Skagit County Monitoring Program

SCMP

Annual Report

2020 Water Year
(October 2019 – September 2020)

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Definitions

Ag-CAO	-	Critical Areas Ordinance: Ongoing Agriculture
Ag-NRL	-	Agricultural Natural Resource Lands
BMP	-	Best Management Practice
County	-	Skagit County
CSI	-	Clean Samish Initiative
CV	-	Coefficient of Variation
DO	-	Dissolved Oxygen
Ecology	-	Washington State Department of Ecology
EPA	-	Environmental Protection Agency
FC	-	Fecal Coliform
GMHB	-	Growth Management Hearings Board
MPN	-	Most Probable Number
NH3	-	Ammonia
NO3+NO2	-	Nitrate + Nitrite
NTU	-	Nephelometric Turbidity Units
OP	-	Ortho-Phosphorous
pH	-	Power of Hydrogen
PIC	-	Pollution Identification and Correction
QAPP	-	Quality Assurance Project Plan
RR-NRL	-	Rural Resource Natural Resource Lands
RSD	-	Relative Standard Deviation
SCC	-	Skagit County Code
SCMP	-	Skagit County Monitoring Program
7-DADMax	-	7-Day Average of Daily Maximum Temperatures
SRC	-	Site Report Card
TKN	-	Total Kjeldahl Nitrogen
TMDL	-	Total Maximum Daily Load
TP	-	Total Phosphorous
TSS	-	Total Suspended Solids
VSP	-	Voluntary stewardship Program
WQI	-	Water Quality Index
WRC	-	State of Washington Water Research Center
WY	-	Water Year

Executive Summary

Skagit County Public Works has completed the seventeenth year of water quality monitoring under the Skagit County Water Quality Monitoring Program, and this is the seventeenth annual report, for the 2020 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 39 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. The Samish and Skagit Rivers have shown drastic improvement and a strong ratio of positive trends over the course of this program. Most of the substandard water quality occurs in slow-moving agricultural sloughs and in creeks that have low flow in the warmer months. Further investigation is ongoing to determine the causes of poor water quality in each case. Some cases may represent natural conditions rather than human-caused problems.

Trends analyses looking at water temperature, dissolved oxygen, fecal coliform concentration, and other metrics reveal strong differences between watersheds and timeframes across the county. Some watersheds have a majority of negative trends across a seventeen year period, but show a majority of positive trends in a more recent timeframe, such as the last five years.

The majority of trends in fecal coliform reduction county-wide are positive over all three analyzed time periods, and can only be a result of the hard work and dedication of the residents, farmers, tribes, government, environmental groups, establishing and enforcing strong regulations, and continued vision for a clean and sustainable environment that the citizens of Skagit County and the state of Washington continually portray. These improvements in water quality will continue to shine as an example for other communities and states across the country. Dissolved oxygen trends across all timeframes across the valley show a majority of positive increase, despite an abundant increase in water temperatures. This may suggest large reductions on biological oxygen demand in the watercourses, and is great news for salmon.

It is the intention of the author that this new format of report be used as the means to sit down and form action plans to address trends in watercourses and sampling sites. The site report cards (SRCs), trends maps, and tabled trends summaries can paint a picture of the overall water quality at each site, in an effort to inform future action and to most efficiently direct public resources and efforts.

The Skagit County Water Quality Monitoring Program has now collected 17 years of high-quality data. Questions on the program can be addressed to Kevin Jackman at kevinj@co.skagit.wa.us or 360-416-1443

What's New and What's Next

There was a lot of new content in last year's report, there is more in this year's report, and sure enough, there will be more on the way in next year's report!

Changes in this year's Water Year 2020 report include:

- Historical site sampling times – See the time windows that the ambient sites have been sampled in over seventeen years, and in the most recent year.
- Historical precipitation and air temperatures – See how much rain has been recorded every month for the entire seventeen year program, and what the average monthly air temperature was. Summary statistics show how a month or year compares to the averages and extremes of the others.
- Site Report Cards have several changes:
    - Addition of more sensitive statistical findings to complement the Up or Down arrows in the trends analysis graphics
    - Removal of the traditional line graphs for water temperature, dissolved oxygen, and fecal coliform. As the program completes more and more years of data collection, traditional line graphs become ungainly and difficult to visually interpret
    - Addition of 3D graphs to replace traditional line graphs. These graphs offer a greater visual understanding of a very large dataset that exhibits a lot of seasonality.
    - Addition of boxplots to assist in visualization of the historical seasonality of each month at each sampling site. This is a different arrangement of information than the 3D plots, and makes a great complement.
    - An introduction section to help assist in interpreting the new plots and figures.

Changes in the works for next year's report include:

- A sampling dataset that includes fecal coliform AND E. coli sampling at every site, all year. The new state standard for recreational water quality, as set forth by the State Department of Ecology, is E. coli. The existing standard on which the outstanding TMDLs were created remains fecal coliform. The standard for shellfish harvesting, as determined by the State Department of Health, will remain as fecal coliform as well. To achieve the aims of all three of these standards, the SCMP will now sample both metrics at each site.
- Addition of new sampling sites and removal of some existing sampling sites. The SCMP is adapting to new changes and information, and will adjust the sites on the sampling route according to their necessity and value to the program and the public.

Skagit County Monitoring Program Annual Report

2020 Water Year
(October 2019-September 2020)

Introduction

The Skagit County Monitoring Program (SCMP) began in October 2003 as part of Skagit County's (County) program to assess the effectiveness of Skagit County Code (SCC) Chapter 14.24.120: Critical Areas Ordinance for Areas of Ongoing Agriculture (Ag-CAO). 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 (GMHB).

The ordinance requires farmers to "do no harm" to adjacent watercourses and relies on specific watercourse protection measures and more generalized best management practices (BMPs) to protect the watercourses instead of requiring buffers. 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 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 GMHB. 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 2020 Water Year (WY).

R20040211 also required the County to conduct a triennial review of the Ag-CAO, including the water quality monitoring program, to seek public comment 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 were studied. The legislature subsequently passed additional legislation to extend the "time out" to 2011. In 2011, the Washington State Legislature adopted the recommendations from one research group studying the critical areas regulations and created the Voluntary Stewardship Program (VSP). Skagit County enrolled in the program in 2012. Any county that enrolled agreed to maintain existing critical areas protections and ensure streams are protected using voluntary measures.

Sampling Locations

Figure 1 is a map with the sampling sites monitored by the SCMP, while **Table 1** and **Table 2** list the sampling site's names and their designations. Forty sites are currently included in the program. These sites are located primarily in agricultural zones, designated by the County as Agriculture-Natural Resource Lands (Ag-NRL) and Rural Resource-Natural Resource Lands (RR-NRL). Other sites were selected 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 SCMP was designed to determine current conditions and long-term trends in water quality at these sampling locations. The data is also suitable for determining compliance with state water quality standards.

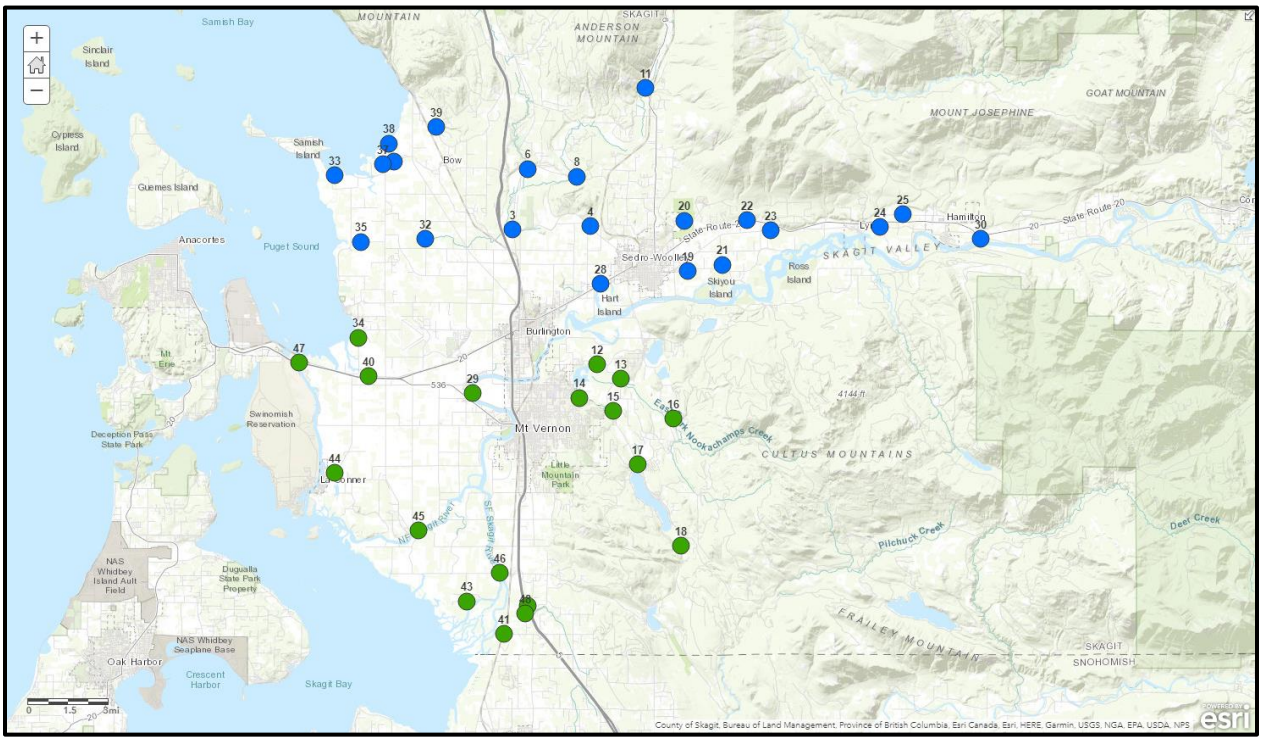


Figure 1 – Ambient sampling sites in the SCMP

A secondary purpose for some of the sites included in the SCMP is to provide data to the Washington State Department of Ecology (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.

Table 1 - Sample site locations and types in the SCMP

Site Number	Watercourse	Location	Latitude	Longitude	Site Type[1]
3	Thomas Creek	Old Hwy 99 N	48.526	-122.339	3
4	Thomas Creek	F&S Grade Rd	48.528	-122.276	2
6	Friday Creek	Prairie Rd	48.559	-122.327	4
8	Swede Creek	Grip Rd	48.555	-122.287	3
11	Samish River	State Route 9	48.602	-122.231	1
12	Nookachamps Creek	Swan Rd	48.454	-122.270	3,6
13	E.F. Nookachamps Creek	State Route 9	48.446	-122.251	3,6
14	College Way Creek	College Way	48.436	-122.286	4
15	Nookachamps Creek	Knapp Rd	48.429	-122.258	2,6
16	E.F. Nookachamps Creek	Beaver Lake Rd	48.424	-122.208	2,6
17	Nookachamps Creek	Big Lake Outlet	48.400	-122.237	1,6
18	Lake Creek	State Route 9	48.356	-122.202	1,6
19	Hansen Creek	Hoehn Rd	48.504	-122.197	3,6
20	Hansen Creek	Northern State	48.531	-122.199	1,6
21	Coal Creek	Hoehn Rd	48.507	-122.169	3
22	Coal Creek	Hwy 20	48.531	-122.149	1
23	Wiseman Creek	Minkler Rd	48.526	-122.130	1
24	Mannser Creek	Lyman Hamilton Hwy	48.528	-122.041	2
25	Red Cabin Creek	Hamilton Cem. Rd	48.534	-122.023	1
28	Brickyard Creek	Hwy 20	48.497	-122.268	4
29	Skagit River	River Bend Rd	48.439	-122.372	5,6
30	Skagit River	Cape Horn Rd	48.521	-121.960	5
32	Samish River	Thomas Rd	48.521	-122.410	3
33	Alice Bay Pump Station	Samish Island Rd	48.555	-122.483	3
34	No Name 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	-122.436	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 Creek	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	Sullivan Slough[2]	La Conner-Whitney	48.395	-122.485	3
45	Skagit River – North Fork	Moore Rd	48.364	-122.416	5,6
46	Skagit River – South Fork	Fir Island Rd	48.342	-122.349	5,6
47	Swinomish Channel	County Boat Launch	48.455	-122.512	7
48	Fisher Creek	Franklin Rd	48.320	-122.328	3,6

[1]See Table 2 for site type descriptions
[2]Site 44 was moved to its current location in June, 2005. See text for details

Table 2 - Sample site type descriptions for the SCMP

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

Sample Site Revisions

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 is used to help interpret trends in water quality for sites continued in the SCMP. 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. Several intermediate sites on the Samish River were discontinued, leaving one upstream and one downstream site on the Samish.

Three sample sites were moved from their original locations as delineated in the Quality assurance Project Plan (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 tide gate 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 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 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 (FC) 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.

For the 2017 season, Skagit County re-designated two sites to better reflect current land use patterns: Site 16 (East Fork Nookachamps Creek) was moved from Ag-Upstream to Ag-Midstream due to some agricultural activity directly upstream of the sample location. Site 23 (Wiseman Creek) was moved from Ag-Midstream to Ag-Upstream due to the cessation of agricultural activities upstream of the sample location.

Results from the first sixteen years of this program have been reported previously (Skagit County 2004-2019). This current report contains data and analysis from water years 2004 – 2020.

Sampling Frequency

Ambient Sampling

Weekly or bi-weekly sampling on a regular schedule is often referred to as ambient sampling to distinguish it from storm sampling, which takes place in response to heavy rain events. All ambient sampling trips were conducted on schedule during the 2020 water year, beginning in October 2019. Sampling takes place on a different day each week, depending on scheduling and logistics.

Storm Sampling

As part of its Pollution Identification and Correction (PIC) Program, 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 ambient sampling events to preclude undue influence of storm events on ambient trends analysis.

Clean Samish Initiative

The Clean Samish Initiative (CSI) was established by Ecology in the fall of 2008 to foster cooperation between local, state, tribal, and federal agencies, non-governmental groups, and citizens to address FC pollution in the Samish Bay Watershed. Excess FC pollution in the

Samish River and other bay tributaries has resulted in numerous closures of the commercial shellfish beds in Samish Bay. The CSI 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 PIC project in the Samish Basin, incorporating CSI work plan elements into a program designed to locate and eliminate FC pollution in the Samish Basin.

The CSI grew out of Ecology's TMDL activities in the Samish Basin. Ecology sampling demonstrated that the Samish River was the largest source of FC 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 determined that the river was, and continues to be, the most important pollution source for Samish Bay.

2008 Review by the 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 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 PIC program), increased use of stream discharge information, and some of the statistical analysis recommendations.

Funding

A proposal was submitted in February 2003 to Ecology for consideration in its 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, fiscal year 2004 through fiscal year 2008.

The Centennial Clean Water Grant, that funded the program at 75%, ended in December 2008, with the remaining 25% having come from County funds. Work since that date has been funded by Skagit County's Clean Water Program (CWP). Skagit County has received some EPA funding to address Samish Bay watershed FC issues, but the core activities of the SCMP will continue to be funded out of the CWP.

Methods

Standard water quality monitoring methods are used in the SCMP. The methods are derived from several sources, including guidance from Ecology and the EPA. A brief description of monitoring procedures follows, and detailed monitoring procedures can be found in the QAPP developed for the program (Skagit County 2004b).

Each site in the monitoring program is visited every two weeks. At each visit, dissolved oxygen (DO), temperature, pH, turbidity, conductivity, and salinity are measured and samples are obtained for FC determinations. Additional water samples are obtained for laboratory quantification of plant nutrients (total nitrogen (TKN), ammonia (NH3), nitrate (NO3), nitrite (NO2), total phosphorus (TP), orthophosphate (OP), and total suspended solids (TSS)) 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 through the length of the program.

Data is collected on paper field sheets and later entered into an electronic database which is then checked for accuracy against the original data sheets. Microsoft Excel spreadsheets are used for data summary and analysis. These spreadsheets are also published on the County's web site: http://www.skagitcounty.net/SCMP

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 SCMP 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 should be undertaken to determine if the they 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 conditions that are likely 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 DO. 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 SCMP 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 for this report was computed using Sanitas 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 the SCMP by the WRC. 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.

The SCMP completed trends analysis via the Seasonal Kendall's Test for 18 key parameters or calculated factors at each sampling location. The parameters tested include pH, DO, DO% saturation, temperature, turbidity, FC, NH3, NO3+NO2, TP, OP, TKN, and TSS. Temperature data from biweekly sampling visits were used for this analysis instead of continuous data collected during the summer months because the 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 bi-weekly 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.

Three periods were analyzed for trends in this report: The 17 full years of SCMP data, the most recent ten years of data, and the most recent five years of data. Analyzing trends over three different timeframes allows for a more detailed picture of what changes have been occurring across the county. For example, a creek may exhibit a small trend in increasing DO from 17 years ago as compared to now, but it may also show a strong trend in decreasing DO from five years ago as compared to now. Analyzing a combination of time periods reveals a clearer picture of what is happening than can be ascertained from a single trend over the course of 17 years.

Several sites have extended dry periods during most summers and/or are flooded during high water events and not sampled. The Sanitas trends analysis program was unable to compute trends based on 12 seasons for those sites due to the consistent lack of data for the dry or flooded periods. For those sites, trends were calculated based on four seasons, beginning in January, April, July, and October. All trends analyses on plant nutrient data mentioned above are also performed using four seasons, as these are only sampled quarterly.

Data used for the Seasonal Kendall's Test can be subject to autocorrelation, where each successive data point is correlated with the previous point. This situation usually occurs when samples are collected more frequently than monthly. For the SCMP, DO, temperature, and FC 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. Our approach for these parameters has been to conduct the analysis using all data, and repeat the analysis using monthly averages to avoid autocorrelation. 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 all parameters, significant or not, can be found in Appendix C.

Data Quality

Quality Assurance Project Plan (QAPP)

The SCMP operates under a QAPP that was approved by Ecology in 2003. This plan details sampling strategies, equipment to be used, and all other aspects of the sampling program. Ecology approval of the QAPP was required in order for Skagit County to be eligible for grant funds.

Equipment Calibration and Maintenance

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

The pH meter (Hanna Instruments Model 8314) is calibrated on the morning of each sampling trip. The pH meter is recalibrated during the trip if questionable results are obtained.

The DO/temperature/conductivity meter (YSI Model 2030 Pro) is calibrated for DO using the built-in calibration chamber (water-saturated air). The meter is recalibrated to local elevation at each sample site prior to sampling.

The DO meter probe is deployed in areas with sufficient current (> 0.5 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 whenever possible with sample containers rinsed at least three times with sample water, and are analyzed immediately.

Lab Samples

Laboratory samples for nutrients are collected using clean equipment and proper procedures, 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 at least three times with the water to be sampled. The sample is then 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 ice until they are picked up by the lab on the same day.

Samples for FC are collected directly into sterile bottles and transported under ice to the laboratory within eight hours of collection.

Personnel

The project manager performs the majority of samplings that generate data for this report. Any other staff that perform samplings and collections are adequately trained by the project manager according to EPA-approved sampling methods prior to sampling. Due to regular

staff turnover and availability of assisting staff members, some staff may collect sample data only once, though repeated participation and experience with the project manager is preferred when possible.

Duplicate Analysis

Duplicate samples are collected for FC at a 20% rate and for selected nutrients at a 10% rate. Selected nutrient duplicates (TP, OP, NO3, and/or NH3) are intended to provide a precision estimate for all the nutrient analyses.

Table 3 summarizes the results of the duplicate analyses for the 2020 water year, using the coefficient of variation (CV) statistic. Variability in FC was above the original target level set out in the 2003 QAPP, of 33. However, the annual average across this program is 44, with a very small annual standard deviation of 3. A score of 41 is on the very lowest end of this program's history. In this report, coefficient of variation is considered synonymous with relative standard deviation (RSD).

The high variability of the FC results is at least partially due to the use of the Most Probable Number (MPN) analysis technique. This method was chosen for the SCMP because the Skagit County Health Department laboratory was certified for the method, and because it is reportedly more reliable for samples with high turbidity, which are often encountered in the SCMP (Michaud 1991). The program continued using MPN when it switched to Edge Analytical in 2009 to maintain data comparability. Fecal coliform variability in the SCMP, although higher than the initial target level, is similar to that seen in other studies in Washington.

Table 3 - Data quality duplicate analysis for 2020 Water Year

		Coefficient of Variation (RSD)	
Parameter	**n**	**2020 Results**	**Target**
Fecal Coliform	176*	41.0	33[1]
Total Phosphorus	3	5.1	10 [2]
Orthophosphate	13	7.7	10 [2]
Nitrate	8	3.0	10 [2]
Ammonia	8	7.5	10 [2]

*Four weeks on each route (eight weeks total) were missed due to COVID-19, resulting in the absence of 32 duplicates (typically 208 for the year).

[1] Target precision as listed in 2003 QAPP
[2] 10% CV target was listed for all nutrients

Site Sampling Times

The SCMP maintains sampling times as a temporal control for data analysis. The higher the precision of sampling time each week, the better. This is an exceptionally difficult task over such a long time period. Unexpected situations have to be expected, and it is common to experience equipment problems, staff availability issues, bad weather, injuries, flat tires, closed roads, and inaccessible watercourses. Despite all of these regularly-encountered obstacles, the SCMP has maintained remarkably small sampling windows across 17 years.

Route 1 - All 17 years combined					
Site	Mean	Min	Max	Range (hrs)	n
28	8:21	7:30	9:40	2:10	190
22	8:39	7:45	10:05	2:20	230
25	8:57	8:10	10:20	2:10	203
30	9:09	8:20	10:30	2:10	230
24	9:26	8:35	10:50	2:15	228
23	9:43	8:50	11:00	2:10	211
21	9:58	9:00	11:20	2:20	208
19	10:10	9:15	11:30	2:15	216
20	10:24	9:15	12:00	2:45	229
11	10:48	9:35	12:05	2:30	230
8	11:28	10:00	12:55	2:55	229
4	11:52	10:15	13:35	3:20	228
3	12:07	10:30	13:50	3:20	228
6	12:20	10:50	14:05	3:15	230
39	12:43	11:05	14:20	3:15	227
36	12:57	11:20	14:35	3:15	229
38	13:12	11:35	14:50	3:15	227
37	13:27	11:50	15:05	3:15	228
33	13:42	12:05	15:20	3:15	226
35	13:56	12:25	15:40	3:15	229
32	14:10	12:35	15:50	3:15	230

Table 4 – Historical sampling times for Route 1, which primarily samples the northern half of Skagit County. The table on the left includes all years of the program that sampling times were recorded. The table on the right is from the most recent water year.

Route 1 - Water Year 2020					
Site	Mean	Min	Max	Range (hrs)	n
28	7:53	7:30	8:20	0:50	14
22	8:10	7:45	8:40	0:55	22
25	8:30	8:10	9:00	0:50	16
30	8:44	8:20	9:15	0:55	22
24	9:04	8:40	9:45	1:05	20
23	9:19	8:55	10:00	1:05	21
21	9:36	9:15	10:15	1:00	20
19	9:51	9:25	10:30	1:05	20
20	10:11	9:50	10:55	1:05	21
11	10:36	10:15	11:20	1:05	22
8	10:56	10:35	11:40	1:05	22
4	11:13	10:50	11:55	1:05	22
3	11:32	11:10	12:15	1:05	22
6	11:47	11:20	12:30	1:10	22
39	12:04	11:35	12:45	1:10	22
36	12:22	11:50	12:55	1:05	22
38	12:38	12:05	13:15	1:10	22
37	12:56	12:20	13:35	1:15	22
33	13:14	12:39	13:55	1:16	22
35	13:32	12:50	14:20	1:30	22
32	13:47	13:08	14:40	1:32	22

Route 1 primarily samples the northern half of the county, while Route 2 primarily covers the southern half. Throughout the years, some short-term project-oriented sites were added in to the sampling days, and those contributed to wider variation in sampling times for certain sites on the routes over the years.

Route 2 - All 17 years combined					
Site	Mean	Min	Max	Range (hrs)	n
29	8:24	7:15	9:44	2:29	228
40	8:51	7:50	10:13	2:23	225
34	9:04	8:05	10:26	2:21	224
47	9:18	8:20	10:40	2:20	231
44	9:36	8:35	11:00	2:25	229
45	10:01	8:55	11:40	2:45	228
43	10:20	9:00	11:56	2:56	231
46	10:35	9:10	12:07	2:57	229
41	10:50	9:25	12:30	3:05	231
48	11:02	9:35	12:47	3:12	231
42	11:17	9:45	13:04	3:19	229
18	11:47	10:10	13:40	3:30	229
17	12:03	10:25	14:00	3:35	229
16	12:24	10:40	14:19	3:39	229
15	12:44	10:55	14:46	3:51	229
13	12:58	11:05	15:01	3:56	228
12	13:12	11:20	15:30	4:10	226
14	13:29	11:30	15:30	4:00	227

Table 5 - Historical sampling times for Route 2, which primarily samples the southern half of Skagit County. The table on the left includes all years of the program that sampling times were recorded. The table on the right is from the most recent water year.

Route 2 - Water Year 2020					
Site	Mean	Min	Max	Range (hrs)	n
29	7:46	7:30	8:04	0:34	20
40	8:15	7:50	8:34	0:44	22
34	8:30	8:05	8:50	0:45	22
47	8:49	8:25	9:10	0:45	22
44	9:09	8:45	9:30	0:45	21
45	9:37	9:15	10:00	0:45	22
43	9:58	9:35	10:20	0:45	22
46	10:14	9:50	10:40	0:50	22
41	10:31	10:05	10:55	0:50	22
48	10:44	10:20	11:10	0:50	22
42	11:00	10:35	11:25	0:50	22
18	11:27	11:00	11:50	0:50	22
17	11:44	11:15	12:10	0:55	22
16	12:09	11:35	12:35	1:00	22
15	12:29	11:55	12:55	1:00	22
13	12:46	12:05	13:20	1:15	22
12	13:02	12:20	13:35	1:15	21
14	13:33	12:35	14:20	1:45	21

Annual Rainfall and Air Temperatures

Monthly precipitation totals and average air temperatures were collected from the Washington State University AgWeatherNet Mount Vernon station for the entire 17 water years of this program and organized into tables. Summary statistics are calculated on the right for each month and below for each year. There is a wealth of information in these tables that can possibly help lend interpretation to changes in water quality geographically over time.

	WY 2004	WY 2005	WY 2006	WY 2007	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	WY 2013	WY 2014	WY 2015	WY 2016	WY 2017	WY 2018	WY 2019	WY 2020
October	5.34	2.71	4.01	1.98	4.82	1.37	5.67	1.76	1.96	3.87	1.51	6.07	3.39	5.26	5.39	2.32	4.21
November	4.94	6.84	4.20	5.61	2.68	5.55	5.31	3.74	4.67	3.89	3.48	3.90	7.85	5.99	6.22	4.20	2.14
December	2.87	4.36	3.36	3.05	3.71	3.18	1.25	3.26	1.25	3.52	2.34	3.73	7.05	3.21	3.76	3.79	3.50
January	4.01	4.02	6.54	5.47	2.75	3.79	2.81	6.01	2.92	5.13	4.70	4.69	3.21	1.62	4.79	1.81	5.90
February	1.35	2.92	3.2	2.96	2.91	1.25	1.25	1.72	4.49	2.02	3.89	2.97	4.63	3.18	5.78	2.27	4.82
March	3.44	2.77	1.51	4.52	4.36	2.24	2.16	3.37	3.77	2.10	4.45	2.51	3.88	5.01	2.79	1.35	2.84
April	0.28	4.11	3.16	0.89	2.40	2.81	2.53	3.90	4.31	4.60	3.26	1.48	2.17	3.00	4.73	2.45	1.61
May	3.65	1.73	2.24	1.09	2.09	2.24	4.57	4.17	2.4	2.58	3.68	0.60	1.27	2.36	0.35	0.88	3.13
June	1.80	1.90	1.10	1.58	2.25	0.16	1.66	0.91	3.14	1.27	1.14	0.61	2.78	0.94	1.52	1.42	3.07
July	0.64	0.74	0.82	1.27	0.64	0.51	0.05	1.39	1.3	0.00	1.29	0.11	0.59	0.01	0.04	0.83	0.83
August	6.29	2.22	0.23	0.81	2.23	0.52	1.17	0.42	0.01	1.34	0.88	1.46	2.88	0.04	0.17	0.86	0.64
September	3.27	1.96	1.78	2.36	0.50	1.31	2.87	0.87	0.14	4.10	2.64	2.12	1.32	1.59	1.36	5.24	1.07

Raw Data Source: WSU AgWeatherNet Mount Vernon Station

	Total	Low	High	Mean
October	61.64	1.37	6.07	3.63
November	81.21	2.14	7.85	4.78
December	57.19	1.25	7.05	3.36
January	70.17	1.62	6.54	4.13
February	51.61	1.25	5.78	3.04
March	53.07	1.35	5.01	3.12
April	47.69	0.28	4.73	2.81
May	39.03	0.35	4.57	2.30
June	27.25	0.16	3.14	1.60
July	11.06	0.00	1.39	0.65
August	22.17	0.01	6.29	1.30
September	34.50	0.14	5.24	2.03
	556.59	0.00	7.85	2.79

	WY 2004	WY 2005	WY 2006	WY 2007	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	WY 2013	WY 2014	WY 2015	WY 2016	WY 2017	WY 2018	WY 2019	WY 2020	Mean	Low	High
Annual	37.88	36.28	32.15	31.59	31.34	24.93	31.30	31.52	30.36	34.42	33.26	30.25	41.02	32.21	36.90	27.42	33.76	32.68	24.93	41.02
Low	0.28	0.74	0.23	0.81	0.5	0.16	0.05	0.42	0.01	0	0.88	0.11	0.59	0.01	0.04	0.83	0.64	0.37	0	0.88
High	6.29	6.84	6.54	5.61	4.82	5.55	5.67	6.01	4.67	5.13	4.7	6.07	7.85	5.99	6.22	5.24	5.9	5.83	4.67	7.85
Mean	3.16	3.02	2.68	2.63	2.61	2.08	2.61	2.63	2.53	2.87	2.77	2.52	3.42	2.68	3.08	2.29	2.81	2.73	2.08	3.42
Mean Wet (Oct-Apr)	3.18	3.96	3.71	3.50	3.38	2.88	3.00	3.39	3.34	3.59	3.38	3.62	4.60	3.90	4.78	2.60	3.57	3.55	2.60	4.78
Mean Dry (May-Sep)	3.13	1.71	1.23	1.42	1.54	0.95	2.06	1.55	1.40	1.86	1.93	0.98	1.77	0.99	0.69	1.85	1.75	1.58	0.69	3.13
Seasonal Extremes	1.01	2.32	3.01	2.46	2.19	3.04	1.45	2.19	2.39	1.93	1.75	3.70	2.60	3.94	6.95	1.41	2.04	2.65	1.01	6.95

No data, filled in with mean value
Neutral value is within +- 0.5 of mean
Greater than 0.5 above mean
Greater than 0.5 below mean

Table 6 - Monthly precipitation totals for the entire history of the Skagit County Monitoring Program. Cells are shaded blue or red to illustrate above and below average rainfall for a month, respectively. The threshold of 0.5 inches of rain to constitute an "average" shading of grey is arbitrarily chosen and does not constitute an authoritative metric.

Some of the most interesting statistics on **Table 6** are at the bottom: The mean wet and dry seasonal rainfall, and the seasonal extremes category, which divides the wet by the dry. This creates a ratio that can illustrate extremes in seasonal rainfall. Monitoring these ratios across a changing climate can be informative in monitoring changes in water quality. You can see that some years you may get a near equivalent amount of total precipitation in the wet season as the dry season, whereas a year can be as extreme as nearly seven times as much precipitation in the wet season as occurs in the dry.

Following the arbitrary 0.9 degrees Fahrenheit rule to average each month as described in the caption of **Table 7**, the Annual total category in the lower section summarizes all of the months of that year in to one large number. If that number exceeds the 0.9 degree average multiplied by twelve months (10.8 total), then it receives a red or blue for above or below for the entire year. Only six out of 17 years exceeded this average above or below.

The Seasonal Extremes ratio in the bottom row is lower if the wet and dry seasons are more disparate in average temperatures, or higher if the two seasons are more similar to each other in that year.

	WY 2004	WY 2005	WY 2006	WY 2007	WY 2008	WY 2009	WY 2010	WY 2011	WY 2012	WY 2013	WY 2014	WY 2015	WY 2016	WY 2017	WY 2018	WY 2019	WY 2020	Total	Low	High	Mean
October	54.3	50.6	46.8	47.2	48.0	50.0	50.6	51.9	50.7	51.3	49.1	56.8	54.4	53.5	49.6	49.8	47.9	862.5	46.8	56.8	50.7
November	44.0	43.2	34.4	42.8	41.1	47.8	47.1	42.5	42.5	46.4	43.7	43.9	41.7	51.0	46.4	46.1	42.9	747.5	34.4	51.0	44.0
December	41.9	41.1	39.8	39.5	38.3	35.9	36.4	42.8	39.6	41.2	37.1	43.1	42.4	36.2	37.4	41.4	42.3	676.4	35.9	43.1	39.8
January	41.9	40.9	43.6	36.2	36.7	38.2	46.7	40.7	40.1	37.2	41.0	43.5	42.6	36.4	44.1	41.7	43.7	695.2	36.2	46.7	40.9
February	43.5	41.2	39.1	41.5	40.0	39.9	45.6	38.0	42.2	43.0	38.7	47.5	46.5	40.1	39.3	33.5	40.9	700.5	33.5	47.5	41.2
March	47.5	46.7	44.0	45.3	40.8	41.4	46.1	45.2	43.1	45.7	46.8	49.3	48.7	45.8	43.6	43.1	42.4	723.1	40.8	49.3	45.0
April	52.4	49.4	46.8	47.4	45.4	49.2	49.2	45.1	49.8	48.6	50.5	49.6	53.4	50.5	49.3	49.8	49.7	786.4	45.1	53.4	49.2
May	56.3	56.2	55.1	52.3	53.7	55.1	52.1	51.6	53.2	55.4	57.1	56.3	56.9	55.4	57.1	56.6	56.0	880.4	51.6	57.1	55.1
June	61.3	57.1	58.6	56.0	55.6	60.0	56.8	57.4	56.1	60.5	59.2	62.8	59.6	59.8	58.9	59.2	58.2	938.9	55.6	62.8	58.7
July	62.3	61.4	61.1	62.0	59.7	64.4	60.7	60.1	60.6	62.5	64.1	65.9	63.1	62.5	64.5	63.0	61.7	997.9	59.7	65.9	62.3
August	65.4	61.5	59.2	59.9	61.9	61.7	60.8	61.1	62.9	63.9	64.4	64.3	63.8	63.7	62.6	64.0	61.9	1001.1	59.2	65.4	62.5
September	57.0	54.7	56.0	54.6	57.0	59.2	58.8	60.4	57.1	59.7	60.4	57.2	57.6	59.7	57.5	59.1	60.2	926.0	54.6	60.4	58.0
																		Mean	Low	High	
Annual	627.8	604	584.5	584.7	578.2	602.80	610.90	596.8	597.9	615.4	612.1	640.2	630.7	614.6	610.30	607.3	607.8	607.41	578.20	640.2	9935.9	33.5	65.9	50.6
Low	41.9	40.9	34.4	36.2	36.7	35.9	36.4	38	39.6	37.2	37.1	43.1	41.7	36.2	37.4	33.5	40.9	38.06	33.5	43.1				
High	65.4	61.5	61.1	62	61.9	64.4	60.8	61.1	62.9	63.9	64.4	65.9	63.8	63.7	64.5	64	61.9	63.13	60.80	65.90				
Mean	52.3	49.9	48.0	48.2	47.4	49.4	50.2	48.8	49.2	50.5	50.2	53.0	52.1	50.4	50.3	49.8	49.8	49.97	47.38	53.00				
Mean Wet (Oct-Apr)	45.5	44.0	41.3	42.1	40.8	42.2	45.4	43.5	43.0	44.1	42.7	47.4	46.1	43.8	43.4	42.6	43.4	43.60	40.82	47.35				
Mean Dry (May-Sep)	59.1	56.7	56.1	55.4	55.6	58.3	56.4	56.0	56.6	58.4	59.3	59.4	59.1	58.6	58.3	58.6	58.0	57.63	55.37	59.35				
Seasonal Extremes	0.77	0.77	0.74	0.76	0.73	0.72	0.81	0.78	0.76	0.76	0.72	0.80	0.78	0.75	0.74	0.73	0.75	0.76	0.72	0.81				

Raw Data Source: WSU AgWeatherNet Mount Vernon Station

	No data, filled in with mean value
	Neutral value is within +- 0.9 of mean
	Greater than 0.9 above mean
	Greater than 0.9 below mean

Table 7 - Monthly air temperature averages for the entire history of the Skagit County Monitoring Program. Cells are shaded red or blue to illustrate above and below average temperature for a month, respectively. The threshold of 0.9 degrees Fahrenheit to constitute an "average" shading of grey is arbitrarily chosen and does not constitute an authoritative metric.

Data Summaries and Trends Analysis

Trends were calculated for 30 measured or calculated parameters (such as monthly averages) at each of 39 sites, for a total of 1,170 tests. Of those, 459 tests showed a statistically significant trend at the 95% confidence level. Trends judged as improving or positive (e.g. increased dissolved oxygen, reduced temperature) made up 272 of the significant trends, or 59 percent. Negative or deleterious trends (e.g. reduced dissolved oxygen, increased nutrients) accounted for the remaining 187, or 41 percent of the significant trends. In relation to the global trend in acidification of surface waters, declining pHs were considered as negative trends for this report. There were also statistically significant nutrient trends where the slope was zero. The statistical analysis used was very sensitive, and a slope of zero simply means that the slope was less than 0.0001 units, though the directionality as positive or negative was still given.

All trends can be found in the tables in **Appendix C**. Positive significant trends are shaded green and negative are shaded red. Trends that achieved 95% confidence in statistical significance are shaded the darkest blue in the confidence column. Some trends were very close to achieving 95% confidence, but fell short. Trends that achieved 90% confidence are shaded in a slightly lighter blue, and trends that achieved 80% confidence in even lighter blue. This helps to inform the reader of all changes that may be occurring at the sampling site, even if they are not statistically significant at a 95% confidence level. Any parameters that showed a significant trend with a slope of 0 are highlighted in yellow in the slope column.

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 for shellfish growers. Dissolved oxygen and temperature conditions are still substandard in many watercourses, resulting in less than ideal rearing conditions for salmonids and other aquatic life.

Gaps in the data represent streams that were either flooded or dry at sampling time, or may represent equipment malfunctions.

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.

Background

For the water years 2004-2007 and 2009-2020, 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 late June and retrieved in early September. During those years, several of the data loggers went missing by the end of each monitoring period. Some may have 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. 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.

In the fall of 2006, Ecology revised its water quality standards (WAC 173-201a) to comply with a request from the EPA. Included in this revision were several changes to temperature and DO standards for Skagit County watercourses. In particular, the lower Skagit River, Hansen, Nookachamps, Fisher, and Carpenter Creeks, and the upper Samish River and its tributaries were placed in the "Core salmonid spawning and rearing" use category. This change had the effect of imposing more stringent temperature and DO standards on these streams. Formerly, each of these streams was held to a 7-day average of the daily maximum temperatures (7-DADMax) standard of 17.5ºC, but with the revised standards, these streams must now meet a 7-DADMax standard of 16ºC. There were no changes to other streams in the county. Currently, Sites 3-4, 28, 31-44, and 48 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.

After a very dry 2015 water year and higher than normal precipitation in 2016, 2017 was characterized by a series of wetter and dryer than normal months. Overall precipitation was near normal for the entire year. The 2018 water year saw a return to below-normal precipitation. The 2019 water year was the driest overall year in the last ten, and would have been worse, had it not been for the rainiest September in the sixteen-year history of this

program occurring in the final month of the water year. Water Year 2020 ended slightly above average for the year, with a drier than average August and September at the end.

Results

Table 8 shows the daily maximum temperatures for the last five years of the study, based on data collected at bi-weekly samplings. Because the state water quality standards are based on 7-DADMax, the maximums reported on **Table 8** 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 9 contains the 7-DADMax values 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.

Twenty-three dataloggers were deployed for the summer of 2020. Of these, one went missing and was not recoverable, and one had been taken out of the water and thrown up the river bank. The remaining 21 dataloggers were retrieved and their data analyzed.

Trends analyses reveal that in comparison to 17 years ago, at the start of this program, nine sites have shown an increase in temperature and one site has shown a decrease (**Figure 2**). Looking at the map of trends from the most recent ten years (**Figure 3**), fourteen sites show an increase, while no sites show a decrease. All of these sites are located in the northern half of the county.

Trends from the most recent five years of data (**Figure 4**) show six sites significantly decreasing in temperature, with no sites showing a significant increase. Two-thirds of these decreasing sites are in the Nookachamps watershed.

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

Table 8 - Maximum watercourse temperatures recorded from bi-weekly sampling. Cells shaded green pass state standard. There is a 0.2 allowance in the standard for variation in equipment calibration. These samplings are taken at nearly the same time of day, each week they are sampled, and do not represent the hottest temperature that each site may have reached on a given day.

Site Number	Watercourse	Location	Highest daily temperature (°C)				
			2016	2017	2018	2019	2020
3	Thomas Creek	Old Hwy 99 North	19.6	19.2	18.4	17.8	18.4
4	Thomas Creek	F&S Grade Rd	15.9	15.3	14.9	14.8	14.7
6	Friday Creek	Prairie Rd	20.1	18.6	19.2	18.0	17.8
8	Swede Creek	Grip Rd	17.8	17.8	16.9	16.5	16.2
11	Samish River	State Route 9	14.1	13.5	13.2	13.6	15.2
12	Nookachamps Creek	Swan Rd	21.4	21.1	22.5	21.0	20.1
13	E.F. Nookachamps Creek	State Route 9	19.1	19.6	21.9	19.4	18.6
14	College Way Creek	College Way	17.7	17.3	19.0	16.7	17.0
15	Nookachamps Creek	Knapp Rd	21.8	22.0	22.7	20.1	22.1
16	E.F. Nookachamps Creek	Beaver Lake Rd	18.7	18.1	19.8	17.5	17.0
17	Nookachamps Creek	Big Lake Outlet	21.9	22.8	23.6	21.3	22.5
18	Lake Creek	State Route 9	16.3	16.3	18.1	16.4	16.3
19	Hansen Creek	Hoehn Rd	18.1	17.3	17.6	18.1	18.5
20	Hansen Creek	Northern State	15.3	15.3	15.4	14.9	14.8
21	Coal Creek	Hoehn Rd	16.1	15.7	15.2	15.6	16.5
22	Coal Creek	Hwy 20	14.6	15.3	15.2	15.3	15.1
23	Wiseman Creek	Minkler Rd	15.2	15.0	14.1	14.2	15.5
24	Mannser Creek	Lyman Ham. Hwy	12.1	12.5	11.9	12.5	12.9
25	Red Cabin Creek	Hamilton Cem. Rd	11.8	11.7	11.2	11.9	12.4
28	Brickyard Creek	Hwy 20	16.7	14.5	14.3	14.7	16.2
29	Skagit River	River Bend Rd	16.6	15.9	16.2	16.0	14.7
30	Skagit River	Cape Horn Rd	14.8	15.3	15.4	15.6	15.0
32	Samish River	Thomas Rd	20.7	20.1	19.3	18.8	18.2
33	Alice Bay Pump Station	Samish Island Rd	23.4	22.7	25.0	22.1	22.9
34	No Name Slough	Bayview-Edison Rd	25.9	21.5	27.0	25.3	24.8
35	Joe Leary Slough	D'Arcy Rd	20.5	20.3	21.3	21.4	18.9
36	Edison Slough at school	W. Bow Hill Rd	27.6	27.0	30.2	28.3	27.0
37	Edison Pump Station	Farm to Market Rd	26.3	23.6	25.5	23.3	25.8
38	North Edison Pump Sta.	North Edison Rd	22.4	22.2	24.4	22.3	20.9
39	Colony Creek	Colony Rd	17.1	16.6	17.4	15.3	20.5
40	Big Indian Slough	Bayview-Edison Rd	17.3	19.4	19.5	18.3	17.7
41	Maddox/Big Ditch	Milltown Rd	21.4	22.4	21.7	21.4	20.8
42	Hill Ditch	Cedardale Rd	21.3	22.0	20.8	20.9	21.2
43	Wiley Slough	Wylie Rd	20.1	19.6	27.2	20.2	19.3
44	Sullivan Slough	La Conner-Whitney	18.1	20.0	18.3	16.7	20.1
45	Skagit River – N. Fork	Moore Rd	17.3	16.4	16.4	17.0	15.6
46	Skagit River – S. Fork	Fir Island Rd	17.7	16.7	16.7	17.0	15.9
47	Swinomish Channel	County Boat Launch	17.0	18.5	16.1	16.2	17.0
48	Fisher Creek	Franklin Rd	13.4	13.5	15.3	14.0	14.0

Table 9 - Seven-day average of the daily maximum temperatures (7-DADMax). This data is from continuous temperature loggers (TidbiTs), with measurements taken every 30 minutes. Cells shaded green pass state standard. There is a 0.2 allowance in the standard for variation in equipment calibration.

Site Number	Watercourse	Location	7-DADMax (°C)				
			2016	2017	2018	2019	2020
3	Thomas Creek	Old Hwy 99 North	21.2	20.2	20.2	n/a	19.9
4	Thomas Creek	F&S Grade Rd	16.7	16.1	17.0	16.5	16.2
6	Friday Creek	Prairie Rd	21.6	n/a	22.6	21.3	20.0
8	Swede Creek	Grip Rd	18.4	17.6	19.0	17.8	17.4
11	Samish River	State Route 9	14.8	14.8	14.8	n/a	15.1
12	Nookachamps Creek	Swan Rd	23.5	22.9	23.5	23.5	21.0*
13	E.F. Nookachamps Creek	State Route 9	20.8	20.5	21.7	n/a	20.7
15	Nookachamps Creek	Knapp Rd	23.3	22.3	23.8	n/a	23.0
16	E.F. Nookachamps Creek	Beaver Lake Rd	21.2	20.8	22.2	20.1	n/a
17	Nookachamps Creek	Big Lake Outlet	25.2	25.5	26.5	n/a	25.6
18	Lake Creek	State Route 9	18.2	18.0	19.5	19.2	18.6
19	Hansen Creek	Hoehn Rd	21.1	19.0	20.1	19.7	20.3
20	Hansen Creek	Northern State	16.3	17.1	17.8	n/a	16.5
21	Coal Creek	Hoehn Rd	20.0	15.9	18.6	20.3	17.8
22	Coal Creek	Hwy 20	17.4	n/a	17.5	16.8	16.7
24	Mannser Creek	Lyman Hamilton Hwy	17.2	13.9	13.7	13.4	14.0
30	Skagit River	Cape Horn Rd	15.2	11.9	n/a	17.1	14.8**
32	Samish River	Thomas Rd	n/a	20.2	21.2	20.6	n/a
39	Colony Creek	Colony Rd	18.3	17.3	18.4	17.5	17.4
41	Maddox Creek/Big Ditch	Milltown Rd	21.1	24.9	25.9	25.0	24.4
42	Hill Ditch	Cedardale Rd	25.9	25.7	25.9	24.9	24.6
45	Skagit River – North Fork	Moore Rd	18.7	17.7	19.4	n/a	17.2*
48	Fisher Creek	Franklin Rd	15.1	14.8	16.8	16.5	16.1

*Incomplete dataset, as the TidbiT probe was out of the water for some of the summer measurement period. It is possible that this value could have been higher.

**TidbiT out of water for part of season. Analysis of USGS temperature monitoring station 12200500 near Mount Vernon, in comparison to the incomplete data from SCMP site 30 infers that the actual 7-DADMAX likely occurred near 16.0 °C.

Figure 2 - Seventeen-year trends in watercourse temperatures

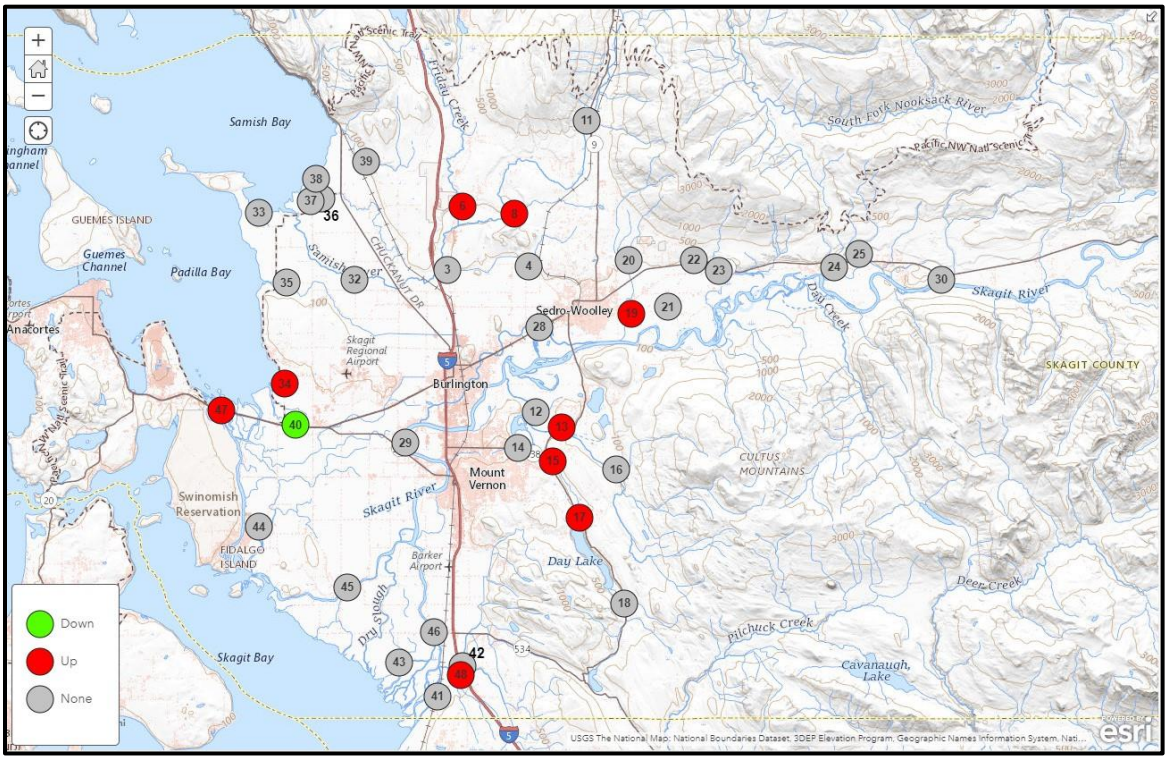


Figure 3 - Ten-year trends in watercourse temperatures

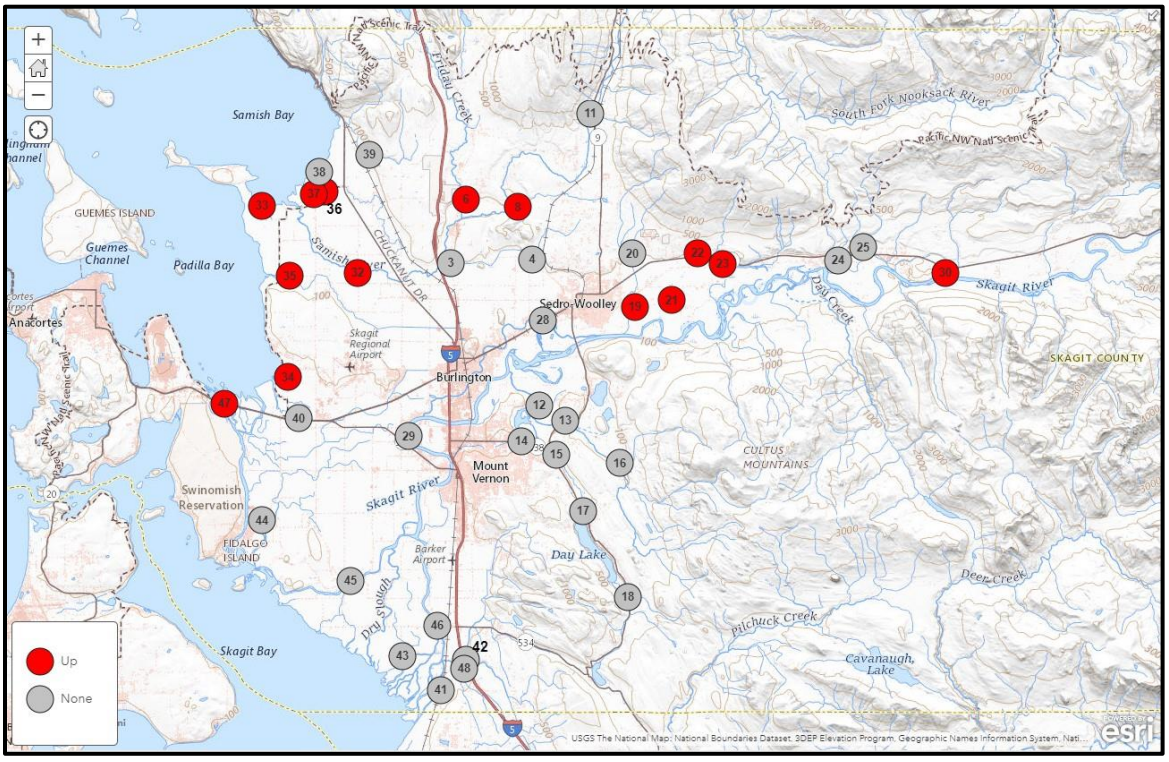
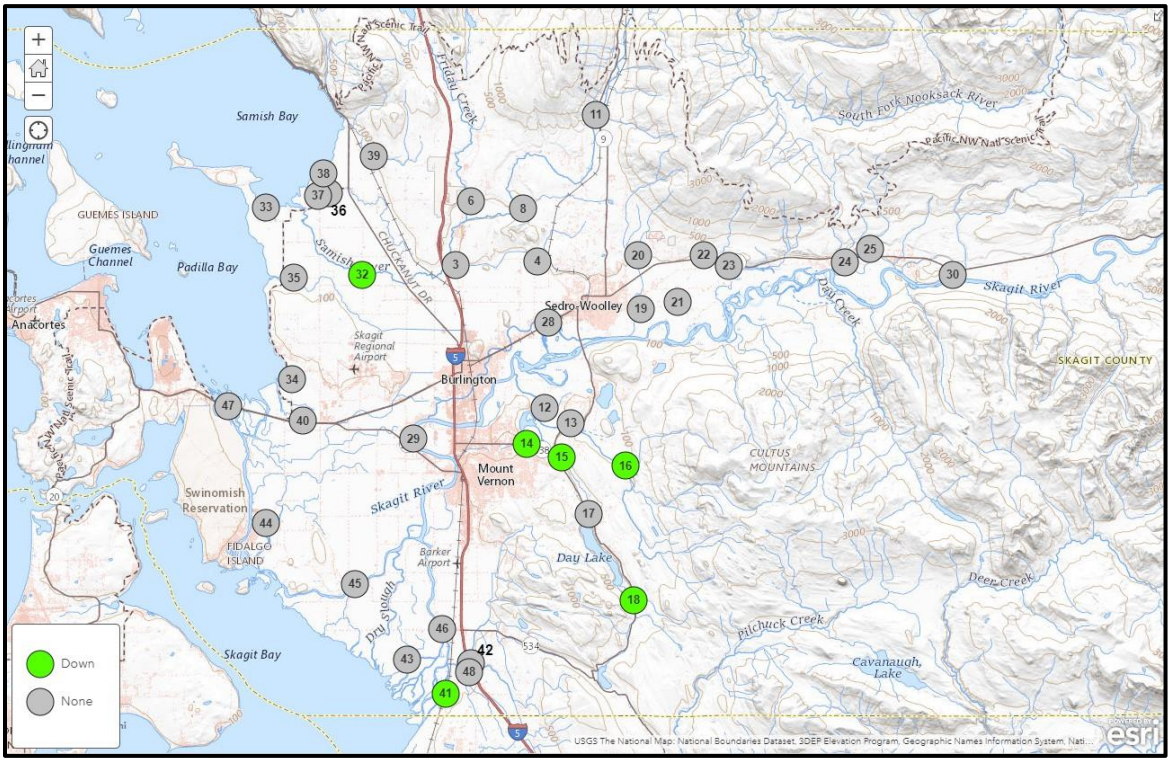


Figure 4 - Five-year trends in watercourse temperatures



Dissolved Oxygen (DO)

Dissolved oxygen measurements determine how much oxygen is available in the water for fish and other organisms.

Background

The state water quality standards for DO are based on single-day minimum measurements. For some lowland watercourses in the SCMP (Sites 3-4, 28, 31-44, and 48), 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.

Results

A summary of DO readings (in mg/L) obtained during the 2020 water year is provided in **Table 10**. A summary of data from the most recent five years of this program can be found in **Table 11**.

Ten sites met the oxygen standards for the entire 2020 water year, compared to eight in 2019. Others met the oxygen standard for most of the year. In a few streams, oxygen levels show steep declines in summer, as can be seen by the graphs on their SRCs. These declines are usually associated with very low flows, less velocity, and higher temperatures.

In the drainage infrastructure and lower sloughs, DO 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, night-time 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 night-time 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 in their SRCs, are widely fluctuating DO levels, depending on the state of the algal blooms at sampling time. These fluctuations are very extreme, and data has been recorded from as low as 0% to as high as 300% typical oxygen saturation.

Trends analysis shows that in the 17 years since the program began, thirteen sites have shown an increase in DO levels, while four have shown a decrease (**Figure 5**). There is a clustering of improved sites in the Samish and South Skagit watersheds. In the most recent ten years (**Figure 6**), trends show fifteen sites increasing DO levels, while only one is decreasing. These sites appear to be spread county-wide. In the most recent five years (**Figure 7**), trends show eight sites increasing DO levels, while only two sites are decreasing. These sites appear to also be spread county-wide. This increase of sites with rising DO levels is great news for water quality across the county, and possible contributions could be from lower water temperatures and lower biological oxygen demand (BOD), which can be a result of a decrease in pollution.

Table 10 - Dissolved oxygen (DO) measurements for 2020 water year. Cells shaded green pass state standard. A margin of error allowance is given at 0.2 mg/L.

Site Number	Watercourse	Location	Mean DO (mg/L)	Minimum DO (mg/L)	St. Std[1]
3	Thomas Creek	Old Hwy 99 N	6.52	0.27	8.0
4	Thomas Creek	F&S Grade Rd	11.42	9.63	8.0
6	Friday Creek	Prairie Rd	11.43	9.07	9.5
8	Swede Creek	Grip Rd	10.95	8.01	9.5
11	Samish River	State Route 9	9.30	7.83	9.5
12	Nookachamps Creek	Swan Rd	8.49	3.94	9.5
13	E.F. Nookachamps Creek	State Route 9	8.91	3.01	9.5
14	College Way Creek	College Way	9.46	7.36	9.5
15	Nookachamps Creek	Knapp Rd	8.14	1.15	9.5
16	E.F. Nookachamps Creek	Beaver Lake Rd	11.66	9.89	9.5
17	Nookachamps Creek	Big Lake Outlet	9.59	7.03	9.5
18	Lake Creek	State Route 9	11.25	9.30	9.5
19	Hansen Creek	Hoehn Rd	10.27	6.72	9.5
20	Hansen Creek	Northern State	11.48	9.13	9.5
21	Coal Creek	Hoehn Rd	11.16	7.12	9.5
22	Coal Creek	Hwy 20	11.76	9.80	9.5
23	Wiseman Creek	Minkler Rd	11.77	9.85	9.5
24	Mannser Creek	Lyman Hamilton Hwy	7.86	5.19	9.5
25	Red Cabin Creek	Hamilton Cem. Rd	11.82	10.28	9.5
28	Brickyard Creek	Hwy 20	8.34	4.03	8.0
29	Skagit River	River Bend Rd	11.42	9.40	9.5
30	Skagit River	Cape Horn Rd	11.43	9.21	9.5
32	Samish River	Thomas Rd	11.30	9.80	8.0
33	Alice Bay Pump Station	Samish Island Rd	8.64	1.82	8.0
34	No Name Slough	Bayview-Edison Rd	7.37	0.00	8.0
35	Joe Leary Slough	D'Arcy Rd	6.42	4.04	8.0
36	Edison Slough at school	West Bow Hill Rd	7.99	4.84	8.0
37	Edison Pump Station	Farm to Market Rd	4.82	0.30	8.0
38	North Edison Pump Station	North Edison Rd	4.00	0.47	8.0
39	Colony Creek	Colony Rd	11.01	7.68	9.5
40	Big Indian Slough	Bayview-Edison Rd	5.06	2.04	8.0
41	Maddox Slough/Big Ditch	Milltown Rd	6.35	0.13	8.0
42	Hill Ditch	Cedardale Rd	7.85	4.67	9.5
43	Wiley Slough	Wylie Rd	4.09	1.13	8.0
44	Sullivan Slough	La Conner-Whitney	7.31	2.25	8.0
45	Skagit River – North Fork	Moore Rd	11.54	8.39	9.5
46	Skagit River – South Fork	Fir Island Rd	11.62	9.54	9.5
47	Swinomish Channel	County Boat Launch	8.71	6.44	6.0
48	Fisher Creek	Franklin Rd	11.44	10.00	9.5

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

Table 11 - Mean dissolved oxygen (DO) levels for the most recent five years. Cells shaded green pass state standard. A margin of error allowance is given at 0.2 mg/L.

Site Number	Watercourse	Location	Mean Dissolved Oxygen (mg/L)				
			2016	2017	2018	2019	2020
3	Thomas Creek	Old Hwy 99 North	6.2	6.6	6.1	5.8	6.5
4	Thomas Creek	F&S Grade Rd	11.2	11.5	11.6	11.5	11.4
6	Friday Creek	Prairie Rd	11.4	11.8	11.6	11.6	11.4
8	Swede Creek	Grip Rd	10.4	10.6	10.8	10.7	11.0
11	Samish River	State Route 9	8.7	9.4	9.4	9.0	9.30
12	Nookachamps Creek	Swan Rd	9.1	8.4	9.0	9.4	8.5
13	E.F. Nookachamps Creek	State Route 9	9.9	10.0	10.0	9.6	8.9
14	College Way Creek	College Way	9.0	9.7	9.9	9.8	9.5
15	Nookachamps Creek	Knapp Rd	7.7	8.4	8.6	8.3	8.1
16	E.F. Nookachamps Creek	Beaver Lake Rd	11.3	11.7	11.7	12.0	11.7
17	Nookachamps Creek	Big Lake Outlet	9.6	10.2	10.4	10.2	9.7
18	Lake Creek	State Route 9	10.8	11.2	11.1	11.3	11.3
19	Hansen Creek	Hoehn Rd	10.2	10.4	10.3	10.3	10.3
20	Hansen Creek	Northern State	11.3	11.6	11.6	11.5	11.5
21	Coal Creek	Hoehn Rd	11.2	11.7	11.8	11.6	11.2
22	Coal Creek	Hwy 20	11.6	11.9	12.1	11.8	11.8
23	Wiseman Creek	Minkler Rd	11.6	12.3	12.2	12.2	11.8
24	Mannser Creek	Lyman Ham. Hwy	7.0	7.5	7.9	7.9	7.9
25	Red Cabin Creek	Hamilton Cem. Rd	12.1	12.3	12.2	12.2	11.8
28	Brickyard Creek	Hwy 20	9.2	10.2	10.4	9.5	8.3
29	Skagit River	River Bend Rd	11.0	11.4	11.4	11.1	11.4
30	Skagit River	Cape Horn Rd	11.2	11.7	11.5	11.3	11.4
32	Samish River	Thomas Rd	10.9	11.4	10.9	11.2	11.3
33	Alice Bay Pump Station	Samish Island Rd	10.3	8.2	11.1	9.2	8.6
34	No Name Slough	Bayview-Edison Rd	7.6	7.8	8.0	7.0	7.4
35	Joe Leary Slough	D'Arcy Rd	5.4	5.0	5.6	5.6	6.4
36	Edison Slough at school	W. Bow Hill Rd	9.9	10.4	11.2	8.9	8.0
37	Edison Pump Station	Farm to Market Rd	8.6	8.3	7.9	8.2	4.8
38	N. Edison Pump Station	North Edison Rd	10.4	8.4	7.5	7.4	4.0
39	Colony Creek	Colony Rd	10.7	11.0	11.0	11.1	11.0
40	Big Indian Slough	Bayview-Edison Rd	4.1	4.7	5.4	5.1	5.1
41	Maddox/Big Ditch	Milltown Rd	7.8	6.6	7.1	7.4	6.4
42	Hill Ditch	Cedardale Rd	9.0	8.3	8.9	8.5	7.9
43	Wiley Slough	Wylie Rd	5.3	4.5	5.0	4.8	4.1
44	Sullivan Slough	La Conner-Whitney	6.2	7.5	6.3	6.3	7.3
45	Skagit River – North Fork	Moore Rd	11.0	11.5	11.6	11.3	11.5
46	Skagit River – South Fork	Fir Island Rd	11.3	11.4	11.6	11.4	11.6
47	Swinomish Channel	County Boat Launch	8.5	9.0	8.8	8.8	8.7
48	Fisher Creek	Franklin Rd	11.0	11.6	11.4	11.6	11.4

Figure 5 - Seventeen-year trends in dissolved oxygen (DO)

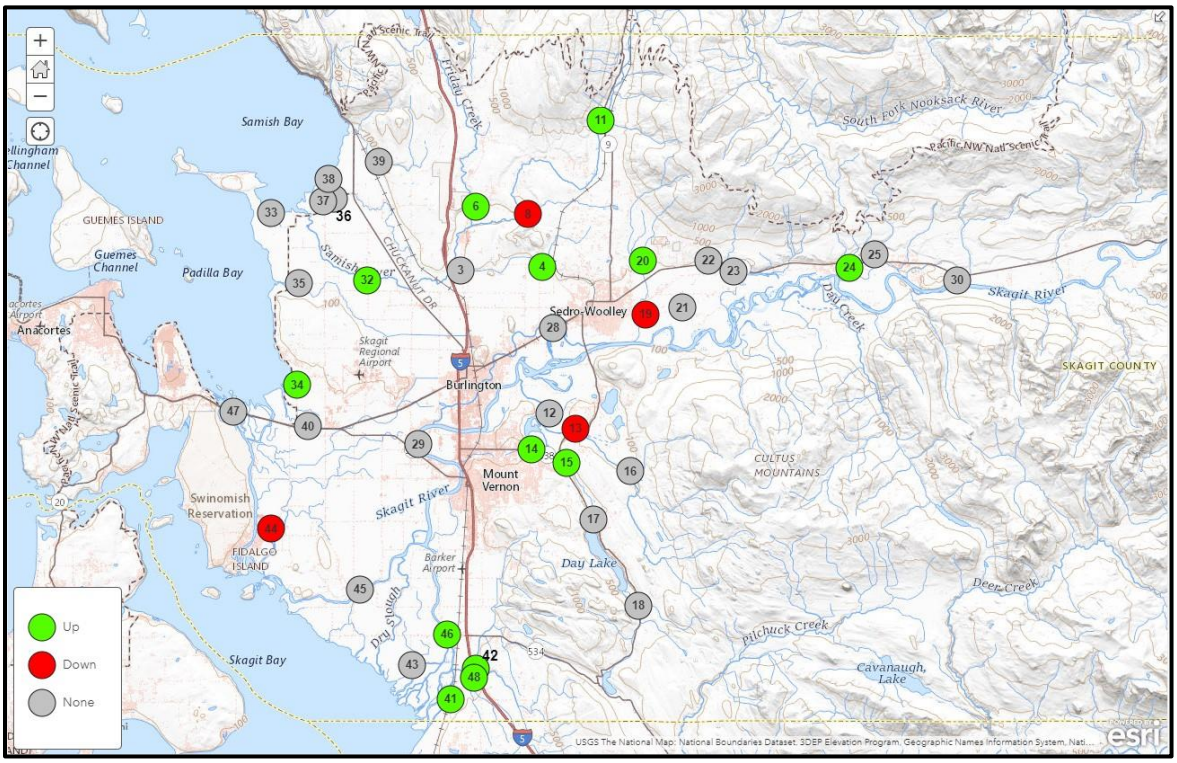


Figure 6 - Ten-year trends in dissolved oxygen (DO)

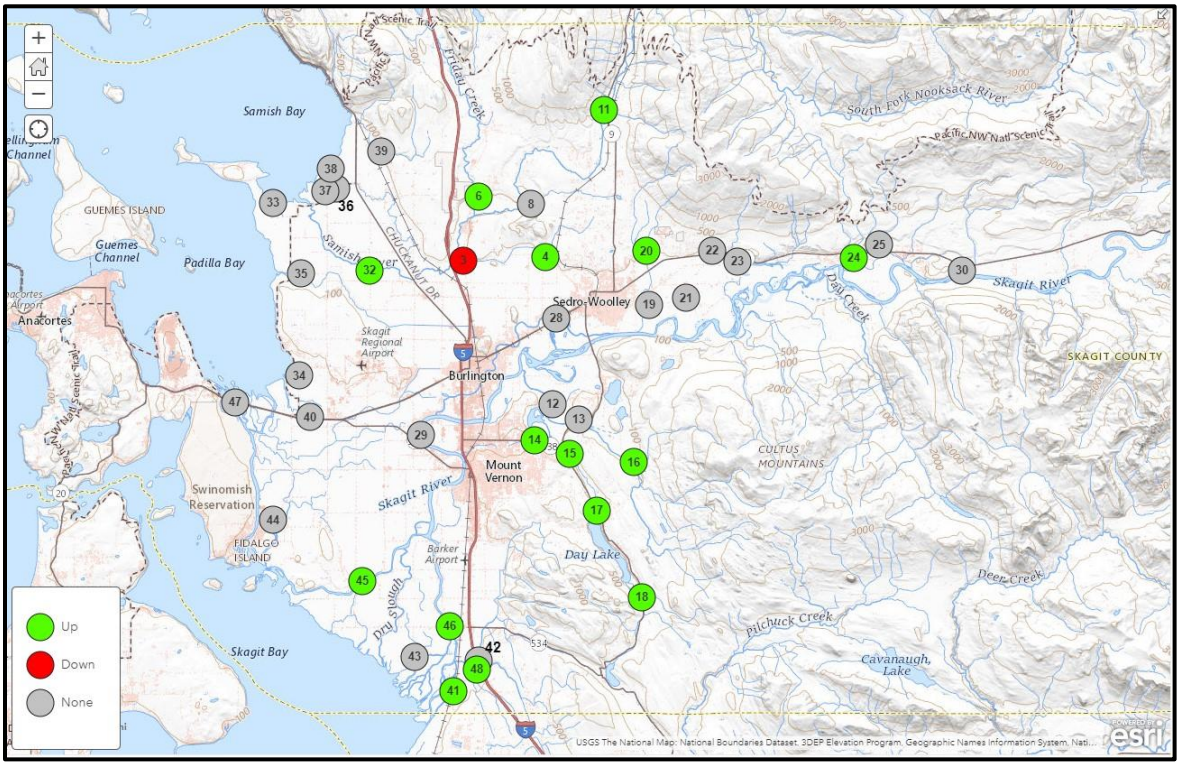
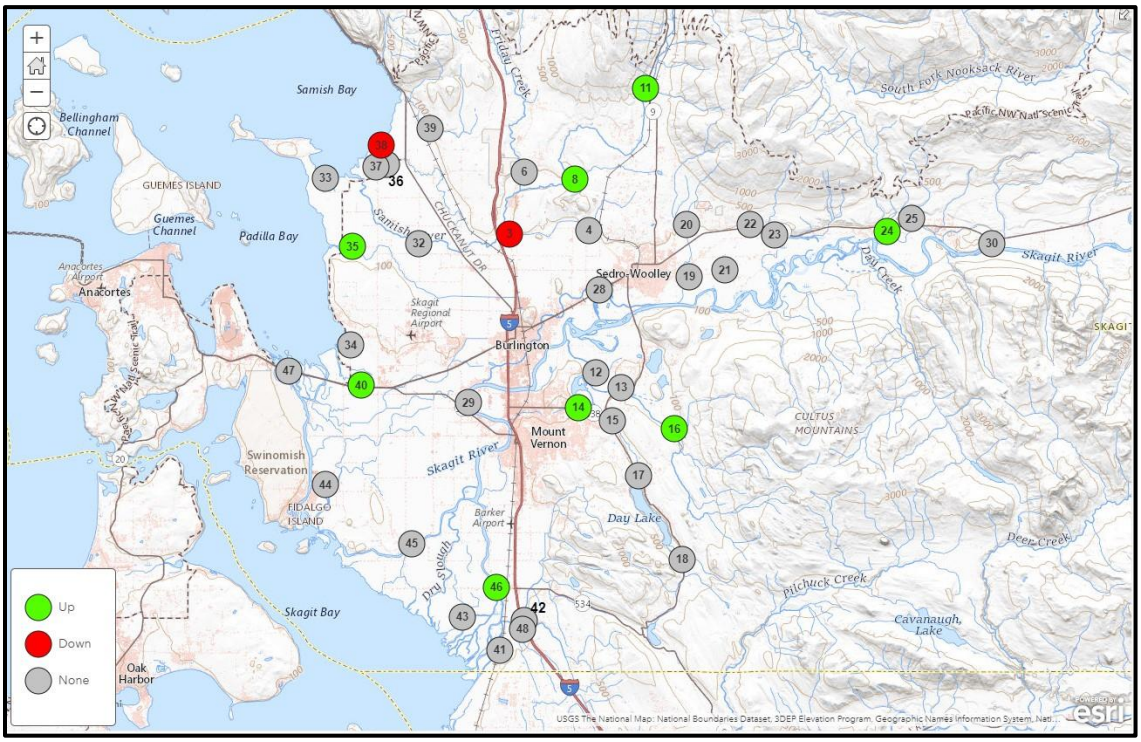


Figure 7 - Five-year trends in dissolved oxygen (DO)



Fecal Coliform (FC)

Fecal coliform is a measurement aimed at estimating the amount of enteric bacteria from warm-blooded animals present in a watercourse. Although FC measurements do not directly quantify disease-causing organisms, they serve as an indicator of the possible presence of such bacteria, viruses, and protozoa. The sources of FC organisms reaching the watercourses of Skagit County may include runoff from failing septic tanks, livestock operations, wildlife, recreationists, and pets.

Background

Samples for FC measurements were taken at each site during each visit and were submitted to the Skagit County Health Department Water Lab (2003-2008) or Edge Analytical (2009-2020) for analysis by the most probable number (MPN) method. State standards for FC 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 SCMP (sites 3-20, 28-29, 31-46, 48), FC 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.

Results

Fecal coliform measurements for the 2020 water year, in MPN of bacterial colonies per 100 ml, are summarized in **Table 12**. The geometric mean FC at each site for the last five years of this program can be found in **Table 13**.

For the 2020 water year, 19 sites met the standard based on ambient sampling for the entire water year, compared to 16 sites in 2019. Most sites that did not meet the standard did so due to having more than 10% of samples with FC counts in excess of 200 MPN. Storm sampling in the Samish Basin also continues to show excessive FC during rain events.

Trends analysis shows that in the 17 years since the program began, twelve sites have shown improvement through a decline in FC counts, while six sites have shown deterioration through an increase in FC counts (**Figure 8**). There is a clear clustering of improved sites in the Samish Bay watershed, relative to the rest of the county. In the most recent ten years, three sites have shown improvement, while two sites have shown deterioration (**Figure 9**). In the most recent five years, four sites have shown improvement, while one site has shown significantly increased FC counts (**Figure 10**).

Table 12 - Fecal coliform (FC) results for 2020 water year (MPN/100ml). Cells shaded green pass state standard.

Site Number	Watercourse	Location	n	Geometric mean (MPN)[1]	% > 100 or 200[1]
3	Thomas Creek	Old Hwy 99 N	22	37	4.5
4	Thomas Creek	F&S Grade Rd	22	94	32
6	Friday Creek	Prairie Rd	22	26	0
8	Swede Creek	Grip Rd	22	54	18
11	Samish River	State Route 9	22	15	0
12	Nookachamps Creek	Swan Rd	21	56	14
13	E.F. Nookachamps Creek	State Route 9	22	42	14
14	College Way Creek	College Way	21	192	48
15	Nookachamps Creek	Knapp Rd	22	50	6
16	E.F. Nookachamps Creek	Beaver Lake Rd	22	19	0
17	Nookachamps Creek	Big Lake Outlet	22	10	0
18	Lake Creek	State Route 9	22	39	14
19	Hansen Creek	Hoehn Rd	20	29	5
20	Hansen Creek	Northern State	21	45	5
21	Coal Creek	Hoehn Rd	20	49	30
22	Coal Creek	Hwy 20	22	7	5
23	Wiseman Creek	Minkler Rd	21	14	10
24	Mannser Creek	Lyman Hamilton Hwy	20	12	5
25	Red Cabin Creek	Hamilton Cemetery Rd	16	10	7
28	Brickyard Creek	Hwy 20	14	13	0
29	Skagit River	River Bend Rd	20	9	5
30	Skagit River	Cape Horn Rd	22	4	0
32	Samish River	Thomas Rd	22	55	14
33	Alice Bay Pump Station	Samish Island Rd	22	42	18
34	No Name Slough	Bayview-Edison Rd	22	88	36
35	Joe Leary Slough	D'Arcy Rd	22	72	23
36	Edison Slough at school	W. Bow Hill Rd	22	106	36
37	Edison Pump Station	Farm to Market Rd	22	291	64
38	N. Edison Pump Station	North Edison Rd	22	127	45
39	Colony Creek	Colony Rd	22	36	23
40	Big Indian Slough	Bayview-Edison Rd	22	92	27
41	Maddox/Big Ditch	Milltown Rd	22	64	14
42	Hill Ditch	Cedardale Rd	22	111	27
43	Wiley Slough	Wylie Rd	22	56	19
44	Sullivan Slough	La Conner-Whitney Rd	21	107	33
45	Skagit River – North Fork	Moore Rd	22	6	0
46	Skagit River – South Fork	Fir Island Rd	22	11	0
47	Swinomish Channel	County Boat Launch	22	7	0
48	Fisher Creek	Franklin Rd	22	60	10

[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. Cells shaded green represent sites that pass state standards.

Table 13 - Geometric mean FC results for most recent five years (MPN/100ml). Cells shaded green pass state standard.

Site Number	Watercourse	Location	2016	2017	2018	2019	2020
3	Thomas Creek	Old Hwy 99 N	49	63	47	50	37
4	Thomas Creek	F&S Grade Rd	138	107	138	131	94
6	Friday Creek	Prairie Rd	34	29	39	28	26
8	Swede Creek	Grip Rd	59	40	53	29	54
11	Samish River	State Route 9	26	14	12	11	15
12	Nookachamps Creek	Swan Rd	65	79	56	45	56
13	E.F. Nookachamps Creek	State Route 9	59	41	22	38	42
14	College Way Creek	College Way	106	172	83	113	192
15	Nookachamps Creek	Knapp Rd	54	62	63	64	50
16	E.F. Nookachamps Creek	Beaver Lake Rd	44	28	22	22	19
17	Nookachamps Creek	Big Lake Outlet	16	12	14	17	10
18	Lake Creek	State Route 9	50	24	26	41	39
19	Hansen Creek	Hoehn Rd	114	53	57	62	29
20	Hansen Creek	Northern State	35	50	48	37	45
21	Coal Creek	Hoehn Rd	84	53	65	63	49
22	Coal Creek	Hwy 20	22	18	13	11	7
23	Wiseman Creek	Minkler Rd	12	10	18	10	14
24	Mannser Creek	Lyman Hamilton Hwy	12	15	13	14	12
25	Red Cabin Creek	Hamilton Cemetery Rd	6	12	5	6	10
28	Brickyard Creek	Hwy 20	33	42	45	53	13
29	Skagit River	River Bend Rd	14	9	9	7	9
30	Skagit River	Cape Horn Rd	6	3	5	4	4
32	Samish River	Thomas Rd	54	48	41	58	55
33	Alice Bay Pump Station	Samish Island Rd	54	30	24	33	42
34	No Name Slough	Bayview-Edison Rd	71	65	59	48	88
35	Joe Leary Slough	D'Arcy Rd	98	91	108	93	72
36	Edison Slough at school	W. Bow Hill Rd	120	97	56	49	106
37	Edison Pump Station	Farm to Market Rd	386	317	214	188	291
38	North Edison Pump Station	North Edison Rd	264	148	148	113	127
39	Colony Creek	Colony Rd	76	57	61	58	36
40	Big Indian Slough	Bayview-Edison Rd	29	43	81	47	92
41	Maddox Slough/Big Ditch	Milltown Rd	61	87	52	46	64
42	Hill Ditch	Cedardale Rd	43	42	51	48	111
43	Wiley Slough	Wylie Rd	106	68	82	74	56
44	Sullivan Slough	La Conner-Whitney Rd	157	127	67	45	107
45	Skagit River – North Fork	Moore Rd	6	7	8	4	6
46	Skagit River – South Fork	Fir Island Rd	9	13	13	9	11
47	Swinomish Channel	County Boat Launch	6	6	6	4	7
48	Fisher Creek	Franklin Rd	92	69	78	56	60

Figure 8 - Seventeen-year trends in fecal coliform (FC)

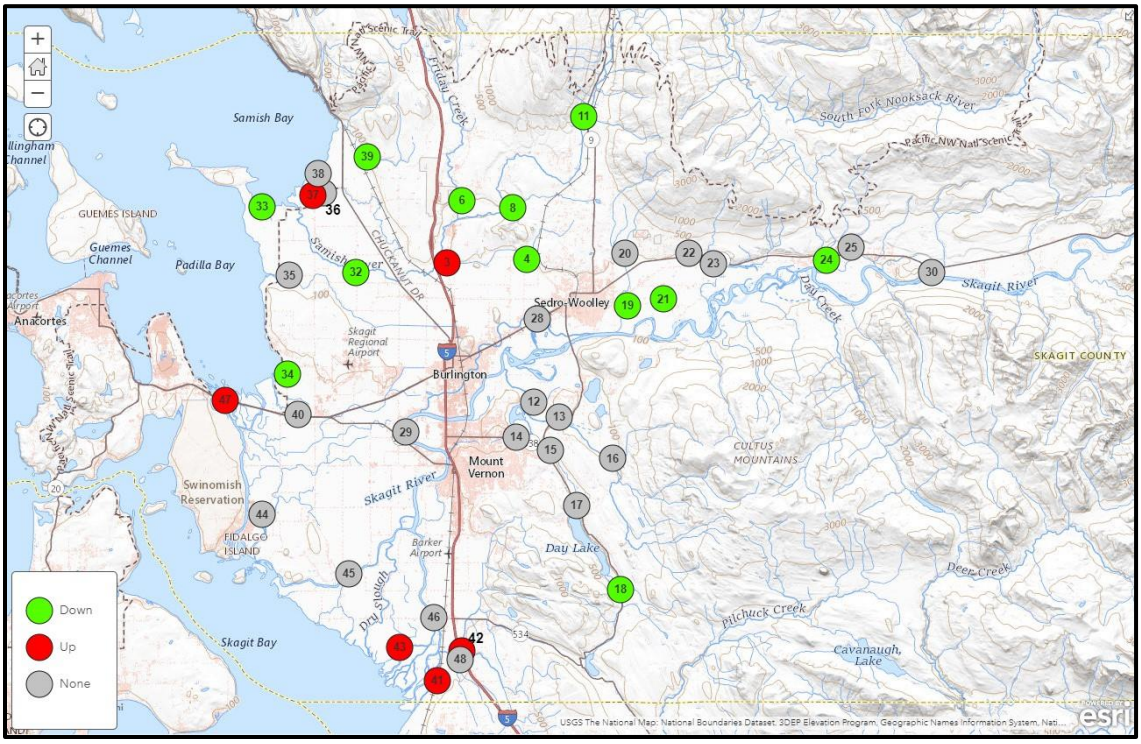


Figure 9 - Ten-year trends in fecal coliform (FC)

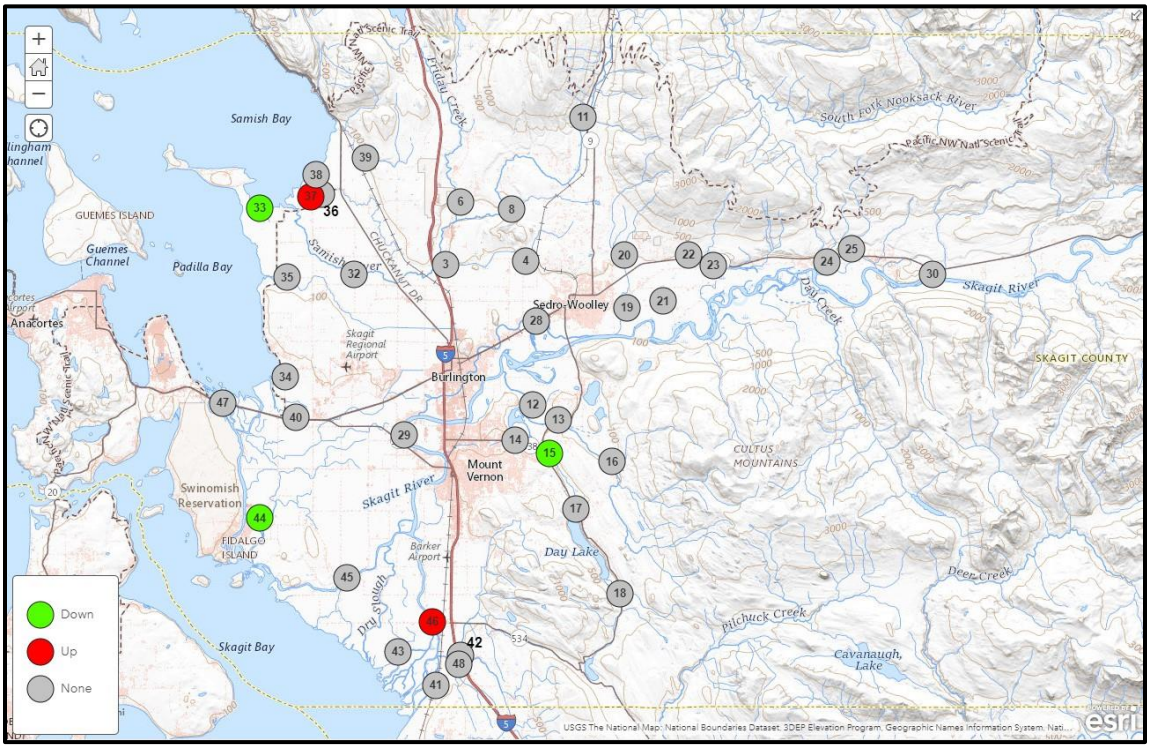
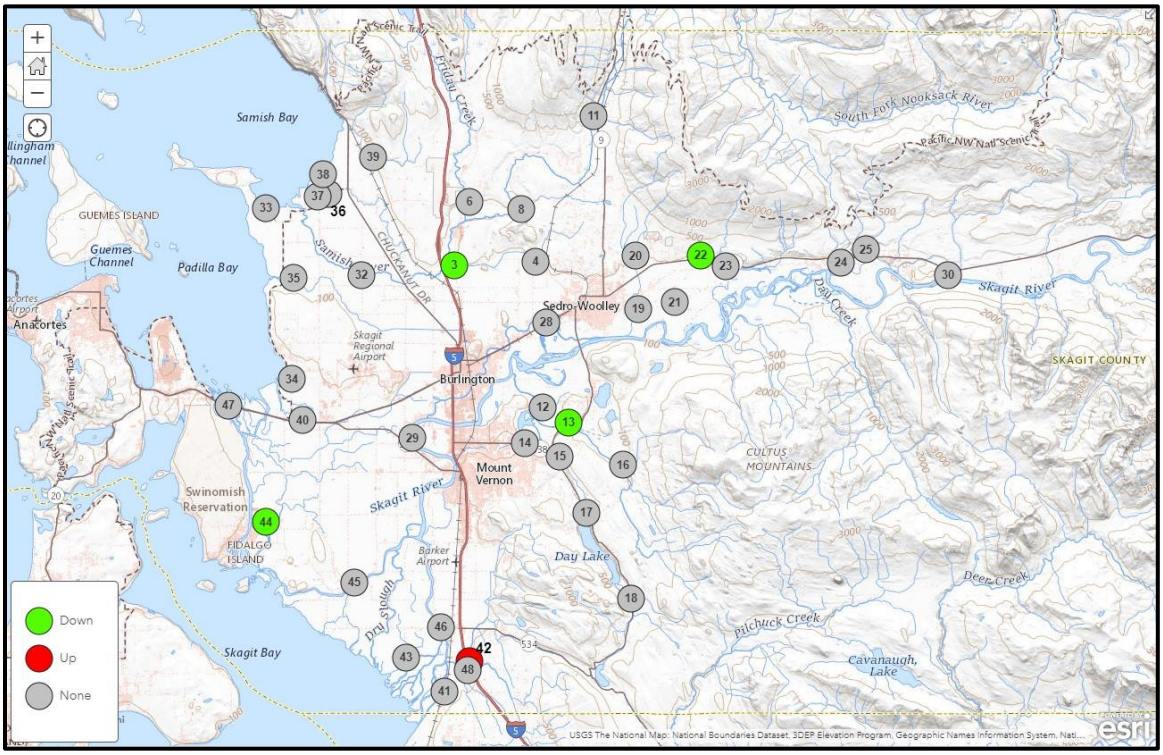


Figure 10 - Five-year trends in fecal coliform (FC)



Nutrients

Nutrient levels in watercourses help determine the potential for algal activity. Excessive nutrient levels can lead to large blooms of algae, which can increase DO levels during the day but lead to large decreases in DO at night, when the algae are respiring, and also when the algae die and decompose. Nutrients from freshwater sources discharged into Puget Sound bays can contribute to marine algal blooms as well. Algal blooms can become harmful to recreationists when there are cyanobacteria present, which make ingestion of the water toxic to humans and their pets.

Background

From the beginning of the program in water year 2004 up until the close of water year 2008 nutrients were sampled on a monthly basis. After the close of the grant from Ecology, maintaining monthly sampling of all nutrients was deemed too cost-prohibitive for the ongoing project budget and was switched to quarterly samplings to allow for four-season trend determinations rather than 12-season.

The subsequent section of this report covering Water Quality Index (WQI) is generated with contribution of this quarterly nutrient data. Therefore, since water year 2008, WQI data has been a four-season metric for this report.

Results

Water samples for measurement of plant nutrients were taken at each station quarterly. Samples were analyzed by Edge Analytical of Burlington, WA. Quarterly sampling brings with it a large caveat: these trends results are determined by a single sampling snapshot in time, on one day, of an entire three-month period. Needless to say, while this method is imperfect, it is still valuable for collecting and analyzing possible trends. If the conditions of the watercourses sampled were truly randomly assorted based on sampling, with too great of an intermittence (3 months) to have value, then running a trends analysis should theoretically show no discernible trend in the data, and any direction of the data would be determined as non-existent or non-significant. The trends analyses returning a large number of significant trends across the county, even with incredibly small slopes (e.g. parts per billion).

A second caveat must be taken: As mentioned in the first, some of these trends are statistically significant, even though the actual change in nutrient levels observed in the watercourse may be incredibly small. Take into consideration the actual change over time of that nutrient in the watercourse, as is provided in the tables in **Appendix C**. For example, over the sixteen year course of this program, a nutrient at a site may have increased by half of a milligram per liter (part per million), or at a different site it may have increased by one microgram per liter (part per billion), or less. Despite this, both analyses could show statistically significant increases in this nutrient on a map.

Table 14 gives mean nutrient values for selected parameters for the 2020 water year. All nutrient values are included in **Appendix A**, with summary statistics found in **Appendix B**, and trends analyses in **Appendix C**.

Most of the natural streams in the program showed moderate levels of total nitrogen, ammonia, and total phosphorus. The drainage infrastructure sampling sites generally had higher levels of nutrients 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, pH, and other factors for each individual ammonia measurement.

The following trends analyses were performed only on the 17-year dataset, representing the entire length of this program's monitoring:

Total Kjeldahl Nitrogen shows a decrease at seven sites, and an increase at no sites, with no obvious clustering pattern (**Figure 11**).

Total Phosphorous shows an increase at fifteen sites, and a decrease in twelve sites (**Figure 12**). The improvements are clustered in the Middle Skagit watershed and down the Skagit River. The sites showing increasing phosphorous levels are observed all across the valley.

Ortho-phosphorous shows an increase at 23 sites, and a decrease in zero sites (**Figure 13**). This is a very negative trend map, and was the worst overall trend among the nutrients measured.

Ammonia levels have gone down at 16 sites around the county and have increased at only one. The decreases are observed all across the valley (**Figure 14**).

Nitrate + Nitrite levels have decreased at nine sites across the county, concentrated in the north and east, and have increased at only one site, the Swinomish Channel (**Figure 15**).

Overall, phosphorous (total and ortho) is the only nutrient showing an increase across the valley. Combination of all significant nutrient trends shows a total of 44 positive trends, or decreases, and 40 negative trends, or increases, with 38 of those being phosphorous. Phosphorous is the most common "limiting nutrient" for algal blooms in the natural environment, which means that when an excess of phosphorous shows up in the watercourse, it is often the only thing required to trigger an algal bloom.

Table 14 - Mean nutrient values (mg/L) for 2020 water year

Site Number	Watercourse	Location	Total Kjeldahl Nitrogen [1]	Total Phosphorus	Ammonia	Nitrate + Nitrite
3	Thomas Creek	Old Hwy 99 N	0.84	0.18	0.17	0.39
4	Thomas Creek	F&S Grade Rd	0.42	0.06	0.02	0.76
6	Friday Creek	Prairie Rd	0.26	0.02	0.01	0.31
8	Swede Creek	Grip Rd	0.37	0.05	0.01	0.27
11	Samish River	State Route 9	0.26	0.02	0.02	0.23
12	Nookachamps Creek	Swan Rd	0.45	0.07	0.09	0.21
13	E.F. Nookachamps Creek	State Route 9	0.42	0.04	0.06	0.18
14	College Way Creek	College Way	0.30	0.05	0.03	0.35
15	Nookachamps Creek	Knapp Rd	0.35	0.08	0.03	0.23
16	E.F. Nookachamps Creek	Beaver Lake Rd	0.25	0.01	0.02	0.29
17	Nookachamps Creek	Big Lake Outlet	0.27	0.03	0.05	0.16
18	Lake Creek	State Route 9	0.26	0.02	0.02	0.36
19	Hansen Creek	Hoehn Rd	0.31	0.03	0.02	0.27
20	Hansen Creek	Northern State	0.28	0.02	0.02	0.37
21	Coal Creek	Hoehn Rd	0.29	0.01	0.01	0.75
22	Coal Creek	Hwy 20	0.28	0.01	0.01	0.66
23	Wiseman Creek	Minkler Rd	0.26	0.01	0.01	0.77
24	Mannser Creek	Lyman Hamilton Hwy	0.28	0.03	0.02	0.19
25	Red Cabin Creek	Hamilton Cem. Rd	0.25	0.01	0.01	0.39
28	Brickyard Creek	Hwy 20	0.32	0.04	0.02	0.47
29	Skagit River	River Bend Rd	0.25	0.01	0.03	0.08
30	Skagit River	Cape Horn Rd	0.25	0.02	0.01	0.07
32	Samish River	Thomas Rd	0.30	0.04	0.03	0.46
33	Alice Bay Pump Station	Samish Island Rd	2.64	0.63	0.83	0.91
34	No Name Slough	Bayview-Edison Rd	0.95	0.93	0.16	0.22
35	Joe Leary Slough	D'Arcy Rd	0.78	0.28	0.57	0.71
36	Edison Slough at school	W. Bow Hill Rd	0.92	0.75	0.15	0.34
37	Edison Pump Station	Farm to Market Rd	16.32	1.35	1.76	0.59
38	N. Edison Pump Station	North Edison Rd	3.62	1.24	2.21	0.47
39	Colony Creek	Colony Rd	0.37	0.07	0.02	0.63
40	Big Indian Slough	Bayview-Edison Rd	0.70	0.15	0.27	0.57
41	Maddox/Big Ditch	Milltown Rd	1.21	0.28	0.46	0.99
42	Hill Ditch	Cedardale Rd	0.39	0.05	0.04	0.36
43	Wiley Slough	Wylie Rd	1.47	0.12	0.86	0.75
44	Sullivan Slough	La Conner-Whitney	1.39	0.25	0.72	0.55
45	Skagit River – North Fork	Moore Rd	0.25	0.01	0.02	0.08
46	Skagit River – South Fork	Fir Island Rd	0.25	0.01	0.03	0.08
47	Swinomish Channel	County Boat Launch	0.25	0.07	0.07	0.24
48	Fisher Creek	Franklin Rd	0.60	0.18	0.04	0.53

Figure 11 - Seventeen-year trends in Total Kjeldahl Nitrogen (TKN)

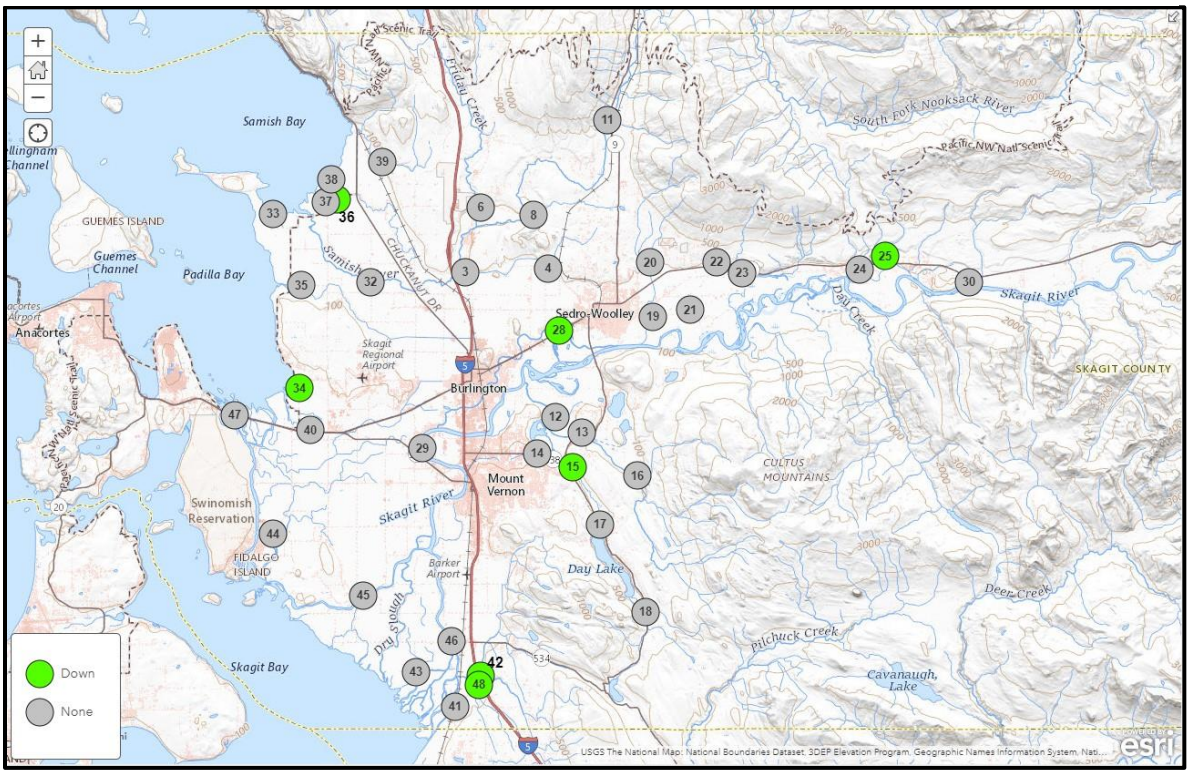


Figure 12 - Seventeen-year trends in Total Phosphorous (TP)

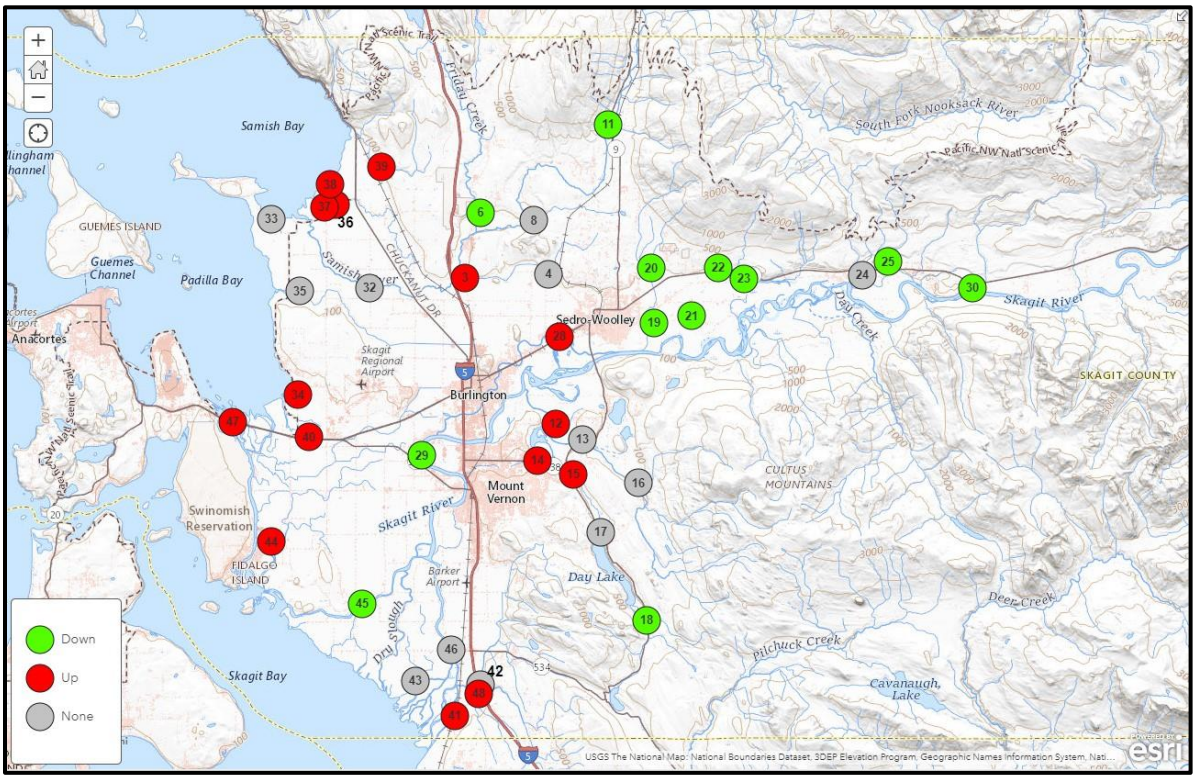


Figure 13 - Seventeen-year trends in Ortho-phosphorous (OP)

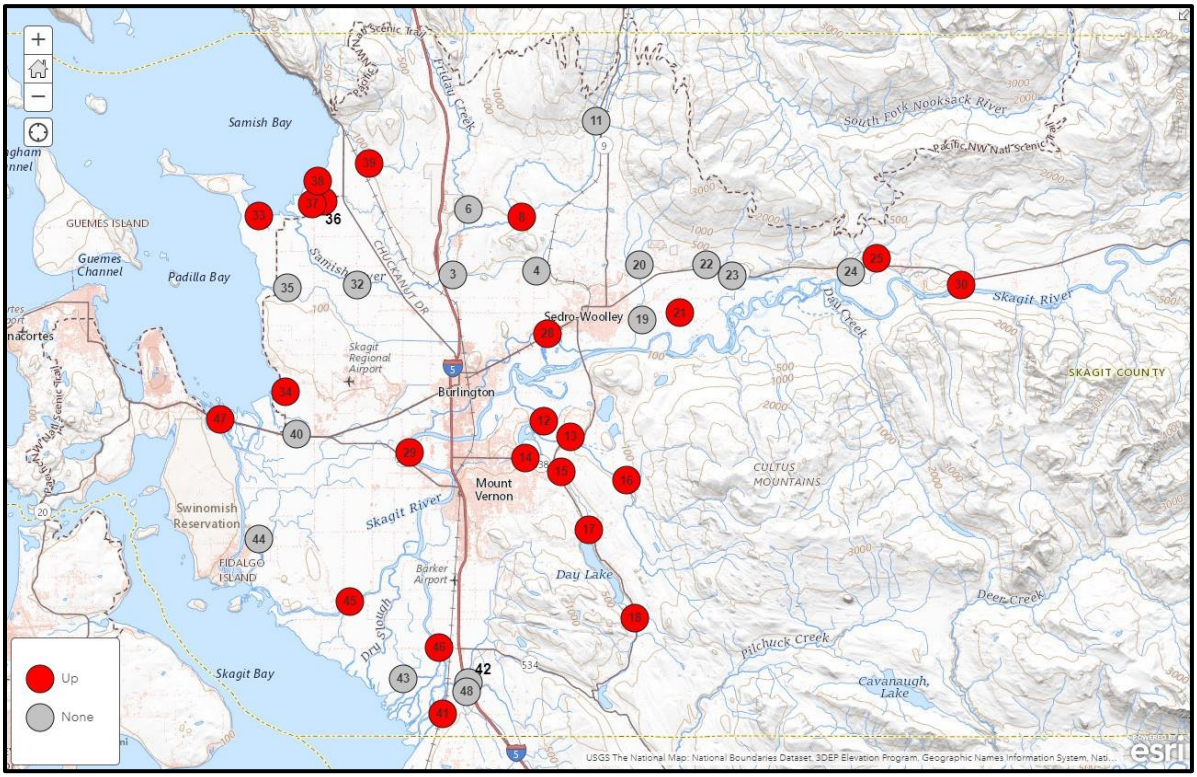


Figure 14 - Seventeen-year trends in Ammonia (NH3)

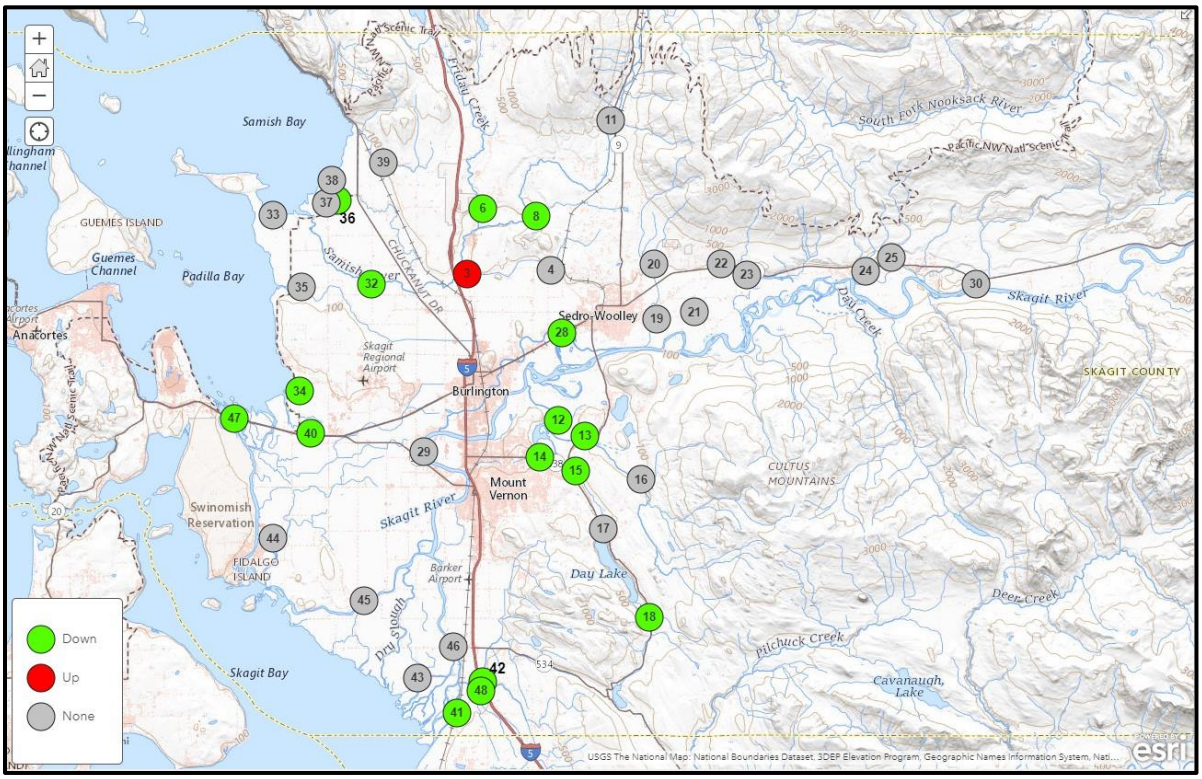
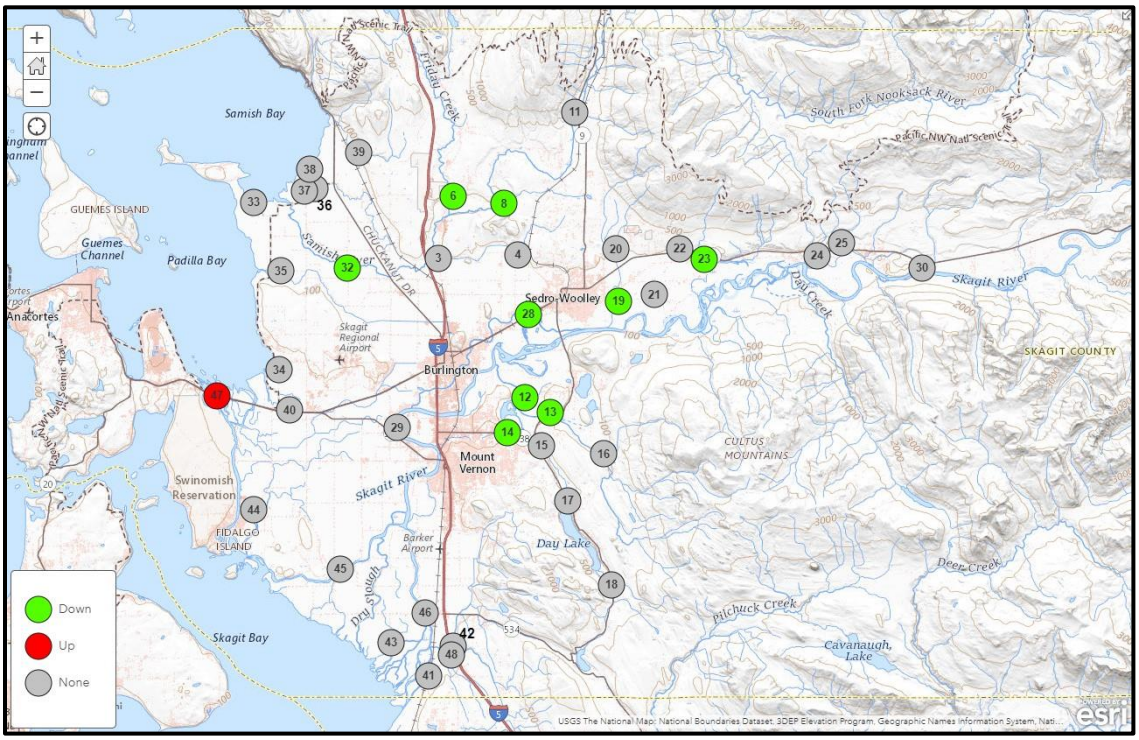


Figure 15 - Seventeen-year trends in Nitrate and Nitrite (NO3 + NO2)



Other Parameters

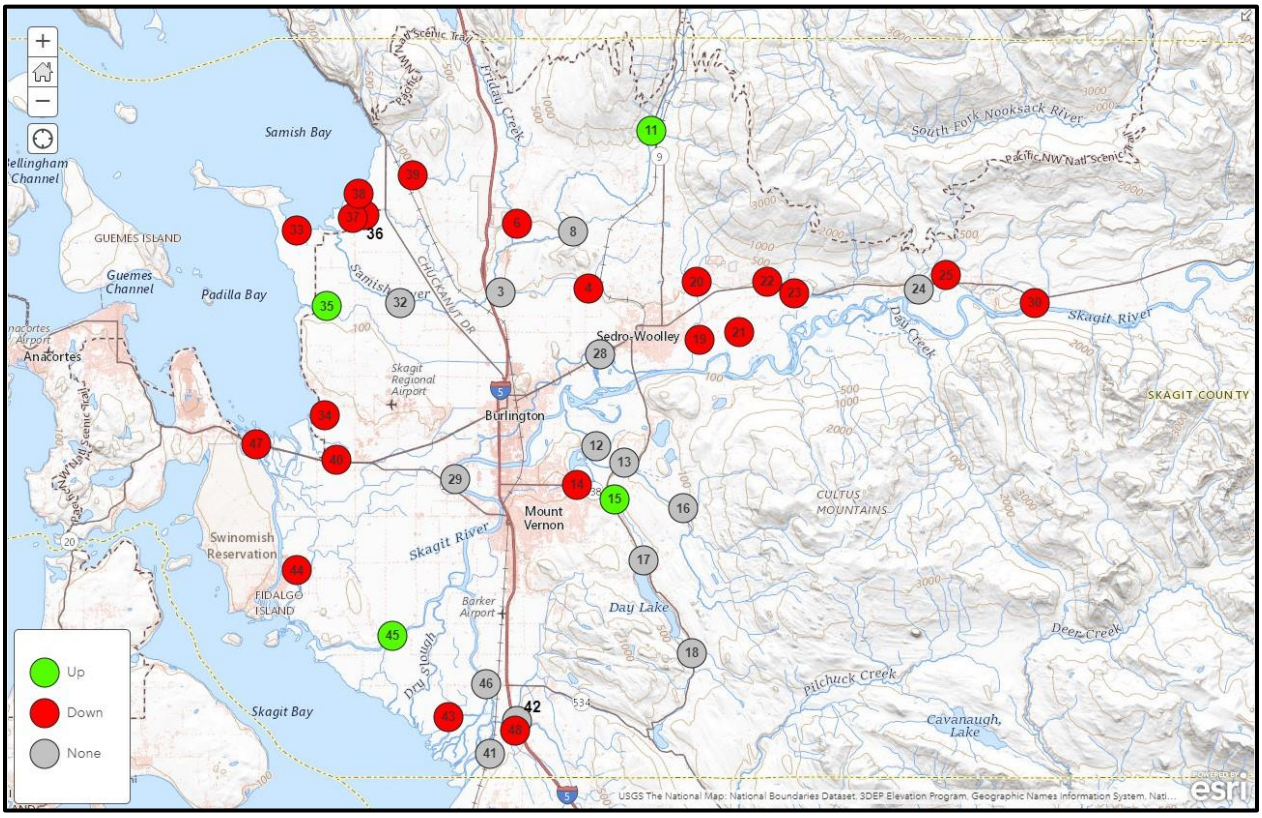
The SCMP also measures pH, during each visit to each site. Measurement of pH shows whether a watercourse is within the range that supports aquatic life. In general, pH in the SCMP has been within state standards.

Discharge measurements were made up until 2008 in selected locations and were intended to provide a general indication of the flow regime for that watercourse and as an aid in interpreting other water quality parameters. As Ecology has added several stream gauges in the area, Skagit County has de-emphasized performing manual discharge measurement.

Seventeen-year trends analysis on pH across Skagit County revealed 21 sites with significantly decreasing pH and four sites with an increase (**Figure 16**).

All measurements for these parameters are available in **Appendix A** and are summarized in **Appendix B**.

Figure 16 - Seventeen-year trends in pH



Summary Statistics of Significant Trends across Skagit County

In an effort to construct a bird's-eye view of what trends are occurring across Skagit County, two summary tables were created. These summary tables were populated from the site-specific tables provided in **Appendix C**. These tables take into account all trends analyses from the 17-year data (18 trends), the ten-year data (six trends), and the five-year data (six trends), combined, for a total of 30 possible significant trends. The results on these tables are biased toward the temperature and FC parameters, as they account for six of the 30 total trends in the group, and biased even further toward DO, as it accounts for eight total categories. Other parameters populate one or two categories each. For this report, positive trends were listed as: Increase in pH, increase in DO, increase in DO% saturation, decrease in temperature, decrease in turbidity, decrease in FC, decrease in nutrients, and decrease in TSS. Negative, or deleterious trends, were considered as the opposite of these statements.

The first table (**Table 15**) arranges all ambient monitoring sites by their percentage of positive significant trends as a ratio of total significant trends. Some sites recorded fewer than ten significant trends, while others recorded over twenty. The first table does not arrange by the number of trends total, but simply by how positively or negatively a particular site is trending overall. The sites in the county that have the highest ratio of positive trends are listed at the top, and the sites exhibiting the highest ratio of negative trends are at the bottom. This table is a quick reference for overall improving or deteriorating water quality for a site.

The second table (**Table 16**) arranges all ambient sampling monitoring sites by their total number of significant trends recorded. Some sites recorded fewer than ten significant trends, while others recorded over twenty. The second table does not arrange by the ratio of positive or negative trends recorded, but simply by the amount of significant change that is occurring at that site. This table is a quick reference for identifying which sites around the county are experiencing the most significant statistical change in water quality, and which sites are not. Sites located at the top of the table are those that have had their water quality parameters change the most.

Table 15 - Summary Statistics of Significant Trends, by Positive/Negative

Site		Significant Trends				Category
		Total	Positive	Negative	% Positive	
Samish River	11	15	15	0	100	Ag - Up
Skagit River	45	11	10	1	91	Skagit - Low
Samish River	32	16	14	2	88	Ag - Down
Thomas Creek	4	12	10	2	83	Ag - Up
Nookachamps Creek	15	16	13	3	81	Ag - Mid
Lake Creek	18	10	8	2	80	Ag - Up
Hansen Creek	20	10	8	2	80	Ag - Up
College Way Creek	14	13	10	3	77	Ref - Urban
Mannser Creek	24	13	10	3	77	Ag - Mid
EF Nookachamps	16	13	10	3	77	Ag - Mid
Skagit River	46	17	13	4	76	Skagit - Low
Joe Leary Slough	35	10	7	3	70	Ag - Down
Friday Creek	6	16	11	5	69	Ref - RR
Alice Bay Pump	33	12	8	4	67	Ag - Down
Nookachamps Creek	12	9	6	3	67	Ag - Down
Skagit River	29	6	4	2	67	Skagit - Mid
Fisher Creek	48	14	9	5	64	Ag - Down
Skagit River	30	13	8	5	62	Skagit - Up
Coal Creek	21	13	8	5	62	Ag - Down
No Name Slough	34	19	11	8	58	Ag - Down
Wiseman Creek	23	7	4	3	57	Ag - Up
Swede Creek	8	18	10	8	56	Ag - Down
Colony Creek	39	9	5	4	56	Ag - Down
Red Cabin Creek	25	11	6	5	55	Ref - RR
EF Nookachamps	13	13	7	6	54	Ag - Down
Thomas Creek	3	13	7	6	54	Ag- Down
Maddox/Big Ditch	41	15	8	7	53	Ag - Down
Brickyard Creek	28	6	3	3	50	Ref - Urban
Hill Ditch/Carpenter	42	14	6	8	43	Ag - Down
Big Indian Slough	40	10	4	6	40	Ag - Mid
Coal Creek	22	8	3	5	38	Ag - Up
Sullivan Slough	44	11	4	7	36	Ag - Down
Hansen Creek	19	15	5	10	33	Ag - Down
Nookachamps Creek	17	7	2	5	29	Ag - Up
Edison Slough	36	8	2	6	25	Ag - Down
N. Edison Pump	38	9	2	7	22	Ag - Down
Swinomish Channel	47	13	2	11	15	Ref - Marine
S. Edison Pump	37	10	1	9	10	Ag - Down
Wiley Slough	43	6	0	6	0	Ag - Down

Table 16 - Summary Statistics of Significant Trends, by Total Count

Site		Significant Trends				Category
		Total	Positive	Negative	% Positive	
No Name Slough	34	19	11	8	58	Ag - Down
Swede Creek	8	18	10	8	56	Ag - Down
Skagit River	46	17	13	4	76	Skagit - Low
Samish River	32	16	14	2	88	Ag - Down
Friday Creek	6	16	11	5	69	Ref - RR
Nookachamps Creek	15	16	13	3	81	Ag - Mid
Maddox/Big Ditch	41	15	8	7	53	Ag - Down
Samish River	11	15	15	0	100	Ag - Up
Hansen Creek	19	15	5	10	33	Ag - Down
Fisher Creek	48	14	9	5	64	Ag - Down
Hill Ditch/Carpenter	42	14	6	8	43	Ag - Down
EF Nookachamps	13	13	7	6	54	Ag - Down
Swinomish Channel	47	13	2	11	15	Ref - Marine
Thomas Creek	3	13	7	6	54	Ag- Down
College Way Creek	14	13	10	3	77	Ref - Urban
Mannser Creek	24	13	10	3	77	Ag - Mid
Skagit River	30	13	8	5	62	Skagit - Up
EF Nookachamps	16	13	10	3	77	Ag - Mid
Coal Creek	21	13	8	5	62	Ag - Down
Thomas Creek	4	12	10	2	83	Ag - Up
Alice Bay Pump	33	12	8	4	67	Ag - Down
Skagit River	45	11	10	1	91	Skagit - Low
Sullivan Slough	44	11	4	7	36	Ag - Down
Red Cabin Creek	25	11	6	5	55	Ref - RR
Lake Creek	18	10	8	2	80	Ag - Up
Hansen Creek	20	10	8	2	80	Ag - Up
Big Indian Slough	40	10	4	6	40	Ag - Mid
S. Edison Pump	37	10	1	9	10	Ag - Down
Joe Leary Slough	35	10	7	3	70	Ag - Down
Nookachamps Creek	12	9	6	3	67	Ag - Down
N. Edison Pump	38	9	2	7	22	Ag - Down
Colony Creek	39	9	5	4	56	Ag - Down
Coal Creek	22	8	3	5	38	Ag - Up
Edison Slough	36	8	2	6	25	Ag - Down
Nookachamps Creek	17	7	2	5	29	Ag - Up
Wiseman Creek	23	7	4	3	57	Ag - Up
Wiley Slough	43	6	0	6	0	Ag - Down
Skagit River	29	6	4	2	67	Skagit - Mid
Brickyard Creek	28	6	3	3	50	Ref - Urban

Water Quality Index (WQI)

The Water Quality Index is a tool developed by 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 DO, temperature, pH, turbidity, suspended solids, FC, 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 significant pollution problems revealed by storm sampling.

Ecology rates streams with WQI Overall Score of 80 or greater "of lowest concern." Streams with ratings of 40-79 are considered "of moderate concern," while scores less than 40 are considered "of highest concern."

Water Quality Index calculations for the sample sites in the SCMP during the 2019 water year are summarized in **Table 17,** and are mapped geographically in **Figure 17**. WQI scores over the length of this program are categorized for the years 2009-2019 in **Table 18**. 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.

Over the course of the SCMP, the number of sites in the Lavender (Lowest Concern) category has generally increased since 2012, while the number of sites in the Red (Highest Concern) category has held steady. Streams and ditches in the Red category can have either one water quality parameter that is well below standards or several categories that are below standards.

Water quality during storm events remains problematic as the results from storm event monitoring in the Samish Basin associated with the CSI continue to show excessive fecal coliform concentrations.

Table 17 - Water Quality Index (WQI) results for the 2020 Water Year

Site Number	Watercourse	Location	Overall Score*
3	Thomas Creek	Old Hwy 99 N	56
4	Thomas Creek	F&S Grade Rd	72
6	Friday Creek	Prairie Rd	87
8	Swede Creek	Grip Rd	75
11	Samish River	State Route 9	82
12	Nookachamps Creek	Swan Rd	58
13	E.F. Nookachamps Creek	State Route 9	57
14	College Way Creek	College Way	66
15	Nookachamps Creek	Knapp Rd	63
16	E.F. Nookachamps Creek	Beaver Lake Rd	90
17	Nookachamps Creek	Big Lake Outlet	69
18	Lake Creek	State Route 9	89
19	Hansen Creek	Hoehn Rd	80
20	Hansen Creek	Northern State	81
21	Coal Creek	Hoehn Rd	93
22	Coal Creek	Hwy 20	81
23	Wiseman Creek	Minkler Rd	96
24	Mannser Creek	Lyman Hamilton Hwy	63
25	Red Cabin Creek	Hamilton Cem. Rd.	94
28	Brickyard Creek	Hwy 20	79
29	Skagit River	River Bend Rd	82
30	Skagit River	Cape Horn Rd	84
32	Samish River	Thomas Rd	83
33	Alice Bay Pump Station	Samish Island Rd	26
34	No Name Slough	Bayview-Edison Rd	20
35	Joe Leary Slough	D'Arcy Rd	29
36	Edison Slough	W. Bow Hill Rd	17
37	Edison Pump Station	Farm to Market Rd	1
38	N. Edison Pump Station	North Edison Rd	1
39	Colony Creek	Colony Rd	75
40	Big Indian Slough	Bayview-Edison Rd	13
41	Maddox Slough/Big Ditch	Milltown Rd	18
42	Hill Ditch	Cedardale Rd	74
43	Wiley Slough	Wylie Rd	7
44	Sullivan Slough	La Conner-Whitney	23
45	Skagit River – North Fork	Moore Rd	93
46	Skagit River – South Fork	Fir Island Rd	93
47	Swinomish Channel	County Boat Launch	75
48	Fisher Creek	Franklin Rd	85

Color code: Lowest Concern (>80 Overall Score), Moderate Concern (40-80), Highest Concern (<40)

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

Figure 17 - Color coded map of 2020 WQI results

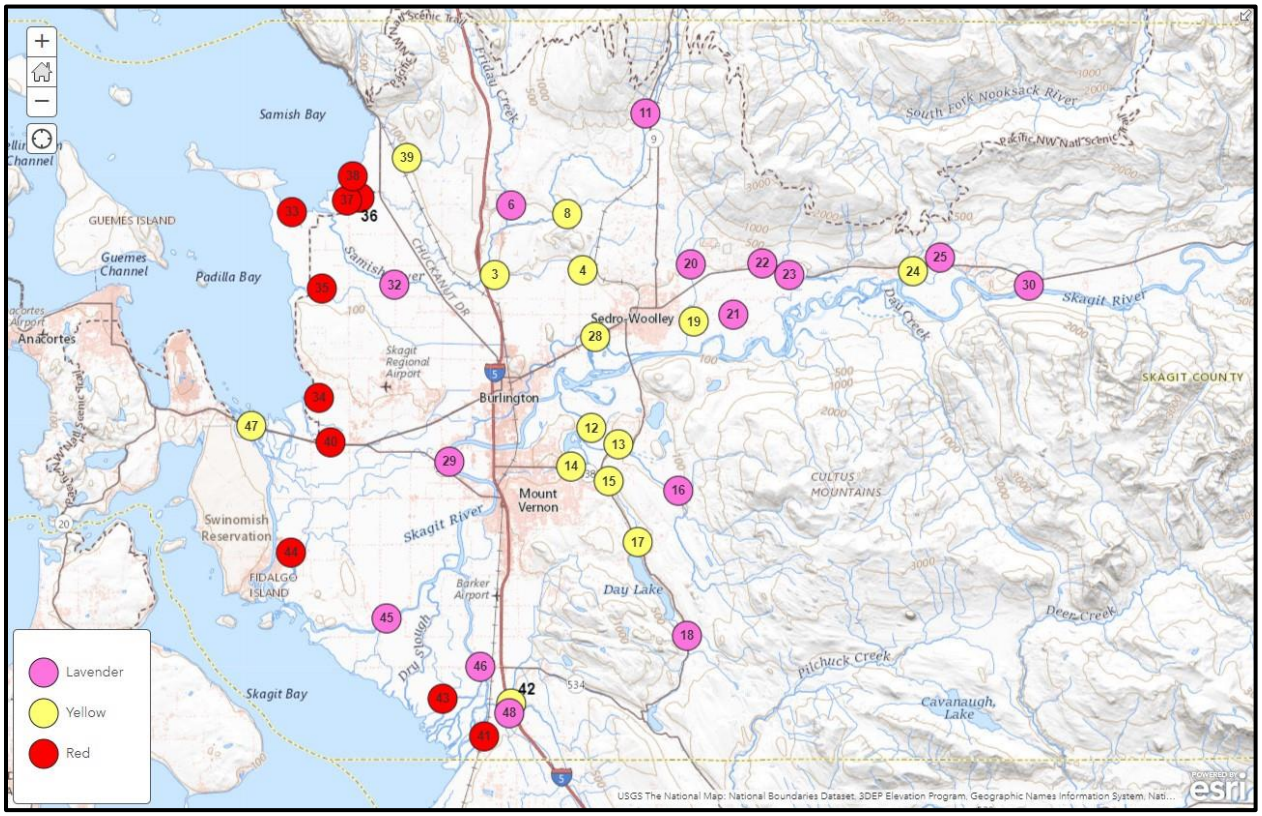


Table 18 - Number of sites in each WQI category for 2019 Water Year

Year	Lavender (80-100)	Light yellow (40-79)	Red (1-40)
2009	17	11	12
2010	13	19	8
2011	20	9	11
2012	13	16	11
2013	15	14	11
2014	16	13	11
2015	16	13	11
2016	15	15	10
2017	20	8	12
2018*	23	6	10
2019*	15	12	12
2020*	15	14	10

*39 sites sampled from 2018 forward

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