URBAN STREAMS MONITORING PROGRAM REPORT 2010

City of Bellingham
Department of Public Works Laboratory

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1.0 Introduction

Urban streams can be tremendous assets. They are an integral part of the environment, economy and community through which they flow. Healthy streams support vital functions of the aquatic environment like providing fish habitat and flood control. Their presence bolsters adjacent property values and allows recreational opportunities such as fishing and swimming. Beyond their banks, stream health is interconnected with disease control, greenway services and the state of the near-shore marine environment. For these reasons and more, the City of Bellingham is committed to maintaining the health and beauty of our urban streams.

As any urban area grows, inevitably so do the effects on urban streams. The City of Bellingham recognizes that urban activities impact streams and is working to understand and minimize these impacts through a variety of water quality improvement programs. These programs include stream restoration, stream hydrology, stormwater treatment, water quality monitoring, public education and ordinances that protect critical areas.

1.1 Effects of Urbanization

Urbanized areas contain large amounts of impervious surface that has replaced natural vegetation. Stormwater that runs across impervious surfaces and is no longer absorbed by soils leads to extremes in stream flow. Runoff from rain events can cause rapid, flashy increases in flow that lead to erosion, scour and habitat loss. Dry season flows are no longer maintained by the slow release of water absorbed by soils.

In addition, as water from rain events moves quickly across pavement and other impervious surfaces it picks up sediment and pollutants to be deposited into streams. Large amounts of sediment can clog gills, smother organisms that are the food source for fish, cover spawning beds, and destroy habitat. Chemicals flushed from streets and lawns can be toxic or increase oxygen depletion in the water. Two separate fish kills on Baker Creek in 2003 were correlated with storm events (LaCroix et al., 2004). Terrestrial bacteria, including fecal coliform, can be flushed into streams rendering them unfit for recreational uses.

Physical alterations to streams can have profound effects on the stability and integrity of natural systems. Artificial channel modifications including channelization, the placement of culverts, and bank stabilization measures such as retaining walls and riprap, degrades or eliminates habitat and in some cases prevents fish passage.

Removal of riparian (near-stream) vegetation can make streams become more prone to erosion and pollution. Additionally riparian vegetation provides canopy cover that helps keep stream water cool, a necessary factor in the survival of many native fish species.

Virtually every pond, creek and stream in the City has been modified through human endeavors, many of which are now considered impaired by Washington State water quality standards. Please read on for details regarding the status of our urban streams.

1.2 Bellingham's 303(d) listings

Section 303(d) of the Federal Clean Water Act requires states to develop lists of impaired water bodies. Table 1.2-1. catalogs Bellingham's current 303(d) category 5 (impaired) listings for urban streams. Maps of current listed stream reaches can be found in Appendix D. As Mill Wheel and Silver Beach Creeks are tributaries to Lake Whatcom, they are monitored as part of Lake Whatcom Total Maximum Daily Load (TMDL) efforts and are not included in the Urban Streams Program. A TMDL is a structured water quality improvement plan that establishes limits on pollutants that can be discharged to a water body in order for state water quality standards to be met. Information regarding Lake Whatcom can be found at: http://www.cob.org/services/environment/lake-whatcom/index.aspx.

The determination of which water bodies included on the 303(d) list will be assigned TMDL plans is made by the Washington State Department of Ecology. Of Bellingham's urban streams, only Whatcom Creek, and by extension it's tributaries, are in the process of being assigned a TMDL (for fecal coliform and temperature). However, Padden and Squalicum Creeks are both considered priority water bodies for TMDL or category 4b consideration. Category 4b is assigned to water bodies that are impaired but do not require a TMDL because they already have pollution control projects in place. Foreseeing this possibility years ago, the City has been actively putting pollution control projects in place on these streams. Such projects include innovative water quality studies, habitat studies, clean-up work and restoration efforts.

In 2010, the city began enhanced water quality monitoring of select 303d listed stream reaches in an effort to better understand the water quality dynamics of our impaired waters. For more information on enhanced monitoring, please see sections 5.2.2 and 9.1 of this document.

Table 1.2-1. Bellingham's Urban Stream 303(d) listings by parameter.

Creek	Temp	DO	Fecal	Zinc
Chuckanut		x	x	
Padden	x	x	x	
Connelly	x	x	x	
Whatcom	x	x	x	
Hanna	x		x	
Cemetery	x	x	x	
Lincoln	x	x	x	
Fever	x	x	x	x
Squalicum	x	x	x	
Baker			x	
Silver		x	x	
Mill Wheel			x	
Silver Beach			x	

2.0 Stream Restoration

The City has spent considerable effort in recent years on stream restoration projects designed to mitigate habitat degradation that has occurred as a consequence of human activities. Figure 2.0-3 shows restoration projects on Bellingham's urban streams. Projects have included restoring and replanting riparian buffers, removing artificial channel modifications, stabilizing banks, and improving fish habitat through a variety of specific habitat objectives. Details of individual projects can be found in Appendix A.

Figure 2.0-1. Fish-passable culvert on Connelly Creek at Donovan Ave.

Riparian buffer restoration (shown in green on Figure 2.0-3) has been performed on stream segments throughout the City. This process of restoring natural function to the land along stream corridors includes the removal of non-native plant species and replanting with native trees, shrubs, and other plants. Riparian vegetation provides a buffer area which filters out pollutants from urban runoff. Riparian vegetation also stabilizes stream banks, regulates stream temperatures, and provides leaf litter that aquatic insects and microorganisms use as a food source. The riparian zone provides habitat and migration corridors for wildlife.

Artificial channel modifications change the natural balance of stream systems. Culverts and other physical barriers can impede passage of fish and cause sedimentation. Figure 2.0-3 provides the locations where fish passage barriers have been removed or modified (pink rectangles). Channelization, the straightening of streambeds, causes increased flooding, sedimentation, erosion, and loss of habitat. In many cases urban streams have been disconnected from their natural flood-plains through channel modifications. Natural flood-plains perform an essential role in flood prevention and habitat creation and they help maintain the hydrological balance in stream systems.

The removal of artificial channel modifications includes removing physical barriers, replacing obstructive culverts with fish-passable culverts (Figure 2.0-1), returning channelized reaches of streams to a more natural meander or braided form, reconnecting streams to their natural flood-plain, and replacing armored bank stabilization structures with more natural structures such as designed log jams (Figure 2.0-2).

Figure 2.0-2. Placement of root wads and large woody debris for bank stabilization on Whatcom Creek.

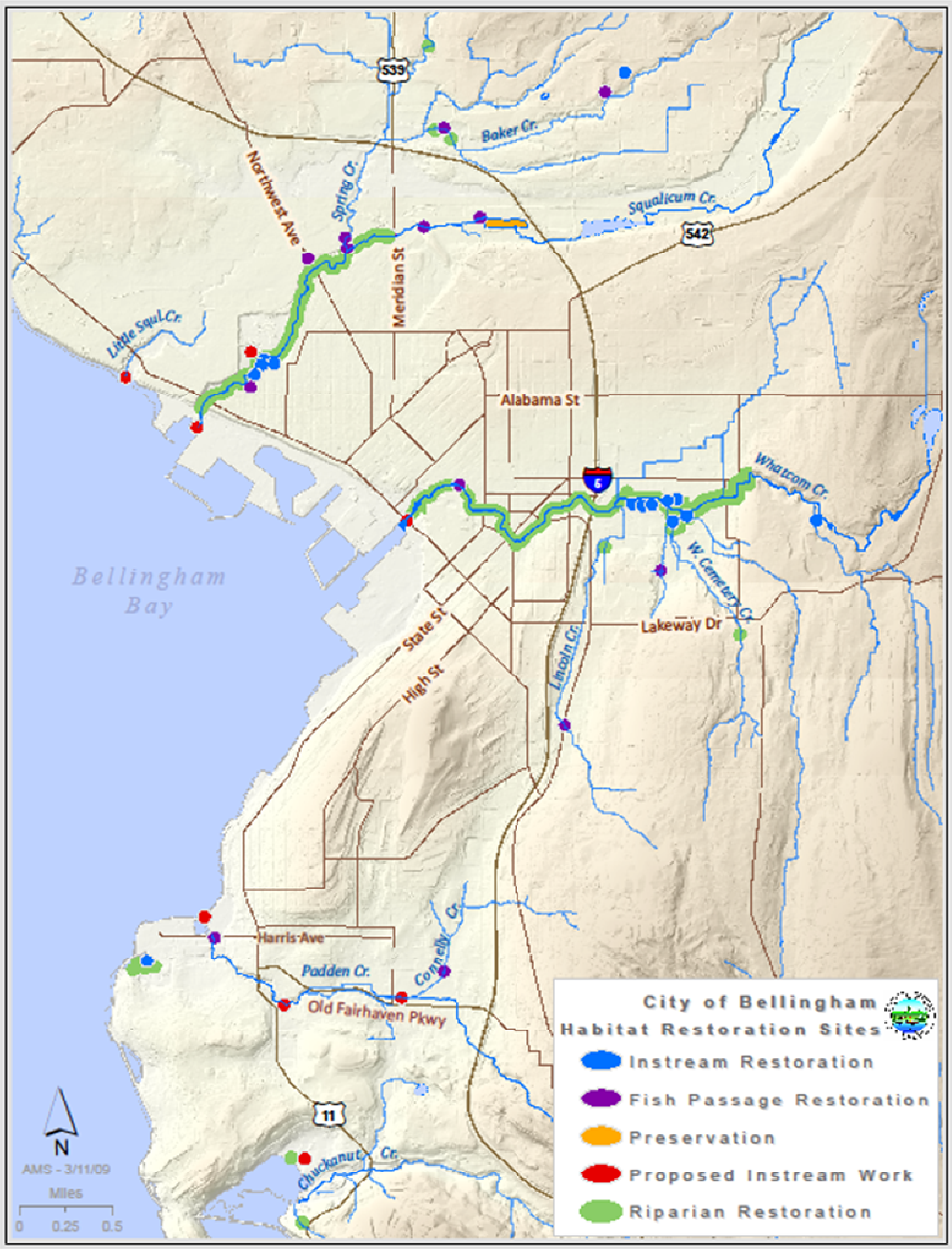


Figure 2.0-3. Location and types of stream restoration projects within the City of Bellingham (March 2009).

Figure 2.0-4. Backwater pond created on Cemetery Creek to provide low velocity refuge for juvenile fish in times of high flow.

The City's strategies to improvement fish habitat have been complex and varied. The course of action for a given stream depends on the specific characteristics of the stream system and the species of fish that currently or could potentially inhabit the stream. Some of the fish habitat restoration projects in Bellingham's urban streams (Figure 2.0-3, shown in blue) have included the creation of backwater areas (Figure 2.0-4) which provide low velocity refuges for juvenile fish in times of high flows, the addition of spawning gravel to streams that have experienced channel erosion, the restoration of pool-riffle sequences which provide spawning and resting areas for fish, and restoring stream banks to a more natural sloped shape rather than the sharply down cut banks indicative of urbanization.

Expected benefits of stream restoration include improved riparian habitat, lessening flow extremes, canopy cover to promote cooler water temperatures and a corresponding increase of dissolved oxygen in the summer months, reduced sediment and pollutant loads, reduced erosion, increased populations of fish and other aquatic life, and improved aesthetics. All of these improvements lead to more recreation opportunities and increased property values along the improved stream corridors.

2.1 Restoration Projects in 2010

During 2010, a project to daylight and restore habitat at Willow Spring (a tributary to Squalicum Creek) highlights the City's efforts to protect the health of our urban streams. The Willow Spring project created 1,030 feet of perennial stream channel, 0.34 acres of adjacent wetlands and 1.54 acres of forested streamside (Figure 2.1-1), a significant increase to valuable fish and wildlife habitat. At the same time, improvements to the Squalicum City Park that contains this waterway is being made to make the site a more enjoyable place for the citizens of Bellingham to visit and recreate in.

In addition, work continues on Padden Creek to restore the creek's path to a more natural condition and improve riparian buffers between the creek and nearby houses. When completed, this project is expected to mark considerable improvements to water quality of Padden Creek.

Figure 3.1-1. Daylighted area of Willow Spring. Depicted in the foreground is the newly created winding course and instream large woody debris.

3.0 Stream Hydrology

Stream hydrology data provide information for developing restoration strategies, determining the adequacy of stormwater infrastructure and assessing land use impacts to stream flows. The City of Bellingham Storm and Surface Water Utility is currently supporting hydrological assessment of specific reaches on Whatcom, Squalicum, Padden, and Chuckanut Creeks. Stream gauging stations on these creeks provide data on gauge heights (relative height of the water) measured at 15 minute intervals.

Based on field studies of how depth relates to flow, rating curves are developed and the stream gauge data is used to create hydrographs that forecast the hydrological regime of the stream reaches. The information derived from hydrographs is used to analyze high/low flows and flow duration.

Decisions based on the analysis of stream discharge affect the operation of instream flood control dams (present on Padden, Squalicum and Whatcom Creeks), the type and size of new stormwater structures to be installed, where different types of stream restoration can have the greatest success, assessing available fish habitat, determining the potential for erosion, scouring and water quality impacts to receiving waters. It can also be used by City planners when considering development options within a watershed. Finally, knowing the hydrology of a given stream provides insight into fluctuations seen in water quality data.

Figure 3.0-1 illustrates the effects of rainfall on flow, temperature and dissolved oxygen levels in Squalicum Creek in May of 2010. Notice that rainfall is always followed by increases in flow and dissolved oxygen, and decreases in temperature. Hydrographs tracking daily mean discharges in 2010 can be found in their respective stream's section.

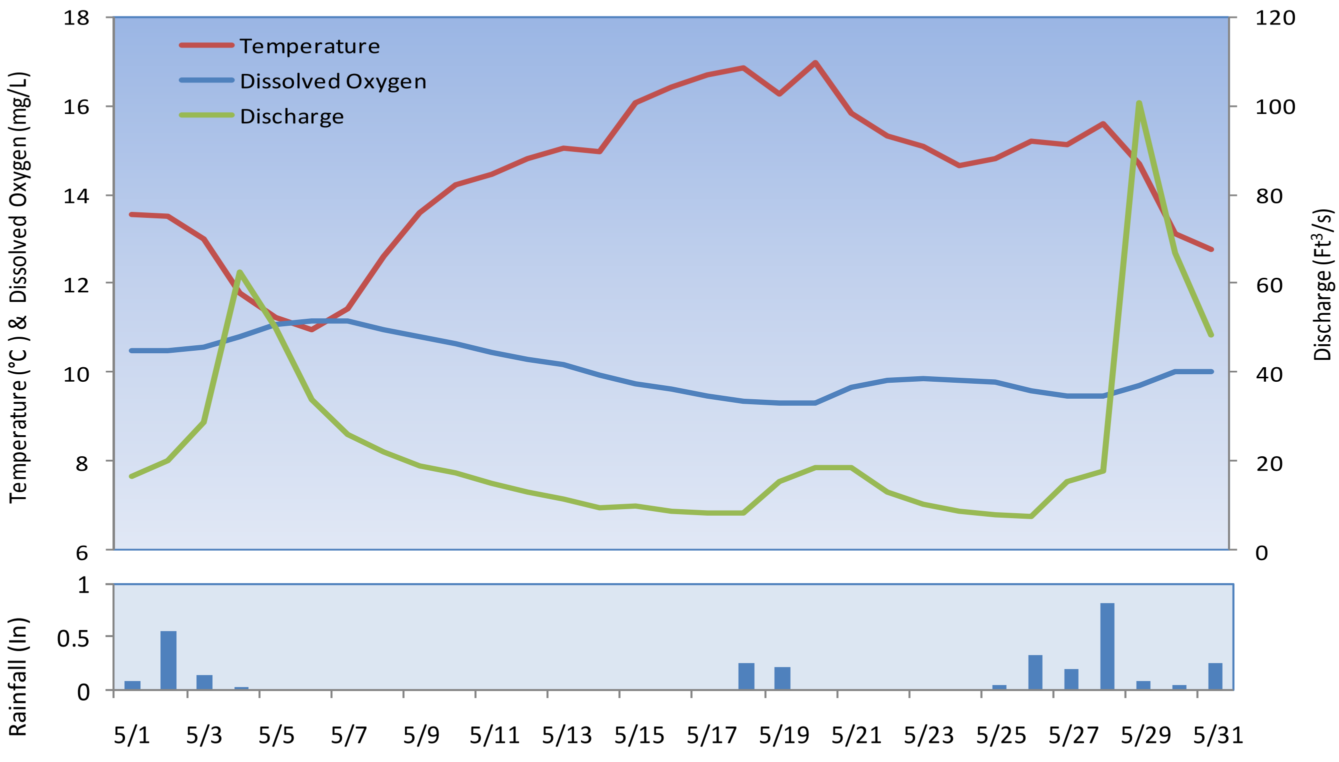


Figure 3.0-1. Effects of rain on flow, temperature and dissolved oxygen levels during on Squalicum Creek, 2010.

4.0 Stormwater Treatment

Over the years, Bellingham has built and expanded buildings, roadways, sidewalks, lawns and other portions of an urban landscape. Bellingham also receives on average 36 inches of rainfall per year. Naturally, runoff from the urban landscape has grown with the City.

Over the years our understanding of the impacts of urban runoff has also grown. Stormwater has come to be considered the single greatest source of pollutants entering our waters. A recent study by the Washington State Department of Ecology found that nearly 75% of pollution entering the Puget Sound is from stormwater outfalls. In Bellingham, a large portion of the City's stormwater system drains to our urban streams on its way to Bellingham Bay.

In 1990 the City of Bellingham began a Storm and Surface Water Utility (SSWU) to address the issues of stormwater pollution. Under the auspices of the federal National Pollutant Discharge Elimination System (NPDES) for stormwater, the City of Bellingham's Storm and Surface Water Utility is charged with working towards improvement of water quality in Bellingham's streams, lakes and nearshore waters.

Figure 4.0-1. The green roof installed on the new Bellingham Children's Museum. An example of the City of Bellingham's commitment to LID practices.

Figure 4.0-2. Rain garden in the Bellingham City Hall parking lot. Run-off enters the rain garden through the curb cut shown in the photograph. Pollutants are taken up by the plants or removed by filtration within the soils. Treated water is slowly discharged to Whatcom Creek, behind the rain garden.

With a population of under 100,000, Bellingham is considered a Phase II municipality for the purposes of NPDES permitting. This defines the requirements of the City for stormwater clean-up and management. The SSWU program provides services including: maintenance of our existing stormwater systems, review and enforcement of codes intended to prevent stormwater pollution, where prevention is not possible administration of proper stormwater mitigation, provision of education to developers and the general public, monitoring water towards meeting compliance and many other services as well. The City's Storm and Surface Water Utility is constantly evaluating, retrofitting and improving Bellingham's stormwater system towards the goal of protecting the health of our local water bodies and by extension, our citizens.

The City of Bellingham stormwater system is comprised of both natural and manufactured conveyance and detention systems. Natural conveyance systems include creeks and lakes that receive and channel runoff from rain and other sources. Manufactured conveyance systems consist of a network of open ditches, catchbasins, closed pipes, manholes, and water quality facilities such as ponds, vaults, storm filters, and bioswales. These two systems work in concert to control the quantity and improve the quality of runoff before it is discharged into major streams, lakes and Bellingham Bay.

Since the advent of the SSWU many stormwater mitigation facilities have been constructed. They fall in two categories, public facilities constructed to mitigate public or regional issues and private facilities owned and maintained by the private sector.

Public Facilities: There is a total of 237 facilities owned and maintained by the Storm and Surface Water Utility. These facilities include 4 regional detention ponds; 114 detention/ water quality ponds, vaults or pipes; 57 water quality swales; 62 stormfilters; 4 raingardens and miles of ditches being maintained to provide water quality function.

Private Facilities: There are 620 private properties providing treatment and/or storage of stormwater. The facilities on these properties serve an area totalling 2,406 acres or 3.76 square miles. The facilities include approximately 341 detention facilities, 84 detention/water quality facilities, 62

infiltration facilities, 285 water quality swales, 141 vaults/pipes and 88 miscellaneous facilities (oil water separators, filter vaults, etc).

Always on the forefront of stormwater treatment technologies, in 2010 the City began installing specialized filter media cartridges in existing vaults around Lake Whatcom. In addition to the removal of suspended solids, the new media also removes dissolved phosphorus from stormwater. Reducing the phosphorus load carried by stormwater to Lake Whatcom is part of the City's commitment to improve the health of Lake Whatcom and meet the goals of the Lake's TMDL. Studies to evaluate the efficiency of the new media in the field are ongoing.

Bellingham also continues to be a leader among Phase II municipalities in integrating low impact development (LID) into their infrastructure. Of special note in 2010 is the integration of a "green roof" on the newly completed Children's Museum downtown (Figure 4.0-1). Like the many raingardens found around Bellingham, the green roof functions to moderate stormwater and pollutants flowing off the site through infiltration and biological removal by the specialized plantings found there.

More information regarding the Storm and Surface Water Utility and its programs can be found online at http://www.cob.org/services/utilities/surface-storm/index.aspx.

5.0 Water Quality Monitoring

One of the longest running monitoring programs within the City is the Urban Streams Monitoring Program. This program, which began in 1990, was developed by the City to obtain baseline water quality data for streams in Bellingham and to use this data to assess water quality in the streams. The City also uses the data to compare the water quality in Bellingham's urban streams to the water quality standards described in the Washington State Department of Ecology (Ecology) rule - Chapter 173-201A WAC, *Water Quality Standards for Surface Waters of the State of Washington* (1997, 2003, 2006). The Urban Streams Monitoring Program is not intended to directly interface with the Ecology rules as they pertain to determination of impaired status but to give context to the water quality observed in Bellingham's urban streams.

While the City makes every attempt to capture meaningful data, it should be recognized that all tests are collected by grab samples. These samples may or may not be representative of the true character of water quality with Bellingham's urban streams. This data should not be used for the determination of regulatory compliance or noncompliance.

Ecology uses various water quality criteria to protect existing and designated uses of surface waters in Washington. The rule was originally promulgated in 1997 and underwent significant revision in 2003. These revisions changed the 1997 class-based system to a designated uses approach. The 2003 rule underwent further revisions after the US Environmental Protection Agency (EPA) failed to approve portions of the rule. Ecology adopted revisions to the 2003 rule on December 21, 2006. Under the 2006 rule, Bellingham's urban streams are designated the Aquatic Life Use (ALU) of Core Summer Salmonid Habitat for temperature, dissolved oxygen, pH, and turbidity. For recreational activities, Bellingham's streams are designated for Primary Contact Recreational Use according to fecal coliform count. With the exception of the fecal coliform bacteria standard that was approved by the EPA in 2005, these changes apply to all stream monitoring conducted since 2006. For purposes of this report, the Class-based designations are presented in addition to Use-based criteria. This allows for ease of comparison of streams from year to year.

5.1 Procedures and Quality Control

All analyses are performed by the staff of the City of Bellingham's state accredited laboratory. Protocols used are described in Standard Methods for the Examination of Water and Wastewater, 21st Edition (APHA, AWWA, WEF, 2005). Protocols for each parameter are listed in Appendix B.

Samples for fecal coliform bacteria are collected one to six inches below the surface of the water in clean, sterile 250-ml polypropylene bottles. Samples are kept on ice for transportation to the laboratory. In the laboratory, samples are kept refrigerated (< 4°C) until analyzed. Analysis for fecal coliform bacteria (SM 9222 D) is completed within six hours of collection (Appendix B).

Quality control for fecal coliform includes a laboratory duplicate (one sample, two measurements) and a field duplicate (two samples collected from the same sampling location) analyzed monthly along with regular stream samples. The laboratory duplicates serve to check the reproducibility of the instruments and the Laboratory Technician's technique. The purpose of the field duplicate is to indicate site heterogeneity or how representative the measurement is for a particular site. Agreement between the duplicates is assessed. If the difference between the duplicate samples is out of the calculated range of acceptable results or data appear questionable, the data are investigated. Results of the investigation are noted. The data can be left unchanged, flagged, or removed as the investigation dictates (Appendix B).

Field measurements for dissolved oxygen (SM 4500-O G), temperature (SM 2550 B), pH (SM 4500-H^+ B), and conductivity (SM 2510 B) are taken using a Hydrolab Quanta field monitor**.** Quality control includes pre and post calibration of the Hydrolab, testing check standards, and two field duplicates (two measurements from the same sampling location). If check standard measurements are out of a specified range, the instrument is recalibrated and retested with the check standards (Appendix B). Assessment of field duplicates follows the same procedure as for fecal coliform bacteria.

Turbidity measurements (SM 2130 B) are conducted on a benchtop turbidimeter. Quality control includes a laboratory duplicate, a field duplicate, and testing check standards. If check standard measurements are out of a specified range, the instrument is recalibrated and retested with the check standards (Appendix B). Assessment of laboratory and field duplicates follows the same procedure as for fecal coliform bacteria.

5.2 Sampling

5.2.1 Conventional Sampling

The City of Bellingham urban streams have been monitored for the past 17 years. Twelve sites have been consistently sampled throughout the monitoring program. Eighteen sites have been sampled since 2002. One additional site was added at the end of 2006. The quantity of samples collected per year from each site has varied from four to twelve. Since 2002 all sites have been sampled monthly. Latitude and longitude of each sample site are provided in Table 5.2-1.

Sampling locations are shown on the drainage basin maps supplied in Appendix E of this report. The sampling program includes four sites on Whatcom Creek as well as four of its tributaries - Hanna, Cemetery, Lincoln, and Fever Creeks (Whatcom Drainage Map). There are three sampling sites on Squalicum Creek and a sampling site on its main tributary, Baker Creek (Squalicum Drainage Map). Padden Creek is sampled at four locations and on its main tributary, Connelly Creek (Chuckanut and Padden Drainage Map). Silver Creek has one sample site (Silver Drainage Map) and Chuckanut Creek is sampled only near the mouth (Chuckanut and Padden Drainage Map).

Table 5.2-1. Latitude and longitude of urban stream sample sites, NAD84 datum.

Stream Site	Latitude	Longitude
Chuckanut Creek (Mouth)	48° 42' 02"	122° 29' 37"
Padden Creek (38th St.)	48° 42' 20"	122° 28' 02"
Padden Creek (30th St.)	48° 42' 49"	122° 28' 41"
Connelly Creek (Donovan)	48° 43' 01"	122° 28' 47"
Padden Creek (22nd St.)	48° 42' 92"	122° 29' 39"
Padden Creek (Mouth)	48° 43' 10"	122° 30' 25"
Whatcom Creek (Control Dam)	48° 45' 27"	122° 25' 20"
Hanna Creek (WTP)	48° 45' 08"	122° 26' 08"
Cemetery Creek (Whatcom Cr)	48° 45' 12"	122° 27' 12"
Lincoln Creek (Fraser)	48° 45' 06"	122° 27' 36"
Fever Creek (Valencia)	48° 45' 35"	122° 26' 47"
Whatcom Creek (Valencia)	48°45' 14"	122° 26' 42"
Whatcom Creek (I-5)	48° 45' 15"	122° 27' 45"
Whatcom Creek (Dupont)	48° 45' 20"	122° 28' 50"
Squalicum Creek (E. Bakerview)	48° 47' 21"	122° 26' 18"
Squalicum Creek (Meridian)	48° 46' 32"	122° 29' 07"
Baker Creek (Squalicum Pkwy)	48° 46' 29"	122° 29' 29"
Squalicum Creek (Mouth)	48° 45' 47"	122° 30' 22"
Silver Creek (Graveline)	48°49' 30”	122°32' 41”

Levels of fecal coliform bacteria, dissolved oxygen, temperature, pH, turbidity, and conductivity are measured at each site. All but conductivity are water quality parameters included in the WAC. Criteria included in the WAC but not sampled by the City include bioassessment, contaminated sediments, phosphorus, toxic substances and total dissolved gases.

The maximum, minimum and average conductivity results for individual stream segments can be found on page 27. The 2010 results for this parameter have not changed significantly from prior years. Conductivity measurements for 2002 and earlier can be found in the *Urban Streams Monitoring Program Report 2002* (City of Bellingham, 2002b).

5.2.2 Enhanced Sampling

In 2010 the City of Bellingham began a ongoing program to conduct enhanced sampling on select 303d listed stream reaches each year. Enhanced sampling uses continuous monitoring equipment and frequent grab sampling to rigorously investigate the causes and validity of our 303d listings. Data collected via these methods provide a more comprehensive picture of overall water quality in our urban streams.

The advantages of enhanced sampling include the ability to calculate 7-day averages of daily maximums (7DADMAX) and 7-day averages of daily minimums (7DADMIN) from continuous monitoring data. The Department of Ecology currently considers the 7DADMAX for temperature and 7DADMIN for dissolved oxygen the best ways to assess water quality for these parameters. They are the preferred method for determining 303d status. In addition, more frequent grab sampling for parameters like fecal coliform allows for a better estimation of overall geometric means (geomeans).

As Bellingham's streams are most often listed for exceedences of temperature, dissolved oxygen and fecal coliform standards, sampling efforts will usually be conducted during Ecology's designated "dry" summer season (June 1 - September 30) when these factors are of most concern. Results of enhanced sampling will then be included in class/aquatic life use/ recreational contact use designation analysis for the streams in question during that year.

In 2010, stream segments in the Squalicum Creek drainage were chosen to be monitored using enhanced sampling protocol. From May 1st until October 1st the Meridian and Mouth sites on Squalicum Creek along with Baker Creek were sampled weekly for fecal coliform. In addition, the Squalicum Creek site at Meridian was continuously monitored (15 min data) for temperature and dissolved oxygen levels. Results of enhanced sampling in the Squalicum Creek drainage can be found in section 9.0.

5.2.3 Historical Sampling

Historically, Bellingham's urban streams have rarely met all of the water quality standards for overall Class A* designation (Table 5.2-2). The overall classification of a stream is based on the parameter which confers the lowest class designation on that water body.

Based on conventional sampling in 2010, Chuckanut Creek met Class AA standards; Padden Creek at 38th, Squalicum Creek at Meridian, Hanna Creek and the Valencia, I-5 and Dupont sites on Whatcom Creek met Class A standards; while Padden Creek at 30th and 22nd, Whatcom Creek at the Control Dam, Cemetery Creek, Baker Creek, and Squalicum Creek at E. Bakerview and the Mouth met Class B standards.

In 2010, Chuckanut Creek, Squalicum Creek at Meridian, and Whatcom Creek at the Control Dam, Valencia, I-5, and Dupont met Primary Contact Recreational Use standards. Only Chuckanut Creek met all of the Aquatic Life Use requirements of Core Summer Salmonid Habitat.

The following sections provide conventional sampling data collected during 2010. Historical data for is also provided for comparison of the water quality parameters sampled for each site. Raw data tables used to construct percent exceedence figures are provided in Appendix C.

Table 5.2-2. Overall class designation for all stream segments from 1991 to 2010. ("AA" - surpassed Class A standards; "A" - met Class A standards; "B" - did not meet Class A standards but met Class B standards; "X" - did not meet Class B standards). Designations based on conventional sampling.

Sampling Site	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10
Chuckanut (mouth)	B	X	X	X	X	X	B	X	X	A	X	B	X	B	X	X	B	B	B	AA
Padden (38th)						B	B	X	AA	A	X	A	B	X	A	A	A	X	A	A
Padden (30th)	X	B	X	X	X	A	B	X	X	A	A	A	X	X	X	B	B	X	B	B
Connelly (Donovan)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X	X
Padden (22nd)															X	X	X	B	X	B
Padden (mouth)	X	X	X	X	X	X	B	X	X	B	X	X	X	X	X	X	X	B	X	X
Whatcom (Control Dam)	X	X	B	X	X	X	B	X	B	B	B	X	X	X	X	X	B	B	B	B
Hanna (WTP)					X							B	X	X	X	X	X	X	B	A
Cemetery (Whatcom Cr)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X	B
Lincoln (Fraser)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X	X
Fever (Valencia)				X	X	X	X	X	X	X	X	X	B	X	X	X	X	X	X	X
Whatcom (Valencia)																	A	B	B	A
Whatcom (I-5)	B	B	X	X	X	X	B	X	X	B	X	B	B	X	B	B	B	B	B	A
Whatcom (Dupont)	X	X	X	X	X	B	B	X	X	X	X	B	X	X	X	X	B	X	X	A
Squalicum (E. Baker-		B		X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	B
Squalicum (Meridian)	B	A	X	X	X	X	B	B	B	X	B	B	A	X	X	B	A	X	A	A
Baker (Squalicum)	B	X	X	X	X	X	A	B	X	X	X	X	X	X	X	X	X	X	X	B
Squalicum (Mouth)	B	B	X	X	X	X	A	X	X	X	X	X	X	B	X	X	X	A	X	B
Silver (Graveline)														X	X	X	X	X	X	X

*For consistency and ease of comparisons, Ecology class designations used before 2006 are presented in addition to current Ecology designated use standards. They are not meant to directly interface with the Ecology rules as they pertain to determination of impaired status but to give context to the water quality observed in Bellingham's urban streams.

5.3 Water Quality Parameters

5.3.1 Fecal Coliform Bacteria

The water quality parameter that historically has most often determined the overall classification of Bellingham's urban streams is fecal coliform bacteria. Stream sites sampled by the City rarely meet the Primary Contact Recreational Use (Class A) standards for this parameter (Table 5.3.1-1).

In 2010, Chuckanut Creek, Squalicum Creek at Meridian and four sites on Whatcom Creek (Control Dam, Valencia, I-5 and Dupont) met the stringent Class AA criteria for fecal coliform bacteria. Padden Creek at 38th and Hanna Creek met Class A criteria. Padden Creek at 30th and 22nd, Cemetery Creek, Baker Creek and Squalicum Creek at E. Bakerview and the Mouth met Class B standards. The remaining 6 sites did not meet Class A or B criteria for fecal coliforms. Figure 5.3.1-1 shows the minimum, maximum, and geomean values for all stream segments sampled in 2010. Figure 5.3.1-2 provides the percent of samples that exceeded fecal coliform water quality standards.

Fecal coliform bacteria are normal inhabitants of the digestive tracts of warm-blooded animals. The presence of fecal coliforms in water indicates contamination from fecal sources. While these bacteria do not usually cause illness directly, fecal coliforms are considered an indicator of pathogens that cause a variety of water-borne illnesses and conditions including eye, ear, and skin conditions, upper respiratory illness, and most commonly, gastro-intestinal illness.

Table 5.3.1-1 The fecal coliform bacteria class designation for all stream segments from 1991 to 2010. ("AA" - surpassed Class A standards; "A" - met Class A standards; "B" - did not meet Class A standards but met Class B standards; "X" - did not meet Class B standards). Designations based on conventional sampling.

Sampling Site	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10
Chuckanut (mouth)	B	X	X	X	A	X	A	X	X	A	X	B	X	B	X	X	B	B	B	AA
Padden (38th)						AA	AA	X	AA	AA	X	AA	B	X	A	AA	AA	X	AA	A
Padden (30th)	X	B	X	X	B	A	A	X	X	AA	A	A	X	X	X	B	B	X	B	B
Connelly (Donovan)	X	X	X	X	B	X	B	X	X	X	X	X	X	X	X	X	X	X	X	X
Padden (22nd)															X	X	X	B	X	B
Padden (mouth)	X	X	X	X	X	X	B	X	X	B	X	X	X	X	X	X	X	B	X	X
Whatcom (Control Dam)	B	AA	B	B	A	B	B	A	A	AA	A	AA	AA	AA	AA	AA	AA	AA	AA	AA
Hanna (WTP)					X							A	X	X	X	X	X	X	B	A
Cemetery (Whatcom Cr)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X	B
Lincoln (Fraser)	X	X	X	X	X	X	B	X	X	X	X	X	X	X	X	X	X	X	X	X
Fever (Valencia)				X	X	X	X	X	X	X	X	X	B	X	X	X	X	X	X	X
Whatcom (Valencia)																	AA	AA	A	AA
Whatcom (I-5)	B	B	X	B	X	X	B	A	X	AA	X	AA	AA	X	B	A	AA	AA	B	AA
Whatcom (Dupont)	X	X	X	X	X	B	B	X	X	X	X	B	X	X	X	X	B	X	X	AA
Squalicum (E. Baker-		B		X	B	X	X	X	X	B	X	X	X	X	X	X	X	X	A	B
Squalicum (Meridian)	B	A	X	X	B	X	B	A	B	X	B	A	AA	X	X	B	A	X	A	AA
Baker (Squalicum)	B	X	X	X	X	X	A	A	X	X	X	X	X	X	X	X	X	X	X	B
Squalicum (Mouth)	B	B	X	X	B	X	A	X	X	X	X	X	X	B	X	X	X	A	X	B
Silver (Graveline)														X	X	X	X	X	X	X

While the origin of fecal coliform bacteria in streams is from fecal sources, the levels of bacteria found in streams arise from a variety of causes. Initially bacteria are washed into streams via surface runoff (primarily animal sources), leaking septic systems, or broken sewer lines. This initial flush of bacteria may be diluted as the stream proceeds downstream or may settle into bottom sediments where extended survival and growth are possible, particularly as temperatures increase (Ishii et al., 2006; Davies et al., 1995; Goyal and Adams, 1984). Recreational and wildlife activities as well as agitation from storm events can cause resuspension of sediment-bound bacteria, increasing the bacterial concentration in overlying waters.

Bellingham's urban streams are classified as Primary Contact Recreational waters by the Surface Water Standards 2006 rule (WAC 173-201A-200). Under the 1997 rule Bellingham's streams were designated as Class A waters (WAC 173-201A-030). Table 5.3.1-2 compares the 1997 rule to the 2006 rule. The requirements for Class A and the designated use are equivalent.

The fecal coliform criteria for Class A (Primary Contact Recreational) fresh waters includes a geometric mean (geomean) value of 100 or less colony forming units (CFU) per 100 milliliters (ml) water where not more than 10 percent of all samples obtained for calculating the geomean exceed 200 CFU/100 ml (WAC 173-201A-030, WAC 173-201A-200 Table 200 (2)(b)).

The Class B (Secondary Contact Recreational) fresh water fecal coliform criteria includes a geomean of 200 or less CFU/100 ml with the caveat that not more than 10 percent of all samples obtained for calculating the geomean have values exceeding 400 CFU/100 ml (WAC 173-201A-030, WAC 173-201A-200 Table 200 (2)(b)). Tables 5.2-2 and 5.3.1-1 classify streams using a geomean calculated from all samples taken within the year, taking into account the percent of those samples that exceed 200 (or 400) CFU/100 ml.

Table 5.3.1-2. Comparison of the 1997 Ecology rule to the 2006 rule for the fecal coliform bacteria standard for fresh surface waters in Washington.

FECAL COLIFORM BACTERIA		
1997 Rule		**2006 Rule**
Class	**Geomean**	**Category**
Class AA	50 CFU/100 ml, no more than 10% of all samples exceed 100 CFU/100 ml	Extraordinary Primary Contact
Class A	100 CFU/100 ml, no more than 10% of all samples exceed 200 CFU/100 ml	Primary Contact
Class B	200 CFU/100 ml, no more than 10 % of all samples exceed 400 CFU/100 ml	Secondary Contact

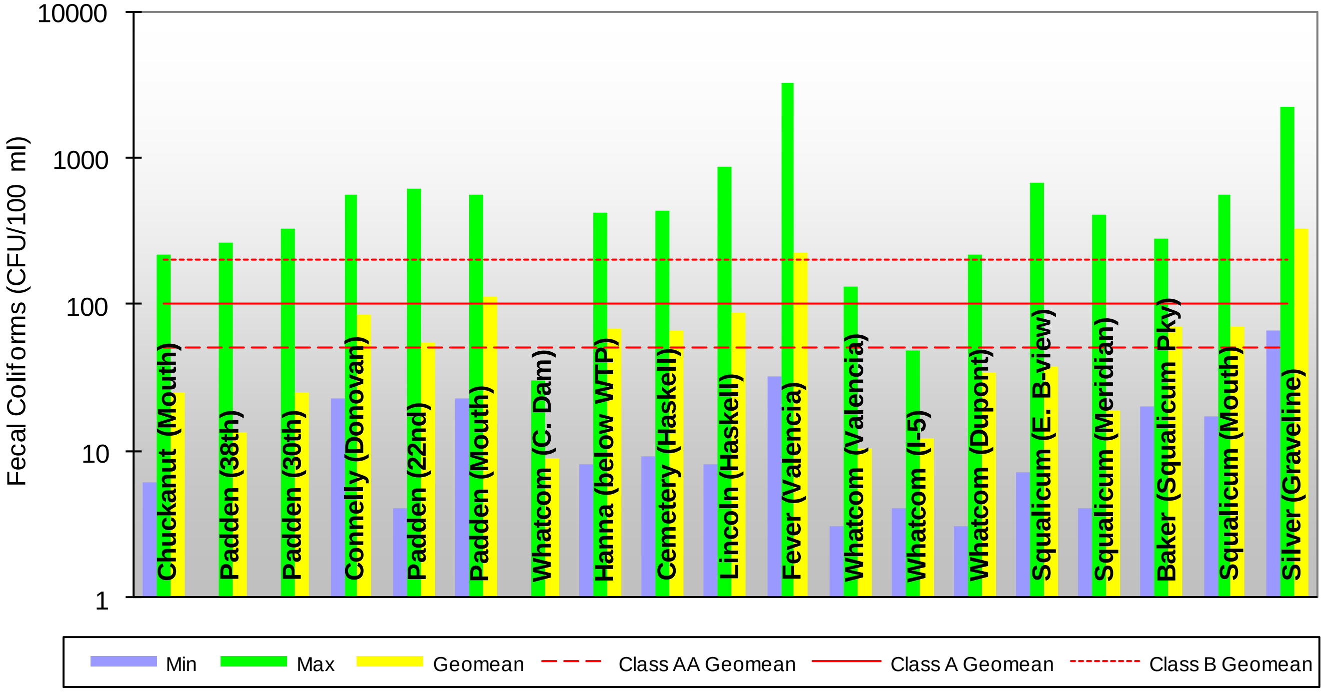


Figure 5.3.1-1. Fecal coliform bacteria minimum, maximum, and geomean values for all stream segments sampled in 2010. Red lines indicate the maximum geomean value allowed by the Class AA, A (Primary Recreational Contact), and B criteria for fecal coliform bacteria. *Note this graph uses a logarithmic scale*.

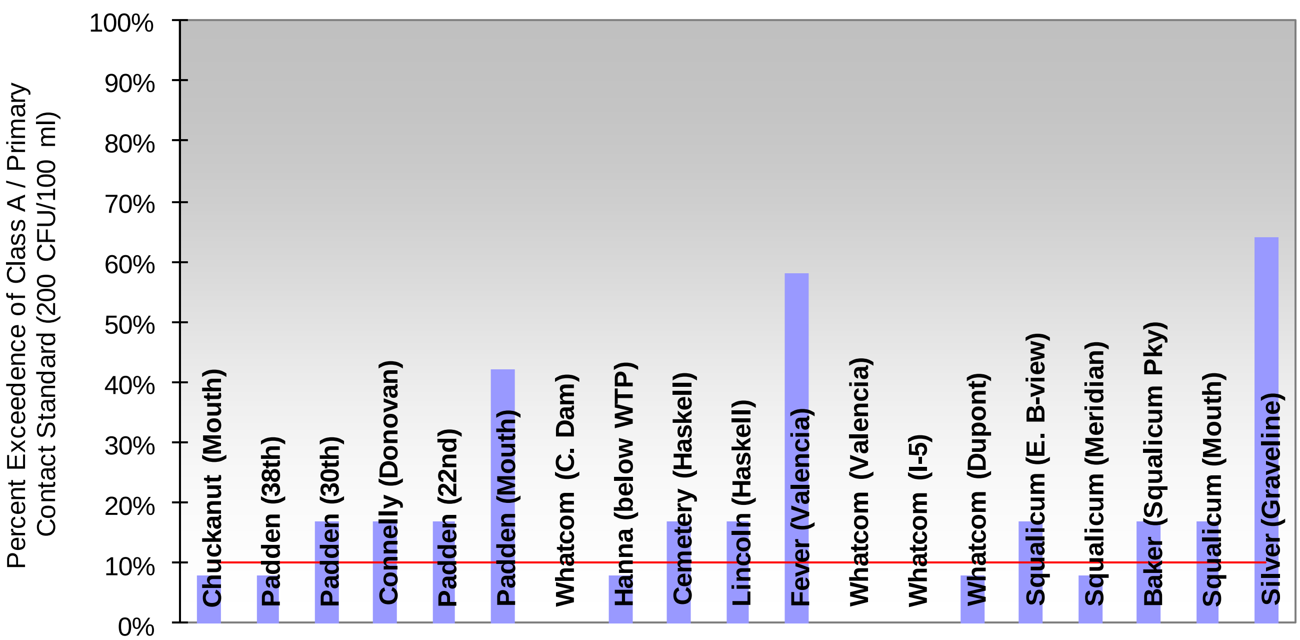


Figure 5.3.1-2. Fecal coliform percent exceedence of the Class A / Primary Recreational Contact standard for all stream segments sampled in 2010. Whatcom Creek at the Control Dam, Valencia and I-5 had no exceedences for 2010. Based on conventional sampling events.

5.3.2 Dissolved Oxygen

Of all the stream sites sampled in 2010, only Chuckanut Creek met the stringent Core Summer Salmonid Habitat Aquatic Life Use (ALU) criterion for dissolved oxygen. The Core Summer Salmonid Habitat ALU level for dissolved oxygen equates to a Class AA designation.

As for the rest of Bellingham's urban streams, all sites on Padden, Whatcom, Squalicum, Hanna, Fever, Baker and Silver Creeks met the Class A criterion for dissolved oxygen in 2010 (Table 5.3.2-1), while Cemetery and Lincoln Creeks met Class B standards. No sites failed to meet at least Class B standards in 2010. Figure 5.3.2-1 provides the minimum, maximum, and average values for dissolved oxygen in all stream segments sampled in 2010. Figure 5.3.2-2 shows the percent of samples that fell below the Class A criterion. All samples besides those taken on Chuckanut Creek were below ALU criterion.

Aquatic organisms require oxygen to survive. Oxygen in water is gained from the atmosphere and produced during photosynthesis. Running water, because of its churning action, contains higher levels of oxygen than still water. Oxygen is consumed during respiration, decomposition, and various chemical reactions.

Oxygen in water is measured in its dissolved form. The amount of oxygen dissolved in water is related to temperature. Cold water can hold more oxygen than warm water; warm water becomes saturated with oxygen more quickly than cold water. In summer months as the water becomes warmer, it holds less and less dissolved oxygen. If the water becomes too warm, even at 100% saturation, dissolved oxygen levels may become suboptimal for some fish and other aquatic organisms.

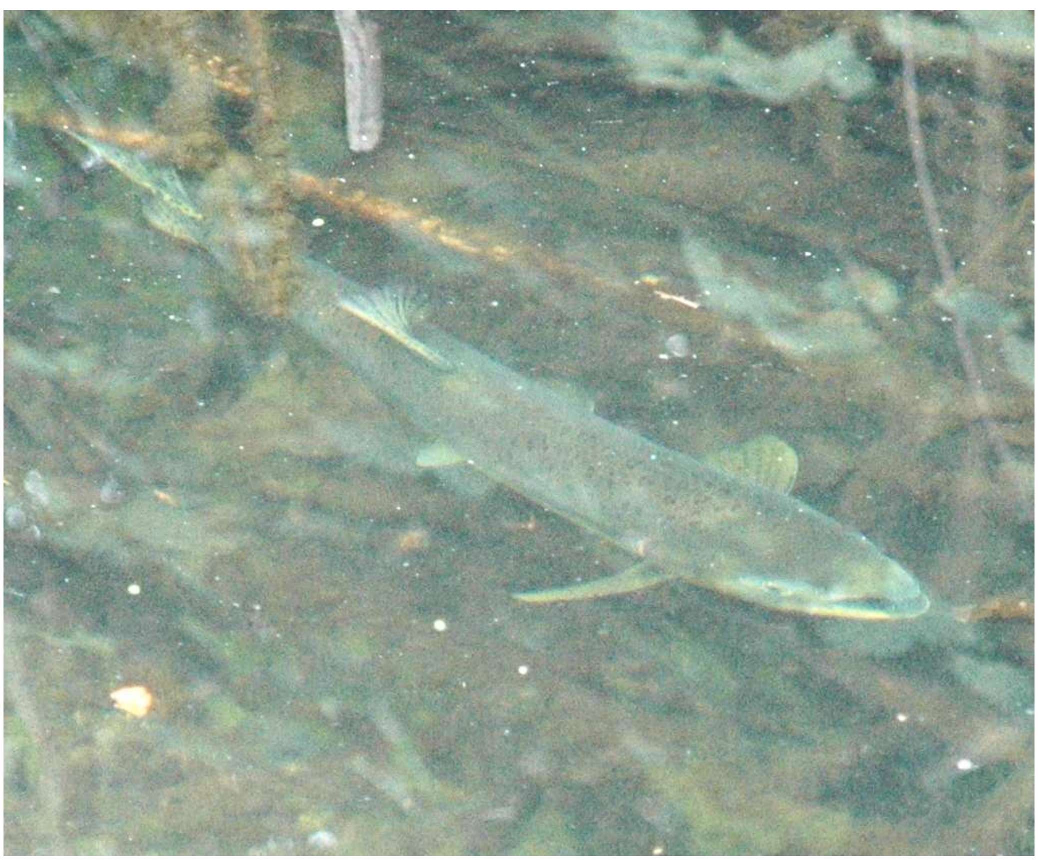
In addition to elevated temperature, inputs of pollution can cause lower dissolved oxygen levels. Feces from animals

Table 5.3.2-1. Dissolved oxygen class designation for all stream segments from 1991 to 2010. ("AA" - surpassed Class A standards; "A" - met Class A standards; "B" - did not meet Class A standards but met Class B standards; "X" - did not meet Class B standards). Designations based on conventional sampling.

Sampling Site	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10
Chuckanut (mouth)	A	A	A	X	X	B	A	A	A	A	A	A	B	A	A	AA	A	A	AA	AA
Padden (38th)						B	A	A	A	A	A	A	A	B	A	A	A	B	A	A
Padden (30th)	A	A	A	X	X	A	A	A	A	A	A	AA	B	B	A	A	A	A	A	A
Connelly (Donovan)	A	A	A	X	X	B	A	B	A	B	B	A	B	B	A	A	A	A	B	A
Padden (22nd)															A	AA	A	A	A	A
Padden (mouth)	B	A	A	X	X	B	A	A	A	A	A	A	A	B	A	A	A	A	B	A
Whatcom (Control Dam)	B	A	A	X	X	B	A	B	B	A	B	A	B	B	A	A	A	A	B	A
Hanna (WTP)					X							B	AA	B	A	A	A	AA	A	A
Cemetery (Whatcom Cr)	X	A	X	X	X	B	B	B	A	A	B	B	X	X	X	A	X	X	X	B
Lincoln (Fraser)	X	A	A	X	X	B	B	X	A	A	B	B	B	B	B	A	B	B	B	B
Fever (Valencia)				X	X	B	A	B	A	A	A	A	A	B	B	A	A	A	A	A
Whatcom (Valencia)																	A	A	A	A
Whatcom (I-5)	B	A	A	X	X	B	A	A	AA	A	A	A	A	B	A	A	A	A	A	A
Whatcom (Dupont)	A	A	A	B	B	B	A	A	AA	A	B	A	A	X	B	A	A	B	B	A
Squalicum (E. Bakerview)				X	X	X	X	X	B	B	A	X	X	X	X	X	X	B	X	A
Squalicum (Meridian)	B	A	A	X	X	B	B	A	B	A	A	A	A	B	B	A	A	A	A	A
Baker (Squalicum)	A	A	A	X	X	B	A	A	A	AA	A	A	B	B	B	B	A	A	A	A
Squalicum (Mouth)	A	A	A	X	X	B	A	A	A	AA	A	A	B	B	A	A	A	A	A	A
Silver (Graveline)														B	A	AA	A	A	A	A

and failing septic systems, grass clippings, leaves and woody debris, and urban and agricultural run-off, all contain organic matter that is decomposed by microorganisms, which use oxygen in the process. The amount of oxygen consumed by these organisms in breaking down organic compounds is known as biochemical oxygen demand (BOD). BOD also measures oxygen consumed by the chemical oxidation of inorganic matter. Variables that can affect the rate of oxygen consumption include temperature, pH, the types and abundance of microorganisms, and the type of organic and inorganic materials present in the water (USEPA, 1997). If BOD is high, less dissolved oxygen is available to fish and macroinvertebrates.

To meet the stringent Core Summer Salmonid Habitat ALU criterion, the revised 2003 WAC states that dissolved oxygen must remain above 9.5 mg/L. This equates to Class AA by the 1997 rule. Also by the 1997 rule, dissolved oxygen must be 8.0 mg/L or higher to qualify as a Class A stream and 6.5 mg/L or higher to meet Class B standards. WQP Policy 1-11 (Ecology, 2006) states that a water body may be considered impaired when a minimum of 3 and at least 10% of single grab samples, such as those collected for the Urban Streams Monitoring Program, in a given year do not meet the dissolved oxygen water quality criteria.



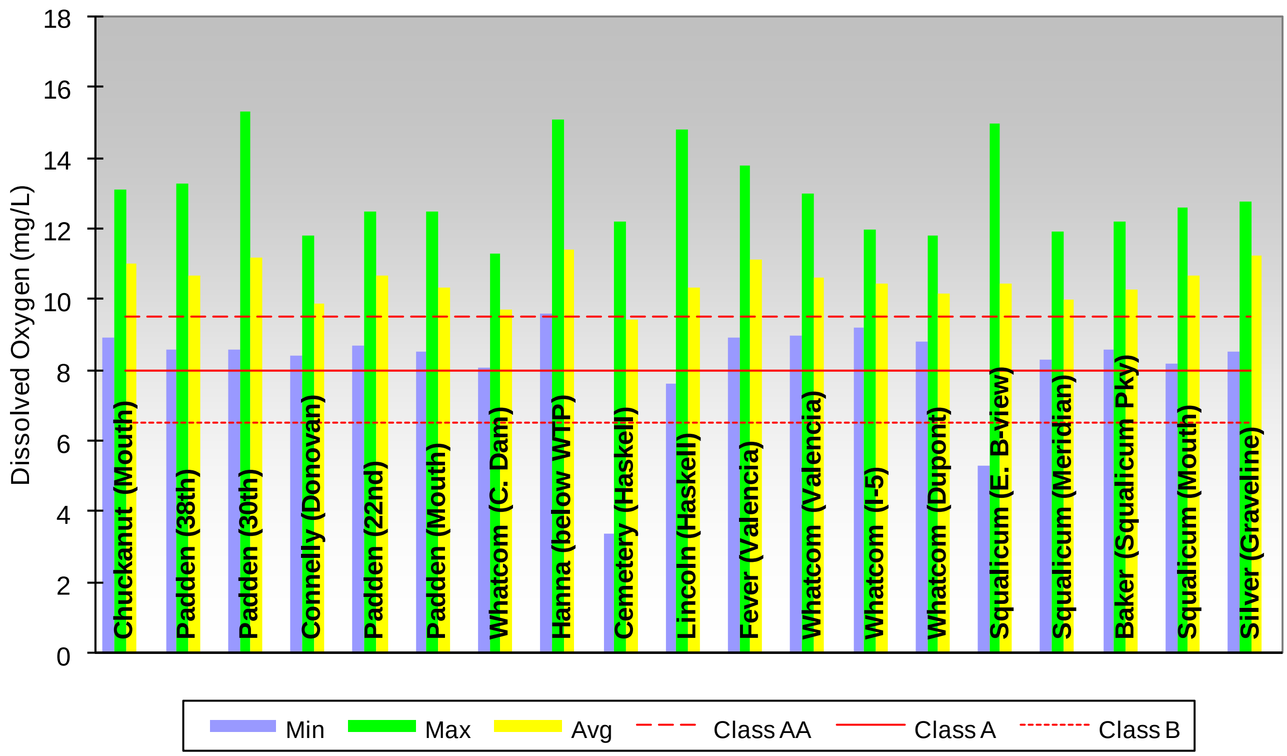


Figure 5.3.2-1. Minimum, maximum, and average dissolved oxygen levels for all stream segments sampled in 2010. Red lines indicate the lowest dissolved oxygen levels allowed for the different surface water classes (AA, A, and B). The Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation is equivalent to Class AA.

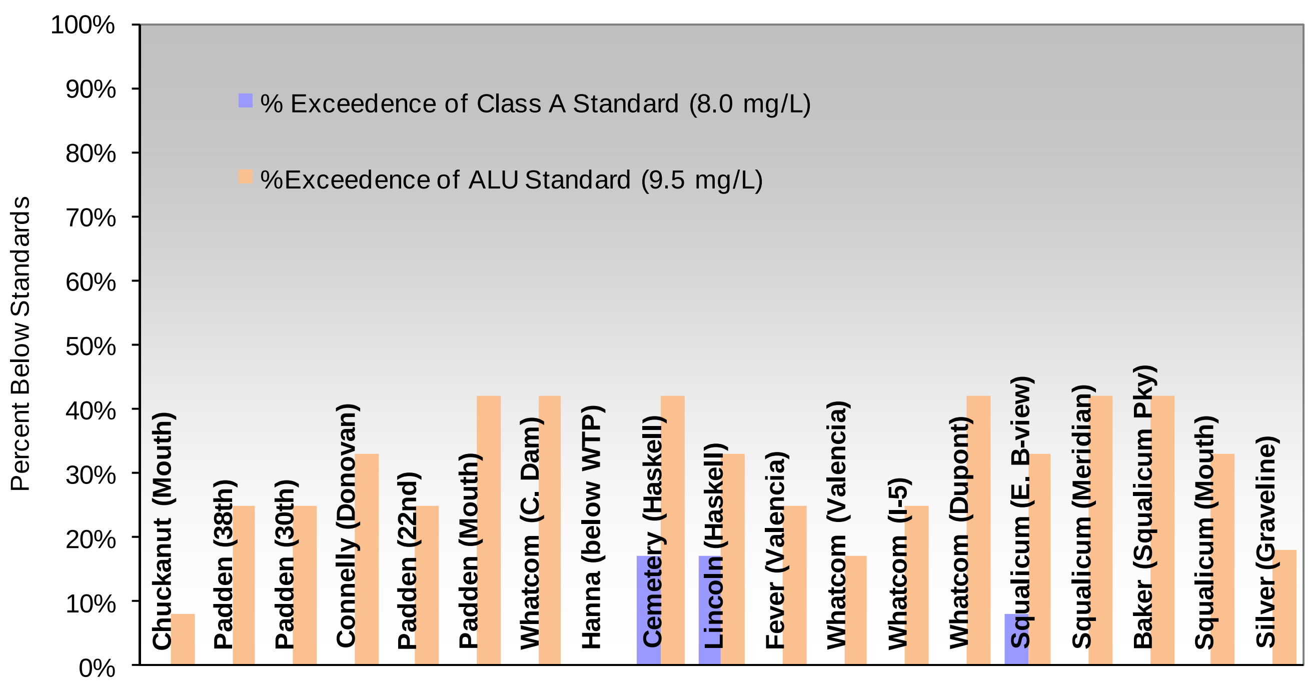


Figure 5.3.2-2. Percent of dissolved oxygen samples below the Class A (8.0 mg/L) and Aquatic Life Use (ALU, 9.5 mg/L) standards for all stream segments sampled in 2010.

5.3.3 Temperature

In 2010, thirteen urban steam segments met the stringent Core Summer Salmonid Habitat ALU / Class AA standard for temperature, while four additional sites met the Class A standard. Whatcom Creek at the Control Dam was the only site in the Class B category. Figure 5.3.3-1 shows minimum, maximum, and average temperatures found in the stream segments sampled in 2010. Figure 5.3.3-2 provides the percent of samples that exceeded the Class A criterion.

The WAC 173-201A-030 states that temperatures in Core Summer Salmonid Habitat (2006) / Class AA (1997) streams may not exceed 16°C, Class A streams may not exceed 18°C, and Class B streams may not exceed 21°C. A water body is considered impaired if more than 3 of all samples and greater than 10% of samples taken during the year in question are in excceedence. A temperature measurement in excess of the standard is not a violation, however, if the exceedence is the result of natural conditions. In this case, temperature increases due to human activities shall not exceed 0.3 °C and incremental temperature increases from nonpoint sources shall not exceed 2.8° C (WAC 173-201A-030, WQP 1-11).

According to WQP 1-11, Aquatic Life Use criterion for temperature is preferably based on a rolling 7 Day Average of Daily Maximums (7DADMAX). It is only in the absence of continuous monitoring data that single grab sample data is considered. In 2010, the sampling frequency for the Urban Streams Monitoring Program did not allow for the calculation of this value for most stream segments. However, the necessary continuous monitoring programs are now being run as part of TMDL and restoration studies. As results become available they will be incorporated into the Urban Streams Monitoring Program.

Table 5.3.3-1. Temperature class designation for all stream segments from 1991 to 2010. ("AA" - surpassed Class A standards; "A" - met Class A standards; "B" - did not meet Class A standards but met Class B standards; "X" - did not meet Class B standards). Designations based on conventional sampling.

Sampling Site	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10
Chuckanut (mouth)	AA	A	AA	A	A	A	B	B	AA	AA	AA	AA	AA	AA	AA	AA	A	AA	AA	AA
Padden (38th)						A	B	A	AA	AA	A	AA	A	A	AA	A	A	AA	A	AA
Padden (30th)	AA	B	A	B	B	A	B	A	AA	AA	A	AA	B	A	AA	AA	A	AA	A	AA
Connelly (Donovan)	AA	B	A	B	A	B	B	B	AA	AA	A	A	A	A	AA	AA	A	AA	AA	AA
Padden (22nd)															AA	AA	A	AA	AA	AA
Padden (mouth)	A	A	A	A	A	A	B	B	AA	AA	A	A	A	A	AA	AA	A	AA	A	AA
Whatcom (Control Dam)	B	X	B	X	B	X	B	X	A	B	B	B	X	X	X	X	B	B	B	B
Hanna (WTP)					B							X	AA	AA	AA	AA	AA	AA	AA	AA
Cemetery (Whatcom Cr)	AA	A	AA	B	A	B	A	B	AA	AA	A	A	A	A	AA	AA	A	A	A	A
Lincoln (Fraser)	A	B	A	B	B	B	A	B	AA	AA	A	AA	A	A	AA	AA	AA	AA	AA	AA
Fever (Valencia)				B	A	A	B	B	AA	A	A	A	A	A	A	A	A	AA	A	AA
Whatcom (Valencia)																	B	B	B	A
Whatcom (I-5)	A	B	B	X	B	B	B	X	AA	B	B	B	B	B	B	B	B	B	B	A
Whatcom (Dupont)	A	B	B	X	B	B	B	X	AA	B	B	B	B	B	B	A	B	A	A	A
Squalicum (E. Baker-				B	A	B	B	B	AA	A	A	A	A	A	A	AA	A	AA	AA	AA
Squalicum (Meridian)	AA	A	A	B	A	B	B	B	A	AA	A	AA	AA	AA	A	A	AA	AA	AA	A
Baker (Squalicum)	AA	AA	A	B	A	A	A	B	AA	AA	AA	AA	A	A	AA	AA	AA	AA	AA	AA
Squalicum (Mouth)	AA	A	A	B	A	A	A	A	AA	AA	AA	AA	AA	A	AA	AA	AA	AA	AA	AA
Silver (Graveline)														A	AA	AA	A	AA	AA	AA

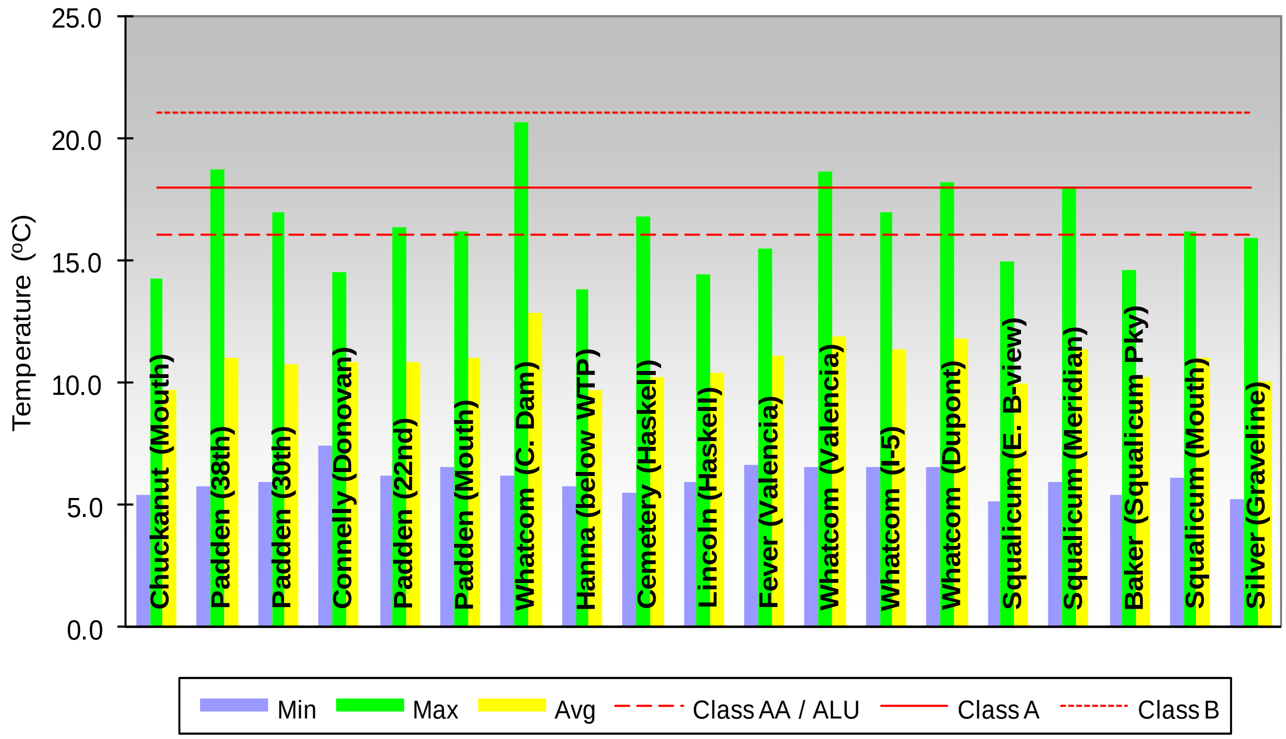


Figure 5.3.3-1. Minimum, maximum, and average temperature values for all stream segments sampled in 2010. Red lines indicate the highest temperature allowed by the different surface water standards (AA/ALU, A, and B).

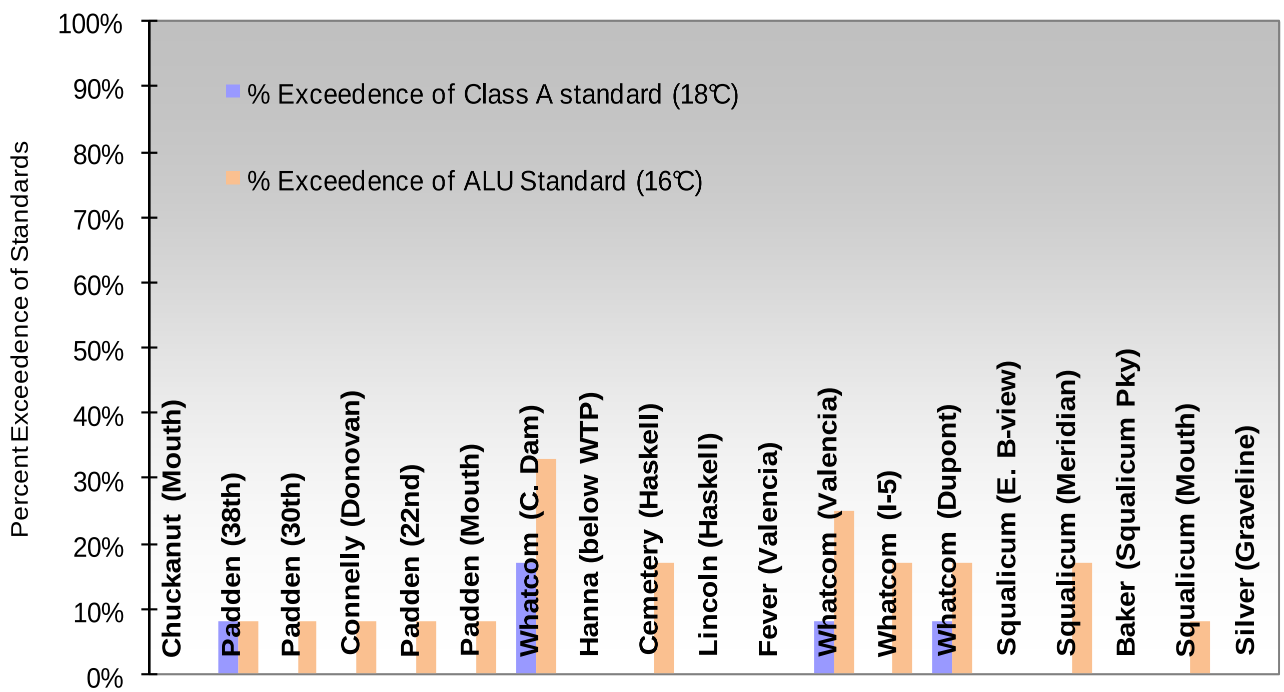


Figure 5.3.3-2. Percent temperature exceedences of Class A (18°C) and Aquatic Life Use (ALU, 16°C) standards for all stream segments sampled in 2010.

5.3.4 pH

The stream segments sampled in the Urban Streams Monitoring Program almost always meet Aquatic Life Use (ALU) and Class A standards for pH. In 2010 that trend was continued.

The pH of water measures the concentration of hydrogen ions in the water, or the relative acidity or alkalinity of water. The value of pH is calculated using the negative logarithm of the hydrogen ion concentration. Thus, a change of one pH unit represents a 10-fold change in the concentration of hydrogen ions.

The pH of a stream can affect organisms living in the water directly. The chemical conditions in acidified waters are intolerable to some aquatic creatures or have sublethal physiological effects; some animals may actively avoid such waters. There are also indirect effects. The solubility and availability of nutrients can be affected by pH. Heavy metals can be more soluble at lower pH, therefore more bioavailable and consequently more toxic.

A change in pH can indicate the presence of pollution. Organic matter introduced into streams during periods of low flow can cause low pH values. Lime applied to agricultural lands, lawns, and golf courses can be washed into streams during storm events, raising pH. Additionally, photosynthesis, respiration, and decomposition also affect pH levels.

The pH of uncontaminated rainwater in equilibrium with atmospheric carbon dioxide is 5.6. Normally the acids in rainwater are neutralized as the rainwater passes through soil (Allan, 1995). In urbanized areas much of the precipitation falls onto impervious surfaces and flows directly into rivers and streams. There may be further acidification processes at work on these surfaces (Mason, 1989). Even when there are not large areas of impervious surface, the acid neutralizing mechanisms in the soil may not be able to keep pace during heavy continuous rain. During an event of this type, rainwater runs over

Table 5.3.4-1. The pH class designation for all stream segments from 1991 to 2010. ("AA" - met Class AA/A/B standards; "X" - did not meet Class AA/A/B standards).

Sampling Site	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10
Chuckanut (mouth)	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Padden (38th)						AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Padden (30th)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Connelly (Donovan)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Padden (22nd)															AA	AA	AA	AA	AA	AA
Padden (mouth)	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	X	AA	AA	AA	AA
Whatcom (Control Dam)	X	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Hanna (WTP)					AA							AA	AA	AA	AA	X	AA	AA	AA	AA
Cemetery (Whatcom Cr)	AA	AA	X	AA	X	AA	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA
Lincoln (Fraser)	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA
Fever (Valencia)				AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Whatcom (Valencia)																	AA	AA	AA	AA
Whatcom (I-5)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA
Whatcom (Dupont)	AA	AA	AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Squalicum (E. Baker-				AA	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Squalicum (Meridian)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Baker (Squalicum)	AA	AA	AA	X	X	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Squalicum (Mouth)	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA	AA
Silver (Graveline)														AA	AA	AA	AA	AA	AA	AA

the surface and enters streams with its chemical composition little changed (Mason, 1989).

Class AA/A/B and Core Summer Salmonid Habitat ALU designated surface water pH must be within the range of 6.5 to 8.5 (WAC 173-201A-030). A stream segment is in violation if more than 3 excursions and greater than 10% of the grab samples taken are outside the 6.5 to 8.5 range (Department of Ecology, WQP Policy 1-11, 2006).

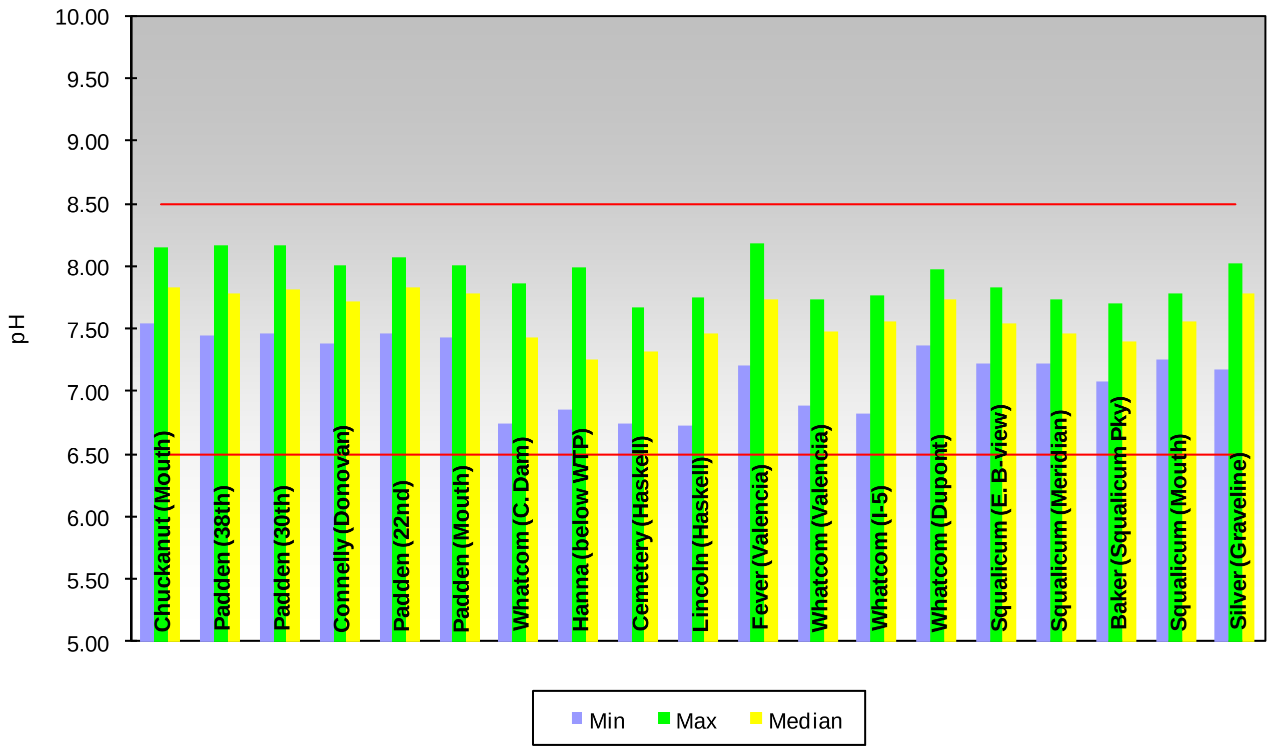


Figure 5.3.4-1. The pH minimum, maximum, and median values for all stream segments sampled in 2010. Red lines indicate the minimum and maximum values allowed by the Class AA/A/B and Aquatic Life Use (ALU) criteria for pH.

5.3.5 Turbidity

Turbidity measures the degree to which light traveling through a water column is scattered by the suspended organic (including algae) and inorganic particles in the water. Turbidity is commonly measured in Nephelometric Turbidity Units (NTU) and is used to estimate the amount of total suspended material in the water. Turbidity readings can be affected by season, water color from dissolved solids (Malcomb, 1985) and the shape, size, and surface area of particles (Packman et al., 2002).

The amount of suspended materials found in stream systems can be attributed to many factors. The flow rate of a water body is a primary factor influencing turbidity concentrations. Fast running water can carry more particles and larger sized sediment. A change in flow rate can also affect turbidity. If the speed of the water current increases, particulate matter from the bottom sediments may be resuspended.

Heavy rains can pick up sand, silt, clay, and organic particles from the land, particularly from construction sites, and carry them to surface waters. Erosion from rainfall, run-off, and high stream velocities may result in higher concentrations of suspended particles in streams. Watershed development and poor land use practices can cause increased erosion, organic matter, and nutrients, all of which cause increases in suspended materials and algae growth. There are large amounts of impervious surfaces and land disturbing activities in urban areas and natural settling areas have been removed. As a consequence, during storm events sediment is carried through storm drains to streams and rivers.

Some suspended matter is natural and beneficial to aquatic systems. Excesses, however, can affect the health of aquatic organisms. Studies have found that exposure to turbidities of 25 to 50 NTU for extended periods can reduce feeding and growth in trout and salmon fingerlings and may cause them to emigrate (Sigler et al., 1984; Harvey, 1989). Other studies have found that turbidities between 10 and 60 NTU for only two to four days can disrupt feeding and territorial behavior in juvenile salmon (Berg, 1982; Bjornn and Reiser, 1991).

The Ecology turbidity criterion for Class A surface waters is based on a relative change in NTU above background rather than a single value or range of values. "Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more that a 10 percent increase in turbidity when the background is more than 50 NTU" (WAC 173-201A-030).

These criteria are mainly used to measure inputs from point sources such as streamside construction activities (Joy, 2002). In this case, background turbidity is established by sampling upstream from the construction site. Determining background turbidity for stream systems that lack such a point source is problematic and the Ecology policy fails to address this issue. Bellingham streams lack reference sites that could provide a true background turbidity measurement.

Due to difficulty in applying point source criteria to non-point source systems, turbidity is not included in class determination for Bellingham's urban streams. In order to provide more pertinent context to the turbidity values recorded by the Urban Streams Monitoring Program, this report presents turbidity values both as yearly average trends for the past 10 years and as a comparison between this year's data and the previous 5 and 10 year overall turbidity averages.

For the ten year period ending in 2010, the majority of Bellingham's urban streams showed decreasing turbidity trends. Chuckanut Creek and Squalicum Creek at Meridian St. were the only stream segments to have ascending turbidity trends. Ten year turbidity trends for the period ending in 2010 and average turbidities are detailed in Table 5.3.5-1. Figure 5.3.5-1 provides minimum, maximum, and average turbidity values for all stream segments sampled in 2010.

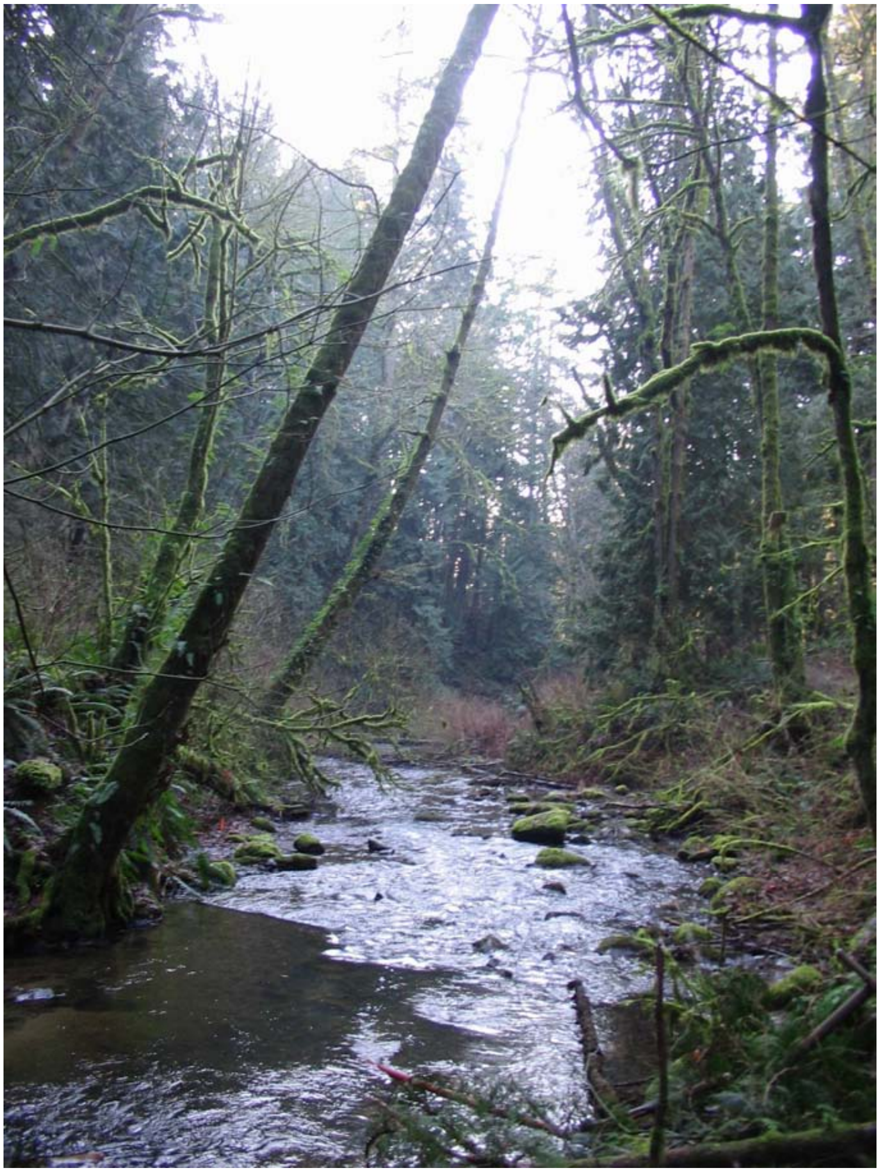


Table 5.3.5-1. Average turbidity trends 2001-2010. A "+" sign indicates an increasing turbidity trend, while a "-" sign indicates a decreasing turbidity trend.

Stream Segment	Slope (NTU/Year)	2010 Average	5 Year Average	10 Year Average
Chuckanut Cr (Mouth)	0.13	4.57	4.90	4.43
Padden Cr (38th)	- 0.22	2.77	2.63	3.33
Padden Cr (30th)	- 0.31	3.18	2.89	3.82
Connelly Cr (Donovan)	- 0.36	9.02	6.56	7.72
Padden Cr (22nd)	- 0.23	3.79	3.93	4.08
Padden Cr (Mouth)	- 0.34	7.14	5.43	6.33
Whatcom Cr (C. Dam)	- 0.04	1.64	1.67	1.91
Hanna Cr (below WTP)	- 0.18	5.82	5.94	6.20
Cemetery Cr (Haskell)	- 0.66	5.55	7.54	8.39
Lincoln Cr (Haskell)	- 0.54	6.53	6.68	8.26
Fever Cr (Valencia)	- 0.65	4.50	5.59	7.48
Whatcom Cr (Valencia)	- 0.61	2.06	2.19	3.56
Whatcom Cr (I-5)	- 0.22	2.49	2.70	3.35
Whatcom Cr (Dupont)	- 0.24	2.70	3.32	4.17
Squalicum Cr (E. Bakerview)	- 0.62	7.23	7.92	9.14
Squalicum Cr (Meridian)	0.29	7.95	9.12	8.01
Baker Cr (Squalicum Pky)	- 0.23	4.59	6.63	6.86
Squalicum Cr (Mouth)	- 0.01	5.98	7.92	7.58
Silver Cr (Graveline)	- 0.32	5.78	7.31	7.70

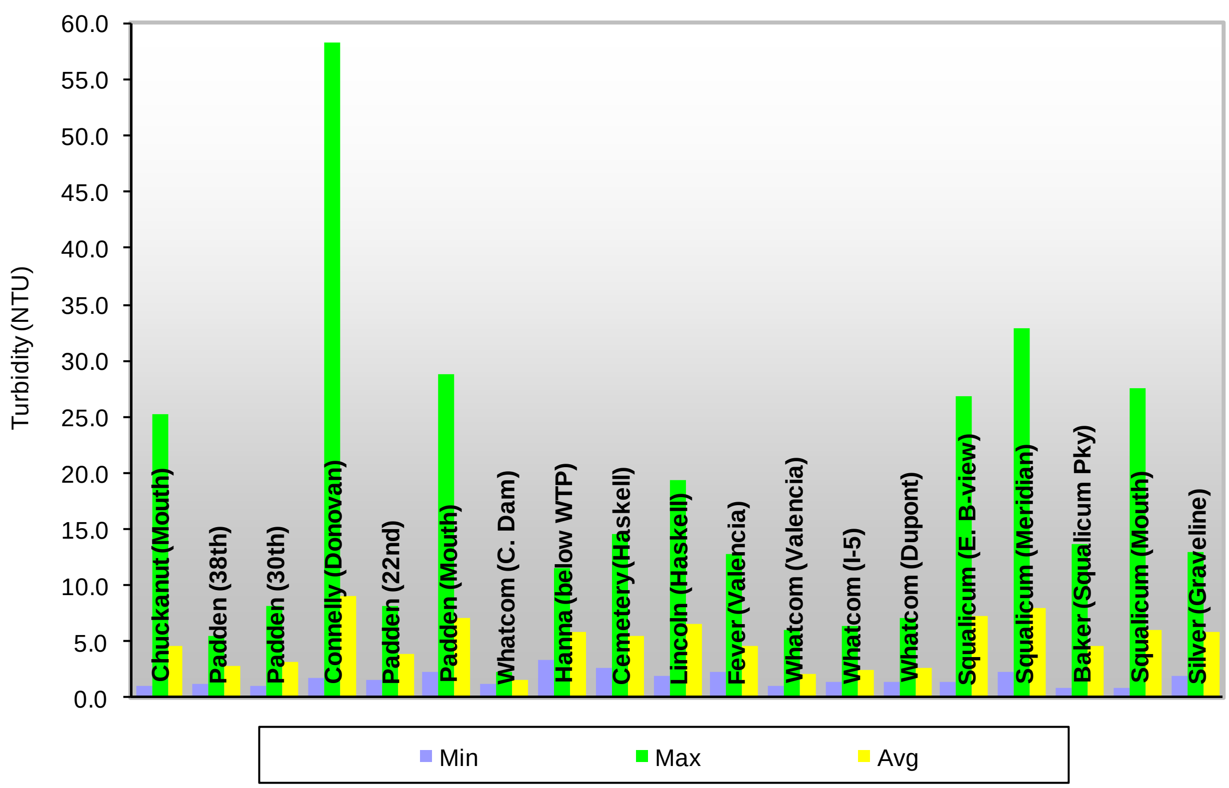


Figure 5.3.5-1. Minimum, maximum, and average turbidity values for all stream segments sampled in 2010.

5.3.6 Specific Conductivity

Conductivity measures the ability of water to conduct an electric current and is directly related to the total dissolved ions in the water. Conductivity is reported in microSiemans per centimeter (µ S/cm) corrected to 25°C. Conductivity in streams can be extremely variable. This natural variation is due to the characteristics of a watershed: mainly the type of rocks weathered, how much precipitation falls, the composition of the precipitation (largely dependant on distance from the ocean), and the relative contribution of ground water to total flow (Allan, 1995). Groundwater typically contains higher concentrations of ions than surface water because of a longer association with rocks (Allan, 1995). Since stream flow is reliant on a combination of surface water and groundwater, during drier periods the concentration of ions in a stream may increase as stream flow becomes more dependent on groundwater inputs. Evaporation can also contribute to increased conductivity levels by concentrating ions in water.

Conductivity can be useful as a general water quality measurement. Pollution from point and non-point sources contributes to the amount of dissolved ions in water. Significant changes in conductivity measurements can indicate contamination from these sources.

The USEPA found that rivers in the United States had a range from 50 to 1500 µS/cm (1997). The USEPA also reported that streams that supported "good mixed fisheries" had a range from 150 to 500 µS/cm. Conductivity outside this range may not support some aquatic organisms.

The City of Bellingham has monitored conductivity since 1994. Historically, the range has been from 28 to 581 µS/cm. This excludes measurements of 1001 µS/cm in 1996 taken at Squalicum Creek mouth and 890 µS/cm taken at Padden Creek mouth in 2001. Both of these measurements were taken at the mouths of streams and it is suspected that the high values are the result of the salt water wedge, an effect of high tide.

In 2010, conductivity in Bellingham's urban streams ranged from 63 to 396 µS/cm (Figure 5.3.6-1), which is not appreciably different from previous years. Low conductivity values are a natural characteristic of Bellingham streams.

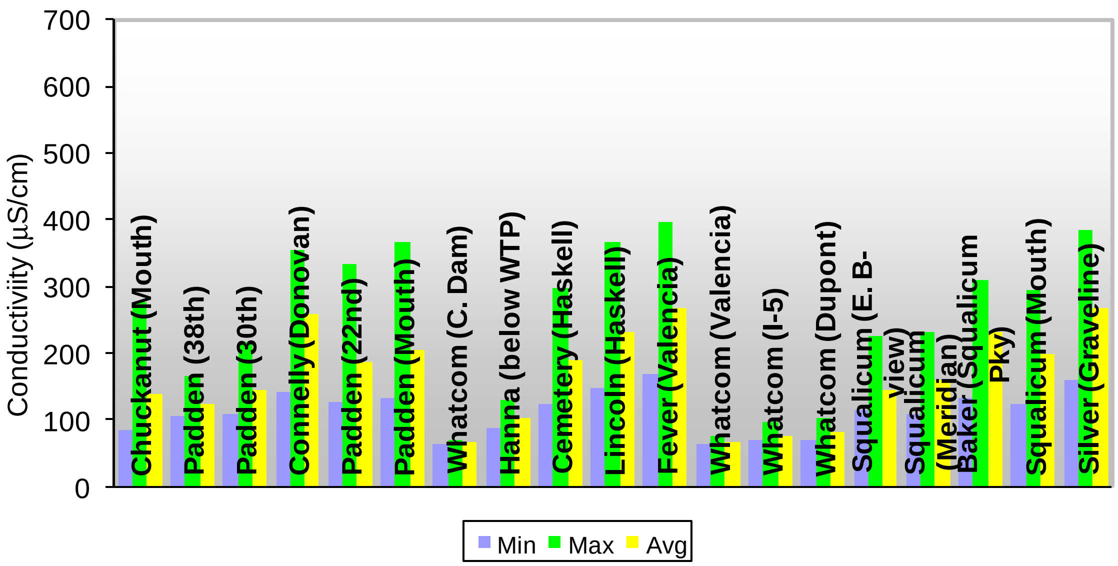


Figure 5.3.6-1. Minimum, maximum, and average conductivity values for all stream segments sampled in 2010. No numeric criterion exists in the WAC for conductivity.

6.0 Chuckanut Creek Drainage Basin

The drainage area of Chuckanut Creek is approximately 4,834 acres (City of Bellingham, 1995). The creek flows through mostly forested lands and some residential areas. It discharges to an estuary in Chuckanut Bay, adjacent to Bellingham Bay. Most of the creek lies outside Bellingham city limits.

Chuckanut Creek has been included in Bellingham's Urban Stream Monitoring Program since 1990 and is sampled at one site, near the mouth (Figure 6.0-1). Samples are collected approximately 1200 feet from the discharge point into Chuckanut Bay (Chuckanut Drainage Map). Table 6.0-1 shows the number of samples collected per year from 2001 to 2010.

In 2010, Chuckanut Creek met all Aquatic Life Use (ALU) criteria and the Primary Recreational Contact designated use criteria. Therefore, it also achieved the highest AA standard for all parameters. This rare feat has only occurred one other time in the history of the Urban Streams Monitoring Program, at the Padden at 38th site in 1999.

The average turbidity for 2010 was 4.6 NTU, which is below the 5 year average (4.9 NTU) but above the 10 year average (4.4 NTU). Conductivity was relatively unchanged from previous years.

Table 6.0-1. Number of samples* taken per year for Chuckanut Creek from 2001 to 2010.

Sampling Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Mouth	8	12	12	12	12	12	12	12	12	12

*Some parameters may not have been sampled with the same frequency.

Figure 6.0-1 Chuckanut Creek mouth sampling site.

Fecal Coliform Bacteria

Fecal coliform concentrations for 2010 follow the expected trend of higher values in the warmer months, possibly as bacteria become more concentrated due to lower flows, and/or as higher temperatures encourage extended survival or growth of bacterial populations (Figure 6.0-2). The geomean for the Chuckanut Creek mouth site was 25 CFU/100 ml. Only one of the twelve samples (8%) collected at the site contained more than 200 CFU/100 ml and no other sample exceeded 100 CFU/100 ml (Figure 6.0-3).

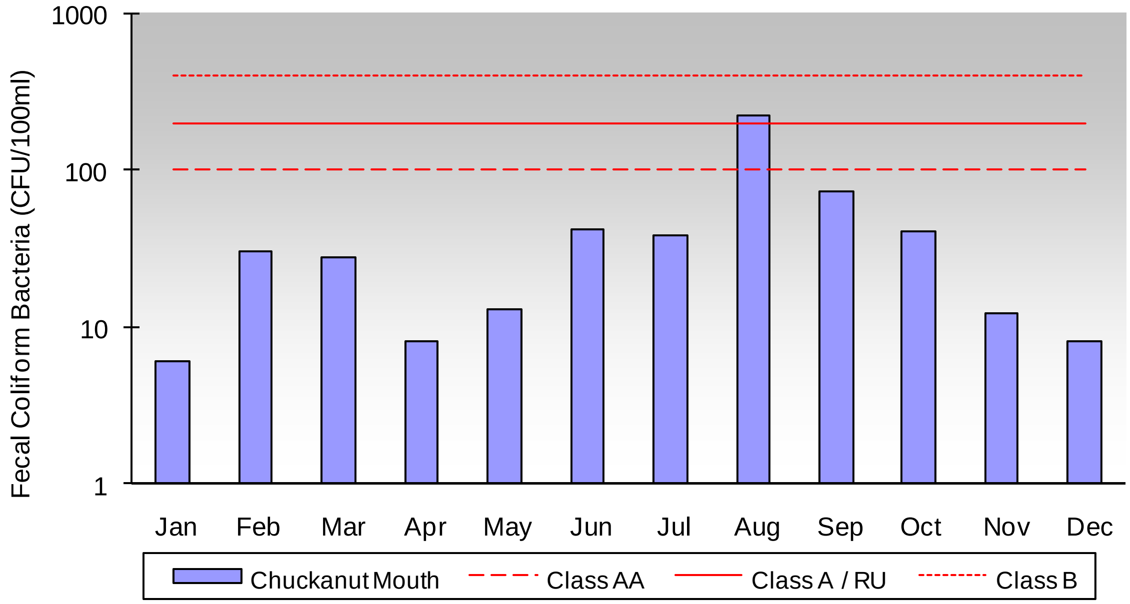


Figure 6.0-2. Fecal coliform bacteria levels for Chuckanut Creek sampling site by month for 2010. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

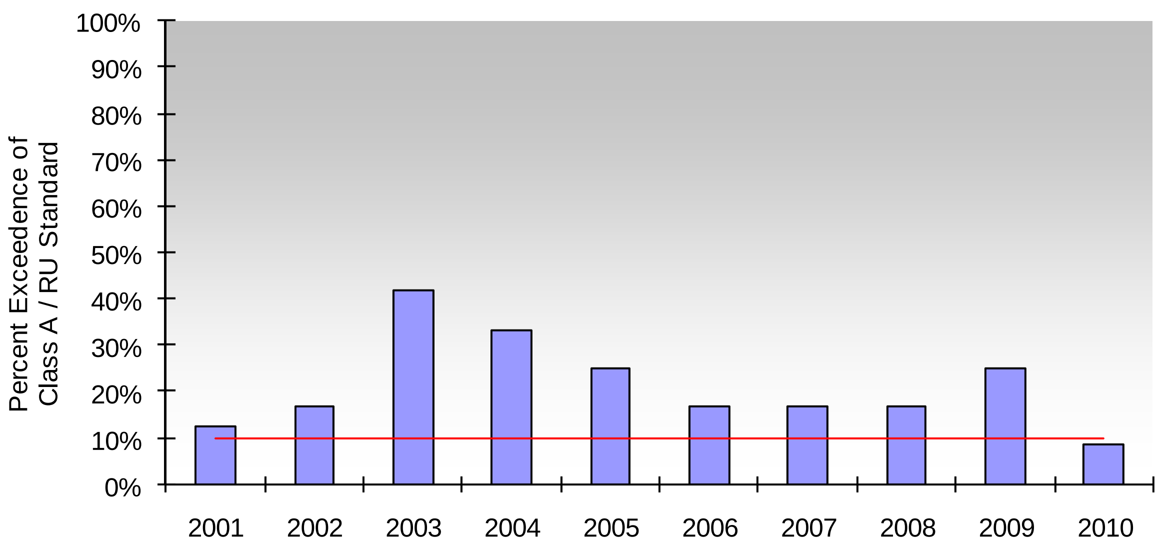


Figure 6.0-3. Percent exceedence of the Class A / Recreational Use standards for fecal coliform bacteria by year for the Chuckanut Creek sampling site, 2001 to 2010.

Dissolved Oxygen

Dissolved oxygen levels for 2010 follow a typical seasonal trend with the lowest levels found in the warmer summer months when temperatures are higher (Figure 6.0-4). The average dissolved oxygen level in 2010 was 11.0 mg/L.

Dissolved oxygen levels in Chuckanut Creek fell below the ALU standard of 9.5 mg/L only once in 2010 and did not fall below the 8.0 mg/L class A standard. The percent of samples below the Class A standard from 2001 to 2010 and below the Core Summer Aquatic Life Use (ALU) standard from 2006 to 2010 are provided in Figure 6.0-5.

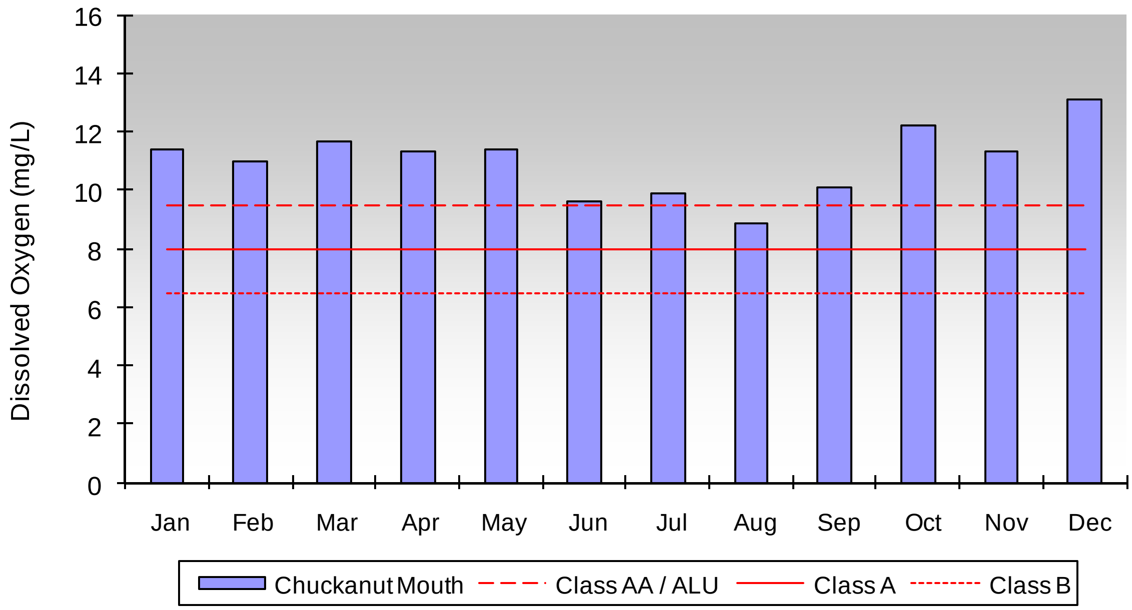


Figure 6.0-4. Monthly 2010 dissolved oxygen levels for Chuckanut Creek. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

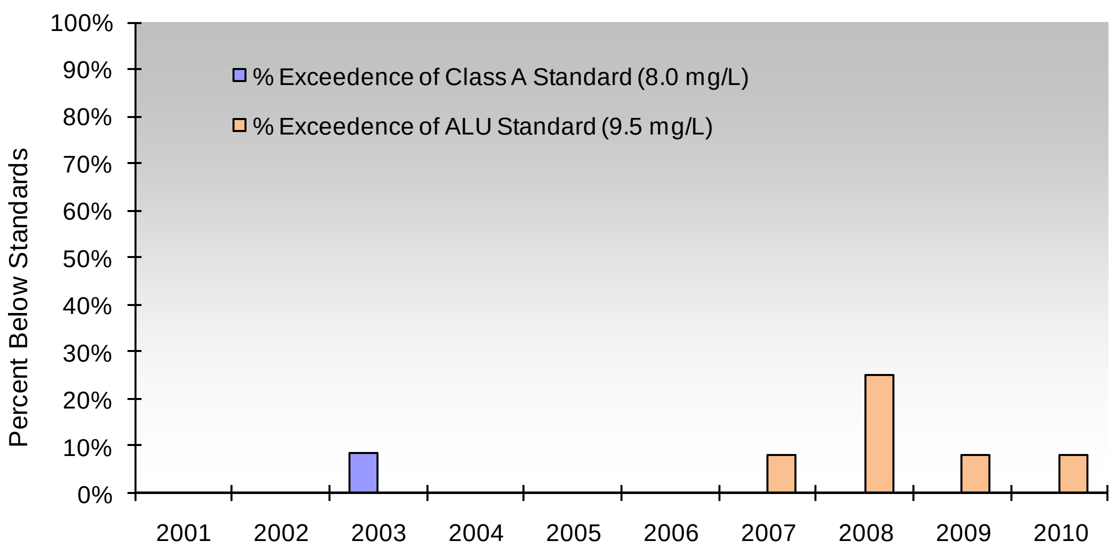


Figure 6.0-5. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for the Chuckanut Creek sampling site 2001 to 2010 and below the Core Summer Salmonid Habitat Aquatic Life Use (ALU, 9.5 mg/L) since implementation in 2006.

Temperature

Recorded temperature for Chuckanut Creek was lower than normal during 2010, and did not exceed the Class A (18℃), nor the Aquatic Life Use (ALU) (16℃) standards during the year. The temperature profile follows a seasonal trend with higher values found in the warmer summer months (Figure 6.0-6). The average temperature for 2009 was 9.7℃.

Temperature in Chuckanut Creek rarely exceeds standards. Temperatures recorded during 2009 represent the only exceedence of the Class A standard during the past 10 years, and the Core Summer Salmonid Habitat ALU standard has been exceeded only twice since its' use began in 2006 (Figure 6.0-7).

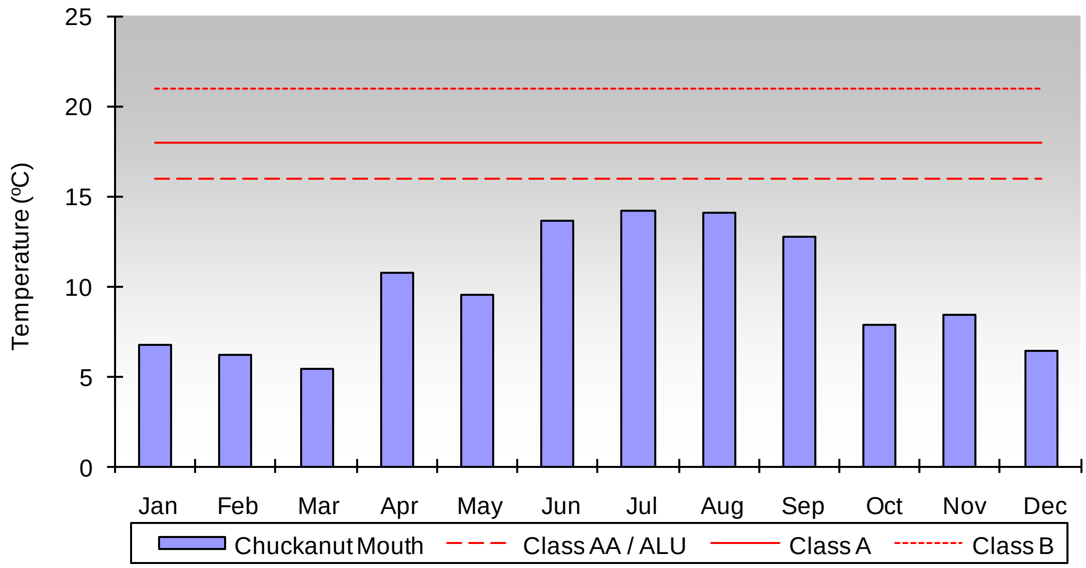


Figure 6.0-6. Monthly temperature measurements for the Chuckanut Creek sampling site in 2010. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). The Core Summer Salmonid Habitat ALU is equivalent to Class AA.

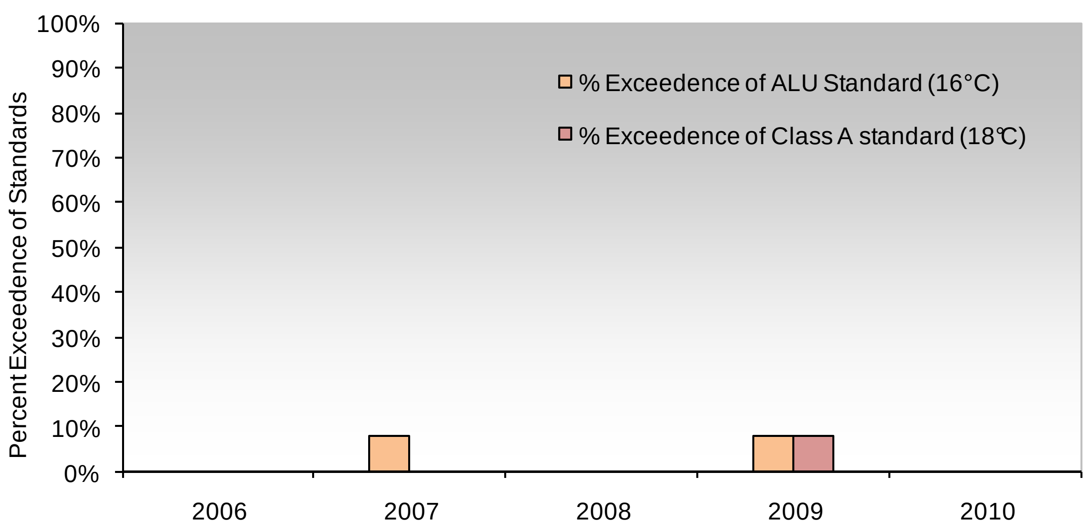


Figure 6.0-7. Percent of samples with temperatures in excess of the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard (16℃) for the Chuckanut Creek sampling site 2006 to 2010. The exceedence of the Class A (18℃) sta ndard in 2009 is the only since 1998.

Turbidity

Turbidity in Chuckanut Creek rarely reaches or exceeds levels considered deleterious to salmon and trout (Berg, 1982; Sigler et al., 1984; Harvey, 1989; Bjornn and Reiser, 1991). Despite a higher maximum than in years past, this trend was continued in 2010. The maximum turbidity measured in was 25.3 NTU in December and the minimum turbidity measured was 1.1 NTU in October. Higher turbidities are expected during the winter months since more precipitation can be expected at this time of year. Despite an average gain of 0.13 NTU/Year over the past 10 years, the average turbidity for Chuckanut Creek in 2010 was 4.57 NTU, which is lower than the 5 year average, yet greater than the 10 year average (Figure 6.0-8).

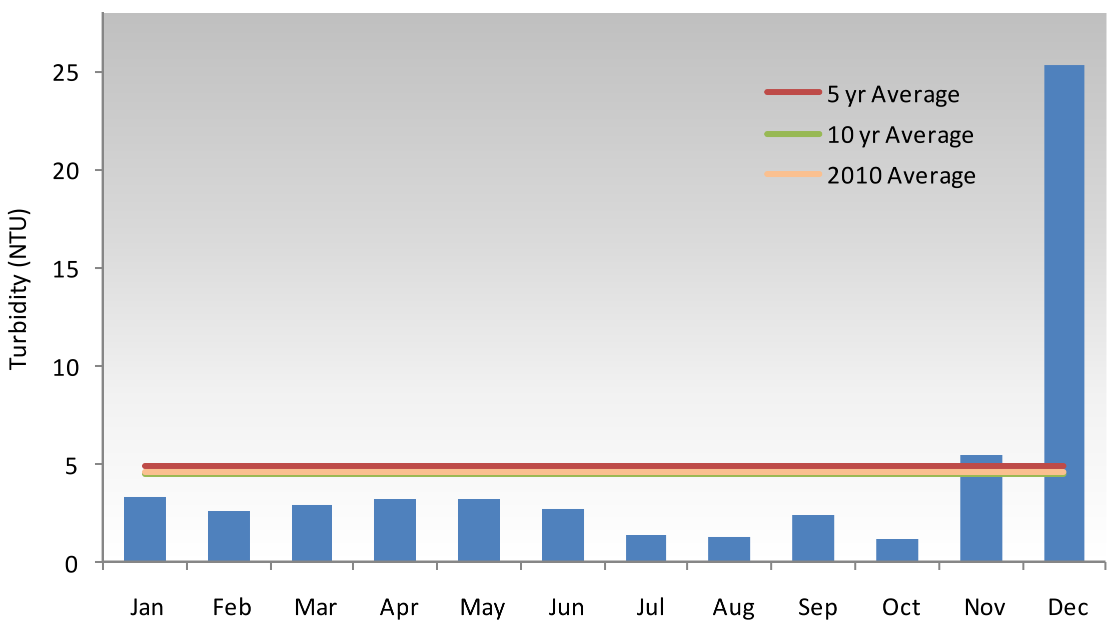


Figure 6.0-8. Monthly turbidity values and yearly averages for the Chuckanut Creek sampling site in 2010. Presented with yearly, 5-year and 10-year averages.

Hydrology

The Chuckanut Creek gauging station has been in service since 2005. It is located approximately 300 feet downstream of the footbridge in Arroyo Park. Chuckanut Creek typically has higher volume of discharge than Padden Creek, but less than Squalicum Creek. Exceptions to this typical trend occur occasionally when rain events cause the peak flow of Padden Creek to spike higher than that of Chuckanut.

In 2010, Chuckanut Creek had a minimum discharge (flow) of 0.41 cubic feet per second (cfs) on August 22nd and 25th, a maximum discharge of 631 cfs on December 12th and an average discharge of 13 cfs.

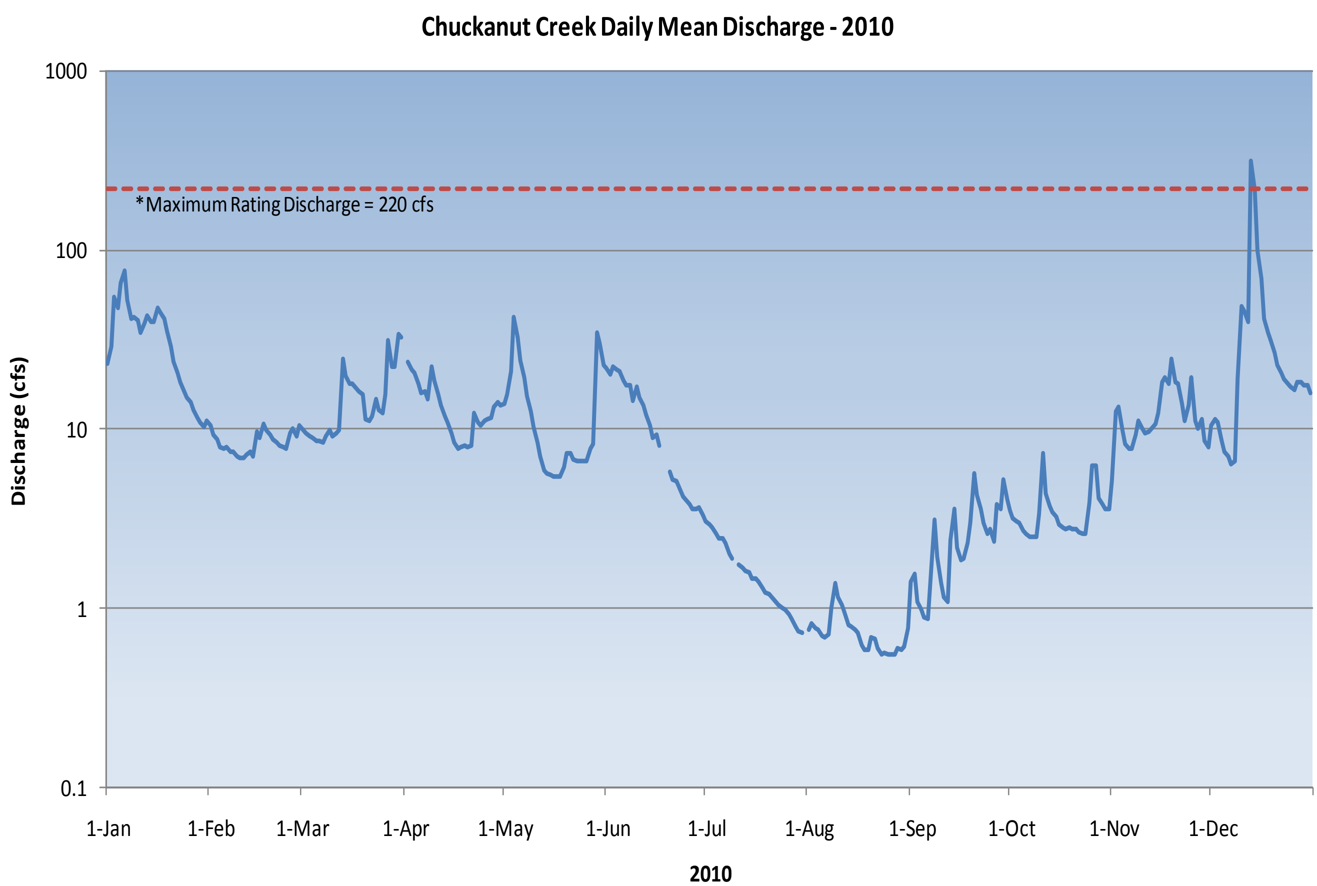


Figure 6.0-9. Daily mean discharge on Chuckanut Creek during 2010. Discharge values above the maximum rating discharge of 220 cfs are of poor quality and should be interpreted cautiously. This hydrograph uses a logarithmic scale.

7.0 Padden Creek Drainage Basin

Padden Creek flows from its headwaters, Lake Padden, to an estuary adjacent to Bellingham Bay. The Padden Creek drainage area is approximately 3840 acres (Ecology, 1997) and the creek receives inputs from Western Washington University as well as residential areas and a commercial area located at the base of Sehome Hill. The largest tributary to Padden Creek is Connelly Creek.

Padden Creek flows through mainly residential areas and parks. A small industrial area is located near the mouth. Much of the riparian zone in wooded. The course of Padden Creek is restricted by the placement of culverts at various points along the waterway, including a 5-block culvert between 17th and 22nd Streets.

Padden Creek is sampled at four locations: 38th St., 30th St. (Figure 7.0-1), 22nd St., and near the mouth (Figure 7.0-4), approximately 1500 feet upstream from its discharge point. Connelly Creek, the main tributary to Padden Creek, is sampled at Donovan Ave. (Figure 7.0-7) (Chuckanut and Padden Drainage Map). Table 7.0-1 shows the number of samples collected at each sampling site from 2001 to 2010.

In 2010, Padden Creek at 38th street was the only site to meet the Recreational Use Standard for Fecal Coliform. However, all sites on Padden Creek and Connelly Creek met the Aquatic Life Use (ALU) standards for Temperature and pH. None of the Padden Creek sites were able to meet the Dissolved Oxygen ALU.

In 2010, the Padden Creek site at 38th street met overall Class A water quality standards, while the sites at 30th St. and 22nd St. met overall Class B standards. Neither the Padden Creek Mouth nor Connelly Creek met overall Class A or Class B standards.

Table 7.0-1. Number of samples* taken per year for Padden and Connelly Creek from 2001 to 2010.

Sampling Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
38th Street	8	12	12	12	12	12	12	12	12	12
30th Street	8	12	12	12	12	12	12	12	12	12
Connelly	8	12	12	12	12	12	12	12	12	12
22nd Street					12	12	12	12	12	12
Mouth	8	12	12	12	12	12	12	12	12	12

*Some parameters may not have been sampled with the same frequency.

In 2010, all of the Padden Creek sites were able to meet the stringent Class AA temperature standard (≤16.0℃), the Class AA/A/B/ pH standard and the Class A Dissolved Oxygen standard (≥8.0 mg/L).

As is often the case, water quality criteria for fecal coliform proved to be the limiting factor in Padden Creek class rankings. Only the Padden Creek site at 38th St. was able to meet the Class A standard. The sites at 30th St. and 22nd St. met the Class B standard. Though Connelly Creek did meet the Class A geomean criterion, more than 10% of the samples contained greater than 400 cfu/100 ml (Class B) and therefore it did not qualify for either Class A or Class B standards. The Padden Creek Mouth site was also disqualified from the class rankings due to the greater than 10% exceedence rule.

In 2010, Padden Creek at 22nd St. was the only site to record a yearly average turbidity below both the 5-year and 10-year averages. Both the 30th St. and 38th St. yearly averages were above their respective 5-year averages but below their 10-year averages. The Padden Mouth site and Connelly Creek both recorded higher yearly averages than both their 5-year and 10-year averages. The highest average turbidity for 2010 was found at Connelly Creek (9.0 NTU), while Padden Creek at 38th St. had the lowest average turbidity (2.8 NTU). Average turbidity values for 2010 are listed along side respective 5 and 10 year averages in Table 7.0-5. Conductivity was consistent with previous years.

Figure 7.0-1. Padden Creek 30th St. sampling site.

Fecal Coliform Bacteria

The fecal coliform levels found in Padden and Connelly Creeks varied slightly from the expected trend of higher levels in the summer months. Numbers of fecal coliform bacteria were also elevated during January and March of 2010 (Figures 7.0-2, 7.0-2a). However, with the exception of 30th St., the geomeans for Padden Creek sites were lower than in 2009. The geomean for each sampling location is provided in Table 7.0-2. The percent of samples that exceeded 200 CFU/100 ml is presented in Figures 7.0-3 and 7.0-3a.

All sampling sites have experienced levels of fecal coliforms over 200 CFU/100 ml in previous years, particularly Connelly Creek and Padden mouth. In 2002, in response to concerns about the elevated levels of fecal coliform bacteria in the lower reaches of Padden Creek, City of Bellingham staff conducted extensive water testing from 30th St. to the mouth. Water samples were collected and tested for fecal coliform bacteria, specifically, *Escherichia coli* (*E. coli*). Connelly Creek was identified as the only point source of bacteria found during the Padden Creek Survey (City of Bellingham, 2002a).

As a follow up to the Padden Creek Survey, in 2003 bacterial testing was performed on Connelly Creek from 40th St. to the confluence with Padden Creek (City of Bellingham, 2003). No point sources of fecal contamination were identified with the exception of a failing septic system. The Whatcom County Department of Health worked with the homeowner to correct this problem and a new septic system was installed at the site.

The City of Bellingham Stormwater Utility also conducted follow up testing on Padden and Connelly Creeks in 2005. Results were inconclusive and further testing will be scheduled to find if additional point sources of fecal coliforms can be determined. The number of exceedences of fecal coliform standards on Connelly Creek have been steadily declining since 2006.

Table 7.0-2. The 2010 fecal coliform geomean values (CFU/100 ml) for sampling sites on Padden and Connelly Creeks.

Sampling Site	**38th Street**	**30th Street**	**Connelly**	**22nd Street**	**Mouth**
Geomean (CFU/100 ml)	13	25	85	55	114

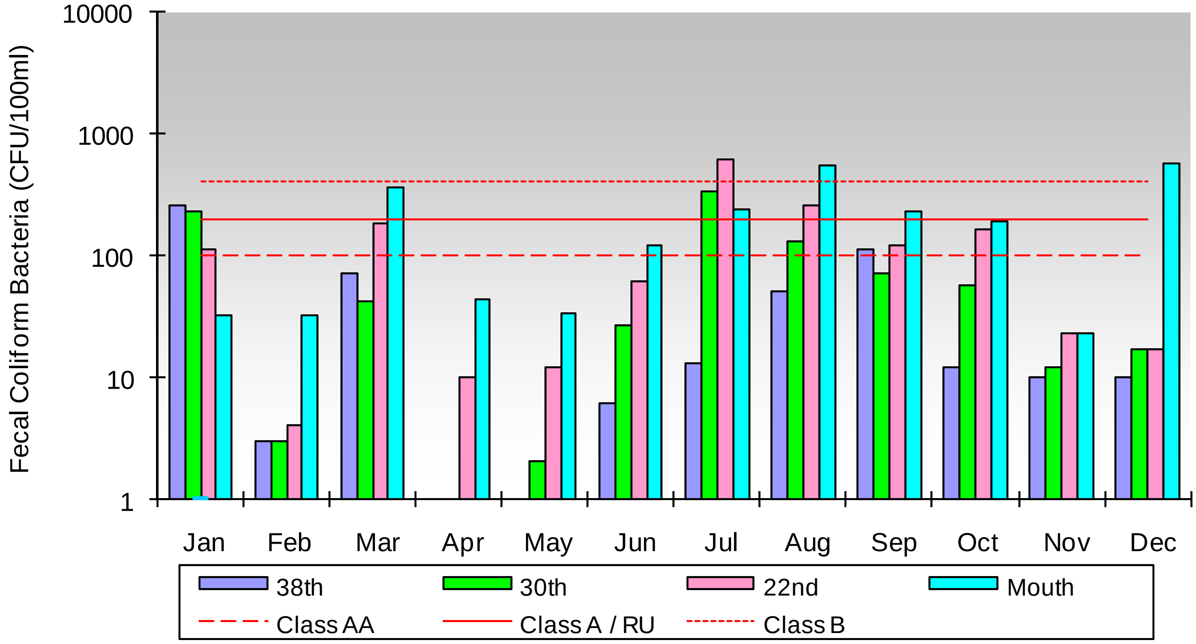


Figure 7.0-2. Monthly 2010 fecal coliform levels for Padden Creek sampling sites. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

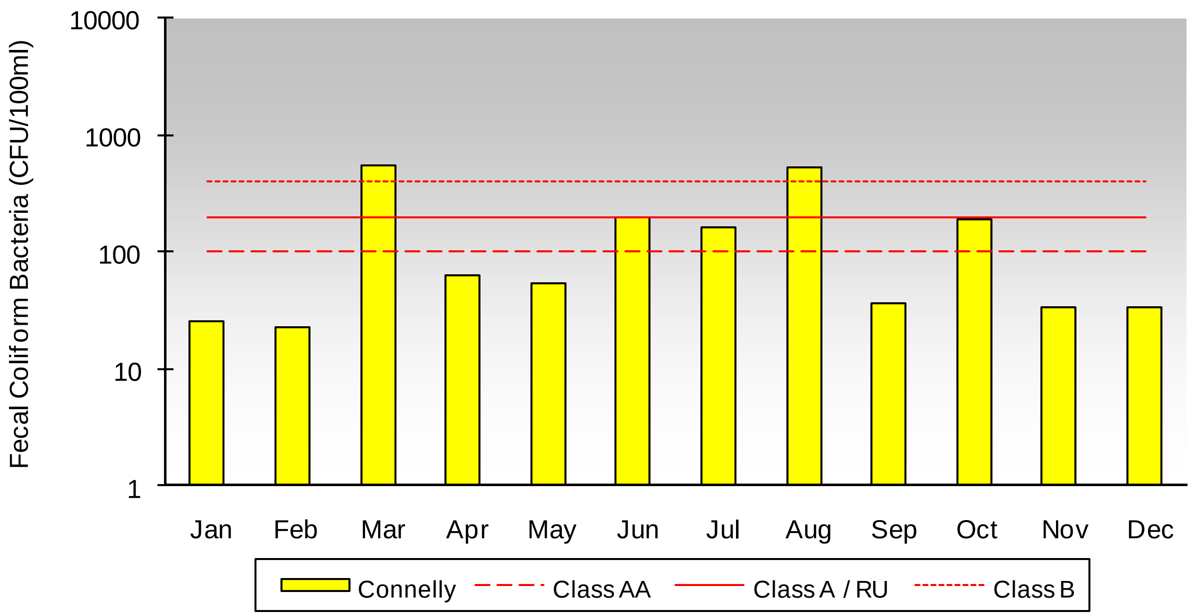


Figure 7.0-2a. Monthly 2010 fecal coliform levels for Connelly Creek sampling site. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

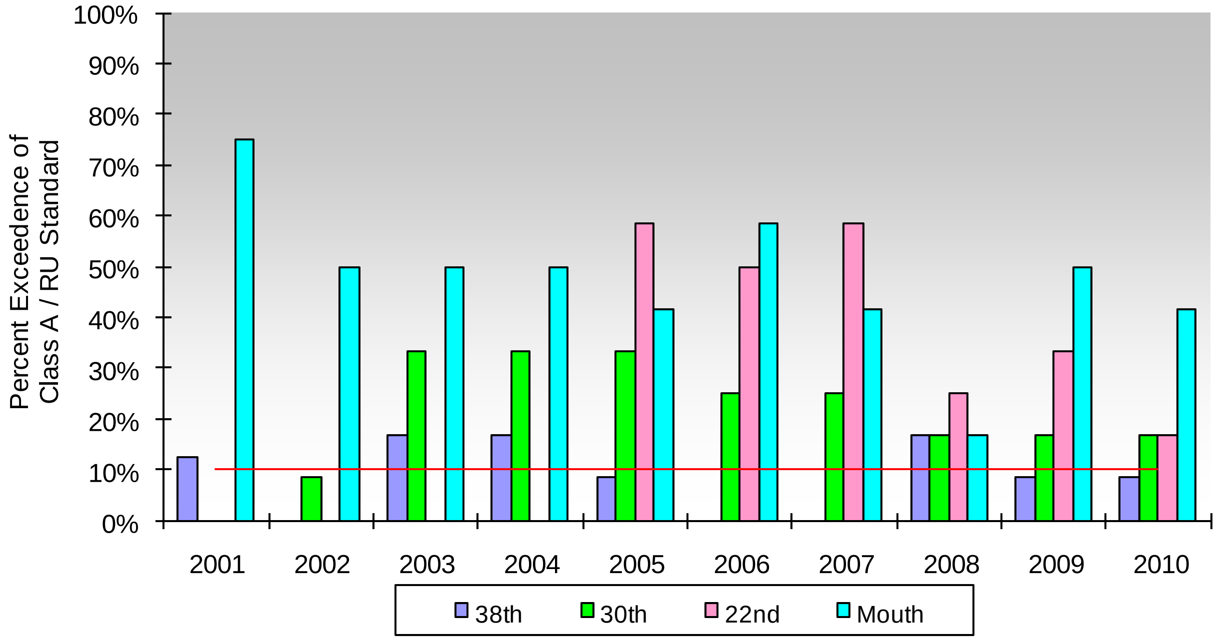


Figure 7.0-3. Percent exceedence of the Class A / Recreational Use (RU) standard for fecal coliform bacteria by year for Padden Creek sampling sites, 2001 to 2010. Sampling began on 22nd Street in 2005. All other gaps represent a 0% exceedence rate.

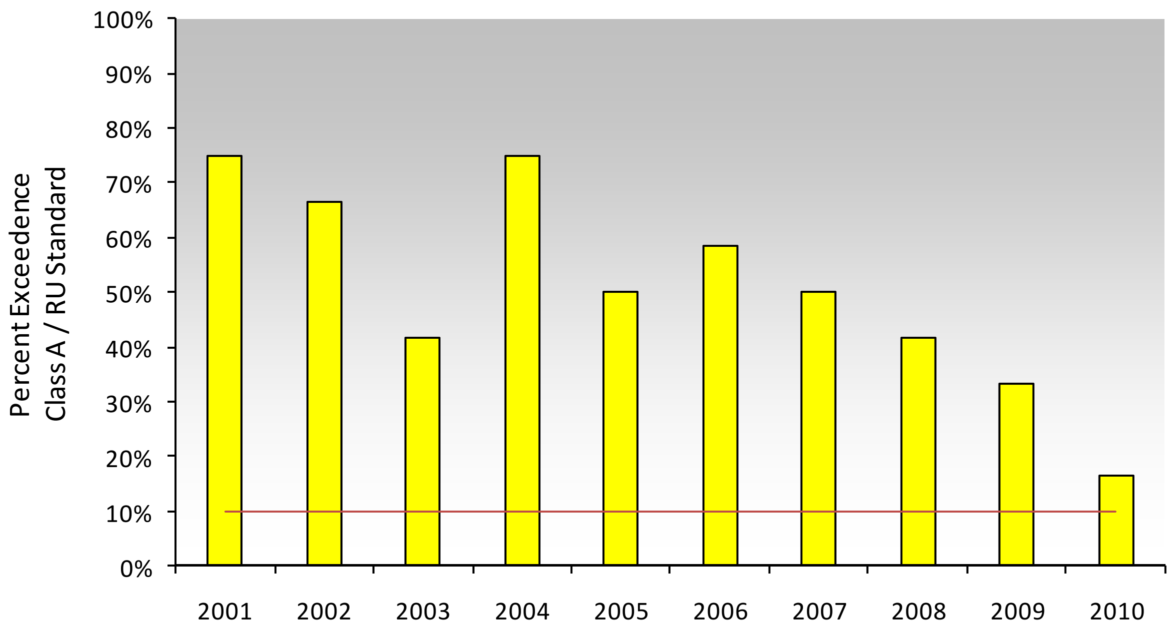


Figure 7.0-3a. Percent exceedence of the Class A / Recreational Use (RU) standard for fecal coliform bacteria by year for Connelly Creek, 2001 to 2010.

Dissolved Oxygen

In 2010, none of the Padden or Connelly Creek sites remained above the Core Summer Salmonid Habitat Aquatic Life Use (ALU) criteria of 9.5 mg/L for dissolved oxygen. The Core Summer Salmonid Habitat ALU is equivalent to the Class AA standard. All sites on Padden Creek and Connelly Creek did remain above the 8.0 mg/L Class A standard however. Dissolved oxygen in these two creeks follows an expected trend with lower levels in the warmer summer months (Figures 7.0-5, 7.0-5a). Average dissolved oxygen values are provided in Table 7.0-3.

Since use designations were implemented in 2006, every stream segment in the Padden Creek drainage has failed to meet the 9.5 mg/L ALU criteria in at least one year (Figures 7.0-6, 7.0-6a). Connelly Creek has had the most frequent occurrence of low dissolved oxygen.

Table 7.0-3. Average dissolved oxygen values for Padden and Connelly Creeks in 2010.

Sampling Site	**38th Street**	**30th Street**	**Connelly**	**22nd Street**	**Mouth**
Average DO (mg/L)	10.7	11.2	9.9	10.7	10.3

Figure 7.0-4. Padden Creek mouth sampling site.

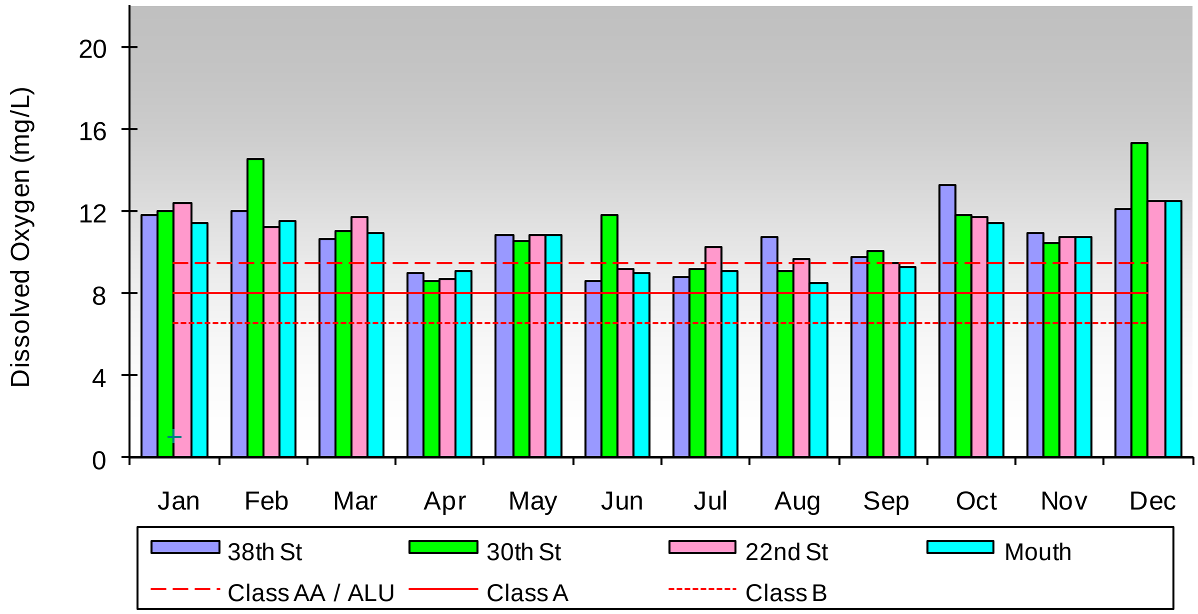


Figure 7.0-5. Dissolved oxygen for Padden Creek sampling sites by month in 2010. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

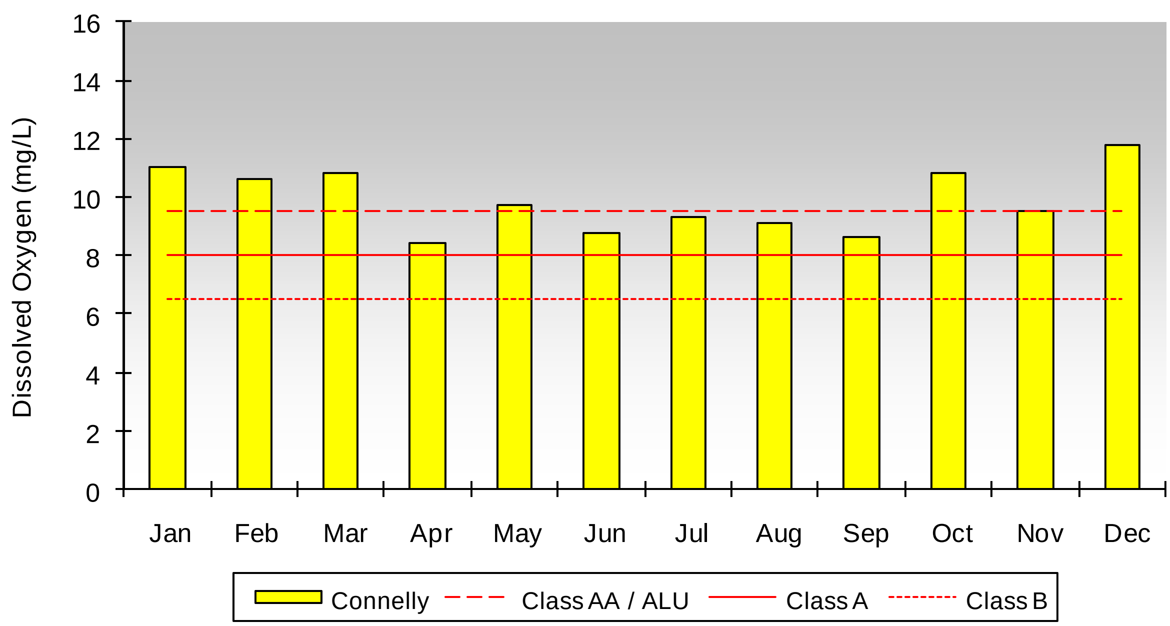


Figure 7.0-5a. Dissolved oxygen for the Connelly Creek sampling site by month in 2010. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

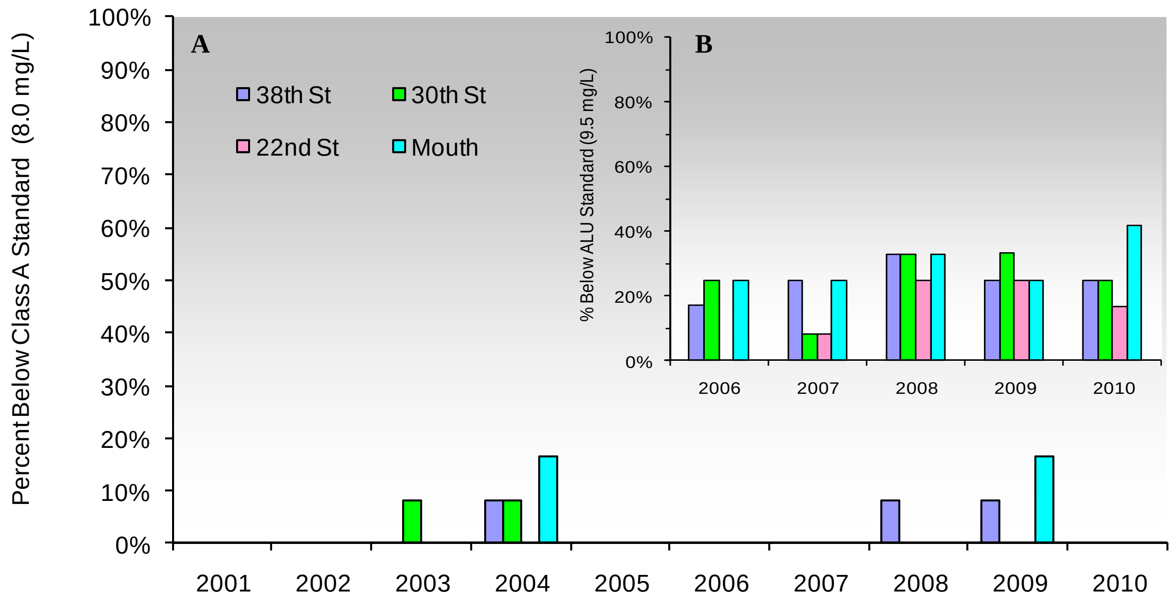


Figure 7.0-6. A. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for Padden Creek sampling sites 2001 to 2010. B. Percent of dissolved oxygen samples below the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (9.5 mg/L) from 2006-2010. Sampling began on 22nd St. in 2005. All other gaps in graph represent a 0% rate of samples below standards.

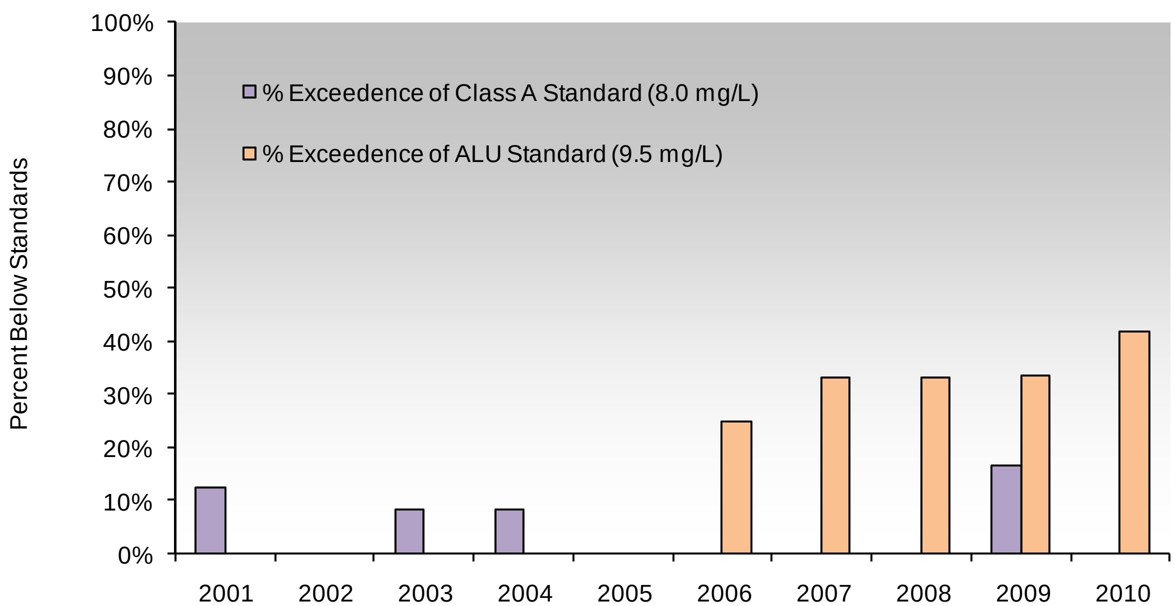


Figure 7.0-6a. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for the Connelly Creek sampling site 2001 to 2010 and below the Core Summer Salmonid Habitat Aquatic Life Use (ALU, 9.5 mg/L) since implementation in 2006. Gaps in graph represent a 0% rate of samples below standards.

Temperature

All sites in the Padden Creek drainage met the 16°C Core Summer Salmonid Habitat Aquatic Life Use (ALU) criterion in 2010. The Core Summer Salmonid Habitat ALU is equivalent to Class AA. The temperature profile for all segments shows the expected seasonal trend with higher temperatures in the summer months (Figures 7.0-8, 7.0-8a). Average temperatures are provided in Table 7.0-4.

Temperatures in Padden and Connelly Creeks do not exceed standards often. The 18°C Class A standard has not been exceeded in greater than 10% of all samples taken in any year since 1999.

Table 7.0-4. Average temperatures for sampling sites on Padden and Connelly Creek, 2010.

Sampling Site	38th Street	30th Street	Connelly	22nd Street	Mouth
Average Temperature (°C)	11.0	10.8	10.8	10.8	11.0

Figure 7.0-7. Connelly Creek sampling site.

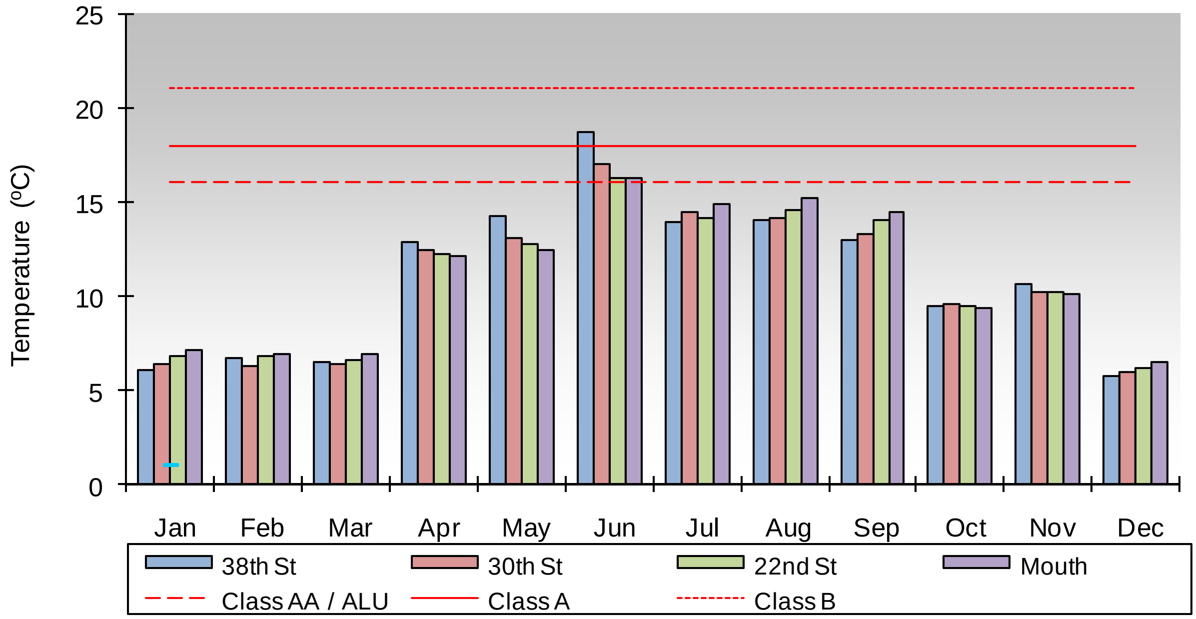


Figure 7.0-8. Monthly temperature measurements for Padden Creek sampling sites in 2010. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

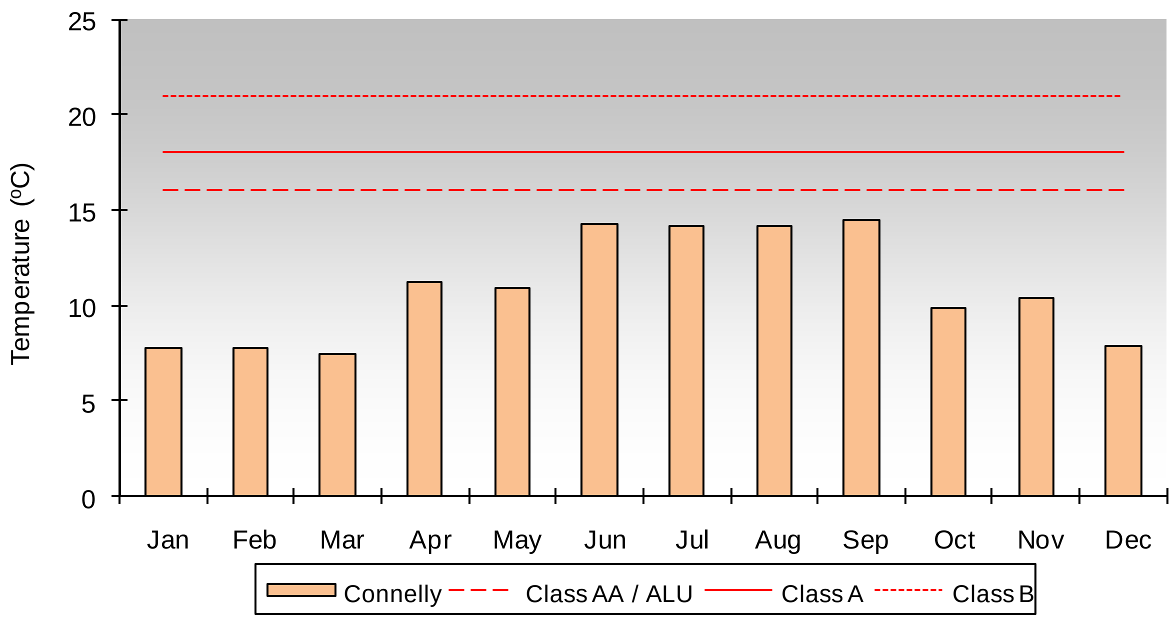


Figure 7.0-8a. Monthly temperature measurements for the Connelly Creek sampling site in 2010. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

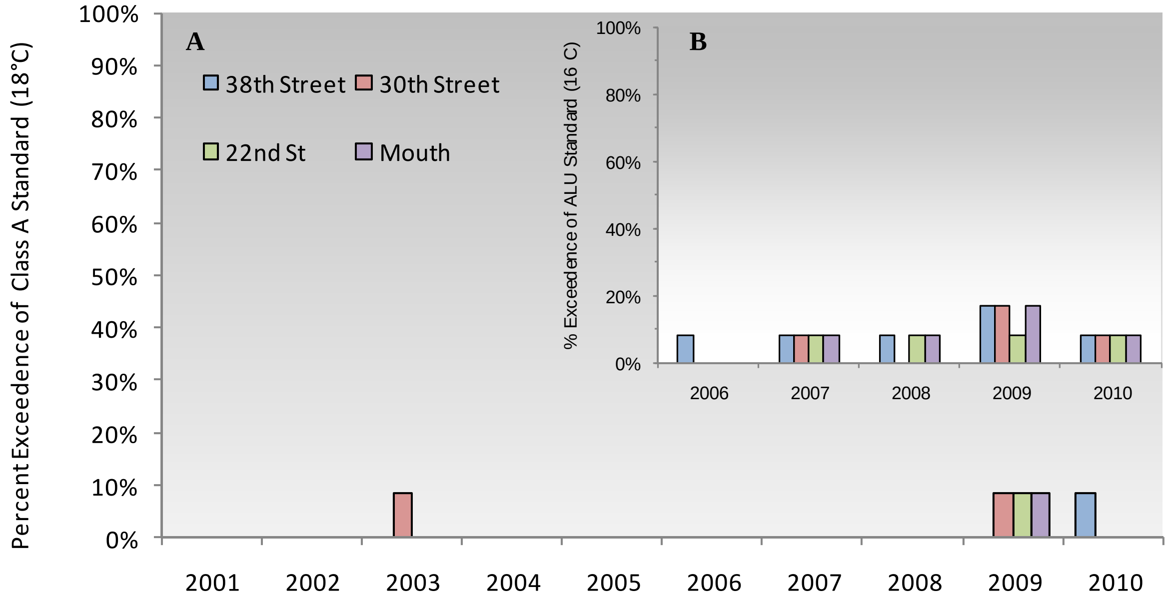


Figure 7.0-9. A. Percent of samples with temperatures in excess of the Class A standard (18°C) for Padden Creek sampling sites 2001 to 2010. B. Percent of temperature samples above the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (16°C) from 2006-2010. Sampling began on 22nd Street in 2005. All other gaps in graph represent a 0% exceedence rate.

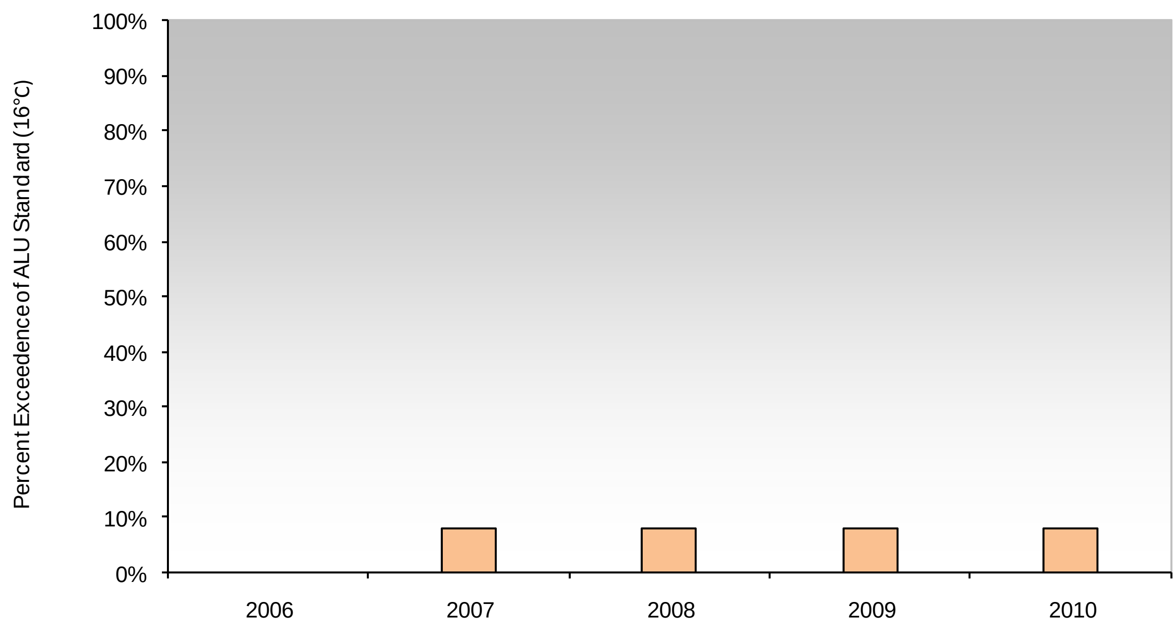


Figure 7.0-9a. Percent of samples with temperatures in excess of the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard (16°C) for the Connelly Creek sampling site 2006 to 2010. There have been no exceedences of the Class A (18°C) standard since 1998. Gaps in graph represent a 0% exceedence rate.

pH

The pH at all sites monitored on Padden and Connelly Creeks generally falls within the range prescribed by Ecology for Aquatic Life Use (ALU) and all classes of freshwater bodies (6.5 to 8.5). In 2010, pH for all sites fell within the prescribed range. Graphs are not included in this section because pH is so rarely exceeded.

Turbidity

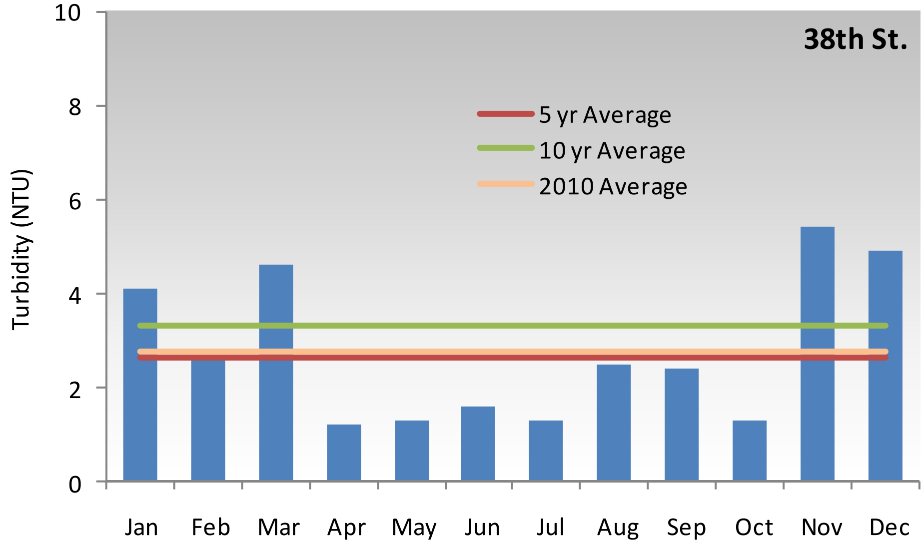
Turbidity in Padden and Connelly Creeks is generally below 10 NTU, with occasional spikes. In 2010, Padden Creek at 22nd St. was the only site to record a yearly average turbidity below both the 5-year and 10-year averages. Both the 30th St. and 38th St. yearly averages were above their respective 5-year averages but below their 10-year averages. The Padden Mouth site and Connelly Creek both recorded higher yearly averages than both their 5-year and 10-year averages. Average turbidity values for 2010 are listed along side respective 5 and 10 year averages in Table 7.0-5. Conductivity was consistent with previous years. Maximum, minimum and average turbidity for all sampling sites in 2010 are provided in Table 7.0-5. The turbidity spike in March correlates with a heavy rainfall event surrounding the sampling date.

Ten year turbidity trends at Padden and Connelly Creek sites were all descending in 2010. A reassuring sign that restoration efforts along the Padden Creek drainage may be having positive effects on water quality. The 38th St. site is decreasing 0.22 NTU/year, 30th St. is decreasing 0.31 NTU/year, 22nd St. is decreasing 0.23 NTU/year and the site at the mouth is decreasing 0.34 NTU/year. Connelly Creek is decreasing 0.36 NTU/year.

Table 7.0-5 The average, maximum and minimum turbidity for sampling sites on Padden and Connelly Creek in 2010.

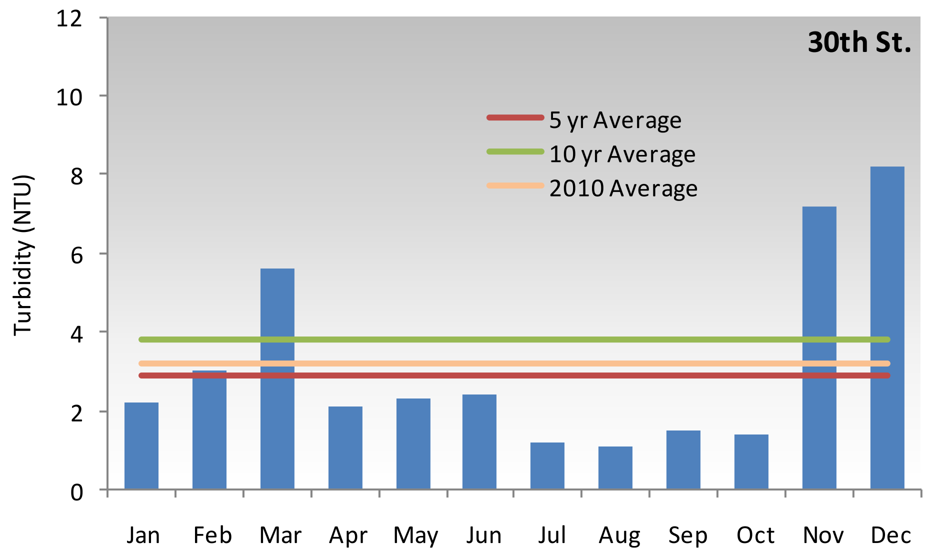
Sampling Site	38th Street	30th Street	Connelly	22nd Street	Mouth
2010 Average (NTU)	2.8	3.2	9.0	3.8	7.1
2010 Maximum (NTU)	5.4	8.2	58.3	8.2	28.8
2010 Minimum (NTU)	1.2	1.1	1.8	1.5	2.2

a.

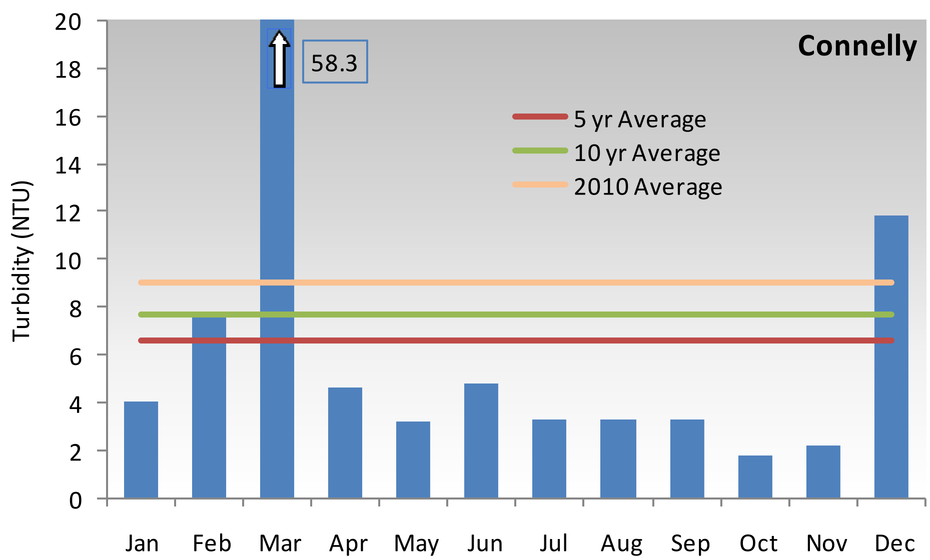


Figures 7.0-10a,b&c. Monthly turbidity values for Padden Creek drainage sampling sites at 38th St., 30th St. and the Connelly Creek during 2010. Presented with yearly, 5-year and 10-year averages.

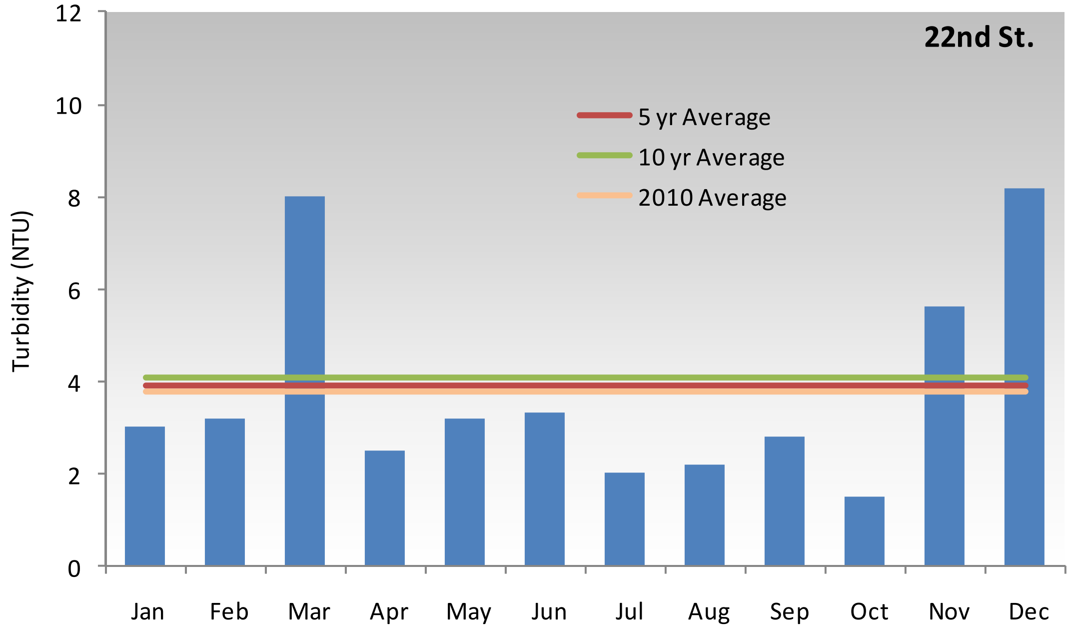
b.



c.

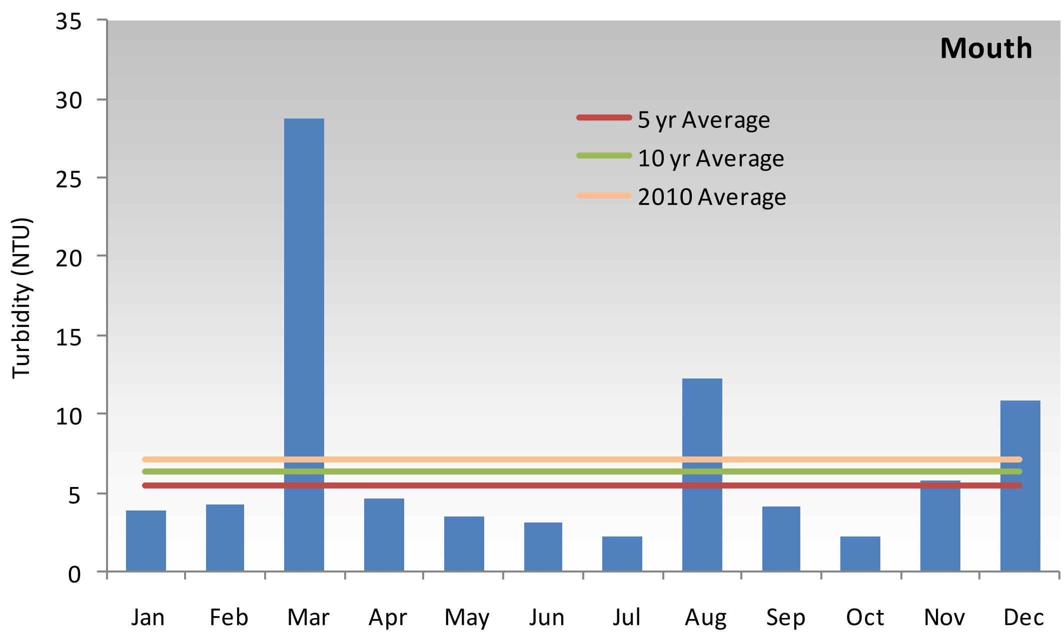


d.



Figures 7.0-10d&e. Monthly turbidity values for Padden Creek sampling sites at 22nd St. and the Mouth during 2010. Presented with yearly, 5-year and 10-year averages.

e.



Hydrology

The Padden Creek gauging station has been in service since 2005. It is located in Fairhaven Park approximately 50 feet downstream of the footbridge below the playground. Overall, Padden Creek has lowest discharge volume of all of Bellingham's gauged sites, yet it is also prone to very sudden and steep increases in flow at the start of rain events.

In 2010, Padden Creek had a minimum discharge (flow) of < 0.01 cubic feet per second (cfs) on multiple days in August and September, a maximum discharge of 218 cfs on December 12th and an average discharge of 8.7 cfs.

Figure 7.0-11. Low flows at the headwaters of Padden Creek. The fully opened control dam at Lake Padden is visible in the background.

As seen during August and September of 2010, Padden Creek is known for its low flows during the summer months (Figures 7.0-11 and 7.0-12). Without adequate flow, it is nearly impossible to meet all of Ecology's water quality criteria.

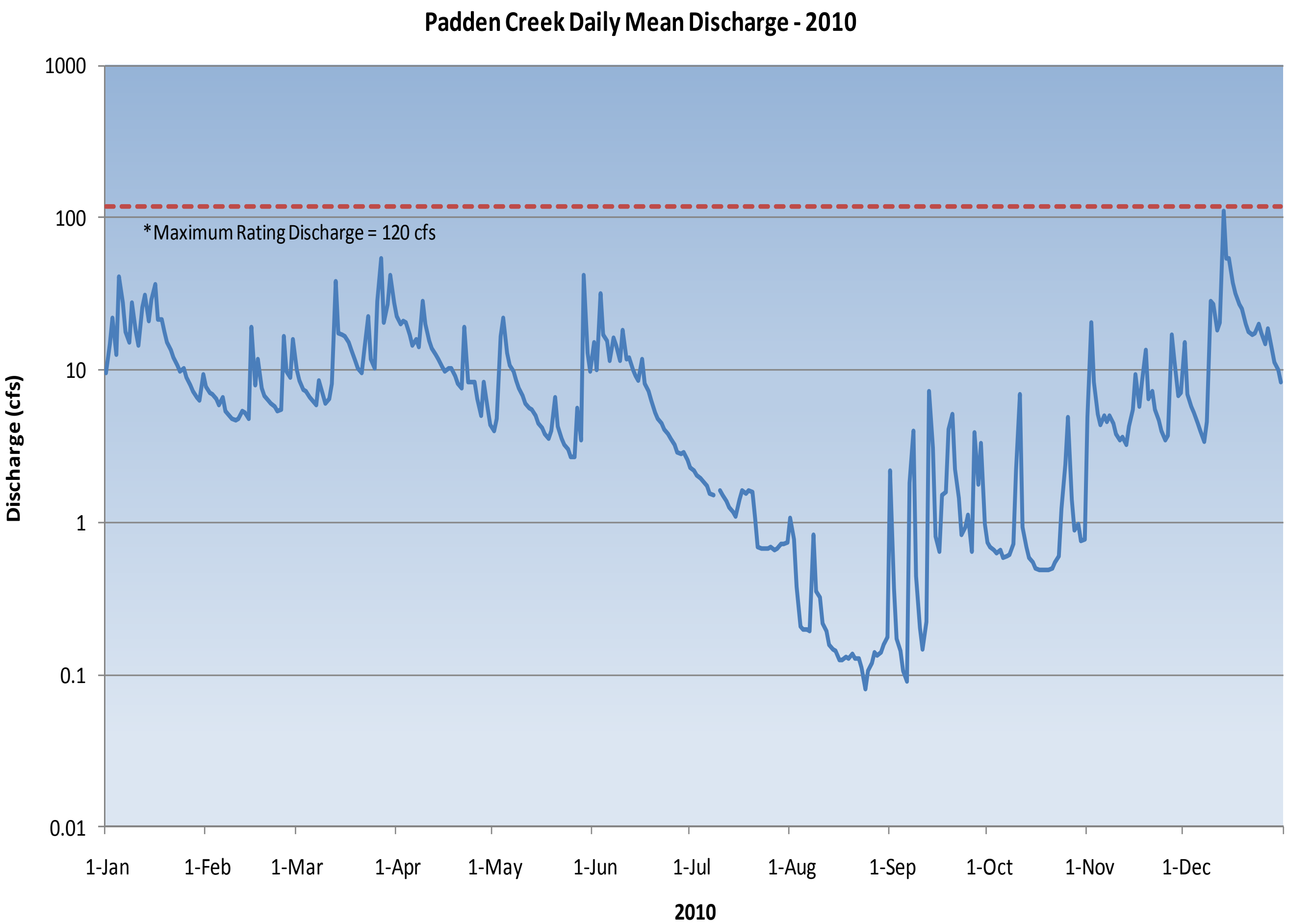


Figure 7.0-12. Daily mean discharge on Padden Creek during 2010. Discharge values above the maximum rating discharge of 120 cfs are of poor quality and should be interpreted cautiously. This hydrograph uses a logarithmic scale.

8.0 Whatcom Creek Drainage Basin

The origin of Whatcom Creek is the natural outlet of Lake Whatcom at the northwest end of the lake. Whatcom Creek flows approximately four miles through residential, commercial, industrial, and wooded areas to the mouth at Bellingham Bay near downtown Bellingham and has a drainage basin of approximately 5,790 acres (City of Bellingham, 1982).

In the upper reaches, the creek cuts through the Chuckanut Sandstone formation, a geological belt of sandstone dating back fifty million years. Erosion of the sandstone has created a deep gorge and waterfalls along the upper reaches. This segment of the creek is in wooded and residential areas. It is shaded and the flow tends to be more rapid.

The creek flattens after leaving the Whatcom Falls Park area and enters a mainly industrial and commercial area. The flow in the lower reaches of the creek is slower than in the upper reaches. A great deal of impervious surface area surrounds this reach of the creek. Much of the creek in this flat area lacks shade, though restoration efforts by the City of Bellingham/Washington Conservation Corps crews in recent years have made enormous strides in revegetating this region with trees and other native plants.

The Whatcom Creek drainage basin contains several creeks that contribute to the flow in Whatcom Creek. Hanna Creek flows into Whatcom Creek in Whatcom Falls Park and is one of the main low flow contributors to Whatcom Creek. Hanna Creek has a drainage area of approximately 480 acres (City of Bellingham, 1995) and flows through residential and wooded areas.

Fever Creek drains into Whatcom Creek near Interstate 5. This small urban creek flows through residential and industrial areas and is characterized by channelization for much of its run. It has a drainage basin of approximately 580 acres (City of Bellingham, 1995).

Lincoln Creek also discharges to Whatcom Creek near Interstate 5 and has been channelized for much of its course. Lincoln Creek flows through commercial, industrial and residential areas and drains approximately 804 acres (City of Bellingham, 1995).

Cemetery Creek flows through mostly residential and wooded areas and joins Whatcom Creek near Racine Street. It has a drainage area of approximately 1,670 acres (City of Bellingham, 1995).

Whatcom Creek is sampled at four locations: below the Control Dam at the south end of Scudders Pond (Figure 8.0-1), at Valencia St. (Figure 8.0-2), adjacent to Interstate 5 (Figure 8.0-3), and at Dupont St. (Figure 8.0-4). Four Whatcom Creek tributaries are sampled. Hanna Creek (Figure 8.0-5) is sampled below the City of Bellingham Water Treatment Plant approximately 1000 feet upstream from the confluence with Whatcom Creek. Cemetery Creek (Figure 8.0-8) is sampled near the Haskell Business Center, just upstream from the confluence with Whatcom Creek. Lincoln Creek (Figure 8.0-11) is sampled at a location adjacent to the Geary softball fields and approximately 1200 feet upstream from the confluence with Whatcom Creek. Fever Creek (Figure 8.0-12) is sampled at Valencia Street approximately 3500 feet upstream from the confluence with Whatcom Creek (see the Whatcom Drainage Map for sampling locations). Table 8.0-1 shows the number of samples taken at each sampling location by year.

Figure 8.0-1. Whatcom Creek sampling site at the Control Dam.

Whatcom Creek and its' tributaries rarely meet all of the designated use criteria. In fact, The City of Bellingham conducted a Total Maximum Daily Load (TMDL) study in 2002/2003 on Whatcom Creek due to an Ecology listing as a 303(d) impaired waterway for temperature and fecal coliform bacteria (Shannahan et al.). Fecal coliform data in the 2004 report of the study detailed the loading of fecal coliforms to the creek system. Ecology has issued an implementation plan to reduce fecal coliform bacteria in Whatcom Creek (Hood, 2006).

In 2010, every site on Whatcom Creek met the Primary Contact Recreational Use Standard for fecal coliform (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml). Hanna Creek was the only tributary to meet the Recreational Use Standard. Alternatively, none of the Whatcom Creek sites met the Aquatic Life Use (ALU) tempera-

Table 8.0-1. Number of samples* taken per year for Whatcom Creek and its tributaries from 2001 to 2010.

Sampling Site	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Control Dam	8	12	12	12	12	12	12	12	12	12
Hanna		9	10	12	10	11	12	12	12	12
Cemetery	8	12	12	12	12	12	12	12	11	12
Lincoln	8	12	12	12	12	12	12	12	12	12
Fever	8	12	12	11	12	12	12	12	12	12
Valencia						4	12	12	12	12
I-5	8	12	12	12	12	12	12	12	12	12
Dupont	8	12	12	12	12	12	12	12	12	12

*Some parameters may not have been sampled with the same frequency.

Figure 8.0-2. Whatcom Creek sampling site at Valencia St.

ture criterion of 16°C, while Hanna Creek, Lincoln Creek and Fever Creek did. Whatcom Creek at the Control Dam and Hanna Creek were the only sites to meet the dissolved oxygen ALU criterion (≥9.5 mg/L). All sites remained within the designated pH ALU range of 6.5-8.5.

In 2010, the Valencia, I-5 and Dupont sites on Whatcom Creek, as well as Hanna Creek were able to meet the overall Class A designation. Whatcom Creek at the Control Dam and Cemetery Creek met the criteria for overall Class B designation. Lincoln Creek and Fever Creek did not meet the Class A or B standards because of fecal coliform levels.

Hanna, Lincoln and Fever Creeks met the more stringent Class AA criterion for temperature (≤ 16℃), while Cemetery Creek and Whatcom Creek at Valencia, I-5 and Dupont met the Class A temperature standard (≤ 18℃). Whatcom Creek at the Control Dam met the Class B standard (≤ 21℃).

In 2010, none of the sampling locations met the Class AA standard for dissolved oxygen (9.5 mg/L). Though Hanna Creek, Fever Creek and all Whatcom Creek sites did meet the Class A standard (8.0 mg/L). Cemetery and Lincoln Creeks met the Class B standard (6.5 mg/L).

Every site on Whatcom Creek met the more stringent Class AA standard for fecal coliform bacteria (geomean ≤50 CFU/100 ml; no more than 10% of samples >100 CFU/100 ml) in 2010. Hanna Creek met the Class A standards (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml), and Cemetery Creek met Class B standards (geomean ≤200 CFU/100 ml; no more than 10% of samples >400 CFU/100 ml). Lincoln and Fever Creeks did not meet Class A or B standards.

All stream segments sampled met the Class AA/A/B standard for pH (6.5 to 8.5).

The highest average turbidity on Whatcom Creek was found at the Dupont site (2.7 NTU), while the Control Dam site had the lowest average turbidity (1.6 NTU). Of the tributaries, Lincoln Creek had the highest average turbidity (6.5 NTU) and Fever Creek had the lowest (4.5 NTU). Average turbidity values for 2010 are listed along side respective 5 and 10 year averages in Table 8.0-5. Conductivity was consistent with previous years.

Fecal Coliform Bacteria

Fecal coliform levels in Whatcom Creek and its tributaries were all lower than those found in 2009. Geomean values for all sampling locations are provided in Table 8.0-2. Bacterial concentrations did not show the expected trend of higher values in the summer months at all sampling locations, possibly due to heavy rain events in the winter months washing more pollutants into creeks (Figures 8.0-6, 8.0-6a). The percent of samples that contained fecal coliform levels higher than 200 CFU/100 ml for 2001 to 2010 is presented in Figures 8.0-7 and 8.0-7a.

Figure 8.0-4. Whatcom Creek sampling site at Dupont Street.

Table 8.0-2. Fecal coliform geomean values for sampling sites on Whatcom Creek and its tributaries, 2010.

Sampling Site	C. Dam	Valencia	I-5	Dupont	Hanna	Cemetery	Lincoln	Fever
Geomean (CFU/100ml)	9	10	12	34	69	66	88	228

Figure 8.0-3. Whatcom Creek sampling site at I-5.

Figure 8.0-5. Hanna Creek sampling site.

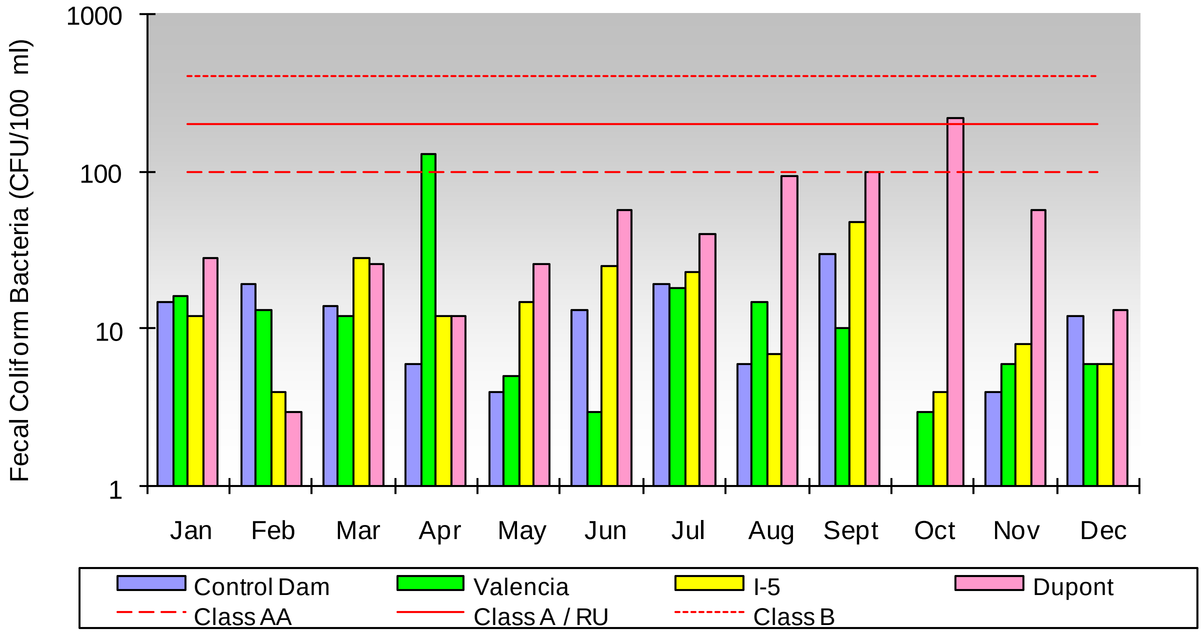


Figure 8.0-6. Monthly 2010 fecal coliform levels for sampling sites on Whatcom Creek. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

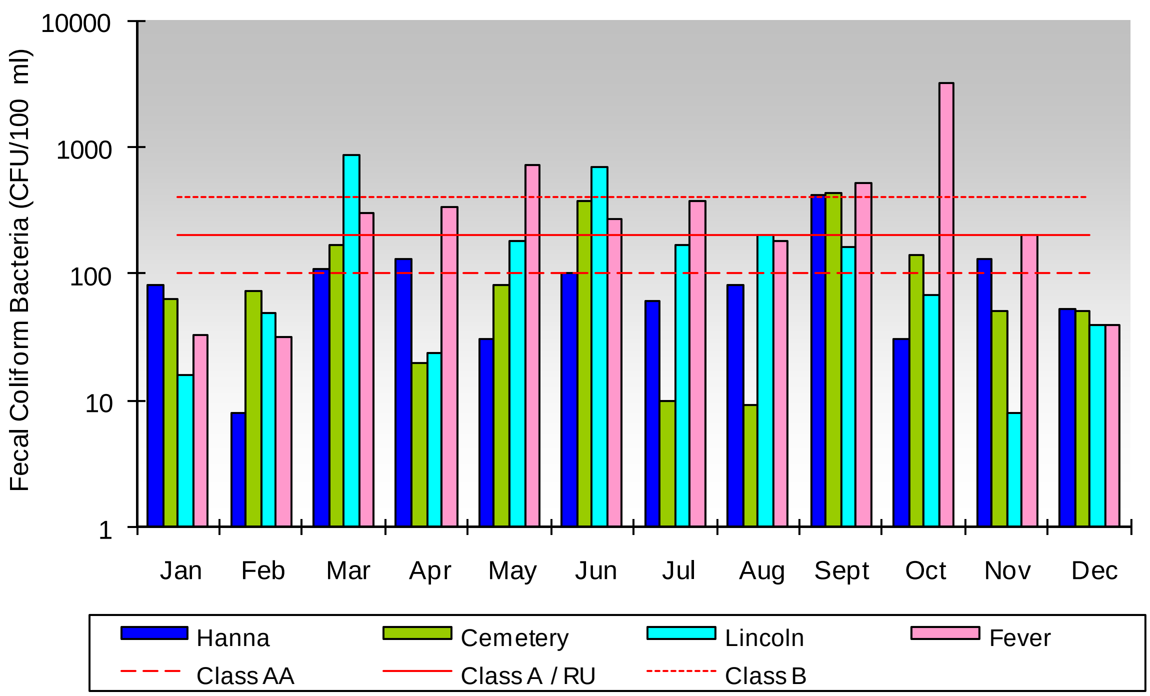


Figure 8.0-6a. Monthly 2010 fecal coliform levels for sampling sites on Whatcom Creek tributaries. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.*

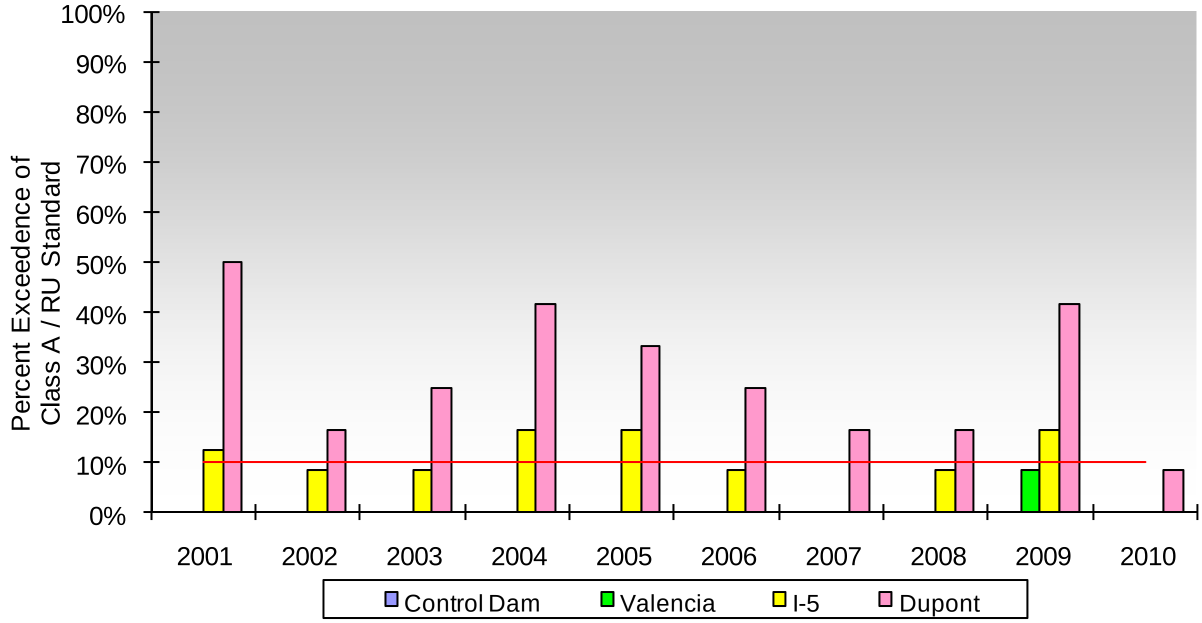


Figure 8.0-7. Percent exceedence of the Class A / Recreational Use (RU) standard for fecal coliform bacteria by year for Whatcom Creek sampling sites, 2001 to 2010. Sampling at Valencia began in 2007. Gaps represent a 0% exceedence rate.

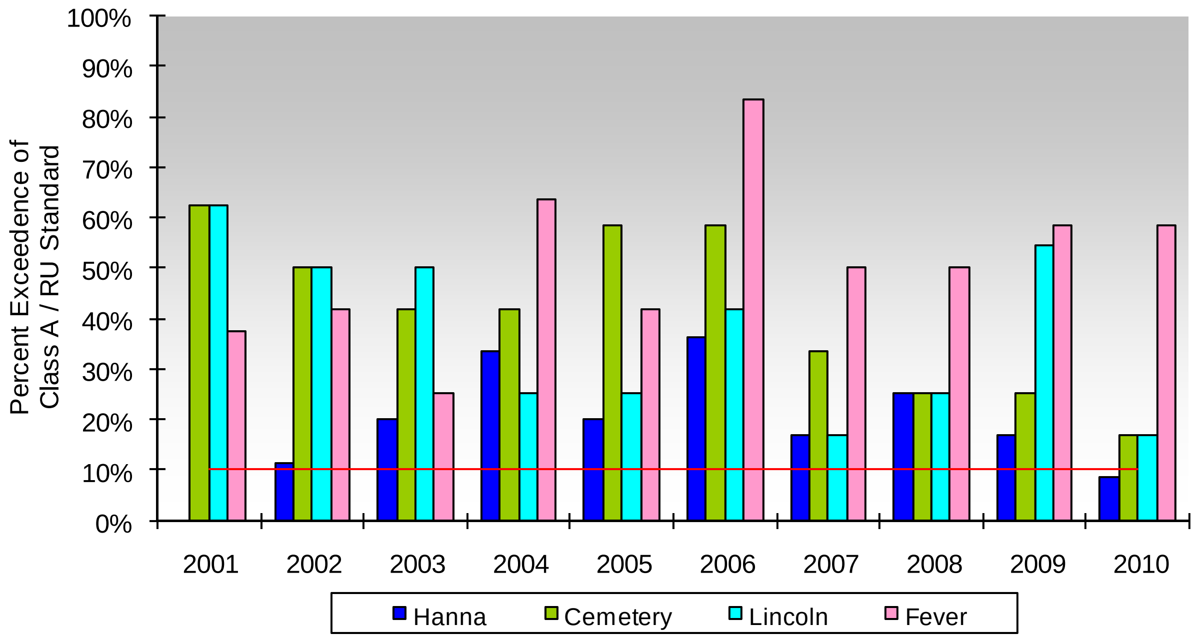


Figure 8.0-7a. Percent exceedence of the Class A / Recreational Use (RU) standard for fecal coliform bacteria by year for Whatcom Creek tributaries sampling sites, 2001 to 2010. Hanna Creek was sampled 2002 to 2010 only. All other gaps represent a 0% exceedence rate.

Dissolved Oxygen

During 2010, none of the Whatcom Creek Drainage sites met the 9.5 mg/L Core Summer Salmonid Aquatic Life Use (ALU) standard for dissolved oxygen. The dissolved oxygen ALU designation equates to the Class AA standard. All sites on Whatcom Creek, along with Hanna and Fever Creeks maintained Class A dissolved oxygen standards (≥8.0 mg/L) however. While Cemetery and Lincoln Creeks met the Class B standards (≥6.5 mg/L; Figures 8.0-9 and 8.0-9a).

Dissolved oxygen levels in Whatcom Creek and its tributaries have fallen below 8.0 mg/L frequently in previous years, but did so rarely in 2010 (Figures 8.0-10, 8.0-10a). Dissolved oxygen followed the expected trend of lower values in the warmer summer months as water temperatures rose. Average dissolved oxygen values are provided in Table 8.0-3.

Table 8.0-3. Average dissolved oxygen values for Whatcom Creek and its tributaries in 2010.

Sampling Site	C. Dam	Valencia	I-5	Dupont	Hanna	Cemetery	Lincoln	Fever
Average DO (mg/L)	9.7	10.6	10.5	10.2	11.4	9.4	10.4	11.1

Figure 8.0-8. Cemetery Creek sampling site

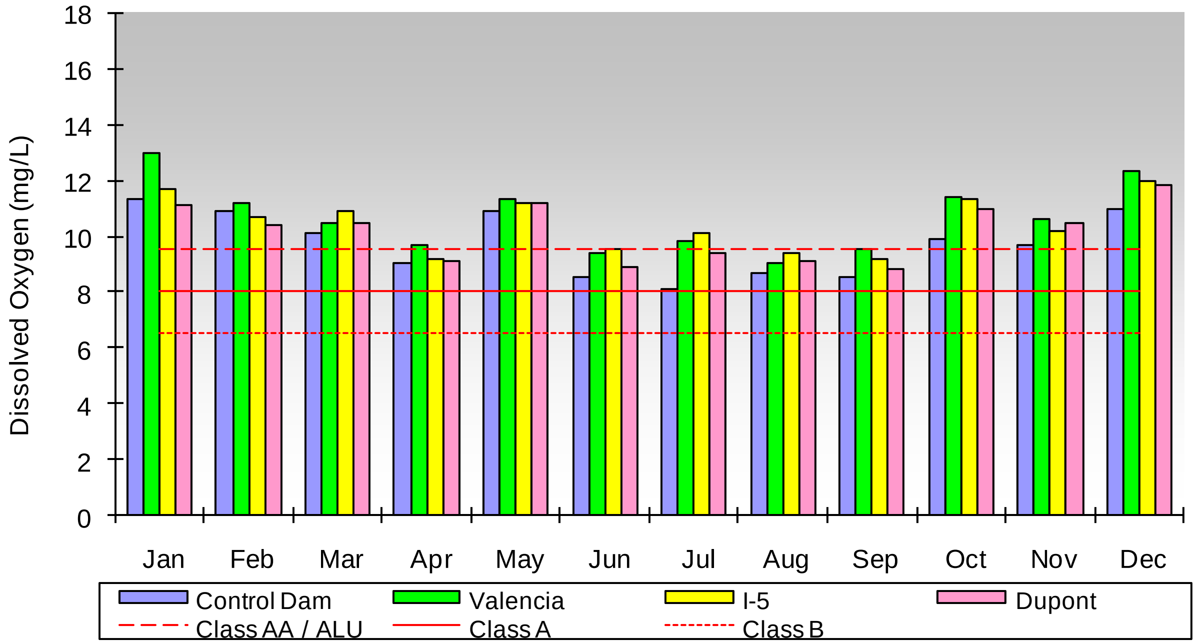


Figure 8.0-9. Monthly 2010 dissolved oxygen levels for Whatcom Creek sampling sites. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

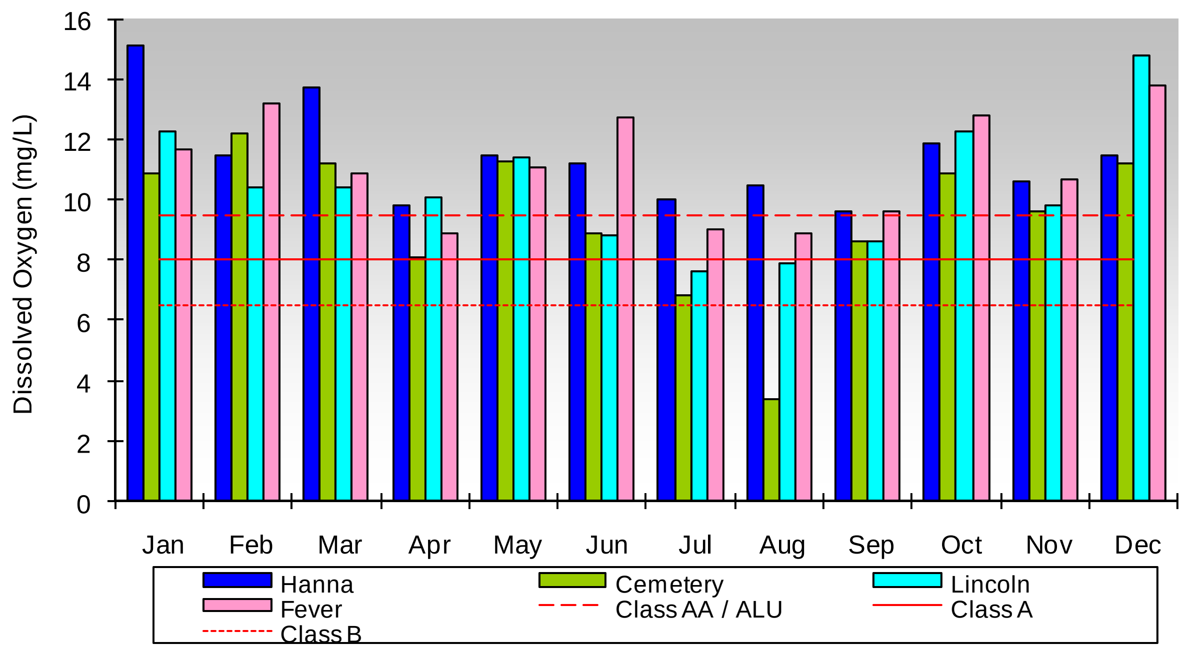


Figure 8.0-9a. Monthly 2010 dissolved oxygen levels for Whatcom Creek tributaries sampling sites. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

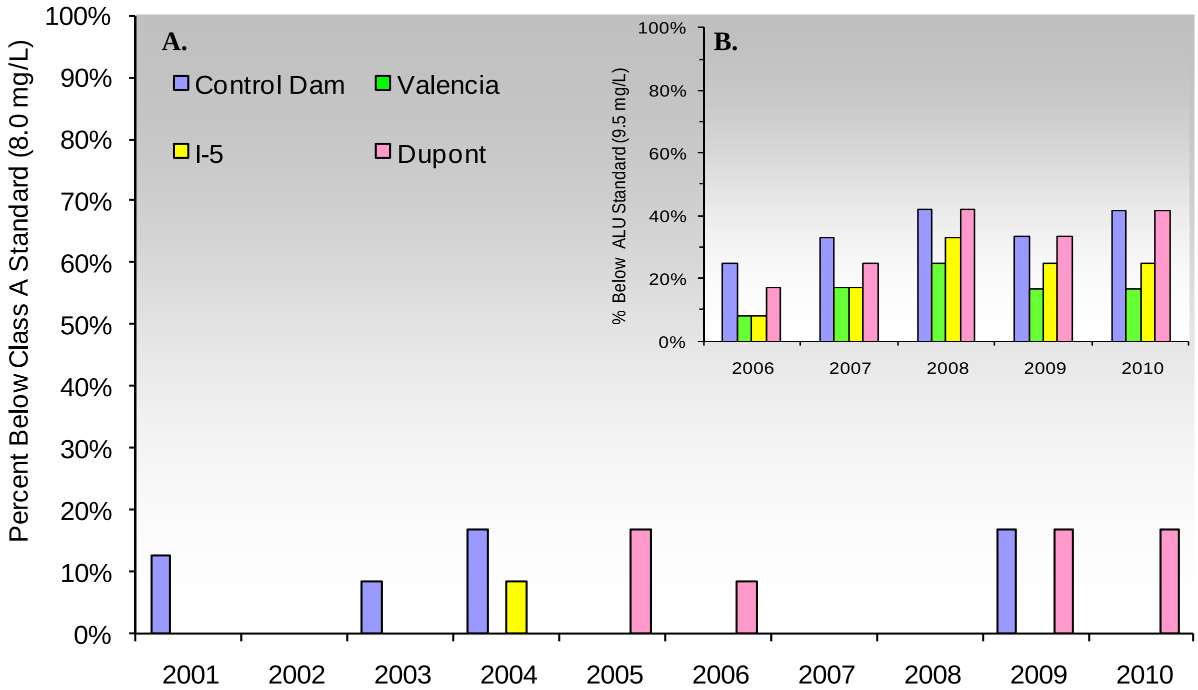


Figure 8.0-10. A. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for Whatcom Creek sampling sites 2001 to 2010. B. Percent of dissolved oxygen samples below the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (9.5 mg/L) from 2006-2010. Sampling at Valencia began in 2007. Gaps represent a 0% rate of samples below standards.

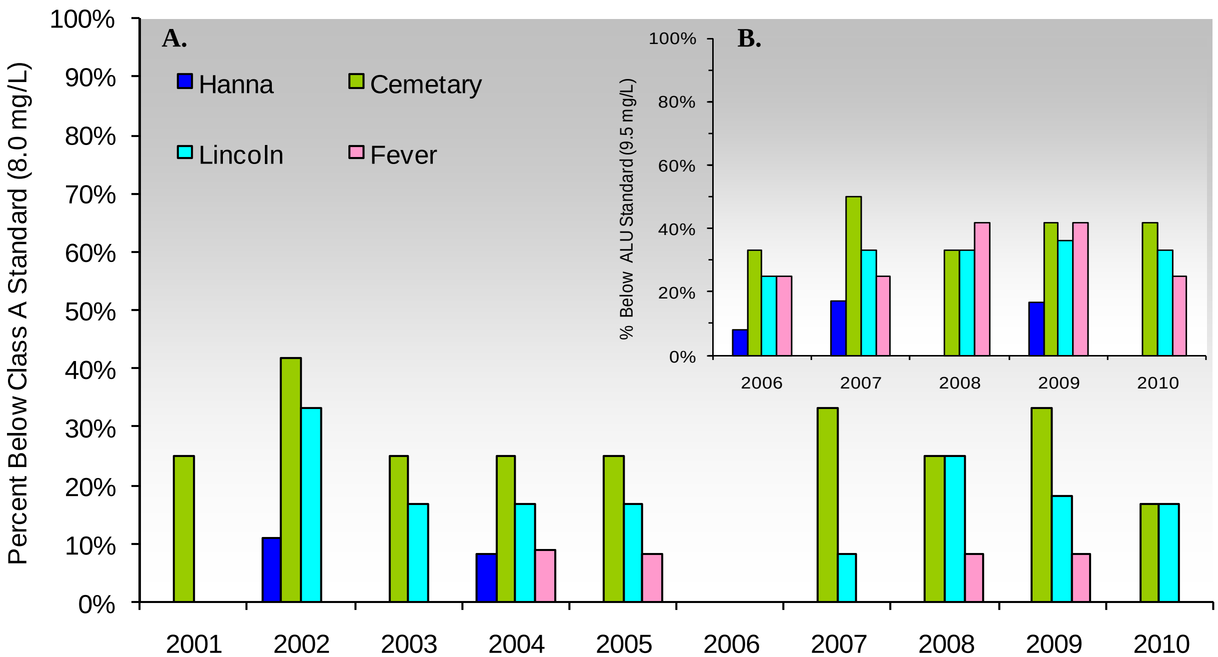


Figure 8.0-10a. A. Percent of dissolved oxygen samples below 8.0 mg/L for Whatcom Creek tributaries sampling sites 2001 to 2010. B. Percent of dissolved oxygen samples below the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (9.5 mg/L) from 2006-2010. Hanna Creek was sampled 2002 to 2010 only. All other gaps represent a 0% rate of samples below standards.

Temperature

Whatcom Creek chronically experiences temperature in excess of the 16°C Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation during the warmer summer months. This phenomenon is not surprising as the source water for Whatcom Creek, basin one of Lake Whatcom, has had recorded temperatures higher than 20° C in the upper epilimnion during summer months. While none of the stream segments on Whatcom Creek were able to meet the ALU standard in 2010, the Dupont, Valencia and I-5 sites did meet the <18℃ Class A standard and the Control Dam site met the <21°C Class B standard.

Temperatures above 16°C are not as common in the Whatcom Creek tributaries. In 2010 Hanna, Lincoln and Fever Creeks maintained temperatures below the <16°C ALU criterion, while Cemetery Creek met the <18°C Class A standard.

The expected seasonal trend with higher temperatures in the warmer summer months is apparent for both Whatcom Creek and its tributaries (Figures 8.0-13, 8.0-13a). Average temperatures for 2010 are provided in Table 8.0-4. The percent of samples with temperatures higher than 18°C for Whatcom Creek and its tributaries for 2001 to 2010 are provided in Figures 8.0-14 and 8.0-14a.

Figure 8.0-11. Lincoln Creek sampling site.

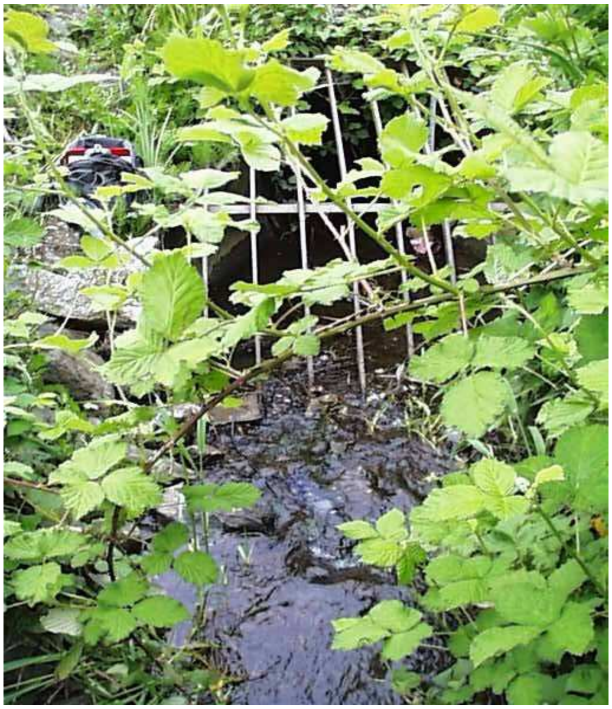


Figure 8.0-12. Fever Creek sampling site.

Table 8.0-4. Average temperatures for sampling sites on Whatcom Creek and tributaries, 2010.

Sampling Site	**C. Dam**	**Valencia**	**I-5**	**Dupont**	**Hanna**	**Cemetery**	**Lincoln**	**Fever**
Average Temperature (℃)	12.8	11.9	11.4	11.8	9.7	10.2	10.4	11.1

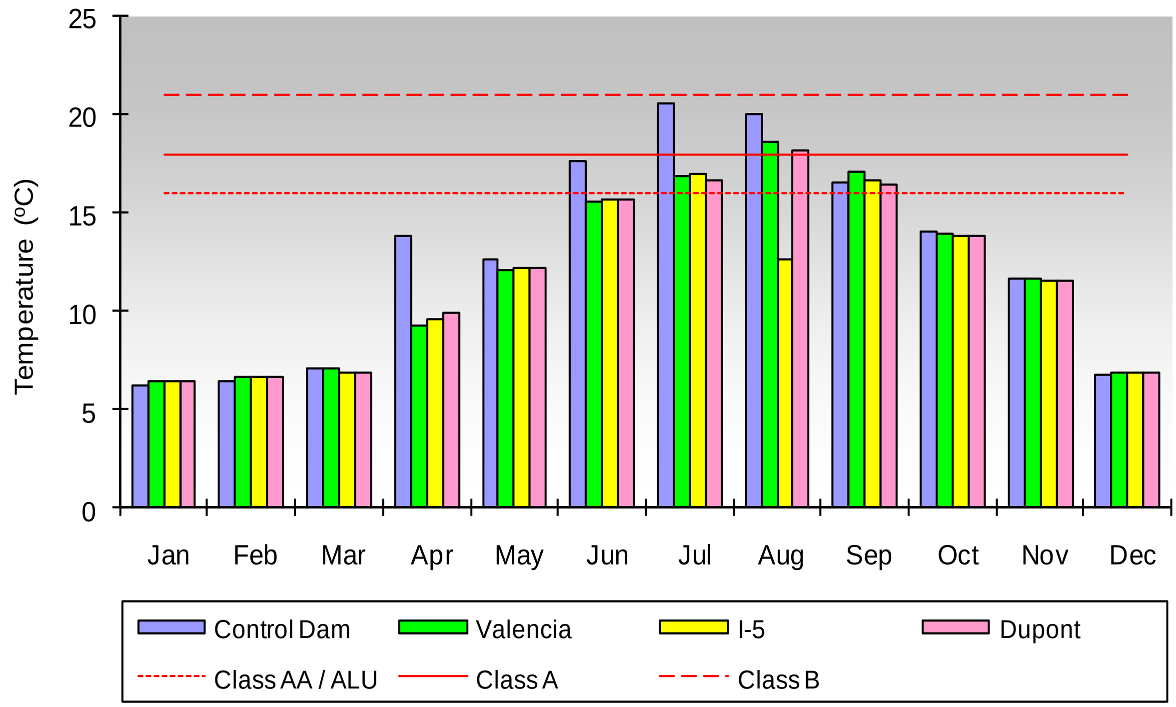


Figure 8.0-13. Monthly temperature measurements for Whatcom Creek sampling sites in 2010. Red lines indicate the highest temperatures allowed by the different surface water standards (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

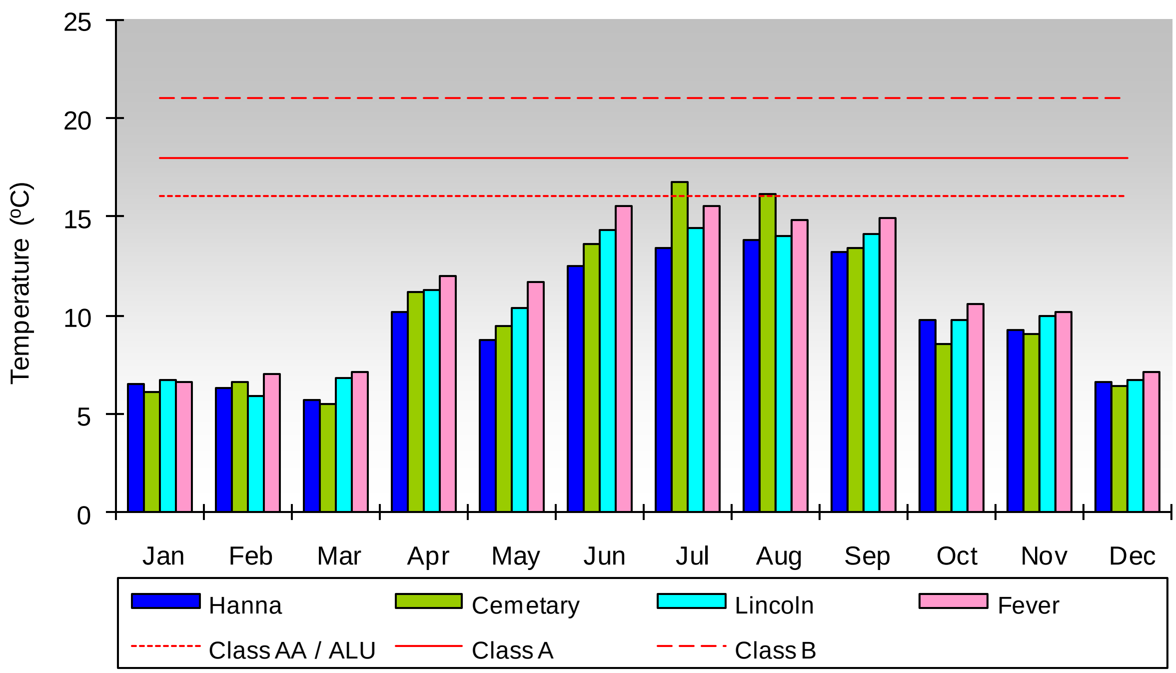


Figure 8.0-13a. Monthly temperature measurements for Whatcom Creek tributaries sampling sites in 2010. Red lines indicate the highest temperatures allowed by the different surface water standards (Class AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

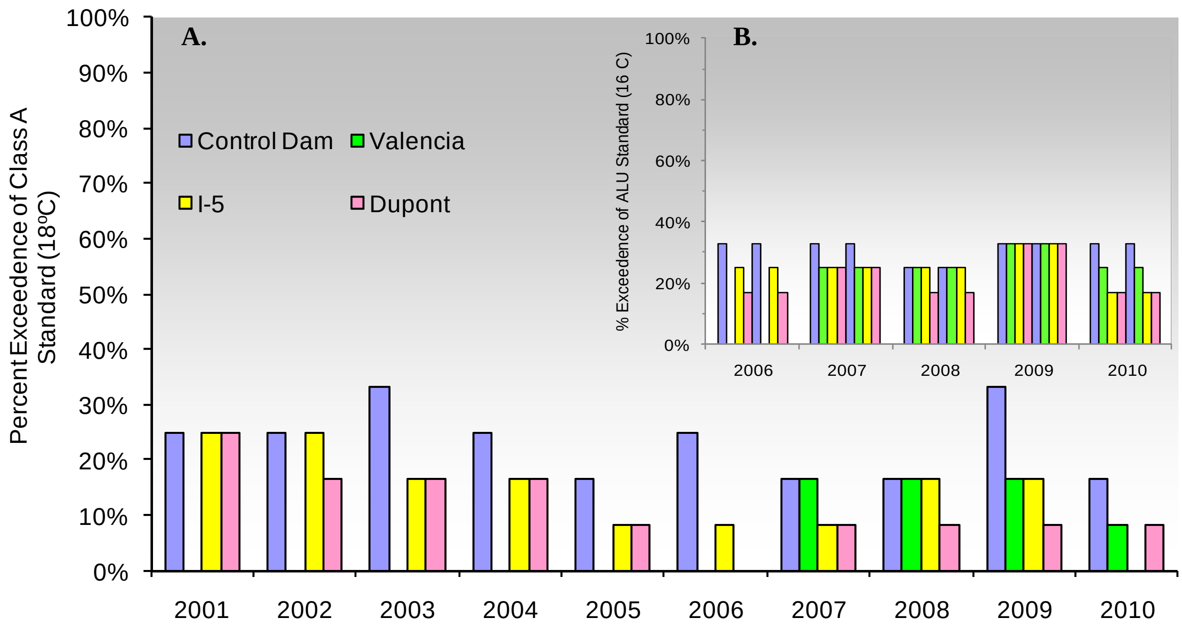


Figure 8.0-14. A. Percent of samples with temperatures in excess of the Class A standard (18℃) for Whatcom Creek sampling sites 2001 to 2010. B. Percent of temperature samples above the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (16℃) from 2006-2010. Sampling at Valencia began in 2007. Gaps represent a 0% exceedence rate.

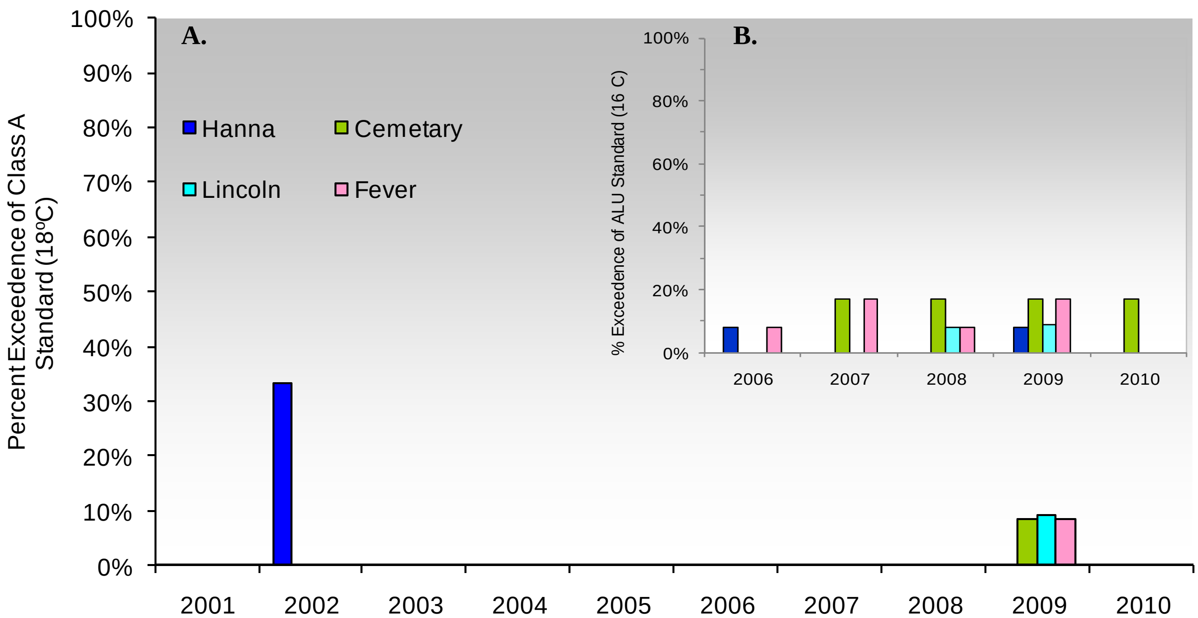


Figure 8.0-14a. A. Percent of samples with temperatures in excess of the Class A standard (18℃) for Whatcom Creek tributary sampling sites 2001 to 2010. B. Percent of temperature samples above the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (16℃) from 2006-2010. Hanna Creek was sampled 2002 to 2010 only. All other gaps represent a 0% exceedence rate.

pH

The pH at all sites monitored on Whatcom Creek and its tributaries generally fall within the range prescribed by Ecology for all classes of freshwater bodies, 6.5 to 8.5. During 2010 all Whatcom Creek and tributary sites were once again within this standard. Graphs are not included in this section because pH is so rarely exceeded.

Turbidity

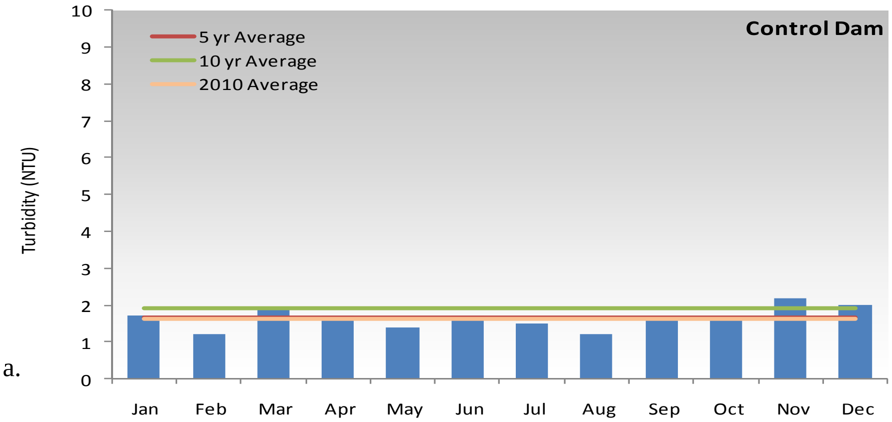
Turbidity in Whatcom Creek is usually lower than its tributaries. This trend continued in 2010. The average turbidities and their respective 5 and 10 year averages are provided in figures 8.0-15a-d and 8.0-16a-d. Maximum, minimum and average turbidity for all sampling sites in 2010 are provided in Table 8.0-5.

Ten year turbidity trends for Whatcom Creek and its' tributaries were all descending in 2010. Such trends are likely in part due to City lead restoration efforts. Average turbidities at the Control Dam, Valencia, I-5 and Dupont sites on Whatcom Creek decreased at rates of 0.04 NTU/Year, 0.61 NTU/Year, 0.22 NTU/Year and 0.24 NTU/Year respectively. Turbidities on the Whatcom Creek tributaries have decreased at rates of 0.18 NTU/Year, 0.66 NTU/Year, 0.54 NTU/Year and 0.65 NTU/Year for Hanna, Cemetery, Lincoln and Fever Creeks respectively.

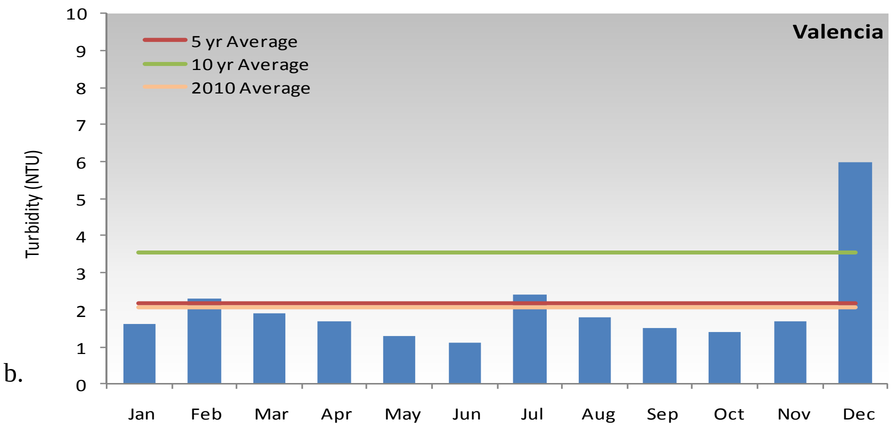
The source of higher than normal turbidity values found at Cemetery Creek during August of 2010 may be decreased flow during this period. Low water levels were observed in all tributaries in August. High turbidity values during March and December correlate with a rain.

Table 8.0-5. The average, maximum and minimum turbidity for sampling sites on Whatcom Creek and its tributaries in 2010.

Sampling Site	C. Dam	Valencia	I-5	Dupont	Hanna	Cemetery	Lincoln	Fever
2010 Average (NTU)	1.6	2.1	2.5	2.7	5.8	5.6	6.5	4.5
2010 Maximum (NTU)	2.2	6.0	6.3	7.1	11.6	14.5	19.4	12.7
2010 Minimum (NTU)	1.2	1.1	1.4	1.4	3.4	2.6	2.0	2.3



a.



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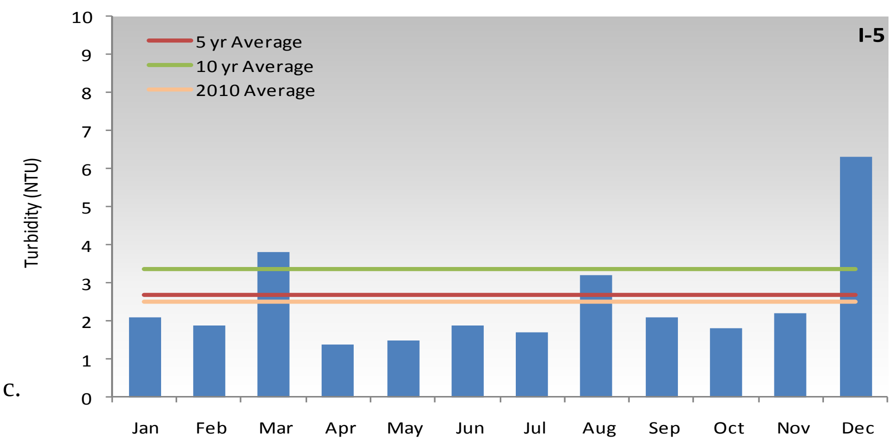

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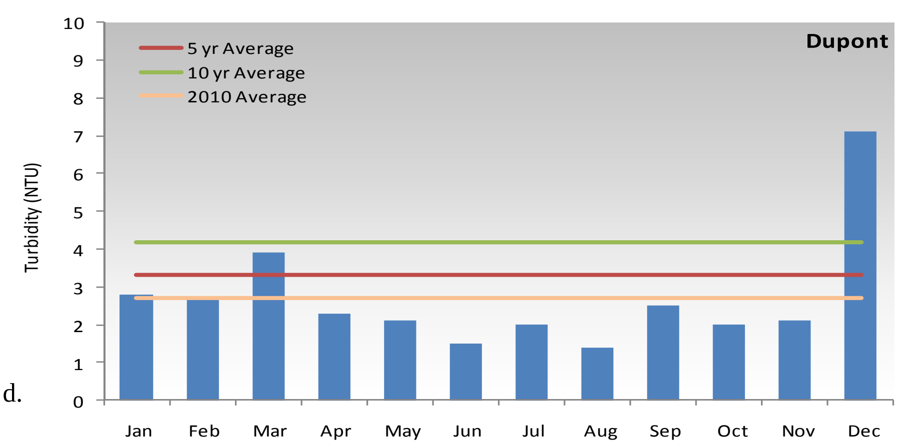
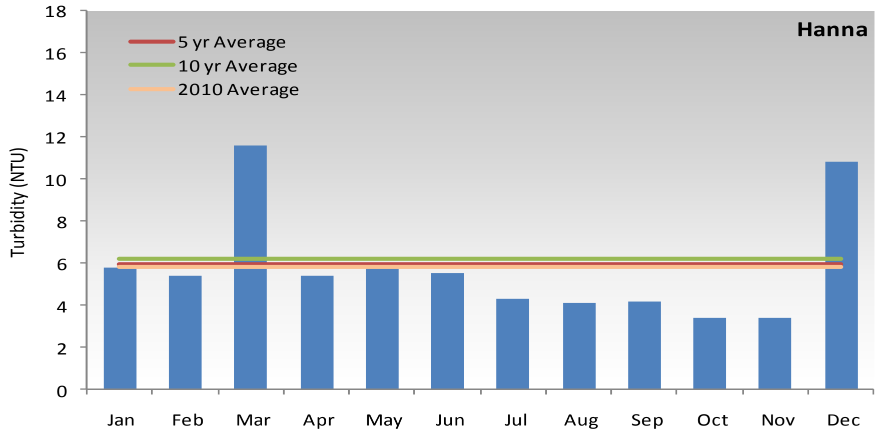


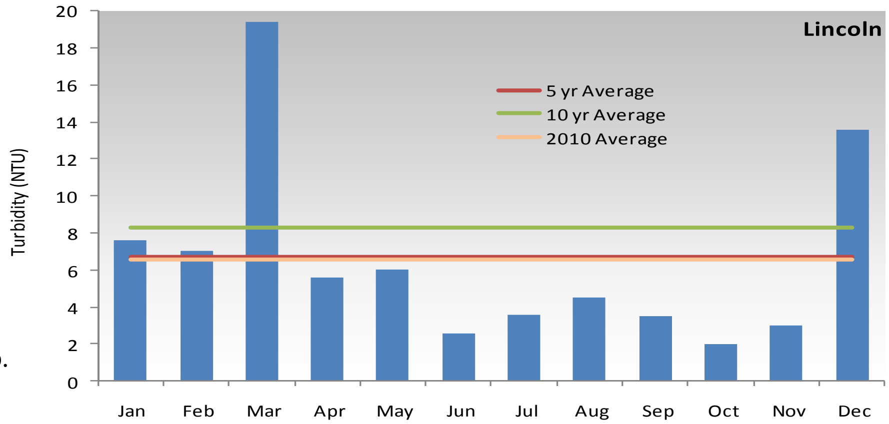
d.

Figures 8.0-15a-d. Monthly turbidity values for Whatcom Creek Sampling sites in 2010. Presented with yearly, 5-year and 10-year averages.

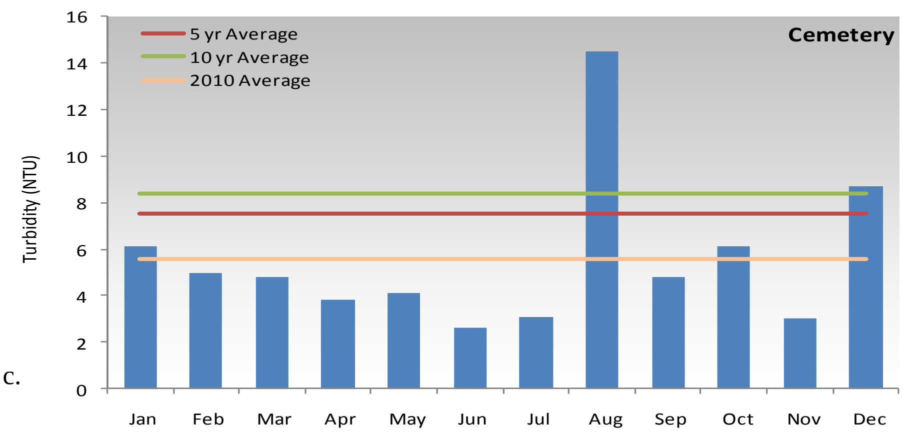
a.



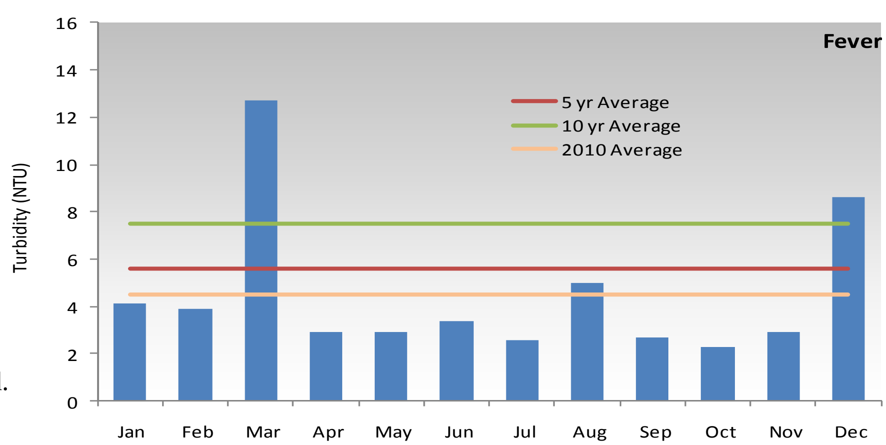
b.



c.



d.



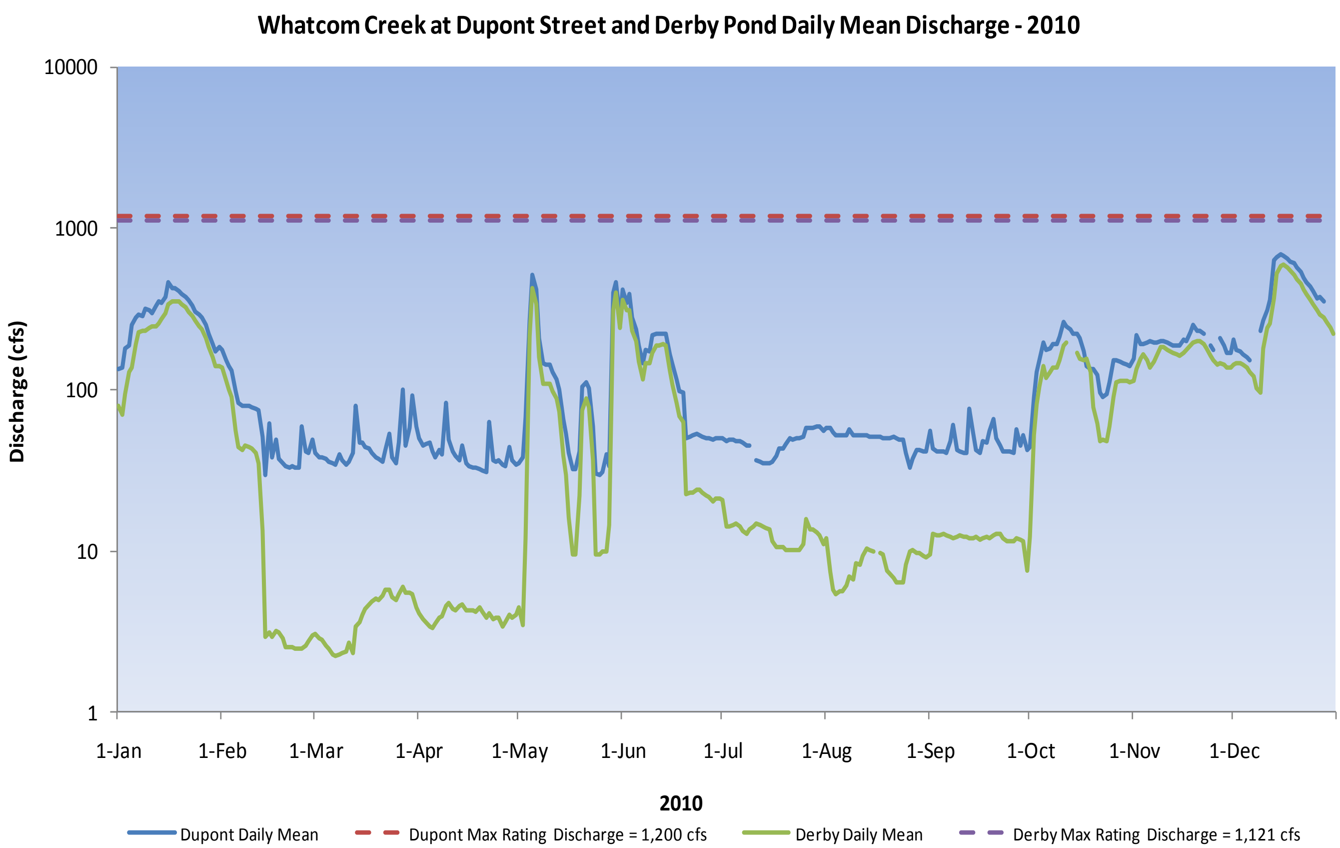
Figures 8.0-16a-d. Monthly turbidity values for Whatcom Creek tributaries in 2010. Presented with yearly, 5-year and 10-year averages.

Hydrology

Being the largest urban stream to flow through Bellingham, two gauging stations were established on Whatcom Creek in 2001. One is located in Whatcom Falls Park on the bank of Derby (Fish) Pond and the other above Dupont Street near the Mouth. Differences between the hydrographs of the two sites can be explained by a combination of two primary factors: control dam operation and the influence of Whatcom Creek's tributaries. Operation of the control dam is easily seen in Derby Pond data as precipitous drops or climbs, while it is moderated by the influence of tributaries at the Dupont St. site. Different bathymetric properties (gradual vs. steep banks) at the two sites also has a slight effect on signal moderation.

The Control Dam is operated as part of the City's Lake Whatcom level management strategy, which is determined by five primary factors: maximum surface elevation as required by law to protect lakeside properties, water availability for storage and treatment, drinking water demand by the citizens of Bellingham, flood control, and salmon habitat in Whatcom Creek. Changes in discharge due to Control Dam operation can be seen approximately 1/2 hour from time of operation at Derby Pond, and 3 to 4 hours later at Dupont St. depending on the amount of discharge. More information regarding Control Dam operation can be found here:http://www.cob.org/services/environment/lake-whatcom/lw-level.aspx

In 2010, Whatcom Creek at Derby Pond had a minimum discharge (flow) of 1.9 cubic feet per second (cfs) on multiple days in February and March, a maximum discharge of 608 cfs on December 15th and 16th, and an average discharge of 94.9 cfs. Whatcom Creek at Dupont St. on the other hand had a minimum discharge (flow) of 26.8 cfs on May 24th, a maximum discharge of 779 cfs on December 12th and an average discharge of 136 cfs.



9.0 Squalicum Creek Drainage Basin

Squalicum Creek runs almost 10 miles from Squalicum and Toad Lakes to Bellingham Bay and has a drainage area of approximately 15,800 acres (City of Bellingham, 1992). It flows through agricultural and wooded land as well as industrial, commercial, and residential areas. Channel modification including large culverts and channelization are present on Squalicum Creek.

Figure 9.0-1. Squalicum Creek mouth sampling

The major contributor to Squalicum Creek is Baker/Spring Creek (called here Baker Creek), which has a drainage area of approximately 3,150 acres (City of Bellingham, 1995). Baker Creek flows through agricultural, wooded, industrial, commercial, and residential areas.

Squalicum Creek is sampled at three locations: at E. Bakerview Rd. (Figure 9.0-2) near the intersection of Hannegan Rd. and E. Bakerview Rd., in Cornwall Park near Meridian St. (Figure 9.0-5), and the mouth (Figure 9.0-1), approximately 1200 feet upstream from its discharge point into Bellingham Bay (Squalicum Creek Drainage Map). Baker Creek (Figure 9.0-8), Squalicum Creek's major tributary, is sampled just upstream from its confluence with Squalicum Creek at Squalicum Pky. (Squalicum Creek Drainage Map). Table 9.0-1 shows the number of samples taken at each sampling location by year.

303d Listings and Enhanced Sampling

Based largely on historical grab sample data from the Urban Streams Monitoring Program (Mid-90's through early 2000's), several stream segments on Squalicum and Baker Creeks are included in Ecology's 303d list (Figure 9.0-1). In 2010, those reaches were chosen for enhanced sampling efforts. From May 1st until October 1st Baker Creek and the Meridian and Mouth sites on Squalicum Creek were sampled weekly for fecal coliform. In addition, the Squalicum Creek site at Meridian was continuously monitored (15 min data) for temperature and dissolved oxygen levels. The enhanced sam-

Table 9.0-1. Number of grab samples* taken per year for Squalicum and Baker Creeks from 2001 to 2010.

Sampling Site	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
E. Bakerview	8	12	12	12	12	12	12	12	12	12
Meridian	8	12	12	12	12	12	12	12	12	12*^
Baker Creek	8	12	12	12	12	12	12	12	12	12^
Mouth	8	12	12	12	12	12	12	12	12	12^

*Temperature, dissolved oxygen, turbidity, pH and conductivity continuously monitored during dry season (May 1 - Oct. 1). ^ Fecal coliform was sampled weekly during dry season (May 1 - Oct. 1).

pling parameters were chosen based on the 303d listings for those stream reaches in early 2010.

All sites in the Squalicum Creek drainage except the Meridian site met the Core Summer Salmonid Habitat Aquatic Life Use (ALU) criteria for temperature (≤16℃) and pH (6.5 to 8.5) in 2010. However, none of the sites met the ≥ 9.5 mg/L dissolved oxygen ALU measure. The Meridian site on Squalicum Creek was the only site to met Primary Contact Recreational Use standards for fecal coliform (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml). The Recreational Use standards are equivalent to a Class A rating.

Based on conventional sampling, the Meridian site on Squalicum Creek would have been the only site to meet overall Class A designation for 2010. However, when the results of enhanced sampling are considered, the Meridian site is lowered to the overall Class B standard. Squalicum Creek at E. Bakerview and Baker Creek also met the overall Class B standard. Squalicum Creek at the Mouth would have achieved the overall Class B

Figure 9.0-1. 303d listings of Squalicum Creek Drainage. Listed segments in red. City of Bellingham sample sites labeled in blue. Yellow shading indicates City limits. All of the listed segments are listed for excess fecal coliform bacteria. The segment containing the Meridian sampling site and the segment outside the City limits are also listed for temperature and dissolved oxygen. The segment below the E. Bakerview is listed for dissolved oxygen and fecal coliform.

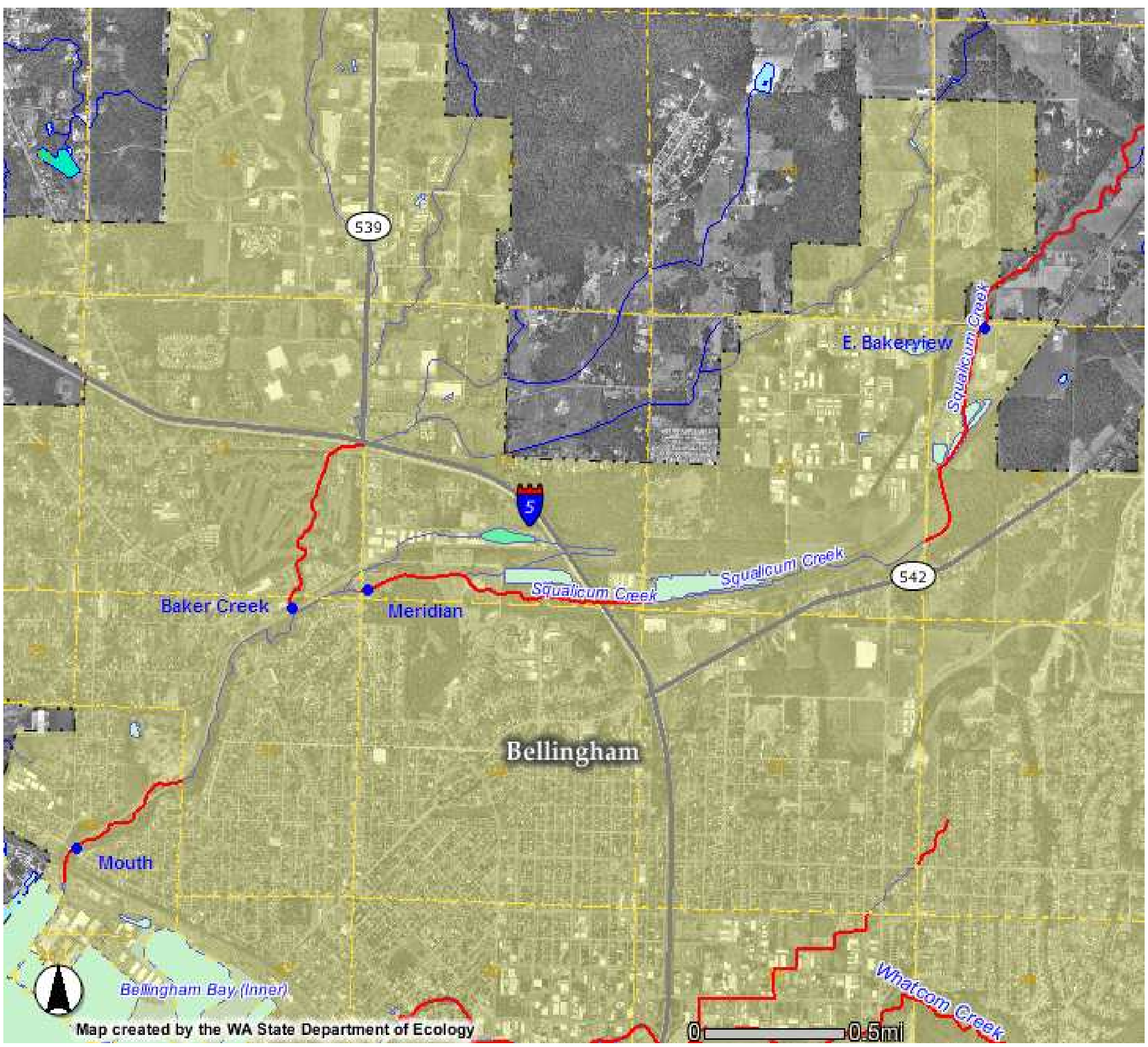


Figure 9.0-2. Squalicum Creek sampling site at E. Bakerview Rd.

standard, however, when enhanced fecal coliform sampling is considered the site failed to meet either overall Class A or Class B standards.

All sites also met the Class AA/ Class A/Class B standards for pH (6.5 to 8.5). Finally, all sites met the Class A standard for dissolved oxygen (≥ 8.0 mg/L).

Besides the E. Bakerview site, the average turbidites for Squalicum and Baker Creek sites in 2010 were lower than averages in 2009. The highest average turbidity on Squalicum Creek was 8.0 NTU at the Meridian site. The lowest average turbidity was 4.6 NTU on Baker Creek. Average turbidity values for 2010 are listed along side respective 5 and 10 year averages in Table 9.0-5. Conductivity was consistent with previous years.

Fecal Coliform Bacteria

Fecal coliform levels recorded during conventional sampling in 2010 were lower than values found in previous years (Figures 9.0-3, 9.0-4). However, results of enhanced sampling show higher fecal coliform geomeans at the Meridian, Mouth and Baker Creek sites than conventional sampling results indicate (Table 9.0-2). Squalicum Creek at Meridian was the only site to meet the Class A fecal coliform standard in 2010 (Class AA by conventional sampling). The E. Bakerview and the Baker Creek sites met the Class B standard, and while the Squalicum Creek Mouth site would have met the Class B standard by conventional sampling, it failed to meet Class A or Class B standards because of enhanced sampling.

Enhanced Fecal Coliform Sampling

Enhanced sampling for fecal coliform was conducted in the Squalicum Creek Drainage from May 1 through October 1, 2010. Samples were taken on a weekly basis during that period. Results of enhanced sampling suggest that fecal coliform levels in Squalicum and Baker Creeks are higher than determined by monthly conventional sampling (Table 9.0-2).

Based on enhanced sampling results, the 303d listings for fecal coliform at Baker Creek and Squalicum Creek at the Mouth were substantiated in 2010. However, the Squalicum Creek site at Meridian was able to meet the Recreational Use/ Class A standard, and therefore would not have been listed based on 2010 data.

It should be noted that the geomeans listed in table 9.0-2 for Baker Creek and Squalicum Creek at the mouth

Table 9.0-2. Conventional sampling (CS) and enhanced sampling (ES) fecal coliform geomean values for monitoring sites on Squalicum and Baker Creek in 2010.

Sampling Site	E. Bakerview	Meridian	Baker Creek	Mouth
CS Geomean (CFU/100ml)	38	19	70	71
ES Geomean (CFU/100ml)	“	45	113	155

were elevated by a abnormally high fecal coliform levels at the two sites on 8/5/2010 (Figure 9.0-5). The recorded values of 29,000 CFU/100 ml at Baker Creek and 143,000 CFU/100 ml at the Squalicum Creek Mouth are indicative of raw sewage entering the waterways, yet no sewage spills or overflows were reported in the creek's drainages during that time. Samples taken a few days later showed fecal coliform levels had returned to similar levels as before the incident (80 and 560 CFU/100 ml, respectively). Therefore, it is presumed that the fecal coliform spike was a one time event and likely the result of an illicit discharge. When the fecal coliform values from 8/5/10 are removed from consideration when calculating the yearly geomeans, the Baker Creek geomean is 92 CFU/100 ml and the Squalicum Mouth geomean is 121 CFU/100 ml.

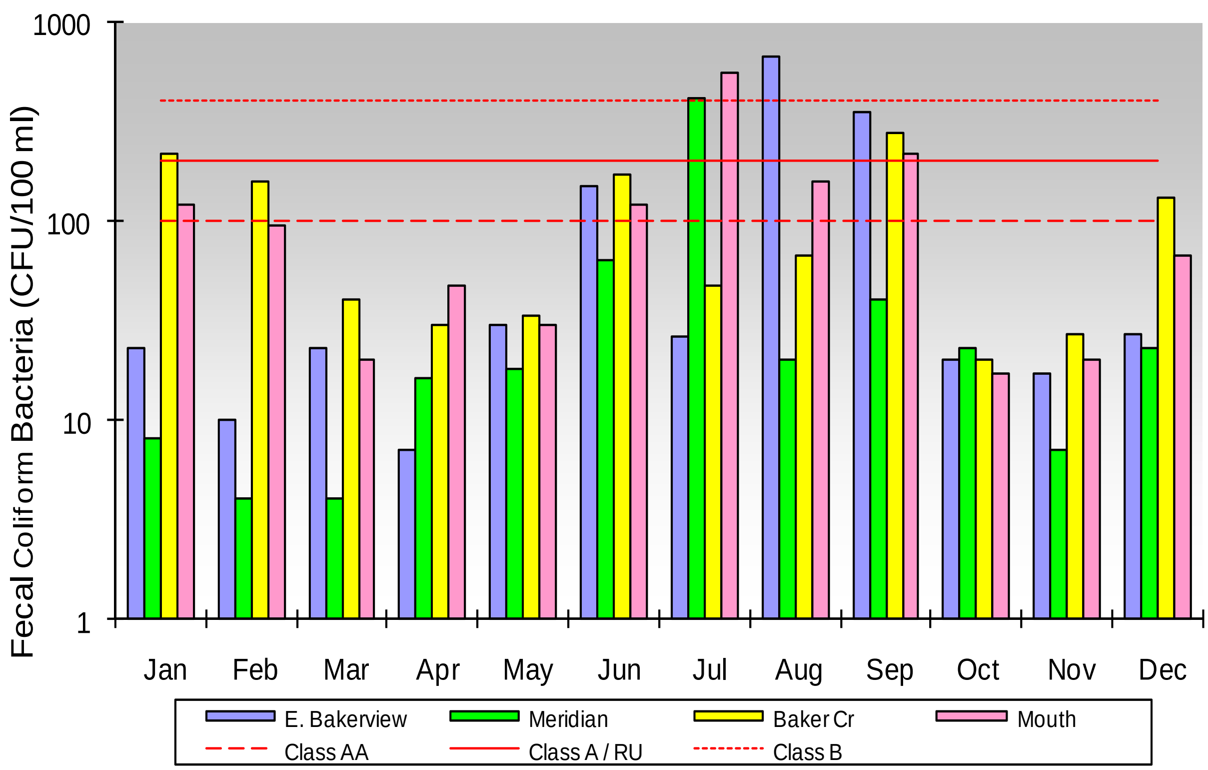


Figure 9.0-3. Monthly 2010 fecal coliform levels for sampling sites on Squalicum and Baker Creeks. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. *Note this graph uses a logarithmic scale.* Based on conventional sampling.

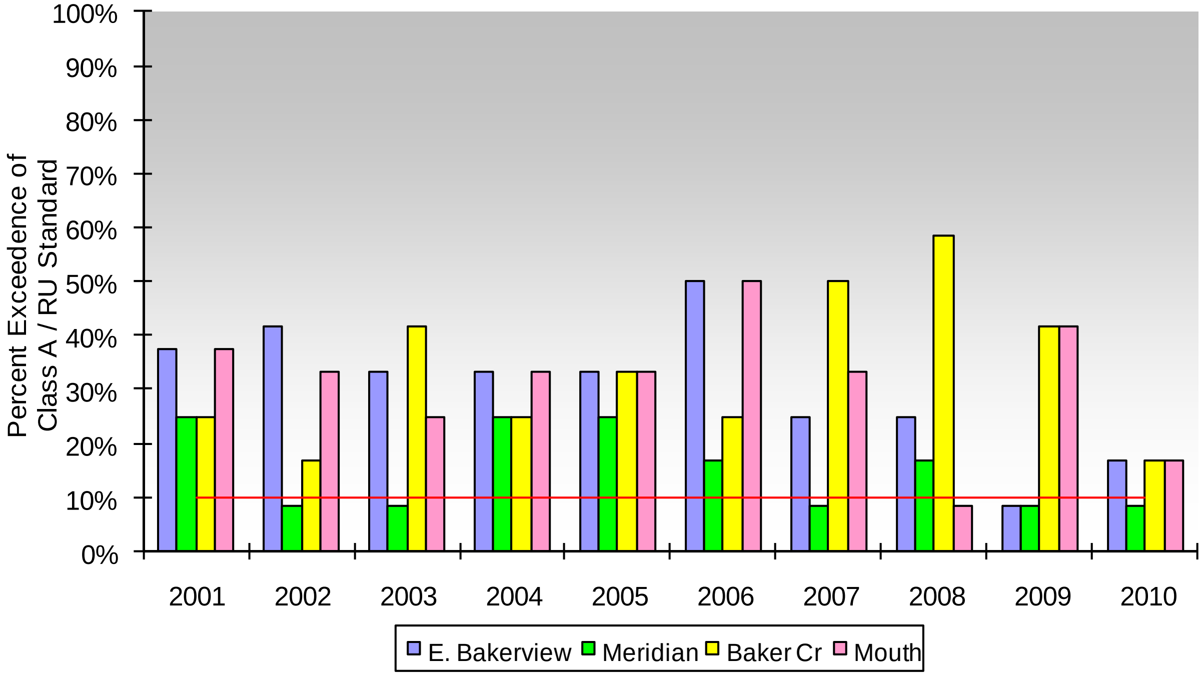


Figure 9.0-4 Percent exceedence of the Class A / RU standard for fecal coliform bacteria by year for Squalicum and Baker Creek sampling sites, 2001 to 2010. Gaps represent a 0% exceedence rate. Based on conventional sampling.

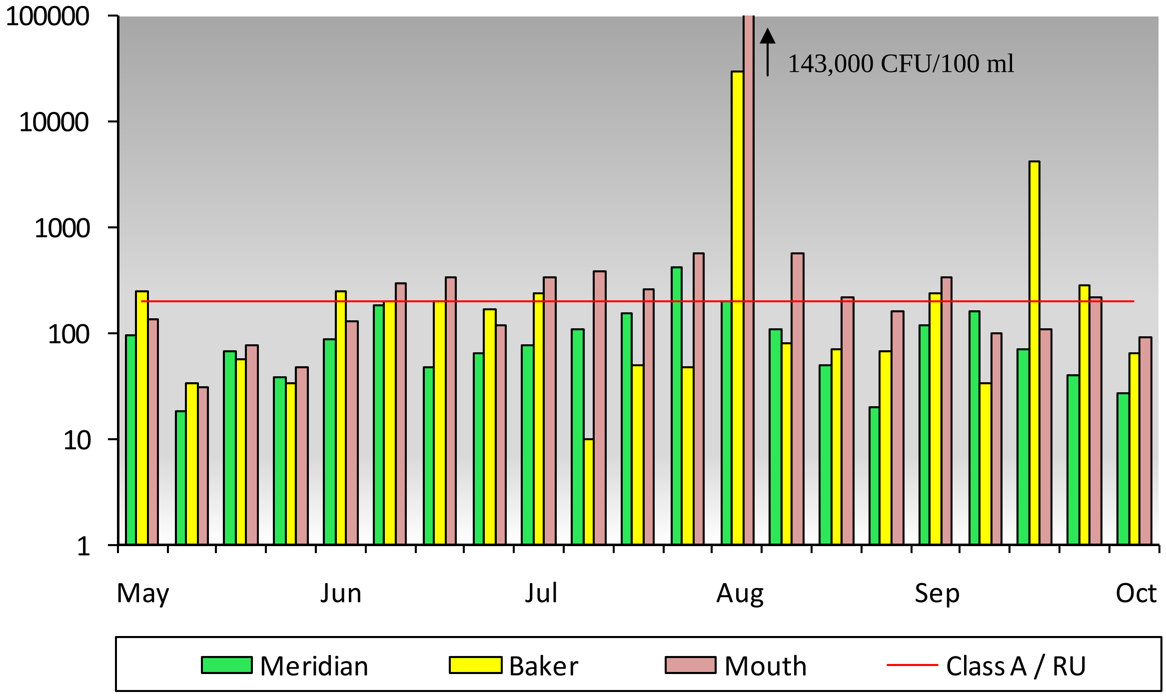


Figure 9.0-5. Fecal coliform levels during enhanced sampling May - October 2010. Extreme values on 8/5/10 are thought to be the result of illicit discharge in the area.

Dissolved Oxygen

None of the stream segments in the Squalicum Creek drainage met the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard in 2010. At ≥9.5 mg/L, the ALU is equivalent to Class AA. Results of enhanced monitoring at the Meridian site show that 7DADMIN dissolved oxygen levels fell below the 9.5 mg/L ALU 92 times between May 1 and October 1, substantiating the 303d listing for that reach.

Despite these results, all Squalicum Creek and Baker Creek sites did meet the Class A standard for dissolved oxygen (≥ 8.0 mg/L) in 2010. The only instance of a site falling below 8.0 mg/L was the E. Bakerview site during August (Figure 9.0-6). The E. Bakerview sampling site has frequently experienced low dissolved oxygen levels during the summer months in previous years, most likely due to low flows and warmer temperatures (Figure 9.0-7). Dissolved oxygen in all creek segments sampled in 2010 followed an expected trend of lower values in the warmer summer months (Figure 9.0-6). Average dissolved oxygen values are shown in Table 9.0-3.

Figure 9.0-5. Squalicum Creek sampling site at Meridian St.

Table 9.0-3. Average dissolved oxygen values for Squalicum and Baker Creek in 2010. Based on conventional sampling.

Sampling Site	**E. Bakerview**	**Meridian**	**Baker Creek**	**Mouth**
Average DO (mg/L)	10.4	10.0	10.3	10.7

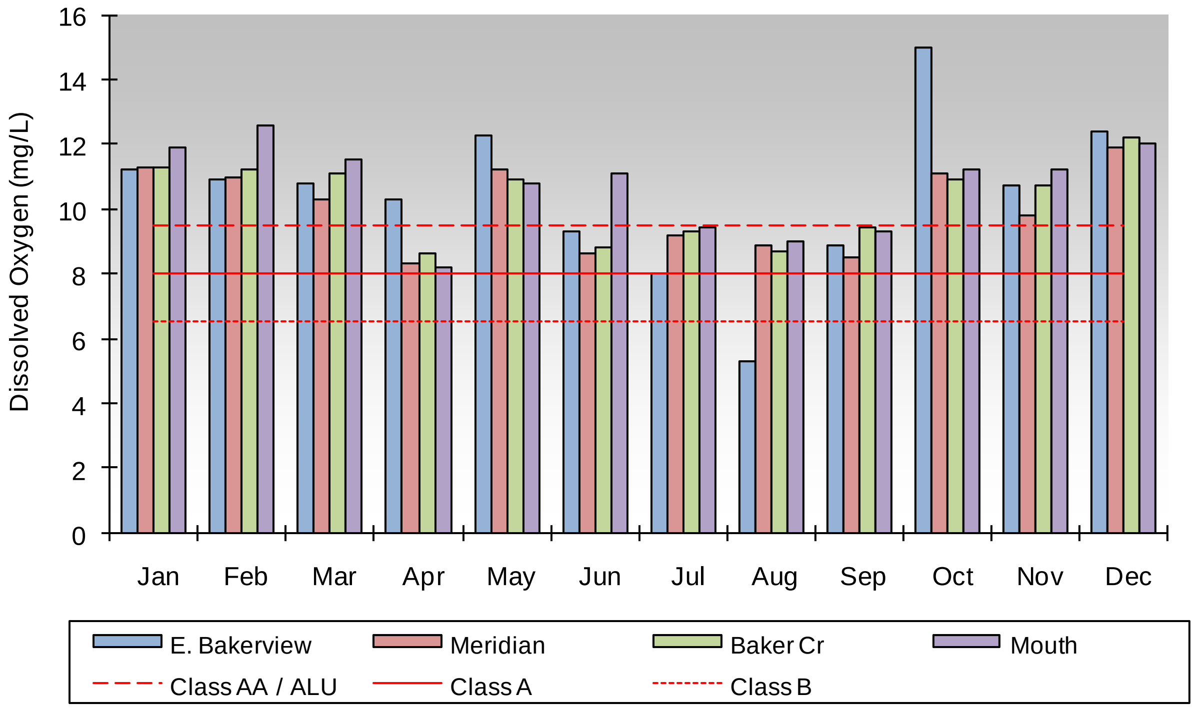


Figure 9.0-6. Monthly 2010 dissolved oxygen levels for Squalicum and Baker Creek sampling sites. Red lines the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA. Based on conventional sampling.

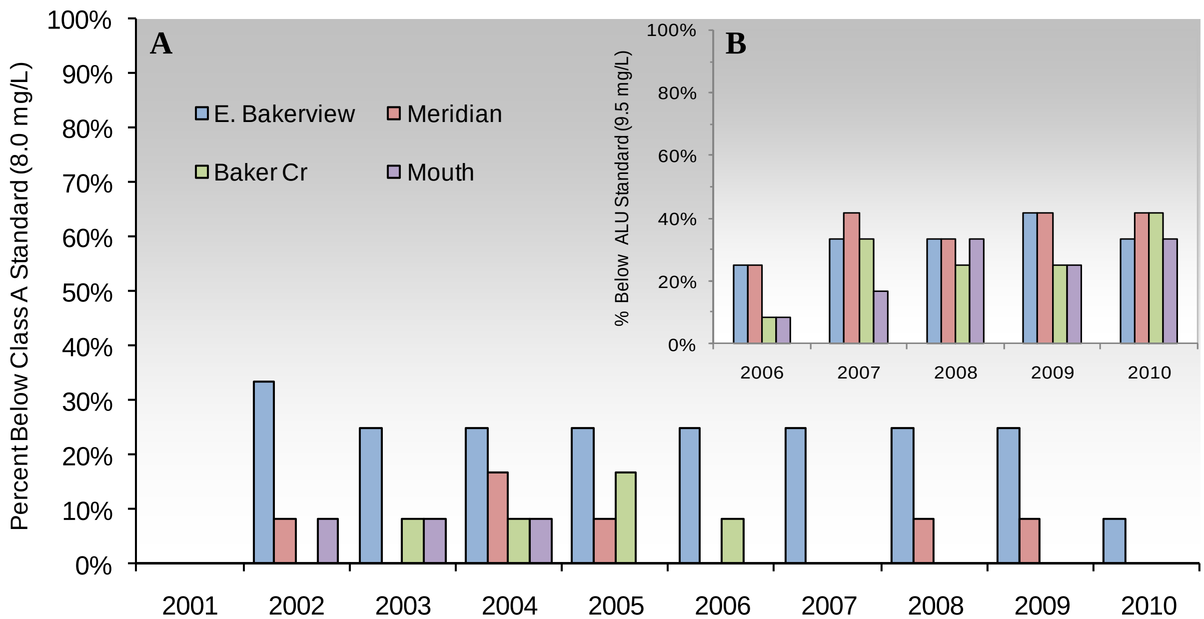


Figure 9.0-7. A. Percent of samples with dissolved oxygen levels below the Class A standard (8.0 mg/L) at Squalicum and Baker Creek sampling sites 2001 to 2010. B. Percent of dissolved oxygen samples below the Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation (9.5 mg/L) from 2006-2010. Gaps represent a 0% rate of samples with dissolved oxygen values below standards. Based on conventional sampling.

Temperature

Temperatures in Squalicum and Baker Creeks remained below the stringent 16℃ Core Summer Salmonid Habitat Aquatic Life Use (ALU) designation for all but the Meridian St. site in 2010. The Core Summer Salmonid Habitat ALU is equivalent to the Class AA rating. Based on Enhanced sampling, the 7DADMAX for the Meridian St. site exceeded the 16℃ ALU 73 times during 2010, substantiating it's 303d listing.

Based on conventional sampling, the Meridian St. site did obtain the Class A (18°C) designation. However, when results of enhanced sampling are considered the site is demoted to Class B based on 7 instances of the 7DADMAX exceeding the 18°C criteria. Prior to 2010, the 18°C Class A standard had not been exceeded in these creeks since 1998. The percent of samples exceeding the 16℃ ALU designation from 2006 to 2010 are presented in Figure 9.0-10.

The expected seasonal trend of higher temperatures in the warmer summer months, lower temperatures in the winter months is apparent for the 2010 data (Figure 9.0-9). Average temperatures for 2010 are provided in Table 9.0-4.

Table 9.0-4. Average temperatures for sampling sites on Squalicum and Baker Creeks, 2010. Based on conventional sampling.

Sampling Site	E. Bakerview	Meridian	Baker Creek	Mouth
Average Temperature (℃)	9.9	11.4	10.2	11.0

Figure 9.0-8. Baker Creek sampling site.

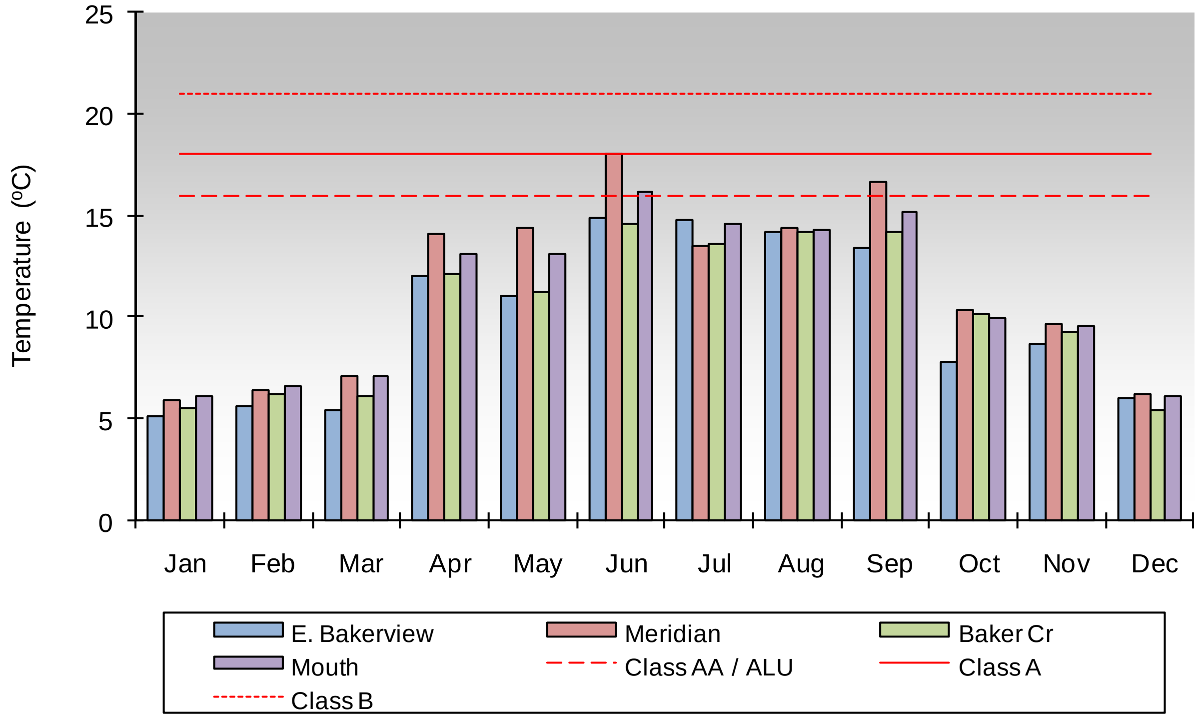


Figure 9.0-9. Monthly temperature measurements for Squalicum and Baker Creek sampling sites in 2010. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA. Based on conventional sampling.

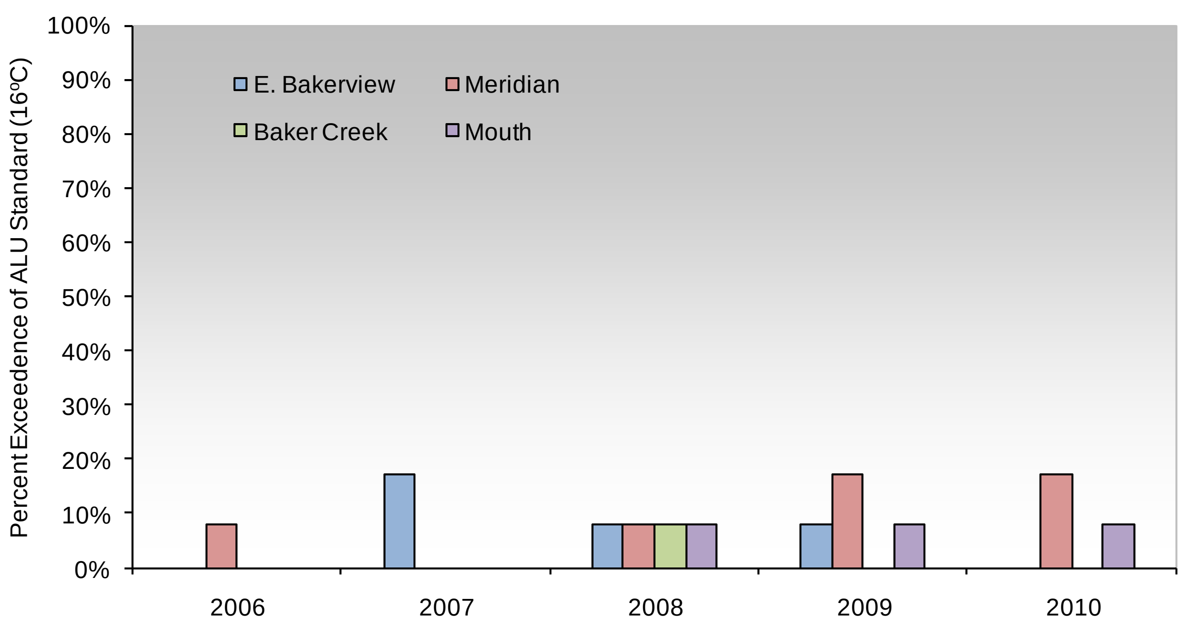


Figure 9.0-10. Percent of samples with temperatures in excess of the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard (16℃) for Squalicu m and Baker Creek sampling sites 2006 to 2010. Results of conventional sampling indicate there have been no exceedences of the 18°C Class A standard since 1998. Gaps represent a 0% exceedence rate.

pH

The pH at sites monitored on Squalicum and Baker Creeks generally fall within the range prescribed by Ecology for all classes of freshwater bodies, 6.5 to 8.5. During 2010 all Squalicum and Baker Creek sites were once again within this standard. Graphs are not included in this section because pH is so rarely exceeded.

Turbidity

With the exception of the E. Bakerview site, the average turbidities of the sampling sites on Squalicum and Baker Creeks were lower than averages in 2009. The average turbidities for all sites in 2010 were below there respective 5-year and 10-year averages (Figures 9.0-11 a-d). The Squalicum Creek site at Meridian was the only site to show increasing 10-year turbidity trends of 0.29 NTU/Year. Squalicum Creek at E. Bakerview, the Mouth and Baker Creek had decreasing 10-year turbidity trends at 0.62 NTU/Year, 0.01 NTU/Year, and 0.23 NTU/Year respectively.

In 2010 the turbidity levels in Squalicum and Baker Creeks show the typical trend of lower values in the drier months and higher values during the wet season (Figures 9.0-11 a-d). High values in December correlate with rainfall. Average, maximum and minimum turbidity values for 2010 is provided in Table 9.0-5.

Table 9.0-5. The average, maximum and minimum turbidity values for Squalicum and Baker Creek sampling sites in 2010 .

Sampling Site	E. Bakerview	Meridian	Baker	Mouth
2010 Average (NTU)	7.2	8.0	4.6	6.0
2010 Maximum (NTU)	26.9	32.8	13.7	27.5
2010 Minimum (NTU)	1.3	2.3	0.9	0.8

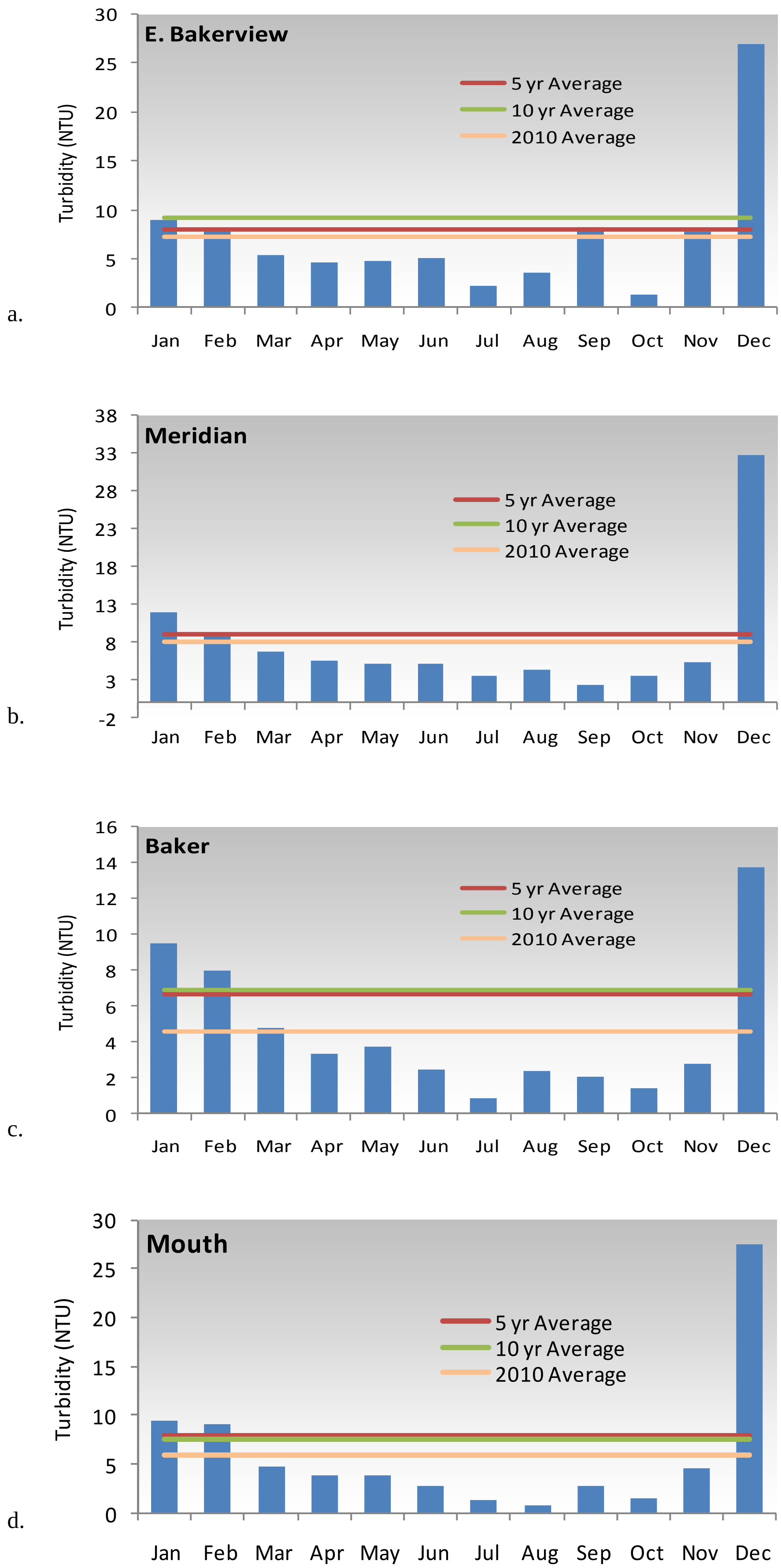


Figure 9.0-11a-d. Monthly turbidity values for Squalicum and Baker Creeks in 2010. Presented with yearly, 5-year and 10-year averages.

Hydrology

The Squalicum Creek gauging station has been in service since 2005. It is located approximately 100 feet upstream West Street off of Squalicum Parkway.

Squalicum Creek typically has a higher volume of discharge than Padden or Chuckanut Creeks. In January, February and December of 2010 peak flow due to rain events were observed to be as high as those of Whatcom Creek at Dupont St. and on December 12th they exceeded measurements at Dupont St. However, the duration of high flows in Squalicum Creek is noticeably less than that of Whatcom Creek, as is the average discharge.

In 2010, Squalicum Creek had a minimum discharge (flow) of 0.33 cubic feet per second (cfs) on August 24th and 25th, a maximum discharge of 1380 cfs on December 12th and an average discharge of 32 cfs.

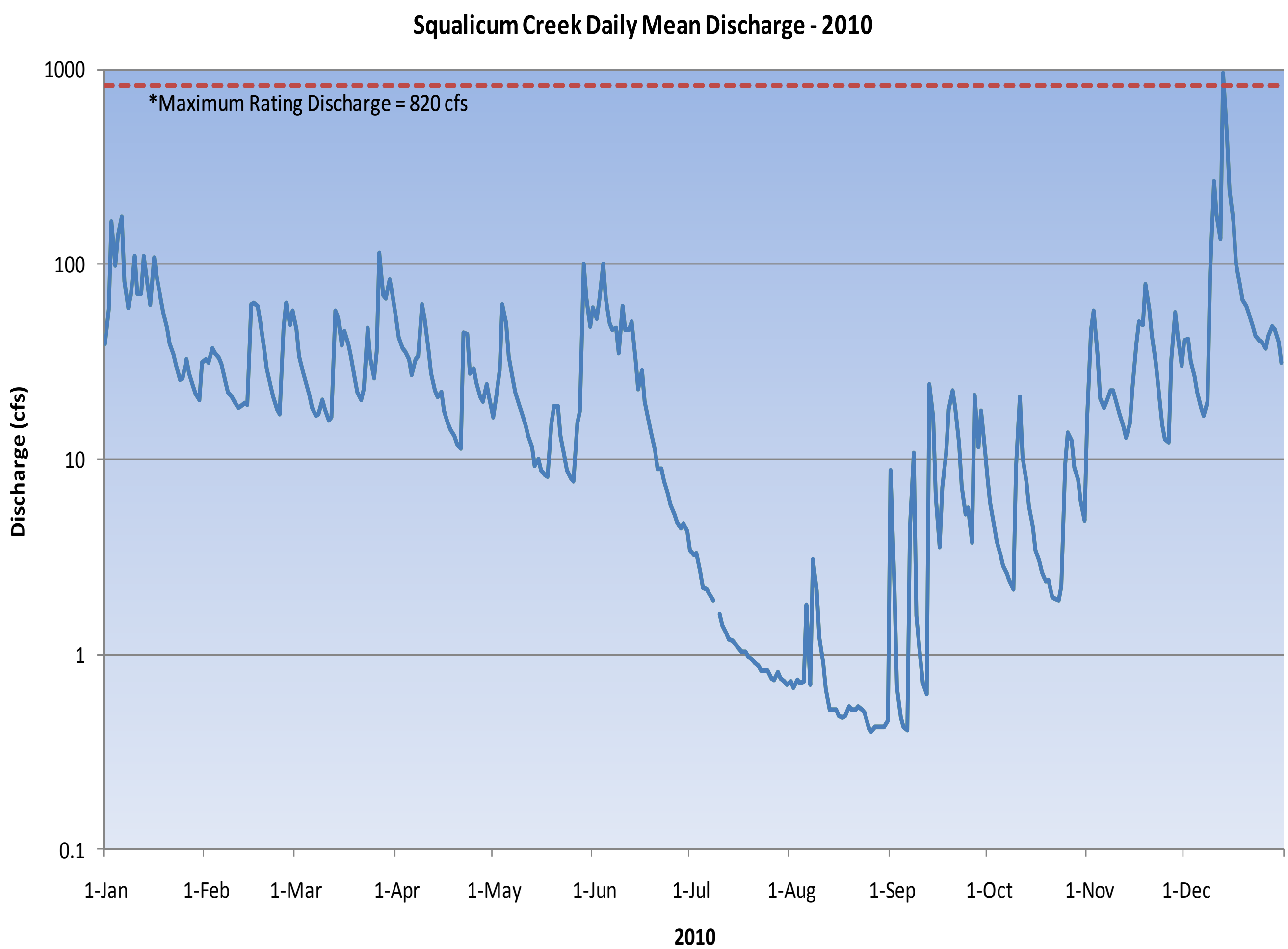


Figure 9.0-12. Daily mean discharge on Chuckanut Creek during 2010. Discharge values above the maximum rating discharge of 820 cfs are of poor quality and should be interpreted cautiously. This hydrograph uses a logarithmic scale.

10.0 Silver Creek Drainage Basin

Silver Creek is a largely rural creek with a drainage basin of approximately 10,240 acres (Whatcom County Council of Governments, 1989). The eastern portion of the creek flows through gently rolling hills and contains several wetlands and small ponds. The lower two miles of Silver Creek is considered a yazoo tributary of the Nooksack River. A yazoo tributary is a tributary that is prevented from joining the main river because of levees, thus flow is parallel to the main channel.

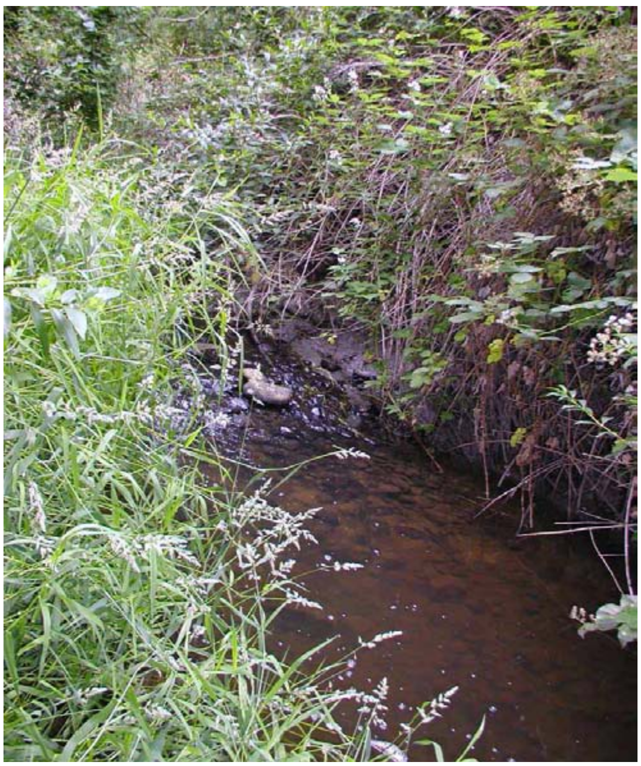


Figure 10.0-1. Silver Creek sampling site at Graveline Road.

Silver Creek is sampled at one location upstream from the yazoo portion of the creek at Graveline Road (Figure 10.0-1). Sampling began at this site in 2004. The Graveline Rd. site is characterized by wooded areas and farmland. Table 10.0-1 shows the number of samples taken at the Graveline Road site from 2004 to 2010. Sampling at two previous sites on Silver Creek was suspended in recent years because the sites failed to provide results representative of the creek system.

In 2010, only the temperature (≤16.0° C) and pH (6.5 - 8.5) designated use criteria were met for Silver Creek. Silver Creek also failed to achieve overall Class A designation, as was the case for previous years. Dissolved oxygen in this segment met Class A levels of ≥ 8.0 mg/L, temperatures remained below the stringent ≤16.0℃ Class AA/ALU standard, and pH was also maintained at Class AA/A/B levels (6.5 to 8.5). However, the stream segment failed to meet Class A / Primary Contact Recreational Use standards for fecal coliform bacteria. The geomean value was higher than 100 CFU/100 ml and more than 10% of the samples had values in excess of 200 CFU/100 ml. Silver Creek also failed to meet Class B standards for fecal coliforms.

The average turbidity of 5.8 NTU for Silver Creek in 2010 was below the respective 5 year and 10 year averages. The 10-year trend is also decreasing at 0.32 NTU/Year. Conductivity was consistent with previous years.

Table 10.0-1. Number of samples taken per year for Silver Creek from 2004 to 2010.

2004	2005	2006	2007	2008	2009	2010
12	12	12	12	12	12	11

Fecal Coliform Bacteria

The number of fecal coliforms found at the Graveline Rd. site in 2010 were higher than the numbers found in 2009 (Figure 10.0-2, 10.0-3). Fecal Coliform levels have far exceeded Primary Contact Recreational Use and Class A standards (geomean ≤100 CFU/100 ml; no more than 10% of samples >200 CFU/100 ml) for all years sampled. The high levels of Fecal Coliform present at this site is likely due to the many pasture fields in the area. The bacteria levels show the expected trend of higher values in the summer months possibly as warmer temperatures allow extended survival or growth of bacteria populations. The geomean value for the site in 2010 was 324 CFU/100ml.

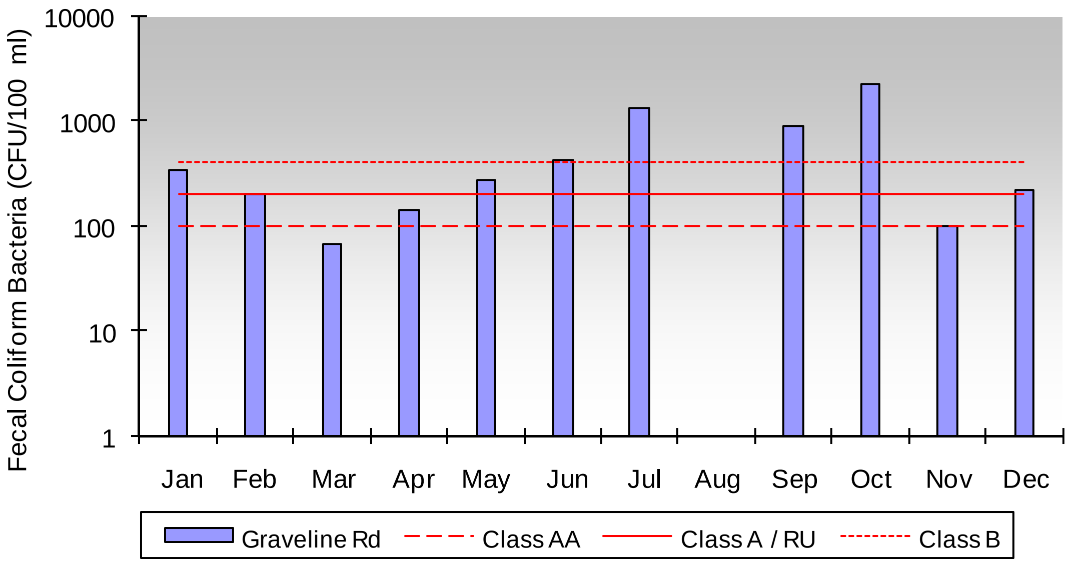


Figure 10.0-2. Monthly 2010 fecal coliform levels for Silver Creek. Red lines indicate the numeric criteria for the calculated geomean for the different surface water classes (AA, A, and B). The Primary Contact Recreational Use (RU) designation is equivalent to Class A. No sample was collected in August of 2010. *Note this graph uses a logarithmic scale.*

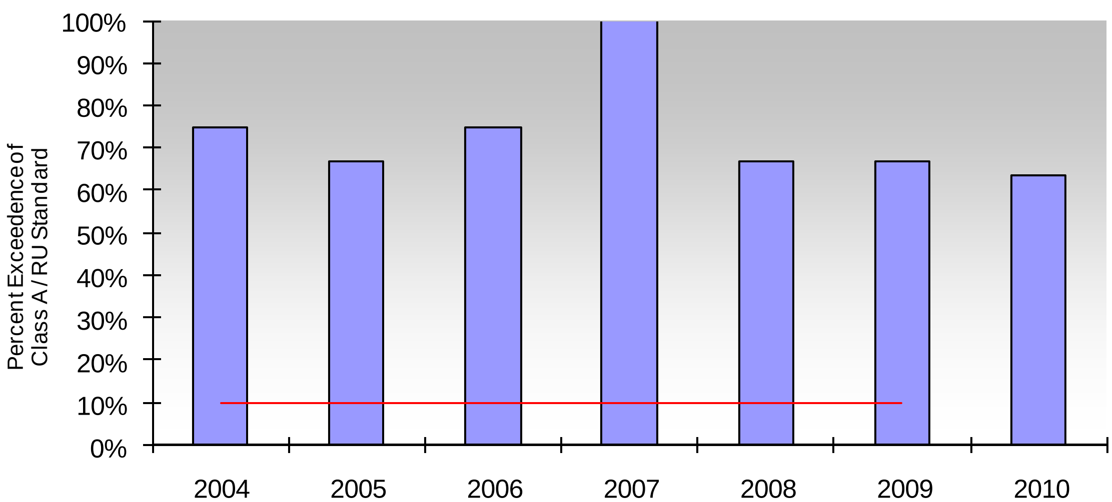


Figure 10.0-3. Percent exceedence of the Class A / RU standard for fecal coliform bacteria by year for Silver Creek, 2004 to 2010.

Dissolved Oxygen

Dissolved oxygen levels in Silver Creek for 2010 fluctuated between 8.5 and 12.8 mg/L, but did not overtly display the normal trend of lower values in the summer months associated with rising temperatures (Figure 10.0-4). Silver Creek was not able to meet the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard of ≥9.5 mg/L, however, levels above 8.0 mg/L (Class A) were maintained throughout the year (Figures 10.0-4 & 10.0-5). The average dissolved oxygen for Silver Creek was 11.2 mg/L.

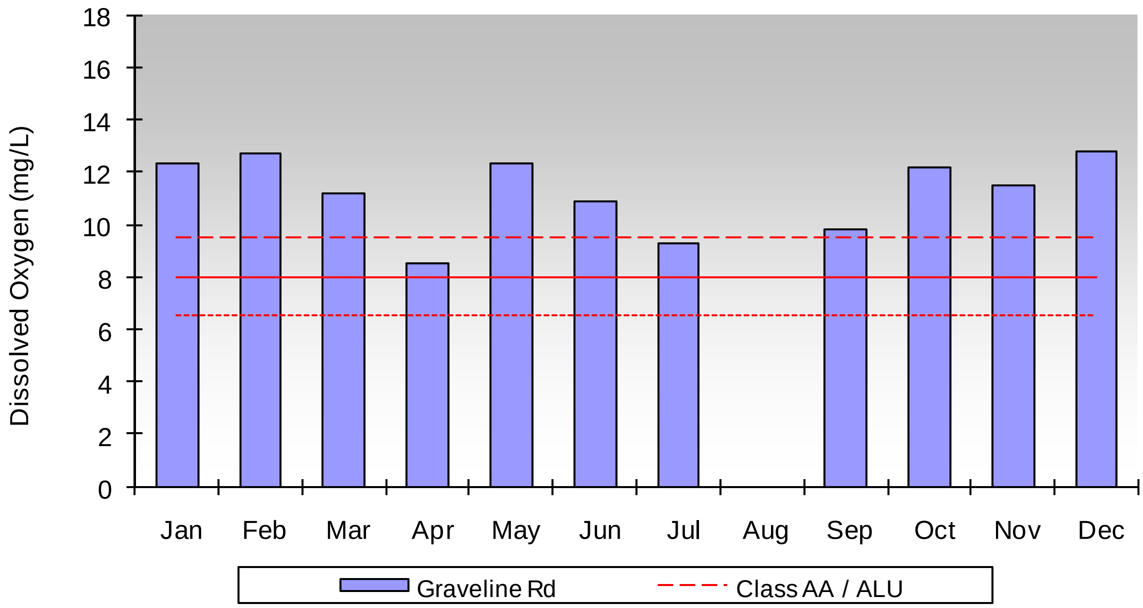


Figure 10.0-4. Monthly 2010 dissolved oxygen levels for Silver Creek at Graveline Rd. Red lines indicate the lowest dissolved oxygen levels allowed by the different surface water classes (AA, A, and B). The Core Summer Salmonid Habitat Aquatic Life Use (ALU) is equivalent to Class AA.

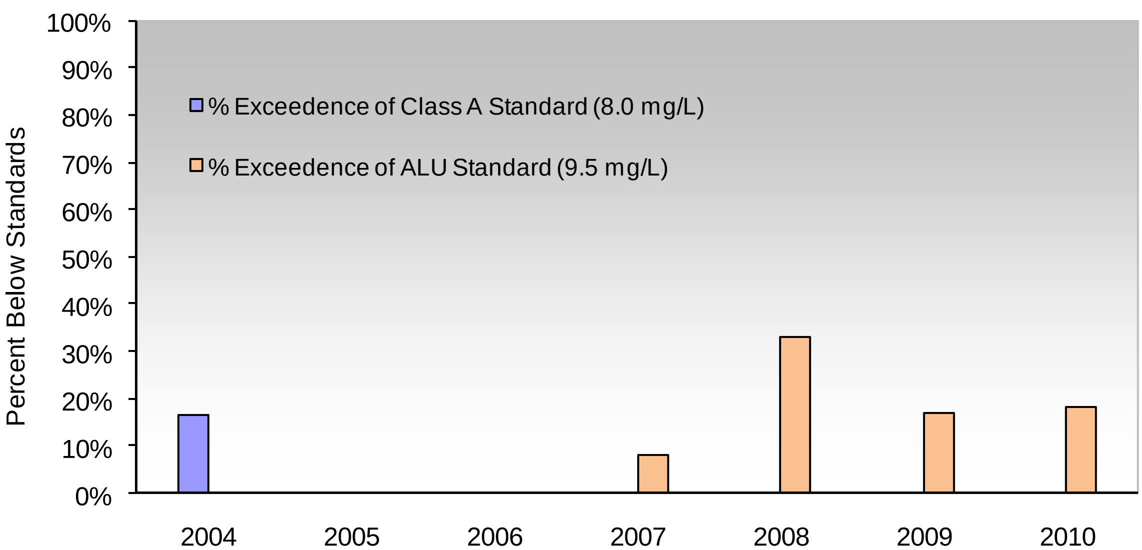


Figure 10.0-5. Percent of dissolved oxygen samples below the Class A standard (8.0 mg/L) for the Silver Creek sampling site 2004 to 2010 and below the Core Summer Salmonid Habitat Aquatic Life Use (ALU, 9.5 mg/L) since implementation in 2006.

Temperature

Since sampling began at the Graveline Rd. site in 2004, temperatures in Silver Creek have remained below the 18°C Class A standard. Most years it has also been below the Class AA / Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard. This trend continued in 2010, when Silver Creek met the 16°C Core Summer Salmonid Habitat ALU and Class AA standard.

The average temperature for Silver Creek in 2010 was 10.0 °C and the temperature profile follows a typical trend of higher values in the warmer months (Figure 10.0-6).

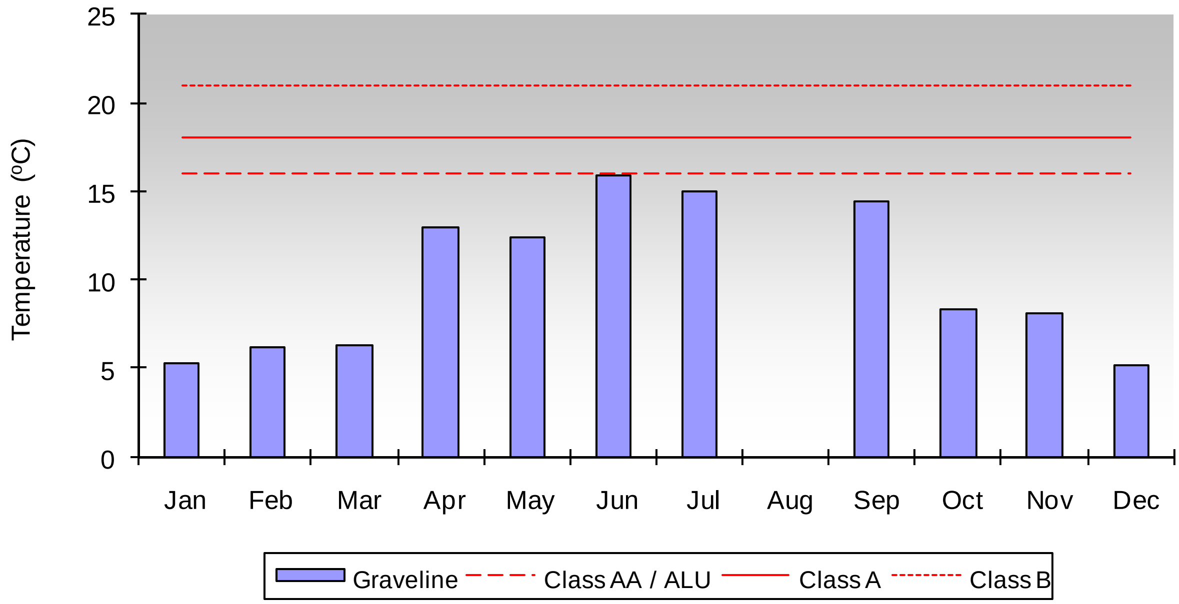


Figure 10.0-6. Monthly temperature measurements for Silver Creek in 2010. Red lines indicate the highest temperatures allowed by the different surface water standards (AA, A, and B). The Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard is equivalent to Class AA. Sampling was not possible during August 2010.

Figure 10.0-7. Percent of samples with temperatures in excess of the Core Summer Salmonid Habitat Aquatic Life Use (ALU) standard (16°C) for Silver C reek sampling sites 2006 to 2010. There have been no exceedences of the 18°C Class A standard since sampling began in 2004. Gaps represent 0% exceedence.

Turbidity

The average turbidity for Silver Creek in 2010 was 5.8 NTU, well below the 5 and 10 year averages. The maximum turbidity of 13.0 NTU was recorded in December and correlates with a rain event. The minimum turbidity of 2.0 NTU was recorded in October (Figure 10.0-7). The 10-year average turbidity trend for Silver Creek was decreasing by 0.32 NTU/Year in 2010.

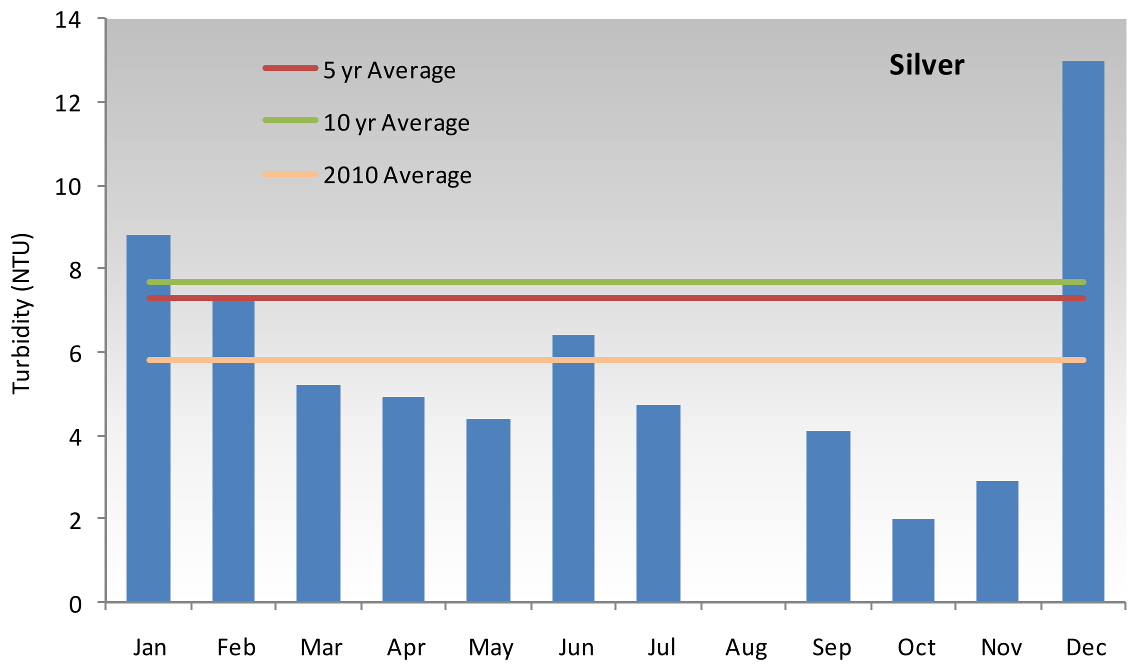


Figure 10.0-7. Monthly turbidity values for Silver Creek in 2010. Presented with the yearly, 5-year and 10-year averages.

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Appendix A.

Detail on selected stream restoration projects within the City of Bellingham. LWD = Large Woody Debris

Creek	Location	Project	Year
Padden	24th St.	Installation of fish friendly culvert	1996
Padden	24th St. to 30th St.	Riparian planting and restoration	2003 on
Padden	24th St. to 30th St.	Placement of LWD Recontour banks Reconnect to historic flood plain Add spawning gravel Create overflow channel	2008/ 2009
Padden	Fairhaven Park	Riparian planting and restoration Move trail away from stream bank	2005/ 2006
Padden	Fairhaven Park	Placement of LWD Recontour banks Reconnect to historic flood plain Add spawning gravel	2008/ 2009
Padden	12th St.	Culvert Improvements: Replace baffles Structures to prevent fish from becoming trapped during high flows	2004
Connelly	Donovan Ave.	Installation of fish passable culvert	2004
Whatcom	Marine Heritage Park	Riparian planting and restoration	1995
Whatcom	Whatcom Falls Park to Mouth	Riparian planting and restoration (some small sections not yet planted)	2000 on
Whatcom	North of Cemetery Creek, East of Racine St.	Salmon Park: Placement of LWD Create backwater swales and a side channel: velocity refuge for fish Breached a constructed berm to reconnect to historic flood plain, creating more natural stream flow	2006
Whatcom	City owned property north of Haskell Business Park	Red Tail Reach: Similar projects to Salmon Park	2007/ 2008
Whatcom	Young St. & Commercial	Culvert Improvements: Replace baffles Work on upstream end to improve fish movement	2004
Cemetery	City owned property east of Haskell Business Park, north of Fraser St.	New creek channel created to mimic an undisturbed stream system Placement of LWD Recontour banks Create three large ponds—velocity refuge and overwintering habitat for juvenile fish	2006
Cemetery	Upstream of confluence with Whatcom Creek	Create Backwater swale—velocity refuge for fish Reconnect to historic flood plain	2006

Creek	Location	Project	Year
Lincoln	Maple St.	Installation of fish friendly culvert	1991
Lincoln	Moore St.	Installation of fish friendly culvert	1998
Squalicum	Meridian St.	Installation of fish friendly culvert	1996/1997
Squalicum	Meridian St. to Mouth	Riparian planting and restoration	2005 on
Squalicum	West St. to Mouth	Lower Squalicum Bank Protection Project: Log jams Log crib wall Root wads Create overflow channel	2005
Squalicum	Squalicum Pkwy.	Retrofit all Culverts: Fish friendly Install baffles Create upstream/downstream pools - fish resting areas	2005
Squalicum	Birchwood Ave. & Squalicum Pkwy	Retrofit culvert to force water from subsurface flow during low flow periods into pipe	2004
Baker	Birchwood Ave.	Installation of fish friendly culvert	1996
Baker	Telegraph Rd.	Riparian planting and restoration Create backwater swale—velocity refuge Recontour banks Reconnect to historic flood plain	2006
Baker	Telegraph Rd.	Installation of fish friendly culvert	2004
Willow Spring (Squalicum)	Squalicum Park	Daylight Placement of LWD Riparian planting and restoration Recontour banks	2010

Appendix B

Quality Control Protocol

Test	Fecal Coliform	Dissolved Oxygen	Temperature	pH	Turbidity	Conductivity
Holding Time	Within 8 hrs	*In situ* analysis	*In situ* analysis	*In situ* analysis	Usually done within 8 hr. Up to 24 hr.	*In situ* analysis
Method	SM 9222 D.	SM 4500-O G.	SM 2550 B.	SM 4500-H^+ B.	SM 2130 B.	SM 2510 B.
Instrumentation		Hydrolab Quanta	Hydrolab Quanta	Hydrolab Quanta	Benchtop Turbidimeter	Hydrolab Quanta
Calibration		Barametric pressure calibration in air.	Factory -set. Annually calibrated against an NIST-traceable thermometer.	Buffers: pH 7.00 and 10.00.	Calibrate with primary standards—1, 10, 100, 1000 NTU standards.	Conductivity standard obtained from an external source. Cell coefficient should be 0.475 +/- 1%, if not, investigate.
Check Standard or Calibration Check		Calibration check-test one sample by Quanta (STM 4500-O G.) and one by Winkler Method (STM 4500-O C). Both samples from same sample site.		Check standard obtained from an external source. Test before and after run.	Calibration check – primary or secondary standard in the range of interest.	In-house conductivity standard, prepared quarterly. Test before and after run.
QC Objectives	Verification of 10% of samples and adjustment of counts based on verification results. Investigate if natural log of lab or field duplicates are different by more than ± 2 δ of calculated control limits.	Investigate if calibration check is different by 0.5 mg/L or more or if field duplicates are different by more than ± 2 δ of calculated control limits.	Add or subtract correction factor as necessary. Investigate if field duplicates are different more than ± 2 δ of calculated control limits.	Investigate if check standard is different by 0.2 pH units or more or if field duplicates are different by more than ± 2 δ of calculated control limits.	Investigate if lab or field duplicates are different by more than ± 2 δ of calculated control limits.	Investigate if check standard are different by more than 10% or if field duplicates are different by more than ± 2 δ of calculated control limits.

Appendix C. Exceedence Frequency Tables

Table C-1. Frequency of Class A surface water standard exceedences for fecal coliform bacteria. Class A surface water standards state that no more than 10% of samples used to calculate the geomean may exceed 200 cfu/100 ml. Shaded cells indicate the number of exceedences, unshaded cells indicate the number of samples per year.

SAMPLING SITE	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	1	8	2	12	5	12	4	12	3	12	2	12	2	12	2	12	3	12	1	12	25	116	22%
Padden (38th)	1	8	0	12	2	12	2	12	1	12	0	12	0	12	2	12	1	12	1	12	10	116	9%
Padden (30th)	0	8	1	12	4	12	4	12	4	12	3	12	3	12	2	12	2	12	2	12	25	116	22%
Connelly (Donovan)	6	8	8	12	5	12	9	12	6	12	7	12	6	12	5	12	4	12	2	12	58	116	50%
Padden (22nd)									7	12	6	12	7	12	3	12	4	12	2	12	29	72	40%
Padden (mouth)	6	8	6	12	6	12	6	12	5	12	7	12	5	12	2	12	6	12	5	12	54	116	47%
Whatcom (Control Dam)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	116	0%
Hanna (Below WTP)			1	9	2	10	4	12	2	10	4	11	2	12	3	12	2	12	1	12	21	100	21%
Cemetery (Whatcom)	5	8	6	12	5	12	5	12	7	12	7	12	4	12	3	12	3	12	2	12	47	116	41%
Lincoln (Fraser)	5	8	6	12	6	12	3	12	3	12	5	12	2	12	3	12	6	12	2	12	41	116	35%
Fever (Valencia)	3	8	5	12	3	12	7	11	5	12	10	12	6	12	6	12	7	12	7	12	59	115	51%
Whatcom (Valencia)											0	4	0	12	0	12	1	12	0	12	1	52	2%
Whatcom (I-5)	1	8	1	12	1	12	2	12	2	12	1	12	0	12	1	12	2	12	0	12	11	116	9%
Whatcom (Dupont)	4	8	2	12	3	12	5	12	4	12	3	12	2	12	2	12	5	12	1	12	31	116	27%
Squalicum (E Bakerview)	3	8	5	12	4	12	4	12	4	12	6	12	3	12	3	12	1	12	2	12	35	116	30%
Squalicum (Meridian)	2	8	1	12	1	12	3	12	3	12	2	12	1	12	2	12	1	12	1	12	17	116	15%
Baker (Squalicum)	2	8	2	12	5	12	3	12	4	12	3	12	6	12	7	12	5	12	2	12	39	116	34%
Squalicum (mouth)	3	8	4	12	3	12	4	12	4	12	6	12	4	12	1	12	5	12	2	12	36	116	31%
Silver (Graveline Rd)							9	12	8	12	9	12	12	12	8	12	8	12	7	11	61	83	73%

Table C-2. Frequency of Class A surface water standard exceedences for dissolved oxygen. Class A surface waters must maintain dissolved oxygen levels of 8.0 mg/L or greater. Shaded cells indicate the number of exceedences, unshaded cells indicate the number of samples per year.

SAMPLING SITE	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	0	8	0	12	1	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	116	1%
Padden (38th)	0	8	0	12	0	12	1	12	0	12	0	12	0	12	1	12	1	12	0	12	3	116	3%
Padden (30th)	0	8	0	12	1	12	1	12	0	12	0	12	0	12	0	12	0	12	0	12	2	116	2%
Connelly (Donovan)	1	8	0	12	1	12	1	12	0	12	0	12	0	12	0	12	1	12	0	12	4	116	3%
Padden (22nd)									0	12	0	12	0	12	0	12	0	12	0	12	0	72	0%
Padden (mouth)	0	8	0	12	0	12	2	12	0	12	0	12	0	12	0	12	2	12	0	12	4	116	3%
Whatcom (Control Dam)	1	8	0	12	1	12	2	12	0	12	0	12	0	12	0	12	2	12	0	12	6	116	5%
Hanna (Below WTP)			1	9	0	10	1	12	0	10	0	11	0	12	0	12	0	12	0	12	2	100	2%
Cemetery (Whatcom)	2	8	5	12	3	12	3	12	3	12	0	12	4	12	3	12	4	12	2	12	29	116	25%
Lincoln (Fraser)	0	8	4	12	2	12	2	12	2	12	0	12	1	12	3	12	2	12	2	12	18	116	16%
Fever (Valencia)	0	8	0	12	0	12	1	11	1	12	0	12	0	12	1	12	1	12	0	12	4	115	3%
Whatcom (Valencia)											0	4	0	12	0	12	0	12	0	12	0	52	0%
Whatcom (I-5)	0	8	0	12	0	12	1	12	0	12	0	12	0	12	0	12	0	12	0	12	1	116	1%
Whatcom (Dupont)	0	8	0	12	0	12	2	12	1	12	0	12	0	12	2	12	2	12	0	12	7	116	6%
Squalicum (E Bakerview)	0	8	4	12	3	12	3	12	3	12	3	12	3	12	3	12	3	12	1	12	26	116	22%
Squalicum (Meridian)	0	8	1	12	0	12	2	12	1	12	0	12	0	12	1	12	1	12	0	12	6	116	5%
Baker (Squalicum)	0	8	0	12	1	12	1	12	2	12	1	12	0	12	0	12	0	12	0	12	5	116	4%
Squalicum (mouth)	0	8	1	12	1	12	1	12	0	12	0	12	0	12	0	12	0	12	0	12	3	116	3%
Silver (Graveline Rd)							2	12	0	12	0	12	0	12	0	12	0	12	0	11	2	83	2%

Table C-3. Frequency of Class A surface water standard exceedences for temperature. Class A surface waters must maintain temperature ≤ 18℃. Shaded cells indicate the number of exceed ences, unshaded cells indicate the number of samples per year.

SAMPLING SITE	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		Ttl	Ttl	Percent Exceedence
Chuckanut (mouth)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	0	12	1	116	1%
Padden (38th)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	1	116	1%
Padden (30th)	0	8	0	12	1	12	0	12	0	12	0	12	0	12	0	12	1	12	0	12	2	116	2%
Connelly (Donovan)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	0	12	1	116	1%
Padden (22nd)									0	12	0	12	0	12	0	12	1	12	0	12	1	72	1%
Padden (mouth)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	0	12	1	116	1%
Whatcom (Control Dam)	2	8	3	12	4	12	3	12	2	12	3	12	2	12	2	12	4	12	2	12	27	116	23%
Hanna (Below WTP)			3	9	0	10	0	12	0	10	0	11	0	12	0	12	0	12	0	12	3	100	3%
Cemetery (Whatcom)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	0	12	1	116	1%
Lincoln (Fraser)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	0	12	1	116	1%
Fever (Valencia)	0	8	0	12	0	12	0	11	0	12	0	12	0	12	0	12	1	12	0	12	1	115	1%
Whatcom (Valencia)											0	4	2	12	2	12	2	12	1	12	7	52	13%
Whatcom (I-5)	2	8	3	12	2	12	2	12	1	12	1	12	1	12	2	12	2	12	0	12	16	116	14%
Whatcom (Dupont)	2	8	2	12	2	12	2	12	1	12	0	12	1	12	1	12	1	12	1	12	13	116	11%
Squalicum (E Bakerview)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	0	12	1	116	1%
Squalicum (Meridian)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	1	12	0	12	1	116	1%
Baker (Squalicum)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	116	0%
Squalicum (mouth)	0	8	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	12	0	116	0%
Silver (Graveline Rd)							0	12	0	12	0	12	0	12	0	12	1	12	0	11	1	83	1%

Table C-4. Frequency of Class A surface water standard exceedences for pH. Class A surface waters must maintain pH levels between 6.5 and 8.5. Shaded cells indicate the number of exceedences, unshaded cells indicate the number of samples per year.

SAMPLING SITE	2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		Ttl Viol	Ttl Samp	Percent Exceedence
Chuckanut (mouth)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Padden (38th)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Padden (30th)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Connelly (Donovan)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Padden (22nd)									0	11	0	12	0	12	0	12	0	12	0	12	0	71	0%
Padden (mouth)	0	8	0	12	0	12	0	12	0	11	1	12	0	12	0	12	0	12	0	12	1	115	1%
Whatcom (Control Dam)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Hanna (Below WTP)			0	9	0	10	0	12	0	9	1	11	0	12	0	12	0	12	0	12	1	99	1%
Cemetery (Whatcom)	1	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	1	115	1%
Lincoln (Fraser)	1	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	1	115	1%
Fever (Valencia)	0	8	0	12	0	12	0	11	0	11	0	12	0	12	0	12	0	12	0	12	0	114	0%
Whatcom (Valencia)											0	4	0	12	0	12	0	12	0	12	0	52	0%
Whatcom (I-5)	1	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	1	115	1%
Whatcom (Dupont)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Squalicum (E Bakerview)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Squalicum (Meridian)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Baker (Squalicum)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Squalicum (mouth)	0	8	0	12	0	12	0	12	0	11	0	12	0	12	0	12	0	12	0	12	0	115	0%
Silver (Graveline Rd)							0	12	0	11	0	12	0	12	0	12	0	12	0	11	0	82	0%

Appendix D. 303d Listing Maps

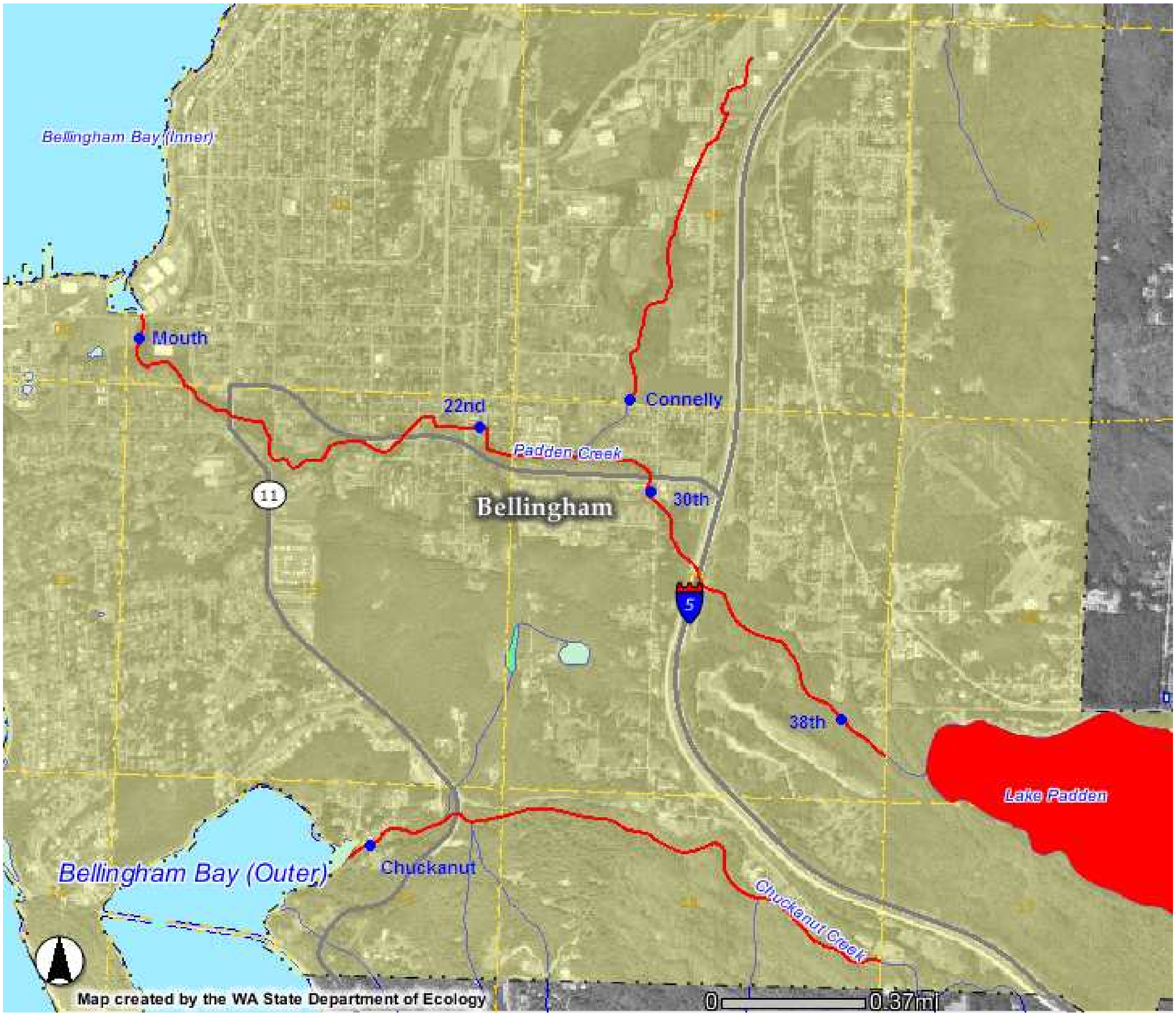


Figure D-1. Map of 303d listed stream segments on Chuckanut and Padden Creek Drainages. Listed segments in red. City of Bellingham sample sites labeled in blue. Yellow shading indicates City limits. All segments are listed for fecal coliform. In addition, the segments containing the Padden Mouth site, the 30th and 38th St. sites, Connelly Creek and the Chuckanut Mouth site are listed for dissolved oxygen. Finally, the Connelly Creek and Padden 30th/38th segments are listed for temperature exceedences.

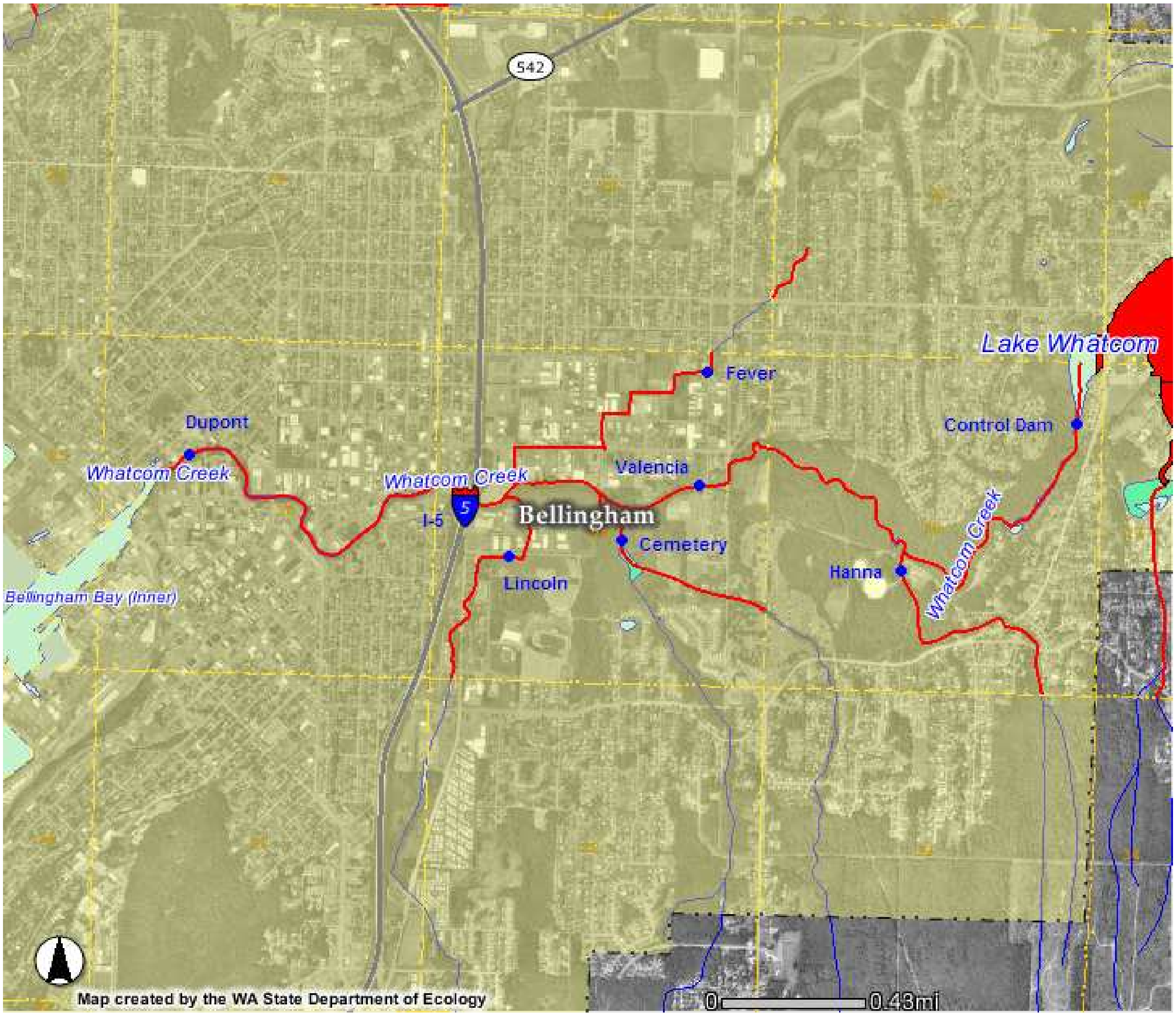


Figure D-2. Map of 303d listings in the Whatcom Creek Drainage. Listed segments in red. City of Bellingham sample sites labeled in blue. Yellow shading indicates City limits. All Segments on Whatcom Creek, as well as Cemetery, Lincoln and Fever Creeks are listed for fecal coliform, temperature and dissolved oxygen. Hanna Creek is listed for fecal coliform and temperature. Fever Creek is also listed for zinc.

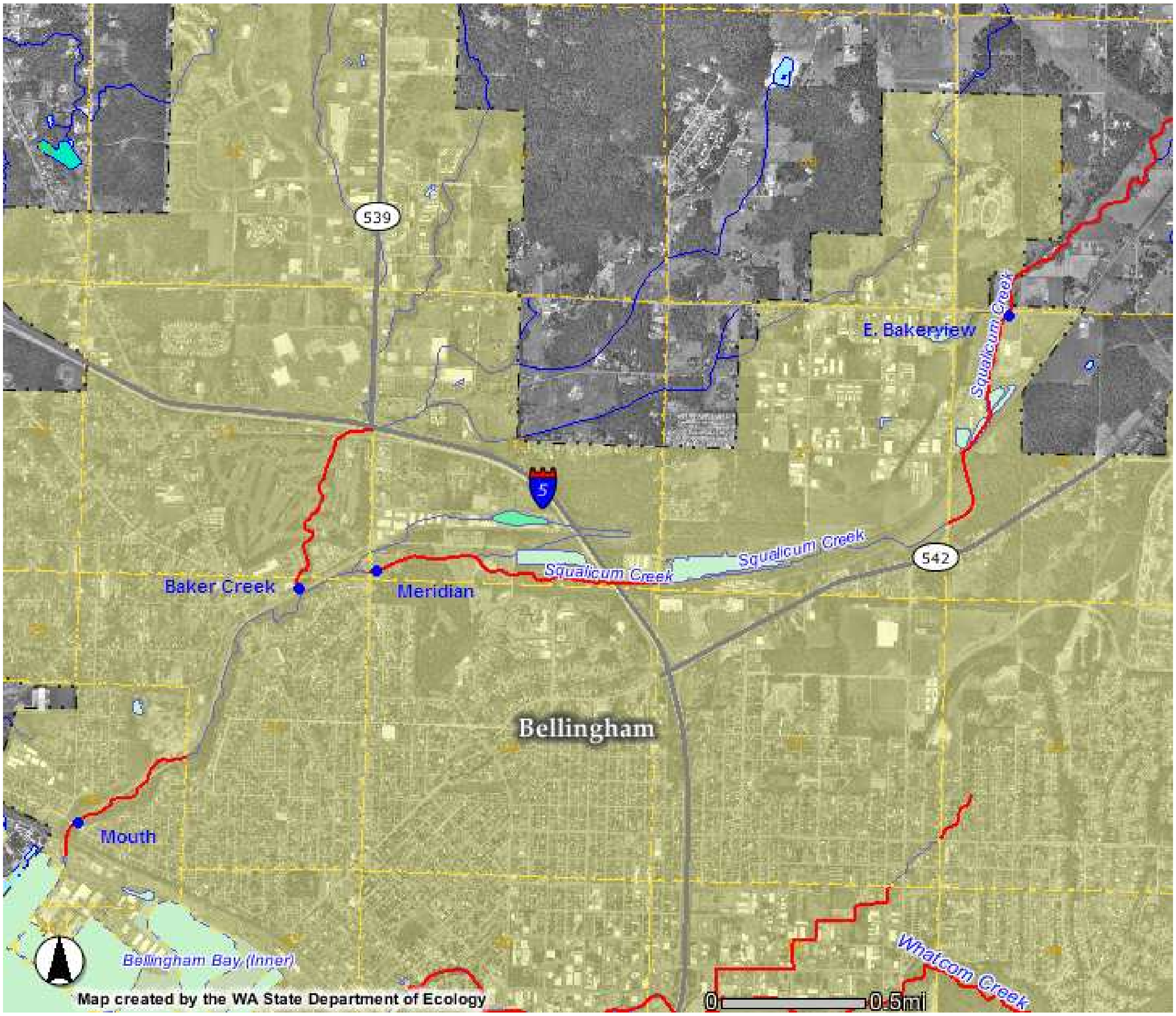
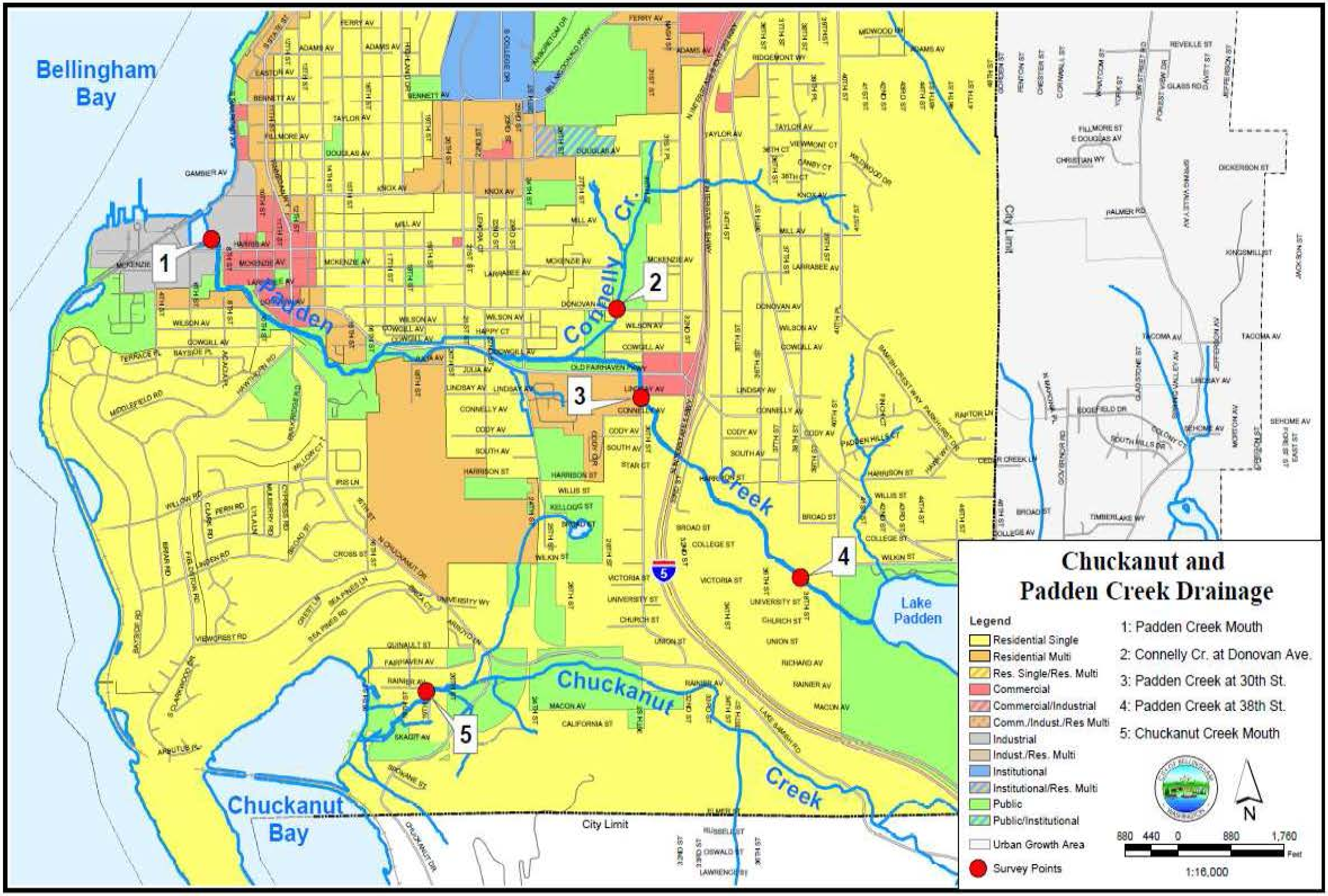
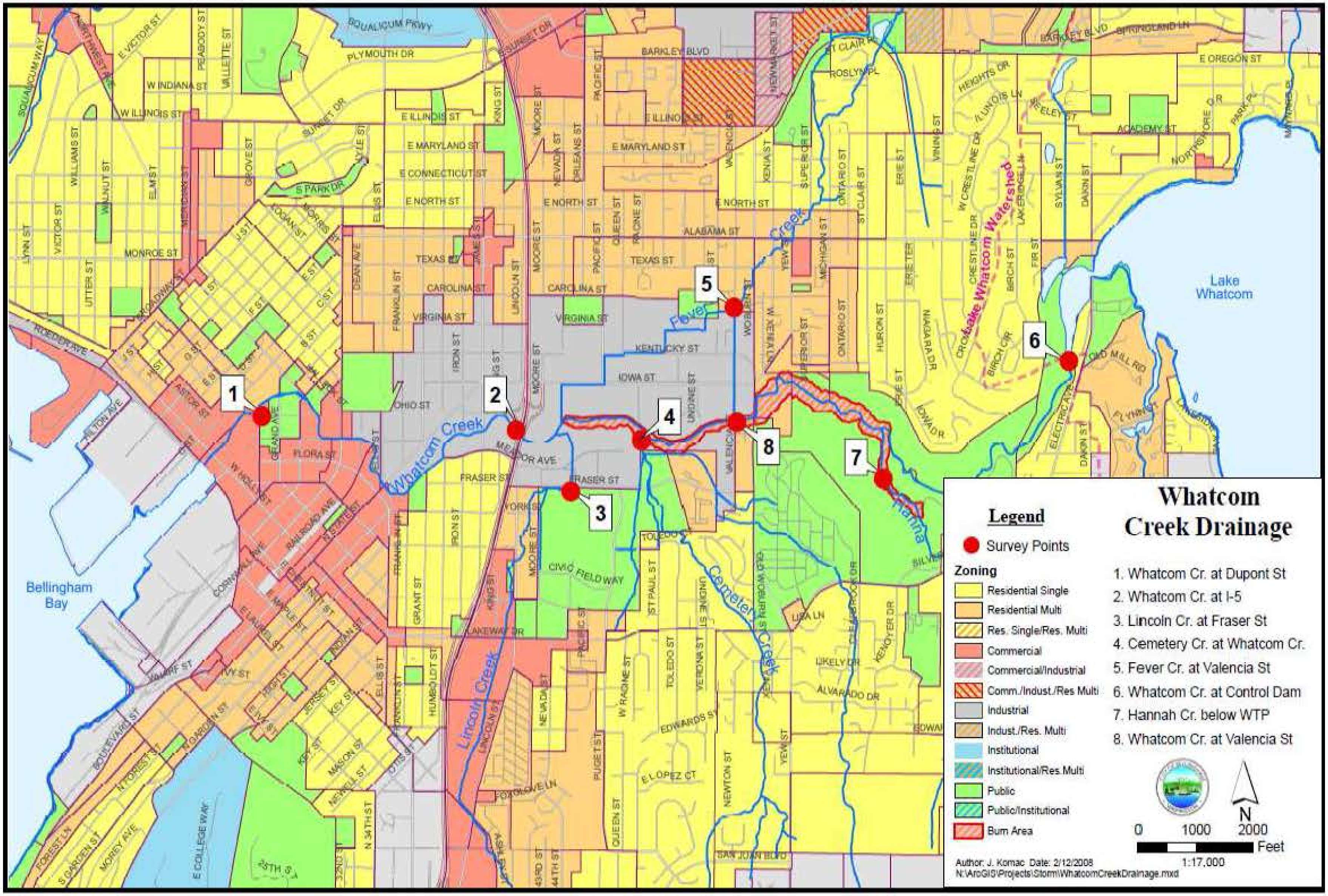
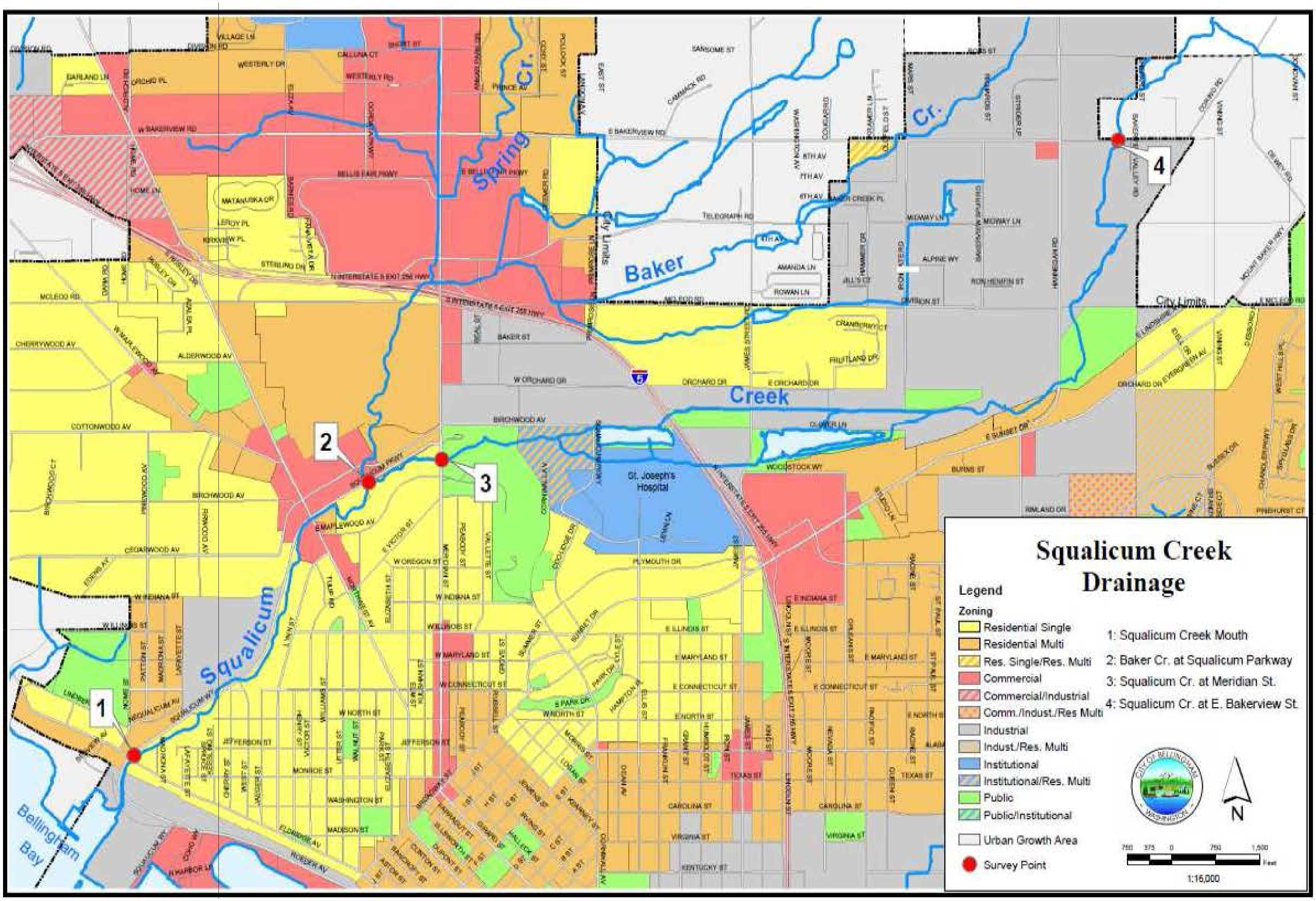


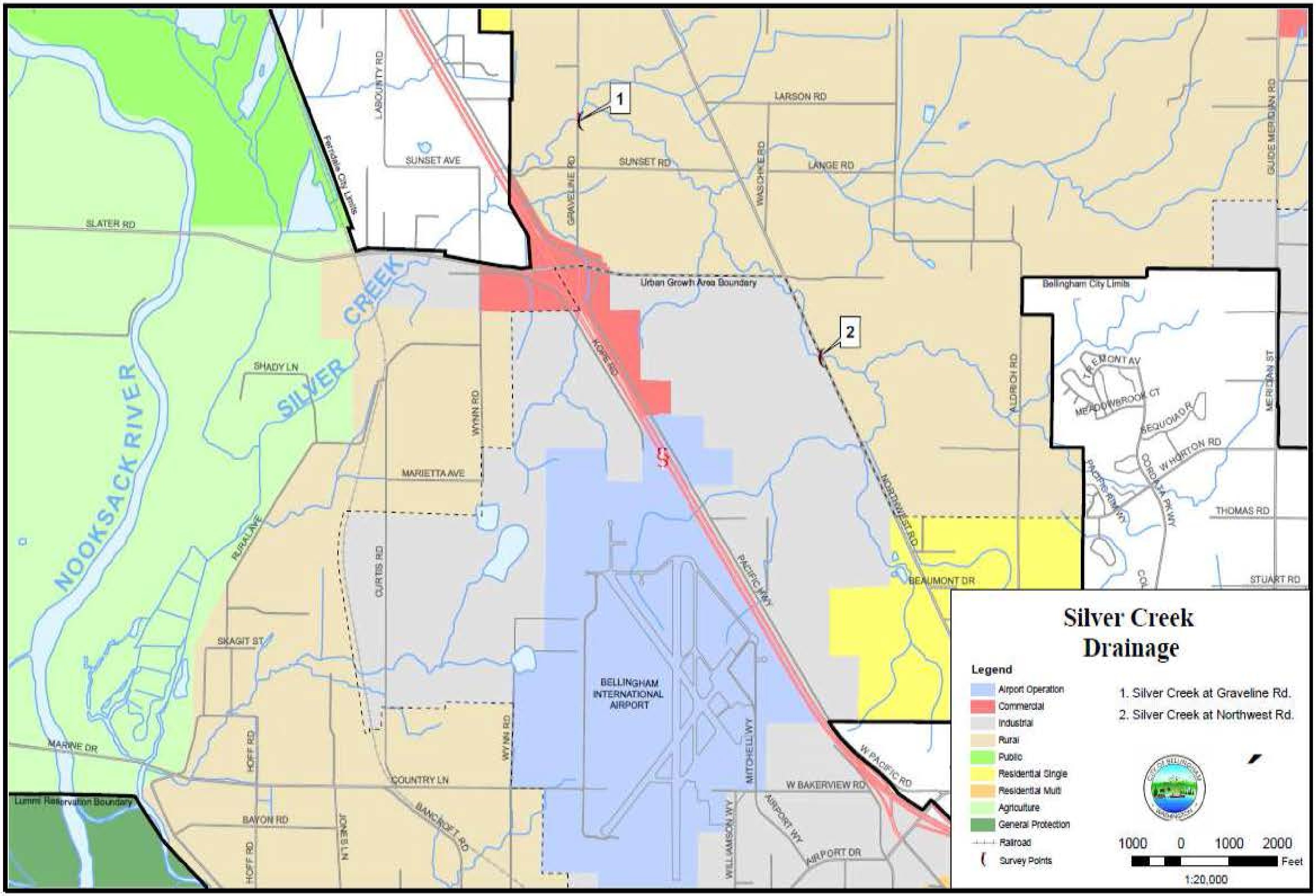
Figure D-3. Map of 303d listings in the Squalicum Creek Drainage. Listed segments in red. City of Bellingham sample sites labeled in blue. Yellow shading indicates City limits. All of the listed segments are listed for excess fecal coliform bacteria. The segment containing the Meridian sampling site and the segment outside the City limits are also listed for temperature and dissolved oxygen. The segment below the E. Bakerview is listed for dissolved oxygen and fecal coliform.

Appendix E. Drainage Maps




Whatcom
Creek Drainage
Legend
Survey Points
Zoning
Residential Single
Residential Multi
Res. Single/Res. Multi
Commercial
Commercial/Industrial
Comm./Indust./Res Multi
Industrial
Indust./Res. Multi
Institutional
Institutional/Res.Multi
Public
Public/Institutional
Burn Area
1. Whatcom Cr. at Dupont St
2. Whatcom Cr. at I-5
3. Lincoln Cr. at Fraser St
4. Cemetery Cr. at Whatcom Cr.
5. Fever Cr. at Valencia St
6. Whatcom Cr. at Control Dam
7. Hannah Cr. below WTP
8. Whatcom Cr. at Valencia St
N
0 1000 2000
Feet
1:17,000
Author: J. Komac Date: 2/12/2008
N:\ArcGIS\Projects\Storm\WhatcomCreekDrainage.mxd
Bellingham Bay
Lake Whatcom
Lake Whatcom Watershed
Whatcom Creek
Lincoln Creek
Cemetery Creek
Fever Creek


Squalicum Creek
Drainage
Legend
Zoning
Residential Single
Residential Multi
Res. Single/Res. Multi
Commercial
Commercial/Industrial
Comm./Indust./Res Multi
Industrial
Indust./Res. Multi
Institutional
Institutional/Res. Multi
Public
Public/Institutional
Urban Growth Area
Survey Point
1: Squalicum Creek Mouth
2: Baker Cr. at Squalicum Parkway
3: Squalicum Cr. at Meridian St.
4: Squalicum Cr. at E. Bakerview St.
1:16,000
N
1
2
3
4
Squalicum
Baker
Creek
Spring
Cr.
Cr.
Bellingham
Bay
City Limits
St. Joseph's Hospital



Silver Creek Drainage
Legend
Airport Operation
Commercial
Industrial
Rural
Public
Residential Single
Residential Multi
Agriculture
General Protection
Railroad
Survey Points
1. Silver Creek at Graveline Rd.
2. Silver Creek at Northwest Rd.
1000 0 1000 2000
Feet
1:20,000
NOOKSACK RIVER
SILVER CREEK
BELLINGHAM INTERNATIONAL AIRPORT
Urban Growth Area Boundary
Bellingham City Limits
Ferndale City Limits
Lummi Reservation Boundary
SLATER RD
SUNSET AVE
SUNSET RD
LARSON RD
LANGE RD
GRAVELINE RD
LABOUNTY RD
GUIDE MERIDIAN RD
ALDRICH RD
NORTHWEST RD
PACIFIC HWY
KOPE RD
WYNN RD
CURTIS RD
MARIETTA AVE
SHADY LN
RURAL AVE
SKAGIT ST
MARINE DR
HOFF RD
BAYON RD
JONES LN
COUNTRY LN
BANCROFT RD
MITCHELL WY
WILLIAMSON WY
AIRPORT WY
AIRPORT DR
W BAKERVIEW RD
W PACIFIC RD
BEAUMONT DR
THOMAS RD
STUART RD
MERIDIAN ST
W HORTON RD
CORDATA PKWY
TREMONT AV
MEADOWBROOK CT
SEQUOIA DR