3	20.8	22.7	19.3
8	Swede Ck	Grip Rd	16.0	19.1	17.5	19.3	18.6	21.8	N/A
11	Samish R	State Route 9	16.0	16.0	16.4	15.8	14.6	15.2	15.4
12	Nookachamps Ck	Swan Rd	16.0	24.2	N/A	20.6	N/A	17.3	21.8
13	E.F. Nookachamps Ck	State Route 9	16.0	21.5	19.8	21.6	20.1	N/A	N/A
14	College Way Ck	College Way	16.0	N/A	17.2	18.4	18.1	20.6	N/A
15	Nookachamps Ck	Knapp	16.0	22.4	21.6	23.2	22.9	24.9	N/A
16	E.F. Nookachamps Ck	Beaver Lake Rd	16.0	21.3	19.8	20.6	20.1	22.1	20.4
17	Nookachamps Ck	Big Lake Outlet	16.0	24.9	24.6	25.1	25.1	20.8	25.1
18	Lake Ck	State Route 9	16.0	18.8	17.6	18.4	18.4	22.4	N/A
19	Hansen Ck	Hoehn Rd	16.0	21.0	19.7	20.7	20.6	20.3	N/A
20	Hansen Ck	Northern State	16.0	19.6	18.9	19.0	18.0	20.7	N/A
21	Coal Ck	Hoehn Rd	16.0	18.6	17.3	18.2	18.2	N/A	N/A
22	Coal Ck	Hwy 20	16.0	N/A	N/A	17.5	17.3	N/A	17.5
23	Wiseman Ck	Minkler Rd	16.0	16.6	20.1	21.3	N/A	N/A	18.0
24	Mannser Ck	Lyman Hamilton Hwy	16.0	15.9	14.6	14.3	13.9	15.0	13.3
25	Red Cabin Ck	Hamilton Cem Rd	16.0	16.0	N/A	17.6	16.0	N/A	N/A
28	Brickyard Ck	Hwy 20	16.0	N/A	N/A	N/A	N/A	N/A	N/A
29	Skagit R	R Bend Rd	16.0	N/A	N/A	N/A	N/A	N/A	N/A
30	Skagit R	Cape Horn Rd	16.0	N/A	N/A	14.9	15.3	N/A	N/A
31	DD 20 near floodgate	Francis Rd	17.5	N/A	N/A	N/A	N/A	N/A	N/A
32	Samish R	Thomas Rd	17.5	20.5	19.1	20.7	19.9	22.7	N/A
33	Alice Bay Pump Station	Samish Island Rd	17.5	21.4	26.2	27.1	N/A	N/A	N/A
34	Noname Slough	Bayview-Edison Rd	17.5	N/A	22.4	22.8	22.9	N/A	N/A
35	Joe Leary Slough	D'Arcy Rd	17.5	22.8	19.5	24.1	18.9	N/A	N/A
36	Edison Slough at school	W. Bow Hill Rd	17.5	30.1	29.8	29.3	27.6	N/A	N/A
37	Edison Pump Station	Farm to Market Rd	17.5	27.4	27.1	26.8	27.9	N/A	N/A
38	North Edison Pump Station	North Edison Rd	17.5	15.9	N/A	28.1	N/A	N/A	N/A
39	Colony Ck	Colony Rd	17.5	20.4	19.0	19.7	N/A	21.1	N/A
40	Big Indian Slough	Bayview-Edison Rd	17.5	N/A	20.2	24.2	22.0	N/A	N/A
41	Maddox Slough/Big Ditch	Milltown Rd	17.5	25.7	N/A	25.7	22.7	25.4	N/A
42	Hill Ditch	Cedardale Rd	17.5	N/A	23.8	24.6	20.2	27.0	23.1
43	Wiley Slough	Wylie Rd	17.5	22.6	N/A	N/A	N/A	N/A	N/A
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	17.5	25.4	22.6	22.3	26.6	23.6	N/A
45	Skagit R – North Fork	Moore Rd	16.0	17.5	18.3	17.6	16.4	16.9	17.2
46	Skagit R – South Fork	Fir Island Rd	16.0	19.1	N/A	N/A	N/A	N/A	N/A
47	Swinomish Channel	County Boat Launch	16.0	N/A	N/A	N/A	N/A	N/A	N/A
48	Fisher Ck	Franklin Rd	16.0	15.7	14.5	15.0	14.7	N/A	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.

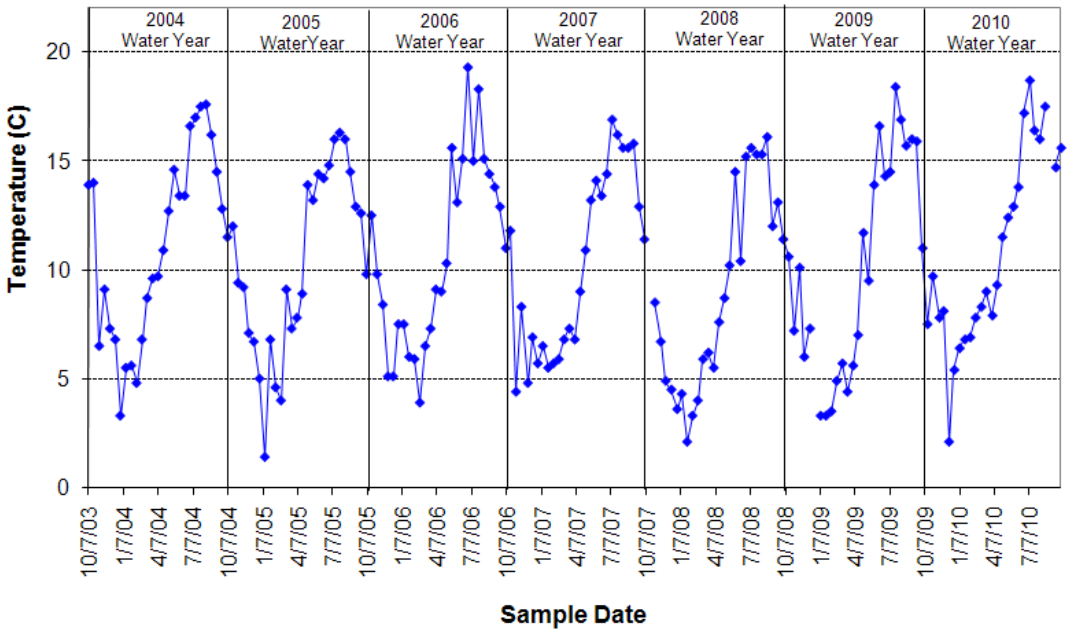
Thomas Creek at Hwy 99 - Site 3
Temperature



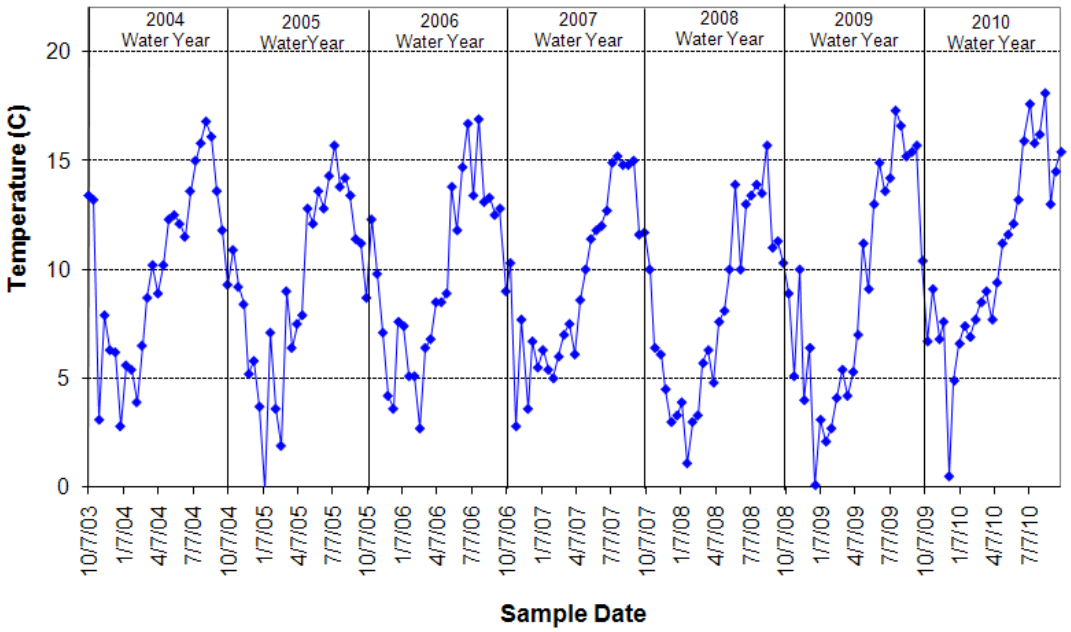
Thomas Creek at F&S Grade Rd - Site 4
Temperature



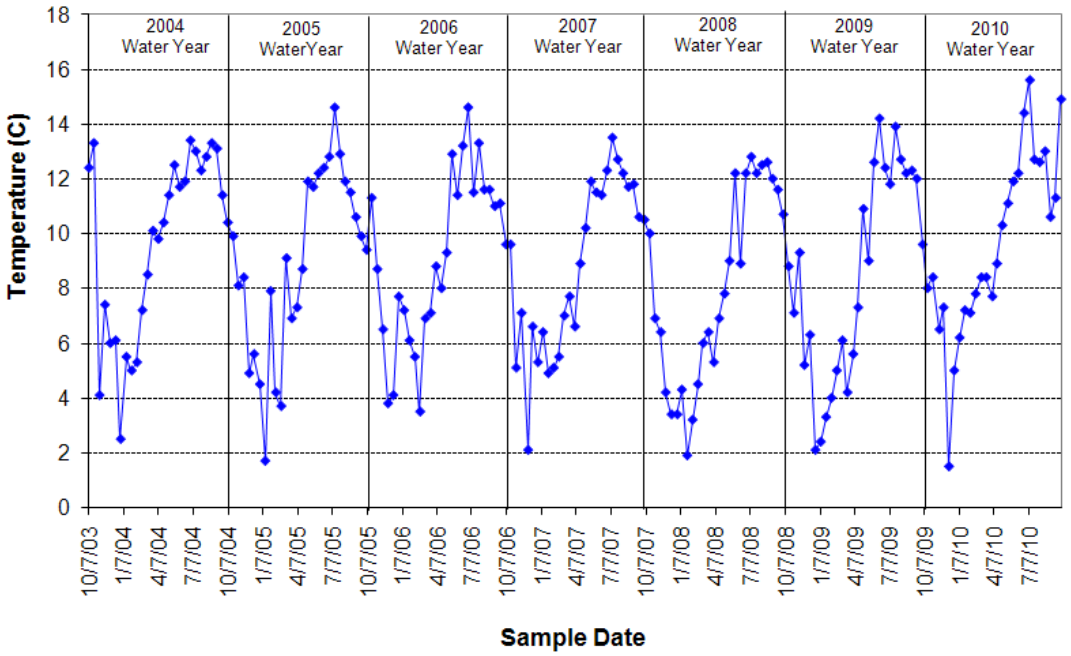
Friday Creek at Prairie Rd - Site 6
Temperature



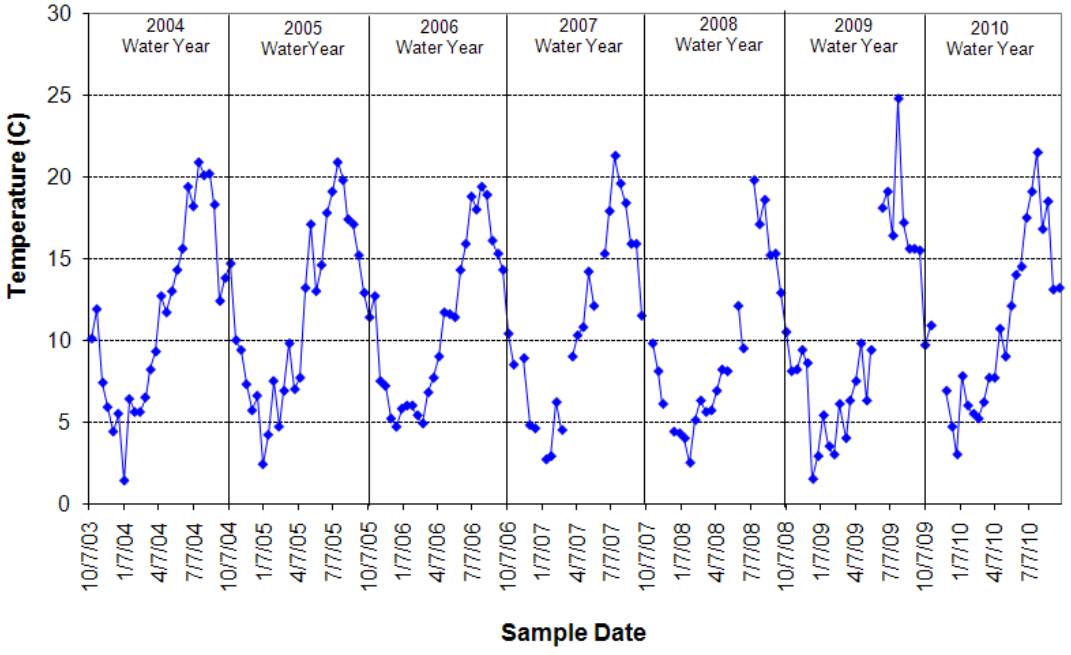
Swede Creek at Grip Rd - Site 8
Temperature



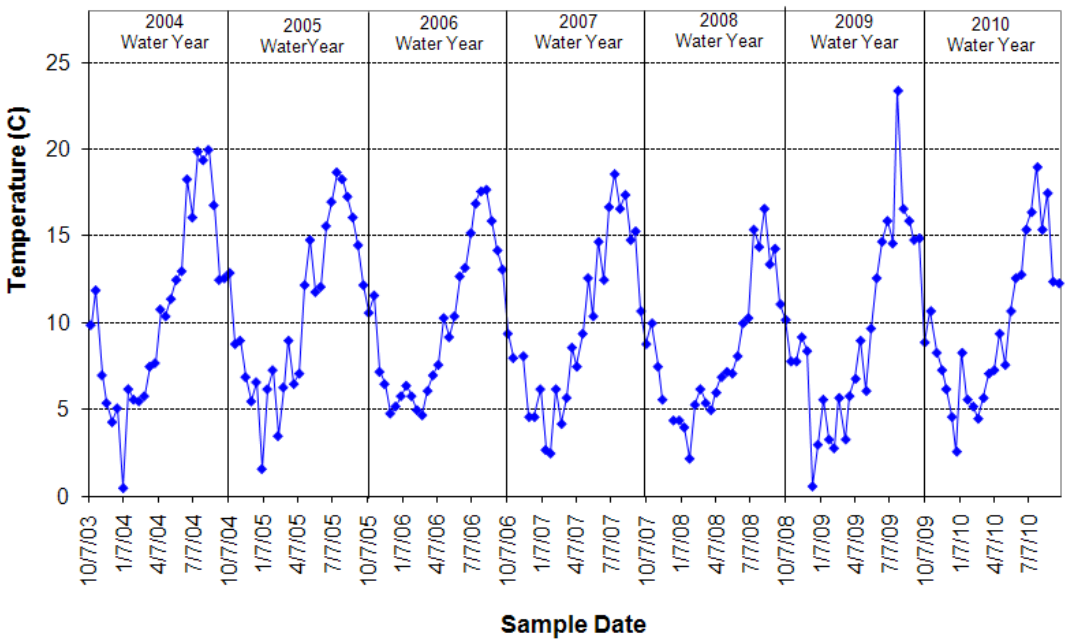
Samish River at Hwy 9 - Site 11
Temperature



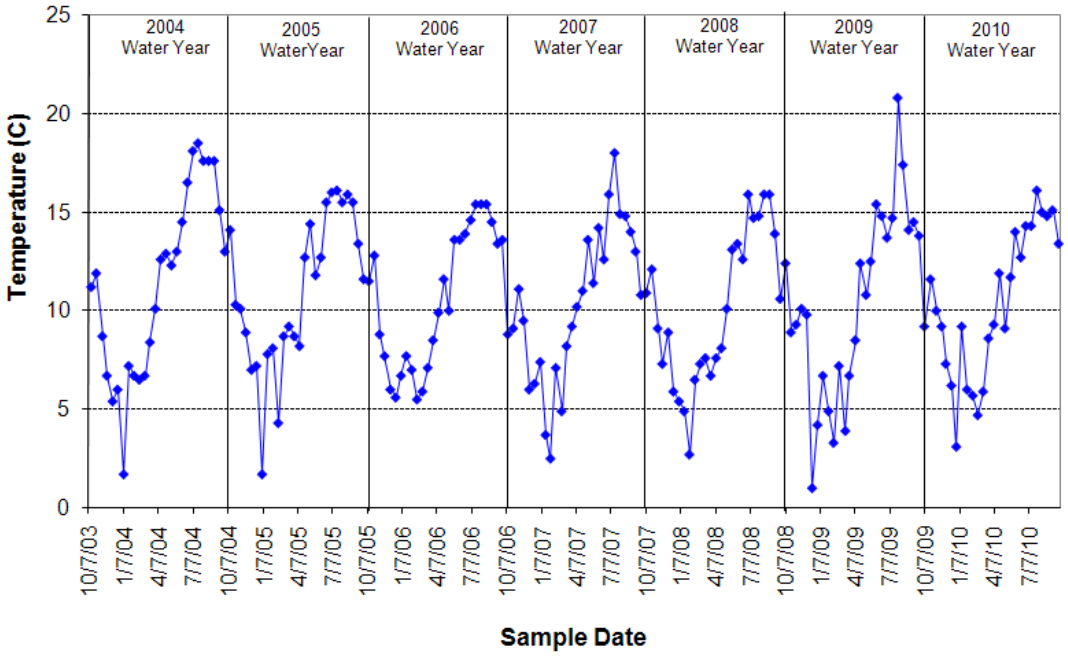
Nookachamps Creek at Swan Rd - Site 12
Temperature



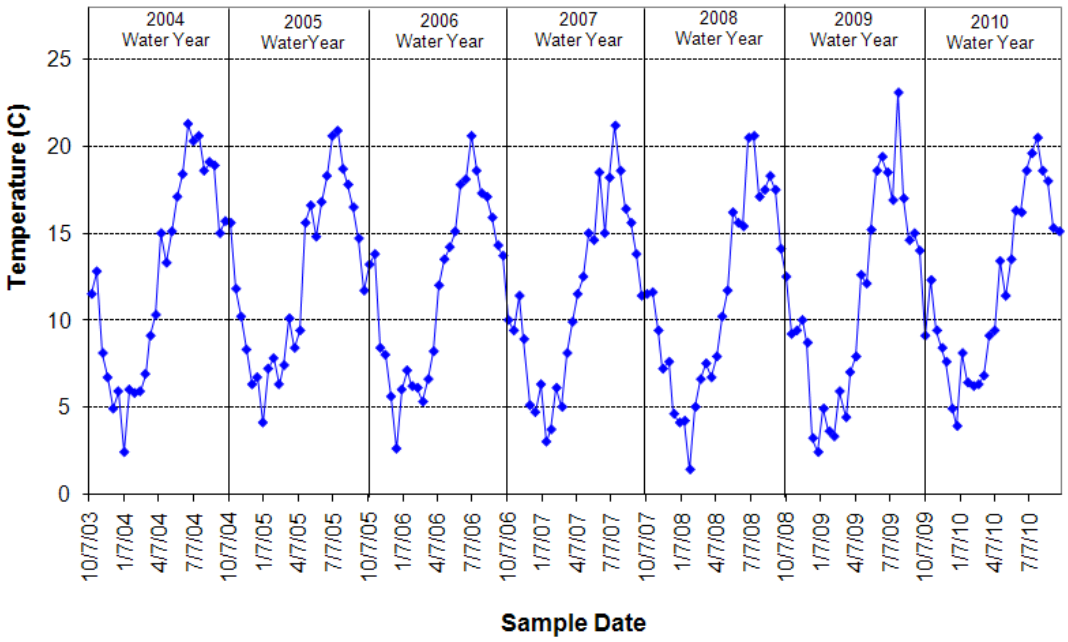
E.F. Nookachamps Creek at Hwy 9 - Site 13
Temperature



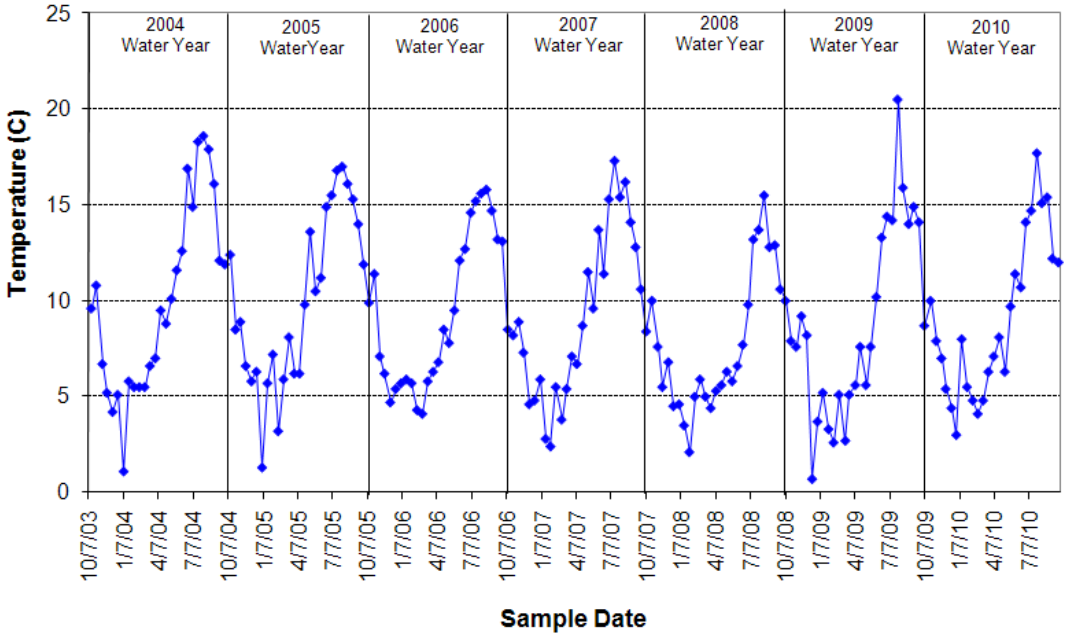
College Way Creek at College Way - Site 14
Temperature



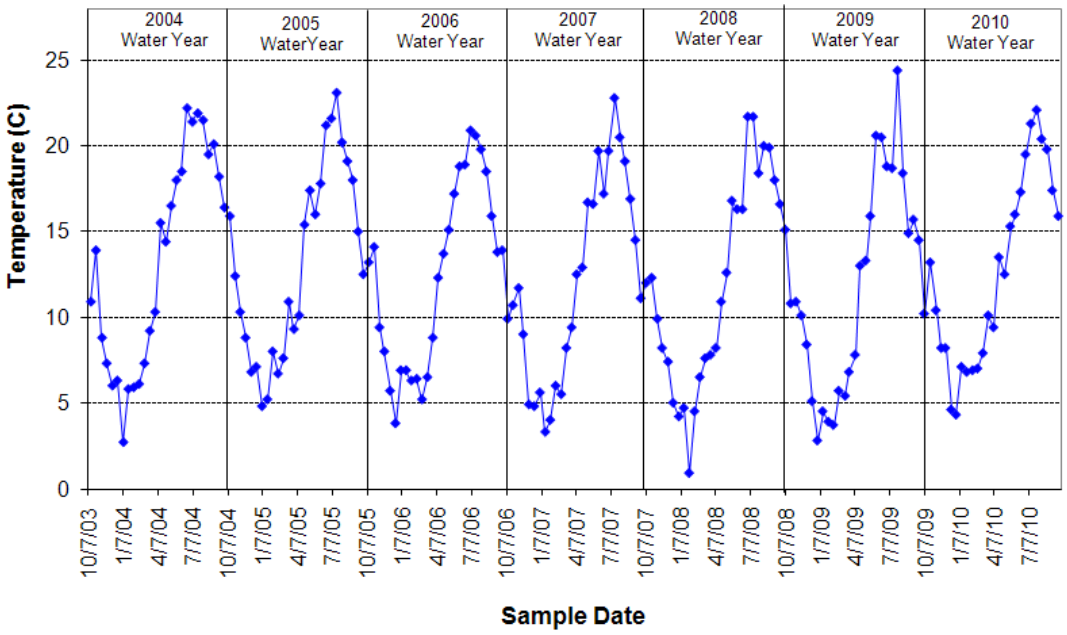
Nookachamps Creek at Knapp Rd - Site 15
Temperature



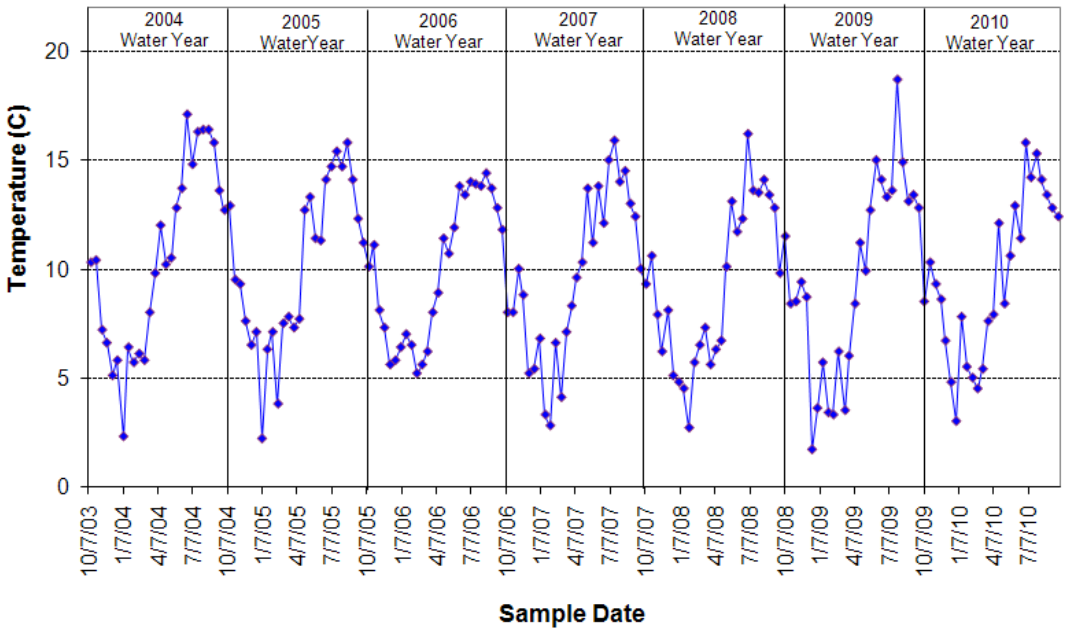
E.F. Nookachamps Creek at Beaver Lake Rd - Site 16
Temperature



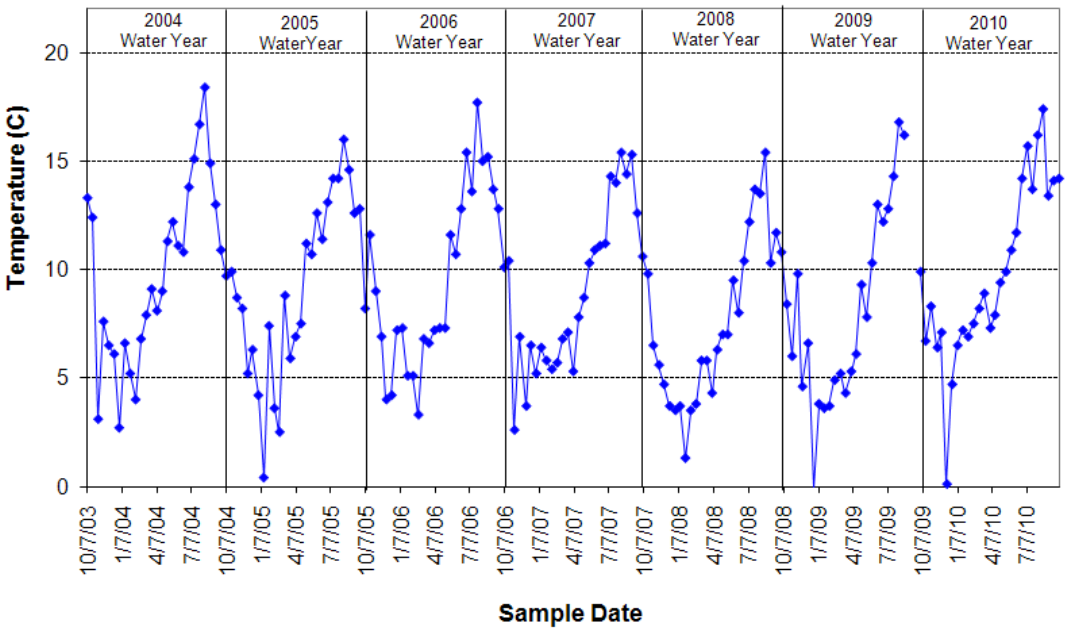
Nookachamps Creek at Big Lake Outlet - Site 17
Temperature



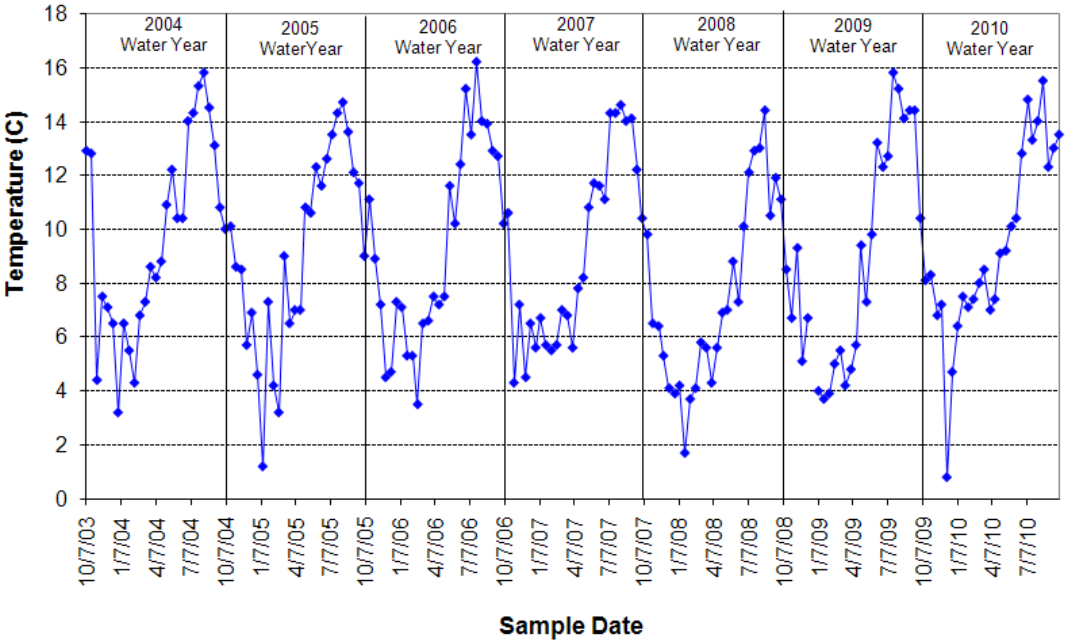
Lake Creek at Hwy 9 - Site 18
Temperature



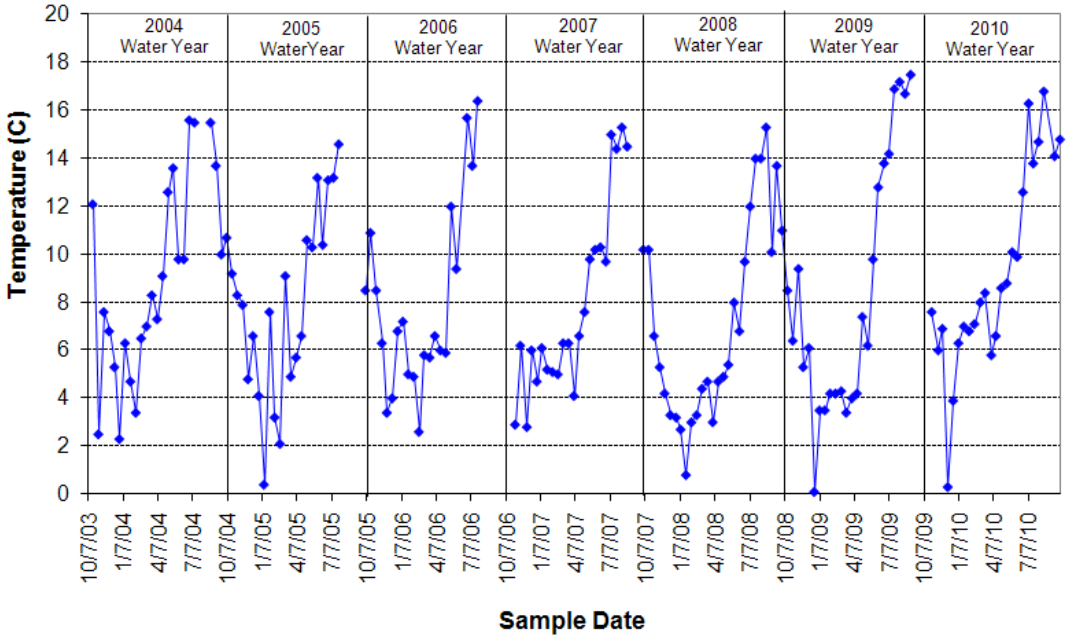
Hansen Creek at Hoehn Rd - Site 19
Temperature



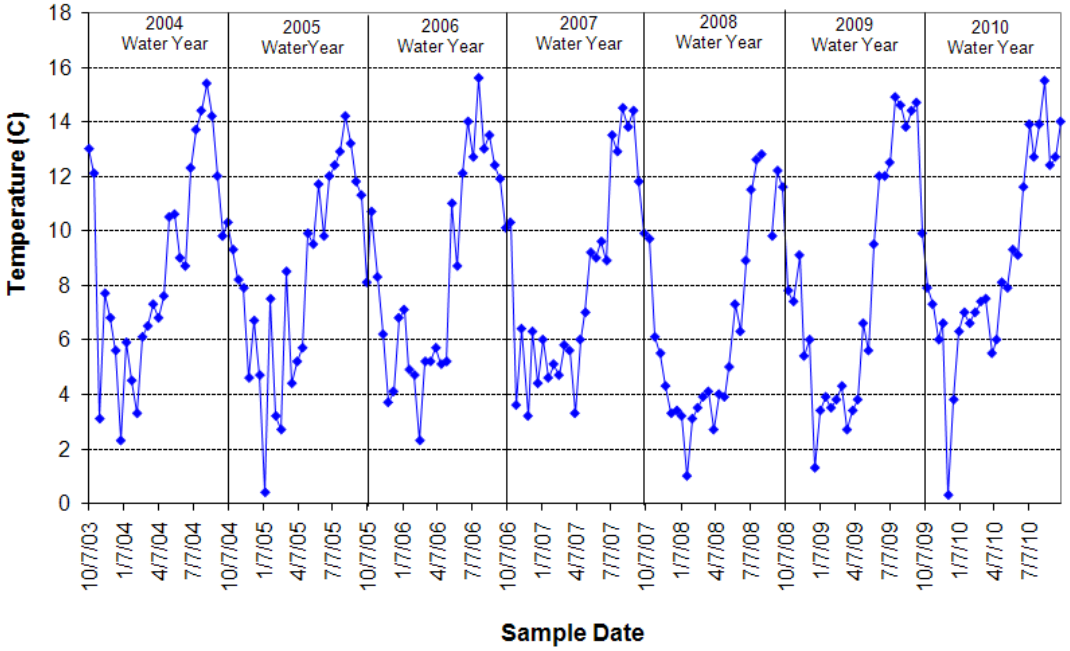
Hansen Creek at Northern State Hospital - Site 20
Temperature



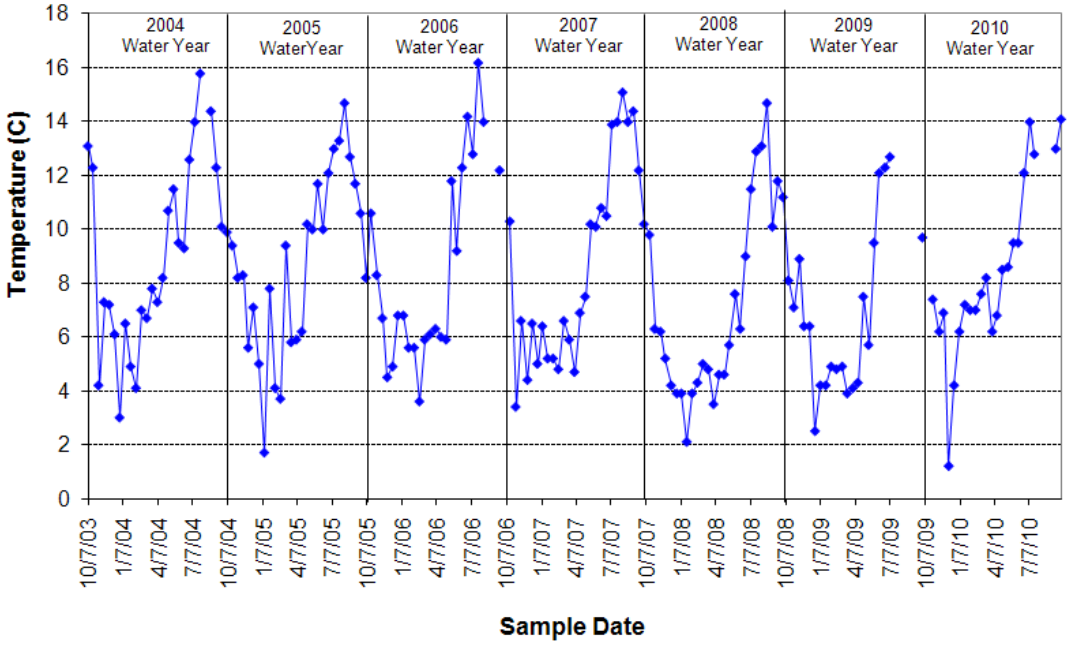
Coal Creek at Hoehn Rd - Site 21
Temperature



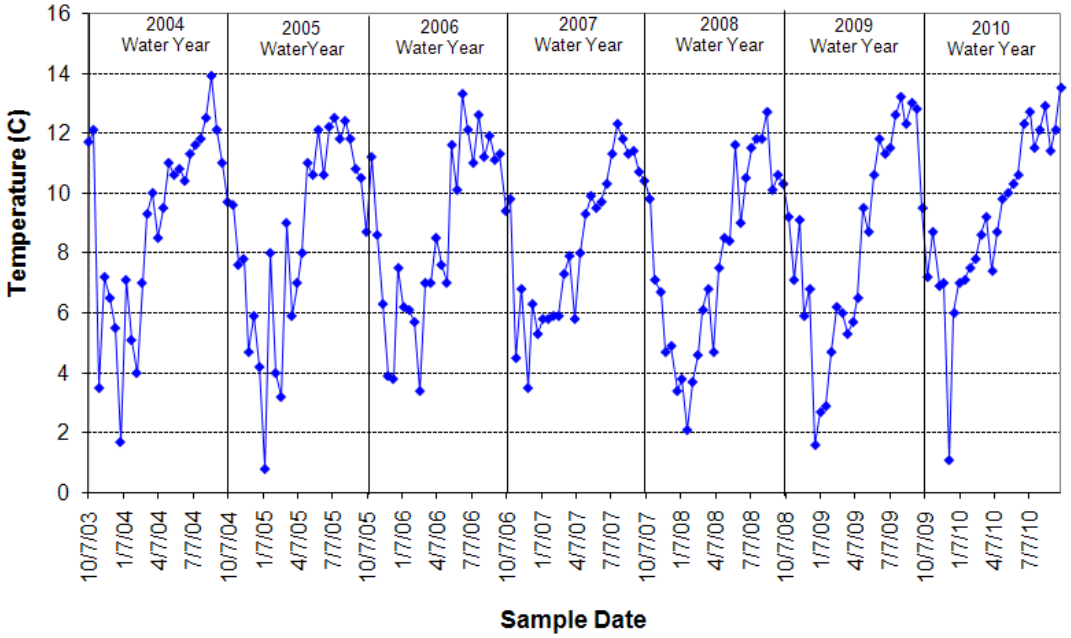
Coal Creek at Hwy 20 - Site 22
Temperature



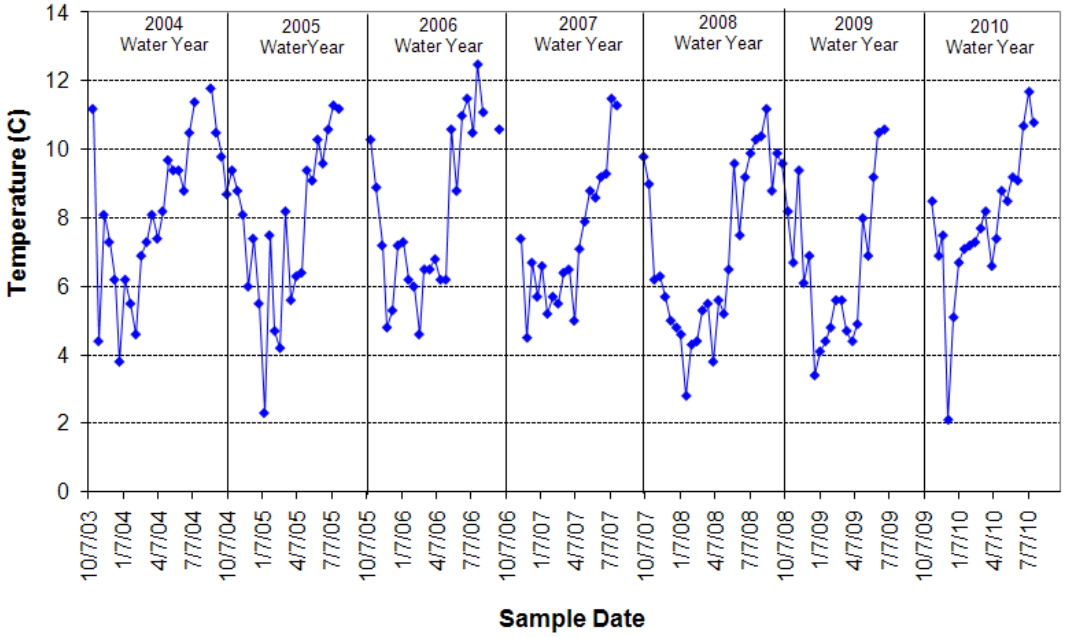
Wiseman Creek at Minkler Rd - Site 23
Temperature



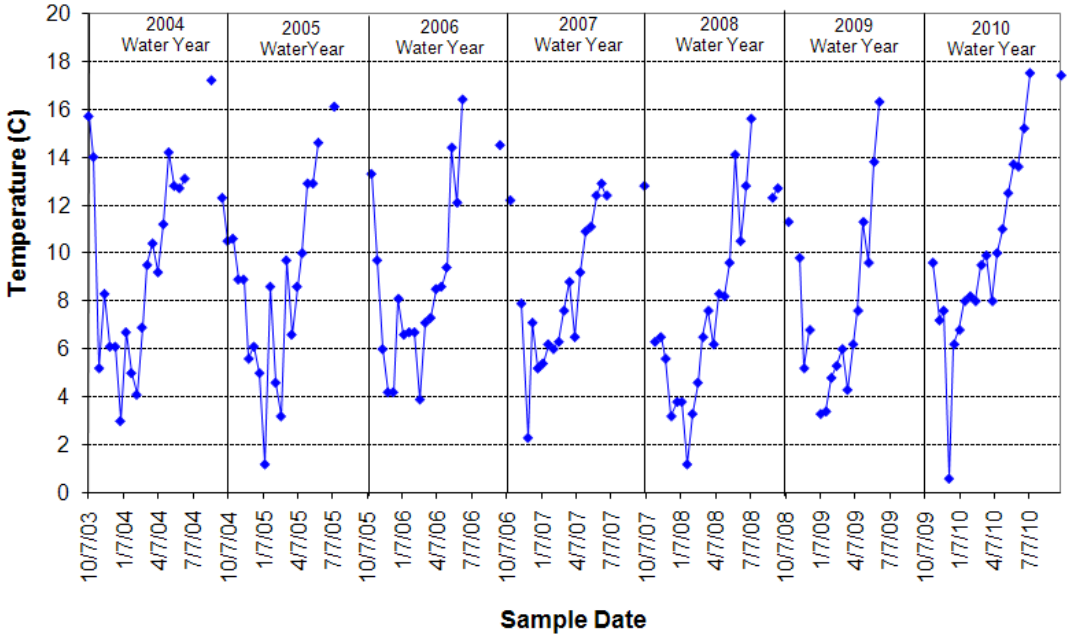
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Temperature



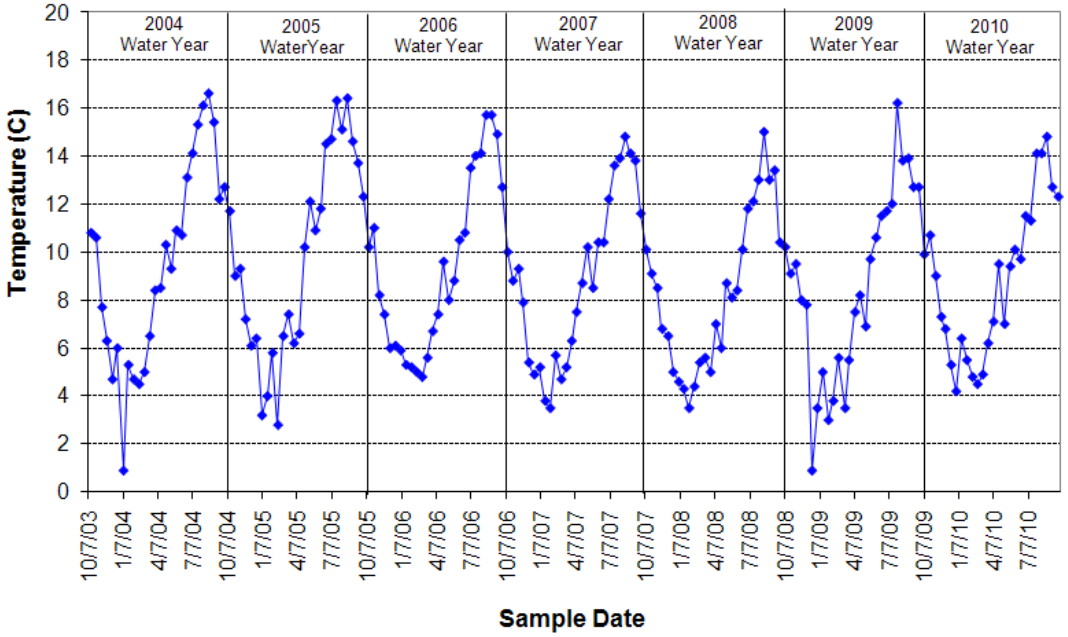
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Temperature



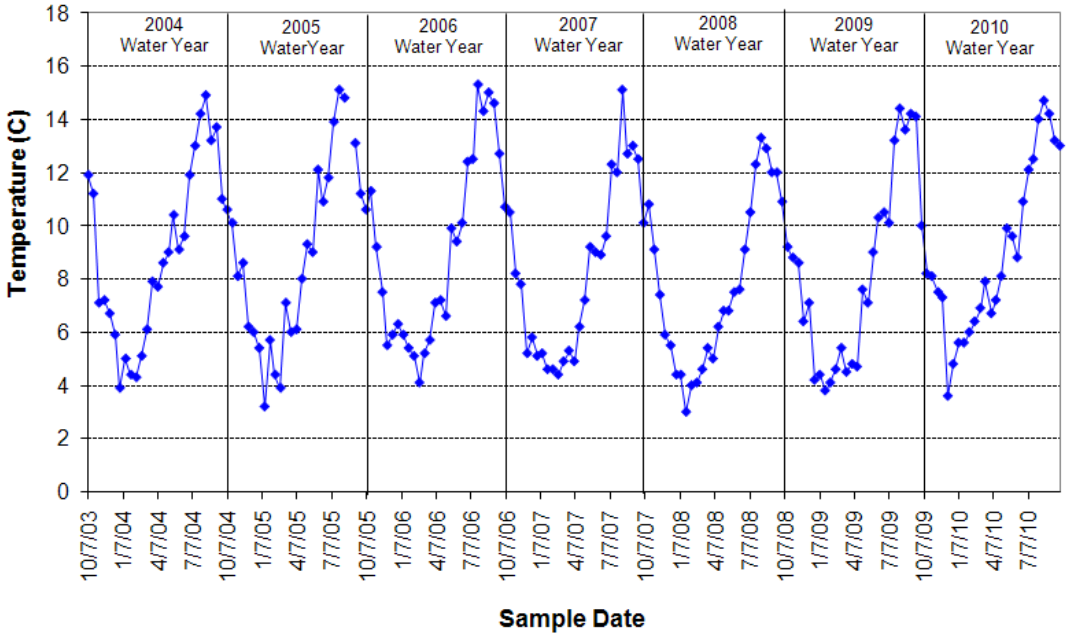
Brickyard Creek at Hwy 20 - Site 28
Temperature



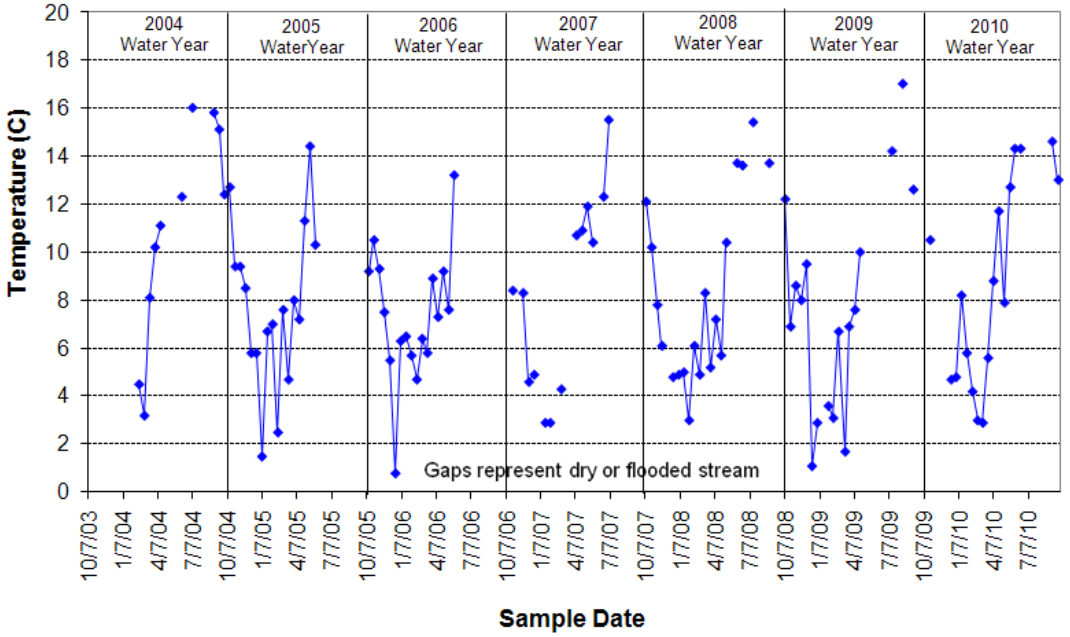
Skagit River at River Bend - Site 29
Temperature



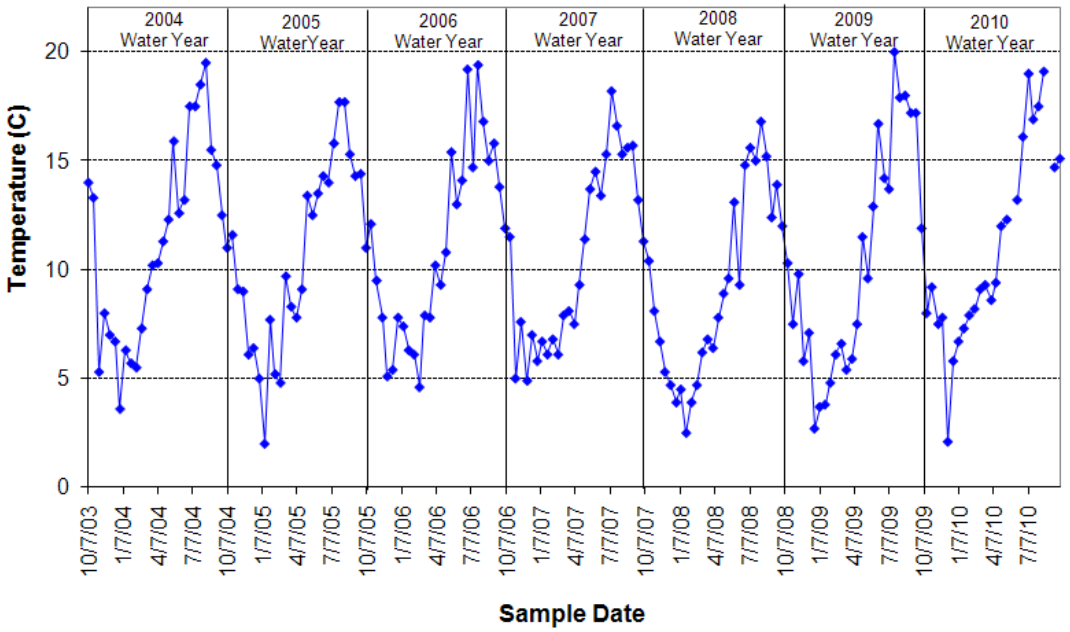
Skagit River at Cape Horn Rd - Site 30
Temperature



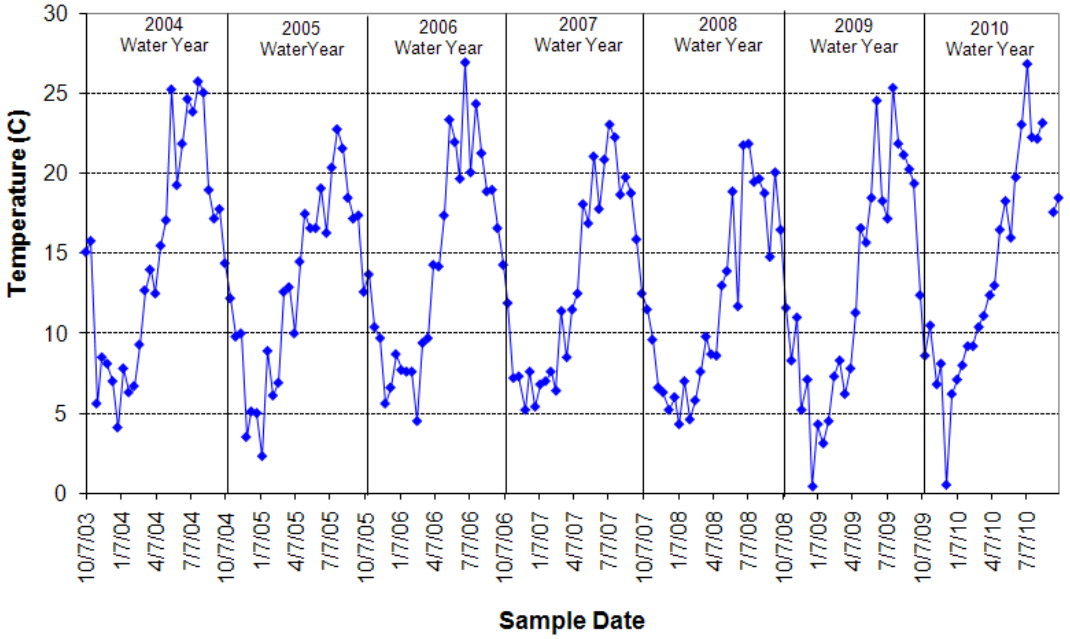
Drainage District 20 Ditch at Floodgate - Site 31
Temperature



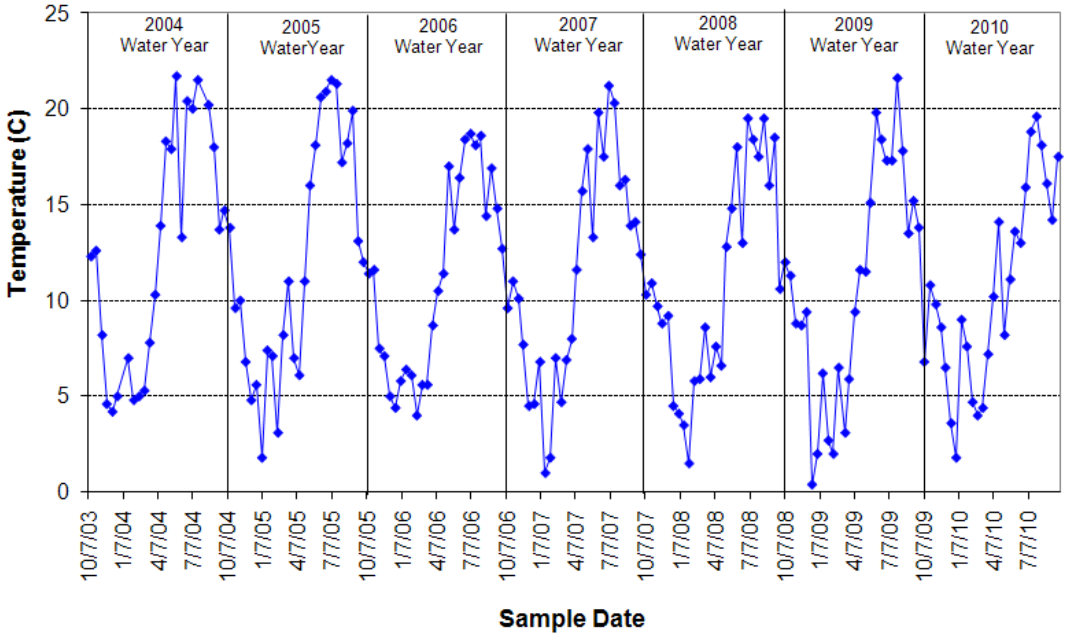
Samish River at Thomas Rd - Site 32
Temperature



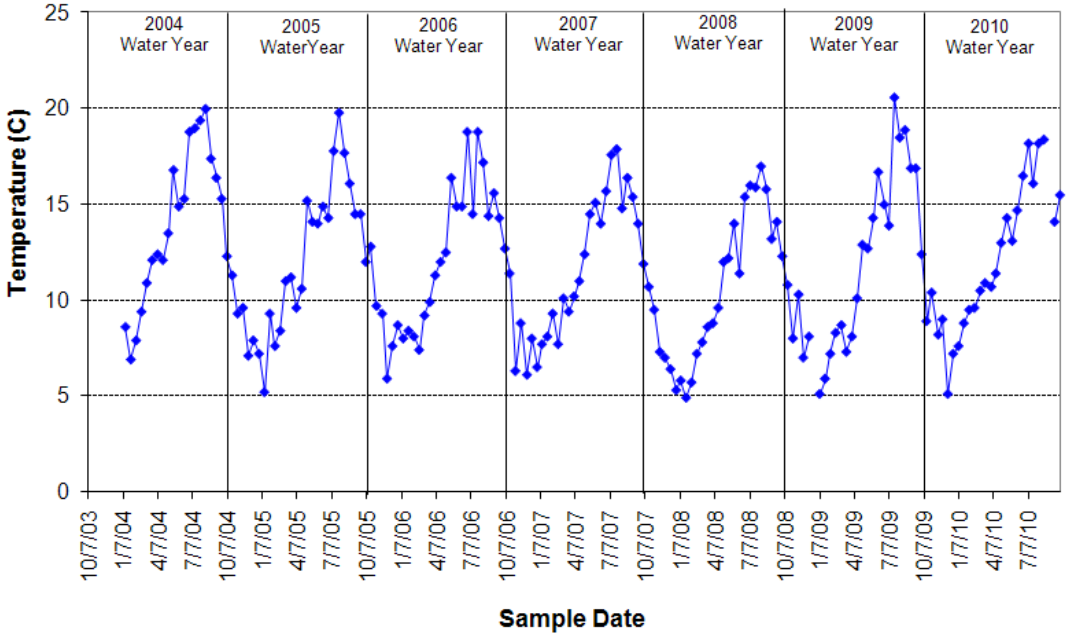
Alice Bay Pump Station - Site 33
Temperature



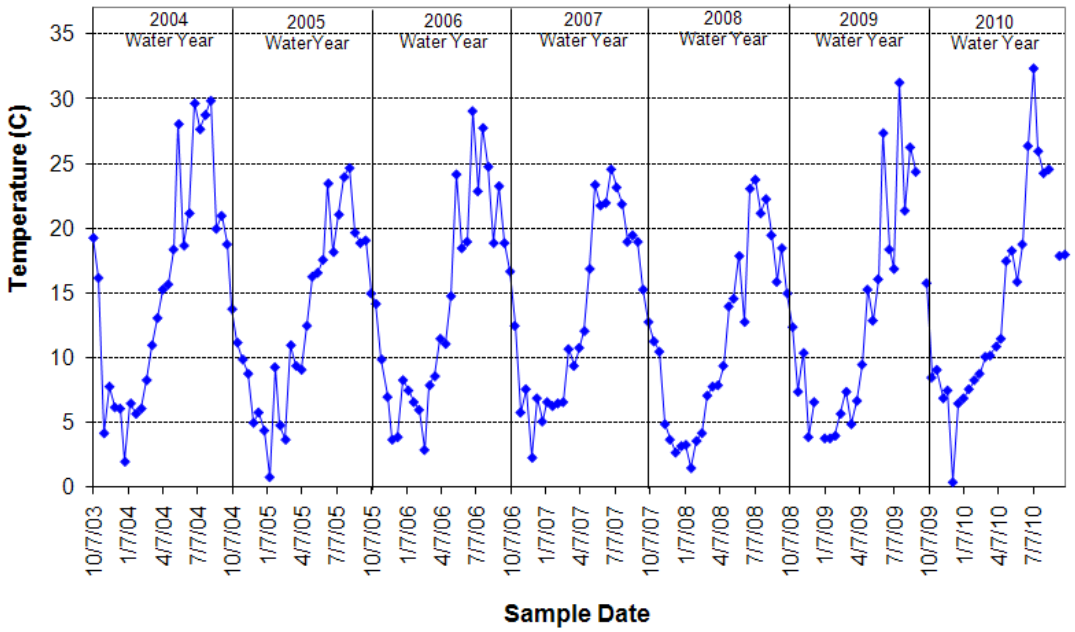
No Name Slough at Bayview-Edison Rd - Site 34
Temperature



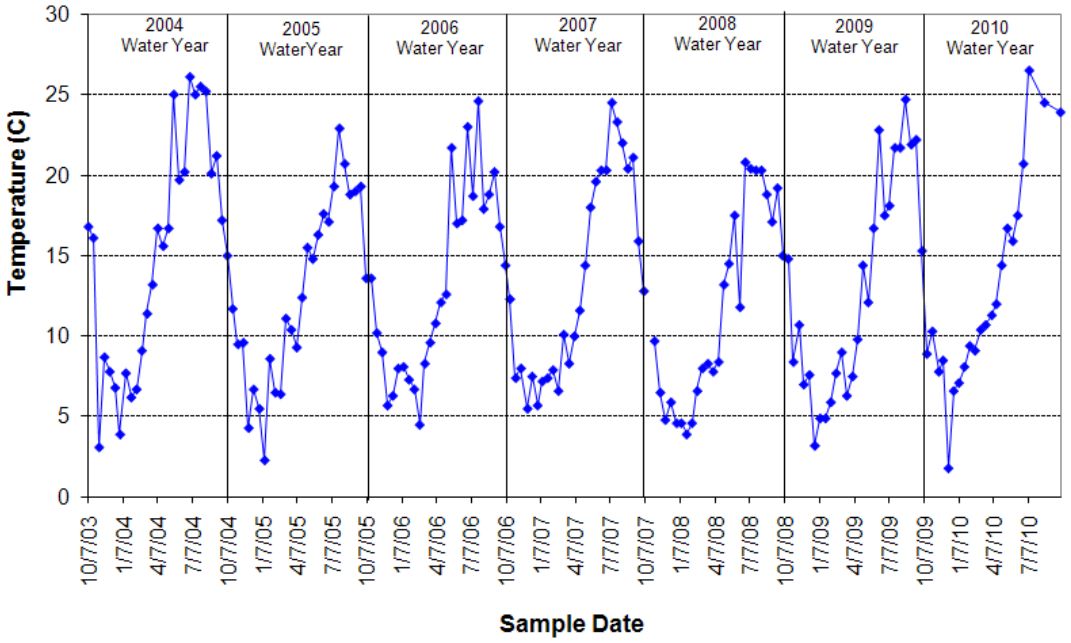
Joe Leary Slough at D'Arcy Rd - Site 35
Temperature



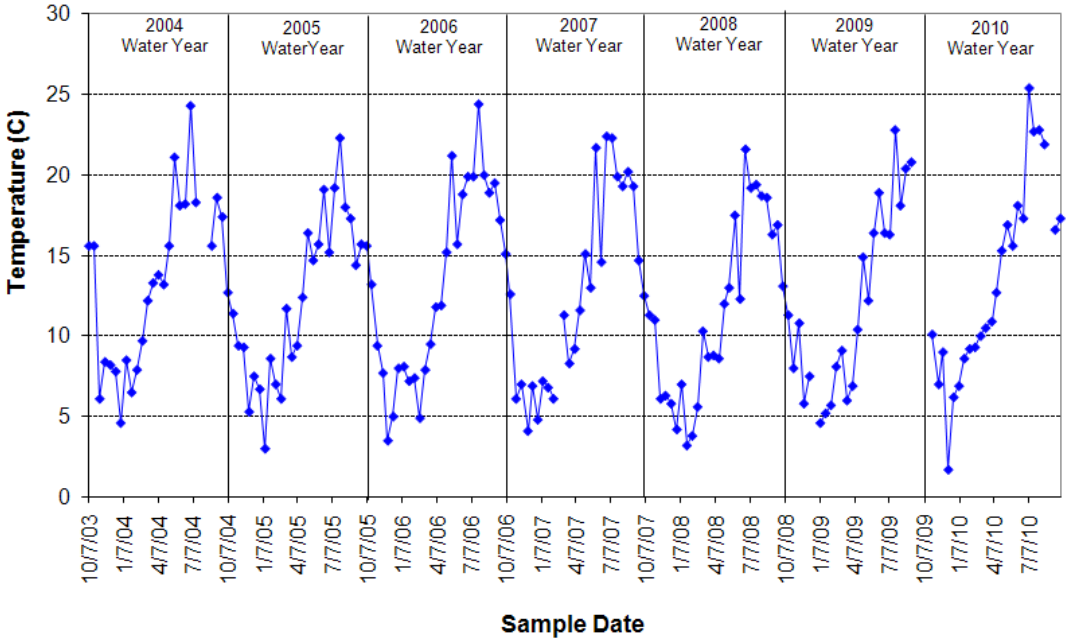
Edison Slough at Edison School - Site 36
Temperature



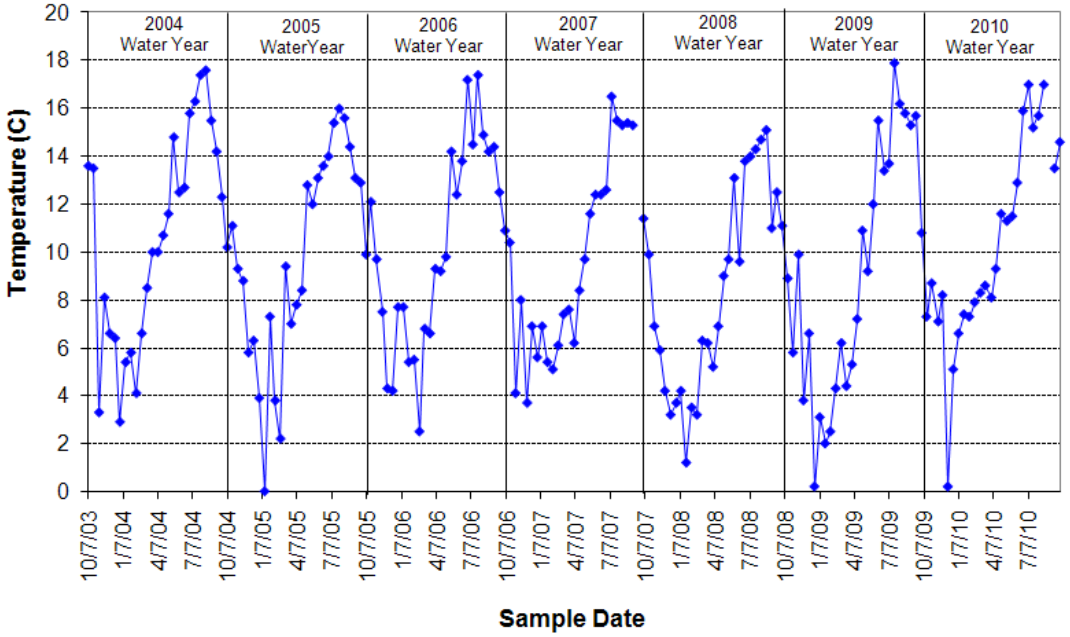
Edison Pump Station - Site 37
Temperature



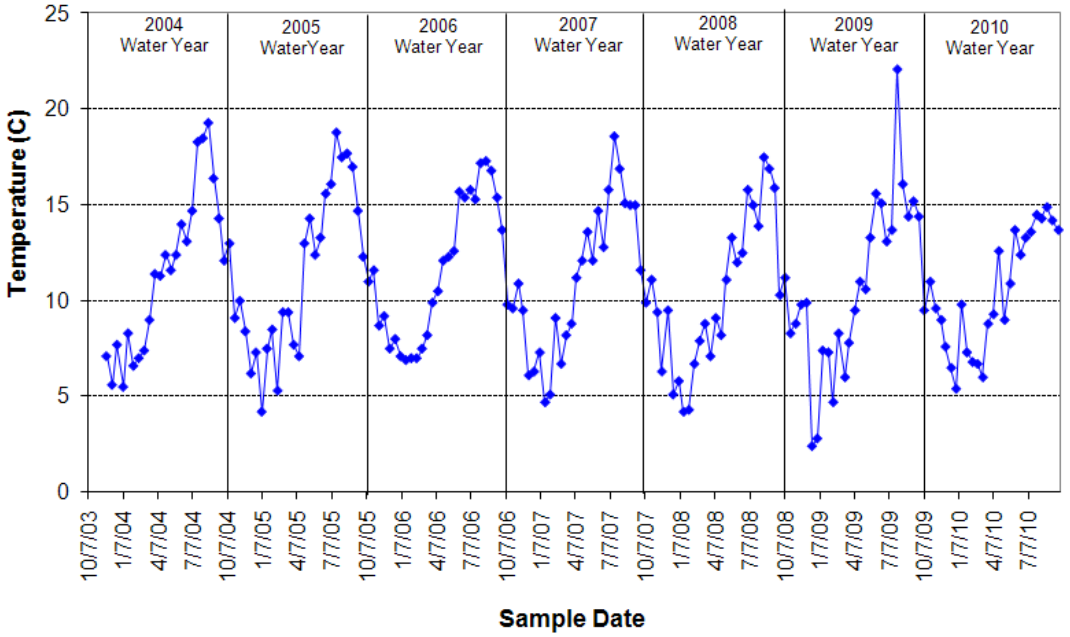
North Edison Pump Station - Site 38
Temperature



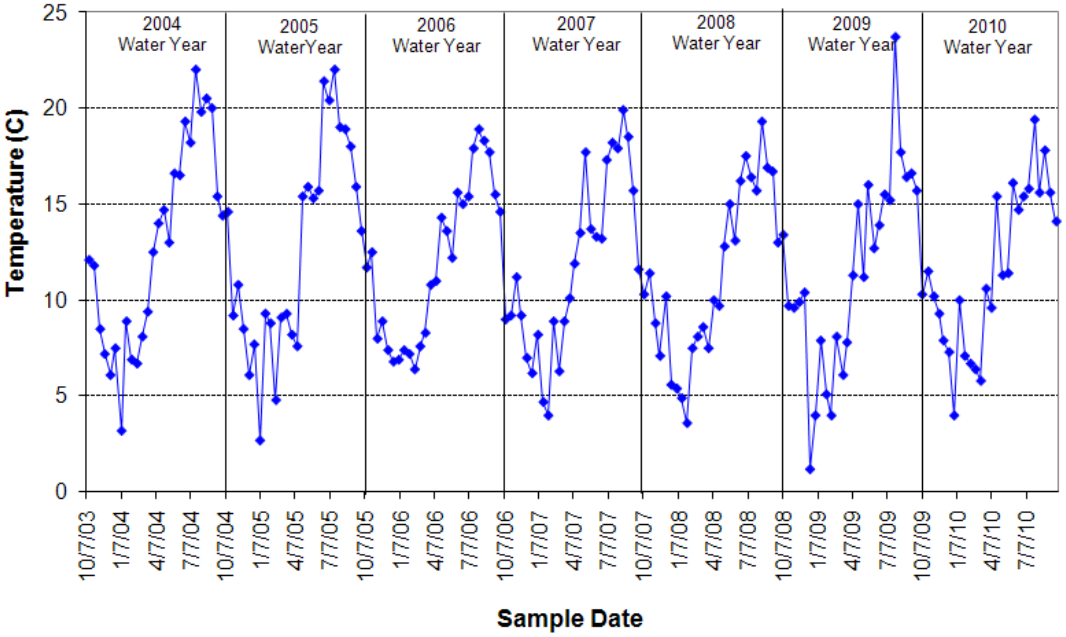
Colony Creek at Colony Rd - Site 39
Temperature



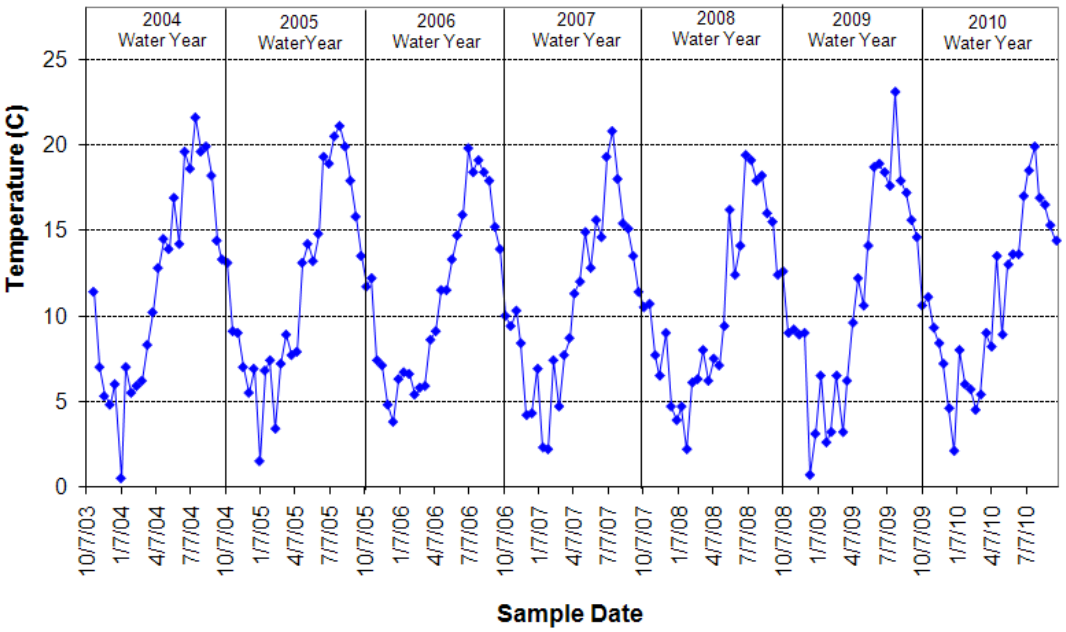
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Temperature



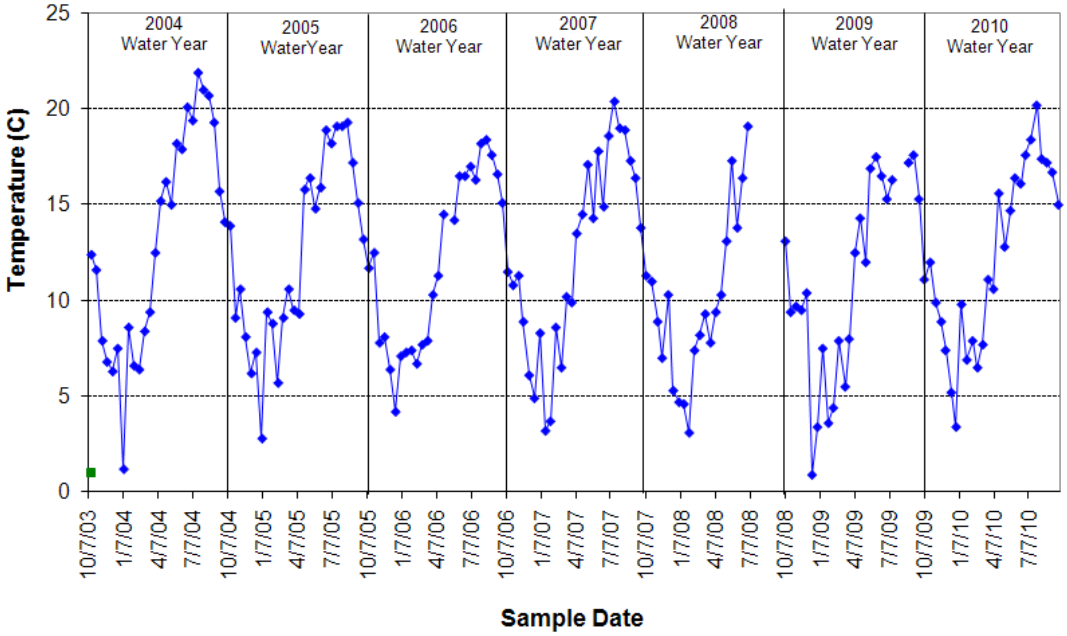
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Temperature



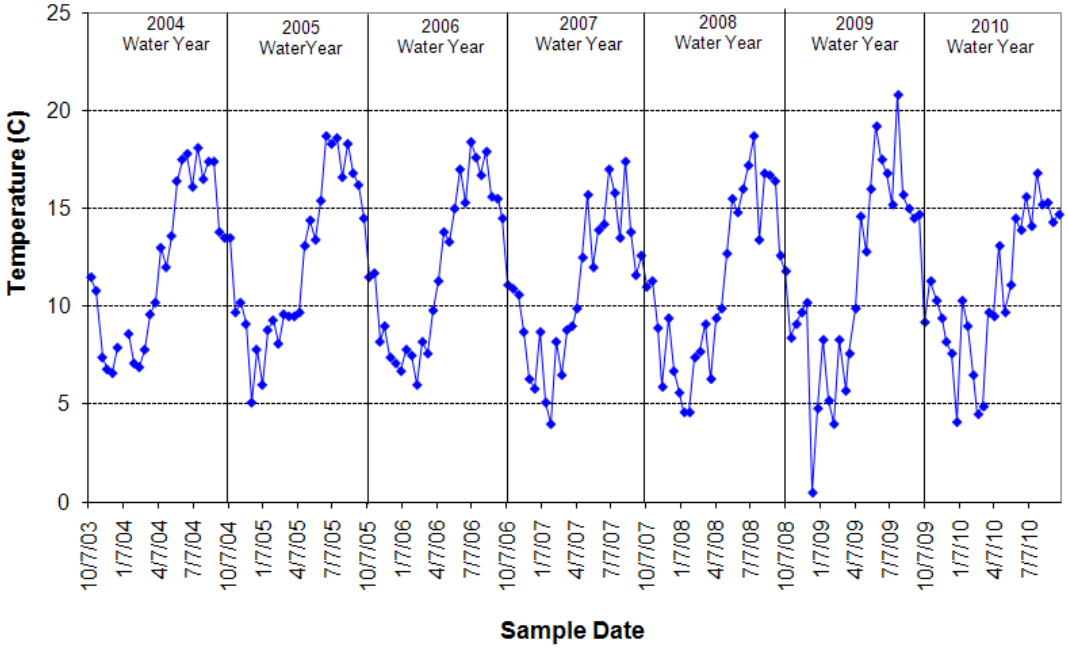
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Temperature



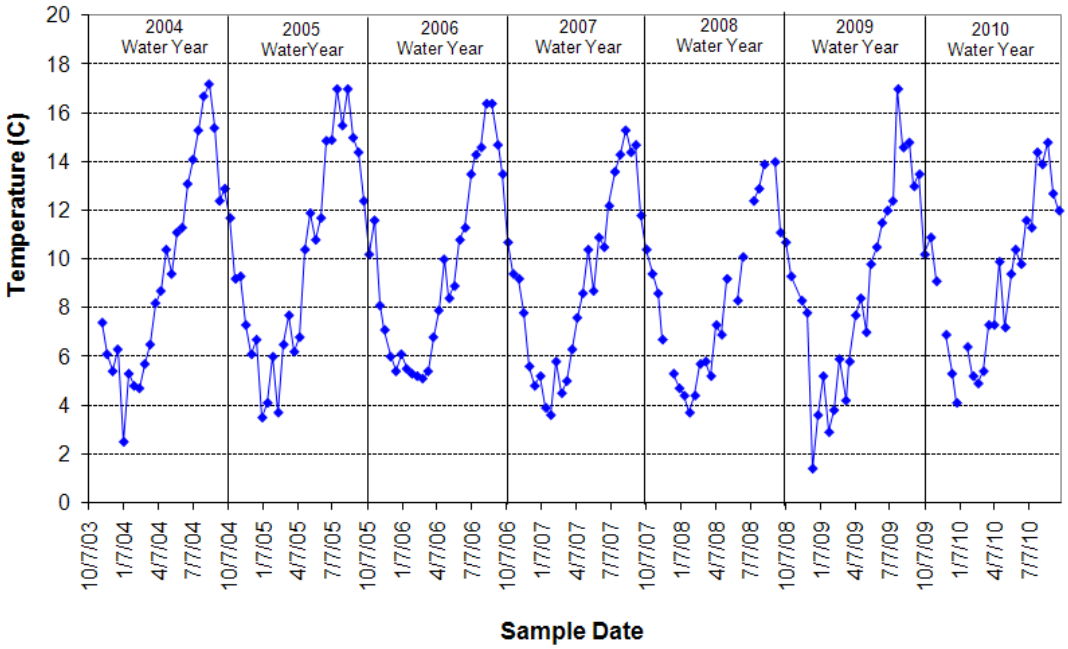
Wiley Slough at Wylie Rd - Site 43
Temperature



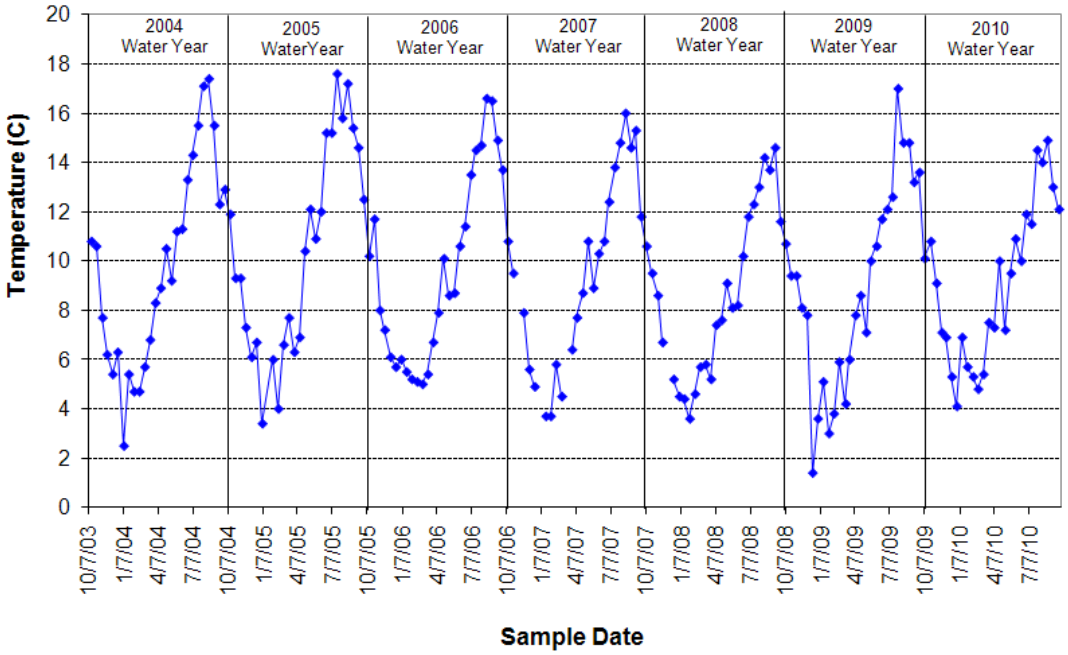
Sullivan Slough at La Conner-Whitney Rd - Site 44
Temperature



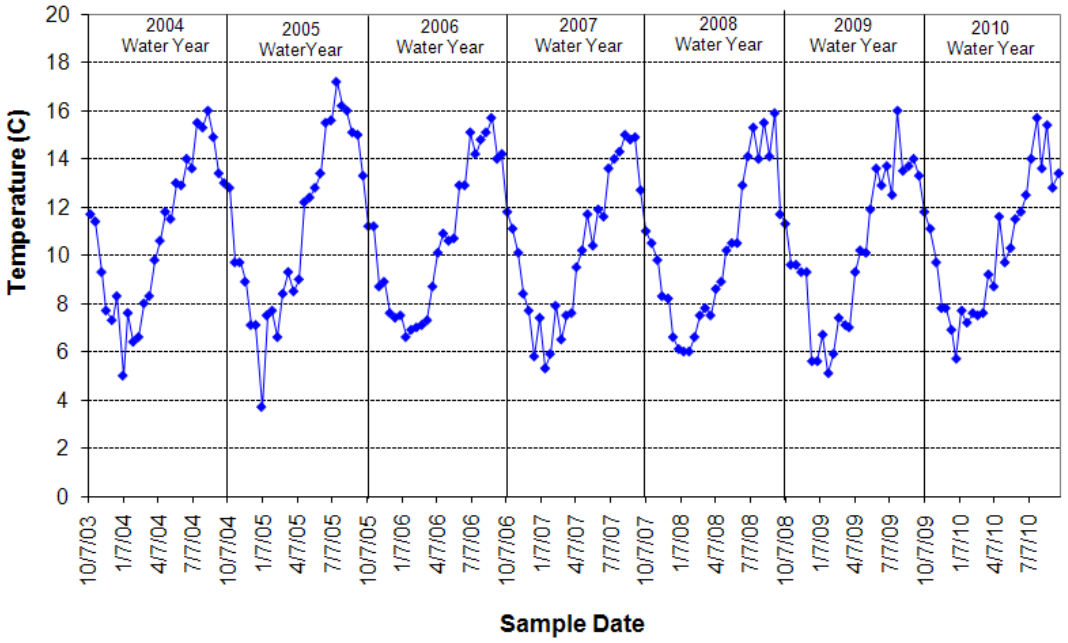
N.F. Skagit near Moore Rd - Site 45
Temperature



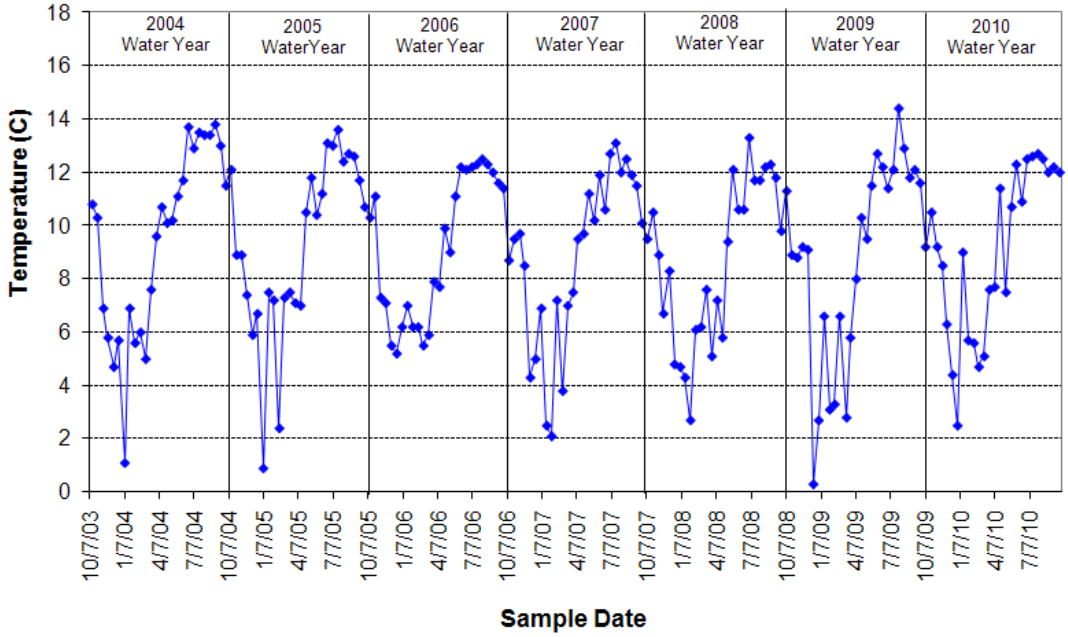
S.F. Skagit at Conway Boat Ramp - Site 46
Temperature



Swinomish Channel at County Boat Ramp - Site 47
Temperature



Fisher Creek at Franklin Rd - Site 48
Temperature



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 2010 water year is provided in Table 5. Table 6 summarizes data from the last six years of the study. The pages following Table 6 contain graphs illustrating dissolved oxygen levels at all sample sites for the 2004-2010 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. The solubility of oxygen in water is inversely related to temperature, so that higher temperatures frequently result in lower dissolved oxygen values.

Nine sites in the Skagit County Monitoring Program met oxygen standards at each measurement in the 2010 water year. Others met the oxygen standard for most of the year. In a few streams, oxygen levels showed steep declines in summer as can be seen by the graphs on the following pages. 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 2010 Water Year

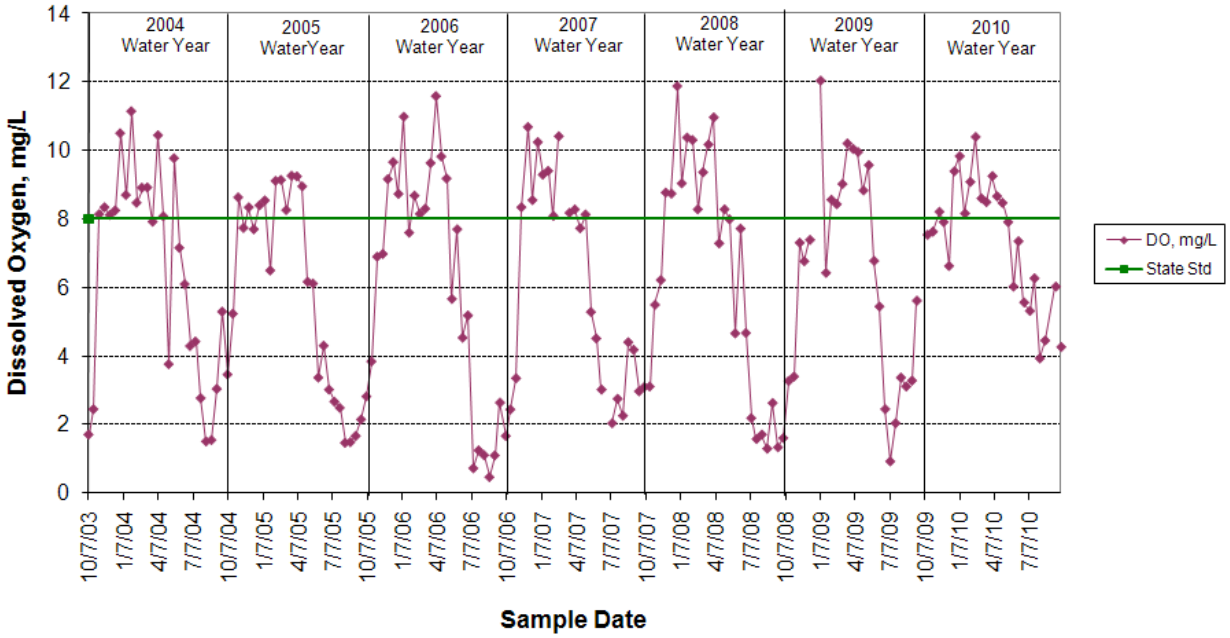
Site Number	Watercourse	Location	Mean DO (mg/L)	Minimum DO (mg/L)	St. Std[1]
3	Thomas Ck	Old Hwy 99 N	7.4	3.9	8.0
4	Thomas Ck	F&S Grade	10.8	9.3	8.0
6	Friday Ck	Prairie Rd	11.1	9.0	9.5
8	Swede Ck	Grip Rd	9.8	5.6	9.5
11	Samish R	State Route 9	8.2	5.5	9.5
12	Nookachamps Ck	Swan Rd	8.6	4.9	9.5
13	E.F. Nookachamps Ck	State Route 9	9.3	6.2	9.5
14	College Way Ck	College Way	9.3	5.3	9.5
15	Nookachamps Ck	Knapp	8.1	1.7	9.5
16	E.F. Nookachamps Ck	Beaver Lake Rd	11.1	7.4	9.5
17	Nookachamps Ck	Big Lake Outlet	10.0	6.7	9.5
18	Lake Ck	State Route 9	10.9	9.2	9.5
19	Hansen Ck	Hoehn Rd	10.2	7.5	9.5
20	Hansen Ck	Northern State	10.8	8.7	9.5
21	Coal Ck	Hoehn Rd	10.7	8.0	9.5
22	Coal Ck	Hwy 20	11.5	9.7	9.5
23	Wiseman Ck	Minkler Rd	11.7	9.9	9.5
24	Mannser Ck	Lyman Hamilton Hwy	6.1	2.8	9.5
25	Red Cabin Ck	Hamilton Cem Rd	11.7	10.2	9.5
28	Brickyard Ck	Hwy 20	8.7	5.6	8.0
29	Skagit R	River Bend Rd	11.0	9.6	9.5
30	Skagit R	Cape Horn Rd	11.1	9.3	9.5
31	Drain Dist 20 floodgate	Francis Rd	8.5	6.0	8.0
32	Samish R	Thomas Rd	10.9	8.9	8.0
33	Alice Bay Pump Station	Samish Island Rd	10.4	3.3	8.0
34	Noname Slough	Bayview-Edison Rd	6.0	0.1	8.0
35	Joe Leary Slough	D'Arcy Rd	5.3	3.0	8.0
36	Edison Slough at school	W. Bow Hill Rd	8.6	2.4	8.0
37	Edison Pump Station	Farm to Market Rd	5.9	2.0	8.0
38	North Edison Pump Station	North Edison Rd	5.9	2.5	8.0
39	Colony Ck	Colony Rd	10.8	8.0	8.0
40	Big Indian Slough	Bayview-Edison Rd	5.2	2.5	8.0
41	Maddox Slough/Big Ditch	Milltown Rd	6.7	2.5	8.0
42	Hill Ditch	Cedardale Rd	8.2	4.6	9.5
43	Wiley Slough	Wylie Rd	5.1	1.2	8.0
44	Rexville PS/Sullivan Slough	La Conner-Bayview Rd	7.7	1.4	8.0
45	Skagit R – North Fork	Moore Rd	11.3	9.5	9.5
46	Skagit R – South Fork	Fir Island Rd	11.3	9.3	9.5
47	Swinomish Channel	County Boat Launch	8.8	6.6	6.0
48	Fisher Ck	Franklin Rd	11.2	9.6	9.5

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

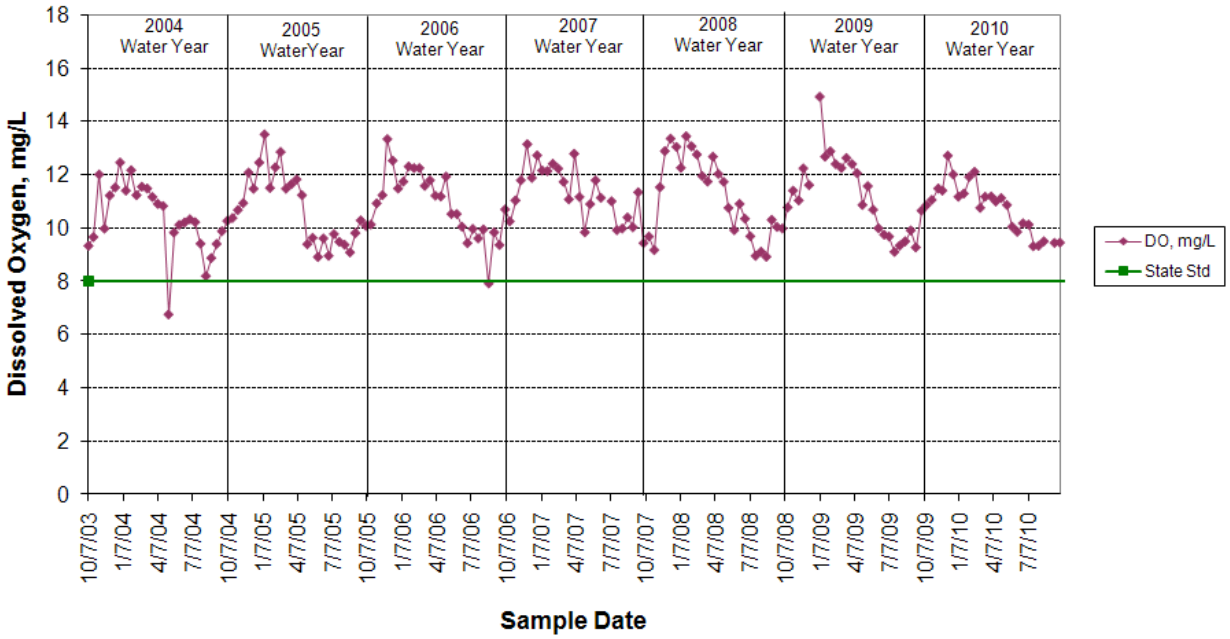
Table 6. Dissolved Oxygen Results Summary
Mean Dissolved Oxygen levels for the Skagit County Monitoring Program

Site Number	Watercourse	Location	Mean Dissolved Oxygen (mg/L)					
			2005	2006	2007	2008	2009	2010
3	Thomas Ck	Old Hwy 99 North	5.9	6.2	6.1	6.2	6.4	7.4
4	Thomas Ck	F&S Grade	10.7	10.9	11.3	11.1	11.2	10.8
6	Friday Ck	Prairie Rd	11.2	11.1	11.6	11.5	11.3	11.1
8	Swede Ck	Grip Rd	11.1	11.2	11.5	11.3	10.9	9.8
11	Samish R	State Route 9	8.2	8.4	9	8.5	9.0	8.2
12	Nookachamps Ck	Swan Rd	9.4	9.5	9.1	10.0	9.7	8.6
13	E.F. Nookachamps Ck	State Route 9	9.8	10.3	10.4	10.3	10.0	9.3
14	College Way Ck	College Way	9.1	9	9.1	9.5	9.3	9.3
15	Nookachamps Ck	Knapp	7.8	8.2	7.8	8.6	7.3	8.1
16	E.F. Nookachamps Ck	Beaver Lake Rd	11.4	11.4	11.6	12.0	11.5	11.1
17	Nookachamps Ck	Big Lake Outlet	9.7	10	10.1	10.4	10.1	10.0
18	Lake Ck	State Route 9	11.1	11.2	11.5	11.3	11.2	10.9
19	Hansen Ck	Hoehn Rd	10.1	10.5	10.9	11.0	10.7	10.2
20	Hansen Ck	Northern State	11	11.2	11.4	11.4	11.1	10.8
21	Coal Ck	Hoehn Rd	11.1	11.4	11.4	11.5	11.1	10.7
22	Coal Ck	Hwy 20	11.8	11.9	12.2	12.2	12.1	11.5
23	Wiseman Ck	Minkler Rd	11.6	11.8	12.1	11.9	12.1	11.7
24	Mannser Ck	Lyman Hamilton Hwy	6.2	6.8	7.6	6.9	7.0	6.1
25	Red Cabin Ck	Hamilton Cem Rd	11.5	11.9	12.2	11.8	12.5	11.7
28	Brickyard Ck	Hwy 20	9.2	9.2	9.9	9.7	9.7	8.7
29	Skagit R	R Bend Rd	10.8	11.3	11.2	10.9	11.2	11.0
30	Skagit R	Cape Horn Rd	11.1	11.3	11.7	11.3	11.4	11.1
31	DD 20 near floodgate	Francis Rd	8.1	9	7.6	7.8	8.2	8.5
32	Samish R	Thomas Rd	10.8	10.8	11.1	10.9	10.9	10.9
33	Alice Bay Pump Station	Samish Island Rd	7.6	9.5	11.7	8.4	9.6	10.4
34	Noname Slough	Bayview-Edison Rd	6.6	6.6	6.1	6.9	6.7	6.0
35	Joe Leary Slough	D'Arcy Rd	4	5	6.3	5.7	5.7	5.3
36	Edison Slough at school	W. Bow Hill Rd	7.6	8.4	9.3	8.4	9.7	8.6
37	Edison Pump Station	Farm to Market Rd	5.5	5.8	7.6	7.3	7.7	5.9
38	North Edison Pump Station	North Edison Rd	7	6.4	9.1	7.6	8.9	5.9
39	Colony Ck	Colony Rd	10.8	10.8	11.1	11.3	11.1	10.8
40	Big Indian Slough	Bayview-Edison Rd	4.6	4.8	5.4	7.5	5.5	5.2
41	Maddox Slough/Big Ditch	Milltown Rd	5.2	5.9	7	6.3	6.6	6.7
42	Hill Ditch	Cedardale Rd	7.1	7.6	8	6.9	7.9	8.2
43	Wiley Slough	Wylie Rd	4.2	4.6	6.2	6.5	5.1	5.1
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	10.4	8.6	8	7.4	7.4	7.7
45	Skagit R – North Fork	Moore Rd	11.1	11.4	11.2	11.2	11.5	11.3
46	Skagit R – South Fork	Fir Island Rd	11	11.3	11.1	11.3	11.4	11.3
47	Swinomish Channel	County Boat Launch	8.7	8.8	9.2	8.9	8.5	8.8
48	Fisher Ck	Franklin Rd	10.9	11	11.3	11.0	11.1	11.2

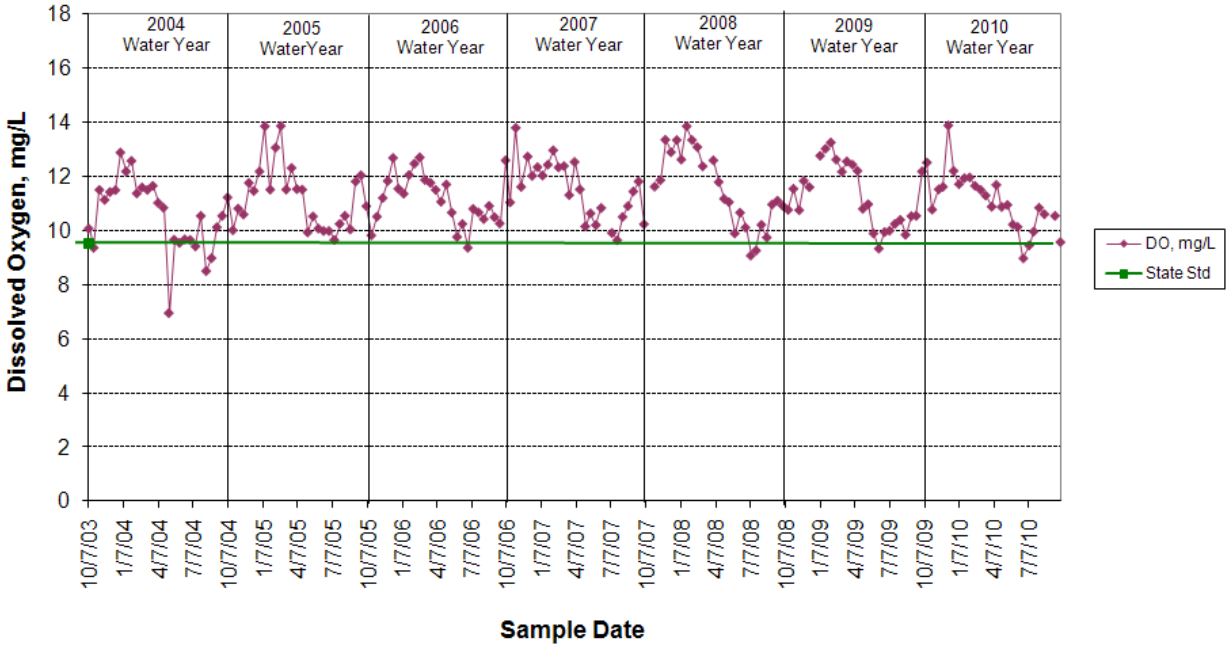
Thomas Creek at Hwy 99 - Site 3
Dissolved Oxygen



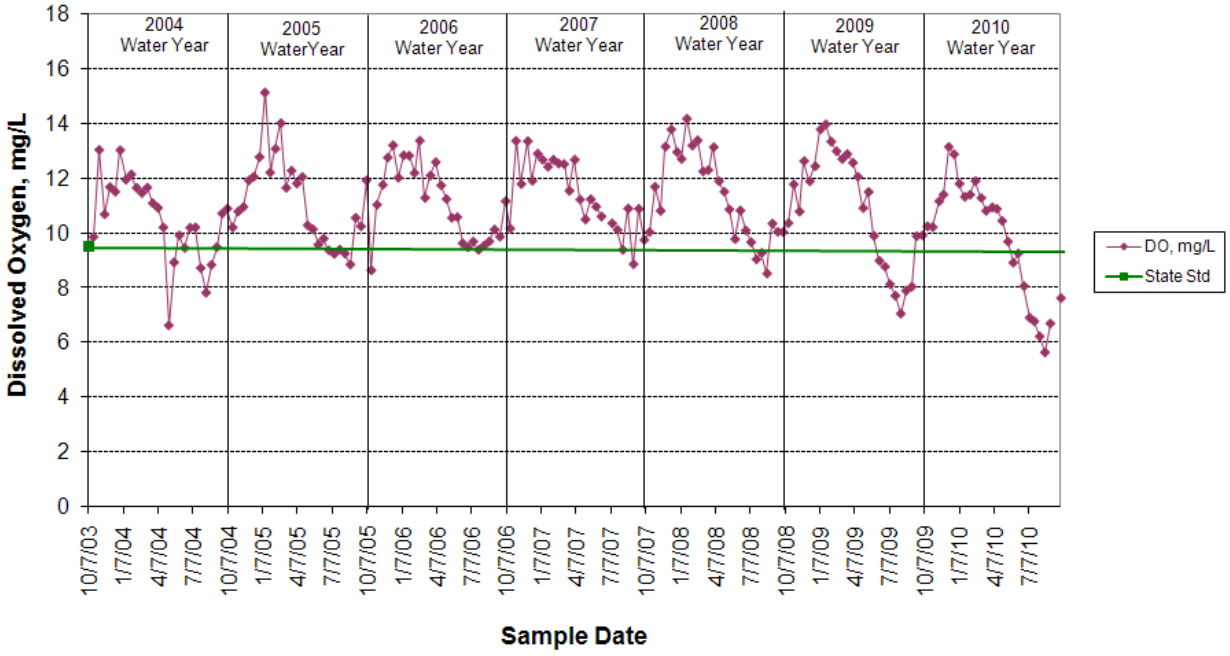
Thomas Creek at F&S Grade Rd - Site 4
Dissolved Oxygen



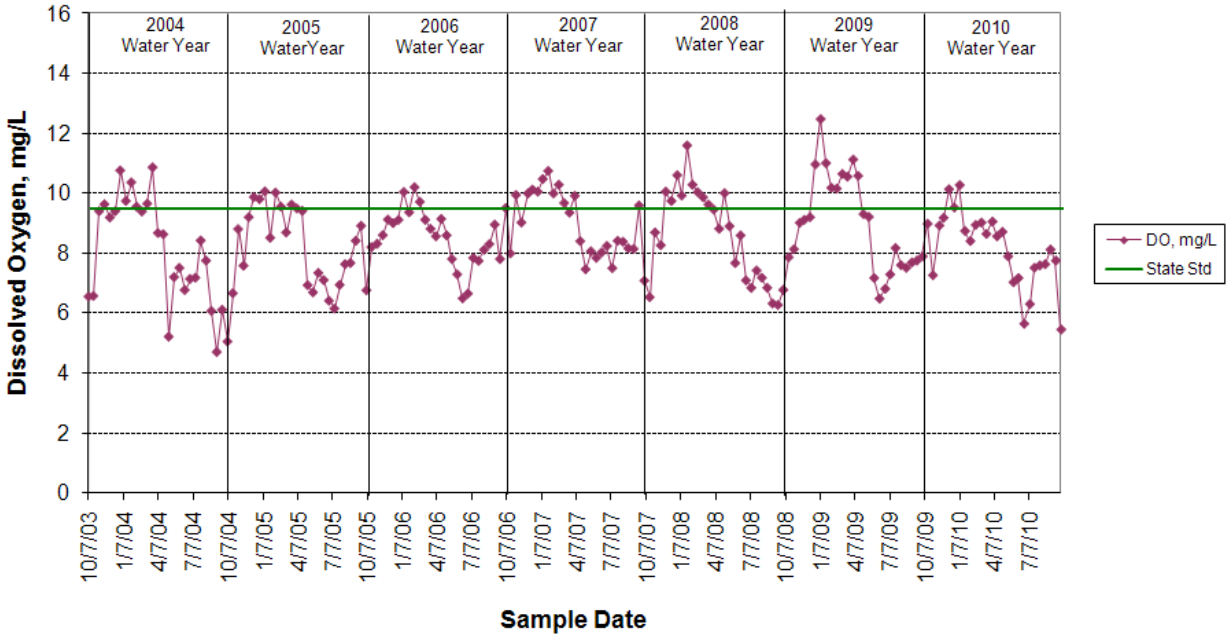
Friday Creek at Prairie Rd - Site 6
Dissolved Oxygen



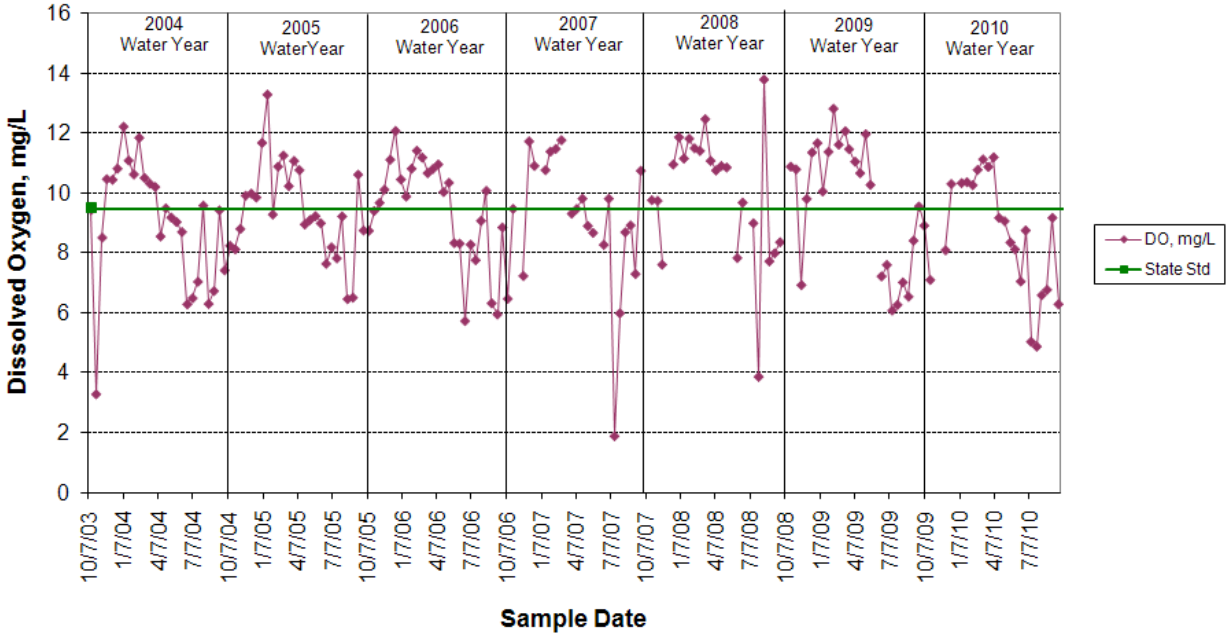
Swede Creek at Grip Rd - Site 8
Dissolved Oxygen



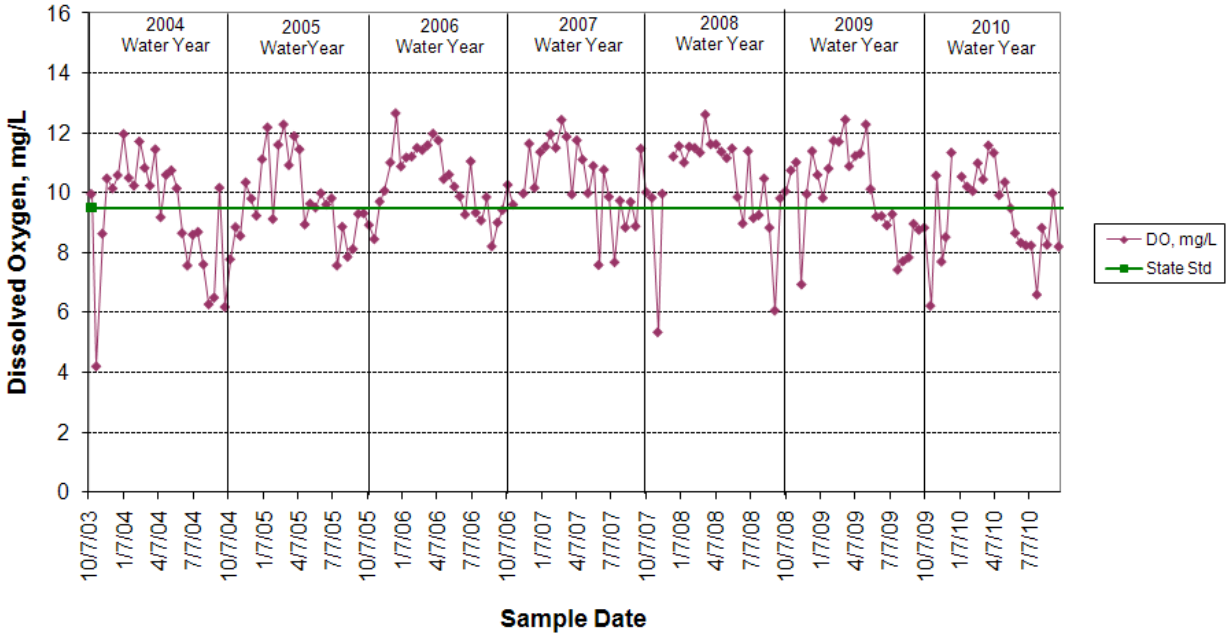
Samish River at Hwy 9 - Site 11
Dissolved Oxygen



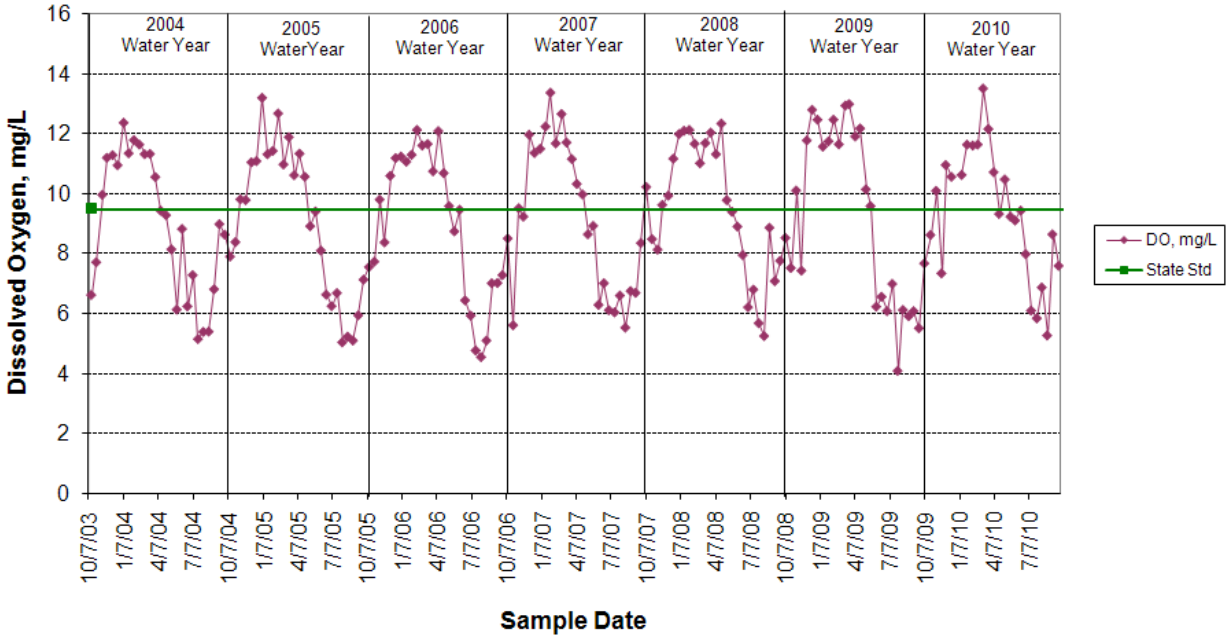
Nookachamps Creek at Swan Rd - Site 12
Dissolved Oxygen



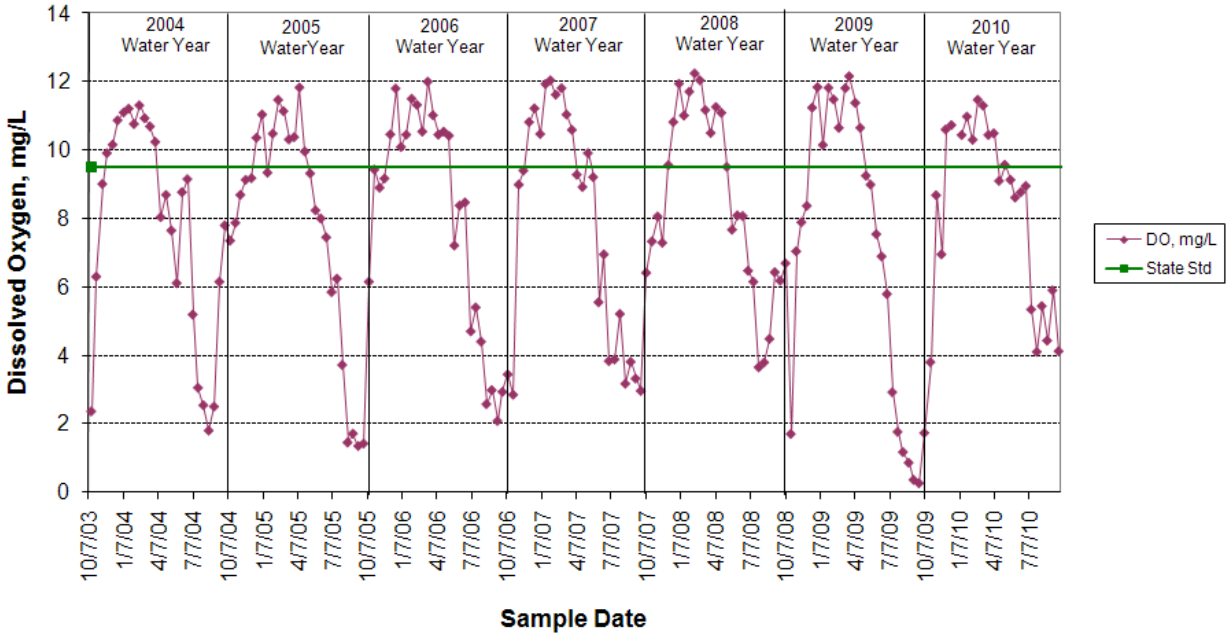
E.F. Nookachamps Creek at Hwy 9 - Site 13
Dissolved Oxygen



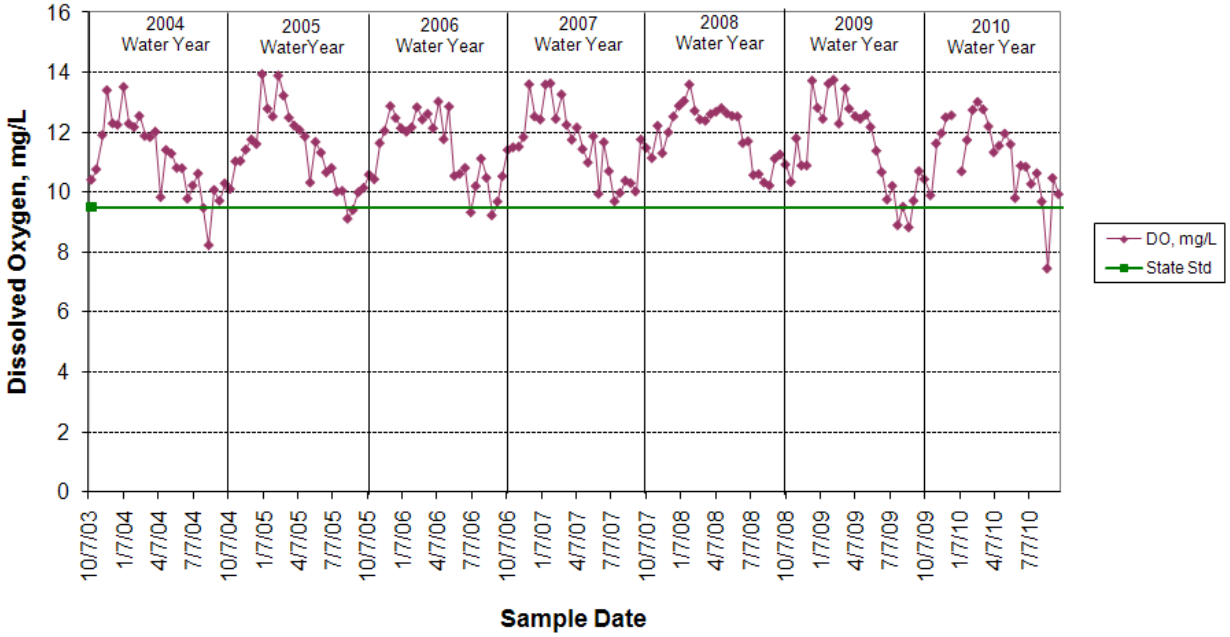
College Way Creek at College Way - Site 14
Dissolved Oxygen



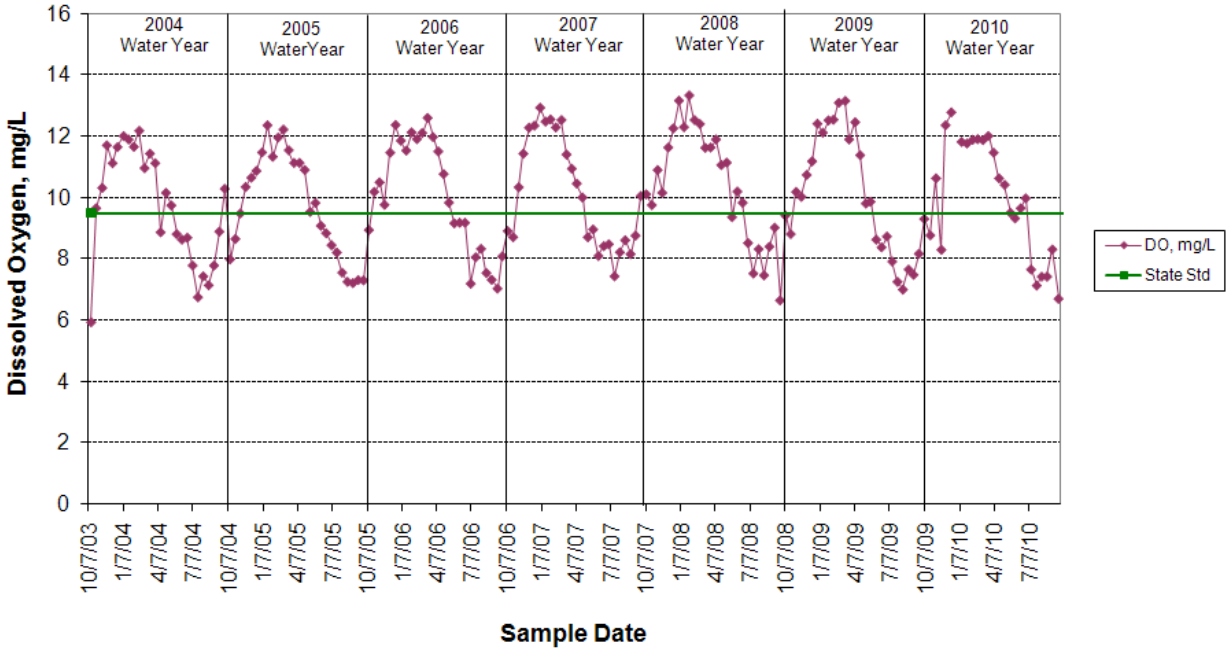
Nookachamps Creek at Knapp Rd - Site 15
Dissolved Oxygen



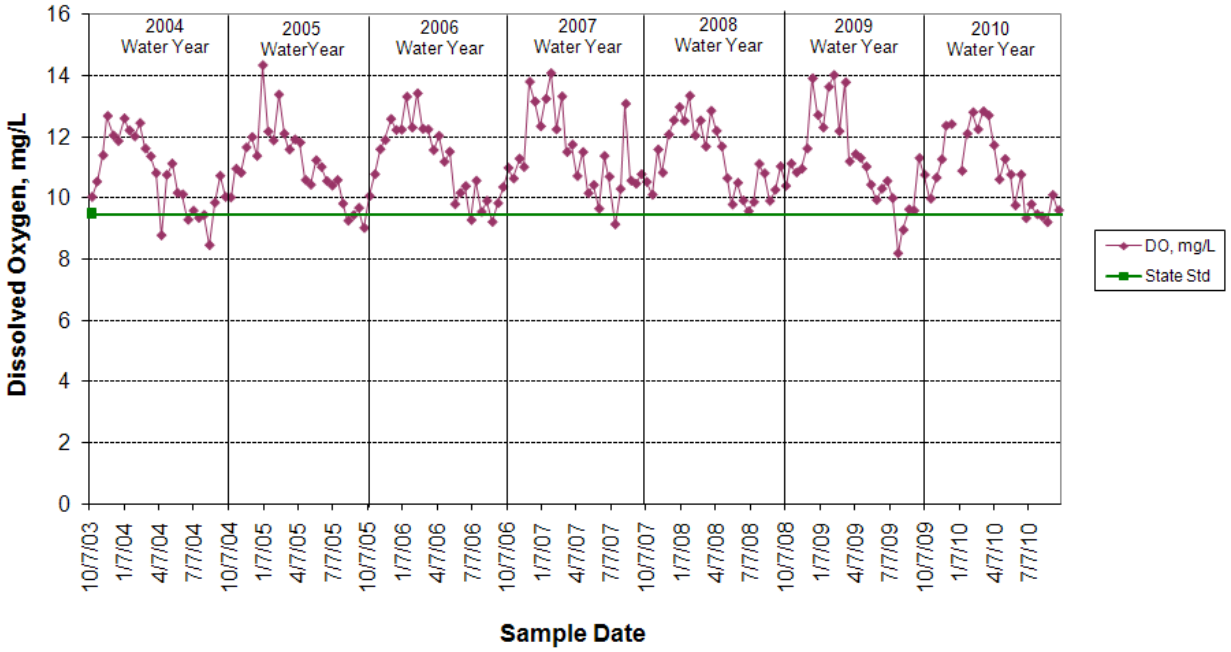
E.F. Nookachamps Creek at Beaver Lake Rd - Site 16
Dissolved Oxygen



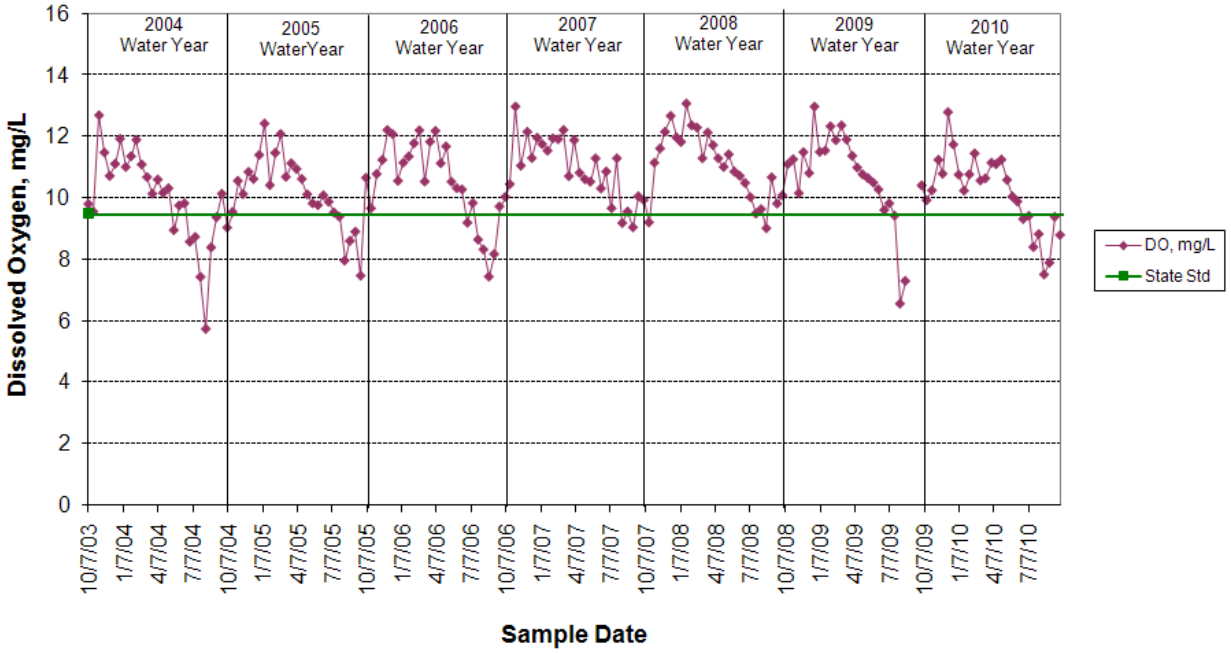
Nookachamps Creek at Big Lake Outlet - Site 17
Dissolved Oxygen



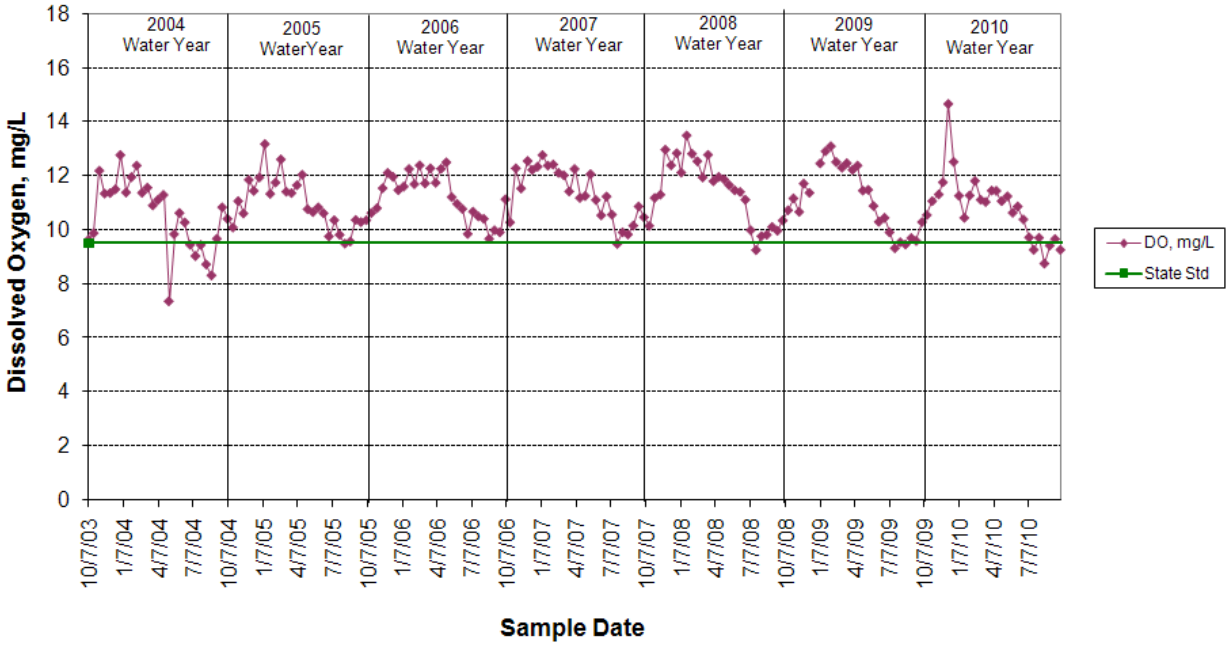
Lake Creek at Hwy 9 - Site 18
Dissolved Oxygen



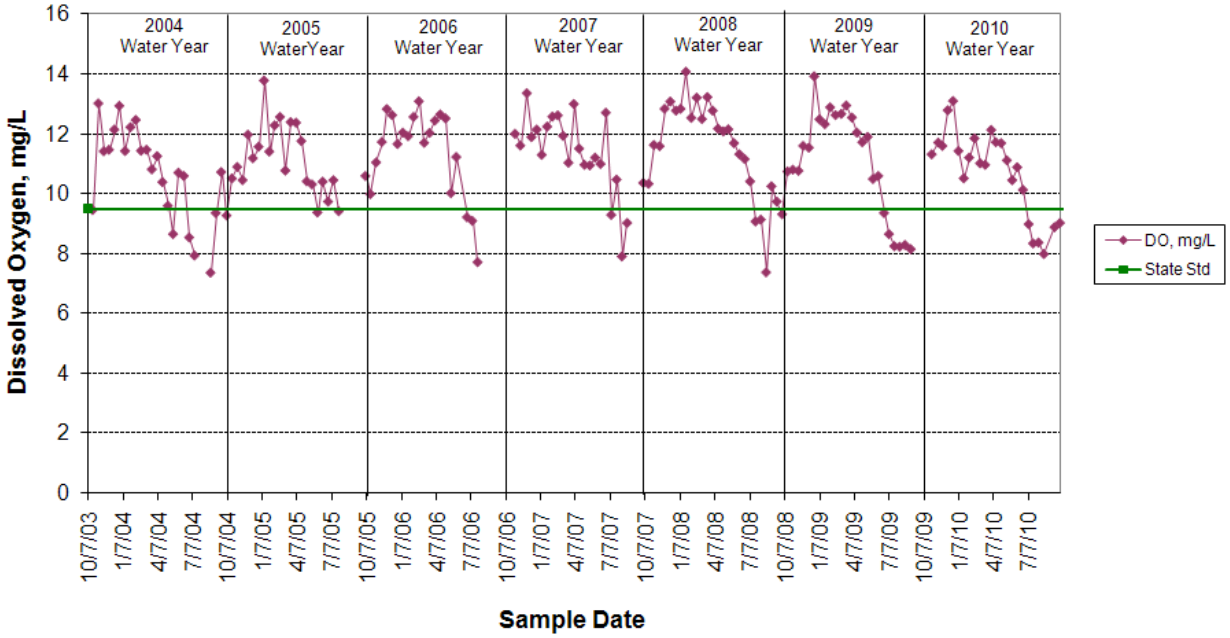
Hansen Creek at Hoehn Rd - Site 19
Dissolved Oxygen



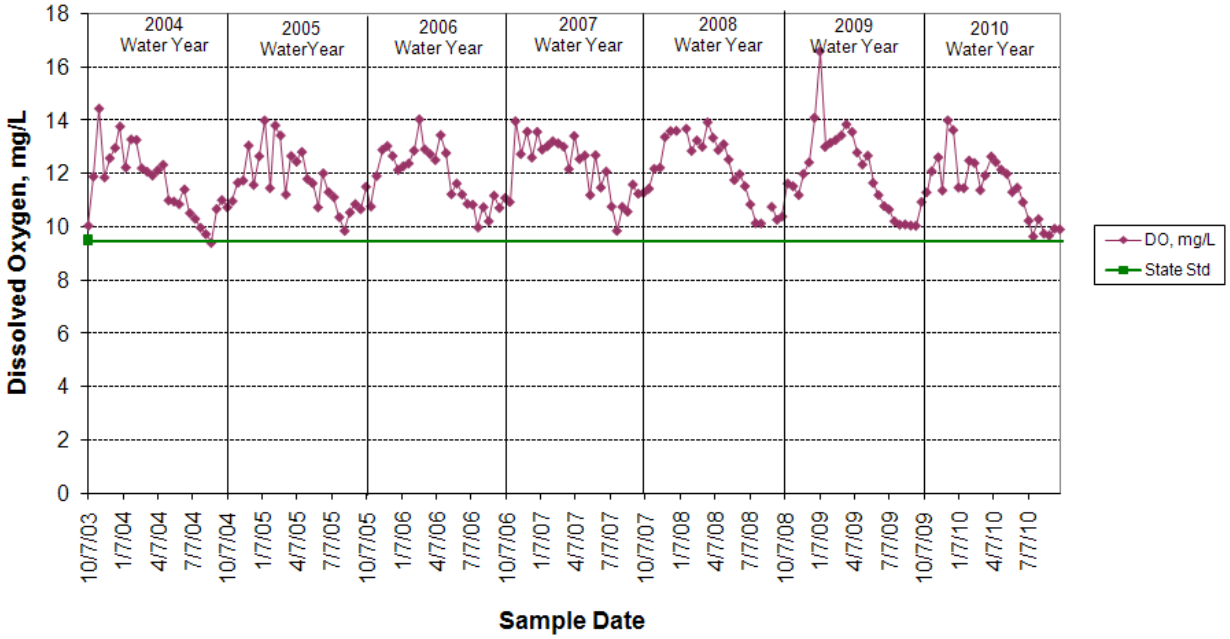
Hansen Creek at Northern State Hospital - Site 20
Dissolved Oxygen



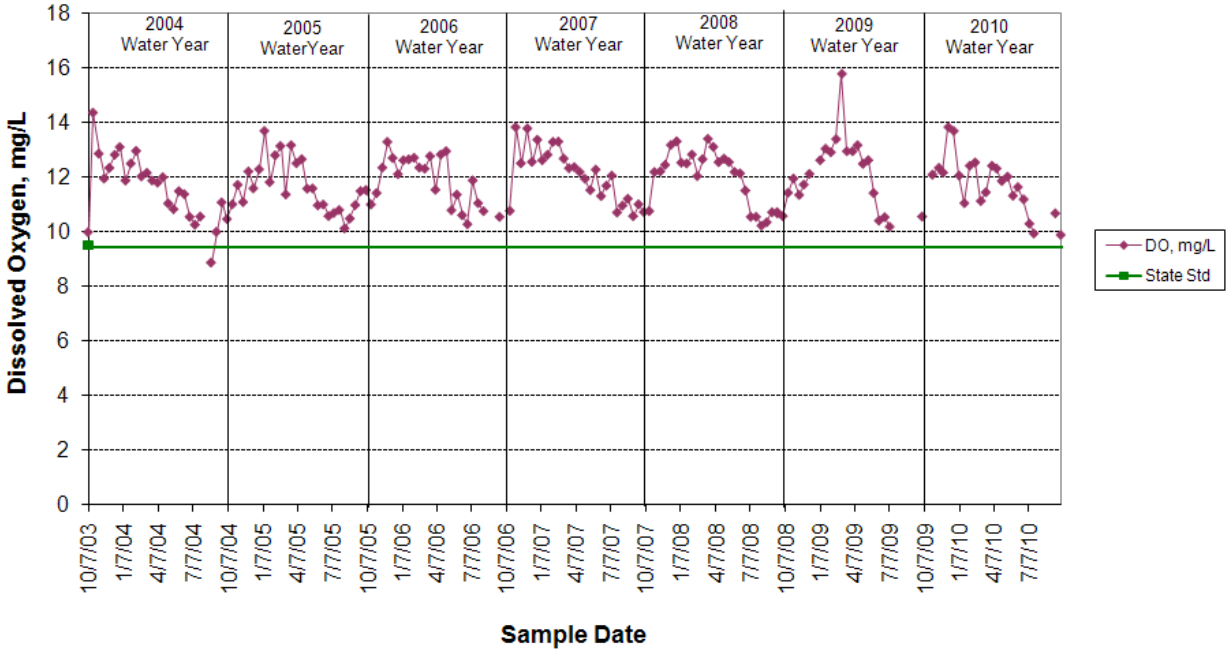
Coal Creek at Hoehn Rd - Site 21
Dissolved Oxygen



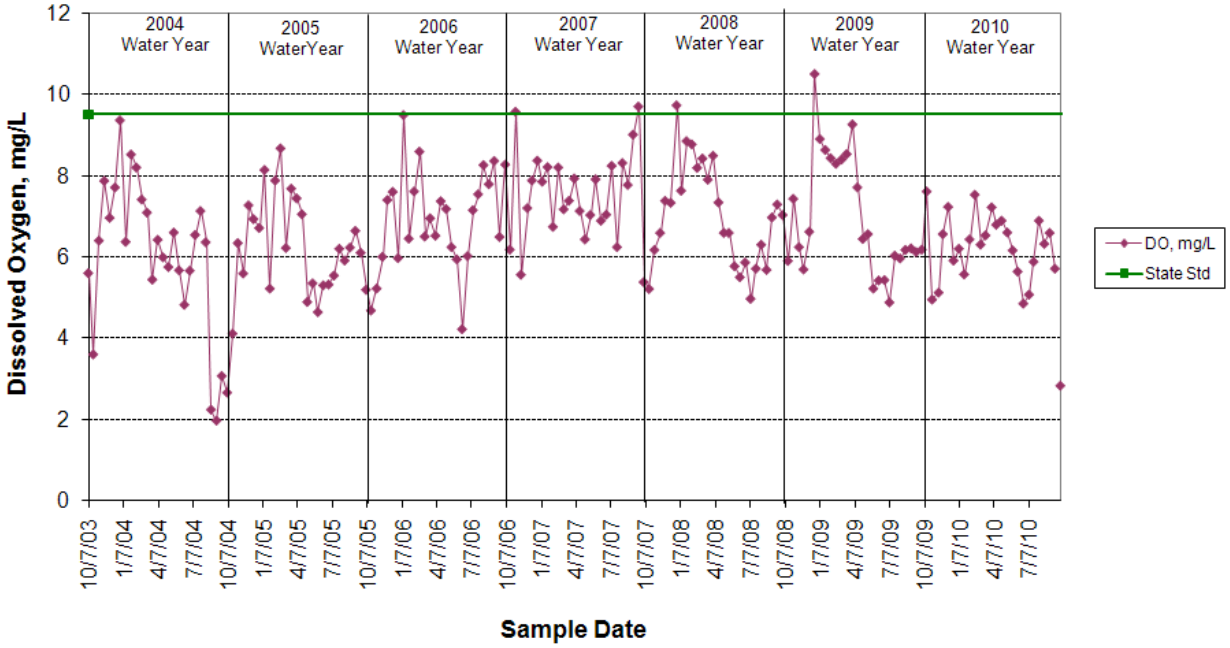
Coal Creek at Hwy 20 - Site 22
Dissolved Oxygen



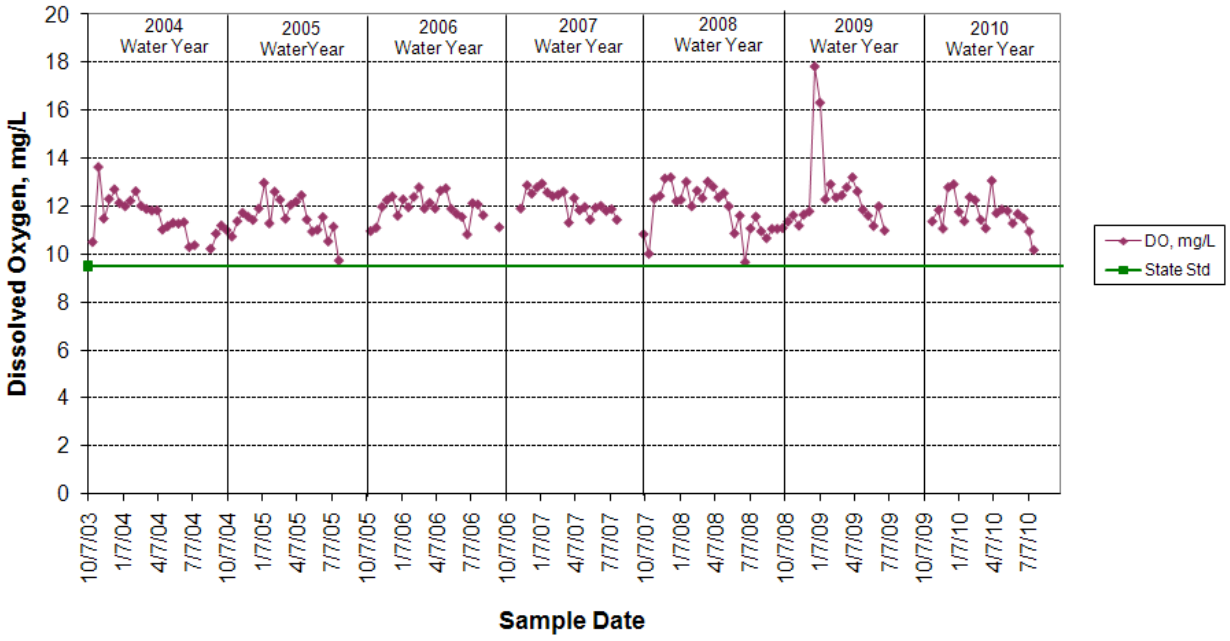
Wiseman Creek at Minkler Rd - Site 23
Dissolved Oxygen



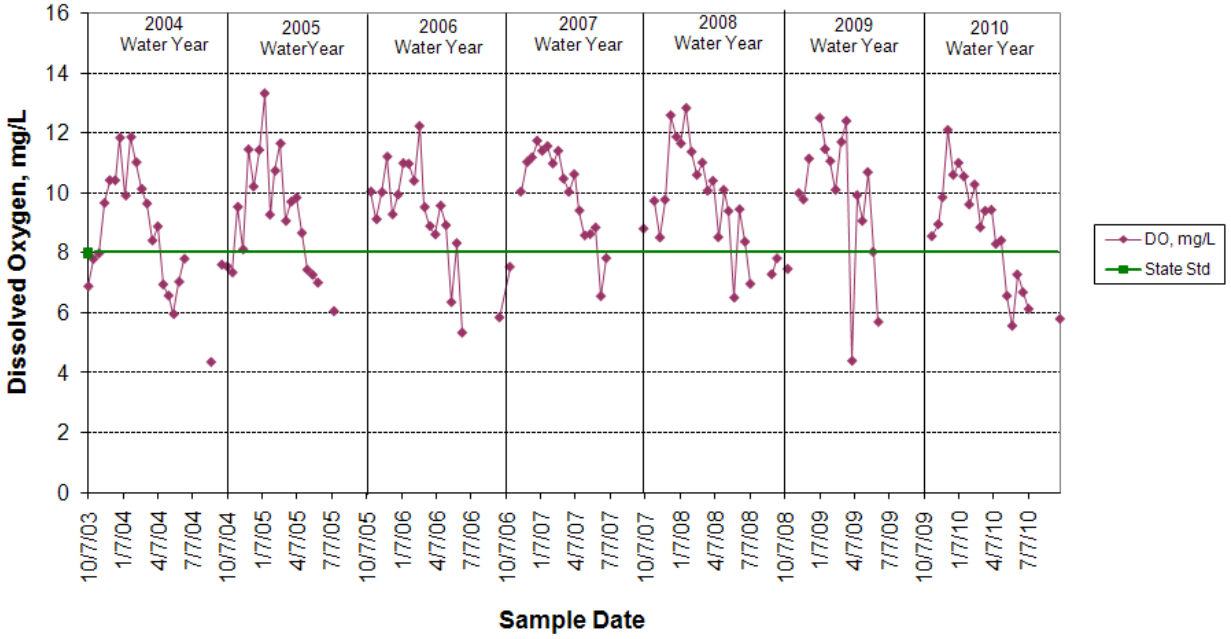
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Dissolved Oxygen



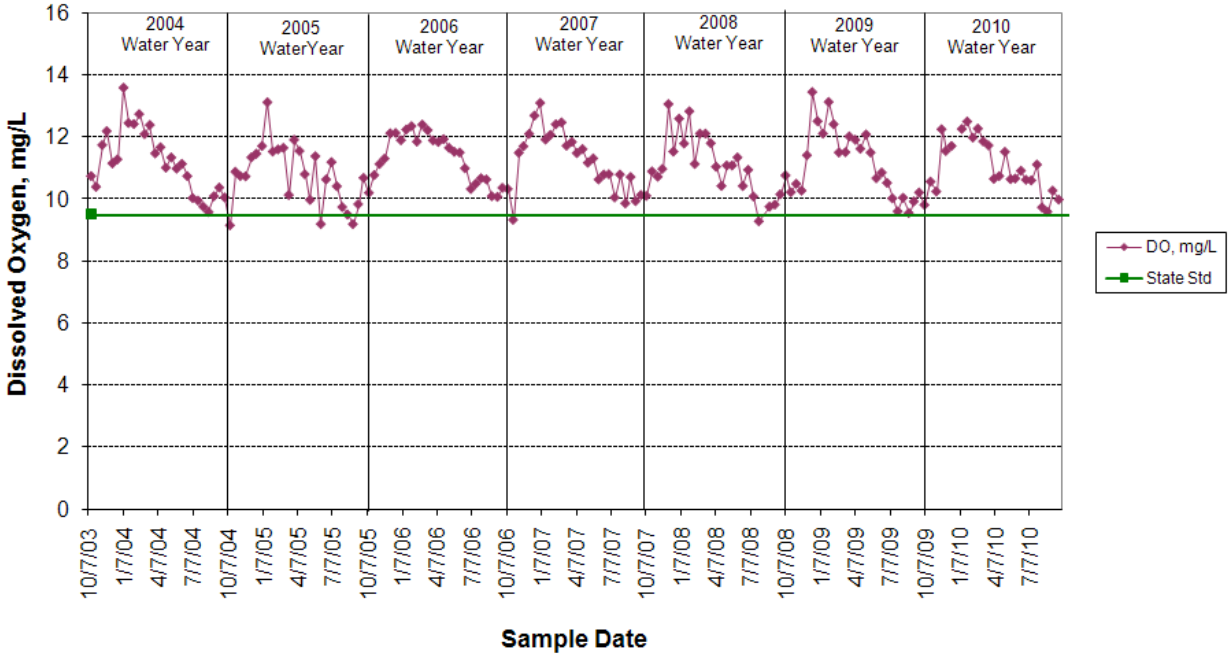
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Dissolved Oxygen



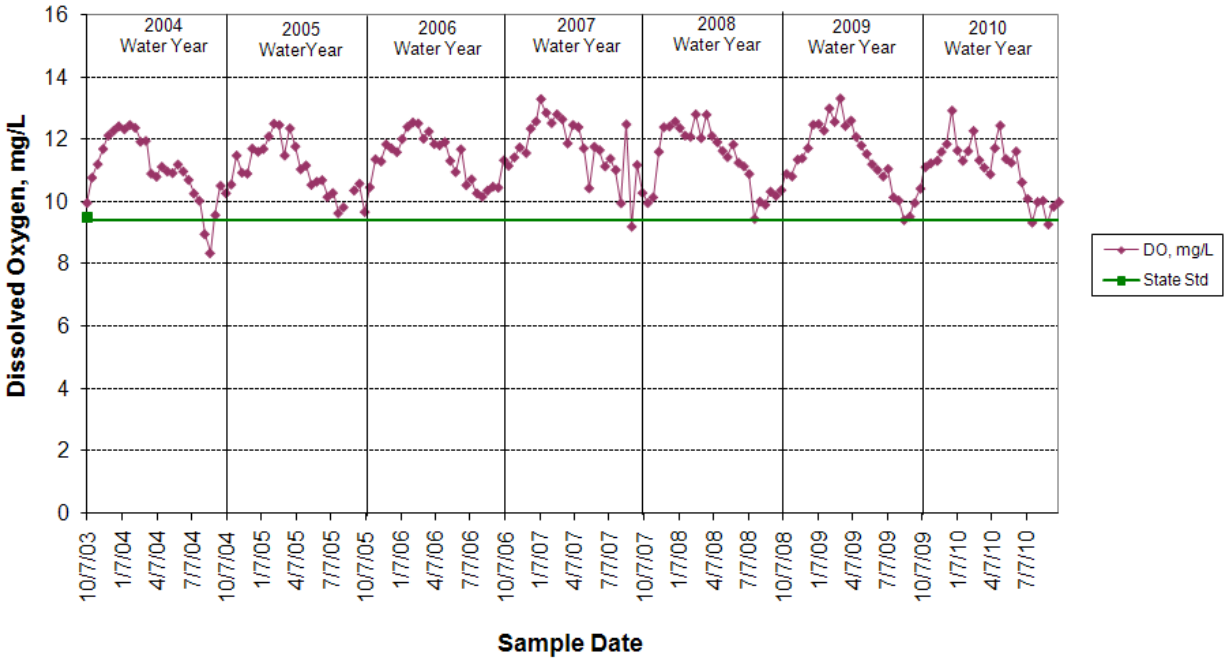
Brickyard Creek at Hwy 20 - Site 28
Dissolved Oxygen



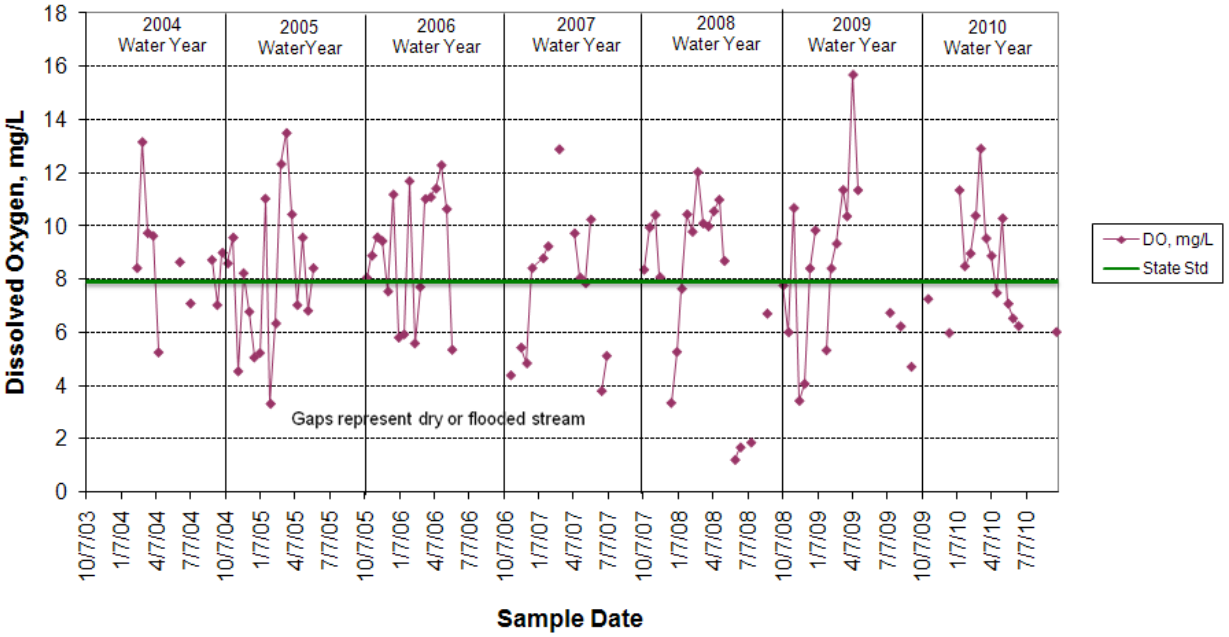
Skagit River at River Bend - Site 29
Dissolved Oxygen



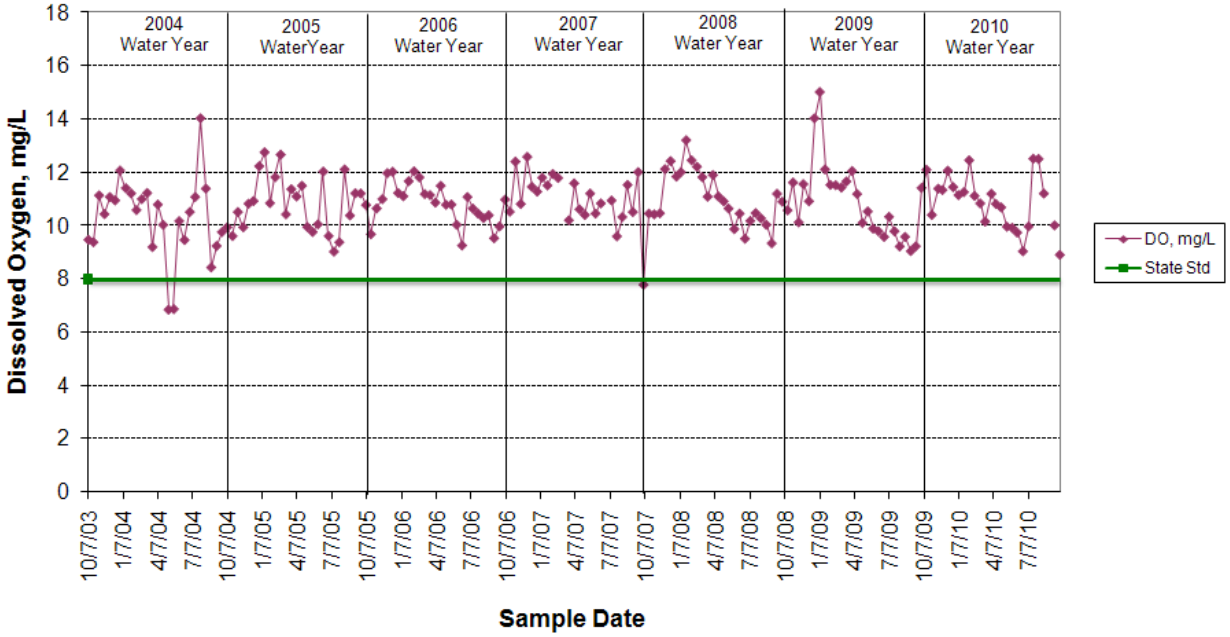
Skagit River at Cape Horn Rd - Site 30
Dissolved Oxygen



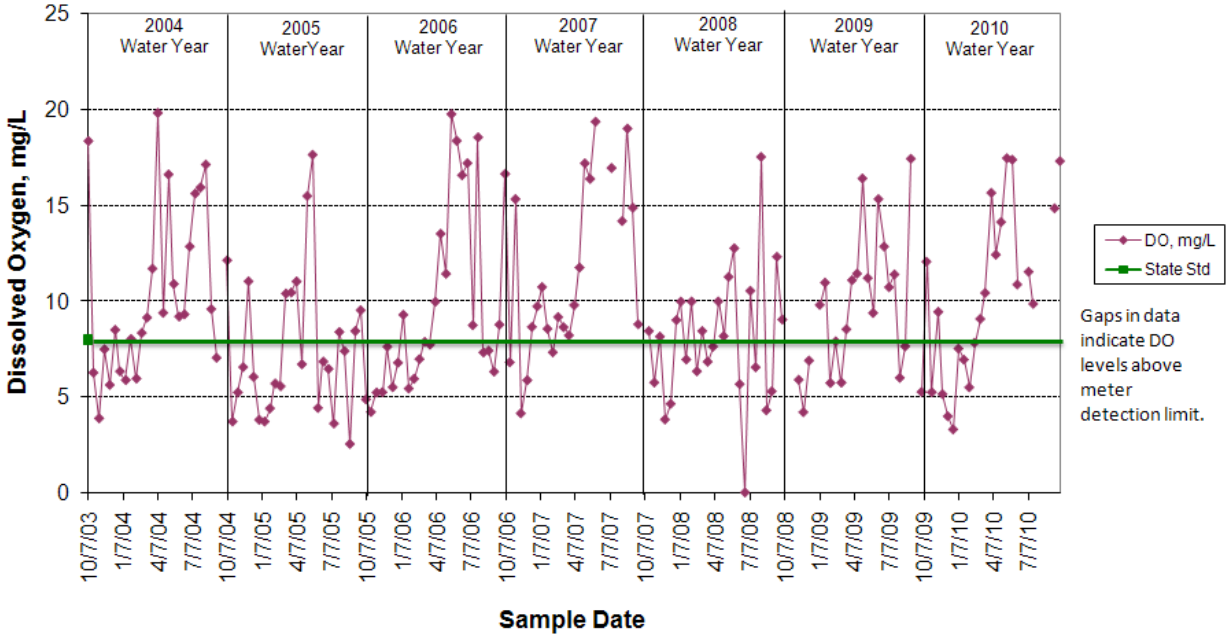
Drainage District 20 Ditch at Floodgate - Site 31
Dissolved Oxygen



Samish River at Thomas Rd - Site 32
Dissolved Oxygen

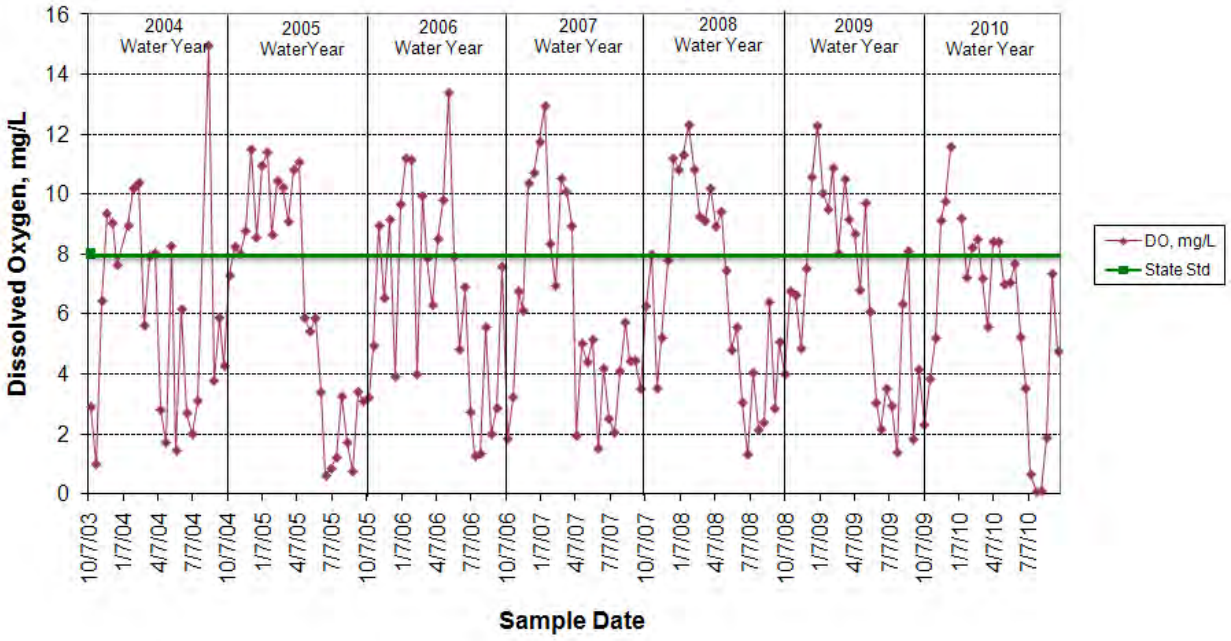


Alice Bay Pump Station - Site 33
Dissolved Oxygen

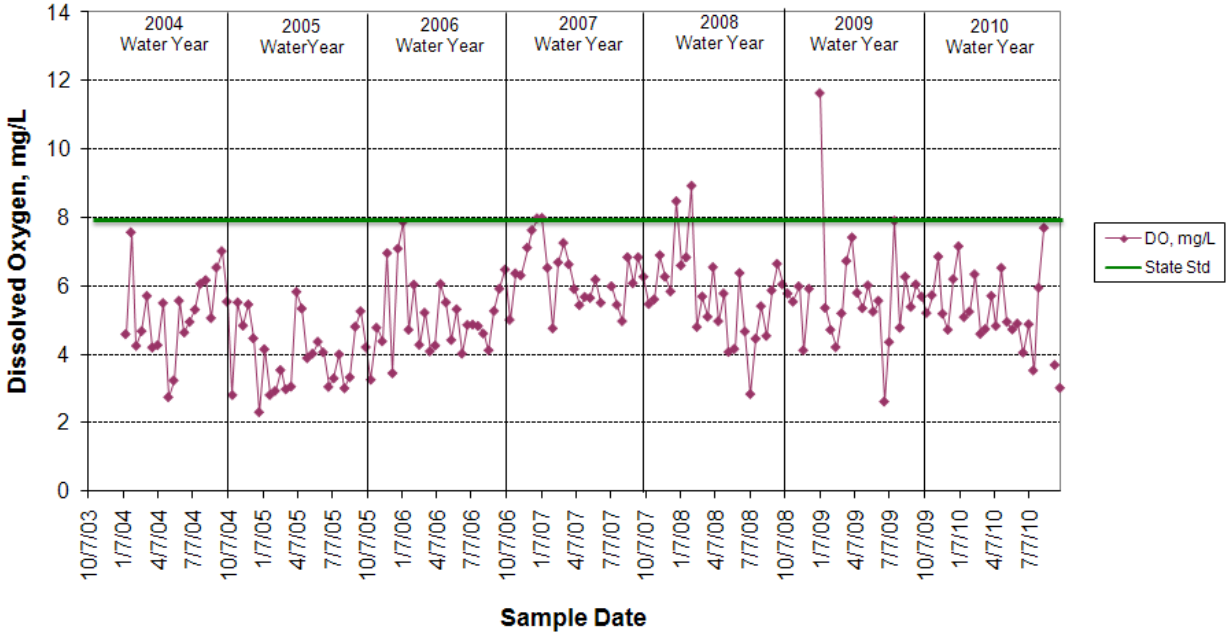


Gaps in data indicate DO levels above meter detection limit.

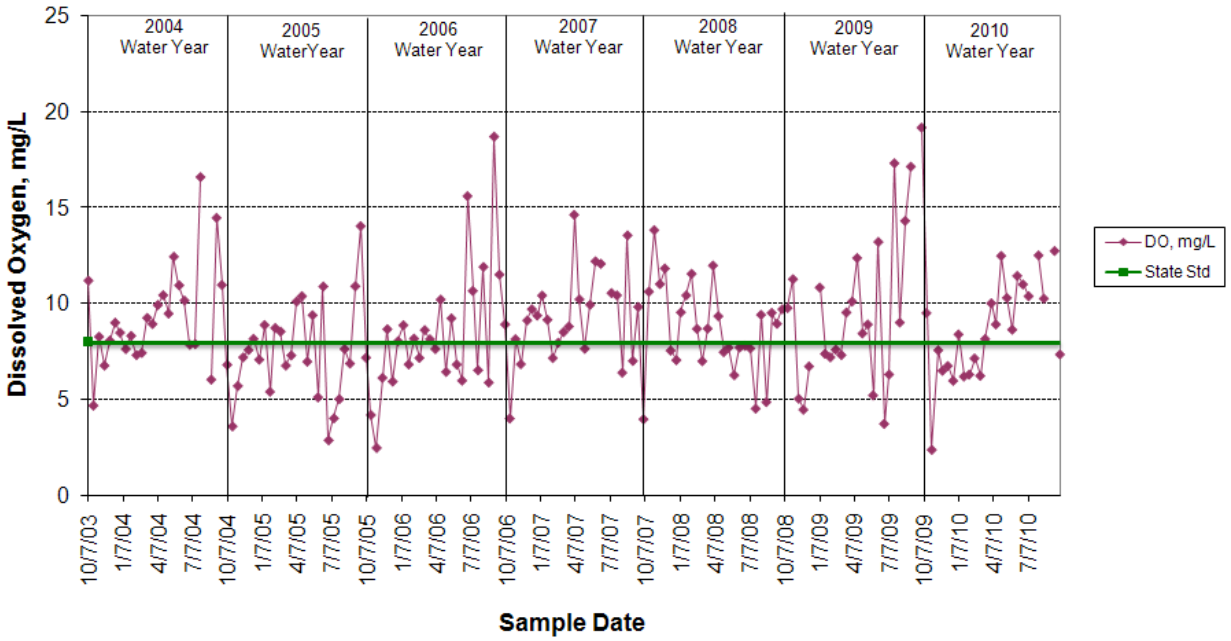
No Name Slough at Bayview-Edison Rd - Site 34
Dissolved Oxygen



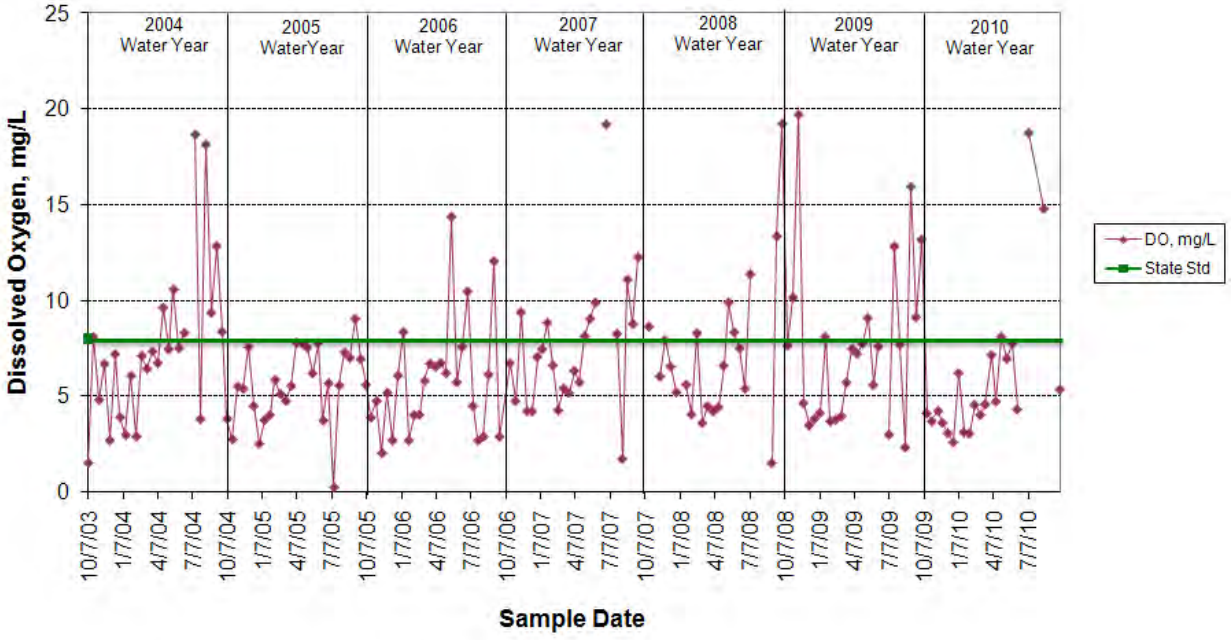
Joe Leary Slough at D'Arcy Rd - Site 35
Dissolved Oxygen



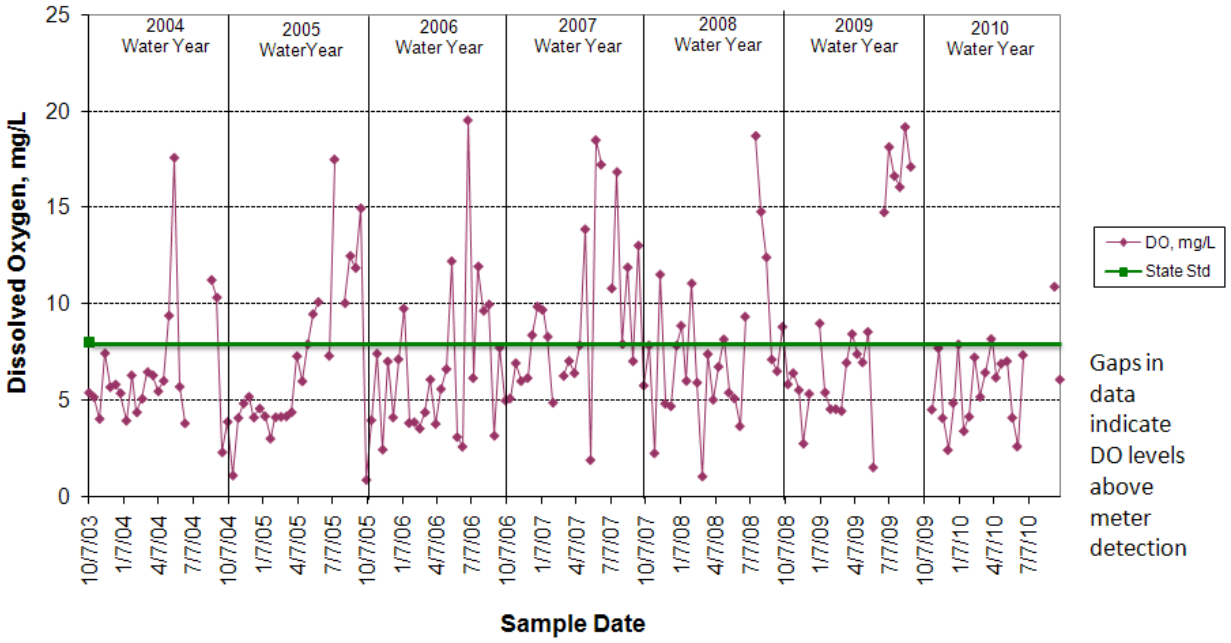
Edison Slough at Edison School - Site 36
Dissolved Oxygen



Edison Pump Station - Site 37
Dissolved Oxygen

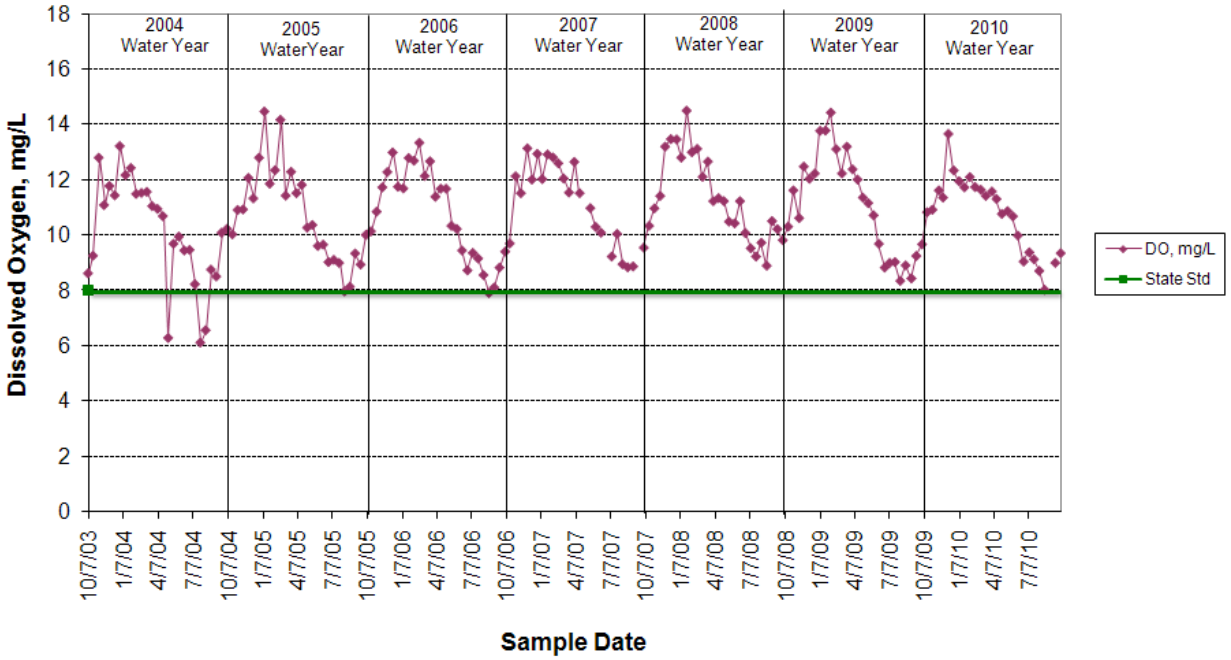


North Edison Pump Station - Site 38
Dissolved Oxygen

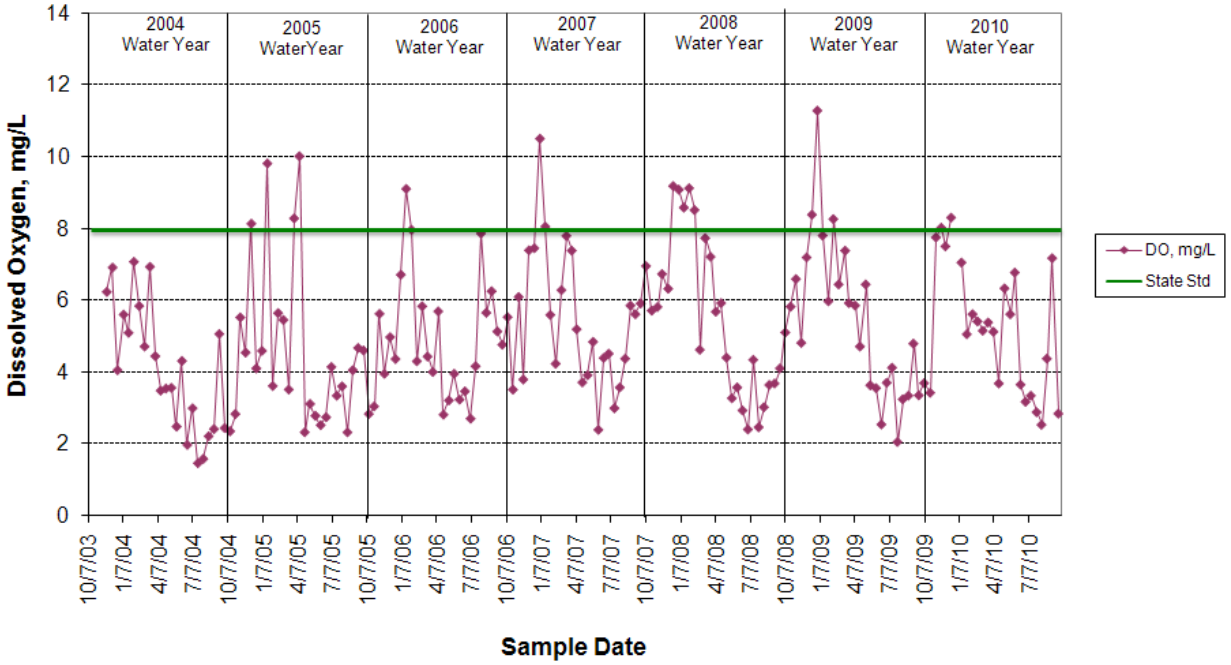


Gaps in data indicate DO levels above meter detection

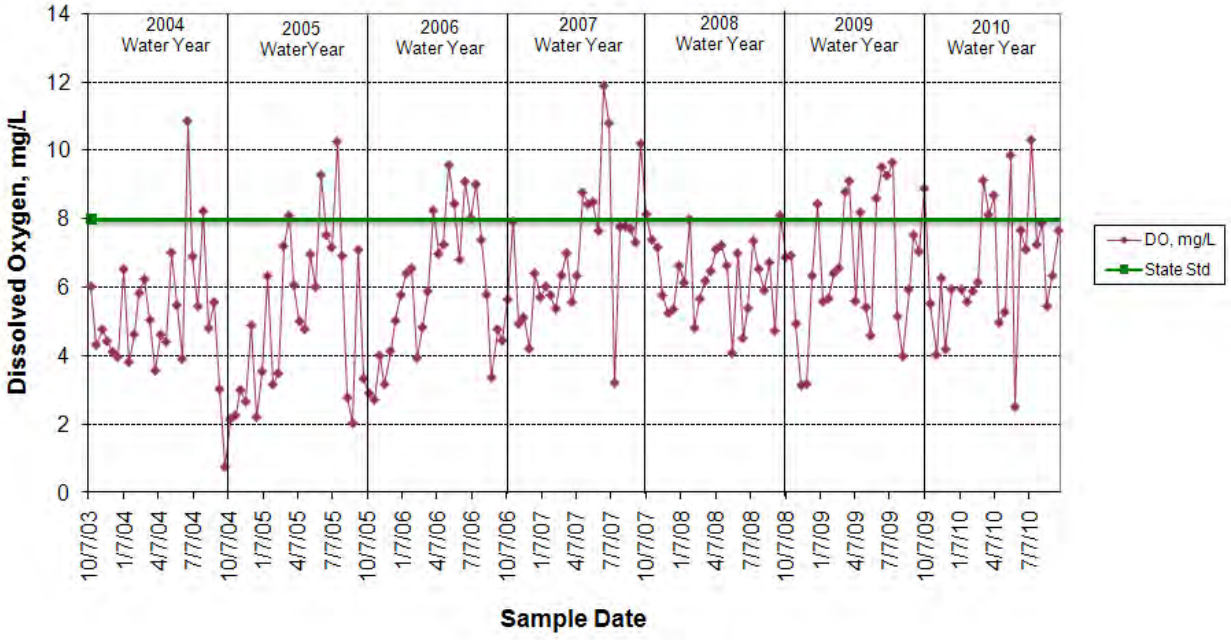
Colony Creek at Colony Rd - Site 39
Dissolved Oxygen



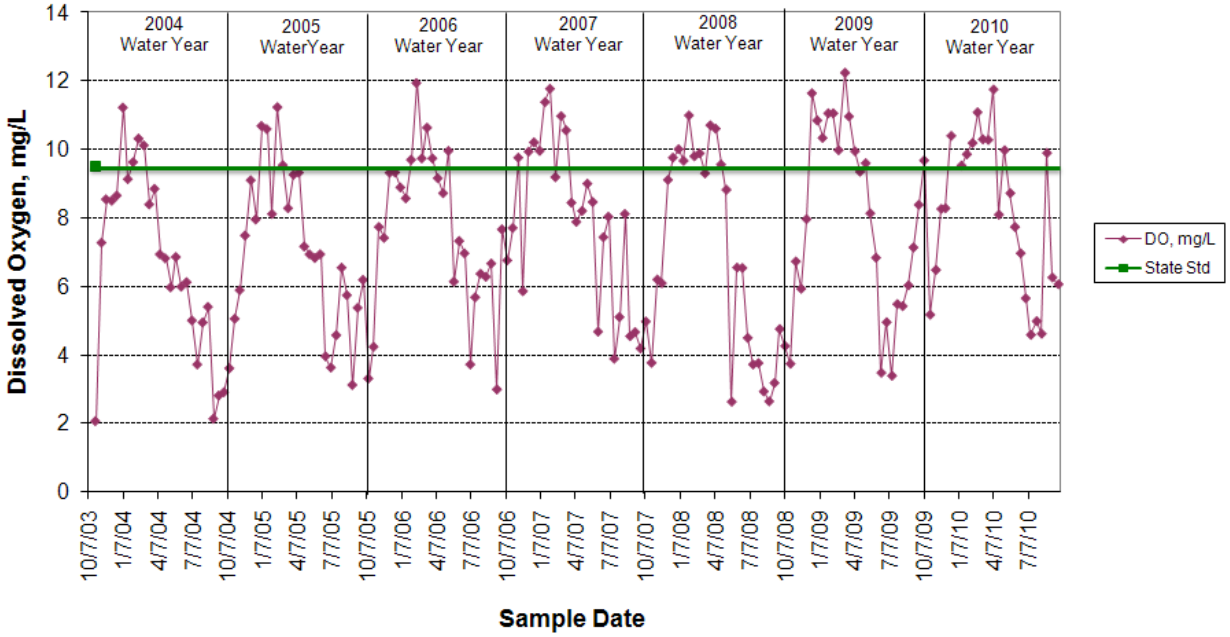
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Dissolved Oxygen



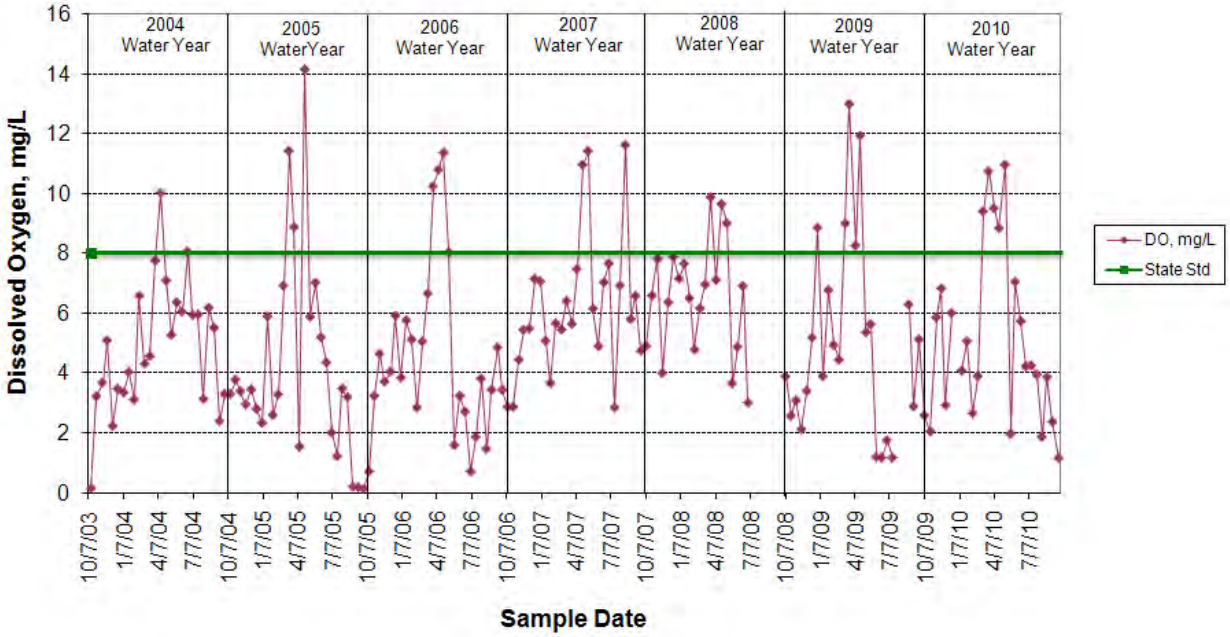
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Dissolved Oxygen



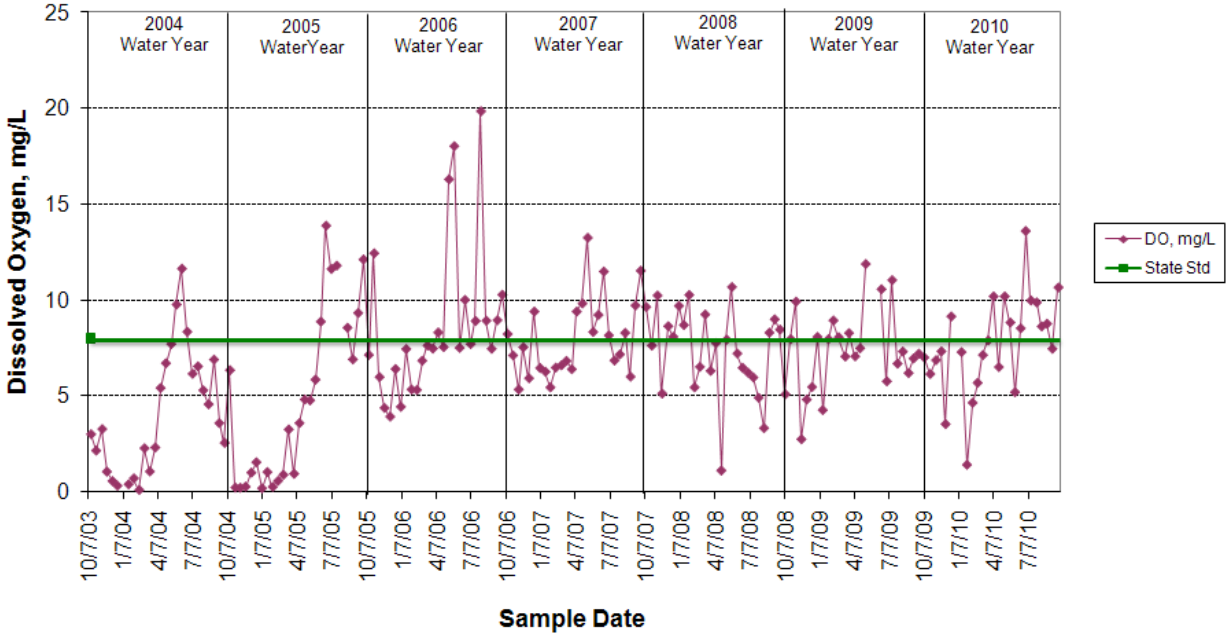
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Dissolved Oxygen



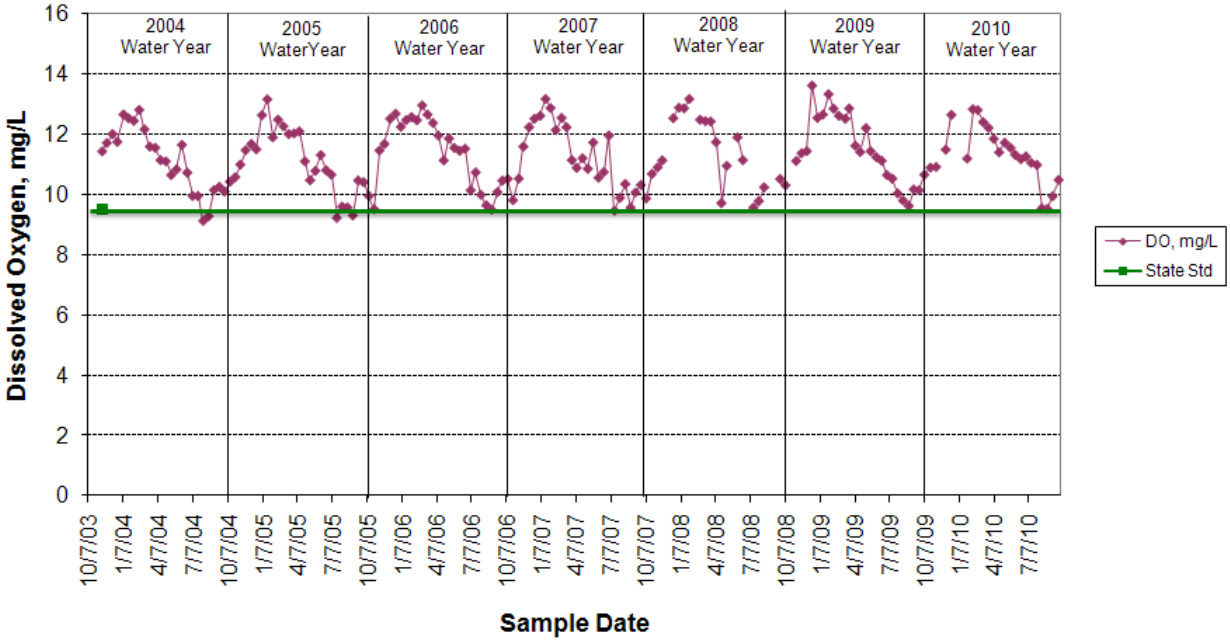
Wiley Slough at Wylie Rd - Site 43
Dissolved Oxygen



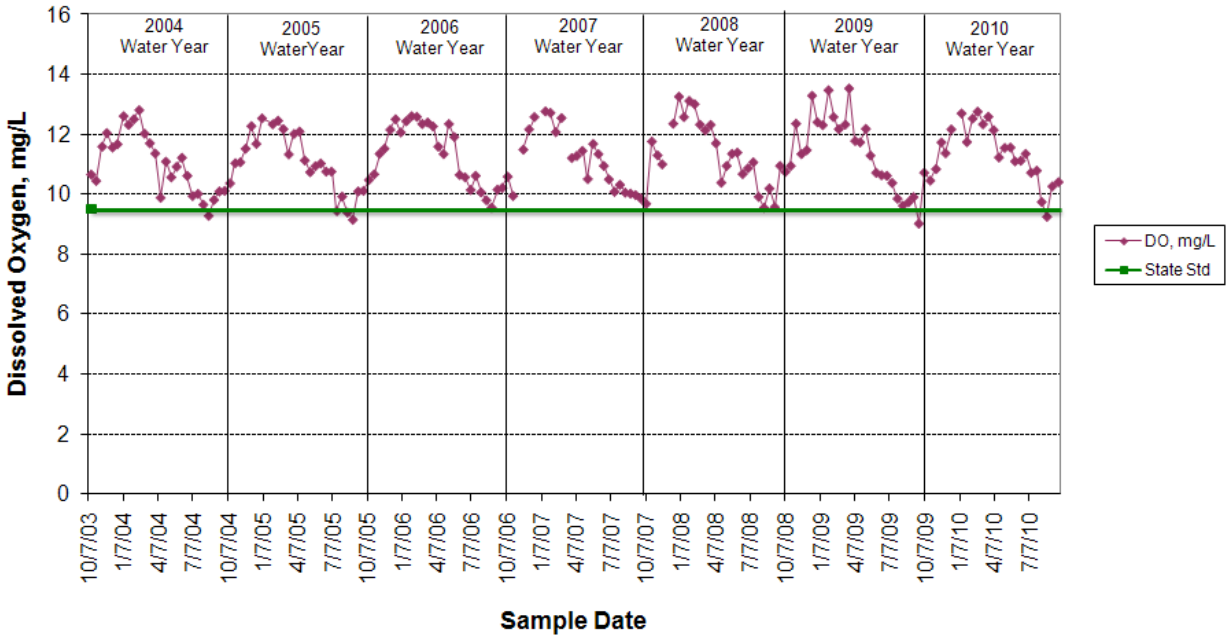
Sullivan Slough at La Conner-Whitney Rd - Site 44
Dissolved Oxygen



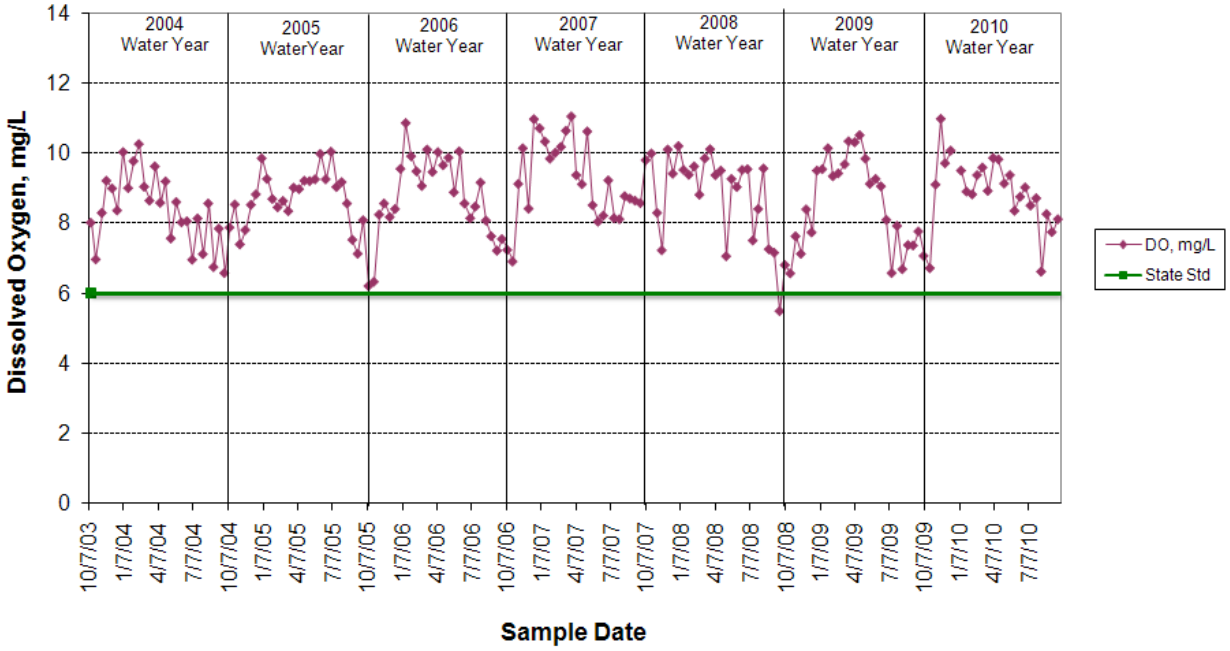
N.F. Skagit near Moore Rd - Site 45
Dissolved Oxygen

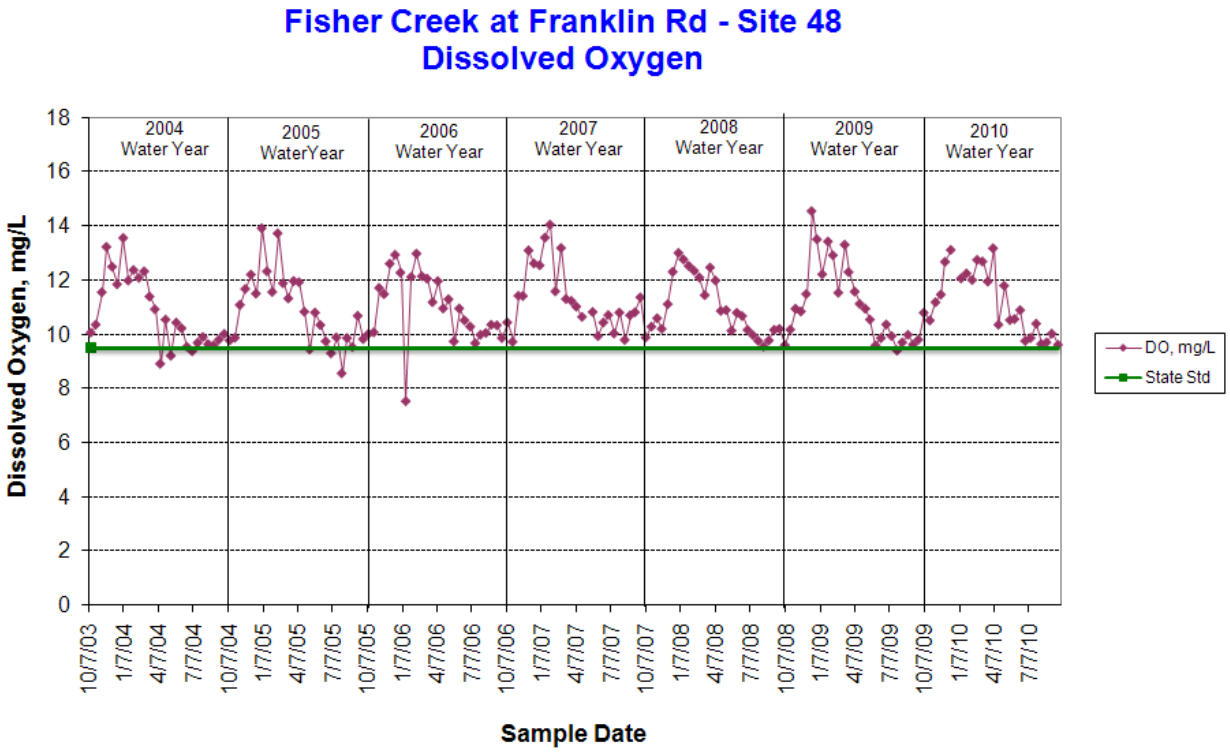


S.F. Skagit at Conway Boat Ramp - Site 46
Dissolved Oxygen



Swinomish Channel at County Boat Ramp - Site 47
Dissolved Oxygen





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 (2009-2010) for analysis by the Most Probable Number method.

Fecal coliform measurements for the 2010 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 the last six 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 seven years of this project. Most other watercourses in the Skagit County Monitoring Program did not meet the standard at some point during the study.

For the 2010 water year, 16 sites met the standard based on ambient sampling for the entire water year. However, storm sampling at several sites in the Samish Basin indicated that many sites meeting the standard based on ambient sampling do not meet the standard during rain events.

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 and 2010 water years saw continued high fecal coliform counts in the Samish River and elsewhere in the Samish Bay Watershed, and many additional closures of shellfish beds. 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 and received grant funding from EPA 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. This program is now in full operation. Water quality sampling results from the Clean Samish Initiative program are summarized later in this report. A full report of Clean Samish Initiative activities will be published separately.

Graphs on the pages following Table 8 illustrate fecal coliform levels for water years 2004-2010 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. 2010 Fecal Coliform Results
Summary of Fecal Coliform Readings in Skagit County Monitoring Program
2010 Water Year

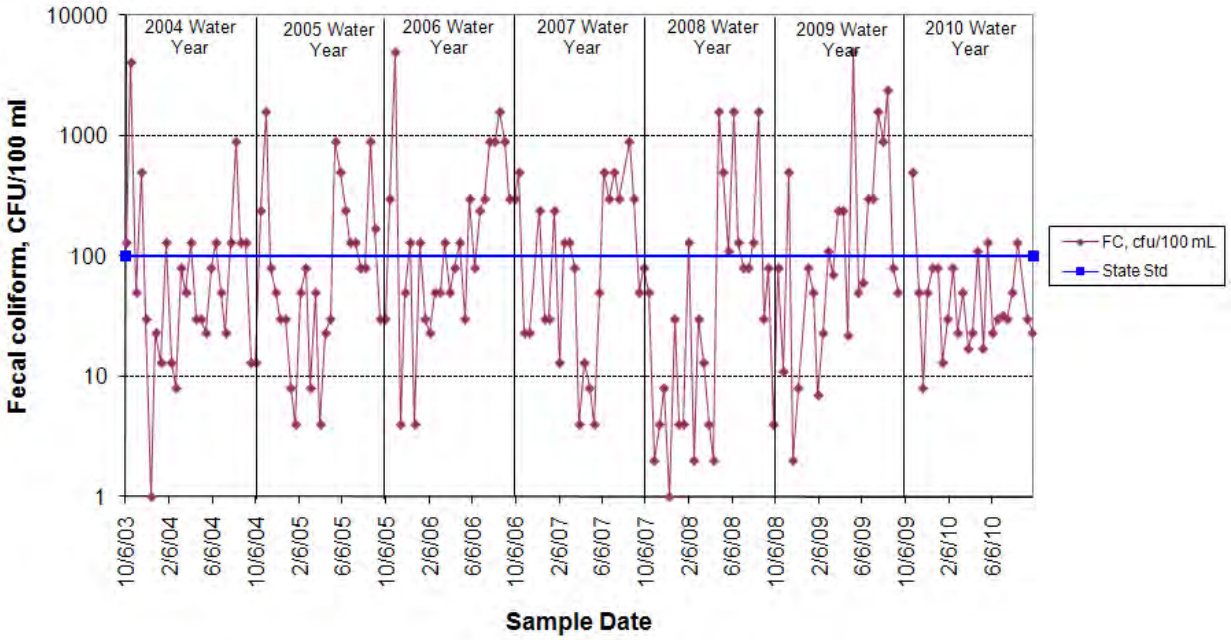
Site Number	Watercourse	Location	N	Geometric mean (cfu)[1]	Standard	% > 100 or 200[1]	Max
3	Thomas Ck	Old Hwy 99 North	25	36	100	4	500
4	Thomas Ck	F&S Grade	26	156	100	50	2400
6	Friday Ck	Prairie Rd	26	35	100	8	1600
8	Swede Ck	Grip Rd	26	61	100	12	900
11	Samish R	State Route 9	25	17	100	4	240
12	Nookachamps Ck	Swan Rd	24	72	100	33	500
13	E.F. Nookachamps Ck	State Route 9	26	59	100	15	1600
14	College Way Ck	College Way	26	307	100	58	16000
15	Nookachamps Ck	Knapp	26	79	100	35	900
16	E.F. Nookachamps Ck	Beaver Lake Rd	24	25	100	4	240
17	Nookachamps Ck	Big Lake Outlet	24	14	100	0	130
18	Lake Ck	State Route 9	26	69	100	31	16000
19	Hansen Ck	Hoehn Rd	26	92	100	35	900
20	Hansen Ck	Northern State	26	53	100	19	500
21	Coal Ck	Hoehn Rd	24	69	50	38	1600
22	Coal Ck	Hwy 20	25	17	50	20	240
23	Wiseman Ck	Minkler Rd	19	13	50	11	300
24	Mannser Ck	Lyman Hamilton Hwy	24	10	50	4	130
25	Red Cabin Ck	Hamilton Cem Rd	17	16	50	6	1600
28	Brickyard Ck	Hwy 20	20	72	100	20	1600
29	Skagit R	R Bend Rd	23	15	100	0	80
30	Skagit R	Cape Horn Rd	24	5	50	0	22
31	Drain Dist 20 near floodgate	Francis Rd	16	23	100	19	300
32	Samish R	Thomas Rd	26	43	100	8	3000
33	Alice Bay Pump Station	Samish Island Rd	25	33	100	16	300
34	Noname Slough	Bayview-Edison Rd	26	216	100	42	6000
35	Joe Leary Slough	D'Arcy Rd	24	85	100	8	9000
36	Edison Slough at school	W. Bow Hill Rd	26	84	100	31	1600
37	Edison Pump Station	Farm to Market Rd	26	120	100	42	1600
38	North Edison Pump Station	North Edison Rd	25	183	100	36	5000
39	Colony Ck	Colony Rd	24	82	100	29	9000
40	Big Indian Slough	Bayview-Edison Rd	26	122	100	38	900
41	Maddox Slough/Big Ditch	Milltown Rd	26	34	100	4	300
42	Hill Ditch	Cedardale Rd	26	66	100	12	9000
43	Wiley Slough	Wylie Rd	25	44	100	8	900
44	Sullivan Slough	La Conner-Whitney Rd	26	68	100	19	300
45	Skagit R – North Fork	Moore Rd	22	11	100	0	50
46	Skagit R – South Fork	Fir Island Rd	24	12	100	0	50
47	Swinomish Channel	County Boat Launch	23	6	14	9	50
48	Fisher Ck	Franklin Rd	26	56	100	19	1600

[1] State water quality standards 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.

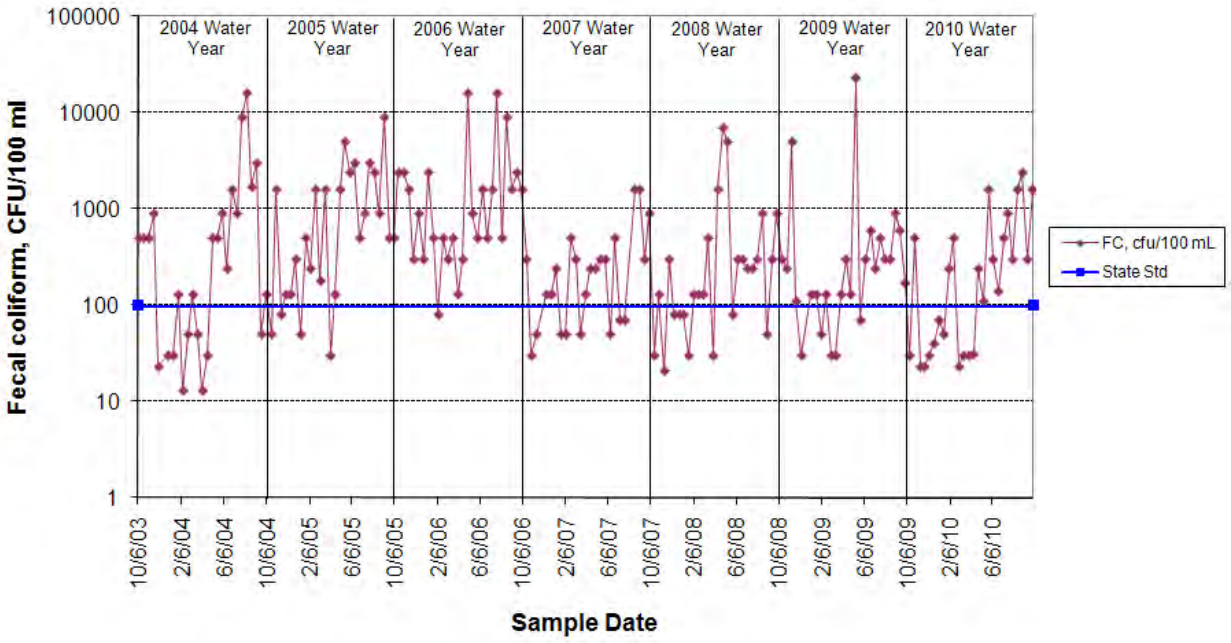
Table 8. Six-Year Fecal Coliform Results Summary
Geometric mean fecal coliform levels (cfu/100 mL) for the last six years of the Skagit County Monitoring Program

Site Number	Watercourse	Location	2005	2006	2007	2008	2009	2010
3	Thomas Ck	Old Hwy 99 North	65	121	77	36	99	36
4	Thomas Ck	F&S Grade	516	950	187	215	234	156
6	Friday Ck	Prairie Rd	24	55	39	35	35	35
8	Swede Ck	Grip Rd	83	113	66	70	91	61
11	Samish R	State Route 9	15	22	14	20	19	17
12	Nookachamps Ck	Swan Rd	64	75	49	43	87	72
13	E.F. Nookachamps Ck	State Route 9	44	57	65	38	84	59
14	College Way Ck	College Way	143	157	193	252	140	307
15	Nookachamps Ck	Knapp	71	78	84	65	80	79
16	E.F. Nookachamps Ck	Beaver Lake Rd	28	20	24	19	33	25
17	Nookachamps Ck	Big Lake Outlet	11	16	16	12	17	14
18	Lake Ck	State Route 9	50	45	61	40	44	69
19	Hansen Ck	Hoehn Rd	54	107	126	71	82	92
20	Hansen Ck	Northern State	43	77	49	31	49	53
21	Coal Ck	Hoehn Rd	112	115	168	117	37	69
22	Coal Ck	Hwy 20	8	11	12	8	21	17
23	Wiseman Ck	Minkler Rd	13	23	21	13	19	13
24	Mannser Ck	Lyman Hamilton Hwy	21	17	16	15	23	10
25	Red Cabin Ck	Hamilton Cem Rd	8	9	7	17	13	16
28	Brickyard Ck	Hwy 20	41	55	58	49	55	72
29	Skagit R	R Bend Rd	10	7	7	13	15	15
30	Skagit R	Cape Horn Rd	3	5	6	5	6	5
31	DD 20 near floodgate	Francis Rd	46	89	24	36	57	23
32	Samish R	Thomas Rd	86	85	42	47	81	43
33	Alice Bay Pump Station	Samish Island Rd	92	62	28	44	64	33
34	Noname Slough	Bayview-Edison Rd	214	204	118	102	198	216
35	Joe Leary Slough	D'Arcy Rd	108	143	192	55	103	85
36	Edison Slough at school	W. Bow Hill Rd	42	71	41	43	53	84
37	Edison Pump Station	Farm to Market Rd	162	197	135	94	109	120
38	North Edison Pump Station	North Edison Rd	70	120	57	157	125	183
39	Colony Ck	Colony Rd	100	156	77	46	68	82
40	Big Indian Slough	Bayview-Edison Rd	43	51	11	56	132	122
41	Maddox Slough/Big Ditch	Milltown Rd	30	73	71	44	58	34
42	Hill Ditch	Cedardale Rd	18	27	61	27	82	66
43	Wiley Slough	Wylie Rd	80	56	75	47	39	44
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	20	44	76	128	148	68
45	Skagit R – North Fork	Moore Rd	9	6	5	7	10	11
46	Skagit R – South Fork	Fir Island Rd	13	8	7	8	9	12
47	Swinomish Channel	County Boat Launch	3	4	3	5	7	6
48	Fisher Ck	Franklin Rd	96	76	106	74	78	56

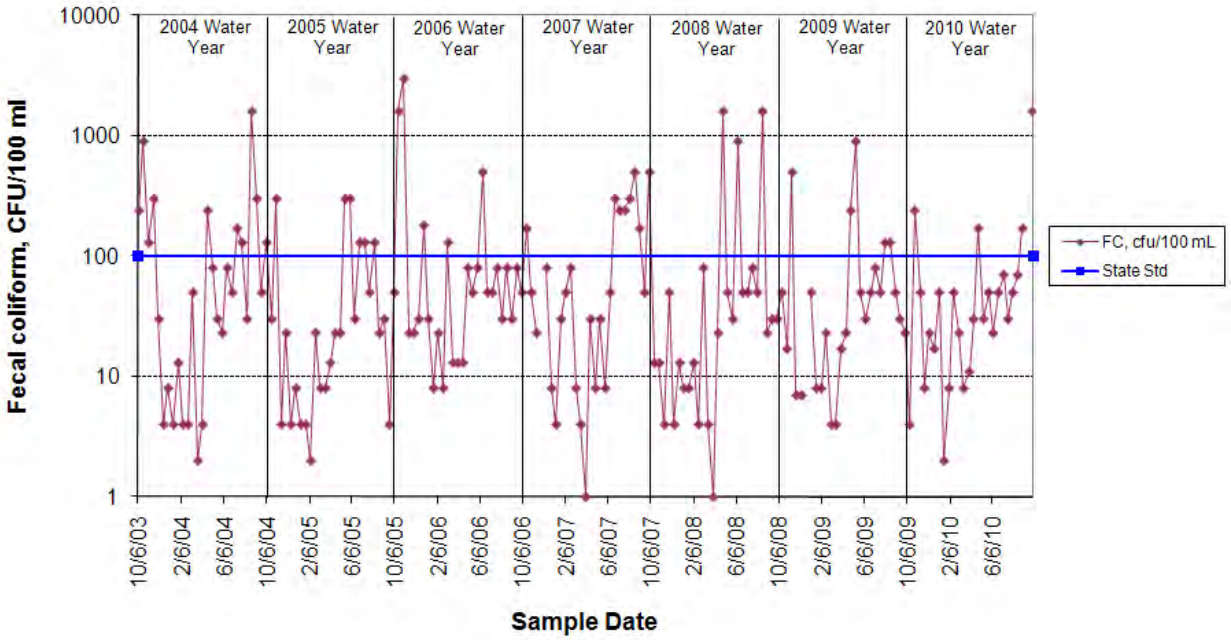
Thomas Creek at Hwy 99 - Site 3
Fecal coliform



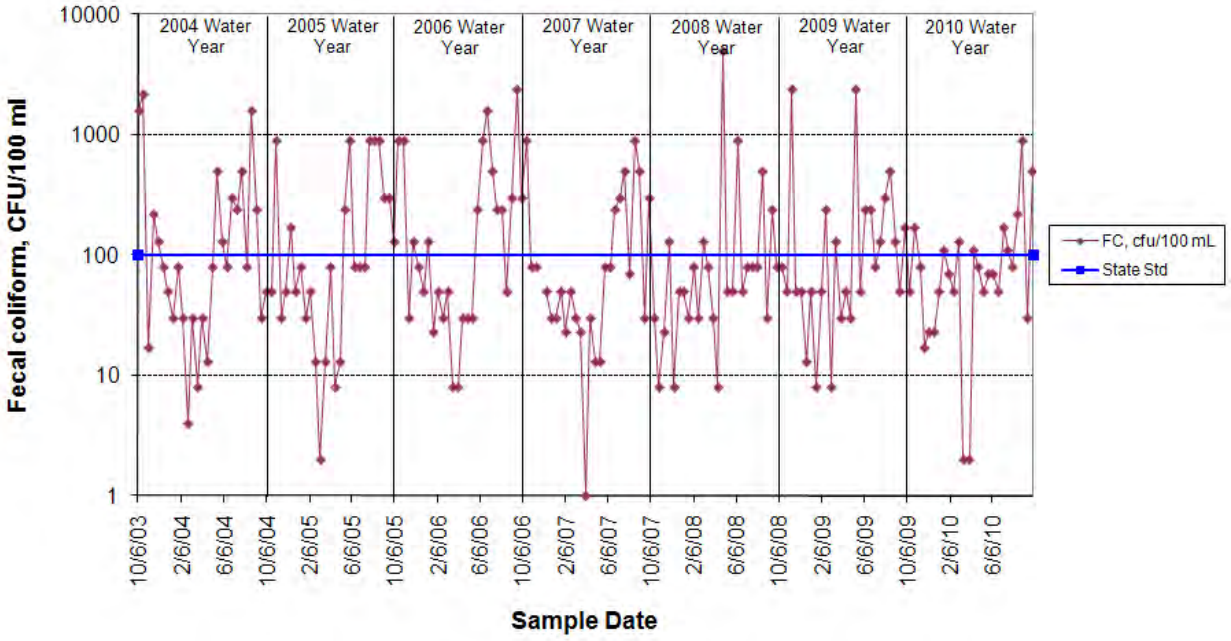
Thomas Creek at F&S Grade Rd - Site 4
Fecal coliform



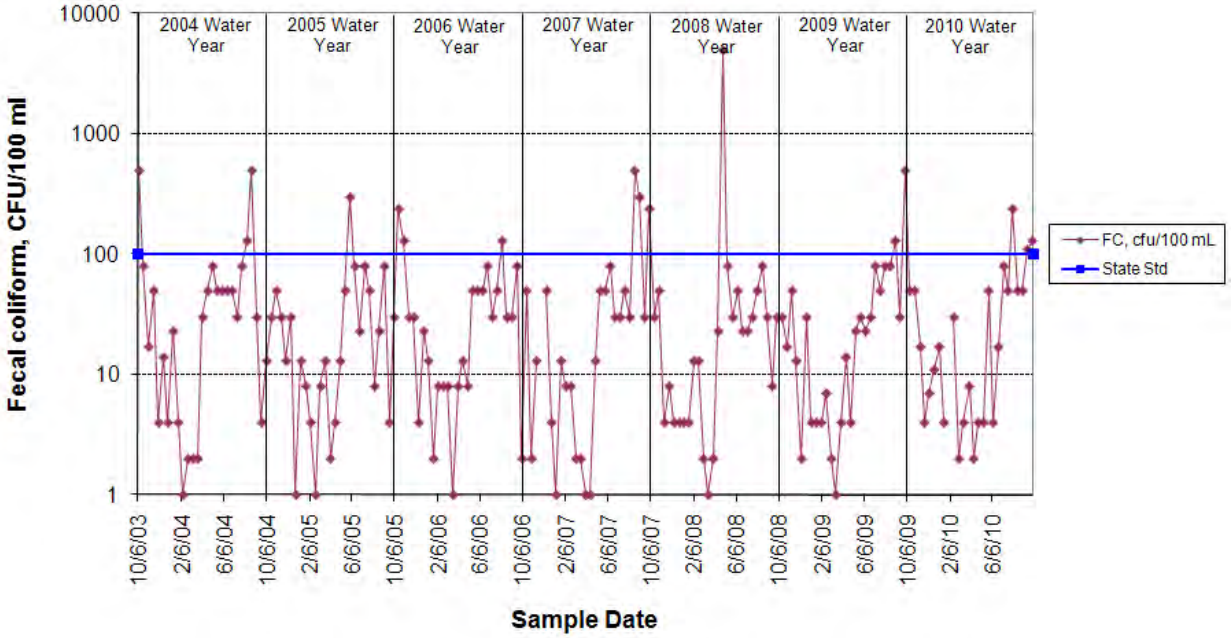
Friday Creek at Prairie Rd - Site 6
Fecal coliform



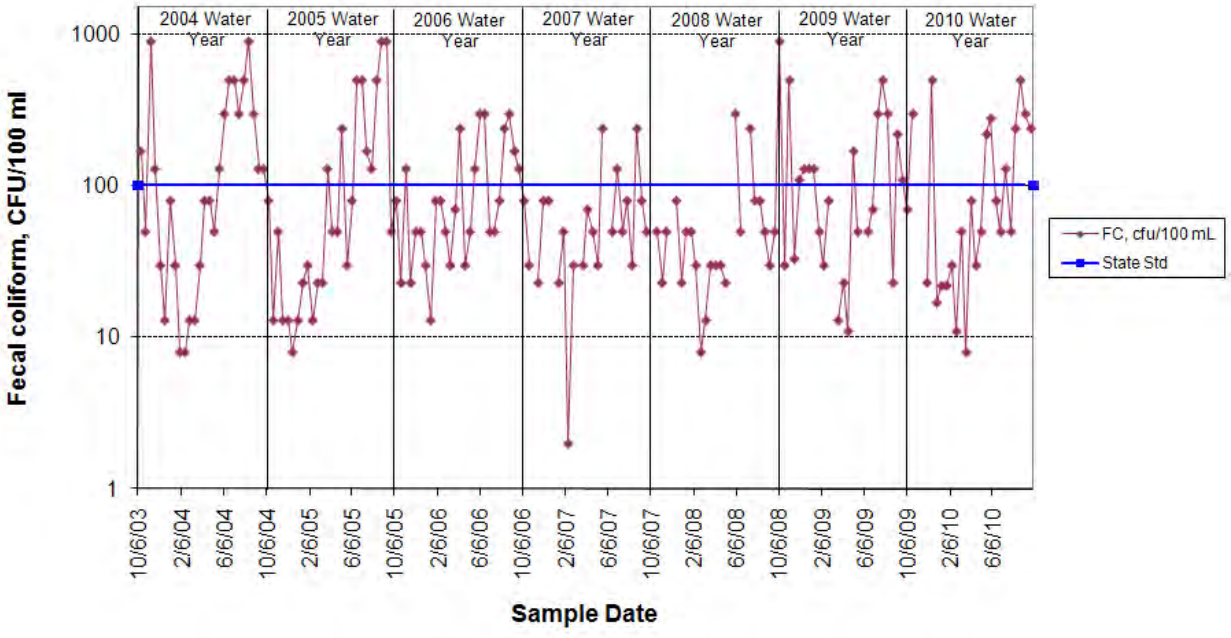
Swede Creek at Grip Rd - Site 8
Fecal coliform



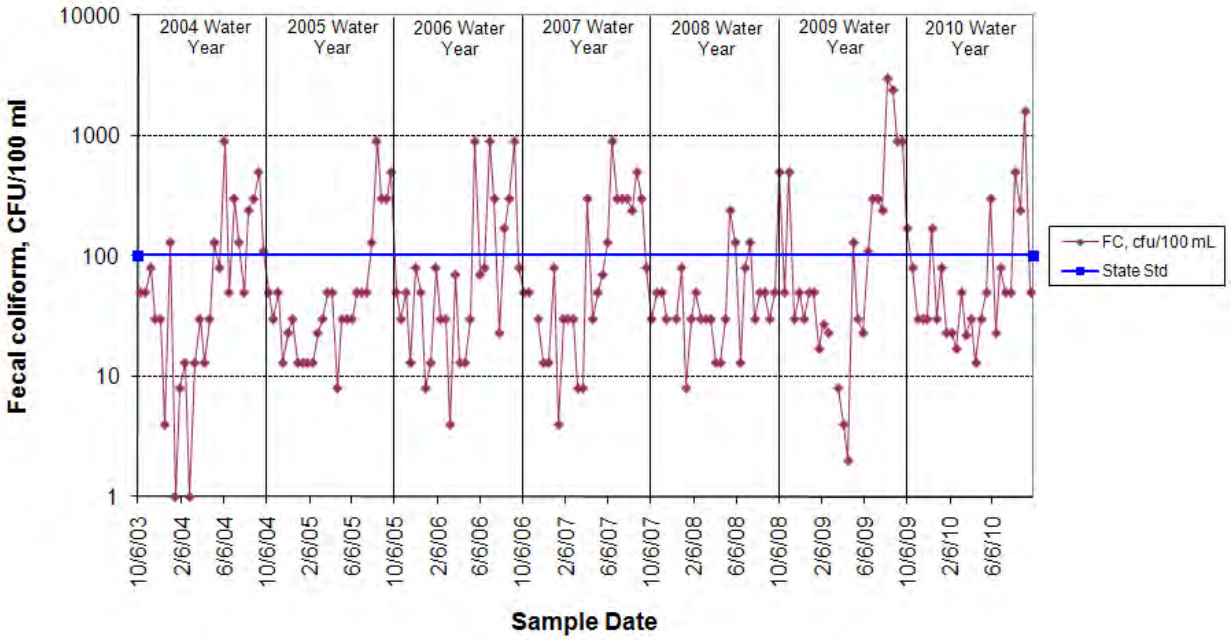
Samish River at Hwy 9 - Site 11
Fecal coliform



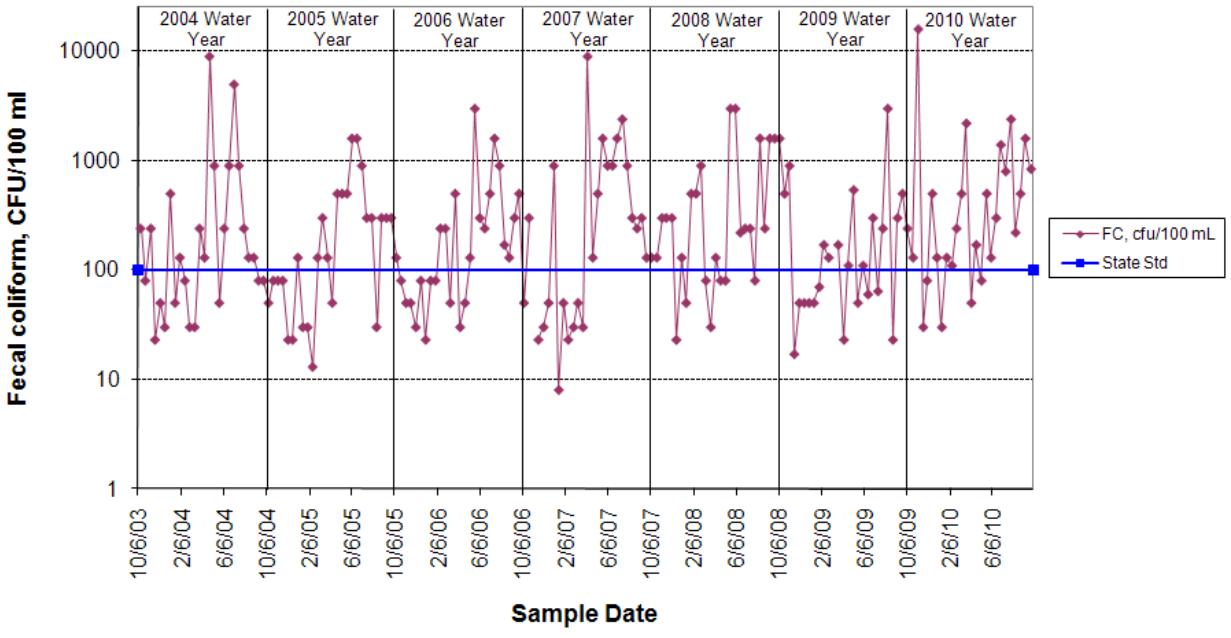
Nookachamps Creek at Swan Rd - Site 12
Fecal coliform



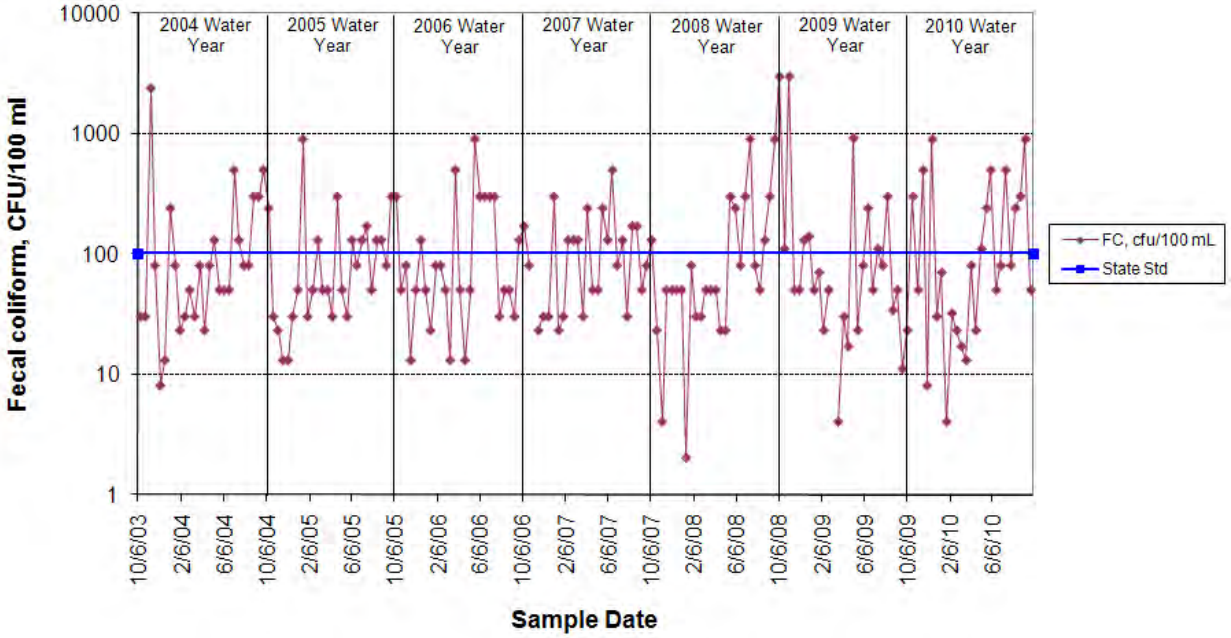
E.F. Nookachamps Creek at Hwy 9 - Site 13
Fecal coliform



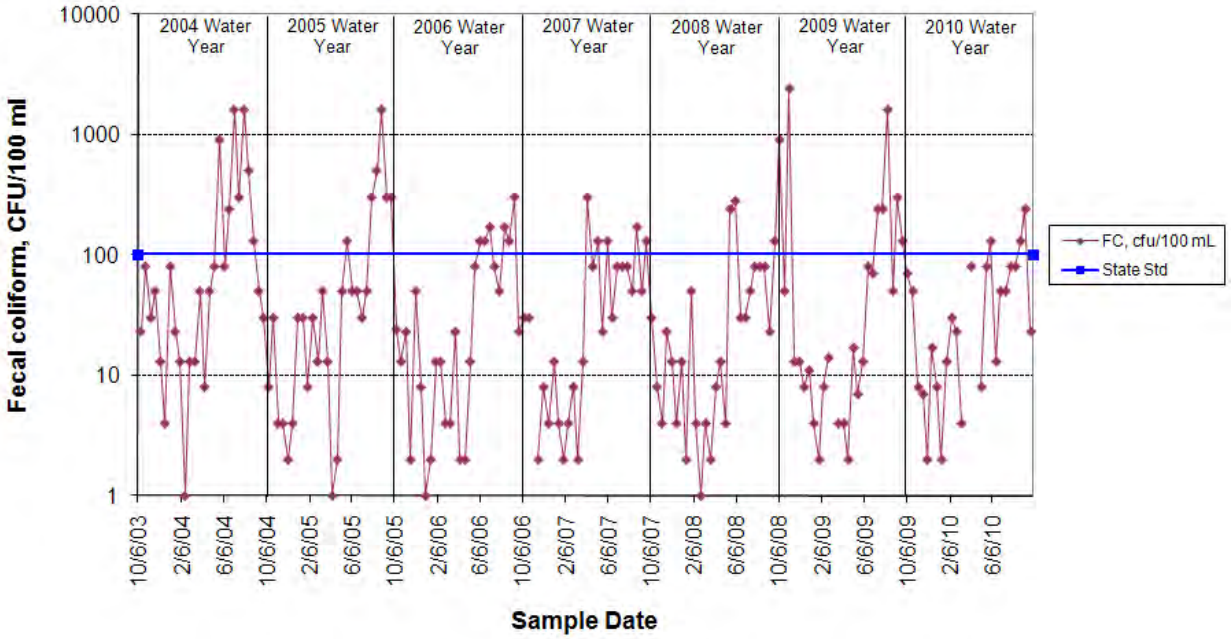
College Way Creek at College Way - Site 14
Fecal coliform



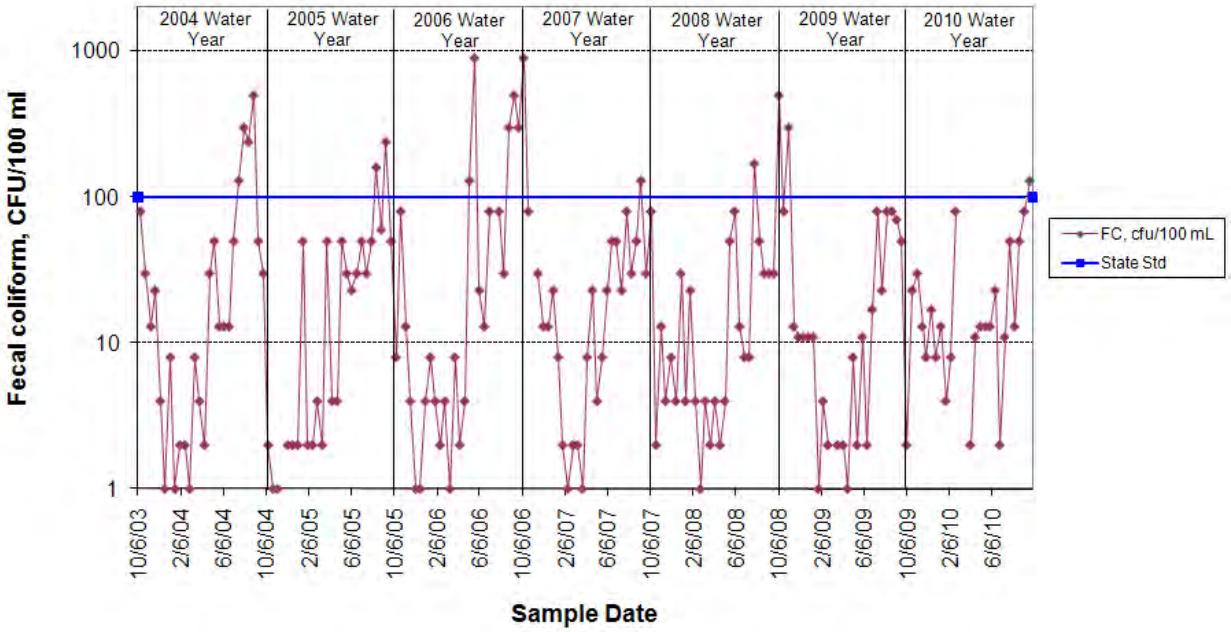
Nookachamps Creek at Knapp Rd - Site 15
Fecal coliform



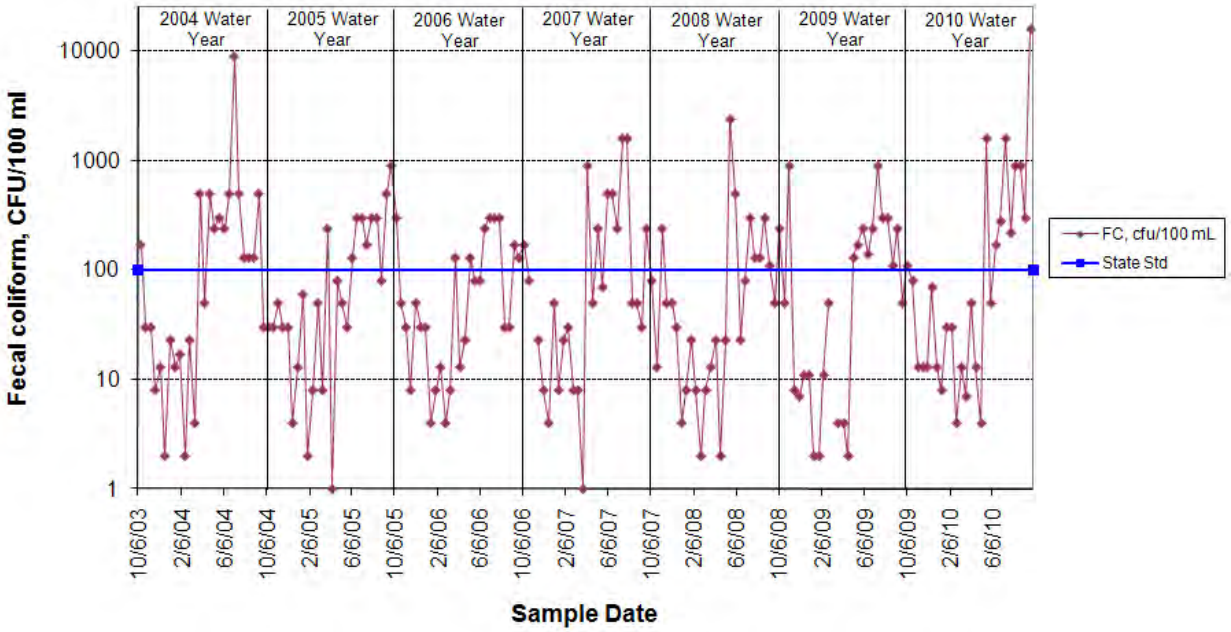
E.F. Nookachamps Creek at Beaver Lk Rd - Site 16
Fecal coliform



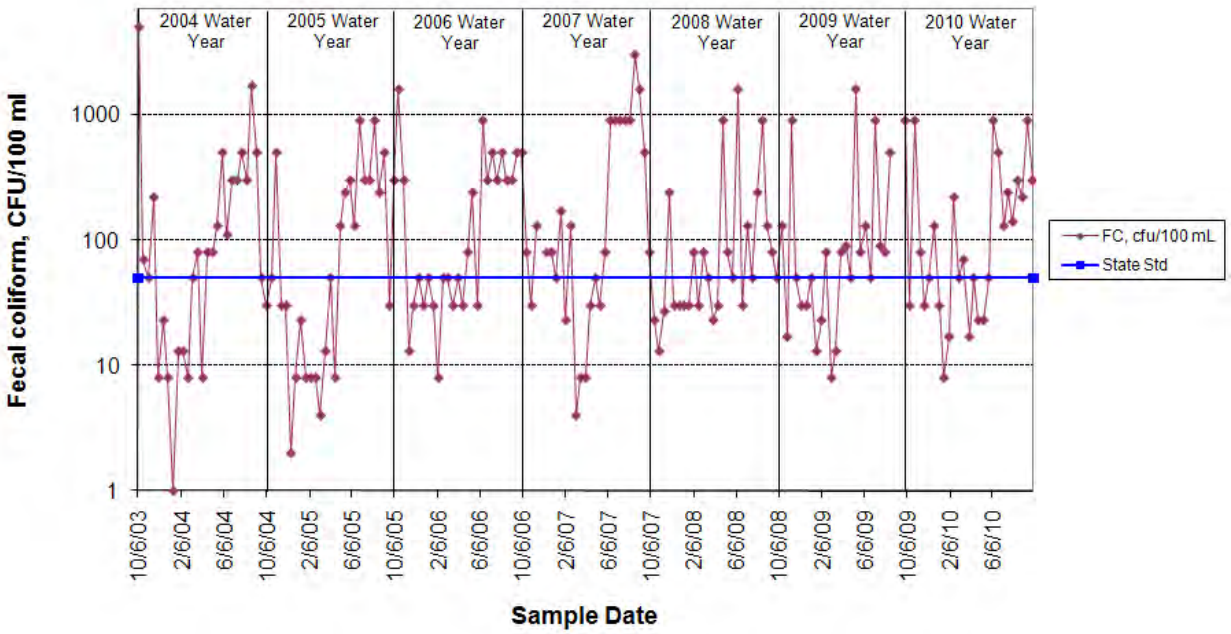
Nookachamps Creek at Big Lake Outlet - Site 17
Fecal coliform



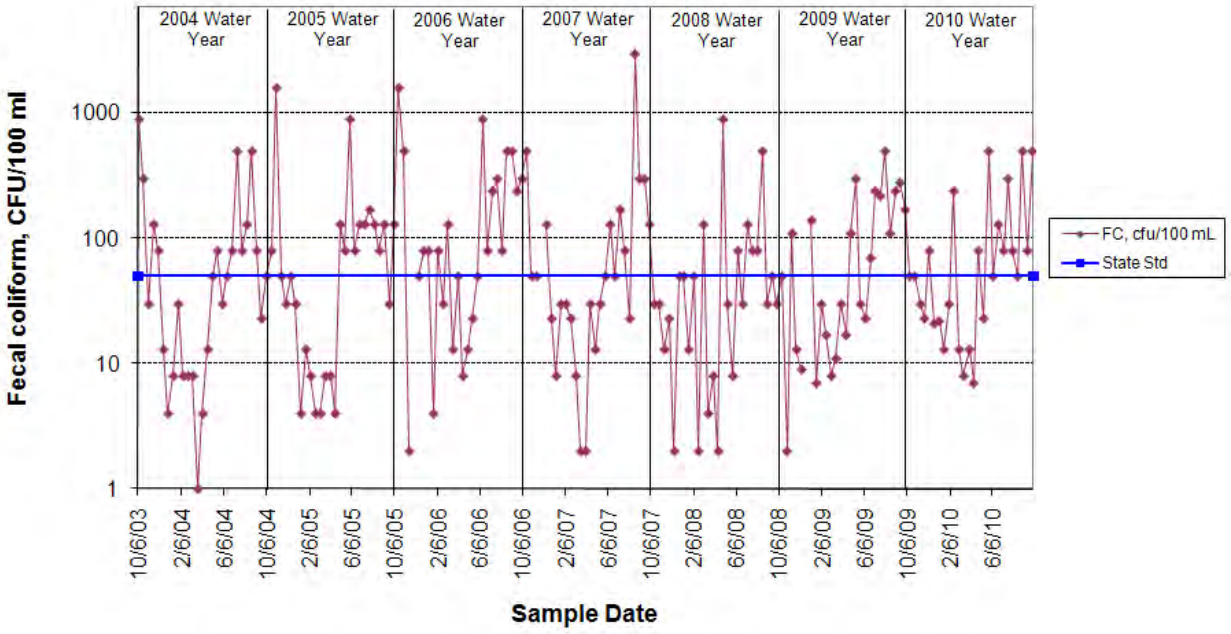
Lake Creek at Hwy 9 - Site 18
Fecal coliform



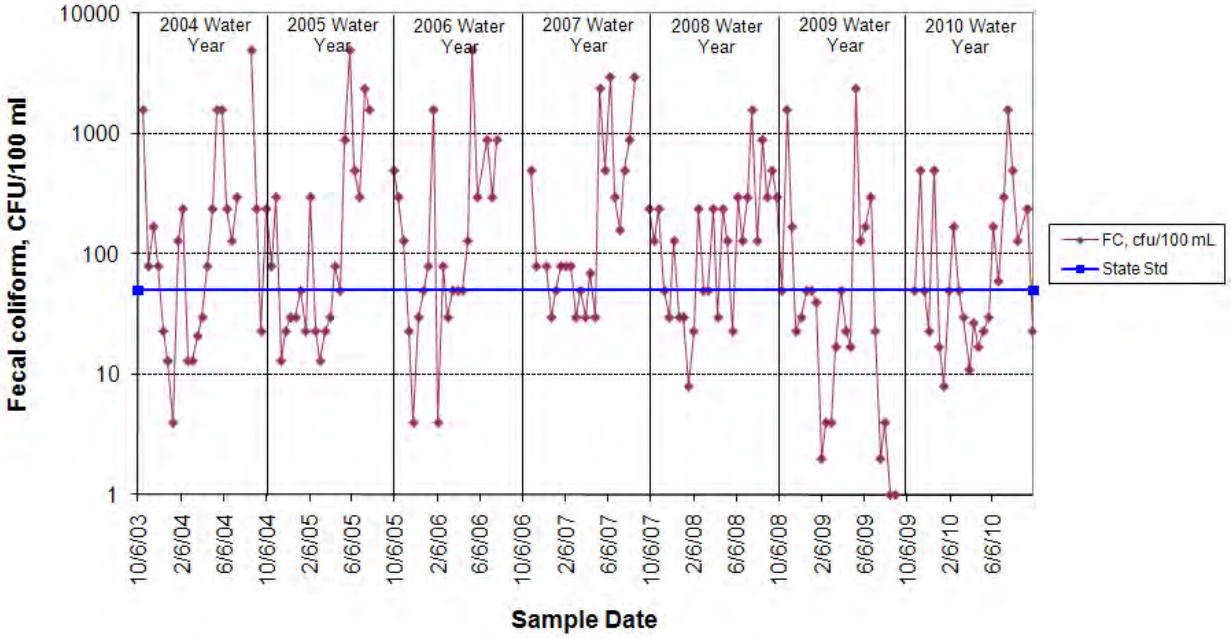
Hansen Creek at Hoehn Rd - Site 19
Fecal coliform



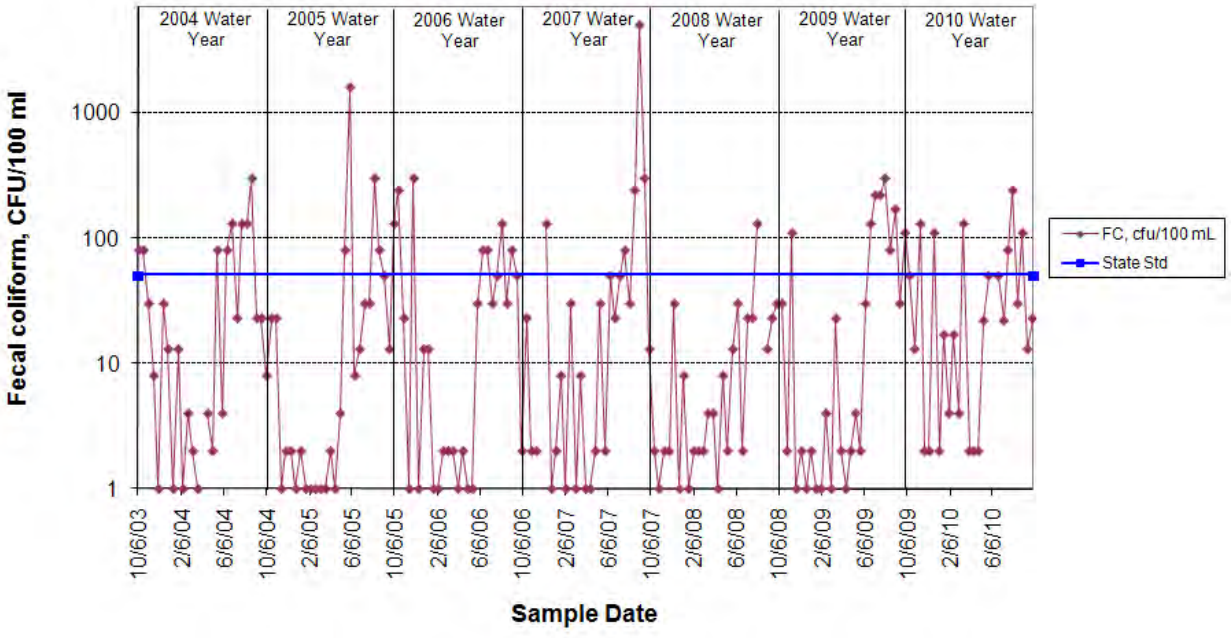
Hansen Creek at Northern State Hospital - Site 20
Fecal coliform



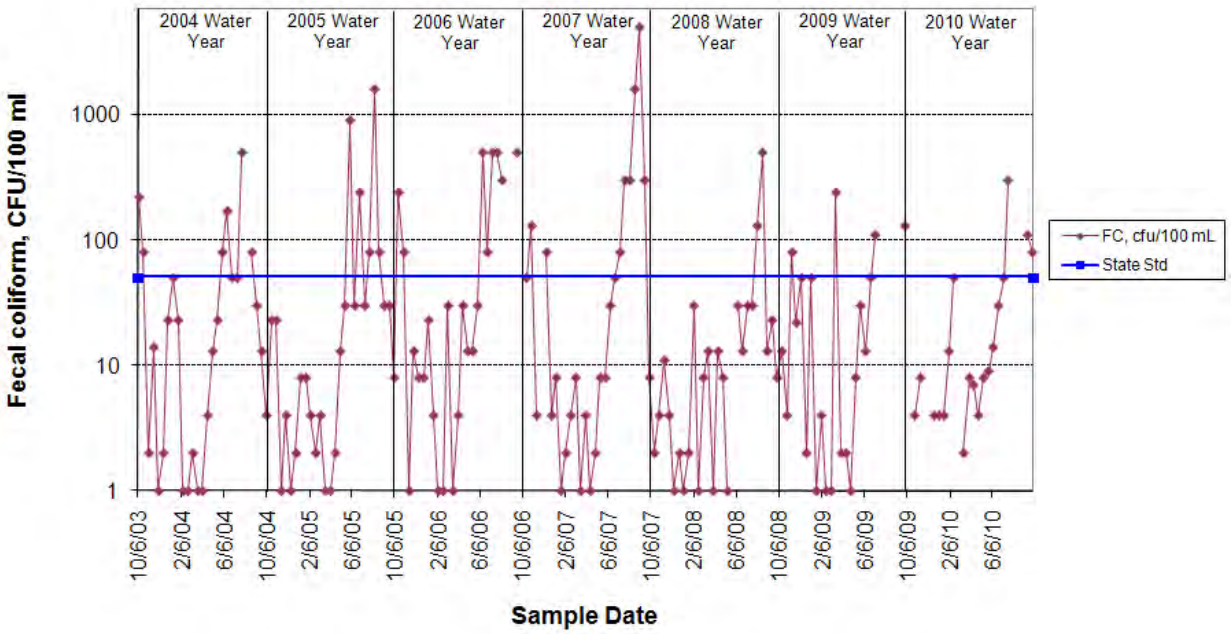
Coal Creek at Hoehn Rd - Site 21
Fecal coliform



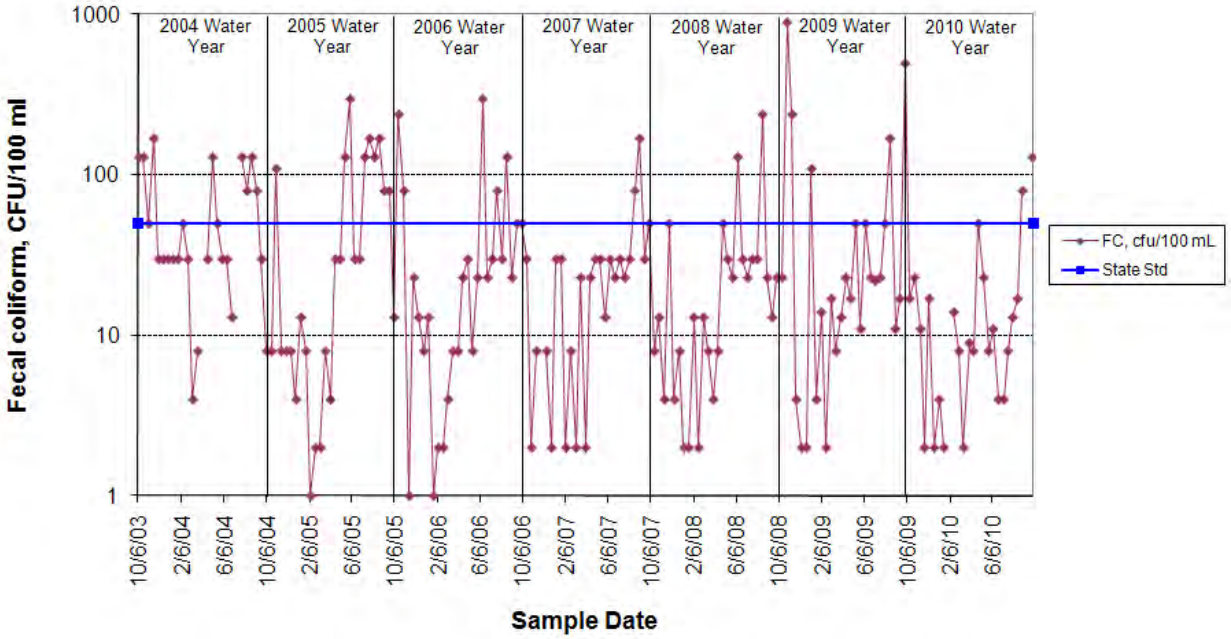
Coal Creek at Hwy 20 - Site 22
Fecal coliform



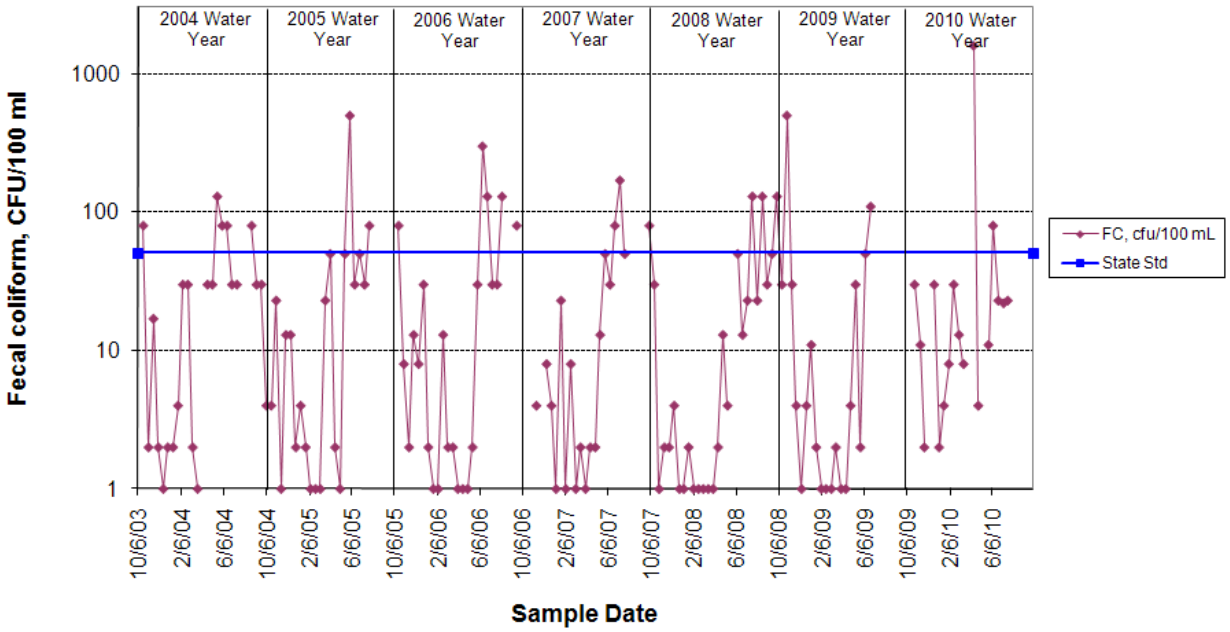
Wiseman Creek at Minkler Rd - Site 23
Fecal coliform



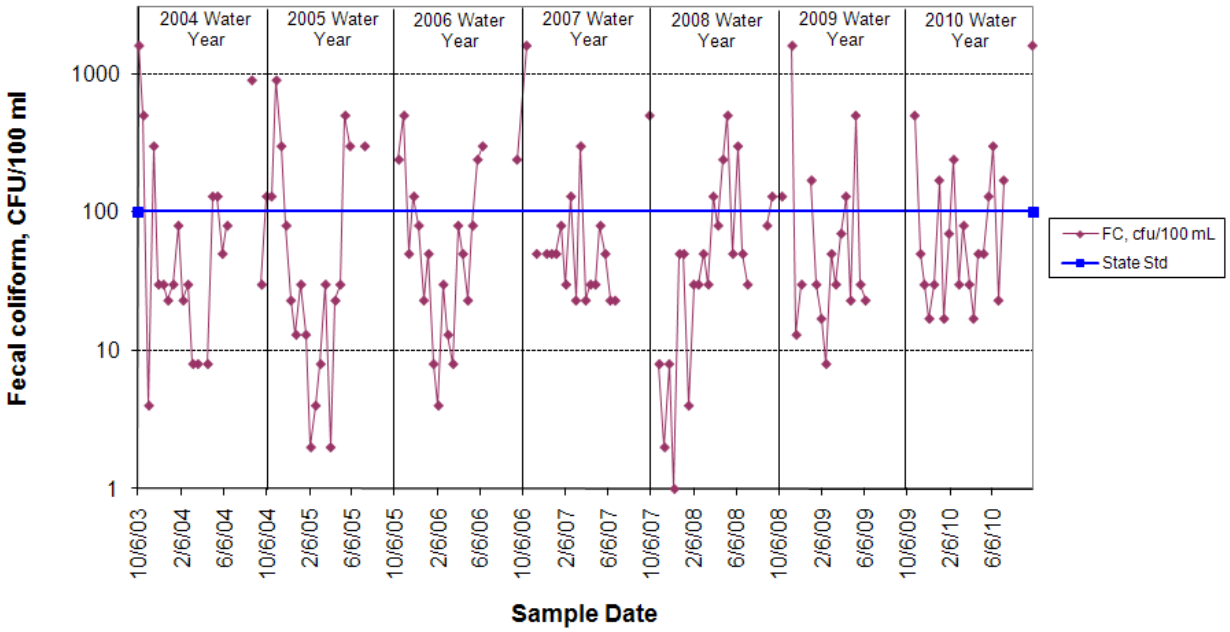
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Fecal coliform



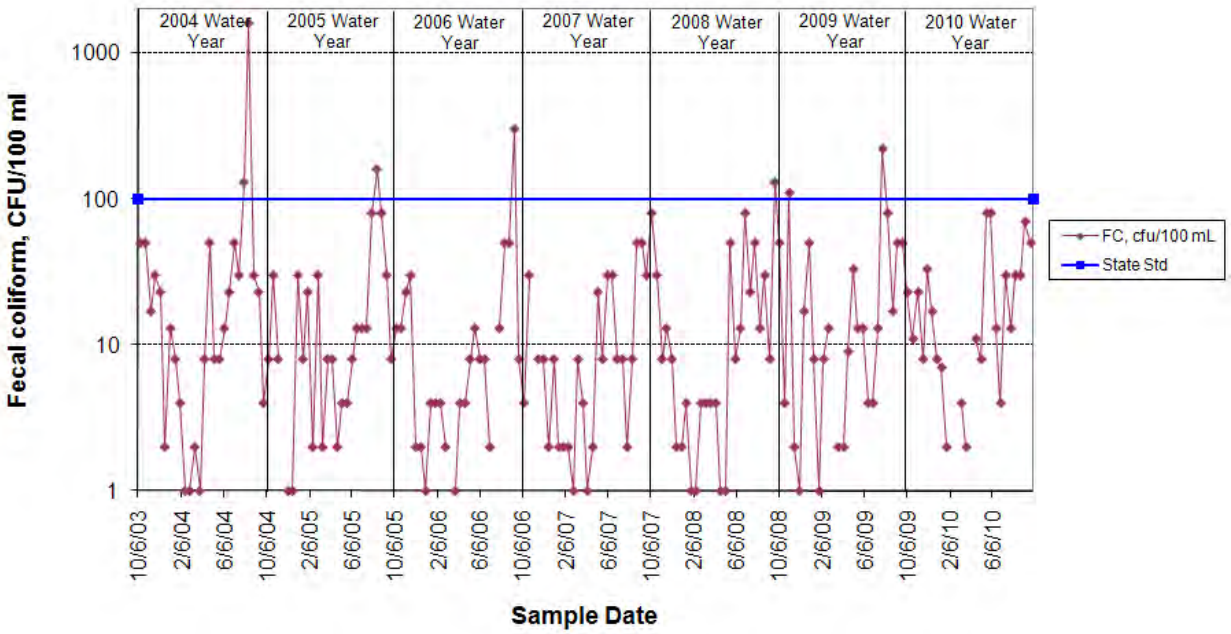
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Fecal coliform



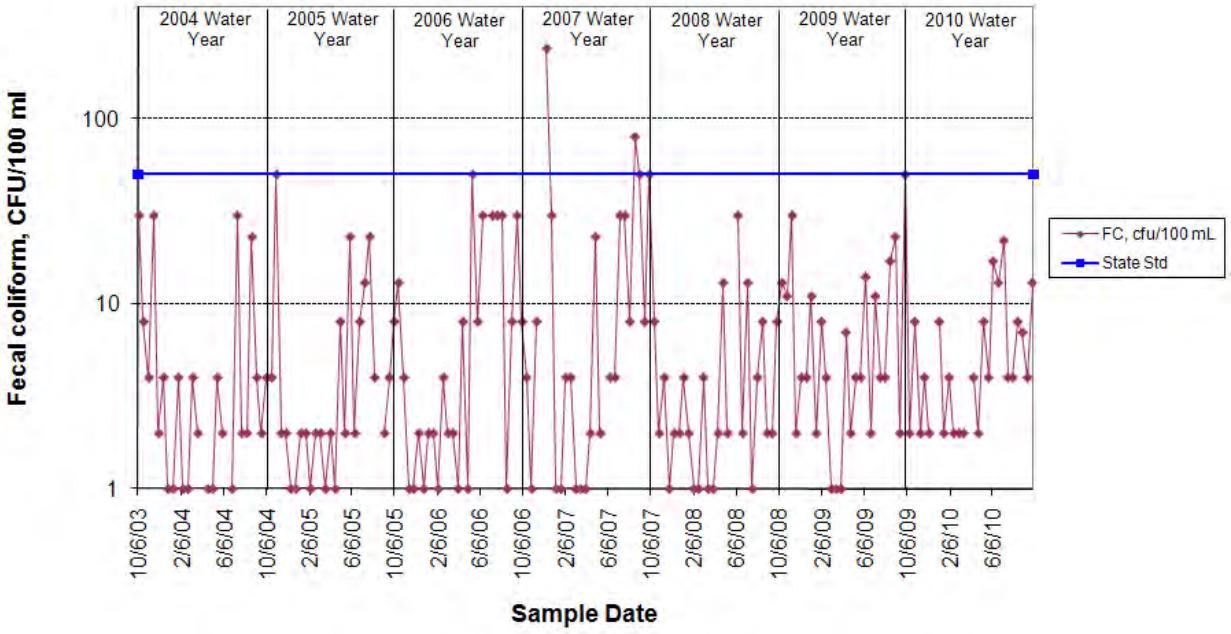
Brickyard Creek at Hwy 20 - Site 28
Fecal coliform



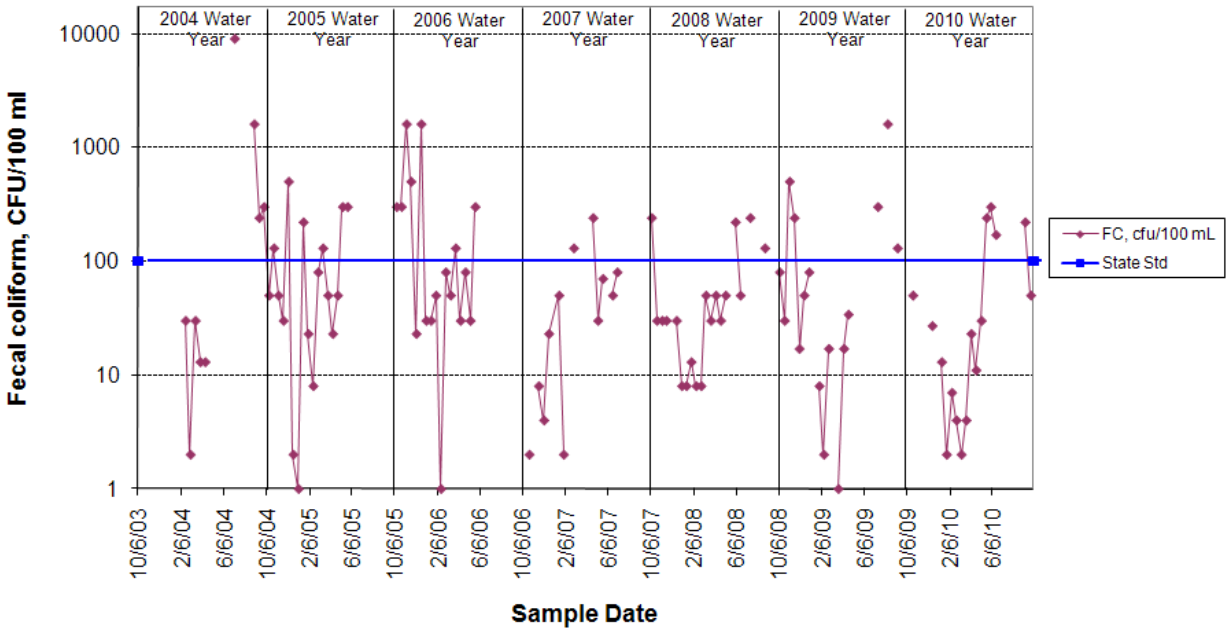
Skagit River at River Bend - Site 29
Fecal coliform



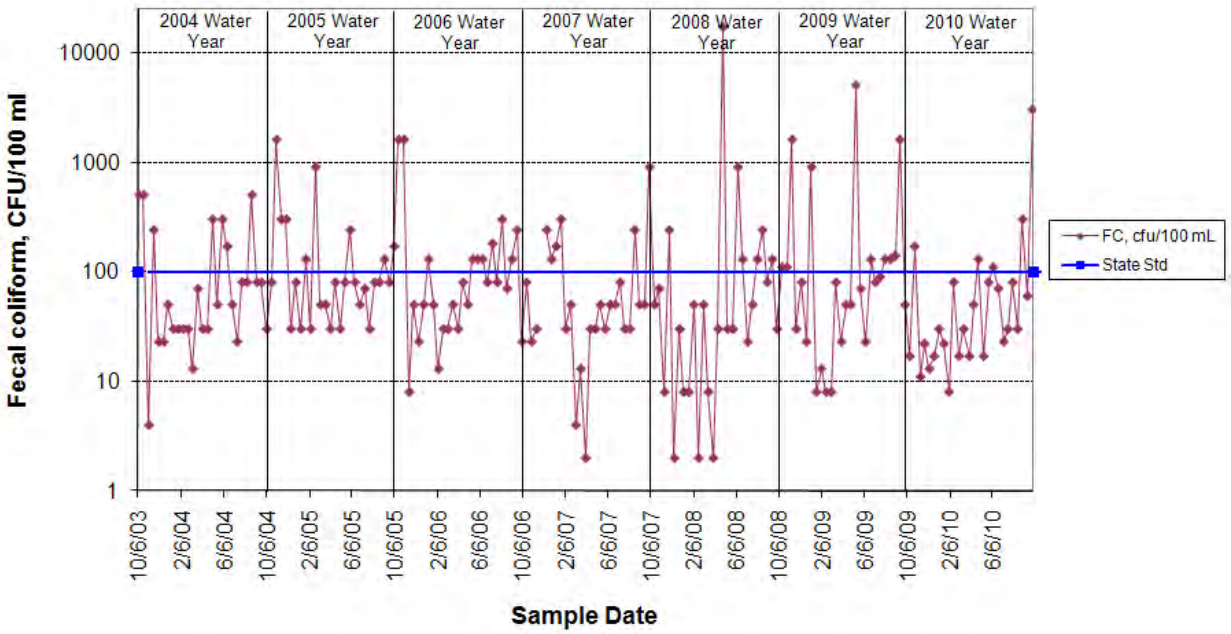
Skagit River at Cape Horn Rd - Site 30
Fecal coliform



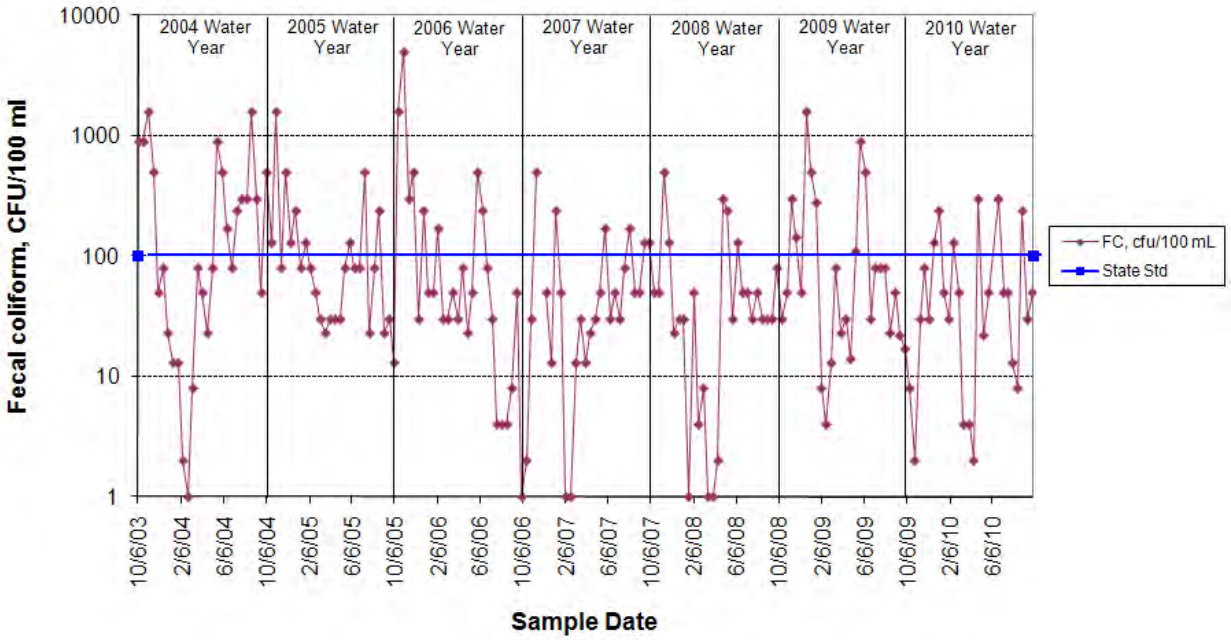
Drainage District 20 Ditch at Floodgate - Site 31
Fecal coliform



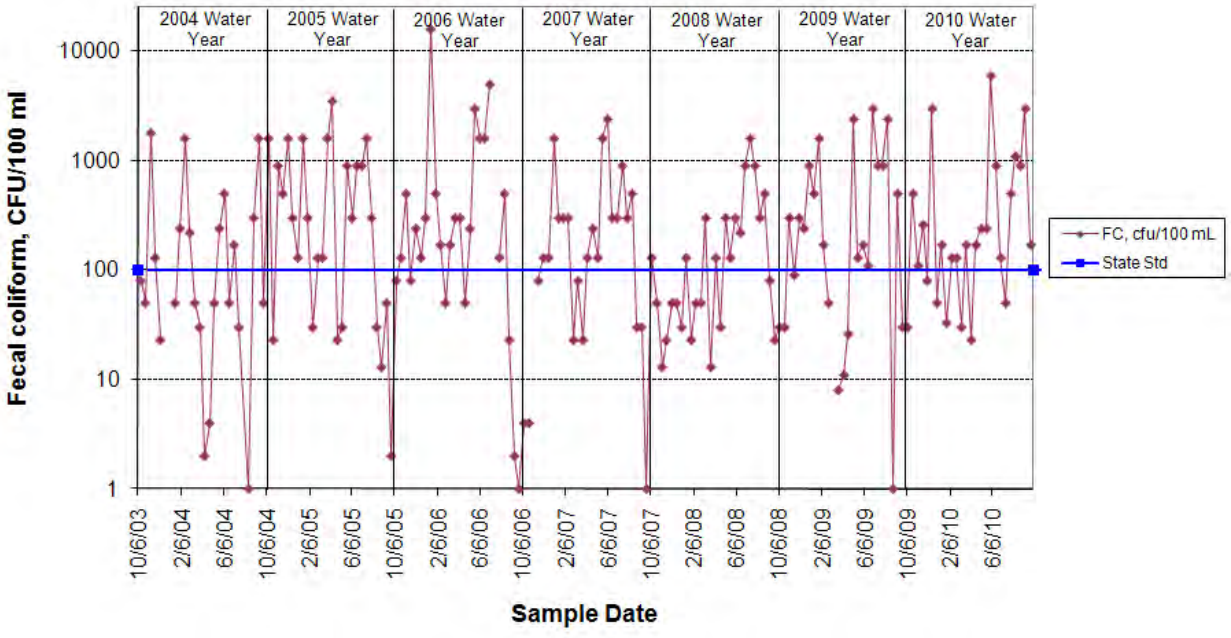
Samish River at Thomas Rd - Site 32
Fecal coliform



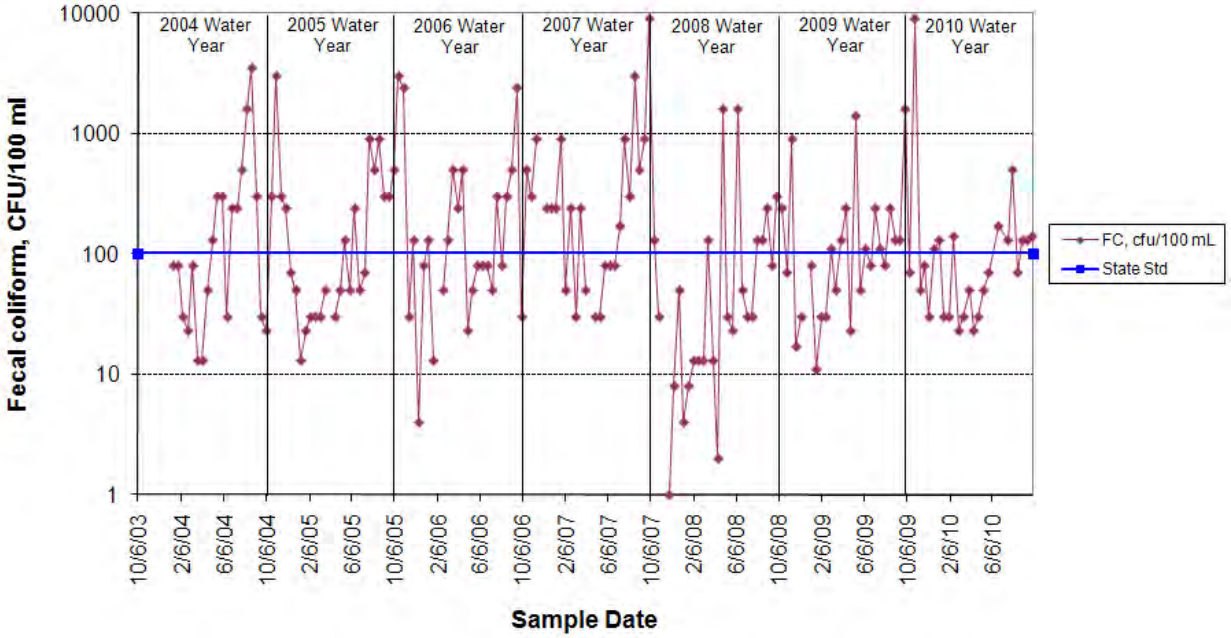
Alice Bay Pump Station - Site 33
Fecal coliform



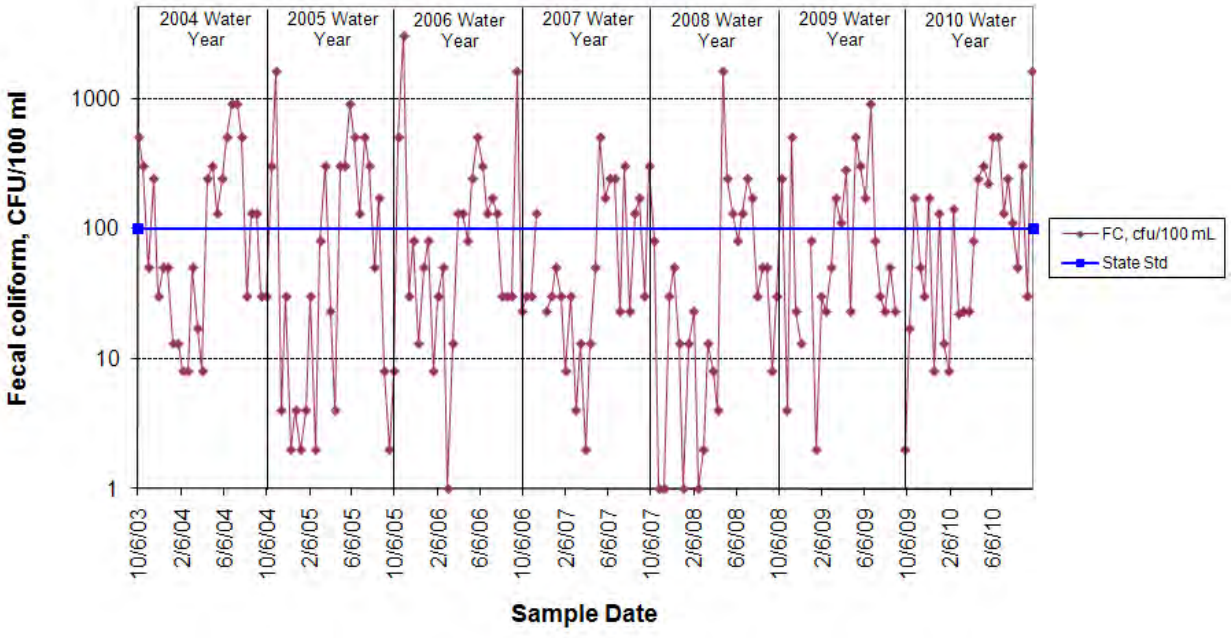
No Name Slough at Bayview-Edison Rd - Site 34
Fecal coliform



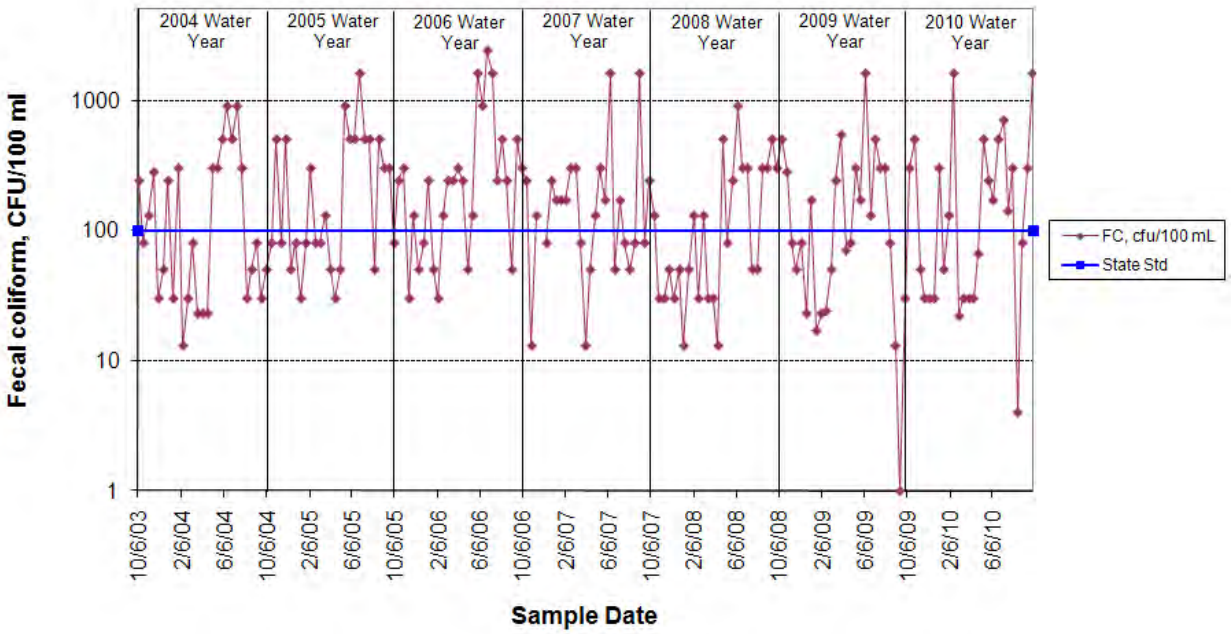
Joe Leary Slough at D'Arcy Rd - Site 35
Fecal coliform



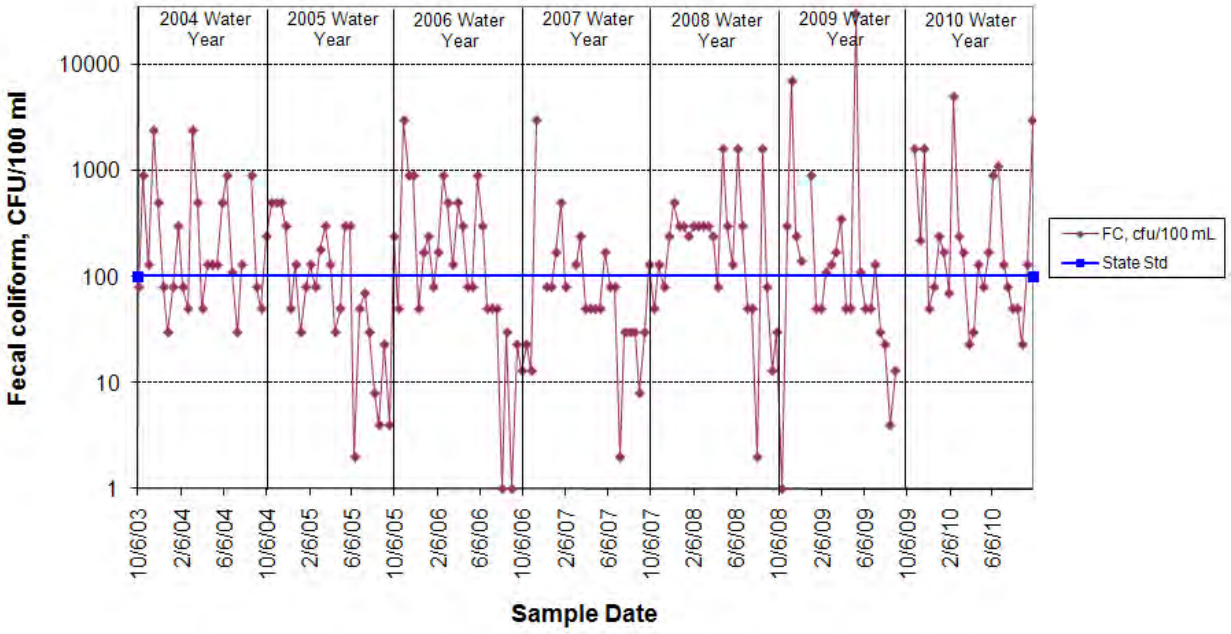
Edison Slough at Edison School - Site 36
Fecal coliform



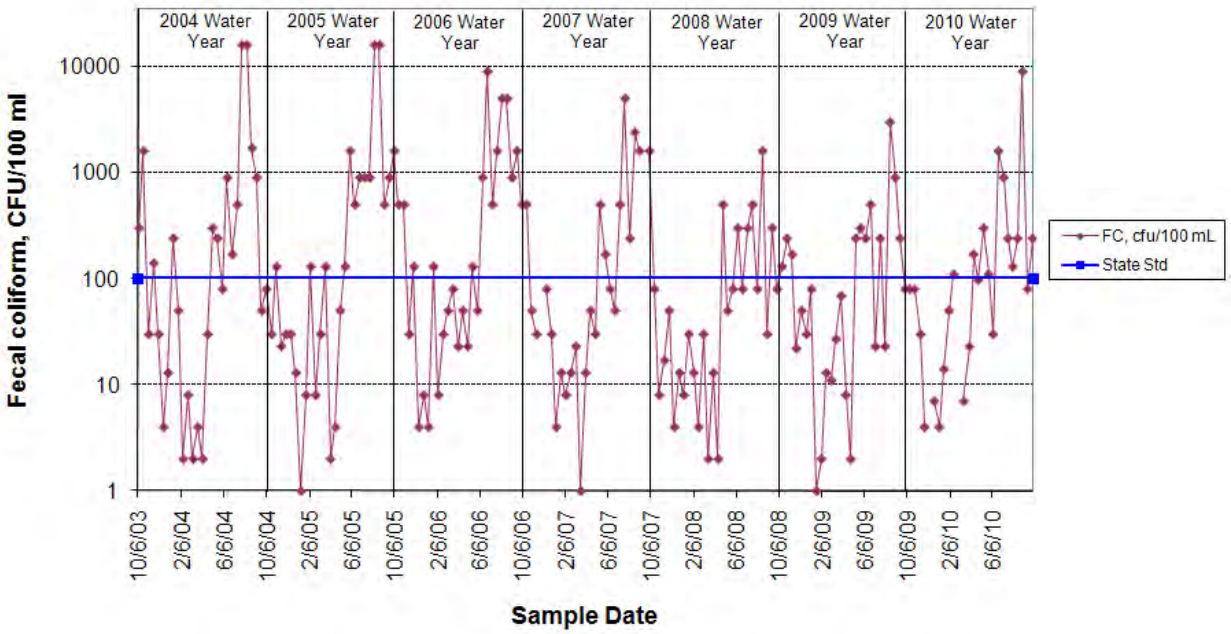
Edison Pump Station - Site 37
Fecal coliform



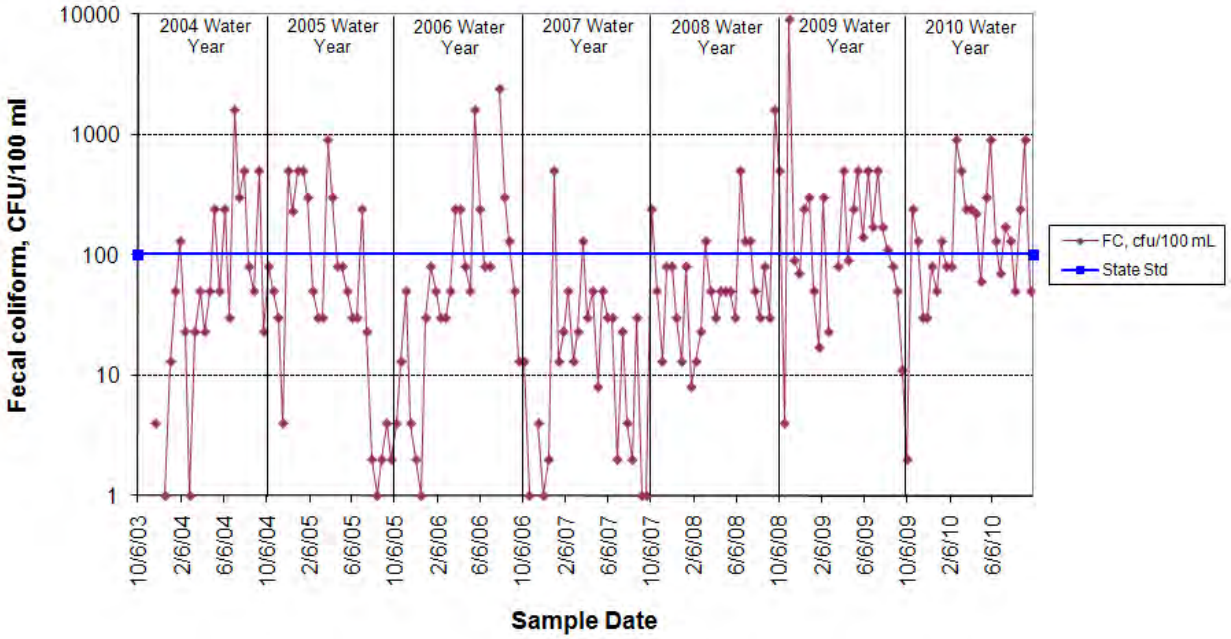
North Edison Pump Station - Site 38
Fecal coliform



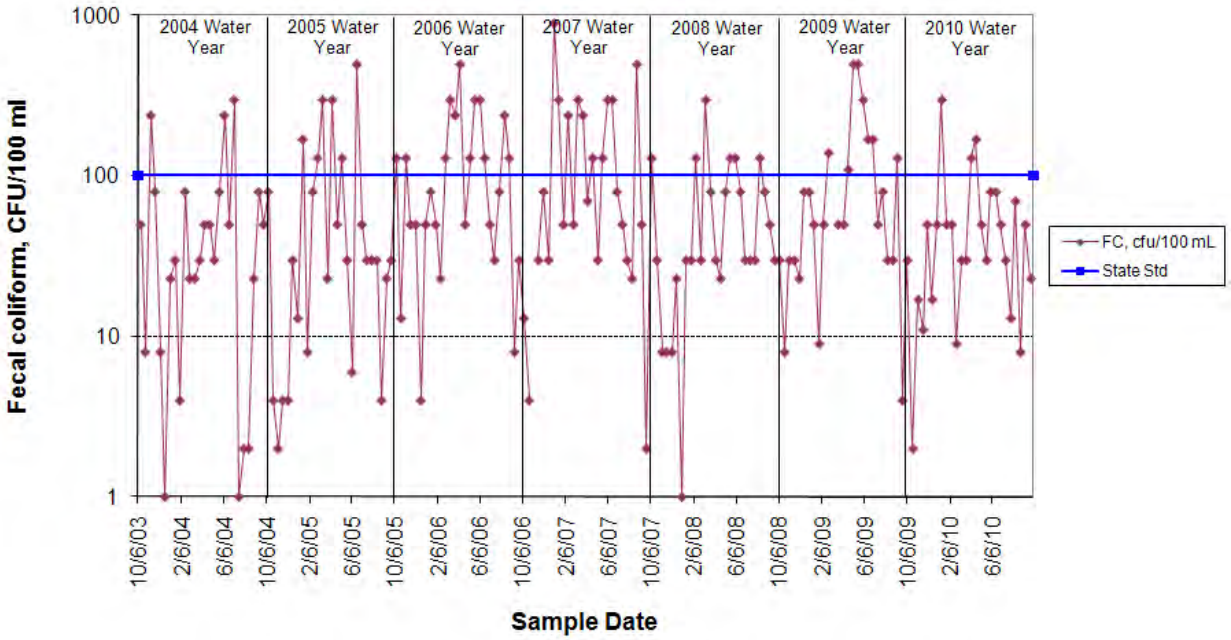
Colony Creek at Colony Rd - Site 39
Fecal coliform



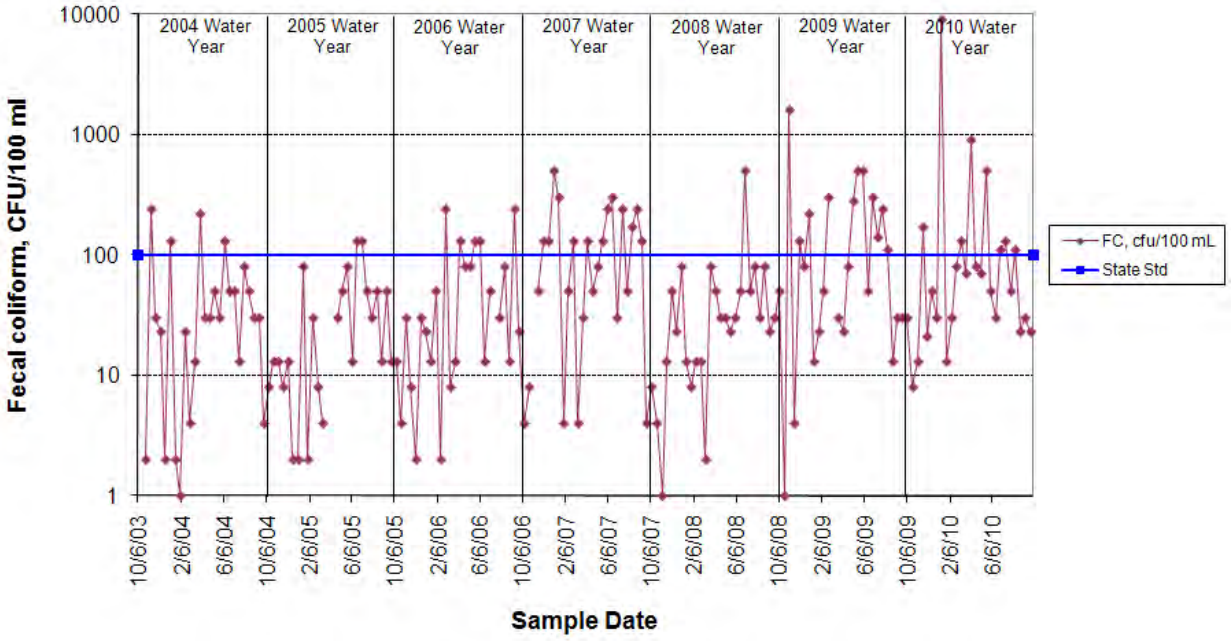
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Fecal coliform



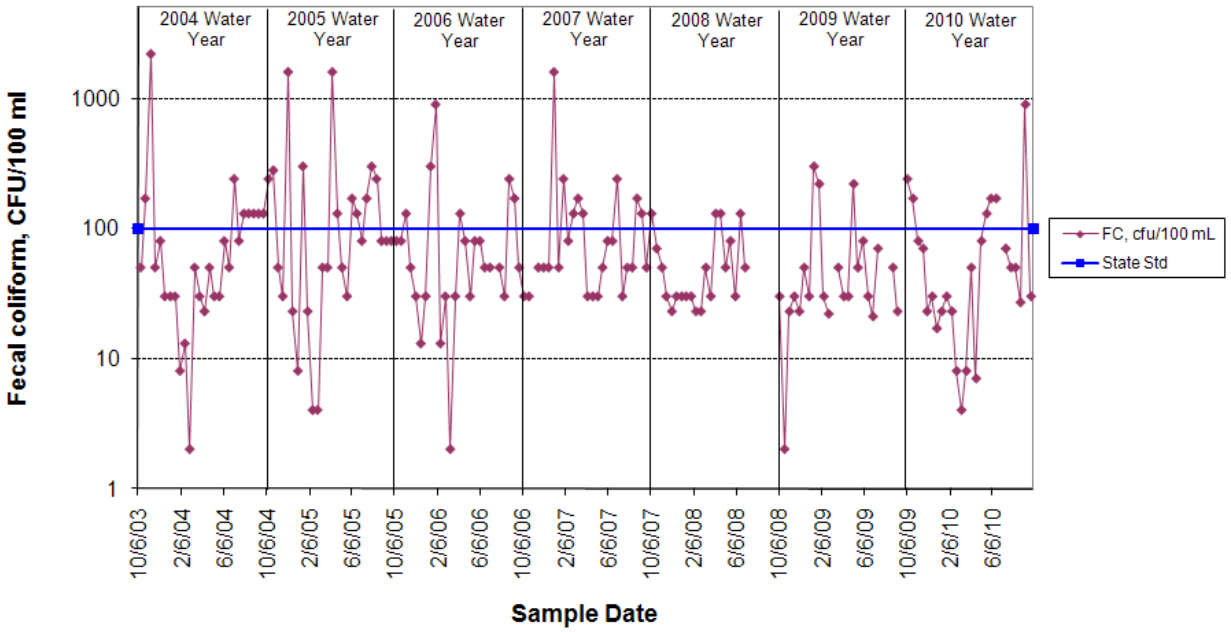
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Fecal coliform



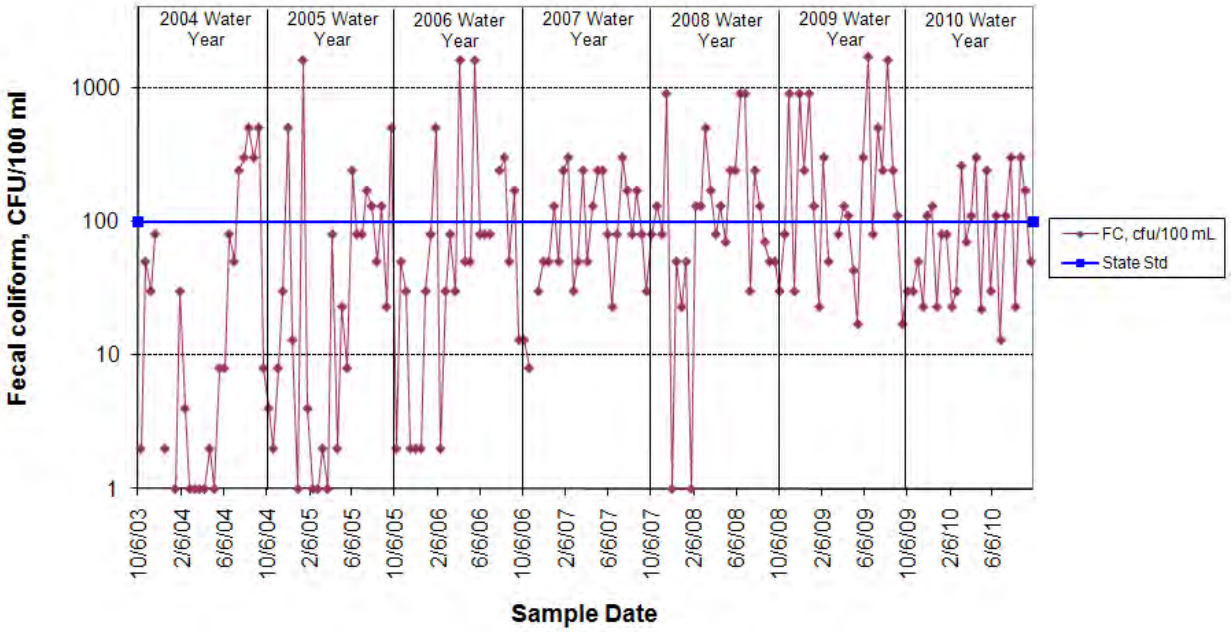
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Fecal coliform



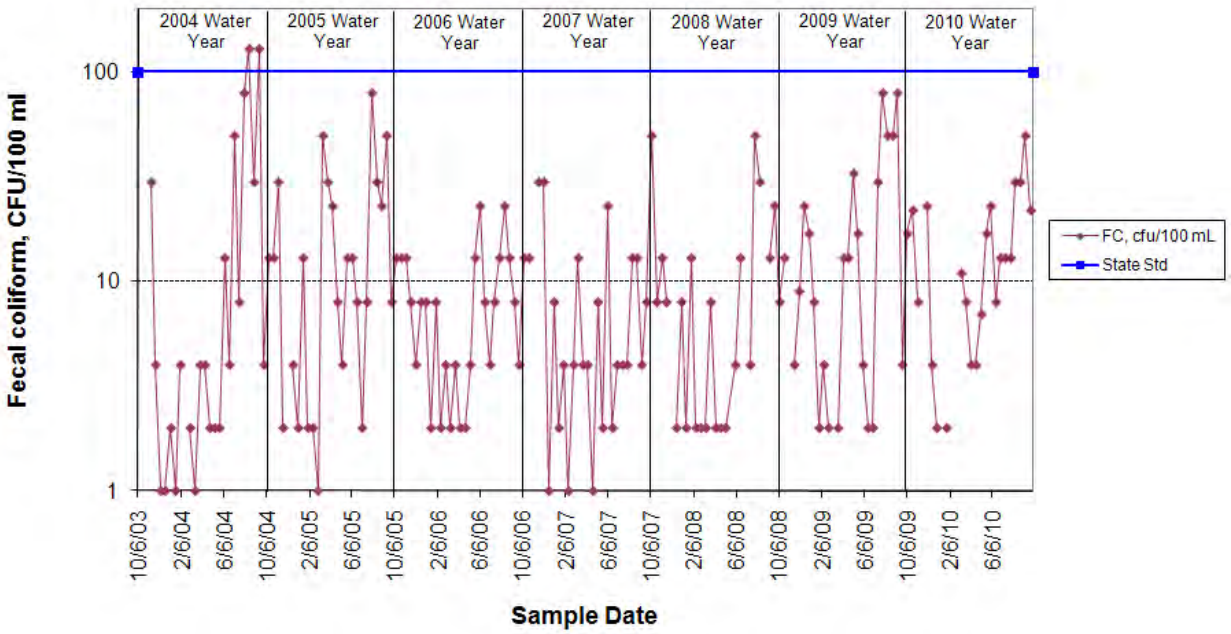
Wiley Slough at Wylie Rd - Site 43
Fecal coliform



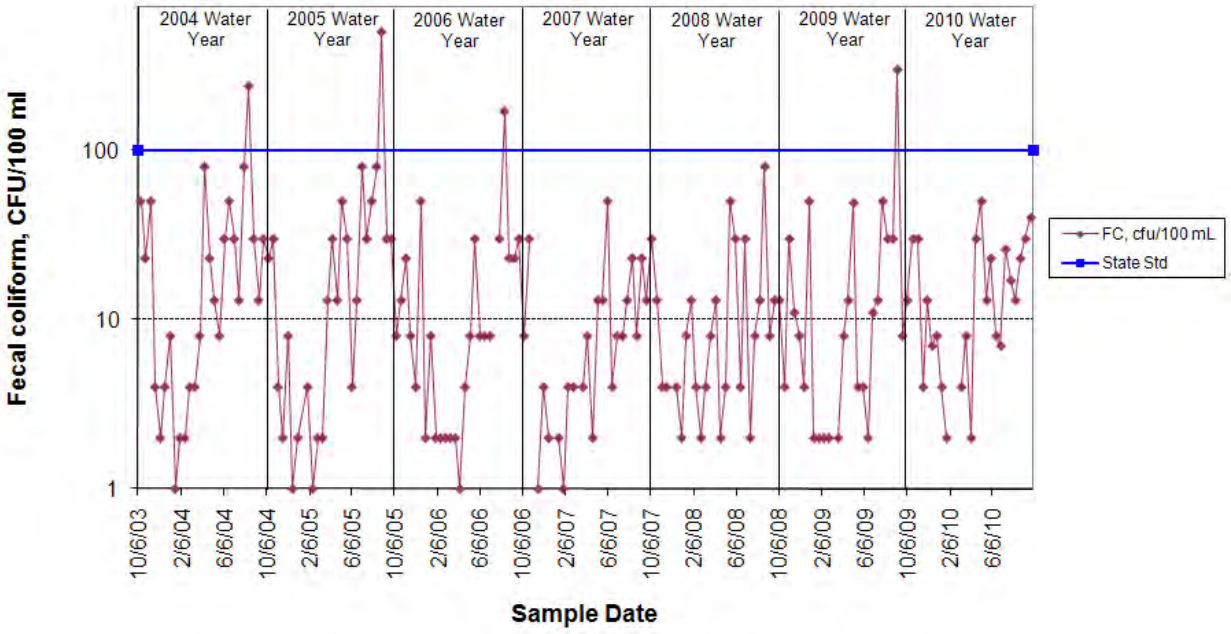
Sullivan Slough at La Conner-Whitney Rd - Site 44
Fecal coliform



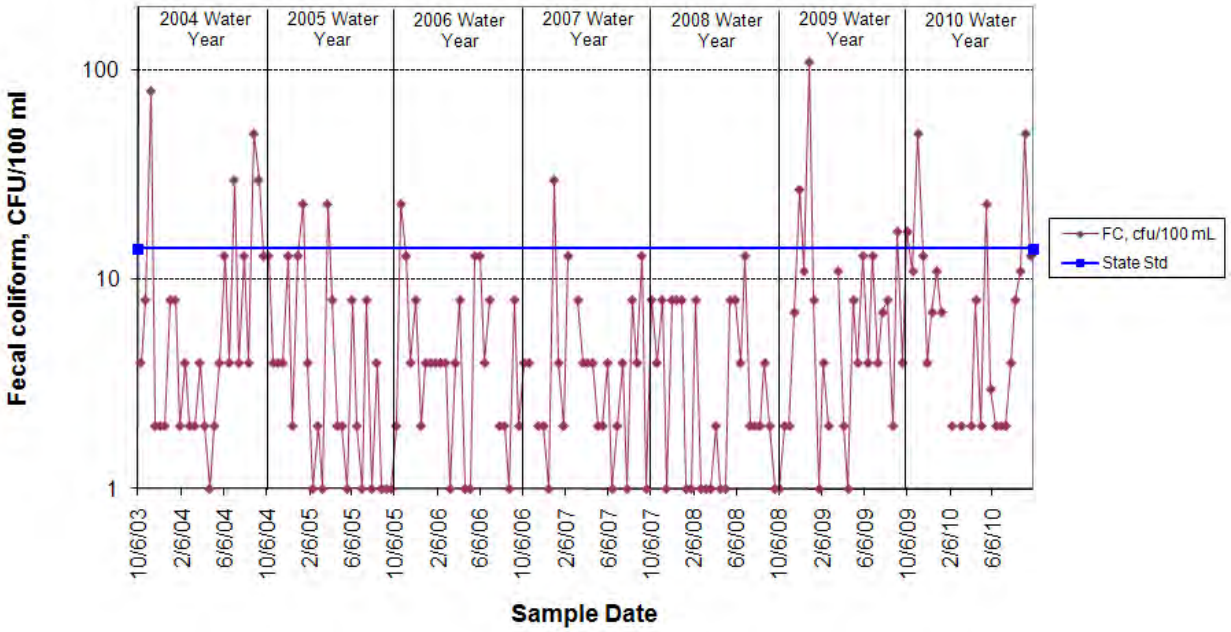
N.F. Skagit River at Moore Rd - Site 45
Fecal coliform



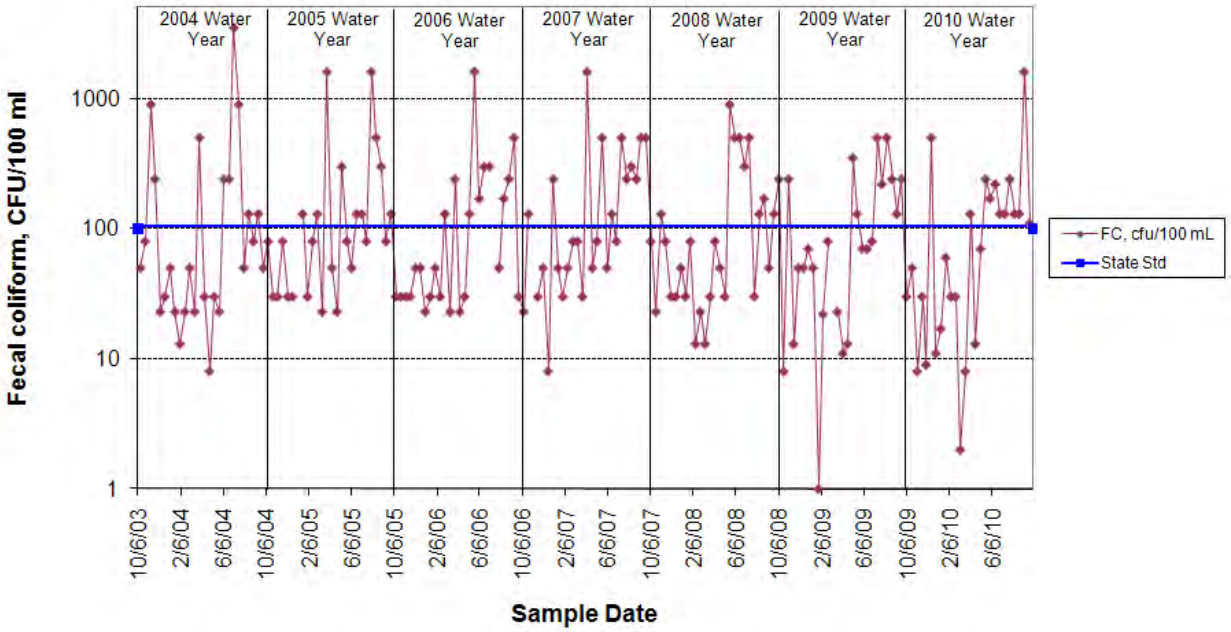
S.F. Skagit River at Conway - Site 46
Fecal coliform



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 2010 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. 2010 Nutrient Results
Mean Nutrient Values (Mg/L) For Watercourses In The Skagit County Monitoring Program, 2010 Water Year.

Site Number	Watercourse	Location	Total Nitrogen[1]	Total Phosphor	Ammonia
3	Thomas Ck	Old Hwy 99 N	0.89	0.12	0.13
4	Thomas Ck	F&S Grade	0.70	0.10	0.07
6	Friday Ck	Prairie Rd	0.65	0.10	0.06
8	Swede Ck	Grip Rd	0.70	0.08	0.07
11	Samish R	State Route 9	0.50	0.08	0.06
12	Nookachamps Ck	Swan Rd	0.70	0.08	0.09
13	E.F. Nookachamps Ck	State Route 9	0.60	0.03	0.07
14	College Way Ck	College Way	0.68	0.10	0.09
15	Nookachamps Ck	Knapp	0.74	0.12	0.12
16	E.F. Nookachamps Ck	Beaver Lake Rd	0.48	0.02	0.05
17	Nookachamps Ck	Big Lake Outlet	0.61	0.03	0.07
18	Lake Ck	State Route 9	0.67	0.03	0.06
19	Hansen Ck	Hoehn Rd	1.01	0.21	0.07
20	Hansen Ck	Northern State	0.81	0.32	0.06
21	Coal Ck	Hoehn Rd	0.61	0.14	0.07
22	Coal Ck	Hwy 20	0.62	0.21	0.06
23	Wiseman Ck	Minkler Rd	0.64	0.26	0.07
24	Mannser Ck	Lyman Hamilton Hwy	0.92	0.03	0.05
25	Red Cabin Ck	Hamilton Cem Rd	0.63	0.10	0.04
28	Brickyard Ck	Hwy 20	0.71	0.05	0.10
29	Skagit R	River Bend Rd	6.36	0.09	0.24
30	Skagit R	Cape Horn Rd	0.55	0.12	0.04
31	Drain Dist 20 floodgate	Francis Rd	1.14	0.14	0.15
32	Samish R	Thomas Rd	0.67	0.13	0.09
33	Alice Bay Pump Station	Samish Island Rd	3.04	0.49	1.27
34	Noname Slough	Bayview-Edison Rd	1.52	0.79	0.35
35	Joe Leary Slough	D'Arcy Rd	1.25	0.21	0.63
36	Edison Slough at school	W. Bow Hill Rd	1.30	0.69	0.30
37	Edison Pump Station	Farm to Market Rd	3.12	0.79	1.63
38	North Edison Pump Station	North Edison Rd	0.52	2.89	0.58
39	Colony Ck	Colony Rd	0.93	0.21	0.08
40	Big Indian Slough	Bayview-Edison Rd	1.12	0.16	0.39
41	Maddox Slough/Big Ditch	Milltown Rd	1.45	0.18	0.45
42	Hill Ditch	Cedardale Rd	0.70	0.12	0.09
43	Wiley Slough	Wylie Rd	1.54	0.41	0.51
44	Rexville Pump Station	Summers Drive	1.46	0.12	0.63
	Sullivan Slough[2]	La Conner-Whitney Rd	0.61	0.06	0.05
45	Skagit R – North Fork	Moore Rd	0.66	0.06	0.05
46	Skagit R – South Fork	Fir Island Rd	0.69	0.11	0.07
47	Swinomish Channel	County Boat Launch	0.79	0.28	0.10
48	Fisher Ck	Franklin Rd	0.89	0.12	0.13

[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. As is demonstrated by the Samish River, a stream can have an adequate WQI score based on ambient sampling, but severe pollution problems revealed by storm sampling.

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 2010 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. 2010 Water Quality Index Results
Water Quality Index (WQI) determinations for watercourses in the Skagit County Monitoring Program, 2010 Water Year

Site Number	Watercourse	Location	Mean WQI	Overall Score*	Max	Min
3	Thomas Ck	Old Hwy 99 N	57	49	80	33
4	Thomas Ck	F&S Grade	78	76	85	75
6	Friday Ck	Prairie Rd	91	90	96	88
8	Swede Ck	Grip Rd	80	76	90	67
11	Samish R	State Route 9	82	78	94	65
12	Nookachamps Ck	Swan Rd	64	58	84	32
13	E.F. Nookachamps Ck	State Route 9	87	85	94	72
14	College Way Ck	College Way	54	44	86	39
15	Nookachamps Ck	Knapp	62	54	86	17
16	E.F. Nookachamps Ck	Beaver Lake Rd	97	97	99	95
17	Nookachamps Ck	Big Lake Outlet	81	75	98	42
18	Lake Ck	State Route 9	71	63	98	16
19	Hansen Ck	Hoehn Rd	78	72	95	68
20	Hansen Ck	Northern State	92	91	97	86
21	Coal Ck	Hoehn Rd	84	80	96	66
22	Coal Ck	Hwy 20	94	93	98	89
23	Wiseman Ck	Minkler Rd	96	95	99	91
24	Mannser Ck	Lyman Hamilton Hwy	64	63	68	55
25	Red Cabin Ck	Hamilton Cem Rd	97	97	98	96
28	Brickyard Ck	Hwy 20	79	79	93	63
29	Skagit R	River Bend Rd	93	92	97	89
30	Skagit R	Cape Horn Rd	94	93	95	92
31	Drain Dist 20 floodgate	Francis Rd	68	68	87	44
32	Samish R	Thomas Rd	86	83	96	79
33	Alice Bay Pump Station	Samish Island Rd	12	12	35	1
34	Noname Slough	Bayview-Edison Rd	21	11	51	1
35	Joe Leary Slough	D'Arcy Rd	9	9	24	1
36	Edison Slough at school	W. Bow Hill Rd	37	25	74	1
37	Edison Pump Station	Farm to Market Rd	12	1	45	1
38	North Edison PS	North Edison Rd	23	16	42	3
39	Colony Ck	Colony Rd	70	63	93	34
40	Big Indian Slough	Bayview-Edison Rd	14	3	44	1
41	Maddox Sl/Big Ditch	Milltown Rd	57	55	61	54
42	Hill Ditch	Cedardale Rd	67	58	92	42
43	Wiley Slough	Wylie Rd	35	22	76	1
44	Sullivan Slough	La Conner-Bayview Rd	48	47	50	45
45	Skagit R – North Fork	Moore Rd	96	95	99	93
46	Skagit R – South Fork	Fir Island Rd	93	91	98	81
47	Swinomish Channel	County Boat Launch	86	83	97	71
48	Fisher Ck	Franklin Rd	75	70	87	57

*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 19 key parameters or calculated factors at each sampling location. The parameters tested include pH, dissolved oxygen, percent oxygen saturation, 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 seven 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).

Several sites have extended dry periods during most summers and/or are flooded during high water events and not sampled. 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 or flooded periods. For those four sites, trends were calculated based on four seasons, starting with January, April, July, and October. Trends in WQI were calculated based on four seasons for some additional sites due to lack of summer nutrient data.

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
2004-2010 Water Years

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
3	DO	178	0.115	1.967	Increasing Oxygen	
	Turb	177	0.531	2.476		Increasing Turbidity
	OP	72	0.010	4.708		Increasing Phosphate
4	pH	179	-0.028	-2.698		
	DO	180	0.084	3.085	Increasing Oxygen	
	FC	179	-32.070	-3.202	Decreasing Coliform	
	MFC	91	-48.770	-2.469	Decreasing Coliform	
	NO3+NO2	73	-0.034	-2.312	Decreasing Nitrate	
	OP	73	0.010	4.573		Increasing Phosphate
	PerDO	180	0.440	2.627	Increasing Oxygen	
	MPerDO	91	0.332	2.483	Increasing Oxygen	
6	pH	178	-0.029	-2.483		
	DO	178	0.065	2.434	Increasing Oxygen	
	NO3+NO2	73	-0.020	-2.366	Decreasing Nitrate	
	OP	73	0.001	3.118		Increasing Phosphate
8	Turb	180	0.545	3.080		Increasing Turbidity
	MTB	91	0.772	2.162		Increasing Turbidity
	TP	73	0.000	-2.745	Decreasing Phosphorus	
	OP	73	0.005	4.206		Increasing Phosphate
	PerDO	181	-0.535	-2.466		Decreasing Oxygen
	MPerDO	91	-0.643	-2.523		Decreasing Oxygen
11	OP	72	0.001	3.359		Increasing Phosphate
	NH3	73	0.000	2.233		Increasing Ammonia
	TSS	72	0.000	-2.329	Decreasing Solids	
12	Temp	171	-0.201	-2.739	Decreasing Temperature	
	TP	70	0.000	2.457		Increasing Phosphorus
	OP	70	0.005	4.361		Increasing Phosphate
	TSS	70	-0.741	-2.220	Decreasing Solids	
13	Temp	180	-0.197	-3.168	Decreasing Temperature	
	OP	73	0.002	4.337		Increasing Phosphate
14	pH	180	-0.020	-2.143		
	MpH	91	-0.024	-2.089		
	Temp	182	-0.170	-2.645	Decreasing Temperature	
	OP	72	0.008	2.683		Increasing Phosphate
	WQI	70	-1.748	-2.574		Decreasing WQI
15	Temp	182	-0.151	-2.460	Decreasing Temperature	
	TKN	73	0.040	2.138		Increasing Nitrogen
	TP	73	0.000	3.469		Increasing Phosphorus
	OP	73	0.009	4.604		Increasing Phosphate
	NH3	73	0.007	2.360		Increasing Ammonia
	WQI	69	-2.105	-2.722		Decreasing WQI
16	Temp	182	-0.199	-3.348	Decreasing Temperature	

Table 11. Trends Analysis Results (continued)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
16 (cont)	FC	180	-0.813	-2.262	Decreasing Coliform	
	OP	73	0.002	4.013		Increasing Phosphate
	NH3	73	0.000	2.490		Increasing Ammonia
17	DO	181	0.077	2.887	Increasing Oxygen	
	Temp	182	-0.181	-2.187	Decreasing Temperature	
	OP	73	0.000	3.683		Increasing Phosphate
18	Temp	182	-0.159	-2.615	Decreasing Temperature	
	TKN	73	0.000	2.088		Increasing Nitrogen
	OP	73	0.006	5.164		Increasing Phosphate
19	DO	181	0.093	3.417	Increasing Oxygen	
	Temp	181	-0.193	-2.395	Decreasing Temperature	
	Turb	178	0.202	3.029		Increasing Turbidity
	MTB	91	0.168	2.010		Increasing Turbidity
	OP	71	0.005	3.928		Increasing Phosphate
	NH3	71	0.003	2.252		Increasing Ammonia
	PerDO	181	0.301	2.023	Increasing Oxygen	
20	DO	182	0.057	2.134	Increasing Oxygen	
	Temp	182	-0.193	-2.622	Decreasing Temperature	
	OP	73	0.005	4.406		Increasing Phosphate
21	DO	163	0.076	2.437	Increasing Oxygen	
	Temp	163	-0.197	-2.058	Decreasing Temperature	
	FC	162	-4.601	-2.598	Decreasing Coliform	
	OP	65	0.002	4.060		Increasing Phosphate
	MPerDO	85	0.363	2.017	Increasing Oxygen	
22	Temp	182	-0.150	-2.135	Decreasing Temperature	
	OP	71	0.000	3.311		Increasing Phosphate
23	pH	167	-0.030	-2.681		
	Temp	170	-0.197	-2.963	Decreasing Temperature	
	NO3+NO2	71	-0.050	-3.596	Decreasing Nitrate	
	OP	71	0.001	3.361		Increasing Phosphate
	NH3	71	0.000	2.030		Increasing Ammonia
24	Turb	181	0.100	3.568		Increasing Turbidity
	MTB	91	0.117	2.258		Increasing Turbidity
	FC	179	-2.269	-4.097	Decreasing Coliform	
	MFC	91	-2.005	-2.047	Decreasing Coliform	
	OP	73	0.008	4.528		Increasing Phosphate
	NH3	73	0.000	3.157		Increasing Ammonia
	WQI	70	2.507	3.144	Increasing WQI	
25	DO	153	0.059	2.281	Increasing Oxygen	
	Temp	153	-0.122	-2.203	Decreasing Temperature	
	OP	64	0.003	4.271		Increasing Phosphate
28	Turb	133	0.425	2.771		Increasing Turbidity
	MTB	76	0.628	3.277		Increasing Turbidity
	NO3+NO2	56	-0.076	-2.860		Increasing Nitrate
	OP	56	0.009	4.281		Increasing Phosphate

Table 11. Trends Analysis Results (continued)

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
29	Temp	182	-0.197	-3.807	Decreasing Temperature	
	Turb	180	-0.550	-3.266	Decreasing Turbidity	
	MTB	91	-0.680	-2.191	Decreasing Turbidity	
	NO3+NO2	71	0.006	3.296		Increasing Nitrate
	OP	71	0.001	4.024		Increasing Phosphate
	PerDO	180	-0.501	-2.714		Decreasing Oxygen
	MPerDO	91	-0.468	-2.042		Decreasing Oxygen
	WQI	69	0.950	2.394	Increasing WQI	
30	DO	182	0.038	2.019	Increasing Oxygen	
	Temp	182	-0.150	-3.173	Decreasing Temperature	
	Turb	180	-0.630	-5.232	Decreasing Turbidity	
	MTB	91	-0.857	-3.722	Decreasing Turbidity	
	OP	72	0.001	3.891		Increasing Phosphate
31	FC	108	-4.450	-2.730	Decreasing Coliform	
	MFC	67	-9.618	-3.684	Decreasing Coliform	
	OP	44	0.010	3.484		Increasing Phosphate
32	MpH	91	0.111	4.108		
	MDO	91	0.124	2.319	Increasing Oxygen	
	Temp	182	-0.205	-2.721	Decreasing Temperature	
	NO3+NO2	72	-0.017	-2.332	Decreasing nitrate	
	OP	72	0.005	4.383		Increasing Phosphate
33	Temp	182	-0.264	-2.275	Decreasing Temperature	
	FC	183	-5.071	-2.763	Decreasing Coliform	
	OP	71	0.029	2.859		Increasing Phosphate
34	Temp	180	-0.295	-3.179	Decreasing Temperature	
	OP	72	0.023	3.233		Increasing Phosphate
	NH3	72	-0.020	-2.346	Decreasing Ammonia	
35	DO	173	0.145	2.617	Increasing Oxygen	
	MDO	85	0.138	2.279	Increasing Oxygen	
	Temp	173	-0.200	-2.890	Decreasing Temperature	
	MT	85	-0.301	-3.596	Decreasing Temperature	
	FC	168	-5.532	-2.156	Decreasing Coliform	
	OP	68	0.020	4.195		Increasing Phosphate
	PerDO	173	1.185	2.511	Increasing Oxygen	
	MPerDO	87	1.354	2.618	Increasing Oxygen	
36	Temp	180	-0.302	-2.672	Decreasing Temperature	
	MT	92	-0.351	-2.008	Decreasing Temperature	
	OP	72	0.018	3.568		Increasing Phosphate
37	TKN	73	0.261	4.152		Increasing Nitrogen
	TP	73	0.035	2.252		Increasing Phosphorus
	OP	73	0.048	4.748		Increasing Phosphate
38	TP	72	0.041	2.681		Increasing Phosphorus
	OP	72	0.059	5.190		Increasing Phosphate
39	DO	179	0.100	3.766	Increasing Oxygen	
	Temp	181	-0.198	-2.353	Decreasing Temperature	
	FC	181	-1.581	-2.107	Decreasing Coliform	

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

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
39 (cont)	TKN	72	0.035	2.425		Increasing Nitrogen
	OP	72	0.010	4.887		Increasing Phosphate
	PerDO	179	0.398	3.289	Increasing Oxygen	
40	DO	178	0.204	3.695	Increasing Oxygen	
	MDO	87	0.282	4.179	Increasing Oxygen	
	Temp	179	-0.196	-3.110	Decreasing Temperature	
	MT	87	0.282	4.179		Increasing Temperature
	Turb	178	1.533	4.411		Increasing Turbidity
	MTB	88	1.869	3.134		Increasing Turbidity
	FC	175	7.260	2.920		Increasing Coliform
	MFC	88	11.170	2.436		Increasing Coliform
	TKN	72	0.034	2.732		Increasing Nitrogen
	TP	72	0.000	2.436		Increasing Phosphorus
	OP	71	0.020	3.528		Increasing Phosphate
	PerDO	178	1.905	3.810	Increasing Oxygen	
	MPerDO	89	2.088	3.248	Increasing Oxygen	
41	DO	181	0.278	3.923	Increasing Oxygen	
	MDO	89	0.285	2.618	Increasing Oxygen	
	Temp	182	-0.223	-2.908	Decreasing Temperature	
	OP	73	0.008	4.406		Increasing Phosphate
	PerDO	181	2.054	3.511	Increasing Oxygen	
	MPerDO	91	2.106	2.986	Increasing Oxygen	
	WQI	69	4.31500	2.33300	Increasing WQI	
42	DO	108	0.198	3.979	Increasing Oxygen	
	MDO	88	0.235	3.461	Increasing Oxygen	
	Temp	181	-0.175	-2.246	Decreasing Temperature	
	MT	89	-0.258	-2.962	Decreasing Temperature	
	Turb	180	0.129	2.700		Increasing Turbidity
	FC	176	3.440	3.252		Increasing Coliform
	MFC	89	5.390	2.810		Increasing Coliform
	TKN	73	0.040	2.264		Increasing Nitrogen
	OP	73	0.015	5.239		Increasing Phosphate
	NH3	73	0.007	2.831		Increasing Ammonia
	PerDO	180	1.550	4.179	Increasing Oxygen	
	MPerDO	90	1.721	4.091	Increasing Oxygen	
43	pH	173	0.023	2.370		
	MpH	86	0.021	2.419		
	Temp	173	-0.148	-2.364	Decreasing Temperature	
	OP	70	0.027	2.468		Increasing Phosphate
44	pH	180	0.040	3.232		
	MpH	90	0.045	2.651		
	DO	177	0.552	3.945	Increasing Oxygen	
	MDO	89	0.473	2.459	Increasing Oxygen	
	Temp	181	-0.201	-2.853	Decreasing Temperature	
	MT	90	-0.196	-2.854	Decreasing Temperature	

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

Site	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
44 (cont)	FC	177	7.449	3.900		Increasing Coliform
	MFC	90	11.410	2.464		Increasing Coliform
	NO3+NO2	72	0.028	3.812		Increasing Nitrate
	TKN	73	0.089	3.255		Increasing Nitrogen
	OP	72	0.028	4.587		Increasing Phosphate
	NH3	73	0.039	2.376		Increasing Ammonia
	PerDO	180	4.826	3.860	Increasing Oxygen	
	MPerDO	91	4.213	2.532	Increasing Oxygen	
45	pH	172	0.071	4.255		
	MpH	90	0.063	3.412		
	DO	170	0.050	3.033	Increasing Oxygen	
	Temp	174	-0.186	-3.541	Decreasing Temperature	
	MT	89	-0.094	-1.966	Decreasing Temperature	
	Turb	173	-0.815	-4.361	Decreasing Turbidity	
	MTB	89	-0.942	-3.729	Decreasing Turbidity	
	NO3+NO2	70	0.007	3.167		Increasing Nitrate
	OP	70	0.000	3.575		Increasing Phosphate
46	pH	176	0.035	2.434		
	MpH	89	0.041	2.214		
	DO	176	0.047	2.907	Increasing Oxygen	
	Temp	177	-0.198	-3.638	Decreasing Temperature	
	MT	89	-0.106	-2.421	Decreasing Temperature	
	Turb	176	-0.730	-4.473	Decreasing Turbidity	
	MTB	89	-0.807	-3.516	Decreasing Turbidity	
	NO3+NO2	71	0.008	3.174		Increasing Nitrate
	OP	71	0.000	3.533		Increasing Phosphate
47	pH	180	-0.020	-3.149		
	MpH	90	-0.019	-2.193		
	Temp	182	-0.125	-3.553	Decreasing Temperature	
	MT	90	-0.089	-2.116	Decreasing Temperature	
	Turb	181	-0.181	-2.072	Decreasing Turbidity	
	MTB	90	-0.277	-2.187	Decreasing Turbidity	
	NO3+NO2	73	0.020	3.328		Increasing Nitrate
	TP	73	0.000	2.709		Increasing Phosphorus
	OP	73	0.011	5.668		Increasing Phosphate
48	OP	73	0.026	3.691		Increasing Phosphate

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 19 parameters or calculated parameters (such as monthly averages) at each site, for a total of 760 tests. Of those, 209 tests showed a statistically significant trend at the 95% confidence level. Trends judged as improving (e.g. increased dissolved oxygen, reduced temperature) made up 106 of the significant trends. Deleterious trends (e.g. reduced dissolved oxygen, increased nutrients) made up 92 of the significant trends. The remaining 11 trends were increasing or decreasing 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), an abbreviated list, using only the unique trends involving the monthly averages (for pH, dissolved oxygen, temperature, and turbidity) plus the nutrient data which was already monthly or quarterly was also looked at for summary statistics. In this truncated data set, there were 118 significant trends, with 36 trends identified as representing improved conditions and 75 identified as deleterious. The remaining 7 were pH trends.

This accounting represents a change from last year, when improving trends greatly outnumbered deleterious trends. It is important to remember that these statistics are calculated over the life of the study, so while the 2010 water year may account for the differences between current and past results, the calculated trends are representative of the entire study from October 2003 to September 2010.

Seven 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. This is a reduction from last year, when 30 stations had significant decreases in water temperature. One site showed a significant increase in monthly mean temperature.

Air temperature data from the Washington State University Extension Service station in West Mount Vernon continues to show an overall declining trend, although this year it was not significant at the 95% confidence level. Air temperature changes can help explain overall trends in water temperature, although site-specific factors such as riparian vegetation changes could override regional trends. In our case, the weakening of the air temperature trend could help explain the reduced number of sites with significant temperature reductions over the life of the study.

Six of the 40 sites showed a significant increasing trend in mean monthly dissolved oxygen over the life of the study. This is also a change from last year, when 22 sites had increasing dissolved oxygen. This change is related to the changes in the temperature trends, as warmer water holds less oxygen, so with a reduced number of decreasing temperature trends, we would also expect a reduced number of increasing oxygen trends. Seven of the 40 sites showed a significant increasing trend in monthly oxygen percent saturation, which takes temperature into account. This indicates that dissolved oxygen improved at those sites independent of the temperature reduction. There were no declining trends in dissolved oxygen, but two sites showed declining percent saturation.

Three of the sites showed a significantly decreasing trend in monthly fecal coliform, while three other sites had significantly increasing fecal coliform.

Three 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. Two sites showed a decreasing trend in WQI, an indicator that water quality could be declining, though this is not likely due to temperature as both sites had improving temperature trends.

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 2010 water year.

Variability in fecal coliform, total phosphorus, nitrate, and ammonia were above target levels. The fecal coliform data showed particularly high variability. Results are similar to last year's findings, with noticeably high variablility in fecal coliform and low variability in Ortho-phosphate. Nitrate variability increased substantially from last year, when it was below the target level. Overall, these results are comparable to what was found in the first six years of the Skagit County Monitoring Program and in Skagit County's previous work in the Baseline and Samish Bay Tributaries studies.

Table 12. 2010 Data Quality Results
Coefficients of Variation for parameter with duplicates in the Skagit County Monitoring Program, 2010 Water Year

		Coefficient of Variationn (CV)	
Parameter	**N**	**2010 Results**	**Target CV (%)[1]**
Fecal Coliform	202	45	33
Total Phosphorus	8	19	10 [2]
Nitrate	8	16	10 [2]
Ortho-phosphate	7	1	10 [2]
Ammonia	8	21	10 [2]

[1] Target precision as listed in QAPP

[2] 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.

Skagit County Water Quality Monitoring for the Clean Samish Initiative

Overview

The Clean Samish Initiative was established by Ecology in the fall of 2008 to foster cooperation between local, state, and federal agencies, non-governmental groups, and citizens to address fecal coliform pollution in the Samish Bay Watershed. Excess fecal coliform pollution in the Samish River and other bay tributaries has resulted in numerous closures of the commercial shellfish beds in Samish Bay. The Clean Samish Initiative participants (over 20 organizations) developed a work plan that included education and outreach, detailed water quality sampling to locate pollution sources, referrals of landowners to resource agencies for pollution abatement, and enforcement of water quality and land use regulations if necessary. Skagit County applied for and received EPA funding to conduct a Pollution Identification and Correction (PIC) project in the Samish Basin, incorporating Clean Samish work plan elements into a program designed to locate and eliminate fecal coliform pollution in the Samish Basin.

The Clean Samish Initiative grew out of Ecology's TMDL activities in the Samish Basin. Ecology sampling demonstrated that the Samish River was the largest source of fecal coliform bacteria to Samish Bay. While some of the independent Samish Bay tributaries (e.g. Edison Slough and Colony Creek) and agricultural drainages also contribute bacterial pollution to Samish Bay, the comparatively high discharge rate of the river combined with occasional high coliform counts meant that the river was and continues to be the most important pollution source for Samish Bay.

Activities

Numerous PIC education and outreach activities occurred during the 2010 water year, and will be summarized in a separate Clean Samish Initiative report. In addition, County staff have begun site visits in areas where water quality sampling results indicate pollution sources are present. These visits form the core of the PIC program and will also be summarized in the separate Clean Samish report. In this document we will report on sampling results and interpretation associated with the Clean Samish PIC program.

Storm sampling

Skagit County personnel have been sampling each available rain storm event in the Samish Basin since April, 2010. Prior to that, volunteer Storm Team members conducted most storm event sampling in the Samish Basin.

Storm Team sample results showed strong indications that the major sources of Samish River pollution were in the reach of river between Grip Road (River Mile 13.5) and upper Prairie Road (RM 20.7), referred to as the "middle Samish." County sampling in the summer and fall of 2010 showed a similar trend. Figure 3 shows the geometric mean fecal coliform results for the middle Samish sampling stations for County samples obtained between April and September, including both storm and ambient sampling. Figure 4 shows the geometric mean fecal coliform results for storm events only.

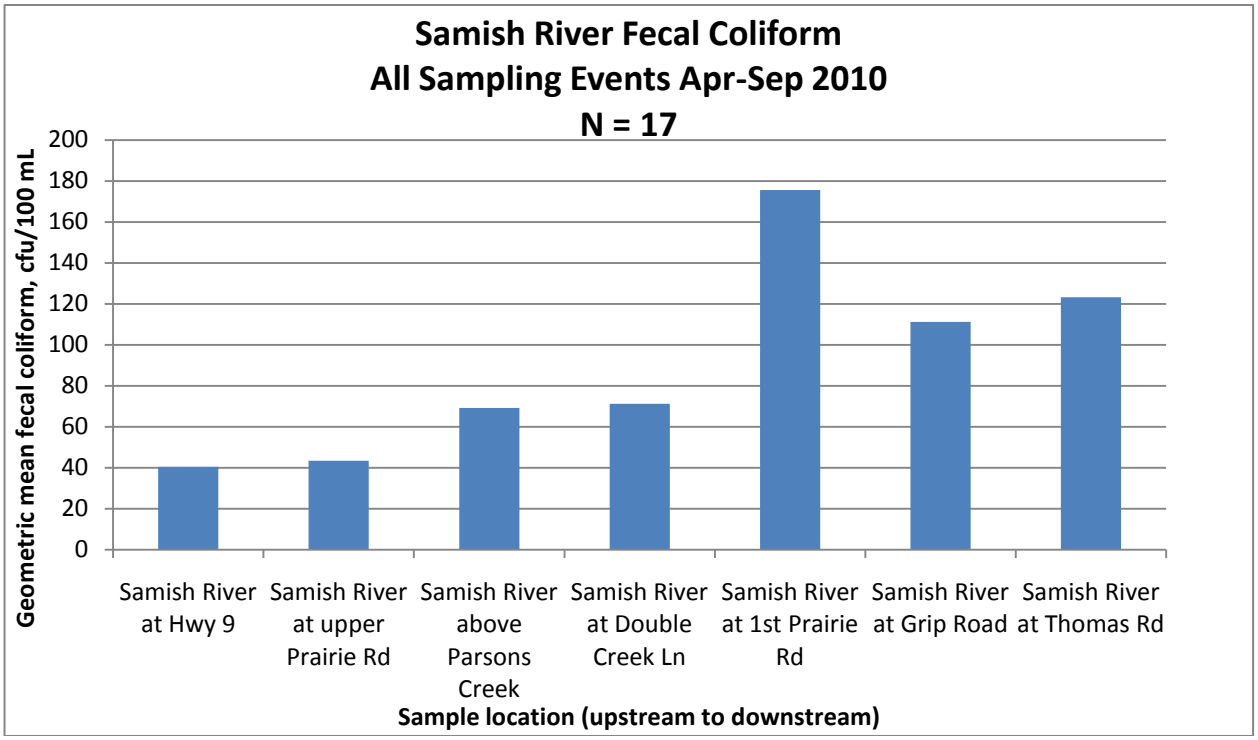


Figure 3. Geometric mean fecal coliform counts for all Samish River samples, Apr-Sep 2010

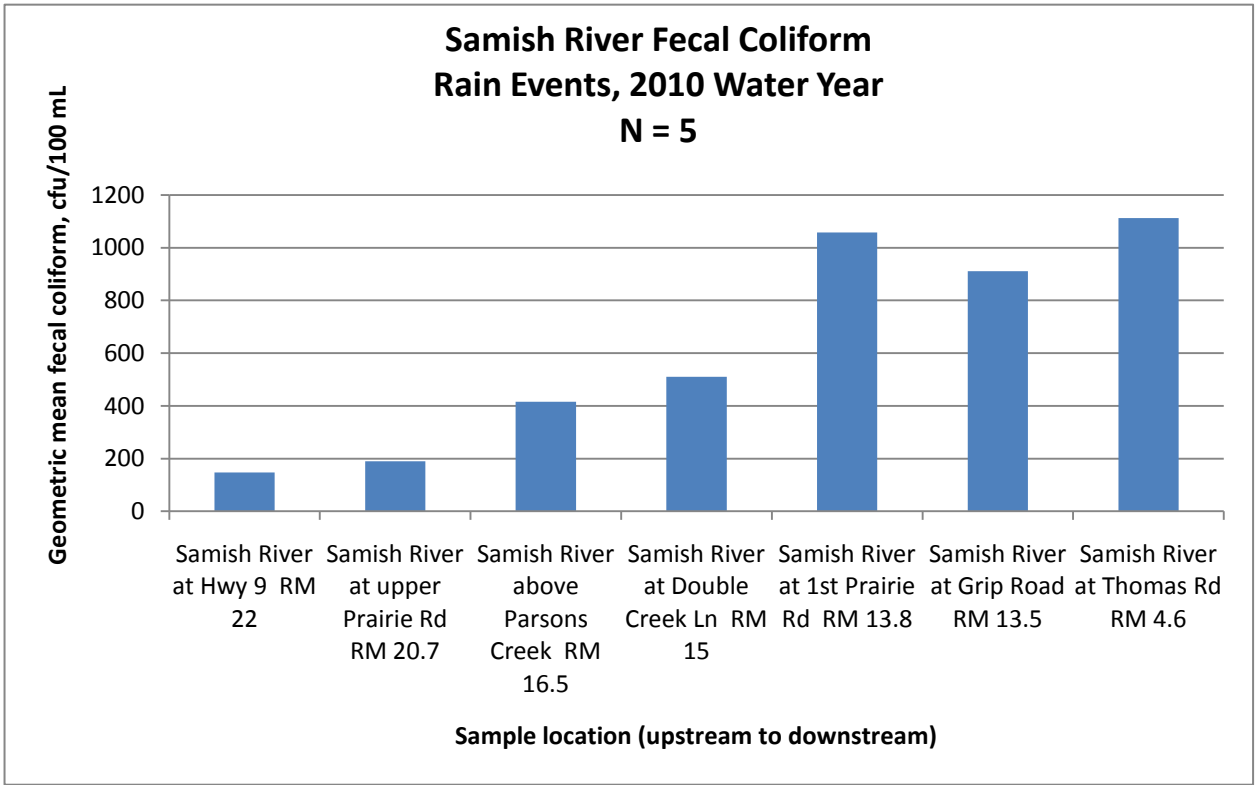


Figure 4. Geometric mean fecal coliform counts for Samish River storm samples, Apr-Sep 2010

Table 13 shows the sample results for the five storm events in the April-September 2010 period. As was evident in the graph above, fecal coliform samples show a pattern of increasing counts from upstream to downstream. Since the discharge also increases from upstream to downstream, fecal coliform loading also increases in the same pattern.

Further detailed reporting on the Samish River fecal coliform conditions and steps taken to reduce bacteria in the Samish Basin is forthcoming in a separate report.

Table 13. Fecal coliform counts (cfu/100 mL) from rain event samples obtained in the Samish Basin, 4/10-9/10

River stations (upstream to downstream)	Site	4/21/10	6/2/10	8/31/10	9/20/10	9/28/10	Geo mean	N
Samish River at Hwy 9 RM 22	11	900	30	50	400	130	148	5
Samish River at upper Prairie Rd RM 20.7	SAM3PR	500	30	130	900	140	190	5
Samish River above Parsons Creek RM 16.5	SAMPAR	500	220	140	1600	500	415	5
Samish River at Double Creek Ln RM 15	SAMDCL	900	170	500	500	900	510	5
Samish River at 1st Prairie Rd RM 13.8	SAM1PR	900	240	2400	1600	1600	1058	5
Samish River at Grip Road RM 13.5	SAMGRIP	900	170	1600	1600	1600	911	5
Samish River at Thomas Rd RM 4.6	32	700	900	300	3000	3000	1112	5
Tributaries (upstream to downstream)								
Parsons Creek at mouth	PAR	3000	30		300		300	3
Skarrup Creek at Double Creek Ln	SKAR	16000	1600		130		1493	3
Swede Creek at Grip Rd	8	9000	500		130		836	3
Friday Creek at Prairie Rd	6	500	110		130		193	3
Rainfall		0.70	0.35	0.50	0.60	0.24		

Note: RM = River Mile

Annual Report Summary

The Skagit County Monitoring Program completed a seventh water year of sampling in September 2010. 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 slightly more improving trends than deleterious ones. As mentioned earlier, Skagit County has taken a leading role in addressing water quality problems in the area through the Clean Samish Initiative.

The program was substantially funded through the 2008 water year by a Centennial Clean Water Grant from the Washington State Department of Ecology. Currently, all project funding comes from Skagit County's Clean Water Program.

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