North Creek and Little Swamp Creek Sample Results 2012 Fecal Coliform Bacteria Total Maximum Daily Loads

Water Quality Monitoring

Annual Summary Report

January 2013

City of Bothell™

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City of Bothell™

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Introduction

In 1996, the Washington State Department of Ecology (WDOE) listed North Creek and Swamp Creek on the 303 (d) list of impaired water bodies for fecal coliform bacteria (FCB) and dissolved oxygen Total Maximum Daily Loads (TMDLs). (http://www.ecy.wa.gov/programs/wq/303d/1996/index-1996.html).

North and Swamp Creek are contaminated by excessive levels of bacterial pollution. As a result of the bacterial pollution problem, WDOE worked with local municipalities to develop the North Creek Fecal Coliform Total Maximum Daily Load Detailed Implementation Plan (Svrjcek, 2003) and Swamp Creek Fecal Coliform Bacteria Total Maximum Daily Load, Water Quality Improvement Report and Implementation Plan (Svrjcek, 2006). In the plans, WDOE established water quality monitoring requirements for local municipalities that collect, treat, and/or convey stormwater.

In 2007, WDOE issued a National Pollution Discharge Elimination System (NPDES) stormwater permit to all small municipalities. The NPDES permit conditioned TMDL(s) to develop a Bacteria Pollution Control Plan (BPCP) for North Creek and Swamp Creek. The City of Bothell's goal is to improve water quality to meet state standards for FCB levels. This document can be viewed on the City's web page and will be periodically updated.

Specific source contributors in North Creek have been identified through the use of DNA testing (Kalenius, 2008). Pet waste, failing septic tanks, sewage, wildlife, and illegal discharges were all identified as sources. It is assumed that Swamp Creek has a similar bacteria source profile. The City of Bothell conducted surveys of businesses and citizens to measure their knowledge of water quality issues of North Creek (Kalenius, 2008). Key findings were that residents were generally unaware of North Creek and their impacts on its water quality, and bacteria alone did not elicit their attention. Future efforts to change people's behavior should emphasize the value of North Creek as an amenity and water quality concerns as secondary.

This report provides an annual update on monitoring as described in North Creek/Swamp Creek Fecal Coliform Bacteria Total Maximum Daily Loads, Water Quality Study Design Quality Assurance Project Plan (Kalenius, 2007). The City of Bothell understands the need to work together with others to understand the bacterial pollution problem in North Creek and find solutions for its residents. The water quality monitoring activities support those efforts and are detailed in this document. TMDL-related permit requirements are satisfied by monitoring conducted at the long-term sites established in the above referenced Quality Assurance Project Plan (QAPP).

Applicable Water Quality Standards

Allowable bacteria concentrations in North Creek are designed to protect Lake Washington, one of the most important recreational waterbodies in Washington State. State Water Quality Standards (Washington Administrative Code 173-201A) establish the use of extraordinary primary recreational contact for both waterbodies. The Standards requires that water quality in these streams meet a geometric mean of 50 cfu/100 mL, and an upper tenth percentile value not to exceed 100 cfu/100 mL.

Basin and Sampling Site Descriptions

North Creek

The North Creek basin drains approximately 30 square miles and discharges to the Sammamish River, which is a tributary to Lake Washington. The watershed is comprised of the main stem of North Creek and all the tributaries that contribute to it. Land use within the basin is primarily urban or suburban with some pockets of rural and forested land. The basin is being rapidly developed for residential and commercial use. Urbanization and land development activities greatly affect water quality in the basin through riparian corridor alteration, conversion of forests, inadequate retention/detention of stormwater from new and existing impervious surfaces, and poorly treated stormwater run-off.

North Creek is located predominantly in south Snohomish County and is shown in Figure 1. The headwaters originate in the Everett Mall Way area of south Everett and flow southerly for 12.6 miles before discharging to the Sammamish River, within the City of Bothell. The Sammamish River drains into Lake Washington and ultimately through the Ballard Locks to Puget Sound. The last 1.5 miles of North Creek is located in King County (Bothell). The stream gradient is flat, decreasing from about 50 feet per mile in the upper basin to less than 20 feet per mile near the mouth. The seven major subbasins within the watershed are main stem North Creek, Penny Creek, Silver Lake Creek, Nickel Creek, Silver Creek, Tambark Creek, and Sulphur Springs Creek (Figure 1). The major lakes are Silver Lake, Ruggs Lake, and Thomas Lake.

The watershed is nearly 10 miles long and 3 miles wide, and encompasses an area of about 19,000 acres. Approximately 10 percent of the watershed lies within the city of Everett, 23 percent lies within the city of Bothell, 12 percent lies within the city of Mill Creek, and the remaining 55 percent lies within unincorporated Snohomish County. Five percent of the total area lies within King County and this area is within Bothell's city limits.

North Creek watershed in Bothell is comprised of multi-land uses: residential, retail, and business parks containing business and light industry, with residual open space. The residential development is mixed sewer and septic averaging 4-6 dwellings per acre. Three sample locations were selected to best represent the various land uses (Figure 2).

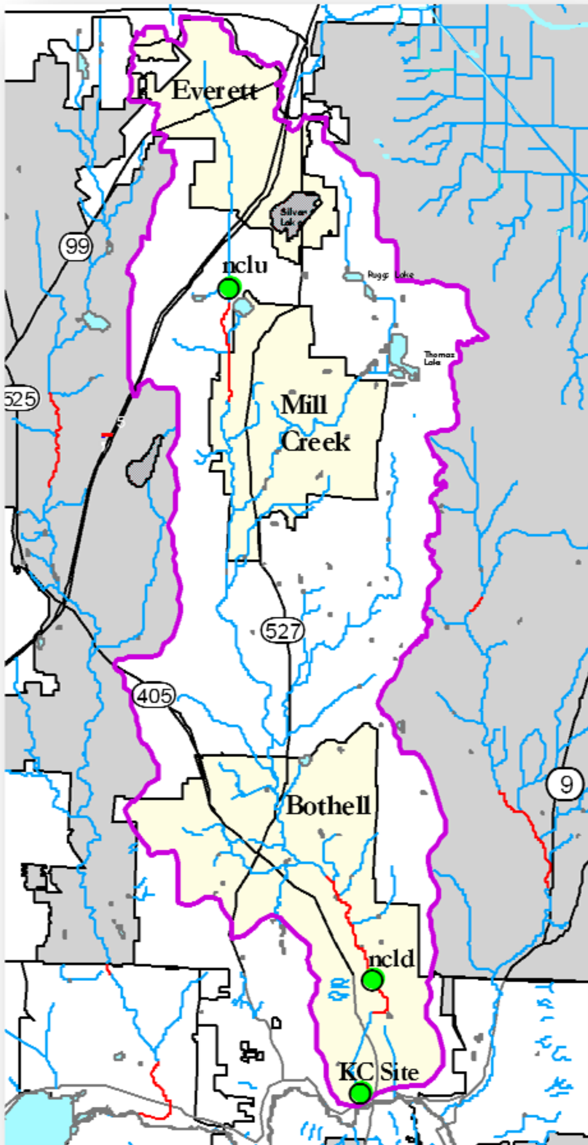

Figure 1 – North Creek Watershed. Current long-term monitoring sites are indicated by green dots. North Creek ncld is also Snohomish County flow gauging site.

Swamp Creek

The Swamp Creek watershed spans about 12 miles in length from top to bottom. Starting just below State Highway 526 in Everett, the mainstem of the creek winds 14 miles through the watershed before it flows into the Sammamish River at Kenmore. Swamp Creek contributes to the quality of water in the Sammamish River, which empties to upper Lake Washington 0.7 miles below the Swamp Creek confluence.

Swamp Creek is typical of Puget Sound lowland watersheds. In the gently sloping upper basin, Swamp Creek flows through a narrow valley which gradually broadens to a floodplain almost .75 miles wide in the lower basin. The middle basin also contains a narrow valley with steep slopes in excess of 15 percent just south of the I-405 and I-5 crossing. Elevation in the headwaters is approximately 520 feet, while the elevation at the mouth is about 20 feet above sea level. The stream gradient is flat, decreasing from about 50 feet per mile in the upper basin to less than 20 feet per mile near the mouth. Scriber Creek, Little Swamp Creek, and Martha Creek are the largest of the 19 streams tributary to Swamp Creek. Major lakes in the Swamp Creek watershed are Scriber Lake, Martha Lake, and Stickney Lake (SWM 1994, 2000).

Most of Swamp Creek and its tributaries are shallow and unsuitable for full-immersion swimming activities. However, several noteworthy exceptions are Wallace Park in Kenmore, Lake Martha, and Lake Stickney. Lake Scriber in Lynnwood is large and deep enough for swimming but this activity is not encouraged by the City. Although public access to the creek is largely limited to road crossings and a few parks, Swamp Creek is fully accessible to adjacent land owners, their children, and in some cases, their neighbors. Limited boating opportunities exist where Swamp Creek meets the Sammamish River.

In the late 1990's, Swamp Creek watershed was highly urbanized with about 50 percent of the land in residential or commercial use, 30 percent with forest cover, 10 percent in commercial use, and less than 10 percent rural property (MRLC 1999, SWM 2002). Commercial and light industrial uses are primarily located within Lynnwood and Everett. Small farms and pastures are most common in the middle of the watershed, especially in Brier and unincorporated Snohomish County. The watershed is located within the US Census Defined Urbanized Area; therefore, it is expected that population growth and urban development will be concentrated in this area.

An examination of orthophotos taken in 1995 was performed as part of the Habitat Inventory and Assessment of North, Swamp, and Little Bear Creeks (KCWLR 2001). This land use analysis method is different than the one used for Swamp Creek's Water Quality Improvement Plan and suggested that forested cover is only 20 percent, mostly composed of deciduous trees. Road density was highest in the Scriber Creek subbasin.

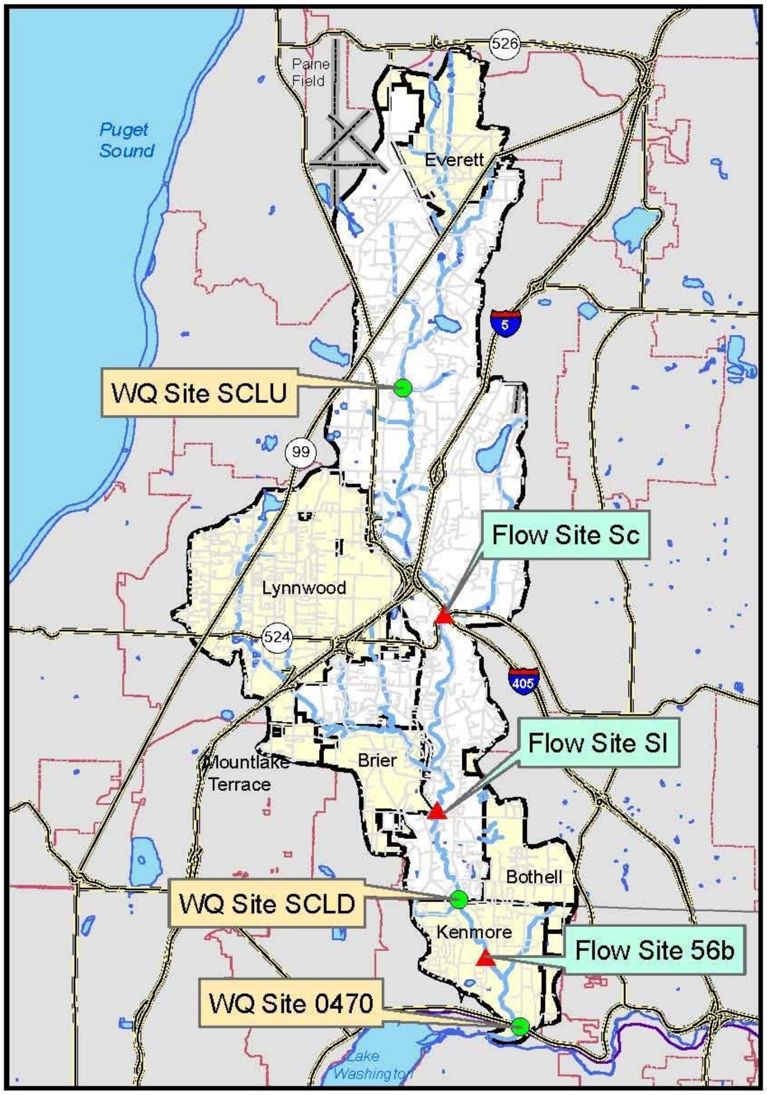

Figure 2 – Swamp Creek's TMDL monitoring locations for Snohomish and King County. Map is from Snohomish County Surface Water Management Study, 2002.

City of Bothell Sampling Sites Descriptions

North Creek

Perry Creek sample site (SARU) is located directly behind Salmon Run Apartments. This stream has two branches. One drains from 9th Avenue SE wetland through I-405 and a commercial area. The second drains from ponds in the Green Acres Mobile Home Park northward through a steep, eroded gully. Both of these drainages pass through a wetland behind the Village Square neighborhood, where local flooding occurs during heavy rains before entering North Creek.

Figure 3 – Perry Creek after a heavy rain event.

JOCO site is an unnamed creek running south out of the Highlands Campus Business Park property north of 228th Street SE and east of 29th Drive SE. A headwater wetland feeds the channeled and piped stream corridor. The site location is on the north side of 228th Street SE.

Figure 4 – JOCO monitoring site. This is an unnamed tributary that flows through a business park.

The Palm Creek sampling site, MONT, is located at Whole Earth Montessori. Palm Creek's water source is a large wetland in a ravine below the area of R-1 zoning. The stream enters a pipe in a trailer park, returning to an open channel in a defunct trout farm that channels the stream through cement weirs. Sediment fills the channel and the surrounding knotweed does not provide adequate shading. The stream reenters a pipe to cross under 228th Street SE, daylighting again on the south side just above the sample site.

Figure 5 – Palm Creek. The non-operational trout farm that Palm Creek flows through, upstream from sampling site MONT.

Swamp Creek

Little Swamp Creek (LSWP) was added as a new sample location beginning in 2010. In 2009, sampling by others found elevated levels of fecal coliform in the stream along 7th Avenue SE. The site will follow all the same protocol for North Creek's QAQC plan. The site will be moved in 2011 to just downstream of the 7th Avenue SE stream crossing.

Figure 6 – Little Swamp Creek. View upstream of Little Swamp Creek adjacent to 7th Avenue NE.

A complete view of City of Bothell sample locations for TMDL monitoring is provided in Figure 7.

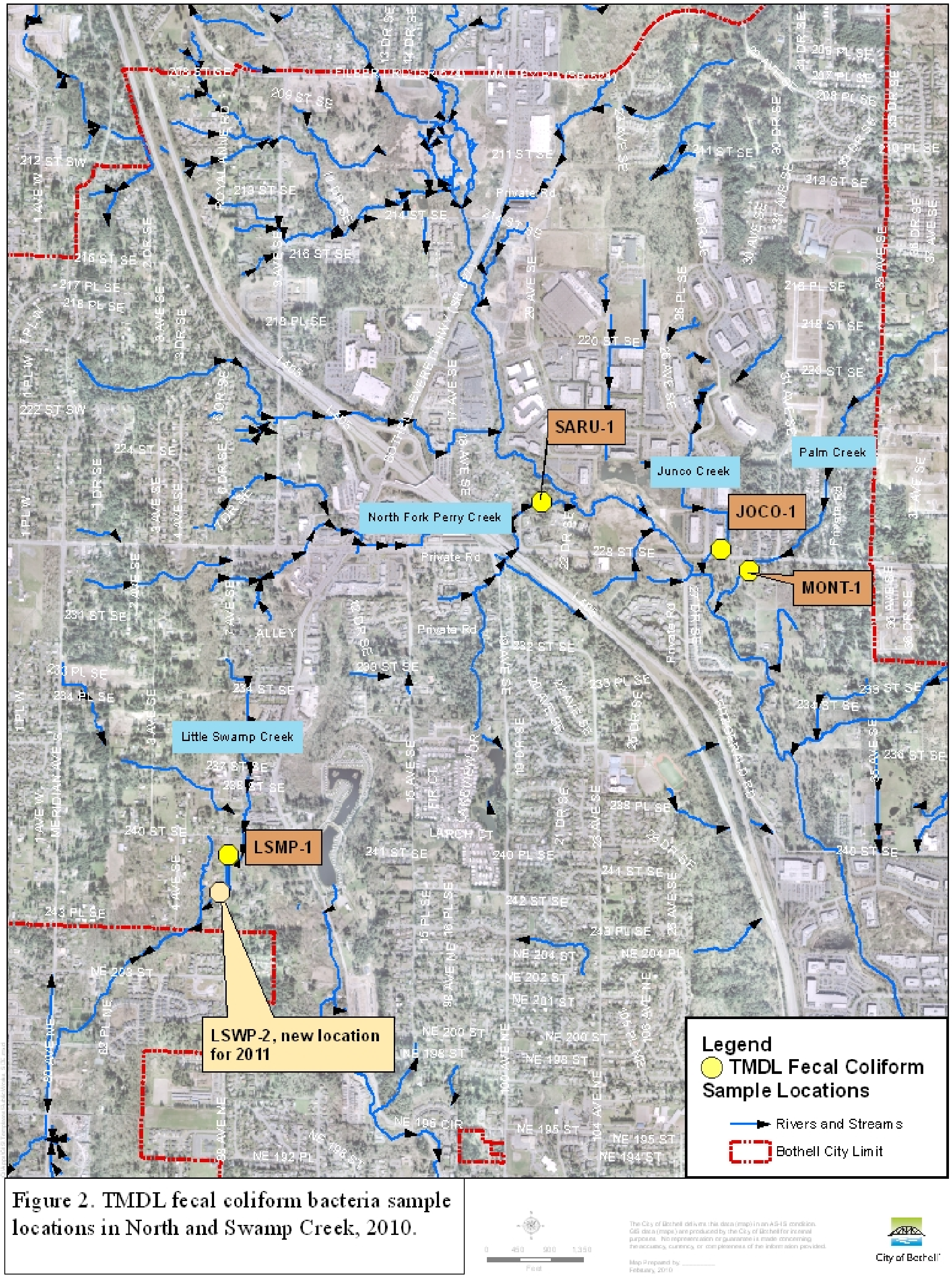

Figure 2. TMDL fecal coliform bacteria sample locations in North and Swamp Creek, 2010.

Figure 7 – City of Bothell TMDL sample locations in North and Swamp Creek.

Pollution Sources – North and Swamp Creek

Pollution in the basin(s) comes from both point and nonpoint sources. The point source contributions come from stormwater and include those discharges currently covered by National Pollutant Discharge Elimination System (NPDES) stormwater permits[1], as well as those from municipal separate storm sewer systems (MS4s) that are currently covered by NPDES stormwater permits that meet the definition of a points source in 40 CFR 122.2. Nonpoint water pollution most commonly results from poor land use management, such as inadequate agricultural practices, failing on-site septic systems, and untreated stormwater runoff that does not come from MS4s. When stormwater comes from rural areas, it may carry wastes from domesticated animals.

Stormwater from urban areas is likely to carry pet wastes to nearby streams. Urban stormwater can carry bacteria from pet wastes on the ground, surfacing wastewater from failing septic tanks, excess nutrients from lawns and gardens, and pollutants associated with activities such as car washing and sidewalk cleaning. Urban and suburban development is continuing in the North and Swamp Creek watersheds; thus, water quality impacts from stormwater runoff are increasing as well.

Many areas of the watersheds have poor soils for locating on-site septic systems, that may be resulting in failing or inadequate septic systems, which contribute significant amounts of bacterial and nutrient pollutants.

Some areas are still rich in wildlife, such as water fowl, deer, and beaver. Fecal coliform bacteria originating from these sources are considered part of the natural background and are generally not considered a source of pollution.

Impaired Areas

North Creek

North Creek was included on Washington's 1996 303(d) list because of numerous exceedances of fecal coliform bacteria standards; 29% to 45% of samples collected at several locations in North Creek, by Snohomish and King Counties between 1992 and 1997, exceeded the upper fecal coliform criterion. We now know that the extent of the bacteria pollution problem stretches throughout the basin based on monitoring conducted by the various municipalities in the watershed.

Swamp Creek

Since the year 2000, a consistent pattern of bacterial pollution has been observed in Swamp Creek. It was placed on Washington's 1996 303(d) list for fecal coliform exceedence and low dissolved oxygen. All areas previously sampled in the basin exceed state criteria for bacteria at all times of the year (Svrjcek, 2006). During the dry summer months when stream flows are low, bacteria levels rise far beyond both the geometric

[1] More information is available at http://www.epa.gov/ow/regs/permit.html.

mean criterion of 50 cfu/100 mL and the 90th percentile criterion of 100 cfu/100 mL. During the wetter months of the year, bacteria concentrations improve at each site, but not enough to meet state standards.

Although it is not reflected in Ecology's current Water Quality Assessment, North and Swamp Creek do not consistently meet state standards for temperature or dissolved oxygen, and benthic invertebrate surveys indicate that overall aquatic habitat quality ranges from fair to poor (SWM 2000 & 2002).

Project Description

The goal of the monitoring is two-fold. First is the need to comply with the requirements of the North and Swamp Creek TMDL. This has been accomplished by establishing specific long term monitoring sites to facilitate trend monitoring and to allow flow duration (or similar) analyses to be conducted after approximately 5 years of monitoring. At that time, there should be approximately 60 randomly collected data points associated with each site.

This report provides the basic procedures for monitoring. The basic procedures for sample collection and processing of samples at the long term sites are sufficient for rudimentary source identification monitoring through bracketing.

Relationship of this monitoring with existing programs

Long term monitoring currently performed by King and Snohomish counties will be important to this monitoring program. Flow gauging stations operated by these entities are critical for establishing when stream flow is dominated by stormwater runoff. Additional water quality stations added by City of Bothell and other local cities will round out the long-term monitoring needs. At this time, the City has established four monthly monitoring stations.

Source Tracking

Beginning in 2010, City of Bothell and Snohomish County entered into an interlocal agreement to improve monitoring within North Creek. In 2010, the City contracted with Snohomish County to conduct bacteria microbial source tracking efforts as described by Britsch, 2009. The microbial source tracking was determined by monitoring results indicating prolonged elevated levels of fecal bacteria exceeding 200 colonies per 100 mL.

In late 2009 and throughout 2010, WDOE lead a collaborative effort with the City to identify sources of high fecal coliform bacteria in Little Swamp Creek. Results from the intensive sampling regime allowed for source tracking of potentially active sources of bacteria discharges to Little Swamp Creek. In 2010, the City added a long- term monitoring station for fecal coliform bacteria in Little Swamp Creek (Figure 7).

Data Quality Objectives

Data quality objectives are qualitative and quantitative statements of the precision, bias, representativeness, completeness, and comparability necessary for the data to address project objectives. The primary indicators of data quality are precision and bias, which together, express the data's accuracy.

Precision, expressed as the standard deviation of replicate sample analyses, is a measure of data scatter due to random error, while bias is a measure of the difference between the result for a parameter and the true value due to systematic errors. Potential sources of errors include sample collection, physical and chemical instability of samples, interference effects, instrument calibration, and contamination. Random error affects the determination of bias; thus, bias estimation may be problematic. Consequently, dedication to established protocols is one method used to reduce concern over sources of bias (Lombard & Kirchmer, 2004).

Fecal coliform bacteria levels are highly influenced by the biological component in the aquatic environment and can be subject to sample contamination problems. Table 1 summarizes the laboratory accuracy and analytical reporting limits for parameters that can reliably be used for decision-making. Seasonal sampling and other sampling design features will be used to better evaluate critical conditions to determine water quality compliance with state bacteria standards.

Our goals for evaluating impacts to water quality require the ability to detect "differences." These differences can be based on: (1) a simple comparison of upstream and downstream locations (e.g., "bracketing", BMP effectiveness evaluations), or (2) determining a trend over time at points on a stream in the absence of changes to upstream land use activities.

Table 1 – Quantitative Data Quality Objectives

Analysis	**Accuracy** % deviation from true value	**Precision** Relative Standard Deviation	**Bias** % deviation from true value	**Required Reporting Limits** (concentration)
LABORATORY ANALYSIS				
Fecal Coliform (MF)[1]	N/A	RSD ± 30%	N/A	1 colony forming unit per 100 mL

[1] Using Standard Method 9222D

Upstream/Downstream Differences

Sources of very high fecal coliform concentrations, such as failing septic systems or leaking sewer lines, can have severe effects on overall stream concentrations even when the volume discharged is low. However, when the concentration upstream of a source is high, the change due to the source can be undetectable.

Trends Over Time

The ability to detect changes in water quality (trends) is the cornerstone of a long-term sampling design. A historical perspective, which only long-term records can provide, is necessary in order to make informed decisions regarding water quality assessments. Data quality objectives were developed to support statistical requirements for trend analysis.

Sampling Process Design

The project objectives of detecting trends and comparing results to the State water quality standards require collecting samples regularly at the same stations over a long time span. This approach will provide randomly collected data for unbiased analysis in the future. No attempt will be made to avoid sampling due to weather or other environmental conditions unless the safety of staff is compromised.

Sampling related to the TMDL is limited to bacterial pollution measured using fecal coliform testing. High quality flow monitoring (daily flows) is also required at selected representative stations throughout the basin. Although WDOE encourages monitoring of temperature and dissolved oxygen levels as well, these additional parameters are not required.

The frequency for monitoring at the long-term sites is monthly. City of Bothell will attempt to sample the first Monday/Tuesday of the month. Small deviations for holidays, illness, and other business reasons are anticipated. This sampling regime will occur throughout the NPDES Phase II Permit life.

Water quality stations for the long-term monitoring component of this project are shown in Figure 1. North Creek's long-term flow monitoring is conducted by Snohomish County Surface Water Management at 240th Street SE, site NCLD (Figure 1). Swamp Creek's long-term flow monitoring is conducted by Snohomish County Surface Water Management at two locations one near State Route 524, and the other at Locust Way just north of 228th Street (Figure 2). King County conducts long-term flow monitoring at one location in the lower basin (Figure 2).

Sampling Procedures

Overview

Fecal coliform bacteria is the preferred indicator of disease-causing microorganisms in Washington State. There are two standard methods for the detection of coliform bacteria – the Membrane Filter (MF) technique and the Most Probable Number (MPN) index. The MF and MPN methods are frequently not comparable. The USEPA currently recommends the MF procedure because it is faster and more precise than the MPN technique (EPA, 2001). However, MPN is better for use in chlorinated effluents, highly turbid waters, and salt or brackish waters. Ecology requires all partners in this program to have samples analyzed by State-accredited laboratories using the MF technique SM9222D. City of Bothell used TestAmerica Analytical until June 2008 and then switched to AmTest, Inc.

Planning

Bacteria samples will be collected in sterilized bottles obtained from AmTest, Inc.

Downstream samples are collected first. Samples will be taken downstream working upstream to minimize the possibility of collecting fecal coliform from sediments that may have been disturbed during the current sampling activities.

In late 2008, the City elected to add analysis for E. Coli and Total Coliform in addition to Fecal Coliform Bacteria count. All QA/QC is consistent with that stipulated for FC when testing for E. Coli and Total Coliform.

Field Procedures

Ambient water quality samples collected as part of this QAPP will generally use the "dipping method." The dipping method is intended to collect the most representative sample taken at a single point in time (also called a grab sample). Staff will avoid collecting water from near the surface and collect samples from the center of flow (thalweg) when possible. A notation will be made in the field notebook if surface samples are taken.

Field measurements and comments are recorded on either a form prepared prior to sampling, ideally in a notebook of water resistant paper, or loose-leaf water resistant paper. All notes should be stored in a safe location after a sampling run. Project name, station location, date and time of sample collection, and sample number should be recorded, at a minimum. Other useful information may include staff gauge or tape down measurements, estimates of discharge, field quality control information, field meter measurements if applicable, weather conditions, and comments about turbidity, color, and odor.

A word about safety: Safety is a primary concern whenever working in or near waterbodies. Many times, sampling locations are sited close to roadway crossings to facilitate access in right-of-ways and to reduce travel times to the actual sample site. In these cases, the need for life vests, reflective clothing, orange marking cones, and flashing lights will be considered to protect staff from injury and to alert passing drivers to their presence on the roadside.

The general procedures for taking a proper fecal coliform sample are discussed below.

Sampling Procedure

1. A sterilized polypropylene sample container provided by the accredited laboratory is used. The minimum sample size is 250 mL.
2. For sites that require entering the stream, care is taken to not stir up sediment. Sites are approached from a downstream to upstream direction.
3. The sample bottle is uncapped. Care is taken not to contaminate the inside of the bottle or the cap.
4. The bottle is inverted and plunged, mouth down, through the surface to a depth of 15 to 30 cm (6 to 12 inches, mid-depth of stream where feasible). While under water, the mouth of the bottle is rotated into the current. The sample bottle is brought back to the surface in an upright position. Water is poured off enough until the water level is at the shoulder of the bottle. This allows room for mixing the sample before analysis at the lab.
5. After recapping the bottle, the bottle is placed on ice upon reaching the vehicle.
6. Other notes:
   - **Do not rinse the bottle.**
   - **Do not pour water into the fecal bottle from another container.**

Field Quality Control

Field Replicates

Total variability (precision) for field sampling and laboratory analysis will be assessed by collecting field replicates. In some cases field duplicates, field blanks, and field splits may also be appropriate.

Field replicates are two samples collected from the same location at the same time. A second bottle is plunged side-by-side with the regular sample. Field replicates will be collected at the rate of 10%, with a minimum of one field replicate per sampling run. If using a pole to collect samples, it may not be possible to collect the samples side-by-side. In this case the field replicate was collected at the same time of the regular sample. Staff were directed to make comments in the field notes if the samples were not collected side-by-side.

Replicate results that are “non-detects” cannot be used to estimate precision. Similarly, the variability found at low concentrations cannot be used to estimate the variability at higher concentrations, and vice versa. Variability, or precision, is estimated as the standard deviation of a number of results. The standard deviation varies with the magnitude of the results. Separate estimates of standard deviation will be determined for each range of concentration. By collecting field replicates often over a long time period, we should be able to calculate standard deviations for a wide range of concentrations.

Field replicates are labeled in such a way as to give the impression that they are completely separate samples as such before they are sent to the laboratory. The laboratory analysts are not made aware of the fact that they are handling field replicates.

Sample Container

A sterile glass or polypropylene bottle will be used for all samples collected. (When working with laboratories associated with wastewater treatment plants, it should be specified that the bottle be empty, with no sodium thiosulfate or other dechlorinating agents.) Although the type and size of bottle will likely be determined by the laboratory’s preferences, WDOE routinely uses polypropylene 250 and 500 mL bottles without preservative for stream samples. Sample bottles should be autoclaved with caps covered in aluminum foil or otherwise sterilized and supplied by an accredited laboratory.

Select a bottle according to the following criteria:

- Use the 500 mL bottle if sampling for enterococci in addition to fecal coliform.
- Use bottles with EDTA added if high metal concentrations are suspected.

At WDOE, empty bottles have a holding time; three months for bottles without thiosulfate or EDTA, and one month for bottles with thiosulfate or EDTA. Individual laboratories may have different recommendations.

Field Processing

No field processing is required.

Sample Storage

All samples were placed in an ice chest with ice packs immediately upon return to the vehicle. The samples were stored in the dark. For chain-of-custody procedures, the vehicle was locked whenever it was not in view of sampling personnel.

Source Tracking Surveys

North Creek

Snohomish County Surface Water Management has developed source tracking methodology for fecal coliform bacteria (Britsch, S. 2009). Perry Creek was subject to a Phase II contaminant source survey (CSS). Field surveys included a windshield survey (driving the roads) and stream walk, where and when feasible, to identify presence of specific sources of bacteria. Types of activities included identifying illicit connections, evidence of failing septic systems, catch basins with accumulated sediment greater than 40%, presence of dog parks, and presence and numbers of birds and dogs. For a complete description of methods, refer to Perry Creek Contaminant Source Survey, 2010 Summary Report (SWM 2010). The results were then translated into a set of recommendations. A similar effort occurred in 2012 on Crystal Creek with results and recommendations found in SWM 2012.

Swamp Creek

The source tracking effort conducted followed a simple pattern of collecting multiple upstream and downstream samples. The sampling was conducted on multiple occurrences and modified based on the previous sample results. The selection of sampling sites was based on narrowing down to a finite world of possible contributing sources. In this manner, sampling typically progressed upstream until no other possible sources of bacteria could be identified.

Measurement Procedures

Field

Station Information

City of Bothell has already determined the coordinate information for its proposed long-term sites and entered this information into Ecology's EIM database. Ecology has indicated that it is not necessary to determine coordinate information for short-term monitoring locations associated with source tracking activities.

Office

Stream Discharge Data

Bacteria concentration data collected as part of this QAPP will be evaluated using flow duration or similar analyses in the future. To accomplish this, high quality flow data collected on a daily, or more frequent, basis is needed at representative locations in the watershed. Currently, stream gauging networks provided by Snohomish County and King County are well-suited for this purpose. At present, three stream gauges are functioning on Swamp Creek.

> King County maintains gauge 56b. Discharge and water temperature data is available in 15-minute, hour, daily, and monthly formats. This data is available at http://dnr.metrokc.gov/wlr/waterres/hydrology/GaugeSelect.aspx.

There are three stream gauges in North Creek.

> Snohomish County monitors stream flow at site NCLU, which is located in lower North Creek at 240th Street SE in Bothell and at site NCLD, which is located at the station near the County line. In 2011 the NCLU site at 240th Street SE was abandoned due to a bridge replacement project. It was relocated upstream to 228th Street SE in late 2011.

> Mill Creek and Snohomish County jointly maintain and operate a flow monitoring station on Penny Creek near the confluence with North Creek.

Lab

Fecal Coliform - Membrane Filtration Method

Laboratory analyses for fecal coliform bacteria were performed by two separate laboratories accredited by the Washington State Department of Ecology. The analytical method used is described by Standard Methods for the Examination of Water and Wastewater, No: 9222 D, 24-hour Membrane Filter (MF) procedure. The detection limit and the precision for this method are both 1 colony per 100 mL. Densities were reported as fecal coliform bacteria per 100 mL.

Quality Control

Quality control procedures used during field sampling and laboratory analysis will provide estimates of the accuracy of the monitoring data. Field replicates were used to determine compliance with measurement quality objectives. Total variation for field sampling and analytical variation were assessed by collecting replicate samples and performing lab replicates as discussed below.

Table 2 – Summary of Field and Laboratory Quality Control Procedures

Analysis	Field Blanks	Field Replicates	Lab Check Standard	Lab Method Blank	Lab Replicates	Matrix Spikes
Fecal Coliform (MF)	N/A	1/10 samples	N/A	1/run	1/10 samples	N/A

Field

Field Notes

The notes from each field run were tabulated and compared to chain-of-custody forms and laboratory results for completeness and accuracy. Any problems and associated corrective actions were recorded. Any unresolved problems were flagged and discussed in the data report.

Fecal Coliform Bacteria

Total variability for field sampling and laboratory analysis were assessed by collecting replicate samples at the rate of 10% of regular samples collected, and a minimum of one replicate per sampling run.

Laboratory

Fecal Coliform

Routine laboratory quality control procedures will be followed. Laboratories should perform at least one analytical duplicate per sampling run. Duplicate laboratory analysis refers to analyzing duplicate aliquots from a single sample container. Each sample is carried through all steps of sample preparation and analysis. The results for laboratory duplicates provide an estimate of analytical precision, including the homogeneity of the sample matrix.

Field personnel may want to request that the analytical duplicate be performed on the same sample that accompanies the field replicate, as this allows staff to estimate total and analytical variability from results for the same sample. There is no advantage to randomly selecting samples for duplicate analysis.

If the samples selected for duplicate analyses do not contain measurable amounts of fecal coliform, the results provide no information on precision. Similarly, if the laboratory selects samples from another study with significantly different levels of fecal coliform or different matrices, the estimate of precision may not be applicable to the samples.

The laboratory must report the results of their analytical duplicates.

Data Qualifiers

Each laboratory had its own list of data qualifiers. Test America Analytical and AMTest, Inc. supplied City of Bothell their list of relevant data qualifiers and supporting documentation so that a cross-reference list could be developed. The laboratories were instructed to contact the City immediately if values over 1000 cfu/100 mL were observed.

Data Management Procedures

Recording field measurements

Time, location, weather conditions, and other observations and environmental factors were recorded at the time of sampling and maintained for public record purposes. Laboratory reports, worksheets, and chain-of-custody records were filed together and stored in a binder and other organized forms.

Data qualifiers were explained in all reports as needed. Tables were used to track seasonal compliance with water quality standards using a dry season period of June through September.

Data Verification and Validation

Verification

Data was verified by examining the data for errors, omissions, and compliance with quality control (QC) acceptance criteria. Once measurement results were recorded, they were verified to ensure that:

- Data are consistent, correct, and complete, with no errors or omissions
- Results for QC samples accompany the sample results
- Established criteria for QC results were met
- Data qualifiers were properly assigned where necessary
- Data specified in Sampling Process Design were obtained
- Methods and protocols specified in the QA Project Plan were followed

Qualified and experienced laboratory staff examined lab results for errors, omissions, and compliance with QC acceptance criteria. Findings were documented in each case narrative if and when they occurred.

Validation

Data validation followed verification. It involved a detailed examination of the data package, using professional judgment to determine whether the method quality objectives (MQOs) were met (Table 3). Validation entailed evaluation of relative percent differences between field duplicates and lab splits. Acceptable precision is outlined in Table 5.

Data Results 2012

Verification

Verification of data found it to be consistent, correct, and complete, with no errors or omissions. Results of QC were calculated and found to be within acceptable tolerance. Hence, established criteria for QC results were met. Data qualifiers were properly assigned by laboratory and by field personnel as needed. Data specified in Sampling Process Design were obtained. Methods and protocols specified in the QA Project Plan were followed.

Validation

Data validation found no anomalies. Method quality objectives were met with a Relative Standard Difference (RSD) of replicates to within the ± 30% tolerance range (Table 3). Duplicate analysis of percent relative difference was within RSD of ± 30%.

Table 3 – Replicate Analysis for 2012

	FC cfus/100 mL	
Date	**Site**	**Replicate**
1/23/2012	18	14
2/6/2012	55	25
3/5/2012	530	8
4/9/2012	5	15
5/7/2012	40	50
6/10/2012	40	35
7/3/2012	420	370
8/13/2012	60	20
9/17/2012	150	130
10/8/2012	40	130
11/5/2012	430	550
12/3/2012	10	10
Average:	**150**	**113**
Standard:	**192.394**	**171.909**
Relative Standard Difference:	**128.406**	**152.02**
Samples Collected:	**48**	
Field Replicates Collected:	**12**	
Field replicates:	**25% for sampling period**	
RSD = 128.4 at ± 30%:	**± 38.5**	

Field Sampling

Field sampling started in October 2007 through the end of 2012. One station was added for Little Swamp Creek in 2010. No unusual observations were detected. For summary of data, see Appendix A. Staff typically sampled on the first Monday or Tuesday of each month. At times this shifted to later in the month due to staff availability.

Laboratory Results

Results of sampling are tabulated in Table 4. In 2008, E. Coli was added to the sample matrix for trend analysis. Highlighted in red font are geometric means that exceed State water quality standards of less than 50 Fecal Coliform colonies per 100 mL or having a geometric mean of 90th percentile greater than 100 Fecal Coliform colonies per 100 mL.

Table 4 – Annual Results for Fecal Coliform Bacteria Sampling. Reported as geometric mean (GMV) of Fecal Coliform bacteria per 100 mL for North and Swamp Creek sample locations. Red indicates exceedance of State water quality standards.

	2006-7 Dry Season				2007 Wet Season (Spring)			
Monitoring Location	# of Samples	FC/100ml GMV	90th percentile	E.Coli/ 100ml	# of Samples	GMV	90th percentile	E. Coli 100/ml
SARU	10	209	632	NSF	9	42	109	NSF
JOCO	10	55	173	NSF	10	7	35	NSF
MONT	10	187	510	NSF	10	93	207	NSF
	2008 Dry Season				2007-08 Wet Season Fall to spring			
SARU	3	107	122	NSF	7	192	452	NSF
JOCO	3	53	205	NSF	7	43	272	NSF
MONT	3	127	173	NSF	7	62	192	NSF
	2009 Dry Season				2008-09 Wet Season Fall to spring			
SARU	8	983	4460	863	8	178	1329	339
JOCO	8	92	2124	89	8	11	80	10
MONT	8	254	1180	239	8	124	581	103
	2010 Dry Season				2009-10 Wet Season Fall to spring			
SARU	5	145	1496	120	7	97	290	106
JOCO	5	40	214	35	7	18	45	17
MONT	5	111	852	99	7	98	230	83
LSWP	5	47	268	43	Not Applicable			
	2011 Dry Season				2010-11 Wet Season Fall to spring			
SARU	4	56	253	53	8	22	105	22
JOCO	4	14	50	14	8	11	29	11
MONT	4	39	590	36	8	23	91	23
LSWP	4	76	414	72	8	37	185	35
	2012 Dry Season				2011-12 Wet Season Fall to spring			
SARU	4	142	1302	119	8	26	54	24
JOCO	4	91	342	82	8	17	180	17
MONT	4	234	596	185	8	24	246	21
LSWP	4	291	2935	245	8	63	346	55

State water quality standards: geometric mean < 50 cfu/100ml and upper tenth percentile < 100 cfu/100ml. There are no state water quality standards for E. Coli.

The trend for dry weather sampling saw a dramatic increase in Fecal Coliform bacteria concentrations in 2009, with a nearly equal decrease in 2010. In 2009, the largest increase of approximately ten-fold occurred in SARU (Figure 8). The high reading for all sites preceded a period of 70-days of clear dry days. The lack of precipitation occurred during hot weather period that included the hottest day in Seattle's history of 103 degrees F that dated back to 1891. On August 10 and 11th, 2009 approximately 0.45 inches of rain fell. The fecal bacteria samples were collected on August 11, 2009. The other sites in 2009 increased over 2008 levels approximately two-fold, but fell back to near 2008 concentration levels. In 2011 dry weather concentrations increased over 2010 levels. In 2012 there was a slight decrease over 2011 except for Junco and North Creek which both saw a slight increase.

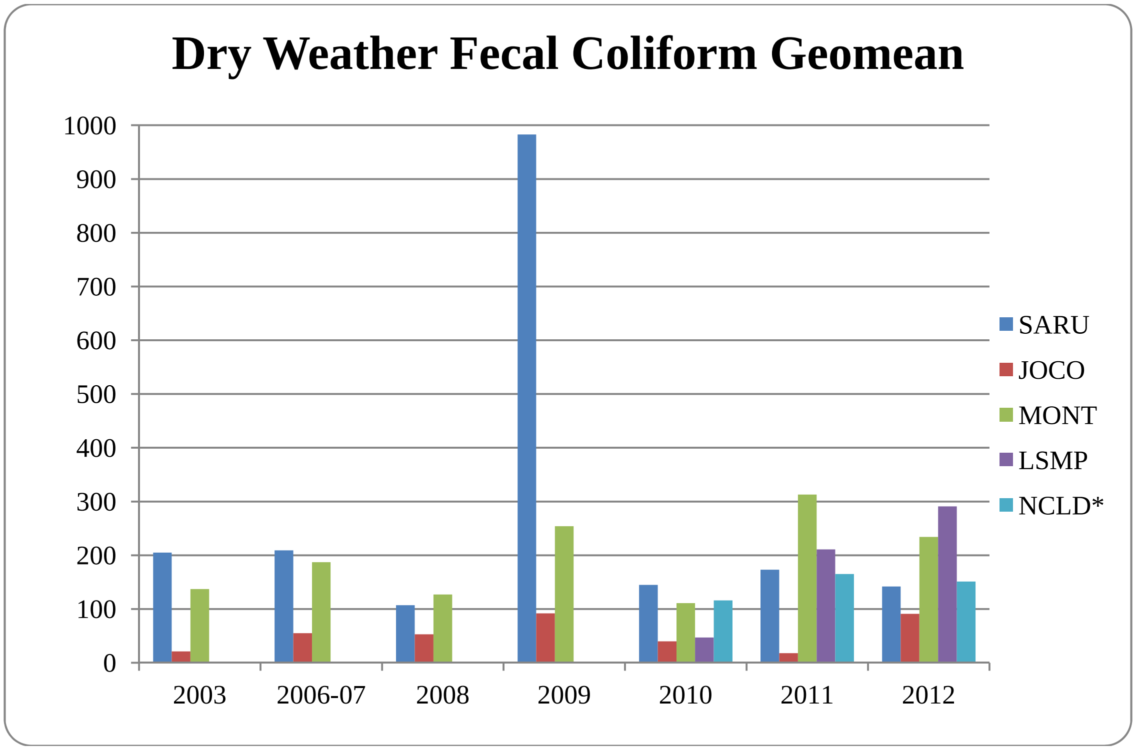

Figure 8 – Dry weather Fecal Coliform geometric mean bar chart, 2003 to 2012. * Data from Snohomish County Surface Water Management report.

Wet weather sampling, October through the following May (Figure 9), shows an overall downward trend since 2007 with a slight increase in 2012. Wet weather period is from October through May. There are no current reliable means to determine the cause of decrease in wet weather fecal coliform concentrations.

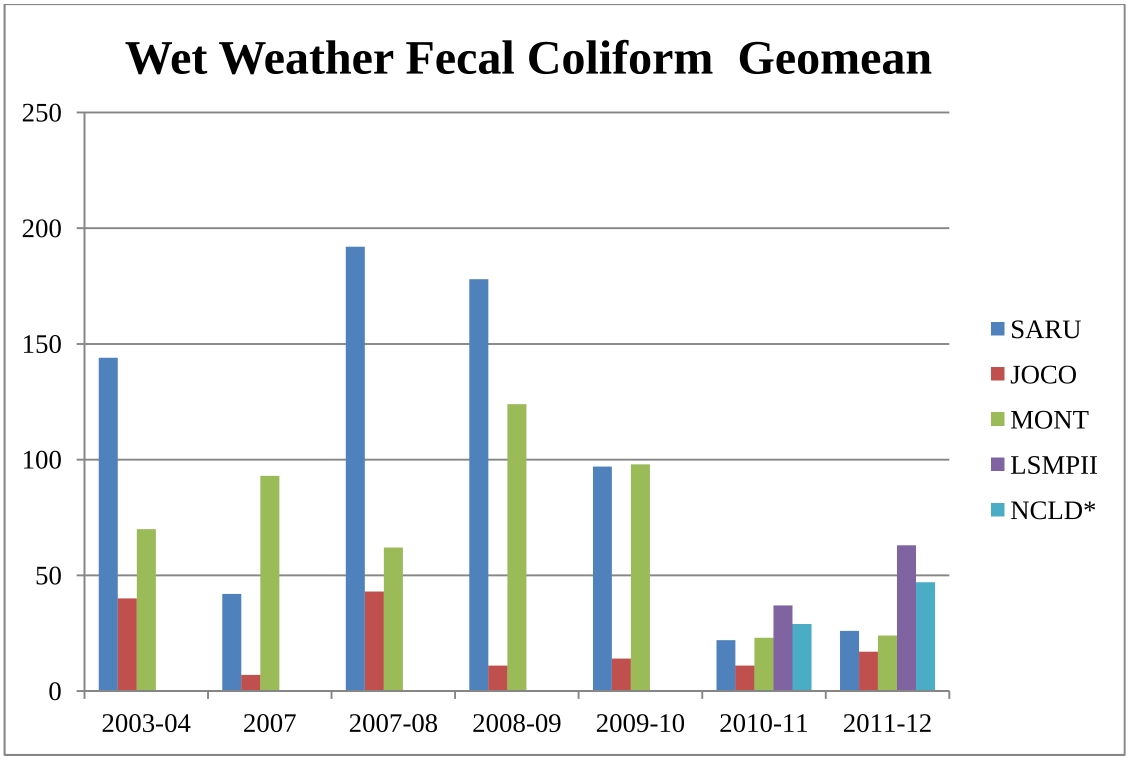

Figure 9 – Wet weather Fecal Coliform geometric mean bar chart, 2003 to 2012.

Annual Fecal Coliform concentrations reflect the spike in 2009 with concentration levels dropping in 2010 to below 2008 levels (Figure 10). Levels stayed low for 2010 and 2011 with a slight increase in 2012.

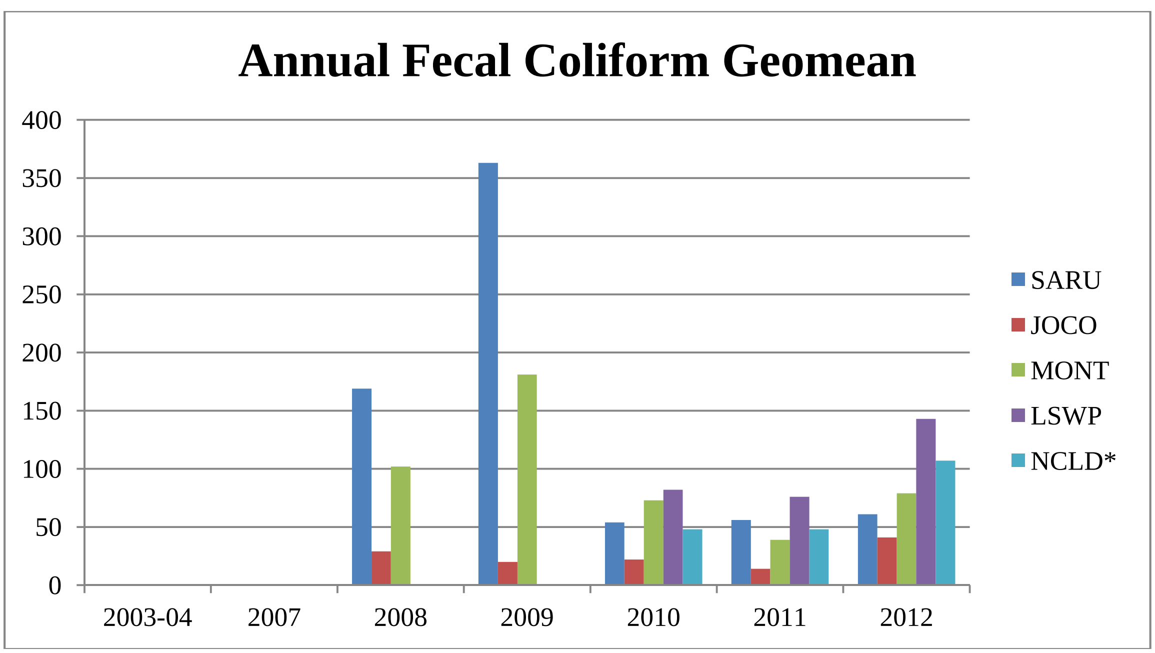

Figure 10 – Annual Fecal Coliform geometric mean bar chart, 2008 to 2012.

Water year period is from October 1st to September 31st of the following year. The Washington Department of Ecology utilizes the water year as standard protocol for assessing water quality data such as fecal coliform bacteria. The trend for available years is an overall general decrease in fecal coliform bacteria (Figure 11.)

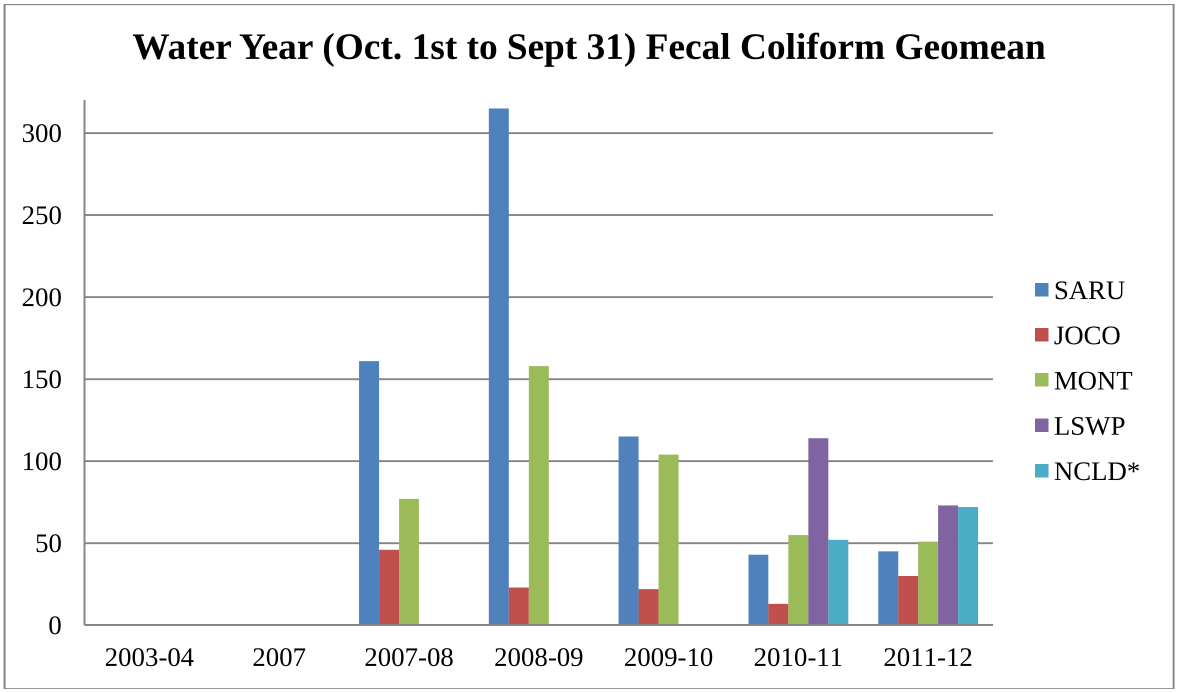

Figure 11 – Water Year (Oct. through Sept.) Fecal Coliform geometric mean bar chart, 2008 to 2012.

Source Tracking Surveys

North Creek, Perry Creek Watershed

Snohomish County prepared a report summarizing their findings from their source tracking efforts of 2010, (SCSWM, 2010).

"The Perry Creek Source Contaminant Survey did not expose significant point sources for fecal coliforms. Phase one of the survey found that elevated fecal coliform results were attributed to dry weather storm events and phase two found that there are potential non-point sources for bacteria within the drainage area, including a potentially large population of wildlife within the wetland and forested areas of the Perry Creek drainage, pet waste, and potential nutrient loading from residential lawns and parks. These findings suggest that the City's long term monitoring station, SARU, should be re-ranked with a MWQA score of C2, indicating a low likelihood of fecal coliform bacteria contamination posing human health risk.

A MWQA ranking of C2 dictates that routine monitoring and source tracking for bacteria should continue at SARU (Figure 7). As part of the continued effort to eliminate anthropogenic sources of bacteria, the City might consider the following action items;

- Locate parcels within the drainage area that have not hooked up to the sewer system and coordinate with the Health district to document the status of their drain fields.
- Spatially track water quality complaints within the area to isolate potential hotspots within the drainage area.
- Focus education and outreach efforts for proper pet waste handling in areas were unpicked pet waste was observed.
- Consider providing pet waste receptacles in City parks and along City walking trails.
- Review or development of a nutrient management plan for City parks, specifically Stipek Park to reduce alleviate nutrient loading to the Green Acres Ponds.
- Continue to implement illicit discharge detection and elimination program to further isolate and remove sources of bacteria.
- Follow up on organic scum found in segment 3 in the commercial area to rule out an intermittent illicit discharge as a source.
- Continue scheduled operations and maintenance on the storm sewer as outlined in the City's storm water management plan.
- Maintain silted catch basins within segment 4.

In 2011 the City followed up on the recommendations. Efforts were undertaken in all categories and noted below.

- Geographic Information System updated with sewer and septic data layer.
- The city routinely tracks all water quality complaints.
- Multiple media sources were used to increase awareness throughout the city over need to properly manage pet wastes.
- Pet waste receptacles were installed at most City parks on a volunteer refill schedule.
- City parks department is reviewing nutrient management at all park facilities, including Stipek.
- Follow up survey of organic scum in segment 3 was no longer an issue.
- City operations division routinely cleans and maintains the storm water system throughout the city. Maintenance efforts have increased over the past several years in response to the National Pollution Discharge Elimination System Permit requirements.
- Catch basins in segment 4 received maintenance service in 2011.

The completion of the listed action items may further reduce the anthropogenic sources of fecal coliform bacteria within the Perry Creek Drainage and could result in a lower MWQA ranking in the future.

Swamp Creek (Little Swamp Creek)

Sampling in 2010 for Little Swamp Creek revealed a general decrease in abundance of bacteria from an upstream duck pond to the stream crossing at 7th Avenue SE. Analysis from multiple sampling occurrences pinpointed the pond as the most likely source of the high bacteria levels. Figure 12 identifies locations sampled and Table 5 provides concentration of Fecal Coliform bacteria.

The pond is located in a popular shopping district. It was observed that people often came to the pond solely to feed the ducks. The owner of the shopping district has been actively trying to discourage this activity over the years. They have limited the ability of shop owners to sell duck feed, and installed landscaping to discourage the ducks from exiting the pond and defecating in areas that people congregate and walk.

The owner, under the City's behest, has taken several more steps towards eliminating the feeding of the ducks. One step is to be the installation of interpretive signs. The sign was designed and installed at the pond in September 2011. An outside vending dispenser of duck food was removed in early 2011. It is expected that through continual monthly sampling and working with the owner, there will be a decrease in Fecal Coliform bacteria concentrations.

A consequence of these efforts is that the City looked at several other locations along the Sammamish River to install similar signs to discourage visitors to the river from feeding the ducks. The Park at Bothell Landing and Sammamish River Trailhead parking lot are historically popular locations where people come to feed ducks. One sign was placed in 2011 at Bothell Landing Park of the Sammamish River. The decrease of feeding ducks should result in a decrease in Fecal Coliform bacteria concentrations in the Sammamish River.

Sampling in 2012 downstream of the ponds found levels of fecal coliform bacteria elevated especially during the summer time. Site visits in 2012 to the duck pond found counts of water fowl remained high. People, typically women with small children, continued to feed the ducks while ignoring the sign, Do Not Feed the Ducks. In 2013 the City will attempt in person to provide education outreach to visitors of the duck pond to discourage them from feeding the waterfowl.

Table 5 – Little Swamp Creek 2010 Fecal Coliform Sample Results.
(Samples taken by WDOE and City of Bothell)

See Figure 11 for locations. Table reads left to right in downstream direction.

	Fecal Coliform Bacteria #/100ml							
	Site							
Date	LSWCVP	LSWCVPS	LSWCPS	LSW240	LSWP	LSW7A1	LSW7A2	LSW7AW
1/12/2010					120			
2/9/2010					40			
3/23/2010					10			
4/27/2010					850			
6/8/2010					10			
7/20/2010	12,000	7100	960	970				
8/3/2010					15			
8/10/2010		11000	970	30000			270	
8/31/2010					250			
9/14/2010	6700	4000	1300	730			200	
9/28/2010					280			
10/11/2010	22000	13000	3500	4300		680	2100	1100

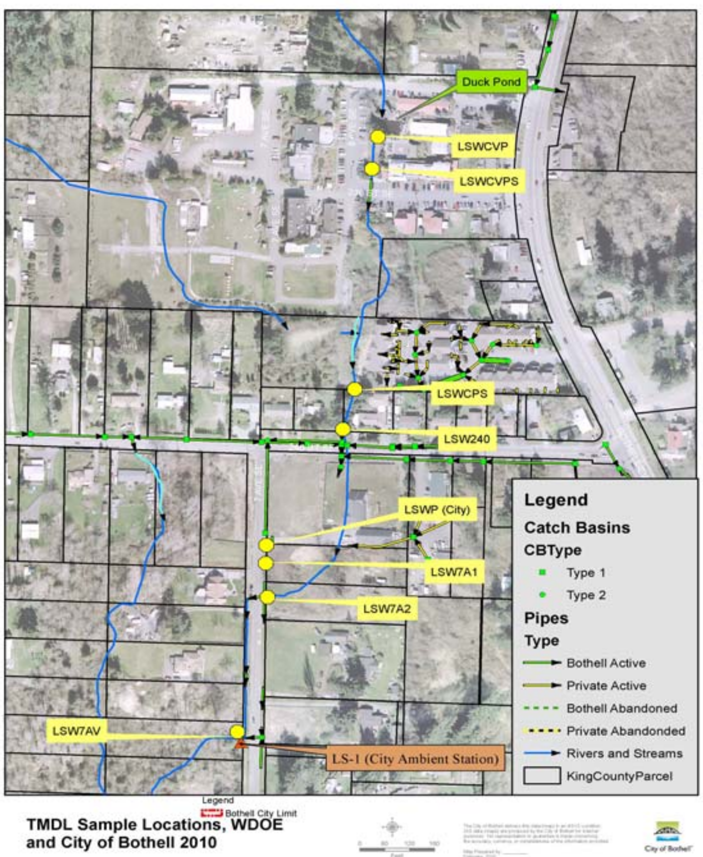

Figure 12 – Fecal Coliform bacteria sample locations within upper headwaters of Little Swamp Creek, 2010.

North Creek, Queens Borough (aka Crystal) Creek Watershed

Snohomish County prepared a report summarizing their findings from their source tracking efforts of 2012, (SCSWM, 2012).

In 2012 the City conducted an analysis of fecal coliform data collected from 2003 – 2007 and found that 63 percent of samples (n=38) collected on Crystal (Queens Borough) Creek, located 100ft upstream of the confluence with North Creek (Figure 13), exceeded the 100 colony water quality standard for extraordinary primary recreational contact. Ongoing monitoring of water quality, habitat and biological metrics on Crystal/Queens Borough Creek has been conducted by the City. The Cities 2010 Stream Health report ranked the creek as severely impaired based upon an esoteric impairment score. http://www.ci.bothell.wa.us/Site/Content/Public%20Works/Surface%20Water%20Mgmt/fnlrptStreamHealth2010.pdf

Based upon these assessments, the City requested the County conduct a Contaminant Source Survey (CSS) on Crystal/Queens Borough Creek to identify potential sources of fecal coliform bacteria. Crystal/Queens Borough Creek is a tributary to North Creek. It is located completely within the City of Bothell's jurisdiction and, from its' confluence with North Creek to headwaters, is approximately 1.6 miles in length. The sub-basin is dominated by high density commercial and residential land use and crosses west to east under Interstate 405 and Bothell Everett Highway prior to its' confluence with North Creek. While the stream's upper reaches are forested within a deep ravine, its' highly impervious nature and density of storm sewer systems suggest potential for a degraded stream system. Based upon data collected in 2003, Ecology's 2008 assessment listed segment 45735 of Crystal/Queens Borough Creek as impaired for fecal coliform bacteria.

The Crystal/Queensborough Creek CSS did not identify active discharges to the creek. Potential discharges of human waste from spalling sewer standpipes and human use were observed. No evidence domestic or wild animals were observed. Data review (2003-2007) found that standards are most frequently exceeded during the dry season. The City discontinued sampling the creek in 2007. As resources allow, the City should consider re-establishing a monthly sampling effort for fecal coliform bacteria over a minimum period of one year at the historic location. This effort and volume of data would be sufficient for analysis in accordance with WAC 173-201A and the WQP. Current conditions may suggest attainment of standards, corroborating the lack of observing any direct or ongoing discharges during the CSS. Newly acquired data which suggests attainment of standards could be submitted to Ecology during the freshwater call for data (mid-2016) to potentially change the listing category from 4a (impaired) to 1 (non-impaired). A non-impaired status would reduce the Cities programmatic obligations under future NPDES permits to reduce discharges of fecal coliform bacteria from the municipal stormwater system.

The City is encouraged to confirm suspected discharge of un-polluted sump discharge from the power transformer located in the park and ride on the south side of segment one. This could be accomplished by obtaining drainage system as-builts for the park and ride and power transformer on the south side of segment one and visiting the three inch PVC pipe during a rain event.

It is recommended the City coordinate with the local sewer district to determine risk of sewage ex-filtration, overflow or mixing with surface waters during high flow within segment three.
An effort to re-examine the upper reaches of segment three to confirm presence of human encampments and potential impacts would be beneficial. A stream clean up effort would help determine current or ongoing encampments or temporary use.

The City should consider focusing illicit discharge detection and elimination programs within the Crystal/Queensborough Creek sub-basin. Focused screening of the six known City outfalls, discharging to the creek, may trigger additional source tracking. Ongoing stormwater drainage system maintenance as required by the Cities Phase II NPDES permit may help reduce the discharge of pollutants from City drainage systems. Illicit discharge detection and elimination cross training of municipal staff responsible for maintenance would help identify potential discharges, and possibly improve efficiency.

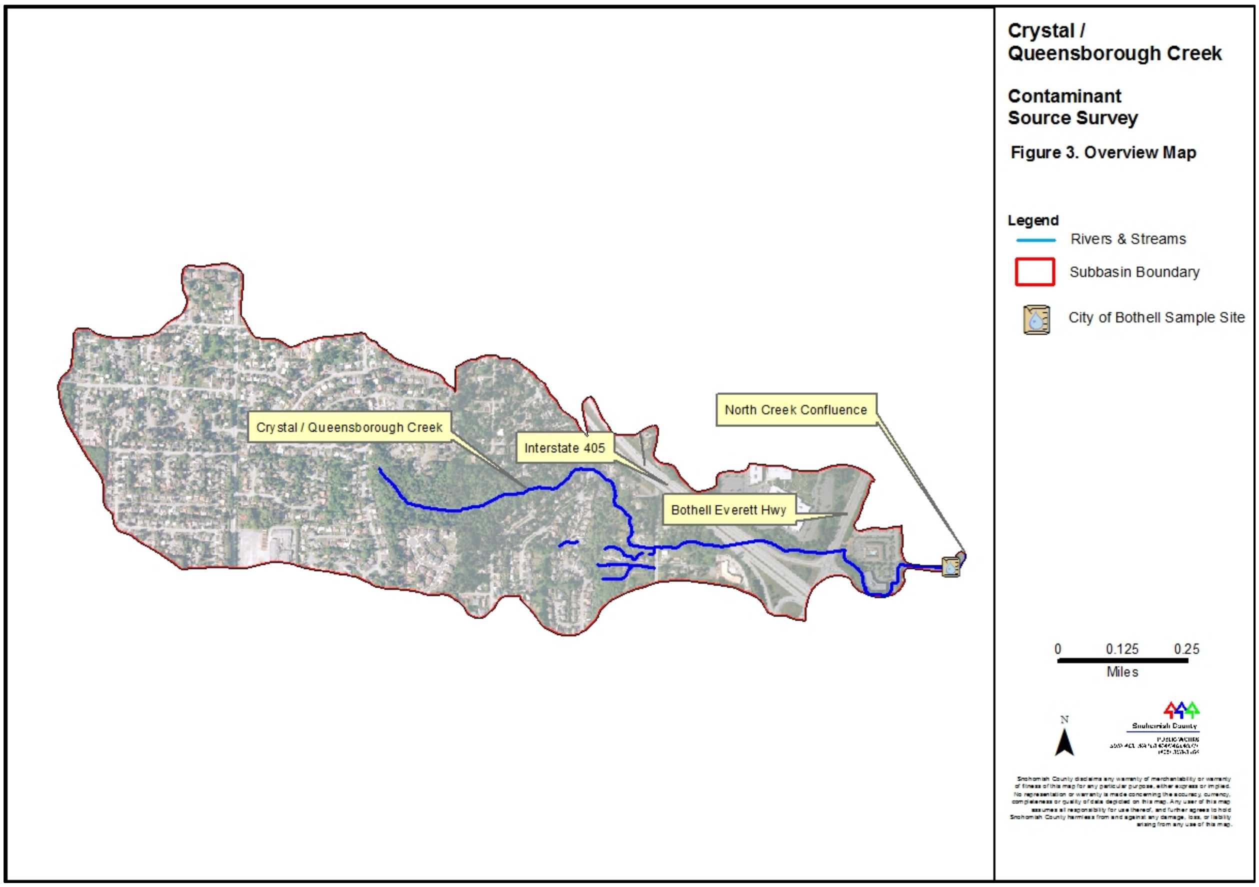

Figure 13. Queens Borough Creek Watershed

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Appendix A

Field Data

North Creek TMDL Sample Results.

Site	Date	Time	Strm Gage Ht, Ft.	Water Temp C	Comments	FC CFU/100ml	E. Coli CFU/100ml	Total Coliform	
JOCO	10/1/2007	11:00	0.64			73			
JOCO	11/5/2007	9:35	0.7	9	Rain over 3-days ago.	16			
JOCO	12/12/2007	9:30	0.5	7		220			
JOCO	1/7/2008	10:10	0.51	7		350		490	
JOCO	2/4/2008	10:05	0.6	6		24			
JOCO	3/3/2008	9:40	0.4	9	clear visibility	Faulty lab			
JOCO	3/10/2008	10:37	0.6	9.5	lite rain	Faulty lab			
JOCO	4/7/2008	9:40	0.6	9	lite rain	4			
JOCO	5/5/2008	10:10	0.55	12		31			
JOCO	6/2/2008	10:12	0.55	12		5			
JOCO	July*				No Sampling Conducted				
JOCO	8/12/2008	10:10	0.6	14.5	no rain past 24-hours	130	87		
JOCO	9/2/2008	10:18	0.6	12		224	220	460	
JOCO	10/14/2008	9:53	0.78	10.5		41	41	120	
JOCO	11/18/2008	10:37	0.8	11	rain in past 24-hours	15	15	150	
JOCO	12/9/2008	10:16	0.8	9		5	4	25	
JOCO	1/13/2009	10:19	0.8	9	Light rain in past 24-hrs	28	22	40	
JOCO	2/10/2009	10:32	0.7	6.5	Lite snow in past 24-hrs	4	4	10	
JOCO	3/10/2009	9:50	0.7	4.5	Snow in past 24-hrs	2	2	40	
JOCO	4/14/2009	9:24	0.7	8.5	Rain in past 24-hours	2	2	18	
JOCO	5/5/2009	10:05	0.8	10.5	Heavy rain in past 24-hrs	170	170	270	
JOCO	6/9/2009	9:05	0.6	13	Sunny no rain	10	10	190	
JOCO	7/7/2009	10:02	0.6	13.5	Light rain in past 24-hrs	30	30	260	
JOCO	8/11/2009	8:55	0.7	14	Rain	3000	2600	4800	
JOCO	9/8/2009	9:15	0.6	13		80	80	1100	
JOCO	10/6/2009	9:10	0.7	9.5		10	10	20	< 10 use value 10
JOCO	11/17/2009	9:45	1	10	Heavy flood raining	10	10	1700	
JOCO	12/15/2009	10:10	0.9	6	Rain in past 24-hrs	10	10	7500	< 10 use value 10
JOCO	1/12/2010	10:00	0.8	9	Heavy rain in past 24-hrs	10	10	1800	
JOCO	2/19/2010	9:40	0.42	8	no rain past 24-hours	20	20	300	
JOCO	3/23/2010	9:35	0.62	9	no rain past 24-hours	10	10	20	< 10 use value 10
JOCO	4/27/2010	9:45	0.62	11	rain in past 24-hrs	56	44	100	
JOCO	6/8/2010	9:20	0.6	12	rain in past 24-hrs	2	2	100	
JOCO	7/6/2010	10:00	0.62	12.5	light rain in past 48-hrs	42	36	140	
JOCO	8/3/2010	9:05	0.6	14	no rain , fog	55	45	280	
JOCO	8/31/2010	9:45	0.64	12.5	rain heavy at times	310	270	3500	
JOCO	9/28/2010	9:40	0.64	14	rain in past 48-hrs	70	60	1300	
JOCO	10/26/2010	9:45	0.66	10	rain in past 48-hrs	10	10	100	< 10 use value 10
JOCO	11/16/2010	9:55	0.72	10	rain in past 48-hrs	10	10	<100	
JOCO	12/14/2010	9:35	0.72	9	flooding in past 48-hrs	10	10	<100	
JOCO	1/25/2011	9:40	0.64	9	Rain in past 24-hrs	5	5	20	< 5 use value of 5
JOCO	2/15/2011	10:05	0.66	7.5	rain in past 48-hrs	50	45	480	
JOCO	3/22/2011	9:45	0.64	8	rain in past 48-hrs	20	20	180	
JOCO	4/19/2011	9:40	0.66	9	rain in past 48-hrs	5	5	140	< 5 use value of 5
JOCO	5/17/2011	9:30	0.66	10	rain in past 48-hrs	10	10	440	
JOCO	6/14/2011	10:57	0.6	12.5	light rain past 24-hrs	20	20	60	
JOCO	7/11/2011	11:46	0.6	13.5	light rain past 24-hrs	8	8	90	
JOCO	8/8/2011	12:05	0.6	13.9	no rain in past 48-hrs	10	10	260	
JOCO	9/26/2011	9:27	0.65	13	rain at times	70	70	14	
JOCO	10/10/2011	11:56	0.65	11.5	rain in past 24-hrs	30	30	300	
JOCO	11/14/2011	10:55	0.7	8.3	rain in past 48-hrs	5	5	180	
JOCO	12/5/2011	9:45	0.7	5.5	no rain in past 48-hrs	10	10	20	
JOCO	1/23/2012	2:00	0.72	6.3	Rain in past 24 hrs	18	18	260	
JOCO	2/6/2012	9:56	.75 cfs	5.7	no rain in past 48-hrs	10	10	180	
JOCO	3/5/2012	9:50	.75 cfs	8.2	rain	530	500	1500	
JOCO	4/9/2012	10:54	1.25 cfs	10.5	no rain in past 48-hrs	5	5	20	
JOCO	5/7/2012	10:39	.75 cfs	11.1	no rain in past 48-hrs	10	10	90	
JOCO	6/10/2012	11:35	1 cfs	12.6	no rain in past 24 hrs	10	10	270	
JOCO	7/3/2012	10:17	1 cfs	12.6	Heavy rain in past 24-hrs	420	360	3600	
JOCO	8/13/2012	11:25	.75cfs	15	No rain in past 23 days	160	160	1200	
JOCO	9/17/2012	10:25	.75 cfs	12.5	No rain in 57 days (?)	100	80	600	
JOCO	10/8/2012	10:50	.75 cfs	10.3	no rain, 77 day drought	220	190	700	
JOCO	11/5/2012	9:51	1.25 cfs	12	rain in past 24 hrs	30	30	100	
JOCO	12/3/2012	10:30	1.5 cfs	9.1	Heavy rain in past-24-hrs	10	10	300	

	Geo Mean/100-ml			FC
JOCO	FC	90th Pertil	E.Coli	% samples > 100 cfu
Wet 07/08	43	272	N/A	29%
Wet 08/09	11	80	10	13%
Wet 09/10	14	34	14	0%
Wet 10/11	11	29	11	0%
Wet 11/12	17	180	17	13%
Dry 2008	53	205	N/A	67%
Dry 2009	92	2124	89	25%
Dry 2010	40	214	35	25%
Dry 2011	18	55	18	0%
Dry 2012	91	342	82	75%
Annual 08	29	236.6	34	30%
Annual 09	20	161	20	17%
Annual 10	22	68.6	20	8%
Annual 11	14	50	14	0%
Annual 12	41	400	39	42%
H2O Yr 07/08	46	237	N/A	40%
H2O Yr 08/09	23	161	21	16%
H2O Yr 09/10	22	69	20	8%
H2O Yr 10/11	13	47	13	0%
H2O Yr 11/12	30	394	29	33%

Little Swamp Creek TMDL Sample Results, 2010 to 2012

Site	Date	Time	Strm Gage Ht, Ft.	Water Temp C	Comments	FC CFU/100ml	E. Coli CFU/100ml	Total Coliform
LSMP	1/12/2010	9:20	.7 cfs	8	Heavy rains	**120**	**100**	**28000**
LSMP	2/9/2010	9:20	.4 cfs	8.5	no rain in past 24-hrs	**40**	**30**	**2000**
LSMP	3/23/2010	8:50	.3 cfs	9.5	no rain in past 24-hrs	**<10**	**<10**	**150**
LSMP	4/27/2010	8:40	.2 cfs	11	rain in past 24-hrs	**850**	**464**	**1400**
LSMP	6/8/2010	8:30	.06 CFS	13.5	rain in past 24-hrs	**10**	**10**	**260**
LSMP	7/6/2010	9:00	0.0008	14	light rain in past 48-hrs	**22**	**20**	**1400**
LSMP	8/3/2010	8:45	0.0008	16.5	no rain , fog	**15**	**15**	**280**
LSMP	8/31/2010	9:00	.16 cfs	16	rain heavy at times	**250**	**180**	**11000**
LSMP	9/28/2010	8:45	.08 cfs	17	rain in past 48-hrs	**280**	**260**	**19000**
LSMP	10/26/2010	8:55	.12cfs	13	rain in past 48-hrs	**90**	**80**	**3900**
LSMP	11/16/2010	9:00	.12cfs	11.5	rain in past 48-hrs	**170**	**170**	**1400**
LSMP	12/14/2010	8:55	3.5cfs	8.5	floods in past 48-hrs	**10**	**10**	**240**
LSMPII	1/25/2011	8:55	.2 cfs	8	rain in past 24-hrs	**75**	**65**	**1600**
LSMPII	2/15/2011	9:20	.2 cfs	6.5	rain in past 48-hrs	**5**	**5**	**1500**
LSMPII	3/22/2011	8:45	.2 cfs	8	rain in past 48-hrs	**5**	**5**	**160**
LSMPII	4/19/2011	8:55	.15 cfs	8	rain in past 48-hrs	**55**	**55**	**520**
LSMPII	5/17/2011	8:50	.22 cfs	11	rain in past 48-hrs	**220**	**195**	**3000**
LSMPII	6/14/2011	11.25	.02 cfs	14	light rain past 24-hrs	**85**	**80**	**760**
LSMPII	7/11/2011	16.5	.01 cfs	16.5	light rain past 24-hrs	**100**	**95**	**2900**
LSMPII	8/8/2011	11:05	.01 cfs	15.7	no rain in past 48-hrs	**270**	**245**	**4700**
LSMPII	9/26/2011	9:50	0.13	16	rain at times	**870**	**830**	**>1000**
LSMPII	10/10/2011	11:37	0.03	13	rain in past 24-hrs	**430**	**390**	**3100**
LSMPII	11/14/2011	10:18	0.05	8	rain in past 48-hrs	**200**	**170**	**1300**
LSMPII	12/5/2011	9:06	0.2	4.5	no rain in past 48-hrs	**10**	**10**	**160**
LSMPII	1/23/2012	11:40	1 cfs	4.7	Rain in past 24 hrs	**190**	**180**	**1600**
LSMPII	2/6/2012	9:18	.09 cfs	4.1	no rain in past 48-hrs	**55**	**50**	**210**
LSMPII	3/5/2012	9:30	.25 cfs	7.1	Rain	**6**	**4**	**210**
LSMPII	4/9/2012	11:59	.15 cfs	10.8	no rain in past 48-hrs	**15**	**15**	**210**
LSMPII	5/7/2012	10:00	.04 cfs	11	no rain in past 48-hrs	**310**	**245**	**660**
LSMPII	6/10/2012	10:55	0.04	13.9	no rain in past 48-hrs	**100**	**100**	**320**
LSMPII	7/3/2012	9:40	1cfs	14.2	heavy rains past 24hrs	**4000**	**2110**	**26000**
LSMPII	8/13/2012	10:49	5 gpm	17.7	no rain in past 23 days	**40**	**40**	**700**
LSMPII	9/17/2012	9:37	5 gpm	14.7	no rain in 57 days (?)	**450**	**430**	**4200**
LSMPII	10/8/2012	10:05	5 gpm	12.1	no rain, 77 day drought	**30**	**30**	**2700**
LSMPII	11/5/2012	10:09	.75cfs	12.9	rain in past 24 hrs	**430**	**400**	**1400**
LSMPII	12/3/2012	9:50	1.5 cfs	8.8	Heavy rains in past 24hrs	**2600**	**2150**	**2700**

	Geo Mean/100-ml			FC	
LSMPII	FC	90th Pertil	E.Coli	% samples > 100 cfu	
Wet 10/11	37	185	35	25%	LSMP/LSMI
Wet 11/12	63	346	55	50%	
Dry 2010	47	268	43	40%	LSMP
Dry 2011	211	690	198	75%	LSMPII
Dry 2012	291	2935	245	50%	LSMPII
Annual 10	68	280	58	42%	LSMP
Annual 11	76	414	72	50%	LSMPII
Annual 12	143	2385	123	58%	LSMPII
H2O Yr 10/11	66	265	63	42%	
H2O Yr 11/12	105	448	91	58%	

North Creek TMDL Sample Results from autumn 2007 to December 2012

Site	Date	Time	Strm Gage Ht, Ft.	Water Temp C	Comments	FC CFU/100ml	E. Coli CFU/100ml	Total Coliform
MONT	10/1/2007	10:45	0.53			**33**		
MONT	11/5/2007	9:45	0.58	9		**78**		
MONT	12/12/2007	9:20	0.6	7		**28**		
MONT	1/7/2008	9:50	0.6	7		**16**		**100**
MONT	2/4/2008	10:12	0.4	7		**100**		
MONT	3/3/2008	9:30	0.6	9	Light rain in past 24-hrs	Faulty lab		
MONT	3/10/2008	10:44	0.4	10		Faulty lab		
MONT	4/7/2008	9:50	0.6	9		**330**		
MONT	5/5/2008	10:20	0.45	11		**90**		
MONT	6/2/2008	10:26	0.4	11		**95**		
MONT	July*				No Sampling Conducted			
MONT	8/12/2008	10:19	0.42	12.5		**114**	**57**	
MONT	9/2/2008	10:29	0.48	11		**188**	**190**	**370**
MONT	10/14/2008	10:07	0.46	10		**82**	**74**	**160**
MONT	11/18/2008	10:49	0.46	10		**125**	**120**	**260**
MONT	12/9/2008	10:29	0.46	9		**120**	**96**	**200**
MONT	1/13/2009	10:38	0.5	8.5	Light rain in past 24-hrs	**118**	**71**	**120**
MONT	2/10/2009	10:43	0.5	7	Light snow in past 24-hrs	**30**	**20**	**40**
MONT	3/10/2009	10:11	0.5	5.5	Snow in past 24-hrs	**40**	**36**	**80**
MONT	4/14/2009	9:41	0.5	9	Rain in past 24-hours	**230**	**230**	**264**
MONT	5/5/2009	10:22	0.6	10.5	Heavy rain in past 24-hrs	**1400**	**1300**	**1800**
MONT	6/9/2009	9:31	0.5	11.5	Sunny no rain	**100**	**100**	**100**
MONT	7/7/2009	10:16	0.4	11.5	Light rain in past 24-hrs	**200**	**180**	**840**
MONT	8/11/2009	9:10	0.5	12	Rain	**1600**	**1400**	**4800**
MONT	9/8/2009	9:36	0.4	11.5		**130**	**130**	**1400**
MONT	10/6/2009	9:25	0.5	9		**120**	**110**	**320**
MONT	11/17/2009	10:00	0.7	9	Heavy flood raining	**230**	**230**	**2600**
MONT	12/15/2009	10:25	0.5	7.5	Rain in past 24-hrs	**230**	**120**	**3900**
MONT	1/12/2010	10:15	0.9	9	Heavy rain in past 24-hrs	**210**	**180**	**2600**
MONT	2/9/2010	9:55	0.5	8	No rain in past 24-hrs	**<10**	**<10**	**600**
MONT	3/23/2010	9:50	0.5	9	No rain in past 24-hrs	**10**	**10**	**80**
MONT	4/27/2010	10:05	0.5	10.5	rain in past 24-hrs	**68**	**62**	**390**
MONT	6/8/2010	9:40	0.48	11	rain in past 24-hrs	**110**	**86**	**790**
MONT	7/6/2010	10:15	0.48	11	light rain in past 48-hrs	**22**	**18**	**430**
MONT	8/3/2010	9:35	0.46	12	no rain , fog	**180**	**180**	**620**
MONT	8/31/2010	10:05	0.5	11.5	rain heavy at times	**1300**	**1120**	**8400**
MONT	9/28/2010	9:55	0.46	12	rain in past 48-hrs	**30**	**30**	**1700**
MONT	10/26/2010	10:00	0.46	10	rain in past 48-hrs	**60**	**60**	**600**
MONT	11/16/2010	10:10	0.44	10	rain in past 48-hrs	**70**	**70**	**200**
MONT	12/14/2010	10:05	0.8	9	floods in past 48-hrs	**30**	**30**	**800**
MONT	1/25/2011	10:00	0.52	9	rain in past 24-hrs	**5**	**5**	**320**
MONT	2/15/2011	10:25	0.58	8	rain in past 48-hrs	**10**	**10**	**360**
MONT	3/22/2011	10:00	0.5	8.5	rain in past 48-hrs	**10**	**10**	**280**
MONT	4/19/2011	9:55	0.46	9	rain in past 48-hrs	**10**	**10**	**180**
MONT	5/17/2011	9:45	0.5	10	rain in past 48-hrs	**140**	**125**	**1300**
MONT	6/14/2011	11:05	0.5	11	light rain past 24-hrs	**130**	**120**	**1100**
MONT	7/11/2011	12:02	0.4	11.5	light rain past 24-hrs	**120**	**115**	**1500**
MONT	8/8/2011	12:18	0.45	12	no rain in past 48-hrs	**640**	**580**	**2800**
MONT	9/26/2011	9:37	0.45	11.5	rain at times	**960**	**900**	**>1000**
MONT	10/10/2011	12:01	0.4	11	rain in past 24-hrs	**20**	**10**	**400**
MONT	11/14/2011	11:05	0.4	8.8	rain in past 48-hrs	**10**	**10**	**400**
MONT	12/5/2011	9:52	0.45	6.5	no rain in past 48-hrs	**10**	**10**	**220**
MONT	1/23/2012	1:50	5.5	6.4	rain in past 24 hrs	**24**	**22**	**380**
MONT	2/6/2012	10:05	1.5 cfs	6.9	no rain in past 48-hrs	**10**	**10**	**350**
MONT	3/5/2012	10:09	2 cfs	8.4	rain	**680**	**650**	**1200**
MONT	4/9/2012	10:40	2 cfs	9.9	no rain in past 48-hrs	**5**	**5**	**70**
MONT	5/7/2012	10:48	2.2 cfs	10.7	no rain in past 48-hrs	**60**	**60**	**570**
MONT	6/10/2012	12:06	1.5 cfs	11.6	no rain in past 24 hrs	**540**	**525**	**1700**
MONT	7/3/2012	10:25	2.5 cfs	12.2	Heavy rain in past 24-hrs	**620**	**400**	**4000**
MONT	8/13/2012	11:35	2 cfs	12.5	no rain in past 23 days	**60**	**40**	**300**
MONT	9/17/2012	10:35	1.5 cfs	11.3	no rain in 57 days (?)	**150**	**140**	**1200**
MONT	10/8/2012	10:59	1.25 cfs	10.1	no rain, 77 day drought	**230**	**220**	**800**
MONT	11/5/2012	10:21	2.25 cfs	11.5	rain in past 24 hrs	**30**	**30**	**100**
MONT	12/3/2012	11:01	2.5 cfs	9	Heavy rain in past 24-hrs	**60**	**60**	**300**

	Geo Mean/100-ml			FC
MONT	FC	90th Pertile	E.Coli	% samples > 100 cfu
Wet 07/08	62	192	N/A	29%
Wet 08/09	124	581	103	63%
Wet 09/10	98	230	83	50%
Wet 10/11	23	91	23	13%
Wet 11/12	24	246	21	13%
Dry 2008	127	173	N/A	67%
Dry 2009	254	1180	239	100%
Dry 2010	111	852	99	60%
Dry 2011	313	864	291	100%
Dry 2012	234	596	185	75%
Annual 08	102	202.2	98	44%
Annual 09	181	1283	152	83%
Annual 10	73	210	67	33%
Annual 11	39	590	36	42%
Annual 12	79	612	72	42%
H2O Yr 07/08	77	202	N/A	40%
H2O Yr 08/09	158	1283	137	58%
H2O Yr 09/10	104	230	90	58%
H2O Yr 10/11	55	590	54	42%
H2O Yr 11/12	51	612	44	33%

North Creek TMDL Sample Results, from autumn 2007 to December 2010

Site	Date	Strm Time	Gage Ht, Ft.	Water Temp C	Comments	FC CFU/100ml	E. Coli CFU/100ml	Total Coliform
SARU	10/1/2007	10:30	0.22		Rained night before	**500**		
SARU	11/5/2007	9:05	1.02	9		**160**		
SARU	12/12/2007	9:00	1.4	6	lrge flood event 12/3	**22**		
SARU	1/7/2008	9:40	1.8	6	periods rain past 3-days	**97**		**330**
SARU	2/4/2008	9:50	1.2	5	no rain past 2-days	**330**		
SARU	3/3/2008	9:20	1.2	8	Slight turbid color	Faulty lab		
SARU	3/10/2008	10:30	1.1	9.5		Faulty lab		
SARU	4/7/2008	9:30	1.5	9		**400**		
SARU	5/5/2008	9:50	1.1	11	rain in past 2-days	**420**		
SARU	6/2/2008	9:54	1	12	no rain past 2-days	**120**		
SARU	July*	No Sampling Conducted			Switched laboratory			
SARU	8/12/2008	9:55	0.94	15		**122**	**100**	
SARU	9/2/2008	9:42	0.96	12.5		**83**	**42**	**450**
SARU	10/14/2008	9:36	1.2	11	rain in past 24-hours	**146**	**130**	**220**
SARU	11/18/2008	10:07	1.5	11		**145**	**140**	**230**
SARU	12/9/2008	9:57	1.4	8.5	lite rain In past 24-hours	**135**	**120**	**265**
SARU	1/13/2009	9:55	2.1	8	light rain in past 24-hrs	**32**	**22**	**150**
SARU	2/10/2009	10:09	1.3	5	Lite snow in past 24-hrs	**94**	**70**	**220**
SARU	3/10/2009	9:28	1.3	3	Snow in past 24-hrs	**116**	**81**	**160**
SARU	4/14/2009	9:08	1.8	8	Rain in past 24-hours	**270**	**270**	**448**
SARU	5/5/2009	9:43	3.1	11	Heavy rain in past 24-hrs	**3800**	**3400**	**5500**
SARU	6/9/2009	8:45	1	13	Sunny no rain	**200**	**200**	**500**
SARU	7/7/2009	9:40	1	14	Light rain in past 24-hrs	**720**	**600**	**1100**
SARU	8/11/2009	8:34	1.4	17	Rain	**5900**	**4200**	**12000**
SARU	9/8/2009	8:52	1.1	14		**1100**	**1100**	**5900**
SARU	10/6/2009	8:50	1.1	9.5		**350**	**310**	**960**
SARU	11/17/2009	9:30	>3.0	9	Heavy flood raining	**250**	**210**	**3000**
SARU	12/15/2009	9:50	1.7	5	Rain in past 24-hrs	**180**	**50**	**20000**
SARU	1/12/2010	9:45	> 3.0	8	flooded sample site	**180**	**150**	**5200**
SARU	2/9/2010	10:10	1.3	7.5	erosion at sample location	**20**	**20**	**500**
SARU	3/23/2010	9:15	1.26	8.5	no rain past 24-hrs	**10**	**<10**	**190**
SARU	4/27/2010	9:20	1.8	11.5	rain in past 24-hrs	**140**	**142**	**740**
SARU	5/1/2010				No Sample			
SARU	6/8/2010	9:00	1.4	12.5	rain in past 24-hrs	**140**	**102**	**770**
SARU	7/6/2010	9:40	1.16	12.5	light rain in past 48-hrs	**64**	**60**	**1000**
SARU	8/3/2010	8:20	1.1	14.5	no rain , fog	**75**	**65**	**800**
SARU	8/31/2010	9:30	1.56	14.5	rain heavy at times	**2400**	**2100**	**4400**
SARU	9/28/2010	9:15	1.12	16	Rain in past 48-hrs	**40**	**30**	**2000**
SARU	10/26/2010	9:25	1.32	10	Rain in past 48-hrs	**20**	**20**	**500**
SARU	11/16/2010	9:25	1.54	10	Rain in past 48-hrs	**10**	**10**	**300**
SARU	12/20/2010	9:35	1.68	6.5	week after 10-yr storm event	**10**	**10**	**240**
SARU	1/25/2011	9:20	1.98	8.5	Rain in past 24-hrs	**10**	**10**	**680**
SARU	2/15/2011	9:50	2.56	6.5	rain in past 24-hrs	**15**	**15**	**1800**
SARU	3/22/2011	9:15	1.82	7	Rain in past 48-hrs	**20**	**20**	**400**
SARU	4/19/2011	9:20	1.7	8	Rain in past 48-hrs	**30**	**30**	**420**
SARU	5/17/2011	9:10	2	11	Rain in past 48-hrs	**280**	**275**	**2200**
SARU	6/14/2011	10:40	1.18	13.5	light rain past 24-hrs	**260**	**250**	**980**
SARU	7/11/2011	11:26	1.1	13	light rain past 24-hrs	**190**	**185**	**840**
SARU	8/8/2011	11:50	1.1	14.5	no rain in past 48-hrs	**140**	**140**	**2700**
SARU	9/26/2011	9:17	1.15	13.5	rain at times	**130**	**120**	**200**
SARU	10/10/2011	11:48	1.2	12	rain in past 24 hrs	**30**	**20**	**500**
SARU	11/14/2011	10:47	1.4	8.5	Rain in past 48-hrs	**85**	**85**	**1100**
SARU	12/5/2011	9:31	1.3	5	Dry for 48-hours	**15**	**15**	**180**
SARU	1/23/2012	2:10	2	5	Rain in past 24 hrs	**16**	**16**	**480**
SARU	2/6/2012	9:50	2 cfs	4	no rain in past 48-hrs	**15**	**15**	**110**
SARU	3/5/2012	9:49	1.75 cfs	7.5	rain, turbid flows	**14**	**14**	**1400**
SARU	4/9/2012	11:17	1.25 cfs	9.1	no rain in past 48-hrs	**35**	**30**	**80**
SARU	5/7/2012	10:27	1.75 cfs	10.5	no rain in past 48-hrs	**40**	**40**	**1500**
SARU	6/10/2012	11:20	1 cfs	12	no rain in past 24 hrs	**40**	**40**	**1000**
SARU	7/3/2012	10:05	4 cfs	14	Heavy rain in past 24-hrs	1800	**950**	**10000**
SARU	8/13/2012	11:13	.5 cfs	15	no rain in past 23 days	**40**	**40**	**800**
SARU	9/17/2012	10:05	1 cfs	13	no rain for 57 days (?)	**140**	**130**	**1000**
SARU	10/8/2012	10:39	.75 cfs	10.5	no rain, 77 day drought	**40**	**40**	**500**
SARU	11/5/2012	9:39	3 cfs	12.7	turbid, rain in past 24hrs	**220**	**210**	**2300**
SARU	12/3/2012	10:17	4.5 cfs	8.5	Heavy rain in past 24-hrs	**160**	**150**	**400**

11/16/2010: <10, use value of 10

12/20/2010: <10, use value of 10

SARU	**Geo Mean/100-ml** FC	90th %-tile	E.Coli	FC % samples > 100 cfu
Wet 07/08	192	452	N/A	71%
Wet 08/09	178	1329	150	75%
Wet 09/10	97	290	106	71%
Wet 10/11	22	105	22	13%
Wet 11/12	26	53.5	24	0%
Dry 2008	107	121.6	65	67%
Dry 2009	983	4460	863	100%
Dry 2010	145	1496	120	40%
Dry 2011	173	239	167	100%
Dry 2012	142	1302	119	50%
Annual 08	168.7	402	98	80%
Annual 09	363	3530	277	83%
Annual 10	54	176	57	33%
Annual 11	56	253	53	42%
Annual 12	61	214	56	33%
H2O Yr 07/08	161	428	65	70%
H2O Yr 08/09	315	3530	268	58%
H2O Yr 09/10	115	340	112	58%
H2O Yr 10/11	43	253	43	42%
H2O Yr 11/12	45	135	41	17%

*In July 2008 switched labs from Test America to AmTest
**Used Junco for Sample Value

North Creek TMDL Sample Results, from autumn 2007 to December 2010						Duplicates			Site Replicate Values			Replicate Value RPD for FC	Duplicate Value RPD for FC	Duplicate's Relative Percent Difference			
Site	Date	Comments	FC CFU/100ml	E. Coli CFU/100ml	Total Coliform	FC	E. Coli	Total Coliform	FC	E.Coli	Total FC	FC	FC	FC	EC	TC	
DOGC	10/1/2007	* replicate for MONT	**210**														
DOGC	11/5/2007	*replicate for SARU	**330**														
DOGC	12/12/2007	* replicate for MONT	**51**														
DOGC	1/7/2008	or JOCO,lost cap discard	**No Data**														
DOGC	2/4/2008	*replicate for MONT	**130**														
DOGC	3/3/2008	*replicat for SARU	Faulty lab														
DOGC	3/10/2008	*replicat for SARU	Faulty lab														
DOGC	4/7/2008	*replicat for SARU	**100**														
DOGC	5/5/2008	*Replicate for JOCO	**21**														
DOGC	6/2/2008	*replicate for MONT	**95**														
DOGC	July	No Sampling Conducted															
DOGC	8/12/2008	*replicate for SARU	**118**	**79**													
DOGC	9/2/2008	*replicate for JOCO	**170**	**170**	**380**												
DOGC	10/14/2008	*replicate for MONT	**102**	**100**	**180**												
DOGC	11/18/2008	*replicate for SARU	**185**	**170**	**240**												
DOGC	12/9/2008	*replicate JOCO	**10**	**8**	**40**												
DOGC	1/13/2009	Replicate for MONT	**126**	**88**	**150**	**20**	**16**	**40**	**118**	**71**	**120**	6.6%					
DOGC	2/10/2009	Replicate for SARU	**90**	**80**	**190**	**102**	**80**	**230**	**94**	**70**	**220**	4.3%					
DOGC	3/10/2009	Replicate for JOCO	**8**	**6**	**60**	**8**	**6**	**80**	**2**	**2**	**40**	120					
DOGC	4/14/2009	Replicate for MONT	**140**	**140**	**244**	**180**	**170**	**234**	**230**	**230**	**264**	48.6					
DOGC	5/5/2009	Replicate SARU	**5100**	**4600**	**5900**	**4900**	**4500**	**6700**	**3800**	**3400**	**5500**	29.2					
DOGC	6/9/2009	Replicate for JOCO	**100**	**<100**	**<100**	**<100**	**<100**	**<100**	**10**	**10**	**190**	163.6					
DOGC	7/7/2009	Replicate for MONT	**220**	**200**	**820**	**170**	**170**	**780**	**200**	**180**	**840**	9.5					
DOGC	8/11/2009	Replicate JOCO	**2900**	**2600**	**3900**	**2700**	**2400**	**3300**	**3000**	**2600**	**4800**	3.4					
DOGC	9/8/2009	Replicate for SARU	**800**	**800**	**5900**	**1300**	**1300**	**5000**	**1100**	**1100**	**5900**	31.6					
DOGC	10/6/2009	Replicate for JOCO	**10**	**<10**	**<20**	**<10**	**<10**	**20**	**10**	**10**	**20**	0					
DOGC	11/17/2009	Replicate for MONT	**470**	**400**	**2100**	**420**	**350**	**1200**	**230**	**230**	**2600**	68.6					
DOGC	12/15/2009	Replicate for SARU	**150**	**80**	**21000**	**120**	**70**	**22000**	**180**	**50**	**20000**	18.2					
DOGC	1/12/2010	Replicate for JOCO	**10**	**10**	**960**	**<10**	**<10**	**1200**	**10**	**10**	**1800**	0.0					
DOGC	2/9/2010	Replicate for MONT	**10**	**10**	**700**	**<10**	**<10**	**900**	**10**	**10**	**600**	0.0					
DOGC	3/23/2010	Replicate for LSMP	**10**	**10**	**290**	**<10**	**<10**	**260**	**10**	**10**	**150**	0.0					
DOGC	4/27/2010	Replicate for SARU	**230**	**138**	**850**	**220**	**154**	**730**	**140**	**142**	**740**	48.6					
DOGC	6/8/2010	Replicate for SARU	**40**	**30**	**610**	**25**	**20**	**600**	**140**	**102**	**770**	111.1					
DOGC	7/6/2010	Replicate for MONT	**64**	**56**	**280**	**70**	**62**	**250**	**22**	**18**	**430**	97.7					
DOGC	8/3/2010	Replicate for JOCO	**40**	**35**	**380**	**5**	**5**	**260**	**55**	**45**	**280**	31.6					
DOGC	8/31/2010	Replicate for SARU	**2000**	**1540**	**3600**	**2300**	**1780**	**3100**	**2400**	**2100**	**4400**	18.2					
DOGC	9/28/2010	Replicate for MONT	**10**	**10**	**1600**	**<10**	**<10**	**1400**	**30**	**30**	**1700**	100.0					
DOGC	10/26/2010	Replicate for JOCO	**90**	**90**	**900**	**120**	**110**	**600**	**10**	**10**	**100**	160.0					
DOGC	11/16/2010	Replicate for SARU	**30**	**30**	**100**	**10**	**10**	**200**	**10**	**10**	**300**	100.0					
DOGC	12/14/2010	Replicate for MONT	**10**	**10**	**700**	**50**	**40**	**1600**	**30**	**30**	**800**	100.0					
DOGC	1/25/2011	Replicate for JOCO	**5**	**5**	**240**	**15**	**10**	**340**	**5**	**5**	**20**	0.0					
DOGC	2/15/2011	Replicate for SARU	**20**	**20**	**1400**	**10**	**10**	**1700**	**15**	**15**	**1800**	28.6					
DOGC	3/22/2011	Replicate for MONT	**5**	**5**	**440**	**5**	**5**	**440**	**10**	**10**	**280**	66.7					
DOGC	4/19/2011	Replicate for JOCO	**5**	**5**	**180**	**< 5**	**< 5**	**180**	**5**	**5**	**140**	0.0					
DOGC	5/17/2011	Replicate for SARU	**160**	**150**	**820**	**160**	**150**	**820**	**280**	**275**	**2200**	54.5					
DOGC	6/14/2011	Replicate for MONT	**120**	**105**	**1300**	**140**	**125**	**1500**	**130**	**120**	**1100**	8.0					
DOGC	7/11/2011	Replicate for LSMPII	**230**	**225**	**2500**	**195**	**40**	**2200**	**100**	**95**	**2900**	78.8					
DOGC	8/8/2011	Replicate for JOCO	**5**	**5**	**160**	**5**	**5**	**240**	**10**	**10**	**260**	66.7					
DOGC	9/26/2011	Replicate for LSMP	**1300**	**1210**	**1300**	**2200**	**950**	**1000**	**870**	**830**	**1000**	39.6					
DOGC	10/10/2011	Replicate MONT	**30**	**30**	**400**	**60**	**50**	**1300**	**20**	**10**	**400**	40.0					
DOGC	11/14/2011	Replicate for LSMPII	**180**	**120**	**1100**	**200**	**145**	**860**	**200**	**170**	**1300**	10.5					
DOGC	12/5/2011	Replicate for SARU	**25**	**25**	**180**	**20**	**20**	**120**	**15**	**15**	**180**	50.0					
DOGC	1/23/2012	Replicate for JOCO	**14**	**14**	**250**	*140*	*140*	*1800*	**18**	**18**	**260**	25.0	**30**	**30**	**25**	**12**	LSMPII Duplicate
DOGC	2/6/2012	Replicate for LSMPII	**25**	**20**	**240**	**15**	**15**	**270**	**55**	**50**	**210**	75.0	**50**	**50**	**29**	**12**	
DOGC	3/5/2012	Replicate for JOCO	**8**	**4**	**210**	**6**	**4**	**170**	**530**	**500**	**1500**	194.1	**29**	**29**	**0**	**21**	
DOGC	4/9/2012	Replicate for MONT	**15**	**15**	**80**	**5**	**5**	**120**	**5**	**5**	**70**	100.0	**100**	**100**	**100**	**40**	
DOGC	5/7/2012	Replicate for SARU	**50**	**50**	**1700**	**50**	**50**	**1600**	**40**	**40**	**1500**	22.2	**0**	**0**	**0**	**6.1**	
DOGC	6/10/2012	Replicate for SARU	**35**	**35**	**810**	*100*	*100*	*320*	**40**	**40**	**1000**	13.3	**18**	**18**	**9.5**	**21**	LSMPII Duplicate
DOGC	7/3/2012	Replicate for JOCO	**370**	**190**	**2100**	*3800*	*2850*	*30000*	**420**	**360**	**3600**	12.7	**5.1**	**5.1**	**30**	**14**	LSMPII Duplicate
DOGC	8/13/2012	Replicate for MONT	**20**	**20**	**1200**	**40**	**40**	**1100**	**60**	**40**	**300**	100.0	**67**	**67**	**67**	**8.7**	
DOGC	9/17/2012	Replicate for MONT	**130**	**120**	**1000**	**110**	**100**	**900**	**150**	**140**	**1200**	14.3	**17**	**17**	**18**	**11**	
DOGC	10/8/2012	Replicate for SARU	**130**	**120**	**800**	**1800**	**50**	**50**	**40**	**40**	**500**	105.9	**50**	**50**	**50**	**40**	
DOGC	11/5/2012	Replicate for LSMPII	**550**	**500**	**2900**	**2200**	**600**	**600**	**430**	**400**	**1400**	24.5	**27**	**27**	**8.7**	**18**	
DOGC	12/3/2012	Replicate for JOCO	**10**	**10**	**600**	**400**	**10**	**10**	**10**	**10**	**300**	0.0	**40**	**40**			