SKAGIT COUNTY
PUBLIC WORKS DEPARTMENT

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February 5, 2007

Dear Interested Party:

The Surface Water Management Section of Skagit County Public Works announces the release of the third Skagit County Water Quality Monitoring Program Annual Report on the Skagit County website. This report for the 2006 Water Year summarizes the findings of water quality monitoring, primarily in and around the agricultural areas of Skagit County.

The report contains a description of the monitoring project and the methods used, followed by a data report with the more important parameters graphed for a quick overview of the data. Brief discussions of these results are included.

This year we have expanded our examination of trends in the water quality data. The Seasonal Kendall's Test was employed to analyze trends over the three years in several key parameters.

The report is available online at www.skagitcounty.net/scmp

Questions or comments should be addressed to:

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Thank you for your interest in the Skagit County Water Quality Monitoring Program.

Sincerely,

Rick Haley

cc: Ric Boge, Surface Water Manager
Dave Brooking, Natural Resources Division Manager
Correspondence File

Skagit County Monitoring Program

Annual Report - 2006 Water Year (October 2005 – September 2006)

Coal Creek near Hoehn Road

Skagit County Public Works
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February, 2007

Acknowledgements

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Annual Report
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This report is available online at www.skagitcounty.net/SCMP

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Introduction

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

The ordinance requires farmers to "do no harm" to adjacent watercourses, and relies on specific Watercourse Protection Measures and more generalized Best Management Practices to protect the watercourses instead of requiring buffers on the streams. The associated Skagit County Resolution R20030210 committed the County to conduct water quality sampling in the agricultural areas as one method of assessing if the County's ordinance was sufficient to protect the aquatic resources in agricultural areas. The resolution was subsequently amended in June, 2004 as Resolution R20040211 in response to additional Compliance Orders from the Western Washington Growth Hearings Board. This second resolution provided details about the water quality monitoring program in addition to other topics not associated with water quality. Included in R20040211 is the requirement for annual reporting on the water quality monitoring program. This document is intended to satisfy that requirement for the 2006 Water Year.

The monitoring program was designed to determine current conditions and long-term trends in water quality in the watercourses being monitored. It was not specifically designed to determine compliance of the watercourses with state water quality standards, although the data is suitable for such determinations.

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.

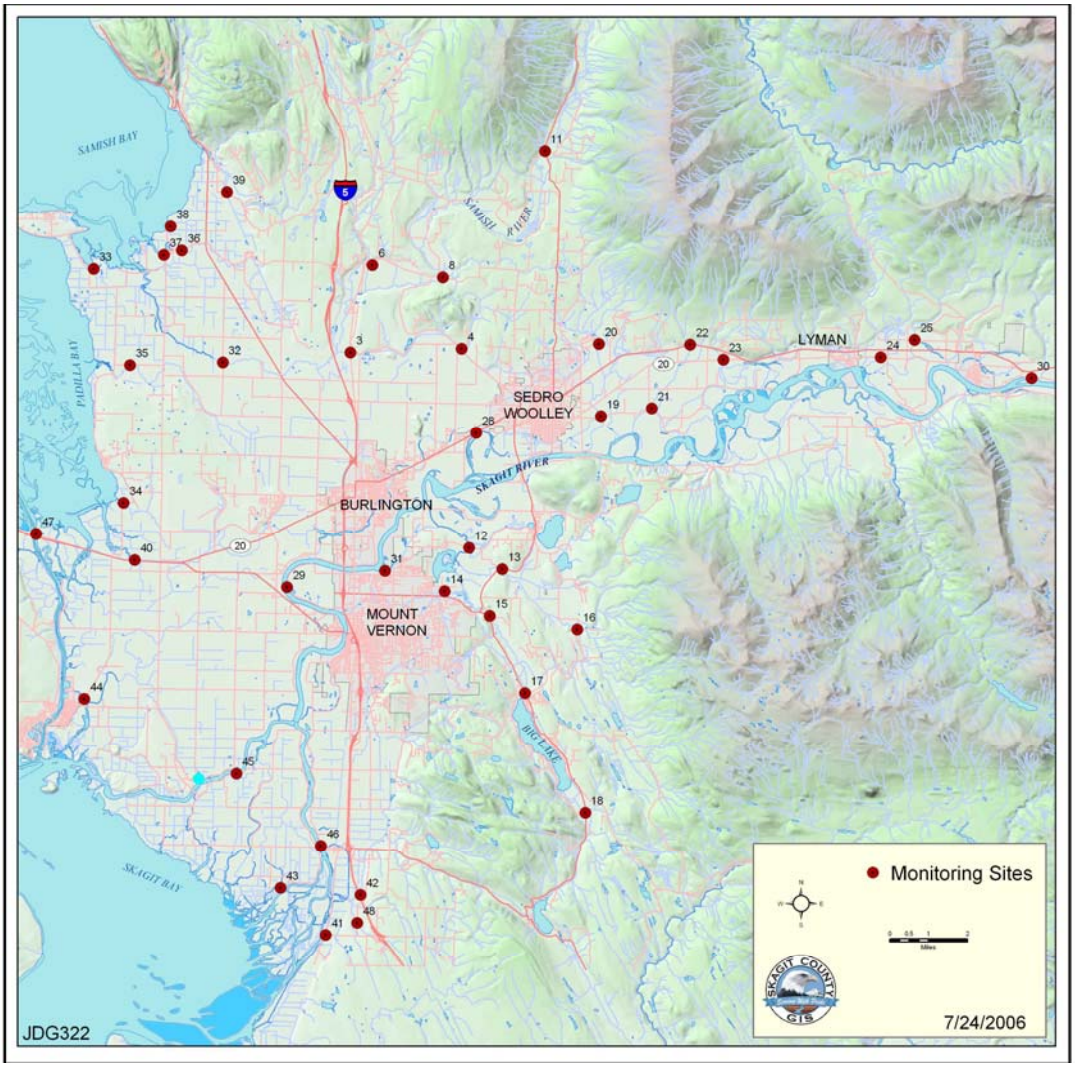


Figure 1. Sample sites in the Skagit County Monitoring Program. Refer to Tables 1 and 2 for site locations and descriptions.

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) 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.

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	1
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	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

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.	7
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.	19
4	Reference: Located to determine status/trends in a non-agricultural area, such as urban/suburban or rural reserve, for comparison with ag area results.	3
5	Skagit River: Located to determine status/trends in the mainstem Skagit River or the forks. The Skagit may show effects from a wide variety of sources.	4
6	TMDL: Located to provide information for the Department of Ecology's TMDL efforts.	12
7	Swinomish Channel: Located to provide a water quality baseline for Swinomish Channel	1

[1]Some sites have more than one 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 two years of this program have been reported previously (Skagit County 2004c, Skagit County 2006). This report contains data and analysis from water years 2004, 2005, and 2006.

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. On alternate visits (every four weeks), additional water samples are obtained for quantifying plant nutrients (total nitrogen, ammonia, nitrate, nitrite, total phosphorus and orthophospate), and total suspended solids. Stream discharge is measured at selected sites during the alternate visits.

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

http://www.skagitcounty.net/SCMP

Activity Summary

Weekly Sampling - All weekly sampling trips were conducted on schedule during the 2006 water year, beginning on October 4, 2005. Sampling normally took place on Tuesdays except during holiday weeks (Thanksgiving and Christmas), when sampling took place on Mondays to accommodate laboratory schedules. Sampling activities are illustrated in Figures 2 and 3.

Grant Activity - Centennial Clean Water grants require a Quality Assurance Program Plan (QAPP). A draft QAPP was submitted to the Department of Ecology in September, 2003. Ecology comments were incorporated into the document and a final QAPP was submitted to Ecology in October, 2003. Ecology accepted the QAPP and a final grant agreement was signed by Ecology and the County Commissioners in January, 2004. At this point expenditures on the Skagit County Monitoring Program became grant-eligible, with reimbursement from the Centennial Clean Water Grant program at a 75% rate.

The grant requires quarterly reports and annual data submissions. Skagit County has submitted quarterly reports for the fourth quarter of 2005 and all quarters of 2006. The

first annual data submission was made in January, 2005. Another submission was made in January, 2006.

Figure 2. Jeff McGowan obtains a water sample from Mannser Creek (Site 24)

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 3500 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 2800 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 4300 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 because it was determined that the majority of flow from that system discharged through the west end of the system 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.

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 sample site are included in Appendix A. A summary of water quality results for each sample site is included in Appendix B.

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.

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. Temperature was also measured at each sampling visit.

Several of the dataloggers were missing at the end of the monitoring period. Some had apparently been lost due to channel changes associated with heavy rains in August, while others may have been vandalized.

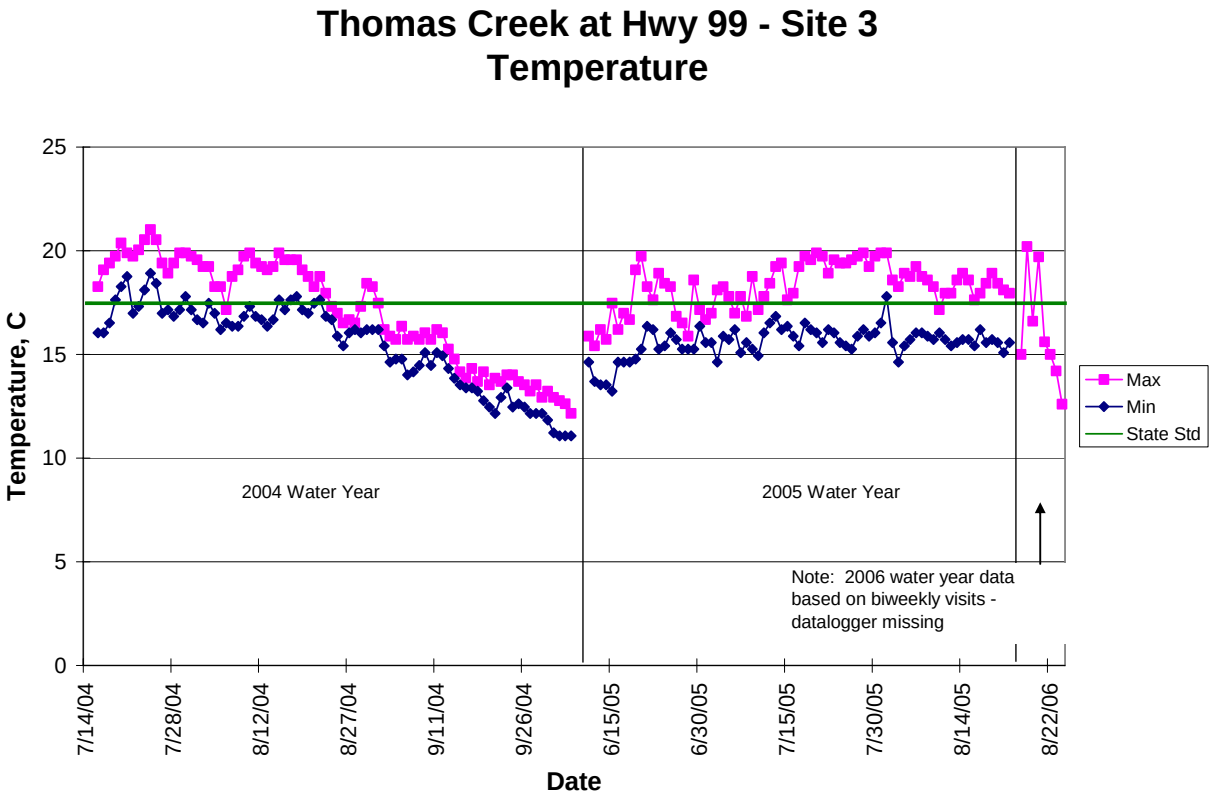
Table 3 shows the daily and 7-day average maximums (7-DAM) for the 2006 water year for those stations where temperature data was obtained, compared to the state standard for that station. The state temperature standards are based on the 7-DAM so that occasional abnormally hot days do not result in temperature standard violations. The Skagit River and tributaries upstream from Skiyou Slough are held to a lower temperature standard (7-DAM = 16ºC) than streams in the rest of the county. Sites 21-25 and 30 are subject to the more stringent standard. Site 47 is held to the "excellent quality" marine standard (also 16ºC). All other streams in the county are held to a standard 7-DAM of 17.5 ºC. Most watercourses in the Skagit County Monitoring Program exceeded state temperature standards at some point during the summer.

Table 3. Maximum temperature and relationship to state standards for watercourses in the Skagit County Monitoring Program, 2006 water year.

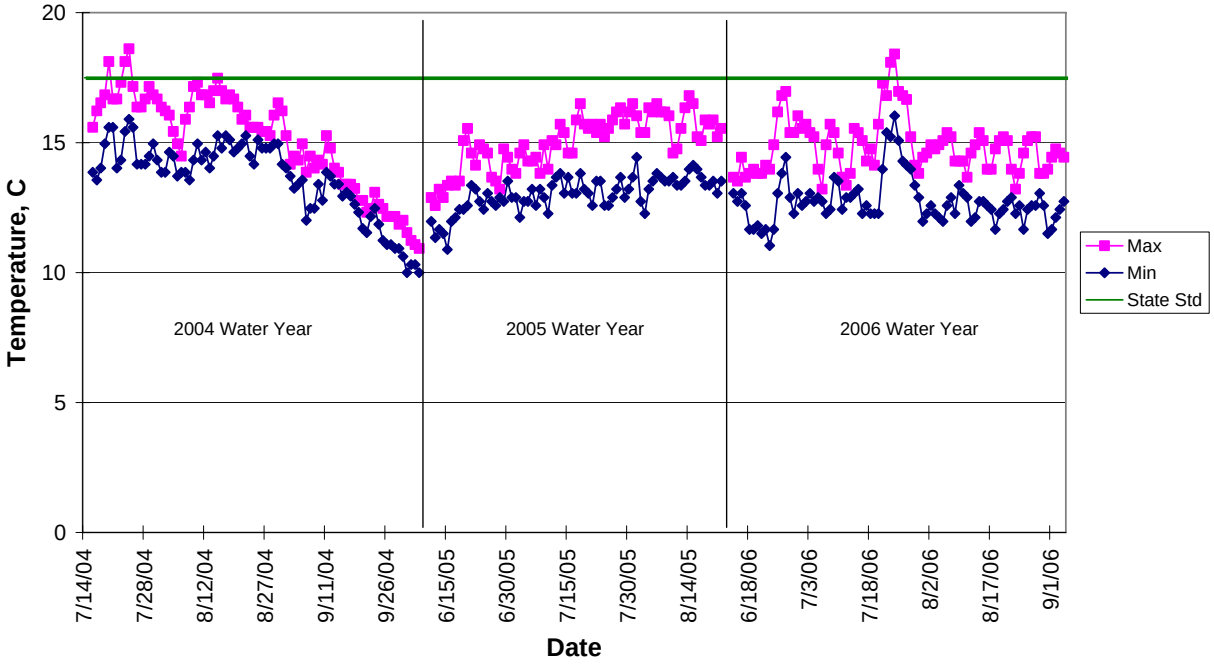
Site Number	Watercourse	Location	Daily Maximum (°C)	Maximum 7-DAM (°C)	State Std[1] (°C)
3	Thomas Ck	Old Hwy 99 N	20.2[3]	N/A	17.5
4	Thomas Ck	F&S Grade	18.4	17.3	17.5
6	Friday Ck	Prairie Rd	22.4	21.3	17.5
8	Swede Ck	Grip Rd	20.4	19.3	17.5
11	Samish R	State Route 9	16.9	15.8	17.5
12	Nookachamps Ck	Swan Rd	21.7	20.6	17.5
13	E.F. Nookachamps Ck	State Route 9	23.2	21.6	17.5
14	College Way Ck	College Way	19.4	18.4	17.5
15	Nookachamps Ck	Knapp	23.7	23.2	17.5
16	E.F. Nookachamps Ck	Beaver Lake Rd	21.8	20.6	17.5
17	Nookachamps Ck	Big Lake Outlet	26.1	25.1	17.5
18	Lake Ck	State Route 9	19.2	18.4	17.5
19	Hansen Ck	Hoehn Rd	22.0	20.7	17.5
20	Hansen Ck	Northern State	20.7	19.0	17.5
21	Coal Ck	Hoehn Rd	20.5	18.2	16.0
22	Coal Ck	Hwy 20	18.5	17.5	16.0
23	Wiseman Ck	Minkler Rd	22.5	21.3	16.0
24	Mannser Ck	Lyman Hamilton Hwy	14.7	14.3	16.0
25	Red Cabin Ck	Hamilton Cem Rd	19.3	17.6	16.0
28	Brickyard Ck	Hwy 20	N/A[2]	N/A	17.5
29	Skagit R	River Bend Rd	15.7[3]	N/A	17.5
30	Skagit R	Cape Horn Rd	16.1	14.9	16.0
31	Drain Dist 20 floodgate	Francis Rd	N/A[2]	N/A	17.5
32	Samish R	Thomas Rd	22.0	20.7	17.5
33	Alice Bay Pump Station	Samish Island Rd	28.7	27.1	17.5
34	Noname Slough	Bayview-Edison Rd	23.6	22.8	17.5
35	Joe Leary Slough	D'Arcy Rd	24.5	24.1	17.5
36	Edison Slough at school	W. Bow Hill Rd	30.5	29.3	17.5
37	Edison Pump Station	Farm to Market Rd	27.7	26.8	17.5
38	North Edison Pump St.	North Edison Rd	29.9	28.1	17.5
39	Colony Ck	Colony Rd	20.8	19.7	17.5
40	Big Indian Slough	Bayview-Edison Rd	25.5	24.2	17.5
41	Maddox Slough/Big Ditch	Milltown Rd	27.8	25.7	17.5
42	Hill Ditch	Cedardale Rd	26.3	24.6	17.5
43	Wiley Slough	Wylie Rd	18.4[3]	N/A	17.5
44	Sullivan Slough	La Conner-Whitney Rd	24.5	22.3	17.5
45	Skagit R – North Fork	Moore Rd	18.0	17.6	17.5
46	Skagit R – South Fork	Fir Island Rd	16.6[3]	N/A	17.5
47	Swinomish Channel	County Boat Launch	15.7[3]	N/A	16.0
48	Fisher Ck	Franklin Rd	15.8	15.0	17.5

[1]Washington State Water Quality Standard per WAC 173-201A
[2]Dry during summer temperature monitoring
[3]Temperatures recorded during biweekly sampling – no continuous datalogger

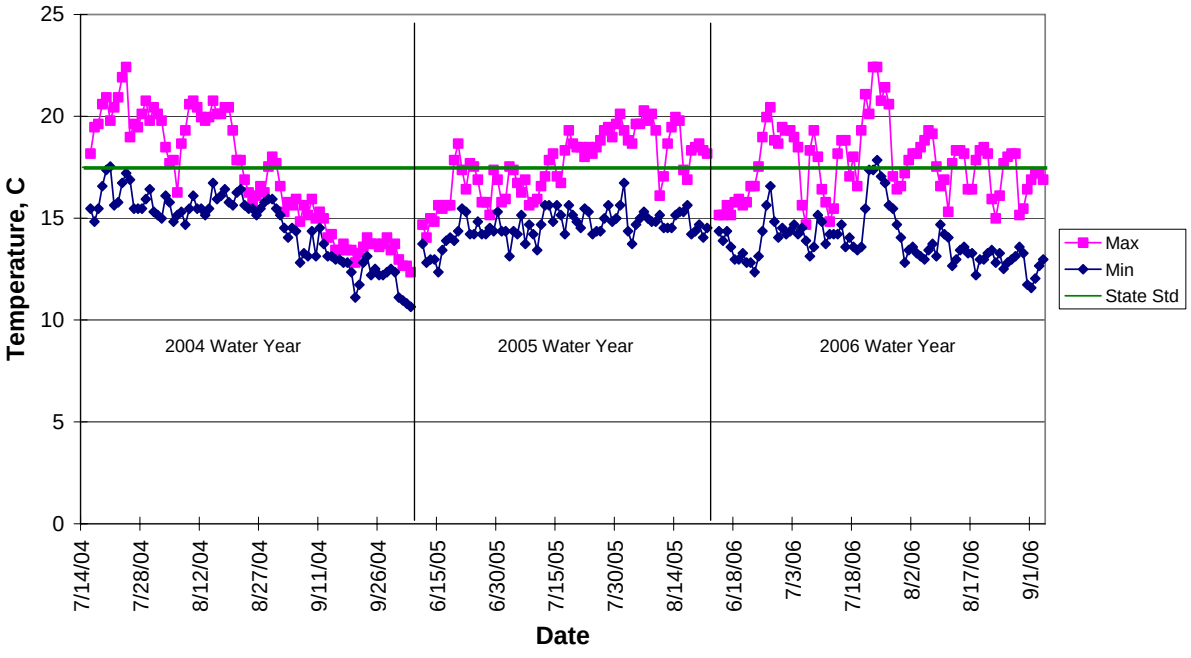
Graphs on the following pages illustrate daily temperature maximums and minimums for the sample sites with temperature data in the Skagit County Monitoring Program. Each graph shows daily high and low temperatures and a line representing the state water quality standard for that water body. The state standard is actually based on the 7-day average maximum temperature, so individual readings over the standard may not constitute a water quality standards violation.



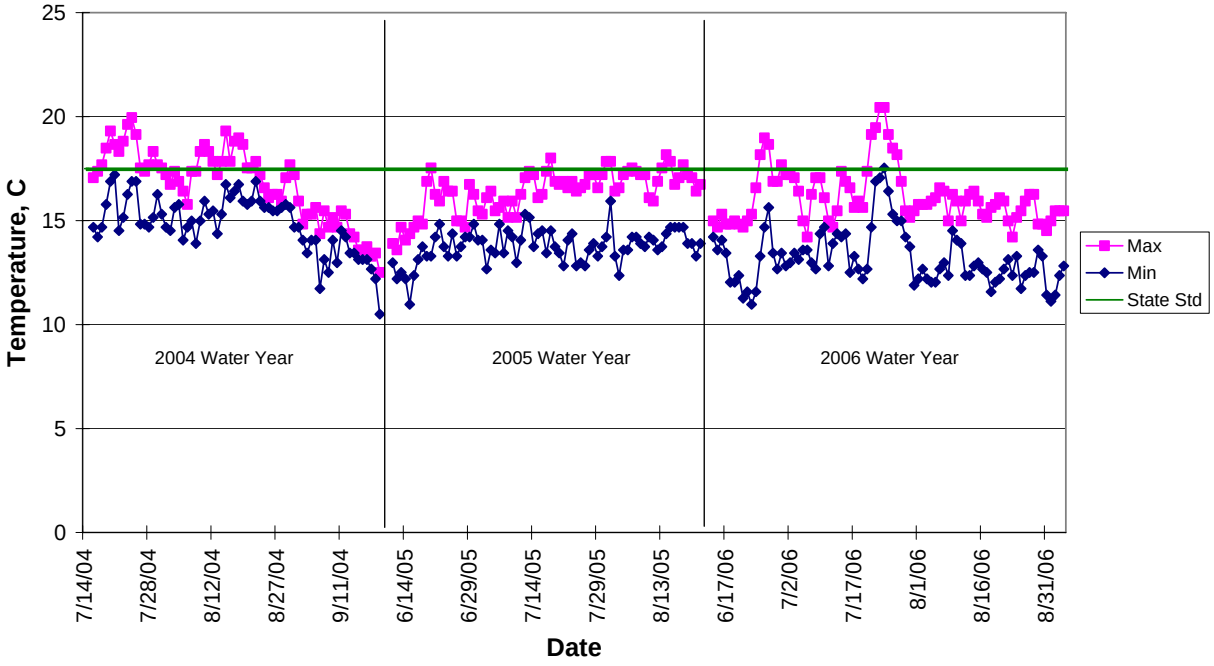
Thomas Creek at F&S Grade Rd - Site 4
Temperature



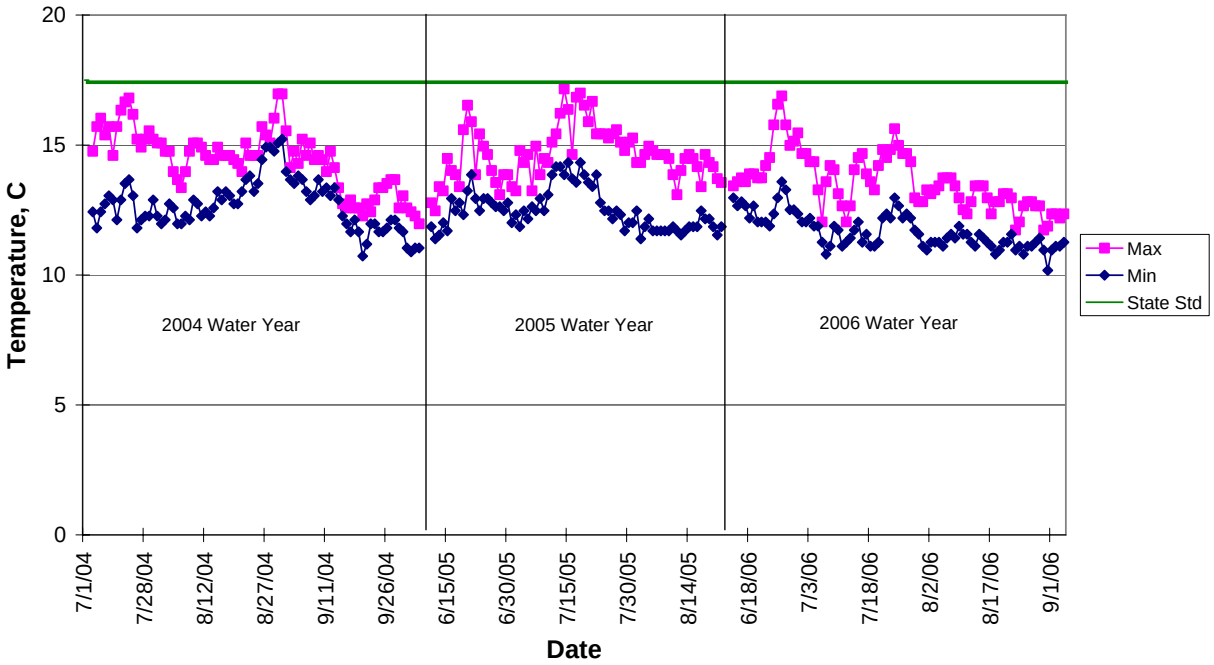
Friday Creek at Prairie Rd - Site 6
Temperature



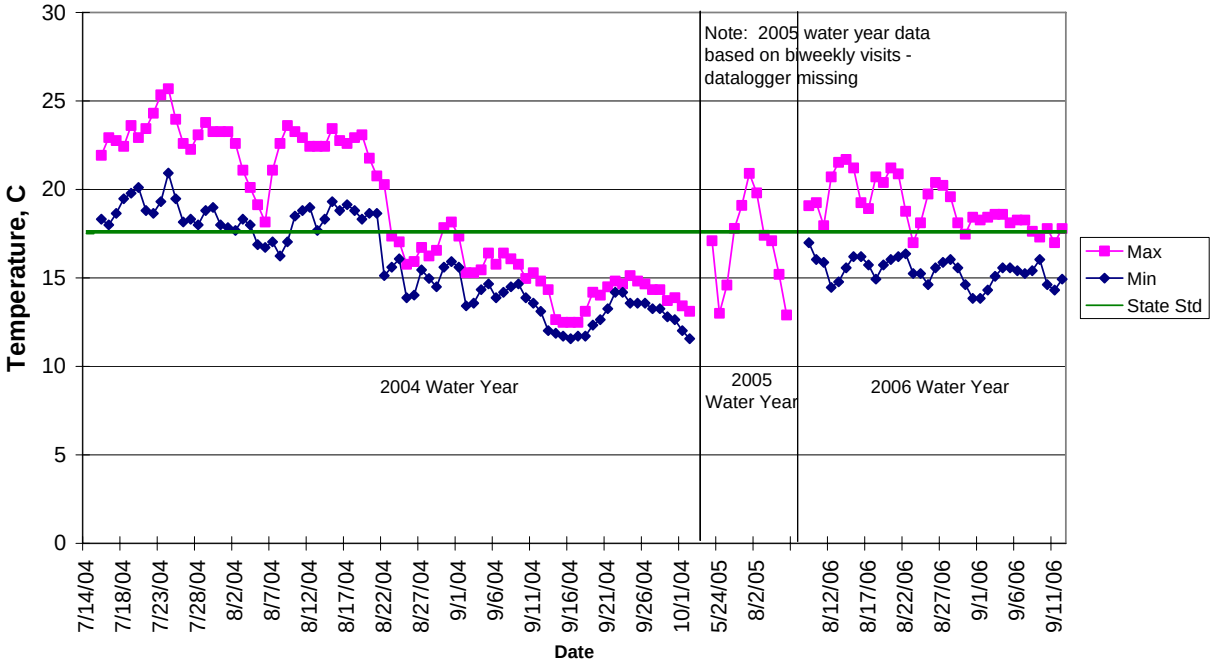
Swede Creek at Grip Rd - Site 8
Temperature



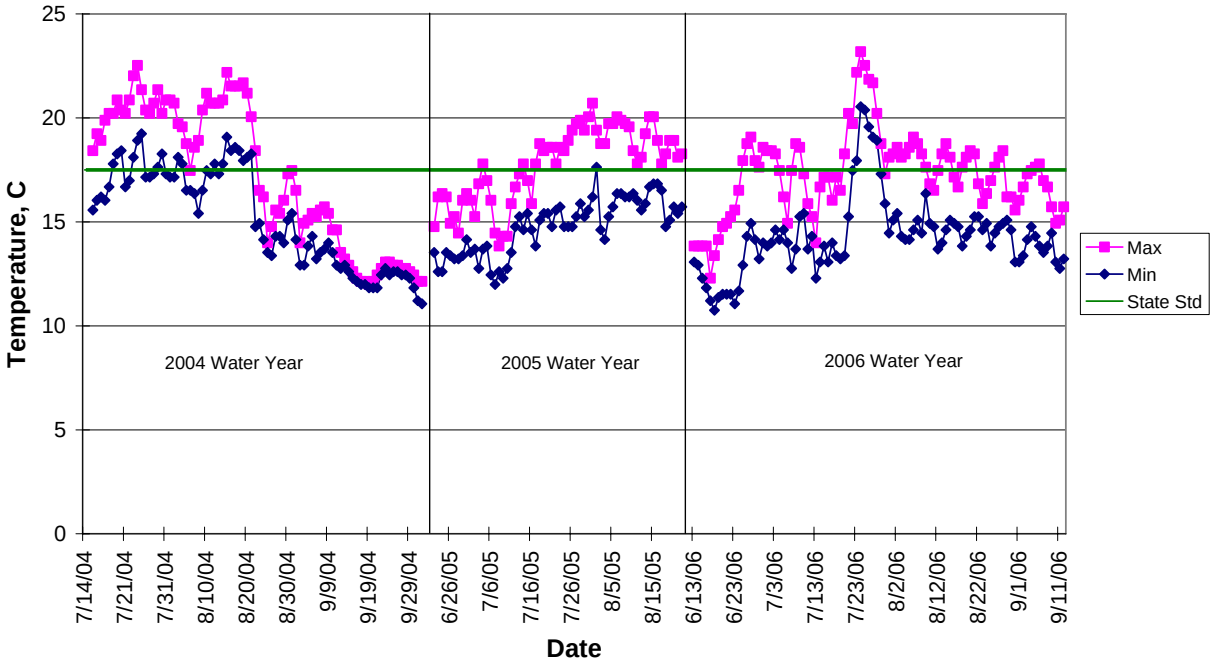
Samish River at Hwy 9 - Site 11
Temperature



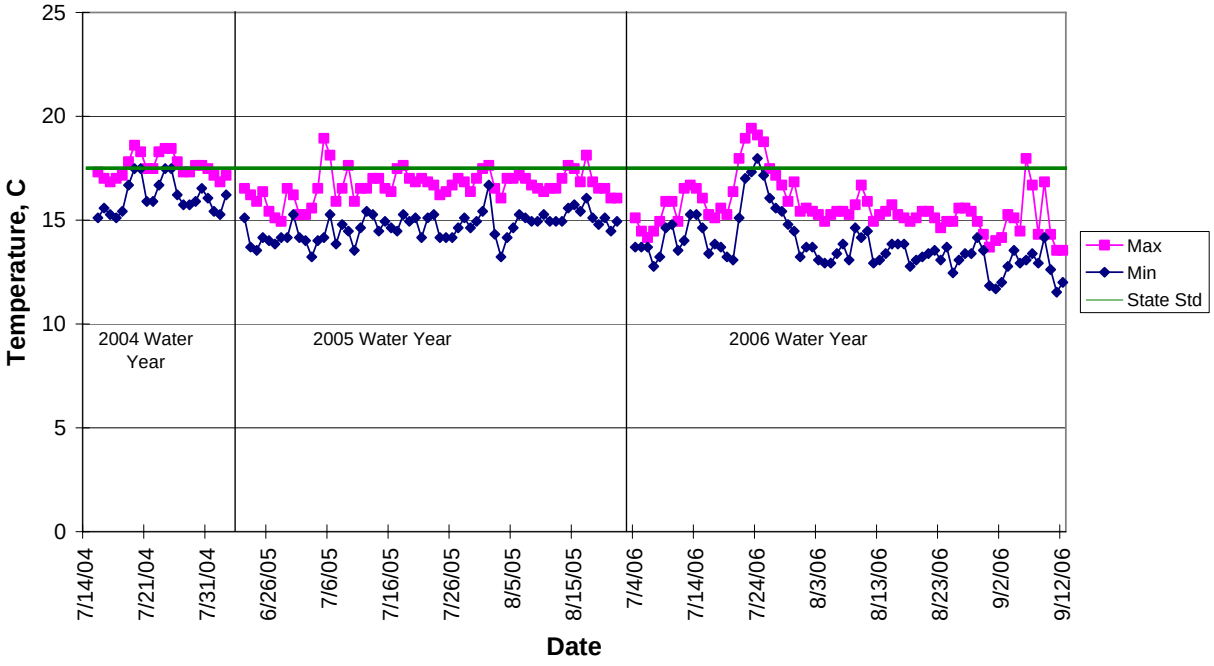
Nookachamps Creek at Swan Rd - Site 12
Temperature



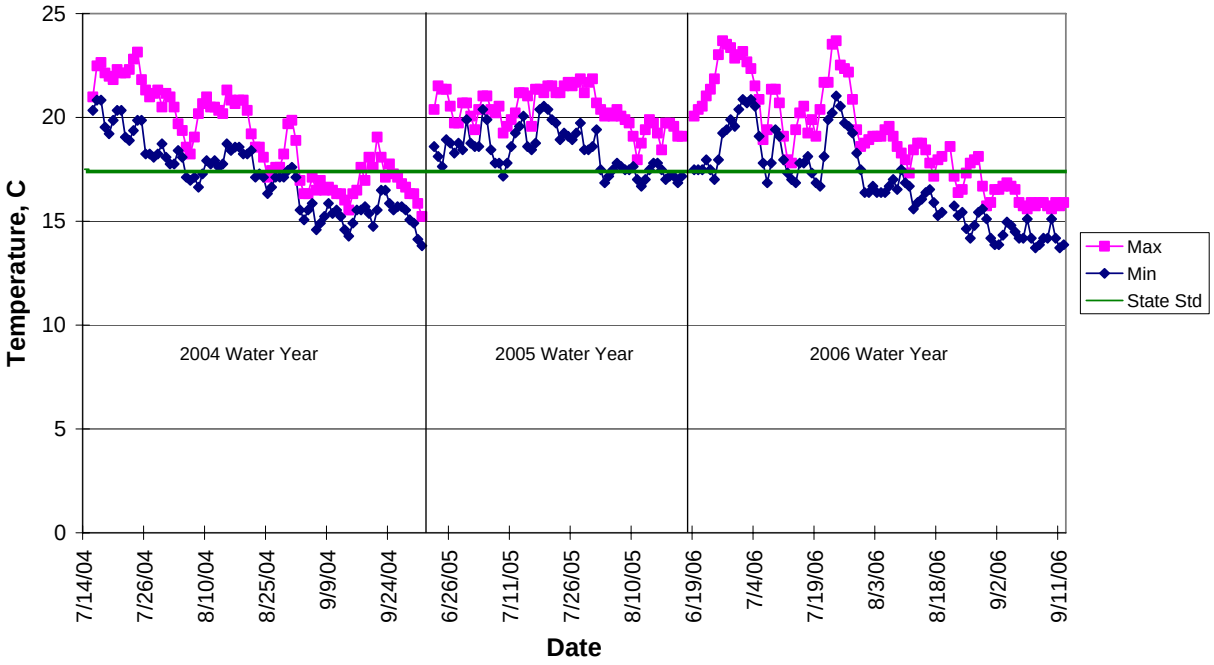
EF Nookachamps Creek at Hwy 9 - Site 13
Temperature



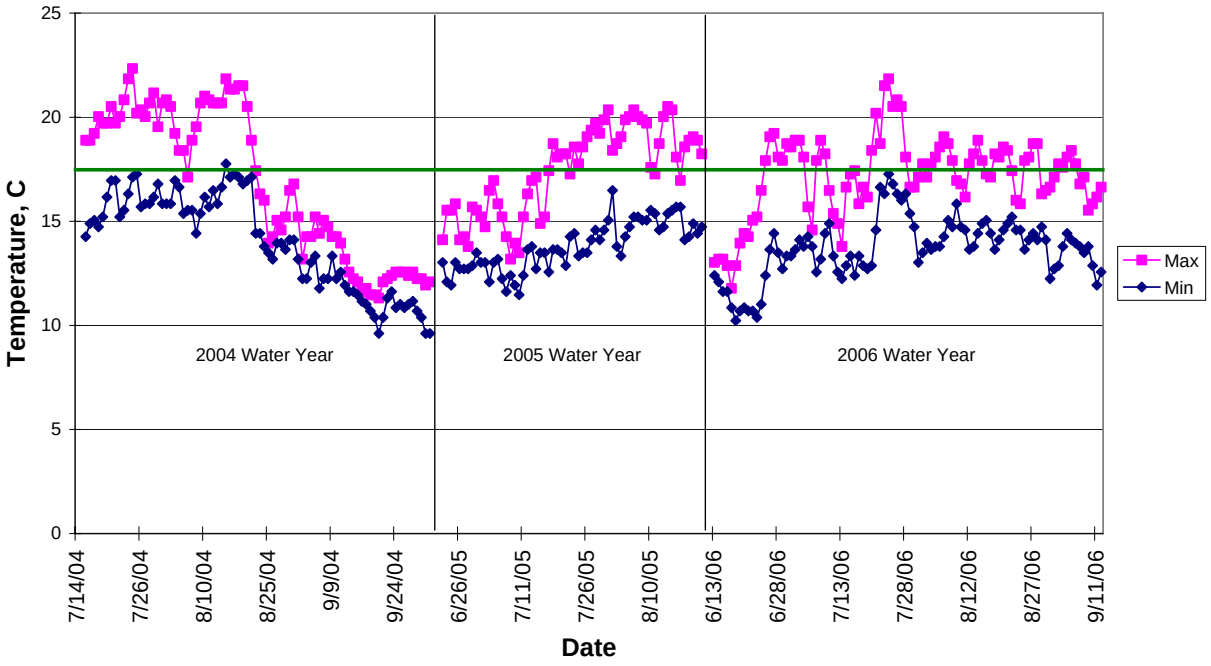
College Way Creek at College Way - Site 14
Temperature



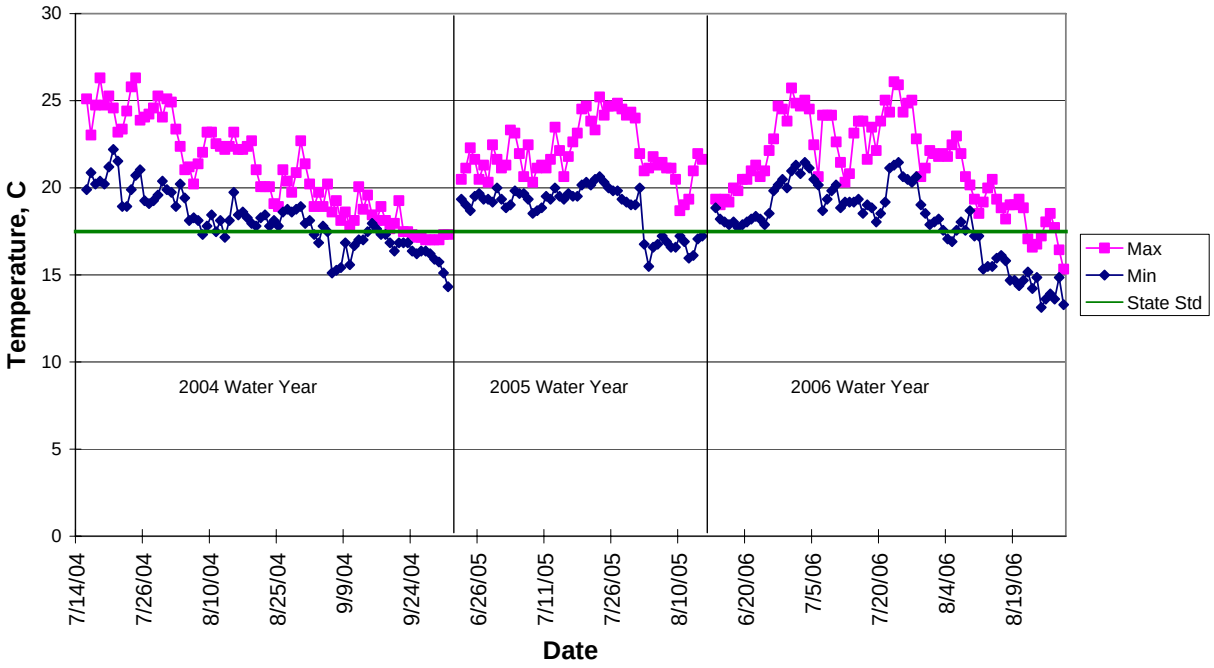
Nookachamps Creek at Knapp Rd - Site 15
Temperature



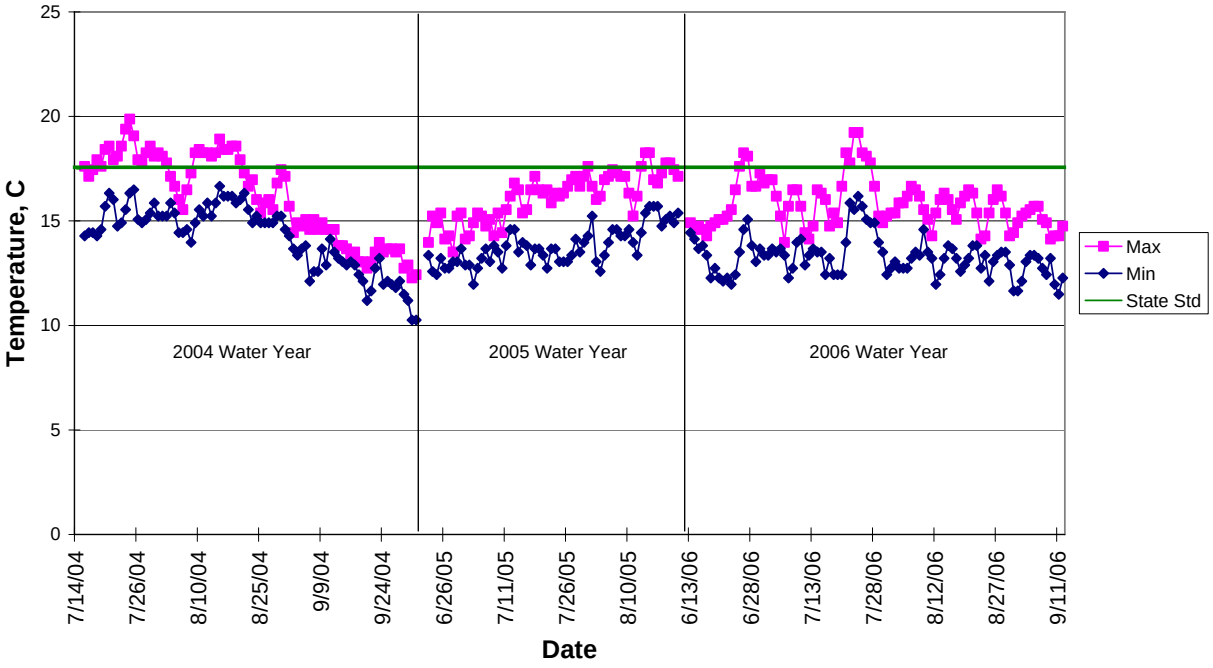
EF Nookachamps Creek at Beaver Lk Rd - Site 16
Temperature



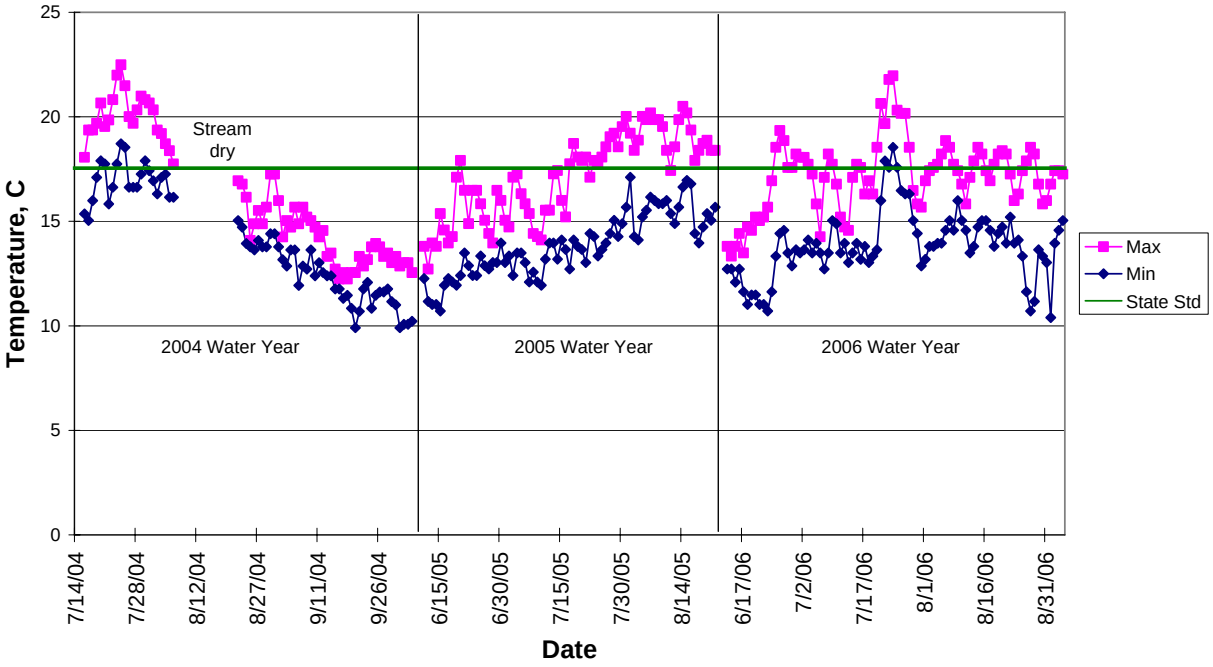
Nookachamps Creek at Big Lake Outlet - Site 17
Temperature



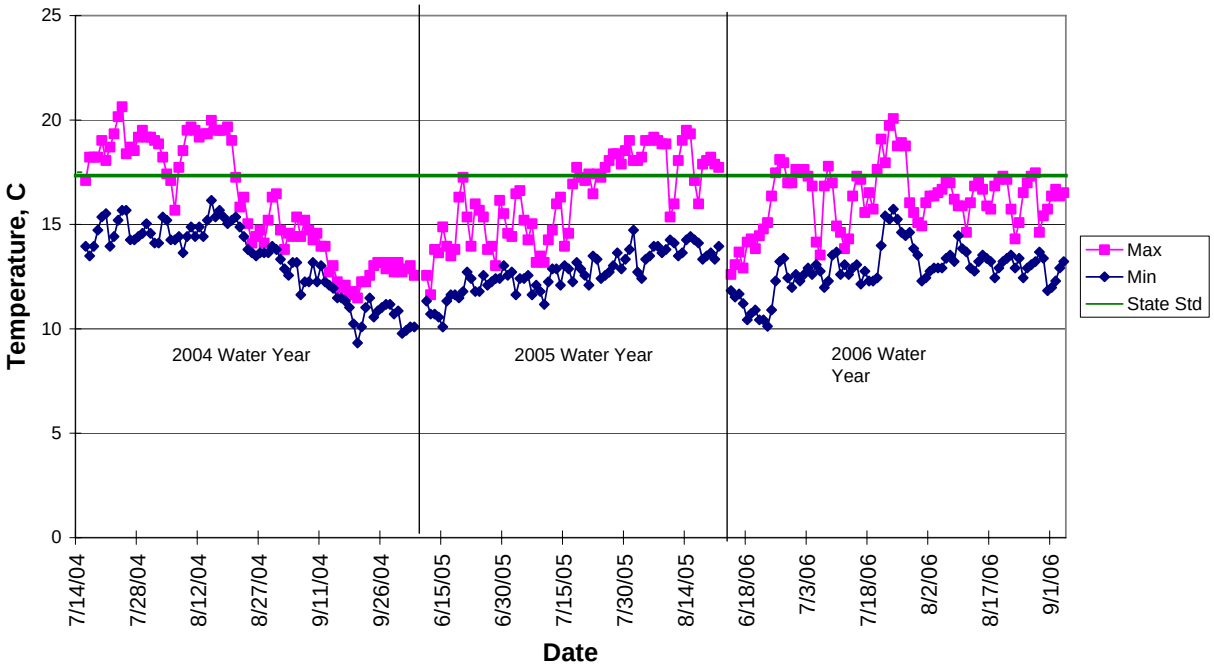
Lake Creek at Hwy 9 - Site 18
Temperature



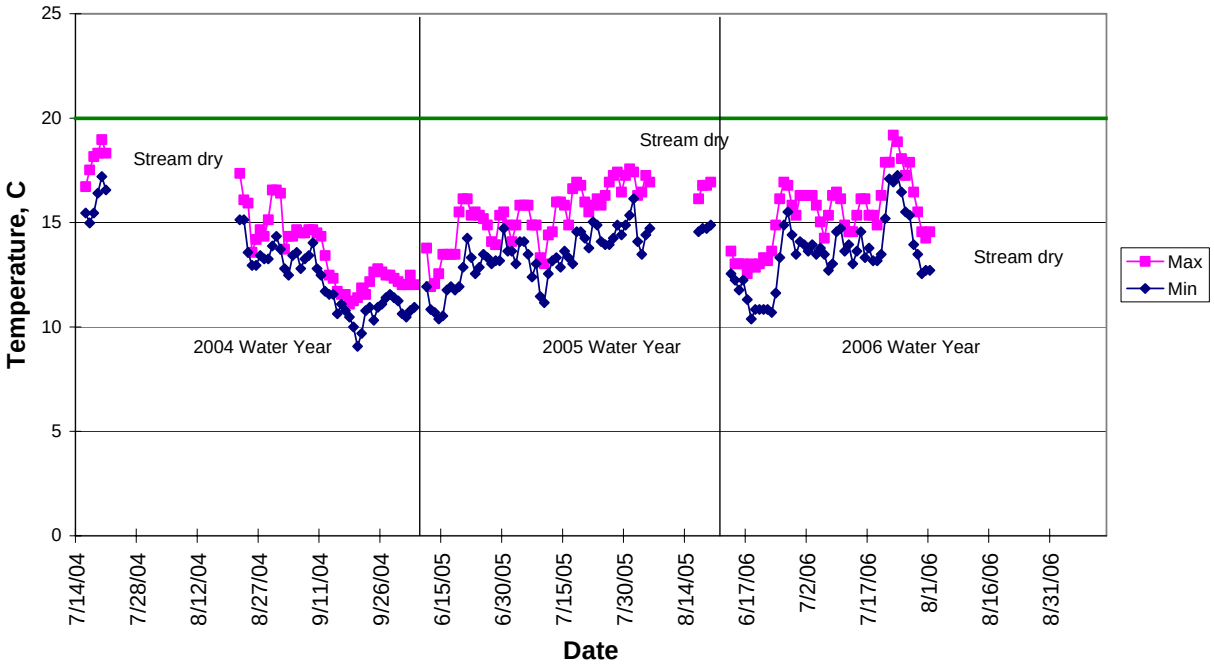
Hansen Creek at Hoehn Rd - Site 19
Temperature



Hansen Creek at Northern State Hospital - Site 20
Temperature



Coal Creek at Hoehn Rd - Site 21
Temperature



Coal Creek at Hwy 20 - Site 22
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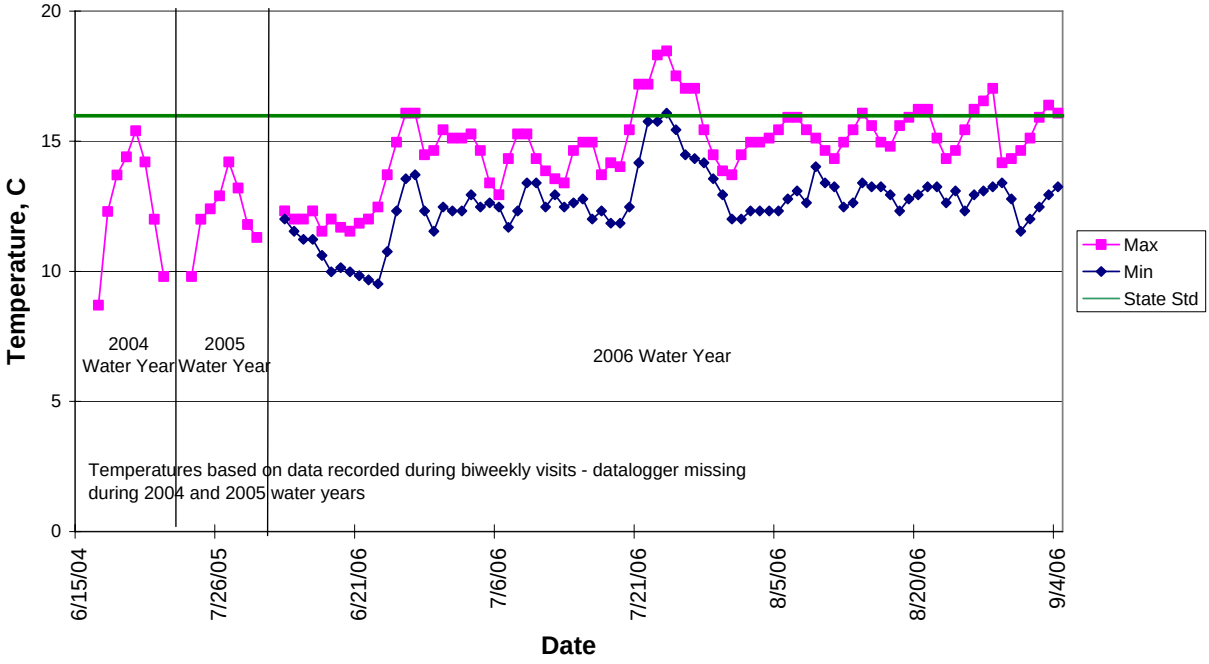
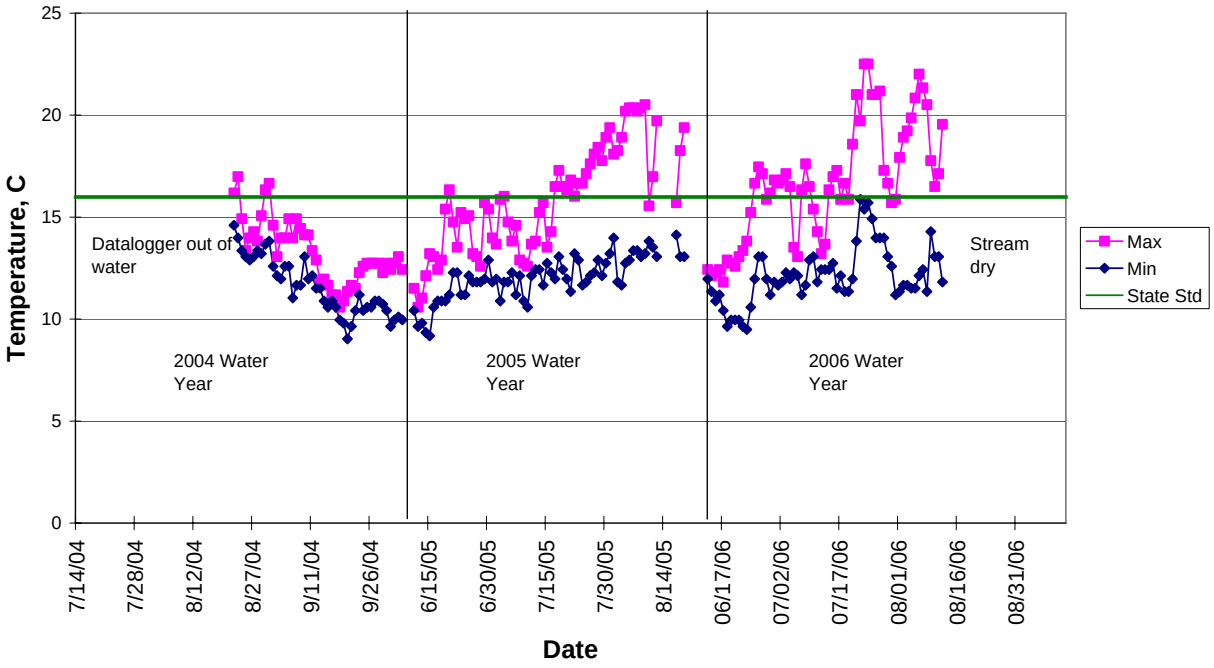
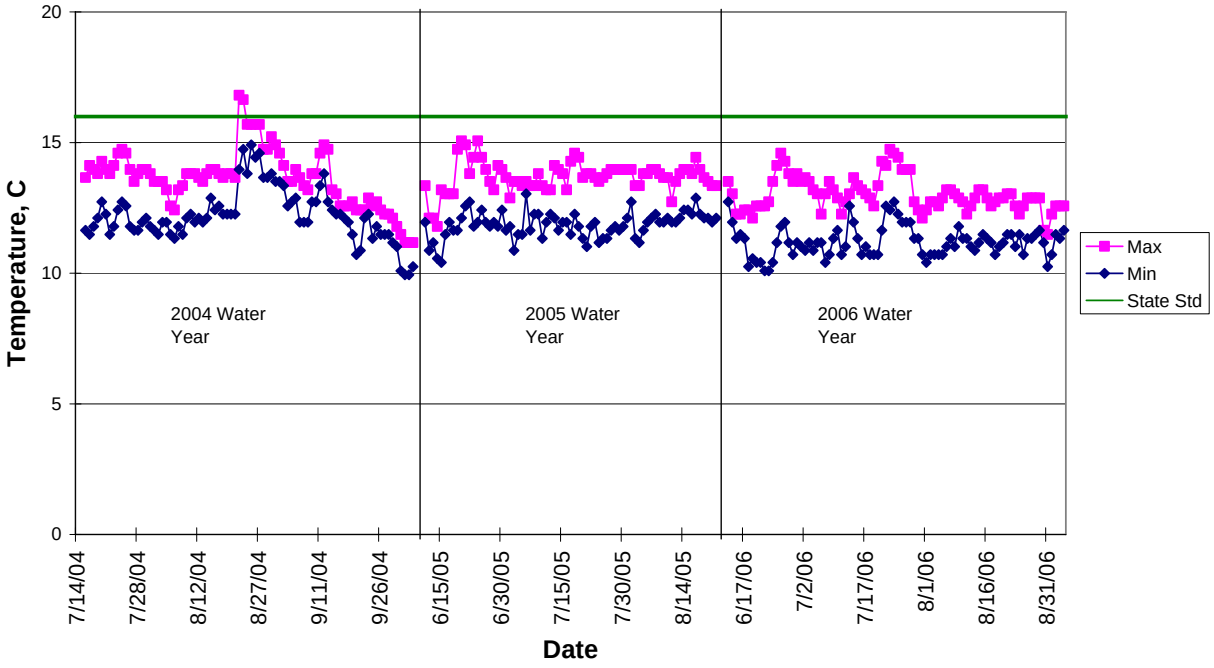


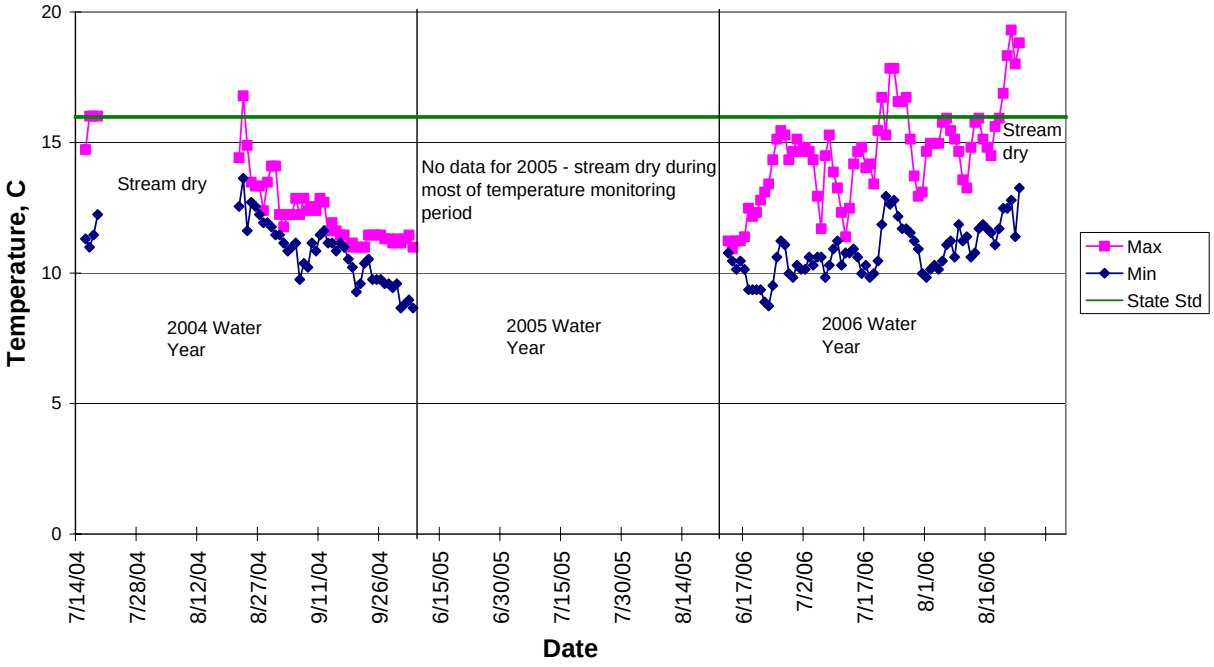
Wiseman Creek at Minkler Rd - Site 23
Temperature



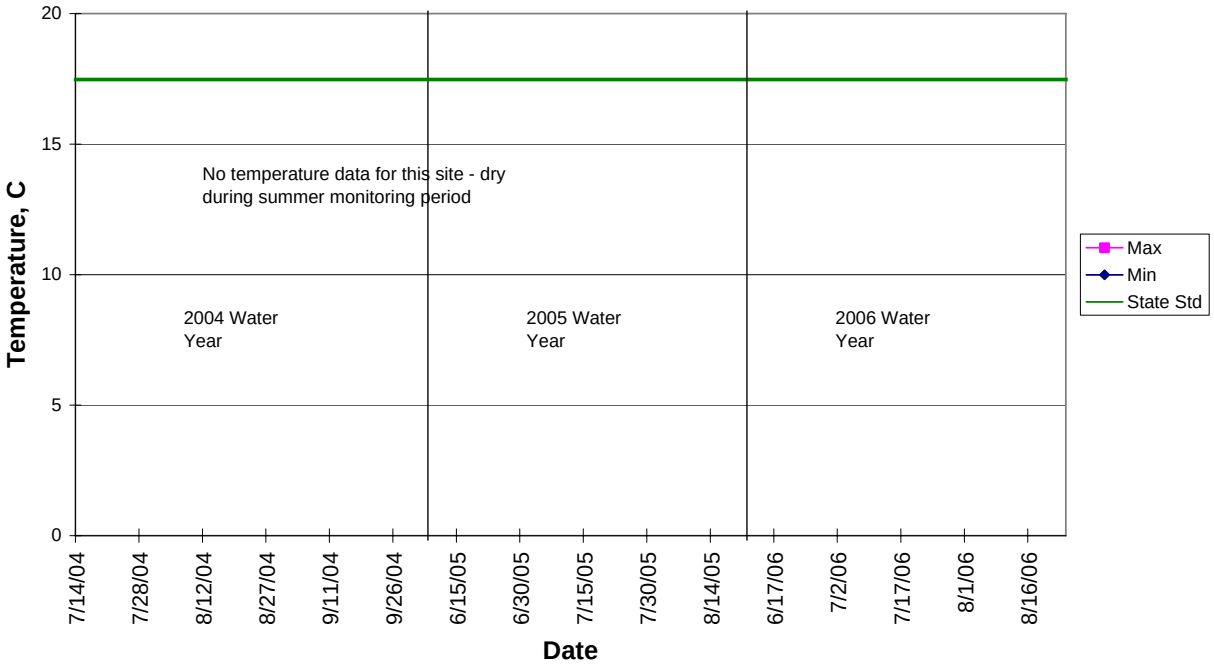
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Temperature



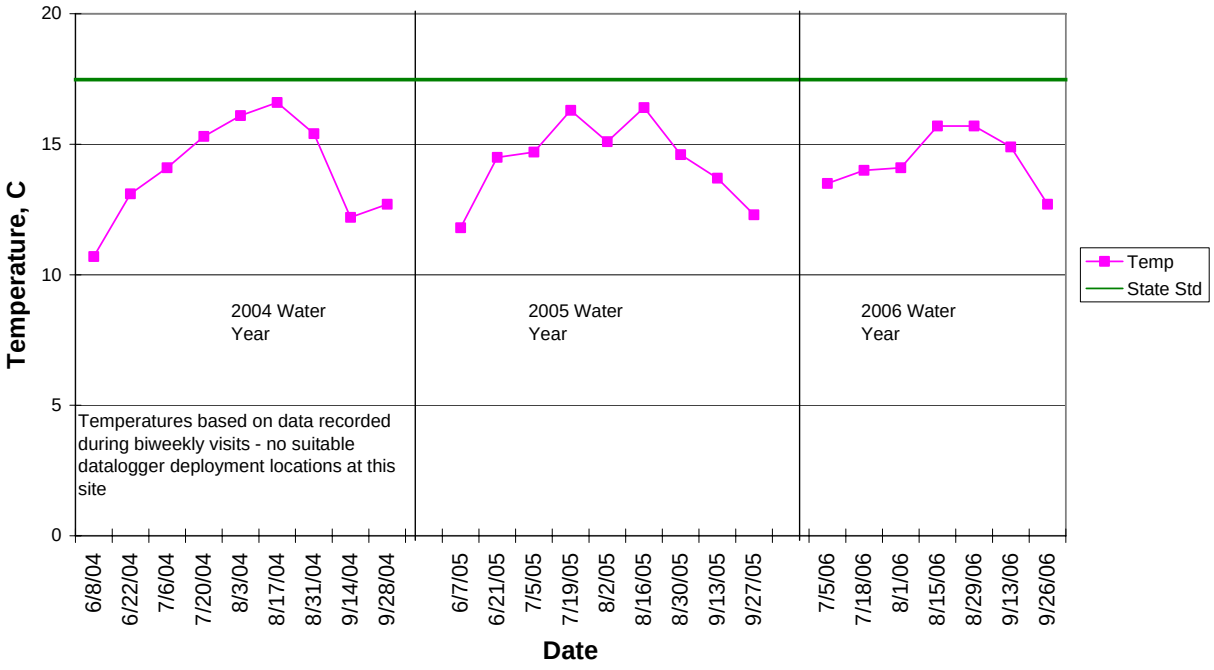
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Temperature



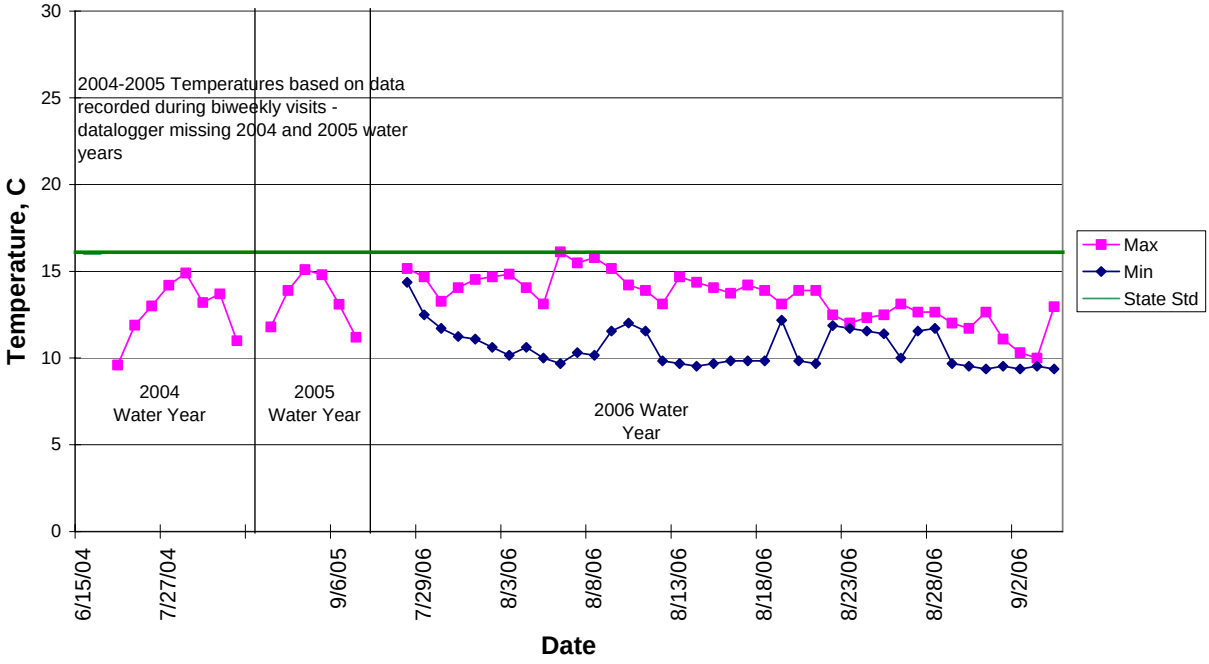
Brickyard Creek at Hwy 20 - Site 28
Temperature



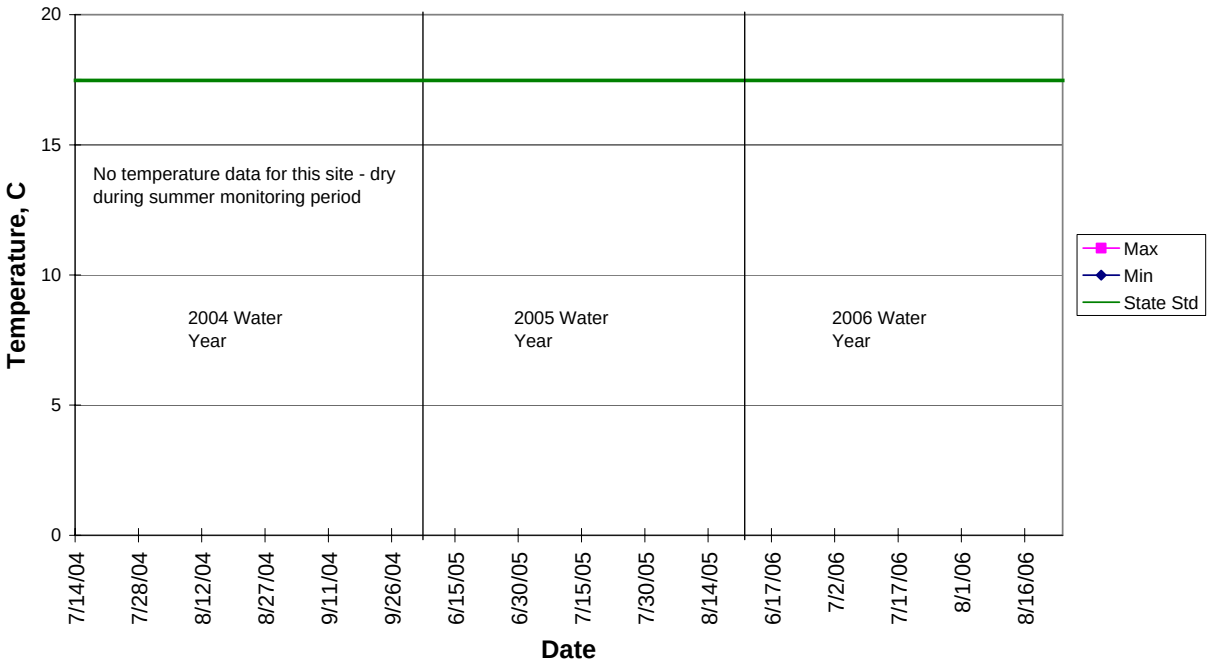
Skagit River at River Bend Rd - Site 29
Temperature



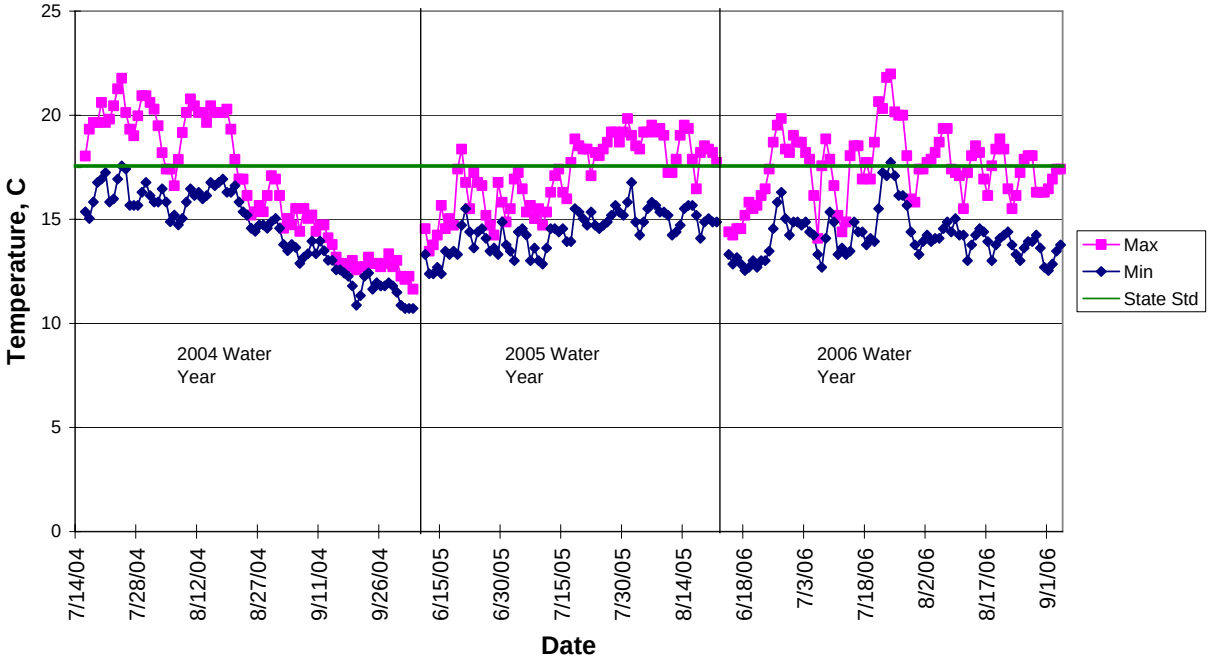
Skagit River at Cape Horn Rd - Site 30
Temperature



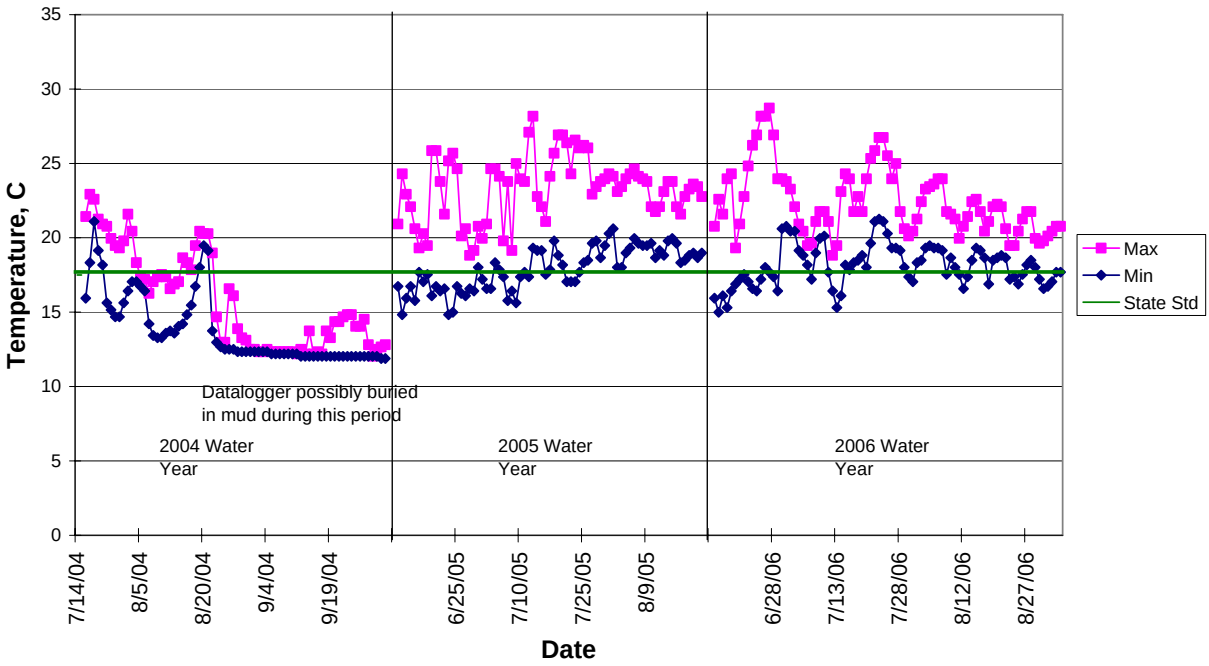
Drainage District 20 Ditch at Floodgate - Site 31
Temperature



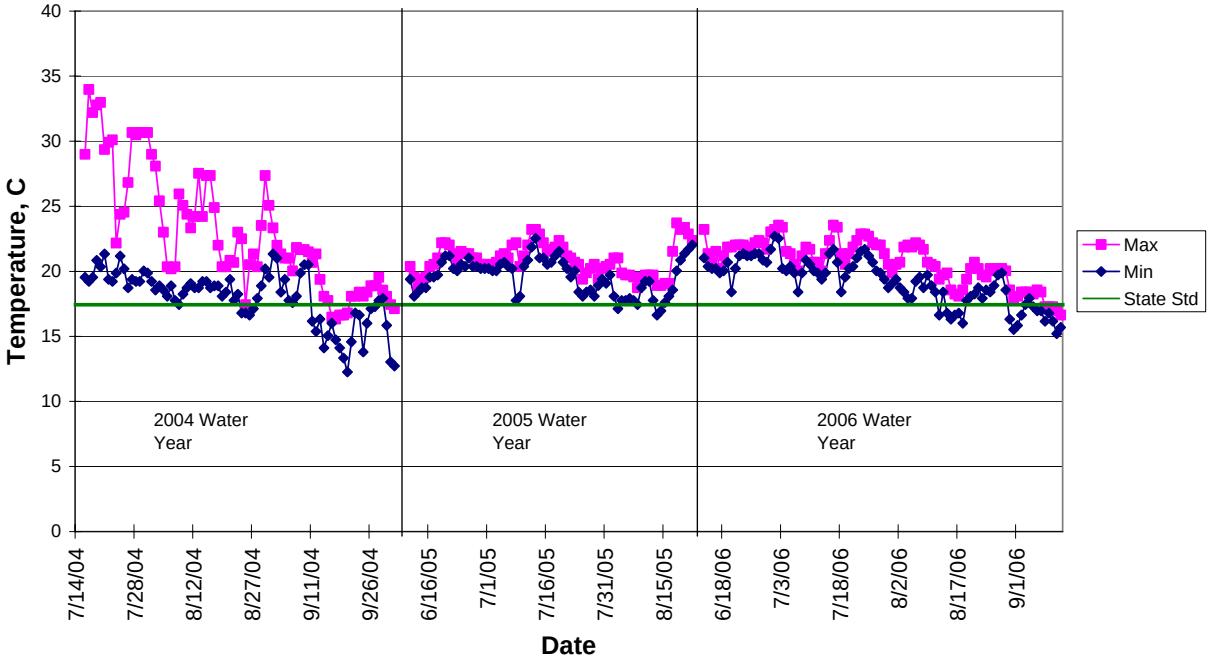
Samish River at Thomas Rd - Site 32
Temperature



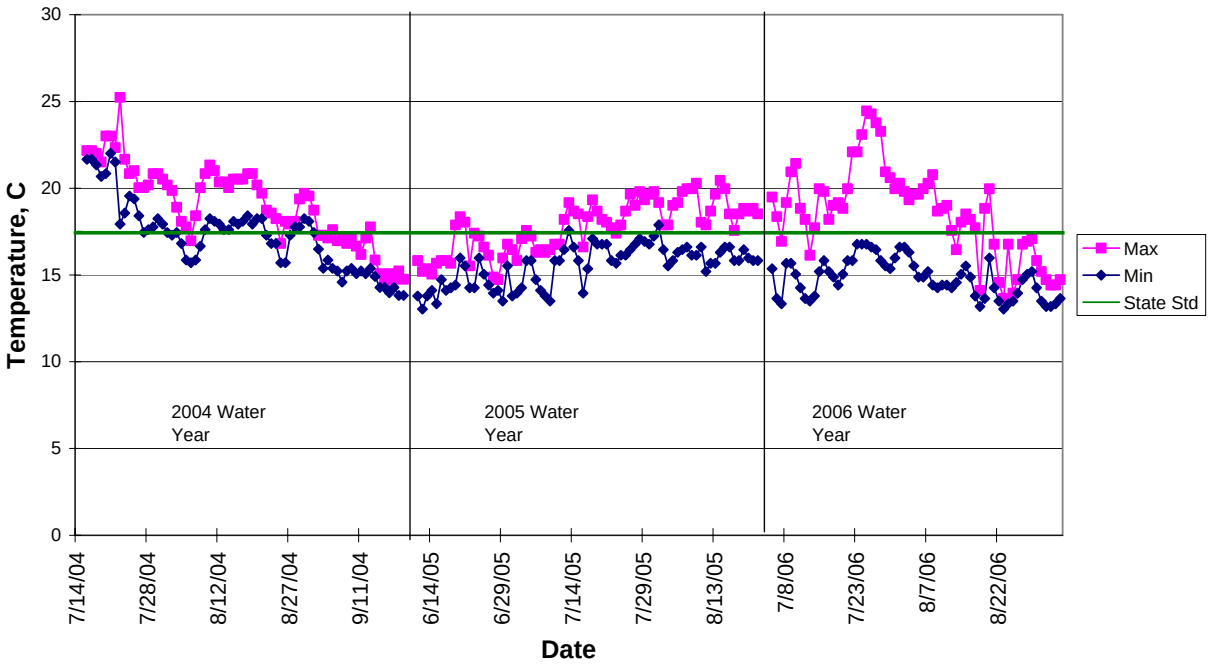
Alice Bay Pump Station - Site 33
Temperature



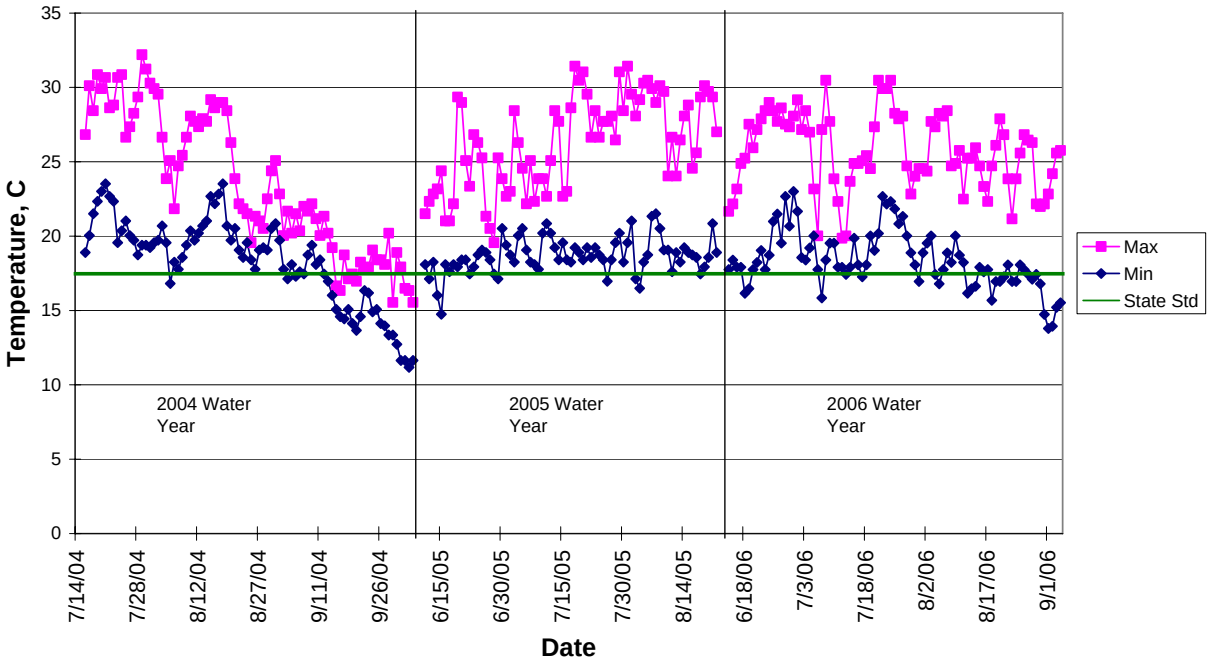
No Name Slough at Bayview-Edison Rd - Site 34
Temperature



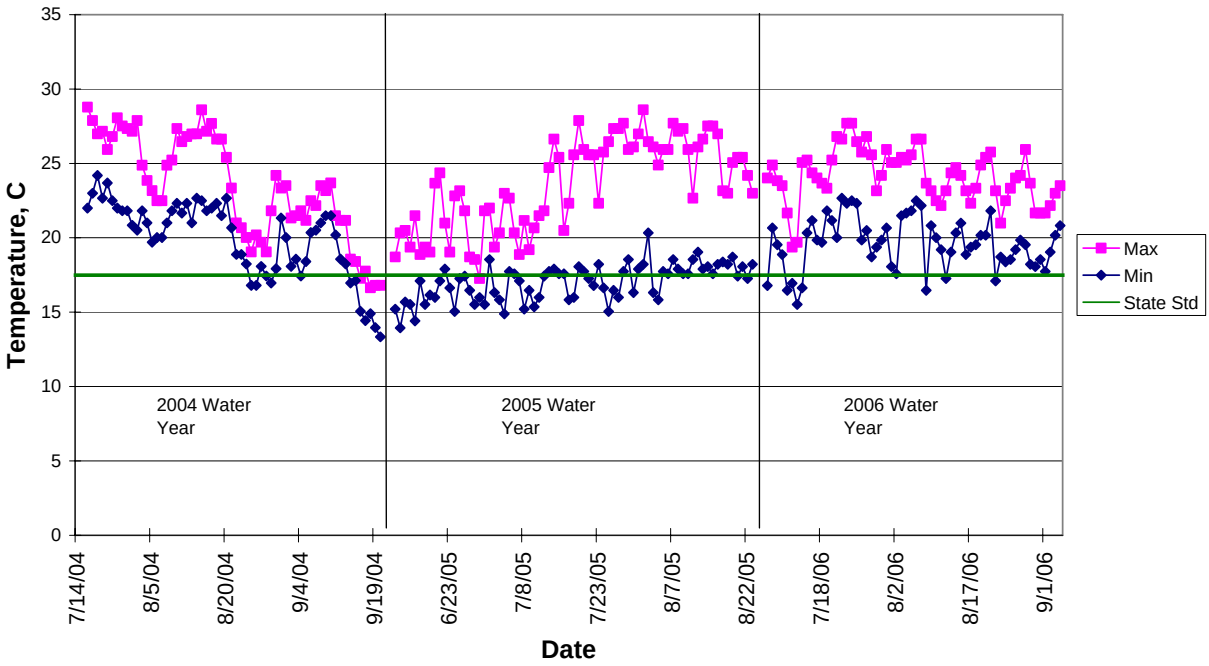
Joe Leary Slough at D'Arcy Rd - Site 35
Temperature



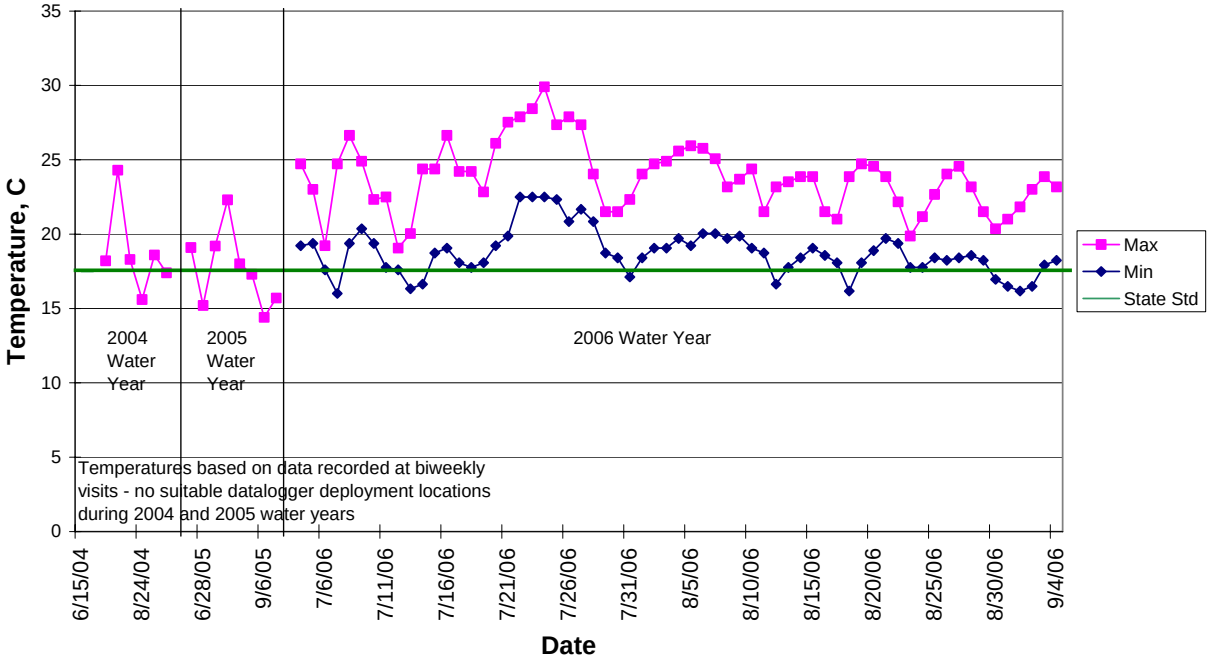
Edison Slough at School - Site 36
Temperature



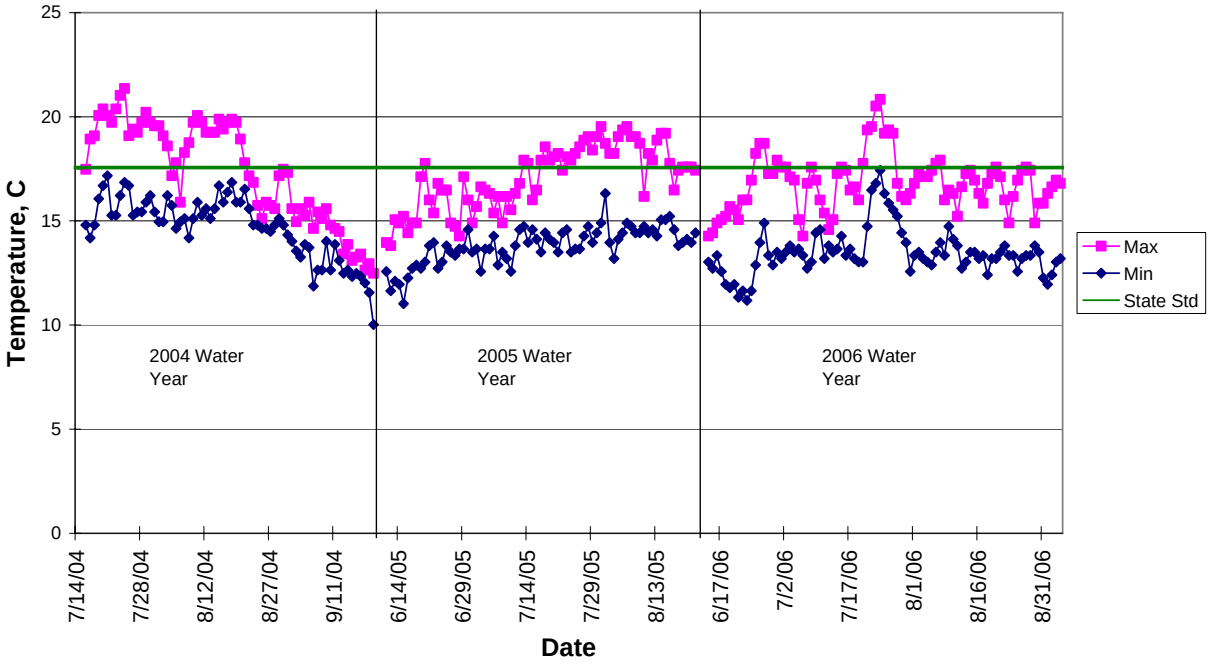
Edison Pump Station - Site 37
Temperature



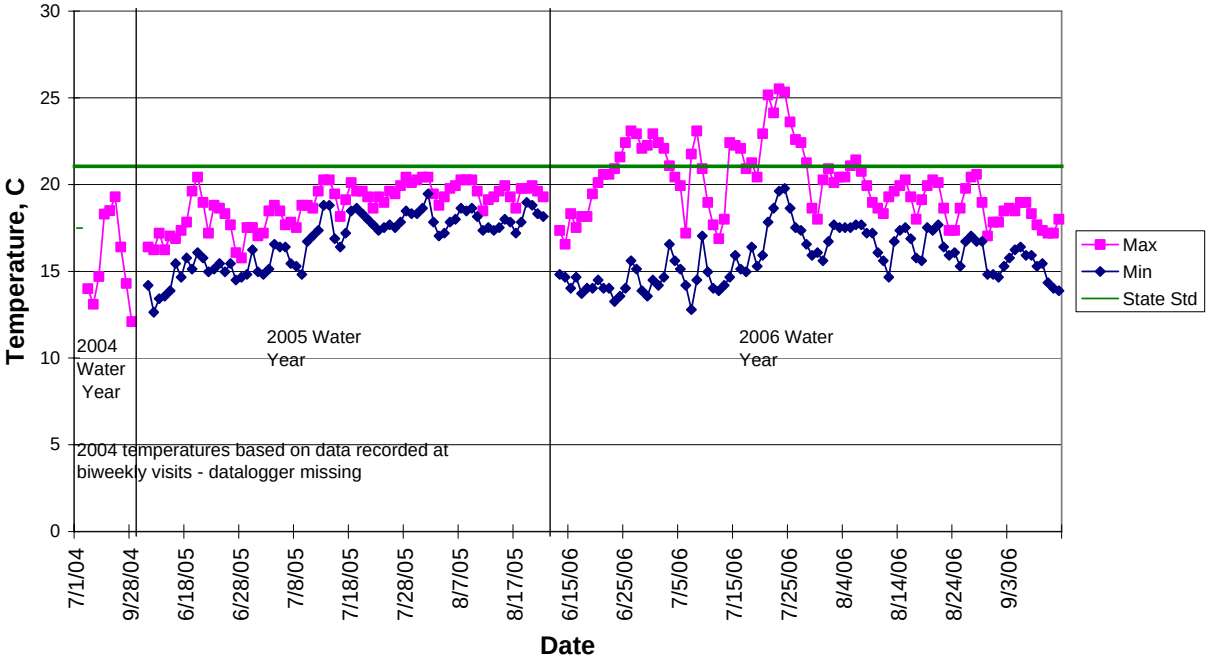
North Edison Pump Station - Site 38
Temperature



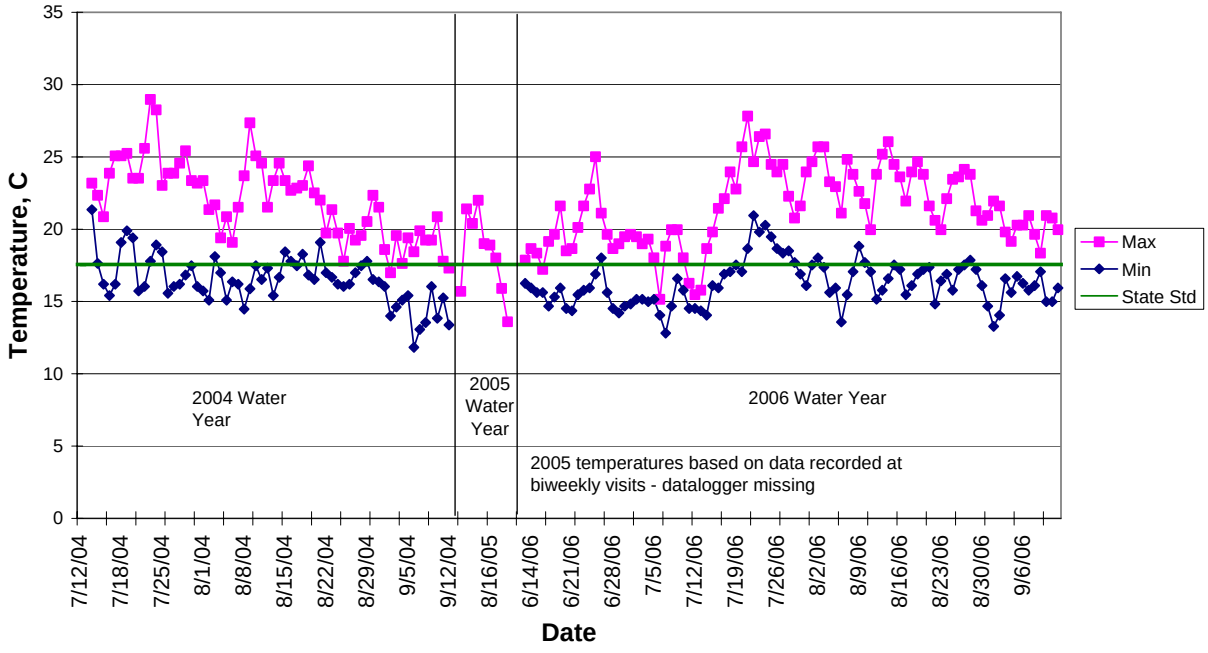
Colony Creek at Colony Rd - Site 39
Temperature



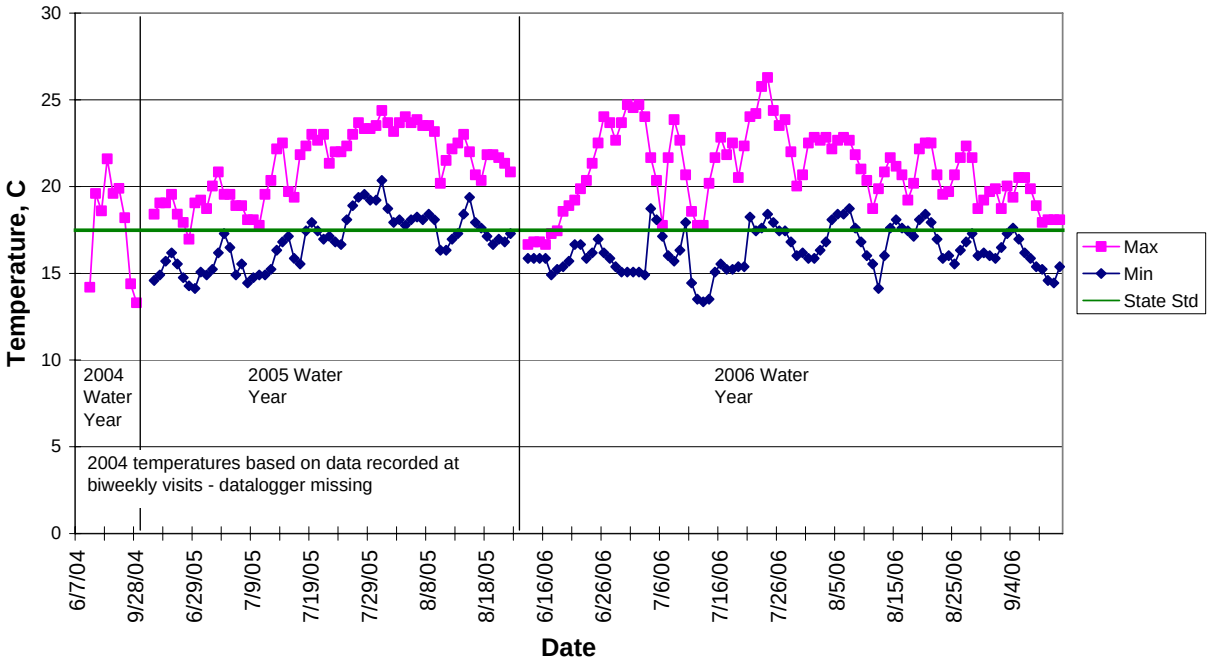
Big Indian Slough at Hwy 20 Truck Scales - Site 40 Temperature



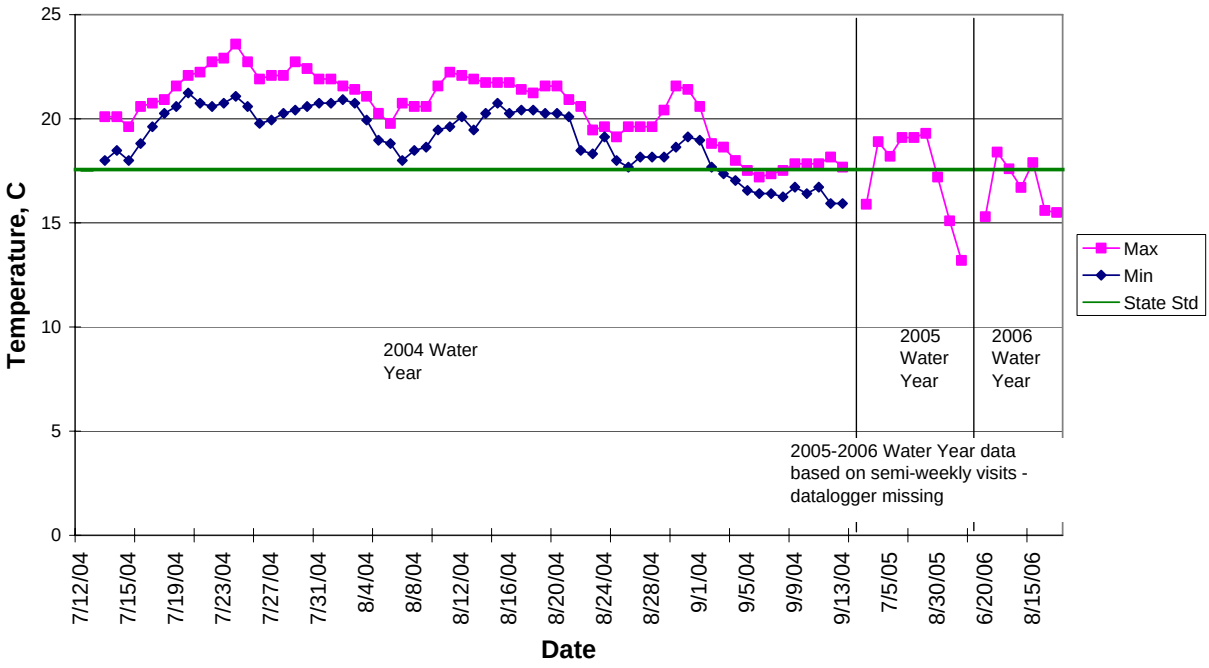
Maddox Creek / Big Ditch at Milltown Rd - Site 41 Temperature



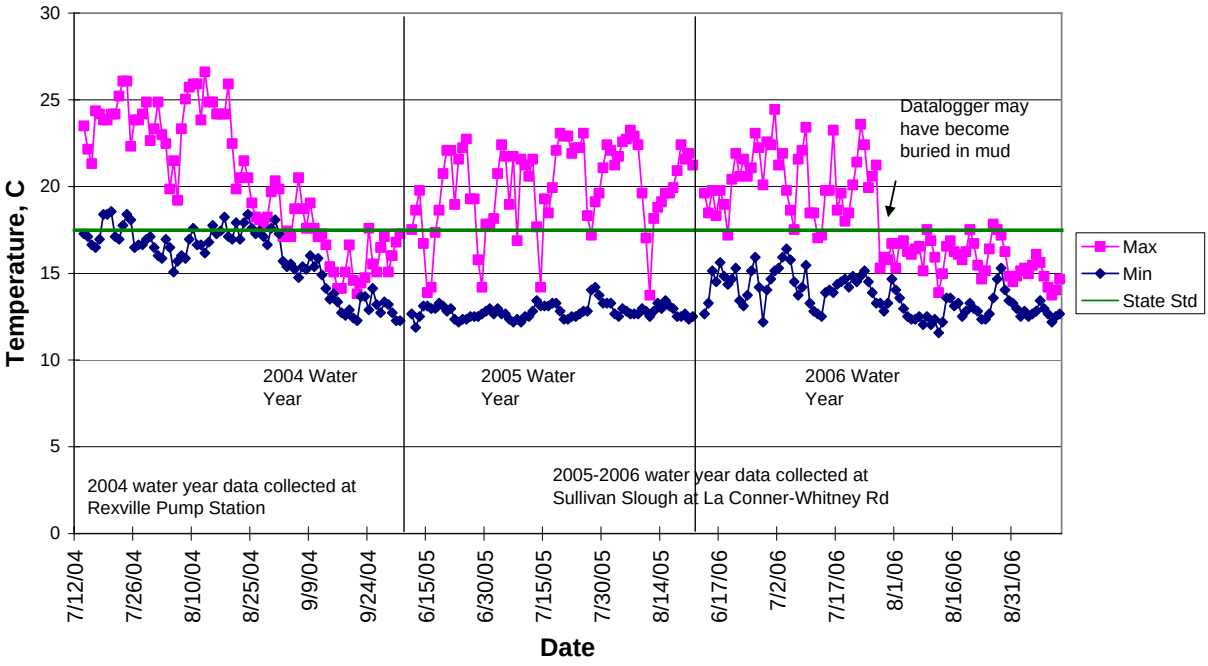
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Temperature



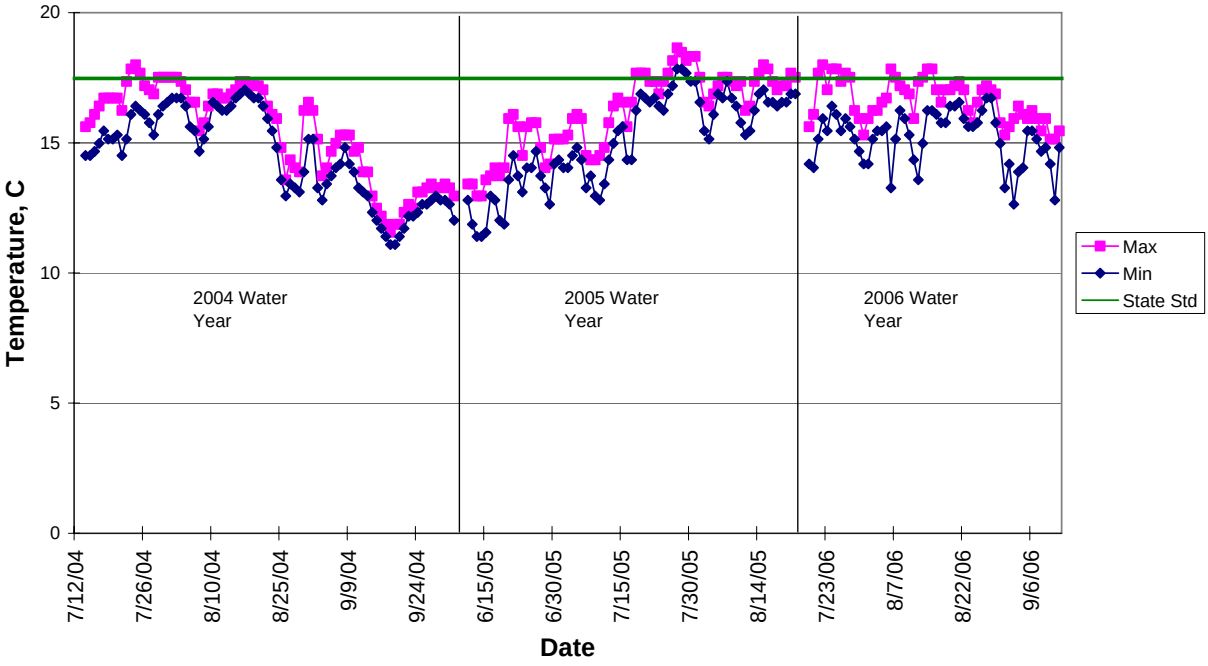
Wiley Slough at Wylie Rd - Site 43
Temperature



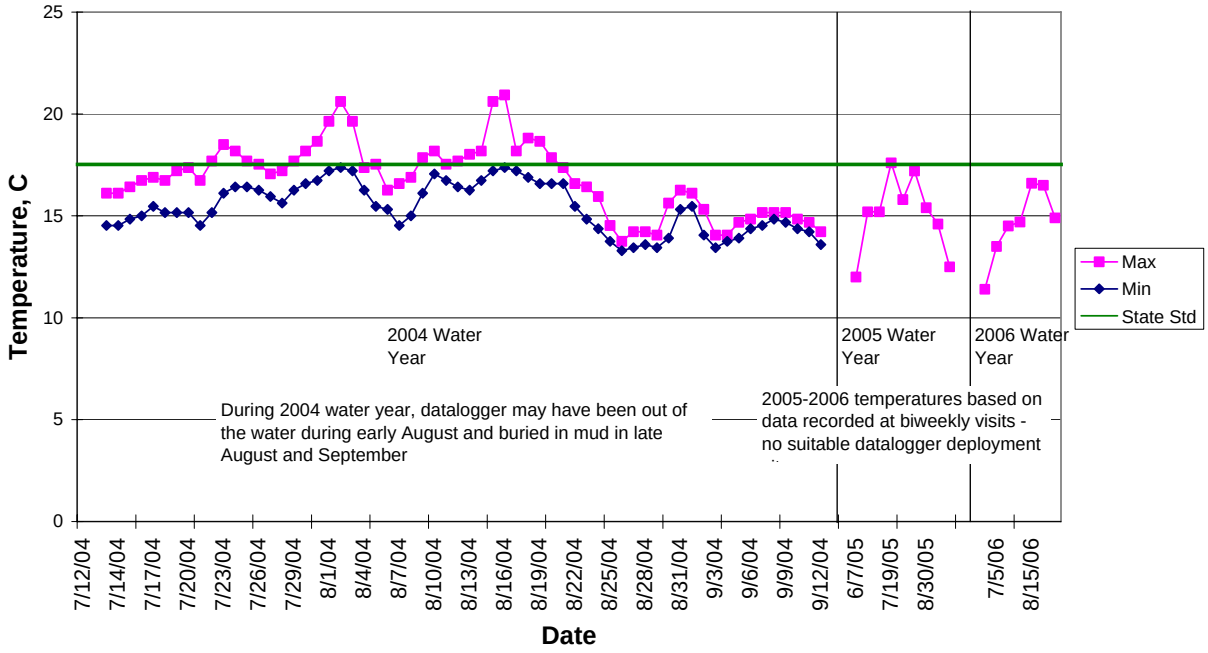
Sullivan Slough at La Conner-Whitney Rd - Site 44
Temperature



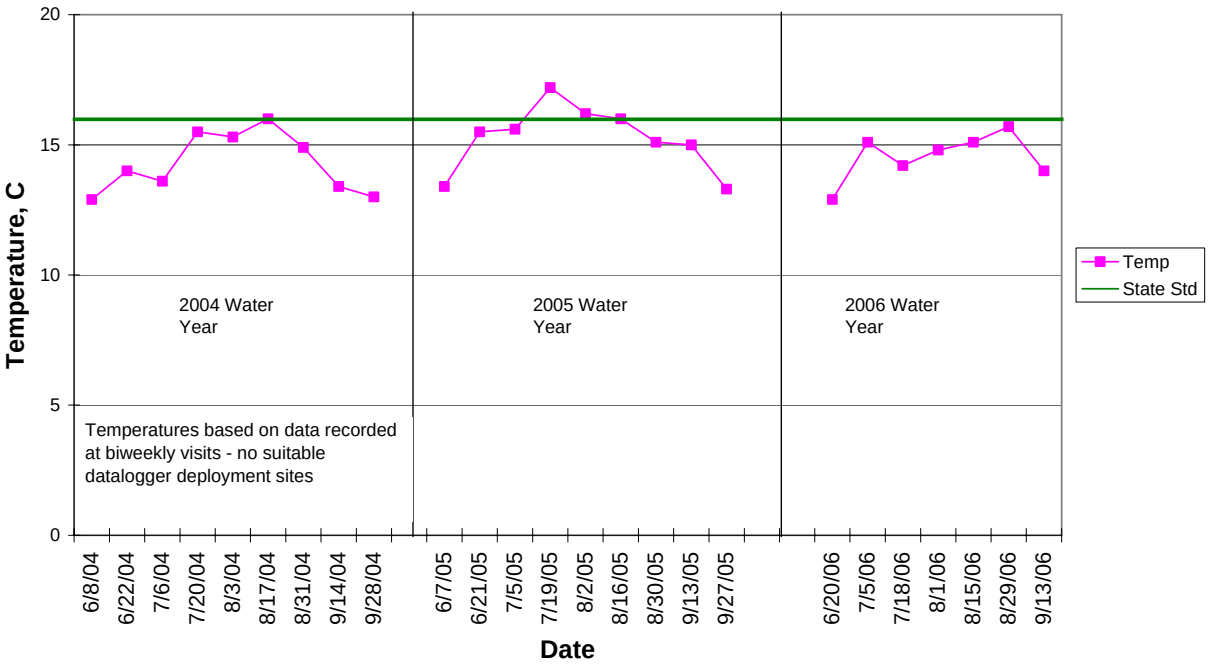
North Fork Skagit River near Moore Rd - Site 45
Temperature

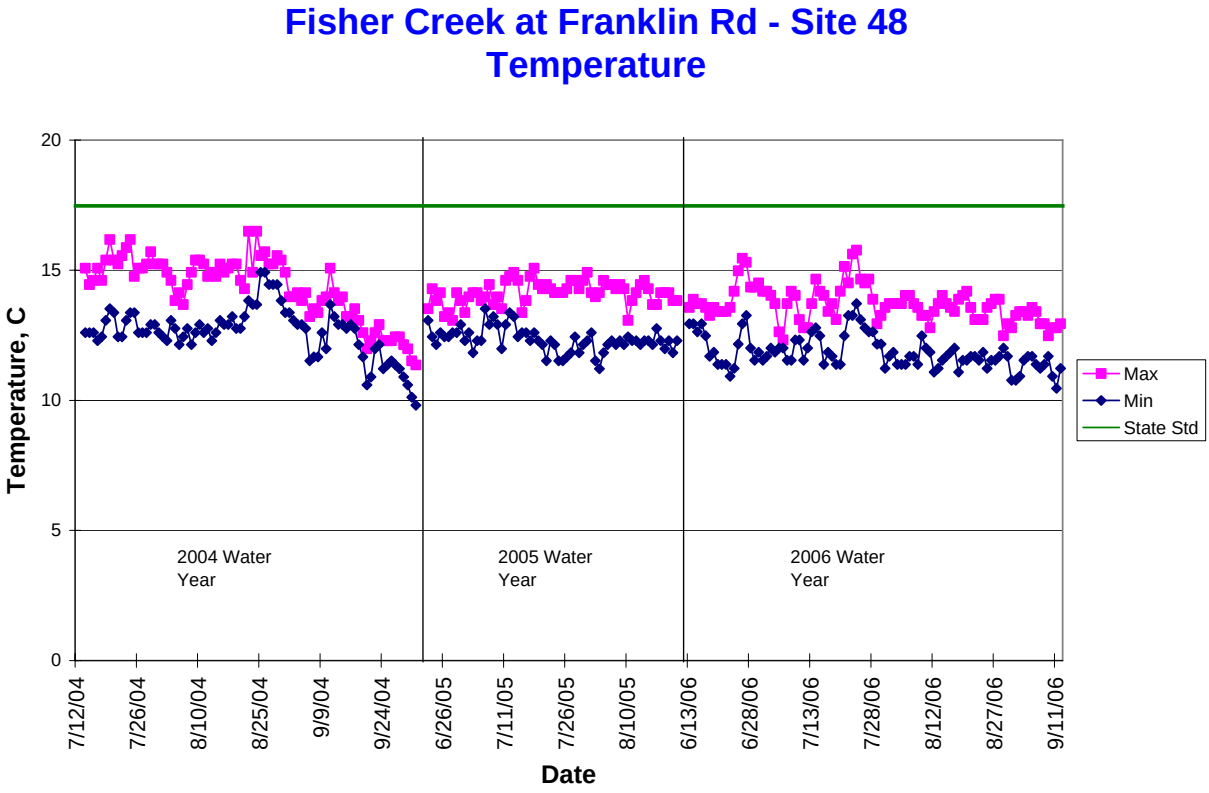


S F Skagit River at Conway Boat Ramp - Site 46
Temperature



Swinomish Channel at County Boat Ramp - Site 47
Temperature




Fisher Creek at Franklin Rd - Site 48
Temperature
Temperature, C
20
15
10
5
0
2004 Water Year
2005 Water Year
2006 Water Year
7/12/04
7/26/04
8/10/04
8/25/04
9/9/04
9/24/04
6/26/05
7/11/05
7/26/05
8/10/05
6/13/06
6/28/06
7/13/06
7/28/06
8/12/06
8/27/06
9/11/06
Date
Max
Min
State Std

Dissolved Oxygen

Dissolved oxygen (DO) measurements determine how much oxygen is available in the water for fish and other organisms. DO measurements were taken at each site during each visit. A summary of DO readings (in mg/L) obtained during the 2006 water year is provided in Table 4. The pages following Table 4 contain graphs illustrating dissolved oxygen levels at all sample sites for the 2004-2006 water years.

The state water quality standards for dissolved oxygen are based on single-day minimum measurements. For most watercourses in the Skagit County Monitoring Program (sites 3-20, 28-29, 31-46, 48), the minimum standard is 8.0 mg/L. For the upriver sites (sites 21-25, 30), the standard is 9.5 mg/L. For the marine site (site 47), the standard is 6.0 mg/L. The solubility of oxygen in water is inversely related to temperature, so that higher temperatures frequently result in lower dissolved oxygen values.

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

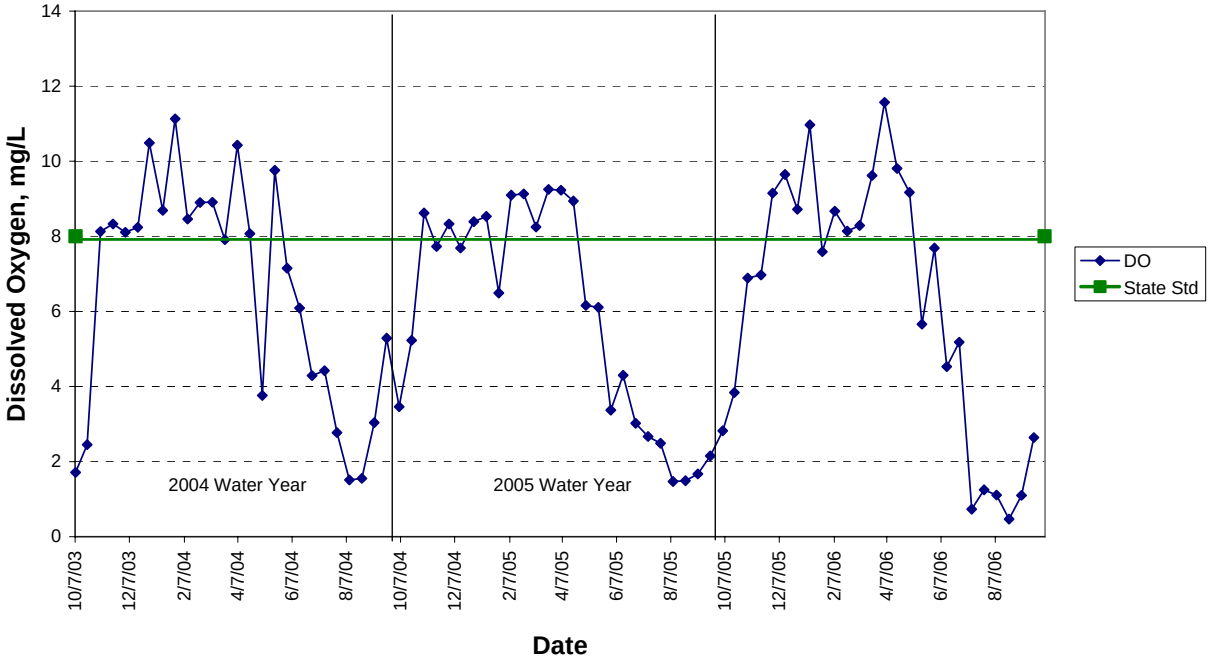
In the drainage infrastructure and lower sloughs, dissolved oxygen levels can be greatly influenced by algal activity. During large algae blooms, the oxygen produced during photosynthesis can lead to very high oxygen levels during the day. However, at those same times, nighttime oxygen levels can be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

Table 4. Dissolved oxygen (DO) measurements in the Skagit County Monitoring Program – 2005 Water Year

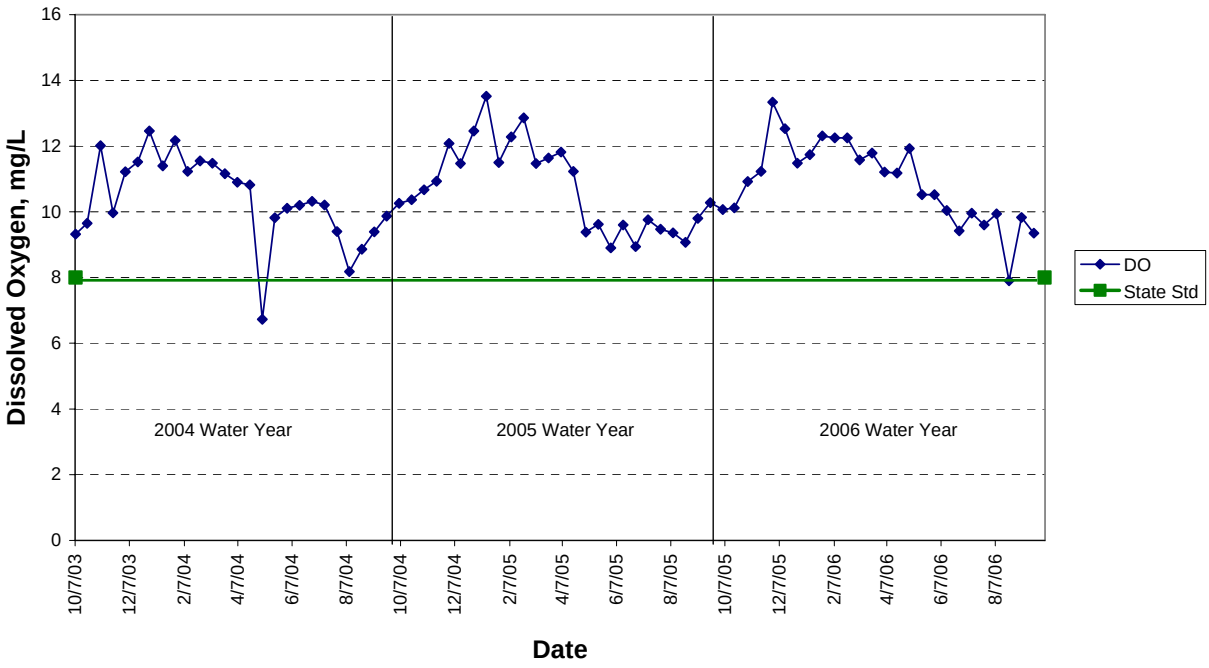
Site Number	Watercourse	Location	Mean DO (mg/L)	Minimum DO (mg/L)	St. Std[1]
3	Thomas Ck	Old Hwy 99 N	6.2	0.5	8.0
4	Thomas Ck	F&S Grade	10.9	7.9	8.0
6	Friday Ck	Prairie Rd	11.1	9.4	8.0
8	Swede Ck	Grip Rd	11.2	8.6	8.0
11	Samish R	State Route 9	8.4	6.5	8.0
12	Nookachamps Ck	Swan Rd	9.5	5.7	8.0
13	E.F. Nookachamps Ck	State Route 9	10.3	8.2	8.0
14	College Way Ck	College Way	9.0	4.6	8.0
15	Nookachamps Ck	Knapp	8.2	2.1	8.0
16	E.F. Nookachamps Ck	Beaver Lake Rd	11.4	9.2	8.0
17	Nookachamps Ck	Big Lake Outlet	10.0	7.0	8.0
18	Lake Ck	State Route 9	11.2	9.2	8.0
19	Hansen Ck	Hoehn Rd	10.5	7.4	8.0
20	Hansen Ck	Northern State	11.2	9.7	8.0
21	Coal Ck	Hoehn Rd	11.4	7.7	9.5
22	Coal Ck	Hwy 20	11.9	10.0	9.5
23	Wiseman Ck	Minkler Rd	11.8	10.3	9.5
24	Mannser Ck	Lyman Hamilton Hwy	6.8	4.2	9.5
25	Red Cabin Ck	Hamilton Cem Rd	11.9	10.8	9.5
28	Brickyard Ck	Hwy 20	9.2	5.3	8.0
29	Skagit R	River Bend Rd	11.3	10.1	8.0
30	Skagit R	Cape Horn Rd	11.3	9.7	9.5
31	Drain Dist 20 floodgate	Francis Rd	9.0	5.4	8.0
32	Samish R	Thomas Rd	10.8	9.3	8.0
33	Alice Bay Pump Station	Samish Island Rd	9.5	4.2	8.0
34	Noname Slough	Bayview-Edison Rd	6.6	1.3	8.0
35	Joe Leary Slough	D'Arcy Rd	5.0	3.3	8.0
36	Edison Slough at school	W. Bow Hill Rd	8.4	2.5	8.0
37	Edison Pump Station	Farm to Market Rd	5.8	2.1	8.0
38	North Edison Pump Station	North Edison Rd	6.4	0.9	8.0
39	Colony Ck	Colony Rd	10.8	7.9	8.0
40	Big Indian Slough	Bayview-Edison Rd	4.8	2.7	8.0
41	Maddox Slough/Big Ditch	Milltown Rd	5.9	2.7	8.0
42	Hill Ditch	Cedardale Rd	7.6	3.0	8.0
43	Wiley Slough	Wylie Rd	4.6	0.7	8.0
44	Rexville PS/Sullivan Slough	La Conner-Bayview Rd	8.6	3.9	8.0
45	Skagit R – North Fork	Moore Rd	11.4	9.5	8.0
46	Skagit R – South Fork	Fir Island Rd	11.3	9.6	8.0
47	Swinomish Channel	County Boat Launch	8.8	6.2	8.0
48	Fisher Ck	Franklin Rd	11.0	7.5	8.0

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

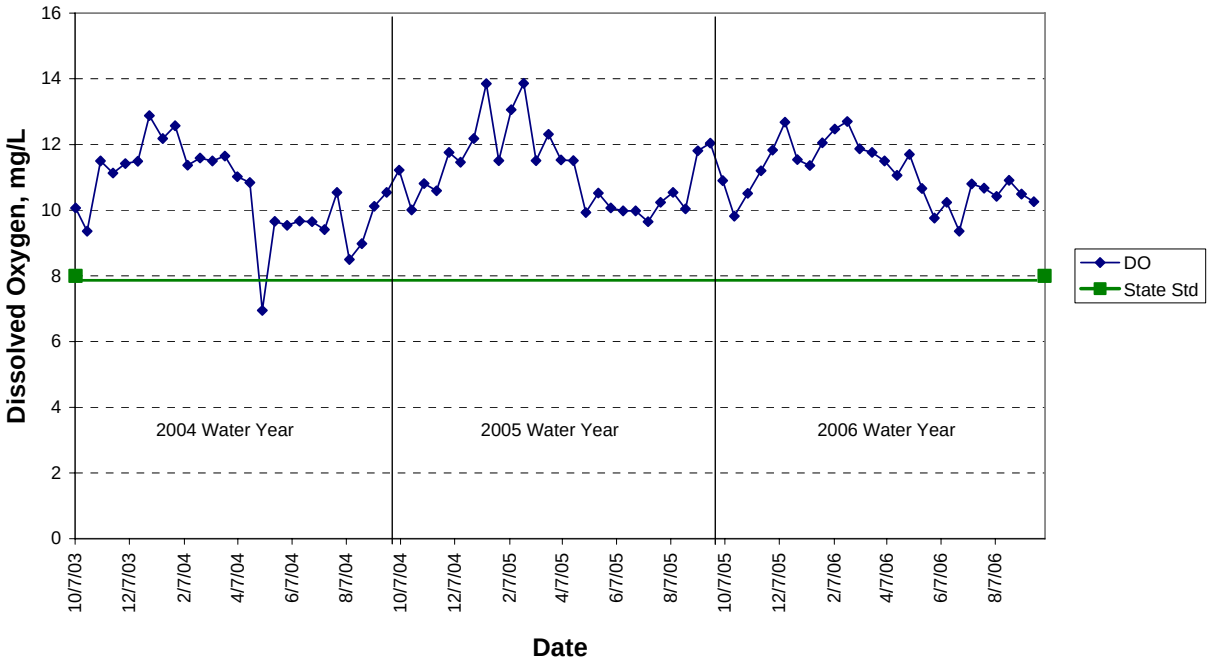
Thomas Creek at Hwy 99 - Site 3
Dissolved Oxygen



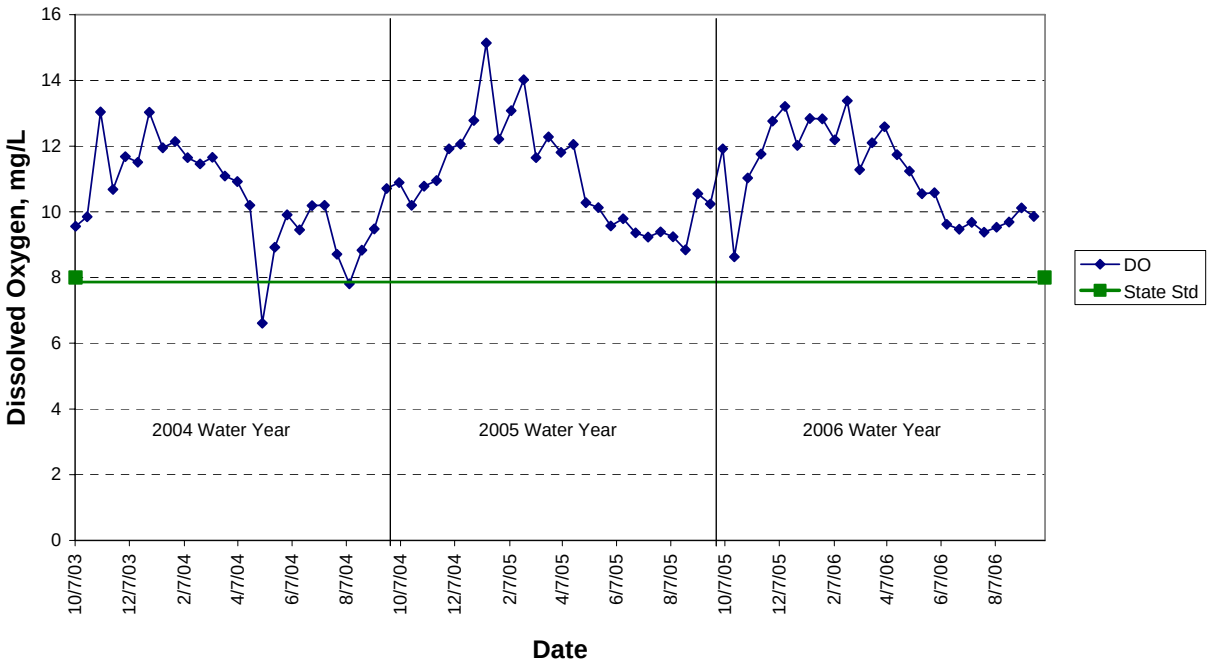
Thomas Creek at F&S Grade Rd - Site 4
Dissolved Oxygen



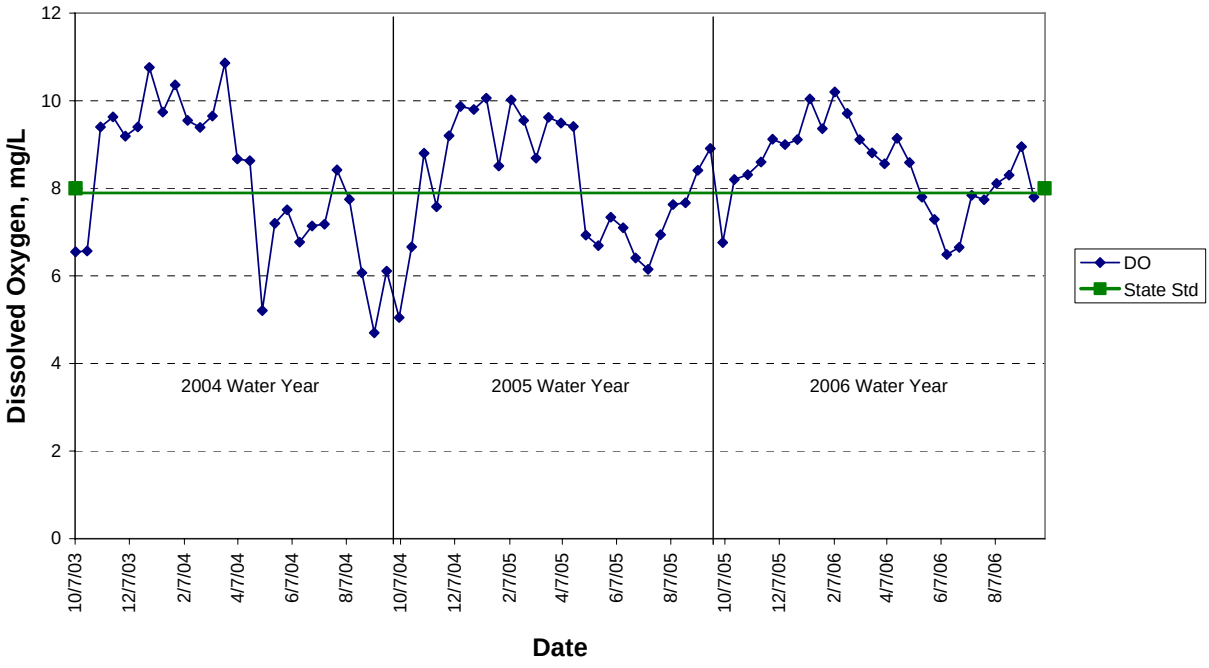
Friday Creek at Prairie Rd - Site 6
Dissolved Oxygen



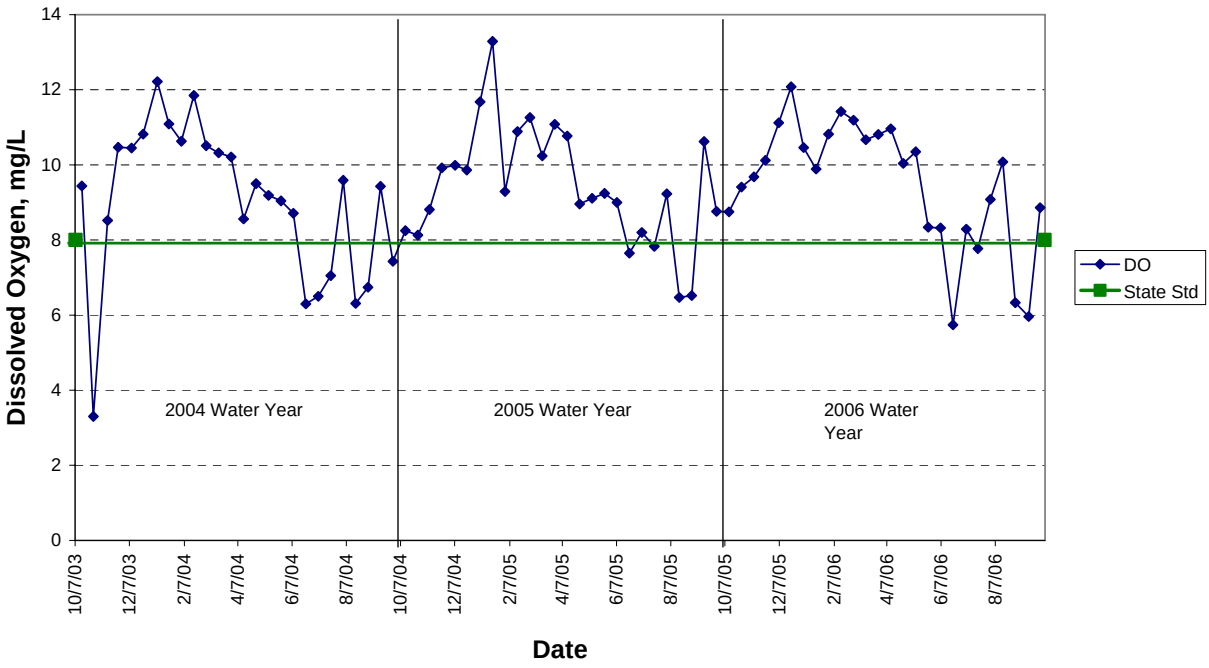
Swede Creek at Grip Rd - Site 8
Dissolved Oxygen



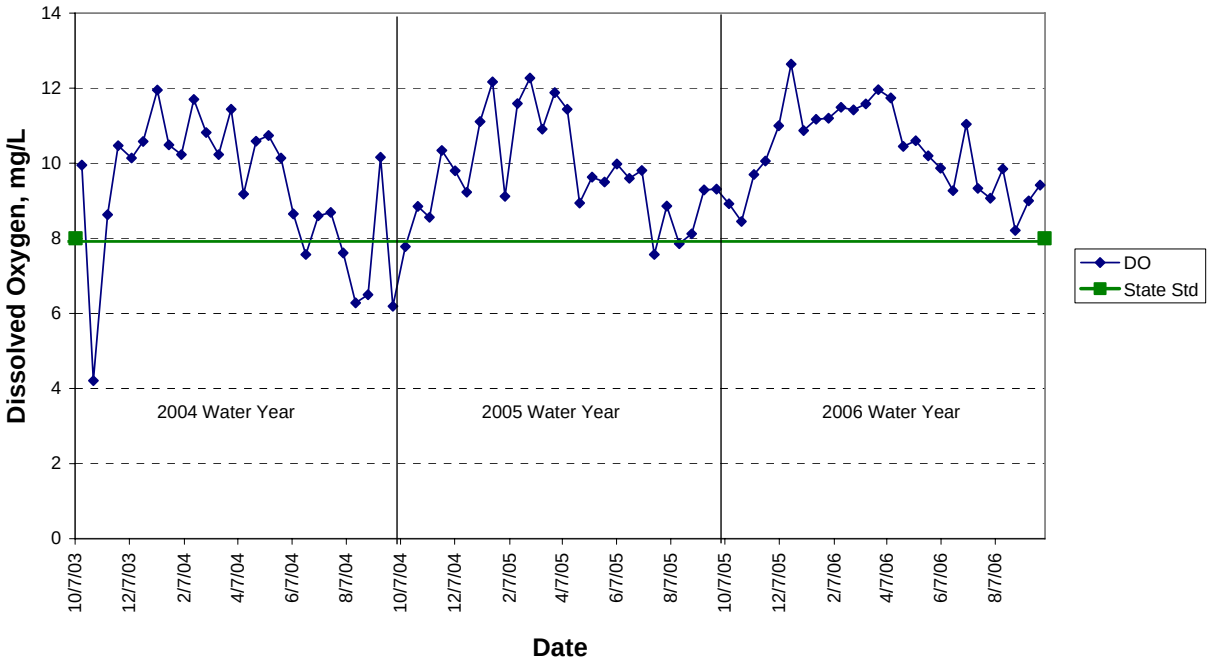
Samish River at Hwy 9 - Site 11
Dissolved Oxygen



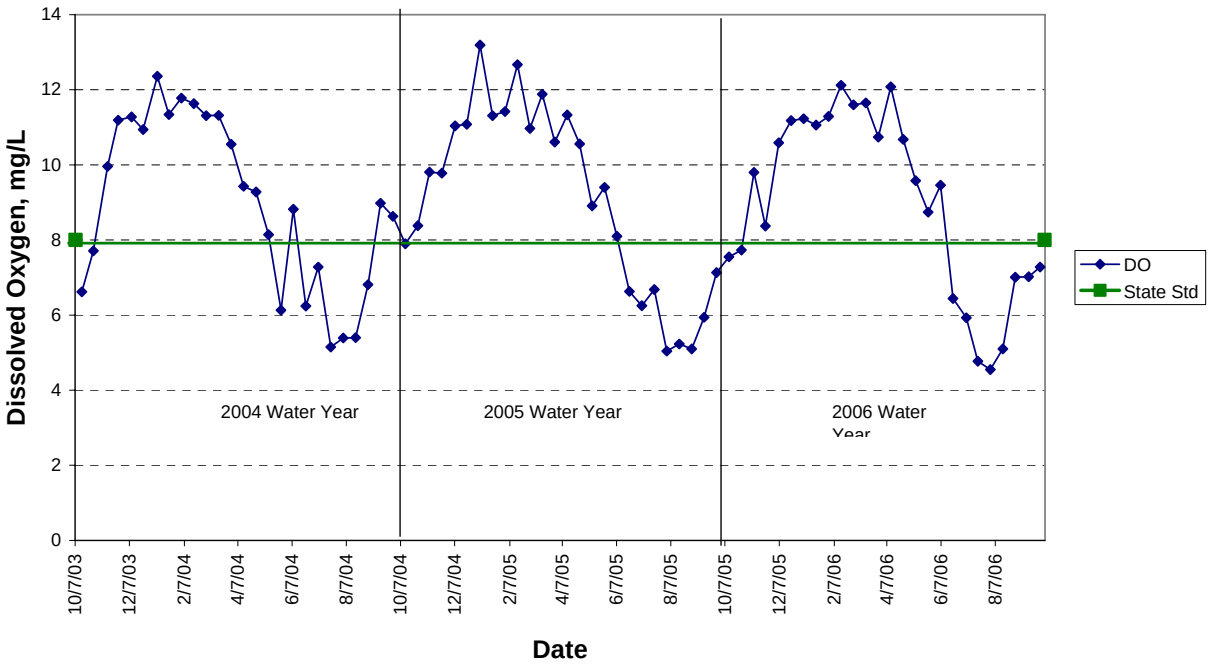
Nookachamps Creek at Swan Rd - Site 12
Dissolved Oxygen



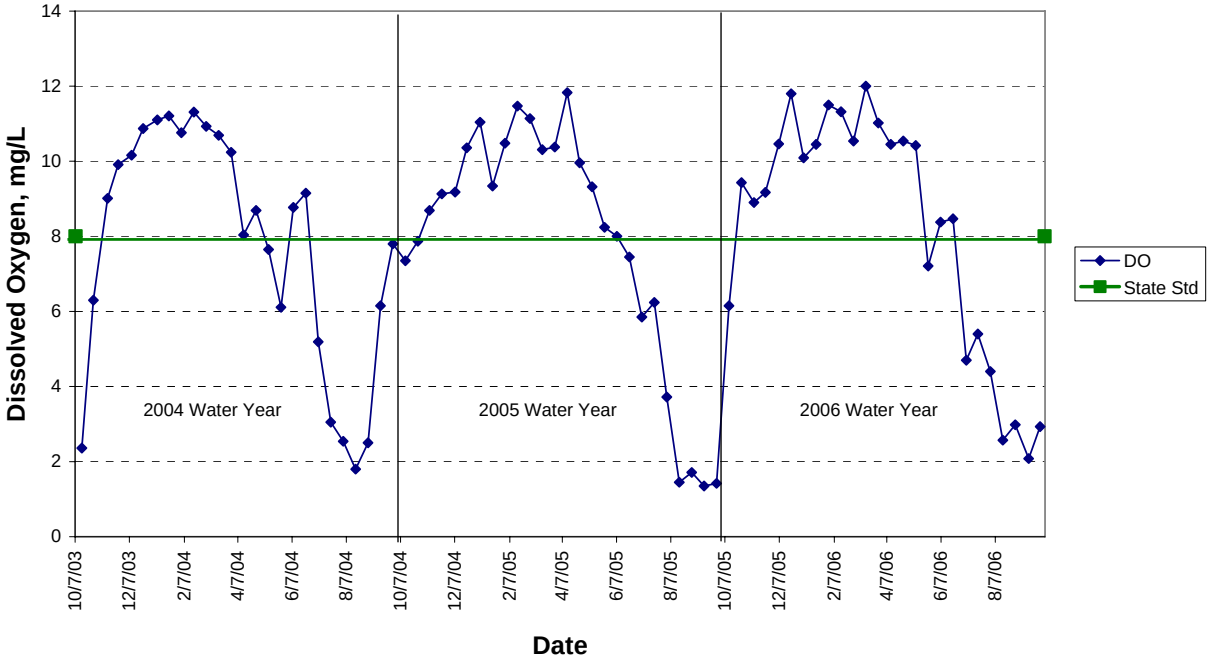
E.F. Nookachamps Creek at Hwy 9 - Site 13
Dissolved Oxygen



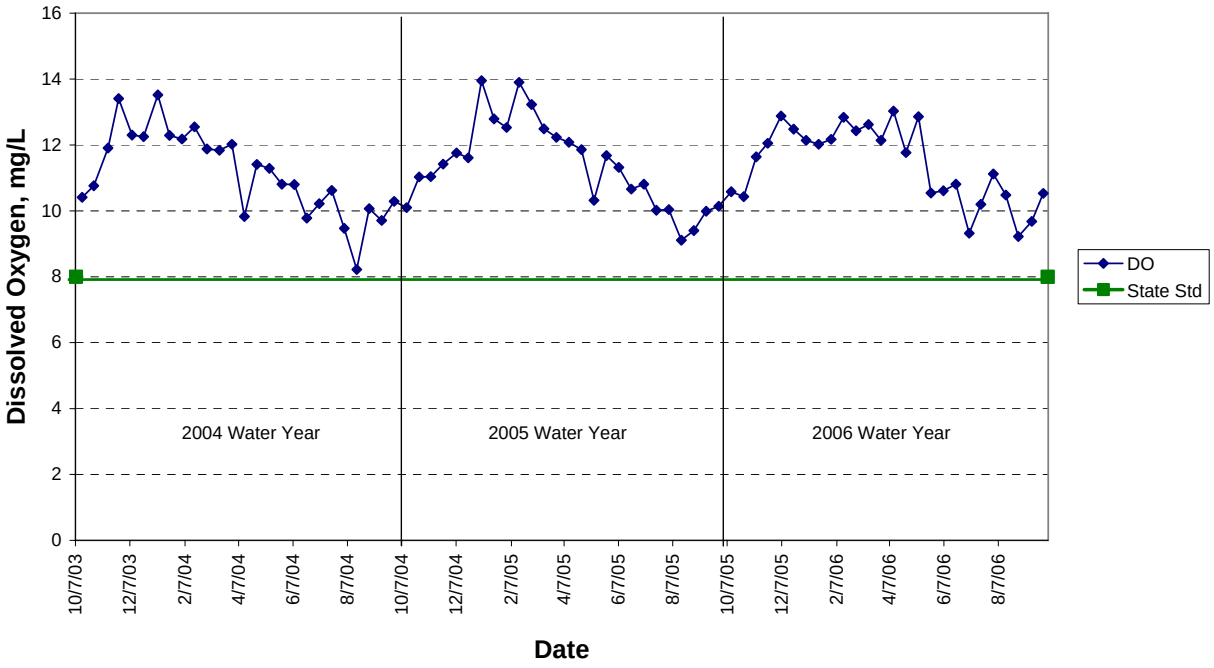
College Way Creek at College Way - Site 14
Dissolved Oxygen



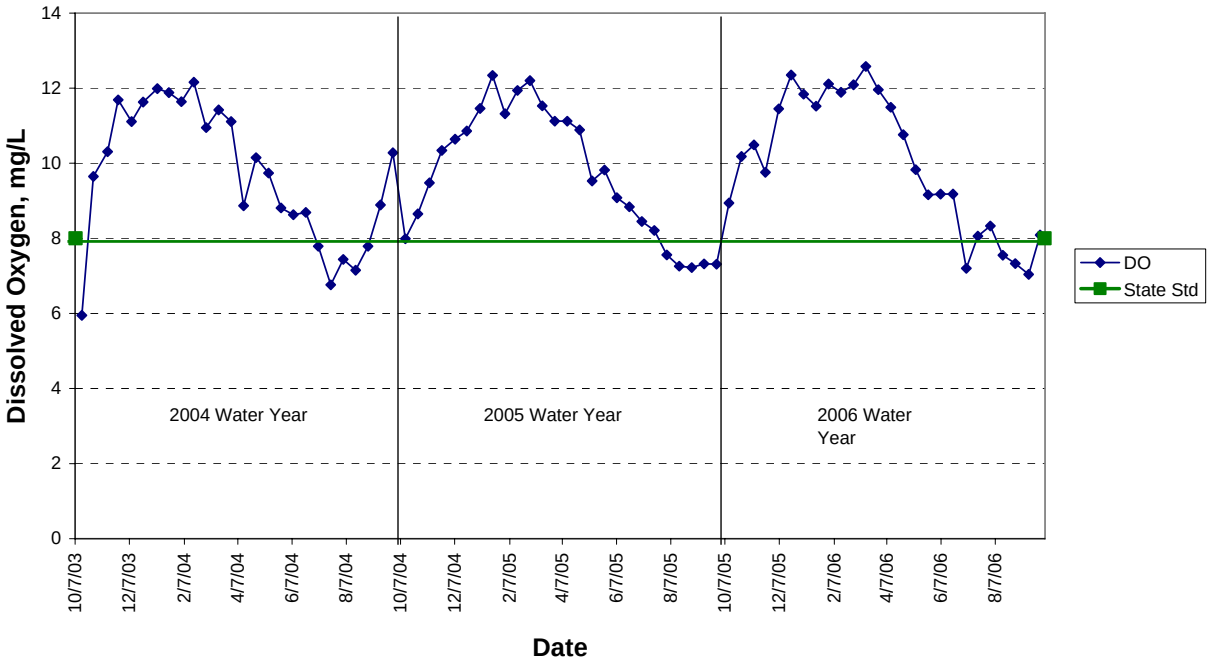
Nookachamps Creek at Knapp Rd - Site 15
Dissolved Oxygen



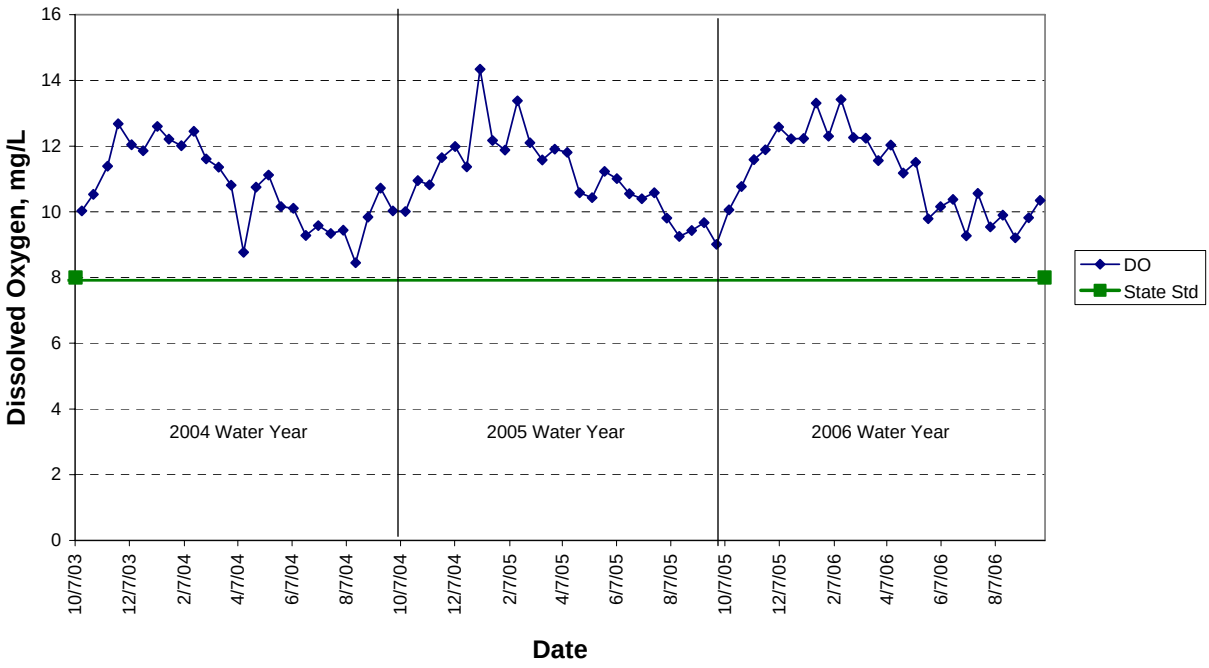
E.F. Nookachamps Creek at Beaver Lk Rd - Site 16
Dissolved Oxygen



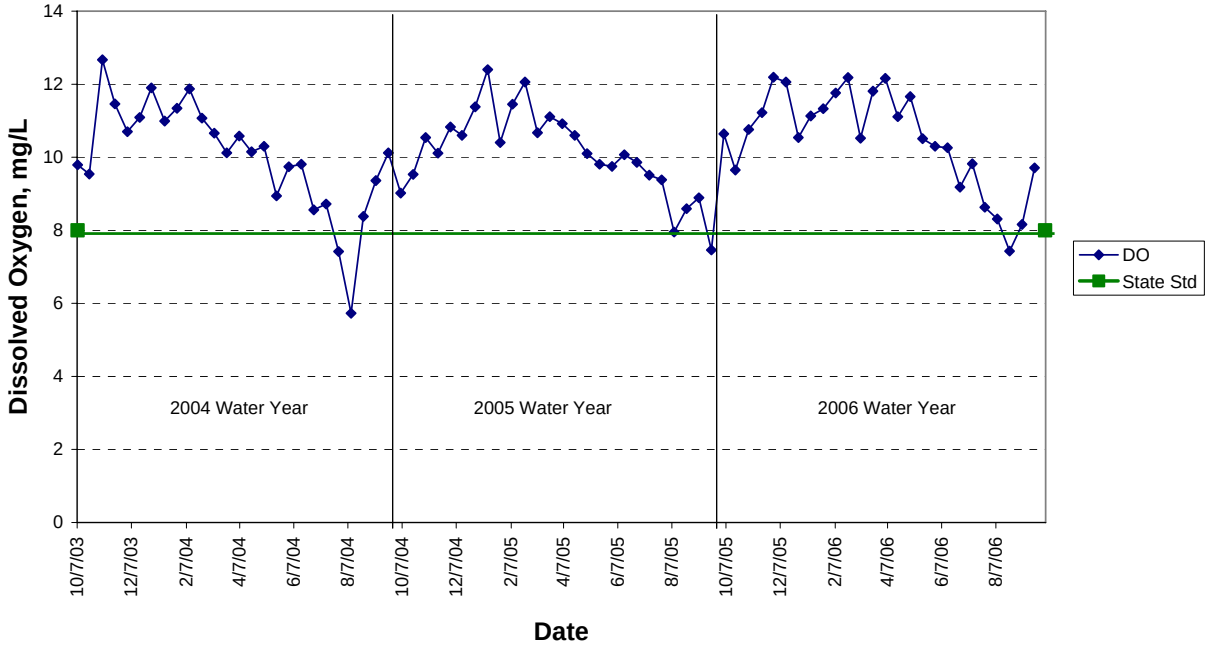
Nookachamps Creek at Big Lake Outlet - Site 17
Dissolved Oxygen



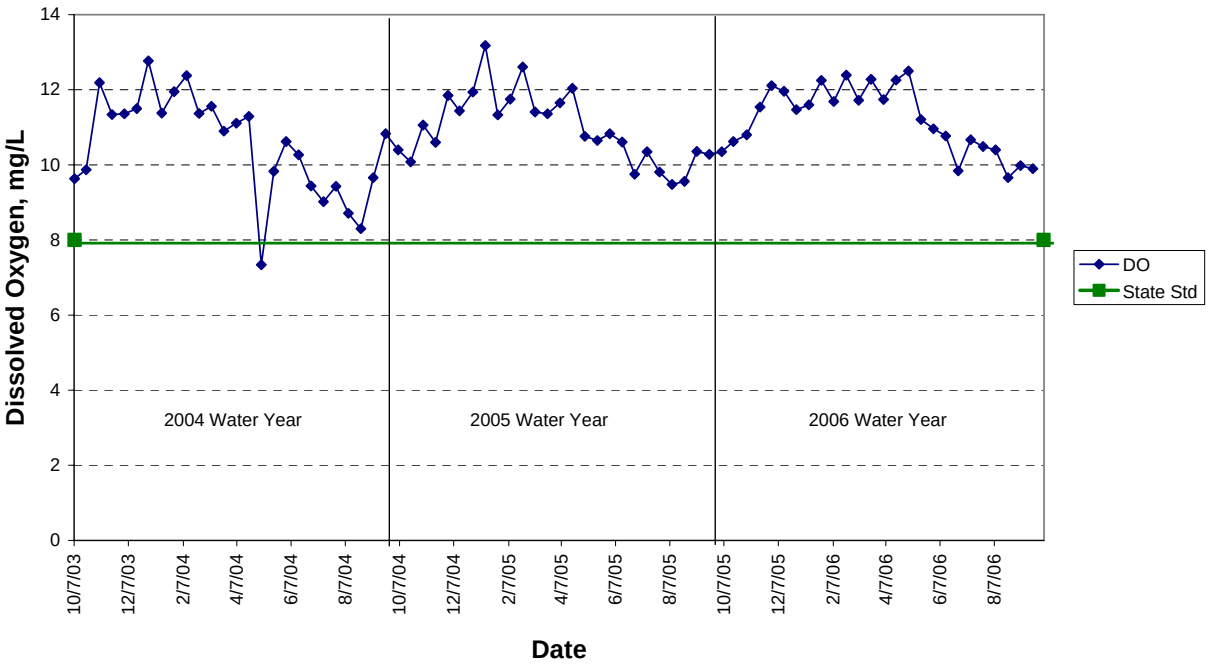
Lake Creek at Hwy 9 - Site 18
Dissolved Oxygen



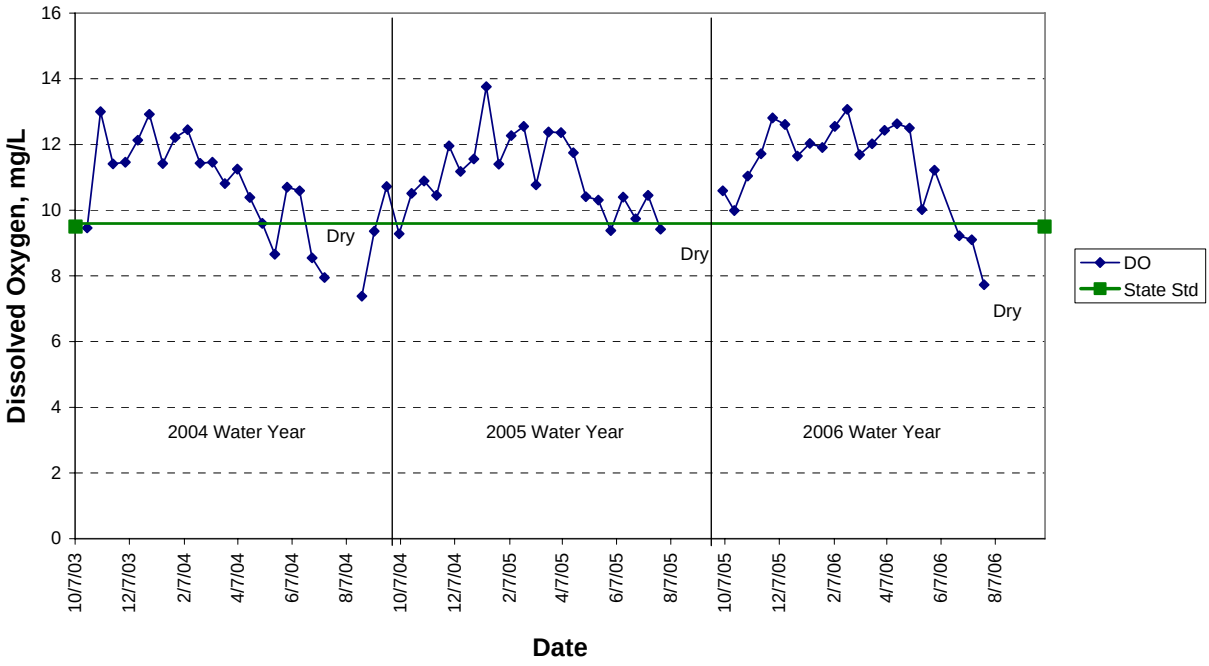
Hansen Creek at Hoehn Rd - Site 19
Dissolved Oxygen



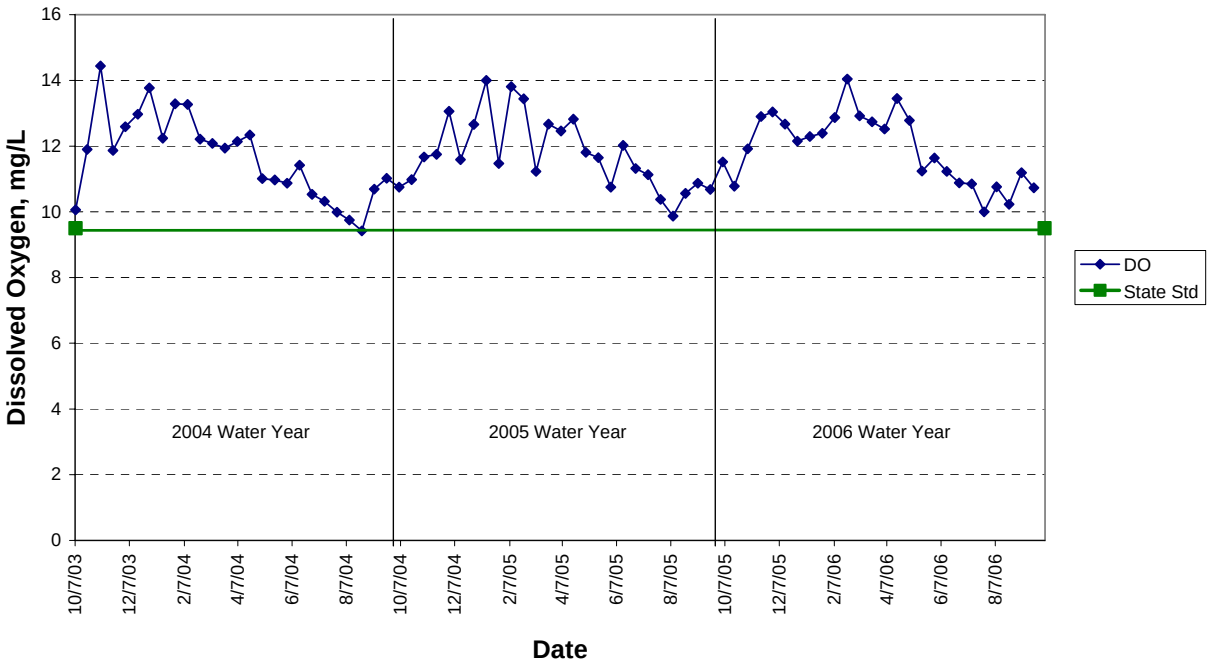
Hansen Creek at Northern State - Site 20
Dissolved Oxygen



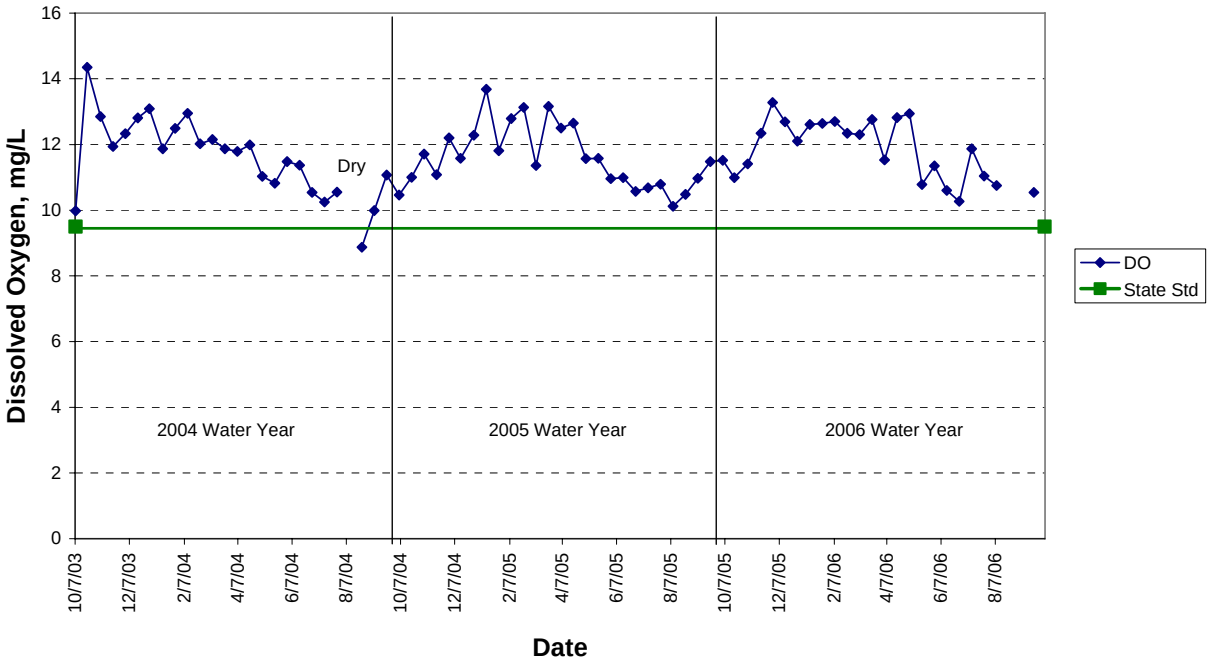
Coal Creek at Hoehn Rd - Site 21
Dissolved Oxygen



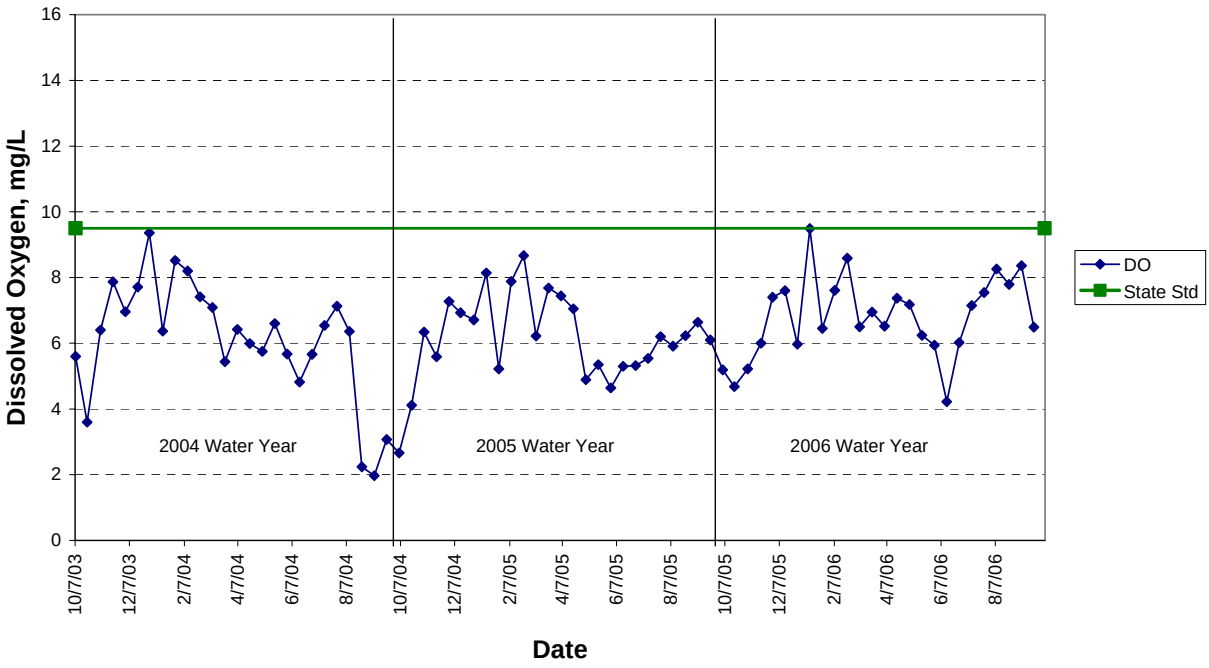
Coal Creek at Hwy 20 - Site 22
Dissolved Oxygen



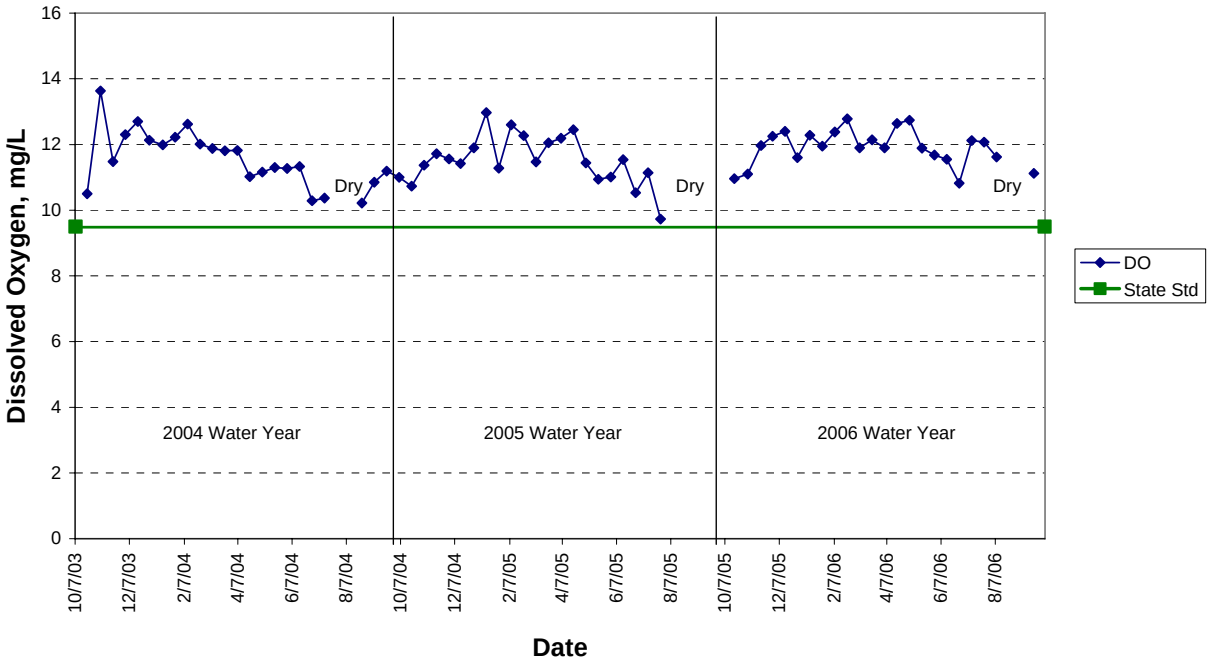
Wiseman Creek at Minkler Rd - Site 23
Dissolved Oxygen



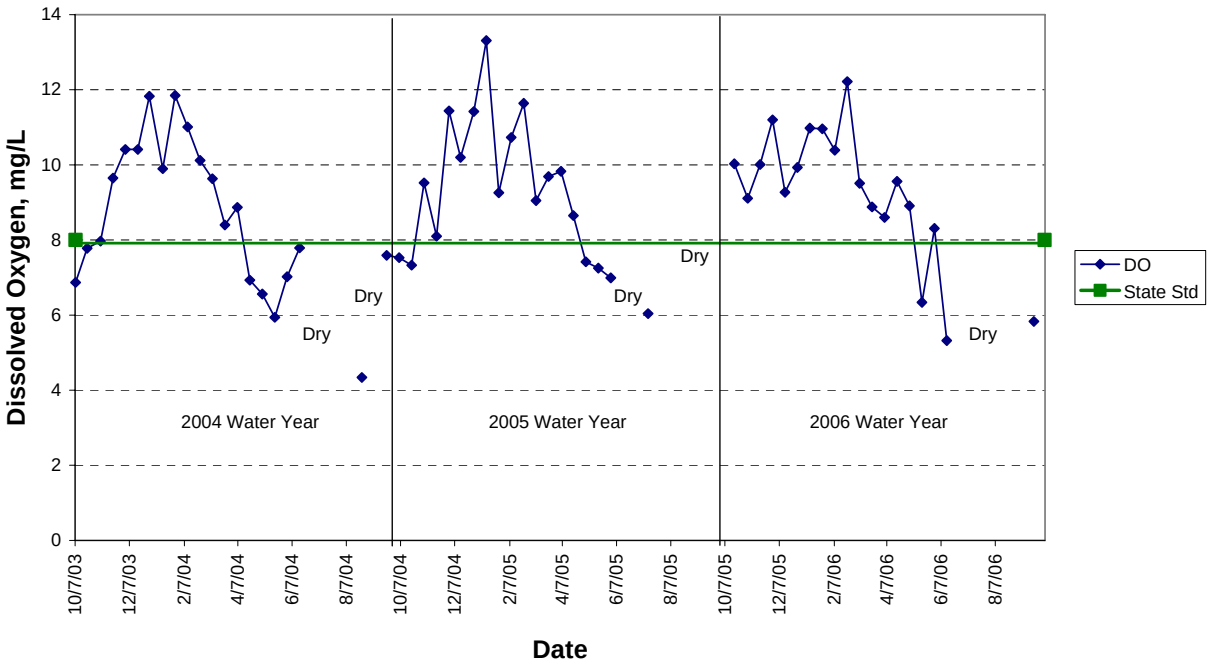
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Dissolved Oxygen



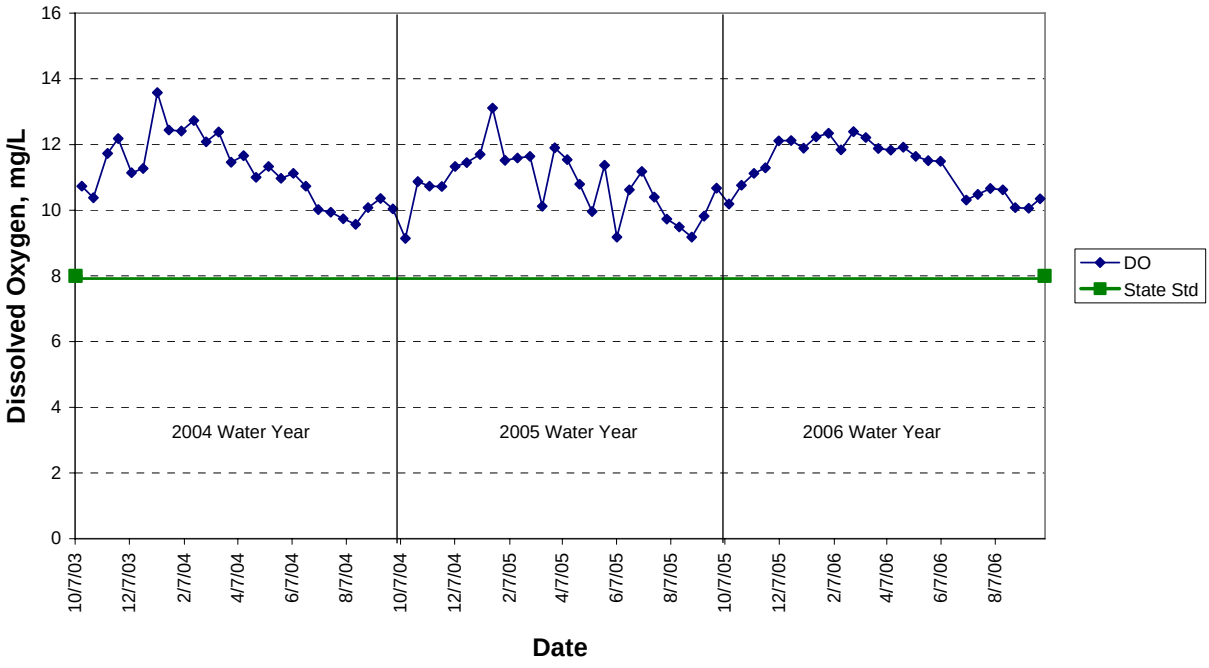
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Dissolved Oxygen



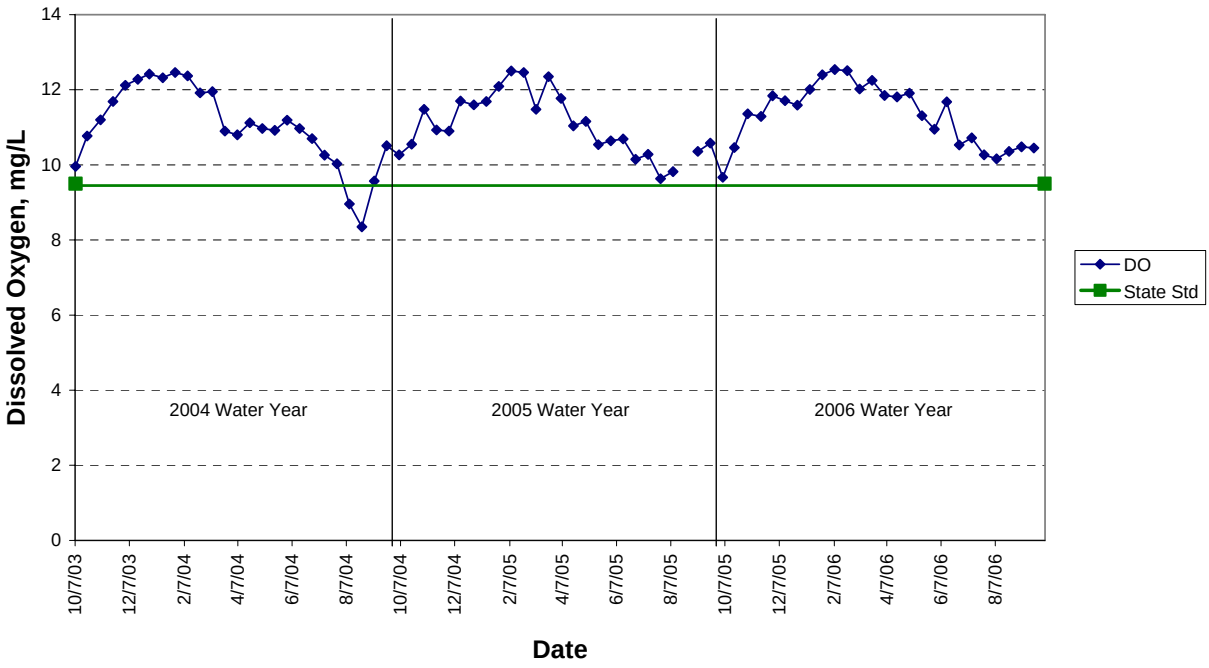
Brickyard Creek at Hwy 20 - Site 28
Dissolved Oxygen



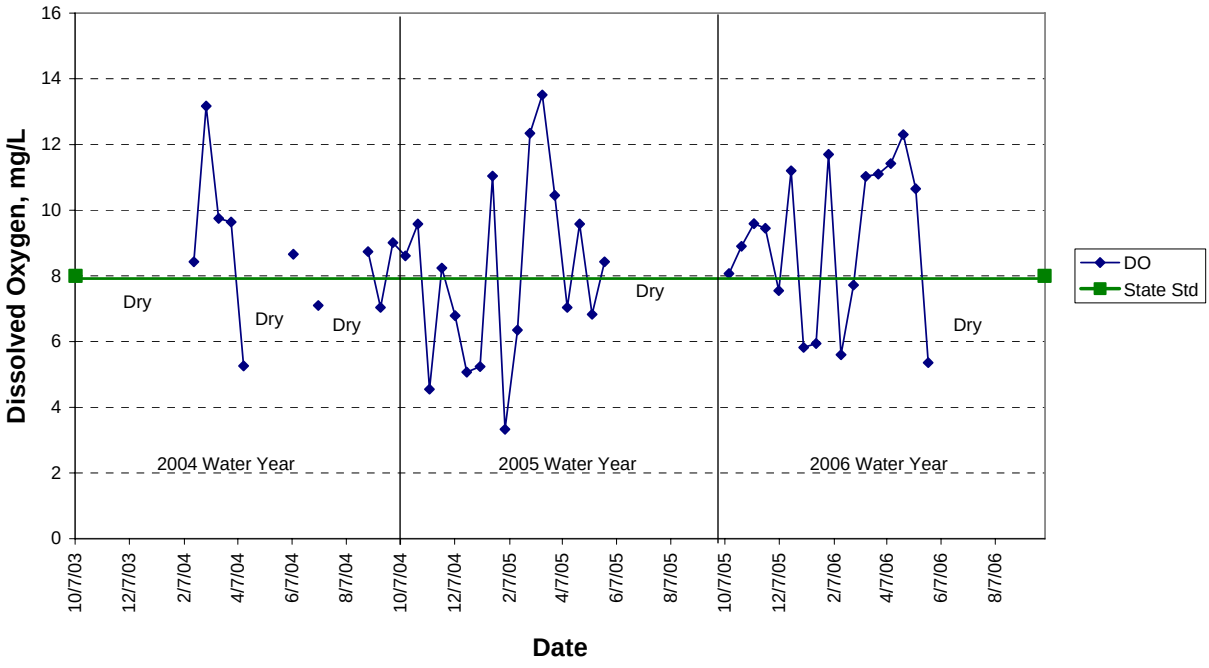
Skagit River at River Bend - Site 29
Dissolved Oxygen



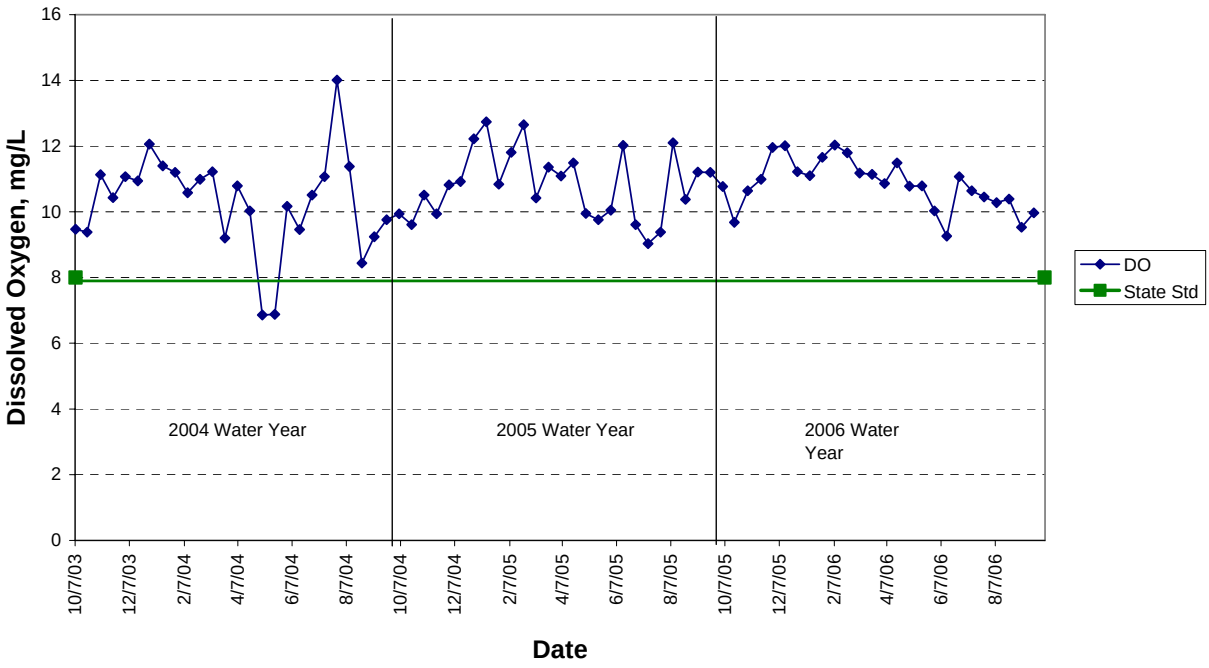
Skagit River at Cape Horn Rd - Site 30
Dissolved Oxygen



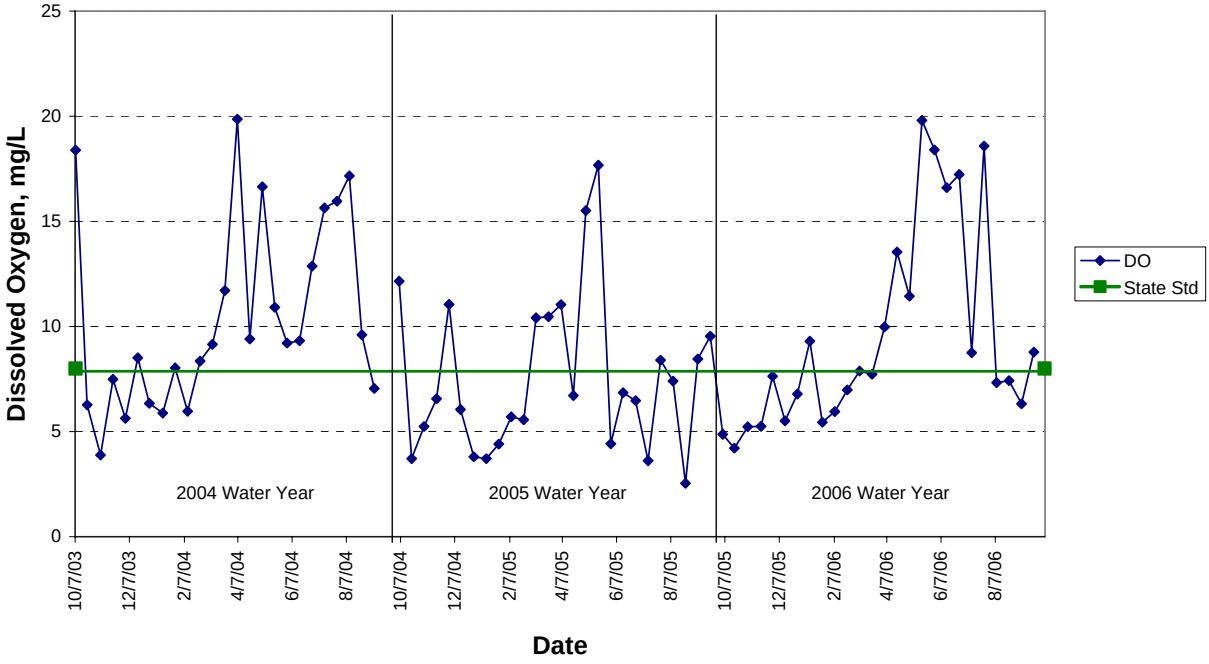
Drainage District 20 Ditch at Floodgate - Site 31
Dissolved Oxygen



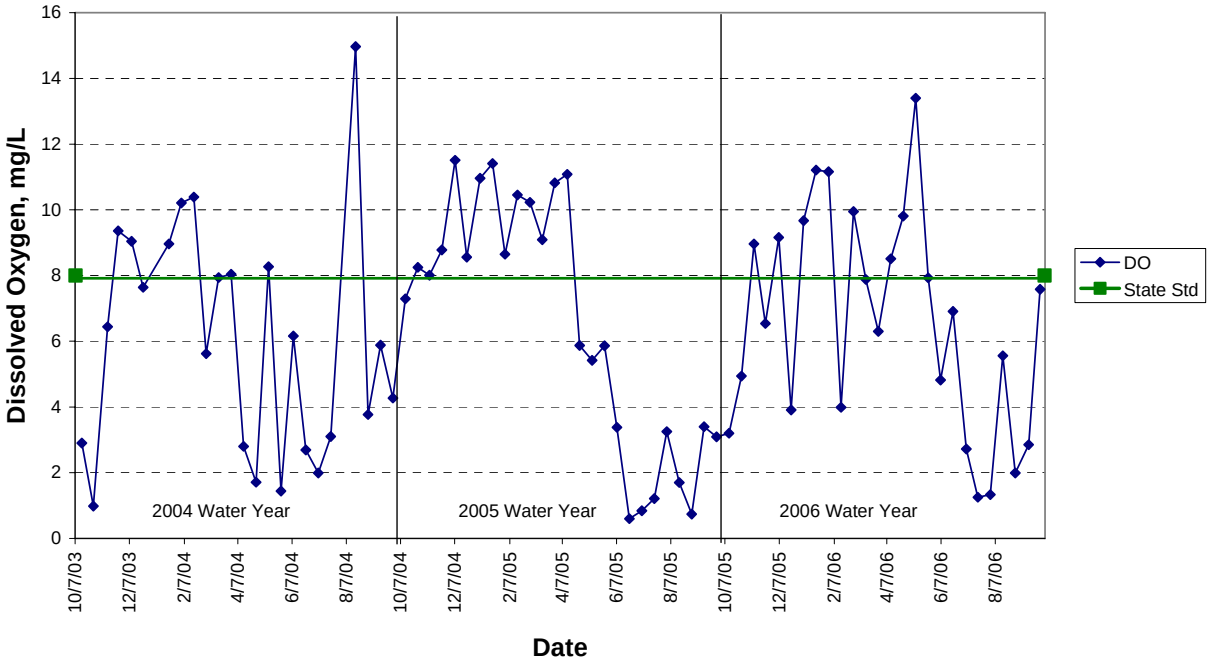
Samish River at Thomas Rd - Site 32
Dissolved Oxygen



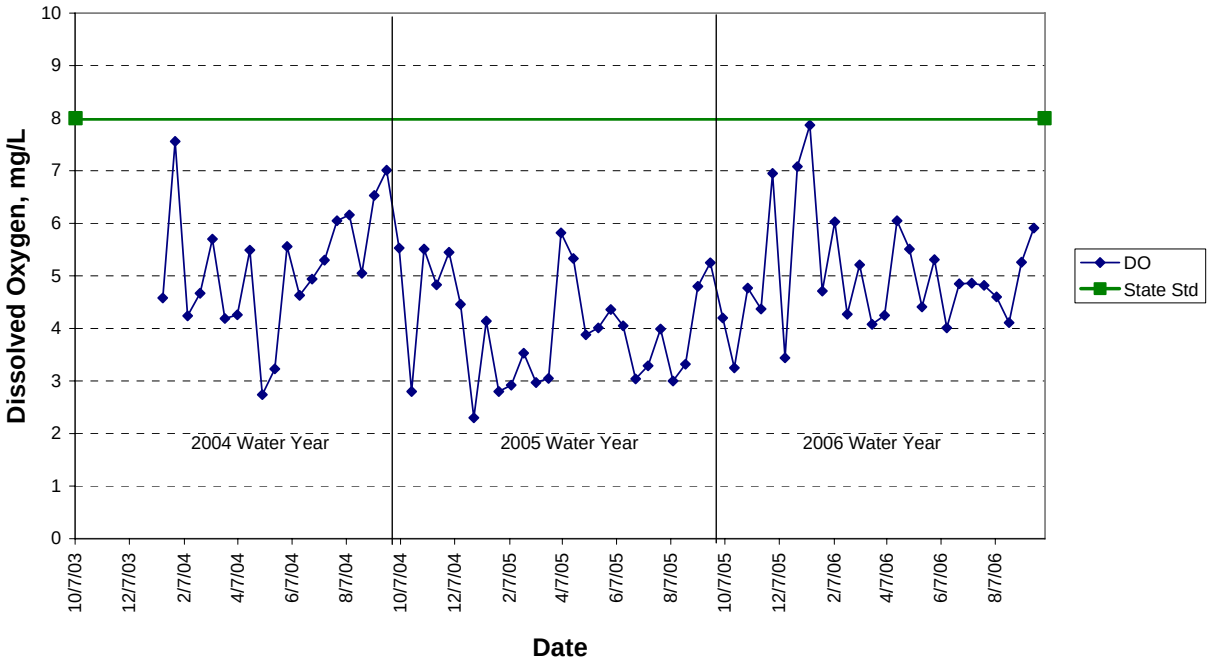
Alice Bay Pump Station - Site 33
Dissolved Oxygen



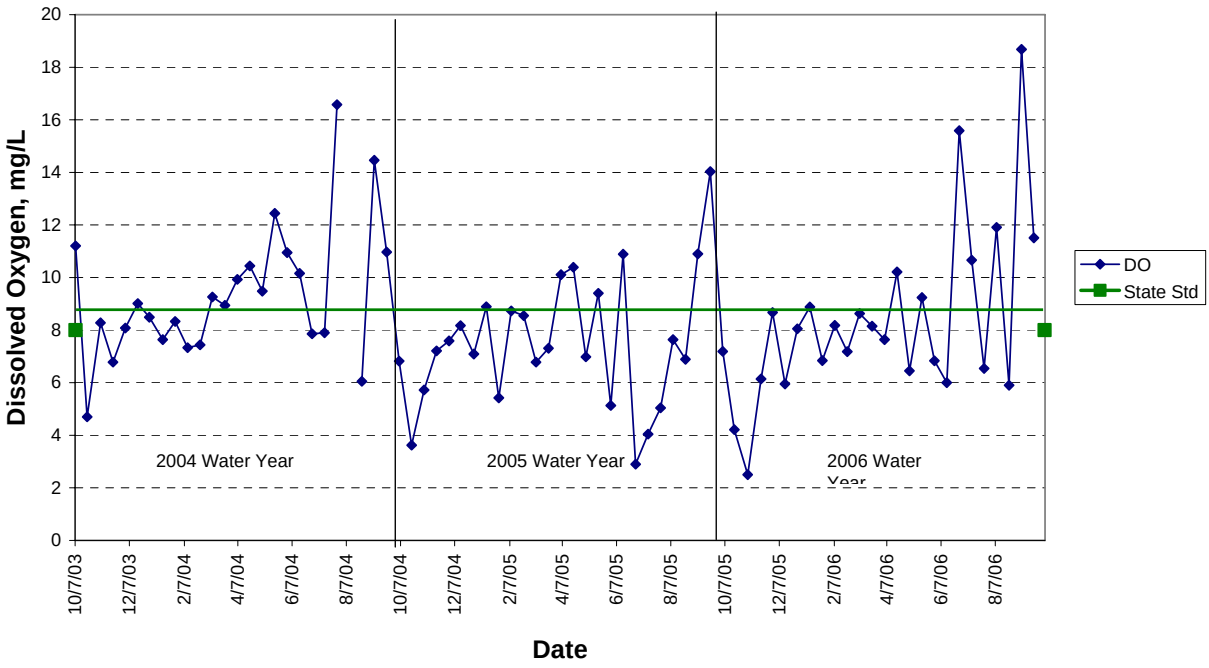
No Name Slough at Bayview-Edison Rd - Site 34
Dissolved Oxygen



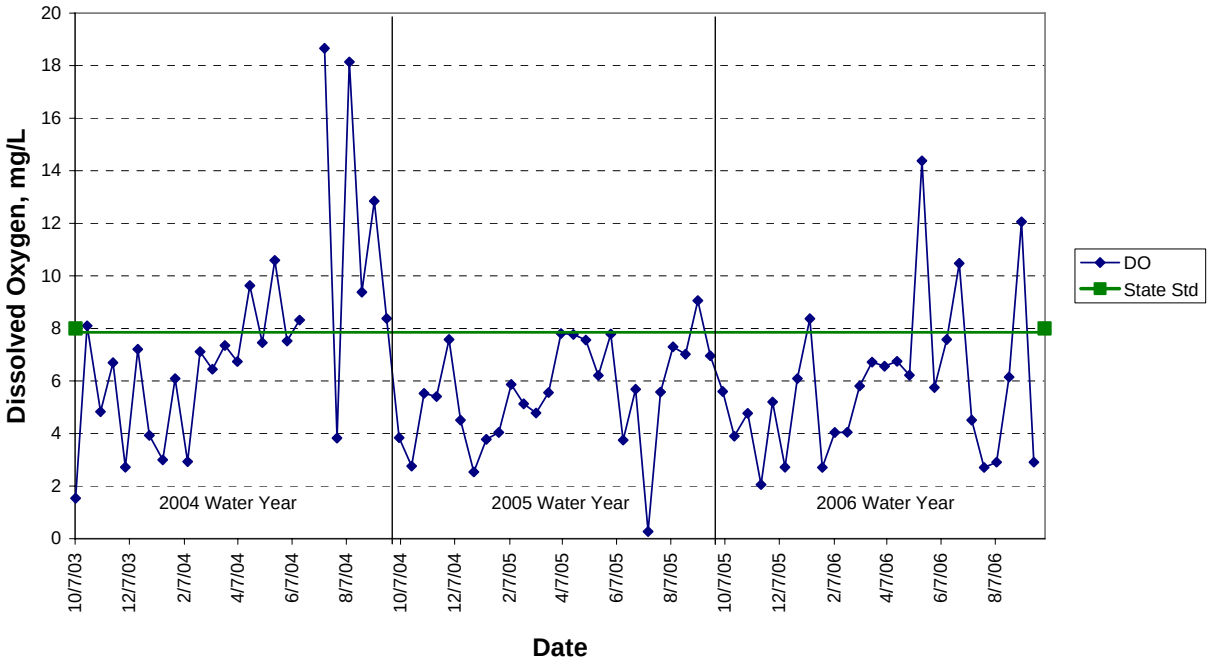
Joe Leary Slough at D'Arcy Rd - Site 35
Dissolved Oxygen



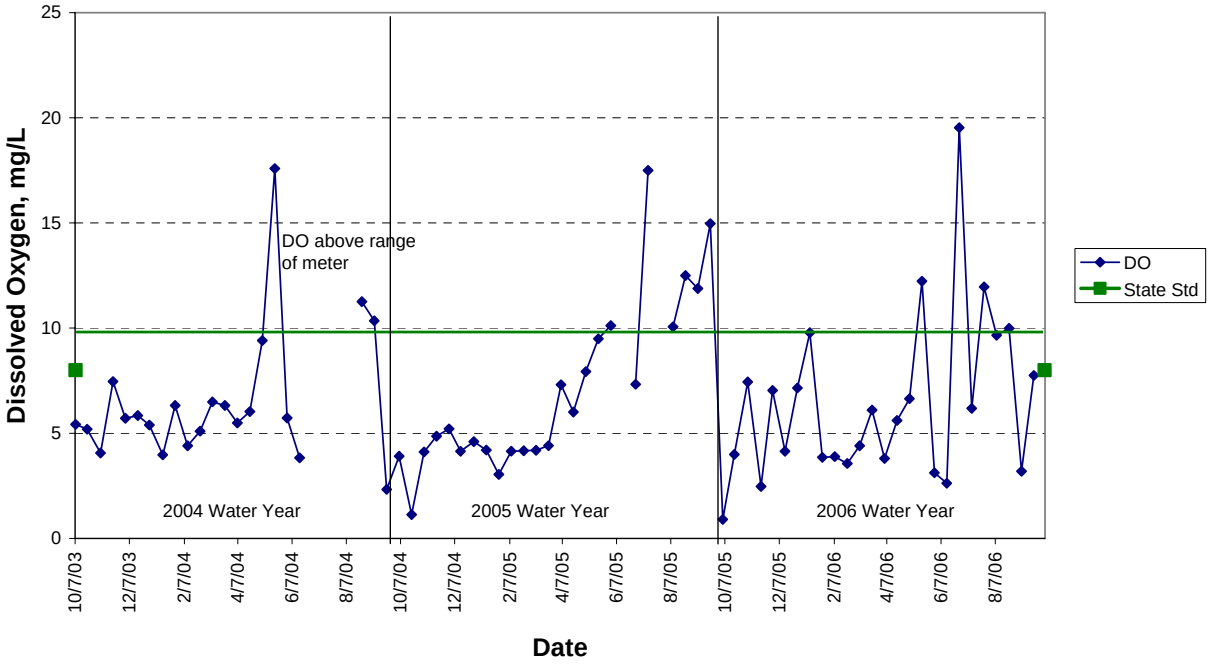
Edison Slough at Edison School - Site 36
Dissolved Oxygen



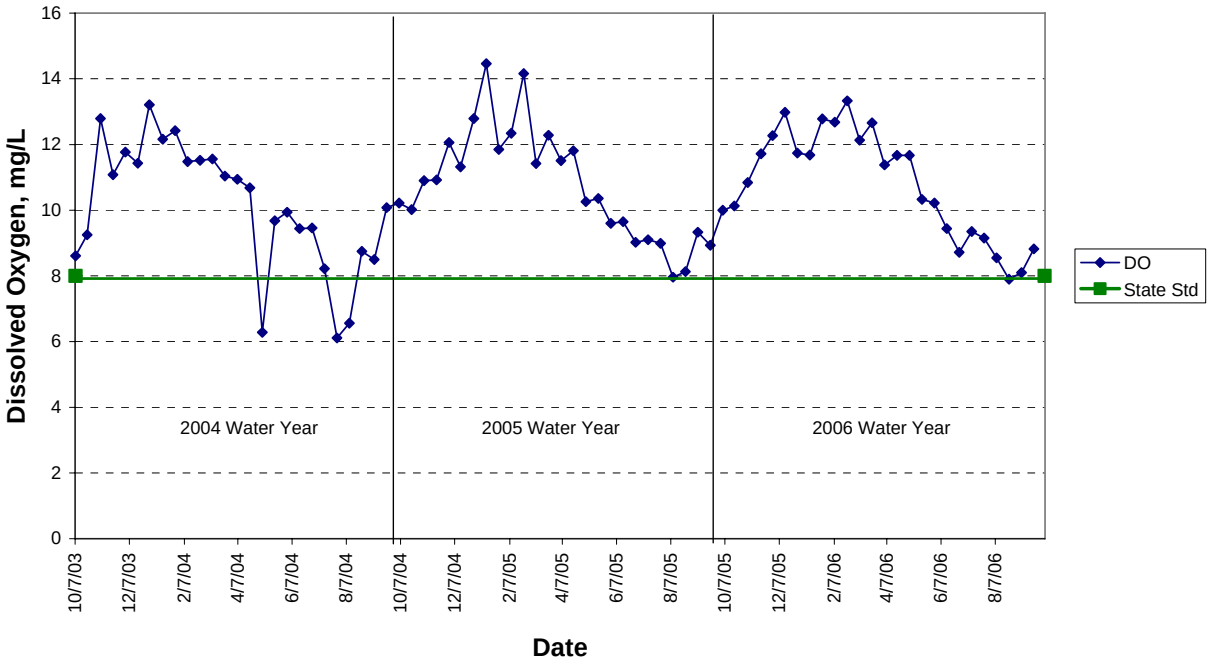
Edison Pump Station - Site 37
Dissolved Oxygen



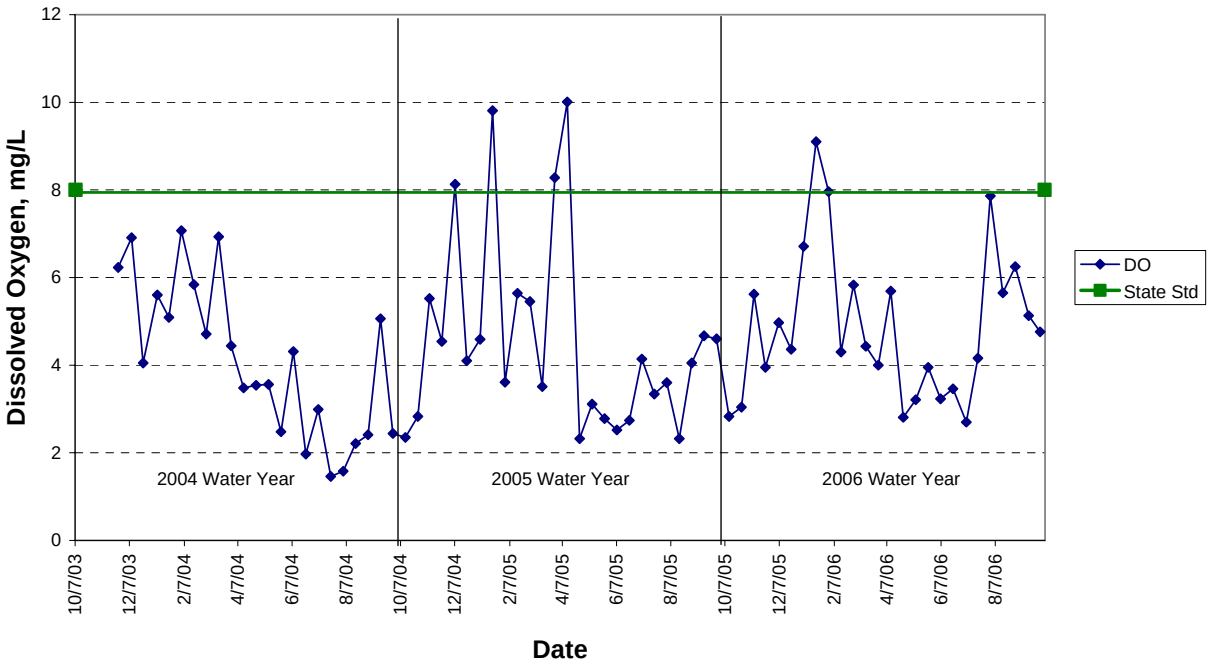
North Edison Pump Station - Site 38
Dissolved Oxygen



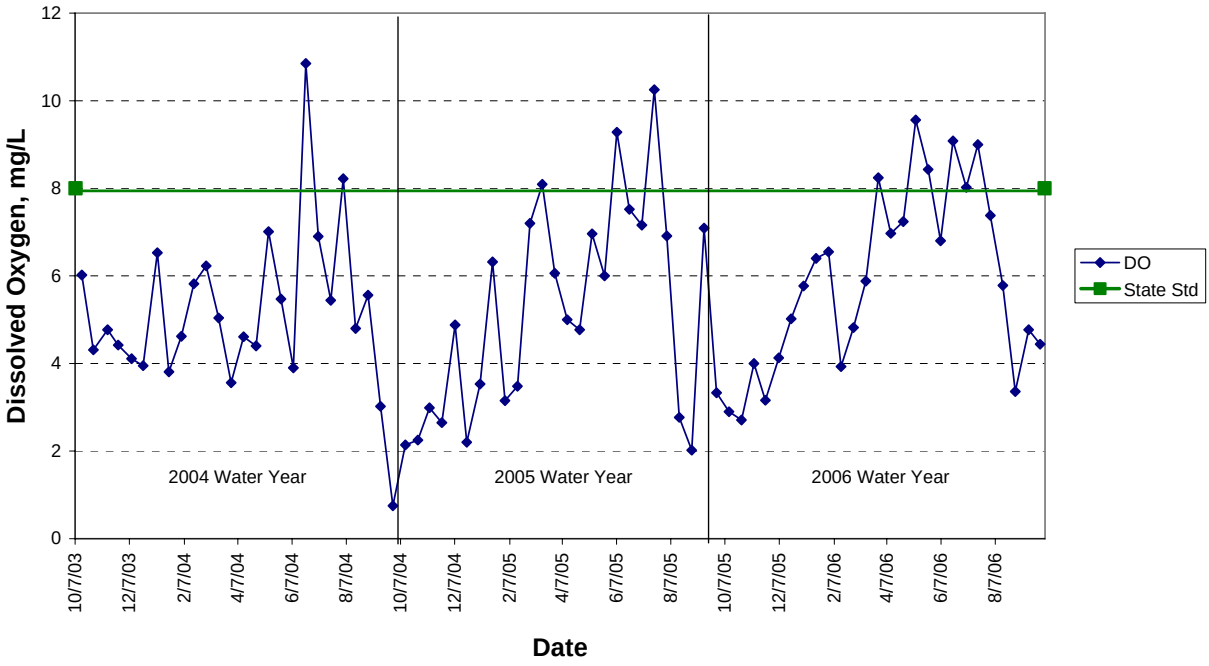
Colony Creek at Colony Rd - Site 39
Dissolved Oxygen



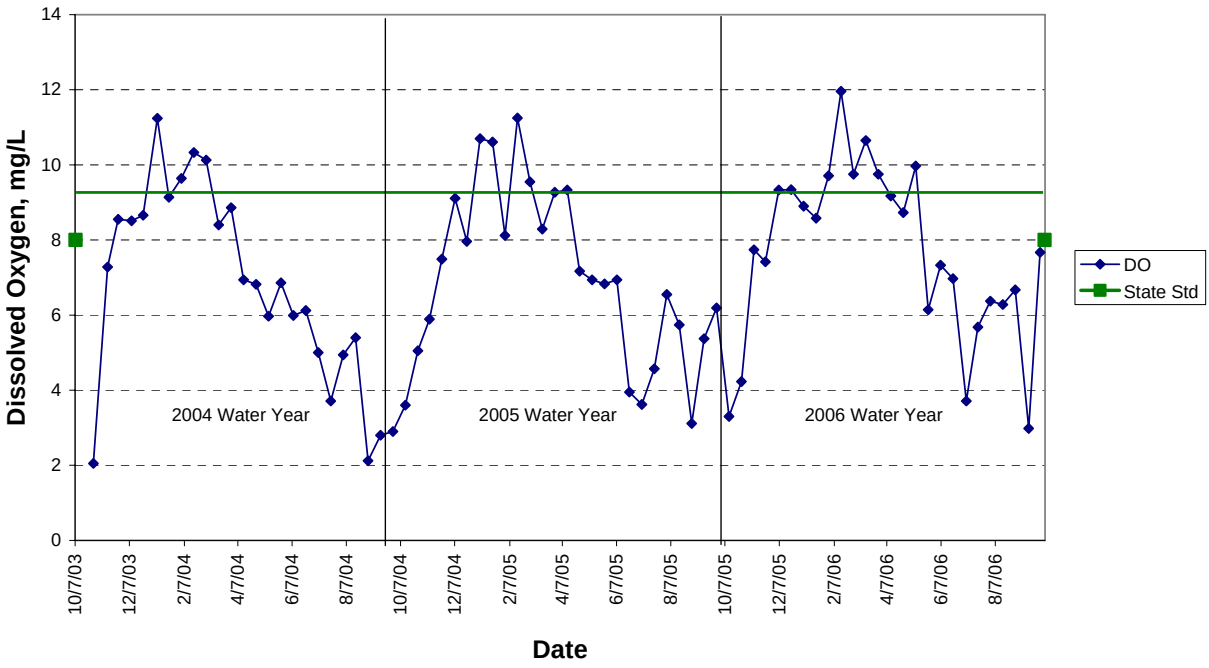
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Dissolved Oxygen



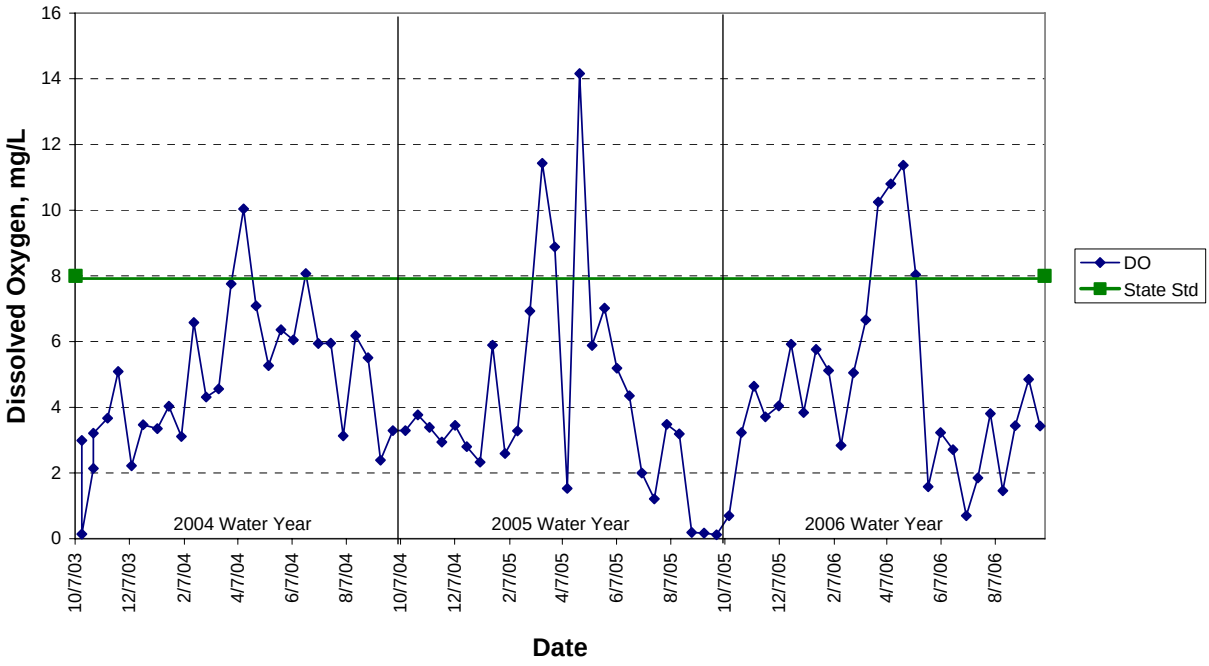
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Dissolved Oxygen



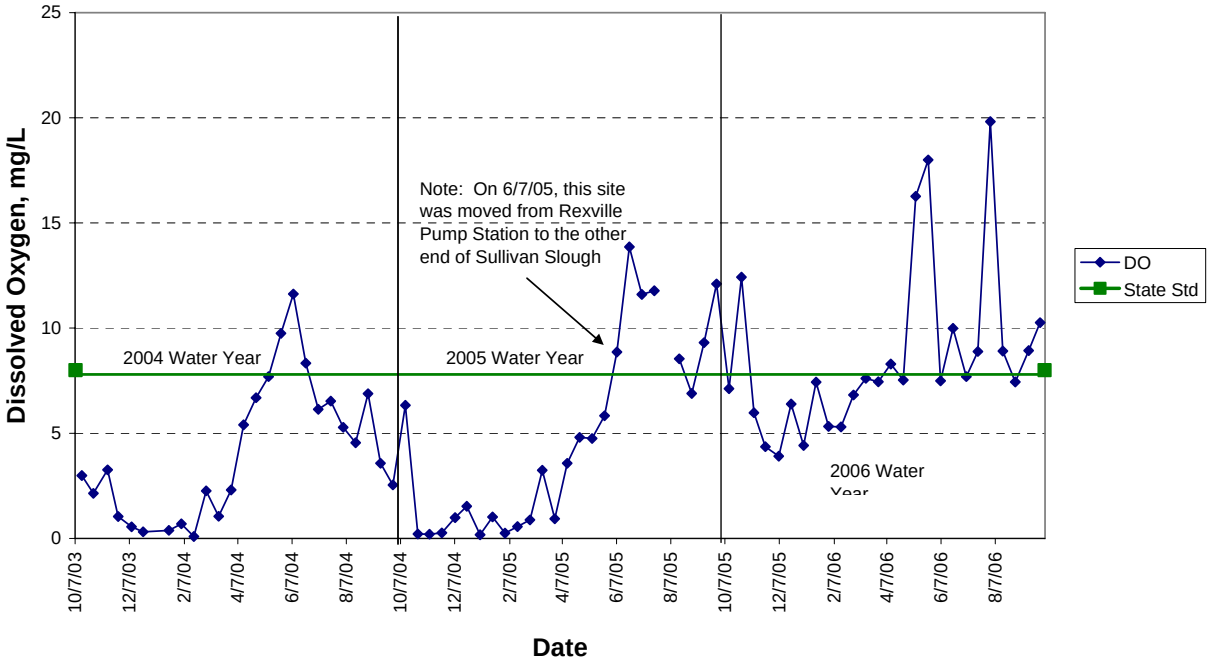
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Dissolved Oxygen



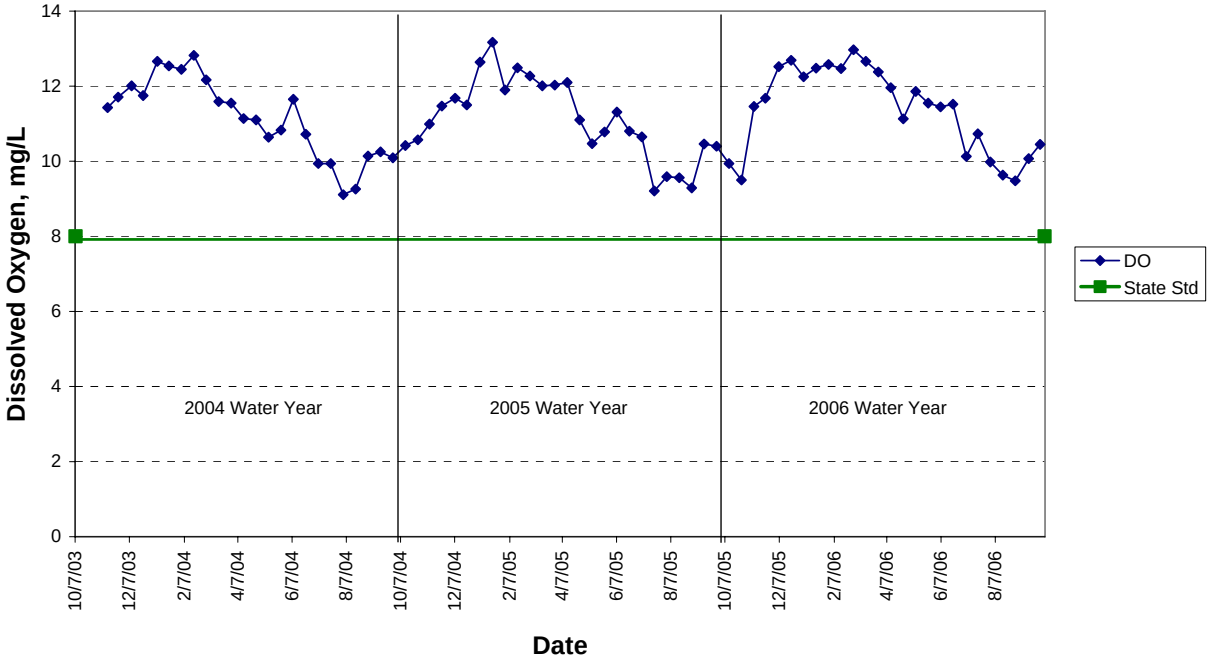
Wiley Slough at Wylie Rd - Site 43
Dissolved Oxygen



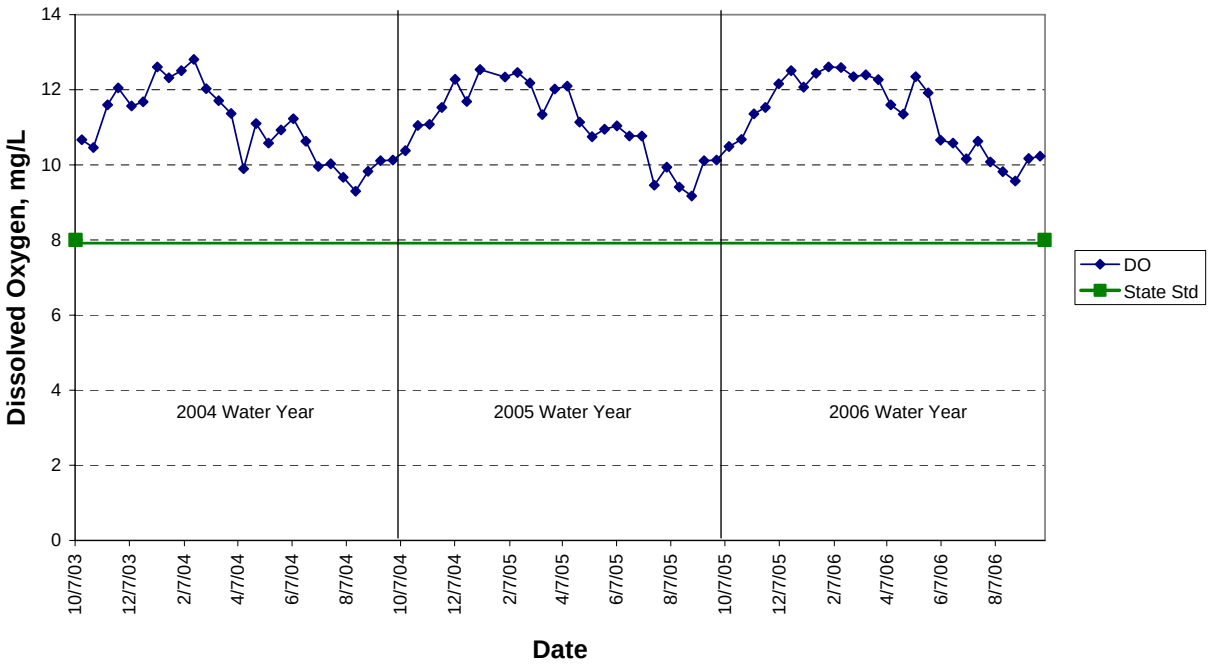
Sullivan Slough at LaConner-Whitney Rd - Site 44
Dissolved Oxygen



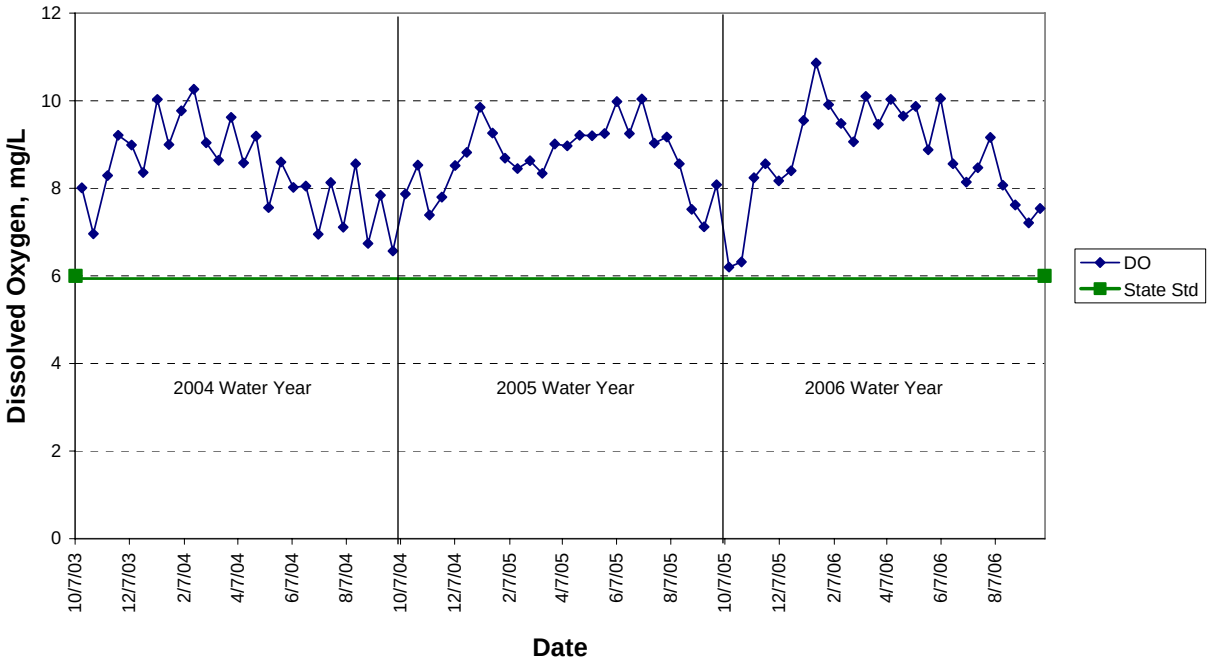
North Fork Skagit near Moore Rd - Site 45
Dissolved Oxygen



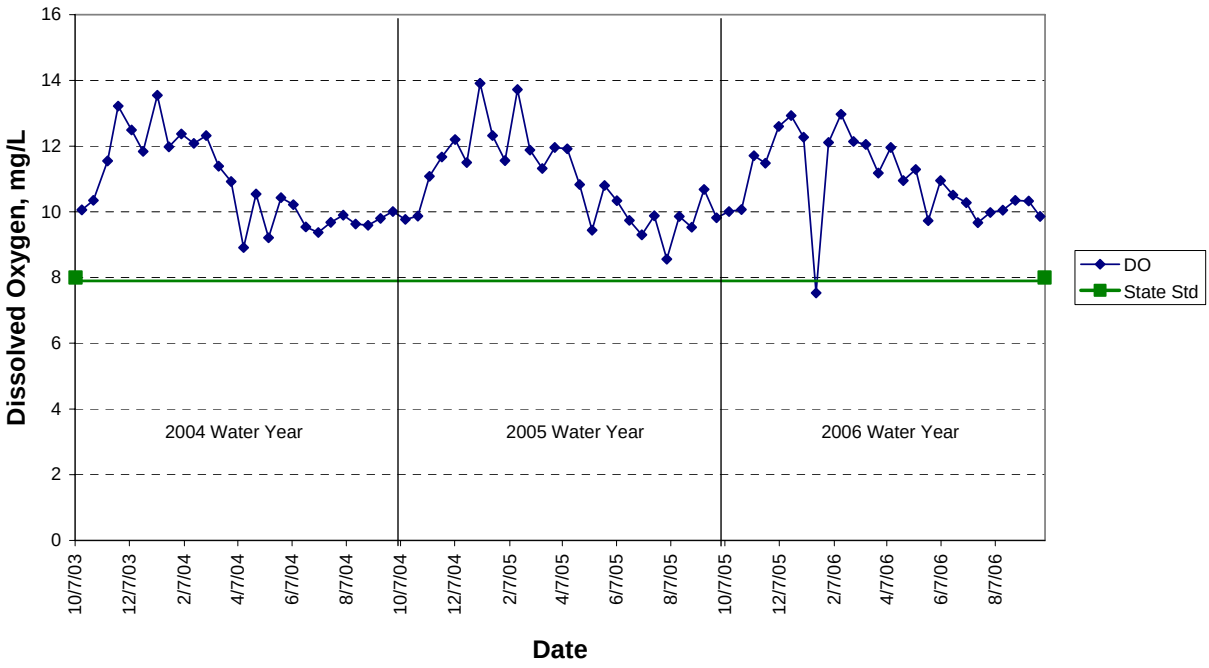
S.F Skagit River at Conway Boat Ramp - Site 46
Dissolved Oxygen



Swinomish Channel at County Boat Ramp - Site 47
Dissolved Oxygen



Fisher Creek at Franklin Rd - Site 48
Dissolved Oxygen



Fecal Coliform

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

Fecal coliform measurements, in colony-forming units per 100 ml (cfu), are summarized in Table 5. 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.

All Skagit River sites (sites 29, 30, 45, and 46) and Swinomish Channel (site 47) met the state standard for fecal coliform for all three years of this project. Most other watercourses in the Skagit County Monitoring Program did not meet the standard.

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.

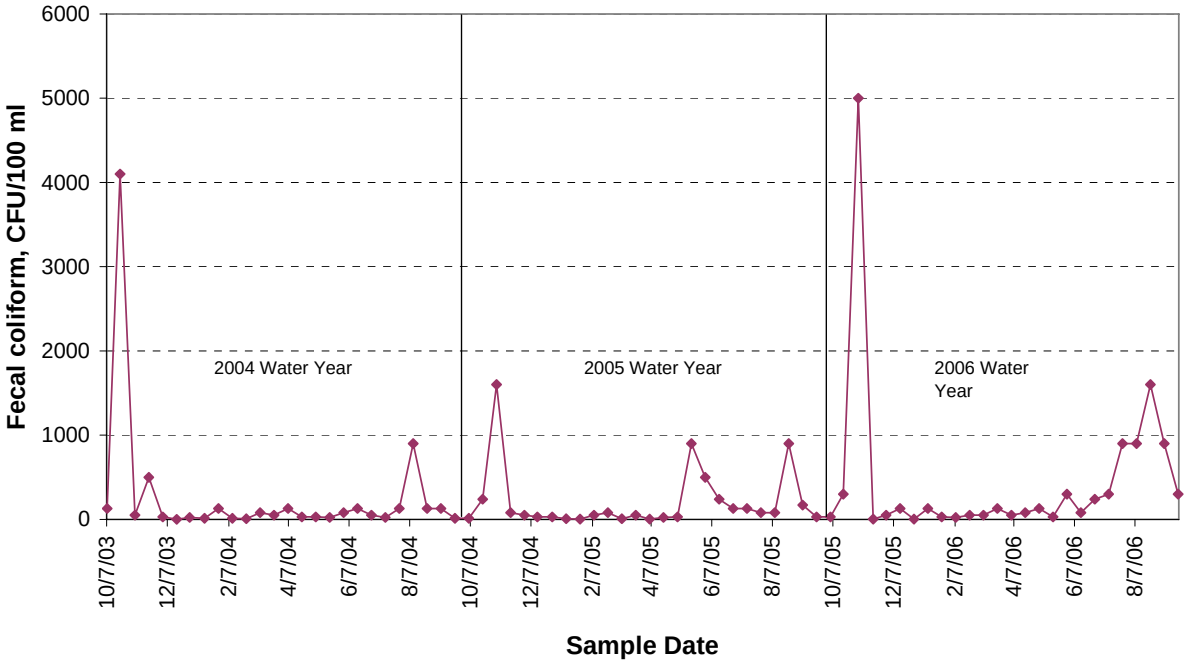
Graphs on the pages following Table 5 illustrate fecal coliform levels for water years 2004-2006 at each of the sample sites. The scale on each graph differs in order to fully illustrate the variability at each site.

Table 5. Summary of fecal coliform readings in Skagit County Monitoring Program, 2006 Water Year

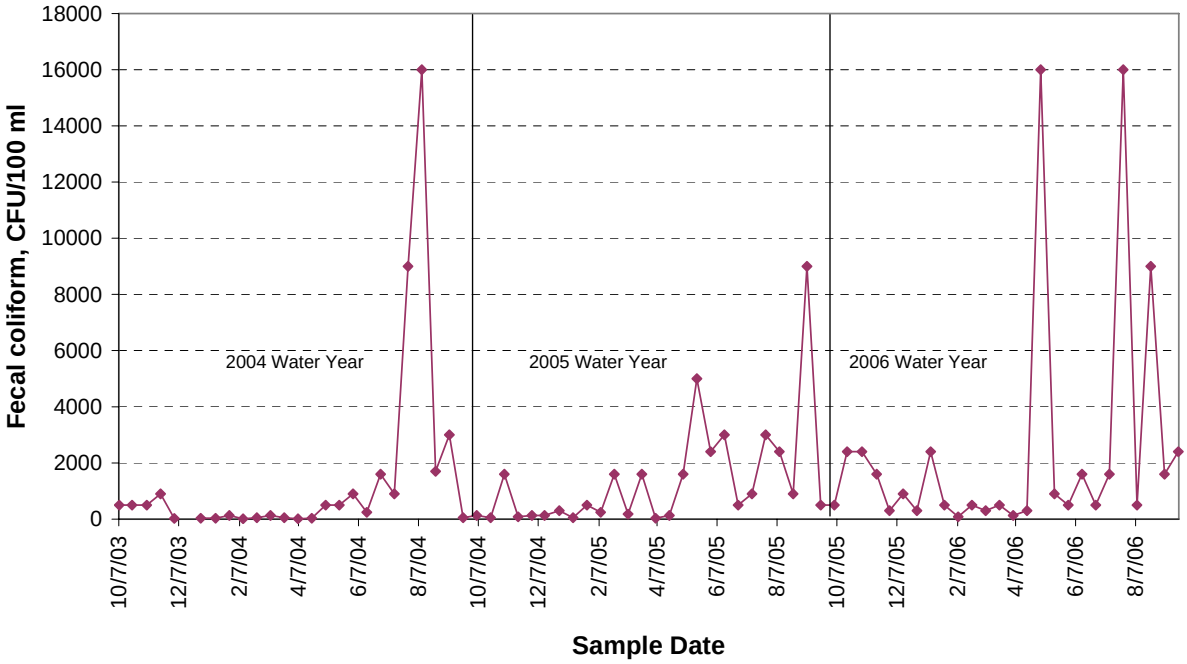
Site Number	Watercourse	Location	N	Geometric mean (cfu)[1]	% > 100 or 200[1]
3	Thomas Ck	Old Hwy 99 North	26	121	38
4	Thomas Ck	F&S Grade	26	950	92
6	Friday Ck	Prairie Rd	26	55	12
8	Swede Ck	Grip Rd	26	113	38
11	Samish R	State Route 9	26	22	4
12	Nookachamps Ck	Swan Rd	26	75	19
13	E.F. Nookachamps Ck	State Route 9	26	57	19
14	College Way Ck	College Way	26	157	42
15	Nookachamps Ck	Knapp	26	78	27
16	E.F. Nookachamps Ck	Beaver Lake Rd	26	20	4
17	Nookachamps Ck	Big Lake Outlet	25	16	16
18	Lake Ck	State Route 9	26	45	19
19	Hansen Ck	Hoehn Rd	26	107	46
20	Hansen Ck	Northern State	25	77	32
21	Coal Ck	Hoehn Rd	21	115	48
22	Coal Ck	Hwy 20	26	11	15
23	Wiseman Ck	Minkler Rd	24	23	25
24	Mannser Ck	Lyman Hamilton Hwy	26	17	12
25	Red Cabin Ck	Hamilton Cem Rd	23	9	13
28	Brickyard Ck	Hwy 20	20	55	25
29	Skagit R	R Bend Rd	23	7	4
30	Skagit R	Cape Horn Rd	25	5	0
31	Drain Dist 20 near floodgate	Francis Rd	17	89	35
32	Samish R	Thomas Rd	26	85	15
33	Alice Bay Pump Station	Samish Island Rd	26	62	27
34	Noname Slough	Bayview-Edison Rd	25	204	52
35	Joe Leary Slough	D'Arcy Rd	25	143	40
36	Edison Slough at school	W. Bow Hill Rd	26	71	23
37	Edison Pump Station	Farm to Market Rd	26	197	58
38	North Edison Pump Station	North Edison Rd	26	120	42
39	Colony Ck	Colony Rd	26	156	42
40	Big Indian Slough	Bayview-Edison Rd	25	51	24
41	Maddox Slough/Big Ditch	Milltown Rd	26	73	23
42	Hill Ditch	Cedardale Rd	25	27	8
43	Wiley Slough	Wylie Rd	25	56	12
44	Rexville PS/Sullivan Slough	La Conner-Whitney Rd	25	44	20
45	Skagit R – North Fork	Moore Rd	26	6	0
46	Skagit R – South Fork	Fir Island Rd	25	8	0
47	Swinomish Channel	County Boat Launch	25	4	0
48	Fisher Ck	Franklin Rd	25	76	24

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

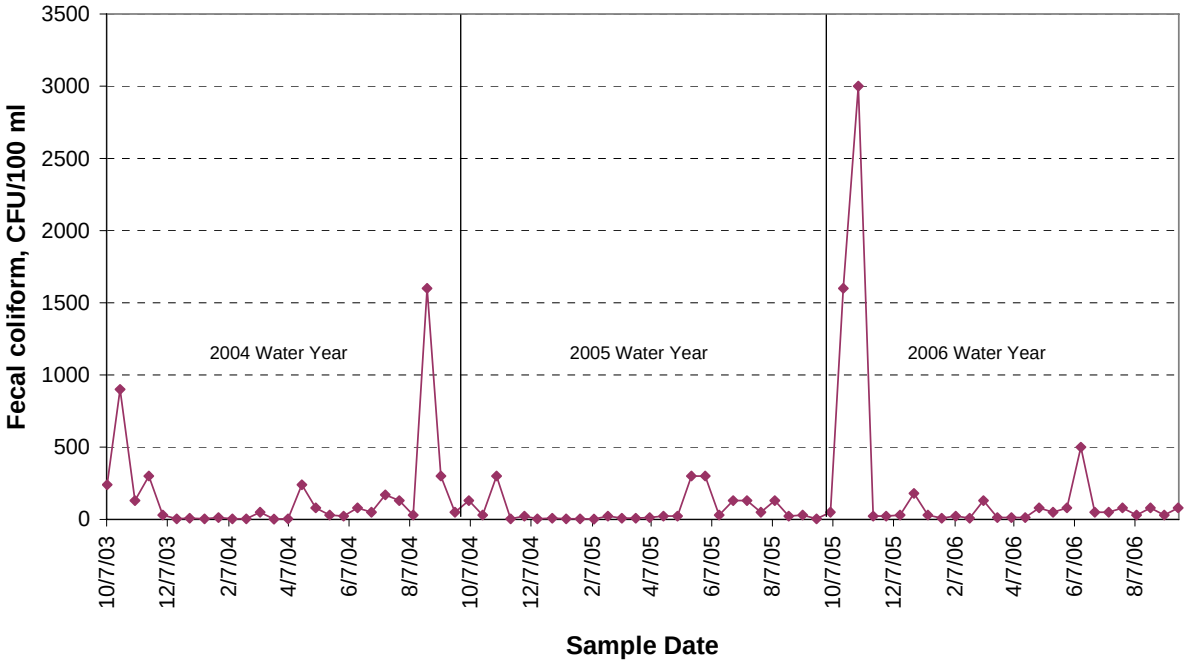
Thomas Creek at Hwy 99 - Site 3
Fecal coliform



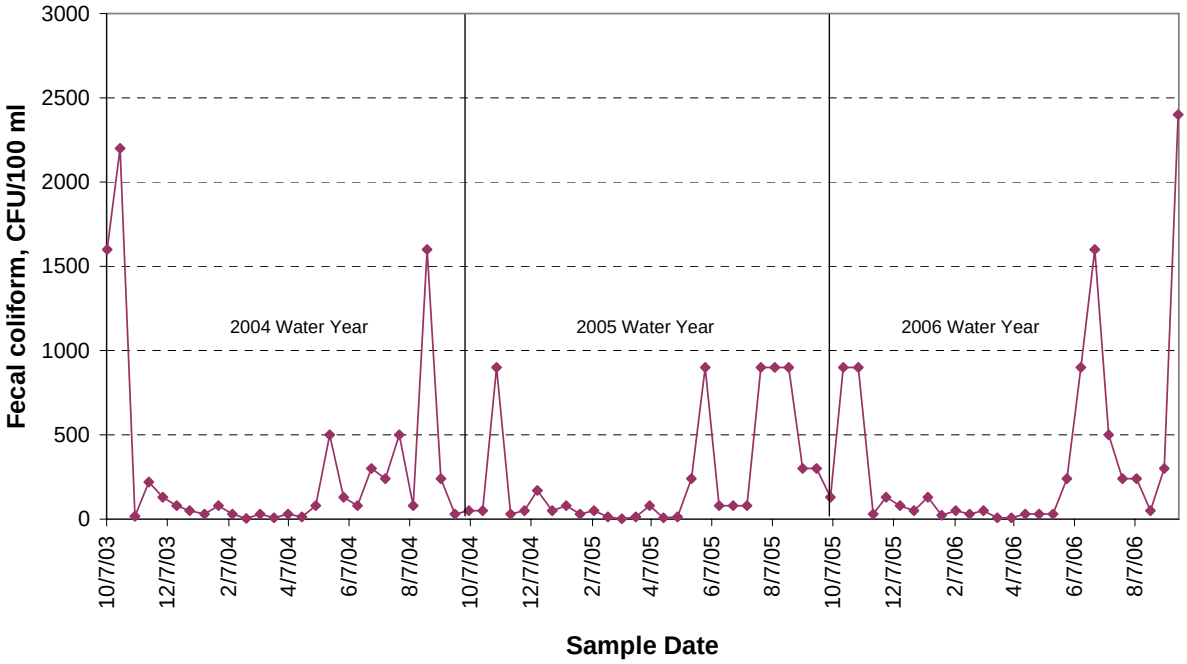
Thomas Creek at F&S Grade Rd - Site 4
Fecal coliform



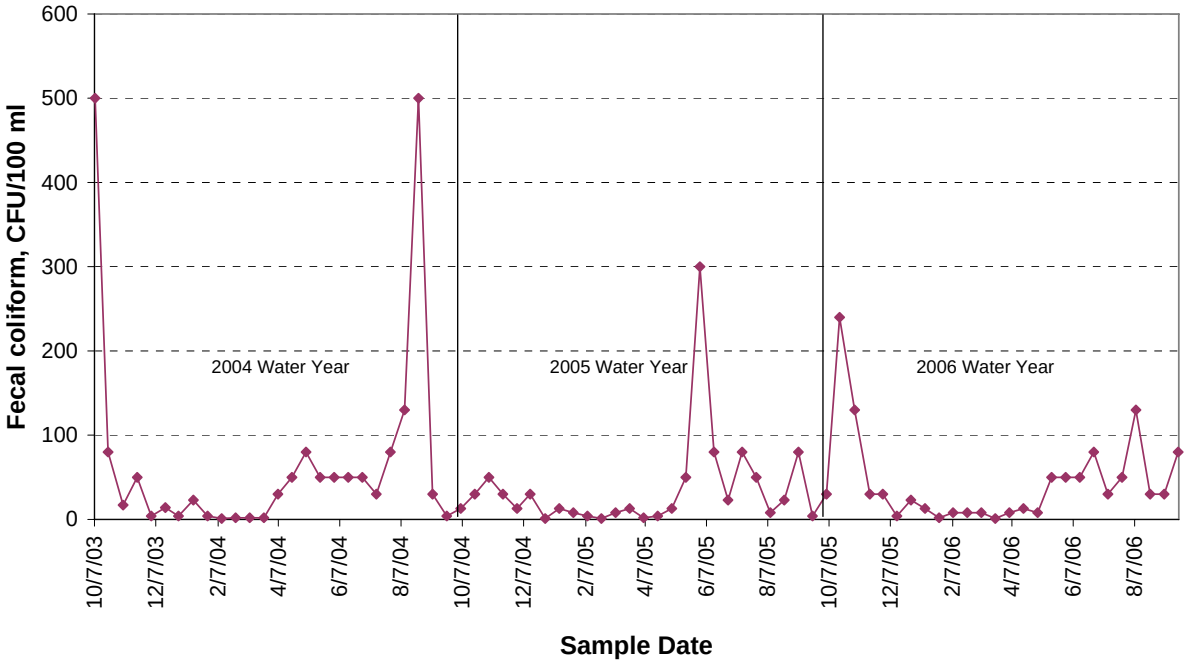
Friday Creek at Prairie Rd - Site 6
Fecal coliform



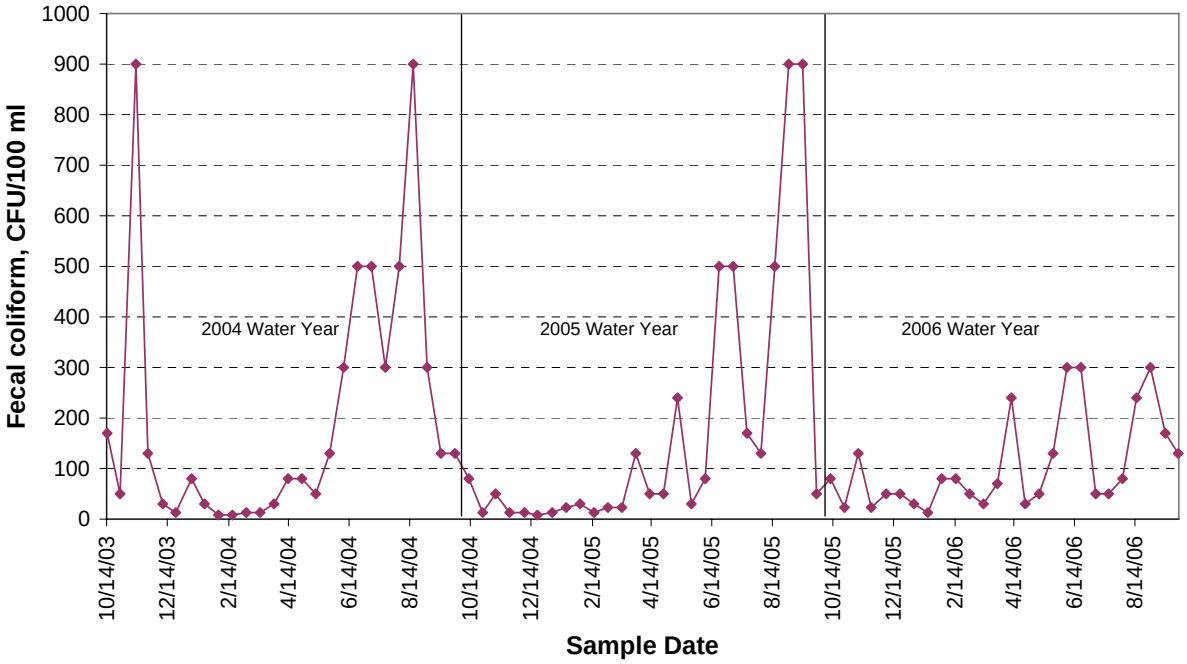
Swede Creek at Grip Rd - Site 8
Fecal coliform



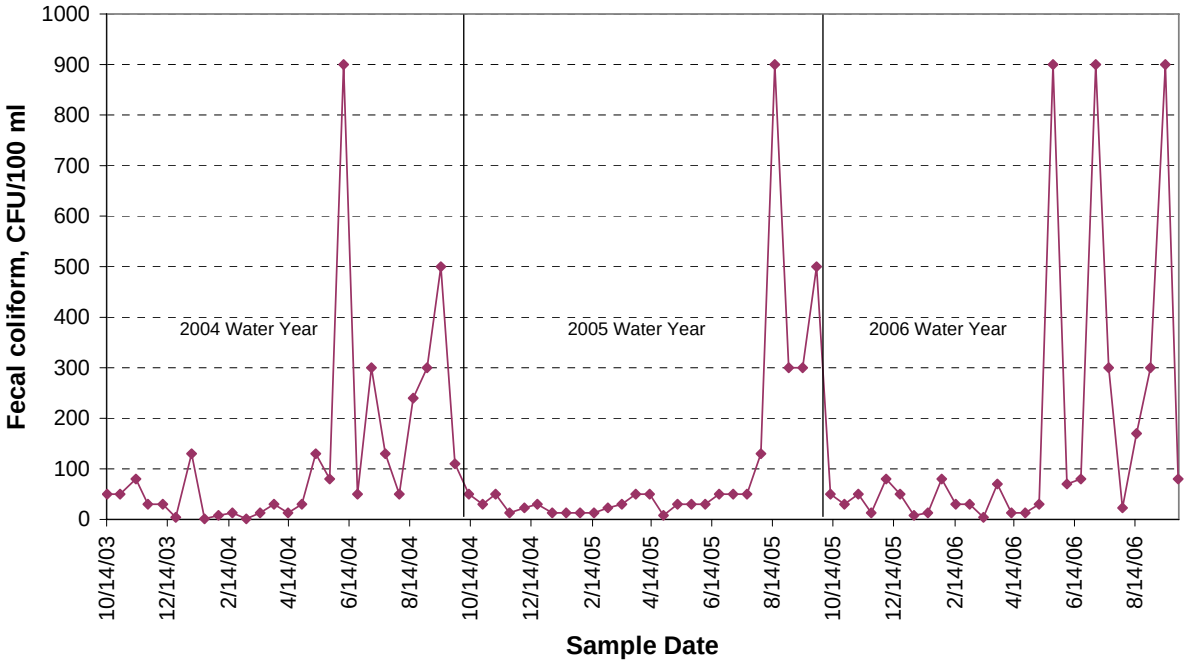
Samish River at Hwy 9 - Site 11
Fecal coliform



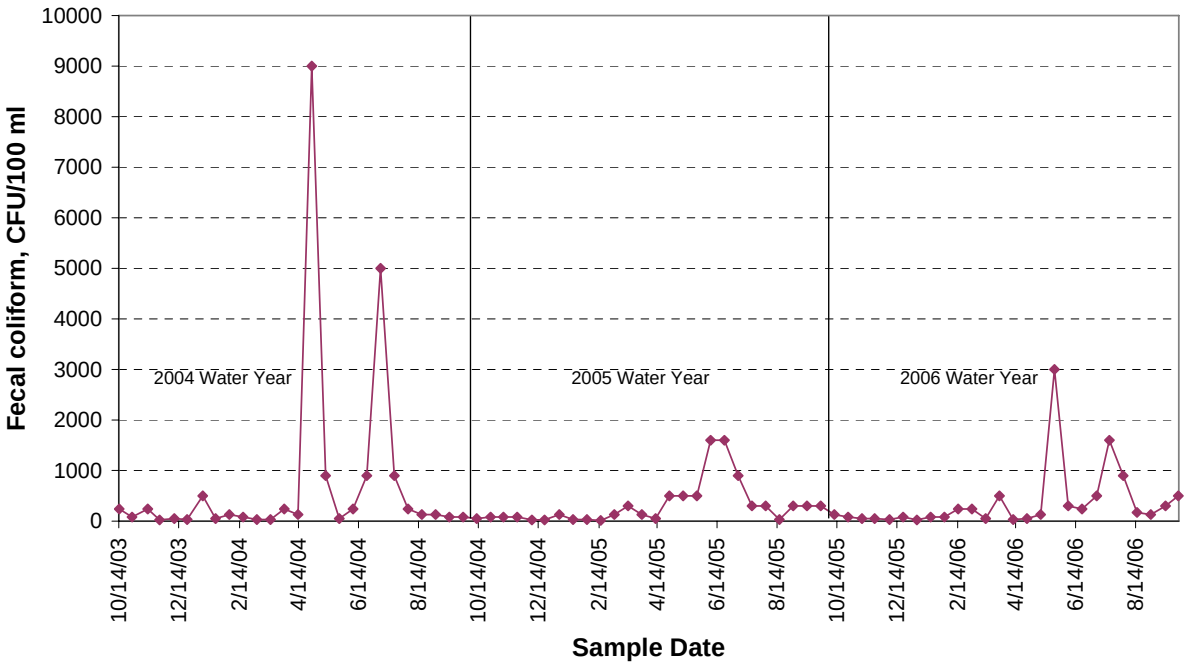
Nookachamps Creek at Swan Rd - Site 12
Fecal coliform



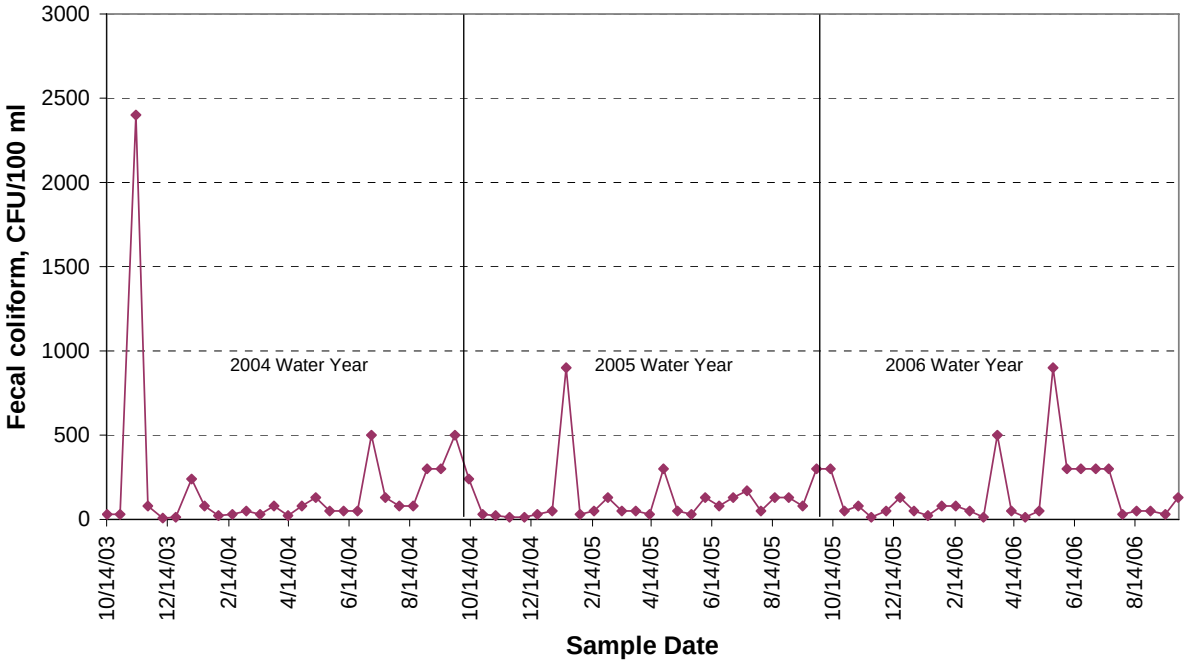
E.F. Nookachamps Creek at Hwy 9 - Site 13
Fecal coliform



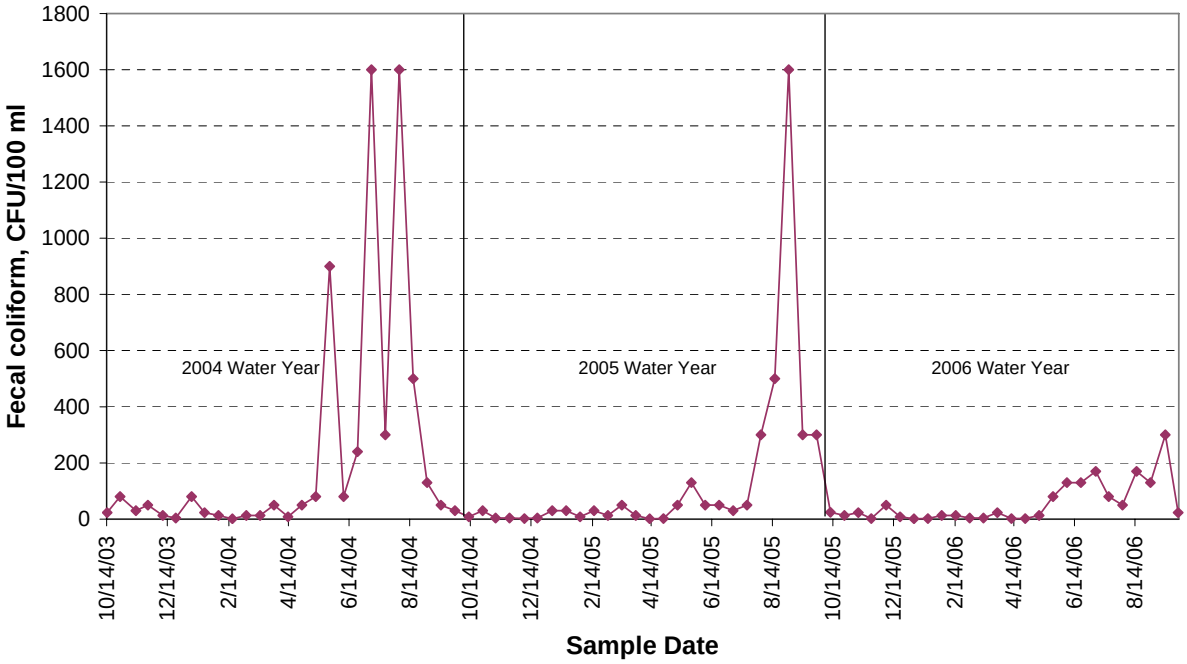
College Way Creek at College Way - Site 14
Fecal coliform



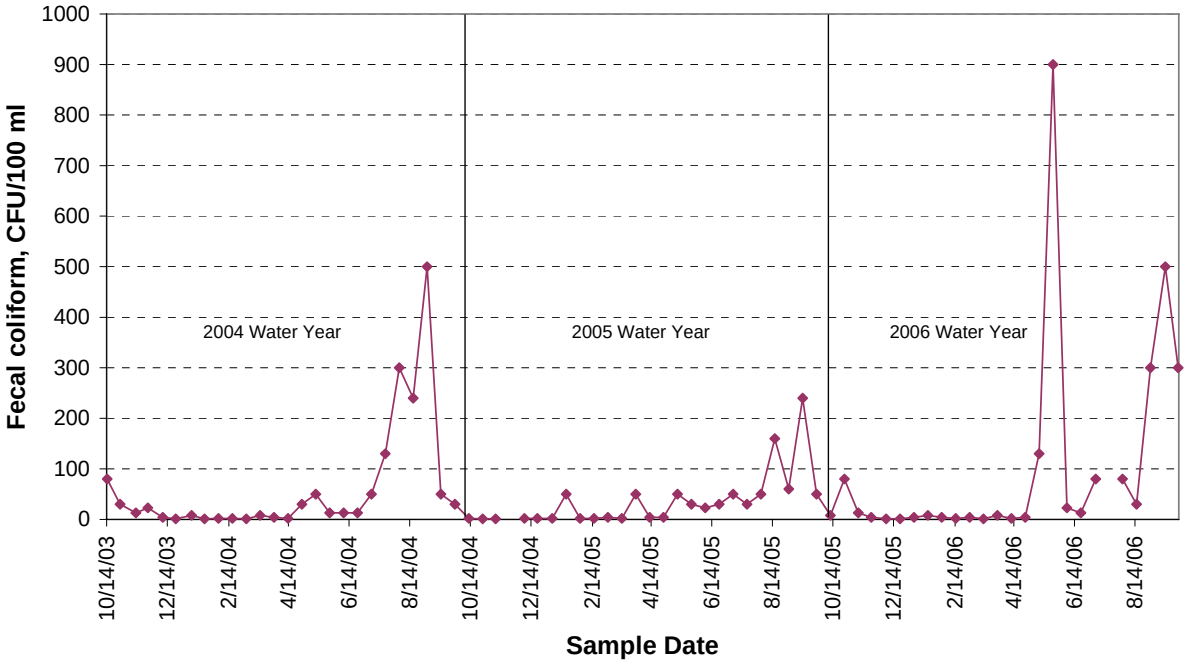
Nookachamps Creek at Swan Rd - Site 15
Fecal coliform



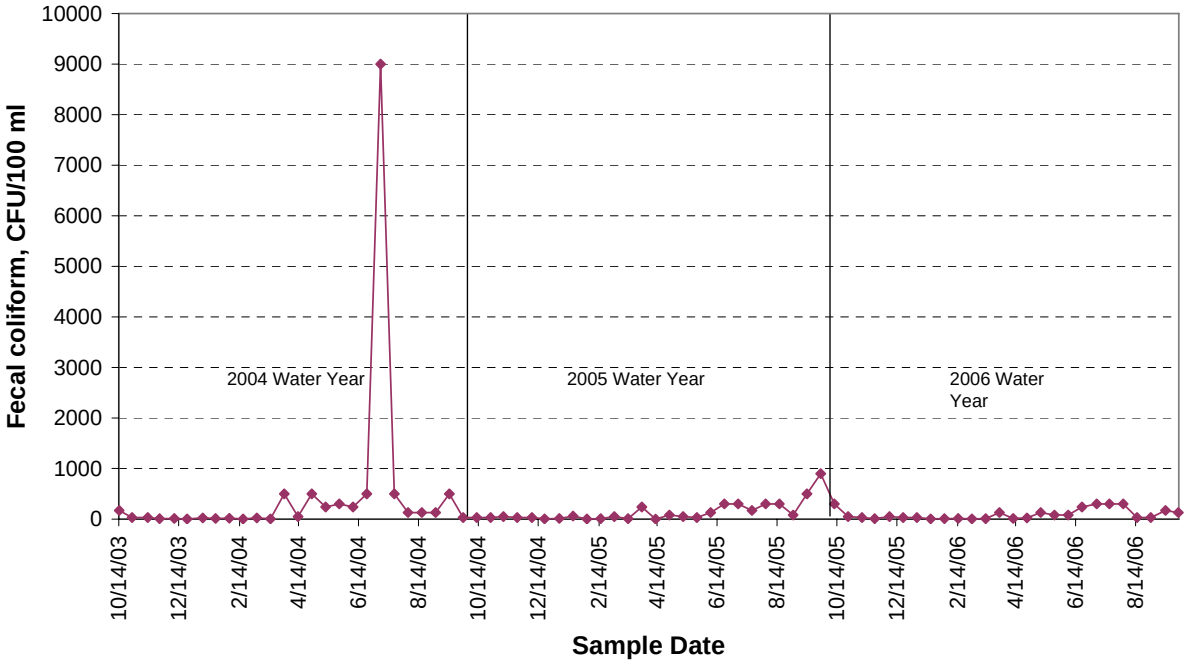
E.F. Nookachamps Creek at Beaver Lake Rd - Site 16
Fecal coliform



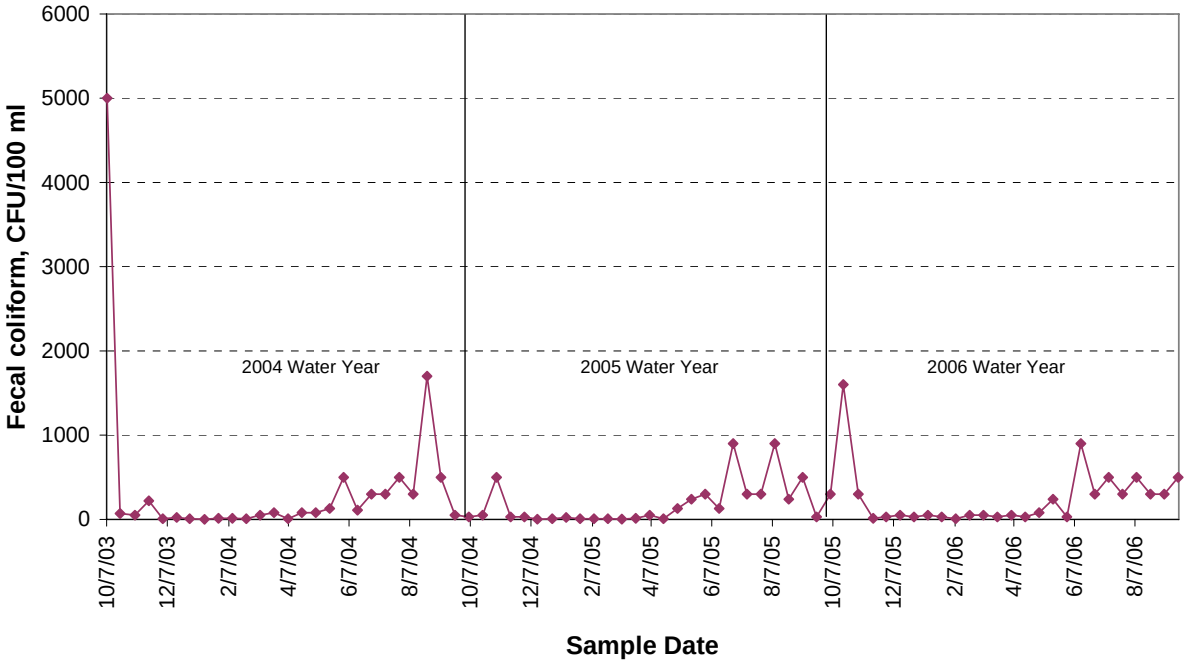
Nookachamps Creek at Big Lake Outlet - Site 17
Fecal coliform



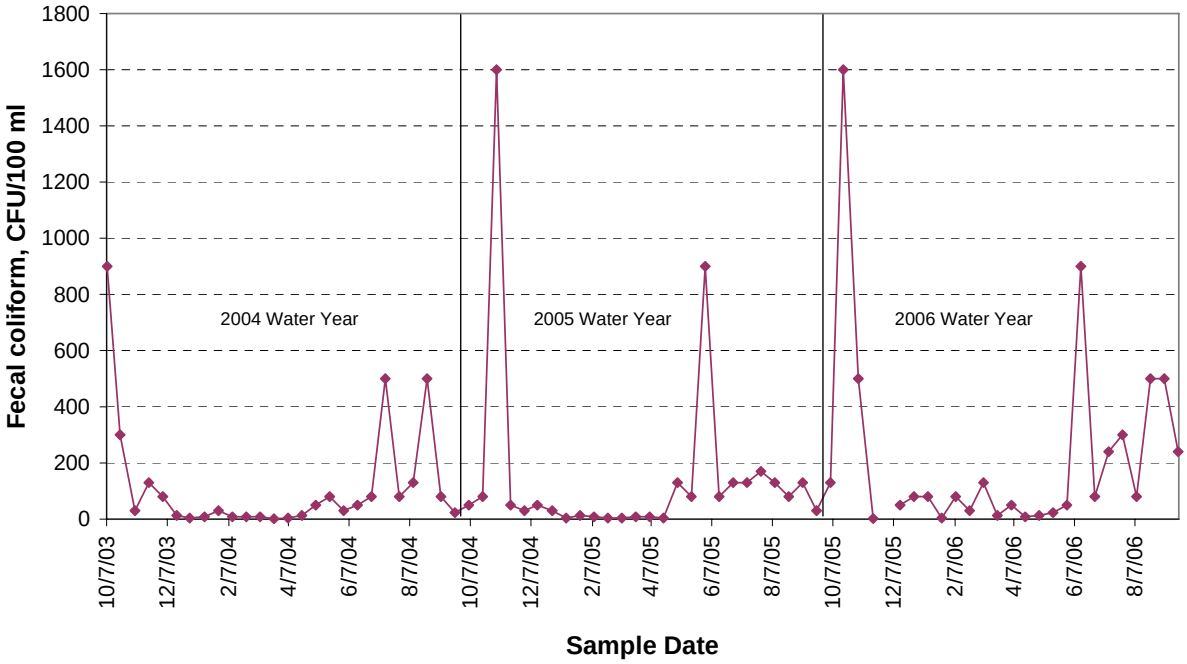
Lake Creek at Hwy 9 - Site 18
Fecal coliform



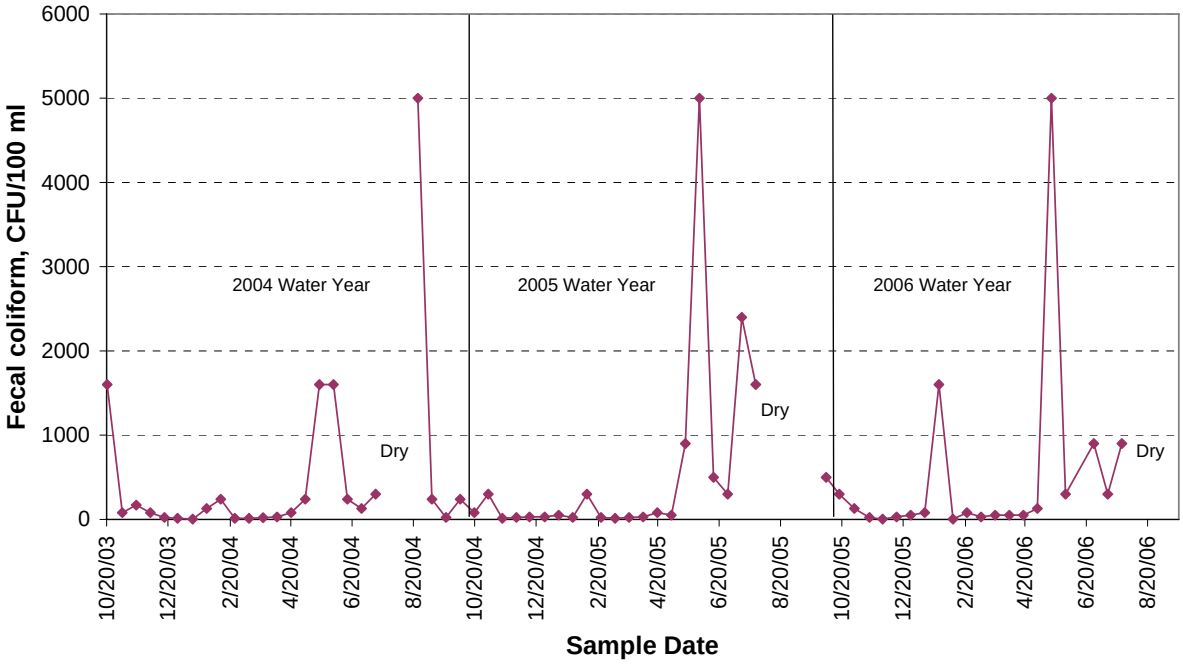
Hansen Creek at Hoehn Rd - Site 19
Fecal coliform



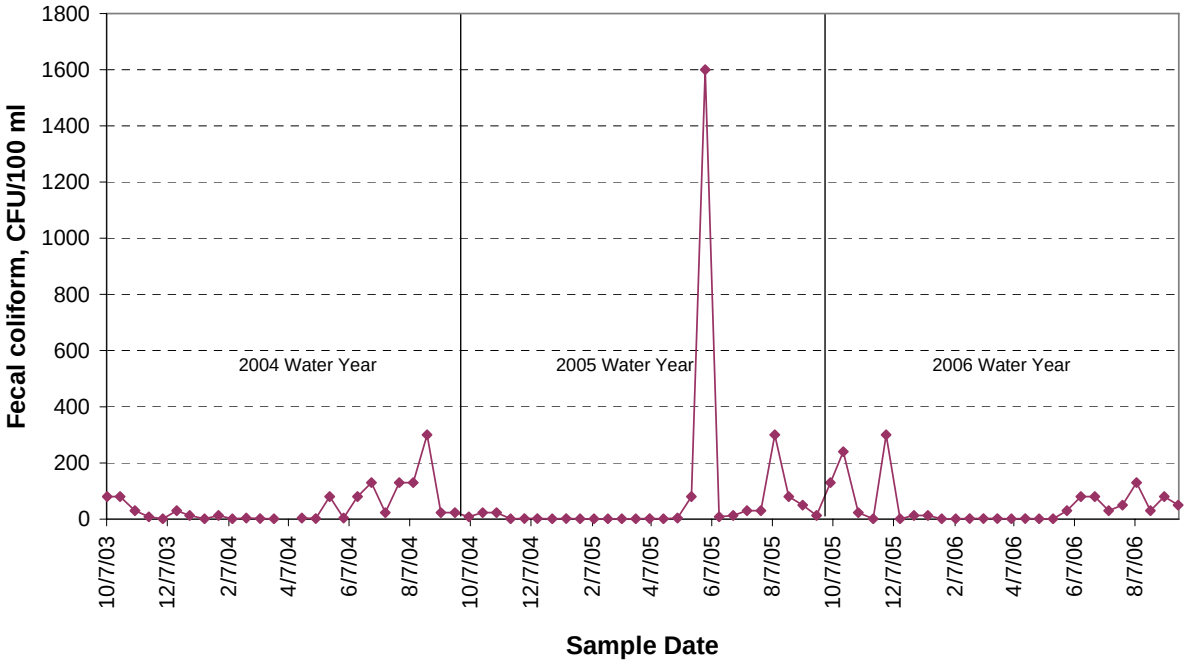
Hansen Creek at Northern State Hospital - Site 20
Fecal coliform



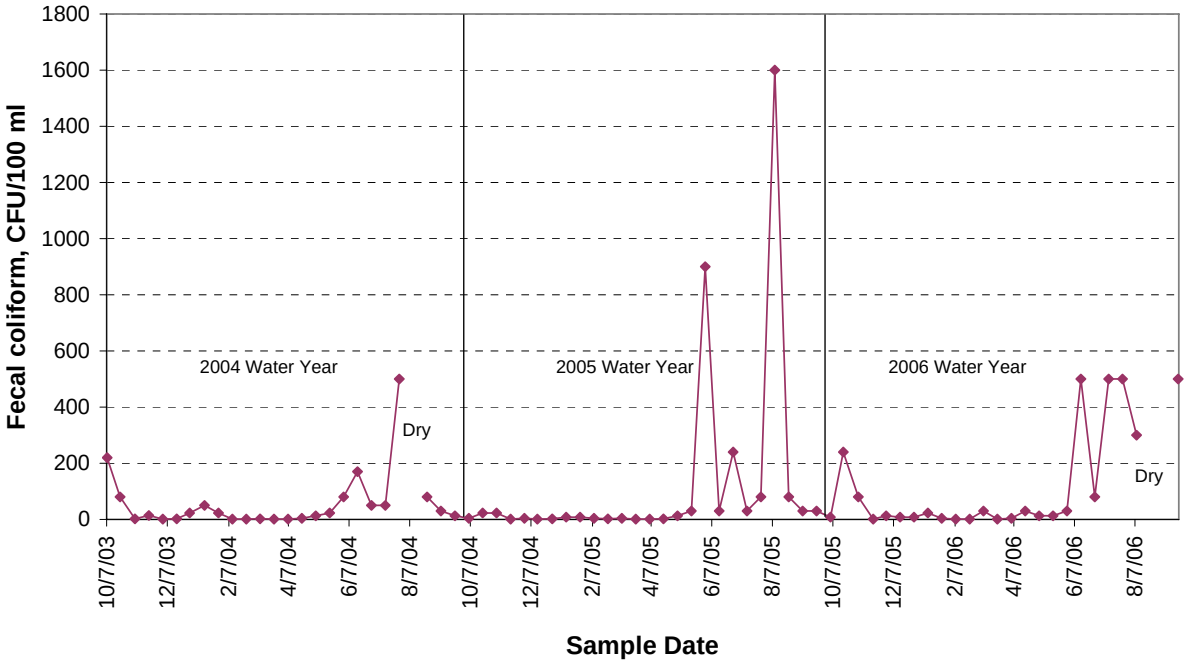
Coal Creek at Hoehn Rd - Site 21
Fecal coliform



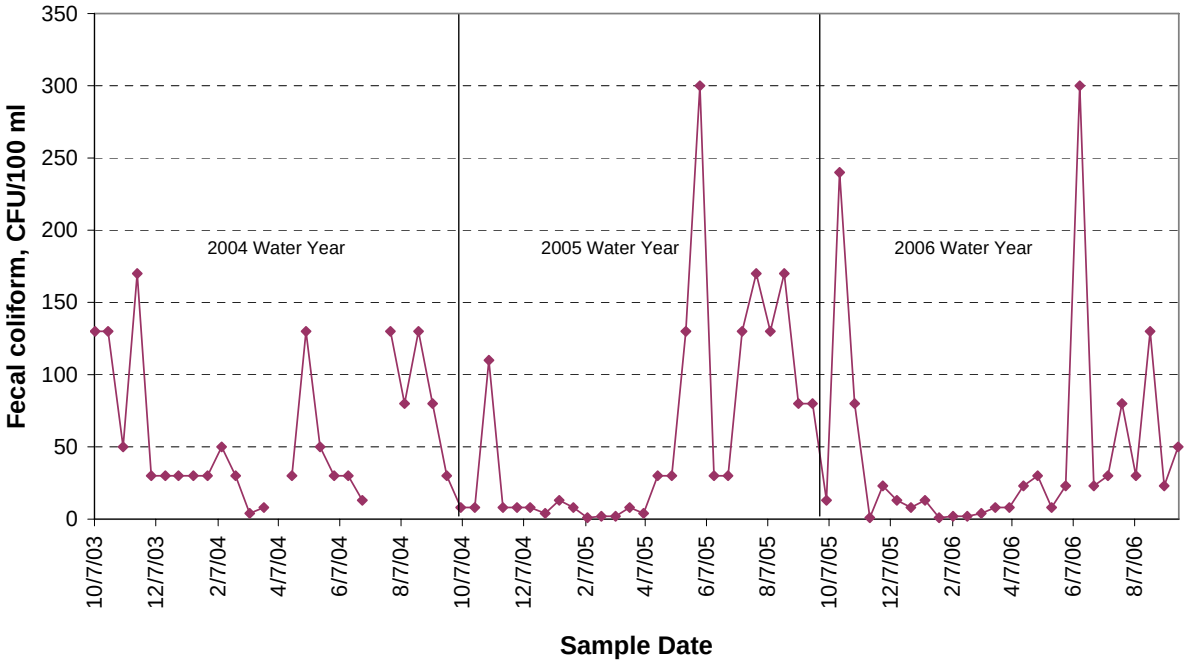
Coal Creek at Hwy 20 - Site 22
Fecal coliform



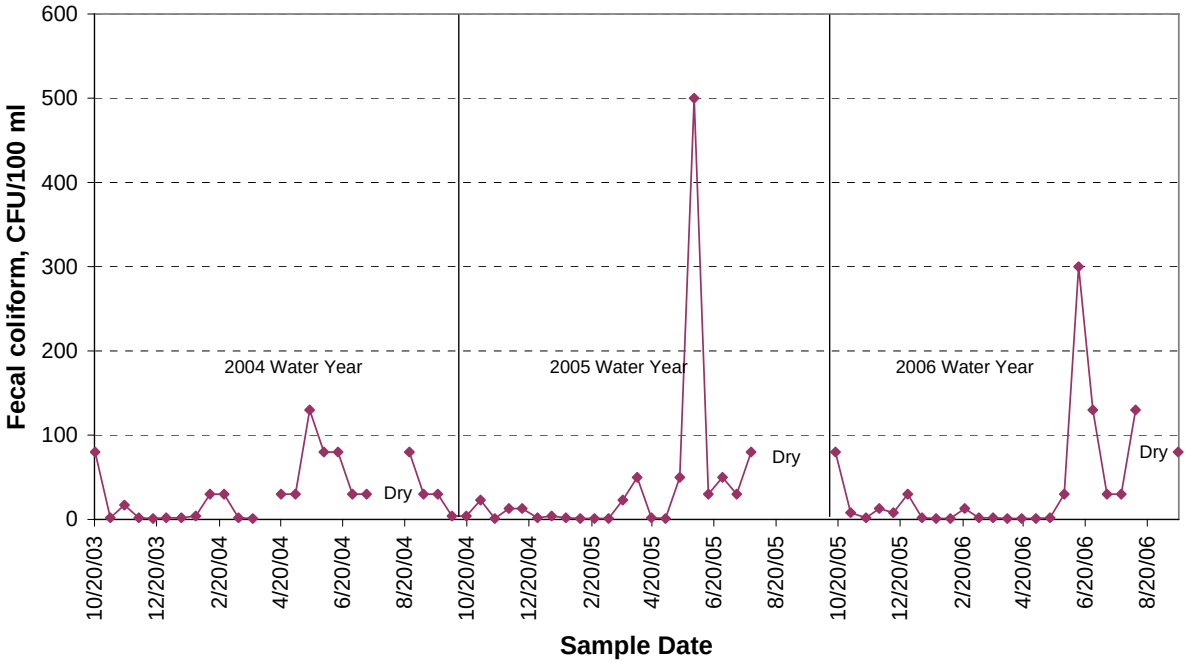
Wiseman Creek at Minkler Rd - Site 23
Fecal coliform



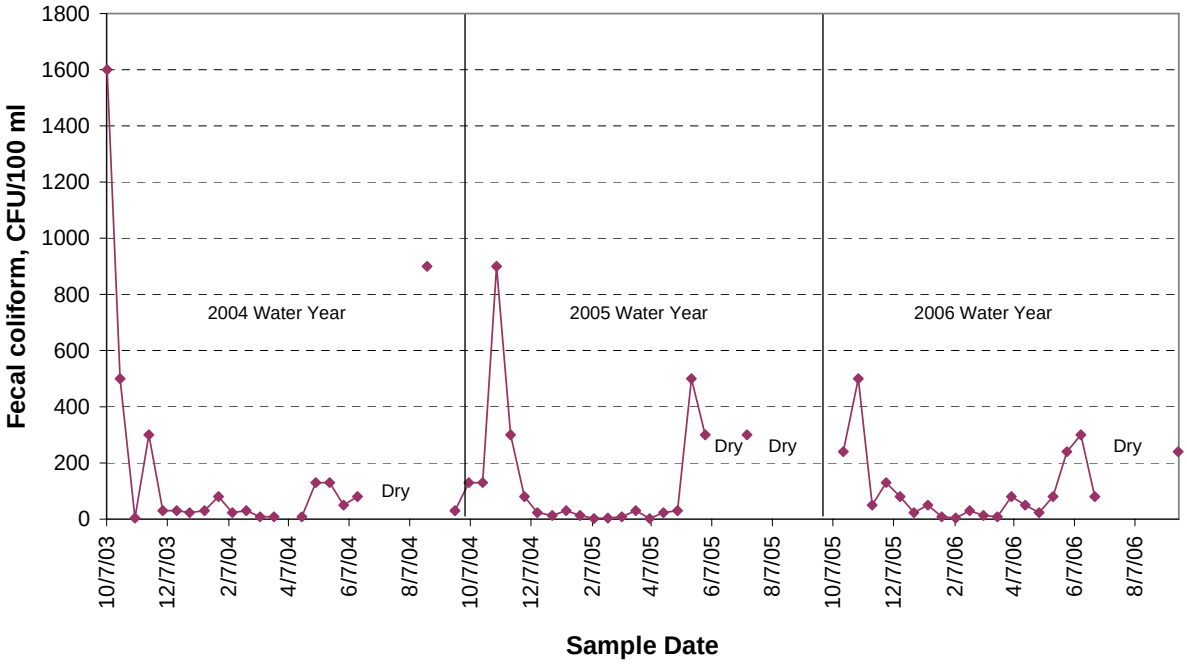
Mannser Creek at Lyman-Hamilton Hwy - Site 24
Fecal coliform



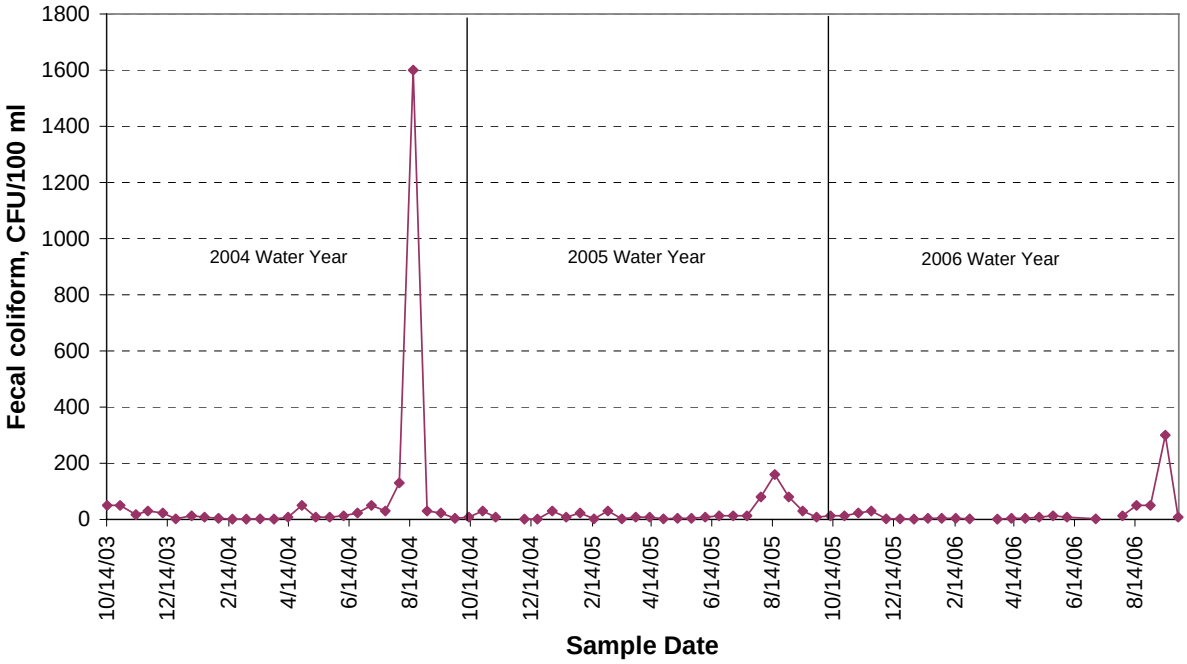
Red Cabin Creek at Hamilton Cemetery Rd - Site 25
Fecal coliform



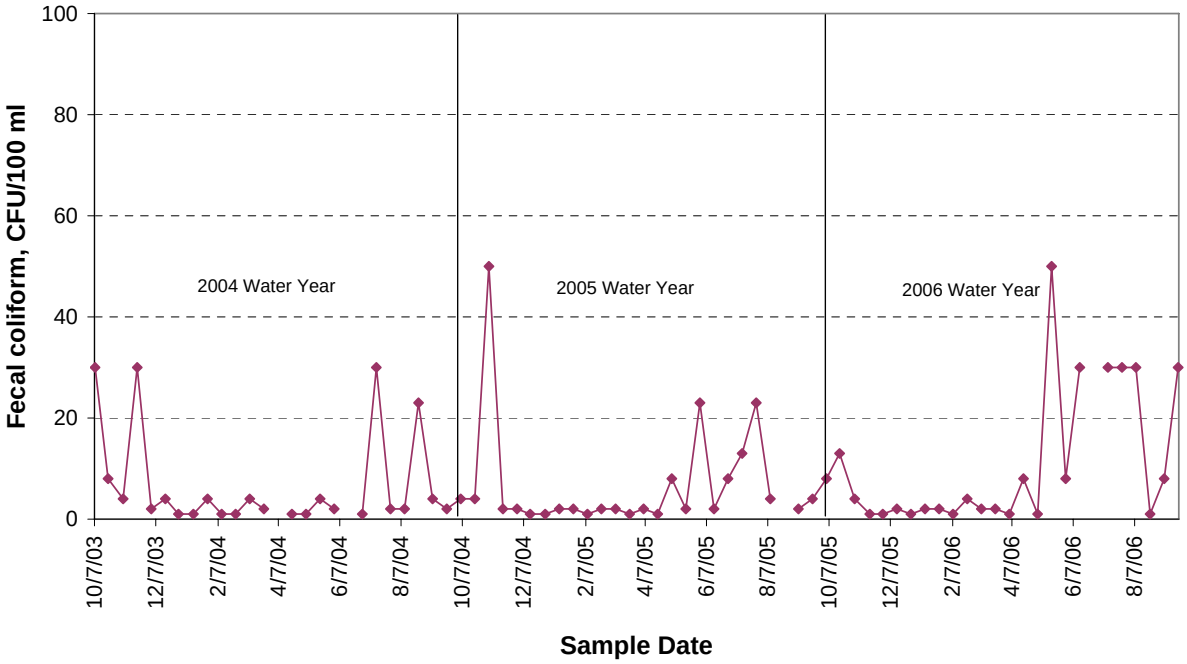
Brickyard Creek at Hwy 20 - Site 28
Fecal coliform



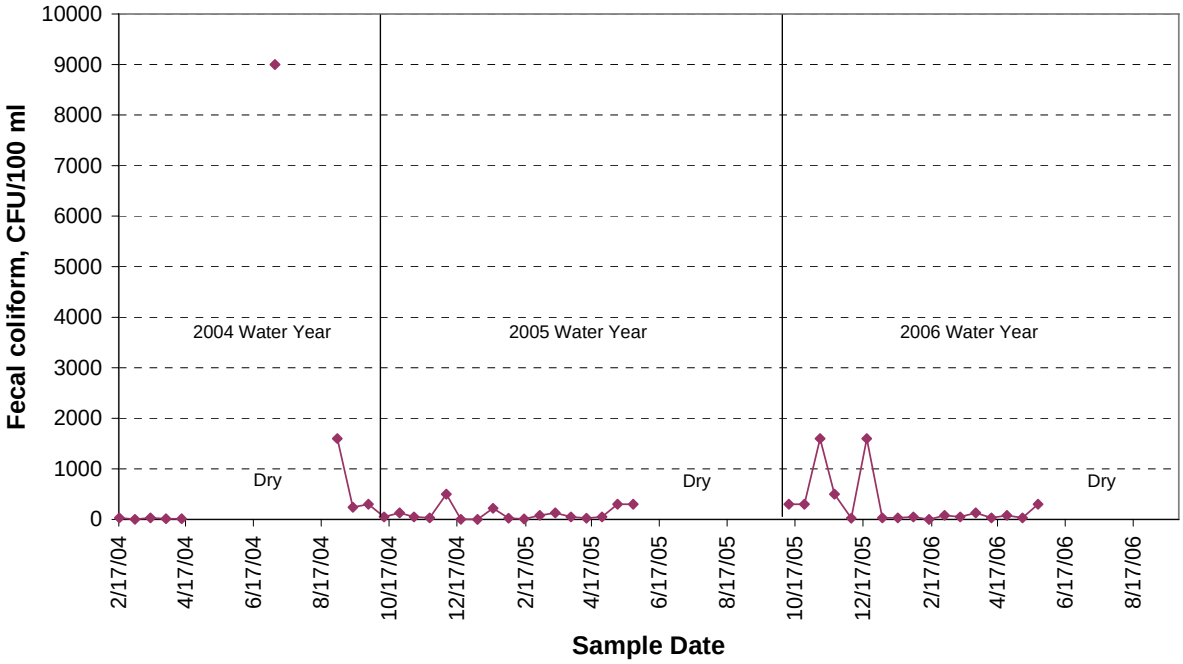
Skagit River at River Bend - Site 29
Fecal coliform



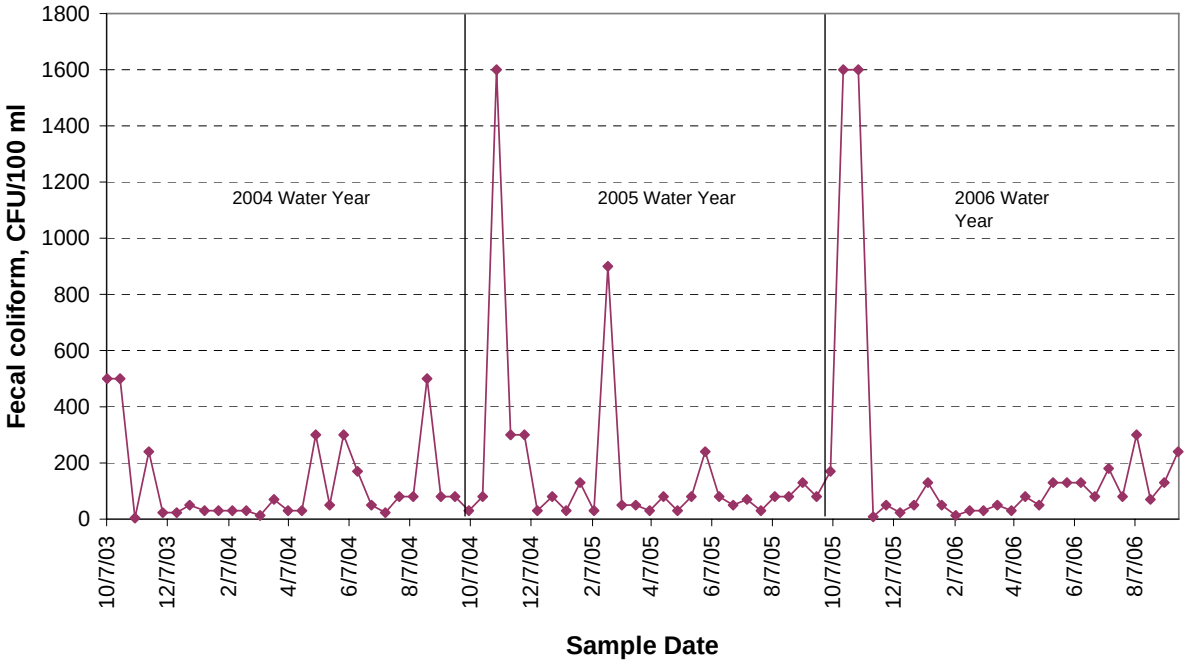
Skagit River at Cape Horn Rd - Site 30
Fecal coliform



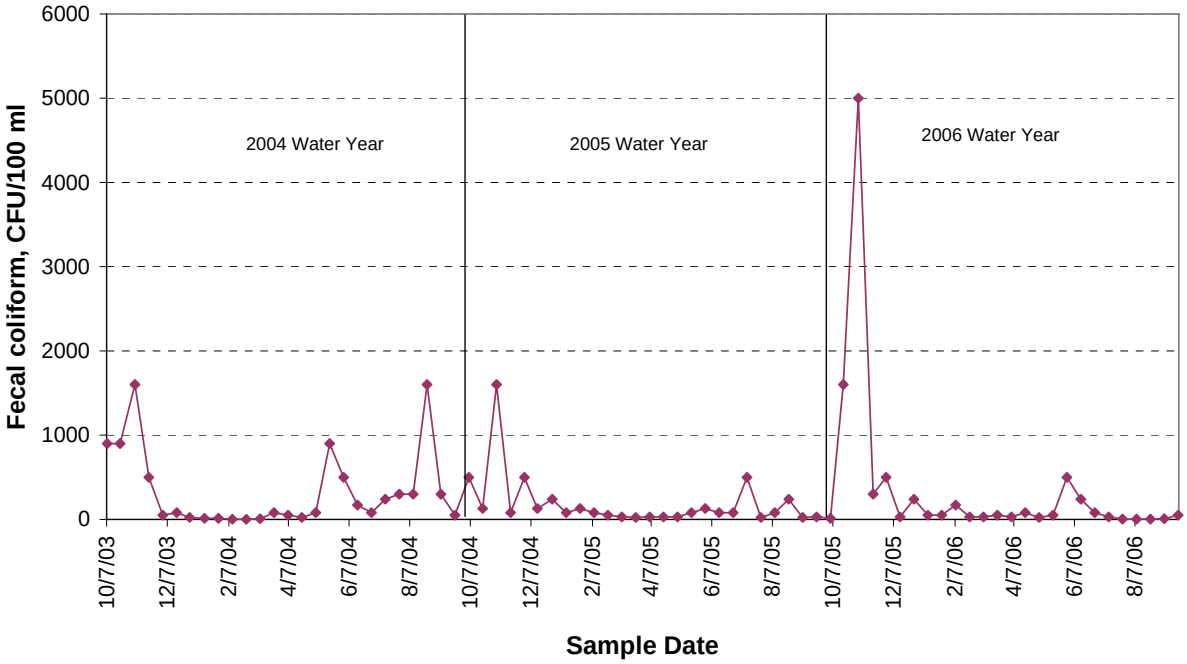
Drainage District 20 Ditch at Floodgate - Site 31
Fecal coliform



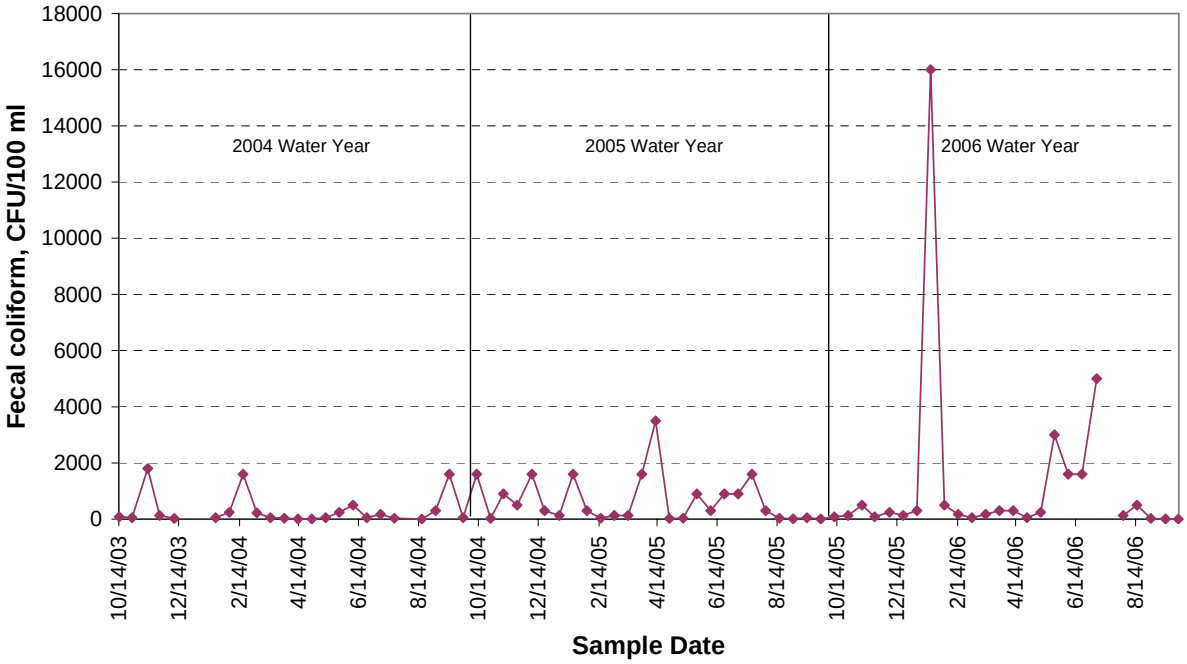
Samish River at Thomas Rd - Site 32
Fecal coliform



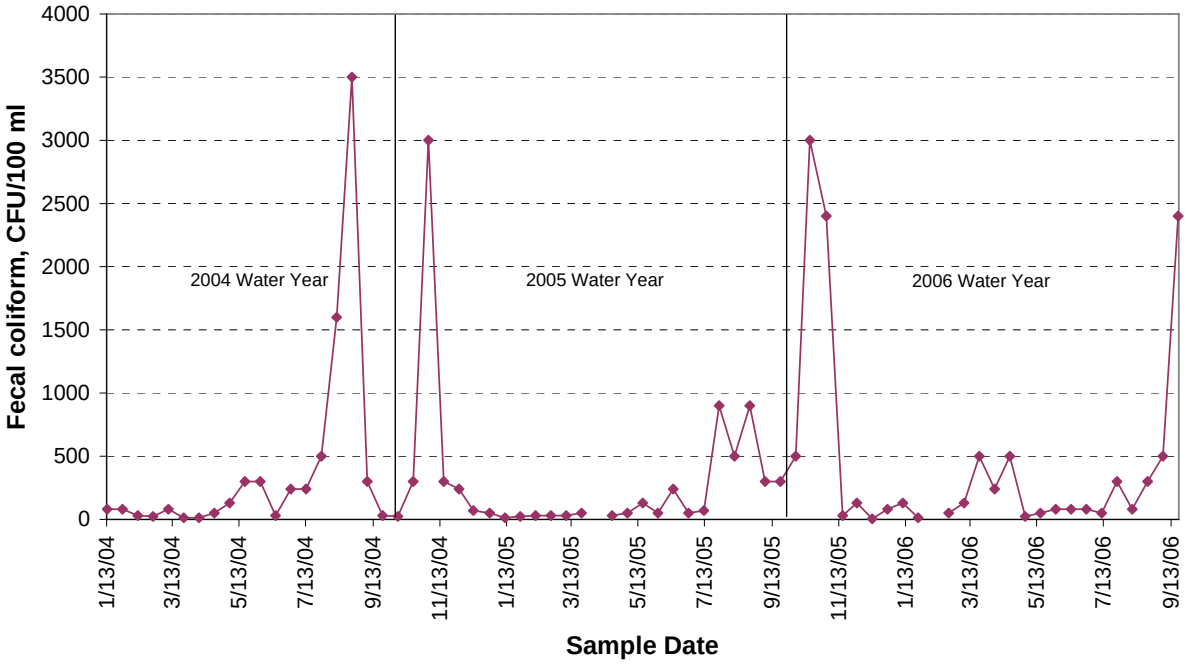
Alice Bay Pump Station - Site 33
Fecal coliform



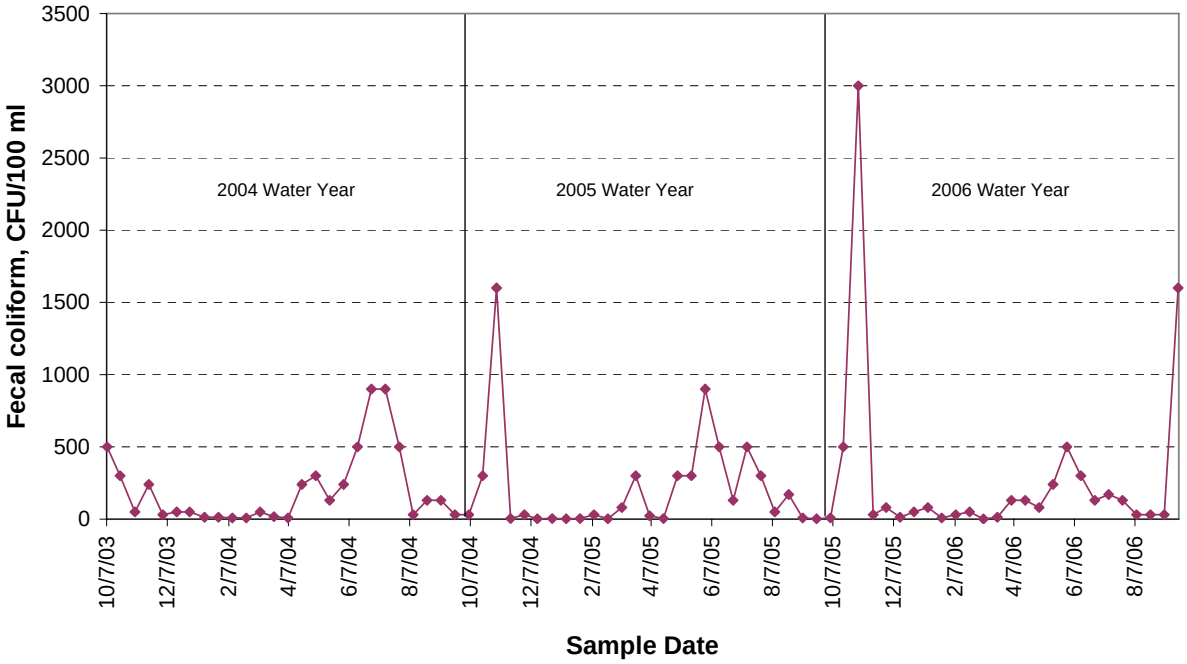
No Name Slough at Bayview-Edison Rd - Site 34
Fecal coliform



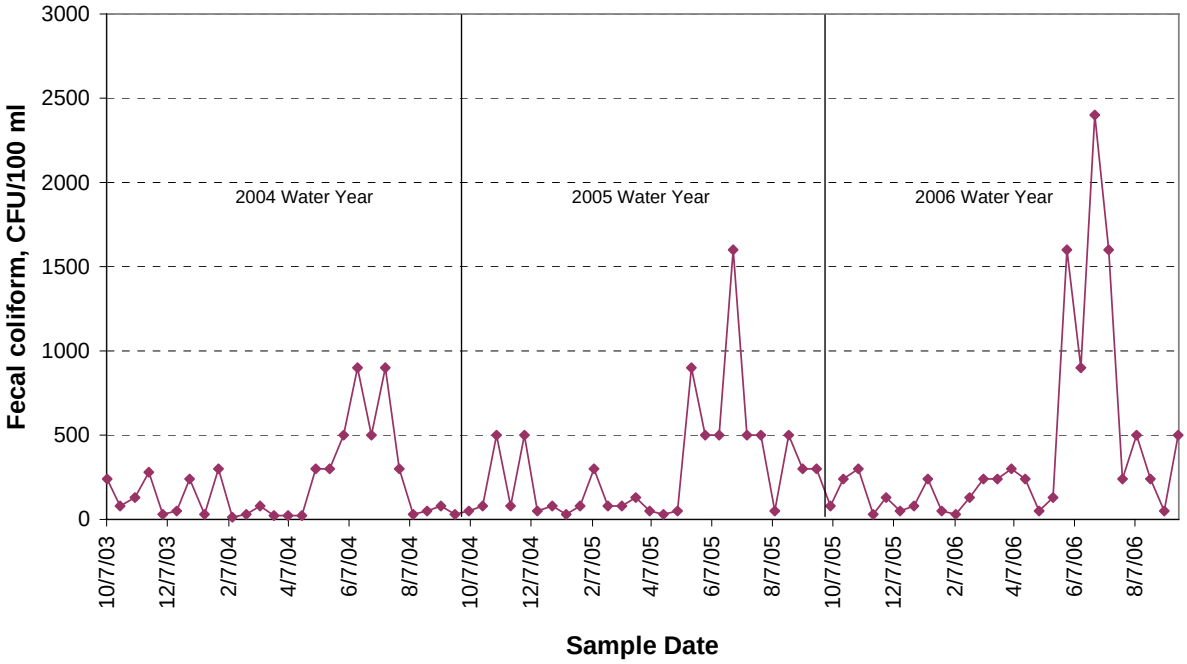
Joe Leary Slough at D'Arcy Rd - Site 35
Fecal coliform



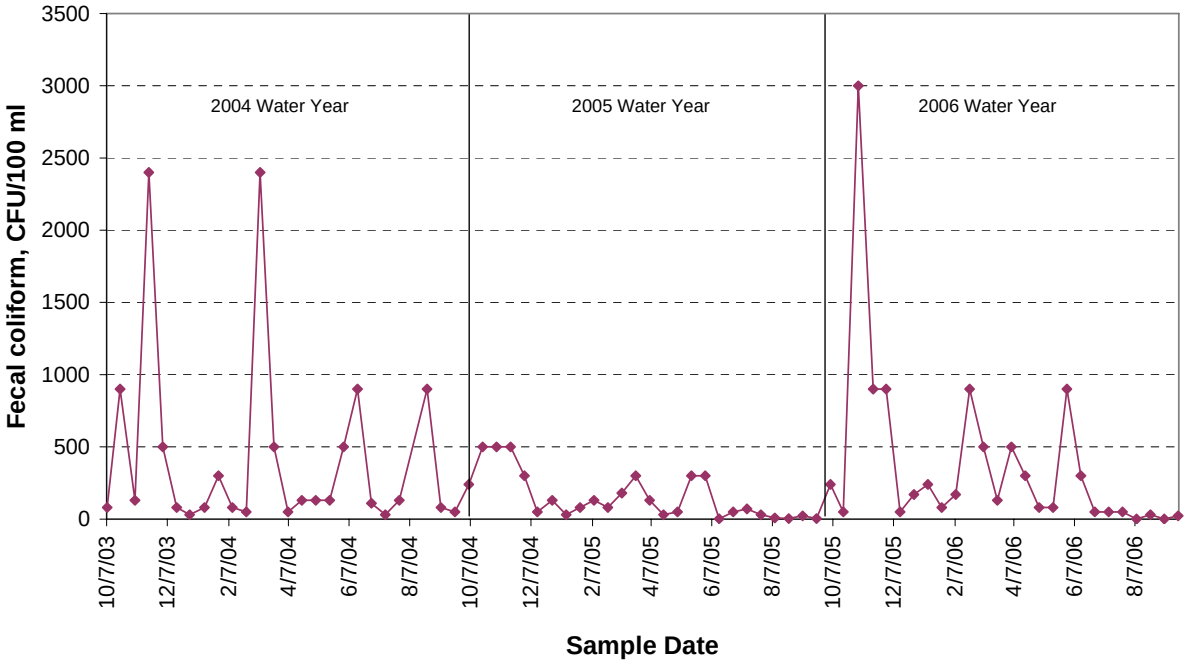
Edison Slough at Edison School - Site 36
Fecal coliform



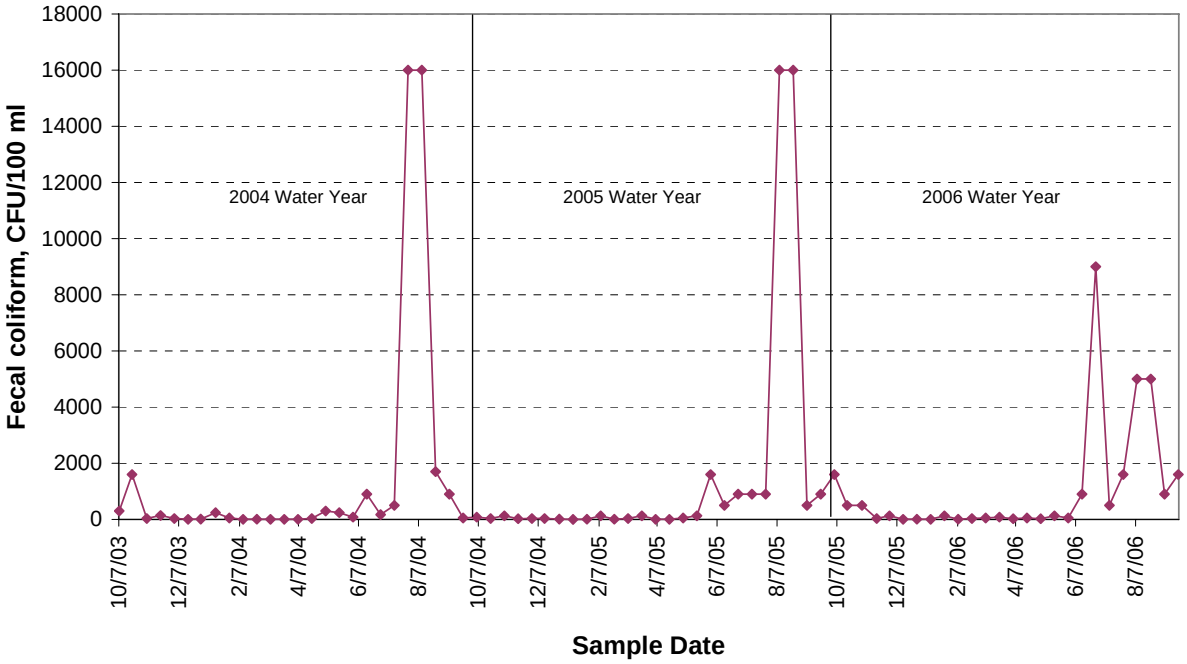
Edison Pump Station - Site 37
Fecal coliform



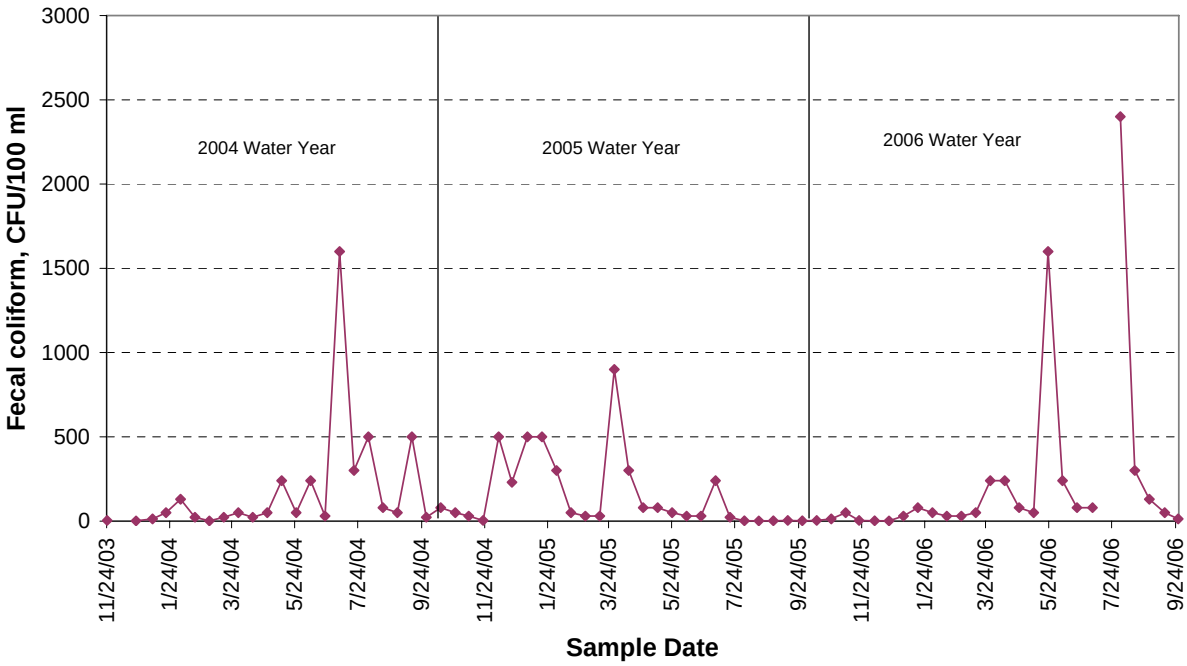
North Edison Pump Station - Site 38
Fecal coliform



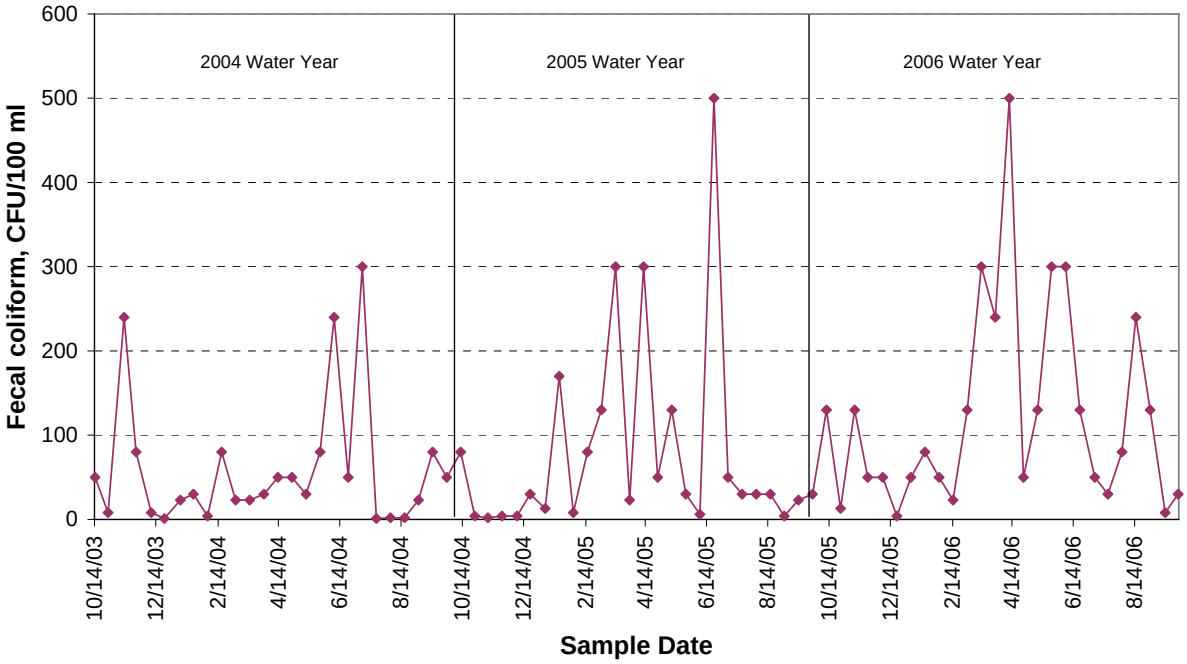
Colony Creek at Colony Rd - Site 39
Fecal coliform



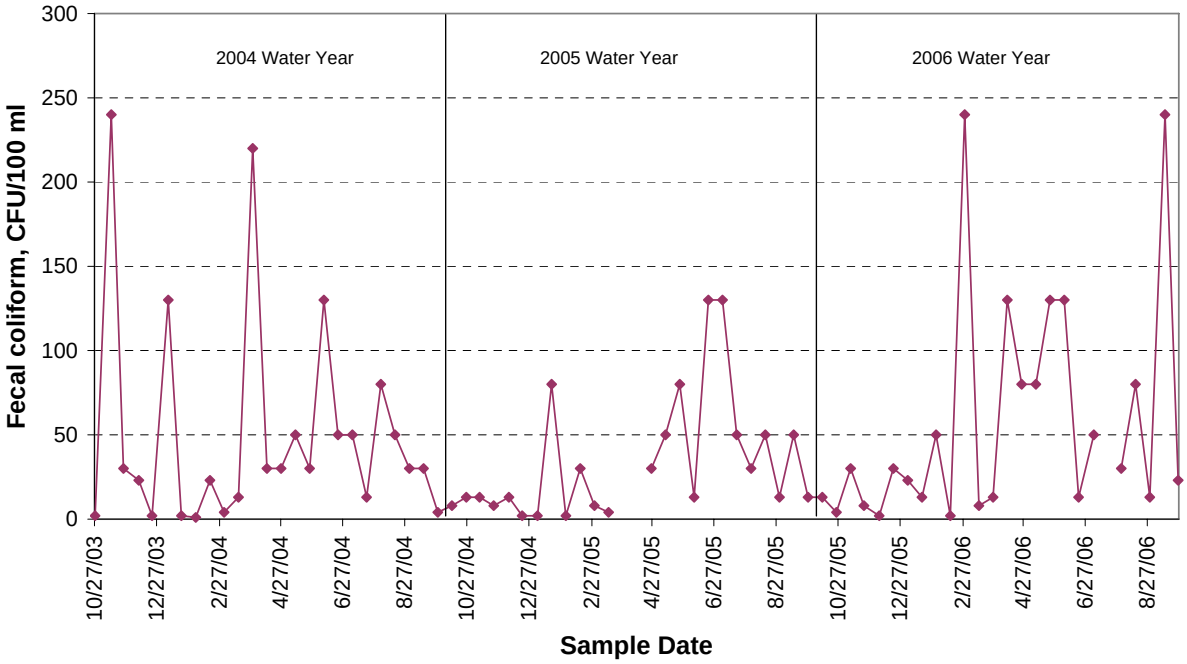
Big Indian Slough at Hwy 20 Truck Scales - Site 40
Fecal coliform



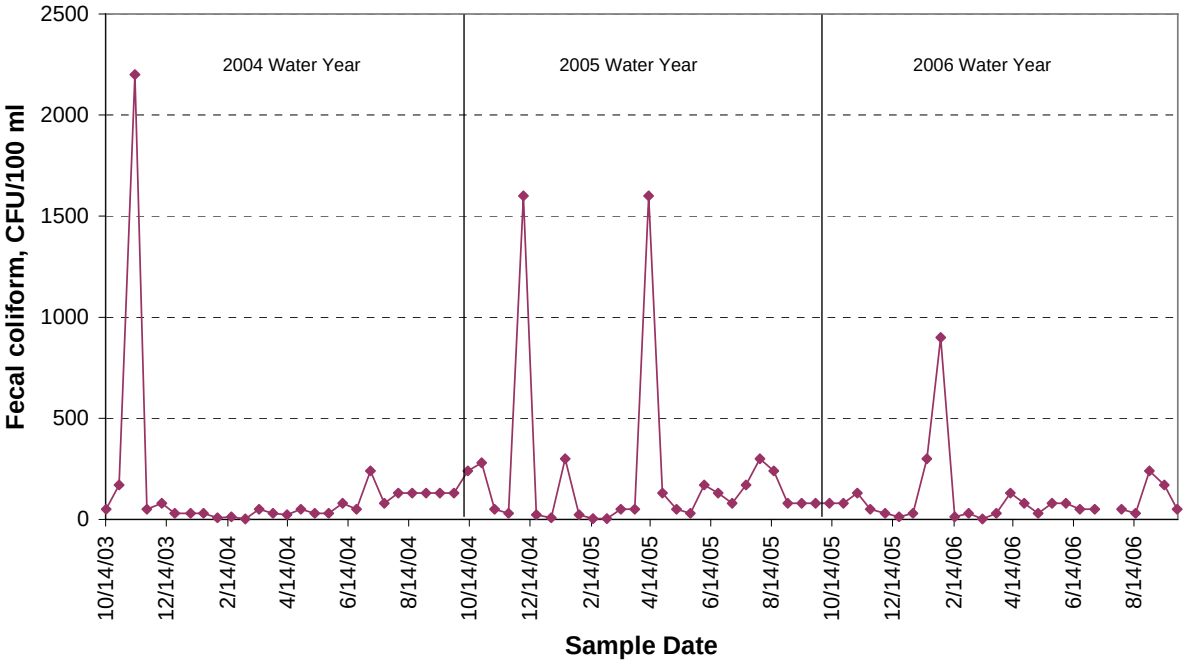
Maddox Creek/Big Ditch at Milltown Rd - Site 41
Fecal coliform



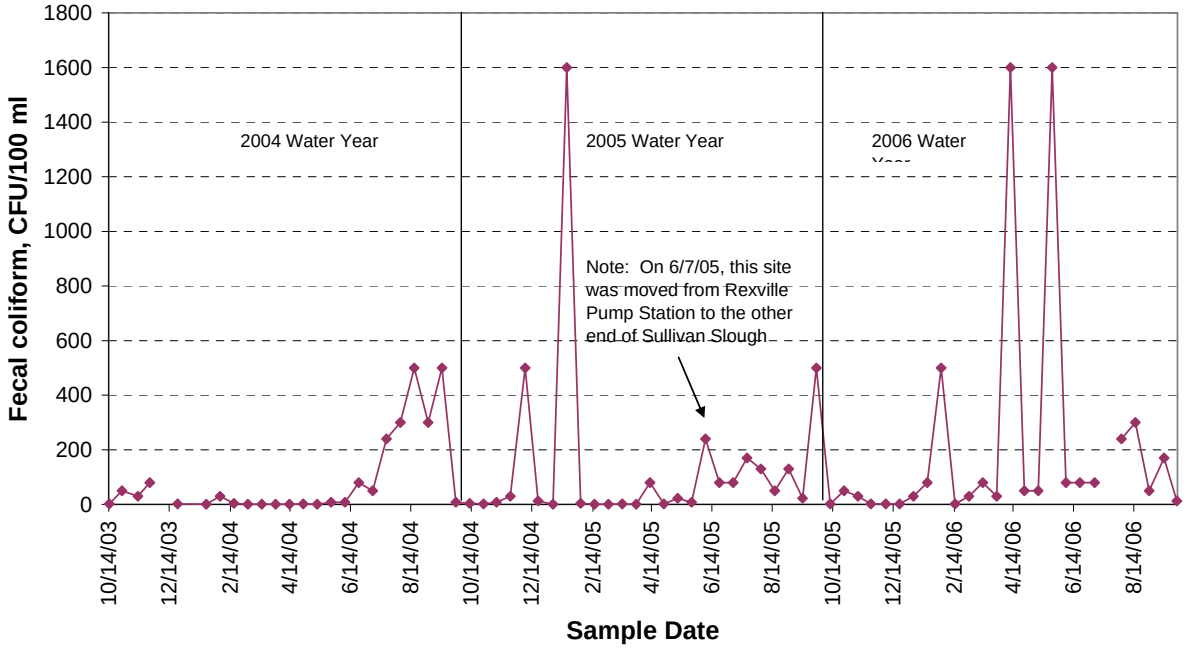
Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
Fecal coliform



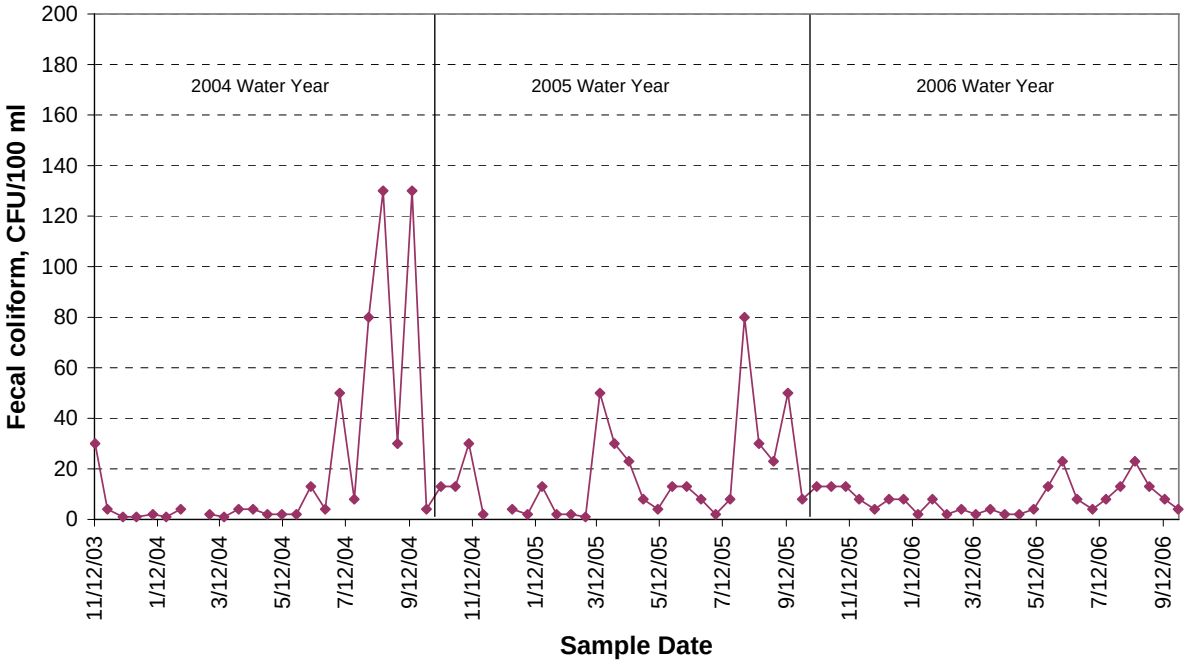
Wiley Slough at Wylie Rd - Site 43
Fecal coliform



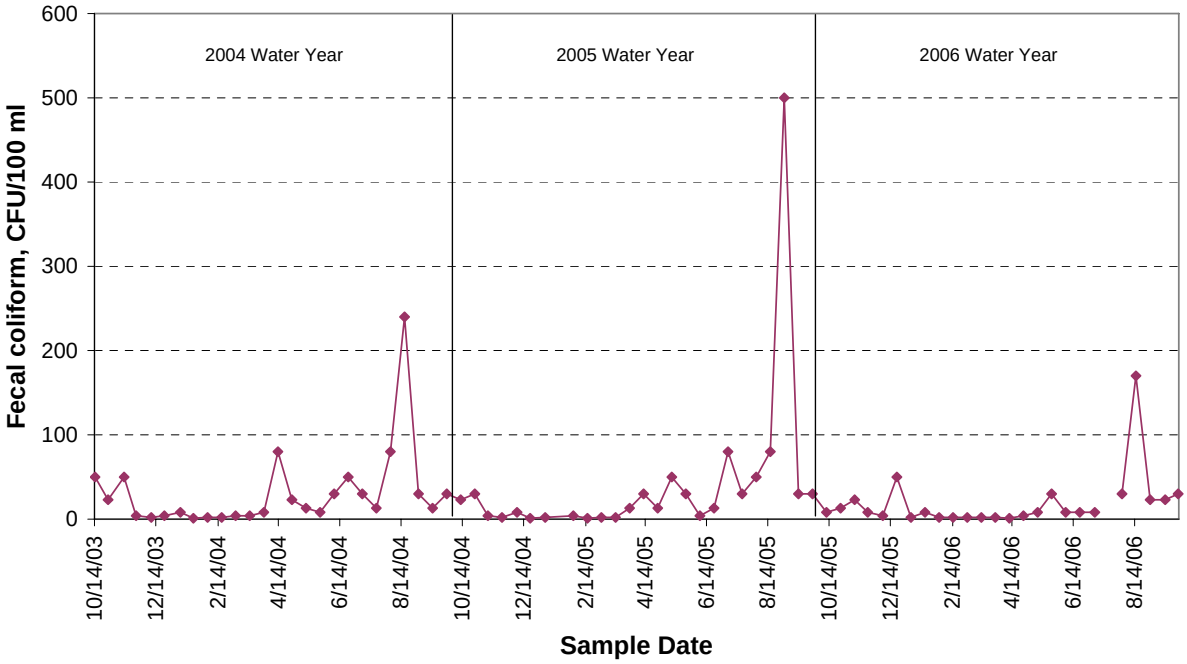
Sullivan Slough at La Conner-Whitney Rd - Site 44
Fecal coliform



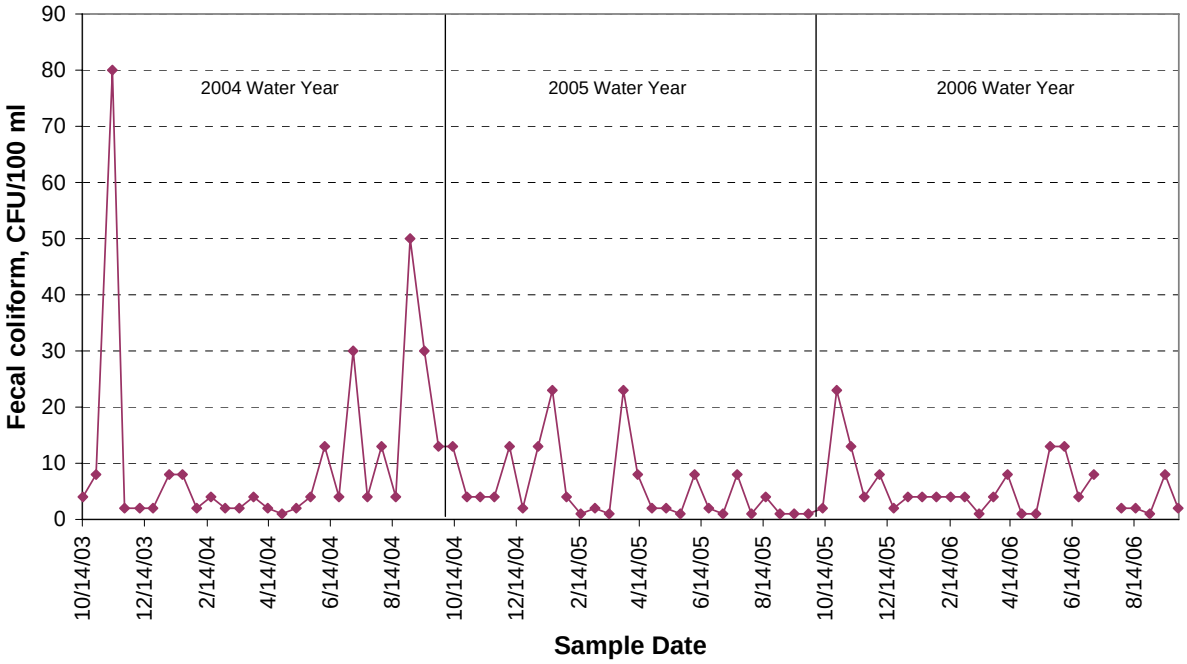
N.F. Skagit River near Moore Rd - Site 45
Fecal coliform



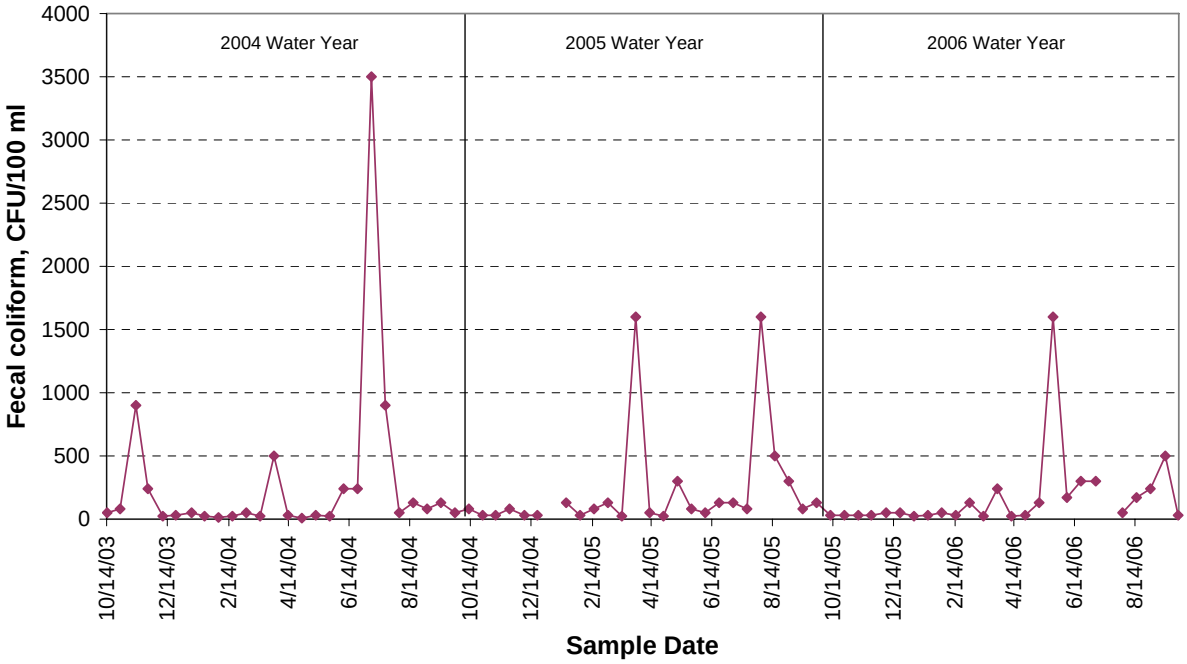
S.F. Skagit River at Conway Boat Ramp - Site 46
Fecal coliform



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 on every other sampling trip, or once every four weeks. Samples were analyzed by Edge Analytical of Burlington, WA. Table 6 gives mean nutrient values for the sampling stations.

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 a few Skagit County watercourses would exceed the state standards on rare occasions.

Table 6. Mean nutrient values (mg/L) for watercourses in the Skagit County Monitoring Program, 2005 Water Year.

Site Number	Watercourse	Location	Total Nitrogen[1]	Total Phosphorus	Ammonia
3	Thomas Ck	Old Hwy 99 N	0.73	0.07	0.13
4	Thomas Ck	F&S Grade	0.53	0.07	0.06
6	Friday Ck	Prairie Rd	0.42	0.08	0.04
8	Swede Ck	Grip Rd	0.48	0.07	0.06
11	Samish R	State Route 9	0.32	0.06	0.04
12	Nookachamps Ck	Swan Rd	0.48	0.04	0.08
13	E.F. Nookachamps Ck	State Route 9	0.36	0.05	0.06
14	College Way Ck	College Way	0.48	0.07	0.08
15	Nookachamps Ck	Knapp	0.56	0.06	0.11
16	E.F. Nookachamps Ck	Beaver Lake Rd	0.28	0.05	0.04
17	Nookachamps Ck	Big Lake Outlet	0.40	0.05	0.05
18	Lake Ck	State Route 9	0.32	0.05	0.04
19	Hansen Ck	Hoehn Rd	0.38	0.11	0.05
20	Hansen Ck	Northern State	0.47	0.18	0.04
21	Coal Ck	Hoehn Rd	0.33	0.08	0.04
22	Coal Ck	Hwy 20	0.38	0.10	0.04
23	Wiseman Ck	Minkler Rd	0.37	0.11	0.03
24	Mannser Ck	Lyman Hamilton Hwy	0.44	0.05	0.03
25	Red Cabin Ck	Hamilton Cem Rd	0.32	0.07	0.03
28	Brickyard Ck	Hwy 20	0.62	0.05	0.12
29	Skagit R	River Bend Rd	2.96	0.07	0.04
30	Skagit R	Cape Horn Rd	0.28	0.09	0.03
31	Drain Dist 20 floodgate	Francis Rd	1.31	0.08	0.15
32	Samish R	Thomas Rd	0.39	0.08	0.08
33	Alice Bay Pump Station	Samish Island Rd	2.73	0.43	1.23
34	Noname Slough	Bayview-Edison Rd	1.43	0.40	0.37
35	Joe Leary Slough	D'Arcy Rd	1.24	0.20	0.64
36	Edison Slough at school	W. Bow Hill Rd	1.28	0.46	0.39
37	Edison Pump Station	Farm to Market Rd	2.51	0.70	1.45
38	North Edison Pump Station	North Edison Rd	2.67	0.71	1.22
39	Colony Ck	Colony Rd	0.76	0.14	0.07
40	Big Indian Slough	Bayview-Edison Rd	0.97	0.10	0.36
41	Maddox Slough/Big Ditch	Milltown Rd	1.22	0.14	0.42
42	Hill Ditch	Cedardale Rd	0.50	0.08	0.08
43	Wiley Slough	Wylie Rd	1.57	0.32	0.52
44	Rexville PS/Sullivan Slough	Summers Dr/La Conner	1.22	0.34	0.52
45	Skagit R – North Fork	Moore Rd	0.31	0.08	0.04
46	Skagit R – South Fork	Fir Island Rd	0.29	0.06	0.03
47	Swinomish Channel	County Boat Launch	0.37	0.07	0.07
48	Fisher Ck	Franklin Rd	0.68	0.16	0.11

[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.

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 Index are dissolved oxygen, temperature, pH, turbidity, suspended solids, fecal coliform, and nutrients.

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

Ecology rates streams with WQI 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 are summarized in Table 7.

Table 7. Water Quality Index (WQI) determinations for watercourses in the Skagit County Monitoring Program, 2006 Water Year

Site Number	Watercourse	Location	Mean WQI	Overall Score*	Max	Min
3	Thomas Ck	Old Hwy 99 N	50	1	95	1
4	Thomas Ck	F&S Grade	54	15	94	1
6	Friday Ck	Prairie Rd	83	45	98	1
8	Swede Ck	Grip Rd	77	34	97	1
11	Samish R	State Route 9	85	57	97	12
12	Nookachamps Ck	Swan Rd	85	63	96	31
13	E.F. Nookachamps Ck	State Route 9	91	74	99	70
14	College Way Ck	College Way	79	48	97	33
15	Nookachamps Ck	Knapp	71	22	97	15
16	E.F. Nookachamps Ck	Beaver Lake Rd	96	88	100	86
17	Nookachamps Ck	Big Lake Outlet	86	60	100	54
18	Lake Ck	State Route 9	94	84	100	82
19	Hansen Ck	Hoehn Rd	76	28	97	1
20	Hansen Ck	Northern State	77	25	99	1
21	Coal Ck	Hoehn Rd	73	36	97	26
22	Coal Ck	Hwy 20	81	37	100	8
23	Wiseman Ck	Minkler Rd	76	27	100	5
24	Mannser Ck	Lyman Hamilton Hwy	60	35	90	11
25	Red Cabin Ck	Hamilton Cem Rd	92	74	100	62
28	Brickyard Ck	Hwy 20	84	62	96	25
29	Skagit R	River Bend Rd	90	76	99	75
30	Skagit R	Cape Horn Rd	88	66	100	54
31	Drain Dist 20 floodgate	Francis Rd	75	55	98	36
32	Samish R	Thomas Rd	79	34	97	1
33	Alice Bay Pump Station	Samish Island Rd	32	2	63	1
34	Noname Slough	Bayview-Edison Rd	30	1	83	1
35	Joe Leary Slough	D'Arcy Rd	12	1	55	1
36	Edison Slough at school	W. Bow Hill Rd	48	1	96	1
37	Edison Pump Station	Farm to Market Rd	10	1	45	1
38	North Edison PS	North Edison Rd	14	1	47	1
39	Colony Ck	Colony Rd	64	17	98	6
40	Big Indian Slough	Bayview-Edison Rd	34	6	67	1
41	Maddox Sl/Big Ditch	Milltown Rd	36	15	82	6
42	Hill Ditch	Cedardale Rd	81	50	99	40
43	Wiley Slough	Wylie Rd	40	1	91	1
44	Rexville PS/Sullivan Sl	La Conner-Bayview Rd	56	28	88	18
45	Skagit R – North Fork	Moore Rd	92	78	100	67
46	Skagit R – South Fork	Fir Island Rd	92	81	100	76
47	Swinomish Channel	County Boat Launch	90	74	97	66
48	Fisher Ck	Franklin Rd	90	75	98	56

*Note: Overall score is the mean of the three lowest monthly scores (Hallock, 2002)

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.

Skagit County has completed trends analysis via the Seasonal Kendall's Test for eight key parameters at each sampling location. The parameters tested include pH, dissolved oxygen, temperature, turbidity, fecal coliform, ammonia, total phosphorus, total Kjeldahl nitrogen (TKN, an estimate of the total available nitrogen), 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. Trends in nutrients and water quality index could not be calculated for three sites due to extended summer dry periods.

The period used for trends analysis was the three 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).

A summary of Seasonal Kendall's Test results is provided in Table 8. Complete trends analysis results can be found in Appendix C. Of the 348 trends tests conducted, there were 58 significant trends detected. Of these 58 trends, 14 were judged to represent deleterious trends, and 16 were considered improving trends. The implications of the remaining 28 trends (all increasing pH) were not readily apparent.

The most striking feature of the trends results is the number of significantly increasing trends in pH. Twenty-eight of the 40 sites showed increasing pH, while no stations showed significantly decreasing pH. This count far exceeds the number of significant trends for any other parameter. The increases were not of great magnitude, but the number of significant increases raises questions about the source and implications of these trends. Skagit County is consulting with Ecology personnel about the pH trends.

Trends in fecal coliform included significant increases at three sites – Sites 4, 20, and 41. Site 20 is considered an "upstream" site, above the influence of most if not all agricultural activities. Sites 4 and 41 have potential agricultural and septic tank influences. There were also two significant decreases in fecal coliform – Sites 16 and 24. Site 16 is considered an upstream site, while Site 24 is designated "Ag-midstream."

Dissolved oxygen trends included significantly increasing dissolved oxygen at six sites (Sites 4, 6, 8, 13, 20, and 42). Significantly decreasing dissolved oxygen trends were detected at three locations (Sites 36, 37, and 38). The increasing trends in dissolved oxygen occurred at both Ag sites and upstream sites. The decreasing trends were all in the Samish Delta drainage infrastructure.

Significantly decreasing turbidity was found at five sample stations (Sites 11, 29, 30, 45, and 46). Increasing turbidity occurred at four sites (Sites 4, 28, 41, and 43). The decreasing turbidity occurred at three downstream Skagit River sites, one upstream Skagit River site, and the upstream Samish River site. Skagit River turbidity is greatly influenced by glacial melt effects. The increasing turbidity occurred at up- and downstream Ag sites and an urban/suburban site.

There were two sites showing significant increases in ammonia – Sites 11 and 35. Site 35 also had a significant increase in total kjeldahl nitrogen

There was only one significant trend in water quality index. Site 30 (Skagit River at Cape Horn Rd) showed a significant increase in water quality index.

The trends analysis results show a mixture of improving and declining trends. The only significant trend present at more than six sites was the increasing pH found at 28 sites. The combination of improving and worsening trends in the water quality data indicates that there is no clear overall direction in the condition of watercourses in the agricultural areas of Skagit County.

Table 8. Summary of significant trends detected in Skagit County Monitoring Program
2004-2006 water years

Site No.	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
3	pH	77	0.059	2.918		
4	pH	77	0.056	2.005		
	Fecal coliform	77	182.5	2.753		Increasing fecal coliform
	Dissolved oxygen	78	0.208	2.138	Increasing dissolved oxygen	
	Turbidity	78	3.448	2.886		Increasing turbidity
	Ammonia	39	0.022	2.708		Increasing ammonia
6	Dissolved oxygen	78	0.241	2.193	Increasing dissolved oxygen	
8	pH	77	0.093	4.293		
	Dissolved oxygen	78	0.358	2.655	Increasing dissolved oxygen	
11	pH	77	0.041	2.169		
	Turbidity	78	-0.515	-3.1	Decreasing turbidity	
	Ammonia	39	0.009	2.223		Increasing ammonia
12	pH	78	0.079	4.307		
13	pH	78	0.067	3.193		
	Dissolved oxygen	78	0.358	2.853	Increasing dissolved oxygen	
14	pH	77	0.052	2.113		
15	pH	78	0.093	5.219		
16	pH	78	0.080	2.908		
	Fecal coliform	78	-8.006	-2.548	Decreasing fecal coliform	
17	pH	78	0.091	2.698		
18	pH	78	0.066	3.446		

Table 8 (Con't)

Site No.	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
19	pH	77	0.093	2.988		
20	pH	77	0.104	3.971		
	Dissolved oxygen	78	0.316	3.064	Increasing dissolved oxygen	
	Fecal coliform	77	9.244	1.995		Increasing fecal coliform
21	pH	65	0.088	3.277		
22	pH	77	0.150	4.262		
23	pH	74	0.108	2.970		
24	pH	77	0.051	3.600		
	Fecal coliform	76	-8.329	-3.199	Decreasing fecal coliform	
25	pH	67	0.129	3.033		
28	Turbidity	59	1.093	3.066		Increasing turbidity
29	Turbidity	78	-2.542	-3.385	Decreasing turbidity	
30	pH	76	0.098	3.998		
	Turbidity	77	-1.486	-2.008	Decreasing turbidity	
	Water quality index	36	1.934	2.135	Increasing WQI	
34	pH	76	0.128	2.979		
35	pH	69	0.063	2.513		
	Turbidity	71	8.258	3.468		
	Ammonia	36	0.168	2.921		Increasing ammonia
	TKN	36	0.193	2.509		Increasing nitrogen
36	Dissolved oxygen	77	-0.517	-2.234		Decreasing dissolved oxygen
37	Dissolved oxygen	77	-0.731	-1.984		Decreasing dissolved oxygen
	Ammonia	39	0.293	2.412		Increasing ammonia
38	Dissolved oxygen	72	-0.573	-2.030		Decreasing dissolved oxygen

Table 8 (Con't.)

Site No.	Parameter	N	Slope	Z	Improving Trends	Deleterious Trends
39	pH	77	0.077	2.824		
40	pH	75	0.090	4.845		
41	Turbidity	78	1.700	3.456		Increasing turbidity
	Fecal coliform	78	20.080	2.868		Increasing fecal coliform
42	pH	77	0.080	5.185		
	Dissolved oxygen	77	0.434	2.752	Increasing dissolved oxygen	
43	Turbidity	78	1.152	2.316		Increasing turbidity
45	pH	76	0.100	3.826		
	Turbidity	76	-2.265	-3.029	Decreasing turbidity	
46	pH	77	0.042	1.987		
	Turbidity	77	-2.542	-3.294	Decreasing turbidity	
47	pH	78	0.086	3.424		
48	pH	78	0.054	2.372		

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

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.

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 each sampling trip, and the reading before calibration is recorded. For 50 calibrations during this period, the average deviation from the calibration standard was 14%. 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 14%.

The pH meter (Hanna Instruments 8314) was calibrated on the morning of each sampling trip, then left on throughout the sampling trip. The pH meter was 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) to local elevation at the first sample site and several times during each sampling trip as needed. The meter is recalibrated if it reads more than 1% saturation different from the calibration level at the next sample site. The meter is also recalibrated if there are significant elevation changes between sample sites. For several weeks during the 2005 water year, Skagit County recorded the meter deviation from the calibration target for those occasions when calibration was needed. During that period, the meter needed calibration 89 times out of 180 sample sites (49%). Average deviation for those 89 calibrations was 2.6%. Since the meter was never used with a drift of more than 1%, 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 Skagit County Health Department laboratory on the same day.

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. He 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 total phosphorus and nitrate at a 10% rate. Total phosphorus and nitrate duplicates are intended to provide a precision estimate for all the nutrient analyses.

Table 9 summarizes the results of the duplicate analyses for the 2006 water year.

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

Table 9. Coefficients of Variation for parameters with duplicate samples in the Skagit County Monitoring Program – 2006 Water Year

		Coefficient of Variation[1]	
Parameter	N	2006 Results	Target CV (%)[2]
Fecal coliform	199	46.5	33
Total phosphorus	52	8.0	10 [3]
Nitrate	53	17.5	10 [3]

[2] Target precision as listed in QAPP

[3] 10% CV target was listed for all nutrients

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

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

The high variability of the fecal coliform results is at least partially due to the use of the Most Probable Number (MPN) analysis technique (Don Lennartson, Washington State Department of Health (retired), personal communication). This method was chosen for the Skagit County Monitoring Program because the Skagit County Health Department laboratory is certified for the method, and because it is reportedly more reliable for samples with high turbidity, which are often encountered in the Skagit County Monitoring Program (Michaud, 1991). 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).

Data Quality Summary

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

Annual Report Summary

The Skagit County Monitoring Program completed a third water year of sampling in September, 2006. 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. The program is substantially funded through the 2008 water year by a Centennial Clean Water Grant from the Washington State Department of Ecology.

References

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

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

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

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

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

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

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

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

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

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

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