# Skagit County Monitoring Program

## Annual Report - 2012 Water Year (October 2011 – September 2012)

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# Skagit County Water Quality Monitoring Program – 2012 Water Year Annual Report

## Executive Summary

Skagit County has completed the ninth 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 ninth annual report, for the 2012 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 eight years of the program reveals a mixed pattern of beneficial and deleterious trends in approximately equal proportions both inside and outside of the agricultural areas. 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, is comprehensively addressing 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 other partners 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 nine years of high-quality data. 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**

2012 Water Year
(October 2011-September 2012)

## 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 2012 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 2011, Washington State Legislature adopted the recommendations from one research group studying the critical areas regulations and created the Voluntary Stewardship Program (VSP). Skagit County decided to enroll in the program in 2012. Any county that enrolled agreed to maintain existing critical areas protections and ensure streams are protected using voluntary measures.

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.

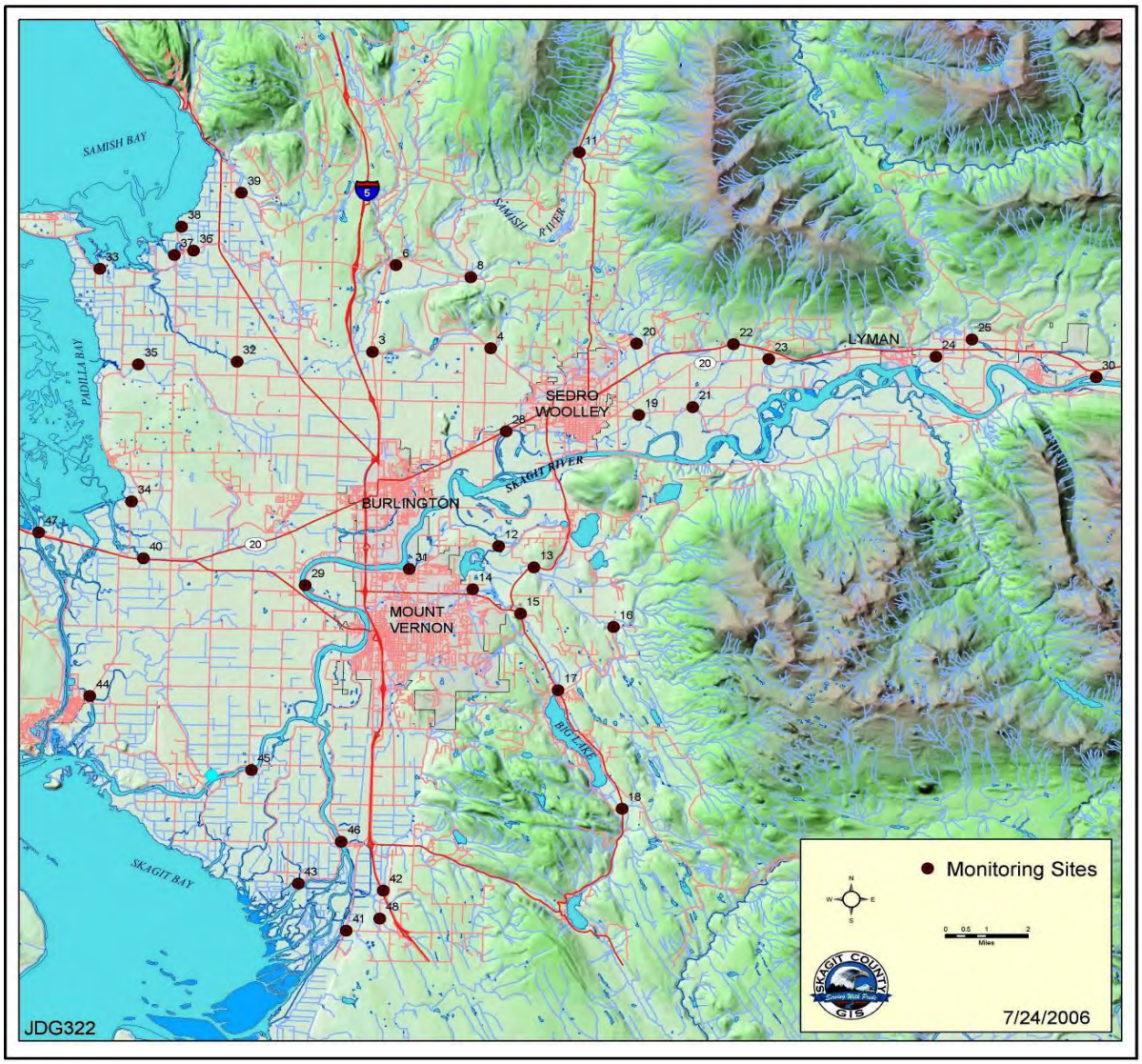



**Figure 1. Sample Sites in the Skagit County Monitoring Program**
**Refer to Tables 1 and 2 for site locations and descriptions.**

## 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 | 1 |
| 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 eight 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, Skagit County 2011, Skagit County 2012). This report contains data and analysis from water years 2004 – 2012.

## 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 2012 water year, beginning on October, 2011. Sampling normally took place on Tuesdays, but occasionally took place on other days 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 reported on the County web site at: http://www.skagitcounty.net/Common/Asp/Default.asp?d=PublicWorksCleanWater&c=General&p=cleansamish.htm

**Funding** – The Centennial Clean Water Grant that funded the program at 75% ended in December 2008, with the remaining 25% coming from County funds. Subsequent 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. Pascale Warren takes dissolved oxygen readings in a snowstorm at Hansen 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.

**2008 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.

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 2009-2012, temperatures were measured with Stowaway Tidbit® data loggers 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 data loggers 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 data loggers measuring temperature for only two weeks in late June and early July. Since annual peak temperatures occur later in the summer, the 2008 data logger 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 data loggers 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 County Clean Water web site when available.

New data loggers were purchased and installed for the 2011 water year. Results from 2001-2012 temperature monitoring will be posted on the Skagit County Clean Water web site when available.

Table 3 shows the daily maximum temperatures for the last five 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 2012. 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.

Only 5 out of 20 sites had a maximum 7-day average maximum temperature that did not exceed the EPA water quality standard in 2011. Gaps in the data prevented the calculation of maximum 7-DAM temperatures for the remaining 20 sites.

Graphs on the pages following Table 4 show the temperature data collected during biweekly visits. Gaps in the data represent streams that were either dry or flooded at sampling time.

**Table 3. Temperature Results**
**Maximum temperature recorded during biweekly sampling for watercourses in the last five years of the Skagit County Monitoring Program**

| Site Number | Watercourse | Location | Highest daily temperature (°C) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2008 | 2009 | 2010 | 2011 | 2012 |
| 3 | Thomas Ck | Old Hwy 99 North | 17.0 | 19.5 | 20.0 | 20.1 | 20.2 |
| 4 | Thomas Ck | F&S Grade | 14.0 | 15.7 | 16.3 | 14.0 | 16.3 |
| 6 | Friday Ck | Prairie Rd | 16.1 | 18.4 | 18.7 | 16.3 | 19.3 |
| 8 | Swede Ck | Grip Rd | 15.7 | 17.3 | 18.1 | 15.2 | 18.1 |
| 11 | Samish R | State Route 9 | 12.8 | 14.2 | 15.6 | 13.9 | 15.8 |
| 12 | Nookachamps Ck | Swan Rd | 19.8 | 24.8 | 21.5 | 18.5 | 20.8 |
| 13 | E.F. Nookachamps Ck | State Route 9 | 16.6 | 23.4 | 19.0 | 17.5 | 17.8 |
| 14 | College Way Ck | College Way | 15.9 | 20.8 | 16.1 | 17.5 | 16.9 |
| 15 | Nookachamps Ck | Knapp | 20.6 | 23.1 | 20.5 | 19.6 | 21.3 |
| 16 | E.F. Nookachamps Ck | Beaver Lake Rd | 15.5 | 20.5 | 17.7 | 16.5 | 16.9 |
| 17 | Nookachamps Ck | Big Lake Outlet | 21.7 | 24.4 | 22.1 | 21.1 | 22.3 |
| 18 | Lake Ck | State Route 9 | 16.2 | 18.7 | 15.8 | 15.5 | 15.8 |
| 19 | Hansen Ck | Hoehn Rd | 15.4 | 16.8 | 17.4 | 15.1 | 18.4 |
| 20 | Hansen Ck | Northern State | 14.4 | 15.8 | 15.5 | 13.6 | 16.2 |
| 21 | Coal Ck | Hoehn Rd | 15.3 | 17.5 | 16.8 | 13.6 | 17.5 |
| 22 | Coal Ck | Hwy 20 | 12.8 | 14.9 | 15.5 | 14.4 | 15.6 |
| 23 | Wiseman Ck | Minkler Rd | 14.7 | 12.7 | 14.1 | 12.9 | 16.2 |
| 24 | Mannser Ck | Lyman Hamilton Hwy | 12.7 | 13.2 | 13.5 | 12.5 | 15.0 |
| 25 | Red Cabin Ck | Hamilton Cem Rd | 11.2 | 10.6 | 11.7 | 11.7 | 12.5 |
| 28 | Brickyard Ck | Hwy 20 | 15.6 | 16.3 | 17.5 | 17.2 | 17.5 |
| 29 | Skagit R | R Bend Rd | 15.0 | 16.2 | 14.8 | 13.1 | 16.6 |
| 30 | Skagit R | Cape Horn Rd | 13.3 | 14.4 | 14.7 | 13.4 | 15.3 |
| 31 | DD20 near floodgate | Francis Rd | 15.4 | 17.0 | 14.6 | 17.6 | 19.2 |
| 32 | Samish R | Thomas Rd | 16.8 | 20.0 | 19.1 | 16.7 | 20.0 |
| 33 | Alice Bay Pump Station | Samish Island Rd | 21.9 | 25.4 | 26.9 | 21.2 | 27.2 |
| 34 | Noname Slough | Bayview-Edison Rd | 19.5 | 21.6 | 19.6 | 18.9 | 23.4 |
| 35 | Joe Leary Slough | D'Arcy Rd | 15.9 | 20.6 | 18.4 | 16.7 | 20.6 |
| 36 | Edison Slough at school | W. Bow Hill Rd | 23.8 | 31.3 | 32.4 | 24.6 | 32.4 |
| 37 | Edison Pump Station | Farm to Market Rd | 20.4 | 24.7 | 26.5 | 23.6 | 26.5 |
| 38 | North Edison Pump Station | North Edison Rd | 21.6 | 22.8 | 25.4 | 20.1 | 25.4 |
| 39 | Colony Ck | Colony Rd | 15.1 | 17.9 | 17.0 | 15.5 | 16.6 |
| 40 | Big Indian Slough | Bayview-Edison Rd | 17.5 | 22.1 | 14.9 | 15.4 | 15.6 |
| 41 | Maddox Slough/Big Ditch | Milltown Rd | 19.3 | 23.7 | 19.4 | 18.1 | 18.1 |
| 42 | Hill Ditch | Cedardale Rd | 19.4 | 23.1 | 19.9 | 18.1 | 20.2 |
| 43 | Wiley Slough | Wylie Rd | 19.1 | 17.6 | 20.2 | 18.9 | 21.9 |
| 44 | Rexville PS/Sullivan Slough | La Conner-Whitney Rd | 18.7 | 20.8 | 16.8 | 18.1 | 20.8 |
| 45 | Skagit R – North Fork | Moore Rd | 14.0 | 17.0 | 14.8 | 11.3 | 17.2 |
| 46 | Skagit R – South Fork | Fir Island Rd | 14.6 | 17.0 | 14.9 | 14.0 | 17.6 |
| 47 | Swinomish Channel | County Boat Launch | 15.9 | 16.0 | 15.7 | 15.6 | 17.2 |
| 48 | Fisher Ck | Franklin Rd | 13.3 | 14.4 | 12.7 | 13.6 | 14.4 |

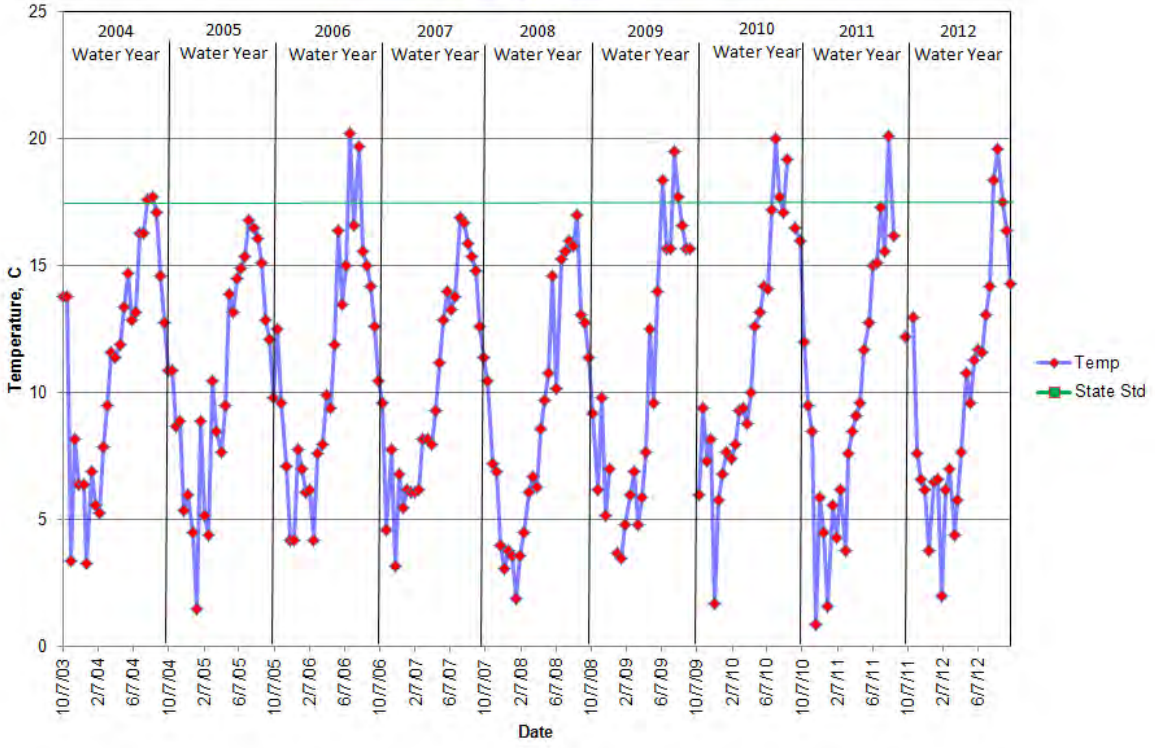
Data from biweekly site visits

## Table 4. Five-Year Temperature Results Summary
## Maximum 7-day average maximum temperatures for 2004-2007 and 2009-2011 of the Skagit County Monitoring Program

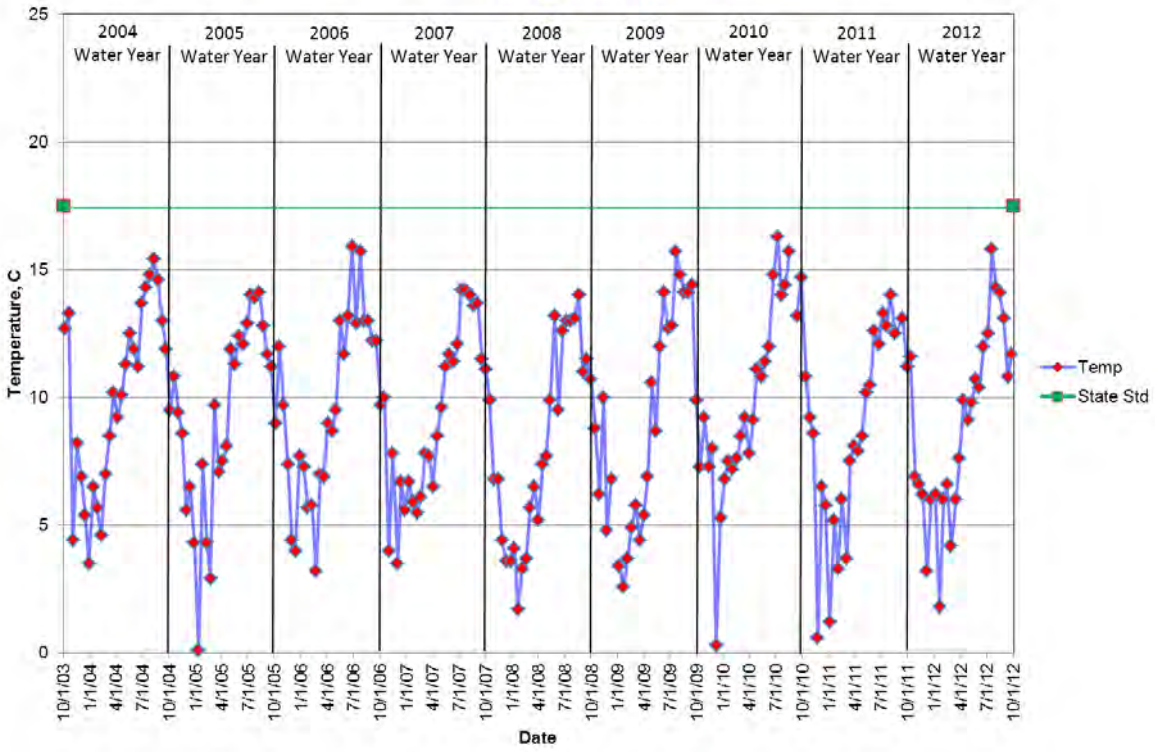
| Site Number | Watercourse | Location | Max. 7DAM (°C) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2006 | 2007 | 2009 | 2010 | 2011 |
| 3 | Thomas Ck | Old Hwy 99 North | **N/A** | N/A | 24.4 | 21.9 | 23.3 |
| 4 | Thomas Ck | F&S Grade | 17.3 | 18.9 | 19.2 | 17 | 15.6 |
| 6 | Friday Ck | Prairie Rd | 21.3 | 20.8 | 22.7 | 19.3 | 18.1 |
| 8 | Swede Ck | Grip Rd | 19.3 | 18.6 | 21.8 | N/A | 17.6 |
| 11 | Samish R | State Route 9 | 15.8 | 14.6 | 15.2 | 15.4 | 15.2 |
| 12 | Nookachamps Ck | Swan Rd | 20.6 | N/A | 17.3 | 21.8 | N/A |
| 13 | E.F. Nookachamps Ck | State Route 9 | 21.6 | 20.1 | N/A | N/A | 18.5 |
| 14 | College Way Ck | College Way | 18.4 | 18.1 | 20.6 | N/A | 17.5 |
| 15 | Nookachamps Ck | Knapp | 23.2 | 22.9 | 24.9 | N/A | 21.9 |
| 16 | E.F. Nookachamps Ck | Beaver Lake Rd | 20.6 | 20.1 | 22.1 | 20.4 | 17.9 |
| 17 | Nookachamps Ck | Big Lake Outlet | 25.1 | 25.1 | 20.8 | 25.1 | 23.4 |
| 18 | Lake Ck | State Route 9 | 18.4 | 18.4 | 22.4 | N/A | 18.2 |
| 19 | Hansen Ck | Hoehn Rd | 20.7 | 20.6 | 20.3 | N/A | 18.9 |
| 20 | Hansen Ck | Northern State | 19 | 18 | 20.7 | N/A | 15.2 |
| 21 | Coal Ck | Hoehn Rd | 18.2 | 18.2 | N/A | N/A | 16.5 |
| 22 | Coal Ck | Hwy 20 | 17.5 | 17.3 | N/A | 17.5 | 16.5 |
| 23 | Wiseman Ck | Minkler Rd | 21.3 | N/A | N/A | 18.0 | 16.5 |
| 24 | Mannser Ck | Lyman Hamilton Hwy | 14.3 | 13.9 | 15 | 13.3 | 12.4 |
| 25 | Red Cabin Ck | Hamilton Cem Rd | 17.6 | 16 | N/A | N/A | N/A |
| 28 | Brickyard Ck | Hwy 20 | N/A | N/A | N/A | N/A | N/A |
| 29 | Skagit R | R Bend Rd | N/A | N/A | N/A | N/A | N/A |
| 30 | Skagit R | Cape Horn Rd | 14.9 | 15.3 | N/A | N/A | N/A |
| 31 | DD 20 near floodgate | Francis Rd | N/A | N/A | N/A | N/A | N/A |
| 32 | Samish R | Thomas Rd | 20.7 | 19.9 | 22.7 | N/A | 18.0 |
| 33 | Alice Bay Pump Station | Samish Island Rd | 27.1 | N/A | N/A | N/A | N/A |
| 34 | Noname Slough | Bayview-Edison Rd | 22.8 | 22.9 | N/A | N/A | N/A |
| 35 | Joe Leary Slough | D'Arcy Rd | 24.1 | 18.9 | N/A | N/A | N/A |
| 36 | Edison Slough at school | W. Bow Hill Rd | 29.3 | 27.6 | N/A | N/A | N/A |
| 37 | Edison Pump Station | Farm to Market Rd | 26.8 | 27.9 | N/A | N/A | N/A |
| 38 | North Edison Pump Station | North Edison Rd | 28.1 | N/A | N/A | N/A | N/A |
| 39 | Colony Ck | Colony Rd | 19.7 | N/A | 21.1 | N/A | 16.8 |
| 40 | Big Indian Slough | Bayview-Edison Rd | 24.2 | 22 | N/A | N/A | N/A |
| 41 | Maddox Slough/Big Ditch | Milltown Rd | 25.7 | 22.7 | 25.4 | N/A | N/A |
| 42 | Hill Ditch | Cedardale Rd | 24.6 | 20.2 | 27 | 23.1 | 19.5 |
| 43 | Wiley Slough | Wylie Rd | N/A | N/A | N/A | N/A | N/A |
| 44 | Sullivan Slough | La Conner-Whitney Rd | 22.3 | 26.6 | 23.6 | N/A | N/A |
| 45 | Skagit R – North Fork | Moore Rd | 17.6 | 16.4 | 16.9 | 17.2 | N/A |
| 46 | Skagit R – South Fork | Fir Island Rd | N/A | N/A | N/A | N/A | N/A |
| 47 | Swinomish Channel | County Boat Launch | N/A | N/A | N/A | N/A | N/A |
| 48 | Fisher Ck | Franklin Rd | 15 | 14.7 | N/A | 14.4 | N/A |

Data from continuous temperature data loggers

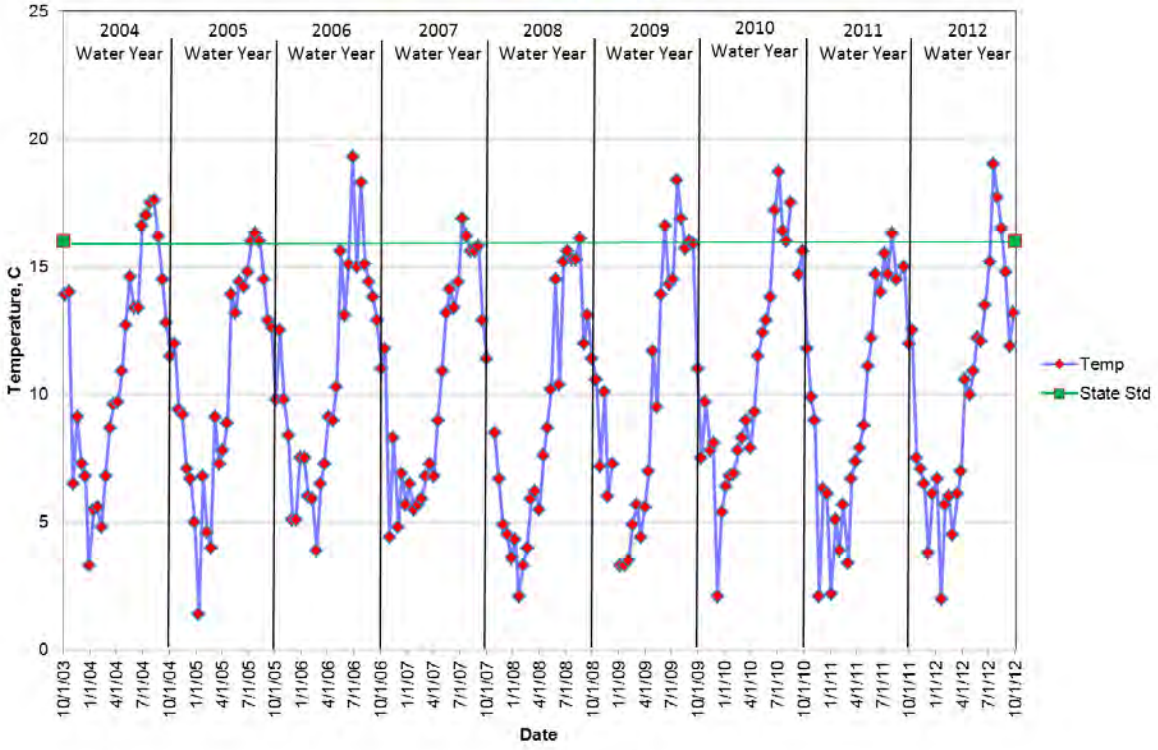
## Thomas Creek at Hwy 99 - Site 3
## Temperature



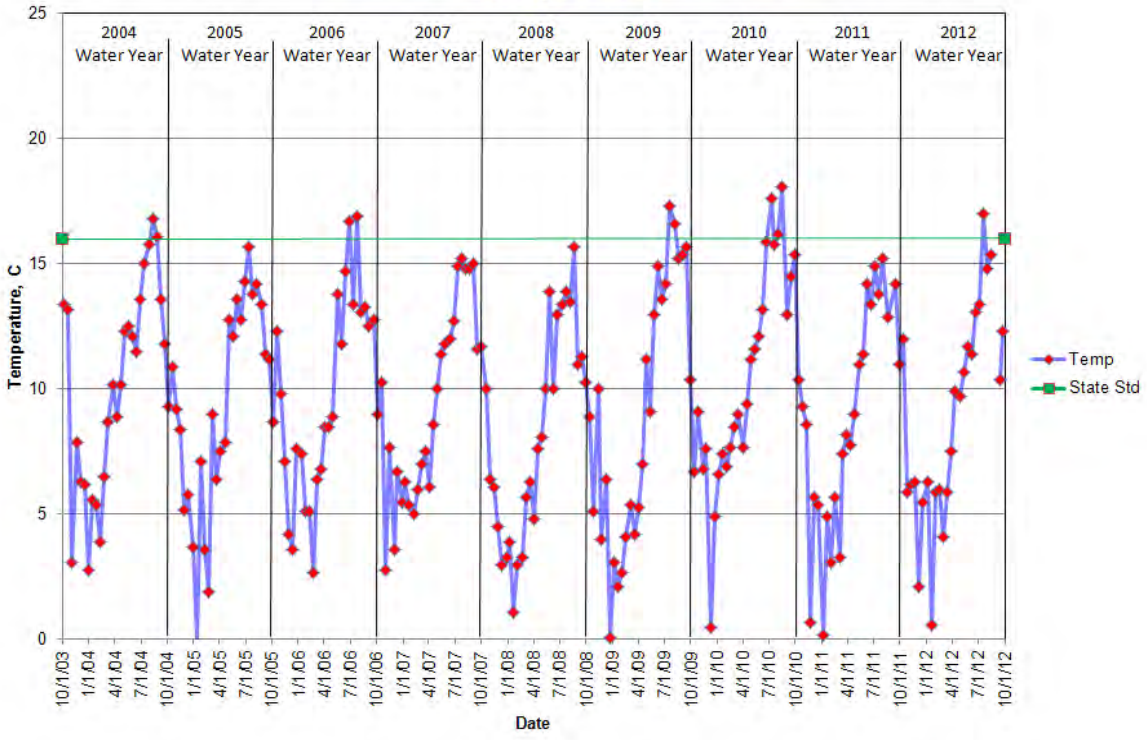

## Thomas Creek at F&S Grade Rd - Site 4
## Temperature



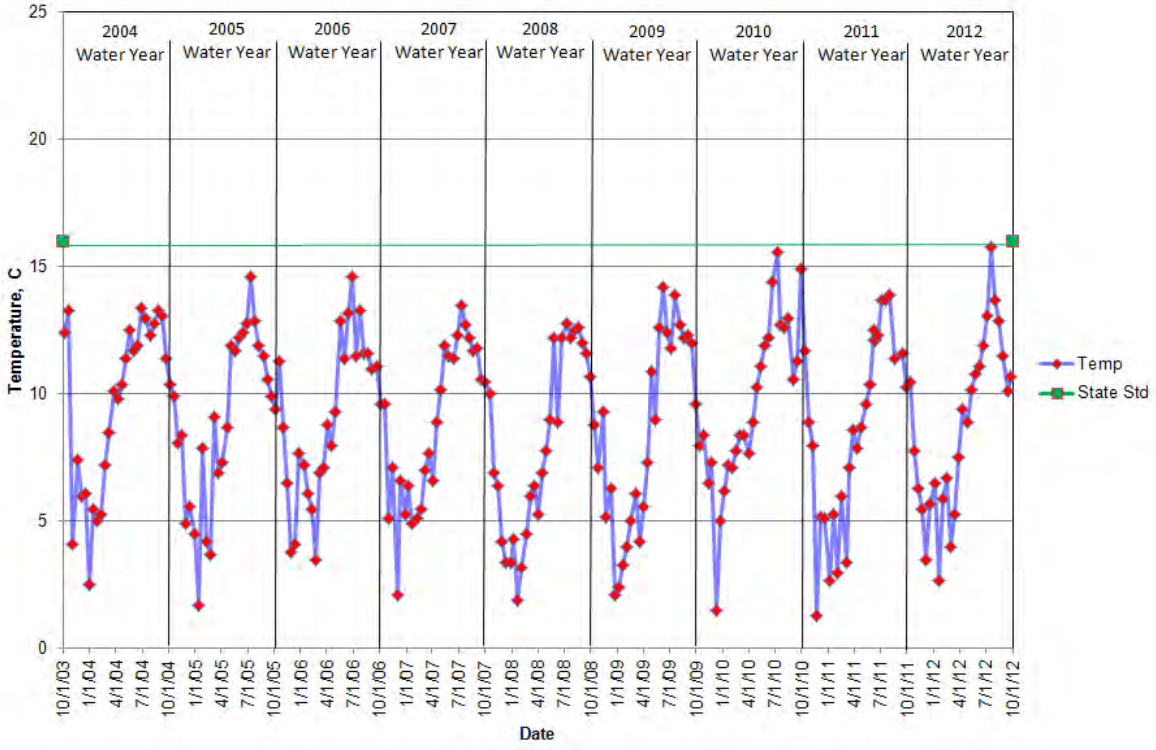
## Friday Creek at Prairie Rd - Site 6
## Temperature



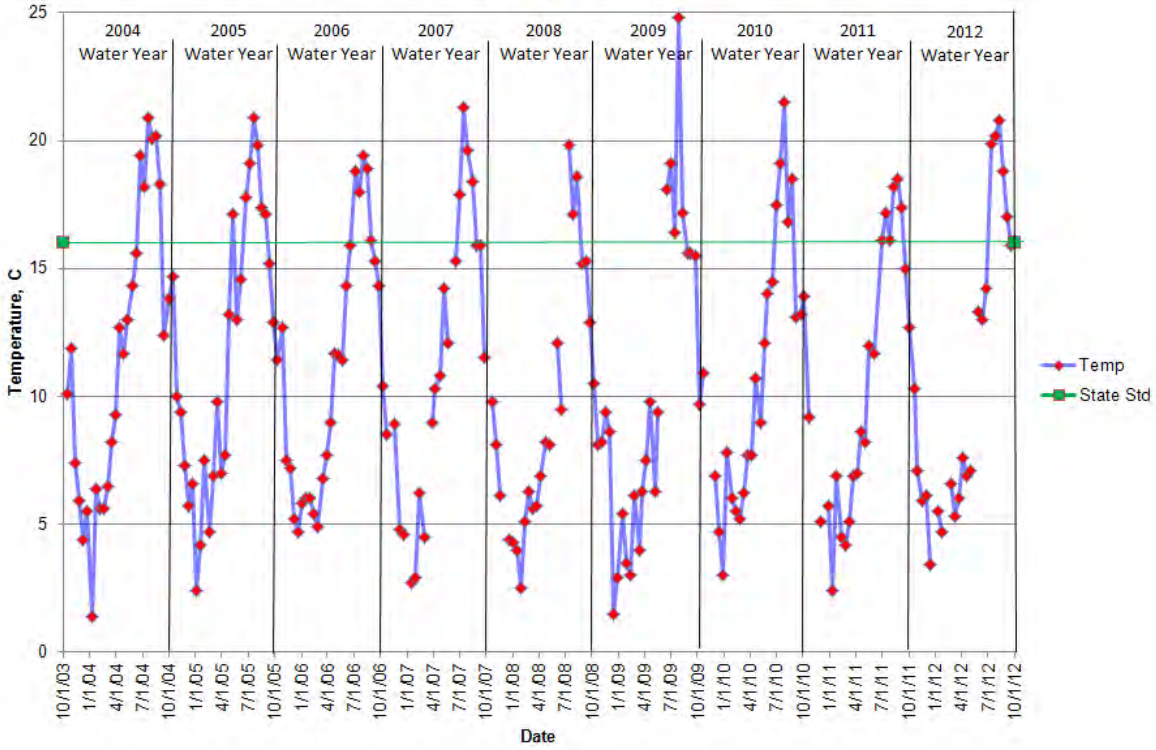

## Swede Creek at Grip Rd - Site 8
## Temperature



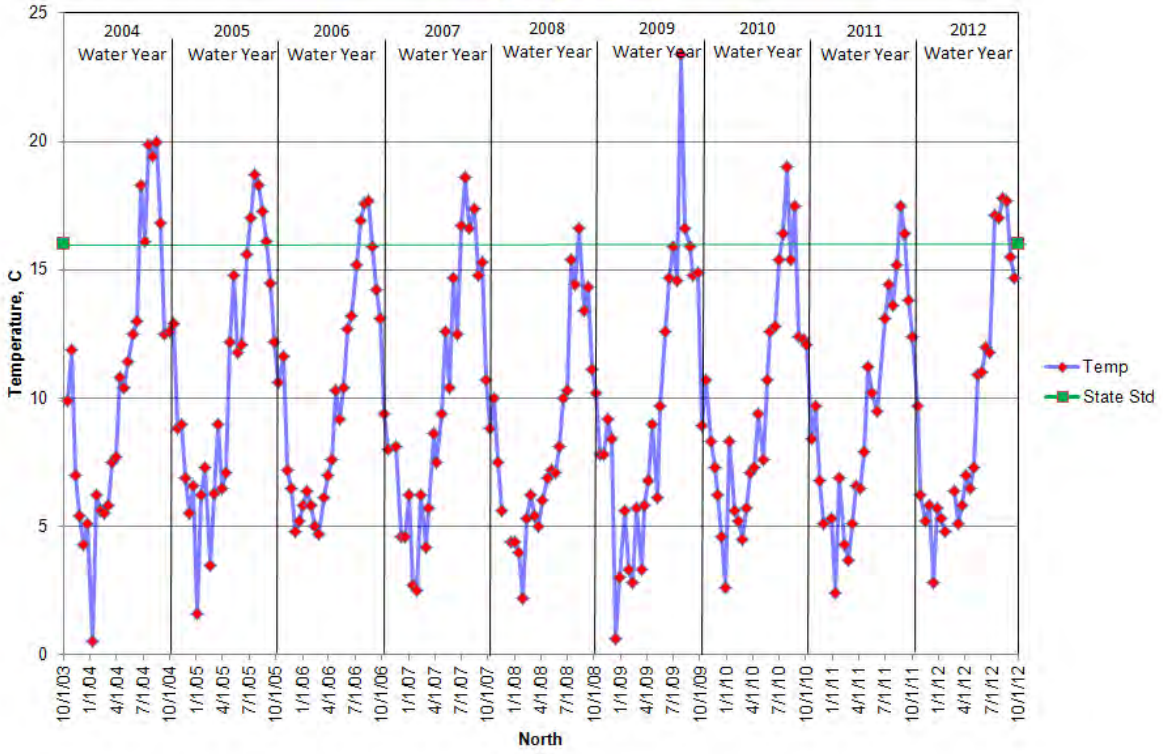
## Samish River at Hwy 9 - Site 11
## Temperature



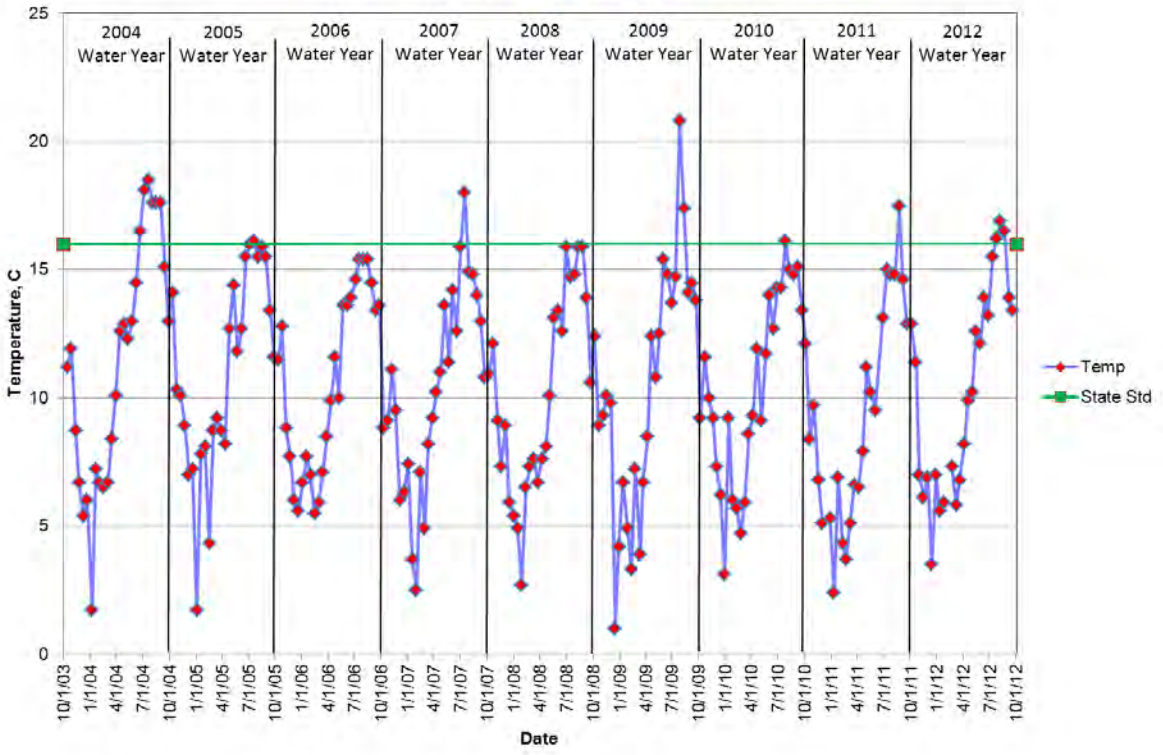

## Nookachamps Creek at Swan Rd - Site 12
## Temperature



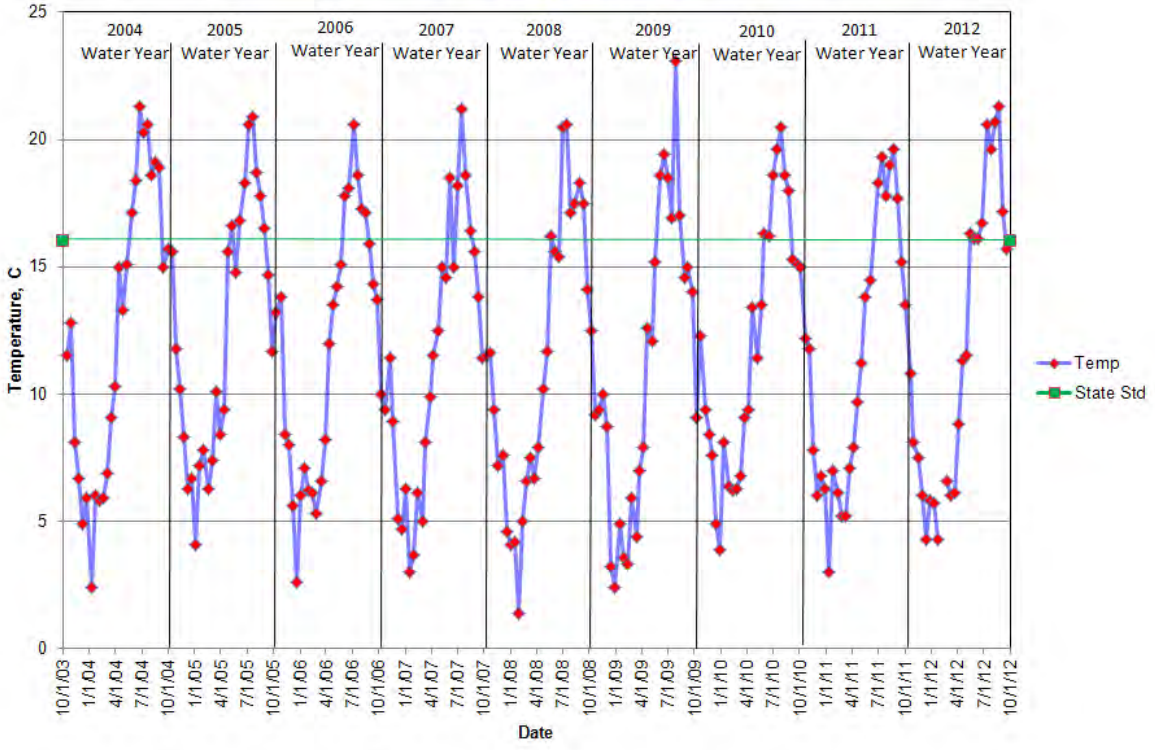
## E.F. Nookachamps Cr at Hwy 9 - Site 13
## Temperature



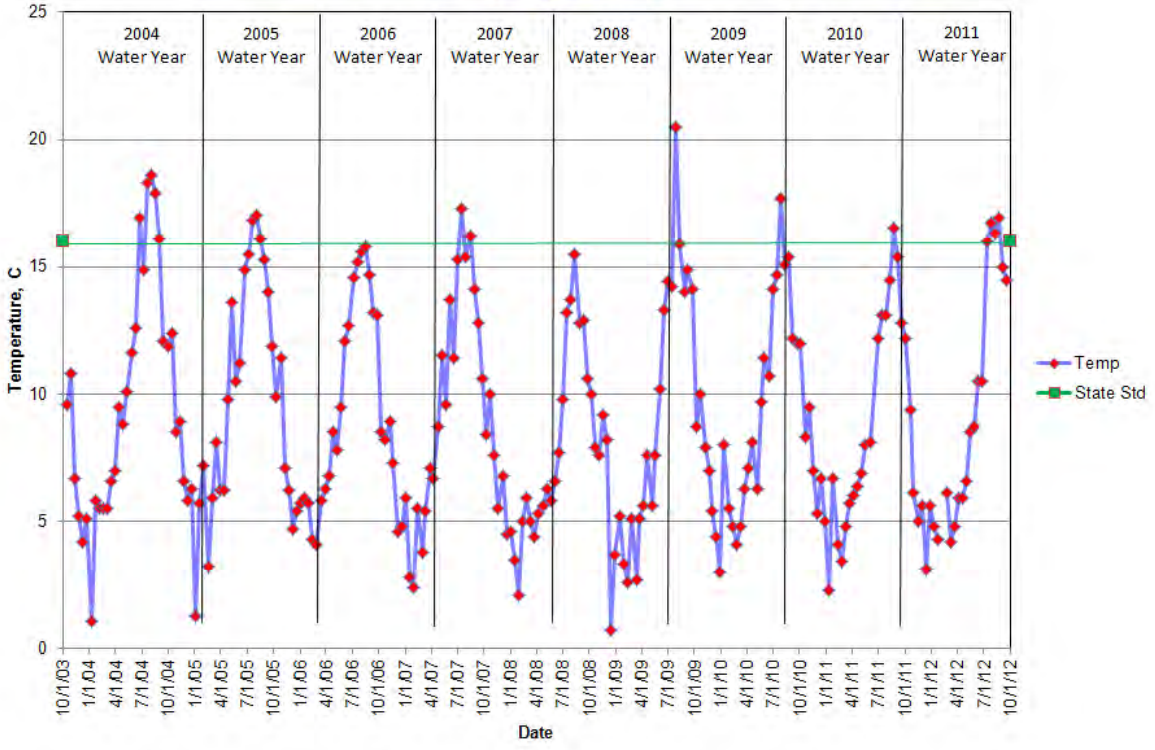

## College Way Creek at College Way - Site 14
## Temperature



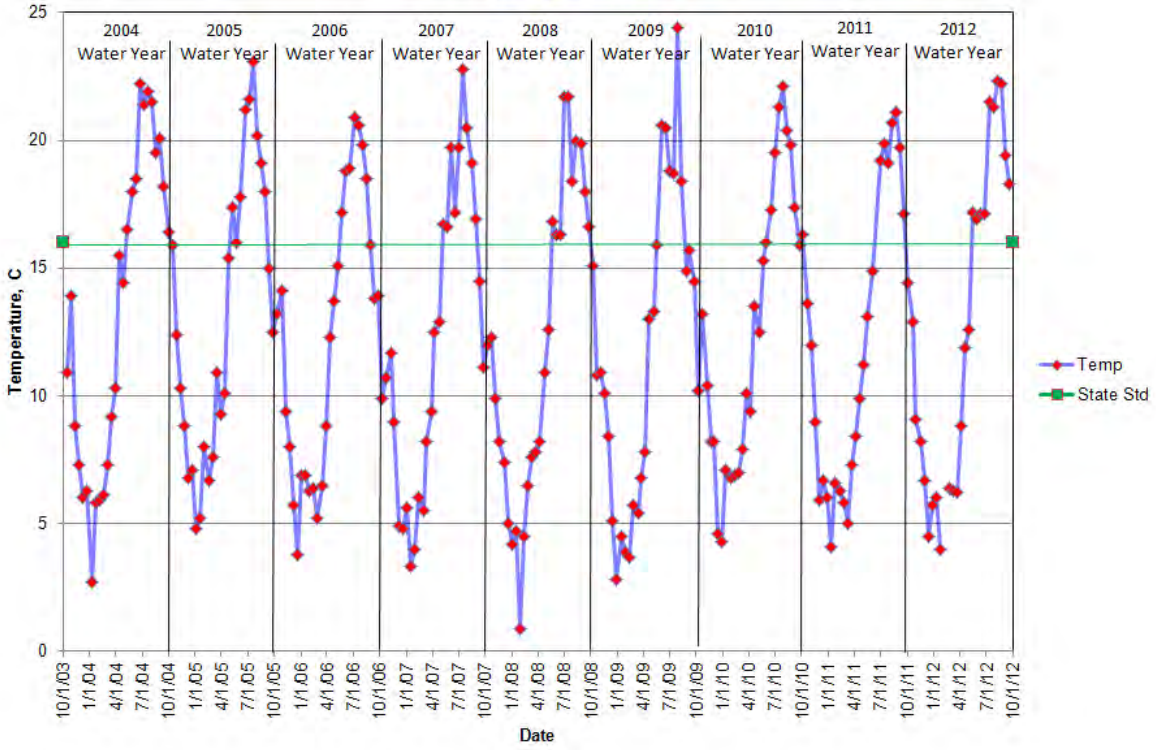
## Nookachamps Creek at Knapp Rd - Site 15
## Temperature



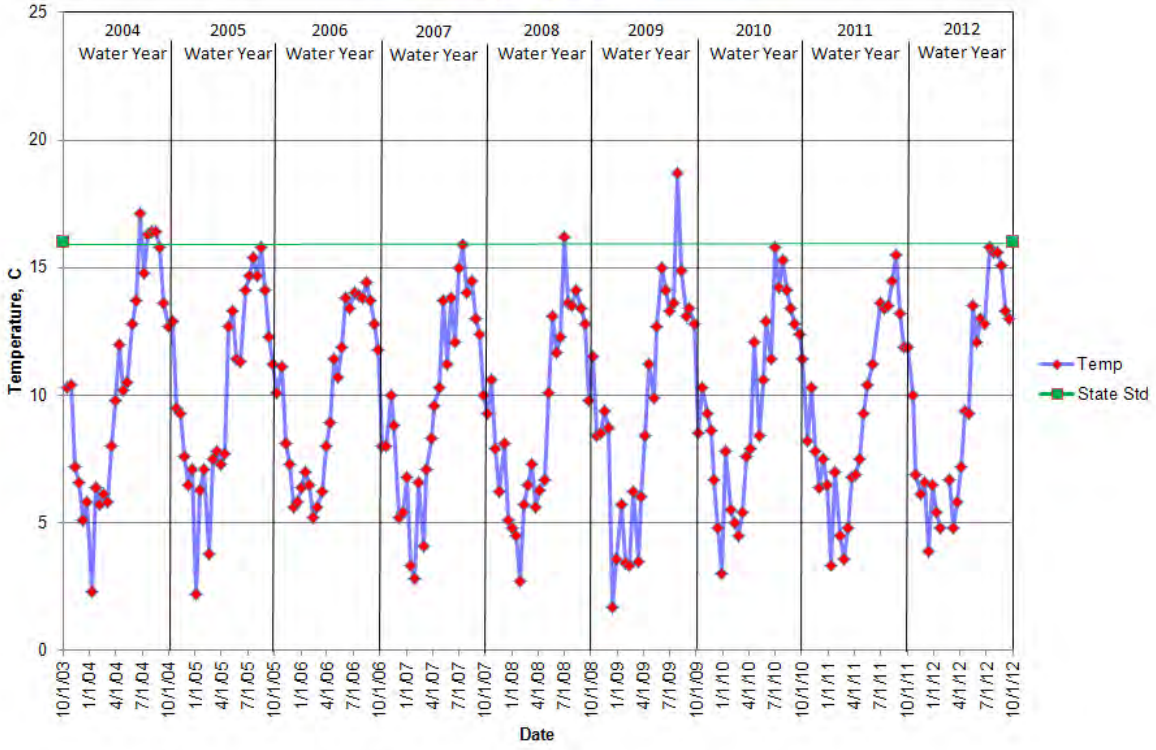

## E.F. Nookachamps Cr at Beaver Lake Rd - Site 16
## Temperature



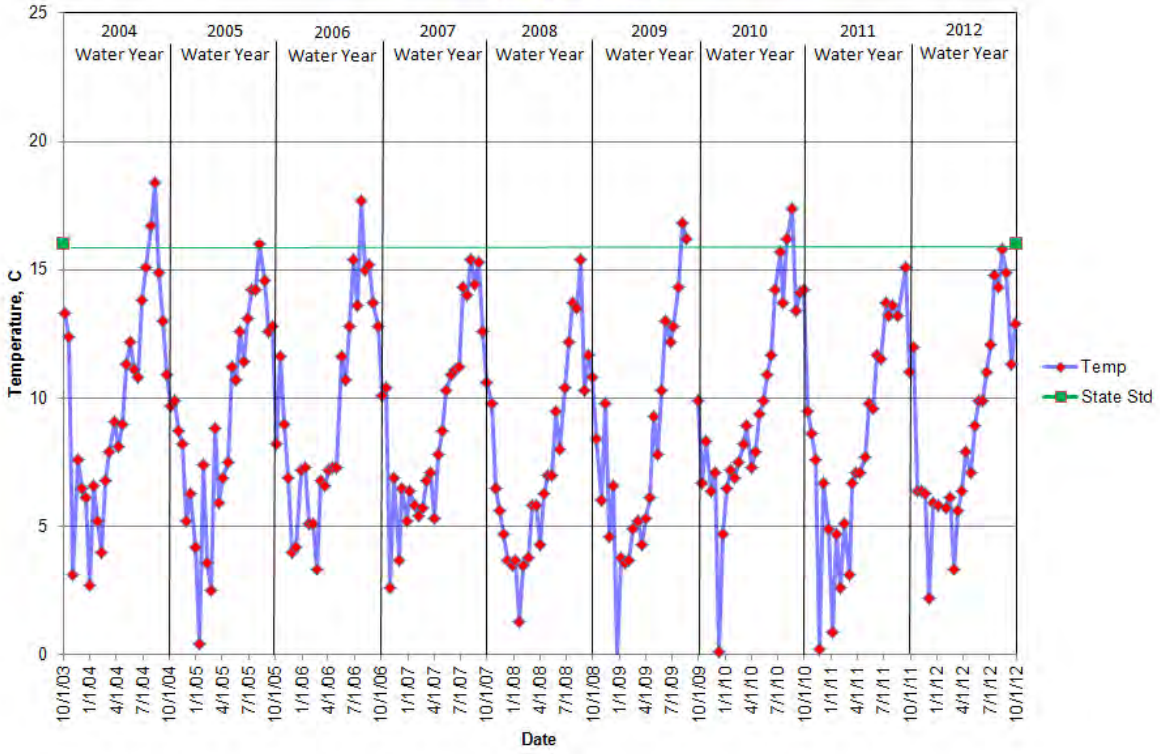
## Nookachamps Creek at Big Lake Outlet - Site 17
## Temperature



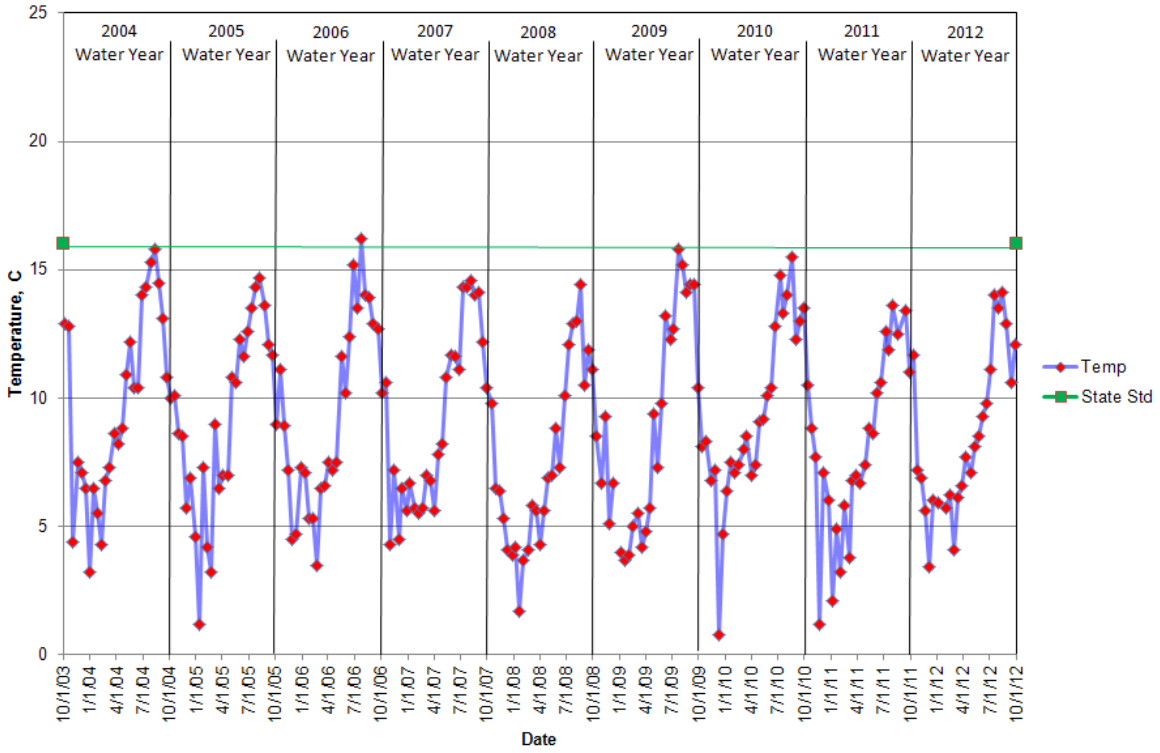

## Lake Creek at Hwy 9 - Site 18
## Temperature



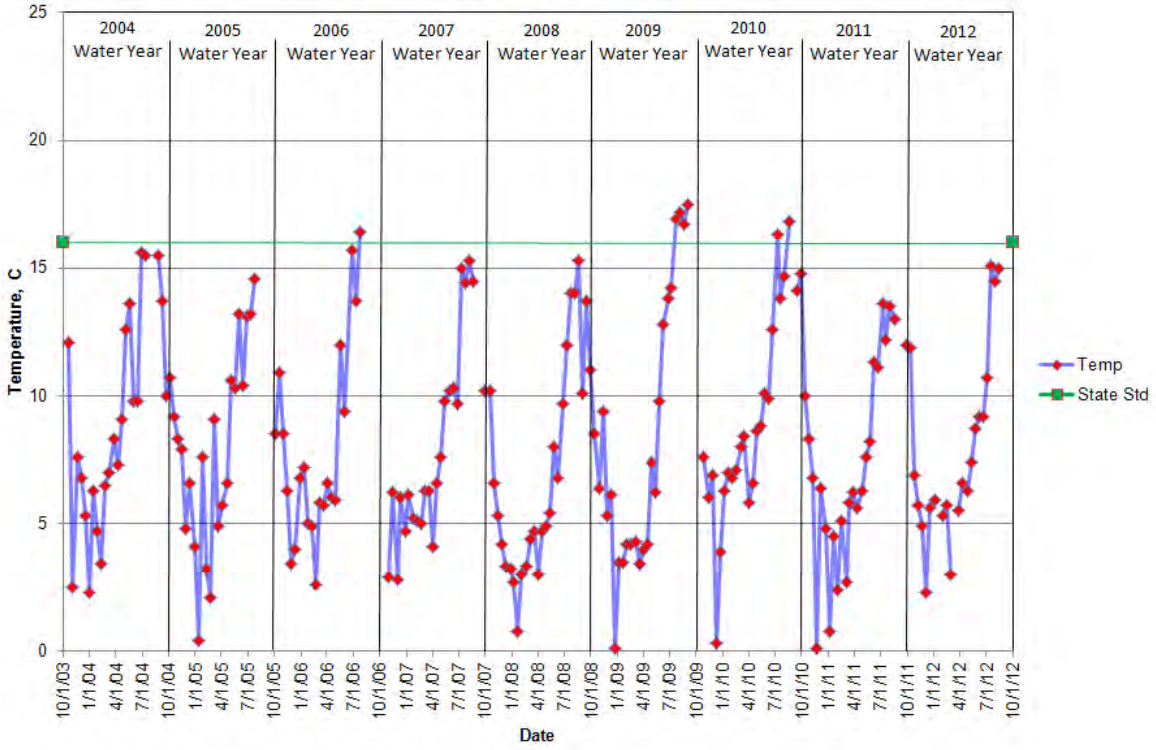
## Hansen Creek at Hoehn Rd - Site 19
## Temperature



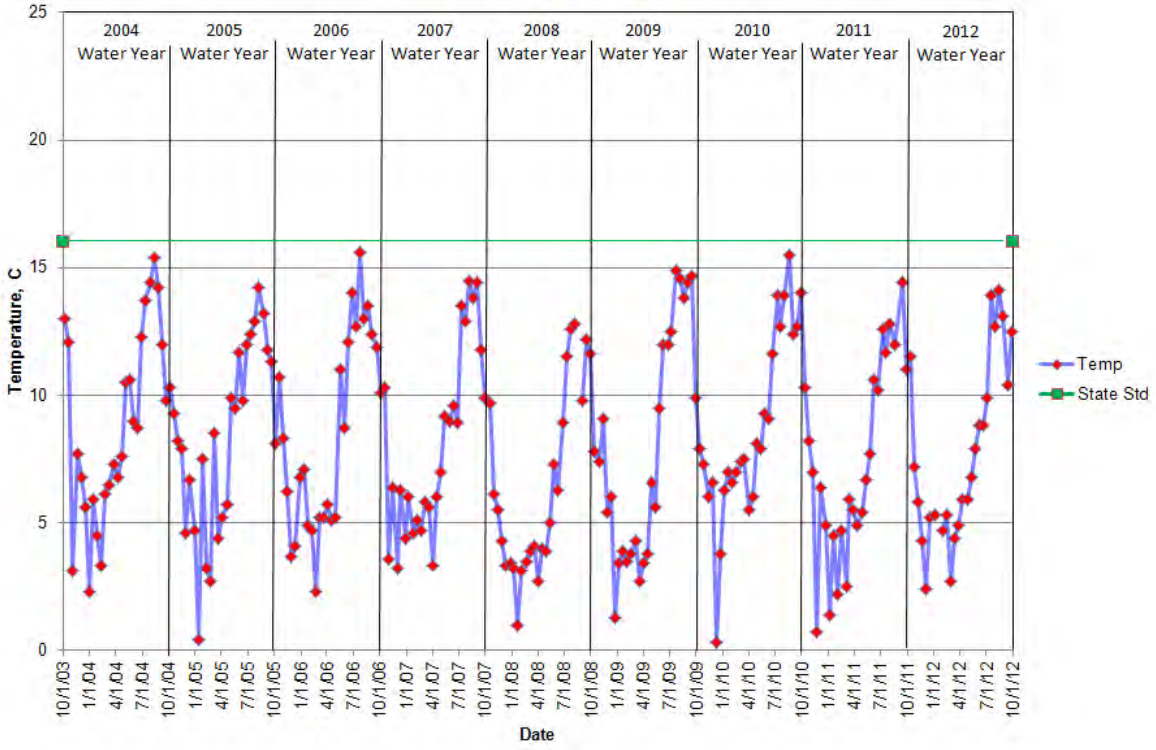

## Hansen Creek at Northern State Hospital - Site 20
## Temperature



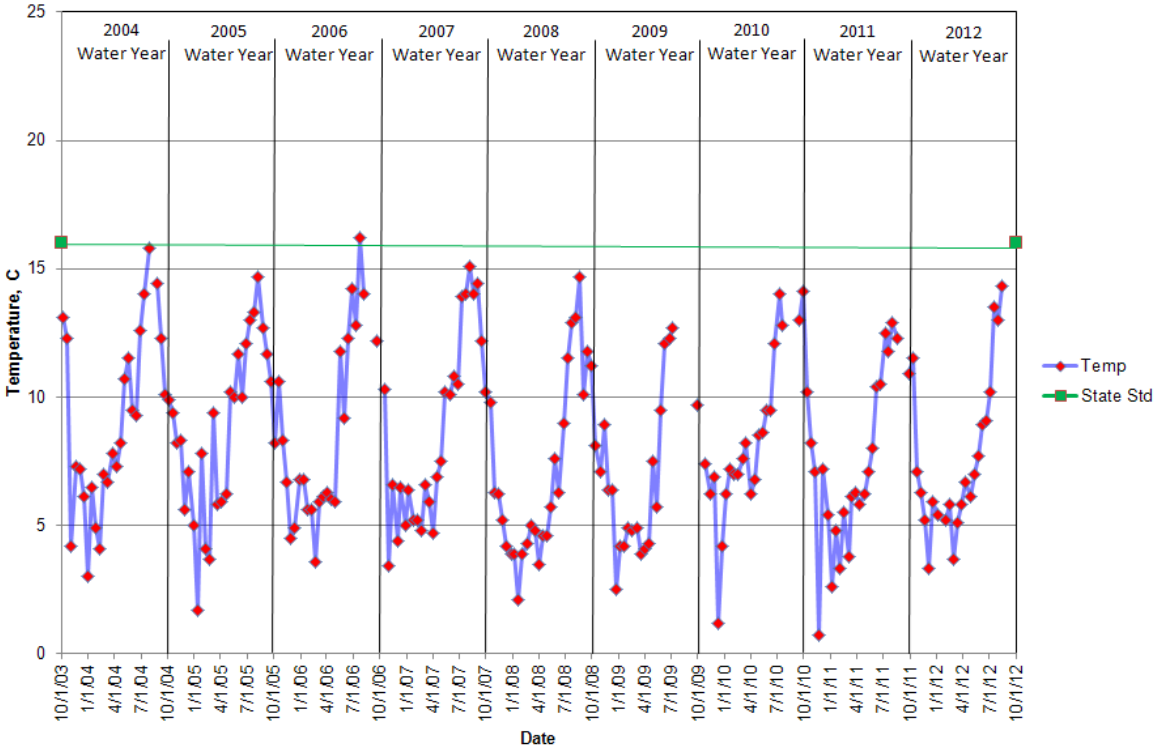
## Coal Creek at Hoehn Rd - Site 21
## Temperature



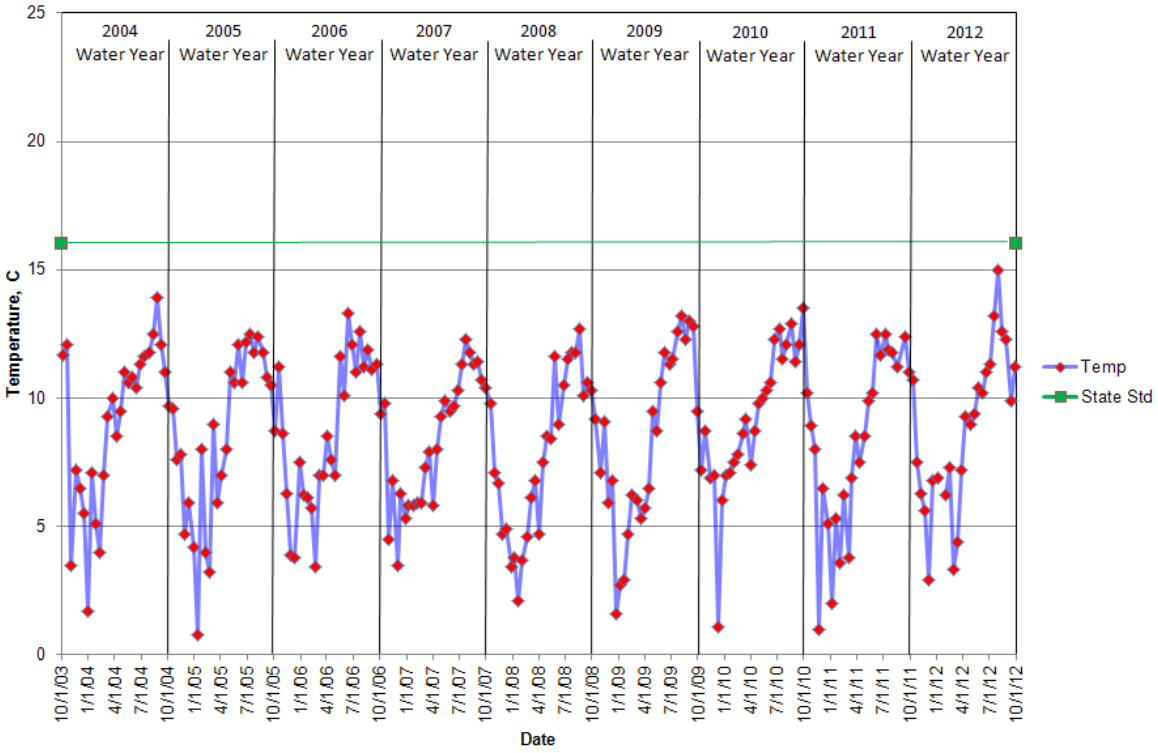

## Coal Creek at Hwy 20 - Site 22
## Temperature



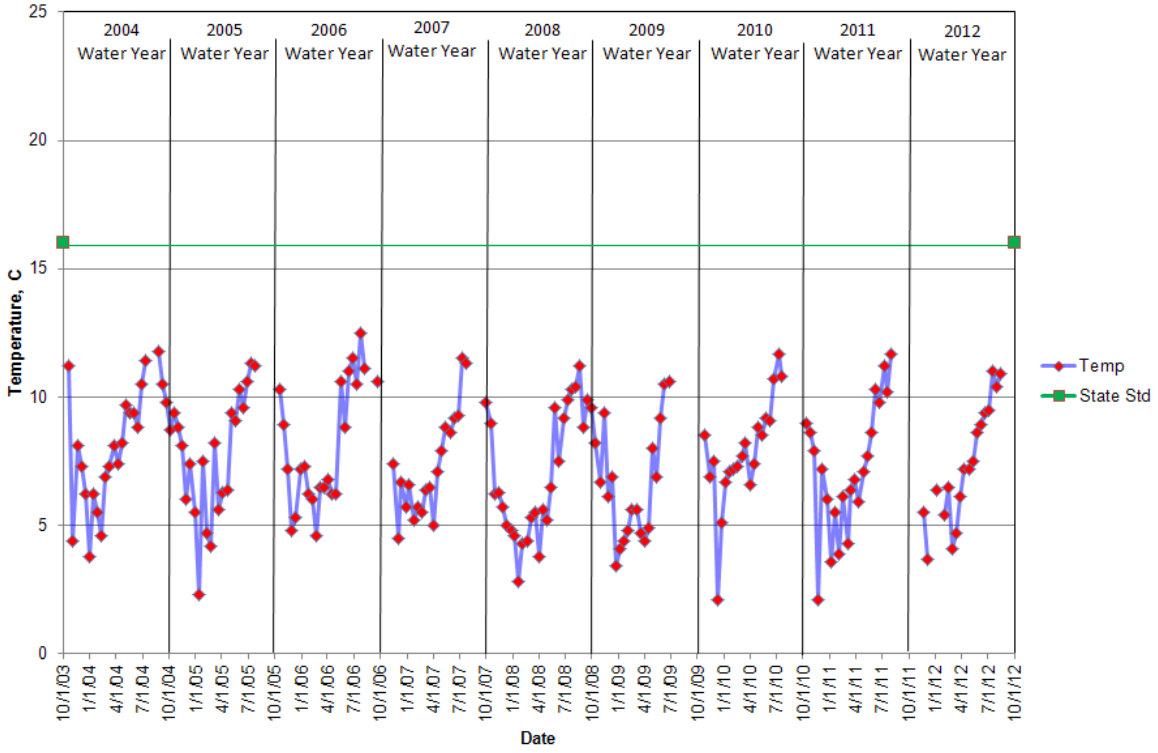
## Wiseman Creek at Minkler Rd - Site 23
## Temperature



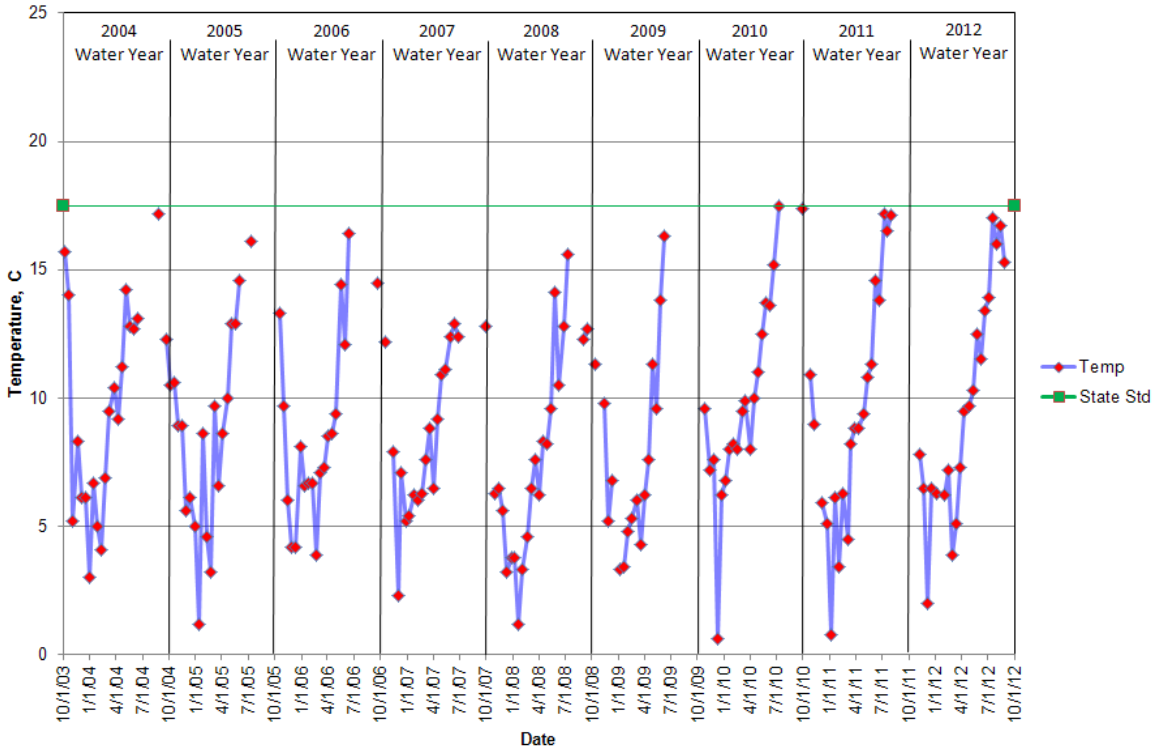

## Mannser Creek at Lyman-Hamilton Hwy - Site 24
## Temperature



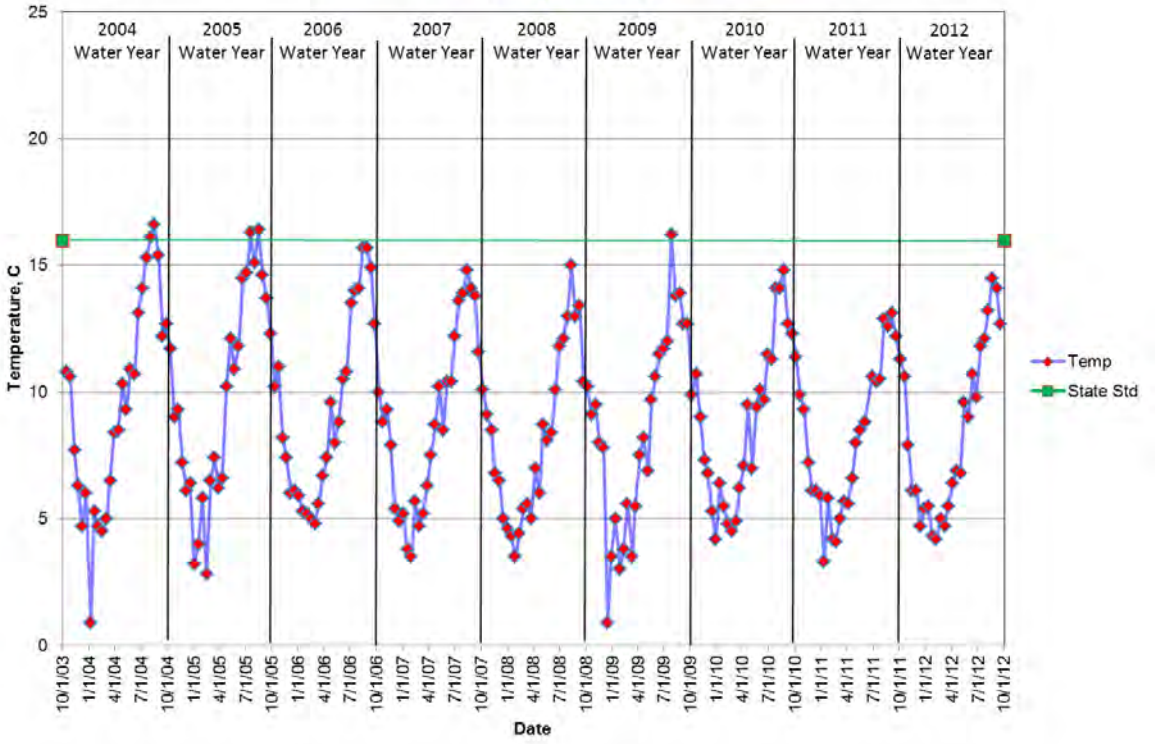
## Red Cabin Creek at Hamilton Cemetery Rd - Site 25
## Temperature



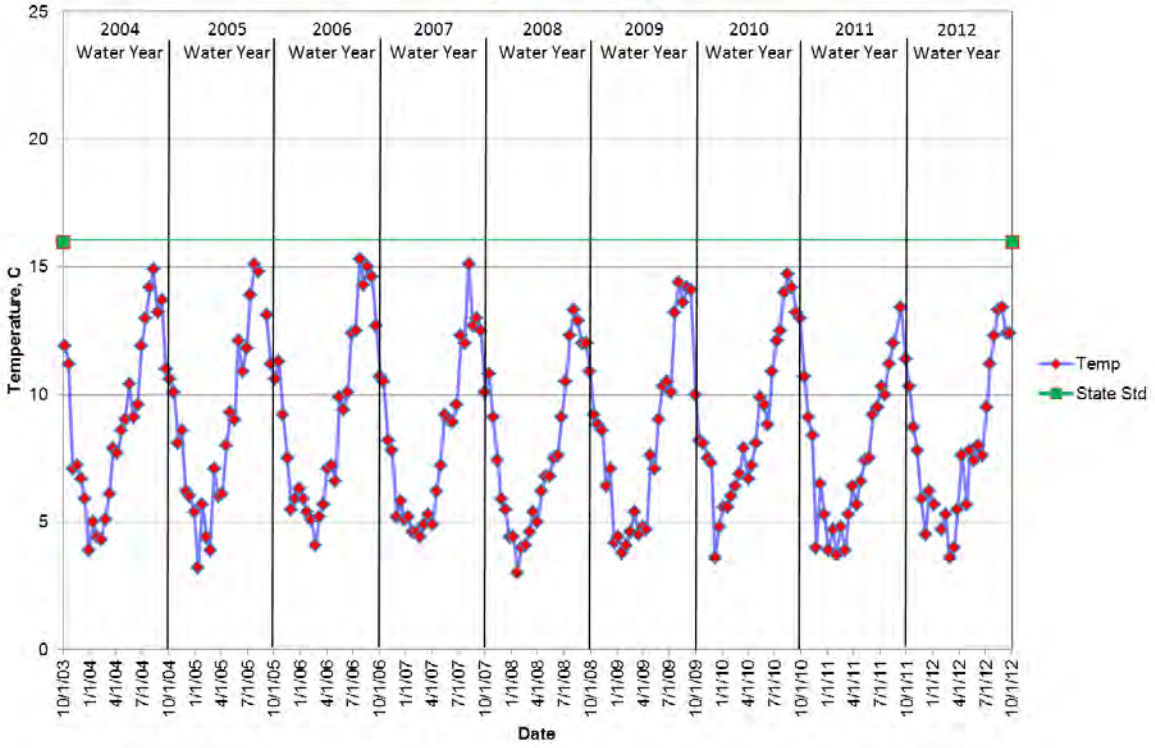

## Brickyard Creek at Hwy 20 - Site 28
## Temperature



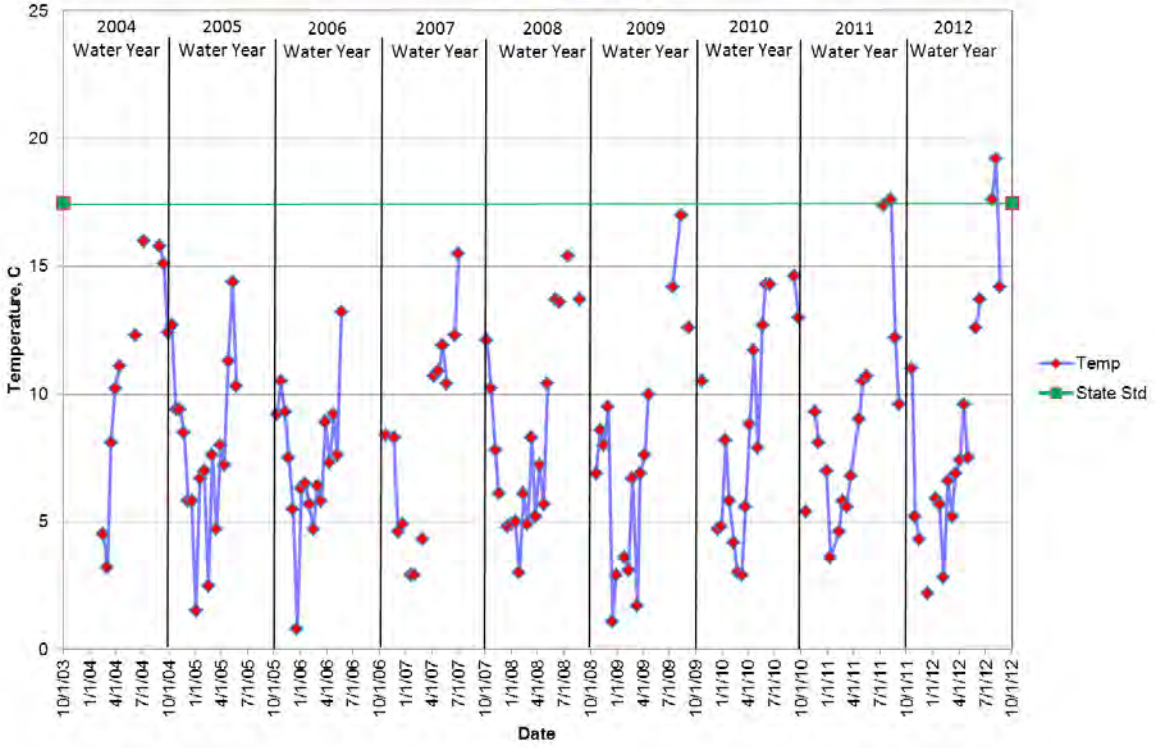
## Skagit River at River Bend - Site 29
## Temperature



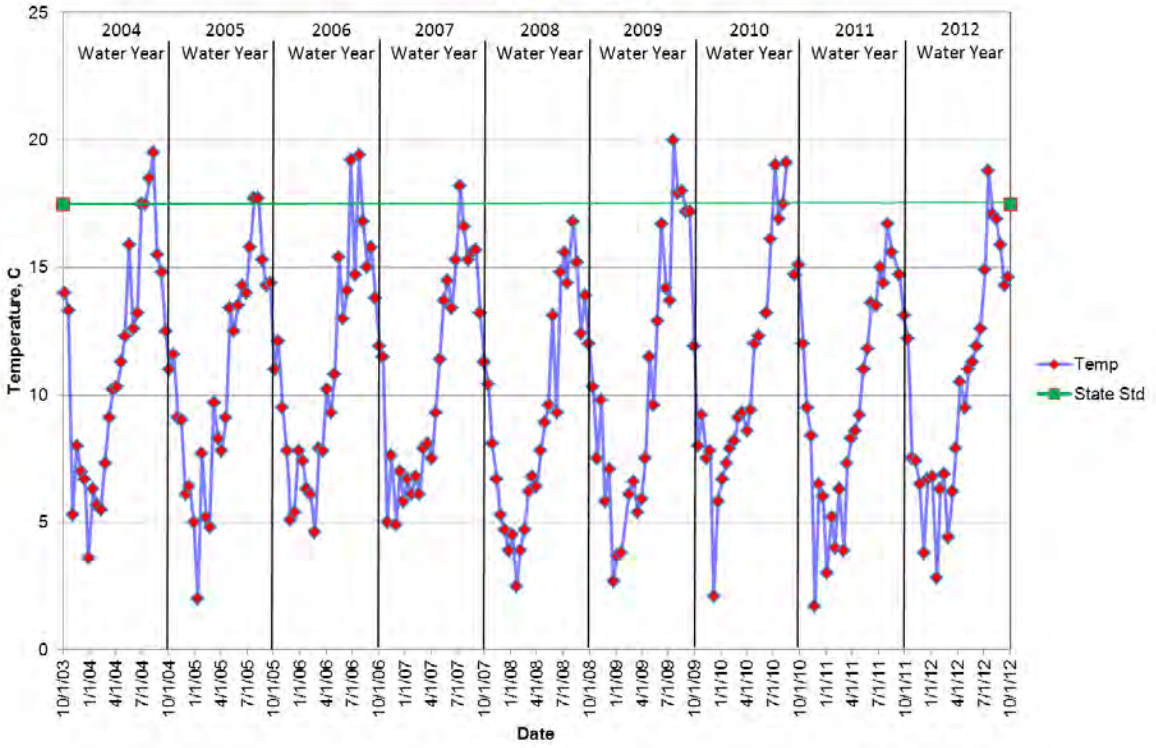

## Skagit River at Cape Horn Rd - Site 30
## Temperature



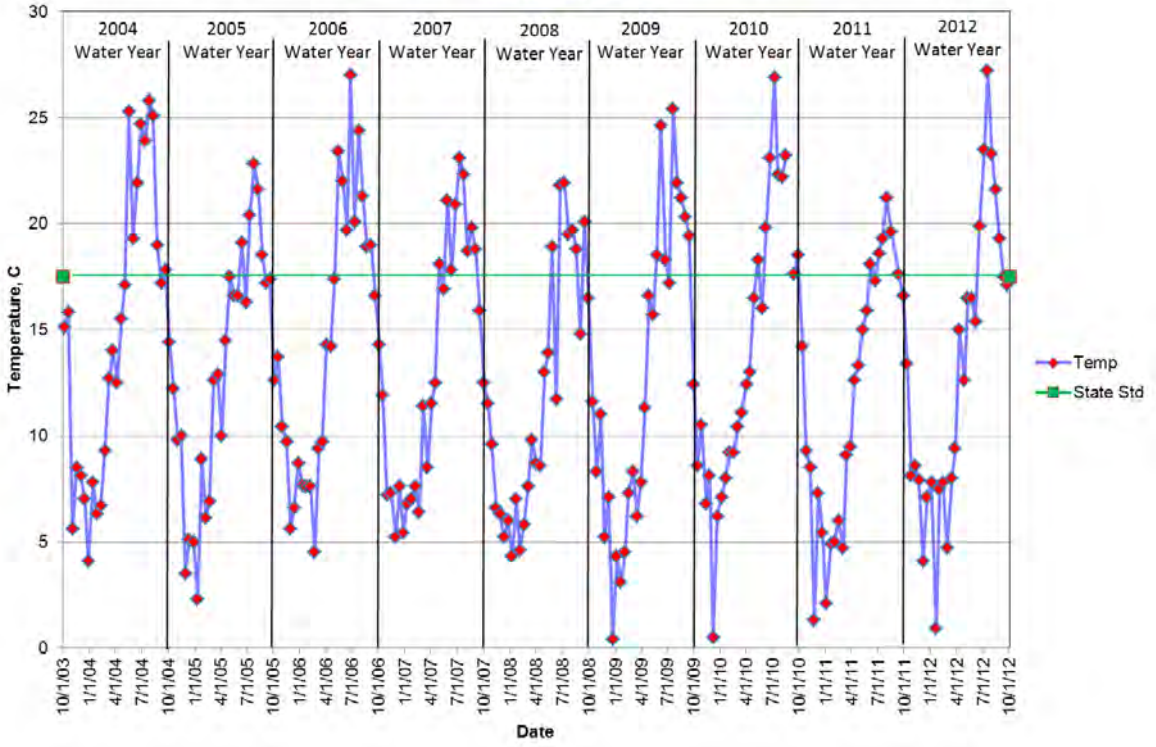
## Drainage District 20 Ditch at Floodgate - Site 31
## Temperature



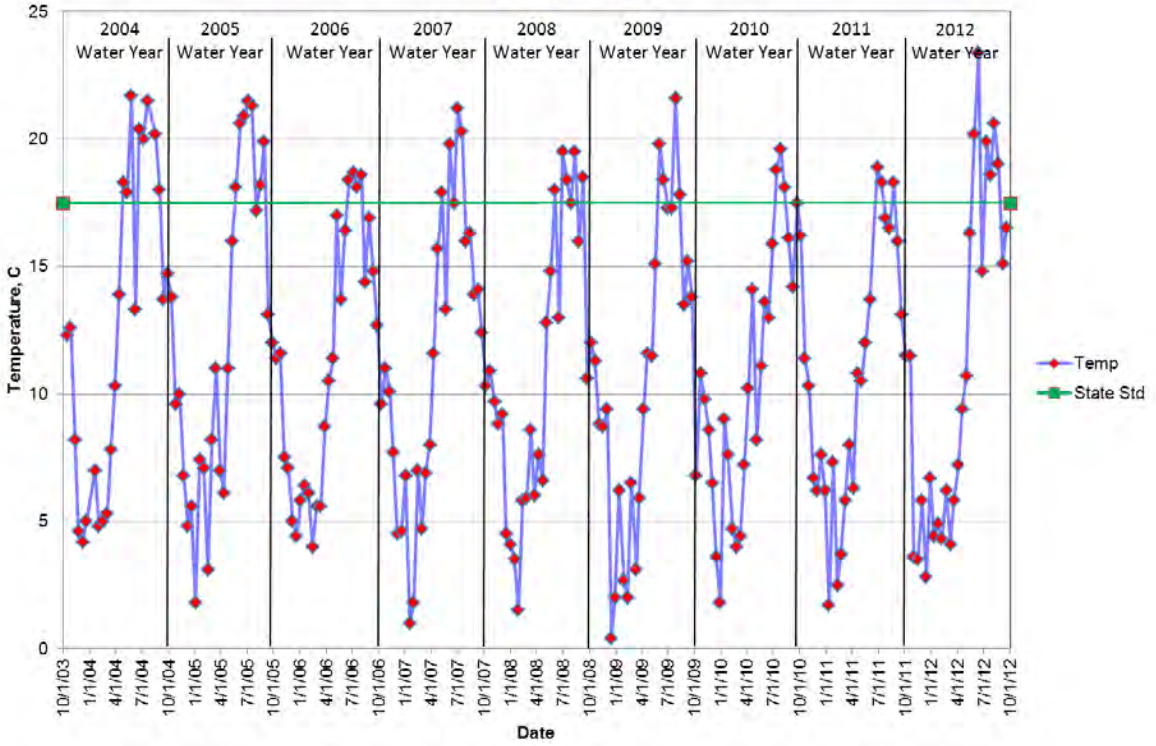

## Samish River at Thomas Road - Site 32
## Temperature



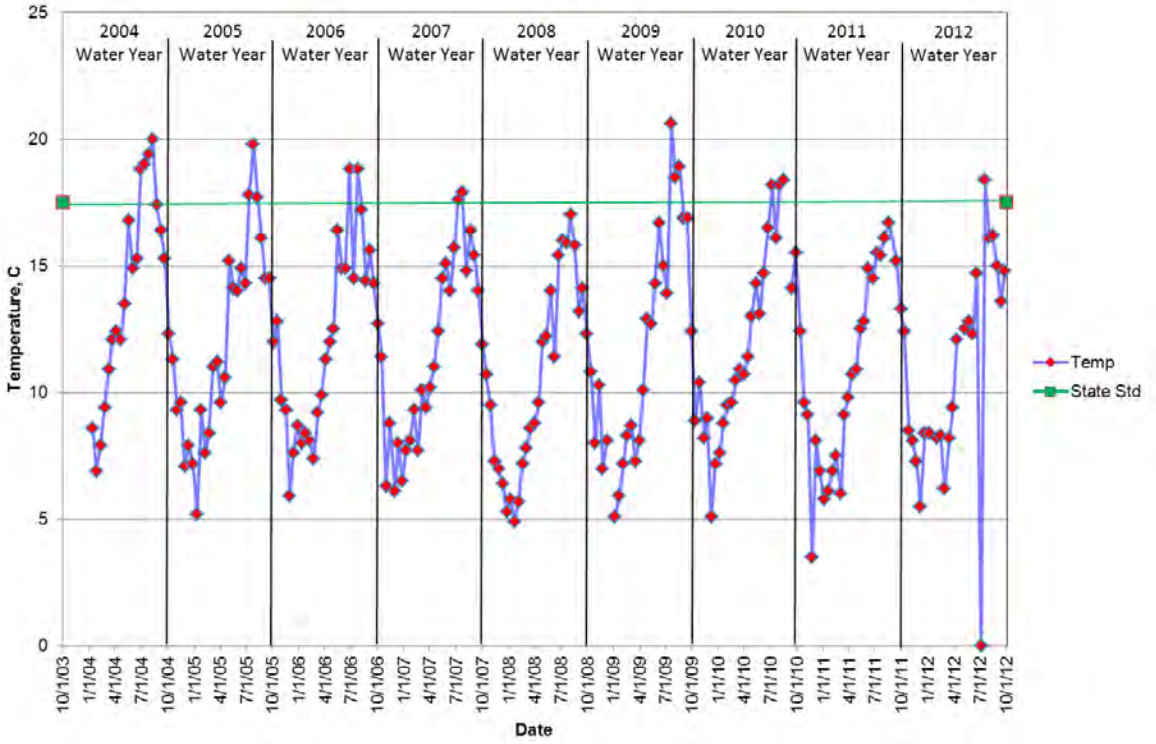
## Alice Bay Pump Station - Site 33
## Temperature



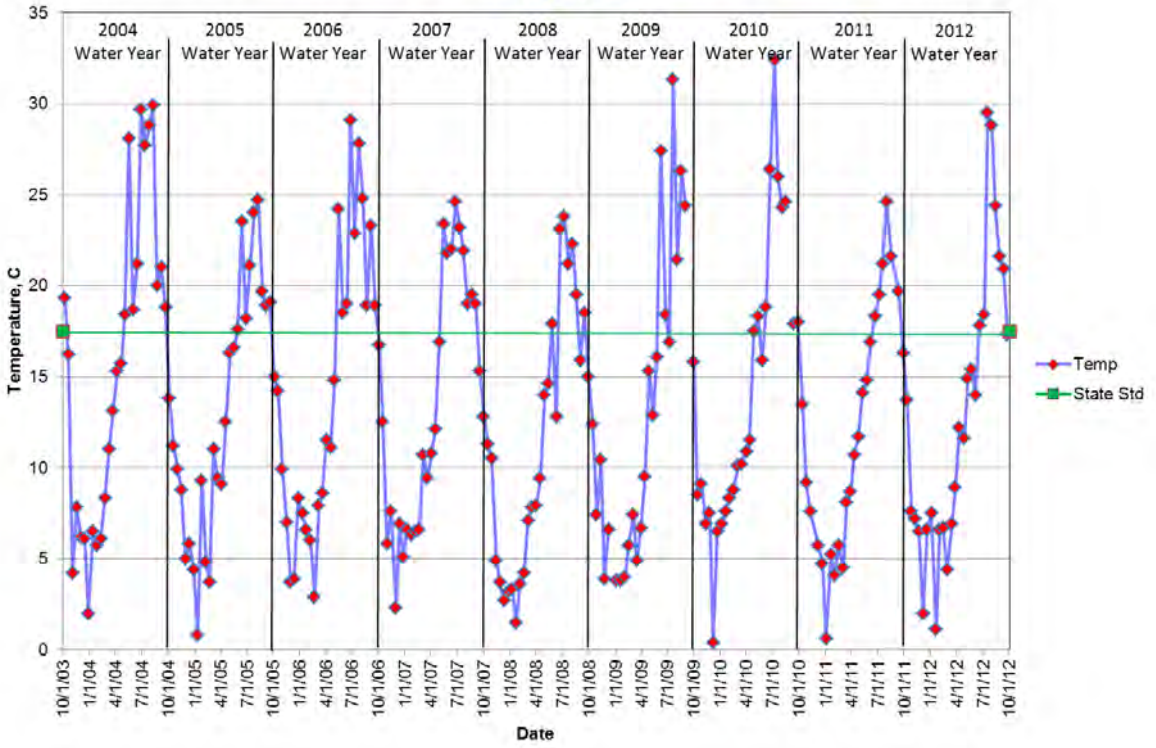

## No Name Slough at Bayview-Edison Rd - Site 34
## Temperature



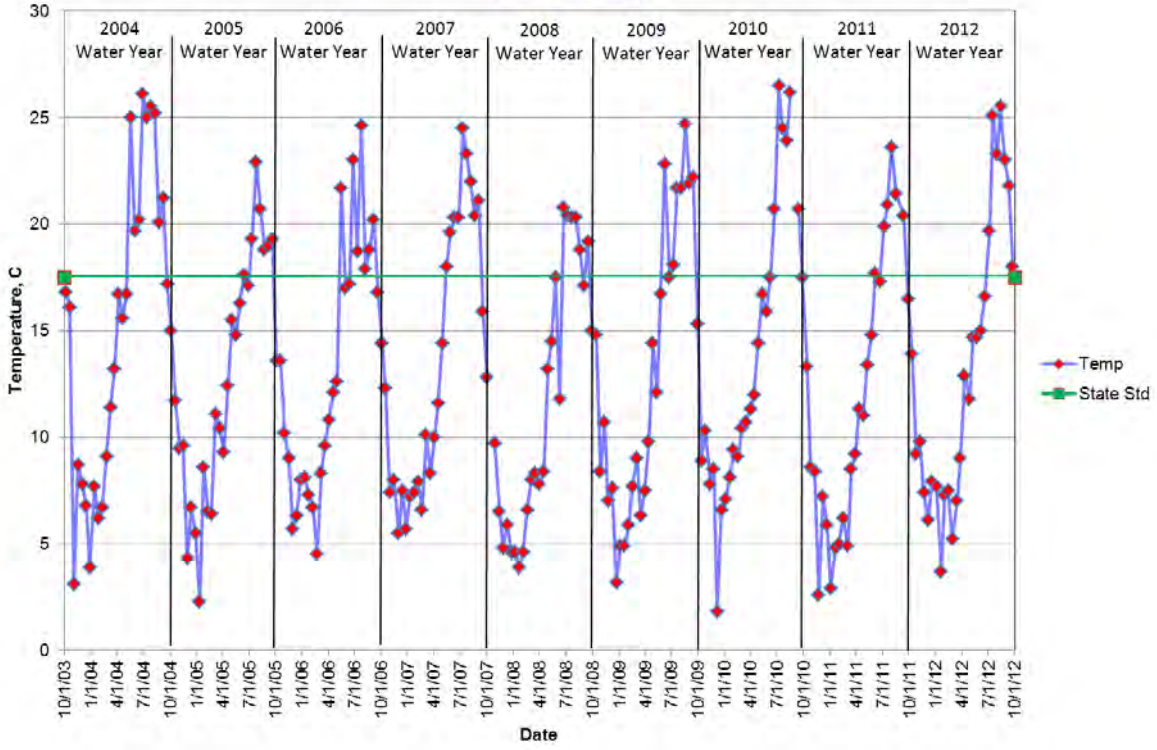
## Joe Leary Slough at D'Arcy Rd - Site 35
## Temperature



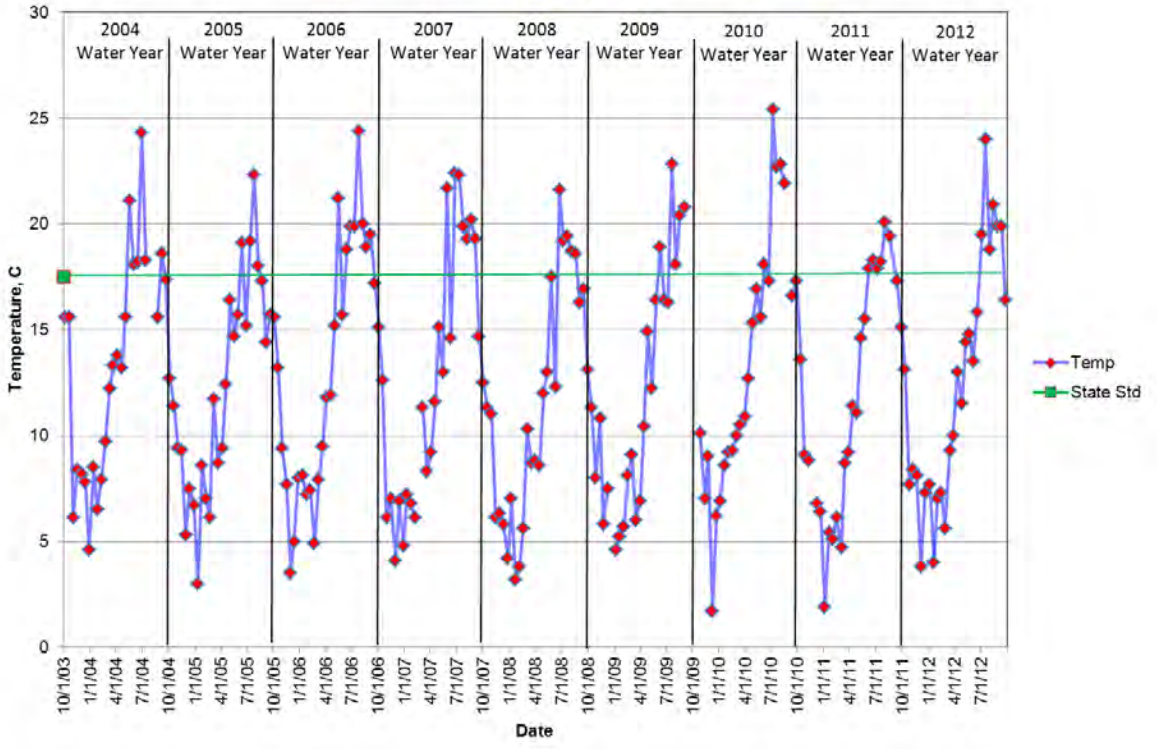

## Edison Slough at Edison School - Site 36
## Temperature



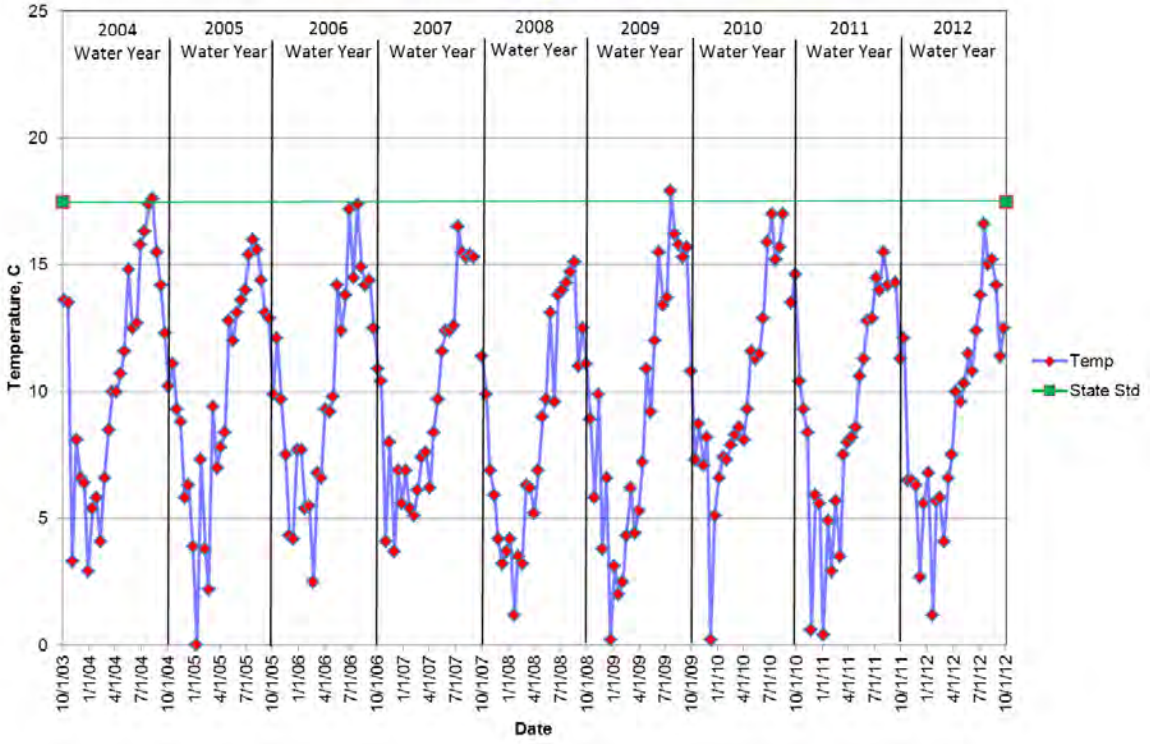
## Edison Pump Station - Site 37
## Temperature



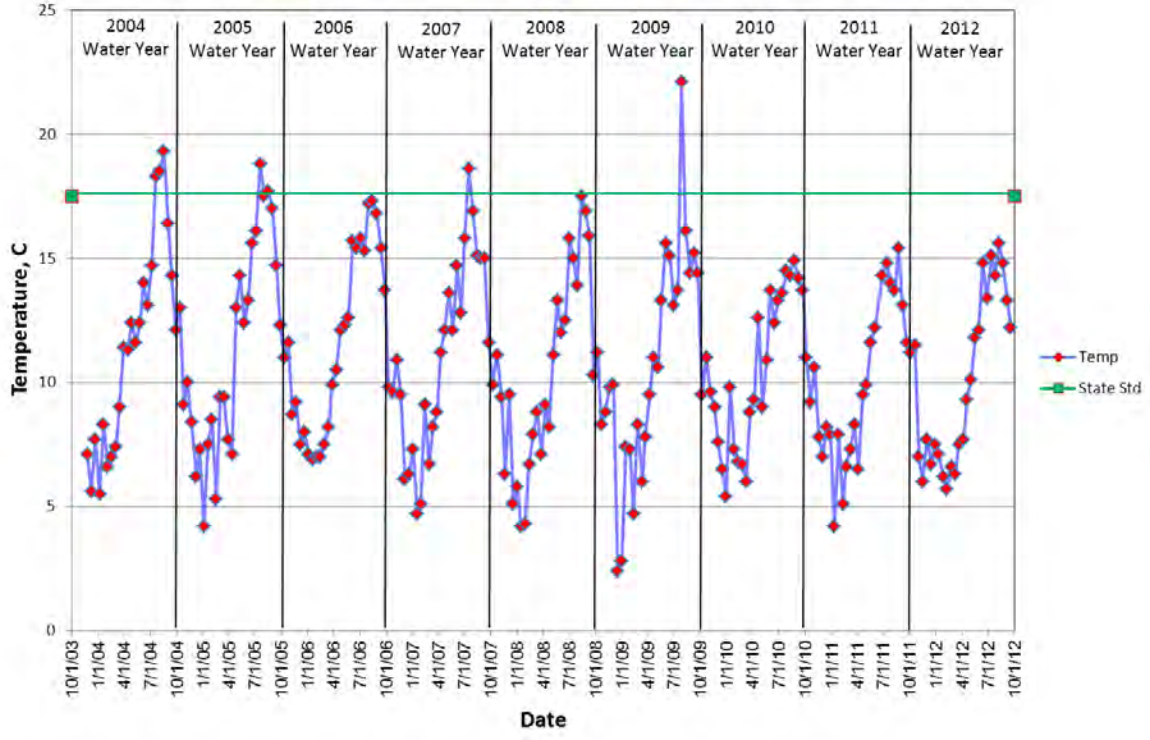

## North Edison Pump Station - Site 38
## Temperature



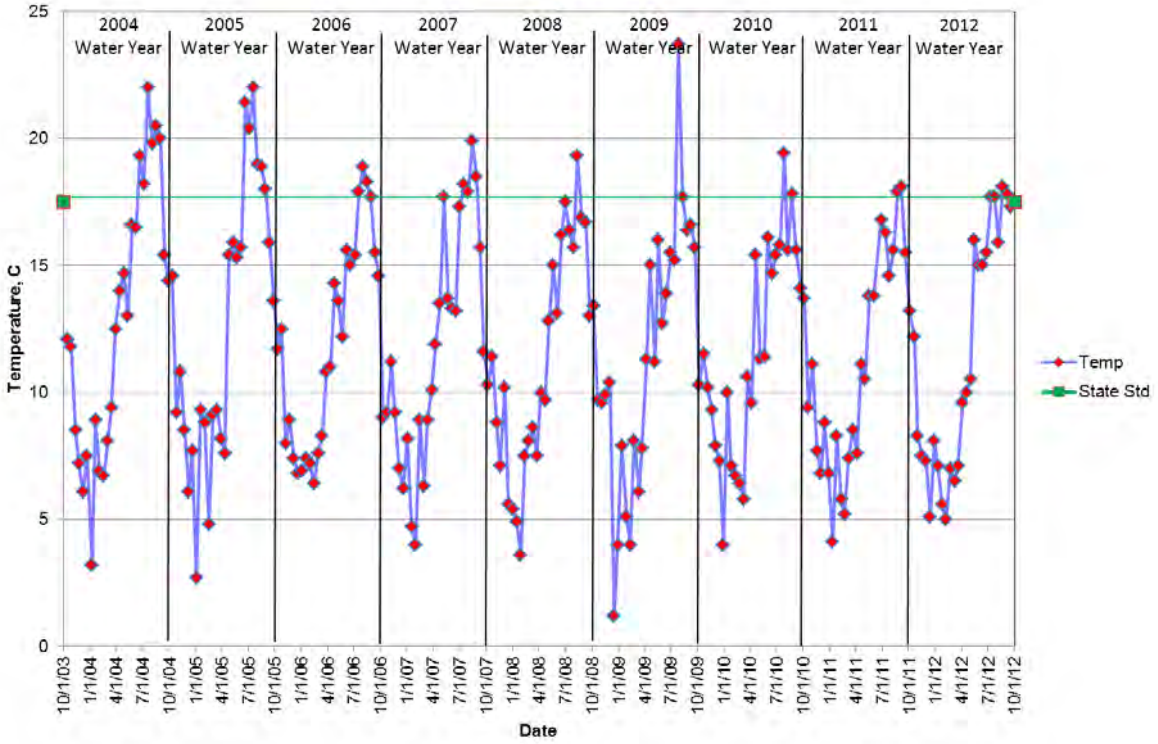
## Colony Creek at Colony Rd - Site 39
## Temperature



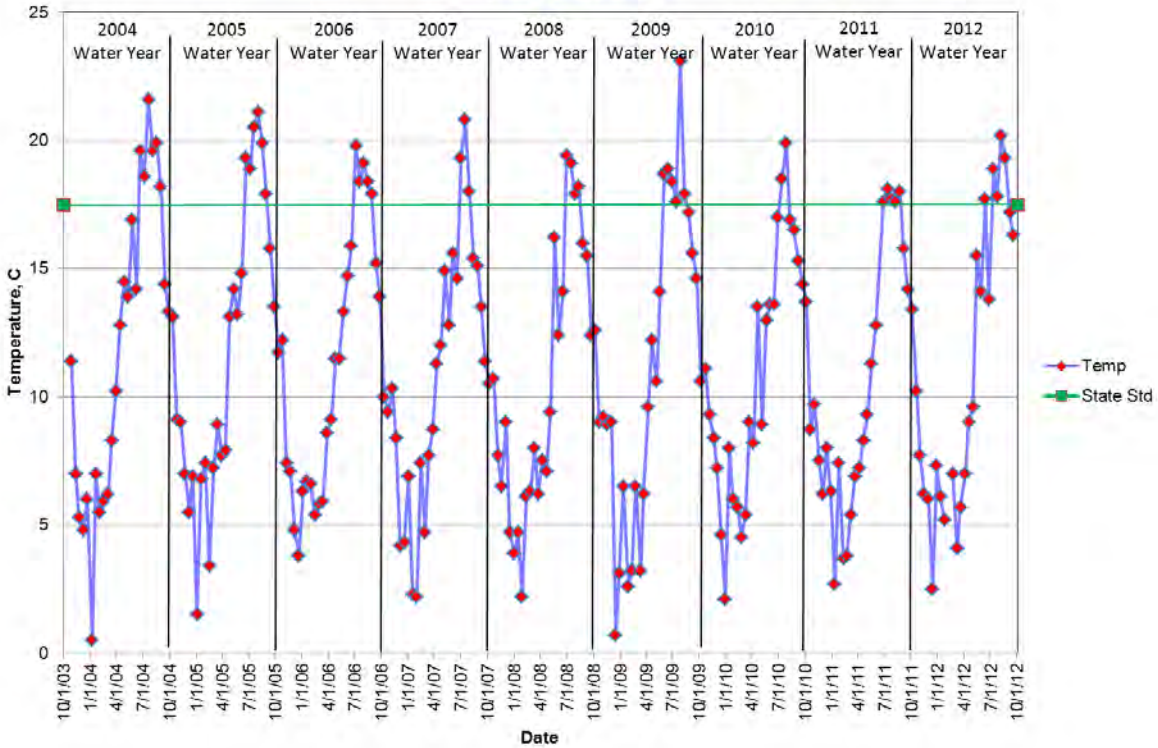

## Big Indian Slough at Hwy 20 Truck Scales - Site 40
## Temperature



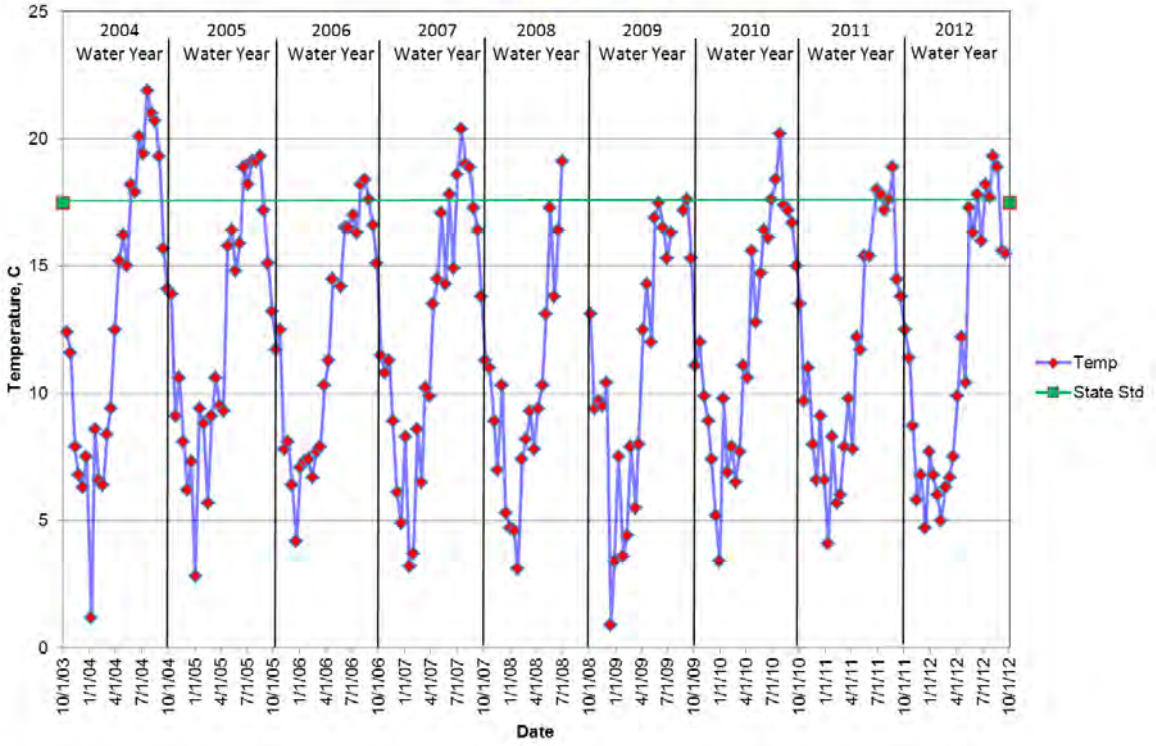
## Maddox Creek/Big Ditch at Milltown Rd - Site 41
## Temperature



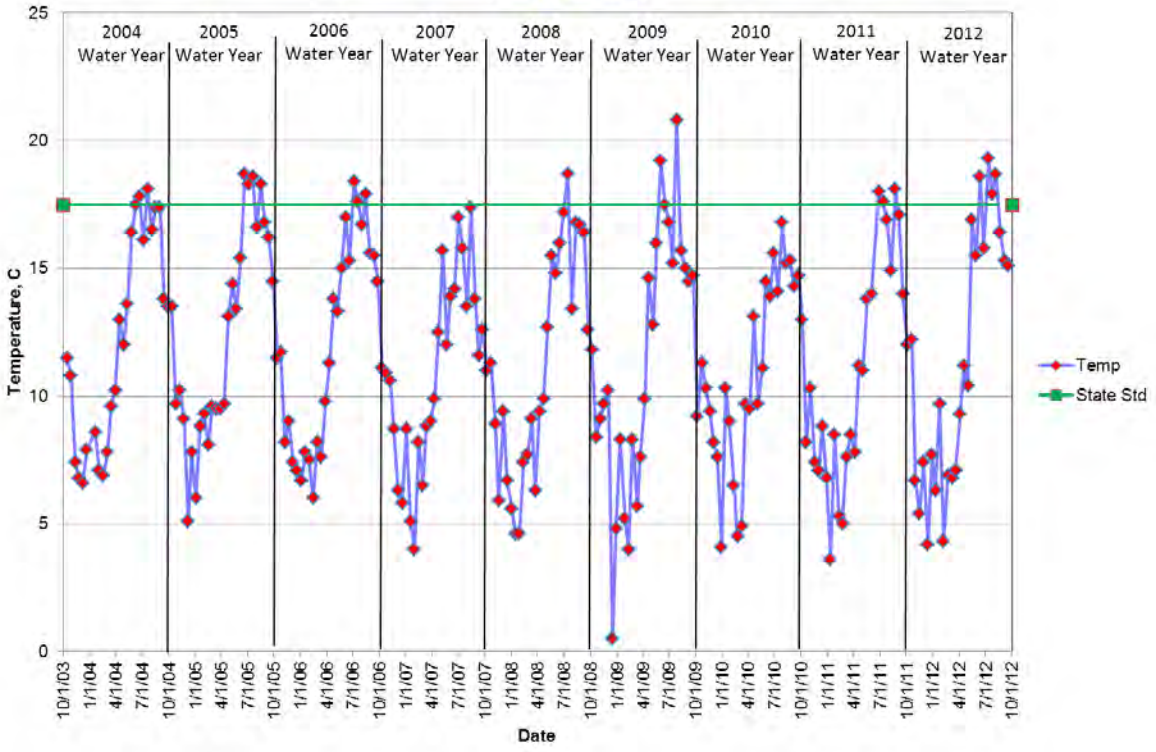

## Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
## Temperature



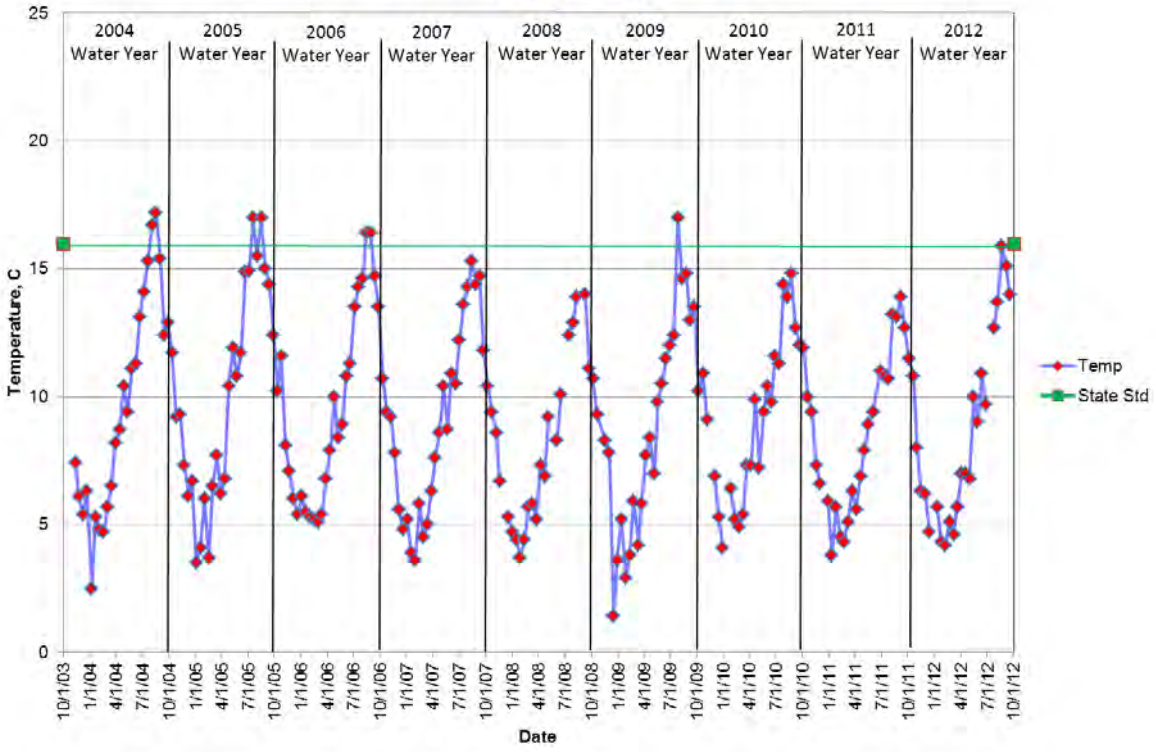
## Wiley Slough at Wylie Rd - Site 43
## Temperature



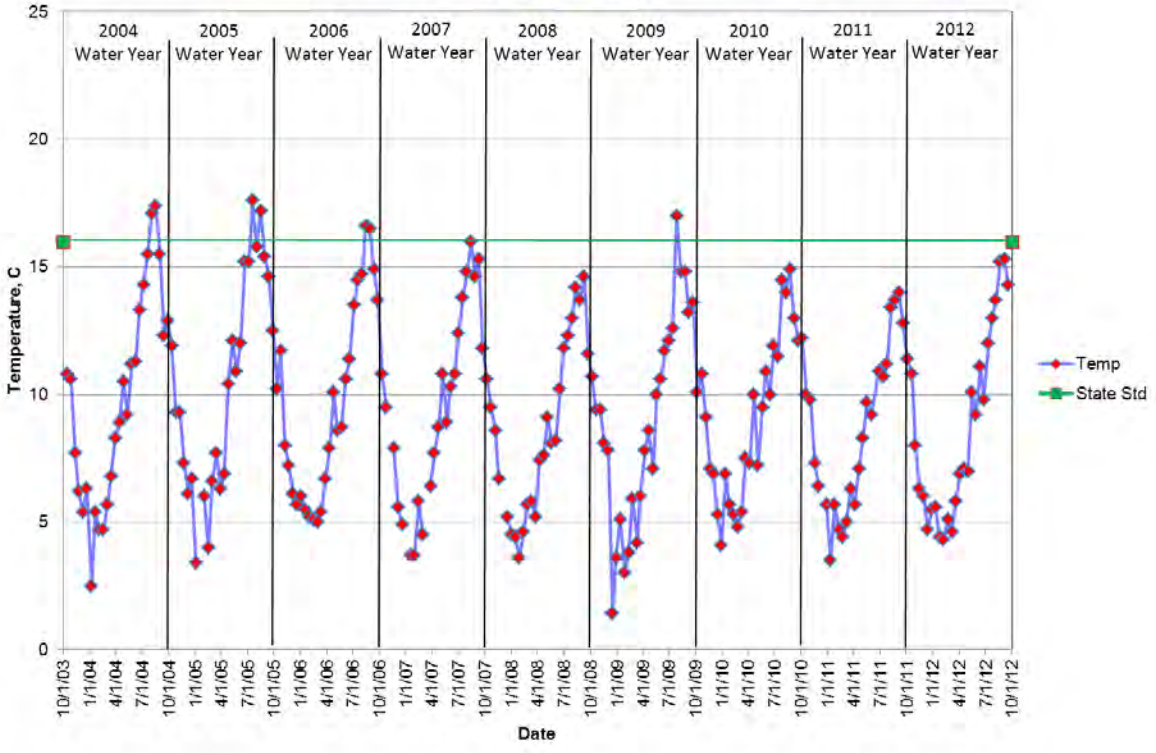

## Sullivan Slough at La Conner-Whitney Rd - Site 44
## Temperature



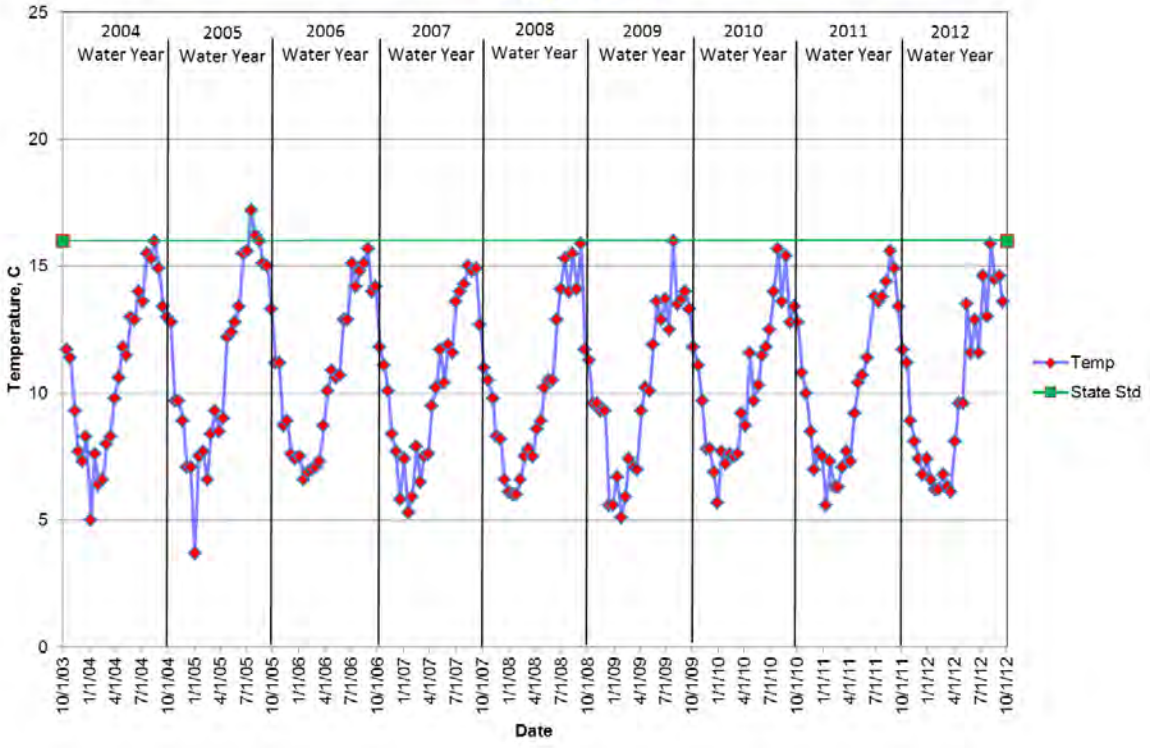
## N.F. Skagit River near Moore Rd - Site 45
## Temperature



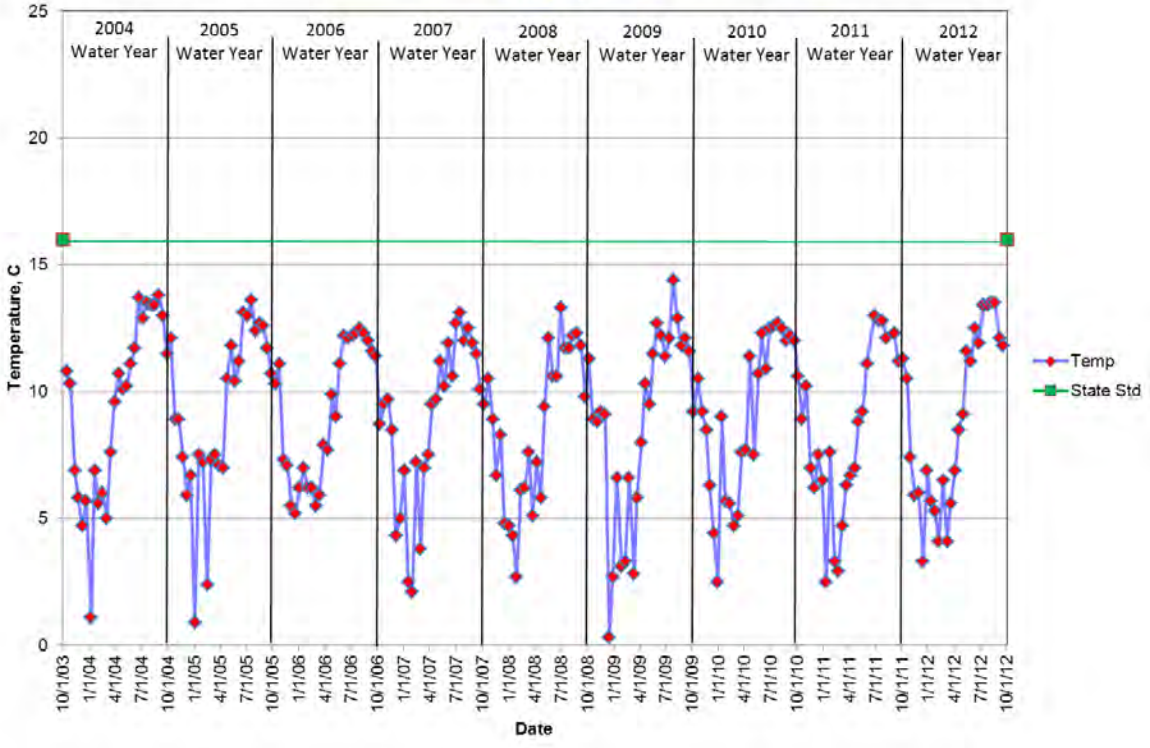

## S.F. Skagit River at Conway Boat Ramp - Site 46
## Temperature



## Swinomish Channel at County Boat Ramp - Site 47
## Temperature




## Fisher Creek at Franklin Rd - Site 48
## Temperature



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 2012 water year is provided in Table 5. Table 6 summarizes data from the last seven years of the study. The pages following Table 6 contain graphs illustrating dissolved oxygen levels at all sample sites for the 2004-2012 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.

Seven sites in the Skagit County Monitoring Program met oxygen standards at each measurement in the 2012 water year, up from five in 2011. 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 2012 Water Year

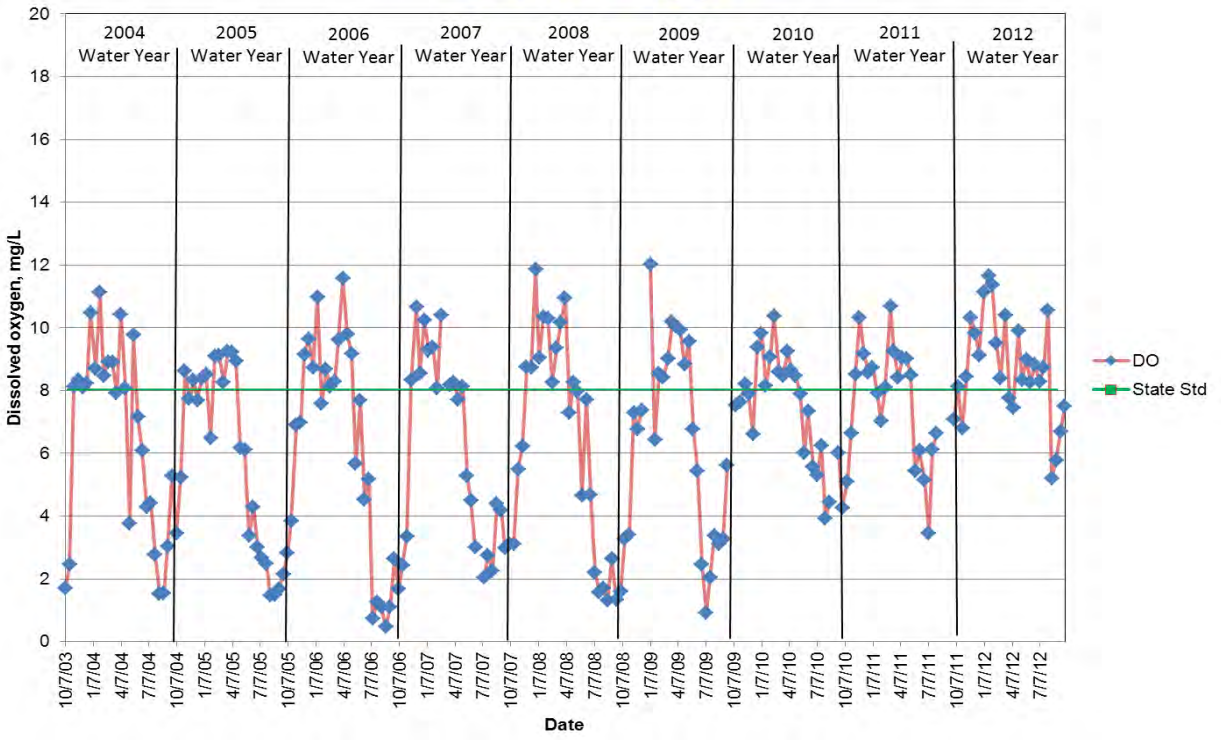
| Site Number | Watercourse | Location | Mean DO (mg/L) | Minimum DO (mg/L) | St. Std[1] |
|---|---|---|---|---|---|
| 3 | Thomas Ck | Old Hwy 99 N | 8.7 | 5.2 | 8.0 |
| 4 | Thomas Ck | F&S Grade | 11.2 | 9.5 | 8.0 |
| 6 | Friday Ck | Prairie Rd | 11.2 | 8.5 | 9.5 |
| 8 | Swede Ck | Grip Rd | 10.7 | 8.7 | 9.5 |
| 11 | Samish R | State Route 9 | 8.6 | 5.9 | 9.5 |
| 12 | Nookachamps Ck | Swan Rd | 8.9 | 4.1 | 9.5 |
| 13 | E.F. Nookachamps Ck | State Route 9 | 9.5 | 5.8 | 9.5 |
| 14 | College Way Ck | College Way | 8.9 | 4.9 | 9.5 |
| 15 | Nookachamps Ck | Knapp | 8.0 | 0.3 | 9.5 |
| 16 | E.F. Nookachamps Ck | Beaver Lake Rd | 11.3 | 8.9 | 9.5 |
| 17 | Nookachamps Ck | Big Lake Outlet | 9.9 | 7.0 | 9.5 |
| 18 | Lake Ck | State Route 9 | 10.6 | 9.1 | 9.5 |
| 19 | Hansen Ck | Hoehn Rd | 10.2 | 7.7 | 9.5 |
| 20 | Hansen Ck | Northern State | 11.0 | 9.1 | 9.5 |
| 21 | Coal Ck | Hoehn Rd | 11.0 | 8.3 | 9.5 |
| 22 | Coal Ck | Hwy 20 | 11.7 | 8.3 | 9.5 |
| 23 | Wiseman Ck | Minkler Rd | 11.9 | 10.3 | 9.5 |
| 24 | Mannser Ck | Lyman Hamilton Hwy | 5.6 | 2.5 | 9.5 |
| 25 | Red Cabin Ck | Hamilton Cem Rd | 11.8 | 10.2 | 9.5 |
| 28 | Brickyard Ck | Hwy 20 | 9.2 | 6.4 | 8.0 |
| 29 | Skagit R | River Bend Rd | 11.4 | 9.1 | 9.5 |
| 30 | Skagit R | Cape Horn Rd | 11.3 | 9.7 | 9.5 |
| 31 | Drain Dist 20 floodgate | Francis Rd | 7.6 | 0.4 | 8.0 |
| 32 | Samish R | Thomas Rd | 10.8 | 9.3 | 8.0 |
| 33 | Alice Bay Pump Station | Samish Island Rd | 8.9 | 2.3 | 8.0 |
| 34 | Noname Slough | Bayview-Edison Rd | 7.0 | 0.1 | 8.0 |
| 35 | Joe Leary Slough | D'Arcy Rd | 5.4 | 2.7 | 8.0 |
| 36 | Edison Slough at school | W. Bow Hill Rd | 9.1 | 5.2 | 8.0 |
| 37 | Edison Pump Station | Farm to Market Rd | 8.7 | 3.0 | 8.0 |
| 38 | North Edison Pump Station | North Edison Rd | 5.7 | 1.9 | 8.0 |
| 39 | Colony Ck | Colony Rd | 10.8 | 8.5 | 8.0 |
| 40 | Big Indian Slough | Bayview-Edison Rd | 5.5 | 2.4 | 8.0 |
| 41 | Maddox Slough/Big Ditch | Milltown Rd | 5.8 | 0.1 | 8.0 |
| 42 | Hill Ditch | Cedardale Rd | 8.4 | 2.4 | 9.5 |
| 43 | Wiley Slough | Wylie Rd | 4.6 | 0.2 | 8.0 |
| 44 | Sullivan Slough | La Conner-Bayview Rd | 7.0 | 3.4 | 8.0 |
| 45 | Skagit R – North Fork | Moore Rd | 11.4 | 9.3 | 9.5 |
| 46 | Skagit R – South Fork | Fir Island Rd | 11.2 | 8.4 | 9.5 |
| 47 | Swinomish Channel | County Boat Launch | 8.8 | 6.7 | 6.0 |
| 48 | Fisher Ck | Franklin Rd | 11.1 | 9.1 | 9.5 |

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

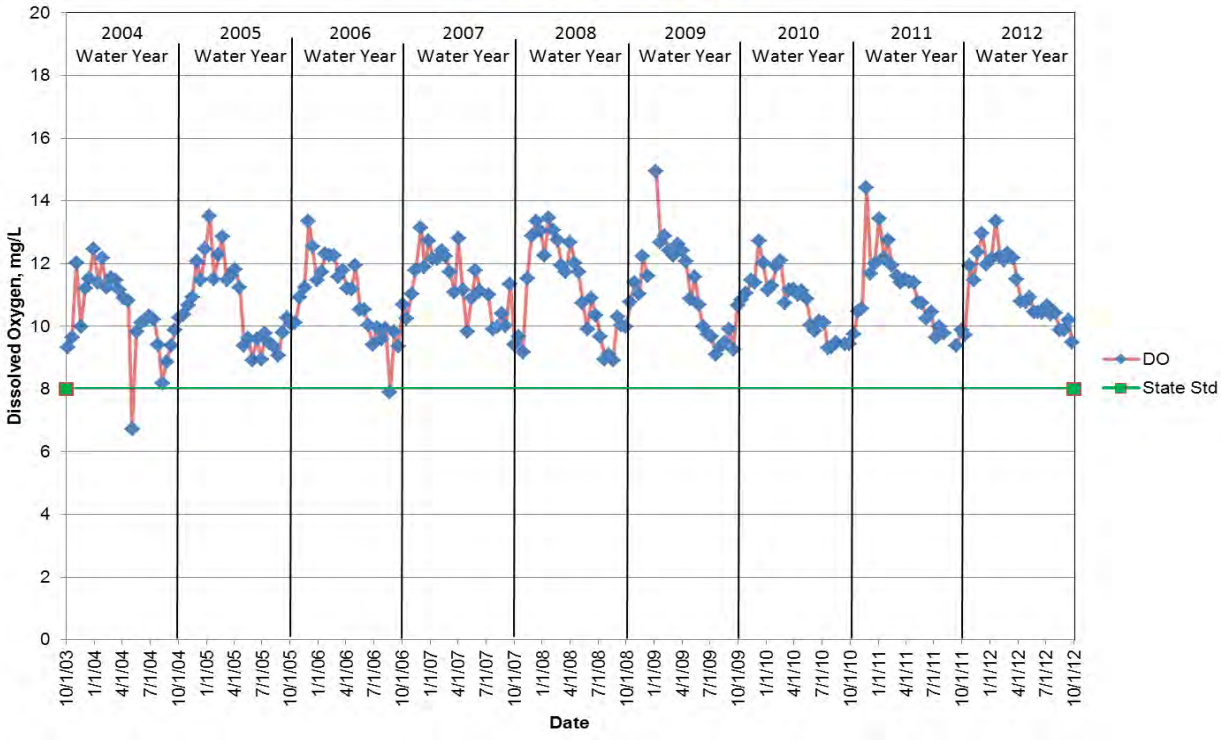
## Table 6. Dissolved Oxygen Results Summary
## Mean Dissolved Oxygen levels for seven years of the Skagit County Monitoring Program

| Site Number | Watercourse | Location | Mean Dissolved Oxygen (mg/L) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| 3 | Thomas Ck | Old Hwy 99 North | 6.2 | 6.1 | 6.2 | 6.4 | 7.4 | 7.5 | 8.7 |
| 4 | Thomas Ck | F&S Grade | 10.9 | 11.3 | 11.1 | 11.2 | 10.8 | 11.1 | 11.2 |
| 6 | Friday Ck | Prairie Rd | 11.1 | 11.6 | 11.5 | 11.3 | 11.1 | 11.1 | 11.2 |
| 8 | Swede Ck | Grip Rd | 11.2 | 11.5 | 11.3 | 10.9 | 9.8 | 10.5 | 10.7 |
| 11 | Samish R | State Route 9 | 8.4 | 9 | 8.5 | 9.0 | 8.2 | 8.6 | 8.6 |
| 12 | Nookachamps Ck | Swan Rd | 9.5 | 9.1 | 10.0 | 9.7 | 8.6 | 9.2 | 8.9 |
| 13 | E.F. Nookachamps Ck | State Route 9 | 10.3 | 10.4 | 10.3 | 10.0 | 9.3 | 10.4 | 9.5 |
| 14 | College Way Ck | College Way | 9 | 9.1 | 9.5 | 9.3 | 9.3 | 10.0 | 8.9 |
| 15 | Nookachamps Ck | Knapp | 8.2 | 7.8 | 8.6 | 7.3 | 8.1 | 8.8 | 8.0 |
| 16 | E.F. Nookachamps Ck | Beaver Lake Rd | 11.4 | 11.6 | 12.0 | 11.5 | 11.1 | 11.4 | 11.3 |
| 17 | Nookachamps Ck | Big Lake Outlet | 10 | 10.1 | 10.4 | 10.1 | 10.0 | 9.8 | 9.9 |
| 18 | Lake Ck | State Route 9 | 11.2 | 11.5 | 11.3 | 11.2 | 10.9 | 11.3 | 10.6 |
| 19 | Hansen Ck | Hoehn Rd | 10.5 | 10.9 | 11.0 | 10.7 | 10.2 | 10.6 | 10.2 |
| 20 | Hansen Ck | Northern State | 11.2 | 11.4 | 11.4 | 11.1 | 10.8 | 11.1 | 11.0 |
| 21 | Coal Ck | Hoehn Rd | 11.4 | 11.4 | 11.5 | 11.1 | 10.7 | 11.0 | 11.0 |
| 22 | Coal Ck | Hwy 20 | 11.9 | 12.2 | 12.2 | 12.1 | 11.5 | 11.9 | 11.7 |
| 23 | Wiseman Ck | Minkler Rd | 11.8 | 12.1 | 11.9 | 12.1 | 11.7 | 12.0 | 11.9 |
| 24 | Mannser Ck | Lyman Hamilton Hwy | 6.8 | 7.6 | 6.9 | 7.0 | 6.1 | 5.5 | 5.6 |
| 25 | Red Cabin Ck | Hamilton Cem Rd | 11.9 | 12.2 | 11.8 | 12.5 | 11.7 | 11.7 | 11.8 |
| 28 | Brickyard Ck | Hwy 20 | 9.2 | 9.9 | 9.7 | 9.7 | 8.7 | 9.4 | 9.2 |
| 29 | Skagit R | R Bend Rd | 11.3 | 11.2 | 10.9 | 11.2 | 11.0 | 11.4 | 11.4 |
| 30 | Skagit R | Cape Horn Rd | 11.3 | 11.7 | 11.3 | 11.4 | 11.1 | 11.3 | 11.3 |
| 31 | DD20 near floodgate | Francis Rd | 9 | 7.6 | 7.8 | 8.2 | 8.5 | 8.1 | 7.6 |
| 32 | Samish R | Thomas Rd | 10.8 | 11.1 | 10.9 | 10.9 | 10.9 | 10.6 | 10.8 |
| 33 | Alice Bay Pump Station | Samish Island Rd | 9.5 | 11.7 | 8.4 | 9.6 | 10.4 | 8.9 | 8.9 |
| 34 | Noname Slough | Bayview-Edison Rd | 6.6 | 6.1 | 6.9 | 6.7 | 6.0 | 8.2 | 7.0 |
| 35 | Joe Leary Slough | D'Arcy Rd | 5 | 6.3 | 5.7 | 5.7 | 5.3 | 5.0 | 5.4 |
| 36 | Edison Slough at school | W. Bow Hill Rd | 8.4 | 9.3 | 8.4 | 9.7 | 8.6 | 8.9 | 9.1 |
| 37 | Edison Pump Station | Farm to Market Rd | 5.8 | 7.6 | 7.3 | 7.7 | 5.9 | 7.0 | 8.7 |
| 38 | North Edison Pump Station | North Edison Rd | 6.4 | 9.1 | 7.6 | 8.9 | 5.9 | 7.7 | 5.7 |
| 39 | Colony Ck | Colony Rd | 10.8 | 11.1 | 11.3 | 11.1 | 10.8 | 11.0 | 10.8 |
| 40 | Big Indian Slough | Bayview-Edison Rd | 4.8 | 5.4 | 7.5 | 5.5 | 5.2 | 5.6 | 5.5 |
| 41 | Maddox Slough/Big Ditch | Milltown Rd | 5.9 | 7 | 6.3 | 6.6 | 6.7 | 6.0 | 5.8 |
| 42 | Hill Ditch | Cedardale Rd | 7.6 | 8 | 6.9 | 7.9 | 8.2 | 8.4 | 8.4 |
| 43 | Wiley Slough | Wylie Rd | 4.6 | 6.2 | 6.5 | 5.1 | 5.1 | 4.7 | 4.6 |
| 44 | Rexville PS/Sullivan Slough | La Conner-Whitney Rd | 8.6 | 8 | 7.4 | 7.4 | 7.7 | 7.2 | 7.0 |
| 45 | Skagit R – North Fork | Moore Rd | 11.4 | 11.2 | 11.2 | 11.5 | 11.3 | 11.5 | 11.4 |
| 46 | Skagit R – South Fork | Fir Island Rd | 11.3 | 11.1 | 11.3 | 11.4 | 11.3 | 11.4 | 11.2 |
| 47 | Swinomish Channel | County Boat Launch | 8.8 | 9.2 | 8.9 | 8.5 | 8.8 | 8.9 | 8.8 |
| 48 | Fisher Ck | Franklin Rd | 11 | 11.3 | 11.0 | 11.1 | 11.2 | 11.3 | 11.1 |

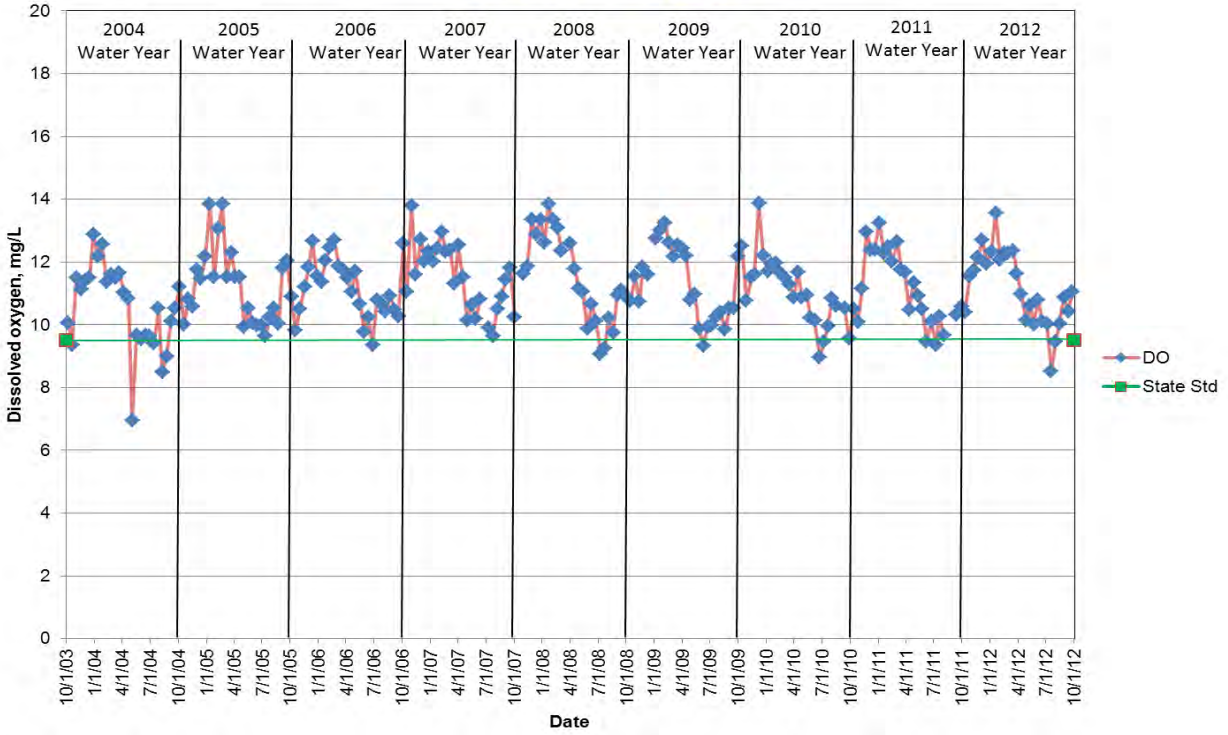
## Thomas Creek at Hwy 99 - Site 3
## Dissolved Oxygen



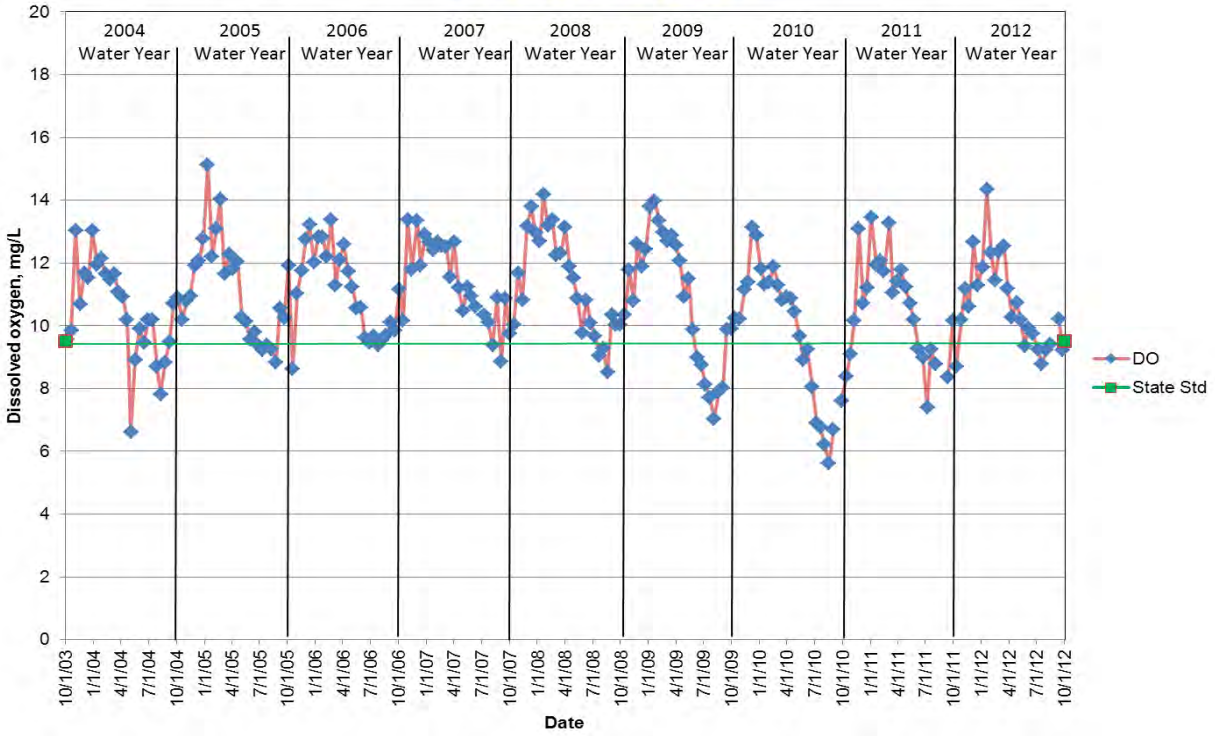

## Thomas Creek at F&S Grade Rd - Site 4
## Dissolved Oxygen



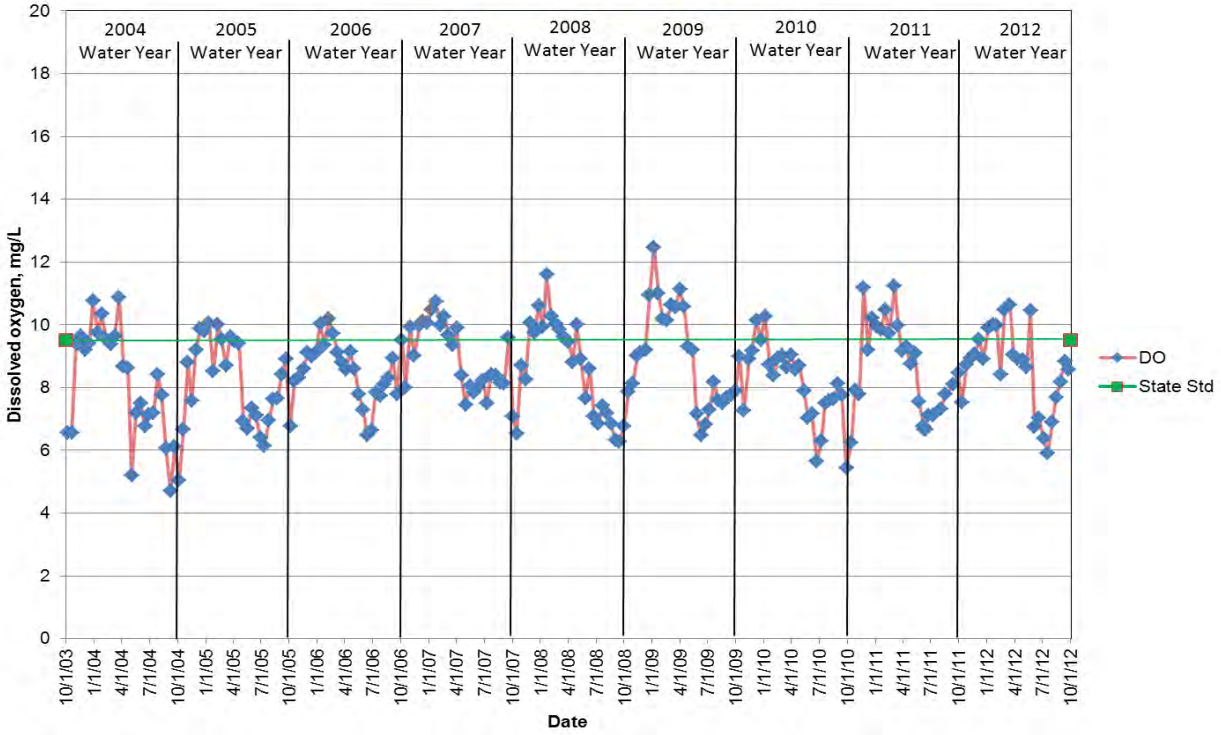
## Friday Creek at Prairie Rd - Site 6
## Dissolved Oxygen



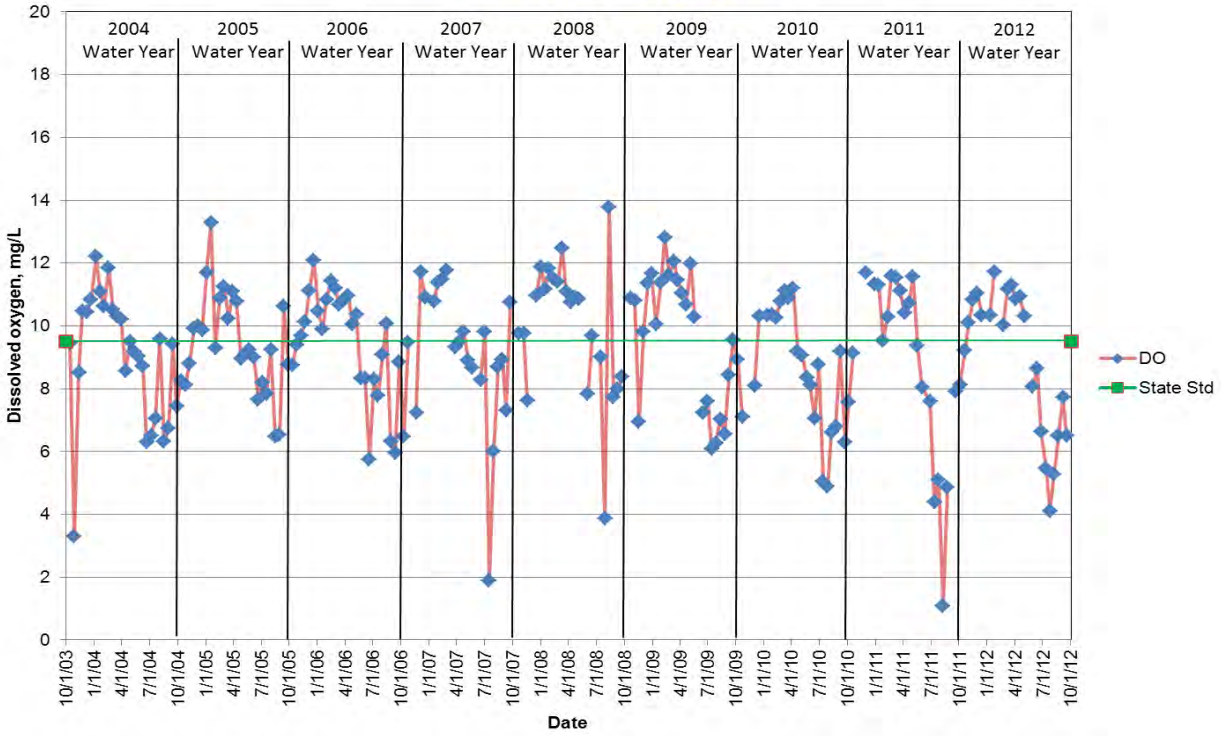

## Swede Creek at Grip Rd - Site 8
## Dissolved Oxygen



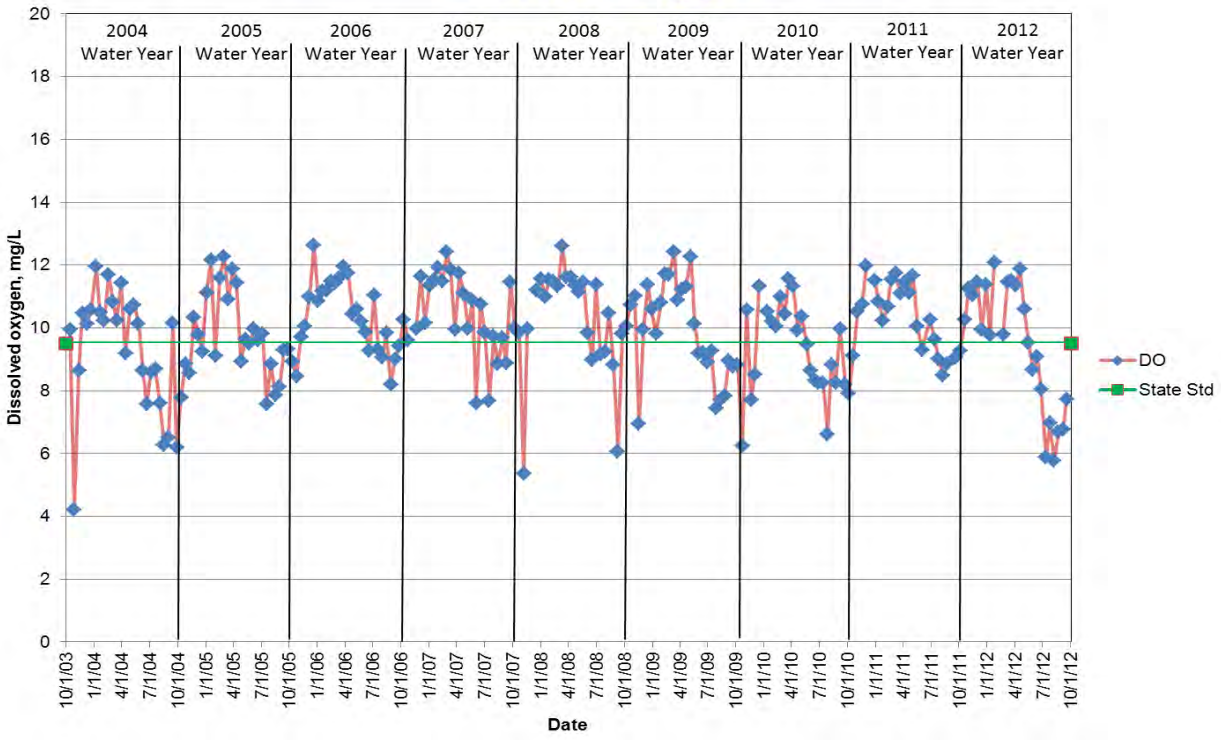
## Samish River at Hwy 9 - Site 11
## Dissolved Oxygen



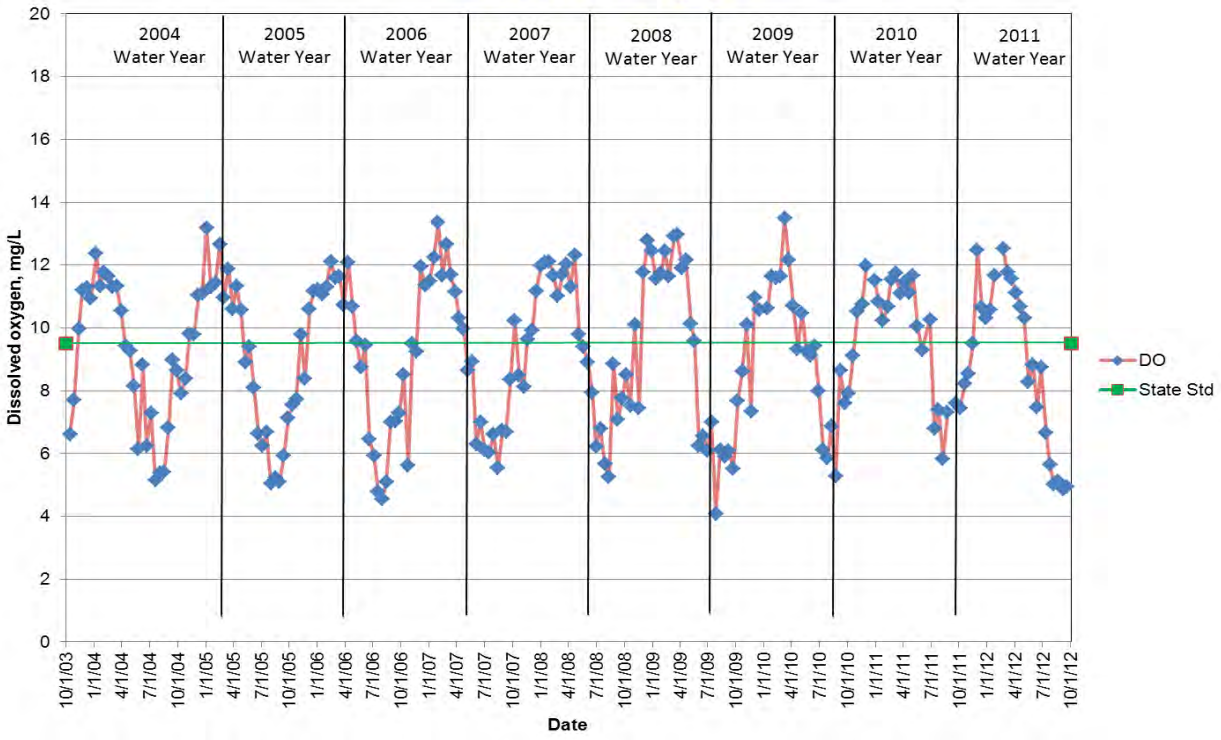

## Nookachamps Creek at Swan Rd - Site 12
## Dissolved Oxygen



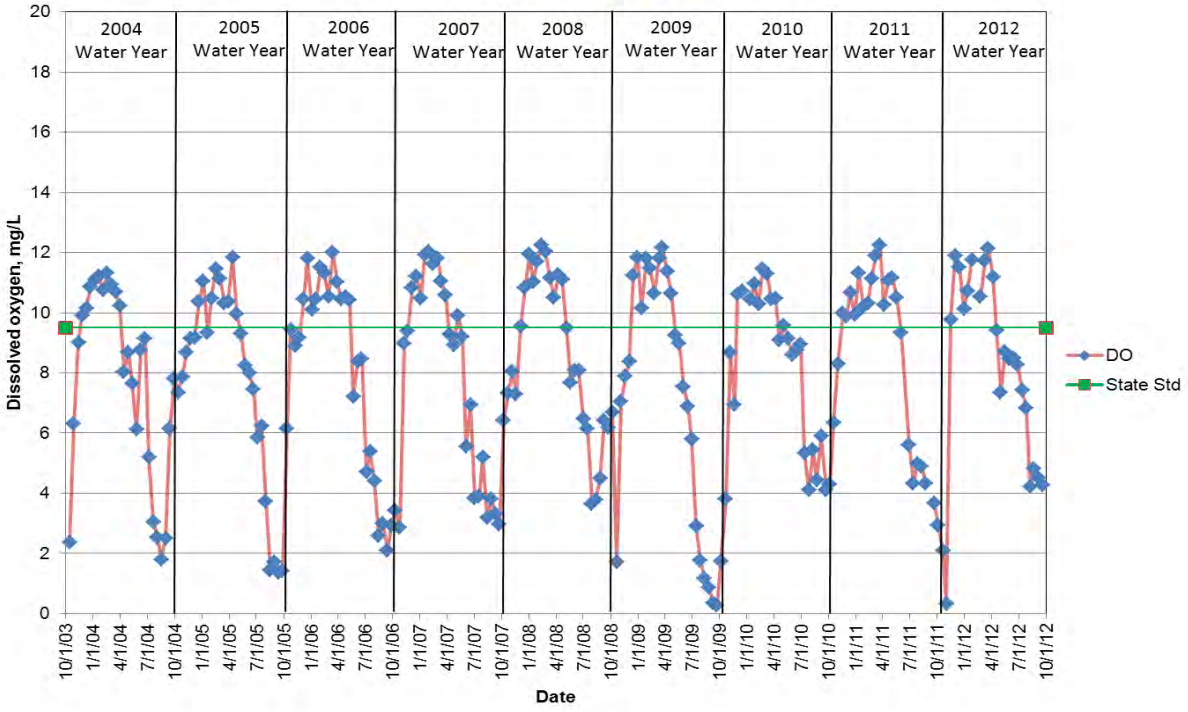
## E. F. Nookachamps Cr at Hwy 9 - Site 13
## Dissolved Oxygen



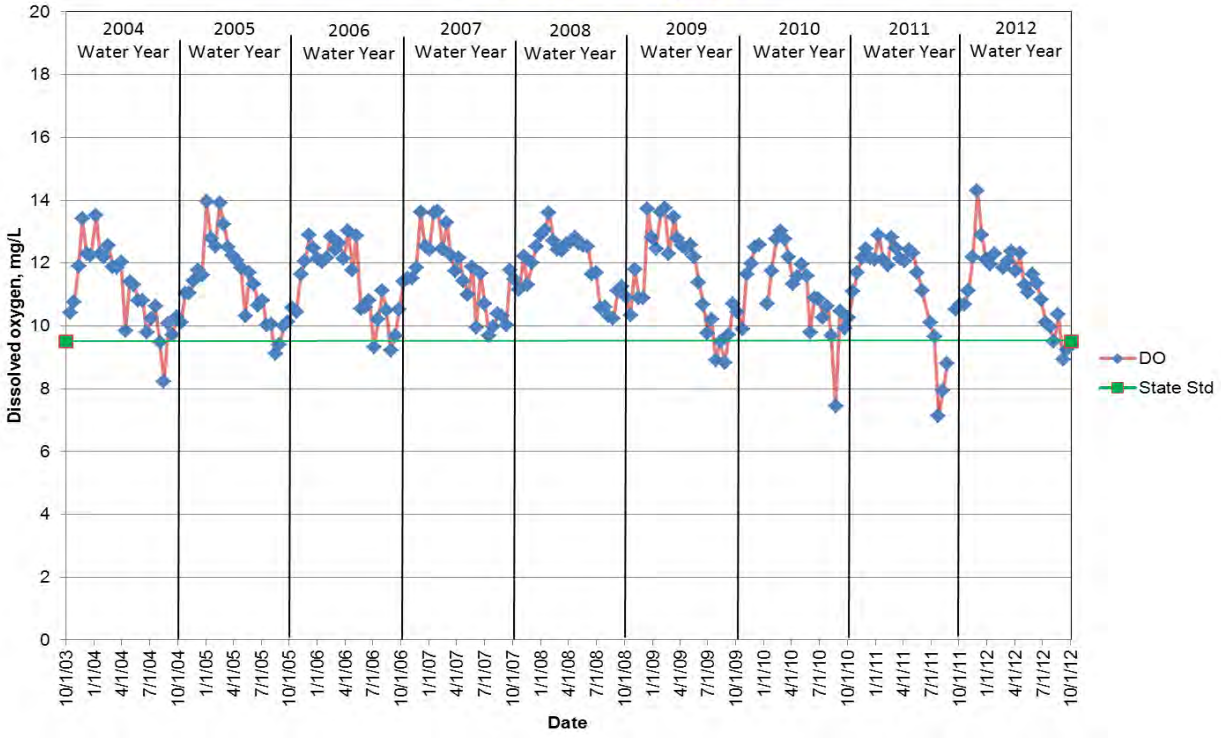

## College Way Cr at College Way - Site 14
## Dissolved Oxygen



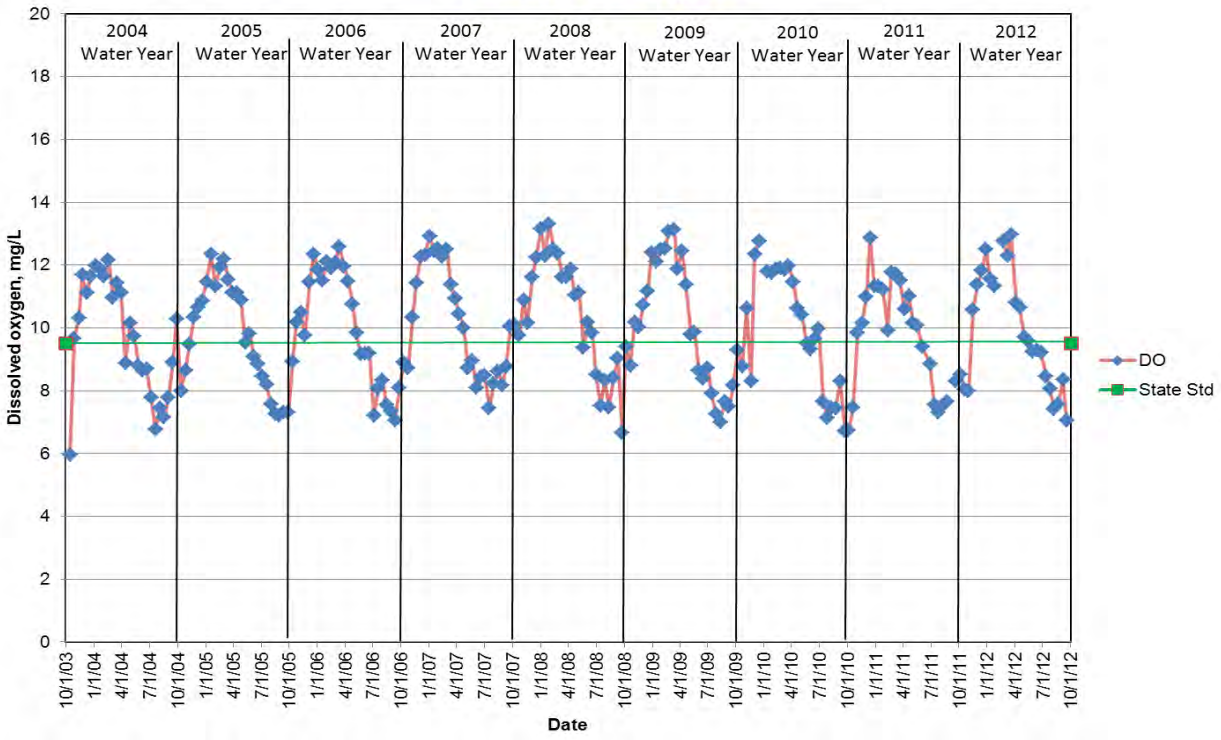
## Nookachamps Creek at Knapp Road - Site 15
## Dissolved Oxygen



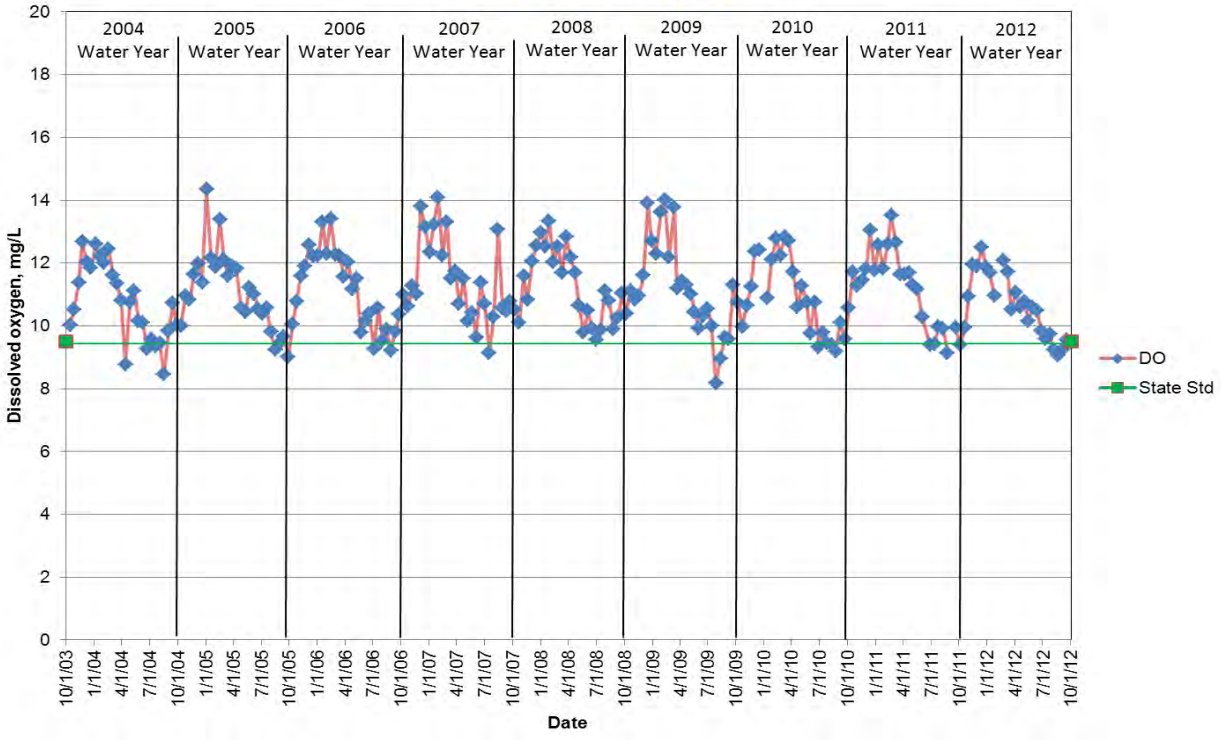

## E.F. Nookachamps Cr. at Beaver Lake Rd - Site 16
## Dissolved Oxygen



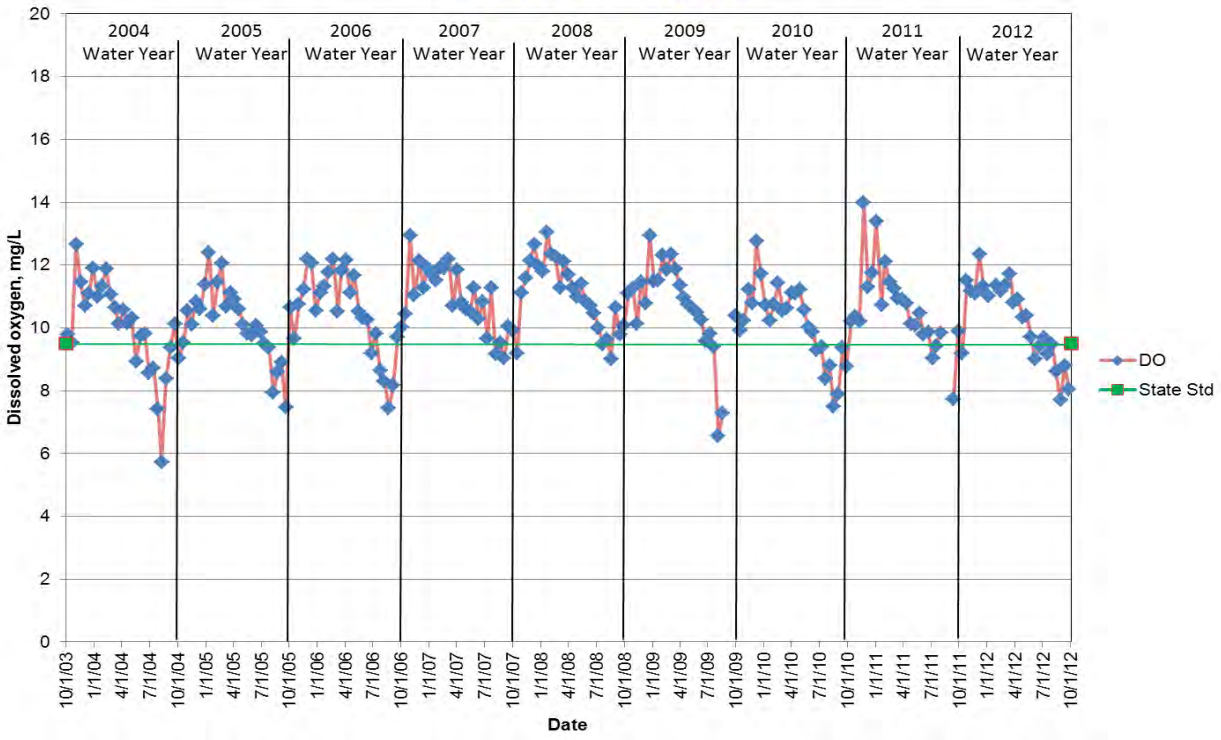
## Nookachamps Creek at Big Lake Outlet - Site 17
## Dissolved Oxygen



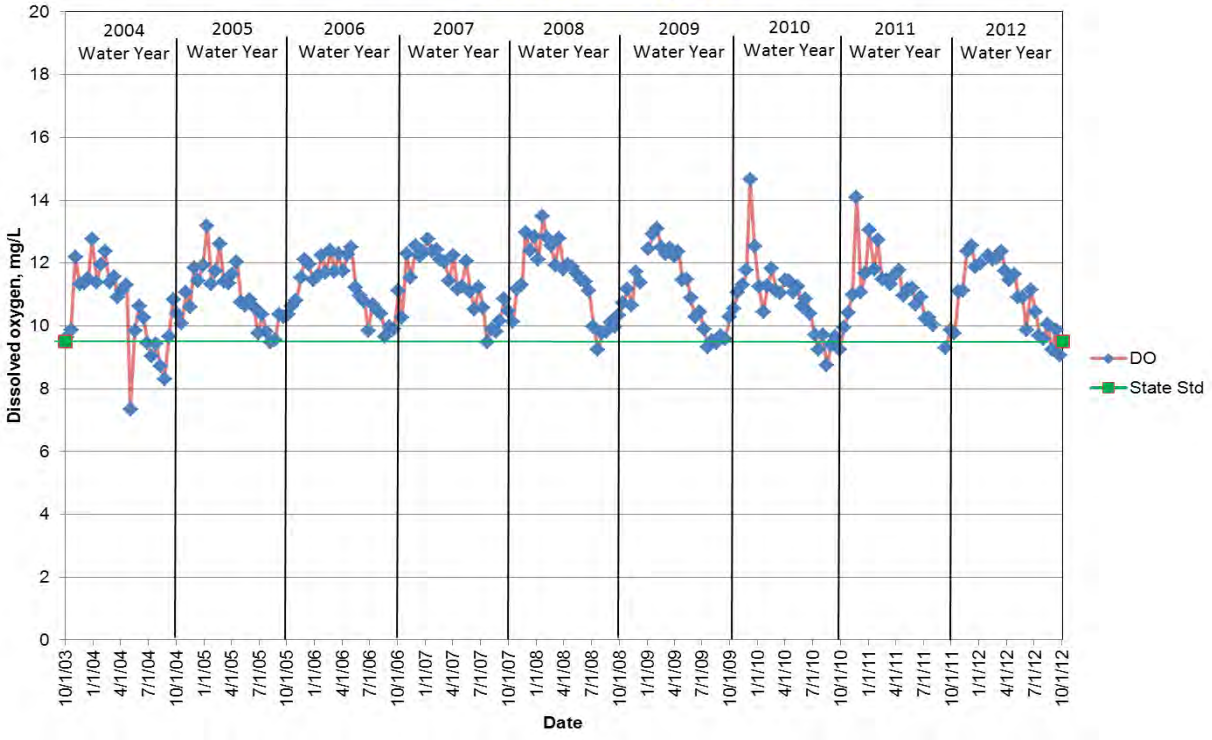

## Lake Creek at Hwy 9 - Site 18
## Dissolved Oxygen



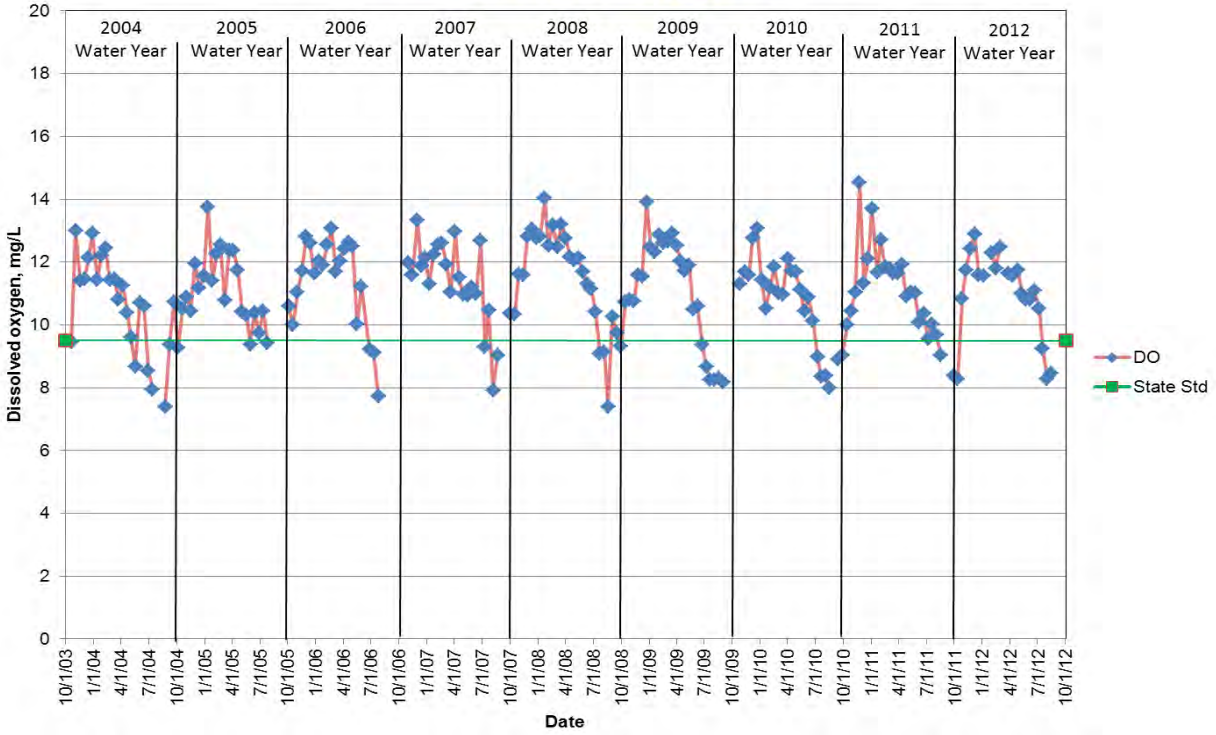
## Hansen Creek at Hoehn Rd - Site 19
## Dissolved Oxygen



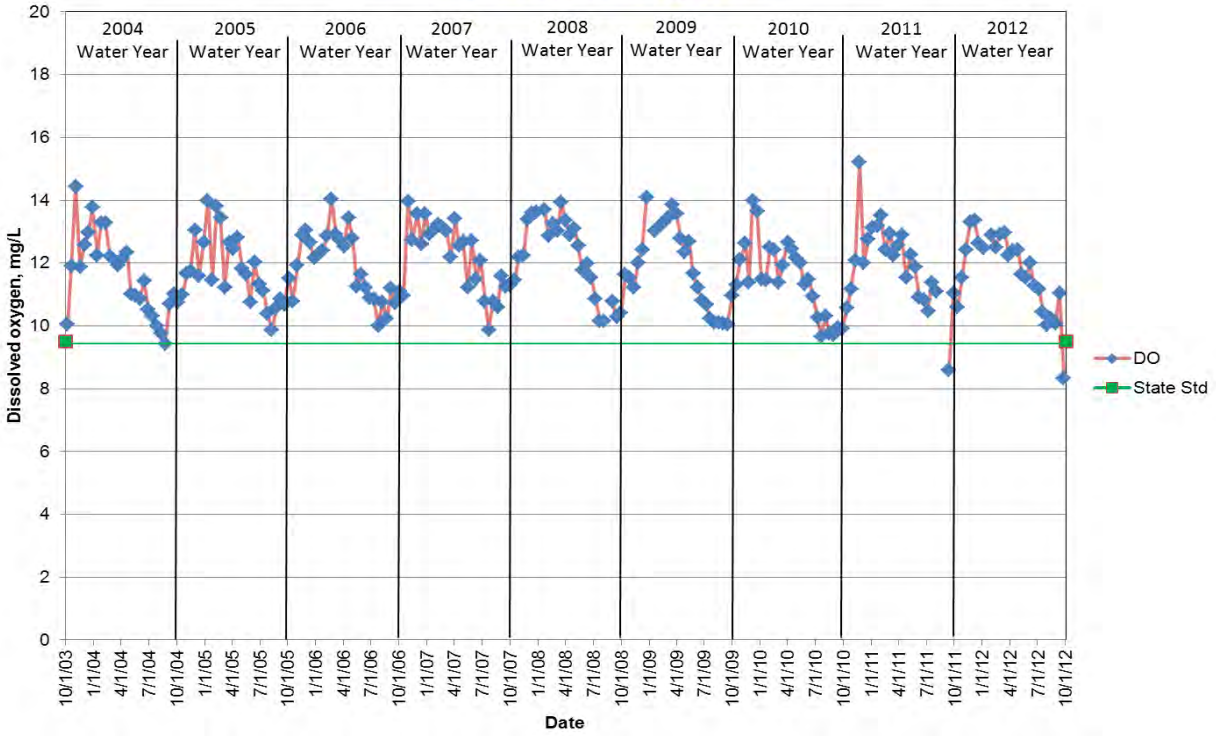

## Hansen Creek at Northern State Hospital - Site 20
## Dissolved Oxygen



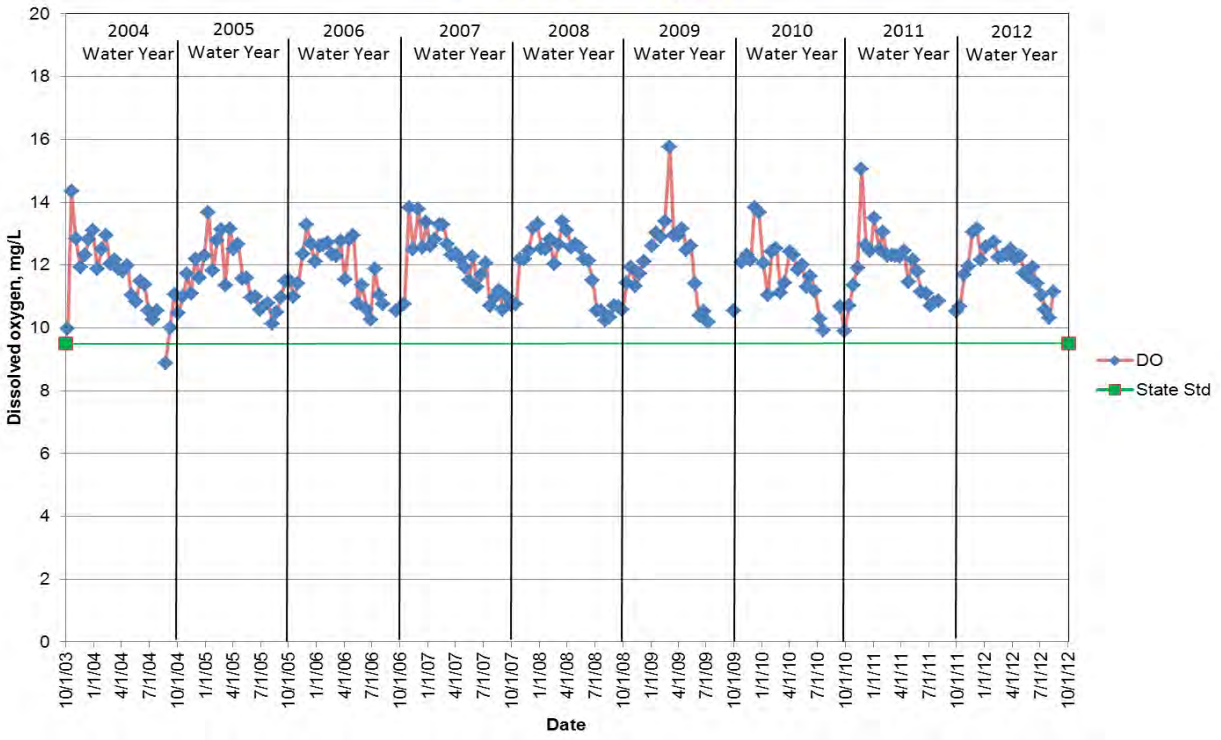
## Coal Creek at Hoehn Rd - Site 21
## Dissolved Oxygen



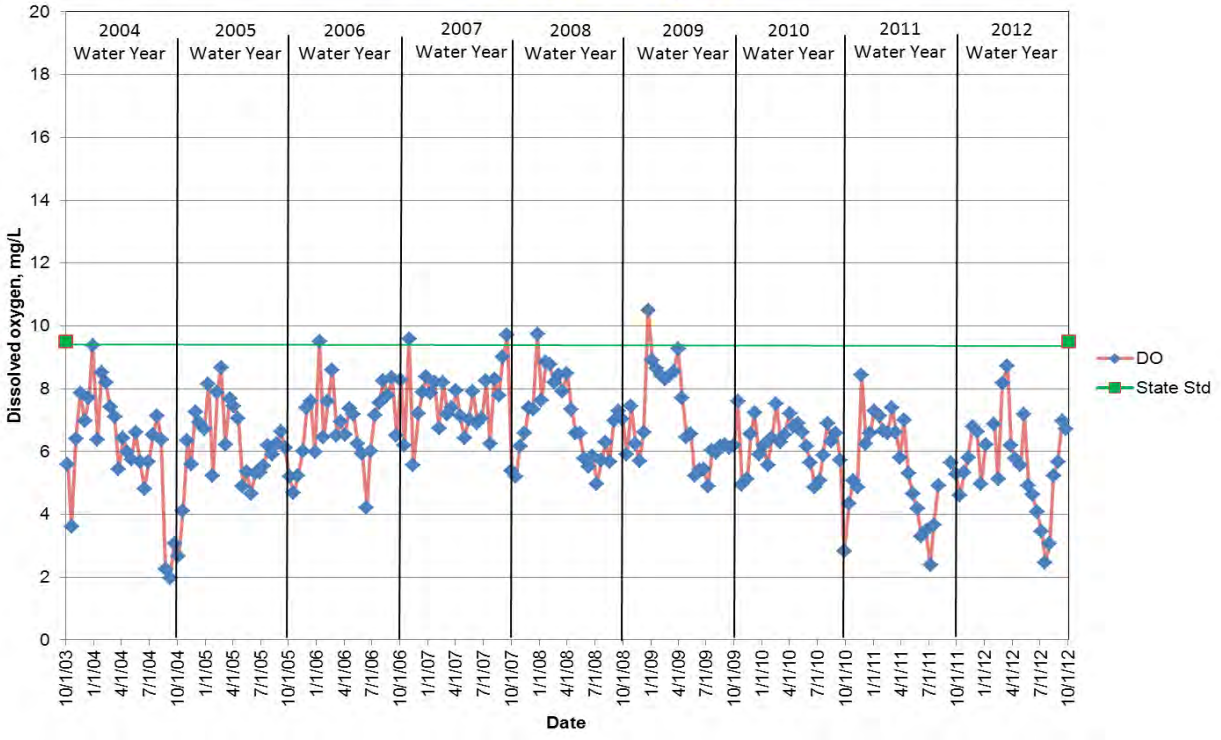

## Coal Creek at Hwy 20 - Site 22
## Dissolved Oxygen



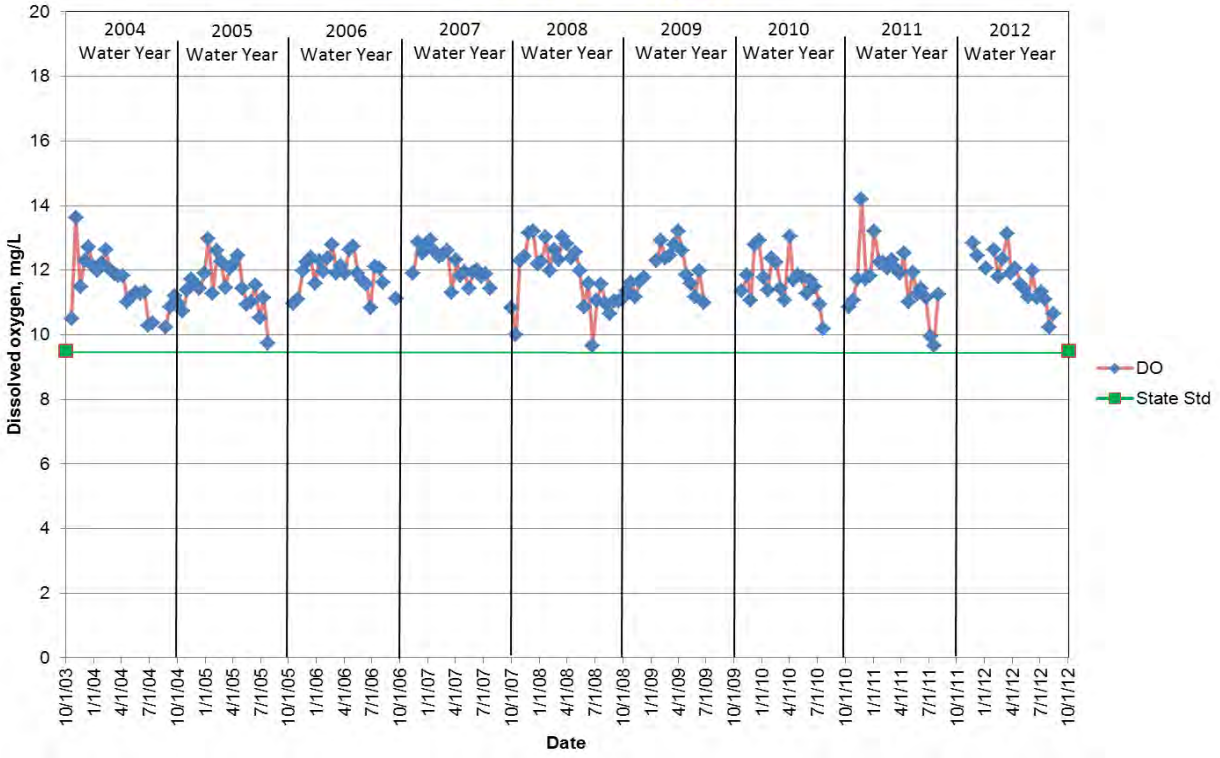
## Wiseman Creek at Minkler Rd - Site 23
## Dissolved Oxygen



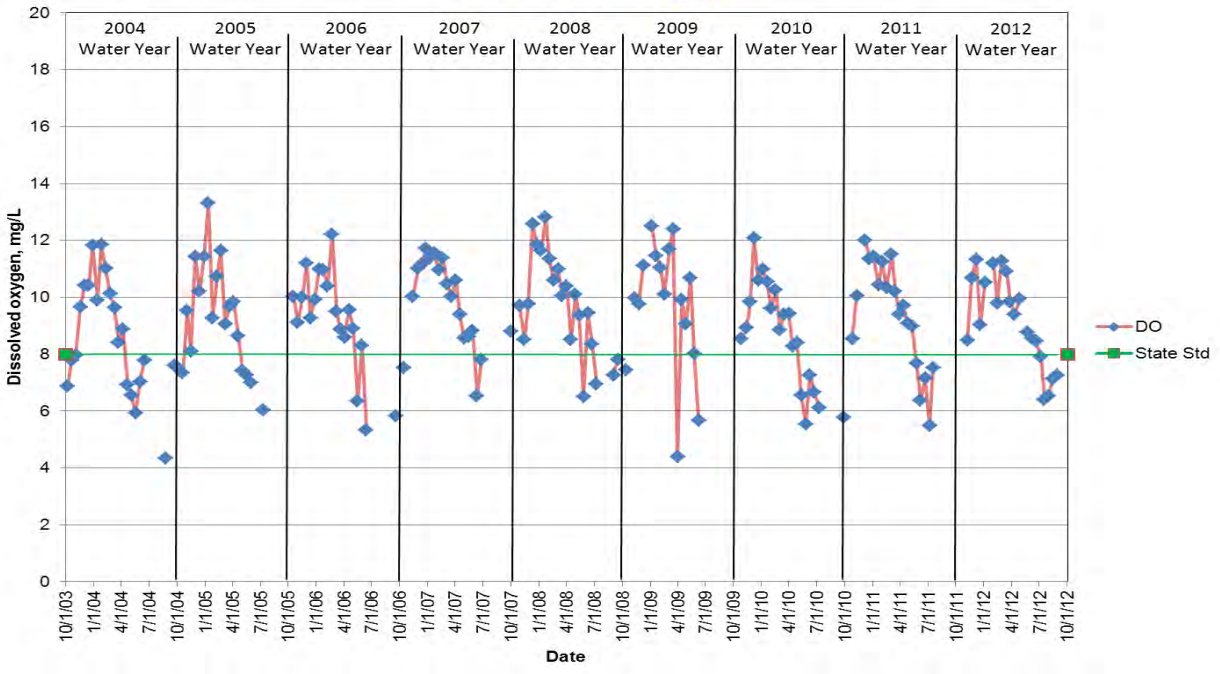

## Mannser Creek at Lyman-Hamilton Hwy - Site 24
## Dissolved Oxygen



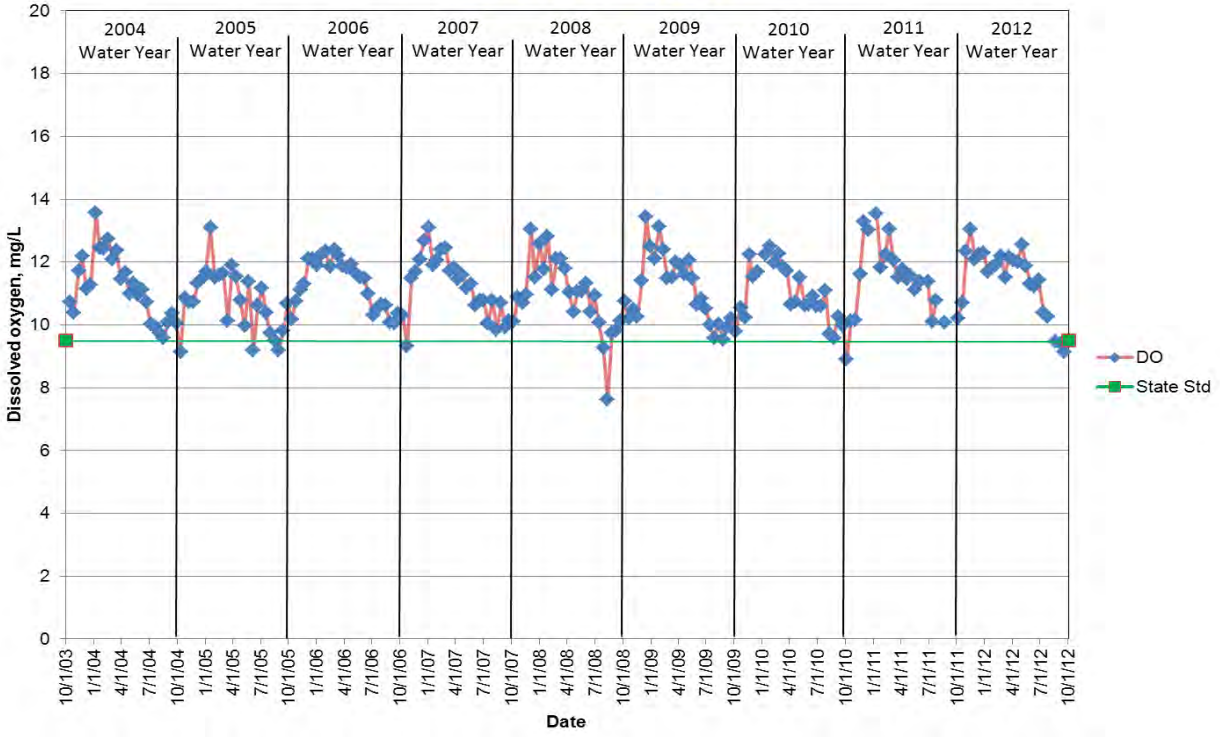
## Red Cabin Creek at Hamilton Cemetery Rd - Site 25
## Dissolved Oxygen



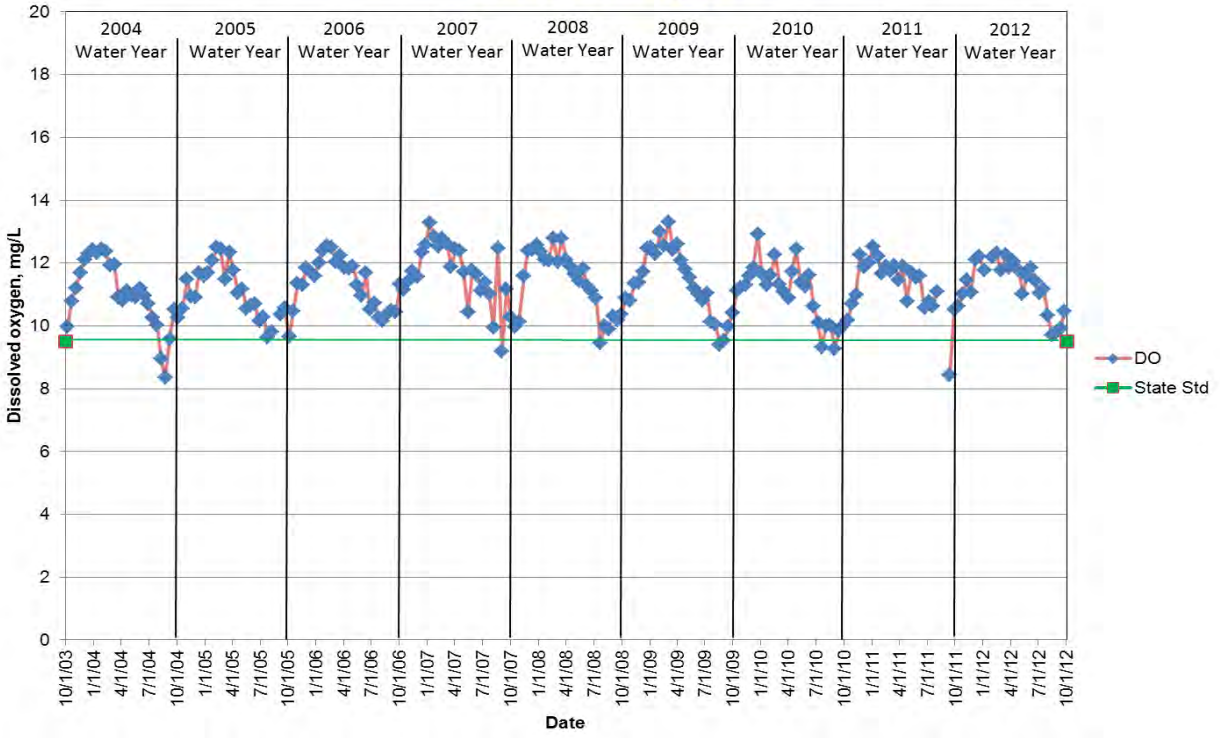

## Brickyard Creek at Hwy 20 - Site 28
## Dissolved Oxygen



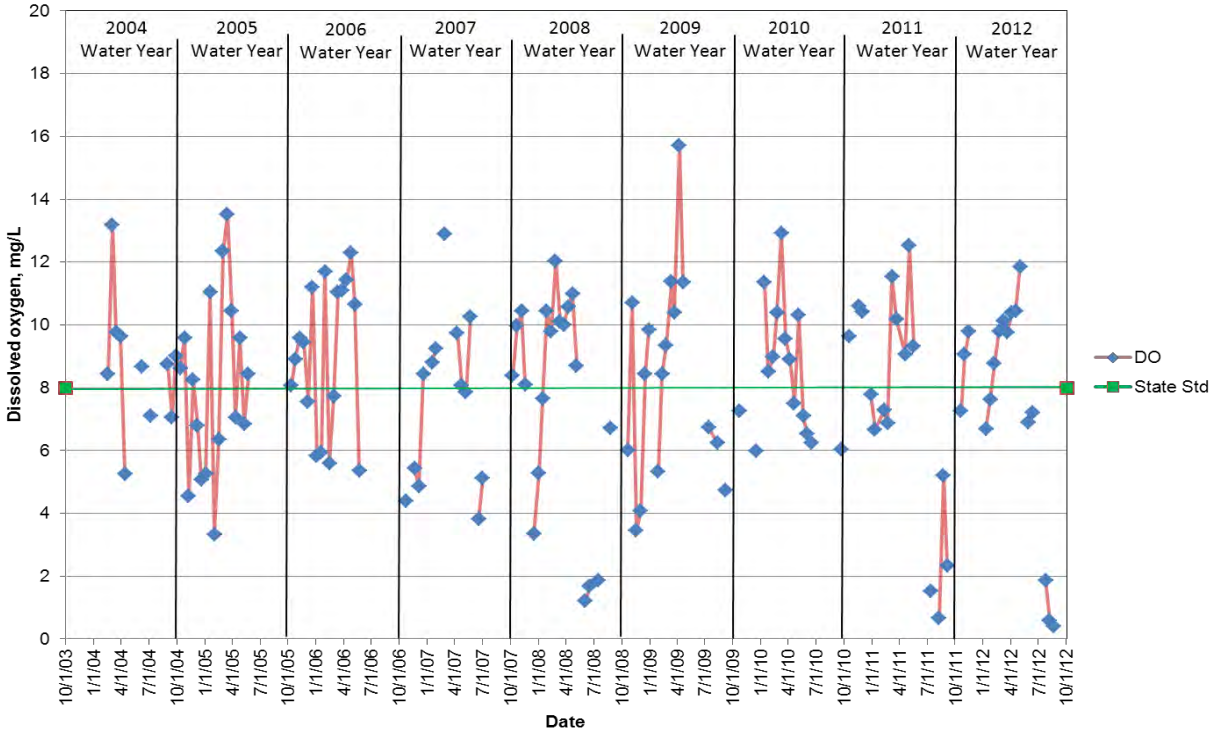
## Skagit River at River Bend - Site 29
## Dissolved Oxygen



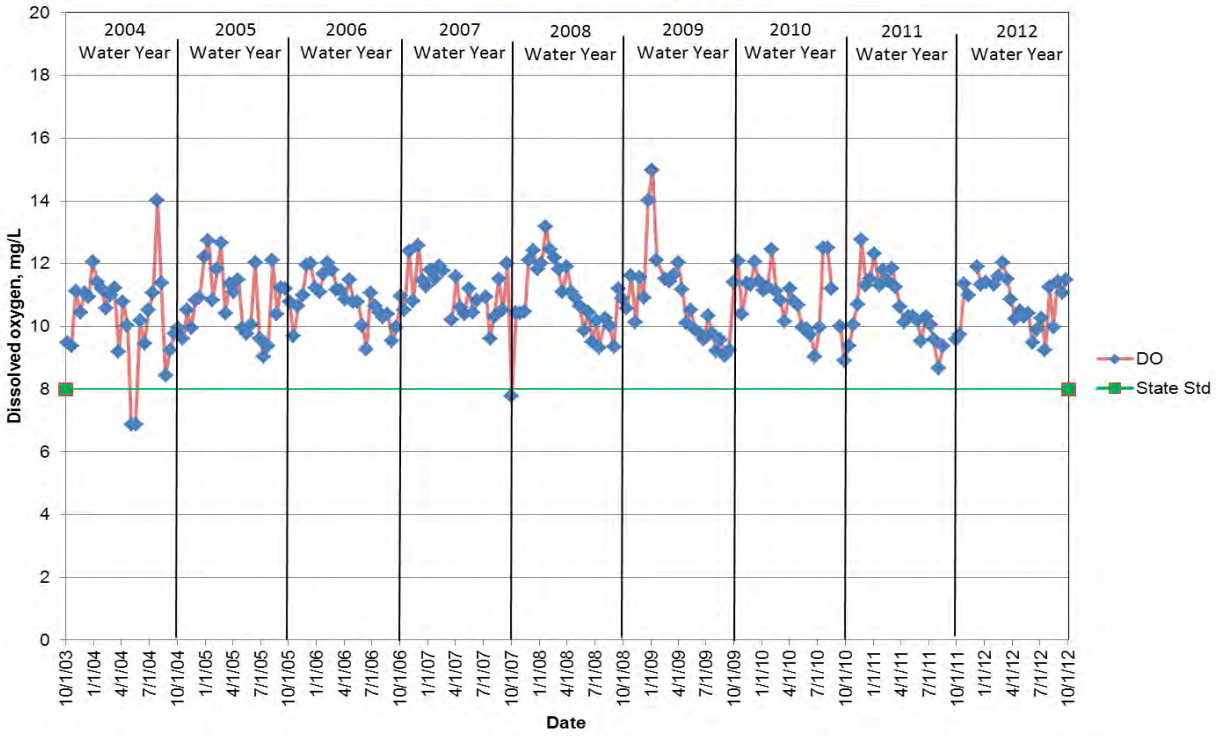

## Skagit River at Cape Horn Rd - Site 30
## Dissolved Oxygen



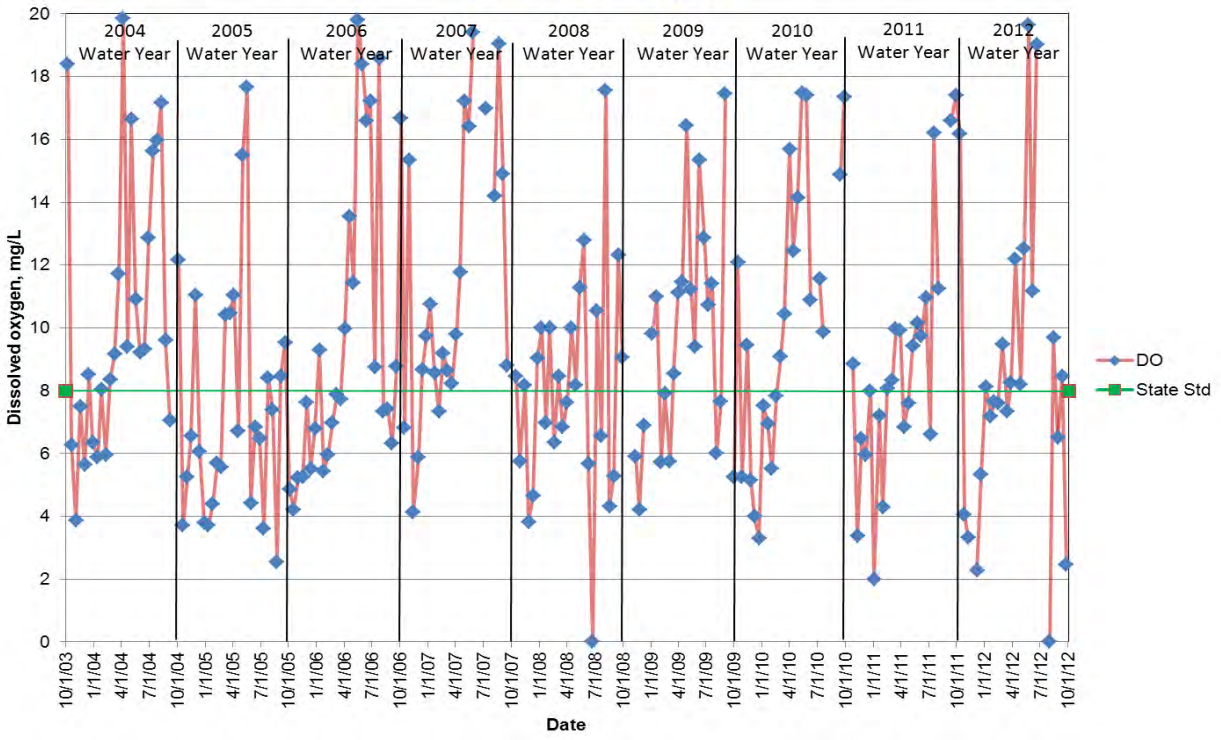
## Drainage District 20 Ditch at Floodgate - Site 31
## Dissolved Oxygen



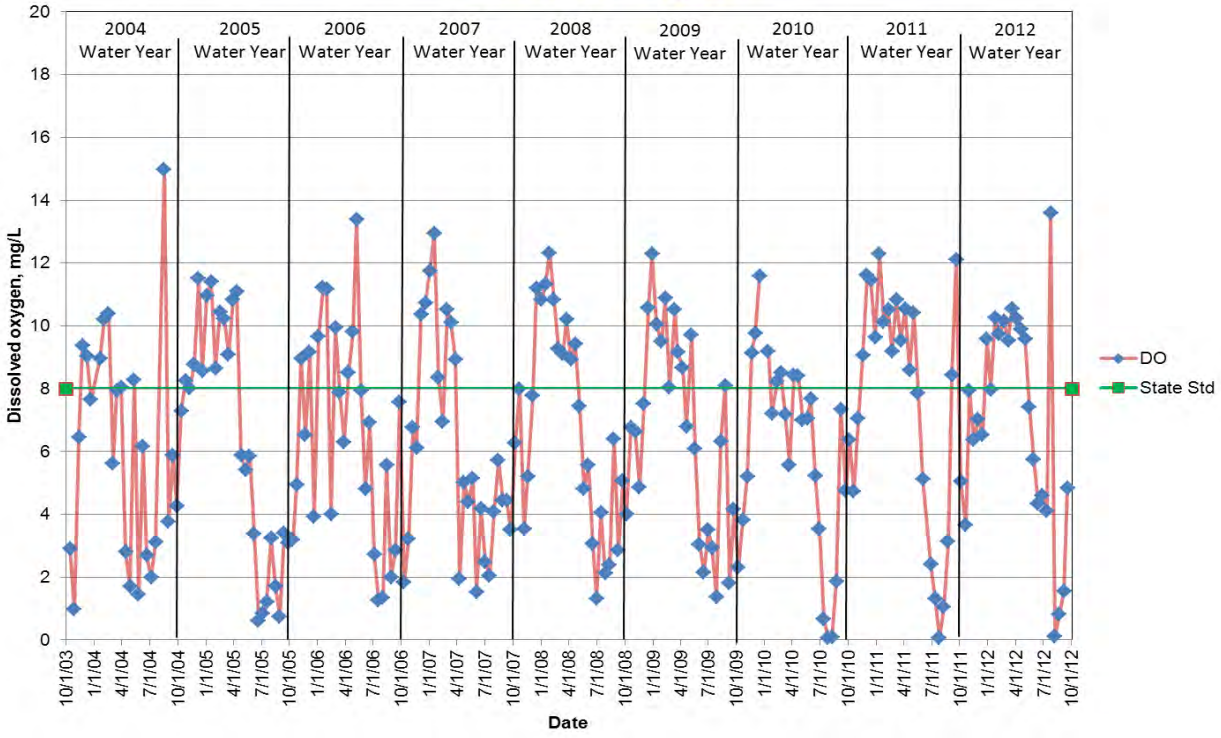

## Samish River at Thomas Road - Site 32
## Dissolved Oxygen



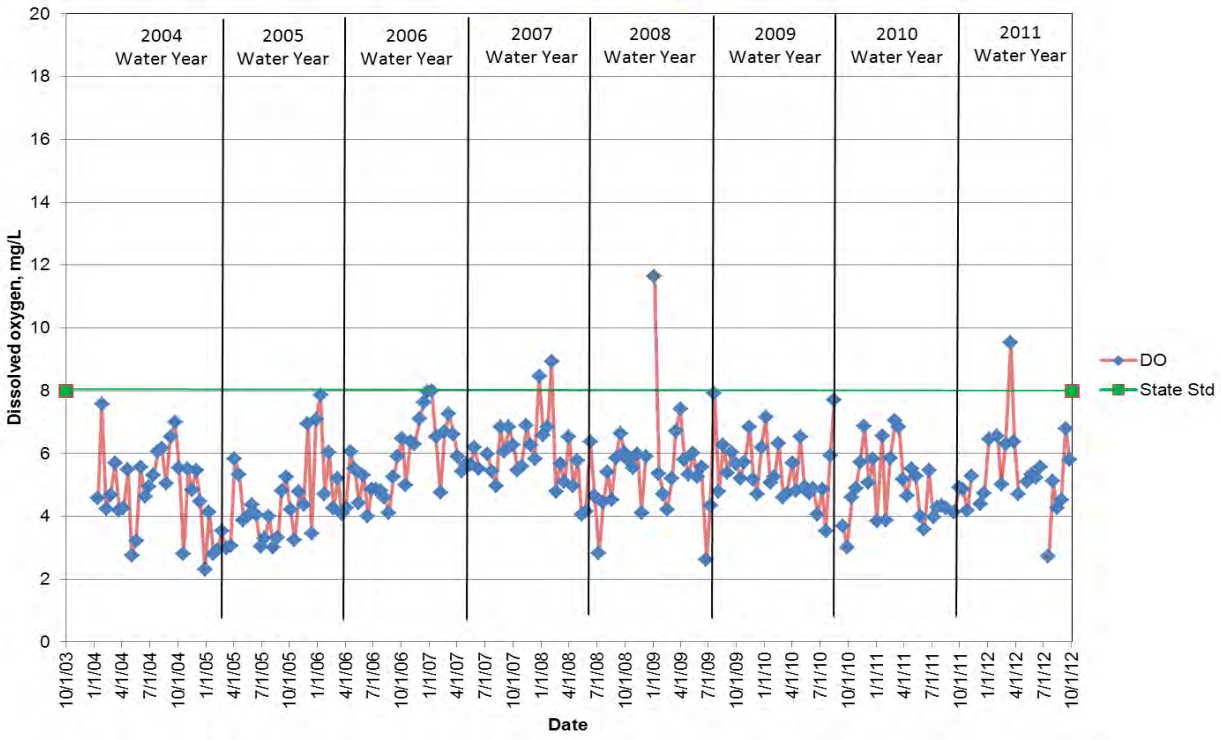
## Alice Bay Pump Station - Site 33
## Dissolved Oxygen



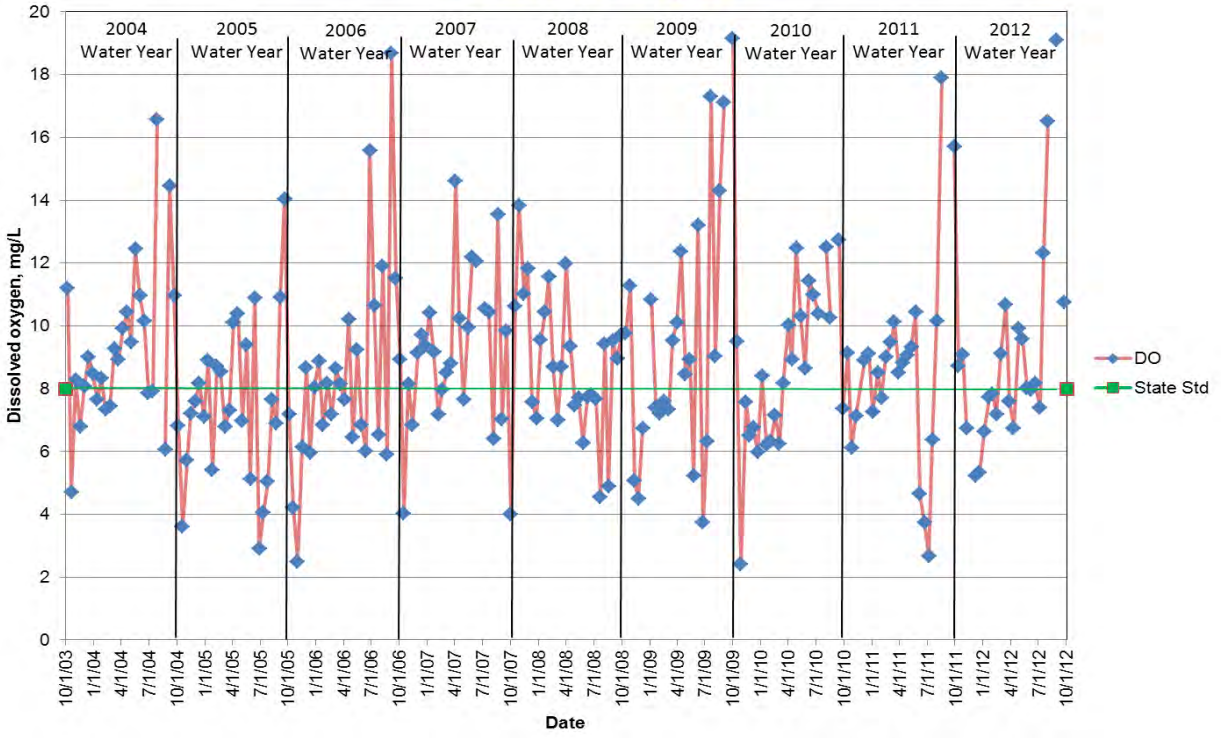

## No Name Slough at Bayview-Edison Rd - Site 34
## Dissolved Oxygen



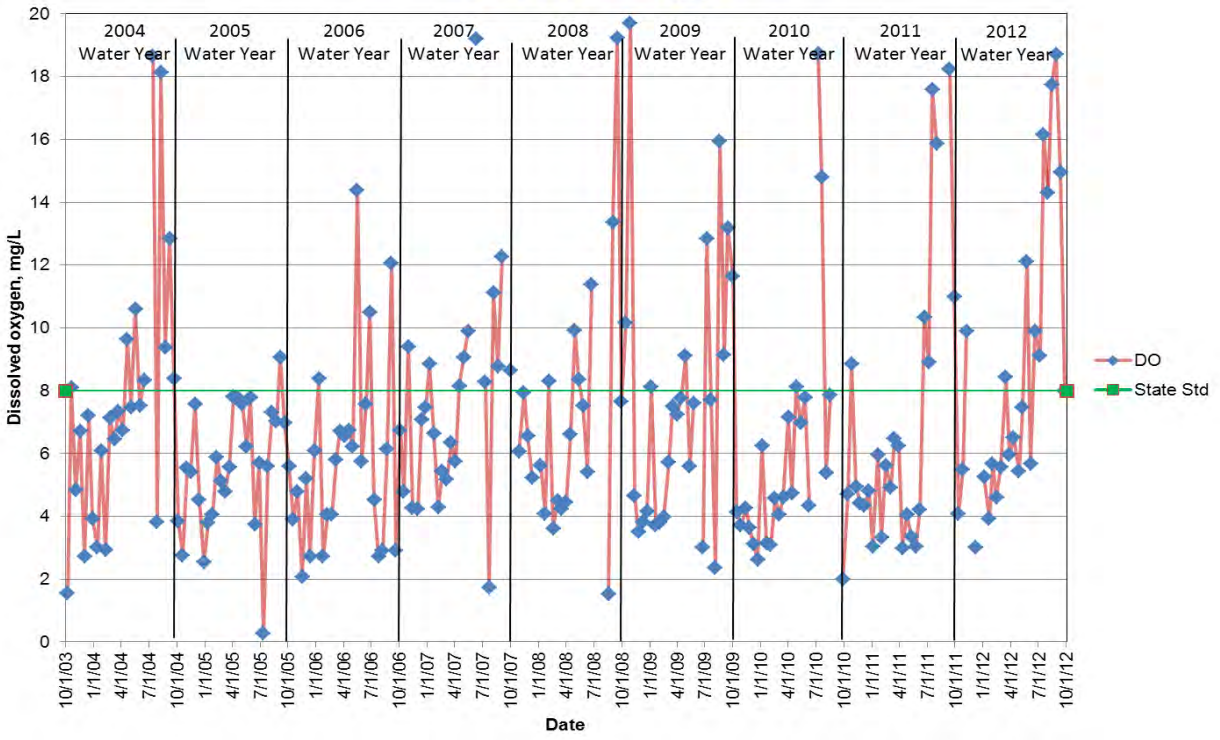
## Joe Leary Slough at D'Arcy Rd - Site 35
## Dissolved Oxygen



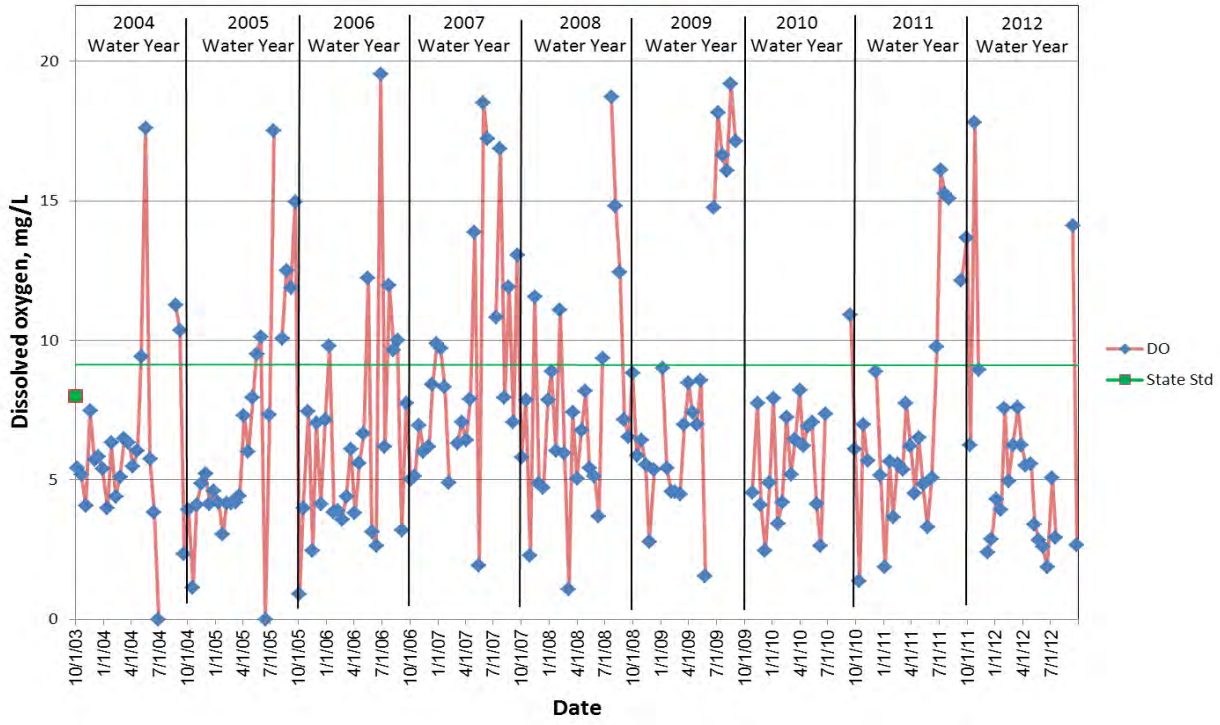

## Edison Slough at Edison School - Site 36
## Dissolved Oxygen



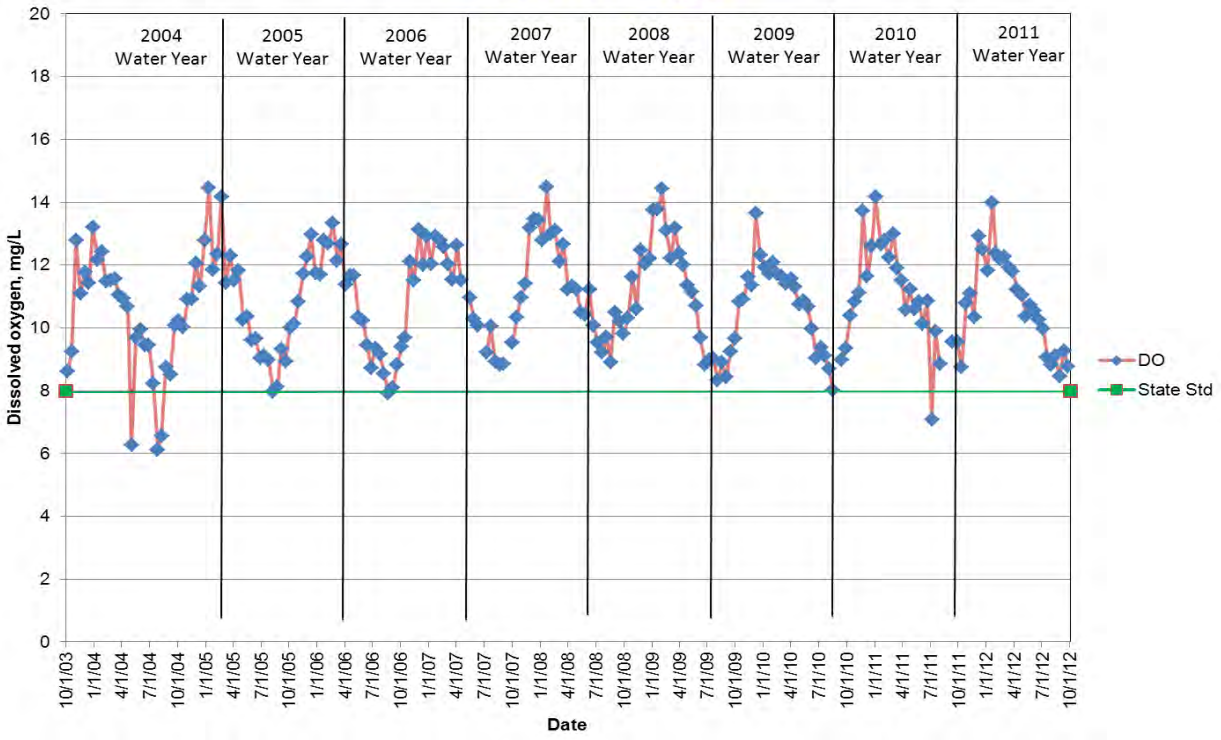
## Edison Pump Station - Site 37
## Dissolved Oxygen



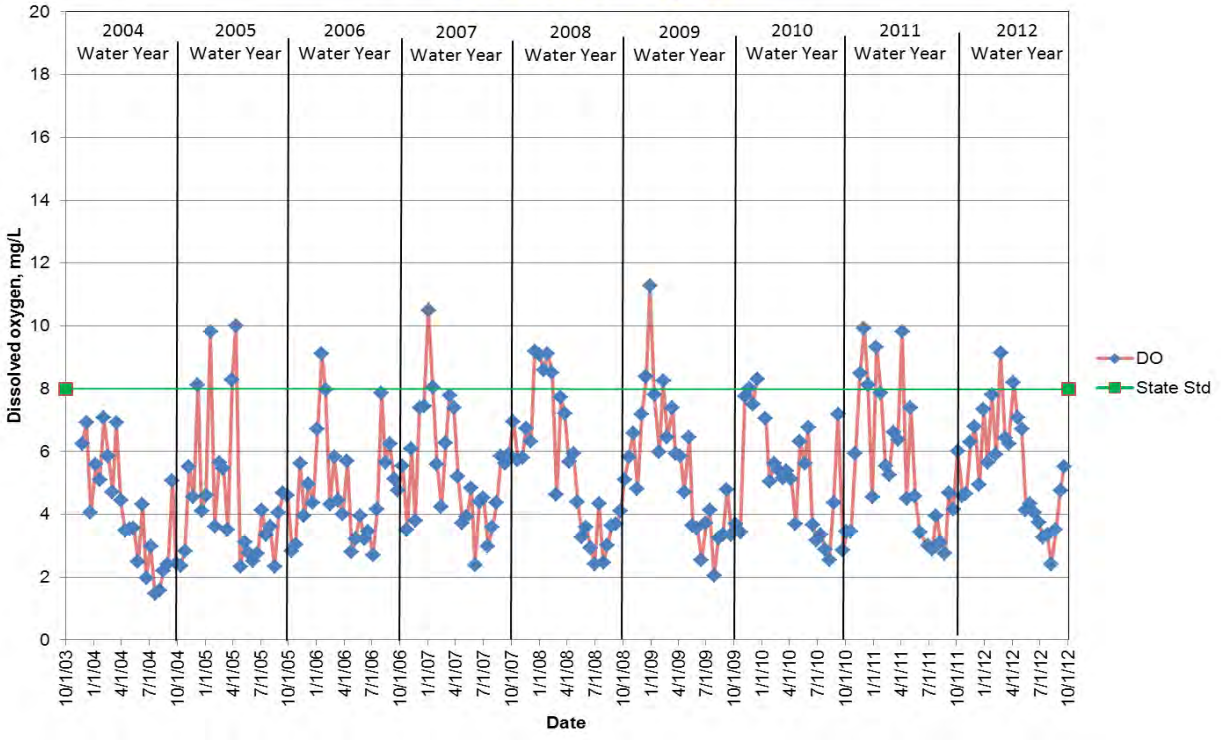

## North Edison Pump Station - Site 38
## Dissolved Oxygen



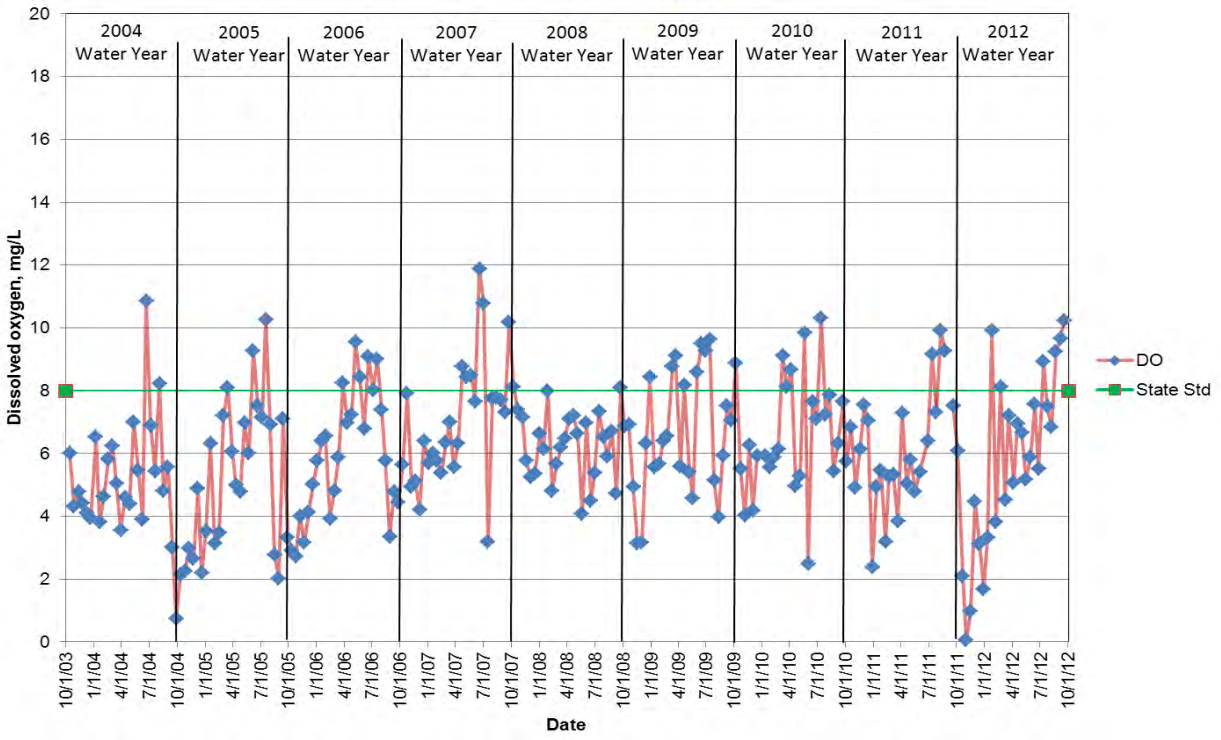
## Colony Creek at Colony Rd - Site 39
## Dissolved Oxygen



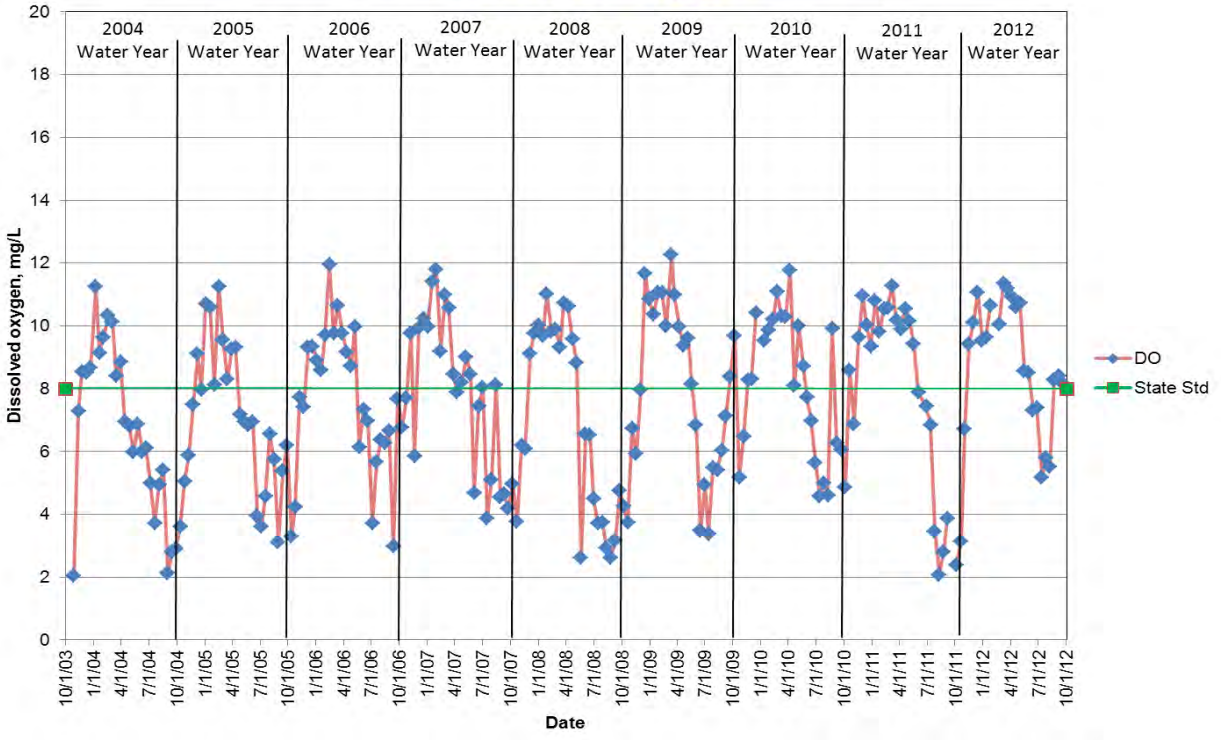

## Big Indian Slough at Hwy 20 Truck Scales - Site 40
## Dissolved Oxygen



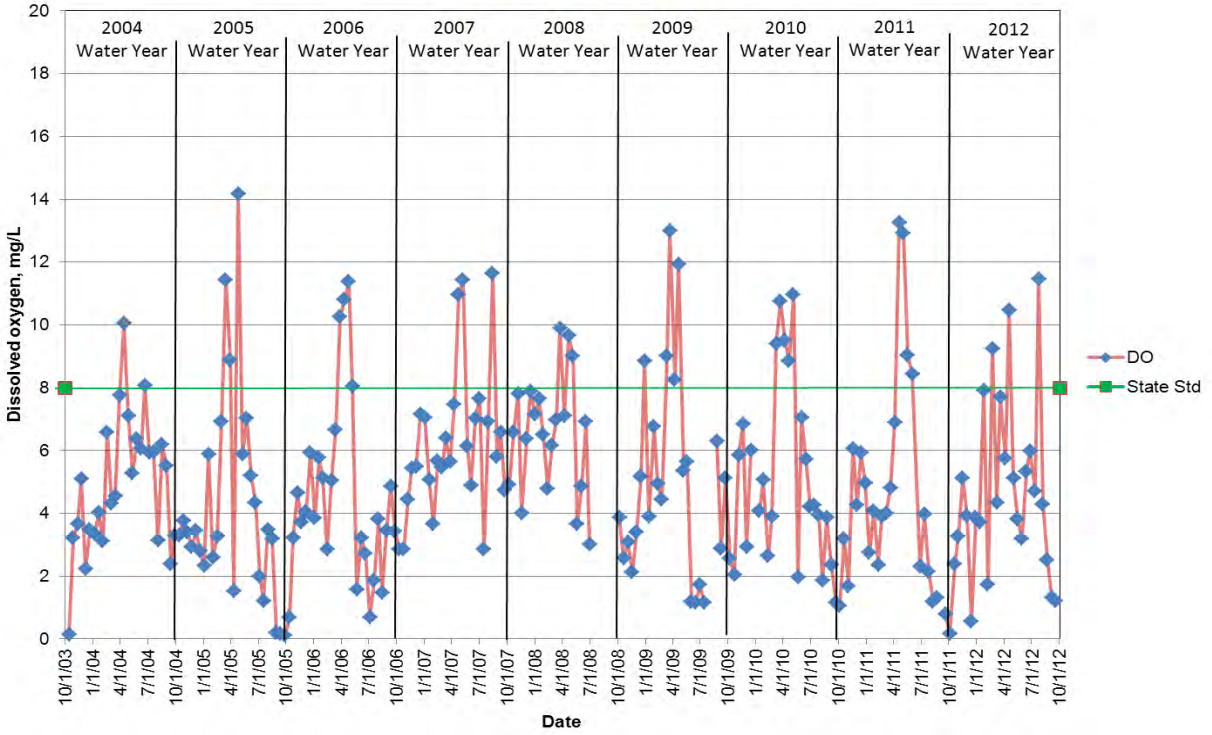
## Maddox Creek/Big Ditch at Milltown Rd - Site 41
## Dissolved Oxygen



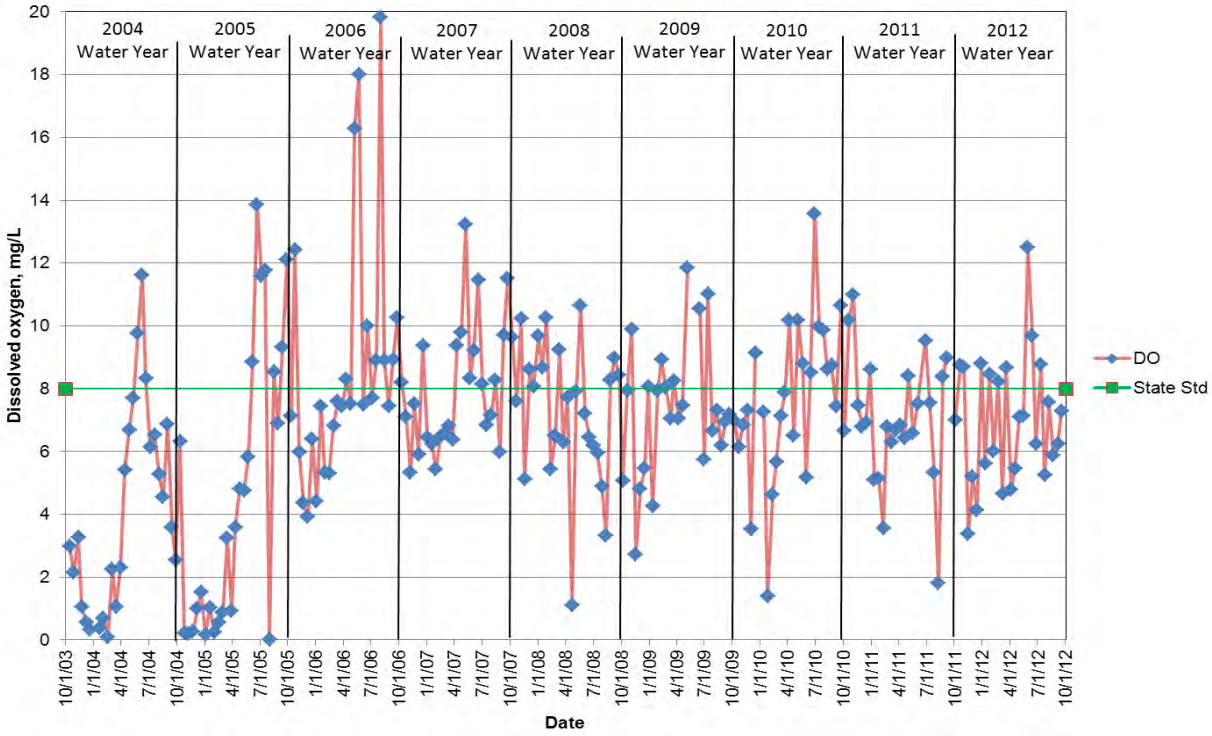

## Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
## Dissolved Oxygen



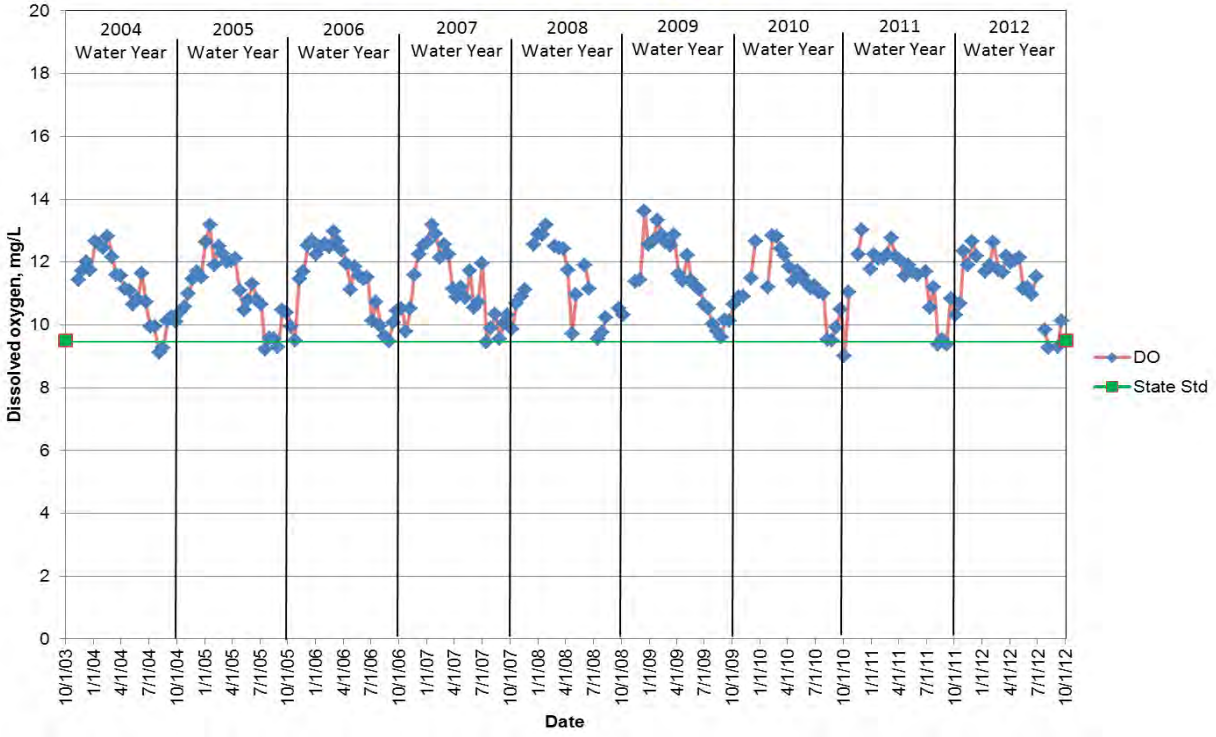
## Wiley Slough at Wylie Road - Site 43
## Dissolved Oxygen



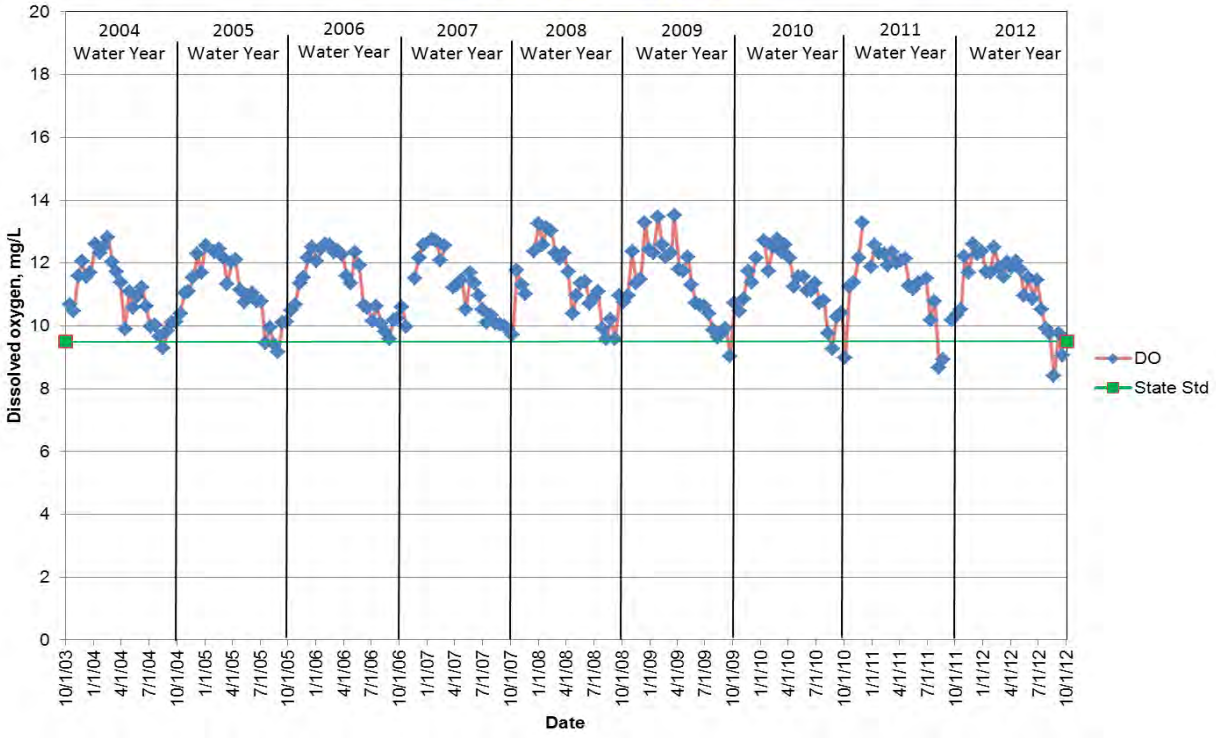

## Sullivan Slough at La Conner-Whitney Rd - Site 44
## Dissolved Oxygen



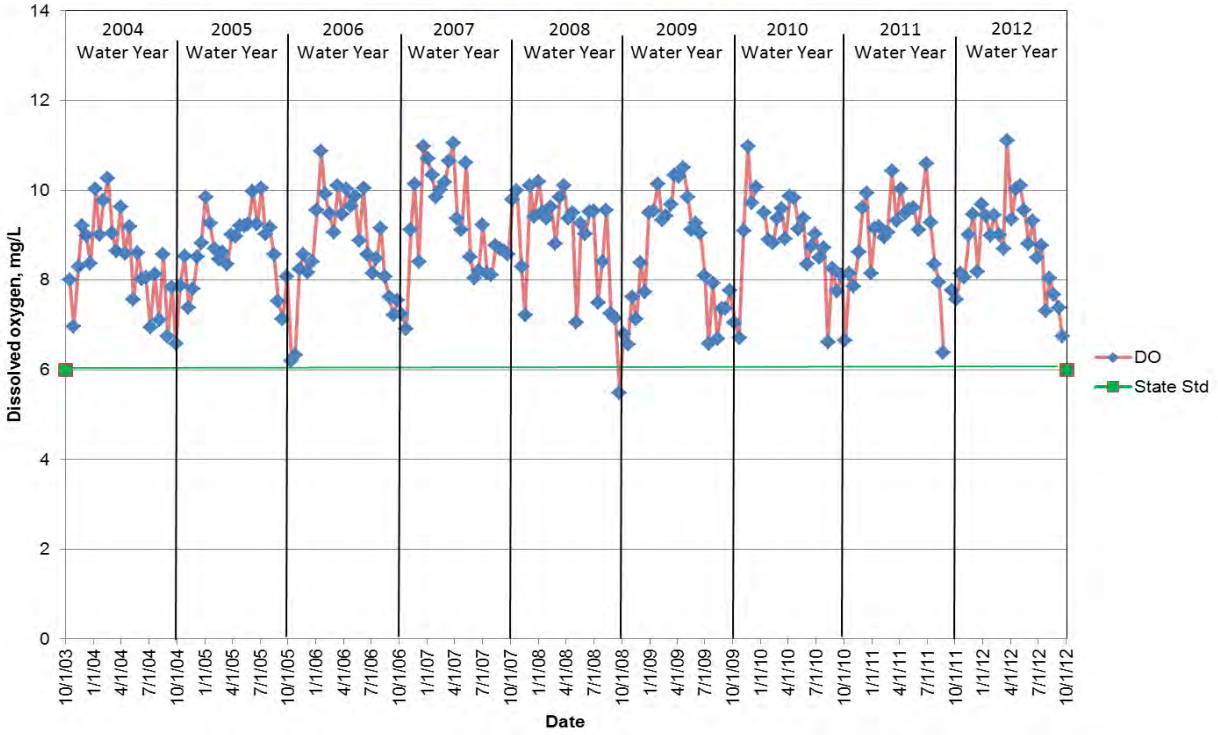
## N.F. Skagit River near Moore Rd - Site 45
## Dissolved Oxygen



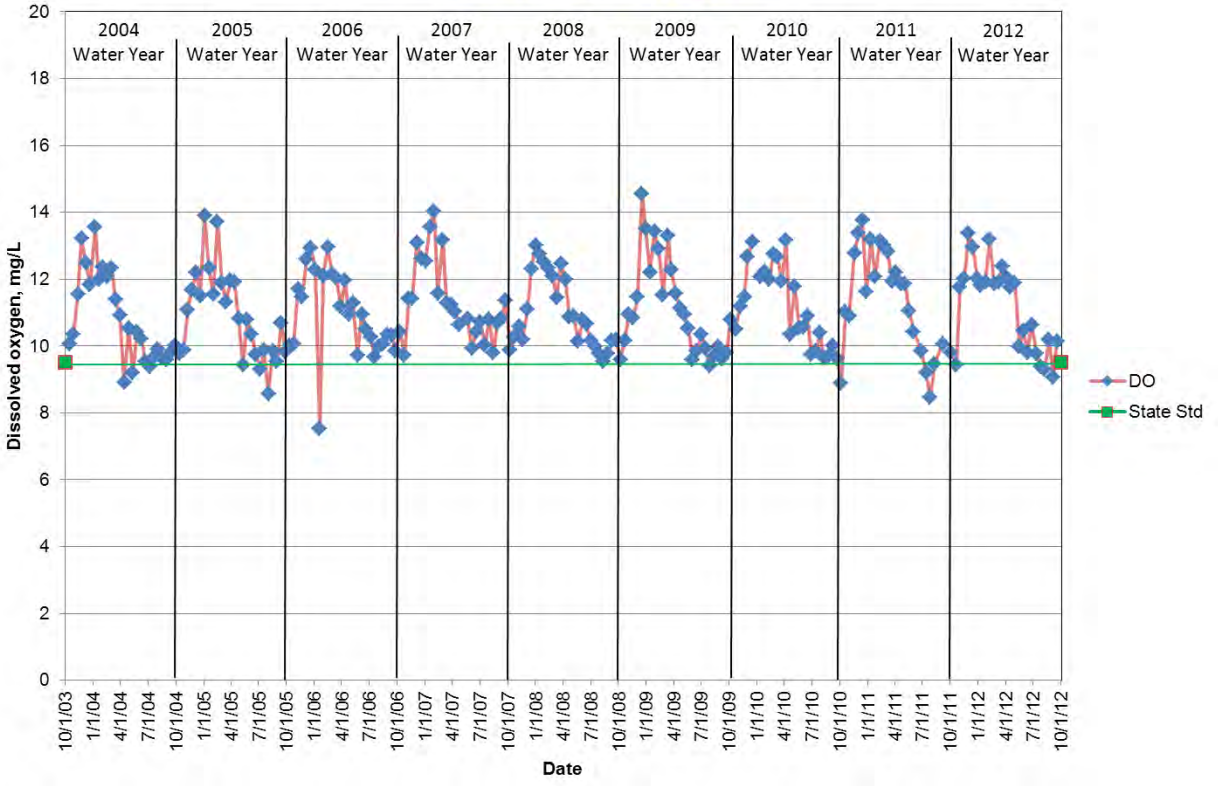

## S.F. Skagit River at Conway Boat Ramp - Site 46
## Dissolved Oxygen



## 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 (2003-2008) or Edge Analytical (2009-2012) for analysis by the Most Probable Number method.

Fecal coliform measurements for the 2012 water year, in "most probable number" (mpn) per 100 ml, are summarized in Table 7. Seven-year results are summarized in Table 9. 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 mpn, with no more than 10% of the measurements exceeding 200 mpn. For the upriver sites (sites 21-25, 30), the standard is a geometric mean of 50 mpn, with no more than 10% of the measurements exceeding 100 mpn. For the marine site (site 47), a more stringent standard of 14 mpn with no more than 10% exceeding 41 mpn is enforced to protect shellfish beds.
Table 8 gives the geometric mean fecal coliform at each site for the last seven 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 2012 water year, 12 sites met the standard based on ambient sampling for the entire water year, which is less than the 17 sites meeting the standard for 2011. Storm sampling in the Samish Basin continues to show excessive fecal coliform 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 mpn units/100 mL from the Samish River at Thomas Road on April 29, 2008.

The 2009, 2010, and 2011 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. Although state standard exceedances and shellfish bed closures continued during 2012, average fecal coliform counts and loading of bacteria to Samish Bay have declined.

The sources of fecal coliform organisms reaching the watercourses of Skagit County could include runoff from failing septic tanks, livestock operations, wildlife, recreationists, 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. A full report of Clean Samish Initiative activities will be published separately.

Graphs on the pages following Table 9 illustrate fecal coliform levels for water years 2004-2012 at each of the sample sites. The scale on each graph differs in order to fully illustrate the variability at each site.

## Table 7. 2012 Fecal Coliform Results
### Summary of Fecal Coliform Readings in Skagit County Monitoring Program
### 2012 Water Year

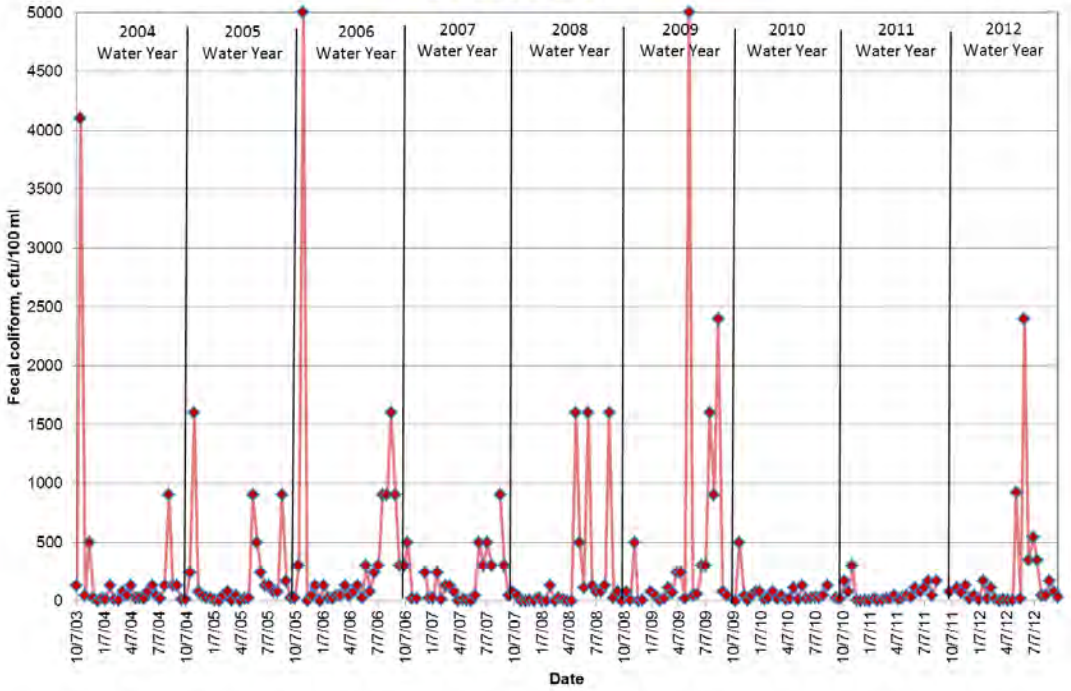
| Site Number | Watercourse | Location | N | Geometric mean (mpn)[1] | % > 100 or 200[1] |
|---|---|---|---|---|---|
| 3 | Thomas Ck | Old Hwy 99 N | 26 | 61 | 19 |
| 4 | Thomas Ck | F&S Grade | 26 | 139 | 50 |
| 6 | Friday Ck | Prairie Rd | 26 | 44 | 15 |
| 8 | Swede Ck | Grip Rd | 25 | 57 | 16 |
| 11 | Samish R | State Route 9 | 26 | 15 | 0 |
| 12 | Nookachamps Ck | Swan Rd | 23 | 47 | 4 |
| 13 | E.F. Nookachamps Ck | State Route 9 | 25 | 47 | 12 |
| 14 | College Way Ck | College Way | 25 | 90 | 16 |
| 15 | Nookachamps Ck | Knapp | 25 | 99 | 32 |
| 16 | E.F. Nookachamps Ck | Beaver Lake Rd | 24 | 25 | 4 |
| 17 | Nookachamps Ck | Big Lake Outlet | 25 | 11 | 0 |
| 18 | Lake Ck | State Route 9 | 25 | 36 | 8 |
| 19 | Hansen Ck | Hoehn Rd | 25 | 87 | 52 |
| 20 | Hansen Ck | Northern State | 24 | 43 | 29 |
| 21 | Coal Ck | Hoehn Rd | 21 | 95 | 48 |
| 22 | Coal Ck | Hwy 20 | 25 | 20 | 12 |
| 23 | Wiseman Ck | Minkler Rd | 22 | 15 | 18 |
| 24 | Mannser Ck | Lyman Hamilton Hwy | 25 | 15 | 8 |
| 25 | Red Cabin Ck | Hamilton Cem Rd | 18 | 7 | 11 |
| 28 | Brickyard Ck | Hwy 20 | 21 | 67 | 29 |
| 29 | Skagit R | River Bend Rd | 26 | 9 | 4 |
| 30 | Skagit R | Cape Horn Rd | 25 | 3 | 0 |
| 31 | Drain Dist 20 floodgate | Francis Rd | 18 | 33 | 28 |
| 32 | Samish R | Thomas Rd | 26 | 52 | 15 |
| 33 | Alice Bay Pump Station | Samish Island Rd | 26 | 51 | 19 |
| 34 | Noname Slough | Bayview-Edison Rd | 26 | 110 | 42 |
| 35 | Joe Leary Slough | D'Arcy Rd | 24 | 56 | 17 |
| 36 | Edison Slough at school | W. Bow Hill Rd | 26 | 64 | 27 |
| 37 | Edison Pump Station | Farm to Market Rd | 26 | 87 | 27 |
| 38 | North Edison Pump Station | North Edison Rd | 26 | 205 | 42 |
| 39 | Colony Ck | Colony Rd | 26 | 55 | 12 |
| 40 | Big Indian Slough | Bayview-Edison Rd | 26 | 55 | 15 |
| 41 | Maddox Slough/Big Ditch | Milltown Rd | 26 | 70 | 23 |
| 42 | Hill Ditch | Cedardale Rd | 25 | 76 | 20 |
| 43 | Wiley Slough | Wylie Rd | 26 | 63 | 15 |
| 44 | Sullivan Slough | La Conner-Bayview Rd | 26 | 88 | 27 |
| 45 | Skagit R – North Fork | Moore Rd | 23 | 6 | 0 |
| 46 | Skagit R – South Fork | Fir Island Rd | 26 | 7 | 0 |
| 47 | Swinomish Channel | County Boat Launch | 26 | 7 | 4 |
| 48 | Fisher Ck | Franklin Rd | 26 | 56 | 8 |

[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) or Most Probable Number (mpn) 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.

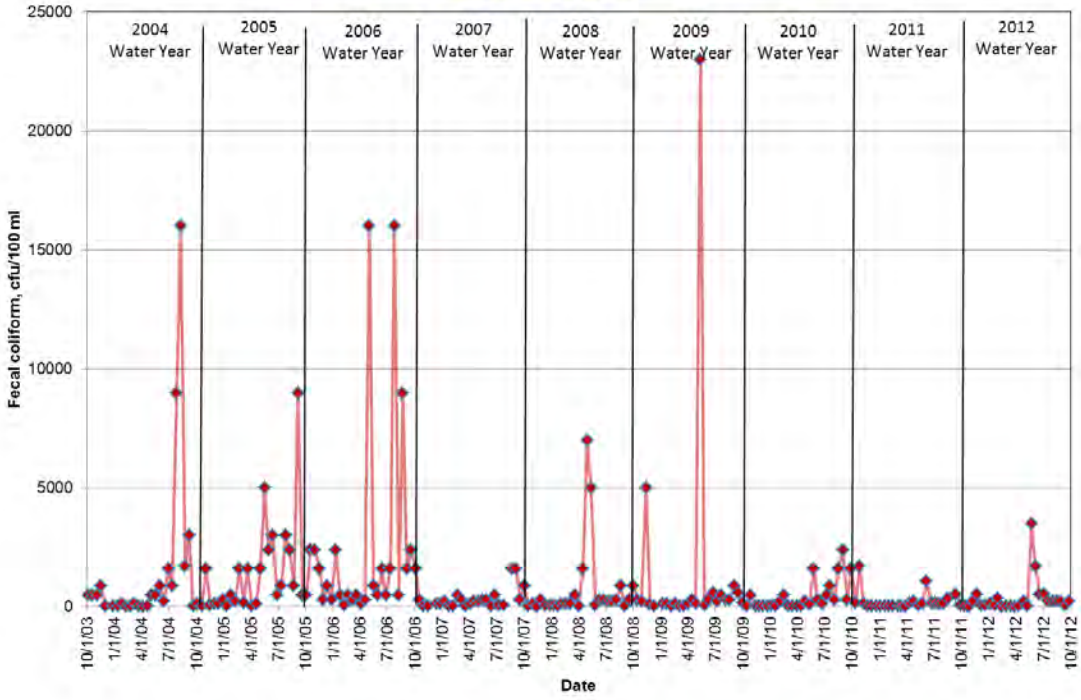
## Table 8. Seven-Year Fecal Coliform Results Summary
## Geometric mean fecal coliform levels (cfu/100 mL) for the last eight years of the Skagit County Monitoring Program

| Site Number | Watercourse | Location | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|
| 3 | Thomas Ck | Old Hwy 99 N | 121 | 77 | 36 | 99 | 36 | 37 | 61 |
| 4 | Thomas Ck | F&S Grade | 950 | 187 | 215 | 234 | 156 | 97 | 139 |
| 6 | Friday Ck | Prairie Rd | 55 | 39 | 35 | 35 | 35 | 45 | 44 |
| 8 | Swede Ck | Grip Rd | 113 | 66 | 70 | 91 | 61 | 46 | 57 |
| 11 | Samish R | State Route 9 | 22 | 14 | 20 | 19 | 17 | 9 | 15 |
| 12 | Nookachamps Ck | Swan Rd | 75 | 49 | 43 | 87 | 72 | 51 | 47 |
| 13 | E.F. Nookachamps Ck | State Route 9 | 57 | 65 | 38 | 84 | 59 | 46 | 47 |
| 14 | College Way Ck | College Way | 157 | 193 | 252 | 140 | 307 | 74 | 90 |
| 15 | Nookachamps Ck | Knapp | 78 | 84 | 65 | 80 | 79 | 84 | 99 |
| 16 | E.F. Nookachamps Ck | Beaver Lake Rd | 20 | 24 | 19 | 33 | 25 | 18 | 25 |
| 17 | Nookachamps Ck | Big Lake Outlet | 16 | 16 | 12 | 17 | 14 | 6 | 11 |
| 18 | Lake Ck | State Route 9 | 45 | 61 | 40 | 44 | 69 | 38 | 36 |
| 19 | Hansen Ck | Hoehn Rd | 107 | 126 | 71 | 82 | 92 | 65 | 87 |
| 20 | Hansen Ck | Northern State | 77 | 49 | 31 | 49 | 53 | 27 | 43 |
| 21 | Coal Ck | Hoehn Rd | 115 | 168 | 117 | 37 | 69 | 43 | 95 |
| 22 | Coal Ck | Hwy 20 | 11 | 12 | 8 | 21 | 17 | 5 | 20 |
| 23 | Wiseman Ck | Minkler Rd | 23 | 21 | 13 | 19 | 13 | 7 | 15 |
| 24 | Mannser Ck | Lyman Hamilton Hwy | 17 | 16 | 15 | 23 | 10 | 8 | 15 |
| 25 | Red Cabin Ck | Hamilton Cem Rd | 9 | 7 | 17 | 13 | 16 | 5 | 7 |
| 28 | Brickyard Ck | Hwy 20 | 55 | 58 | 49 | 55 | 72 | 56 | 67 |
| 29 | Skagit R | River Bend Rd | 7 | 7 | 13 | 15 | 15 | 9 | 9 |
| 30 | Skagit R | Cape Horn Rd | 5 | 6 | 5 | 6 | 5 | 4 | 3 |
| 31 | DD 20 floodgate | Francis Rd | 89 | 24 | 36 | 57 | 23 | 41 | 33 |
| 32 | Samish R | Thomas Rd | 85 | 42 | 47 | 81 | 43 | 41 | 52 |
| 33 | Alice Bay Pump Station | Samish Island Rd | 62 | 28 | 44 | 64 | 33 | 59 | 51 |
| 34 | Noname Slough | Bayview-Edison Rd | 204 | 118 | 102 | 198 | 216 | 102 | 110 |
| 35 | Joe Leary Slough | D'Arcy Rd | 143 | 192 | 55 | 103 | 85 | 54 | 56 |
| 36 | Edison Slough at school | W. Bow Hill Rd | 71 | 41 | 43 | 53 | 84 | 48 | 64 |
| 37 | Edison Pump Station | Farm to Market Rd | 197 | 135 | 94 | 109 | 120 | 74 | 87 |
| 38 | North Edison Pump Stn. | North Edison Rd | 120 | 57 | 157 | 125 | 183 | 144 | 205 |
| 39 | Colony Ck | Colony Rd | 156 | 77 | 46 | 68 | 82 | 51 | 55 |
| 40 | Big Indian Slough | Bayview-Edison Rd | 51 | 11 | 56 | 132 | 122 | 104 | 55 |
| 41 | Maddox Slough/Big Ditch | Milltown Rd | 73 | 71 | 44 | 58 | 34 | 32 | 70 |
| 42 | Hill Ditch | Cedardale Rd | 27 | 61 | 27 | 82 | 66 | 38 | 76 |
| 43 | Wiley Slough | Wylie Rd | 56 | 75 | 47 | 39 | 44 | 58 | 63 |
| 44 | Sullivan Slough | La Conner-Bayview Rd | 44 | 76 | 128 | 148 | 68 | 125 | 88 |
| 45 | Skagit R – North Fork | Moore Rd | 6 | 5 | 7 | 10 | 11 | 5 | 6 |
| 46 | Skagit R – South Fork | Fir Island Rd | 8 | 7 | 8 | 9 | 12 | 8 | 7 |
| 47 | Swinomish Channel | County Boat Launch | 4 | 3 | 5 | 7 | 6 | 5 | 7 |
| 48 | Fisher Ck | Franklin Rd | 76 | 106 | 74 | 78 | 56 | 44 | 56 |

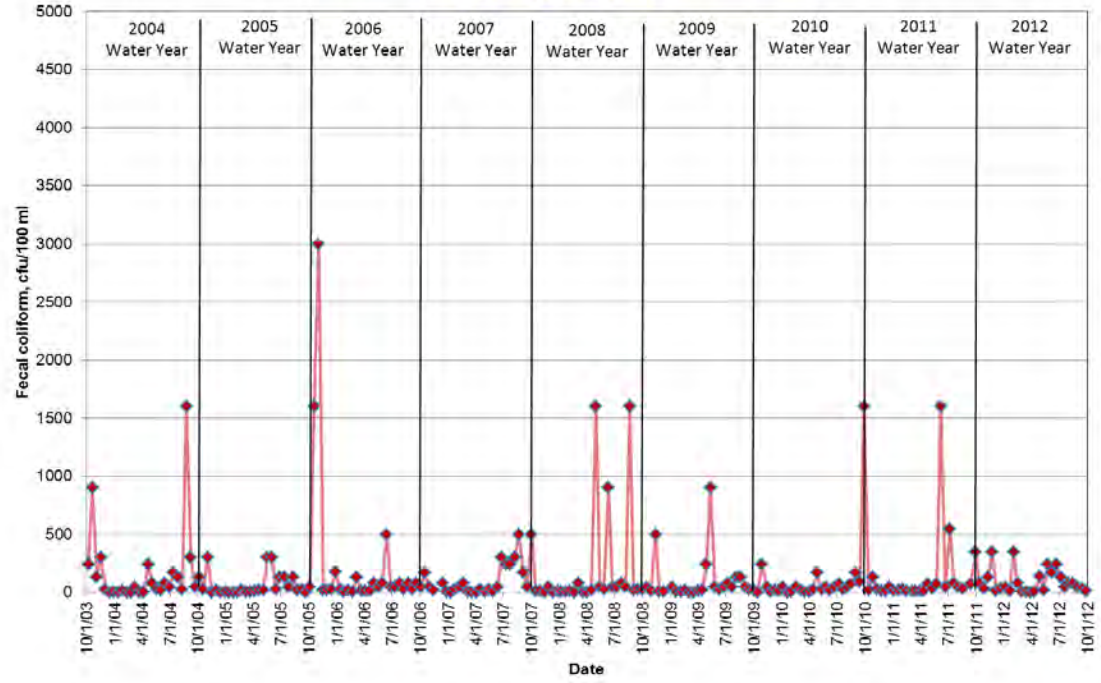
## Thomas Creek at Hwy 99 - Site 3
## Fecal Coliform



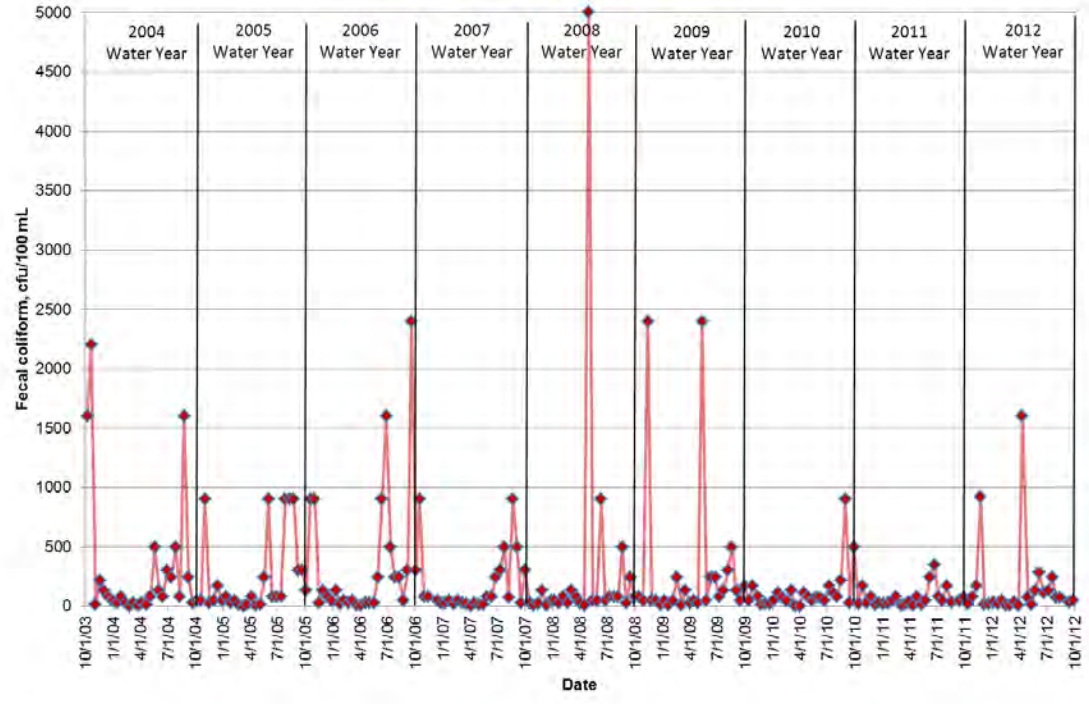

## Thomas Creek at F&S Grade Rd - Site 4
## Fecal Coliform



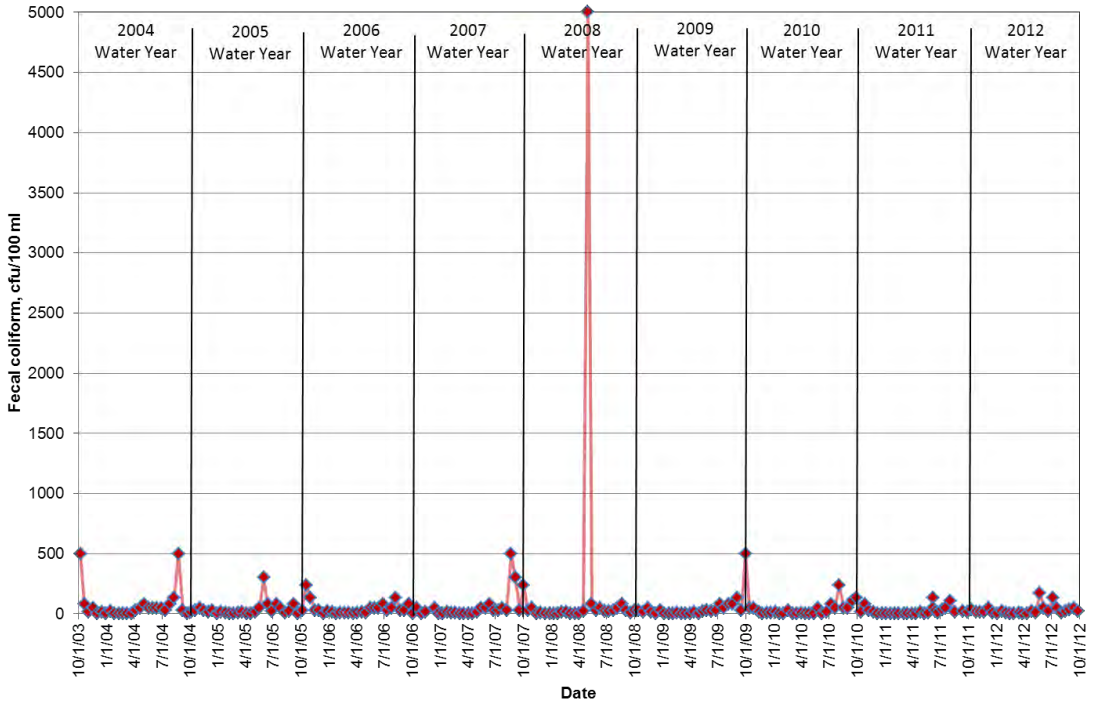
## Friday Creek at Prairie Rd - Site 6
## Fecal Coliform



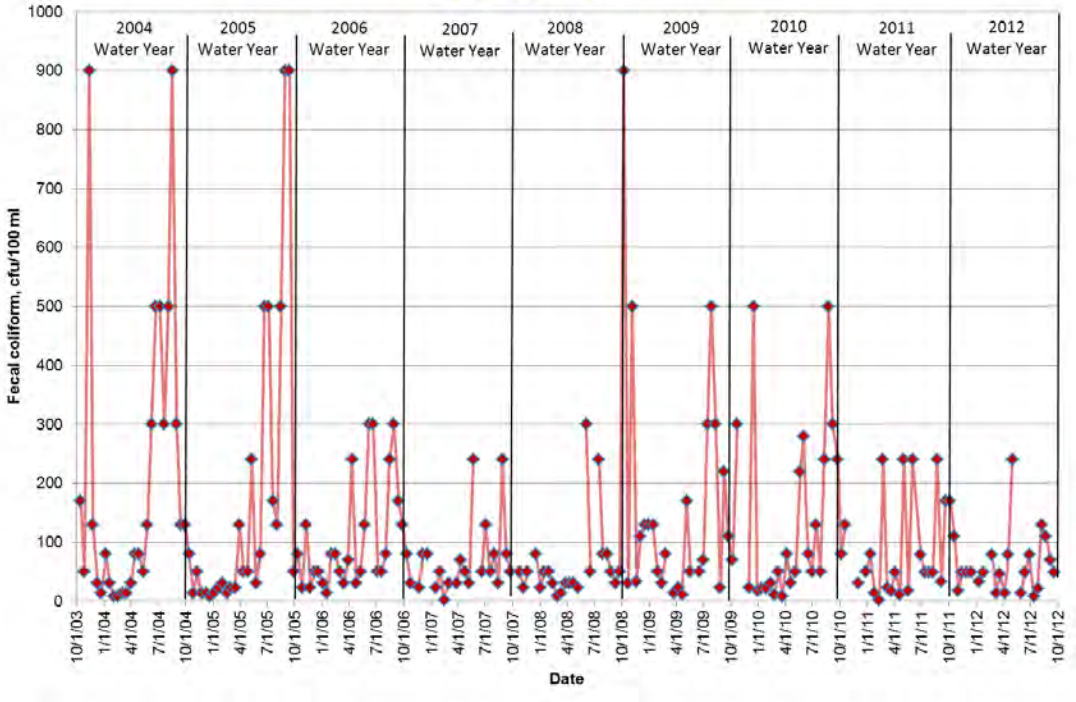

## Swede Creek at Grip Rd - Site 8
## Fecal Coliform



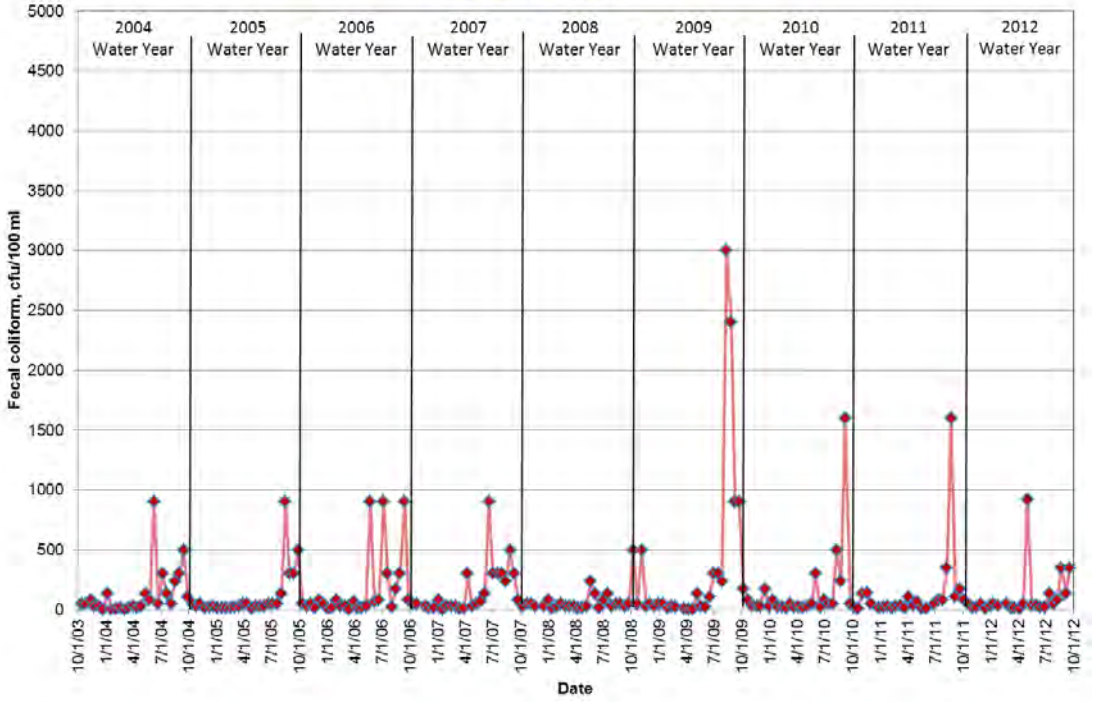
## Samish River at Hwy 9 - Site 11
## Fecal Coliform



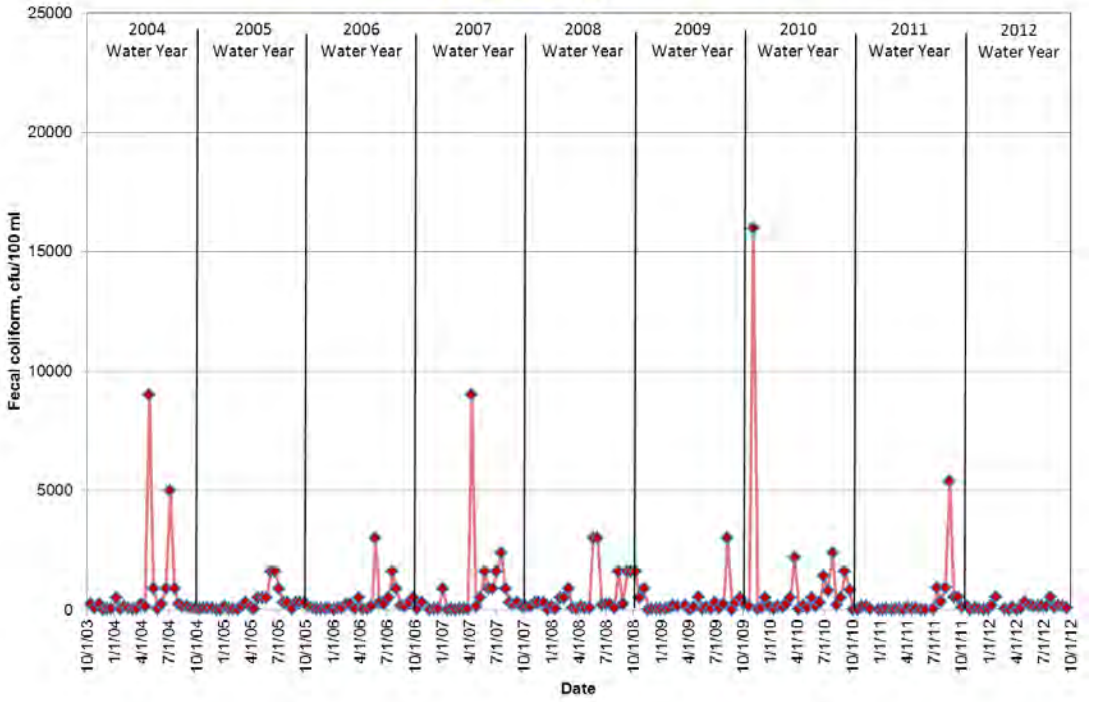

## Nookachamps Creek at Swan Rd - Site 12
## Fecal Coliform



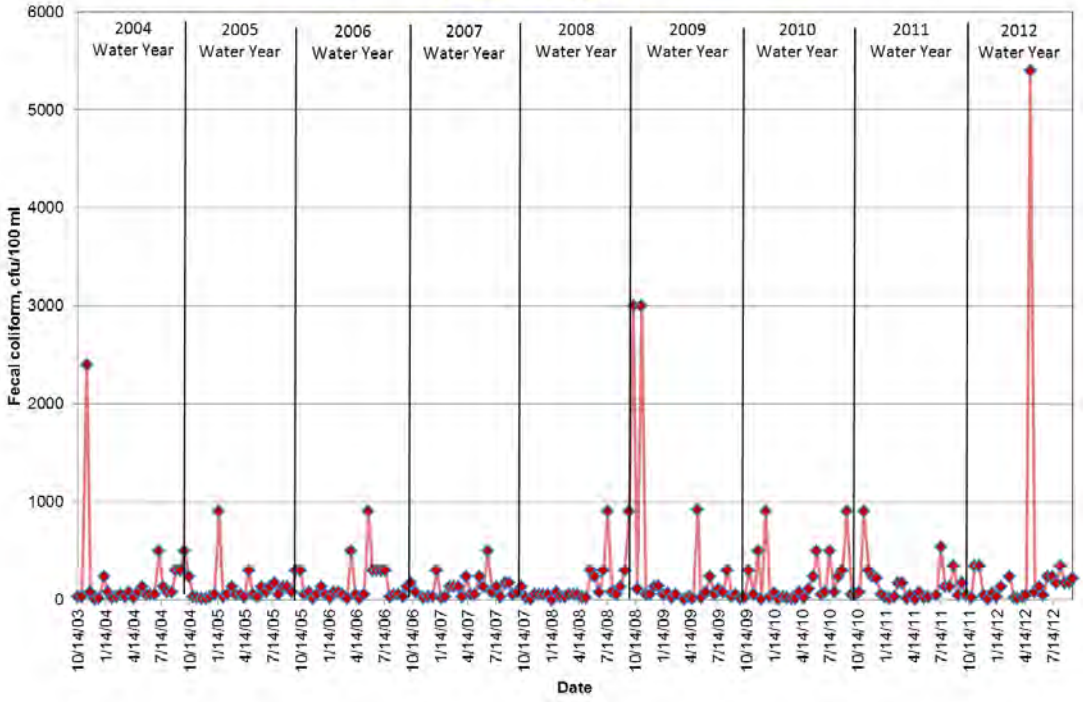
## E.F. Nookachamps Cr at Hwy 9 - Site 13
## Fecal Coliform



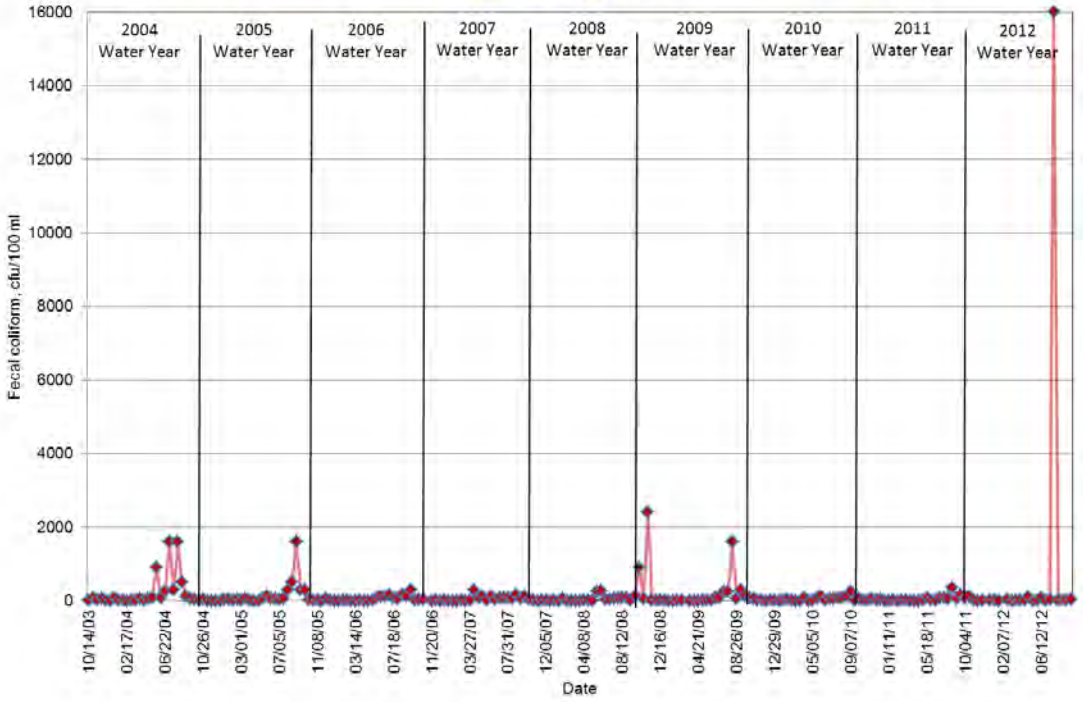

## College Way Cr at College Way - Site 14
## Fecal Coliform



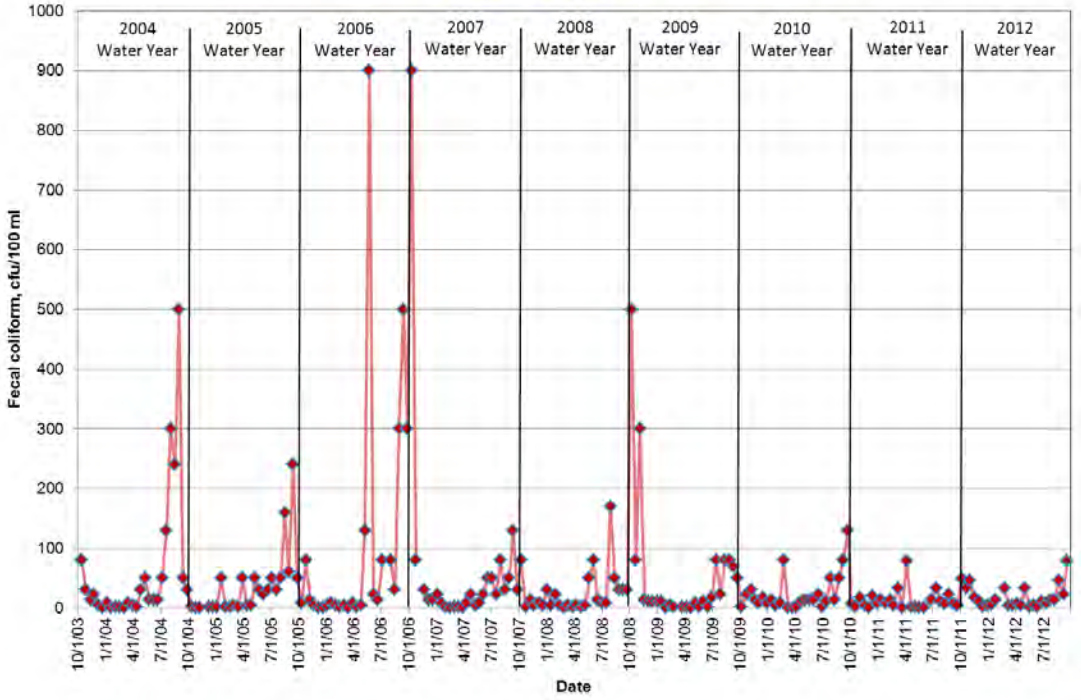
## Nookachamps Creek at Knapp Rd - Site 15
## Fecal Coliform



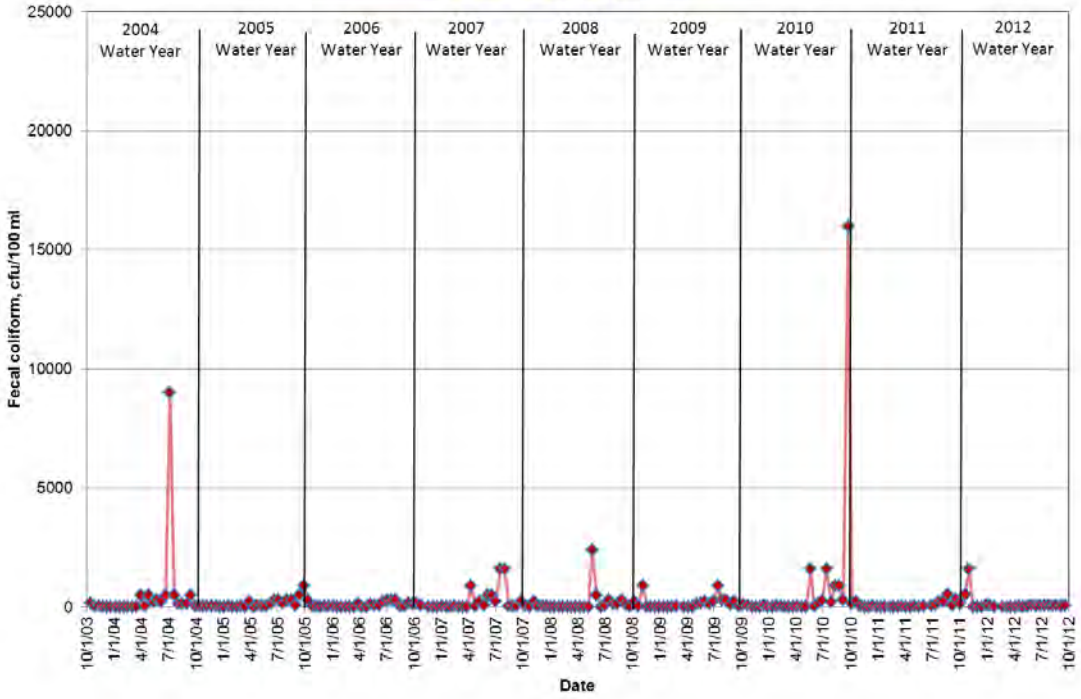

## E.F. Nookachamps Creek at Beaver Lake Rd - Site 16
## Fecal Coliform



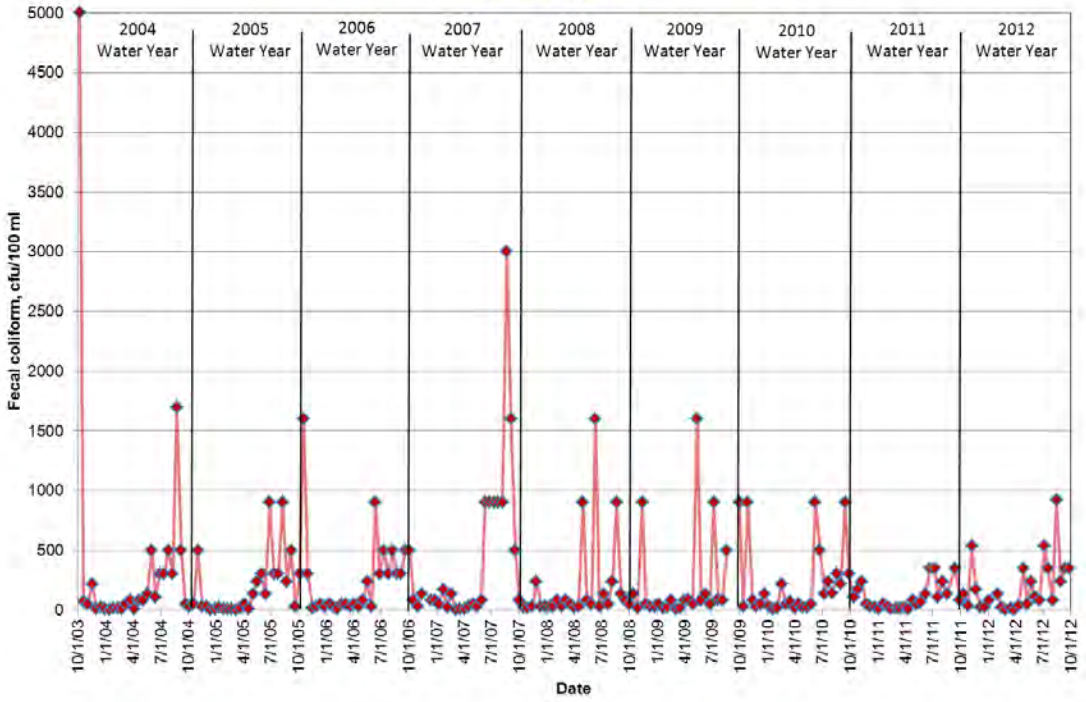
## Nookachamps Creek at Big Lake Outlet - Site 17
## Fecal Coliform



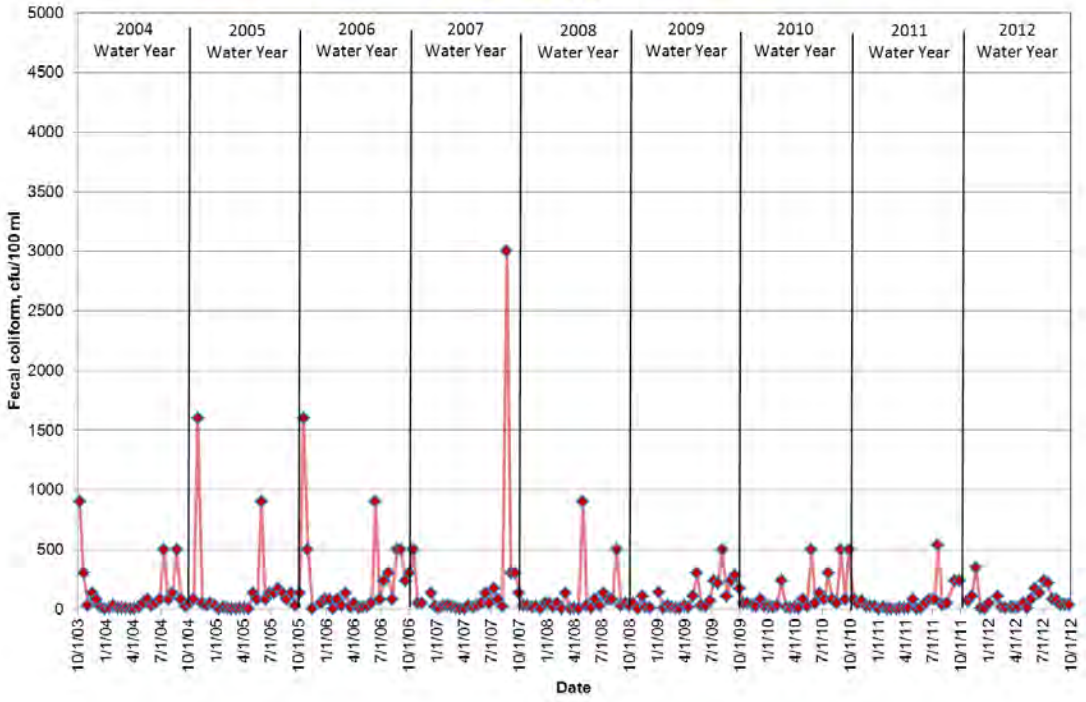

## Lake Creek at Hwy 9 - Site 18
## Fecal Coliform



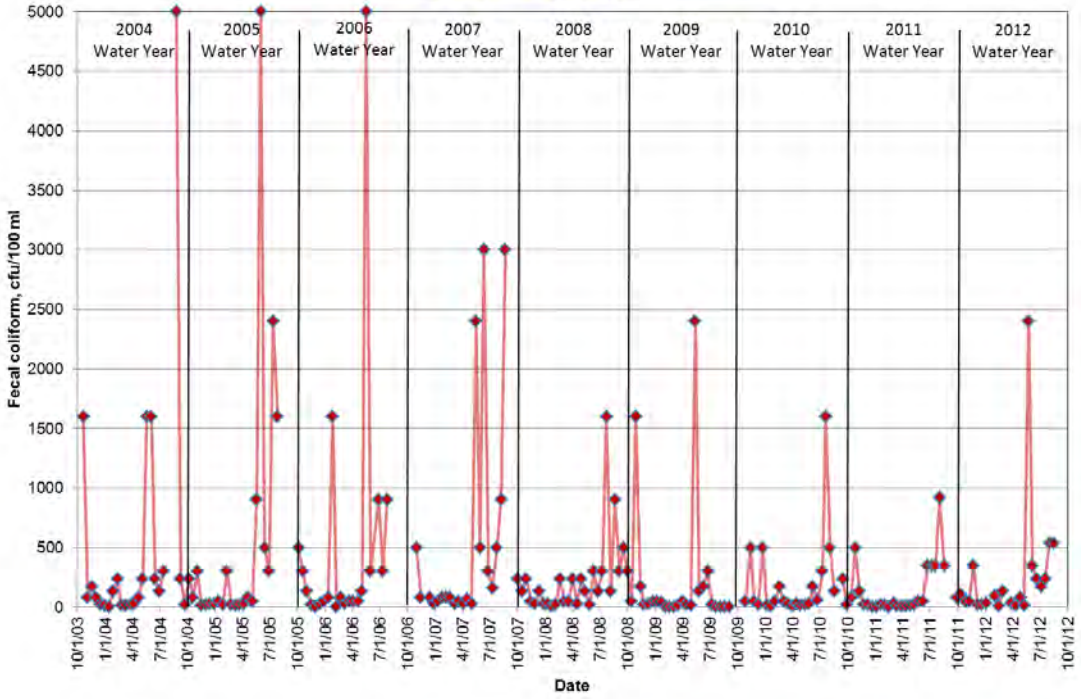
## Hansen Creek at Hoehn Rd - Site 19
## Fecal Coliform



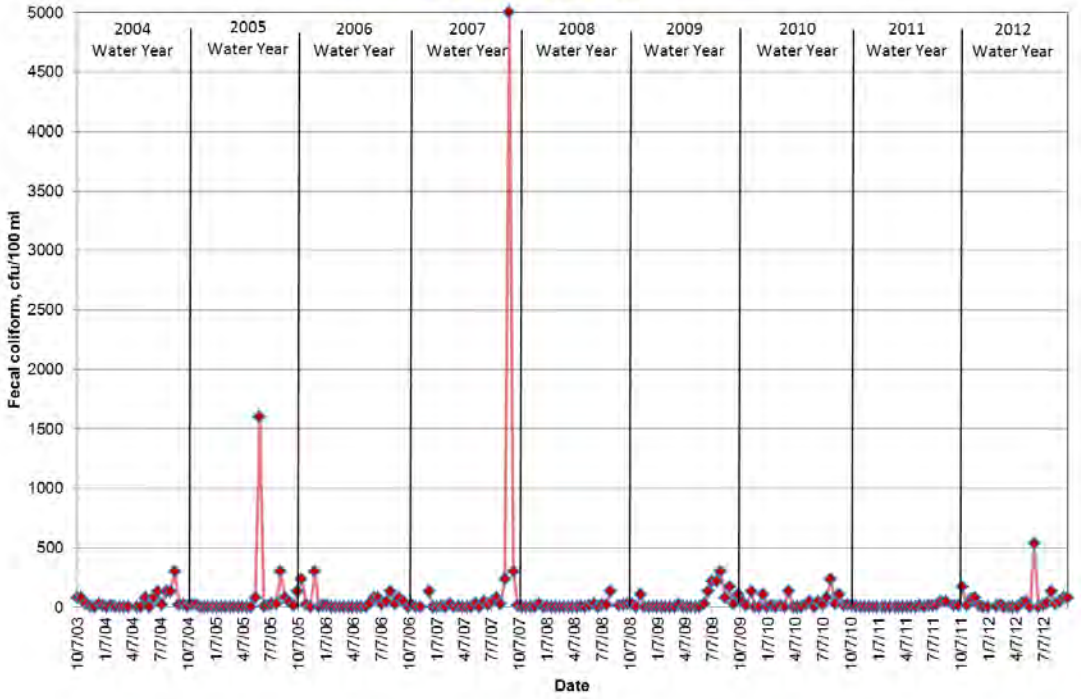

## Hansen Creek at Northern State Hospital - Site 20
## Fecal Coliform



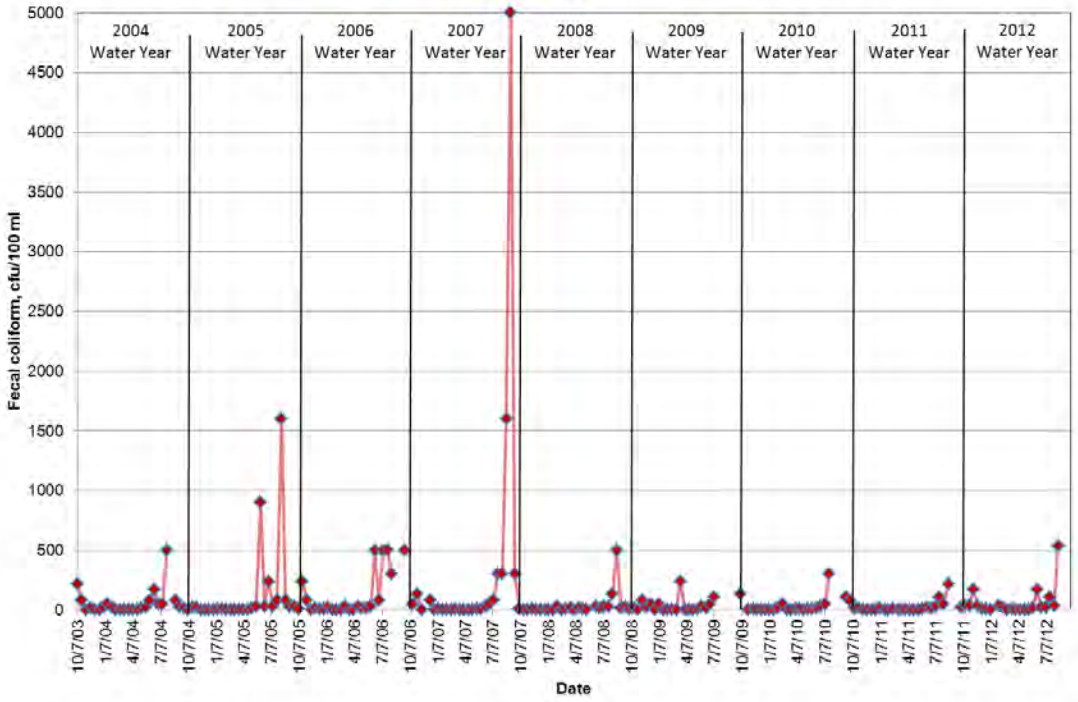
## Coal Creek at Hoehn Rd - Site 21
## Fecal Coliform



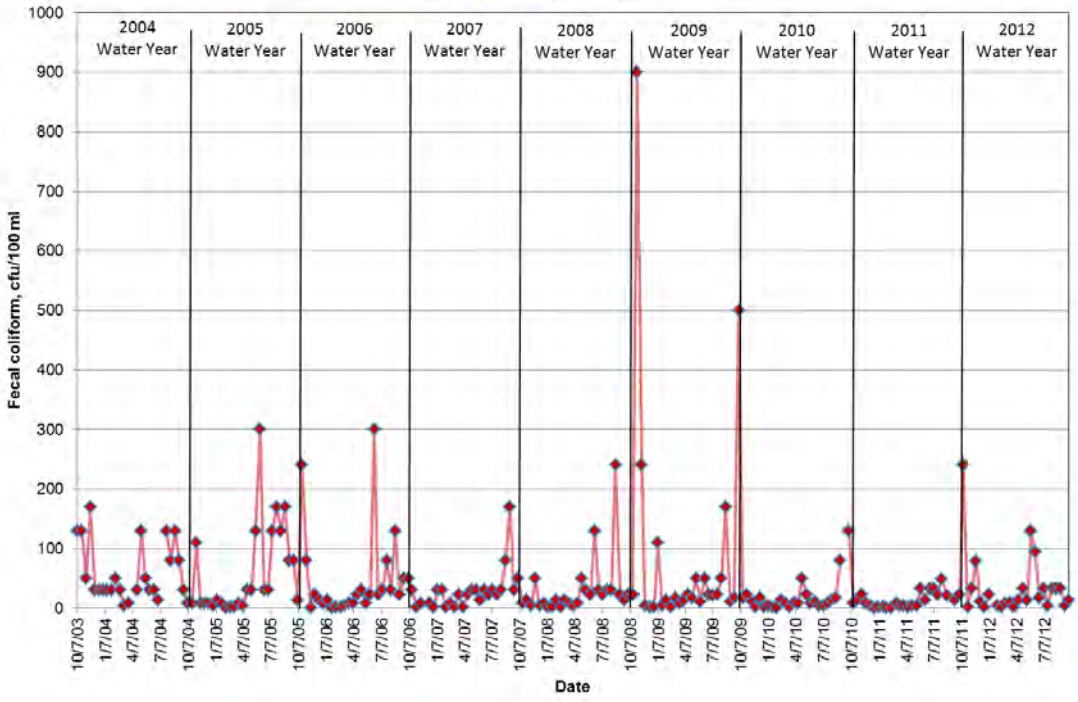

## Coal Creek at Hwy 20 - Site 22
## Fecal Coliform



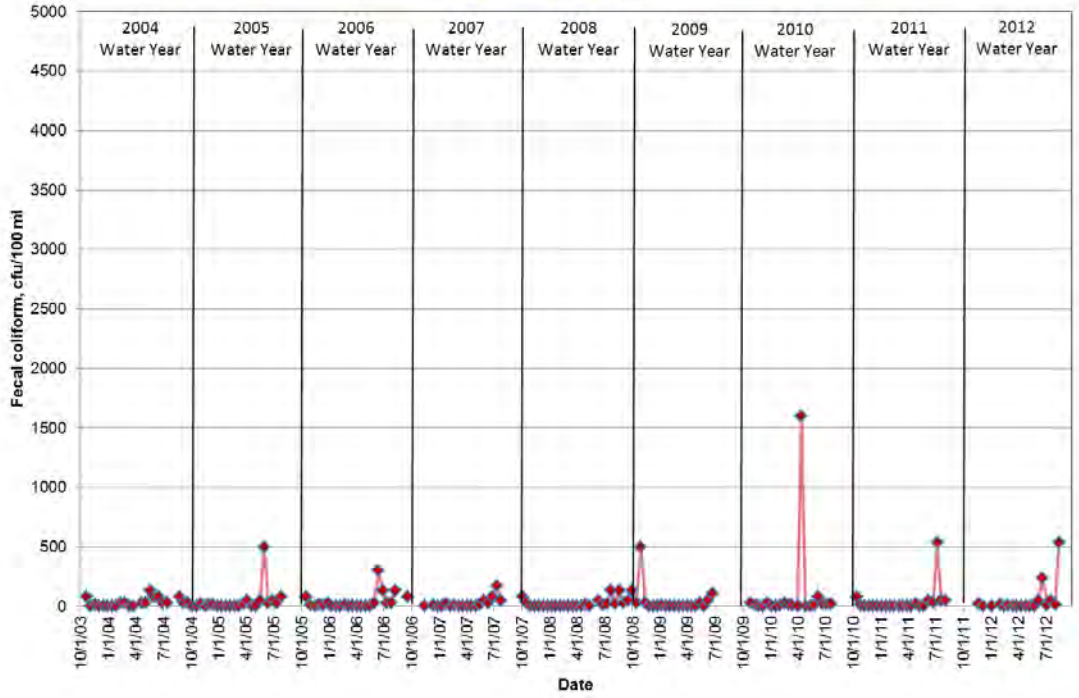
## Wiseman Creek at Minkler Rd - Site 23
## Fecal Coliform



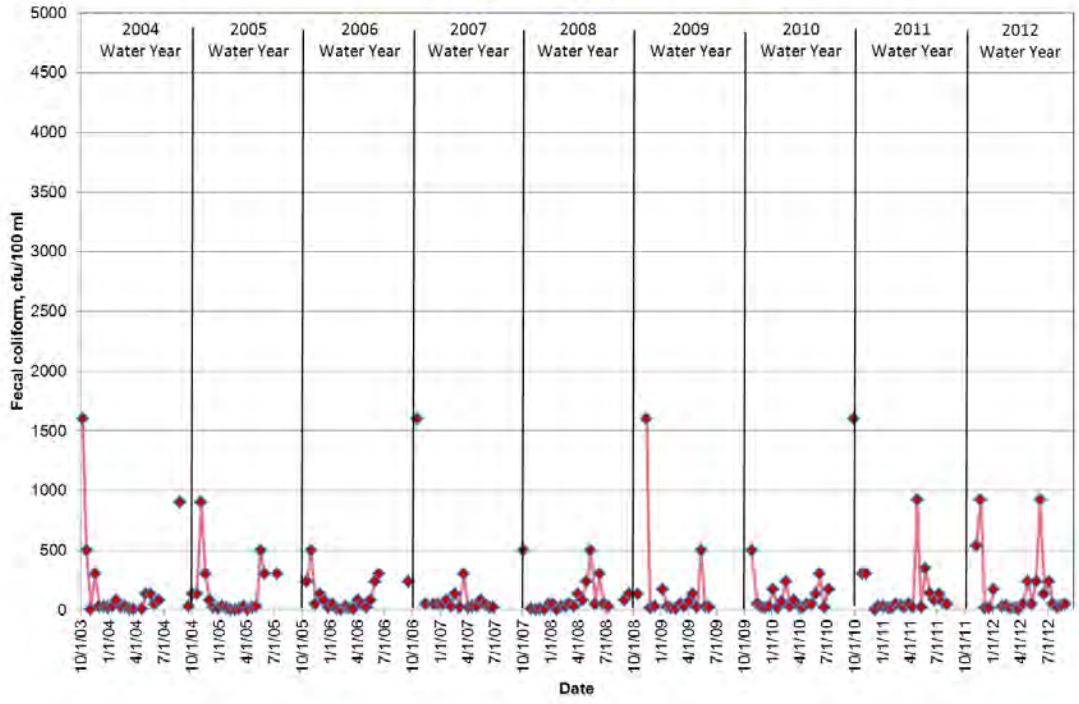

## Mannser Creek at Lyman-Hamilton Hwy - Site 24
## Fecal Coliform



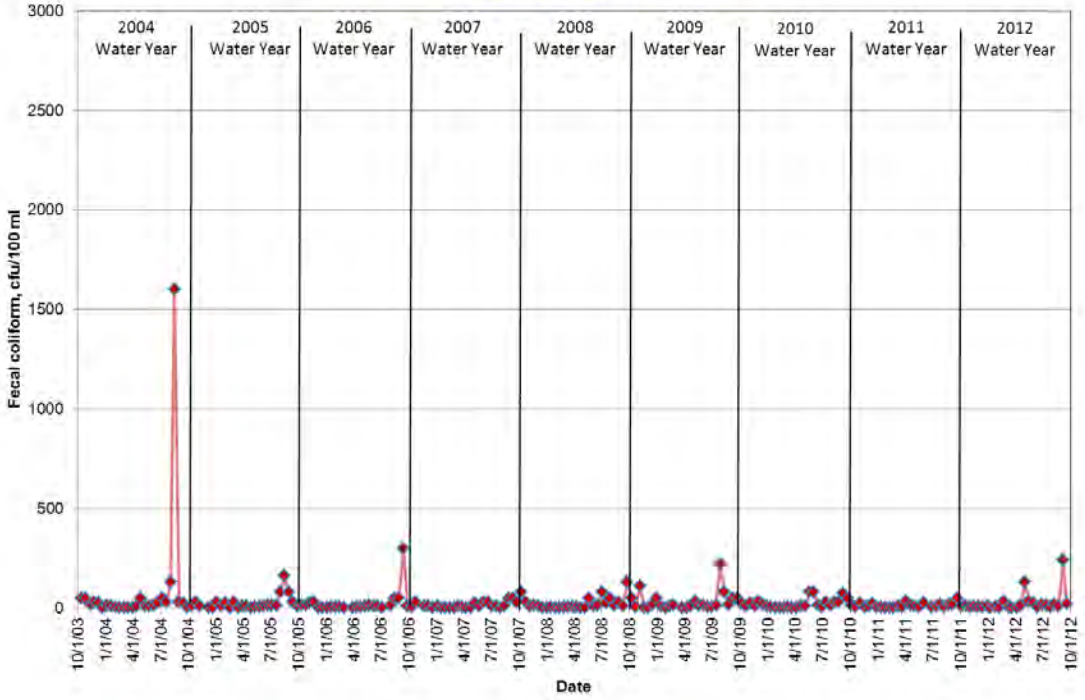
## Red Cabin Creek at Hamilton Cemetery Rd - Site 25
## Fecal Coliform



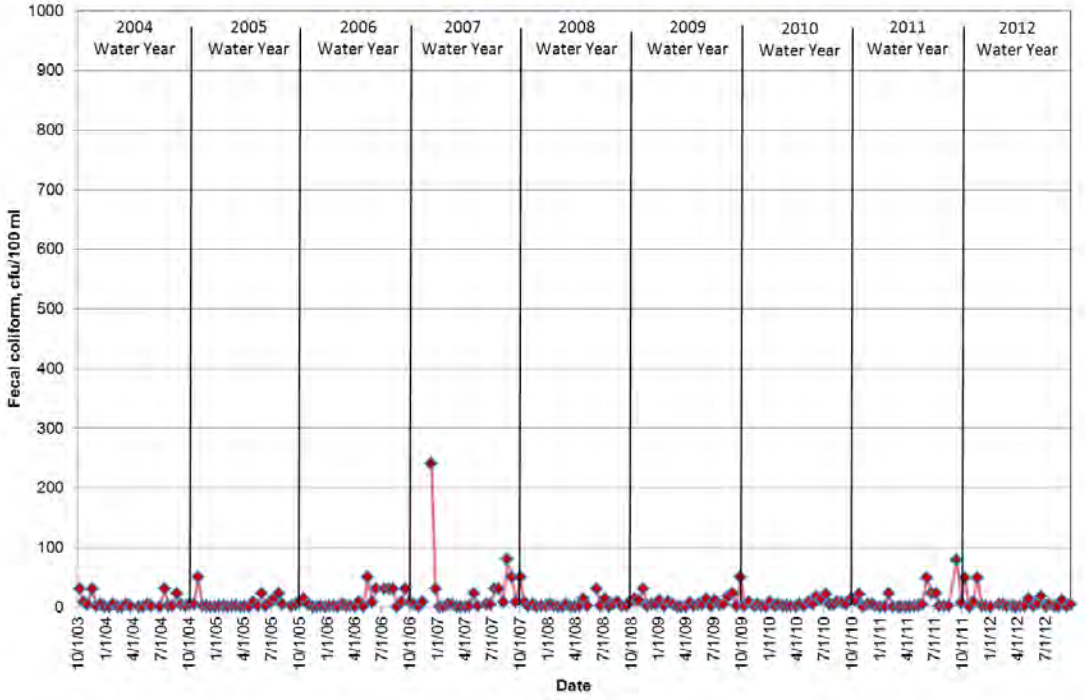

## Brickyard Creek at Hwy 20 - Site 28
## Fecal Coliform



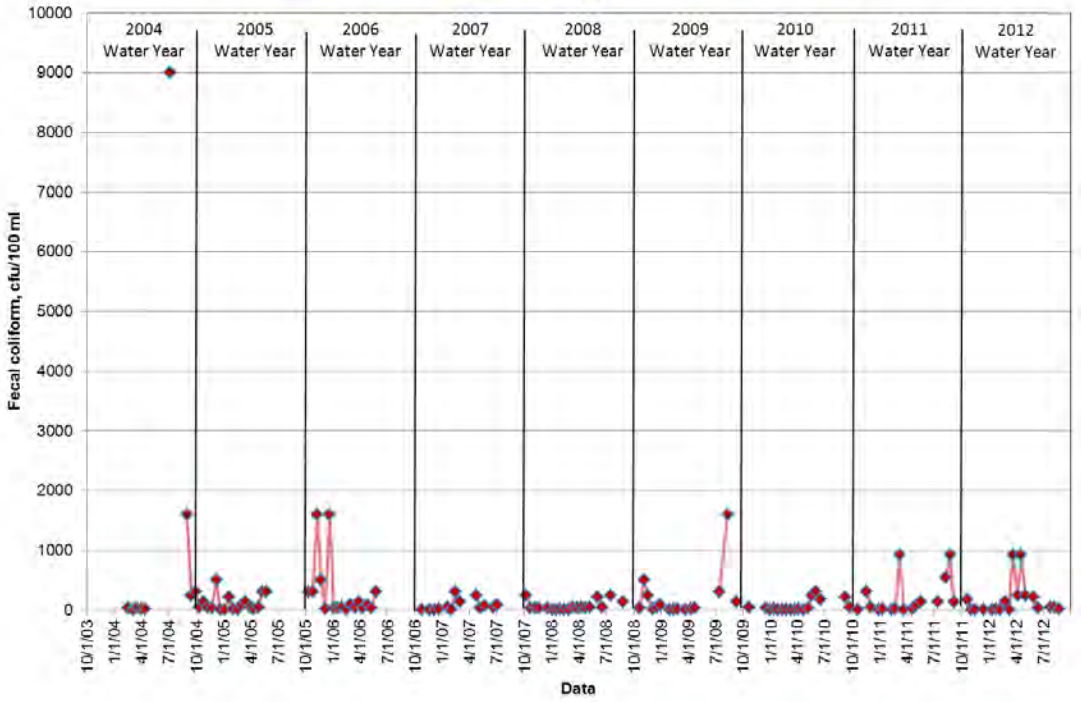
## Skagit River at River Bend - Site 29
## Fecal Coliform



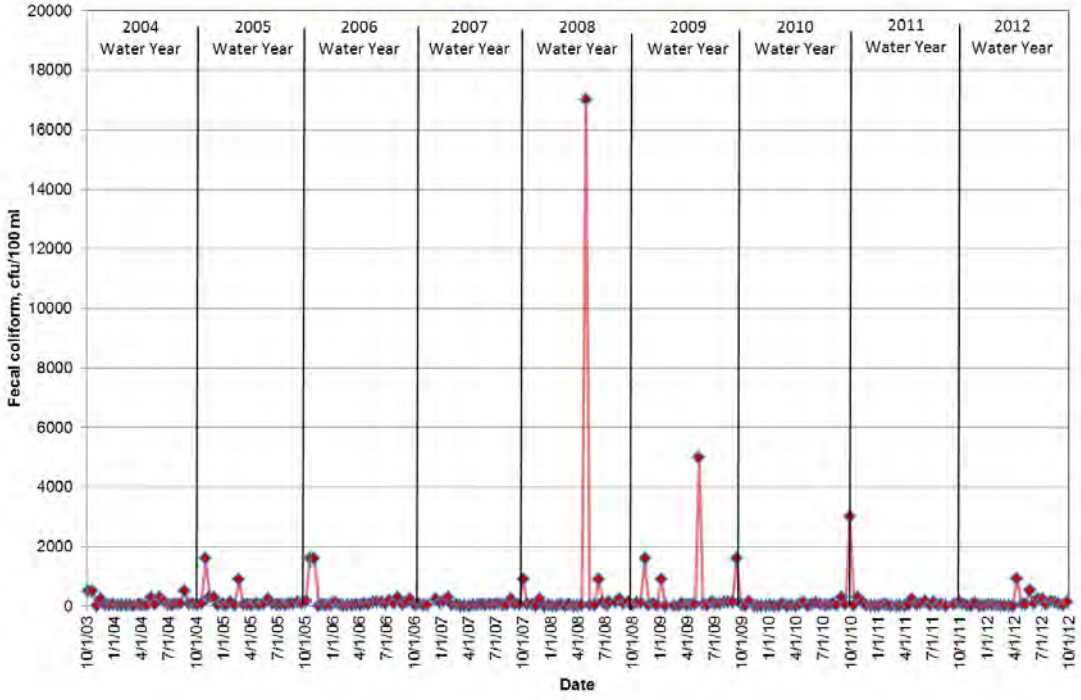

## Skagit River at Cape Horn Rd - Site 30
## Fecal Coliform



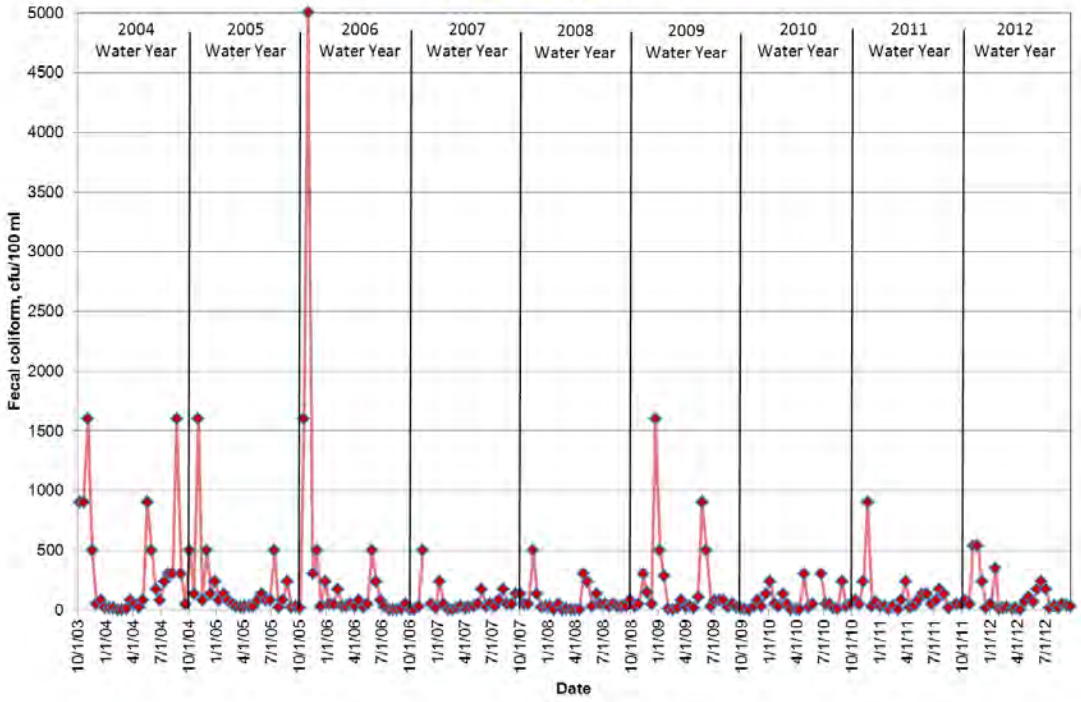
## Drainage District 20 Ditch at Floodgate - Site 31
## Fecal Coliform



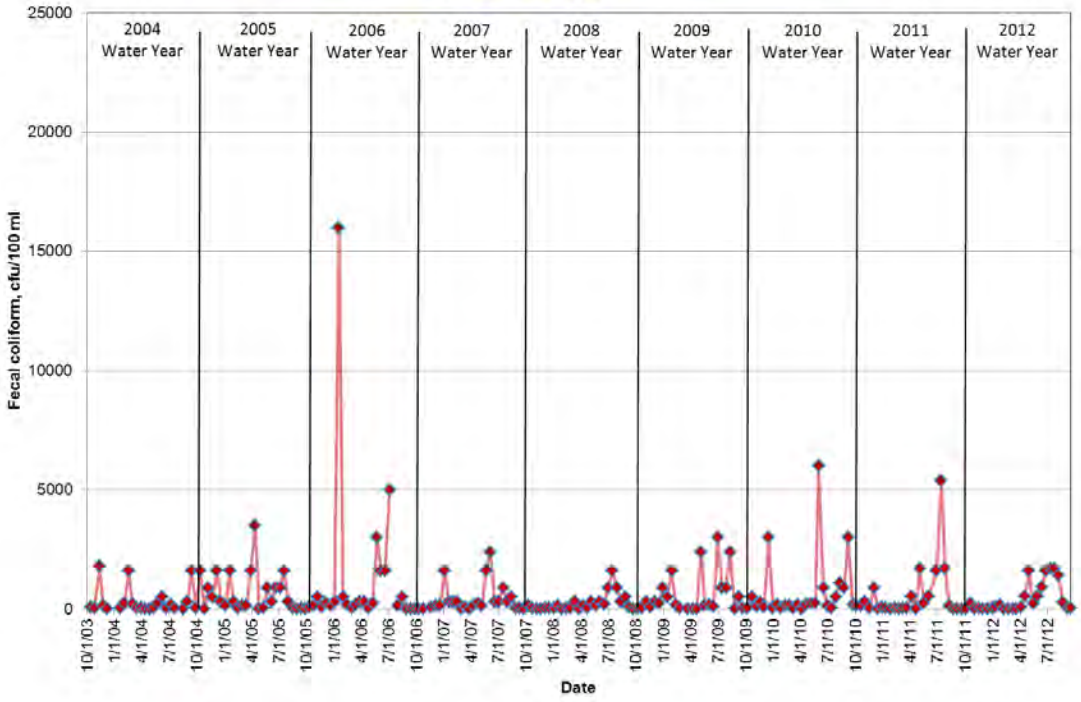

## Samish River at Thomas Road - Site 32
## Fecal Coliform



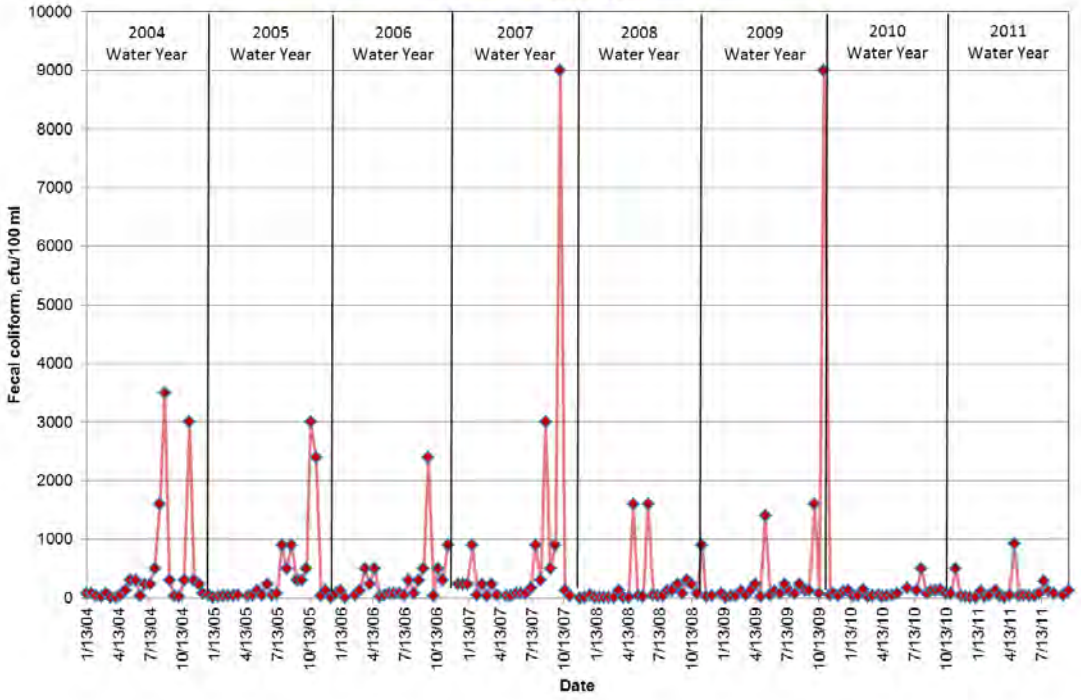
## Alice Bay Pump Station - Site 33
## Fecal Coliform



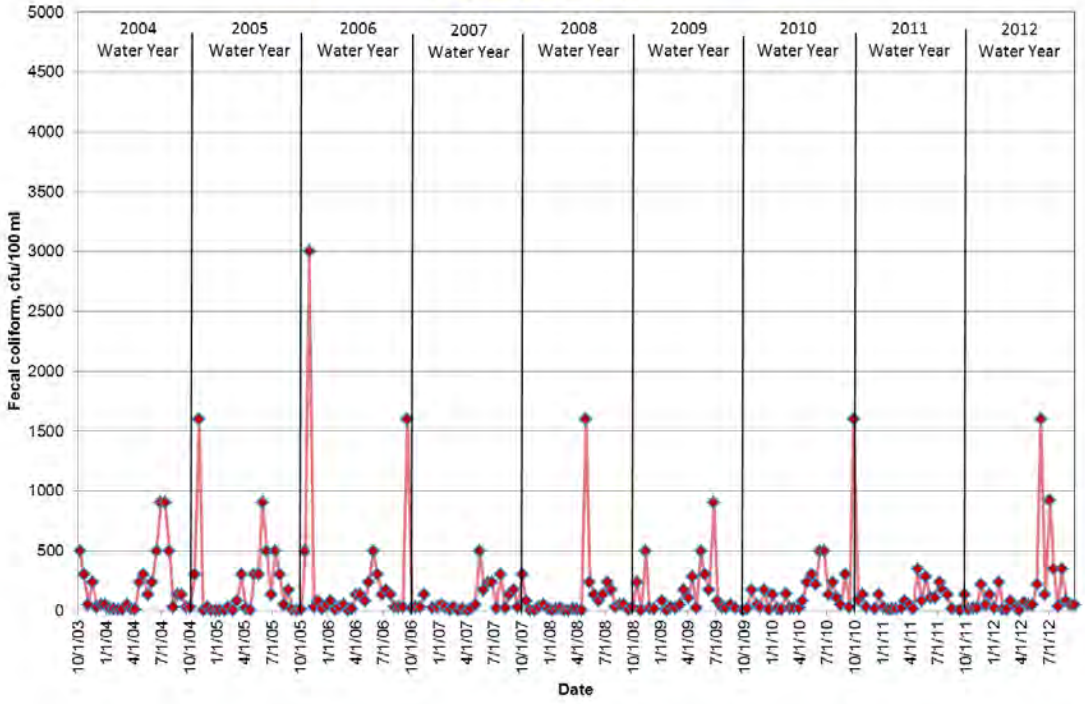

## No Name Slough at Bayview-Edison Rd - Site 34
## Fecal Coliform



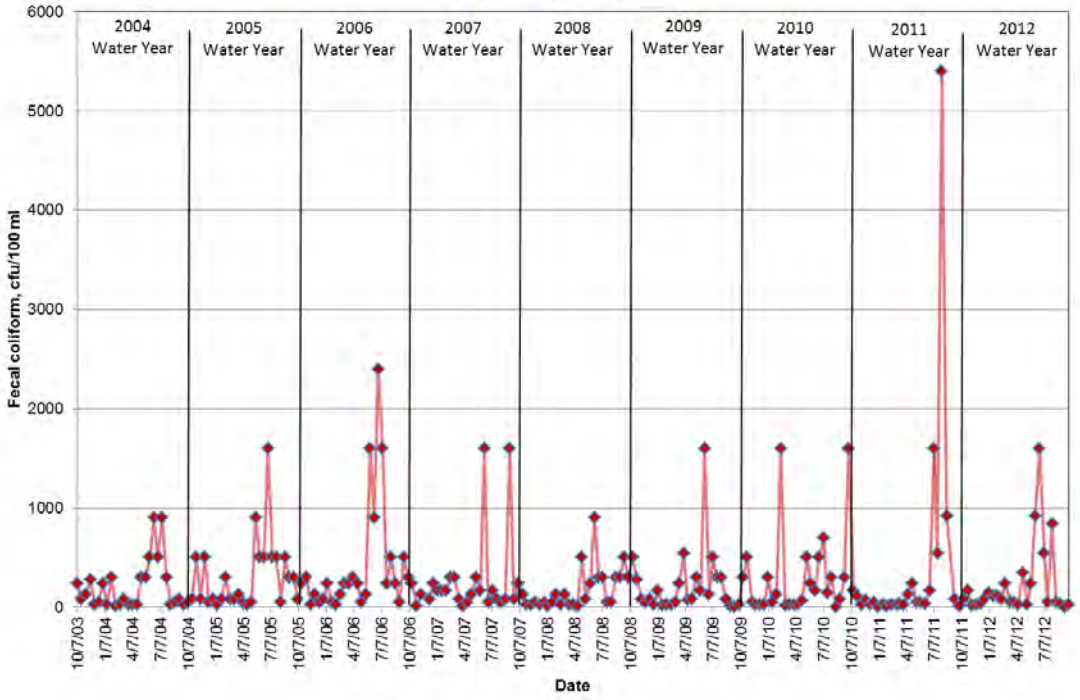
## Joe Leary Slough at D'Arcy Rd - Site 35
## Fecal Coliform



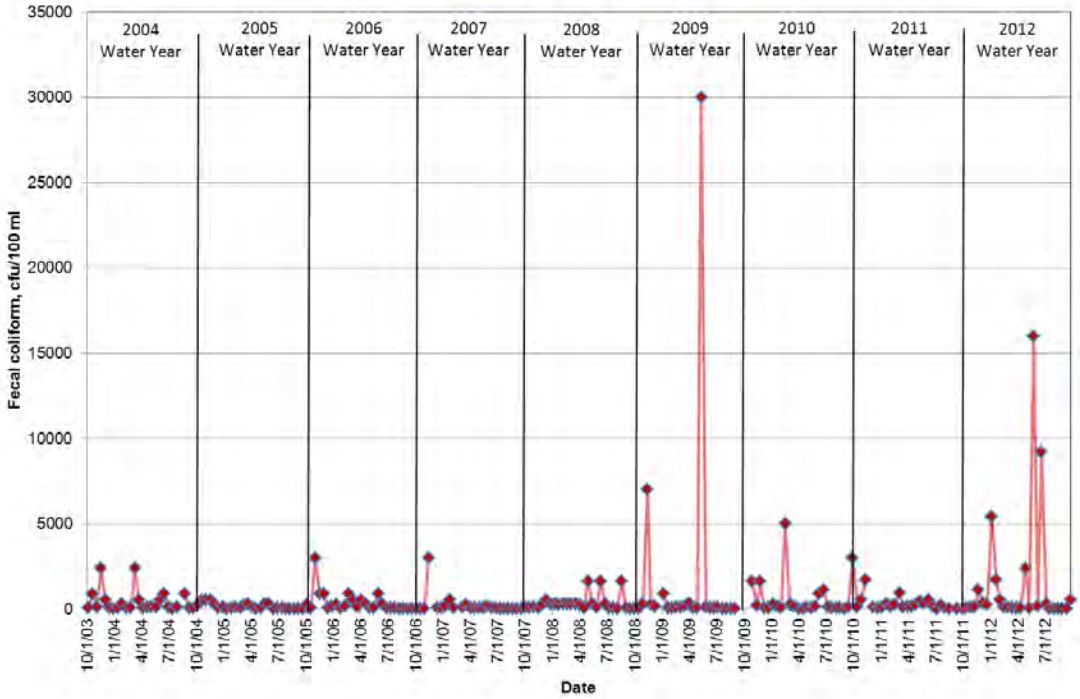

## Edison Slough at Edison School - Site 36
## Fecal Coliform



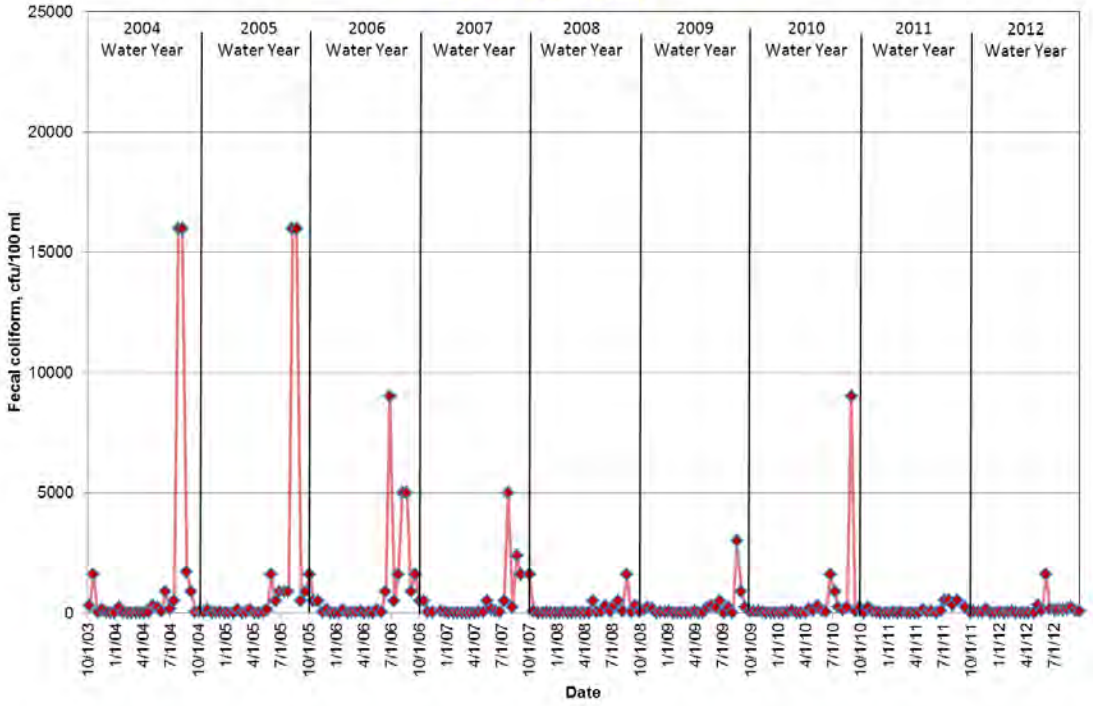
## Edison Slough at Edison School - Site 37
## Fecal Coliform



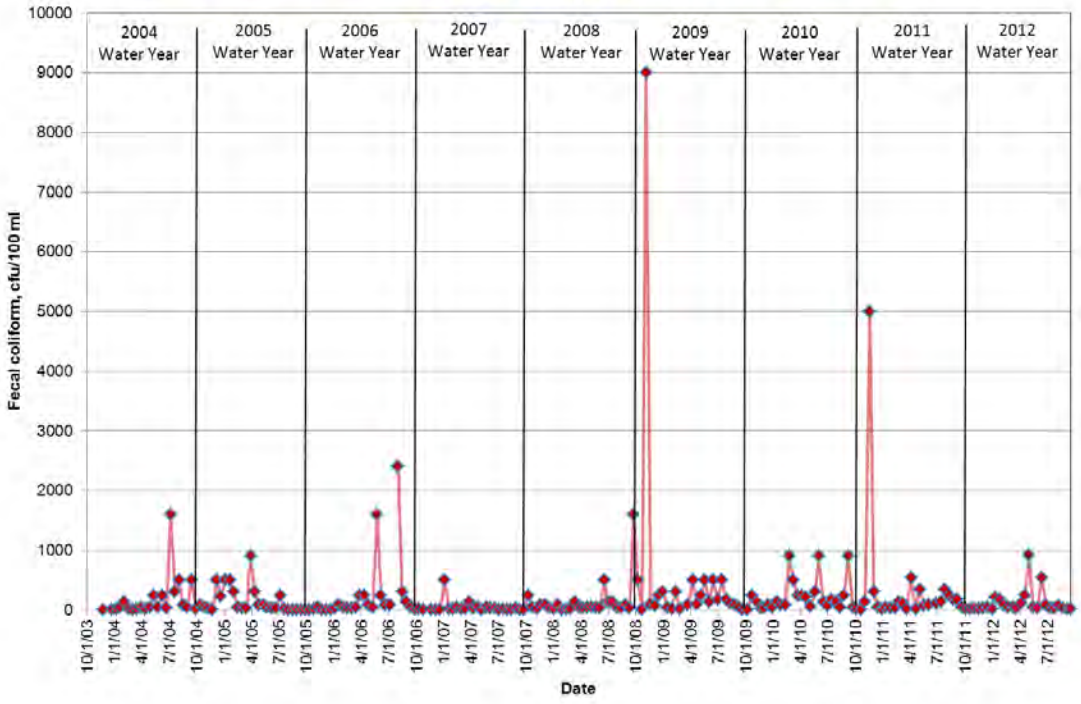

## North Edison Pump Station - Site 38
## Fecal Coliform



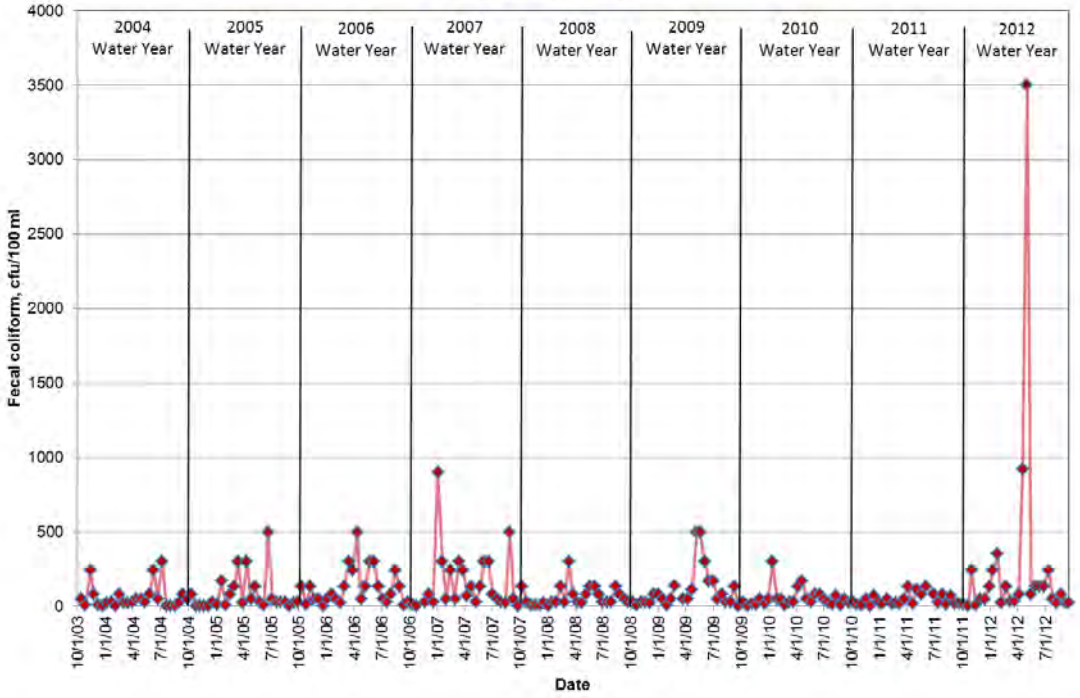
## Colony Creek at Colony Rd - Site 39
## Fecal Coliform



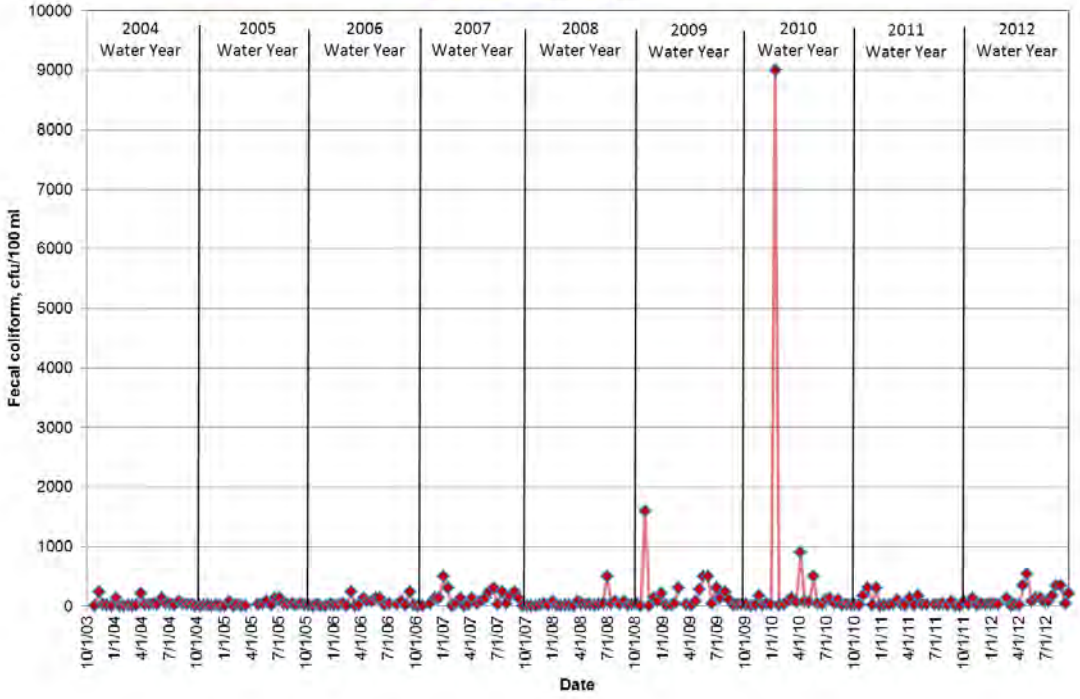

## Big Indian Slough at Hwy 20 Truck Scales - Site 40
## Fecal Coliform



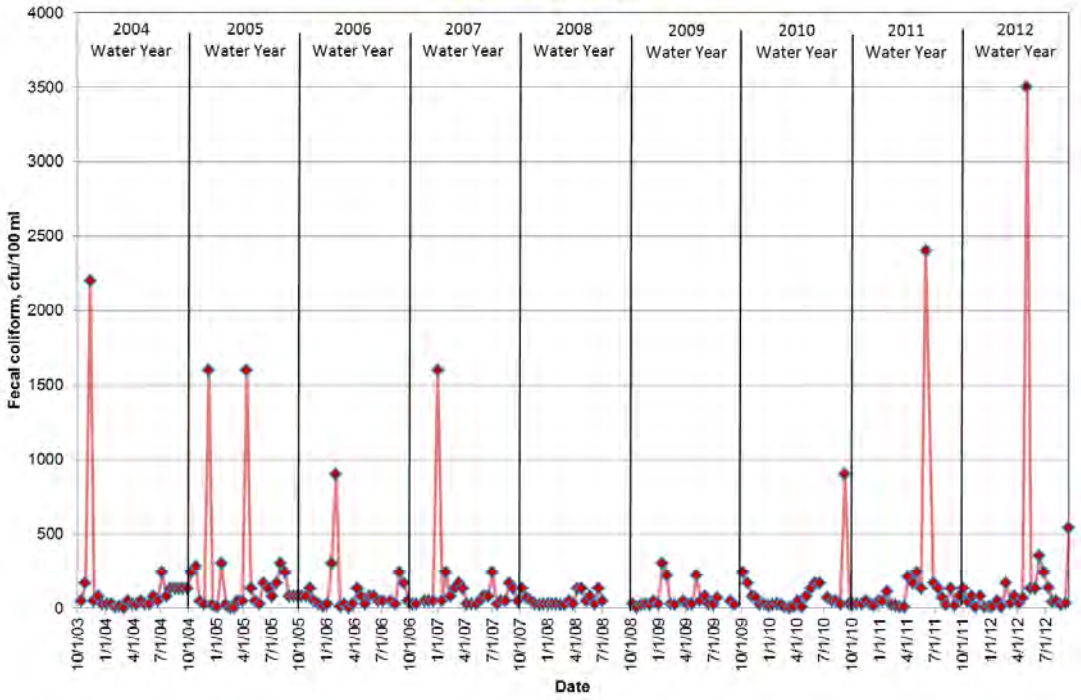
## Maddox Creek/Big Ditch at Milltown Rd - Site 41
## Fecal Coliform



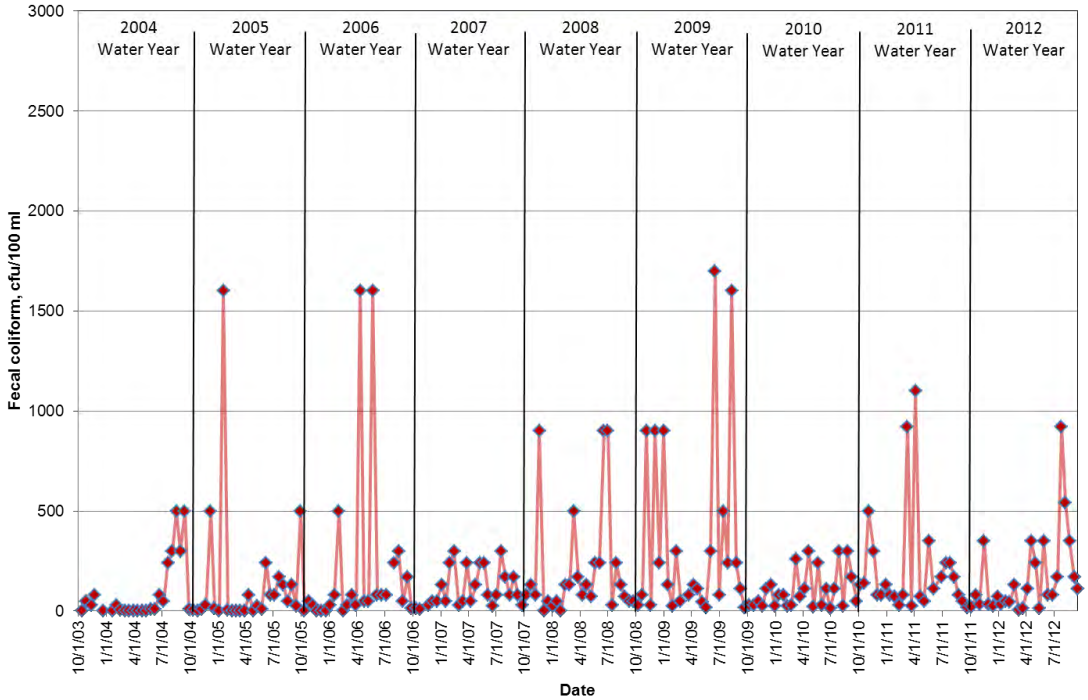

## Carpenter Creek/Hill Ditch at Cedardale Rd - Site 42
## Fecal Coliform



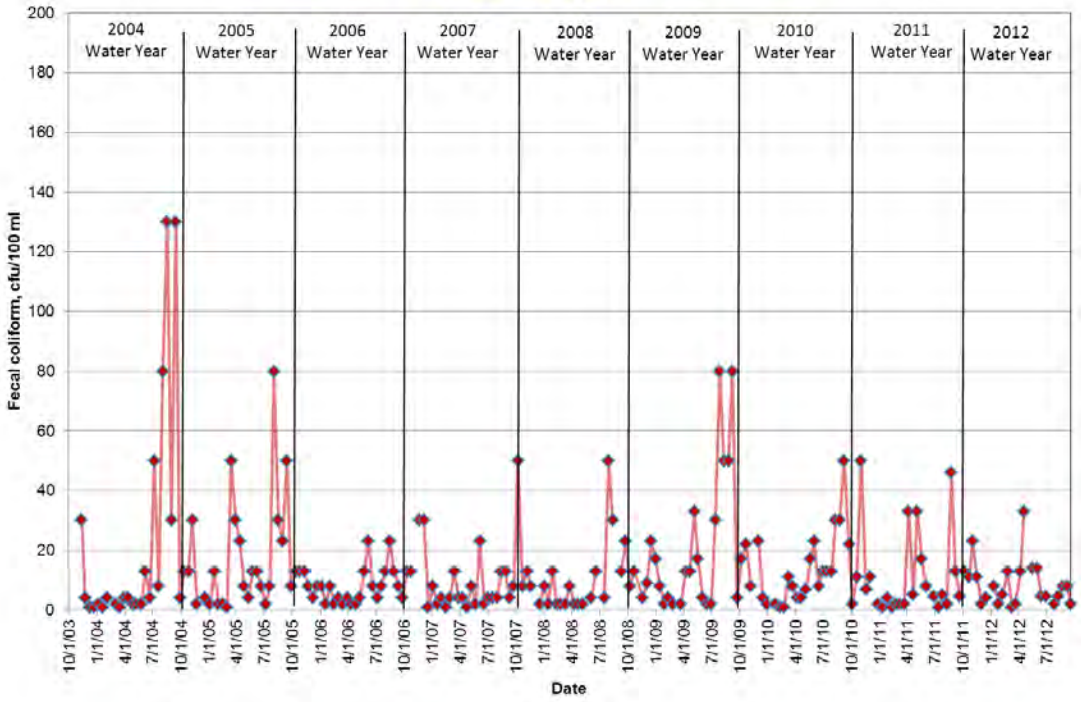
## Wiley Slough at Wylie Rd - Site 43
## Fecal Coliform



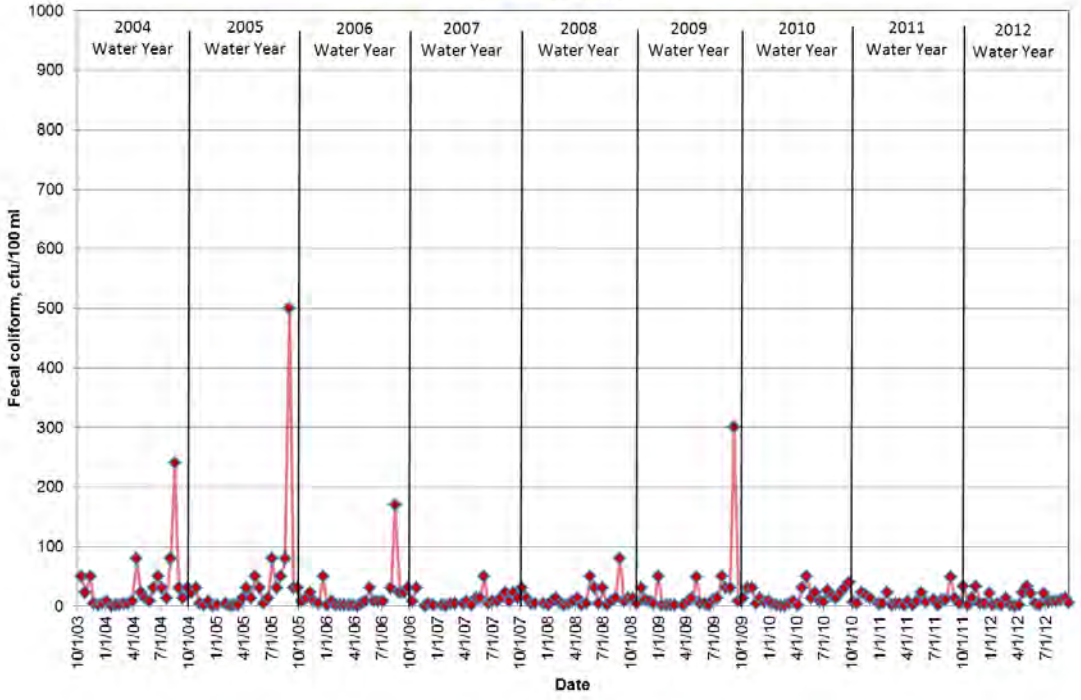

## Sullivan Slough at La Conner-Whitney Rd - Site 44
## Fecal Coliform



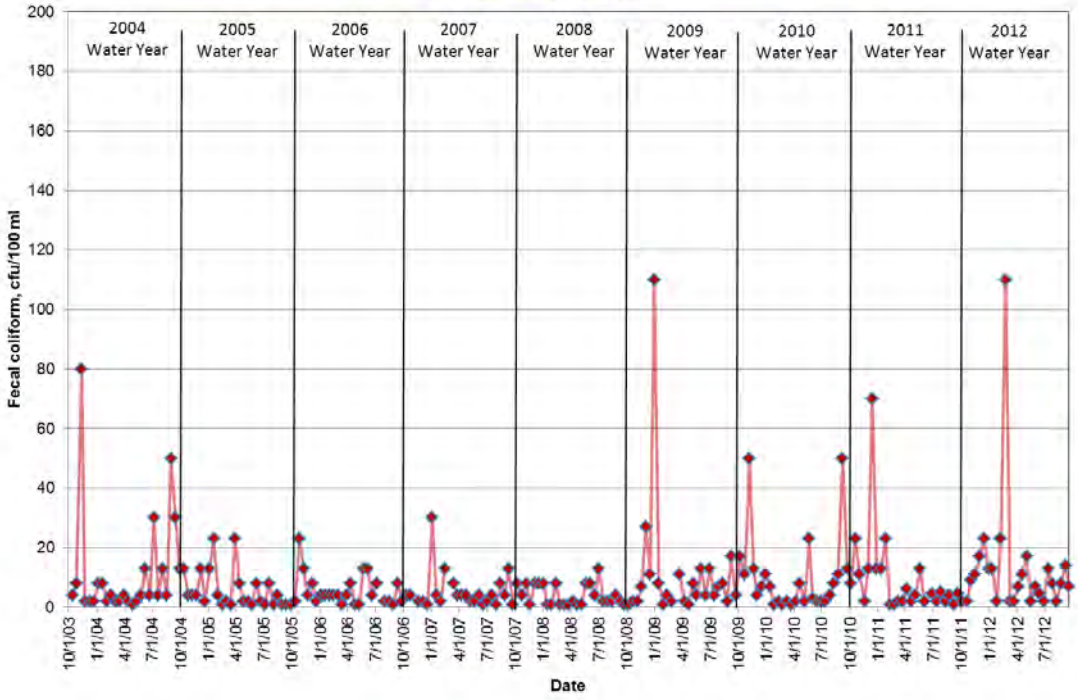
## N.F. Skagit River near Moore Rd - Site 45
## Fecal Coliform



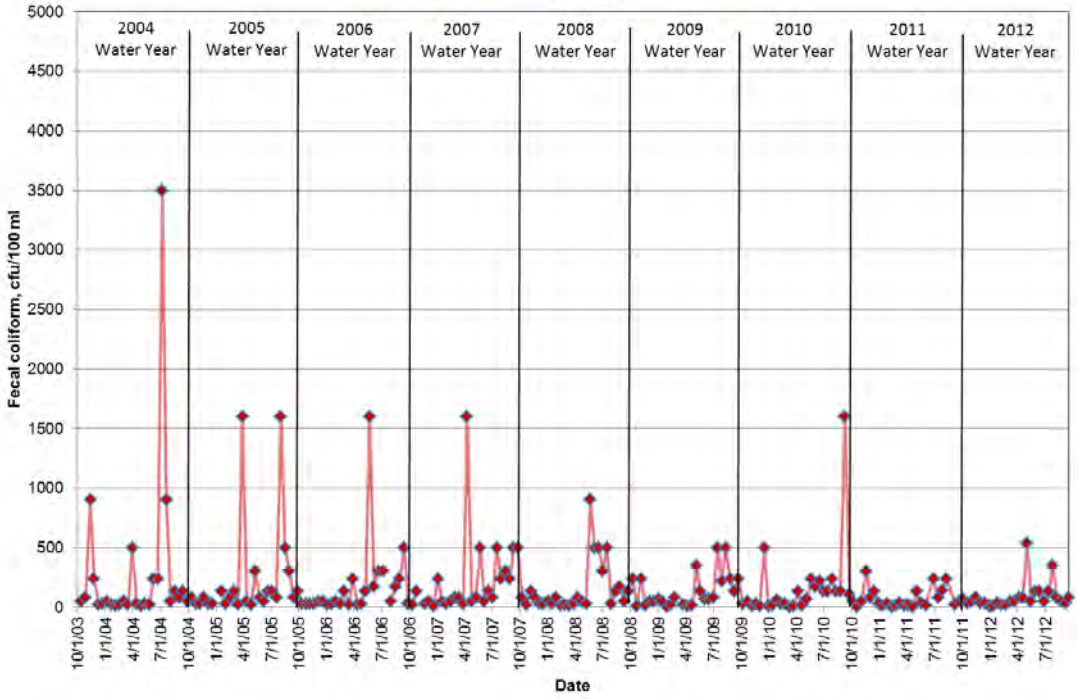

## S.F. Skagit River at Conway Boat Ramp - Site 46
## Fecal Coliform



## 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 quarterly. Samples were analyzed by Edge Analytical of Burlington, WA. Table 9 gives mean nutrient values for selected parameters for the 2012 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. 2012 Nutrient Results
## Mean Nutrient Values (Mg/L) For Watercourses In The Skagit County Monitoring Program, 2012 Water Year.

| Site Number | Watercourse | Location | Total Nitrogen[1] | Total Phosphorus | Ammonia |
|---|---|---|---|---|---|
| 3 | Thomas Ck | Old Hwy 99 N | 0.81 | 0.07 | 0.13 |
| 4 | Thomas Ck | F&S Grade | 0.52 | 0.06 | 0.06 |
| 6 | Friday Ck | Prairie Rd | 0.41 | 0.08 | 0.04 |
| 8 | Swede Ck | Grip Rd | 0.48 | 0.06 | 0.06 |
| 11 | Samish R | State Route 9 | 0.30 | 0.05 | 0.04 |
| 12 | Nookachamps Ck | Swan Rd | 0.53 | 0.06 | 0.09 |
| 13 | E.F. Nookachamps Ck | State Route 9 | 0.04 | 0.04 | 0.06 |
| 14 | College Way Ck | College Way | 0.57 | 0.06 | 0.09 |
| 15 | Nookachamps Ck | Knapp Rd | 0.66 | 0.08 | 0.11 |
| 16 | E.F. Nookachamps Ck | Beaver Lake Rd | 0.31 | 0.04 | 0.03 |
| 17 | Nookachamps Ck | Big Lake Outlet | 0.45 | 0.04 | 0.05 |
| 18 | Lake Ck | State Route 9 | 0.39 | 0.04 | 0.04 |
| 19 | Hansen Ck | Hoehn Rd | 0.46 | 0.09 | 0.04 |
| 20 | Hansen Ck | Northern State | 0.40 | 0.13 | 0.03 |
| 21 | Coal Ck | Hoehn Rd | 0.34 | 0.07 | 0.04 |
| 22 | Coal Ck | Hwy 20 | 0.33 | 0.07 | 0.02 |
| 23 | Wiseman Ck | Minkler Rd | 0.34 | 0.08 | 0.02 |
| 24 | Mannser Ck | Lyman Hamilton Hwy | 0.37 | 0.05 | 0.03 |
| 25 | Red Cabin Ck | Hamilton Cem Rd | 0.31 | 0.06 | 0.02 |
| 28 | Brickyard Ck | Hwy 20 | 0.58 | 0.05 | 0.09 |
| 29 | Skagit R | River Bend Rd | 0.33 | 0.06 | 0.05 |
| 30 | Skagit R | Cape Horn Rd | 0.28 | 0.06 | 0.02 |
| 31 | Drain Dist 20 floodgate | Francis Rd | 1.02 | 0.08 | 0.14 |
| 32 | Samish R | Thomas Rd | 0.40 | 0.07 | 0.07 |
| 33 | Alice Bay Pump Station | Samish Island Rd | 3.01 | 0.46 | 1.29 |
| 34 | Noname Slough | Bayview-Edison Rd | 1.47 | 0.52 | 0.34 |
| 35 | Joe Leary Slough | D'Arcy Rd | 1.25 | 0.20 | 0.62 |
| 36 | Edison Slough at school | W. Bow Hill Rd | 1.28 | 0.46 | 0.28 |
| 37 | Edison Pump Station | Farm to Market Rd | 3.06 | 0.83 | 1.59 |
| 38 | North Edison Pump Station | North Edison Rd | 2.92 | 0.81 | 1.21 |
| 39 | Colony Ck | Colony Rd | 0.68 | 0.10 | 0.07 |
| 40 | Big Indian Slough | Bayview-Edison Rd | 1.04 | 0.11 | 0.40 |
| 41 | Maddox Slough/Big Ditch | Milltown Rd | 1.25 | 0.14 | 0.42 |
| 42 | Hill Ditch | Cedardale Rd | 0.60 | 0.07 | 0.09 |
| 43 | Wiley Slough | Wylie Rd | 1.53 | 0.31 | 0.51 |
| 44 | Sullivan Slough[2] | La Conner-Whitney Rd | 1.42 | 0.26 | 0.63 |
| 45 | Skagit R – North Fork | Moore Rd | 0.31 | 0.06 | 0.03 |
| 46 | Skagit R – South Fork | Fir Island Rd | 0.30 | 0.05 | 0.02 |
| 47 | Swinomish Channel | County Boat Launch | 0.34 | 0.07 | 0.07 |
| 48 | Fisher Ck | Franklin Rd | 0.66 | 0.18 | 0.10 |

[1]Total Kjeldahl Nitrogen

Other Parameters

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

Discharge measurements are made in selected locations and 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 2012 water year are summarized in Table 10 and categorized for the entire study in Table 11. 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 that are not considered salmonid habitat.

## Table 10. 2012 Water Quality Index Results
## Water Quality Index (WQI) determinations for watercourses in the Skagit County Monitoring Program, 2012 Water Year

| Site Number | Watercourse | Location | Mean WQI | Overall Score* | Max | Min |
|---|---|---|---|---|---|---|
| 3 | Thomas Ck | Old Hwy 99 N | 47 | 41 | 65 | 35 |
| 4 | Thomas Ck | F&S Grade | 72 | 62 | 92 | 50 |
| 6 | Friday Ck | Prairie Rd | 85 | 81 | 96 | 60 |
| 8 | Swede Ck | Grip Rd | 76 | 71 | 93 | 41 |
| 11 | Samish R | State Route 9 | 72 | 65 | 95 | 27 |
| 12 | Nookachamps Ck | Swan Rd | 60 | 50 | 90 | 30 |
| 13 | E.F. Nookachamps Ck | State Route 9 | 72 | 65 | 95 | 48 |
| 14 | College Way Ck | College Way | 40 | 40 | 61 | 8 |
| 15 | Nookachamps Ck | Knapp | 46 | 31 | 89 | 1 |
| 16 | E.F. Nookachamps Ck | Beaver Lake Rd | 92 | 91 | 97 | 87 |
| 17 | Nookachamps Ck | Big Lake Outlet | 80 | 74 | 97 | 48 |
| 18 | Lake Ck | State Route 9 | 89 | 87 | 98 | 81 |
| 19 | Hansen Ck | Hoehn Rd | 70 | 62 | 93 | 53 |
| 20 | Hansen Ck | Northern State | 85 | 82 | 95 | 71 |
| 21 | Coal Ck | Hoehn Rd | 82 | 82 | 93 | 65 |
| 22 | Coal Ck | Hwy 20 | 91 | 89 | 97 | 81 |
| 23 | Wiseman Ck | Minkler Rd | 95 | 95 | 98 | 92 |
| 24 | Mannser Ck | Lyman Hamilton Hwy | 49 | 45 | 60 | 22 |
| 25 | Red Cabin Ck | Hamilton Cem Rd | 96 | 96 | 96 | 95 |
| 28 | Brickyard Ck | Hwy 20 | 68 | 68 | 79 | 47 |
| 29 | Skagit R | River Bend Rd | 85 | 82 | 95 | 73 |
| 30 | Skagit R | Cape Horn Rd | 92 | 90 | 96 | 88 |
| 31 | Drain Dist 20 floodgate | Francis Rd | 66 | 47 | 86 | 47 |
| 32 | Samish R | Thomas Rd | 75 | 70 | 87 | 57 |
| 33 | Alice Bay Pump Station | Samish Island Rd | 42 | 37 | 57 | 20 |
| 34 | Noname Slough | Bayview-Edison Rd | 32 | 22 | 62 | 1 |
| 35 | Joe Leary Slough | D'Arcy Rd | 22 | 22 | 33 | 1 |
| 36 | Edison Slough at school | W. Bow Hill Rd | 30 | 21 | 58 | 1 |
| 37 | Edison Pump Station | Farm to Market Rd | 21 | 16 | 35 | 1 |
| 38 | North Edison PS | North Edison Rd | 18 | 12 | 38 | 1 |
| 39 | Colony Ck | Colony Rd | 82 | 78 | 94 | 61 |
| 40 | Big Indian Slough | Bayview-Edison Rd | 24 | 19 | 38 | 2 |
| 41 | Maddox Sl/Big Ditch | Milltown Rd | 46 | 34 | 83 | 24 |
| 42 | Hill Ditch | Cedardale Rd | 76 | 70 | 93 | 55 |
| 43 | Wiley Slough | Wylie Rd | 28 | 19 | 56 | 1 |
| 44 | Sullivan Slough | La Conner-Bayview Rd | 47 | 36 | 79 | 33 |
| 45 | Skagit R – North Fork | Moore Rd | 92 | 90 | 99 | 82 |
| 46 | Skagit R – South Fork | Fir Island Rd | 91 | 89 | 98 | 85 |
| 47 | Swinomish Channel | County Boat Launch | 86 | 81 | 98 | 85 |
| 48 | Fisher Ck | Franklin Rd | 82 | 77 | 97 | 63 |

*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)

**Table 11. Number of sites in Water Quality Index (WQI) categories for Skagit County Monitoring Program (n = 40 sites)**

| Year | Green (WQI ≥ 80) | Yellow (WQI 40-79) | Red (WQI <40) |
|---|---|---|---|
| 2006 | 3 | 15 | 22 |
| 2007 | 6 | 17 | 17 |
| 2008 | 10 | 13 | 17 |
| 2009 | 17 | 11 | 12 |
| 2010 | 13 | 19 | 8 |
| 2011 | 20 | 9 | 11 |
| 2012 | 13 | 16 | 11 |

After several years of seemingly increasing numbers of water quality sampling sites in the "Green" category and reduced numbers of "Red" sites, 2012 data showed more sites in the "Yellow" category, while the "Red" site count remained the same.

Water quality during storm events remains problematical as the results from storm event monitoring in the Samish Basin associated with the Clean Samish Initiative continue to show excessive fecal coliform concentrations. More information on Samish water quality is included below.

**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 sampling time of day.

The period used for trends analysis was the nine 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 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 12. Complete trends analysis results can be found in Appendix C.

**Table 12. Trends Analysis Results**
**Summary of Significant Trends Detected in Skagit County Monitoring Program**
**2004-2012 Water Years**

| Site | Parameter | N | Slope | Z | Improving Trends | Deleterious Trends |
|---|---|---|---|---|---|---|
| 3 | DO | 228 | 0.226 | 5.026 | Increasing DO | |
| | DO % sat | 229 | 1.589 | 4.901 | Increasing DO % sat | |
| | MDO | 115 | 0.214 | 3.288 | Increasing DO | |
| | MDO % sat | 116 | 1.417 | 2.638 | Increasing DO % sat | |
| | Turb | 222 | 0.850 | 5.626 | | Increasing turbidity |
| | MTurb | 114 | 0.923 | 3.768 | | Increasing turbidity |
| | TP | 80 | 0.000 | 2.557 | | |
| | OP | 79 | 0.007 | 3.233 | | Increasing orthophos |
| 4 | pH | 225 | -0.037 | -4.797 | | |
| | MpH | 116 | -0.031 | -3.641 | | |
| | DO | 231 | 0.056 | 3.422 | Increasing DO | |
| | DO % sat | 232 | 0.225 | 2.077 | Increasing DO % sat | |
| | MDO | 117 | 0.070 | 3.045 | Increasing DO | |
| | MDO % sat | 117 | 0.238 | 2.213 | Increasing DO % sat | |
| | Temp | 233 | -0.100 | -2.155 | Decreasing temperature | |
| | FC | 231 | -27.320 | -5.105 | Decreasing fecal coliform | |
| | MFC | 115 | -48.280 | -4.136 | Decreasing fecal coliform | |
| | OP | 81 | 0.005 | 2.658 | | Increasing orthophos |
| | NH3 | 81 | 0.003 | 2.497 | | Increasing ammonia |
| 6 | pH | 223 | -0.048 | -5.592 | | |
| | MpH | 116 | -0.047 | -4.495 | | |
| | Temp | 232 | -0.127 | -2.614 | Decreasing temperature | |
| | MTemp | 117 | -0.125 | -2.307 | Decreasing temperature | |
| | Turb | 225 | 0.118 | 2.282 | | Increasing turbidity |
| | TP | 81 | 0.000 | 3.297 | | |
| | OP | 81 | 0.000 | 2.460 | | |
| | NH3 | 81 | 0.000 | 2.036 | | |
| 8 | pH | 225 | -0.048 | -5.532 | | |
| | MpH | 116 | -0.045 | -3.636 | | |
| | DO | 231 | -0.064 | -2.665 | | Decreasing oxygen |
| | MDO | 117 | -0.040 | -2.039 | | Decreasing oxygen |
| | DO % sat | 232 | -0.728 | -5.240 | | Decreasing oxygen |
| | MDO % sat | 117 | -0.720 | -4.191 | | Decreasing oxygen |
| | Turb | 225 | 0.298 | 2.175 | | Increasing turbidity |
| | FC | 233 | -2.341 | -2.843 | Decreasing fecal coliform | |
| | MFC | 117 | -6.184 | -2.947 | Decreasing fecal coliform | |
| | OP | 81 | 0.000 | 2.628 | | |

Table 12 (cont.)

| Site | Parameter | N | Slope | Z | Improving Trends | Deleterious Trends |
|---|---|---|---|---|---|---|
| 11 | pH | 227 | -0.026 | -2.421 | | |
| | FC | 234 | -0.155 | -2.629 | Decreasing fecal coliform | |
| | TP | 81 | 0.000 | -2.643 | | |
| | OP | 80 | 0.000 | 2.134 | | |
| | NH3 | 81 | 0.000 | 2.234 | | |
| 12 | MpH | 112 | -0.025 | -2.425 | | |
| | DO % sat | 215 | -0.363 | -2.173 | | Decreasing oxygen |
| | Temp | 217 | -0.142 | -2.793 | Decreasing temperature | |
| | FC | 216 | -0.441 | -2.301 | Decreasing fecal coliform | |
| | TP | 77 | 0.000 | 3.210 | | |
| | OP | 77 | 0.002 | 4.159 | | Increasing orthophos |
| 13 | pH | 221 | -0.027 | -3.231 | | |
| | MpH | 114 | -0.033 | -2.656 | | |
| | DO % sat | 228 | -0.377 | -2.502 | | Decreasing oxygen |
| | Temp | 230 | -0.134 | -2.927 | Decreasing temperature | |
| | TP | 80 | 0.000 | -1.968 | | |
| | OP | 80 | 0.001 | 4.118 | | Increasing orthophos |
| 14 | pH | 223 | -0.039 | -5.603 | | |
| | MpH | 115 | -0.036 | -5.050 | | |
| | Temp | 233 | -0.150 | -3.571 | Decreasing temperature | |
| | WQI | 77 | -2.399 | -2.919 | | Decreasing WQI |
| 15 | Turb | 226 | 0.132 | 3.053 | | Increasing turbidity |
| | MTurb | 115 | 0.115 | 1.966 | | Increasing turbidity |
| | MFC | 117 | 5.515 | 2.862 | | Increasing fecal coliform |
| | NO3+NO2 | 81 | 0.008 | 1.976 | | Increasing nitrate |
| | TP | 81 | 0.000 | 3.853 | | |
| | OP | 81 | 0.006 | 4.554 | | Increasing orthophos |
| | WQI | 77 | -2.494 | -4.131 | | Decreasing WQI |
| 16 | pH | 224 | -0.040 | -4.565 | | |
| | MpH | 115 | -0.040 | -3.537 | | |
| | DO % sat | 231 | -0.387 | -3.227 | | Decreasing oxygen |
| | MDO % sat | 117 | -0.451 | -2.793 | | Decreasing oxygen |
| | Temp | 233 | -0.140 | -3.156 | Decreasing temperature | |
| | Turb | 226 | 0.102 | 3.155 | | Increasing turbidity |
| | MTurb | 115 | 0.077 | 2.185 | | Increasing turbidity |
| | FC | 230 | -0.461 | -2.335 | Decreasing fecal coliform | |
| | TKN | 81 | 0.000 | 2.239 | | |
| | OP | 81 | 0.001 | 3.016 | | Increasing orthophos |
| | NH3 | 81 | 0.000 | 2.438 | | |
| 17 | pH | 224 | -0.036 | -4.390 | | |
| | MpH | 115 | -0.038 | -3.860 | | |
| | Turb | 226 | 0.094 | 3.924 | | Increasing turbidity |
| | MTurb | 115 | 0.090 | 2.895 | | Increasing turbidity |
| | FC | 229 | -0.168 | -2.130 | Decreasing fecal coliform | |
| | TP | 81 | 0.000 | 2.223 | | |

Table 12 (cont.)

| Site | Parameter | N | Slope | Z | Improving Trends | Deleterious Trends |
|---|---|---|---|---|---|---|
| 18 | pH | 224 | -0.024 | -2.866 | | |
| | MpH | 115 | -0.029 | -3.159 | | |
| | DO % sat | 231 | -0.385 | -3.168 | | Decreasing oxygen |
| | MDO % sat | 117 | -0.401 | -2.766 | | Decreasing oxygen |
| | Temp | 233 | -0.100 | -2.500 | Decreasing temperature | |
| | Turb | 226 | 0.065 | 2.654 | | Increasing turbidity |
| | FC | 231 | -0.669 | -1.738 | Decreasing fecal coliform | |
| | NO3+NO2 | 81 | 0.015 | 2.229 | | Increasing nitrate |
| | OP | 81 | 0.003 | 4.133 | | Increasing orthophos |
| | WQI | 78 | -0.459 | -2.716 | | |
| 19 | pH | 225 | -0.045 | -4.873 | | |
| | MpH | 116 | -0.037 | -3.774 | | |
| | Temp | 232 | -0.150 | -3.210 | Decreasing temperature | |
| | MTemp | 117 | -0.181 | -2.941 | Decreasing temperature | |
| | Turb | 223 | 0.183 | 3.451 | | Increasing turbidity |
| | MTurb | 115 | 0.166 | 2.390 | | Increasing turbidity |
| | TKN | 79 | 0.000 | 2.623 | | |
| | OP | 79 | 0.001 | 2.236 | | Increasing orthophos |
| | NH3 | 79 | 0.003 | 2.313 | | |
| 20 | pH | 225 | -0.044 | -5.231 | | |
| | MpH | 116 | -0.048 | -3.985 | | |
| | Temp | 233 | -0.166 | -4.028 | Decreasing temperature | |
| | MTemp | 117 | -0.159 | -3.100 | Decreasing temperature | |
| | TP | 81 | 0.000 | -3.428 | | |
| | OP | 81 | 0.001 | 2.661 | | Increasing orthophos |
| 21 | pH | 202 | -0.045 | -4.547 | | |
| | MpH | 108 | -0.037 | -3.157 | | |
| | Temp | 209 | -0.161 | -3.101 | Decreasing temperature | |
| | MTemp | 109 | -0.225 | -3.180 | Decreasing temperature | |
| | FC | 208 | -1.316 | -3.826 | Decreasing fecal coliform | |
| | MFC | 109 | -7.297 | -3.070 | Decreasing fecal coliform | |
| | OP | 71 | 0.001 | 3.431 | | Increasing orthophos |
| 22 | pH | 225 | -0.069 | -6.093 | | |
| | MpH | 114 | -0.067 | -4.338 | | |
| | DO % sat | 232 | -0.276 | -3.127 | | Decreasing oxygen |
| | MDO % sat | 117 | -0.288 | -2.660 | | Decreasing oxygen |
| | Temp | 233 | -0.136 | -3.155 | Decreasing temperature | |
| | MTemp | 116 | -0.165 | -2.849 | Decreasing temperature | |
| | OP | 79 | 0.000 | 2.920 | | |
| 23 | pH | 209 | -0.070 | -6.944 | | |
| | MpH | 111 | -0.078 | -4.661 | | |
| | Temp | 216 | -0.167 | -3.945 | Decreasing temperature | |
| | MTemp | 113 | -0.169 | -3.251 | Decreasing temperature | |
| | NO3+NO2 | 77 | -0.040 | -3.308 | | |
| | TP | 77 | 0.000 | -2.038 | | |
| | OP | 77 | 0.000 | 2.401 | | |

Table 12 (cont.)

| Site | Parameter | N | Slope | Z | Improving Trends | Deleterious Trends |
|---|---|---|---|---|---|---|
| 24 | pH | 227 | -0.027 | -3.127 | | |
| | DO | 233 | -0.111 | -3.493 | | |
| | MDO | 117 | -0.093 | -2.054 | | |
| | DO % sat | 234 | -0.844 | -3.644 | | Decreasing oxygen |
| | MDO % sat | 117 | -0.750 | -2.528 | | Decreasing oxygen |
| | Turb | 226 | 0.073 | 3.310 | | Increasing turbidity |
| | MTurb | 115 | 0.071 | 2.217 | | Increasing turbidity |
| | FC | 230 | -1.738 | -4.585 | Decreasing fecal coliform | |
| | MFC | 116 | -1.468 | -3.160 | Decreasing fecal coliform | |
| | OP | 81 | 0.004 | 2.565 | | Increasing orthophos |
| | NH3 | 81 | 0.000 | 2.942 | | |
| | WQI | 78 | 2.004 | 2.386 | Increasing WQI | |
| 25 | pH | 187 | -0.060 | -4.899 | | |
| | MpH | 101 | -0.063 | -3.838 | | |
| | Temp | 193 | -0.100 | -3.104 | Decreasing temperature | |
| | MTemp | 103 | -0.113 | -2.356 | Decreasing temperature | |
| | FC | 190 | 0.000 | -2.000 | | |
| | OP | 70 | 0.001 | 3.111 | | Increasing orthophos |
| 28 | DO | 174 | 0.068 | 2.025 | | |
| | MDO | 98 | 0.075 | 2.172 | | |
| | MDO % sat | 94 | 0.719 | 2.804 | | |
| | Turb | 170 | 0.213 | 2.241 | | Increasing turbidity |
| | MTurb | 97 | 0.393 | 2.807 | | Increasing turbidity |
| | NO3+NO2 | 62 | -0.052 | -2.665 | | |
| | OP | 62 | 0.005 | 3.107 | | Increasing orthophos |
| 29 | pH | 223 | -0.053 | -4.266 | | |
| | MpH | 116 | -0.040 | -3.264 | | |
| | DO % sat | 228 | -0.268 | -2.224 | | Decreasing oxygen |
| | Temp | 233 | -0.152 | -5.158 | Decreasing temperature | |
| | MTemp | 117 | -0.117 | -2.468 | Decreasing temperature | |
| | Turb | 226 | -0.350 | -3.151 | Decreasing turbidity | |
| | NO3+NO2 | 79 | 0.005 | 3.697 | | Increasing nitrate |
| | OP | 79 | 0.000 | 3.617 | | |
| 30 | pH | 226 | -0.050 | -5.222 | | |
| | MpH | 116 | -0.050 | -4.015 | | |
| | Temp | 233 | -0.159 | -4.602 | Decreasing temperature | |
| | MTemp | 117 | -0.150 | -3.911 | Decreasing temperature | |
| | Turb | 225 | -0.381 | -4.684 | Decreasing turbidity | |
| | MTurb | 115 | -0.547 | -3.674 | Decreasing turbidity | |
| | OP | 80 | 0.000 | 2.919 | | |
| 31 | pH | 136 | -0.050 | -2.837 | | |
| | MpH | 88 | -0.062 | -3.549 | | |
| | MTemp | 89 | -0.191 | -2.411 | Decreasing temperature | |
| | FC | 138 | -2.951 | -2.306 | Decreasing fecal coliform | |
| | MFC | 88 | -5.964 | -3.333 | Decreasing fecal coliform | |
| | OP | 47 | 0.005 | 2.018 | | Increasing orthophos |
| | NH3 | 47 | -0.007 | -2.236 | | |

Table 12 (cont.)

| Site | Parameter | N | Slope | Z | Improving Trends | Deleterious Trends |
|---|---|---|---|---|---|---|
| 32 | Temp | 234 | -0.142 | -3.053 | Decreasing temperature | |
| | MTemp | 118 | -0.151 | -2.843 | Decreasing temperature | |
| | Turb | 227 | 0.136 | 2.396 | | Increasing turbidity |
| | FC | 235 | -0.992 | -2.117 | Decreasing fecal coliform | |
| | OP | 81 | 0.002 | 2.442 | | Increasing orthophos |
| 33 | Temp | 236 | -0.200 | -3.222 | Decreasing temperature | |
| | MTemp | 117 | -0.205 | -3.359 | Decreasing temperature | |
| | TKN | 80 | 0.091 | 2.066 | | Increasing nitrogen |
| | OP | 79 | 0.018 | 2.161 | | Increasing orthophos |
| 34 | pH | 223 | -0.032 | -3.052 | | |
| | MpH | 115 | -0.032 | -2.575 | | |
| | Temp | 232 | -0.172 | -2.579 | Decreasing temperature | |
| | OP | 80 | 0.011 | 2.250 | | Increasing orthophos |
| | NH3 | 80 | -0.014 | -2.947 | Decreasing ammonia | |
| 35 | pH | 213 | 0.032 | 4.076 | | |
| | MpH | 111 | 0.033 | 3.578 | | |
| | Temp | 224 | -0.192 | -4.412 | Decreasing temperature | |
| | MTemp | 112 | -0.267 | -5.159 | Decreasing temperature | |
| | FC | 218 | -6.772 | -3.951 | Decreasing fecal coliform | |
| | MFC | 112 | -7.521 | -3.040 | Decreasing fecal coliform | |
| | TP | 77 | 0.007 | 2.157 | | Increasing phosphate |
| | WQI | 74 | 2.256 | 2.434 | Increasing WQI | |
| 36 | Temp | 231 | -0.201 | -3.185 | Decreasing temperature | |
| | MTemp | 118 | -0.281 | -2.644 | Decreasing temperature | |
| | OP | 80 | 0.011 | 2.298 | | Increasing orthophos |
| 37 | Temp | 233 | -0.140 | -2.380 | Decreasing temperature | |
| | MTemp | 117 | -0.169 | -2.121 | Decreasing temperature | |
| | FC | 236 | -1.661 | -2.066 | Decreasing fecal coliform | |
| | TKN | 81 | 0.140 | 3.300 | | Increasing nitrogen |
| | TP | 81 | 0.024 | 2.167 | | Increasing phosphate |
| | OP | 81 | 0.033 | 3.662 | | Increasing orthophos |
| 38 | MTemp | 116 | -0.152 | -2.689 | Decreasing temperature | |
| | TP | 80 | 0.030 | 2.366 | | Increasing phosphate |
| | OP | 80 | 0.051 | 4.687 | | Increasing orthophos |
| 39 | pH | 224 | -0.030 | -4.257 | | |
| | MpH | 116 | -0.027 | -2.541 | | |
| | DO | 232 | 0.054 | 2.689 | | |
| | Temp | 235 | -0.159 | -3.576 | Decreasing temperature | |
| | MTemp | 117 | -0.190 | -3.049 | Decreasing temperature | |
| | FC | 235 | -2.023 | -2.616 | Decreasing fecal coliform | |
| | MFC | 117 | -8.798 | -2.965 | Decreasing fecal coliform | |
| | TKN | 80 | 0.021 | 2.357 | | Increasing nitrogen |
| | OP | 80 | 0.005 | 3.092 | | Increasing orthophos |
| 40 | pH | 222 | -0.014 | -2.058 | | |
| | DO | 229 | 0.144 | 4.034 | Increasing oxygen | |
| | MDO | 113 | 0.181 | 4.541 | Increasing oxygen | |
| | DO % sat | 229 | 1.254 | 4.214 | Increasing oxygen | |

Table 12 (cont.)

| Site | Parameter | N | Slope | Z | Improving Trends | Deleterious Trends |
|---|---|---|---|---|---|---|
| 40 (cont) | MDO % sat | 115 | 1.403 | 3.722 | Increasing oxygen | |
| | Turb | 224 | 1.621 | 5.772 | | Increasing turbidity |
| | MTurb | 112 | 1.869 | 4.515 | | Increasing turbidity |
| | FC | 227 | 3.017 | 2.456 | | Increasing fecal coliform |
| | NO3+NO2 | 79 | 0.025 | 2.466 | | Increasing nitrate |
| | TP | 80 | 0.001 | 3.248 | | Increasing phosphate |
| 41 | Temp | 234 | -0.167 | -3.285 | Decreasing temperature | |
| | Turb | 227 | 0.298 | 3.188 | | Increasing turbidity |
| | MTurb | 114 | 0.264 | 2.125 | | Increasing turbidity |
| | OP | 81 | 0.003 | 2.955 | | Increasing orthophos |
| | WQI | 77 | 2.933 | 2.295 | Increasing WQI | |
| 42 | DO | 229 | 0.195 | 5.738 | Increasing oxygen | |
| | MDO | 114 | 0.233 | 4.987 | Increasing oxygen | |
| | DO % sat | 230 | 1.388 | 6.137 | Increasing oxygen | |
| | MDO % sat | 116 | 1.453 | 5.693 | Increasing oxygen | |
| | Temp | 232 | -0.122 | -2.136 | Decreasing temperature | |
| | MTemp | 115 | -0.220 | -3.785 | Decreasing temperature | |
| | Turb | 225 | 0.203 | 5.872 | | Increasing turbidity |
| | MTurb | 113 | 0.235 | 3.816 | | Increasing turbidity |
| | FC | 227 | 3.318 | 3.829 | | Increasing fecal coliform |
| | MFC | 115 | 4.794 | 2.785 | | Increasing fecal coliform |
| | NO3+NO2 | 81 | 0.023 | 2.498 | | Increasing nitrate |
| | OP | 81 | 0.006 | 3.601 | | Increasing orthophos |
| | NH3 | 81 | 0.003 | 2.311 | | Increasing ammonia |
| | TSS | 81 | 0.000 | 2.267 | | |
| 43 | pH | 217 | 0.023 | 3.283 | | |
| | MpH | 111 | 0.020 | 3.328 | | |
| | Temp | 225 | -0.125 | -2.954 | Decreasing temperature | |
| | Turb | 219 | 0.324 | 3.203 | | Increasing turbidity |
| | TKN | 78 | 0.053 | 2.369 | | Increasing nitrogen |
| | OP | 78 | 0.020 | 2.562 | | Increasing orthophos |
| 44 | pH | 182 | -0.030 | -2.766 | | |
| | DO | 185 | -0.261 | -3.258 | | Decreasing oxygen |
| | MDO | 94 | -0.232 | -2.824 | | Decreasing oxygen |
| | DO % sat | 188 | -2.772 | -3.608 | | Decreasing oxygen |
| | MDO % sat | 96 | -2.455 | -2.749 | | Decreasing oxygen |
| | Turb | 184 | 0.697 | 2.341 | | Increasing turbidity |
| | TP | 60 | 0.010 | 2.189 | | Increasing phosphate |
| 45 | DO | 216 | 0.032 | 2.400 | Increasing oxygen | |
| | Temp | 223 | -0.150 | -4.414 | Decreasing temperature | |
| | MTemp | 115 | -0.088 | -2.337 | Decreasing temperature | |
| | Turb | 216 | -0.538 | -4.656 | Decreasing turbidity | |
| | MTurb | 112 | -0.688 | -3.884 | Decreasing turbidity | |
| | NO3+NO2 | 77 | 0.005 | 2.927 | | Increasing nitrate |
| | TP | 77 | 0.000 | -3.086 | | |
| | OP | 77 | 0.000 | 2.745 | | |
| | NH3 | 77 | 0.000 | 2.614 | | |

Table 12 (cont.)

| Site | Parameter | N | Slope | Z | Improving Trends | Deleterious Trends |
|---|---|---|---|---|---|---|
| 46 | DO % sat | 226 | -0.251 | -2.661 | | Decreasing oxygen |
| | Temp | 228 | -0.152 | -4.607 | Decreasing temperature | |
| | MTemp | 115 | -0.151 | -4.074 | Decreasing temperature | |
| | Turb | 221 | -0.469 | -4.276 | Decreasing turbidity | |
| | MTurb | 113 | -0.506 | -3.193 | Decreasing turbidity | |
| | FC | 226 | 0.000 | -2.094 | | |
| | NO3+NO2 | 78 | 0.006 | 3.130 | | Increasing nitrate |
| | OP | 78 | 0.000 | 3.114 | | |
| | NH3 | 78 | 0.000 | 2.492 | | |
| 47 | pH | 224 | -0.022 | -4.489 | | |
| | MpH | 115 | -0.021 | -3.568 | | |
| | Temp | 234 | -0.100 | -4.093 | Decreasing temperature | |
| | MTemp | 116 | -0.057 | -2.308 | Decreasing temperature | |
| | Turb | 226 | -0.131 | -2.242 | Decreasing turbidity | |
| | NO3+NO2 | 81 | 0.012 | 2.770 | | Increasing nitrate |
| | TP | 81 | 0.000 | 2.778 | | |
| | OP | 81 | 0.008 | 4.932 | | Increasing orthophos |
| | WQI | 66 | -1.000 | -2.736 | | Decreasing WQI |
| 48 | pH | 225 | -0.025 | -3.313 | | |
| | MpH | 115 | -0.022 | -2.542 | | |
| | OP | 81 | 0.015 | 2.152 | | Increasing orthophos |
| | NH3 | 81 | -0.003 | -2.454 | Decreasing ammonia | |

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 measured or calculated parameters (such as monthly averages) at each site, for a total of 760 tests. Of those, 293 tests showed a statistically significant trend at the 95% confidence level. Trends judged as improving (e.g. increased dissolved oxygen, reduced temperature) made up 102 of the significant trends. Deleterious trends (e.g. reduced dissolved oxygen, increased nutrients) also accounted for 98 of the significant trends. The remaining 93 trends were increasing or decreasing pH or monthly pH, or nutrient trends where the slope was zero. 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. We also eliminated any pH trends and nutrient trends with a slope of zero. In this truncated data set, there were 114 significant trends, with 45 trends identified as representing improved conditions and 69 identified as deleterious. The proportion of deleterious trends were about the same in ag and non-ag sites.

Last year's report indicated 92 improving and 92 declining trends for this data set. It is important to remember that these statistics are calculated over the life of the study, so while the 2012 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 2012.

Twenty-two 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 an increase from last year, when ten stations had significant decreases in water temperature. No site showed a significant increase in monthly mean temperature.

Four of the 40 sites showed a significant increasing trend in mean monthly dissolved oxygen over the life of the study, one more than last year. Two 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 any temperature reduction. There were two stations with a declining trend in dissolved oxygen, and one site showed declining percent saturation.

Five sites showed a significantly decreasing trend in monthly fecal coliform, including three sites in the Samish basin, while two sites had significantly increasing fecal coliform. Neither site with increasing fecal coliform was in the Samish Basin.

Three sites showed a significant increasing trend in Water Quality Index (WQI). This can be seen as a general indicator of improving water quality. Three other sites showed a decreasing trend in WQI, an indicator that water quality could be declining.

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. There were also many cases where a statistically significant trend in nutrient values was found, but the calculated slope for the nutrient was zero. This is seen as a statistical anomaly based on the number of "ties" in the data, in our case samples that had no detectable nutrients (Younos, 2001). These cases were not included in the tabulation of improving or deleterious trends.

Many of the nutrient trends were increasing orthophosphate. These observations were widespread and included both areas with human activities, reference locations (Red Cabin Creek), and even Swinomish Channel. Due to the widespread nature of these trends, both within and external to the agricultural areas, Skagit County will be examining the data set and lab activities to determine if changes in lab procedures may explain these orthophosphate trends.

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 2020e) 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 8424) 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 30 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 13 summarizes the results of the duplicate analyses for the 2010 water year. Although duplicate samples continue to be taken, this analysis was not completed for this annual report.

Variability has remained relatively constant over the life of this program, so the 2010 results are thought to be representative of overall variability in our water quality parameters.

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.

Fecal coliform duplicate sampling changed last year at EPA's request. Duplicates are collected as follows: A sterile 500-ml sample collection bottle is filled and emptied twice with water from the sampling site to serve as rinses for any residual sterilant. 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.

**Table 13. 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

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 in 2010 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 continued during the 2012 water year, and will be summarized in a separate Clean Samish Initiative report. In addition, County staff, in cooperation with the Department of Ecology, have conducted site visits in areas where water quality sampling results indicate pollution sources are present. These visits form the core of the PIC program and are summarized in the separate quarterly Clean Samish reports. Samish sampling results are also available on the County web site at this address: http://www.skagitcounty.net/Common/asp/default.asp?d=PublicWorksCleanWater&c=General&P=samplearchive.htm

**Annual Report Summary**

The Skagit County Monitoring Program completed the ninth water year of sampling in September 2012. 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 more deleterious trends evident this year. 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.

Figure 3. Chinook salmon in the Samish River

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