Snohomish County
Total Maximum Daily Load Monitoring
Quality Assurance Project Plan

Snohomish River Tributaries, Stillaguamish Basin, North, Swamp and Little Bear Creek TMDL Coverage Areas
2015 – 2018

Prepared by

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Program and Publication Information

The monitoring activities described in this Quality Assurance Project Plan (QAPP) are triggered by the Federal Water Pollution Control Act (Clean Water Act) Title 33 United States Code, Section 1251 et seq. and Appendix 2 (Total Maximum Daily Loads) of the 2013-2018 National Pollutant Discharge Elimination Systems Phase 1 Municipal Stormwater Permit issued to Snohomish County by the Washington State Department of Ecology (Ecology). The program is funded by surface water fees collected by Snohomish County Public Works under the authority of the Revised Code of Washington RCW 36.89 and 90.72 and codified in Snohomish County Code Title 25.

This plan is available on Snohomish County’s website at: http://snohomishcountywa.gov/Archive.aspx?AMID=73

Data for this project is uploaded to Ecology’s Environmental Information Management (EIM) database at www.ecy.wa.gov/eim/index.htm.

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Distribution List

Electronic copies of the finalized QAPP and potential updates will be provided to the partners identified in Table 1. The laboratory manager is responsible for distributing the QAPP to personnel within their organization.

Table 1. Distribution List

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<th>Name</th>
<th>Title</th>
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<tbody>
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<td>Steve Britsch</td>
<td>Project Manager</td>
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<td>Department of Ecology</td>
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<td>Permit Specialist</td>
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Introduction and Problem Statement

In 1990, the Environmental Protection Agency (EPA) promulgated regulations for the National Pollutant Discharge Elimination System (NPDES) Phase 1 municipal stormwater discharge permit program in response to the 1987 amendments to the Clean Water Act (CWA). The Phase 1 municipal stormwater permit is a type of permit known as a "general permit," which is a single set of permit conditions applicable to multiple entities that must obtain coverage. The Phase 1 NPDES permit applies to municipalities that own or operate municipal separate storm sewer systems (MS4’s) that serve an area with a population of 100,000 or more.

In Washington State, the Department of Ecology (Ecology) is responsible for administering all NPDES permits. In 1995, Ecology issued the first NPDES Phase I municipal stormwater permit developed under which six cities and counties, including Snohomish County, were required to obtain coverage.

In the years between 1995 and 2008, Ecology determined that numerous waterbody segments in Snohomish County did not meet existing water quality standards for fecal coliform bacteria (FCB). As required by the CWA, Ecology developed FCB Total Maximum Daily Load (TMDL) water cleanup plans in the Snohomish River Tributaries, North Creek, Swamp Creek, Little Bear, and Stillaguamish coverage areas. The TMDLs identify the percent reductions in fecal coliform bacteria needed to achieve water quality standards.
In 2013, Ecology reissued the Phase 1 municipal stormwater permit. The 2013-2018 NPDES permit requires developing and implementing a water quality monitoring program that samples streams and/or discharges from stormwater conveyances within the Stillaguamish, Snohomish Tributaries, North, Swamp, and Little Bear Creek TMDL coverage areas to:

- characterize the receiving waters or waste stream,
- contribute to long term trends evaluation of FCB and,
- identify and eliminate sources of bacterial pollution.

This FCB focused QAPP is written to guide the water quality monitoring program to address requirements in the NPDES permit, assure the reliability of measurement data, and move towards achievement of water quality standards for FCB.

Snohomish County Surface Water Management (SWM) is currently assessing and re-structuring water resource monitoring programs. This QAPP addresses a small part of Surface Water Management’s anticipated overall water resource monitoring program. This QAPP may be updated and re-submitted to Ecology for approval as necessary to reflect changes related to NPDES permit required TMDL monitoring.

**Background**

Pursuant to the federal Clean Water Act (CWA), Ecology has adopted water quality standards found in Washington State Administrative Code (Chapter 173-201A) for FCB in order to reduce human health risk.

Fecal coliform bacteria are a subset of bacteria that are present in the feces of warm blooded animals and which belong to the larger group of *enterobacteriacea (total coliforms)*. They are used as an indicator of the sanitary quality of water because they are associated with pathogens found in feces. A pathogen is a microbe, virus or other organism that is known to cause disease. Examples of bacterial pathogens frequently found in storm water runoff or surface waters include *Shigellis* and *Salmonella*.

Water quality standards for FCB within the Lower Snohomish River Tributaries are classified as extraordinary primary or primary contact for recreation and are expected to meet numeric criteria for those classifications. North, Swamp and Little Bear Creek waters are expected to meet extraordinary primary contact standards because they are tributaries to Lake Washington. Bacteria standards for TMDL coverage areas where monitoring will take place are identified in table 2.
Since 1992, SWM has collected water quality data streams and rivers, including FCB. These data were used by Ecology to determine many stream segments do not meet water quality standards for FCB. Therefore, as required by section 303d of the CWA, Ecology listed impaired segments within the Stillaguamish and Snohomish River Tributaries, North, Swamp, and Little Bear Creeks.

There are many types of potential bacterial pollution sources in the TMDL basins including, but not limited to, direct discharge or deposit to streams of domesticated and wild animal feces, runoff from manure stockpiles or manure-fertilized land, unauthorized discharges or leaks from sanitary sewers, discharges from on-site sewage treatment systems and re-suspension of contaminated sediments. Some of these discharges may be conveyed by Snohomish County’s municipal storm sewer system and others may be discharged directly to the stream. The challenge is determining the primary source of FCB within a given municipal stormwater system, receiving waterbody or associated stream segment, and acting to remove sources such that water quality standards are attained.

Given the inherent complexity and difficulty in isolating and eliminating sources of FCB pollution, this QAPP employs the use of a Decision Support Tool (PBS&J 2008) or phased approach, for monitoring and source identification of FCB to determine sources of contamination within the study areas. The PBS&J (2008) protocol was modeled after similar approaches developed by the World Health Organization (WHO 2000, 2003), the National Research Council (NRC 2004) and Environmental Protection Agency (EPA 1983, 1984, 2004, 2006). The approach is described under the experimental design section of this QAPP.
Study Areas

Snohomish River Tributaries
The Snohomish River basin (WRIA 7) encompasses 1,856 square miles and is the second largest basin in Washington State draining to Puget Sound. In Snohomish County, the three primary rivers in the basin flowing from the west slope of the Cascade mountains are the Skykomish River, the Snoqualmie River, and the Snohomish River. These rivers and many smaller rivers such as the Pilchuck River, the Sultan River, and the Wallace River provide significant habitat for five salmon species, three trout species and one char species. Over 1,730 tributary rivers and streams have been identified in the Snohomish River basin, totaling approximately 2,718 miles in length (Williams et al. 1975).

Historical land uses in the basin have been mainly agriculture and forest related, but are being rapidly developed for residential and commercial use. Increased urbanization and land development activities are impacting water quality in the basin with riparian corridor alteration, conversion of forests, inadequate retention/detention of stormwater from new impervious surfaces, and poorly treated stormwater run-off (Wright et. al. 2001).

Wright et. al. (2001) identified that 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. The Snohomish River tributaries are susceptible to agricultural nonpoint pollution with large rural areas and farmland in the watershed. Approximately 20 dairies are located within the Snohomish River Tributaries as well as numerous commercial livestock and small farms. Many areas of the watershed have poor soils for locating on-site septic systems, resulting in failing or inadequate septic systems that may also contribute pollutants. Stormwater from urban areas may carry pet wastes to nearby streams. Urban development is continually increasing in certain areas of the Snohomish River Tributaries and water quality impacts from urban stormwater runoff are increasing. The watershed is also rich in wildlife, such as waterfowl, elk, deer, and beaver. A portion of FCB found in Snohomish River tributaries will originate from these natural sources (Wright et al. 2001).
**Quilceda Creek and Allen Creeks**

Quilceda and Allen Creeks flow south through the city of Marysville. The combined area of the watershed is about 49 square miles with Quilceda Creek draining roughly 38 square miles of land and Allen Creek about 11 square miles. Both streams enter the Snohomish River delta near Marysville. The upper portions of both the Quilceda and Allen watersheds have a significant amount of agricultural and rural land uses while the lower watersheds are rapidly urbanizing with increased amounts of residential and commercial development. About half of the city of Arlington contributes to the Quilceda watershed—due to the porous soils in the area much of that stormwater is infiltrated and thus recharges groundwater supplies to feed Quilceda Creek. Approximately fifty-three (53) percent of the Quilceda/Allen watershed is in unincorporated Snohomish County (Svrjcek, 2003a).

Surface Water Management monitored water quality at several locations within Quilceda and Allen Creek sub-basins from 2010 – 2014. Figures 1 and 2 show sub-basin locations, sampling locations, and their microbial water quality rank relative to waters listed in 2012 as impaired for FCB.
Figure 1. Quilceda Creek Sub-basin
Figure 2. Allen Creek Sub-basin
**French Creek Sub-basin**

As described by Svrjcek (2003a), French Creek flows westerly for approximately 11 miles and encompasses about 28 square miles. French Creek drains a portion of south central Snohomish County north and west of the city of Monroe and southeast of the city of Snohomish, some of which is part of the Snohomish River floodplain. A small portion of the French Creek sub-basin is located within the city of Monroe, leaving roughly eighty-nine (89) percent of the basin within unincorporated Snohomish County. Discharge of French Creek to the Snohomish River at about river mile 15 is controlled by a pumping station that is operated and maintained by the French Slough Flood Control District. The lower portion of the French Creek sub-basin flows through the flat Snohomish River floodplain where much of the stream network has been straightened and channeled for agricultural purposes. Agricultural practices and lack of stream buffers along the lower reaches of the creek are causing water quality problems. The upper three-quarters of the French Creek sub-basin above the Snohomish River floodplain flow over gentle, largely forested slopes. Rural development in the upper watershed has more recently become significant, increasing runoff from land clearing and residential development activities. The land uses in the upper reaches of the drainage are primarily a mix of residential development, small farms and pastures, forested areas, and equestrian centers. Commercial agriculture, dairies, and duck hunting preserves dominate the lower reaches.

Surface Water Management monitored water quality at several locations within the French Creek sub-basin from 2010 – 2014. Figure 3 shows the sub-basin location, sampling locations, and their microbial water quality rank relative to waters listed in 2012 as impaired for FCB.
Figure 3. French Creek Sub-basin
**Pilchuck Sub-basin**

As described in Svrjeck (2003a), the Pilchuck River flows 39 miles west and south from the western slopes of the Cascades to the Snohomish River and drains about 130 square miles of land (Figure 4). Approximately 96 percent of the total Pilchuck Watershed lies within unincorporated Snohomish County. An average annual discharge of 364 cfs makes the Pilchuck River the largest tributary to the Snohomish River. The city of Granite Falls operates a wastewater treatment plant (WWTP), which discharges secondary treated effluent to the river. The discharge from the Granite Falls WWTP is located more than 6 miles upstream from the upper-most segment of the Pilchuck River on the 303(d) list. The upper Pilchuck River watershed is generally considered to be of high quality. The cities of Lake Stevens, Snohomish, and Granite Falls contribute stormwater to the Pilchuck River. Historically, the Pilchuck River has had a good riparian buffer. Low-density residential development and small farms dominate the land use in the basin. Urbanization is taking place around Lake Stevens, the city of Snohomish, and the town of Granite Falls.

Surface Water Management monitored water quality at several locations within the Pilchuck River basin from 2010 – 2014. Figure 4 shows the sub-basin location, sampling locations, and their microbial water quality rank relative to waters listed in 2012 as impaired for FCB.
Figure 4. Pilchuck River basin
Woods Creek Sub-basin

Woods Creek, near Monroe flows into the Skykomish River just upstream of the confluence with the Snoqualmie River (approx. river mile 25). Draining about 62 square miles of land, Woods Creek flows southerly from near Lake Roesiger entering the river at Monroe (Figure 5). Land use in the lower portion of the creek is mostly residential (around Monroe) and rural residential with some small-scale, noncommercial farms and several equestrian centers. Land use in the upper portion of the drainage is low-density rural residential, small farms, and tree farms. Just over sixty-three (63) percent of the Woods Creek watershed is within unincorporated Snohomish County (Svrjcek 2003a).

Surface Water Management monitored water quality at several locations within the Woods Creek sub-basin from 2010 – 2014. Figure 5 shows the sub-basin location, sampling locations, and their microbial water quality rank relative to waters listed in 2012 as impaired for FCB.
Figure 5. Woods Creek Sub-basin
Stillaguamish Basin
The Stillaguamish River basin (Figure 6) includes portions of Snohomish and Skagit Counties. The basin covers 1770km and extends from sea level to 2,086 meters in elevation on Whitehorse Mountain in the Squire Creek drainage. It is the fifth largest tributary to Puget Sound (Lawrence and Joy 2005). The Stillaguamish River has two major forks at river kilometer 28.6 (river mile 17.8); the North Fork drains 736 km², and the South Fork drains 660 km². Average annual precipitation in the watershed ranges from about 80 cm/year (about 30 inches/year) at lower elevations to about 380 cm/year (150 inches/year) at higher elevations (Lawrence and Joy 2005).

The primary riparian land use along the mainstem and lower reaches of the major forks is agriculture. The lower basin has diverse land uses, and most land is privately owned. Arlington (population est. 14,330) and Stanwood (population est. 4,190) have active urban growth areas. (Lawrence and Joy 2005). Stienbarger (1995) estimated there were at least 909 commercial and non-commercial farms in the lower basin. Agriculture is still quite active in the lower basin, but conversions from agriculture to rural residential or non-commercial farm uses are becoming common along the Interstate 5 corridor. The DNR controls approximately 72.5 km² (28 mi2) in the Pilchuck Creek sub-basin. Privately held forests are scattered throughout the upper reaches of other tributaries as well.

Surface Water Management monitored water quality at several locations throughout the Stillaguamish basin from 2010 – 2014. Figure 6 shows the sub-basin location, sampling locations, and their microbial water quality rank relative to waters listed in 2012 as impaired for FCB.
Figure 6. Stillaguamish Basin
North Creek Sub-basin
North Creek (Figure 7) comprises approximately 30 square miles, discharging to the Sammamish River, which is tributary to Lake Washington. 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 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 runoff (Svrjcek, 2003).

Surface Water Management monitored water quality at several locations throughout North Creek sub-basin from 2010 – 2014. Figure 7 shows the sub-basin location, sampling locations, and their microbial water quality rank relative to waters listed in 2012 as impaired for FCB.
Figure 7. North Creek Sub-basin
Swamp Creek Sub-basin
Swamp Creek subbasin (Figure 8) comprises approximately 24 square miles. Swamp Creek discharges to the Sammamish River, which empties to upper Lake Washington 0.7 miles below the Swamp Creek confluence. Swamp Creek flows through a narrow valley which gradually broadens to a floodplain almost ¾ of a mile 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 for 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 (Svrjcek 2006). In the late 1990s, 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 (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 (Svrjcek 2006).

Surface Water Management monitored water quality at two locations throughout Swamp Creek sub-basin from 2010 – 2014. Figure 8 shows the sub-basin location, sampling locations, and their microbial water quality rank relative to waters listed in 2012 as impaired for FCB.
Figure 8. Swamp Creek Sub-basin
Little Bear Creek Sub-basin

Little Bear Creek originates in Snohomish County, Washington, and flows southward for approximately 7.7 miles, where it empties into the Sammamish River near Woodinville, in King County (Figure 9). The drainage basin is fifteen square miles and covers approximately 9,600 acres. Approximately 80 percent of the Little Bear Creek watershed is located within Snohomish County; the rest (1,920 acres) is situated within the city limits of Woodinville in King County (Dettelbach and Garland 2005). In 2001, it was estimated that roughly 40 percent of the basin was forested and that 37 percent was covered with impervious surface such as pavement (Kerwin 2001). Considerable development pressures continue, however, and are likely to result in diminishing forest cover and increasing impervious surfaces. The creek’s overall gradient is very gradual, with an average slope of 0.8 percent (Woodinville 2004).

The creek’s upper mainstem is characterized by predominantly young deciduous riparian forest and contains numerous riparian wetlands (Woodinville, 2004). Land uses in the upper watershed include several small farms (many of which have horses and other livestock) and dog kennels. The middle portion contains some farms but is primarily residential in nature, with several new developments in place. The lower portion of the creek, especially the lower 2.2 miles, runs through the commercial portion of downtown Woodinville and is heavily urbanized and/or industrialized. Parts of the lower creek have been modified to straighten and control the channel (Woodinville, 2004). In 2004, King County received approval to site the Brightwater Wastewater Treatment Facility within the Little Bear Creek watershed. The facility became operational during the fall of 2012.

Surface Water Management monitored water quality at several locations throughout Little Bear Creek sub-basin from 2010 – 2014. Figure 9 shows the sub-basin location, sampling locations, and their microbial water quality rank relative to waters listed in 2012 as impaired for FCB.
Figure 9. Little Bear Creek Sub-basin
Logistical Problems

This study area poses several logistical problems related to the proactive identification and correction of bacterial and nutrient pollution. The first logistical problem is that much of the land bordering streams is privately owned. This may require county personnel to seek written permission from landowners to access any private properties for water quality sampling and source identification and elimination efforts. Only in extreme cases where public safety and health are at risk will Snohomish County exercise its authority to access private property without permission of the landowner.

Periods of dry weather often result in low or no stream flows which preclude sampling. The logistical constraint may impact the quality assurance completeness goal and ability to analyze bacteria data in a fashion consistent with WAC 173-201A and Ecology Water Quality Policy 1-11.

Previous or Ongoing Studies

Several organizations have historically or are currently monitoring water quality within the study areas. Summaries of SWM and partners monitoring efforts relevant to this QAPP are described below. Surface Water Management routinely coordinates with partners to share information and limit potential overlap.

Snohomish County Surface Water Management

Since 1992, SWM has collected water quality data monthly at various sites within each TMDL coverage area. The goal of this monitoring program has been to detect trends in FCB, dissolved oxygen, temperature, pH, conductivity, nutrients, sediment, and metals. Several historical reports are available and others are pending production. Long term ambient data is maintained in Ecology’s Environmental Information Management (EIM) system

https://fortress.wa.gov/ecy/eimreporting/Detail/Detail.aspx?DetailType=Study&Syst emProjectId=99970536

As a requirement of Snohomish County’s 2007-2012 NPDES permit, beginning in 2010, the County focused monitoring efforts to characterize, identify and eliminate sources of FCB. Summaries of County led efforts to identify and eliminate sources of FCB within TMDL coverage areas follow.
Snohomish River Tributaries
On March 9, 2011, a storm event producing .75 inches of rain over 24hrs occurred during a normally scheduled sample event in Woods Creek at Florence Acres road. Fecal coliform results exceeded 30,000 colonies. This single highest FCB result recorded by SWM during receiving water sampling, triggered bracketed sampling, source identification and follow up business inspections. Follow up multi-parameter bracketed sampling during storm and non-storm events did not result in conclusively identifying a source. However, GIS analysis indicated the potential for nearby animal handling facilities to contribute pollutants to Woods Creek. Follow up business inspections resulted in determining no potential for pollution.

Little Bear Creek Sub-basin
Annual FCB data analysis on July 2008 –December 2010, indicated that Little Bear Creek at 51st Ave (LBLU, Figure 9) was the poorest ranking monitoring location in 2011. The ranking triggered GIS analysis and source identification and elimination efforts. A total of 2 stream miles and several miles of County storm sewer infrastructure were surveyed for evidence illicit discharges or connections. Although sampling of discharges to the County MS4 was conducted, no sources of sewage were found. Seven parcels were initially identified to have potential for contributing animal sources of bacteria to Little Bear Creek. Referrals were made internally to the water quality complaint investigation and business inspection programs for follow up to confirm the potential to pollute. After inspection and coordination with Ecology and the Snohomish Conservation District, it was determined the likelihood of pollution did not warrant required best management practices. Additionally, the team coordinated with the SWM drainage capital improvement group to determine if funding was available to remove a previously man-made pond on the mainstem of Little Bear Creek where duck populations were believed to contribute pollutants. Funding sources were not available.

Swamp Creek Sub-basin
The 2007 NPDES Phase 1 municipal stormwater permit required Snohomish County to “Estimate changes in bacterial levels in Swamp Creek as a result of stormwater inputs through receiving water monitoring coupled with flow duration or comparable analyses.” The evaluation of flow, precipitation and FCB illustrated that exceedences of the FC standards at monitoring locations in Swamp Creek (Figure 8) appear more related to heavy precipitation events during the dry season rather than increased flow. These efforts support seasonal and annual FC data analysis. In an effort to target dry season sources of FC, SWM conducts dry weather illicit discharge detection and elimination efforts and contaminant source surveys targeted at pro-active identification and removal of sources of FCB. The 2013 – 2018 permit requires a continuation of these programs in support of objectives to reduce FCB levels in Swamp Creek.
**Stillaguamish Basin**

In 2011, the County led an effort to collect and analyze FCB data from all partners within the Stillaguamish basin. The goal was to identify areas to prioritize for proactive source identification efforts. Results of the analysis are found in a report titled Stillaguamish Basin Microbial Water Quality Assessment Revised FCB Data Summary Report (Britsch et. al. 2011), available at [http://snohomishcountywa.gov/documentcenter/view/7506](http://snohomishcountywa.gov/documentcenter/view/7506).

As driven by Britsch et. al. (2011) recommendations, in 2012, the County, City of Arlington, Ecology, and Snohomish Health District implemented source identification efforts in Portage Creek. The project raised awareness of issues in Portage Creek and identified six parcels where domestic animals created the potential for non-point source pollution. Of the six parcels, two received technical assistance to improve animal handling and land-use practices. No evidence of failing septic systems conveying FCB directly to Portage Creek was found.

In November 2013, the Washington State Departments of Health and Ecology awarded Snohomish County an EPA National Estuary Program Grant. Snohomish County and partners, are using grant funding to identify and remove sources of FCB and nutrient pollution in the Lower Stillaguamish River basin. The project area has been identified as one with significant water pollution problems, which affects 4,000 acres of commercial shellfish growing areas in South Skagit Bay and Port Susan. Program objectives, scheduled for completion June 2016, are being accomplished through water quality monitoring, contaminant source surveys, outreach and technical assistance to identify and eliminate pollution generated from failing onsite septic systems, and livestock manure.
Washington State Department of Ecology

Long Term Status and Trends
Ecology’s Environmental Assessment group currently conducts monthly sampling at nine long-term stations within the Snohomish and Stillaguamish watersheds, (Table 2). Stations are monitored for temperature, conductivity, pH, dissolved oxygen, turbidity, total suspended solids, FCB, ammonia, nitrate plus nitrite, total nitrogen, total phosphorus, soluble reactive phosphorus, and, at most stations, discharge. Dissolved metals are monitored every other month at a few stations. The purpose of the program is to detect trends and characterize water quality. A description of the program, results and updates to the information in table 2 are found at http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html

Table 3. Ecology Water Quality Monitoring Stations in Snohomish County

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<tr>
<th>WRIA</th>
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<th>Station Name link to monitoring results</th>
<th>Type</th>
<th>Last Year Sampled</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>05A070</td>
<td>Stillaguamish R nr Silvana</td>
<td>long-term</td>
<td>2014</td>
</tr>
<tr>
<td>5</td>
<td>05A090</td>
<td>SF Stillaguamish R @ Arlington</td>
<td>long-term</td>
<td>2014</td>
</tr>
<tr>
<td>5</td>
<td>05A110</td>
<td>SF Stillaguamish R nr Granite Falls</td>
<td>long-term</td>
<td>2014</td>
</tr>
<tr>
<td>5</td>
<td>05B070</td>
<td>NF Stillaguamish R @ Cicero</td>
<td>long-term</td>
<td>2014</td>
</tr>
<tr>
<td>5</td>
<td>05B110</td>
<td>NF Stillaguamish R nr Darrington</td>
<td>long-term</td>
<td>2014</td>
</tr>
<tr>
<td>7</td>
<td>07A090</td>
<td>Snohomish R @ Snohomish</td>
<td>long-term</td>
<td>2014</td>
</tr>
<tr>
<td>7</td>
<td>07C070</td>
<td>Skykomish R @ Monroe</td>
<td>long-term</td>
<td>2014</td>
</tr>
<tr>
<td>7</td>
<td>07D050</td>
<td>Snoqualmie R nr Monroe</td>
<td>long-term</td>
<td>2014</td>
</tr>
<tr>
<td>7</td>
<td>07D130</td>
<td>Snoqualmie R @ Snoqualmie</td>
<td>long-term</td>
<td>2014</td>
</tr>
</tbody>
</table>

Regional Status and Trends Monitoring in Receiving Waters
Beginning in 2015, Ecology and partner organizations are implementing a regional status and trends monitoring program with western Washington municipal stormwater permit contributions. The goal is to measure whether water quality is getting better or worse and identify patterns in health and impaired Puget Sound Lowland streams and urban shoreline areas. Within unincorporated Snohomish County, Ecology has identified 10 lowland fresh water stream stations where water quality (including FCB), stream benthos, sediment chemistry, flow, and habitat monitoring will take place. This QAPP takes this new regional monitoring program into account to avoid overlap.
**Lower Snohomish River Tributaries TMDL**

To meet CWA section 303(d) requirements, Ecology conducted a technical study within the Lower Snohomish River Tributaries to verify the existence of bacteria problems and provide a basis for future water cleanup efforts. The TMDL technical study consisted of using long-term monitoring and special short-term study data collected by Ecology and SWM during the period November 1992 to April 1996. The TMDL study areas were Quilceda Creek, Allen Creek, Woods Creek, French Creek, Marshland Drainage, and the Pilchuck River. Figures 1-5 show these watersheds, with the exception of Marshland Drainage. Collectively, for the purposes of the TMDL study, these watersheds are referred to as the Lower Snohomish River Tributaries.

The technical study identified the in-stream loading capacity or waste load allocations expressed as a percent reduction needed to meet water quality standards. These data are shown in table 3. The data generally indicate that dry weather FCB levels at most monitoring stations exceed those found during wet weather.

**Table 4. Snohomish River Tributaries percent reductions and geometric means**

<table>
<thead>
<tr>
<th>Waterbody</th>
<th>Station</th>
<th>Target Percent Reduction</th>
<th>Target Geometric Mean</th>
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</thead>
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<tr>
<td></td>
<td></td>
<td>Wet Season %</td>
<td>Dry Season %</td>
</tr>
<tr>
<td>Allen Creek</td>
<td>ACLU</td>
<td>90</td>
<td>91</td>
</tr>
<tr>
<td>Allen Creek</td>
<td>AMC</td>
<td>54</td>
<td>84</td>
</tr>
<tr>
<td>Allen Creek</td>
<td>ACSF</td>
<td>66</td>
<td>72</td>
</tr>
<tr>
<td>Allen Creek</td>
<td>ACNF</td>
<td>61</td>
<td>54</td>
</tr>
<tr>
<td>Allen Creek</td>
<td>ACMS</td>
<td>57</td>
<td>70</td>
</tr>
<tr>
<td>Allen Creek</td>
<td>ACLD</td>
<td>0</td>
<td>64</td>
</tr>
<tr>
<td>Quilceda Creek</td>
<td>QCLU</td>
<td>26</td>
<td>70</td>
</tr>
<tr>
<td>Quilceda Creek</td>
<td>QCEF</td>
<td>89</td>
<td>92</td>
</tr>
<tr>
<td>Quilceda Creek</td>
<td>QCUS</td>
<td>0</td>
<td>7</td>
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<td>Quilceda Creek</td>
<td>QCWF</td>
<td>50</td>
<td>87</td>
</tr>
<tr>
<td>Quilceda Creek</td>
<td>QCMS</td>
<td>68</td>
<td>63</td>
</tr>
<tr>
<td>Quilceda Creek</td>
<td>QCLD</td>
<td>74</td>
<td>70</td>
</tr>
<tr>
<td>French Creek</td>
<td>FL1</td>
<td>2</td>
<td>84</td>
</tr>
<tr>
<td>French Creek</td>
<td>TRUS</td>
<td>0</td>
<td>32</td>
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<td>Waterbody</td>
<td>Station</td>
<td>Target Percent Reduction</td>
<td>Target Geometric Mean</td>
</tr>
<tr>
<td>------------</td>
<td>---------</td>
<td>--------------------------</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Wet Season %</td>
<td>Dry Season %</td>
</tr>
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<td>French Creek</td>
<td>LH2</td>
<td>0</td>
<td>87</td>
</tr>
<tr>
<td>French Creek</td>
<td>CCUS</td>
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<td>LH1</td>
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<td>FCMS</td>
<td>91</td>
<td>90</td>
</tr>
<tr>
<td>French Creek</td>
<td>FCDD</td>
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<td>85</td>
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<tr>
<td>French Creek</td>
<td>FCLD</td>
<td>78</td>
<td>82</td>
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<tr>
<td>French Creek</td>
<td>PUMP</td>
<td>73</td>
<td>81</td>
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<td>FCMSb</td>
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<td>90</td>
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<td>French Creek</td>
<td>PUMPb</td>
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<td>79</td>
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<td>Pilchuck River</td>
<td>PR8.6</td>
<td>0</td>
<td>19</td>
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<td>0</td>
<td>80</td>
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<td>Pilchuck River</td>
<td>CCDN</td>
<td>0</td>
<td>67</td>
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<td>Pilchuck River</td>
<td>DCDN</td>
<td>0</td>
<td>67</td>
</tr>
<tr>
<td>Marshland</td>
<td>MLUP</td>
<td>93</td>
<td>87</td>
</tr>
<tr>
<td>Marshland</td>
<td>MLDN</td>
<td>90</td>
<td>65</td>
</tr>
<tr>
<td>Woods Creek</td>
<td>WCUP</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Woods Creek</td>
<td>WCMF</td>
<td>0</td>
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<td>Woods Creek</td>
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<td>70</td>
</tr>
<tr>
<td>Woods Creek</td>
<td>WCDN</td>
<td>0</td>
<td>20</td>
</tr>
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</table>
North Creek TMDL

North Creek was included on Ecology’s 1996 and 1998 303(d) lists because samples collected by SWM at NCLU and NCLD between 1992 and 1995 showed exceedances beyond the upper criteria (Thornburgh 1996). Figure 7 shows NCLU, NCLD, listed segments and the coverage area for the North Creek TMDL.

Ecology developed the North Creek FCB TMDL through a water quality technical study which consisted of using long-term monitoring data collected monthly by SWM at stations NCLU and NCLD during the period of May 1992 – May 1998. The technical study titled North Creek Fecal Coliform Total Maximum Daily Load Submittal Report. Publication 02-10-020, may be obtained at http://www.ecy.wa.gov/pubs/0103020.pdf

Based upon monthly FCB data from May 1992 - 1998, a consistent pattern of bacterial pollution has been observed in North Creek at NCLU and NCLD. During the dry summer months when stream flows are low, bacteria levels rise beyond both the geometric mean criterion of 100 cfu/100 mL and the 90th percentile criterion 200 cfu/100 mL. During the wetter months of the year, bacteria concentrations improve at each station, but not enough to meet the 10 percent not to exceed criterion.

The Statistical Theory of Rollback (Ott 1995) was used in the technical study to calculate target percent reductions and target geometric means at NCLU and NCLD for wet and dry seasons. Table 4 identifies the waste load allocations at each station through percent reductions and target geometric means (Glenn 2001).

Table 5. North Creek percent reductions and geometric means

<table>
<thead>
<tr>
<th>North Creek Stations</th>
<th>Target Percent Reduction</th>
<th>Target Geometric Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wet Season %</td>
<td>Dry Season %</td>
</tr>
<tr>
<td>NCLU (McCollum Park)</td>
<td>92</td>
<td>96</td>
</tr>
<tr>
<td>NCLD (County line)</td>
<td>93</td>
<td>93</td>
</tr>
</tbody>
</table>
The technical study was used as a basis for development, and EPA approval, of the North Creek Detailed Implementation Plan (DIP). Recommendations from the approved DIP were then used as a basis for current permit driven TMDL requirements. The approved North Creek DIP can be found at http://www.ecy.wa.gov/pubs/0310047.pdf.

**Swamp Creek TMDL**

As discussed in Svrjcek (2006), Ecology evaluated water quality and quantity data collected by SWM (2005) and King County Water and Land Resources Division (KCWL RD 2005) to characterize bacteria levels in the Swamp Creek Watershed. Long term water quality data sets are available for Swamp Creek at the three locations stations SCLU, SCLD, and 0470 (Figure 8). These stations characterize the upper, middle, and lower portions of the basin, respectively. Data were then analyzed to determine the geometric mean value (GMV) and the 90th percentile bacteria concentrations to assess compliance with state standards. Looking over many years, the pattern of bacteria levels varied among the water quality monitoring stations. At station 0470, bacteria levels fluctuated within a consistent range for the entire period of record. Station SCLU data showed similar fluctuations. In contrast, a significant change in water quality occurred at SCLD during the mid 1990’s.

Using monthly FCB sampling data from 2000 - 2004, Svrjcek (2006) found a consistent pattern of bacterial pollution in Swamp Creek at each of the Snohomish County long term stations. At SCLU during the dry summer months when stream flows are low, bacteria levels rise beyond both the geometric mean criterion of 100 cfu/100 mL and the 90th percentile criterion 200 cfu/100 mL. At SCLD, during the dry summer months, bacteria levels were lower but still exceeded the geometric mean criterion and 90th percentile criterion. During the wetter months of the year, bacteria concentrations improve at each station, but not enough to meet the 10 percent not to exceed criterion.

The Swamp Creek TMDL technical study calculated target percent reductions and target 90th percentiles at SCLU and SCLD for wet and dry seasons. Table 5 identifies point source waste load allocations at each station, irrespective of jurisdiction, through percent reductions and target 90th percentiles.
### Table 6. Swamp Creek percent reductions and 90th percentiles

<table>
<thead>
<tr>
<th>Swamp Creek Stations</th>
<th>Target Percent Reduction</th>
<th>Target 90th percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wet Season %</td>
<td>Dry Season %</td>
</tr>
<tr>
<td>SCLU (148th St SW)</td>
<td>84</td>
<td>96</td>
</tr>
<tr>
<td>SCLD (County line)</td>
<td>68</td>
<td>78</td>
</tr>
</tbody>
</table>

The Swamp Creek technical study and implementation plan were developed by Ecology and subsequently used as a basis for current NPDES TMDL requirements. The report can be found at [http://www.ecy.wa.gov/pubs/0610021.pdf](http://www.ecy.wa.gov/pubs/0610021.pdf)

**Stillaguamish River TMDL**

As summarized in Joy (2004), Ecology used FCB data from various agencies and used a statistical rollback method to derive statistical summaries, including geometric means, 90th percentiles for bacteria at sampling stations in the Stillaguamish watershed (Figure 6).

Several high level conclusions were made by Joy (2004) based upon data gathered in 2000-2002 for the FCB TMDL study. In summary, and as adapted slightly from Joy (2004), these included but are not limited to:

- More than 10% of the FC counts at stations just below the confluence of the North and South forks, below Arlington, and at I-5 are greater than 200 cfu/100 mL. It is unlikely that Arlington WWTP effluent is a primary source of elevated FC in this area since its FC load is small. Data collected from stations above the outfall indicate a FC problem during storm runoff events.

- The elevated FC counts in Port Susan are usually associated with short pulse storm events during the spring and through the fall. The fall storms and increased discharge to Port Susan prevent many of the stations in the bay from complying with marine water criteria.

- Jim Creek was the only tributary evaluated in the basin that met both parts of the state primary contact recreation FC criteria. Only six stations on other tributaries had geometric mean counts below 100 cfu/100 mL: Pilchuck Creek at Jackson Gulch Road, the mouth of Armstrong Creek and below the hatchery, Lake Martha Creek, Warm Beach Creek, and Douglas Slough.
• Glade Bekken experienced a significant improvement in FC counts in 1999 to 2001 compared to 1996 to 1998. This may be a result of Snohomish Conservation District and SWM efforts upstream of Silvana Terrace Road.

• FC counts collected at Portage Creek crossing with 212th appear to have increased between 2001 and 2002. No trend was apparent from data collected at Portage and 43rd. Fish creek showed major improvements in FC counts from 1997 – 2002 compared with 1994 - 1996. This suggests a FC source between 212th and these upstream monitoring stations.

• Although geometric mean counts of FC in Armstrong Creek and below the hatchery met the Primary contact standard, Kackman and Harvey Creeks did not meet the geometric mean or 90th percentile standard.

• Unidentified sources may be increasing FC counts in the mainstem: between Arlington and Armstrong Creek, on the North Branch below I-5, and between Silvana and Marine Drive

• Port Susan FC counts were decreasing in 1999, but increased at many stations from 2000 - 2002. FC loading from the Stillaguamish basin to Port Susan and small tributaries around the bay in September – December appear to degrade water quality in Port Susan.

• Large flocks of snow geese, other shorebirds and waterfowl arrive in September on migration or to winter in the lower reaches of the basin and Port Susan. Spring migration brings large flocks of shorebirds. These birds could be a significant source of seasonal FC loading.

• Flooding is not uncommon during the spring and winter months. Agricultural and residential areas in flooded areas can contribute FC loads from freshly manured fields, commercial animal handling facilities, inundated septic systems, pet waste or other sources.

• More severe winds arrive in spring and autumn. Wind and wave action could re-suspend sediment contaminated with bacteria in the lower reaches of the river or Port Susan.

To help gauge the progress of the Stillaguamish River FCB Implementation Plan, Ecology chose eleven geographically separated monitoring locations for evaluation of bacteria levels in the year 2010 (Svrjcek and Lawrence 2007).
A 50 percent reduction in 2002 bacteria levels was set as the interim target for 2010. Reductions in the 90<sup>th</sup> percentile value are assessed as shown in table 6.

Table 7. Stillaguamish River percentile targets

<table>
<thead>
<tr>
<th>Stillaguamish Stations w/interim targets</th>
<th>2002 90&lt;sup&gt;th&lt;/sup&gt; Percentile Value</th>
<th>2010 Target 90&lt;sup&gt;th&lt;/sup&gt; Percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designated by Ecology</td>
<td>Wet Season %</td>
<td>Dry Season %</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glade Bekken @ Silvana Terrace – TR30</td>
<td>365</td>
<td>828</td>
</tr>
<tr>
<td>Fish Creek @ 5&lt;sup&gt;th&lt;/sup&gt; Ave. - FISH</td>
<td>790</td>
<td>852</td>
</tr>
<tr>
<td>Armstrong @ Grandview - ARMM</td>
<td>516</td>
<td>486</td>
</tr>
<tr>
<td>Pilchuck @ Jackson Gulch - PILC</td>
<td>NA</td>
<td>338</td>
</tr>
<tr>
<td>Jim Creek @ Jordon Rd. JIMJ</td>
<td>NA</td>
<td>590</td>
</tr>
<tr>
<td>Portage Creek @ 212&lt;sup&gt;th&lt;/sup&gt; St. NE - PORL</td>
<td>420</td>
<td>808</td>
</tr>
<tr>
<td>Portage Creek @ 43&lt;sup&gt;rd&lt;/sup&gt; - PORU</td>
<td>336</td>
<td>910</td>
</tr>
</tbody>
</table>

Joy (2004) recommended that monitoring programs addressing bacteria in the Stillaguamish should focus on the following goals:

- Monitoring should be conducted at stations used to develop reduction goals.
- Intensive monitoring (source tracking) to identify sources and problem reaches are useful, but data should not be mixed with long term monitoring efforts to determine overall progress of TMDL related activities.
- Nonpoint sources active during dry and wet weather periods along the mainstem Stillaguamish and its two major forks need to be identified and removed.
- Stormwater conveyance infrastructures and stormwater quantity and quality need better characterization to establish more accurate stormwater load and wasteload allocations.
Following up on the work of Joy (2004), in 2012, Ecology completed a bacterial pollution loading study of Skagit Bay, which included one year of water quality and stream flow monitoring at about twelve stations in Snohomish County and twelve stations in Skagit County (Kardouni 2012). This study provides substantial information about FCB inputs to the Old Stillaguamish Channel.

**Little Bear TMDL**

Surface Water Management has maintained water quality monitoring stations at 2 long term and 4 short term stations within the Little Bear watershed (Figure 9). A summary of data from each station in table 7 shows that several stations have historically exceeded a threshold of 200 colonies/100ml greater than 50% of the time. To support the Little Bear Creek FCB TMDL development, Dettelbach and Garland (2005) analyzed FCB data collected over variable periods by SWM. The analysis, summarized in table 7, shows FCB concentrations, expressed as the geometric mean during the wet and dry seasons, and seasonal targets for percent reductions at each station.

Table 8. Little Bear percent reductions and geomeans

<table>
<thead>
<tr>
<th>Little Bear Creek Stations</th>
<th>Geometric Means through 2004</th>
<th>Target Percent Reduction</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Wet Season</td>
<td>Dry Season</td>
</tr>
<tr>
<td>LBHW</td>
<td>537</td>
<td>873</td>
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<tr>
<td>LBLU</td>
<td>248</td>
<td>449</td>
</tr>
<tr>
<td>LBLD</td>
<td>223</td>
<td>364</td>
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<tr>
<td>TROT</td>
<td>36</td>
<td>32</td>
</tr>
<tr>
<td>DANE</td>
<td>53</td>
<td>86</td>
</tr>
<tr>
<td>CUTT</td>
<td>85</td>
<td>152</td>
</tr>
</tbody>
</table>
Snohomish Health District

In 1991, the Snohomish Health District completed a sanitary survey of the Warm Beach area with grant support from the Centennial Clean Water Fund to address the longstanding problem of inadequate on-site sewage systems (Plemel 1991). This study evaluated on-site sewage systems for 194 residential properties and found a 55% failure rate. Recommendations from this study addressed the need for both long-term and short-term alternatives for residential sewage disposal. The Snohomish Health District conducted a follow-up sanitary survey for the Warm Beach area in 2009 (McCormick 2009), which only found one failed system.

The Snohomish Health District also conducted a sanitary survey of on-site sewage systems in the Skagit Flats area north of Stanwood and the Leque Road area just south of Stanwood in 2012 (Hutchison 2014).

King County

King County Water and Land Resources division carries out water resource monitoring within Snohomish County. Beginning in November 2014, King County re-established water quality monitoring locations in lower North, Swamp and Little Bear Creek. Locations overlap with SWM stations SCLD (Swamp Creek) and NCLD (North Creek). Surface Water Management stopped sampling NCLD station December 2014. The lower Swamp Creek station will not be targeted due to overlap with King County. Current King County monitoring stations can be found at King County, Washington.

Stillaguamish Tribe

Since 1994, the Stillaguamish Tribe has been involved in monitoring the water quality in the Stillaguamish Watershed as part of their efforts to recover salmon. The Stillaguamish Natural Resources Department maintains an accurate water quality database for selected stations on the North and South Forks and selected tributaries, the mainstem and selected tributaries, and Port Susan. The Department collects a variety of water quality data. From December 1993-May 2002, the tribe collected various water quality data from 79 locations throughout the watershed. Currently, water quality samples are collected on a quarterly basis from 51 locations. Water quality data such as temperature, conductivity, dissolved oxygen, turbidity, total suspended solids, alkalinity, hardness, and FCB are among the parameters the Stillaguamish Natural Resources Department collects and shares with other agencies.
Tulalip Tribe

The Tulalip Tribes monitored water quality in the Lower Stillaguamish River from 1991 to 1994, including dry and wet season sampling of Fish Creek, Church Creek, Miller Creek and Tributary 30 for the following parameters: dissolved oxygen, FCB, turbidity, nitrate-nitrite, and ortho-phosphate (O’Neal et al. 2001). This study found that all four streams exceeded water quality standards for FCB bacteria, Church Creek and Miller Creek had low dissolved oxygen, and all four streams had high turbidity during the wet season. This study also noted that water quality in Church Creek and Miller Creek was negatively affected by existing tide gates. Improved livestock management was recommended for all four streams.

In 1994, the Tulalip Tribes produced an issue paper on the mitigation of impacts on water quality and aquatic habitat from commercial and non-commercial agriculture in the Stillaguamish watershed (Currie 1994). This study identified Fish Creek, Tributary 30, Church Creek, and Miller Creek as sub-basins of greatest concern due to consistently high levels of FCB bacteria, nitrate-nitrite, and turbidity. These water quality conditions were associated with livestock operations and lack of adequate flushing flows from tide gates in some cases.
Organization, Budget and Project Schedule

Project Team
The project team is identified in table 9 and composed of:
- SWM staff: project management, quality control, sampling, and analysis
- Ecology: QAPP review and approval.
- AmTest: Laboratory testing

Table 9. Project Staff and Responsibilities

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Phone Number</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steve Britsch</td>
<td>Snohomish County</td>
<td>425-388-3464 ext. 4668</td>
<td>Project Management, Field Work</td>
</tr>
<tr>
<td>Janell Majewski</td>
<td>Snohomish County</td>
<td>425-388-3464 ext. 6641</td>
<td>Project Review</td>
</tr>
<tr>
<td>TBD</td>
<td>Snohomish County</td>
<td>TBD</td>
<td>Field Work/Analysis/Reporting</td>
</tr>
<tr>
<td>Keith Westlund</td>
<td>Snohomish County</td>
<td>425-388-3464 ext. 2740</td>
<td>Project Field Work</td>
</tr>
<tr>
<td>Aaron Young</td>
<td>AmTest, Inc</td>
<td>425-885-1664</td>
<td>Laboratory Services</td>
</tr>
<tr>
<td>Ralph Svrjcek</td>
<td>Department of Ecology</td>
<td>425-649-7165</td>
<td>TMDL Coordinator</td>
</tr>
<tr>
<td>Rachel McCrea</td>
<td>Department of Ecology</td>
<td>(425) 649-7223</td>
<td>Stormwater Permit Coordinator</td>
</tr>
</tbody>
</table>
Project Budget

The estimated annual budget (Table 10) is subject to change based upon County Executive or Council discretion, SWM priorities, increased or decreased professional services, supplies and labor costs, or for other reasons.

Table 10. Estimated Annual Project Budget

<table>
<thead>
<tr>
<th>Professional Services: Contract Laboratory Analysis – Routine Sampling/Equipment Maintenance</th>
<th>Quantity</th>
<th>Cost/Unit $</th>
<th>Total Cost $</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCB – SM9222D (includes duplicates, field &amp; trip blanks)</td>
<td>250</td>
<td>10</td>
<td>2,500</td>
</tr>
<tr>
<td>Total Suspended Solids (includes duplicates, field &amp; trip blanks)</td>
<td>250</td>
<td>10</td>
<td>2,500</td>
</tr>
<tr>
<td>Optical Brightener Analysis — does not include shipping</td>
<td>10 (est)</td>
<td>25</td>
<td>250</td>
</tr>
<tr>
<td>Ammonia, Potassium MBAS/CTAS</td>
<td>10 (est)</td>
<td>135</td>
<td>1,350</td>
</tr>
<tr>
<td>Hydrolab Maintenance and Calibration</td>
<td>3</td>
<td>1900</td>
<td>5,700</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>1</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal</strong></td>
<td><strong>17,300</strong></td>
<td></td>
</tr>
<tr>
<td>Supplies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field and Lab Supplies</td>
<td>1</td>
<td>5,500</td>
<td>5,500</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal</strong></td>
<td><strong>5,500</strong></td>
<td></td>
</tr>
<tr>
<td>SnoCo Labor (includes benefits, overhead and admin)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Specialist</td>
<td>600</td>
<td>57</td>
<td>34,200</td>
</tr>
<tr>
<td>Eng. Technician</td>
<td>750</td>
<td>44</td>
<td>33,000</td>
</tr>
<tr>
<td>Water Quality Analyst</td>
<td>400</td>
<td>42</td>
<td>16,800</td>
</tr>
<tr>
<td>Supervisor</td>
<td>20</td>
<td>62</td>
<td>1,240</td>
</tr>
<tr>
<td>GIS Analyst</td>
<td>20</td>
<td>48</td>
<td>960</td>
</tr>
<tr>
<td></td>
<td><strong>Subtotal</strong></td>
<td><strong>86,200</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Estimated Annual Project Total</strong></td>
<td><strong>109,000</strong></td>
<td></td>
</tr>
</tbody>
</table>
## Project Schedule

Table 11. Annual FCB TMDL Monitoring and Management Schedule (○ = ongoing, ● = complete)

<table>
<thead>
<tr>
<th>Project Management</th>
<th>Jan</th>
<th>Feb</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Review/Audit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>Budget Development</td>
<td>○</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Routine Ambient Monitoring Field Work</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Routine Monitoring (5 stations/month/2 runs = 2 days to</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>complete - Aug 1 2015 Start and monthly thereafter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Annual Factory Calibration</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Routine Ambient Monitoring Data Management</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Data Verification/Validation</td>
<td></td>
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<tr>
<td>EIM Data Prep and Load</td>
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</tr>
<tr>
<td><strong>Wet/Dry Season Ambient Monitoring Bacteria Data Analysis</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Bacteria Data Analysis and Data Review to Support Written Documentation (permit requirement due to Ecology March 31, 2015)</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Written documentation of data review and prioritization (permit requirement due to Ecology March 31, 2015)</td>
<td>●</td>
<td></td>
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</tr>
<tr>
<td><strong>Targeted Source Identification/Elimination (Permit Requirement)</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Review/Methods/Cross Training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Collect and synthesize GIS data for station/Produce field maps</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Verify Landowner Addresses and Investigate Access Rights</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Send Landowner Permission Notices and Track Progress</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Conduct Targeted Source ID Field Work</td>
<td></td>
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<td></td>
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<tr>
<td>Coordinate with partners (to remove sources) as necessary</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Review/ edit GPS/Lab Data</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft /Review Summary report</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Edit Report (Finalize Report Before March 31 following Year)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>○</td>
</tr>
</tbody>
</table>
Project Specific NPDES Phase I Permit Requirements

Ecology has determined through technical studies that waterbodies within the Stillaguamish basin, Snohomish River Tributaries, North, Swamp and Little Bear Creeks, do not meet fresh water FCB standards. Table 12 shows monitoring and source identification conditions required by the 2013-2018 NPDES permit.

Table 12. 2013-2018 NPDES - TMDL Monitoring and Source Identification

<table>
<thead>
<tr>
<th>Snohomish Tributaries / North Creek / Swamp Creek</th>
<th>Little Bear Creek</th>
<th>Stillaguamish River</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface Water Monitoring</strong></td>
<td><strong>Surface Water Monitoring</strong></td>
<td><strong>Select at least one surface water monitoring location for continued characterization and long term trend evaluation of FCB concentrations.</strong></td>
</tr>
<tr>
<td>Review FCB data collected in accordance with the QAPP approved under the 2007 NPDES permit and select at least one surface water monitoring location for continued characterization and long term trend evaluation of FCB concentrations.</td>
<td>Select at least one surface water monitoring location for continued characterization and long term trend evaluation of FCB concentrations.</td>
<td>By Feb 2, 2015, submit QAPP to Ecology. By August 1, 2015, begin sampling per QAPP. Submit data to Ecology annually by May 31.</td>
</tr>
<tr>
<td>By Feb 2, 2015, submit QAPP to Ecology. By August 1, 2015, begin sampling per QAPP</td>
<td>By Feb 2, 2015, submit QAPP to Ecology. By August 1, 2015, begin sampling per QAPP.</td>
<td>Provide data summaries and narrative evaluation of the data in each annual report’s TMDL summary – March 31. Provide data summaries and narrative evaluation of the data in each annual report’s TMDL summary – March 31.</td>
</tr>
<tr>
<td>Submit data to Ecology annually by May 31</td>
<td>Submit data to Ecology annually by May 31</td>
<td>Provide data summaries and narrative evaluation of the data in each annual report’s TMDL summary – March 31.</td>
</tr>
<tr>
<td>Provide data summaries and narrative evaluation of the data in each annual report’s TMDL summary – March 31</td>
<td>Provide data summaries and narrative evaluation of the data in each annual report’s TMDL summary – March 31.</td>
<td></td>
</tr>
</tbody>
</table>

**Targeted Source Identification and Elimination:**

By February 2, 2014, review FCB data collected in accordance with the QAPP approved under the 2007 NPDES permit, and identify at least one high priority area for FCB source identification and elimination. This requirement can be combined with surface water monitoring in accordance with the QAPP for the microbial water quality assessment program. By August 1, 2014, begin to implement source identification and elimination actions in MS4 subbasins, and implement required actions under S5.C.8.

<table>
<thead>
<tr>
<th><strong>Targeted Source Identification and Elimination:</strong></th>
<th><strong>Targeted Source Identification and Elimination:</strong></th>
<th><strong>Targeted Source Identification and Elimination:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>[No TMDL requirement]</td>
<td>[No TMDL requirement]</td>
<td>[No TMDL requirement]</td>
</tr>
</tbody>
</table>


Project Description

As required by NPDES permit conditions, the intent of this FCB TMDL monitoring study is to collect bacteria samples from stations within the study boundaries at a sufficient frequency and duration and at strategically selected stations to: (1) compare results to established state fresh water bacteria standards and (2) identify upstream sources and provide recommendations for clean-up.

Study Boundaries
Per NPDES permit requirements, the study boundaries (Figures 1 – 9) are:
1. Stillaguamish
2. Snohomish River Tributaries
3. North Creek
4. Swamp Creek
5. Little Bear Creek

Study Objectives
The objectives of this FCB TMDL Monitoring Plan are:

- Apply a decision support tool framework (PBS&J 2008) for FCB to focus TMDL monitoring and source identification efforts.

- Select one sampling station within each of the five TMDL study areas based upon probability of impairment, frequency of FCB water quality criteria exceedance, dry season geometric means and other factors as needed.

- Collect 12 FCB samples at each location per calendar year.

- Evaluate sample results and generate Microbial Water Quality Assessment MWQA ranks based upon frequency of FCB standard exceedances and follow up with targeted source identification and elimination efforts.

- Analyze and summarize data plus targeted source identification efforts and document efforts in progress reports.

Experimental Design
In March 2007, the EPA convened a panel of experts to address known issues, identify information gaps, and review potential approaches that could be used by EPA to develop alternative microbial water quality criteria for water bodies that are used for recreational purposes. The panel selected three potential approaches for doing so, based on methodological frameworks currently recommended by the EPA (1983, 1984, 2004, 2006), WHO (2003), and European Union (EU) (2006). Each of the reviewed methodologies used a phased approach where FCB data collected through routine monitoring were to provide an early warning against human health risks. Expanded investigation at hot spots, were recommended as the second phase to identify potential sources.

To meet NPDES permit FCB TMDL monitoring and source identification requirements, SWM will use the Microbial Water Quality Assessment (MWQA) approach developed in 2008 by the Florida Department of Environmental Protection. MWQA is based on the approaches used by WHO (2000, 2003), EPA (1983, 1984, 2004, 2006), and NRC (2004) to identify FCB sources within the Hillsborough River Watershed in South Florida. The MWQA process ranks FCB data based upon the frequency they exceed standards. Ranks are assigned to each sample station in categories A, B, C, D and E where A exhibits the lowest frequency of FCB standard exceedences and E exhibits the highest. The MWQA rank decision tree is shown in Figure 10.

SWM first employs this tool to help identify routine monitoring stations. On an annual basis, the most current 30 FCB results for each station are analyzed and ranked. Stations ranking poorest are prioritized for targeted source identification and elimination efforts within required TMDL coverage areas.

---

**Figure 10. Microbial Water Quality Assessment Rank Decision Tree**
Routine Monitoring Design and Hypothesis

Appendix 2 of the Phase I NPDES permit requires municipalities to collect 12 samples at one station per study area each calendar year.

Given these requirements, the sample design used to select sampling stations is considered “judgment” or authoritative, where sample numbers and locations are selected based upon expert knowledge of the problem.

Generally, conclusions drawn from a judgmentally-based sample design apply only to those individual samples; aggregation may result in severe bias due to lack of representativeness and lead to highly erroneous results (EPA 2006). That is, data from each sampling station can’t be extrapolated to the entire population (stream length or watershed) where collection is subject to unknown selection bias (EPA 2006). Further, EPA (2006) states that judgment based designs do not allow the level of confidence (uncertainty) to be accurately quantified.

Defining the problem includes translating study objectives into testable null and alternative hypothesis. As mentioned under the introduction, the primary problem is that FCB bacteria levels at selected stations/stream segments within the study boundaries have historically exceeded state water quality standards designed to protect human health.

The hypotheses used to test whether exceedances of FCB bacteria standards at selected stations continue are:

- **Null (H₀)** = Seasonal and annual geometric mean and percentile FCB levels are greater than the geometric mean and percentile standards as established in WAC 173-201A.

- **Alternative (H₀)** = Seasonal and annual geometric mean and percentile FCB levels are less than or equal to the geometric mean and percentile standards as established in WAC 173-201A.

A judgment-based design precludes setting acceptable limits for decision errors relative to consequences Methods of analysis to test the hypothesis are found under the data analysis section of this QAPP.
Establishing Routine Monitoring Stations

For prioritization and selection of routine monitoring stations required by the 2013-2018 NPDES permit, SWM generated MWQA ranks, probabilities of impairment, dry season geometric means, and evaluated FCB trends (Table 13). With the exception of trends analysis, which utilized a minimum of nine years of data through 2012, all other analyses are based upon the most recent 30 months of data ending December 2013.

Although the NPDES permit lists the Marshlands drainage as a geographic area where TMDL requirements apply, no stations are proposed within the Marshlands drainage. Segments impaired for FCB in the drainage are entirely within the Marshland’s Flood Control district fee area and not SWM’s watershed management fee area. Snohomish County title 25 prohibits funds for these monitoring activities from being spent outside fee areas.
### Table 13. Routine TMDL Monitoring Station Selection Analysis

<table>
<thead>
<tr>
<th>TMDL Coverage Area</th>
<th>Subbasin</th>
<th>Sample Station</th>
<th>% Samples &gt; 100 or 200 Colonies</th>
<th>MWQA Rank</th>
<th>% Probability of Impairment</th>
<th>Dry Season Geomean cfu/100ml</th>
<th>Overall Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Creek</td>
<td>North Creek</td>
<td>NCLU</td>
<td>27</td>
<td>B</td>
<td>99</td>
<td>48</td>
<td>Improving</td>
</tr>
<tr>
<td>North Creek</td>
<td>North Creek</td>
<td>NCLD</td>
<td>40</td>
<td>C</td>
<td>99</td>
<td>125</td>
<td>Improving</td>
</tr>
<tr>
<td>North Creek</td>
<td>North Creek</td>
<td>NCMU</td>
<td>47</td>
<td>C</td>
<td>99</td>
<td>148</td>
<td>NA</td>
</tr>
<tr>
<td>North Creek</td>
<td>North Creek</td>
<td>NCMS</td>
<td>26</td>
<td>B</td>
<td>98</td>
<td>90</td>
<td>NA</td>
</tr>
<tr>
<td>North Creek</td>
<td>North Creek</td>
<td>FILBERT</td>
<td>20</td>
<td>C</td>
<td>86</td>
<td>142</td>
<td>NA</td>
</tr>
<tr>
<td>North Creek</td>
<td>North Creek</td>
<td>SULFUR</td>
<td>27</td>
<td>C</td>
<td>99</td>
<td>93</td>
<td>Improving</td>
</tr>
<tr>
<td>Swamp Creek</td>
<td>Swamp Creek</td>
<td>SCLU</td>
<td>23</td>
<td>B</td>
<td>97</td>
<td>45</td>
<td>Improving</td>
</tr>
<tr>
<td>Swamp Creek</td>
<td>Swamp Creek</td>
<td>SCLD</td>
<td>27</td>
<td>B</td>
<td>99</td>
<td>45</td>
<td>Improving</td>
</tr>
<tr>
<td>Little Bear</td>
<td>Little Bear</td>
<td>LBLD</td>
<td>23</td>
<td>B</td>
<td>97</td>
<td>51</td>
<td>Improving</td>
</tr>
<tr>
<td>Little Bear</td>
<td>Little Bear</td>
<td>LBLU</td>
<td>13</td>
<td>B</td>
<td>65</td>
<td>39</td>
<td>Improving</td>
</tr>
<tr>
<td>Little Bear</td>
<td>Little Bear</td>
<td>LBMR</td>
<td>27</td>
<td>B</td>
<td>98</td>
<td>80</td>
<td>NA</td>
</tr>
<tr>
<td>Little Bear</td>
<td>Little Bear</td>
<td>LBHW</td>
<td>23</td>
<td>B</td>
<td>93</td>
<td>38</td>
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</tr>
<tr>
<td>Little Bear</td>
<td>Little Bear</td>
<td>CUTT</td>
<td>7</td>
<td>A</td>
<td>18</td>
<td>32</td>
<td>NA</td>
</tr>
<tr>
<td>Little Bear</td>
<td>Little Bear</td>
<td>DANE</td>
<td>27</td>
<td>B</td>
<td>99</td>
<td>50</td>
<td>NA</td>
</tr>
<tr>
<td>Little Bear</td>
<td>Little Bear</td>
<td>TROT</td>
<td>10</td>
<td>A</td>
<td>42</td>
<td>16</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Allen Creek</td>
<td>ACLU</td>
<td>43</td>
<td>C</td>
<td>99</td>
<td>271</td>
<td>Improving</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Allen Creek</td>
<td>ACHW</td>
<td>5</td>
<td>A</td>
<td>10</td>
<td>42</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Cripple Creek</td>
<td>CCUS</td>
<td>7</td>
<td>A</td>
<td>18</td>
<td>54</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>French Creek</td>
<td>FCLU</td>
<td>13</td>
<td>B</td>
<td>65</td>
<td>48</td>
<td>Improving</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>French Creek</td>
<td>STABLES</td>
<td>7</td>
<td>A</td>
<td>18</td>
<td>76</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Lower Snoqualmie</td>
<td>RILY</td>
<td>0</td>
<td>A</td>
<td>0</td>
<td>37</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Pilchuck River</td>
<td>CATH</td>
<td>10</td>
<td>A</td>
<td>42</td>
<td>34</td>
<td>Improving</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Pilchuck River</td>
<td>DUBQ</td>
<td>0</td>
<td>A</td>
<td>0</td>
<td>15</td>
<td>Improving</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Pilchuck River</td>
<td>LPIL</td>
<td>0</td>
<td>A</td>
<td>0</td>
<td>12</td>
<td>Improving</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Pilchuck River</td>
<td>PILOK</td>
<td>0</td>
<td>A</td>
<td>0</td>
<td>9</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Quilceda Creek</td>
<td>QCLU</td>
<td>30</td>
<td>C</td>
<td>42</td>
<td>37</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Quilceda Creek</td>
<td>QCWF2</td>
<td>17</td>
<td>B</td>
<td>82</td>
<td>40</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Quilceda Creek</td>
<td>QCMFU</td>
<td>10</td>
<td>A</td>
<td>42</td>
<td>21</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Quilceda Creek</td>
<td>QCWD</td>
<td>7</td>
<td>A</td>
<td>18</td>
<td>20</td>
<td>NA</td>
</tr>
<tr>
<td>Snohomish River Tribs</td>
<td>Woods Creek</td>
<td>WCMS</td>
<td>3</td>
<td>A</td>
<td>4</td>
<td>53</td>
<td>NA</td>
</tr>
</tbody>
</table>
Table 13 Continued. Routine TMDL Monitoring Station Selection Analysis

<table>
<thead>
<tr>
<th>Snohomish River Tribs</th>
<th>Woods Creek</th>
<th>WCFA</th>
<th>0</th>
<th>A</th>
<th>4</th>
<th>51</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snohomish River Tribs</td>
<td>Woods Creek</td>
<td>WCWF</td>
<td>3</td>
<td>A</td>
<td>4</td>
<td>50</td>
<td>Improving&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Church Creek</td>
<td>CCPK</td>
<td>20</td>
<td>B</td>
<td>93</td>
<td>115</td>
<td>NA</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Glade Bekken</td>
<td>TR30</td>
<td>23</td>
<td>B</td>
<td>97</td>
<td>125</td>
<td>Improving&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Jim Creek</td>
<td>JIMJ</td>
<td>3</td>
<td>A</td>
<td>4</td>
<td>36</td>
<td>NA</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Lower Stillaguamish</td>
<td>DOUG</td>
<td>55</td>
<td>D</td>
<td>99</td>
<td>168</td>
<td>NA</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Portage Creek</td>
<td>FISH</td>
<td>20</td>
<td>B</td>
<td>93</td>
<td>79</td>
<td>NA</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Portage Creek</td>
<td>PORL</td>
<td>10</td>
<td>A</td>
<td>42</td>
<td>51</td>
<td>Improving&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Portage Creek</td>
<td>PORU</td>
<td>3</td>
<td>A</td>
<td>4</td>
<td>44</td>
<td>Improving&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Port Susan</td>
<td>UNAM&lt;sup&gt;b&lt;/sup&gt;</td>
<td>48</td>
<td>C</td>
<td>99</td>
<td>308</td>
<td>NA</td>
</tr>
<tr>
<td>Stillaguamish</td>
<td>Skagit Flats</td>
<td>05-UN1-3&lt;sup&gt;a,c&lt;/sup&gt;</td>
<td>50</td>
<td>D</td>
<td>ND</td>
<td>301</td>
<td>NA</td>
</tr>
</tbody>
</table>

a: sample location and majority of upstream tributaries are outside or through annexation are expected to be outside county jurisdiction

b: sample size < 30, MWQA rank preliminary, additional data preferred for prioritization of targeted source identification and elimination

c: Results initially influenced by failing septic system found and repaired immediately upstream of site in late 2013. 2014 results show MWQA rank of B with 18% of samples exceeding primary contract criteria as determined through 2013 salinity monitoring.

d: Significantly overall (dual season) trend using Seasonal Kendalls Trends Analysis

NA = Insufficient data for analysis

= Station located on stream segment listed as impaired for FCB Ecology (2008).
Microbial water quality assessment ranks, probabilities of impairment, dry season geometric means and trends analysis provide the level of among station discrimination needed upon which to select sample stations in accordance with NPDES permit requirements. Monitoring stations selected for this TMDL monitoring QAPP are shown in table 14.

In addition to the data in Table 13, the following was also considered for station selection:
- whether the station is on a stream segment listed as impaired for bacteria,
- spatial distribution of stations in a watershed,
- feasibility of potential upstream field screening efforts,
- overlap with other organizations current sampling efforts.

Table 14. Snohomish County TMDL Monitoring Stations

<table>
<thead>
<tr>
<th>WRIA</th>
<th>Subbasin</th>
<th>Sample Station</th>
<th>Location</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>North Creek</td>
<td>NCMU</td>
<td>SILVER CREEK PRIOR TO CONFLUENCE WITH TAMBARK CREEK FROM UPSTREAM SIDE OF 196TH ST SE. 190FT SE OF INTERSECTION WITH BOTHELL EVERETT HWY</td>
<td>1303061.05</td>
<td>302302.94</td>
</tr>
<tr>
<td>8</td>
<td>Swamp Creek</td>
<td>SCLU</td>
<td>SWAMP CREEK FROM SOUTH SIDE OF 148TH ST SW. 625FT EAST OF INTERSECTION WITH MANOR WAY. SAMPLE DOWNSTREAM OF CONFLUENCE WITH DITCHES ALONG SOUTH SIDE OF 148TH DISCHARGING INTO SWAMP CREEK.</td>
<td>1288708.69</td>
<td>318462.10</td>
</tr>
<tr>
<td>8</td>
<td>Little Bear Creek</td>
<td>LBLD</td>
<td>LITTLE BEAR CREEK FROM DOWNSTREAM SIDE OF BRIDGE 552 AT 228TH ST SE</td>
<td>1318160.87</td>
<td>1318160.87</td>
</tr>
<tr>
<td>7</td>
<td>Allen Creek</td>
<td>ACLU</td>
<td>67TH AVE NE AND 100TH ST NE. PARK AT GRANGE AND WALK EAST APPROXIMATELY 525FT TO CREEK. SAMPLE FROM UPSTREAM SIDE OF 67TH</td>
<td>1321706.76</td>
<td>398457.58</td>
</tr>
<tr>
<td>5</td>
<td>Lower Stillaguamish</td>
<td>DOUG</td>
<td>DOUGLAS SLOUGH WEST SIDE OF PIONEER HWY OUTLET OF BOX CULVERT DOWN PRIVATE ACCESS ROAD</td>
<td>1269971.26</td>
<td>460599.51</td>
</tr>
</tbody>
</table>

Notes: Latitude and Longitude are provided in NAD_1983_StatePlane_Washington_North_FIPS_4601_Feet
Monitoring

Receiving Water / Conveyance System Monitoring
The target population is FCB within receiving waters, associated tributaries, and/or stormwater conveyance systems. Washington State Administration Code (WAC 173-201A) indicates that when averaging bacteria sample data for comparison to a geometric mean standard, it is preferable to average by season and include five or more samples within each period.

For comparison to bacteria standards and to employ the MWQA classification ranking, monthly sampling for FCB will take place starting August 2015 and last through the permit period.

Basic Physical and Chemical Field Measurements
To help explain potential sources of FCB bacteria and retain continuity of past sample designs, temperature, pH, dissolved oxygen, conductivity, turbidity, and total suspended solids (TSS) will also be gathered during routine monthly monitoring. Field measurements will be gathered using a Hydrolab Minisonde5a™ and Hach 2100P turbidimeter at each station.

Advanced Monitoring to Support Targeted Source Identification and Elimination
Targeted source identification and elimination efforts are required by the 2013-2018 NPDES permit within the Snohomish River Tributaries, North and Swamp Creek basins, but not specifically within the Stillaguamish and Little Bear Creek basins.

Source identification benefits from use ammonia, potassium, surfactants, optical brighteners, and/or other parameters and methods to further isolate a potential source of pollution.
Field Sampling Procedures

Routine water quality monitoring will be carried out in accordance with this quality assurance plan. Sampling methods are designed to support water quality monitoring objectives while ensuring samples results are of high integrity.

Persons involved with water quality monitoring could be subjected to unsafe environments. Hazards include, but are not limited, to roadside traffic, slips, trips, falls, drowning, heat and cold stress, exposure to chemicals and biological pathogens. Washington State Department of Labor and Industries requires employers provide a safe work environment through communicating hazards and providing adequate training. Health and safety guidelines are found in Appendix A.

Calibration

Hydrolab Minisonde 5a™’s and Hach 2100P™’s are utilized for field measurements. Both instruments are calibrated in accordance with manufacturers recommendations, prior to and after field work. Calibrations are recorded on standardized forms (Appendix C) and maintained in binders with field forms and lab results. Each Hydrolab is factory calibrated and updated with the latest software and firmware on an annual basis. Instrument sensors are repaired or replaced as necessary.

All records for water quality instruments are retained for a minimum of five years as required by section G9 of the NPDES permit and Washington State archival timelines.

Hydrolab Minisonde 5a™

All Hydrolab Minisonde 5a’s™ currently held by SWM employ the use of luminescent dissolved oxygen (LDO) sensors using Hach method 10360. EPA has reviewed this method and determined the supporting validation data meets all requirements for measurements of dissolved oxygen in water and wastewater. It has been recommended by EPA’s director of analytical methods that Hach method 10360 be included in the Code of Federal Regulations 40 part 136.3.

Calibration methods for Hydrolab’s are found at [http://www.ott.com/en-us/resources/](http://www.ott.com/en-us/resources/). Special attention should be paid to the LDO sensor. These sensors may be calibrated using one of three methods. The preferred method is #1 or calibration in air saturated water. Field readings in mg/l based upon % saturation calibrations at known barometric pressures remain accurate even when altitudes change.

The Hach 2100P Turbidimeter

Turbidimeters are calibrated following manufacturers recommendations [http://www.hach.com/2100p-portable-turbidimeter/product-downloads?id=7640450099](http://www.hach.com/2100p-portable-turbidimeter/product-downloads?id=7640450099). Primary standards are used on a quarterly basis, while Stablcal™ secondary standards are used during daily calibrations.
Invasive Species Procedures

Washington State law RCW 77.15.290 prohibits the transportation of fish, wildlife, or aquatic plants from one location to another. New Zealand mudsnails (*Potamopyrgus* sp.) are invasive species currently found within the Stillaguamish, Snohomish and Lake Washington Watersheds that can be spread through contact with areas of concern and transporting through use of field equipment without proper decontamination. Ecology defines problem invasive species into two categories: Areas of extreme concern, and Areas of moderate concern.

Current and future areas of concern can be identified through Ecology’s Invasive Species webpage and the USGS at their Nonindigenous Aquatic Species webpage. Additionally, staff may call Jesse Shultz at the Washington State Department of Fish and Wildlife or Jenifer Parsons at Ecology’s Central Regional Office for assistance with areas of concern, decontamination procedures or species identification.

To prevent the spread of New Zealand Mudsnails, a sampling pole will be used where feasible to minimize disturbance of sediments, with sampling in an upstream to downstream sequence as necessary within a watershed or sub-basin. Where staff travel between sample sites or watershed to watershed, appropriate decontamination procedures will be used on equipment as needed. Detailed decontamination procedures are found in Appendix F.

Water Quality Field Sampling and Measurement, Transport and Chain of Custody

Field observations, locations, measurements and samples for lab analysis are recorded on standardized field forms (Appendix G). Field forms are maintained in binders with instrument calibration and lab results for a minimum of five years.

While sampling, staff must be aware of hazards and the potential for cross contamination. As noted in the health and safety section, always be aware of hazards associated with work on or near roadways, unstable surfaces and/or depths of water.

When sampling, field instruments are placed downstream of grab sample locations while limiting contact with sediment. This minimizes potential for re-suspension of sediment that may influence grab samples.

It is preferred to collect bacteria samples prior to samples where preservatives are used. This reduces the potential for sediment re-suspension and preservatives cross-contamination.

Order of Sampling

1. Bacteria
2. In-situ parameters
3. TSS
4. Turbidity
5. Sample for Advanced parameters (when necessary)
Field Sampling for FCB

With a few general exceptions sampling for FCB is performed according to Ecology's Environmental Assessment program Standard Operating Procedure for Sampling Bacteria in Water, Version 2.1 (Ward and Mathieu, 2011). A copy of this procedure is found in Appendix D.

Sample bottles and corresponding fields on the Chain of Custody (COC) for each sample are labeled as follows:

- Client: SnoCo SWM
- Sample/Client ID: Sample Station
- Date: MM/DD/YY
- Time: time of sampling
- Analysis: FCB SM9222D
- Preservative: Ice

Preservation of FCB sample is recommended by APHA (1998) using sodium thiosulfate to reduce chlorine expected in samples. This preservative is commonly used when sampling for bacteria from waste water plant discharges. Since this is not the case for sampling under this QAPP, sodium thiosulfate will not be added to sample bottles.

Similarly, preservation of FCB samples with disodium salt of ethylenediaminetetraacetic acid (EDTA) is used when sampling waste water with metals concentrations including copper and zinc > 1.0 mg/l (APHA 1998). A review of data collected at long-term stations from 2004-2009 shows that only two results for zinc exceeded 1.0 mg/l during that period. For these reasons, EDTA will not be used as a preservative for sampling bacteria under this QAPP.

Ecology’s procedure for FCB sampling written by Ward and Mathieu (2011) indicates that FCB samples should be preserved in a cooler and held at or below 4°C. APHA (1998) indicates that non-potable water for either compliance or non-compliance-based purposes should be held below 10°C during a maximum transport time of 6 hours for compliance-based samples and 24 hours for non-compliance-based samples. While it is not the intent of monitoring under this QAPP to gather samples for enforcement purposes, sample results obtained that meet the 6h transport time requirement may be used to suggest a potential violation of Snohomish County Code (SCC 7.53) and Washington State Administrative Code (WAC 173-201A).

Snohomish County will adhere to the APHA (1998) 9060B preservation requirements for FCB samples. Sample temperatures that exceed 10°C upon lab receipt will be qualified as estimates.

Field Measurements using Hydrolab Minisonde 5a™

The steps for preparing the Hydrolab Minisonde 5a™ and in-situ sampling are:

Preparation
1. Ensure the instrument is set up, calibrated, maintained, and stored according to manufacture's guidance – NOTES:
   - Follow the manual's order of calibration
   - Ensure calibration standards are not expired
   - Do not use the Minisonde stirrer when measuring dissolved oxygen.
   - Specific Conductance parameter set up uses the Freshwater Temperature Compensation function
   - Select a two-point calibration to set up the pH sensor and parameter
   - Obtain barometric pressure readings for calibration of LDO sensors from the surveyor 4’s barometric pressure as recorded in the SWM lab.

2. Set up a manually triggered file in the Surveyor 4a to gather data for the sample run.
3. Ensure the Surveyor 4a internal battery has at least a 9-volt charge.
4. Use the instruments’ carrying case to transport from the lab to vehicles and back.

Field Use
1. Unscrew the calibration cup from the sensors and affix the weighted sensor guard.
2. Turn on the Surveyor 4.
3. Submerge all sensors to mid-depth (where feasible) and point into flow – Do not allow sensors to contact bottom sediment. Muddy or sandy bottom substrates are the most likely to impact measurements.
   a. If flow is not great enough for submersion, triple rinse the calibration cup and use it for submersion of sensors,
4. Wait for temperature to stabilize such that it doesn’t vary more than 0.1 Deg C.
5. Manually trigger Surveyor 4a to capture measurements.
6. Remove instrument from water.
7. Review manually triggered measurements from the Surveyor 4a file and record on the field data sheets.
8. Rinse sensors with de-ionized water between sample stations.

Note: If ice or high water makes it difficult to obtain measurements from shore, secure the Hydrolab and its’ cable using the sample extension pole to obtain measurements.

Field Sampling for TSS

Samples for TSS are gathered using the sample pole and an unpreserved 250ml or 500ml plastic bottle. With the cap off, the sample bottle is plunged neck down through the water surface and turned sideways at mid-depth into the flow until full. The bottle is capped and stored in a cooler for transport to Snohomish County offices.

Samples bottles and the corresponding sample ID on the water quality monitoring field form are labeled accordingly:

Client: SnoCo SWM
Sample ID/Client ID: Sample Station (ex. NCLU)
Date: MM/DD/YY
Time: time of sampling
Analysis: TSS (SM2540D)
Field Sampling for Turbidity

Samples for turbidity are gathered and analyzed in accordance with procedures identified in the HACH 2001P turbidimeter user manual. A 1L unpreserved sample bottle attached to the sample pole is plunged neck down through the water turned sideways at mid-depth into the flow. This process is repeated three times to “triple rinse” the sample bottle. A sample is collected on the fourth plunge.

Turbidity samples are analyzed in the field using the HACH 2100P Turbidimeter following protocols for turbidity measurement in section 2 of the manual. An electronic copy of this manual is found on the County network at...

A summary of field analysis methods is:

1. Thoroughly mix the 1L sample by shaking for 30 seconds.
2. Triple rinse a clean (non-scratched) 25 ml glass turbidity sample vial.
3. Use the fill the vial with the fourth pour and cap the sample vial.
4. Place the turbidimeter on a level, stationary surface.
5. Wipe the vial with a lint-free cloth.
6. Apply silicon oil and wipe with lint free cloth.
7. Remove any gas bubbles using the syringe and stopper method.
8. Turn on the Turbidimeter and orientate the sample vial such that the diamond is aligned with the raised mark on the instrument.
9. Select signal averaging mode on the Turbidimeter.
10. Press read and record the value on the field data sheet.

Field Sampling for Ammonia

Samples obtained for analysis of Ammonia may be taken during targeted source identification efforts using a 125ml HDPE sample bottle preserved with sulfuric acid (H₂SO₄). Samples are gathered through grab methods with a sample pole from flowing water within the thalwag of the tributary or conveyance system.

Samples bottles and the corresponding sample ID on the water quality monitoring field form are labeled accordingly:

- Client: SnoCo SWM
- Sample ID: Sample Station, Location Upstream (a,b,c,d etc) and date MMDDYY Date: MM/DD/YY
- Time: time of sampling
- Analysis: Ammonia
- Preservative: H₂SO₄ / Ice

Field Sampling for Potassium
Samples obtained for analysis of Potassium may be taken during targeted source identification efforts using a 125ml HDPE sample bottle preserved with nitric acid (HNO$_3$). Samples are gathered through grab methods with a sample pole from flowing water within the thalwag of the tributary or conveyance system.
Samples bottles and the corresponding sample ID on the water quality monitoring field form are labeled accordingly:

- **Client**: SnoCo SWM
- **Sample ID**: Sample Station, Location Upstream (a,b,c,d etc) and date MMDDYY Date: MM/DD/YY
- **Time**: time of sampling
- **Analysis**: Potassium
- **Preservative**: HNO₃/Ice

**Field Sampling for Surfactants MBAS/CTAS**

Samples obtained for analysis of Surfactants may be taken during targeted source identification efforts using a 125ml HDPE sample bottle preserved with ice. Samples are gathered through grab methods with a sample pole from flowing water within the thalwag of the tributary or conveyance system.

Samples bottles and the corresponding sample ID on the water quality monitoring field form are labeled accordingly:

- **Client**: SnoCo SWM
- **Sample ID/Client ID**: Sample Station (ex. NCLU)
- **Date**: MM/DD/YY
- **Time**: time of sampling
- **Analysis**: MBAS/CTAS (SM5540C/SM5540D)
- **Preservative**: Ice

**Sample Preservation, Transport and Chain of Custody**

Preservation of samples is conducted as identified in table 1060:1 of APHA (1998). Samples are stored and transported in a cooler at or below 10°C. Following each sampling event, staff transport samples to Snohomish County’s secure sample drop off/pick up box to meet the preservation and hold time requirements. Field staff use a COC for all samples transported to the office or laboratory using a form supplied by the laboratory (Appendix E). A standard 10 day turn-around time is expected unless results must be received more quickly.

In accordance with Standard Method 9020 for bacterial examination, lab duplicate analysis must be performed on at least 10% of all samples. To ensure that the lab performs duplicate analysis on Snohomish County samples, the check box on the far right hand side of the COC for QA/QC must be checked where and when the randomized process has already identified a station for field duplicates and blanks.
The contract laboratory can receive samples from Monday through Friday. By contract, the lab will pick up samples at Snohomish County offices no later than 3:30pm each day. The principal investigator will maintain a file of COC forms in a binder with field data sheets and lab reports.

Field Sample and Measurement Methods

The analytical laboratories used in this project to analyze surface water samples are accredited by Ecology or in the case of EPA Manchester, through the National Environmental Laboratory Accreditation Council (NELAC) for all parameters and analytical methods in the project. The analytical laboratory shall maintain Ecology or NELAC accreditation during the contract / MOU period with Snohomish County. Table 12 identifies the parameter, analytical method, volume of sample required, the bottle type, the holding time and preservation for surface water samples collected for laboratory analysis.

Table 15. Field Sample Methods

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analytical Method</th>
<th>Recommended Quantity</th>
<th>Container</th>
<th>Holding Time</th>
<th>Preservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCB</td>
<td>SM9222D</td>
<td>125ml</td>
<td>Sterile HDPE</td>
<td>24hr</td>
<td>&lt; 10 Deg C</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>SM2540D</td>
<td>250 or 500 ml</td>
<td>Sterile HDPE</td>
<td>28 day</td>
<td>&lt; 10 Deg C</td>
</tr>
<tr>
<td>Ammonia</td>
<td>EPA350.1</td>
<td>125 ml</td>
<td>Sterile HDPE</td>
<td>28 day</td>
<td>H2SO4</td>
</tr>
<tr>
<td>Potassium</td>
<td>SM200.7</td>
<td>125 ml</td>
<td>Sterile HDPE</td>
<td>6 mo</td>
<td>HN03</td>
</tr>
<tr>
<td>MBAS/CTAS Surfactants</td>
<td>SM5540C/SM5540D</td>
<td>125 ml</td>
<td>Sterile HDPE</td>
<td>48 hr</td>
<td>&lt; 10 Deg C</td>
</tr>
</tbody>
</table>
Field instrument sensors employ methods conforming to guidelines establishing test procedures for analysis of pollutants contained in 40 CFR Part 136.

Table 16. Field Measurement Methods

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sensor Methods</th>
<th>Units</th>
<th>Method Detection Limit and/or Resolution</th>
<th>Sensor Accuracy</th>
<th>Required Reporting Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>SM2550B-F</td>
<td>°C</td>
<td>±0.10</td>
<td>+/- 0.1°C</td>
<td>0.1°C</td>
</tr>
<tr>
<td>Luminescent Dissolved Oxygen</td>
<td>SM4500OG</td>
<td>mg/l</td>
<td>0.01</td>
<td>+/- 0.1 &lt; 8 mg/l</td>
<td>0.1 mg/l</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+/- 0.2 &gt; 8 mg/l</td>
<td></td>
</tr>
<tr>
<td>Specific Conductance</td>
<td>SM2510B</td>
<td>us/cm</td>
<td>0.001</td>
<td>+/- 0.5%</td>
<td>1 us/cm</td>
</tr>
<tr>
<td>Turbidity</td>
<td>EPA 180.1</td>
<td>NTU</td>
<td>0.01</td>
<td>+/- 2%</td>
<td>+/- 0.2 NTU</td>
</tr>
<tr>
<td>pH</td>
<td>EPA150.1M</td>
<td>Units</td>
<td>±0.2</td>
<td>+/- 0.2</td>
<td>0.01 NTU</td>
</tr>
<tr>
<td>Optical Brighteners – In house analysis</td>
<td>+/-</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Visual Fluorescence</td>
</tr>
</tbody>
</table>

**Quality Control**

Quality assurance/quality control (QA/QC) measures are those activities taken to demonstrate the accuracy (how close to the real result you are) and precision (how reproducible results are) of your monitoring. Quality Control (QC) consists of the steps taken to determine the validity and usability of field measurements and samples. There are specific data quality objectives for field measurements and samples and an overarching completeness goal for the study.

Surface Water Management has established internal data verification and validation processes, associated data quality objectives and qualifiers consistent with EPA and Ecology guidance while maintaining consistency of data management needs.
Completeness

Completeness is the measure of the amount of valid data needed to be obtained from a study. The completeness goal will be 90 percent for field measurements and sampling. The project manager will discuss implications for analysis and reporting should this goal not be met. Advanced sampling parameters will not be subject to a completeness goal.

Field Measurement Quality Control

Field measurement data quality is assessed through use of daily, post-monitoring calibration checks. Dissolved oxygen, pH, conductivity, and turbidity data gathered in-situ using the Hydrolab Minisonde™ and Hach 2100P™ Turbidimeter will be qualified on calibration check data sheets (Appendix C) in accordance with conditions in table 21. Daily calibration and post monitoring checks will be conducted using methods and thresholds for acceptance or rejection of field measurements outlined in table 14.

Data are qualified as either accepted or rejected from analysis based upon those quality control criteria accordingly. The project manager will work with field staff to determine the cause of rejected data and work to correct any issues.

Table 17. Quality Control Criteria for Field Measurements

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Accept</th>
<th>Qualify</th>
<th>Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH *</td>
<td>std. units</td>
<td>&lt; or = ± 0.25</td>
<td>&gt; ± 0.25 and &lt; or = ± 0.5</td>
<td>&gt; ± 0.5</td>
</tr>
<tr>
<td>Conductivity*</td>
<td>μS/cm</td>
<td>&lt; or = ± 5%</td>
<td>&gt; ± 5% and &lt; or = ± 15%</td>
<td>&gt; ± 15%</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>% saturation</td>
<td>&lt; or = ± 5%</td>
<td>&gt; ± 5% and &lt; or = ± 10%</td>
<td>&gt; ± 10%</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>&lt; or = ± 5%</td>
<td>&gt; ± 5% and &lt; or = ± 10%</td>
<td>&gt; ± 10%</td>
</tr>
</tbody>
</table>

* Criteria expressed as a percentage of readings; for example, buffer = 100.2 μS/cm and Hydrolab = 98.7 μS/cm; (100.2 - 98.7)/100.2 = 1.49% variation, which would fall into the acceptable data criteria of less than 5%. Calibration checks for pH and conductivity are conducted using two point checks. Conductivity and pH standard values change with temperature. Calibration checks take this into consideration.

Field Sample Quality Control

Representativeness

In accordance with FCB sampling procedures in Mathieu (2006), un-biased water quality sampling efforts for FCB are dependent upon the presence of flowing waters. Sampling of stagnant waters will not adequately represent point or non-point sources of pollutants, nor is it recommended for comparison to water quality standards. Flow may be limited in the spring or summer months. Sampling will not take place when waters are stagnant, therefore reducing potential sample event opportunities and impacting analysis, informed decision making and potentially the ability to identify and elimination polluted discharges.
Once representative samples are obtain, field sample result quality is assessed based upon an evaluation of field duplicate, blank and trip sample results.

**Field Duplicates**

Field duplicate samples are obtained for 10% of collected samples to determine whether the data quality objectives of bias, precision, accuracy and ultimately relative standard deviations are met. Results are analyzed to question homogeneity, precision of sampling procedures or illustrate issues with field technique, equipment contamination of other issues. Stations are chosen randomly for collection of field duplicates. Field duplicates will be taken using side by side sampling techniques such that duplicates are gathered at the same time and place.

Field duplicates are labeled such that each is unique and blind to the laboratory. To partially achieve this, time of sampling is not noted on the sample bottle or chain of custody, but recorded on field sheets. Field duplicates for field measurements are uniquely identified on field sheets.

Field duplicate samples for bacteria and TSS will be labeled and identified on the COC using the following convention:

- **Client:** SnoCo SWM
- **Sample/Client ID:** Date MMDDYY, Analyte(s), Dup, # (011310BactDup1) for bacteria or (0113110TSSDup1) for TSS
- **Date:** MM/DD/YY
- **Time:** No time noted on sample bottle or COC
- **Analysis:** FCB SM9222D / TSS
- **Preservative:** Ice

**Evaluation of FCB Field Duplicate Data**

Field duplicate analyses on an individual sample and programmatic basis will indicate the degree of imprecision due to the combined effects of heterogeneity of the stream, variation in sample collection methods, and imprecision of analytical methods. This enables program managers to more quickly identify and correct error.
Precision of field sampling will be assessed by calculating the relative standard deviation (RSD) between field duplicate samples.

$$\%RSD = \frac{s}{x} \times 100$$

Where:
- $\%RSD = \text{relative standard deviation}$
- $s = \text{standard deviation of original and duplicate sample}$
- $x = \text{mean of original and duplicate sample}$

The County has chosen to evaluate both individual and programmatic FCB field duplicates’ as recommended by Mathieu (2006) where evaluation is split between duplicate pairs with means of > 20 or < 20. The process for evaluating programmatic FCB field duplicate samples is illustrated in Figure 11.

Figure 11. FCB Field Duplicate Evaluation

Fifty percent of FCB duplicate pairs with means > 20 colonies, must exhibit < 20 percent relative standard deviation (RSD) and 90 percent of the duplicate results must be < 50 percent different.

In SWM’s experience, the ability to meet the same individual or programmatic based measurement quality objective for means of FCB duplicates < 20 has been poor. Mathieu (2006) indicates that where the mean of duplicate pairs is < 20 colonies, project managers review results for determination of data usability. No other clear recommendations are made by Mathieu (2006) on how to treat data where the RSD’s for these data exceed criteria. Sargeant (2000) wrote that where duplicate means are close to method detection limits, RSD’s are expected to be greater than 50 percent, and data are generally accepted for use.
Using this guidance, the County has chosen to set the allowed RSD for 50 and 90 percent of field FCB duplicates where means are < 20 at 50 and 75 percent RSD respectively.

Where individual and programmatic field duplicates meet established data quality objectives and pass verification, data are considered useable. Tables 16 and 17 show how individual and programmatic field duplicates are evaluated, qualified and treated for usability.

Table 18. Individual FCB Field Duplicate Quality Control

<table>
<thead>
<tr>
<th>Duplicate Pair Means</th>
<th>Relative Standard Deviation</th>
<th>Qualifier if Confirmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Duplicate Means &lt; 20 Colonies</td>
<td>&lt; 50 %</td>
<td>Sample result is accepted without qualification</td>
</tr>
<tr>
<td></td>
<td>&gt; 50% &lt; 75%</td>
<td>Sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>&gt; to 75%</td>
<td>Sample result is rejected</td>
</tr>
<tr>
<td>Field Duplicate Means &gt; 20 Colonies</td>
<td>&gt; 20% &lt; 50%</td>
<td>Sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>&gt; 50%</td>
<td>Sample result is rejected</td>
</tr>
</tbody>
</table>

Table 19. Programmatic FCB Field Duplicate Quality Control

<table>
<thead>
<tr>
<th>Duplicate Pair Means</th>
<th>Relative Standard Deviation</th>
<th>Decision if Confirmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Duplicate Means &lt; 20 Colonies</td>
<td>50% of duplicate pairs ≤ 50% RSD and 90% of duplicate pairs ≤ 75% RSD</td>
<td>Programmatic Quality Control Met</td>
</tr>
<tr>
<td></td>
<td>50% of duplicate pairs &gt; 50% RSD and/or 90% of duplicate pairs &gt; 75% RSD</td>
<td>Evaluate field/lab records and consider implications for dataset</td>
</tr>
<tr>
<td>Field Duplicate Means &gt; 20 Colonies</td>
<td>50% of duplicate pairs ≤ 20% RSD and 90% of duplicate pairs ≤ 50% RSD</td>
<td>Programmatic Quality Control Met</td>
</tr>
<tr>
<td></td>
<td>50% of duplicate pairs &gt; 20% RSD and/or 90% of duplicate pairs &gt; 50% RSD</td>
<td>Evaluate field/lab records and consider implications for dataset</td>
</tr>
</tbody>
</table>
Evaluation of Total Suspended Solids Field Duplicate Data

Like that for FCB, field duplicates for TSS will be collected for ten percent of the total samples. Precision of field sampling will be assessed by calculating the relative standard deviation (RSD) between field duplicate samples.

\[ \% \text{RSD} = \frac{S}{\bar{x}} \times 100 \]

Where:

\( \% \text{RSD} = \) relative standard deviation
\( S = \) standard deviation of original and duplicate sample
\( \bar{x} = \) mean of original and duplicate sample

The County has chosen to evaluate individual and programmatic TSS field duplicate RSD’s as recommended by Matheiu (2006) where RSD’s of duplicate pairs are qualified against established quality control criteria on the basis of whether the sample result was either above or below 5x the detection limit.

Programmatic evaluations conducted on duplicate sets are split between results above or below 5x the detection limit. A cumulative distribution is then used to determine whether programmatic TSS field duplicates meet quality control thresholds. The programmatic concept is illustrated in figure 12. Data quality thresholds for individual and programmatic TSS samples are found in tables 18 and 19.

![Diagram of Programmatic TSS Field Duplicate Evaluation](image)

Figure 12. Programmatic TSS Field Duplicate Evaluation
Table 20. Individual TSS Field Duplicate Pair Quality Control

<table>
<thead>
<tr>
<th>Sample Result vs Method Detection Limit</th>
<th>Relative Standard Deviation</th>
<th>Qualifier if Confirmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 x’s MDL</td>
<td>&lt; 50%</td>
<td>Sample result is accepted without qualification</td>
</tr>
<tr>
<td></td>
<td>≥ 50% and &lt; 75%</td>
<td>Sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>&gt; to 75%</td>
<td>Sample result is rejected</td>
</tr>
<tr>
<td>&gt; 5 x’s MDL</td>
<td>&lt; 20%</td>
<td>Sample result is accepted without qualification</td>
</tr>
<tr>
<td></td>
<td>≥ 20% &lt; 50%</td>
<td>Sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>≥ 50%</td>
<td>Sample result is rejected</td>
</tr>
</tbody>
</table>

Table 21. Programmatic TSS Field Duplicate Pair Quality Control

<table>
<thead>
<tr>
<th>Sample Result vs Method Detection Limit</th>
<th>Relative Standard Deviation</th>
<th>Decision if Confirmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 x’s MDL</td>
<td>50% of duplicate pairs &lt; 50% RSD and 90% of duplicate pairs ≤ 75% RSD</td>
<td>Programmatic Quality Control Met</td>
</tr>
<tr>
<td></td>
<td>50% of duplicate pairs &gt; 50% RSD and 90% of duplicate pairs &gt; 75% RSD</td>
<td>Evaluate field/lab records and consider implications for dataset</td>
</tr>
<tr>
<td>&gt; 5 x’s MDL</td>
<td>50% of duplicate pairs &lt; 25 % RSD and 90% of duplicate pairs &lt; 50% RSD</td>
<td>Programmatic Quality Control Met</td>
</tr>
<tr>
<td></td>
<td>50% of duplicate pairs &gt; 25% RSD and 90% of duplicate pairs &gt; 50% RSD</td>
<td>Evaluate field/lab records and consider implications for dataset</td>
</tr>
</tbody>
</table>

Field Blanks

Field blank samples are used to determine whether lab or field measurements may have been cross-contaminated through sample collection, storage and transport (Ecology, 2004). Field blanks are taken at randomly selected stations. Ultra-clean de-ionized lab water is transported to the field, transferred from a sterile, lab-provided container into the appropriate sample container for 10 percent of samples collected.

Field blank samples are labeled such that each is unique. Time of sampling is noted on samples bottles for analysis.
Field blank samples for FCB and TSS will be labeled and identified on the COC using the following convention:

- Client: SnoCo SWM
- Sample/Client ID: Date MMDDYY, Analyte(s), Blank, # (011310BactFB1) for Bacteria or (011310TSSFB1) for TSS
- Date: MM/DD/YY
- Time: Same time of sampling as the original sample
- Analysis: FCB SM9222D, TSS
- Preservative: Ice

Evaluation of Field Blank Results
Detections in field blanks for either FCB bacteria or TSS result in estimating the original sample result.

Trip Blank Samples
Trip blank samples are taken to identify contaminant carry over from the time that sample bottles are handled at Snohomish County offices through field efforts. Detection of a pollutant in a trip blank sample will identify cross-contamination due to handling of sample bottles while prepping for field work. Ultra clean de-ionized lab water is transferred from a sterile, bacteria free lab provided container into the appropriate sample container prior to leaving Snohomish County offices. Samples are labeled accordingly, and treated the same as all other bacteria samples for that day.

One trip blank sample for analysis of FCB and TSS will taken on a quarterly basis by random selection.

Trip blank samples for bacteria and TSS will be labeled and identified on the COC using the following convention:

- Client: SnoCo SWM
- Sample/Client ID: Date MMDDYY, Analytes(s) Trip Blank, # (011310BactTB1) for Bacteria or (011310TSSTB1) for TSS
- Date: MM/DD/YY
- Time: Time samples prepared in the lab
- Analysis: TSS SM2450D, FCB SM9222D
- Preservative: Ice

Evaluation of Trip Blank Results
Detections in trip blanks for either FCB bacteria or TSS result in estimating the original sample result.
Lab Quality Control

While evaluation of field sampling and analytical lab methods utilize similar metrics of bias, precision and accuracy, analytical lab methods and thresholds for acceptance or rejection differ from evaluation of field sampling processes.

**Bias**
Definition: The difference between the population mean and the true value.

Example: The bias and precision associated with data collection can directly affect the level of uncertainty in parameter estimates. Bias and precision (collectively known as accuracy) are two principal attributes, or characteristics, of data quality in environmental studies. Bias represents systematic error (i.e., persistent distortion that causes constant errors in a particular direction), while precision represents random error (i.e., error among repeated measures of the same property under identical conditions, but not systematically in the same direction). Estimates of bias and precision and associated minimum detection limits are used to determine how well a measurement method performs for a specific range of concentrations.

**Precision**
Precision is a measure of how close the computed value is to the same quantity measured several times. Precision will be evaluated using field and laboratory duplicate sample analysis. Field duplicate analyses will indicate the degree of imprecision due to the combined effects of heterogeneity of the stream, variation in sample collection methods, and imprecision of analytical methods. Laboratory duplicate analyses will indicate the degree of imprecision due to the combined effects of sample splitting in the laboratory, and imprecision of analytical methods. Lab sample precision will be determined by calculating the RPD expressed as a percent.

\[
\text{%RPD} = \frac{(S - D)}{(S+D)/2} \times 100
\]

Where:

- %RPD = relative percent difference
- S = Analytical result of sample of origin
- D = Analytical result of the duplicate sample
**Accuracy**

Accuracy is the degree of agreement of a measurement result and a true value and is represented as the percent recovery of a spike.

\[
\text{Accuracy} = \% \text{ recovery of the MS/MSD samples} = \frac{X_s - X_o}{C_s} \times 100\% 
\]

Where:
- \(\% \text{R}\) = percent recovery
- \(X_s\) = spike sample result
- \(X_o\) = original sample amount

The results of the bacteria, in situ physical and chemical water quality sampling and laboratory quality assurance and quality control samples will be reviewed. Results from the sampling and laboratory quality assurance and controls samples will be compared to established criteria.

Results that do not meet the data quality objectives will be noted. Appropriate qualifiers will be applied to any decision that relies on data that do not meet the measurement quality objectives.


Lab analysis and precision for parameters specific to this QAPP are found in table 20.

**Table 22. Lab Methods and Quality Control**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Analytical Methods</th>
<th>Reporting Limit</th>
<th>Method Detection Limit</th>
<th>Allowed Lab Duplicate Precision (%RPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCB</td>
<td>Colonies 100ml</td>
<td>SM9222D Membrane Filtration</td>
<td>2 min, 2 E^6</td>
<td>1</td>
<td>&lt;50%</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>mg/l</td>
<td>SM2540D</td>
<td>1</td>
<td>1</td>
<td>&lt;32%</td>
</tr>
<tr>
<td>Ammonia-Nitrogen</td>
<td>mg/l</td>
<td>EPA350.1</td>
<td>0.01</td>
<td>0.01</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>Surfactants (MBAS/CTAS)</td>
<td>mg/l</td>
<td>SM5540C/SM5540D</td>
<td>0.025/0.05</td>
<td>0.025/0.05</td>
<td>&lt;24/&lt;50%</td>
</tr>
<tr>
<td>Potassium</td>
<td>mg/l</td>
<td>EPA 200.7</td>
<td>0.1</td>
<td>0.1</td>
<td>70 - 130%</td>
</tr>
<tr>
<td>Optical Brighteners – Lab Analysis</td>
<td>nm</td>
<td>Shimadzu RF-540</td>
<td>415-422 nm</td>
<td>5nm</td>
<td>NA</td>
</tr>
</tbody>
</table>
Data Verification, Validation and Quality Assessment

While data verification and validation are parallel processes, they reflect two separate functions. Data verification serves as an evaluation of performance, while validation focuses on data needs for a project as stated in much of this QAPP. The processes are outlined in figure 13 and described in EPA Guidance Document on Environmental Data Verification and Data Validation – QA/G-8 (2002).

To conduct data verification and validation, a reviewer must reference this QAPP, field and laboratory records.

Figure 13. Data Verification and Validation Process
Data Verification

Data verification is the process of evaluating the completeness, correctness, and conformance or compliance of a specific data set against the method, procedural, or contractual requirement. SWM has developed detailed procedures for verification of water quality data.

Field measurement and lab analysis and sample verification, requirements, and responsibilities

Trained support staff are responsible for data management and verification. The project manager reviews entry of data and verification conducted by support staff. Field and lab data are verified as received. Spreadsheets are used to record the verification process and identify non-conformance with established measurement quality objectives.

Field Measurements
- Duplicate field measurements within acceptable % RSD
- Field blank measurements within expected range?
- Checks against known standards

Field Samples and Lab Analysis
- Sample analyzed in accordance with method identified on Chain of Custody?
- Duplicate field sample results within acceptable % RSD?
- Blank field sample results non-detect?
- Analytical hold times met?
- Hold temperatures met?
- Chain of Custody signed and dated?
- Lab duplicate RPD met?
- Lab method blanks resulted in non-detects?
- Standard reference materials % recovery met?
- Matrix and matrix spike duplicates within recovery limits?

Verification of field measurements and analytical lab processes will result in qualifying data for usability in accordance with SWM procedures and conformance with EIM requirements. Appendix H contains field sample data qualifiers.

Corrective actions including investigation or review of field and/or lab sampling and analysis methods are taken when non-conformance occurs.

Data Validation

Data validation includes annual inspection of verified field and lab data to determine the analytical quality. It includes, were possible, a determination of the reasons for any failure to meet method, procedural, or contractual requirements and an evaluation of the impacts to the quality of the dataset. While typically performed by someone independent from the activity, SWM does not have this luxury. The project manager, engineering technician and water quality analyst will be responsible for performing validation.
Data Quality Assessment
A data quality assessment is the scientific and statistical evaluation of data to determine if data obtained are of the right type, quality and quantity to support their intended use (EPA 2000). Data quality assessments are designed to:

1. Review the data quality objectives and sample design
2. Conduct a preliminary data review
3. Select a statistical test
4. Verify assumptions of the statistical test
5. Draw conclusions from the data

Processes described here are adapted from EPA (2000) guidance on data quality assessments and practical methods for data analysis. The steps are similar to those that a statistician would take when analyzing a set of data.

Review of data quality objectives and sample design
If data validation indicated that sampling and analysis deviated in significant ways from the original planning process, that discussion should be included in the data validation report.

A review of study objectives is conducted to ensure the problem is clearly defined, there is no missing information, and that the scale of decision making is specified.

Preliminary data review
Extensive use of the data validation report is involved here. The analyst looks at the report to examine flagged data and note abnormalities in recorded data.

Statistical Data Review
A statistical data review will be conducted to identify outliers and other abnormalities in the data. Statistical analysis will vary between field measurements and lab data, but generally include calculations of the mean, median, mode, sample range, sample variance, and standard deviations. Outliers or data that is anomalous with the entire data set will be reviewed for the origin of the error in data collection, laboratory analysis, data input and recording, QA/QC, and data verification. If the data is unable to conform, does not meet the data quality objectives then the data are qualified prior to analysis.

Graphical Review
The data will be plotted using a scatter plot to identify additional outliers or confirm outliers and abnormal data. Outlying data will be compared against the statistical and the preliminary data review to confirm that the point is an outlier or anomaly.

Non-Detects
Non-detect results for FCB and TSS will be treated is provided a qualifier of “U” and treated by substitution using the method detection limit for analysis and database load.
Data Management Procedures

Field Data
In-situ chemical and physical parameters are recorded on standardized field sheets and manually entered into verification and data storage spreadsheets. Data are checked for completeness, verified and transformed for transfer to Ecology’s EIM database as required or reasonable. Field data sheets for monthly monitoring and targeted source identification efforts are kept in hardcopy and retained for 5 years.

Laboratory Data
Data packages for lab analysis will be sent to SWM by the laboratory within 10 days of the sampling date. The data packages will be provided electronically via the laboratory’s website and hard copies will be mailed to the project manager. Data reports from the analytical laboratory will be reviewed for completeness by the project manager. Potential errors and omissions will be reported to the responsible laboratory personnel. The analytical reports will be compared to the COC by the project manager or designee to ensure that all requested analyses have been performed. Errors or missing data will be reported to the responsible laboratory personnel immediately. Amended and corrected analytical reports will be attached to the report being corrected to ensure that only the corrected data are reported in the database and used in the data analysis. Acceptable laboratory reports will be stored in project notebooks. Laboratory results will be entered into a database and verified.

Data will be accepted without qualifiers if the analytical reports meet the data verification and validation requirements in this QAPP. Before qualifiers are attached to any data, the project manager will make every effort to correct the data by reviewing the sample documentation, meeting with SWM staff, and contacting the analytical laboratory. All data will be reported, regardless of the qualifiers attached; however, the project manager may elect not to include qualified data in the water quality data analysis. Qualifiers applied to field samples under this QAPP are found in Appendix H.
Data Analysis

Graphical Representations
Scatter plots, histograms and box and whisker plots are useful tools for visually displaying datasets to identify outliers, determine frequency of standards exceedance and observe data ranges.

Descriptive Statistics
Descriptive statistics will be calculated by season and water year for pH, DO, conductivity, temperature and turbidity data gathered at each station. When appropriate, data will be compared to state water quality standards and plotted for trends and seasonal variability.

Calculation of Geometric Means and Percent Exceedences
FCB data are log transformed for normality as necessary and geometric means are calculated by water year and season for comparison to Washington State Water Quality Standards. A stations exceedance of seasonal geometric means results in partial acceptance of the null hypothesis.

Valid data will be compared to each waterbodies 10 percent not to exceed standard. If greater than 10% of samples obtained for calculation of the geometric mean exceed the standard then, the standard is violated, resulting in partial acceptance of the null hypothesis.

Calculation of Probabilities and MWQA Ranks
Where a sufficient volume of valid FCB data exists, true probabilities of impairment or non-impairment will be conducted to assist in making a determination about continued monitoring at a location. Microbial Water Quality Assessment (MWQA) ranks based upon the percent of FCB samples exceeding the 10 percent not to exceed standard aids in prioritizing sample stations where upstream targeted source identification and elimination efforts will take place.

Exploratory Analysis
Research conducted by Jolley et. al. (2008) suggests that bottom sediment can be a source of FCB upon re-suspension in the water column during storm events. To evaluate potential relationships TSS and FCB data may be subjected to a correlation analysis. Fecal
coliform data are analyzed for normality using a Shapiro Wilk Test. Non normal data are log transformed for normality. If data are considered normal, a Pearson’s r test is run on TSS and FCB data. If data are not normal after log transformation, a non-parametric Spearman’s r test is run on the same data. Correlation between TSS and FCB levels at a particular station may suggest that a portion of the FCB loading is due to sediment re-suspension and not fresh non-point sources.

**Trends Analysis**

Where a sufficient volume of valid data exists, seasonal and overall trends analysis may be conducted to determine if water quality is improving, getting worse or remaining the same.

**Audits and Reports**

**Audits**

An annual audit will be conducted by the project manager. The audit will review the staff conformance to the QAPP procedures. If project implementation is not in conformance to the QAPP, corrective procedures will be taken as soon as possible. If the audit identifies a deficiency or a required change in the QAPP, that change will be made and submitted to the Department of Ecology as soon as possible.

**Reports**

The project manager, support staff and/or consultants will produce project reports according to NPDES permit requirements or as needed to support internal decision making.
References

http://snohomishcountywa.gov/documentcenter/view/7506


Environmental Protection Agency (EPA). 1983. Health effects criteria for marine recreational waters. EPA-600/1-80-031. Cincinnati, OH

EPA. 1984. Health effects criteria for fresh recreational waters. EPA 600-1-84-004. Cincinnati, OH


Hutchison, Jeff. 2014. Personal communication with Sean Edwards by phone on January 30, 2014. Snohomish Health District, Environmental Health Division, Water and Wastewater Section. Everett, WA.


King County Water and Land Resources Division. 2005. Electronic data request through Bob Brenner, May 9, 2005, 201 S. Jackson Street, Suite 600, Seattle, WA 98104.


McCormick, Bruce. 2009. Warm Beach On-site Sewage System Sanitary Survey. Snohomish Health District, Environmental Health Division, Water and Wastewater Section. Everett, WA.


Appendix A. Health and Safety
Persons involved with water quality monitoring could be subjected to unsafe environments. Hazards include, but are not limited to roadside traffic, slips, trips, falls, drowning, heat and cold stress, exposure to chemicals and biological pathogens. Washington State Department of Labor and Industries requires the employers provide a safe work environment through communicating hazards and providing adequate training.

Staff are provided appropriate PPE to ensure limited contact with pollutants to minimize risk associated with blood-borne pathogens. Using proper PPE and sampling procedures can also help limit potential for cross contamination of samples. Staff carrying out work under this QAPP, are encouraged to receive vaccinations for Hepatitis A and B and are provided hazard communication and training in the following areas;

- Proper sign in/out procedure
- Fire extinguisher use
- Roadway Safety
- Chemical Hygiene/Lab Safety
- Biological Hazards
- Confined space entry
- Defensive driving
- River safety training
- Heat and Cold stress
- Hazard Communications through 24hr Hazardous Materials Training

Each training emphasizes the identification and use of personal protective equipment (PPE) to minimize hazards. Staff are encouraged to identify potential deficiencies in PPE or unsafe work conditions and report them to the project manager, supervisor or safety office so needs may be addressed.

General guidelines that water quality monitoring team members should follow include:

- Sign in and out according to SWM procedure,
- Carry a cell phone with you at all times,
- Check to ensure your PPE (boots, high visibility clothing, eye safety, ear protection, personal floatation device, gloves etc.) are adequate,
- Be aware of rising water levels and road closures due to heavy rain/flooding,
- Always wear appropriate PPE when working near surface waters and the roadway,
- Watch out for slippery surfaces, especially while accessing or leaving sample stations,
- Never enter a confined space, unless you have received confined space entry and followed all applicable county/state safety policies,
- Do not work in the railroad right of way, unless trained and certified to do so and proper notifications have been made
• Do not touch your hands or sampling equipment to your face or mouth during the course of the day, and immediately wash your hands after sampling is finished,
• Always ask the project manager if unsure about field or laboratory safety

In case of an emergency, field personal should call 911 or have injuries treated by the nearest hospital. Hospitals have been identified for each of the major watersheds in which work will be conducted.

Stillaguamish Watershed:

• Cascade Valley Hospital
  330 S Stillaguamish Ave
  Arlington, WA 98223
  (360) 435-2133

• Skagit Valley Hospital
  9631 269th St, Stanwood
  WA, 98292
  (360) 629-5800

Snohomish Watershed:

• Valley General Hospital
  14701 179th Ave SE, Monroe
  WA 98272
  (360) 794-7497

• Providence Regional Medical Center – Everett
  1321 Colby Ave Everett
  Everett, WA, 98201
  (425) 261-2000

Lake Washington Watersheds (Little Bear, North and Swamp Creek):

• Providence Regional Medical Center – Mill Creek Campus
  12800 Bothell-Everett Highway
  Everett WA  98208
  425-316-5000

• University of Washington Medicine – Woodinville Clinic
  17638 140th Ave. N.E.
  (425) 485-4100
Appendix B. Glossary, Acronyms, and Abbreviations
Quality Assurance Glossary

**Accredited** - A certification process for laboratories, designed to evaluate and document a lab’s ability to perform analytical methods and produce acceptable data. For Ecology, it is “Formal recognition by (Ecology)...that an environmental laboratory is capable of producing accurate analytical data.” [WAC 173-50-040] (Kammin, 2010)

**Accuracy** - the degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms precision and bias be used to convey the information associated with the term accuracy. (USGS, 1998)

**Analyte** - An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e. g. fecal coliform, Klebsiella, etc. (Kammin, 2010)

**Bias** - The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system, and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI). (Kammin, 2010; Ecology, 2004)

**Blank** - A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process. (USGS, 1998)

**Comparability** - The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator. (USEPA, 1997)

**Completeness** - The amount of valid data obtained from a data collection project compared to the planned amount. Completeness is usually expressed as a percentage. A data quality indicator. (USEPA, 1997)

**Data Quality Objectives (DQO)** - Data Quality Objectives are qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. (USEPA, 2006)

**Dataset** - A grouping of samples, usually organized by date, time and/or analyte. (Kammin, 2010)

**Data validation** - An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data
set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the data quality objectives for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the dataset.

**Data verification** - Examination of a dataset for errors or omissions, and assessment of the Data Quality Indicators related to that dataset for compliance with acceptance criteria (MQO’s). Verification is a detailed quality review of a dataset. (Ecology, 2004)

**Detection limit** (limit of detection) - The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero. (Ecology, 2004)

**Duplicate samples** - Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis. (USEPA, 1997)

**Field blank** - A blank used to obtain information on contamination introduced during sample collection, storage, and transport. (Ecology, 2004)

**Matrix spike** - A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects. (Ecology, 2004)

**Measurement result** - A value obtained by performing the procedure described in a method. (Ecology, 2004)

**Method** - A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed. (EPA, 1997)

**Method blank** - A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

**Method Detection Limit (MDL)** - This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)
**Percent Relative Standard Deviation (%RSD)** - A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

Percent relative standard deviation, %RSD = \( \frac{100 \times s}{x} \) where \( s \) = sample standard deviation, and \( x \) = sample mean (Kammin, 2010)

**Parameter** - A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene, nitrate+nitrite, and anions are all “parameters”. (Kammin, 2010; Ecology, 2004)

**Population** - The hypothetical set of all possible observations of the type being investigated. (Ecology, 2004)

**Precision** - The extent of random variability among replicate measurements of the same property; a data quality indicator. (USGS, 1998)

**Quality Assurance (QA)** - A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

**Quality Assurance Project Plan (QAPP)** - A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

**Quality Control (QC)** - The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

**Relative Percent Difference (RPD)** - RPD is commonly used to evaluate precision. The following formula is used:

\[ \text{Abs}(a-b)/((a+b)/2) \times 100 \]

Where \( a \) and \( b \) are 2 sample results, and abs() indicates absolute value

RPD can be used only with 2 values. More values, use %RSD. (Ecology, 2004)

**Representativeness** - The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

**Sample (field)** – A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

**Sensitivity** - In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit. (Ecology, 2004)
**Spiked blank** - A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method. (USEPA, 1997)

**Standard Operating Procedure (SOP)** – A document which describes in detail a reproducible and repeatable organized activity. (Kammin, 2010)

**Glossary – General Terms**

*Ambient:* Background or away from point sources of contamination.

*Clean Water Act:* A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation’s waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

*Fecal coliform:* That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform are “indicator” organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

*Geometric mean:* A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

*National Pollutant Discharge Elimination System (NPDES):* National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

*Nonpoint source:* Pollution that enters any waters of the state from any dispersed land-based or water-based activities. This includes, but is not limited to, atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination is considered a nonpoint source. Legally, any source of water pollution that does not meet the legal definition of “point source” in section 502(14) of the Clean Water Act is a nonpoint source.
**Pathogen:** Disease-causing microorganisms such as bacteria, protozoa, viruses.

**pH:** A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

**Point source:** Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

**Pollution:** Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or is likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

**Riparian:** Relating to the banks along a natural course of water.

**Stormwater:** The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

**Sub-basin:** A structural geologic feature where a basin forms within a larger basin.

**Surface waters of the state:** Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

**Total Maximum Daily Load (TMDL):** A distribution of a substance in a waterbody designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

**303(d) list:** Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are
impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standard, and are not expected to improve within the next two years.
Appendix C. Field Instrument Calibration Check Form
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### Snohomish County Ambient Water Quality Monitoring – Field Instrument Calibration Checks

<table>
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<th>Date:</th>
<th>Sample Run:</th>
<th>Personnel:</th>
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#### Data quality criteria for Hydrolab/Hach Calibration Checks

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<td>DO% sat. 100.6</td>
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* Standard pH & Conductivity is measured during the Calibration process and is set base upon the room temperature of the conductivity solution at the time of calibration.

**How to Calculate Percent Difference**

**Method**

1. Divide the New Value by the Old Value (you will get a decimal number)
2. Convert that to a percentage (by multiplying by 100 and adding a "%" sign)
3. Subtract 100% from that

*Note: if the result is positive it is a percentage increase, if negative, just remove the minus sign and call it a decrease.*

**Use the Table below to evaluate % difference & assign qualifier**

A = Accept, Q = Qualify, R = Reject

#### Data quality criteria for Hydrolab/Hach Calibration Checks

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
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<th>Qualify</th>
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<td>pH</td>
<td>std. units</td>
<td>&lt; or = +0.25</td>
<td>&gt; +0.25 and &lt; or = +0.5</td>
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<tr>
<td>Conductivity*</td>
<td>µS/cm</td>
<td>&lt; or = +5%</td>
<td>&gt; +3% and &lt; or = +15%</td>
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<tr>
<td>Dissolved Oxygen**</td>
<td>% saturation</td>
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<td>&gt; +5% and &lt; or = +10%</td>
<td>&gt; +10%</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>&lt; or = +5%</td>
<td>&gt; +5% and &lt; or = +10%</td>
<td>&gt; +10%</td>
</tr>
</tbody>
</table>

* Criteria expressed as a percentage of readings; for example, buffer = 100.2 µS/cm and Hydrolab = 98.7 µS/cm; (100.2-98.7)/100.2 = 1.49% variation, which would fall into the acceptable data criteria of less than 5%.
Hydrolab Calibration Check Procedures

DO

Step 1. Take a 1 liter bottle and fill it 50% full with deionized water which has been at equilibrium with atmospheric pressure for at least 12 hours i.e. unscrew /open the bottle well in advance of calibration; Make sure the water in the bottle is close to temperature equilibrium with the calibration environment, then shake the 1 liter bottle for 40 seconds.

Step 2. Immediately fill the calibration cup with the shaken deionized water up to the black line near the top of the calibration cap. Turn the black calibration cup cap upside down (concave upward) and lay it over the top of the calibration cup.

Step 3. Immediately, record three results of DO% sat. shown on the Surveyor Screen at 5 second intervals, on the reverse of this form for 15 seconds, average the three results and record averaged result in “DO% sat. - Measured” on the reverse of this form.

pH – two point calibration check

pH 7

Step 1. Read the pH 7 Standard at Room Temp. from the Chart on the pH 7.00 Buffer solution label and record the pH Standard at Room Temp. in the “pH 7* Standard” box shown on the reverse of this form.

Step 2. Fill the calibration cup about 25% with pH buffer 7 solution and screw the black calibration cup on. Shake the Hydrolab for six seconds and pour the pH buffer 7 out.

Step 3. Fill the calibration cup with buffer solution pH 7 again to just above the top of the pH sensor. Wait one minute for the readings to stabilize. When the readings are stable record the result in the “pH 7 Measured” box on the reverse of this form.

pH 4

Step 1. Read the pH 4* Standard at Room Temp. from the Chart on the pH 4.00 Buffer solution label and record the pH Standard at Room Temp. in the pH 4* “Standard” box shown on the reverse of this form.

Step 2. Fill the calibration cup about 25% full with pH buffer 4 and screw the storage cap on. Shake for six seconds and pour the pH buffer 4 out.

Step 3. Fill the cup with buffer solution pH 4 again to just above the top of the pH sensor. Wait one minute for the readings to stabilize. When the readings are stable, record the result in the “pH 4 Measured” box on the reverse of this form.

Conductivity - two point calibration check

Step 1. Empty and rinse out the calibration cup from the previous step then, then dry off the conductivity sensor targets with a cotton swab. Read the Cond. us/cm reading shown on the Surveyor’s Screen, it should read “0.0”, if so, record the result in the “Measured - Cond. 0” box.

Step 2. Find the Conductivity Standard at Room Temperature using Chart on the 447 us/cm Solution Bottle and Record the Standard in the “Cond.* Standard” box;

Step 3. Fill the calibration cup with 447 us/cm - Conductivity Solution to just above the top of the sensor, when the readings are stable record the result in the Cond.* - “Measured” box on the reverse of this form.
Appendix D. Ecology Procedure for Sampling Bacteria in Water
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Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Sampling Bacteria in Water

Version 1.0

Author – Nuri Mathieu
Date -

Reviewer – Karol Erickson, Water Quality Studies Supervisor
Date -

QA Approval – Bill Kammin, Ecology QA Officer
Date -

Program Approval – Will Kendra, Watershed Ecology Section Manager
Date -

EAP012

PROVISIONALLY APPROVED: June 26, 2006

Signatures on File
Please note that the Washington State Department of Ecology’s Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.
## SOP Revision History

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<th>Summary of changes</th>
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Environmental Assessment Program

Standard Operating Procedure for Sampling Bacteria

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Water Quality Studies Unit Standard Operating Procedure (SOP) for Sampling Bacteria. The most common type of bacteria sampled for is fecal coliform; however, this SOP also covers E. coli and other types of bacteria.

2.0 Applicability

2.1 This SOP should be followed for all sampling for bacteria in water. It includes procedures for collecting grab samples from a wadable stream and from boats, sampling from a bridge, collecting samples from wastewater treatment plant effluent, and collecting samples from swimming beaches.

3.0 Definitions

3.1 Lotic: Flowing water systems such as rivers and streams.

3.2 Thalweg: The line defining the lowest points along the length of a river bed.

4.0 Personnel Qualifications/Responsibilities

4.1 No special qualifications required.

5.0 Equipment, Reagents, and Supplies

5.1 Supplies

5.1.1 250 or 500 mL autoclaved glass or polypropylene bottle.

5.1.2 Latex gloves (for sites where bacteria level is known or suspected to be high).

5.1.3 Anti-bacterial hand sanitizer or soap.

5.1.4 Coolers.

5.1.5 Ice (Regular, blue, or dry—depending on shipping method).

5.1.6 Tap water. Sample tags with sample numbers assigned by MEL.

5.1.7 Lab Analysis Request (LAR) forms.

5.1.8 Sampling extension pole.

5.1.9 Specialized bridge sampler (if applicable).
Figure 1. Left: Specialized bridge sampler with bottle. Center: 250 mL polypropylene and glass bottles. Right: Sampling extension pole.

5.2 Sample Containers

5.2.1 The normal container for bacteria sampling is a 250-mL pre-autoclaved glass bottle (with cork stopper) or polypropylene bottle and cap. The bottle normally comes from the lab with aluminum foil wrapped over the cover to preserve sterility (Figure 1).

5.2.2 When chlorine is suspected to be present, bottles with thiosulfate added should be requested from the laboratory. The bottles will be marked with yellow stickers on top to indicate the sodium thiosulfate addition. Thiosulfate will not affect samples if chlorine is not present. The stopper should have masking tape with black lines, which means the bottle has been autoclaved.

5.2.3 If high metal contamination is suspected, bottles must have EDTA added. This is a special request and must be set up through the laboratory.

5.2.4 Holding times for bottles:

5.2.4.1 3 months without thiosulfate/EDTA
5.2.4.2 1 month with thiosulfate/EDTA

5.2.5 500 mL autoclaved bottles should be used when collecting a sample for multiple bacteria parameters. For example, if analysis for both Fecal Coliform and E. coli is required, then one sample may be collected in a 500 mL bottle, rather than two separate 250 mL samples or one 250 mL sample (250 mL does not provide enough sample to analyze for multiple parameters).
6.0 Summary of Procedure

6.1 Sample Collection

6.1.1 General Procedures and Techniques

6.1.1.1 The laboratory needs to prepare medium for bacterial analysis. It is especially important that sampling is prearranged with the lab. Two weeks is the preferred amount of notice.

6.1.1.2 Sampling for bacteria on Thursday through Sunday must be pre-approved with the laboratory.

6.1.1.3 If the range of bacteria concentrations can be estimated before sampling (from past samples or otherwise), let the lab microbiologist know beforehand or on the sample tags so the proper set of dilutions can bracket the range.

6.1.1.4 Since there are two possible methods (Membrane Filter, MF, and Most Probable Number, MPN), record which method is to be used in the proper fields on the Pre-Sampling Notification (PSN) form, as well as on the Laboratory Analysis Requested (LAR) form. Both forms can be located in the MEL Lab User's Manual (MEL, 2005).

6.1.1.5 If the water is extremely turbid (<25 mL can be filtered) the MPN method is necessary. Call the lab as soon as possible so they can prepare for this method.

6.1.1.6 General techniques and procedures apply to sampling special sources such as stormwater and combined sewer overflows. The Quality Assurance Project Plan (QAPP) may contain further guidance on sample planning and techniques for special circumstances.

6.1.1.7 Prior to collecting sample, have sample tag prepared containing the project name, sample number, site, date, and space for time. Also have field lab book or page prepared with similar information.

6.1.1.8 Do not rinse the bottle and do not pour water into a bacteria bottle from another non-sterilized container.

6.1.1.9 Face the opening of the bottle upstream and collect sample from thalweg or predominant flow. Avoid back eddies and side channels in lotic systems.

6.1.1.10 Collect sample at approximately 40 to 60 percent of the water's depth. Avoid collecting sample near the stream bed or surface layer. In shallow depths, collect sample from surface if unavoidable and record in field notes. Do not to let the bottle touch the stream bed.
6.1.1.11 When possible do not collect samples from stagnant waters. If unsure whether or not water is stagnant, use flow meter to measure velocity. Try not to collect samples from water where velocity is less than 0.1 feet per second. In some situations (e.g. sampling behind a pump station or tide gate) sampling stagnant water may be unavoidable.

6.1.1.12 Be careful not to disturb sediment from the stream bed, particularly in slower moving waters. For slow moving streams with easily disturbed sediment, collect sample from stream bank using sampling extension pole (Figure 1).

6.1.1.13 When filling the sample bottle, be careful to pull the bottle out of the water as it reaches the point where it is filled to at or near the shoulder of the bottle. If the bottle is filled above this level, immediately pour out (downstream of sampler) enough of sample so that the water level is at or near the shoulder of the bottle. This will allow enough air space above the sample for proper mixing before analysis at the lab.

6.1.1.14 For samples with preservative, if overfilling does occur the sample is not lost. The thiosulfate and EDTA that MEL adds to the bottles is in excess. Pour excess sample out of overfilled bottles with preservative, otherwise the sample result will be qualified as "bottle overfill."

6.1.1.15 If sampling from a boat, avoid gas and oil contamination. Hold the bottle upstream while the boat moves forward.

6.1.1.16 Place labeled sample bottle in cooler. It is important to cool to 4°C immediately and store in dark cooler, as bacteria samples are sensitive to light.

6.1.2 Grab samples (Without Preservative)

6.1.2.1 Remove stopper/lid from bottle just before sampling, leaving the aluminum foil over stopper/lid. Be careful not to contaminate the cork (glass bottle), cap (plastic bottle) or the inside of the bottle with your fingers, dirt particles, or dripping water from bridges, or other sources of contamination.

6.1.2.2 Remember, DO NOT RINSE the bottle.

6.1.2.3 Hold the bottle near its base, plunge it (mouth down) below the surface, avoiding the top micro-layer where bacteria tend to concentrate.

6.1.2.4 While under water, turn the bottle into the current and away from you, the shore, and the side of the sampling platform or boat.

6.1.2.5 Fill the bottle to the appropriate level (see techniques above).

6.1.2.6 Securely replace the aluminum covered stopper/lid.

6.1.2.7 Rinse any large amount of dirt or debris from the outside of the container.
6.1.3 Grab samples (with preservative).
6.1.3.1 Remove stopper/lid from bottle just before sampling and set the aluminum foil somewhere free of dirt or other sources of contamination.
6.1.3.2 Place the lid over the mouth leaving a small opening on one side.
6.1.3.3 Place hand around bottle with one finger holding lid in place.
6.1.3.4 Quickly plunge bottle (mouth facing up) through the top micro-layer with the top of the bottle tilted forward and the opening facing upstream.
6.1.3.5 Keep the bottle submerged long enough for the bottle to fill to at or near the shoulder of the bottle. Try to avoid overfilling the bottle.
6.1.3.6 Quickly remove bottle from water to avoid surface layer.
6.1.3.7 Immediately pour out excess sample if bottle was overfilled.
6.1.3.8 Securely replace the aluminum covered stopper/lid.
6.1.3.9 Rinse any large amount of dirt or debris from the outside of the container.
6.1.4 Samples Collected using Specialized Bridge Sampler (Figure 1)
6.1.4.1 Remove stopper/lid just before lowering the sampler-with-bottle down on the rope. Hold the stopper/lid via the aluminum foil, or set it somewhere free of dirt or other sources of contamination.
6.1.4.2 Lower the sampler in such a manner so as not to contaminate the open bottle with dirt or dripping water.
6.1.4.3 When approaching the water surface, drop the sampler quickly through the surface to avoid the micro-layer.
6.1.4.4 Keep the bottle submerged long enough for the bottle to fill (or 1-2 inches below the top).
6.1.4.5 Pull up the sampler and bottle, careful not to contaminate the sample with dirt or water from either the rope or bridge, or other sources of contamination.
6.1.4.6 Pour out sample to allow for the air space needed for proper mixing at the lab (unless bottle contains preservative).
6.1.4.7 Securely replace the aluminum covered stopper/lid.
6.1.4.8 Rinse any large amount of dirt or debris from the outside of the container.
6.1.5 Samples collected from wastewater/point source effluent.

6.1.5.1 Prior to sampling request MPN method for chlorinated effluent.

6.1.5.2 Locate an appropriate sampling location representative of water being discharged to the receiving water body. In particular, the location should be below any chlorination or ultra-violet (UV) application.

6.1.5.3 Use a sampling extension pole (Figure 1) to collect samples without contacting the effluent with your hands.

6.1.6 Samples collected from marine water bathing beach (from the Beach Environmental Assessment, Communication and Health (BEACH) program guidance). More beach sampling information is available from the Quality Assurance Project Plan: BEACH Program (Schneider, 2004).

6.1.6.1 Wade into roughly 2.5 feet of water.

6.1.6.2 Fill a water bottle at each of three sampling sites by wading into knee deep water, unscrewing the cap and inserting the bottle and cap into the water at a 45 degree angle (with the bottle opening facing down). Turn the bottle upright a few inches below the surface and allow it to fill. Remove the cap and bottle from the water and pour off enough water to leave an air space. Cap the bottle. If possible use a sampling extension pole (Figure 1) to avoid collecting disturbed sediment.

6.2 Sample Labeling and Storage

6.2.1 After collecting sample, immediately loop the string attached to the sample tag over stopper/lid until secure (at least three loops for 250 mL and at least two loops for 500 mL). Make sure to attach sample tag beneath, not on top of, the aluminum foil cover, as the covers can be easily separated from the sample during transport and handling.

6.2.2 Record the time each station was sampled on the sample tag and in the field notes.

6.2.3 Samples collected to determine compliance with National Pollutant Discharge Elimination System (NPDES) permits must be analyzed within 6 to 8 hours. Samples collected for the BEACH Program should be delivered to the laboratory within six hours of collection. Samples of ambient and contaminated water should be analyzed within 6 to 8 hours (APHA, 1998); however, due to the logistics of sampling over the course of a day, MEL allows a 24 hour holding time (MEL, 2005). A holding time study may be in order for some studies.

6.3 Sample Transport

6.3.1 Samples transported from the EAP Operations Center (OC) by MEL courier
Appendix E. AMTEST Chain of Custody
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### AmTest Chain of Custody Record

**Client Name & Address:**

**Invoice To:**

<table>
<thead>
<tr>
<th>Contact Person</th>
<th>Invoice Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone No</td>
<td>PO Number</td>
</tr>
<tr>
<td>Fax No</td>
<td>Invoice Ph/Fax</td>
</tr>
<tr>
<td>E-mail</td>
<td>Invoice E-mail</td>
</tr>
</tbody>
</table>

**Report Delivery:** (Choose all that apply)
- Mail
- Fax
- Email
- Posted Online

Data posted to online account: YES / NO

Web Login ID:

**Special Instructions:**

**Requested TAT:** (Rush must be pre-approved by lab)
- Standard
- Rush 1 (5 Day / 3 Day / 48 HR / 24 HR)

Temperature upon Receipt:

<table>
<thead>
<tr>
<th>Analysis Requested</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>AmTest ID</th>
<th>Client ID (35 characters max)</th>
<th>Date Sampled</th>
<th>Time Sampled</th>
<th>Matrix</th>
<th>No. of containers</th>
<th>QA/QC</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Collected/Relinquished By</th>
<th>Date</th>
<th>Time</th>
<th>Received By</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relinquished By</td>
<td>Date</td>
<td>Time</td>
<td>Received By</td>
<td>Date</td>
<td>Time</td>
</tr>
<tr>
<td>Relinquished By</td>
<td>Date</td>
<td>Time</td>
<td>Received By</td>
<td>Date</td>
<td>Time</td>
</tr>
</tbody>
</table>

**COMMENTS:**
Appendix F. Invasive Aquatic Species Procedures
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Invasive Aquatic Species Procedures

Special care must be taken to prevent the spread of aquatic invasive species (AIS). Two problem species have been tentatively or definitively identified in western Washington watersheds. These include *Didymopsphenia geminate* (Didymo) and New Zealand Mud Snail (*Potamopyrgus sp.*).

Ecology currently defines problem invasive species areas into two categories: Areas of Extreme Concern and Areas of Moderate Concern. Watersheds with New Zealand Mud Snails are Extreme Concern Areas. Staff must follow these standard operating procedures as adapted from (Parsons et al., 2012).

Staff designing studies in the greater Puget Sound watershed will evaluate two potential sampling sites for the likely presence of mud snails (see Ecology’s Invasive Species webpage at [www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html](http://www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html) and the USGS Nonindigenous Aquatic Species webpage at [http://nas2.er.usgs.gov/viewer/omap.aspx?SpeciesID=1008](http://nas2.er.usgs.gov/viewer/omap.aspx?SpeciesID=1008) and contact Jesse Shultz (Washington Department of Fish and Wildlife Invasive Aquatic Species Unit) or Jenifer Parsons (EAP Central Regional Office) with questions that arise.

Any sampling done in a watershed contributing to Lake Washington should be followed by decontamination procedures for Areas of Extreme Concern.

- Sampling will be done in these watersheds using a pole, if feasible, and avoiding contact with wet streamside soils.
- Sampling will proceed from upstream to downstream.
- Between sampling sites, boots that have contacted stream water or wet streamside soils during sample collection will undergo decontamination procedures using chemicals or heat, especially when cold treatment (4hrs at -4°C) or drying (48 hrs to fully dry) cannot be completed in time.
- Wearing short rubber boots will simplify decontamination, while wearing felt-soled boots will make decontamination more difficult.

New Zealand Mud Snails

New Zealand Mud Snails have been found in numerous areas of Washington State, where they can potentially cause tremendous environmental and economic impacts. These areas are now considered to be of Extreme Concern. In western Washington they include Marathon Park, Capital Lake (Olympia), and Kelsey and Thornton Creeks in the Seattle area, and Union Slough in the lower Snohomish River (Figure F-1).
**Specialized sampling devices to reduce contamination risk**

A sampling extension pole may be used to collect stream samples where feasible. Use of the sampling pole can reduce overall disturbance of the stream and riparian zone, help prevent the spread of New Zealand mud snails, and help ensure a representative sample is collected where wading would be dangerous. The use of a sampling pole can also speed up sample collection times and increase overall staff safety. When using a sampling pole, caution should be taken to prevent the pole from collecting water internally and spilling into the sample bottle. Similarly, if the previous sampling site is suspected to have very high bacteria levels, the end of the pole should be rinsed prior to taking a sample at the next location to avoid contamination.
Sampling and Decontamination Procedures

The following is modified language from Ecology’s Approved Standard Operating Procedure 070 that addresses decontamination procedures in Areas of Moderate Concern and Areas of Extreme Concern.

Prior to field work

- Check if the sampling will take place in an area of extreme concern – maps at this link: [www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html](http://www.ecy.wa.gov/programs/eap/InvasiveSpecies/AIS-PublicVersion.html)
- Plan field activities to minimize contact between equipment and potential sources of invasive species, particularly aquatic plants and sediment.

After conducting field work

- **Inspect and clean** all equipment. Remove any visible soil, vegetation, vertebrates, invertebrates, aquatic plants, algae or sediment. If necessary, use a scrub brush and rinse with clean water either from the site or brought for that purpose. Continue this process until the equipment is clean. **Drain** all water in bilges, samplers or other equipment that could harbor water from the site. This step should take place before leaving the sampling site or at an interim site. If cleaning after leaving the sampling site, ensure that no debris will leave the equipment and potentially spread invasive species during transit or cleaning.

- **Additional Requirements for felt sole waders used anywhere in the state and equipment that contacted sediment, aquatic vegetation or fish in areas of extreme concern:**
  - Smooth surfaced sampling equipment that can be easily and fully wiped down – *wipe until dry*. The equipment must be smooth enough so there are no cracks or crevices that could harbor a sand-grain-sized juvenile New Zealand mud snail while being wiped dry.
  - For all other equipment, use one of the decontamination treatments found in the table below. Conduct decontamination where the procedure can be carried out effectively and safely. Wash and rinse water must not drain to surface water, and all chemicals must be disposed of to a sanitary sewer.
  - **Dry** – Between field sites and upon returning from the field, when cleaning and decontamination requirements are complete store gear to facilitate drying.
Table F-1. Decontamination Options

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Concentration or temperature</th>
<th>Exposure Time</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>hot water wash or soak</strong></td>
<td>60° C (140° F)</td>
<td>5 min</td>
<td>Ensure all parts of the equipment reach temperature for the full exposure time</td>
</tr>
<tr>
<td></td>
<td>49° C (120° F)</td>
<td>10 min</td>
<td>Ensure all parts of the equipment reach temperature for the full exposure time</td>
</tr>
<tr>
<td>cold</td>
<td>-4° C</td>
<td>4 hours</td>
<td>Time starts after the equipment reaches -4 °C</td>
</tr>
<tr>
<td>drying</td>
<td>low humidity, in sunlight is best</td>
<td>48 hours</td>
<td>Time starts after the equipment is thoroughly dry</td>
</tr>
<tr>
<td><strong>Formula 409 All-Purpose Cleaner</strong></td>
<td>100% (full strength)</td>
<td>10 min</td>
<td>Follow proper procedures for storage and handling.</td>
</tr>
<tr>
<td><strong>sparquat 256</strong></td>
<td>3.1% or higher</td>
<td>10 min</td>
<td>Follow proper procedures for storage and handling.</td>
</tr>
<tr>
<td>Quat 128</td>
<td>4.60%</td>
<td>10 min</td>
<td>Follow proper procedures for storage and handling.</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>30,000 ppm (3%)</td>
<td>15 min</td>
<td>Spray on until soaked, then keep damp for contact time (cover or place gear in a dry bag)</td>
</tr>
<tr>
<td>Virkon Aquatic®</td>
<td>2%</td>
<td>20 min</td>
<td>Must soak (not spray on) Follow proper procedures for storage and handling</td>
</tr>
</tbody>
</table>

1 Must be antibacterial (make sure it has quaternary ammonia, otherwise it is ineffective)
2 Sparquat is corrosive; read the MSDS and use with caution.
3 May be corrosive; read the MSDS and follow safety precautions
4 Rinse gear after soak to prolong life. Solution degrades, lasts up to 7 days, best if mixed fresh
Figure F-2. Invasive Species Decontamination Summary Flow Chart
Appendix G. TMDL Monitoring Field Data Sheet
Snohomish County – TMDL Monitoring

General Information
Station Name: __________________ Sample Run: _____________ Sampler’s Name(s): _____________

Date: ____________

Observations
Weather: { Recent Rain, Rain, Dry }
Water Color: { Clear, Muddy, Tannic }  In-stream Activity: ____________________________________________________________________________
Other Foreign Matter {junk, trash}: ____________________________________________________________________________
Other Comments {Wildlife, Farm Animals, Recreational Uses, etc.}: ____________________________________________________________________________

In-situ Water Quality Measurements: Hydrolab – { Professor, Skipper, L’il Buddy } HACH - { #1 or #3 }

<table>
<thead>
<tr>
<th>Time</th>
<th>Temp. °C</th>
<th>pH</th>
<th>DO (mg/L)</th>
<th>Spec. Cond. us/cm</th>
<th>Turbidity [NTU]</th>
</tr>
</thead>
</table>

Collected Water Quality Samples (use check marks on left-hand side)

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Analysis</th>
<th>Time</th>
<th>Volume</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fecal coliform</td>
<td></td>
<td>250 mL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Suspended Solids</td>
<td></td>
<td>250 mL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NH₃, K MBAS/CTAS</td>
<td></td>
<td>250 mL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0A/00</td>
<td>Fecal coliform</td>
<td></td>
<td>250 mL</td>
<td>Field / Trip Blank</td>
</tr>
<tr>
<td></td>
<td>Total Suspended Solids</td>
<td></td>
<td>250 mL</td>
<td>Field / Trip Blank</td>
</tr>
<tr>
<td></td>
<td>NH₃, K, MBAS/CTAS</td>
<td></td>
<td>250 mL</td>
<td>Field / Trip Blank</td>
</tr>
<tr>
<td></td>
<td>Other:</td>
<td></td>
<td></td>
<td>Field / Trip Blank</td>
</tr>
<tr>
<td></td>
<td>Fecal coliform</td>
<td></td>
<td>250 mL</td>
<td>Field Dup</td>
</tr>
<tr>
<td></td>
<td>Total Suspended Solids</td>
<td></td>
<td>250 mL</td>
<td>Field Dup</td>
</tr>
<tr>
<td></td>
<td>NH₃, K, MBA/CTAS</td>
<td></td>
<td>250 mL</td>
<td>Field Dup</td>
</tr>
<tr>
<td></td>
<td>Other:</td>
<td></td>
<td></td>
<td>Field Dup</td>
</tr>
</tbody>
</table>

Additional Notes:

Data Verified: Date ___________ Initials ___________
Data Entered into EMI Spread Sheet: Date ___________ Initials ___________
Appendix H. Individual Field Sample Data Qualifiers
This page is purposefully left blank for duplex printing
<table>
<thead>
<tr>
<th>Quality Control Condition</th>
<th>Data Qualifier</th>
<th>Data Qualifier Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non Detect Data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Result is non-detect</strong></td>
<td>U</td>
<td>The analyte was analyzed for, but was not detected at a level above the Method Detection Level (MDL)</td>
</tr>
<tr>
<td><strong>Hold Time Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Method Specific Hold Time Not Met</strong></td>
<td>REJ</td>
<td>Sample analysis performed past the method specific hold time; sample result is unusable</td>
</tr>
<tr>
<td><strong>Hold Temperature Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Method Specific Hold Temperature Not Met Upon Receipt From Laboratory</strong></td>
<td>J</td>
<td>Sample exceeded method specific hold temperature upon receipt of laboratory; sample result is considered an estimate</td>
</tr>
<tr>
<td></td>
<td>UJ</td>
<td>Analyte was not detected at or above the reported estimate</td>
</tr>
<tr>
<td><strong>Method Specific Hold Temperature Is Unknown At Time of Receipt From Laboratory</strong></td>
<td>J</td>
<td>Method specific hold temperature for sample is unknown, sample result is considered an estimate</td>
</tr>
<tr>
<td></td>
<td>UJ</td>
<td>Method specific hold temperature for sample is unknown; sample result is non-detect and considered an estimate</td>
</tr>
<tr>
<td>Quality Control Condition</td>
<td>Data Qualifier</td>
<td>Data Qualifier Comment</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------</td>
<td>------------------------</td>
</tr>
<tr>
<td><strong>Chain Of Custody Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample Not Analyzed with Method On Chain Of Custody</td>
<td>J</td>
<td>Sample was analyzed with a method that differs from the dataset; methods are comparable and sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>UJ</td>
<td>Sample was analyzed with a method that differs from the dataset; methods are comparable and sample result is non-detect and considered an estimate</td>
</tr>
<tr>
<td></td>
<td>REJ</td>
<td>Sample was analyzed with a method that differs from the dataset; methods are not comparable and sample result is unusable</td>
</tr>
<tr>
<td>Date and/or Time Information For Sample Collection Does Not Match the Chain Of Custody</td>
<td>J</td>
<td>Date and/or time information for sample collection does not match the COC; sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>UJ</td>
<td>Date and/or time information for sample collection does not match the COC; sample result is non-detect and considered an estimate</td>
</tr>
<tr>
<td></td>
<td>EST</td>
<td>Date and/or time information for sample collection does not match the COC; sample result is an estimate unless otherwise rectified</td>
</tr>
<tr>
<td>Quality Control Condition</td>
<td>Data Qualifier</td>
<td>Data Qualifier Comment</td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
<td>----------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Laboratory Duplicate Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory Duplicate RPD Are Outside of Acceptance Limits</td>
<td>J</td>
<td>Laboratory Duplicate RPD exceeds acceptance limits; sample result is an estimate</td>
</tr>
<tr>
<td>RPD= ((X_1 - X_2) / ((X_1 + X_2)/2))*100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(X_1) = sample result</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(X_2) = duplicate result</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Matrix Spike And Matrix Spike Duplicate Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Matrix Spike and/or Matrix Spike Duplicate Recoveries Are Outside of Acceptance Limits</td>
<td>J</td>
<td>Matrix Spike and/or matrix spike duplicate recoveries are outside acceptance limits; sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>UJ</td>
<td>Matrix Spike and/or matrix spike duplicate recoveries are outside acceptance limits; sample result is non-detect and considered an estimate</td>
</tr>
<tr>
<td><strong>Standard Reference Material Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Reference Material Recoveries Are Above Acceptance Limits, Sample Result is Non-Detect</td>
<td>U</td>
<td>Standard reference material recovery above acceptance limits; sample result is non-detect and data is not impacted</td>
</tr>
<tr>
<td>Standard Reference Material Recoveries Are Outside Acceptance Limits</td>
<td>REJ</td>
<td>Standard reference material recoveries are outside acceptance limits; sample is unusable</td>
</tr>
<tr>
<td>Quality Control Condition</td>
<td>Data Qualifier</td>
<td>Data Qualifier Comment</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>----------------</td>
<td>----------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Laboratory Method Blank Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target Analyte Was Detected In Associated Method Blank</td>
<td>U</td>
<td>Target analyte was detected in the method blank; sample result is non-detect and data is not impacted</td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>Target analyte was detected in the method blank and the sample result is greater than or equal to 10x the blank result; sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>bis(2-ethylhexyl)phthalate was detected in the method blank and is greater than 5x MDL; sample result for bis(2-ethylhexyl)phthalate is an estimate</td>
</tr>
<tr>
<td></td>
<td>REJ</td>
<td>Target analyte was detected in the method blank and the sample result is less than 10x the blank result; sample result is unusable</td>
</tr>
<tr>
<td><strong>Surrogate Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surrogate Recoveries Were Outside Acceptance Limits</td>
<td>J</td>
<td>Surrogate recoveries are outside acceptance limits; sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>REJ</td>
<td>Surrogate recoveries are below minimum acceptance limits; sample result is non-detect and considered unusable</td>
</tr>
<tr>
<td>Quality Control Condition</td>
<td>Data Qualifier</td>
<td>Data Qualifier Comment</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>----------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Field Sample Blank Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target Analyte Was Detected In</td>
<td>J</td>
<td>Target analyte was detected in the field blank; sample</td>
</tr>
<tr>
<td>Associated Field Blank</td>
<td></td>
<td>result is an estimate</td>
</tr>
<tr>
<td>Target Analyte Was Detected In</td>
<td>J</td>
<td>Target analyte was detected in the trip blank; sample</td>
</tr>
<tr>
<td>Associated Trip Blank</td>
<td></td>
<td>result is an estimate</td>
</tr>
<tr>
<td><strong>Field Sample Duplicate Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fecal coliform field duplicate</td>
<td>J</td>
<td>Field Duplicate RSD &gt; ± 50% and &lt; ± 75%; sample result is</td>
</tr>
<tr>
<td>Means are &lt; 20 Colonies and RSD</td>
<td></td>
<td>an estimate</td>
</tr>
<tr>
<td>is &gt; 50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSD = (StDev/mean) * 100%</td>
<td>UJ</td>
<td>Sample result is non-detect. Field Duplicate RSD &gt; ± 50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and &lt; ± 75%; sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>REJ</td>
<td>Field Duplicate RSD &gt; ± 75%; sample result is rejected</td>
</tr>
<tr>
<td><strong>Field Sample Duplicate Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fecal coliform field duplicate</td>
<td>J</td>
<td>Field Duplicate RSD &gt; ± 20% and &lt; ± 50%; sample result is</td>
</tr>
<tr>
<td>Means are &gt; 20 Colonies and RSD</td>
<td></td>
<td>an estimate</td>
</tr>
<tr>
<td>is &gt; 50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSD = (StDev/mean) * 100%</td>
<td>UJ</td>
<td>Sample result is non-detect. Field Duplicate RSD &gt; ± 20%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and &lt; ± 50%; sample result is an estimate</td>
</tr>
<tr>
<td>X₁ = sample result</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X₂ = duplicate result</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>REJ</td>
<td>Field Duplicate RSD &gt; ± 50%; sample result is rejected</td>
</tr>
<tr>
<td>Quality Control Condition</td>
<td>Data Qualifier</td>
<td>Data Qualifier Comment</td>
</tr>
<tr>
<td>---------------------------</td>
<td>----------------</td>
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<tr>
<td>Field Sample Duplicate Actions</td>
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<tr>
<td>TSS field duplicate Means at or below 5x detection limit</td>
<td>J</td>
<td>Field Duplicate RSD &gt; ± 50% and &lt; ± 75%; sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>UJ</td>
<td>Sample result is non-detect. Field Duplicate RSD &gt; ± 50% and &lt; ± 75%; sample result is rejected</td>
</tr>
<tr>
<td></td>
<td>REJ</td>
<td>Field Duplicate RSD &gt; ± 75%; sample result is an estimate</td>
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<td>Field Sample Duplicate Actions</td>
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<tr>
<td>TSS field duplicate Means greater than 5x detection limit</td>
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