Snohomish County
Total Maximum Daily Load Monitoring
Quality Assurance Project Plan

Snohomish River Tributaries, Stillaguamish Basin,
North and Swamp Creek TMDL Coverage Areas
2021 – 2024

Prepared by

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December 2020
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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 2019-2024 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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Quality Assurance Project Plan
2021 - 2024

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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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<tr>
<th>Name</th>
<th>Title</th>
<th>Organization</th>
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<tbody>
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<td>Supervisor</td>
<td>Snohomish County</td>
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<td>Water Quality Analyst</td>
<td>Snohomish County</td>
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<td>Rob Plotnikoff</td>
<td>Senior Habitat Specialist</td>
<td>Snohomish County</td>
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<tr>
<td>Keith Westlund</td>
<td>Engineering Technician</td>
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<td>Aaron Young</td>
<td>Laboratory Manager</td>
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<td>Heather Khan</td>
<td>Water Clean Up Lead WRIA 5 and 7</td>
<td>Department of Ecology</td>
</tr>
<tr>
<td>Cleo Neculae</td>
<td>Water Clean Up Lead WRIA 8</td>
<td>Department of Ecology</td>
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<td>Mak Kaufman</td>
<td>Municipal Stormwater Permit Implementation Planner</td>
<td>Department of Ecology</td>
</tr>
<tr>
<td>Arati Kaza</td>
<td>Quality Assurance Officer</td>
<td>Department of Ecology</td>
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Abstract

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). Contact with waters contaminated with FCB poses a risk to human health.

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 2019, Ecology reissued the Phase I municipal stormwater permit. Appendix 2 of the permit contains programs focused on addressing waters impaired by FCB.

Appendix 2 of the 2019-2024 NPDES permit requires Snohomish County to conduct surface water monitoring for characterization and long term trends evaluation of FCB within the Stillaguamish, Snohomish Tributaries, North, and Swamp Creek TMDL coverage areas.

Snohomish County has developed this QAPP to address the requirements. Data gathered under this project are also used to help prioritize areas for targeted source identification and elimination of FCB pollution.
Introduction and Problem Statement

In 1990, the Environmental Protection Agency (EPA) promulgated regulations for the National Pollutant Discharge Elimination System (NPDES) Phase I municipal stormwater discharge permit program in response to the 1987 amendments to the Clean Water Act (CWA). The Phase I 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 I 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 based on the 1990 census.

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 under which six cities or 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 I municipal stormwater permit. The 2013-2018 NPDES permit required 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 FCB in receiving waters or waste stream,
- contribute to long term trends evaluation of FCB and,
- identify and eliminate sources of FCB pollution.

In 2019, Ecology reissued the Phase I municipal stormwater permit. The 2019 – 2024 permit requires continued surface water monitoring for characterization and long terms trends evaluation of FCB in accordance with the QAPP approved under the 2013 permit.

However, if changes to surface water locations or other updates are needed, each permittee is required to submit a draft revised QAPP to Ecology for review and approval. The 2019-2024 permit excluded requirements for surface water monitoring in Little Bear Creek. Additionally, changes to surface water standards for FCB occurred in 2019. These changes alone require updates to the QAPP.
At a minimum, the 2019 – 2024 permit requires that monitoring include:

- Collection of 12 samples taken in at least one location per calendar year. For the reporting year of 2019, samples taken any time between January 01, 2019 through December 31, 2019 may be included.
- Submittal of available data to the Environmental Information Management (EIM) database by May 31 of each year.
- Summary of and narrative evaluation of the data in each annual report’s TMDL summary.

This QAPP is written to guide the water quality monitoring program addressing requirements in the 2019 – 2024 NPDES permit.
Background

Pursuant to the federal Clean Water Act (CWA), Washington State Department of Ecology (Ecology) has adopted surface water quality standards for fecal coliform bacteria (FCB) in order to reduce human health risk for people having contact with rivers, lakes, and streams. Standards for FCB and now E.coli are found in Washington State Administrative Code (WAC 173-201A). Across Washington State, and within Snohomish County, organizations collect surface water samples for analysis of FCB and/or E.coli to assess the risk for humans having contact with surface waters.

Fecal coliform bacteria and E.coli are a subset of bacteria that are present in the feces of warm blooded animals, which belong to the larger group of enterobacteriacea (total coliforms). They are used as indicators 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 stormwater runoff or surface waters include Shigellis and Salmonella.

Beginning in 1995 and continuing every two to four years thereafter, Ecology evaluated Snohomish County and partner FCB data to determine whether waterbody segments in Snohomish County meet water quality standards. As a result, over time, hundreds of water body segments have been identified as not meeting surface water quality standards.

As required by the CWA, Ecology then developed FCB (TMDL) water cleanup plans in the waterbody segments found within the Snohomish River Tributaries, North Creek, Swamp Creek, Little Bear, and Stillaguamish watersheds. The TMDLs identify actions to take to reduce discharges of FCB to surface waters to achieve water quality standards.

Over time a subset of these actions, including ongoing monitoring of surface water quality for FCB, became requirements of municipal stormwater permits. Since 2007, Snohomish County has been required to implement surface water monitoring specifically for FCB under Quality Assurance Project Plans (QAPP). This QAPP documents monitoring activities required of Snohomish County by its 2019-2024 Phase I Municipal Stormwater Permit (Permit).
Water Quality Standards and Microbial Water Quality Assessment

January 23, 2019 amendments to freshwater recreational contact standard for surface waters (WAC 173-201A) include, but are not limited to, replacing FCB as the freshwater recreational contact indicator with E.coli, updating the numeric criteria and changing the minimum number of samples required for comparison to standards.

Beginning January 23, 2019 through December 31, 2019, recreational contact standards for FCB were amended, where waters previously designated for secondary contact (200 cfu/100 mL) were moved to primary contact (100 cfu/100 mL).

Additionally, beginning January 1, 2021 FCB are phased out and new recreational contact criteria for E.coli are phased in. The new indicator and its criteria apply to all TMDL coverage areas required for monitoring under the 2019 – 2024 permit. Updated recreational contact criteria for both indicators are found in Table 2.

Table 2. Washington State Water Quality Standards WAC 173-201A

<table>
<thead>
<tr>
<th>Bacterial Indicator</th>
<th>Criteria</th>
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<tr>
<td>E. coli</td>
<td>E. coli organism levels within an averaging period must not exceed a geometric mean value of 100 CFU or MPN per 100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained within the averaging period exceeding 320 CFU or MPN per 100 mL.</td>
</tr>
<tr>
<td>Fecal coliform (expires 12/31/2020)</td>
<td>Fecal coliform organism levels within an averaging period must not exceed a geometric mean value of 100 CFU or MPN per 100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained within an averaging period exceeding 200 CFU or MPN per 100 mL.</td>
</tr>
</tbody>
</table>
To support permit requirement to identify and eliminate sources of FCB pollution, and maintain consistency with the QAPP approved under the 2013 permit, the County employs a system of ranking monitoring sites for prioritization of source identification and elimination efforts (PBS&J 2008). The ranks are based upon the percentage of single sample values that exceed the water quality standard. The PBS&J 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 ranking system is referred to as the Microbial Water Quality Assessment (MWQA). Ranks are assigned to each sample station in categories A, B, C, D and E where A exhibits the lowest frequency of FCB standard exceedances and E exhibits the highest. As needed, the most current 30 FCB results for each station are ranked. Stations ranking C or worse are prioritized for consideration of targeted source identification and elimination efforts within required TMDL coverage areas.

The MWQA ranks and thresholds are in table 3 and displayed on maps for each TMDL basin in figures 2 – 9.

Table 3. MWQA Ranks

<table>
<thead>
<tr>
<th>Rank</th>
<th>Percent Samples Exceeding Water Quality Standard</th>
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<tbody>
<tr>
<td>A</td>
<td>0 - 10</td>
</tr>
<tr>
<td>B</td>
<td>11 - 30</td>
</tr>
<tr>
<td>C</td>
<td>31 - 50</td>
</tr>
<tr>
<td>D</td>
<td>51 - 75</td>
</tr>
<tr>
<td>E</td>
<td>Greater than 75</td>
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TMDL Study Area

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 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 were mainly agriculture and forestry. Over time, this has changed to increasingly favor residential and commercial use. The increasing urbanization and associated 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 pollution of surface waters with FCB is commonly associated with 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 FCB pollution with large rural areas and farmland in the watershed. 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 and/or E.coli found in Snohomish River tributaries will originate from these natural sources (Wright et al. 2001).

Quilceda Creek and Allen Creeks

Quilceda and Allen Creeks originate near Marysville and Arlington and flow south through the city of Marysville (Figures 1 and 2). 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. 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 (percentage of samples exceeding the single sample water quality standard from A best to E worst).
Figure 1. Quilceda Creek Sub-basin
Figure 2. Allen Creek Sub-basin
French Creek Sub-basin
As described by Svrjcek (2003a), French Creek is outside of Monroe and flows westerly for approximately 11 miles and encompasses about 28 square miles (Figure 3). 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 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. The upper three-quarters of the French Creek sub-basin, above the Snohomish River floodplain, flows over gentle, largely forested slopes. Rural development in the upper watershed has recently become significant, increasing runoff from land clearing and residential development activities. 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.

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, waters impaired for FCB, sampling locations, and their microbial water quality rank (percentage of samples exceeding the single sample water quality standard from A best to E worst).
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. 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, waters impaired for FCB, sampling locations, and their microbial water quality rank (percentage of samples exceeding the single sample water quality standard from A best to E worst).
Figure 4. Pilchuck River basin
**Woods Creek Sub-basin**

Woods Creek is near Monroe and 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, waters impaired for FCB, sampling locations, and their microbial water quality rank (percentage of samples exceeding the single sample water quality standard from A best to E worst).
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. It is the fifth largest tributary to Puget Sound (Lawrence and Joy 2005). The Stillaguamish River has two major forks at river mile 17.8; the North Fork drains 736 km², and the South Fork drains 660 km².

The primary land use along the mainstem and lower reaches of the major forks is agriculture. The lower basin has diverse land uses and most 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.

Surface Water Management monitored water quality at several locations throughout the Stillaguamish basin from 2010 – 2014. Figure 6 shows the sub-basin location, waters impaired for FCB, sampling locations, and their microbial water quality rank (percentage of samples exceeding the single sample water quality standard from A best to E worst).
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 has 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, waters impaired for FCB, sampling locations, and their microbial water quality rank (percentage of samples exceeding the single sample water quality standard from A best to E worst).
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). Beginning in the late 1990s, Swamp Creek watershed became 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). Over time, this urbanization has continued with commercial and light industrial uses, 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, waters impaired for FCB, sampling locations, and their microbial water quality rank (percentage of samples exceeding the single sample water quality standard from A best to E worst).
Figure 8. Swamp Creek Sub-basin
Summary of Previous and Existing Data

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

Long Term Water Quality Monitoring

Since 1992, SWM has collected ambient water quality data, independent of habitat, aquatic life or other indicators of watershed health, at various sites within each TMDL coverage area and beyond. The goal of this monitoring program was to characterize conditions, detect trends in water quality and identify opportunities for restoration and protection.

Several historical reports are available and others are pending production. Long term ambient data is maintained in Snohomish County’s online database at KISTERS Web Portal\(^1\) and to a more limited degree at Ecology’s Environmental Information Management (EIM) system.\(^2\)

Beginning in 2017, SWM implemented its State of Our Waters\(^3\) program, where we collect biological, physical, and chemical data from our waterways in order to:

- Understand and provide information on the health of local waterways
- Track changes over time to identify problems and their causes
- Focus County resources to protect healthy waters and improve impaired ones

Data, inclusive of FCB, and reports are available online.

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Bacterial Pollution Identification and Correction (PIC) Grants

To support protection of shellfish and human health, beginning in 2014 and ending in 2020, Snohomish County led partner organizations through implementation of two phases of bacterial pollution identification and correction (PIC) grants in the Lower Stillaguamish basin. Primary tasks included water quality monitoring and source identification, education and outreach, technical assistance and enforcement. During PIC Phase one, several major and minor sources of bacterial pollution were identified and corrected. This included measured reductions in FCB downstream of a dairy and sand and gravel operation discharging to Miller Creek and Port Susan. Additionally, efforts included implementation of horse manure confinement best management practices at an Arabian horse stable discharging to a small tributary of the Stillaguamish River. Outreach strategies inclusive of web page development, public events such as a shellfish dinner and targeted workshops increased public awareness of the importance of clean water and encouraged implementation of land use practices supportive of being good stewards.

Water quality monitoring efforts during phase two of PIC resulted in investigating a diffuse non-point source of waste water suspected of contributing pollutants to Greenwood Creek and Port Susan.

Monitoring data for both PIC phase one and two are available through Ecology’s Environmental Information Management System at https://apps.ecology.wa.gov/eim/search/Eim/EIMSearchResults.aspx?ResultType=EI MTabs&StudyName=Lower+stillaguamish&StudyNameSearchType=Contains

Beginning in 2020, the Snohomish Conservation is leading efforts to develop and implement a third phase of PIC comprised of similar partners and bacterial pollution correction efforts in the Stillaguamish basin.
Washington State Department of Ecology

Long Term Status and Trends
Ecology’s Environmental Assessment Program currently conducts monthly sampling at long-term stations within the Snohomish and Stillaguamish watersheds (Table 4). 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 river and stream water quality monitoring\(^4\) program, results and updates to the information in Table 4 are available online.

Table 4. Ecology Water Quality Monitoring Stations in Snohomish County

<table>
<thead>
<tr>
<th>WRIA</th>
<th>Station Code</th>
<th>Station Name</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>2020</td>
</tr>
<tr>
<td>5</td>
<td>05A090</td>
<td>SF Stillaguamish R @ Arlington</td>
<td>long-term</td>
<td>2020</td>
</tr>
<tr>
<td>5</td>
<td>05A110</td>
<td>SF Stillaguamish R nr Granite Falls</td>
<td>long-term</td>
<td>2020</td>
</tr>
<tr>
<td>5</td>
<td>05B070</td>
<td>NF Stillaguamish R @ Cicero</td>
<td>long-term</td>
<td>2020</td>
</tr>
<tr>
<td>5</td>
<td>05B110</td>
<td>NF Stillaguamish R nr Darrington</td>
<td>long-term</td>
<td>2020</td>
</tr>
<tr>
<td>7</td>
<td>07A090</td>
<td>Snohomish R @ Snohomish</td>
<td>long-term</td>
<td>2020</td>
</tr>
<tr>
<td>7</td>
<td>07C070</td>
<td>Skykomish R @ Monroe</td>
<td>long-term</td>
<td>2020</td>
</tr>
<tr>
<td>7</td>
<td>07D050</td>
<td>Snoqualmie R nr Monroe</td>
<td>long-term</td>
<td>2020</td>
</tr>
</tbody>
</table>

\(^4\) https://ecology.wa.gov/Research-Data/Monitoring-assessment/River-stream-monitoring/Water-quality-monitoring
**Regional Status and Trends Monitoring in Receiving Waters**

Beginning in 2015, Ecology and partner organizations implemented a regional status and trends monitoring program with western Washington municipal stormwater permit contributions. The goal is to determine if water quality is getting better or worse and identify patterns in healthy and impaired Puget Sound Lowland streams and urban shoreline areas. Within unincorporated Snohomish County, Ecology identified lowland stream stations where water quality (including FCB), stream benthos, sediment chemistry, flow, and habitat monitoring takes place. From time to time, these locations are changed. This QAPP takes this 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 and waste load allocations expressed as a percent reduction needed to meet water quality standards. These data are shown in Table 5. The data generally indicate that during dry summer months when stream flows are low, FCB levels at most monitoring stations rise beyond both the geometric mean and 90th percentile criteria. During the wetter months of the year, FCB concentrations generally improve but not enough to meet criteria.
Table 5. 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>
</tr>
</thead>
<tbody>
<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>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>
</tr>
<tr>
<td>French Creek</td>
<td>LH2</td>
<td>0</td>
<td>87</td>
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<td>French Creek</td>
<td>CCUS</td>
<td>29</td>
<td>42</td>
</tr>
<tr>
<td>French Creek</td>
<td>LH1</td>
<td>23</td>
<td>90</td>
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<tr>
<td>French Creek</td>
<td>FL2</td>
<td>64</td>
<td>82</td>
</tr>
<tr>
<td>French Creek</td>
<td>STUS</td>
<td>0</td>
<td>75</td>
</tr>
<tr>
<td>French Creek</td>
<td>STLS</td>
<td>0</td>
<td>77</td>
</tr>
<tr>
<td>French Creek</td>
<td>CCLS</td>
<td>44</td>
<td>83</td>
</tr>
<tr>
<td>French Creek</td>
<td>CCH2</td>
<td>0</td>
<td>91</td>
</tr>
<tr>
<td>French Creek</td>
<td>FCLU</td>
<td>24</td>
<td>79</td>
</tr>
<tr>
<td>French Creek</td>
<td>FCMS</td>
<td>91</td>
<td>90</td>
</tr>
<tr>
<td>French Creek</td>
<td>FCDD</td>
<td>55</td>
<td>85</td>
</tr>
<tr>
<td>French Creek</td>
<td>FCLD</td>
<td>78</td>
<td>82</td>
</tr>
<tr>
<td>French Creek</td>
<td>PUMP</td>
<td>73</td>
<td>81</td>
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<tr>
<td>French Creek</td>
<td>FCMSb</td>
<td>No data</td>
<td>90</td>
</tr>
<tr>
<td>French Creek</td>
<td>PUMPb</td>
<td>No data</td>
<td>79</td>
</tr>
<tr>
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<td>PRUP</td>
<td>0</td>
<td>0</td>
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<td>Pilchuck River</td>
<td>PR8.6</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
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<td>PR4.2</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Pilchuck River</td>
<td>PRDN</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td>Pilchuck River</td>
<td>LPDN</td>
<td>0</td>
<td>80</td>
</tr>
</tbody>
</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 in FCB 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 https://fortress.wa.gov/ecy/publications/documents/0210020.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 of 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 6 identifies the waste load allocations at each station through percent reductions and target geometric means (Glenn 2001).

<table>
<thead>
<tr>
<th></th>
<th>DCDN</th>
<th>0</th>
<th>67</th>
<th>n/a</th>
<th>54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marshland</td>
<td>MLUP</td>
<td>93</td>
<td>87</td>
<td>40</td>
<td>61</td>
</tr>
<tr>
<td>Marshland</td>
<td>MLDN</td>
<td>90</td>
<td>65</td>
<td>69</td>
<td>61</td>
</tr>
<tr>
<td>Woods Creek</td>
<td>WCUP</td>
<td>0</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Woods Creek</td>
<td>WCMF</td>
<td>0</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Woods Creek</td>
<td>WCWF</td>
<td>0</td>
<td>70</td>
<td>n/a</td>
<td>56</td>
</tr>
<tr>
<td>Woods Creek</td>
<td>WCDN</td>
<td>0</td>
<td>20</td>
<td>n/a</td>
<td>77</td>
</tr>
</tbody>
</table>

Table 5. Continued
Table 6. 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 [https://fortress.wa.gov/ecy/publications/documents/0310047.pdf](https://fortress.wa.gov/ecy/publications/documents/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 (KCWLKD 2005) to characterize bacteria levels in the Swamp Creek Watershed. Long term water quality data sets are available for Swamp Creek at the three 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 90\textsuperscript{th} 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, where FCB levels were much higher from 1995 – 1997, then dropping to between a range of 200 – 300 colonies per sample through 2004.

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 of 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 7 identifies point source waste load allocations at each station, irrespective of jurisdiction, through percent reductions and target 90th percentiles.

Table 7. 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 https://fortress.wa.gov/ecy/publications/documents/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 and 90th percentiles for FCB 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 FCB 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 FCB in this area since its FC load is small. Data collected from stations above the outfall indicate a FCB problem during storm runoff events.

- The elevated FCB 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 FCB 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 FCB 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.

- FCB counts 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 FCB counts from 1997 – 2002 compared with 1994 - 1996. This suggests a FCB source between 212th and these upstream monitoring stations.

- Although geometric mean counts of FCB 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 FCB counts in the mainstem: between Arlington and Armstrong Creek, on the North Branch below I-5, and between Silvana and Marine Drive.

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

• 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 FCB loading.

• Flooding is not uncommon during the spring and winter months. Agricultural and residential land uses in flooded areas can contribute FCB 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 90th percentile value are assessed as shown in Table 8.

Table 8. Stillaguamish River percentile targets

<table>
<thead>
<tr>
<th>Stillaguamish Stations w/interim targets</th>
<th>2002 90th Percentile Value</th>
<th>2010 Target 90th Percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designated by Ecology</td>
<td>Wet Season %</td>
<td>Dry Season %</td>
</tr>
<tr>
<td>Glade Bekken @ Silvana Terrace – TR30</td>
<td>365</td>
<td>828</td>
</tr>
<tr>
<td>Fish Creek @ 5th 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 @ 212th St. NE - PORL</td>
<td>420</td>
<td>808</td>
</tr>
<tr>
<td>Portage Creek @ 43rd - PORU</td>
<td>336</td>
<td>910</td>
</tr>
</tbody>
</table>
Joy (2004) recommended that monitoring programs addressing FCB 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.

**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 and found several failing septic systems (Hutchison 2014).
**King County**

King County Water and Land Resources division carries out water quality monitoring within Snohomish County. Beginning in November 2014, King County re-established water quality monitoring locations in lower North, Swamp and Little Bear Creek. 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 a 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 1993-2013, the tribe collected water quality data, including FCB, from 79 locations throughout the watershed. Brown and Taylor (2018) reported on water quality trends for a subset of locations.

**Tulalip Tribes**

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, 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, 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.
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>Staff</th>
<th>Organization</th>
<th>Title</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Janell Majewski</td>
<td>Snohomish County</td>
<td>Resource Monitoring Supervisor</td>
<td>Project Oversight</td>
</tr>
<tr>
<td>Steve Britsch</td>
<td>Snohomish County</td>
<td>Project Specialist IV</td>
<td>Project Management/Reporting</td>
</tr>
<tr>
<td>Stuart Baker</td>
<td>Snohomish County</td>
<td>Water Quality Analyst</td>
<td>Sample Collection/Analysis/Reporting</td>
</tr>
<tr>
<td>Keith Westlund</td>
<td>Snohomish County</td>
<td>Engineering Technician</td>
<td>Sample Collection Lead/Data Management</td>
</tr>
<tr>
<td>Rob Plotnikoff</td>
<td>Snohomish County</td>
<td>Senior Habitat Specialist</td>
<td>Sample Collection/Analysis/Reporting</td>
</tr>
<tr>
<td>Aaron Young</td>
<td>AmTest, Inc</td>
<td>Lab Owner/Project Manager</td>
<td>Laboratory Services</td>
</tr>
<tr>
<td>Heather Khan</td>
<td>Department of Ecology</td>
<td>TMDL Lead</td>
<td>QAPP review/approval</td>
</tr>
<tr>
<td>Cleo Neculae</td>
<td>Department of Ecology</td>
<td>TMDL Lead</td>
<td>QAPP review/approval</td>
</tr>
<tr>
<td>Mak Kaufman</td>
<td>Department of Ecology</td>
<td>Municipal Stormwater Permit Implementation Planner</td>
<td>QAPP review/approval</td>
</tr>
<tr>
<td>Arati Kaza</td>
<td>Department of Ecology</td>
<td>Quality Assurance Officer</td>
<td>QAPP review/approval</td>
</tr>
</tbody>
</table>

Special training and certifications
The Resource Monitoring Supervisor, Project Specialist, Water Quality Analyst, Senior Habitat Specialist and Engineering Technician have over 50 years of combined experience in environmental sciences with special emphasis in developing and managing water quality monitoring programs, collecting and processing samples, quality control of field and lab data, analysis, and reporting. Skills specific to implementation of this QAPP include regulatory and
scientific knowledge of FCB and E.coli, their sources and follow-up source identification. Some team members have implemented NPDES permit monitoring, data management, analysis, reporting, and source identification efforts for FCB and/or E.coli since 2001.

**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</th>
<th>Quantity</th>
<th>Cost/Unit $</th>
<th>Total Cost $</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCB (includes duplicates, field &amp; trip blanks)</td>
<td>110</td>
<td>10</td>
<td>1100</td>
</tr>
<tr>
<td>E.coli (includes duplicates, field &amp; trip blanks)</td>
<td>110</td>
<td>15</td>
<td>1650</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td><strong>2750</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Labor (includes benefits, overhead and admin)</th>
<th>Quantity</th>
<th>Cost/Unit $</th>
<th>Total Cost $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisor</td>
<td>40</td>
<td>75</td>
<td>3000</td>
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<tr>
<td>Project Specialist</td>
<td>160</td>
<td>68</td>
<td>11,000</td>
</tr>
<tr>
<td>Water Quality Analyst</td>
<td>100</td>
<td>55</td>
<td>5500</td>
</tr>
<tr>
<td>Eng. Technician</td>
<td>200</td>
<td>52</td>
<td>10,500</td>
</tr>
<tr>
<td>Senior Habitat Specialist</td>
<td>40</td>
<td>62</td>
<td>2500</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td><strong>32,500</strong></td>
</tr>
</tbody>
</table>

**Estimated Annual Project Total** 35,250
### Project Schedule

Table 11. Annual FCB/E.coli 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>Routine Monitoring Field Work</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>Routine Monthly Monitoring (5 stations/month/1 run = 1 days to complete)</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>Annual Factory Instrument Calibration</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>Routine Ambient Monitoring Data Management</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>Data Verification/Validation</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>EIM Data Prep and Load</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>Bacteria Data Analysis/Reporting</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>Bacteria Data Analysis and Annual NPDES Reporting</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>
</tbody>
</table>
Project Description

As required by the permit, the intent of this FCB/E.coli TMDL monitoring study is to collect 12 bacteria samples from at least one location within each TMDL area per calendar year for the purpose of characterization and long term trend evaluation.

TMDL Areas
The TMDL areas (Figures 1 – 8) are:
   1. Stillaguamish
   2. Snohomish River Tributaries
   3. North Creek
   4. Swamp Creek

Study Objectives
The objectives of this FCB/E.coli TMDL Monitoring Plan are to: 1) characterize conditions, which Snohomish County interprets as a comparison of FCB and E.coli to surface water quality standards, and 2) gather data supportive of long term trend evaluation. These data may also be used by SWM or other organizations to prioritize follow-up actions which may include source identification and elimination efforts.

Routine Monitoring Design and Hypothesis
Appendix 2 of the permit requires Snohomish County to collect 12 samples at one station per TMDL 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.

Generally, conclusions drawn from a judgment-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 hypotheses. As mentioned under the introduction, the primary problem is that FCB 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 and/or E. coli bacteria standards at selected stations continue are:

- Null \((H_0)\) = Averaging Period, Seasonal, and/or Water Year geometric mean and percentile FCB and/or E. coli levels are greater than the geometric mean and percentile standards as established in WAC 173-201A.

- Alternative \((H_A)\) = Averaging Period, Seasonal, and/or Water Year geometric mean and percentile FCB and/or E.coli 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. Stations found in Table 12 are retained in this QAPP for reference.
## Table 12. Snohomish County 2013 – 2018 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 APROXIMATELY 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
For the 2019 – 2024 permit cycle, selection of routine monitoring stations is driven by 2013-2018 site data, locations of State of Our Waters program long-term sampling sites, knowledge of additional streams of concern, and the presence of year-round flow. These stations are found in Table 13. As allowed by the permit, the County is proposing the following changes to monitoring stations over the 2013-2018 permit monitoring efforts.

- Discontinue monitoring in Little Bear at LBLD as the permit does not require continued sampling here. The County’s State of Our Waters program conducts long-term water quality monitoring for FCB and E. coli at a location just downstream.
- Replace DOUG with 05TUNIDE. The monitoring station at DOUG requires access through private land, which presents a challenge to permit compliance should the landowner deny access. Additionally, the County’s State of Our Waters program conducts long-term water quality monitoring for FCB and E. coli at this same location. The 05TUNIDE station, also known as UNAM, has been found through the Pollution Identification and Correction Phase 2 grant to have elevated concentrations of FC (Figure 6). The Stillaguamish TMDL identified as having the highest geometric means and 90th percentiles of all smaller tributaries sampled.
- Replace SCLU with SCLD (Figure 8). SCLU met both the geometric mean and 10% not to exceed standards for FCB during the 2018/2019 water year. This station also frequently dries up during summer months, confounding collection of the required 12 samples per calendar year. For these reasons, the County proposes to replace this station with SCLD. This station has not historically dried up and has a long record upon which additional FCB and/or E. coli data would be useful for trends evaluation.
<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 TAMBERK CREEK FROM UPSTREAM SIDE OF 196TH ST SE. 190FT SE OF INTERSECTION WITH BOTHELL EVERETT HWY</td>
<td>47.82049</td>
<td>122.20660</td>
</tr>
<tr>
<td>8</td>
<td>Swamp Creek</td>
<td>SCLD REPLACED SCLU</td>
<td>SWAMP CREEK FROM SOUTH SIDE OF BRIDGE 505 AT LOCKWOOD ROAD. 850FT SE OF THE INTERSECTION WITH CARTER ROAD</td>
<td>47.77730</td>
<td>122.25007</td>
</tr>
<tr>
<td>7</td>
<td>Allen Creek</td>
<td>ACLU</td>
<td>SAMPLED DOWNSTREAM OF CULVERT AND UPSTREAM OF SMALL TRIBUTARY THAT COMES IN ALONG 112TH.SITE MOVED TO THE SOUTH SIDE OF 100TH ST. NE IN 10-98 AND FOR PRESENT STUDY.</td>
<td>48.08494</td>
<td>122.13735</td>
</tr>
<tr>
<td>5</td>
<td>Lower Stillaguamish</td>
<td>OSITUNIDE REPLACED DOUG</td>
<td>GREENWOOD CREEK IMMEDIATELY DOWNSTREAM OF SOUNDVIEW DRIVE</td>
<td>48.16488</td>
<td>122.36781</td>
</tr>
</tbody>
</table>
Sampling Process Design

Surface Water Monitoring
The target population is FCB and E.coli within surface waters. Washington State Administration Code (WAC 173-201A) and Water Quality Policy 1-11 indicate that a minimum of three samples are required to calculate a geometric mean for comparison to the geometric mean criteria.

Sample collection dates shall be well distributed throughout the averaging period so as not to mask noncompliance periods. For each water year, the averaging periods are consecutive rolling 90 day periods (i.e. Jan/Feb/Mar, Feb/Mar/Apr) and critical periods (seasons) as established by TMDLs.

Although a minimum of three samples are required per averaging period (Water Quality Policy 1-11), the 2019-2024 permit requires that 12 samples be taken in at least one location per calendar year.

Logistical Problems
Sample collection on the intended date can be prevented by periods of no flow or frozen waters. In the event this occurs, additional sample collection attempts will be made to ensure a minimum of 12 samples are collected at each location over the calendar year. Additional sample events will be scheduled such that samples are well distributed throughout the applicable 90-day averaging period.

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

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, and 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.

Routine water quality monitoring for collection of FCB and E.coli will be carried out in accordance with this quality assurance plan and sampling methods found in Snohomish County Standard Operating Procedure for the Collection, Processing and Analysis of Stream Samples (Appendix D).

Methods for field measurements of temperature, pH, conductivity, and dissolved oxygen are found in Snohomish County Standard Operating Procedures for Hydrolab® DataSonde®, MiniSonde®, and HL4 Multiprobes (Appendix E).

Calibration

Hydrolab Minisonde 5a™ and Hach 2100P™ are utilized for field measurements. Both instruments are calibrated in accordance with manufacturers’ recommendations, prior to and after field work. Calibration methods are found in Appendix E. Calibrations are recorded on standardized forms (Appendix C) and maintained in binders with lab results. Each Hydrolab is factory calibrated and updated with the latest software and firmware annually. 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 the permit and Washington State archival timelines.

Hydrolab Minisonde5a™
All Hydrolab Minisonde 5a™ currently used by SWM use luminescent dissolved oxygen (LDO) sensors using Hach method 10360. The 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 the EPA’s director of analytical methods that Hach method 10360 be included in the Code of Federal Regulations 40 part 136.3.

The Hach 2100P Turbidimeter
Turbidimeters are calibrated following manufacturers recommendations.⁵
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 invasive fish, wildlife, or aquatic plants from one location to another. New Zealand mudsnails (*Potamopyrgus sp.*) are an invasive species currently found within the Stillaguamish, Snohomish and Lake Washington watersheds that can be spread through the use of field equipment and field gear 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 at [https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=1008](https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=1008). Additionally, staff may call the Washington State Department of Fish and Wildlife or Ecology's 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.
Field Sampling for FCB and E. coli

With a few general exceptions, sampling for FCB and E. coli is performed using Snohomish County Operating Procedure for the Collection, Processing and Analysis of Stream Samples (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 and E.col SM9222G
- **Preservative**: Ice

Preservation of FCB and E. coli samples is recommended by APHA (1998) using sodium thiosulfate to reduce chlorine expected in samples. This preservative is commonly used when sampling for bacteria from wastewater plant discharges. Since sample sites have the potential to be downstream of wastewater discharges, sodium thiosulfate is added to the sample bottles.

Similarly, preservation of FCB samples with disodium salt of ethylenediaminetetraacetic acid (EDTA) is used when sampling wastewater with metals concentrations including copper and zinc > 1.0 mg/l (APHA 1998). EDTA will also be added 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 for that purpose.

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

Field Measurements using Hydrolab Minisonde 5a™

Methods for collection of field measurements are found in Appendix E. Standard Operating Procedures for Hydrolab® DataSonde®, MiniSonde®, and HL4 Multiprobes.
Field Sampling for Turbidity

Samples for turbidity are gathered and analyzed in accordance with procedures identified in the HACH 2100P turbidimeter user manual. A 1L unpreserved sample bottle attached to the sample pole is plunged neck down through the water and then 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 user manual. An electronic copy of this user manual is found at https://www.hach.com/2100p-portable-turbidimeter/product-downloads?id=7640450099

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. 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. Turn on the Turbidimeter and orientate the sample vial such that the diamond is aligned with the raised mark on the instrument.
8. Select signal averaging mode on the Turbidimeter.
9. Press read and record the value on the field data sheet.

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 laboratory supplied COC for all samples transported to the office or laboratory.

A standard 10 day turn-around time for lab analysis 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 is 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 lab reports.

**Field Sample and Measurement Methods**

The analytical laboratories used in this project are accredited by Ecology 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 15 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 14. 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>E. coli</td>
<td>SM9222G</td>
<td>125ml</td>
<td>Sterile HDPE</td>
<td>24hr</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 15. 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>
</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 that are consistent with EPA and Ecology guidance.

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 15. Daily calibration and post-monitoring checks will be conducted using methods and thresholds for acceptance or rejection of field measurements outlined in table 15. Data are qualified as either accepted or rejected from being used for analysis based upon these quality control criteria. The project manager will work with field staff to determine the cause of rejected data and work to correct any issues.

Table 16. 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 sampling procedures in Mathieu (2006), un-biased water quality sampling efforts for bacteria 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 eliminate polluted discharges.

Once representative samples are obtained, 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 or 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 FCB and E. coli will be labeled and identified on the COC using the following convention:

- Client: SnoCo SWM
- Sample/Client ID: Date MMDDYY, Analyte(s), Dup, # (011310FCDup1) for Fecal coliform or (0113110ECDup1) for E.coli
- Date: MM/DD/YY
- Time: No time noted on sample bottle or COC
- Analysis: FCB SM9222D / E.coli SM9222G
- Preservative: Ice
Evaluation of FCB and E. coli 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 errors.

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:

- $\%RSD$ = relative standard deviation
- $S$ = standard deviation of original and duplicate sample
- $x$ = mean of original and duplicate sample

The County evaluates both individual and programmatic FCB and E. coli 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 9.

Figure 9. FCB and E. coli Field Duplicate Evaluation

Fifty percent of FCB and E. coli duplicate pairs with means > 20 colonies/100 mL, 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 and E. coli 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 17. Individual FCB and E.coli 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>≥ 50% &lt; 75%</td>
<td>Sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>&gt; 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 18. Programmatic FCB and E. coli 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 &lt; 50% RSD and 90% of duplicate pairs &lt; 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 &lt; 20% 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; 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>

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 E. coli will be labeled and identified on the COC using the following convention:

- Client: SnoCo SWM
- Sample/Client ID: Date MMDDYY, Analyte(s), Blank, # (011310FCFB1) for Fecal coliform or (011310ECFB1) for E.coli
- Date: MM/DD/YY
- Time: Same time of sampling as the original sample
- Analysis: FCB SM9222D / E.coli SM9222G
- Preservative: Ice
**Evaluation of Field Blank Results**

Detections in field blanks for either FCB or E. coli result qualifying the original sample result as an estimate.

**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 E. coli will be taken on a quarterly basis by random selection.

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

- **Client**: SnoCo SWM
- **Sample/Client ID**: Date MMDDYY, Analytes(s)Trip Blank, # (011310FCTB1) for Fecal coliform or (011310ECTB1) for E.coli
- **Date**: MM/DD/YY
- **Time**: Time samples prepared in the lab
- **Analysis**: FCB SM9222D / E.coli SM9222G
- **Preservative**: Ice

**Evaluation of Trip Blank Results**

Detections in trip blanks for either FCB and E. coli result in qualifying the original sample result as an estimate.
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.

\[
\frac{(X_o - X_d)}{X_d} \times 100
\]

Where:
- \(X_o\) = original sample result
- \(X_d\) = duplicate sample result

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 principle 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 samples. 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:
- \(\%\text{RPD}\) = 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.

\[
\%R = \frac{X_s - X_o}{C_s} \times 100\%
\]

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

The results of the bacteria, insitu 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.

The contact lab maintains a [quality control manual](http://amtestlab.com/aboutus/QC_Manual.pdf), which describes all analytical methods and quality control guidelines.

Lab analysis and precision for parameters specific to this QAPP are found in Table 19.

---

Table 19. Lab Methods and Quality Control

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Analytical Methods</th>
<th>Reporting Limit/ Sensitivity</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>E.coli</td>
<td>Colonies 100ml</td>
<td>SM9222G Membrane Filtration</td>
<td>2 min, 2 E^6</td>
<td>1</td>
<td>&lt;50%</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 this QAPP. The processes are outlined in Figure 10 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 10. Data Verification and Validation Process
Data Verification
Data verification is the process of evaluating the completeness, correctness, and conformance or compliance of a specific dataset 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 staff are responsible for data management and verification. The project manager reviews entry of data and verification conducted by trained 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 G 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, where 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 due to lack of resources. 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, a 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.

**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 are anomalous with the entire dataset 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 are unable to conform and do not meet the data quality objectives, 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 E.coli will be qualified with a “U” and the result will be substituted with the method detection limit for analysis and database load.

**Data Management Procedures**

**Field Data**
In-situ chemical and physical parameters are recorded on digital forms and loaded into verification and data storage spreadsheets. Data are checked for completeness, verified and transformed for transfer to SWM’s WISKI database for export to Ecology’s EIM database as required or reasonable. Records are retained for 5 years.

**Laboratory Data**
Data packages for lab analysis will be sent to SWM 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. Data reports from the analytical laboratory will be reviewed for completeness. Potential errors and omissions will be reported to laboratory personnel. The analytical reports will be compared to the COC to ensure that all requested analyses have been performed. Errors or missing data will be reported to laboratory personnel immediately. Amended and corrected analytical reports will be attached to the original report 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, every effort will be made 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, qualified data may not be used in the water quality data analysis. Qualifiers applied to field samples under this QAPP are found in Appendix G.
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 may 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 Exceedances
FCB and E. coli data are log transformed for normality as necessary and geometric means are calculated by season and rolling 90-day periods for comparison to Washington State Water Quality Standards. Given the standard has two parts (geometric mean and 10% not to exceed) a station’s exceedance of seasonal geometric means results in partial acceptance of the null hypothesis.

Valid data will be compared to the 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 acceptance of the null hypothesis.

Calculation of Probabilities and MWQA Ranks
Where a sufficient volume of valid FCB and E. coli data exists, true probabilities of impairment or non-impairment may 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 or E. coli samples exceeding the 10 percent not to exceed standard aid in prioritizing sample stations where targeted source identification and elimination may take place.

Trends Analysis
Where a sufficient volume of valid data exists, seasonal kendall trends analysis may be conducted to determine if water quality is improving, getting worse or remaining the same. To determine whether a sufficient volume of data exists, the County runs existing FCB data through Ecology’s sample size for trends analysis calculator to determine the number of samples needed to detect a minimum of a 50 percent change with 80 percent power and at 90 percent confidence.
Audits and Reports

Audits
Periodic audits 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 annual NPDES permit requirements or as needed to support internal decision making.
References


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
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, \( \%\text{RSD} = \left(\frac{100 \times s}{x}\right) \) 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
# Snohomish County Ambient Water Quality Monitoring - Field Instrument Calibration Checks

## Data quality criteria for Hydrolab/Hach Calibration Checks

<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; \pm 0.35)</td>
<td>(\pm 0.5) and (&lt; \pm 0.5)</td>
<td>(\pm 0.5)</td>
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<tr>
<td>Conductivity*</td>
<td>(\mu)S/cm</td>
<td>(&lt; \pm 3%)</td>
<td>(\pm 3%) and (&lt; \pm 15%)</td>
<td>(\pm 15%)</td>
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<tr>
<td>Dissolved Oxygen**</td>
<td>% saturation</td>
<td>(&lt; \pm 5%)</td>
<td>(\pm 5%) and (&lt; \pm 10%)</td>
<td>(\pm 10%)</td>
</tr>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>(&lt; \pm 5%)</td>
<td>(\pm 5%) and (&lt; \pm 10%)</td>
<td>(\pm 10%)</td>
</tr>
</tbody>
</table>

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

---

### 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
Hydrolab Calibration Check Procedures

**DO**

Step 1. Take a 1 liter bottle and fill it 50% full with deionized water which has been has been at equilibrium with atmospheric pressure for at least 12 hours i.e. unseal/unopen 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 (cone face 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 half 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% full with pH buffer 7 solution and screw the black calibration cap 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 swap. 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 at the Room Temp 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. Snohomish County Standard Operating Procedure for the Collection, Processing and Analysis of Stream Samples
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Snohomish County Surface Water Management
Resource Monitoring Group

Standard Operating Procedures for the Collection, Processing, and Analysis of Stream Water Quality Samples

Samples Version 1.0

Author - Steve Britsch
Date – 9/10/2019

Reviewer – Robert Plotnikoff
Date – 09/10/2019

QA Approval - Rob Plotnikoff – Quality Assurance Officer
Date – 10/21/2019

SWM-RM-003

Original Approval Date:
10/21/2019

Latest Recertification Date:

Latest QA Approval Date:
Please note that Snohomish County Surface Water Management’s (SWM) Standard Operating Procedures (SOPs) are adapted from Washington State Department of Ecology Standard Operating Procedure EAP 034 version 1.5, other published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Snohomish County 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 Snohomish County.

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

<table>
<thead>
<tr>
<th>Revision Date</th>
<th>Rev number</th>
<th>Summary of changes</th>
<th>Sections</th>
<th>Reviser(s)</th>
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</table>
Resource Monitoring Group

Standard Operating Procedure for the Collection and Processing of Stream Water Quality Samples

Introduction

Collection and processing of stream water quality samples supports Snohomish County Public Works Surface Water Management’s (SWM) mission to protect and enhance water quality and aquatic habitat for future generations. The Resource Monitoring (RM) group holds primary responsibility for this work and uses the data to describe watershed health and inform efforts to protect human health and aquatic life.

1.0 Purpose and Scope

This Standard Operating Procedure (SOP) details a method used by RM group to collect and process water quality measurements and samples from streams and rivers. It may also contain methods that other entities would find useful for their monitoring work.

1.1 The scope of this SOP applies to general stream monitoring procedures used for run preparation, measurement and sample collection, processing, preservation, and shipment. The document generally describes quality assurance and quality control procedures.

1.2 The standard set of samples and field measurements collected, measured, or processed include: temperature, pH, conductivity, dissolved oxygen, turbidity, total suspended solids, fecal coliform bacteria, E.coli, ammonia, nitrate plus nitrite-nitrogen, total nitrogen (derived by combining NO$_3$ + NO$_2$ concentrations), total phosphorus, dissolved copper and zinc.

2.0 Applicability

This SOP is intended for any SWM program involving the collection, processing and analysis of water quality samples for core (water quality index) parameters from streams.
3.0 Definitions

3.1 **Accuracy** – The degree to which a measured value agrees with the true value of the measured property.

3.2 **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 parameter being measured.

3.3 **Conductivity** – A measure of the ability of water to carry an electrical current. It is dependent upon the concentrations and types of dissolved ions and the water temperature. In general, a greater concentration of ions in the water will lead to a larger conductivity value.

3.4 **Dissolved Oxygen (DO)** – The concentration of dissolved oxygen (mg/L) in a water sample.

3.5 **Fecal coliform** – A group of bacteria that inhabit the intestinal tract of warm-blooded animals and remain viable in freshwater for a variable period of time. The presence of fecal coliform bacteria in water indicates fecal contamination of the water by a warm-blooded animal; harmful bacteria and viruses associated with fecal contamination may also be present.

3.6 **E.coli** – Escherichia coli, also known as E.coli is a gram negative facultative anaerobic, rod shaped, coliform bacterium commonly found in the lower intestine of warm-blooded animals.

3.7 **Field Forms** – Weather resistant hardcopy and/or digital field forms (iPADs®) are used to document any and all field activities, sample data, methods and observations for each and all sample sites.

3.8 **Field Blank** – Samples of ultra-clean de-ionized water provided by the lab and used to determine whether lab or field samples have been cross contaminated through sample collection, storage or transport.

3.9 **Field Duplicate** - Samples representative of the same water as the original sample, obtained at the same time and place. Generally obtained for 10% of collected samples to determine whether data
quality objectives of bias, precision, accuracy and ultimately relative standard deviations are me

**MQO’s** – Measurement 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 error used as the basis for establishing the quality of data used to support decision making.

3.10 **MSDS** – Material Safety Data Sheets provides both workers and emergency personnel with the proper procedures for handling or working with a particular substance. MSDS’s include information such as physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, and first response.

3.11 3.12 **NTU** – Nephelometric Turbidity Units (units for reporting turbidity in freshwater)

3.13 **Precision** – The extent of random variability among replicate measurements of the same property.

3.14 **pH** – A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. The pH scale ranges from 0 to 14.

3.15 **Relative Standard Deviation/Percent Difference** – A measure of precision through comparing the difference between two sample results and expressed as a percentage.

3.16 **Run** – Scheduled sampling event.

3.17 **SWM Lab** – Surface Water Management Lab and location of field equipment storage, calibration and sample processing.

3.18 **Total Suspended Solids** - Dry weight of suspended particles that are not dissolved in water.

3.19 **Trip Blank** – Samples of ultra-clean de-ionized water provided by the lab and used to identify contaminant carry over from the time samples are handled through field efforts.

3.20 **Turbidity** – The measure of relative clarity of liquid expressed as the amount of light that is scattered by material in a sample or
3.21 Nephelometric Turbidity Units.

3.22 $\mu$hmhos – micro mhos (mho = 1/ohm = 1 Siemen) per centimeter

3.21 Water Quality Index – A tool to summarize and report on water quality conditions. It’s a unitless number ranging from 1 to 100; a higher number indicative to better water quality.

4.0 Personnel Qualifications/Responsibilities

4.1 Field operations require training specified by job title in SWM’s Safety Training database.

4.2 This SOP pertains to all Natural Resource Scientists, Environmental Specialists, Interns and Environmental Technicians in the RM group or other staff using this SOP.

4.3 All field staff must have read the instrument manual, this SOP, completed field training and be familiar with procedures for data collection.

4.4 All field staff must be familiar with the electronic data recording tablet.

4.5 The field lead directing sample collection must be knowledgeable of all aspects of the project’s Quality Assurance Monitoring Plan (QAMP) to ensure that credible and useable data are collected. All field staff should be briefed by the field lead or project manager about the sampling goals and objectives prior to arriving at the site.

5.0 Equipment, Reagents, and Supplies

5.0.1 iPad w/ car charger
5.0.2 Phone/camera
5.0.3 Vehicle Gas Card and Personal PIN number
5.0.4 Quality Assurance Management Plan
5.0.5 Any rights of entry
5.0.6 Bridge sampler (as necessary)
5.0.7 Extension pole with bottle clamp
5.0.8 Field Forms/Pencil/Pen
5.0.9 Chain of custody
5.1.0 Instrument Calibration Log Form
5.2.0  ???
5.2.1  Sample Run Checklist
5.2.2  Sample coolers w/ bags of ice
5.2.3  Sample bottles/w labels
5.2.4  Bagged Ice
5.2.5  Gel-Ice (Blue Ice) as necessary
5.2.6  Deionized water for field/trip blanks
5.2.7  Calibration standards
5.2.8  Hach 2100P Turbidimeter
5.2.9  Hach/Hydromet – Hydrolab MS5 and/or HL4
5.3.0  Hardness – 250m wide mouth poly bottle preserved with HNO3 to pH<2
5.3.1  Total Phosphorus – 250 ml poly bottle preserved with H2SO4 to pH<2
5.3.2  Nitrate-Nitrite – N – 250 ml poly bottle preserved with H2SO4 to pH<2
5.3.3  Total Suspended Solids – 500ml poly bottle
5.3.4  Fecal coliform / E.coli bacteria – 250m sterile poly bottle with EDTA/Sodium Thiosulfate
5.3.5  Deionized water (DI water) used to rinse sampling bottles and equipment.
5.3.6  Tap water
5.3.7  1L sample bottle for turbidity sampling
5.3.8  500mL Teflon FEP bottles pre-filled with de-ionized water by the lab
5.3.9  125 mL narrow mouth poly bottle containing H2SO4 preservative for hardness sample disposable 0.45 micron cellulose acetate filter unit (pre-cleaned)
5.4.0  Spare sample bottles/labels
5.4.1  Nitrile disposable gloves
5.4.2  Eyewash Stations
5.4.3  First aid kit
5.4.4  Personal protective equipment (boots, gloves, hardhat, eye/ear protection, traffic control devices)
6.0 Summary of Procedures

6.1 Pre-Project/Sample Planning: Work with project managers/leads to determine the location of proposed and/or confirmed sampling locations. In some cases permission to access private property is needed and requires attention to landowner requests prior to sampling. Reconnaissance of sample sites prior to obtaining samples may be necessary to identify logistical, access or safety related issues.

6.2 Run Preparation. This should begin several days in advance of a run and requires requests for sample bottles from the contract lab and notifications of sample pick up. It may also require coordination with landowners where access to private property is necessary and has been granted.

6.3 Staff should always prepare for a run using the equipment checklist to ensure that all sampling equipment, supplies, sample containers, and personal protective equipment are available and loaded to the vehicle.

6.4 Daily Pre-Departure Procedures

6.4.1 Turn on the cell phone. Enable “Location Services” for safety purposes when sampling alone.

6.4.2 Review equipment checklist and gather any equipment/materials necessary.

6.4.3 Pre-labeling bottles and chain of custody: To the extent possible, it may expedite field sampling if sample bottle labels and the chain of custody can be partially filled out prior to field work.

6.4.4 It may be helpful to use ArcGIS and mapping software to ensure you understand the best place to park at each sample location.

6.4.5 Obtain any right of entry paperwork necessary.
6.4.6 Check out on the white board and hardcopy check in/out sheet to ensure a supervisor, management team member or project manager knows where you are going and when you expect to return. *Note Cell phones need to be kept on during work hours to allow the lab courier or other staff to get shipment information or to discuss other program related needs.*

6.4.7 Refill the de-ionized water containers.

6.4.8 Put several scoops of ice into bags, load each sample cooler needed and load the coolers into the vehicle.

6.4.9 Calibrate the Hydrolab® instrument being used in accordance with Standard Operating Procedure SWM_RM_001.

7.0 **Field Measurement Procedures**

7.0.1 Field measurements are obtained using properly set up and calibrated Hydrolab® Surveyor 4 and Hach 2100P Turbidimeters.

7.0.2 Set up a manually triggered file in the Surveyor 4 to gather field measurements using the Hydrolab® during the sample run.

7.0.3 Ensure the Surveyor 4’s internal battery is fully charged.

7.0.4 Upon arrival to the sample location, power the Surveyor 4 on, unscrew the calibration cup and affix the weighted sensor guard over the sensors.

7.0.5 Put on Nitrile gloves

7.0.6 Submerge all sensors to mid-depth (where feasible) and point into flow. Do not allow sensors to contact the stream bottom. It is preferable to place the instrument downstream of where collection of water for lab analysis will occur.

7.0.7 If flow is not deep enough for sensor submersion, triple rinse the calibration cup, collect a stream sample in it and submerge sensors.

7.0.8 If ice or high water make it difficult to obtain measurements from shore, using the sample pole, drape the Hydrolab® and cable over the end and extend the pole and instrument out over and into the water.
7.0.9 Wait for temperature to stabilize such that it doesn’t vary more than 0.1 Deg C. Collection of water samples for lab analysis may occur while temperature is stabilizing.

7.1.0 If collecting field measurement duplicates, leave the instrument in-stream, collect samples for lab analysis, return to the Hydrolab® and record duplicate field measurements.

7.1.1 Manually trigger the Surveyor 4 to capture measurements.

7.1.2 Remove the instrument from the water.

7.1.3 Review field measurements stored in the Surveyor 4 and record on hardcopy and/or in digital field sheets.

7.1.4 Rinse sensors with de-ionized water between sample stations.

7.1.5 Samples for turbidity measurements are gathered and analyzed in accordance to procedures identified in the Hach 2100P user’s manual found at https://www.hach.com/2100p-portable-turbidimeter/product-downloads?id=7640450099

7.1.6 Using an unpreserved 1L Nalgene sample bottle, plunge neck down through the water to fill and pour out downstream. Repeat this three times to “triple rinse” the bottle. Obtain a 1L sample on the fourth plunge.

7.1.7 Thoroughly mix the 1L sample by shaking for 30 seconds

7.1.8 Triple rinse a clean (non-scratched) 25ml glass turbidity vial with the 1L sample.

7.1.9 Fill the vial with the fourth pour and cap.

7.2.0 Place the turbidimeter on a level, stationary surface.

7.2.1 Wipe the vial with a lint-free cloth. (Apply silicon oil to vial and wipe as necessary)

7.2.2 Turn the turbidimeter on and orient the sample vial such that the diamond is aligned with the raised mark on the instrument.

7.2.3 Select the signal averaging mode on the turbidimeter.

7.2.4 Press read and record the value on the hardcopy and/or digital field sheet.
7.2.5 If called for, measure the stream stage height and record result on the hardcopy and/or digital field form.

7.3 Field Sampling Procedures

7.3.1 Extension Pole Method. This method is typically used to reach a more representative undisturbed sample location from the stream bank or to sample a shallow stream from a bridge.

7.3.2 Put on Nitrile gloves and complete fields on sample bottle label.

7.3.3 Carry all equipment to a well-mixed location, such as the deepest part of the active channel or other location where a representative sample may be collected. Do not contaminate the sample location by wading upstream of it.

7.3.4 As described in section 7, submerge the Hydrolab® sensors and wait allow temperature to stabilize such that it doesn’t vary more than 0.1 Deg C.

7.3.5 If called for, measure the stage height and record the measurement in the hardcopy and/or digital field form.

7.3.6 Ensure all information is filled out on bottle labels, including time of sampling.

7.3.6 Secure a sample bottle to the extension pole clamp, remove the cap and place where cross contamination will not occur. If obtaining field duplicates, secure a second sample bottle on the pole next to the first.

7.3.7 Extend the pole to the desired sample location, invert the bottle and in one quick motion, plunge the mouth of the bottle into the water, and tip the mouth toward the water surface moving in a downstream to upstream motion.

7.3.8 Wait until the bottle(s) have filled, (but not overfilled), remove the bottle(s), cap it and remove from the clamp. Place into receptacle for transport to the vehicle.

7.3.9 Repeat this bottle filling process for the remaining samples. Return to the vehicle and place samples on ice.

7.4.0 Hand Dip Method. This method is typically used to collect samples from a small or shallow stream
7.4.1 Put on Nitrile gloves and complete fields on sample bottle label.

7.4.2 Carry all equipment to a well-mixed location, such as the deepest part of the active channel or other location where a representative sample may be collected. Do not contaminate the sample location by wading upstream of it.

7.4.3 As described in section 7, submerge the Hydrolab® sensors and wait allow temperature to stabilize such that it doesn’t vary more than 0.1 Deg C.

7.4.4 If called for, measure the stage height and record the measurement in the hardcopy and/or digital field form.

7.4.5 Grab the base of the sample bottle with one hand, invert the sample bottle, remove the cap, and reaching upstream – plunge the bottle into the water and tip the mouth toward the water surface moving in a downstream to upstream motion.

7.4.6 Wait until the bottle has filled, (but not overfilled), remove the bottle, cap it and place into receptacle for transport to the vehicle.

7.4.7 Repeat this bottle filling process for the remaining samples – including field duplicates. Return to the vehicle and place sample set in the one-gallon freezer bag, partly seal, and store on ice.

7.5 Field Blank Collection

7.5.1 Transport a laboratory supplied container of ultra-clean de-ionized water to the field.

7.5.2 At a predetermined sample location, transfer the ultra-clean de-ionized water from the lab supplied container into a field sample bottle for the parameter(s) of interest.

7.5.3 Label the field blank sample container as determined by the project manager or quality assurance project plan and preserve the sample on ice.

7.5.4 Ensure the field blank is identified on the chain of custody for submittal to the lab.

7.6 Field Duplicate Collection

7.6.1 As dictated by the project QAPP and field sample QC schedule, field duplicate samples are collected simultaneously with the primary sample
and treated in the same manner as the primary during all phases of collection, handling and analysis.

7.6.2 Repeat steps 7.0 – 7.47 for collection of field duplicates.

7.7 **Trip Blank Collection**

7.7.1 Trip blank samples are collected/processed using ultra-clean de-ionized water as supplied by the contract lab.

7.7.2 As dictated by the project QAPP and field sample QC schedule, fill necessary sample bottles with ultra-clean de-ionized water while at the predetermined QC sample location.

7.7.3 Samples are treated in the same manner as the primary during all phases of handling, transport and analysis.

8.0 **Records Management**

8.1 Records created are inclusive of history of programmatic changes/issues/resolution, equipment maintenance, calibration records, field forms, chains of custody, electronic data/observations, and hardcopy reports.

8.2 Samples are documented and tracked using chain of custody forms and resulting electronic field data and lab results.

8.3 The field lead is responsible for ensuring hardcopy and/or electronic field forms are complete and reviewed for correctness and completeness.

8.4 Data are verified for usability and populated into SWM’s database.

8.5 Hardcopy records are archived every 5 years and stored in perpetuity.
9.0 Safety

9.1 Persons involved with collection of samples 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.

9.2 Staff are provided appropriate PPE to minimize hazards. Teams of two especially for sites where samples are gathered on larger streams/rivers during moderate to high flow events.

9.3 Washington State Department of Labor and Industries requires the employers provide a safe work environment through communicating hazards and providing adequate training.

9.4 Required safety training, inclusive of General Field Safety, Chemical Hygiene, Hazwoper, Roadway Safety and Swiftwater awareness have been identified by position.

10.0 References


Appendix E. Standard Operating Procedures for Hydrolab® DataSonde®, MiniSonde®, and HL4 Multiprobes
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Snohomish County Surface Water Management
Resource Monitoring Group
Standard Operating Procedures for Hydrolab® DataSonde®, MiniSonde®, and HL4 Multiprobes Version 1.0

Author - Steve Britsch
Date - March 6, 2018

Reviewer - Stuart Baker and Keith Westlund
Date - May 10, 2018

QA Approval – Robert Plotnikoff – Quality Assurance Officer
Date – September 16, 2019

SWM-RM-001

Original Approval Date: September 16, 2019
Latest Recertification Date:
Latest QA Approval Date:
Please note that Snohomish County Surface Water Management’s (SWM) Standard Operating Procedures (SOPs) are adapted from Washington State Department of Ecology Standard Operating Procedure EAP 033, other published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Snohomish County 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 Snohomish County.

Although SWM follows the SOP in most cases, there may be instances in which the County uses an alternative methodology, procedure, or process.
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Resource Monitoring Group

Standard Operating Procedure for Hydrolab® DataSonde®, MiniSonde®, and HL4 Multiprobes

Introduction

DataSondes®, MiniSondes®, and HL4s are multi-parameter water quality probes used by Snohomish County Public Works, Surface Water Managements (SWM) Resource Monitoring (RM) Group to measure pH, dissolved oxygen, conductivity, temperature, depth, and barometric pressure. They can be used for discrete measurements as the user moves from site to site throughout the course of a day, depth profiling, or short and long-term unattended monitoring at specified time intervals. Currently, the RM group does not use Hydrolabs® to gather chlorophyll a, blue-green algae, ambient light and photosynthetically active radiation (PAR), turbidity, ammonium, chloride, or nitrate/nitrite data, but these non-standard sensors are available through Hach/Hydrolab® if needed.
1.0 Purpose and Scope

This Standard Operating Procedure (SOP) details methods used by the RM group for using Hydrolab® DataSondes®, MiniSondes®, and HL4s®. It may also contain methods that other users would find helpful for their monitoring work.

The scope of this SOP applies to cleaning, calibration, general set up and use, storage, and equipment protection (theft) of Hydrolab® multi-parameter water quality probes.

Each new Hydrolab® user must be trained by a custodian or other designated, trained user. Hydrolab® user’s manuals should be consulted for detailed instructions on maintenance, deployment, and troubleshooting of Hydrolab®. Failure to do so may result in injury to the operator or equipment. Additionally, training videos are available online.

If the Hydrolab® User’s manual does not provide adequate information, consult a Hydrolab® custodian or call technical support. For information on using rhodamine, TDG, ORP, and other non-standard sensors, please consult the appropriate Hydrolab® manual or Hach’s website and contact technical support.

Non-program reservations for RM group Hydrolab® equipment must be made through Outlook® as the primary reservation resource. Non-program staff must be properly trained to use any Hydrolab® equipment. A Hydrolab® custodian or company representative can help fulfill the training requirement. See your supervisor for further details.

2.0 Applicability

2.1 This SOP is intended for any SWM monitoring program that makes water quality measurements. The Hydrolab® instrument has a great range of uses from routine water quality monitoring to collecting


in situ water quality data that is companion to biological monitoring. This instrument is a primary tool for conducting limnological studies in lakes and reservoirs.

### 3.0 Glossary of Terms

3.1 **Calibration** – To standardize or correct sensors after determining, by measurement or comparison with a standard, the correct value.

3.2 **Conductivity** – A measure of the ability of water to pass an electrical current. This parameter indicates the amount of dissolved substances (salts) present in the water.

3.3 **DO** – Dissolved oxygen in water, measured in mg/L.

3.4 **DO %** – The percent saturation of dissolved oxygen in water.

3.5 **LDO** – Luminescent dissolved oxygen. The Hach LDO sensor cap is coated with a luminescent material. Blue Light from an LED strikes the luminescent chemical on the sensor. The luminescent chemical instantly becomes excited. As the excited chemical relaxes, it releases red light. The higher the oxygen concentration, the less red light given off by the sensor cap. The red light is detected by a photo diode. The time it takes for the chemical to return to a relaxed state is measured. The oxygen concentration is inversely proportional to the time it takes for the luminescent material on the sensor cap to return to a relaxed state. Between flashes from the blue LED, a red LED of known intensity is flashed. The red LED (light emitting diode) acts as an internal standard for reference comparison to the red light given off by the luminescent sensor cap. This comparison allows the sensor readings to remain stable for long periods of time.

3.6 **m** – meter

3.7 **Multi-parameter** – The combination of several sensors or sensor assemblies into a complete, stand-alone piece of equipment, which simultaneously measures multiple parameters for profiling, spot-checking, or logging readings and data.
Personnel Qualifications/Responsibilities

4.6 Field operations require training for all staff conducting monitoring and identified by job title as listed in the SWM Safety Training database.

4.7 This SOP pertains to all Natural Resource Scientists, Environmental Specialists, Interns and Environmental Technicians in the RM group or other staff using this SOP.

4.8 All field staff must have read the instrument manual, this SOP, completed field training and be familiar with procedures for data collection.
4.9 All field staff must be familiar with the electronic data recording tablet and entries required for a monitoring program.

4.10 The field lead directing sample collection must be knowledgeable of all aspects of the project’s Quality Assurance Monitoring Plan (QAMP) to ensure that credible and useable data are collected. All field staff should be briefed by the field lead or project manager about the sampling goals and objectives prior to arriving at the site.

Equipment, Reagents, and Supplies

5.0 pH buffer solution (2 - 3 low or normal ionic strength buffers) that bracket the typical range of water quality observations expected for a set of sampling sites

5.1 Conductivity standard, typical to the range of water to be measured

5.2 DO water bath equipped with an aquarium pump and air stone

5.3 1 liter poly bottle.

5.4 Tap and deionized water

5.5 DataSonde®, MiniSonde®, or HL4 instrument

5.6 Surveyor (deck unit) or Surveyor HL with charger

5.7 5 m cable (calibration or discrete measurements)

5.8 25 m cable (profiling)

5.9 Calibration/Storage cup

5.10 Calibration stand

5.11 Weighted sensor guard

5.12 Barometer

5.13 DataSonde® or MiniSonde® bail kit or HL4 mooring cap (profiling)

5.14 Laptop or tablet (communication with instrument)

5.15 Hydras 3LT communication software or Hydrolab® Operating Software (HL4)

5.16 Hydras 3LT manual, Surveyor manual, Hydrolab® manual (model specific)

5.17 Toolbox containing:

- Spare parts: o-rings, screws, calibration cups, etc.
- Soft wipes
- Cotton swabs
- Silicone grease
- pH reference electrolyte solution
- pH potassium chloride pellets
- Ethyl alcohol
- Phillips and flathead screwdrivers
- Toothbrush
• Pliers
• Crescent wrench
• Tweezers
• Electrical tape
• ‘AA’, ‘C’, and/or ‘D’ cell batteries
• Allen wrenches

6.0 General Instrument Set Up and Sensor Configuration

6.1 Hydrolab® DataSondes®, MiniSondes®, and HL4 instrument sensors must be configured prior to initial use or considered when monitoring locations change from fresh to salt waters. Sensor configuration for specific conductance allows for the computation of conductivity using 5 different methods, including for measurements from fresh and salt water. The Hydrolab® user’s manual and the custodian should be consulted for sensor configuration. For general measurements of specific conductance in freshwater streams and rivers, it is recommended that users apply the instruments freshwater computational function which corrects measurements to 25°C, allowing for comparison across sites. Sensor configuration for salt waters are established based upon project needs. See each instruments user’s manual for more detailed instruction.

Summary of Procedure

6.2 Calibration

Note: ORP, TDG, and rhodamine sensors are non-standard and not covered in this SOP

6.3 Temperature is factory-calibrated (it can be checked against a NIST standard during the DO calibration if using a water bath)

6.4 LDO can be moved after pH if preferred.

6.5 Conductivity

6.6 pH
6.7 Depth (if needed)

6.8 Preparation of Hydrolab®(s) for Calibration

6.9 Remove the battery cover for the Surveyor data collection device and install freshly charged 9V battery. Place the discharged battery in an appropriate container for recycling.

6.10 If planning for short or long term deployment of Hydrolab®(s), remove the battery cover sleeve and install new batteries (properly dispose of old batteries).

6.11 Put a thin layer of silicone grease on the O-rings to seal battery compartments.

6.12 Re-install the battery cover making sure to tighten snugly to the O-rings. **IMPORTANT:** Over tightening the battery covers can cause leaking at the O-rings, crack covers and strip screws. O-ring damage can cause catastrophic failure of the instrument resulting in data loss and broken equipment. Inspect the Surveyor data collection device and Hydrolab®(s), housing and all installed probes for any obvious damage or deficiencies and cleanliness. If there is damage to the Surveyor, Datasonde housing or probes that would make the instruments unusable, do not use it and notify the custodian as soon as possible. If the Hydrolab® is dirty, proceed to 6.13. If the Hydrolab® is visually clean, proceed to 7.0

6.13 Clean the Surveyor and Hydrolab® housing and probes with a mild detergent and a soft toothbrush. Make sure to clean in between all of the probes. Take care not to scrub the ends of the probes with the toothbrush

6.14 Gently clean the tip of the LDO probe with a dampened cotton swab or soft wipe. If too much pressure or vigor is used during cleaning sensors will be damaged. LDO probes require little maintenance and should only be done under the guidance of a custodian or experienced user referencing manuals for specific maintenance steps.

6.15 Gently clean the glass bulb of the pH sensor and the pH reference electrode with a dampened cotton swab. If the glass bulb and sensor area are visibly dirty, a soft bristled toothbrush can be used. The glass
6.16 bulb is fragile, so take care not break the bulb while cleaning. **Do not use alcohol for cleaning.** If the Hydrolab® has not been used for a long period of time or has had issues with calibration in the past, replace the reference electrolyte and KCL tablets in the reference electrode following the instructions in the Hydrolab® manual (model specific).

6.17 Firmly wipe the conductivity electrodes with a dampened cotton swab. Alcohol may be used with the conductivity probe, if necessary.

6.18 If the Hydrolab® is equipped with a stirrer, remove all iron shavings from in and around the stirrer.

6.18 Inspect the depth port (pressure sensor) to ensure that there are no blockages. Rinse out if necessary. Do not put anything down the port as the membrane damages easily.
7.0  LDO Calibration

7.1  There are three different methods for calibrating the LDO sensor. Each method requires a single point calibration for measurement of concentrations in mg/L. To calibrate the sensor for percent saturations, the barometric pressure where the calibration is being performed must be determined. It can be read from the Surveyor.

7.2  To limit confusion, two calibration options will be presented. The first is the preferred method and the other is a secondary method that can be used if the preferred method is not able to be performed. The preferred method is saturating water with air by shaking in a 1 liter bottle and the secondary method is air saturated water using a water bath.

Large changes in elevation do not require re-calibration because instruments have integrated barometric pressure sensors and automatically compensate dissolved oxygen measurements for changes in pressure.

7.3  Preferred LDO Method

7.4.1  Connect the Hydrolab® to the Surveyor or PC, using the 5 meter calibration cable and turn the units on.

7.4.2  Pour existing tap water out of calibration cup.

7.4.3  Complete top portion of calibration form to record instrument use for the day. This includes recording the User, Date, Time, Instrument Used, Purpose for Use, Barometric pressure (measured outside using either the Surveyor or a credible source of nearby barometric pressure.), Air temperature and Surveyor Battery Voltage.

7.4.4  Set out a 1 liter bottle half full of tap water with the cap slightly threaded on. Make sure the bottle is out long enough for temperature to equilibrate with the calibration environment.
7.4.5 Tighten the cap on the 1 liter bottle of tap water and shake the bottle for 40 seconds. Pour the water from the bottle into the calibration cup up to the bottom of the threads.

7.4.6 Remove any water droplets from the sensor cap with a tissue or clean cotton cloth. Set the calibration cup cap on top of the calibration cup upside down.

7.4.7 Navigate to the appropriate software’s calibration menu and choose the appropriate unit for calibration, either mg/l or % saturation.

Note: It is important to maintain temperature stability during calibration. Care should be taken to minimize exposure to sunlight if calibrating in the field. If the temperature in the calibration cup changes by more than 0.5°C during calibration, it is recommended to recalibrate the sensor.

7.4.8 Wait for equilibration, which may take several minutes.

7.4.9 Enter the barometric pressure as measured outside using either the Surveyor or a credible source of nearby barometric pressure.

7.4.10 Click Done. A “Calibrate Successful” message should appear. If not, repeat calibration. If a valid calibration cannot be achieved, maintenance of the DO probe is required.

7.4.11 Record post calibration value, temperature, brand, lot# and expiration dates of standards on the calibration form.

7.5 Secondary LDO Method

7.5.1 Connect the Hydrolab® to the Surveyor or PC, using the 5 meter calibration cable and turn the units on.

7.5.2 Once connected to the Hydrolab®, navigate to calibration, and choose the percent saturation option.

7.5.3 To calibrate using the secondary air saturated water method, assemble a water bath with an air stone and aquarium pump at least 30 minutes prior to calibration. To achieve an accurate calibration, it is important that the temperature of the water bath not change more than 0.5 °C.
7.5.4 To achieve a stable temperature in the water bath, let the water sit out overnight so that it can equilibrate to the temperature of the room. A battery operated portable aquarium pump is recommended for field calibrations.

7.5.5 Pour existing tap water out of calibration cup.

7.5.5 Place the Hydrolab® in the water bath and let it sit for a minimum of 5 minutes to allow the temperature to equilibrate. To ensure the probes are not damaged during this calibration make sure that a clean sensor guard is on the Hydrolab®.

7.5.6 Complete top portion of calibration form to record instrument use for the day. This includes recording the: User, Date, Time, Instrument Used, Purpose for Use, Barometric pressure, Air temperature and Surveyor Battery Voltage.

7.5.7 Record and then enter the current local barometric pressure in millimeters of mercury (mm Hg). If the available barometric pressure is in inches Hg, multiply it by 25.4 to get mm Hg. For detailed steps on calibration of DO using a Surveyor or Hydras 3 LT, consult the corresponding user’s manual.

7.5.8 Before leaving the DO calibration screen make sure to record the post calibration reading.

7.5.9 Use temperature and barometric pressure and the USGS oxygen solubility tables to verify that the calibration was accurate. Record the value from the USGS table. If the calibration was not successful repeat the calibration process. If a valid calibration cannot be achieved, maintenance on the DO probe is required.

8.0 Conductivity Calibration

8.1 If not already connected, connect the Hydrolab® to a Surveyor or Hydras 3 LT and navigate to the calibration screen. Choose specific conductance. For detailed instructions on how to connect to a Hydrolab® using a Surveyor or Hydras 3 LT and getting to the calibration section of the software consult the corresponding user’s manual.
8.2 Sensor configuration for specific conductance allows for the computation of conductivity using 5 different methods, including for measurements from fresh and salt water. The Hydrolab® user’s manual and the custodian should be consulted for sensor configuration. For general measurements of specific conductance in freshwater streams and rivers, it is recommended that users apply the instruments freshwater computational function which corrects measurements to 25°C, allowing for comparison across sites. Sensor configuration for salt waters are established based upon project needs. See each instruments user’s manual for more detailed instruction.

8.3 Rinse thoroughly with deionized water. It is recommended to remove the calibration cup and pour copious amounts of deionized water from a clean container over the sensors to avoid contamination from the pH reference sensor. The pH reference sensor contains a high conductivity solution used in measuring pH. When rinsing the sensors with the calibration cup attached to the Hydrolab® this solution can be drawn out and contaminate the sensors and cup.

8.4 After rinsing, reinstall the calibration cup. Note: For most applications, a two point calibration is recommended. This includes a zero check in air and a reference solution above your highest expected values.

8.5 Zero check in air. Pour any remaining deionized water out of the calibration cup. With no liquid in the calibration cup and the sensor free of water droplets, record the specific conductance and temperature reading from the calibration screen. The Hydrolab® should be reading 0 µS/cm. If it is higher, repeat steps until the specific conductance is 0 µS/cm.

8.6 With the calibration cup in place, rinse the probes 3 times with standard to be used for the calibration.

8.7 After rinsing, fill the calibration cup with the appropriate standard and carefully place the Hydrolab® in the calibration stand. The correct concentration of conductivity standard will be determined by the expected range of conductivity of the water being studied.
8.8 Wait 1-2 minutes for a stable reading. If the reading is within 5% of the standard, record the temperature and pre-calibration specific conductance reading from the calibration screen. If the reading is greater than 5% of the standard repeat 7.6.6 – 7.6.8 until within 5% of the standard.

8.9 Once the Hydrolab® is reading within 5% of the standard, enter the value of the conductivity standard + temperature and calibrate the sensor. Record the post calibration reading from the calibration screen. If the calibration fails, the conductivity sensor is in need of maintenance.

9.0 pH Calibration

9.1 The pH sensor can be calibrated with a 2 or 3 point calibration. It is most common for users to use a 2 point calibration. Calibrate the sensor to bracket the expected field readings. A pH 7 buffer must always be the first point in the calibration sequence followed by the 4 or 10 buffer. If doing a 3 point calibration, start with the 7, follow it with the 10 buffer, and then finish with 4 buffer.

9.2 If not already connected, connect the Hydrolab® to a Surveyor or Hydras 3 LT and navigate to the calibration screen. Choose a 2 or 3 point calibration. For detailed instructions on how to connect to a Hydrolab® using a Surveyor or Hydras 3 LT and getting to the calibration section of the software consult the corresponding user’s manual.

9.3 With the calibration cup installed rinse the sensors 3 times with deionized water. To do this partially fill the calibration cup with deionized water, cap and shake vigorously for 6 seconds. Empty and repeat.

9.4 After the deionized water rinse, triple rinse the sensors with each pH buffer prior to the individual calibration.

9.5 Triple rinse the sensors with the pH 7 buffer and then place the Hydrolab® in the calibration stand. Fill the calibration cup with the pH 7 buffer so that it covers the pH sensor by at least one centimeter.
9.6 Record the temperature from the calibration screen and corresponding pH buffer value from the standards bottle. Enter the temperature corrected value for the pH 7 buffer in the calibration window. Let the sensors sit until a stable reading is achieved, usually within 3-5 minutes.

9.7 After a stable reading has been achieved calibrate the pH sensor and record the post- calibration reading. If the calibration fails repeat calibration with a fresh bottle of pH buffer. If repeating the calibration with a fresh bottle of pH buffer does not work, then the pH sensor needs maintenance.

9.8 For a 2 point or 3 point calibration, repeat calibration with the selected pH buffer (4 or 10).

10.0 Depth Calibration (If needed)

10.1 It is recommended that for the most accurate depth data that the calibration be done in the field.

10.2 If not already connected, connect the Hydrolab® to a Surveyor or Hydras 3 LT and navigate to the calibration screen. Choose depth. For detailed instructions on how to connect to a Hydrolab® using a Surveyor or Hydras 3 LT and getting to the calibration section of the software consult the corresponding user’s manual.

10.3 Remove the calibration cup and install the weighted sensor guard. Turn the Hydrolab® so that the sensors are pointing down.

10.4 Navigate to the depth calibration screen and record the pre-calibration reading.

10.5 Enter 0 for the calibration standard and calibrate the pressure sensor. Record the post calibration reading. If the calibration fails, the pressure sensor needs maintenance.
11.0 General Field Use

11.1 Using a Hydrolab® for discrete measurements or profiling requires a field tablet with the operating software for the selected Hydrolab® or the handheld Surveyor or Surveyor HL (HL4). The user will also need the appropriate length of cable to connect the Hydrolab® to the field tablet or handheld. If the Hydrolab® is to be lowered in any way, a bail kit or mooring cap (HL4) is required for instrument safety. Detailed information on using Hydrolabs® for discrete measurements or profiling is covered in the training and SOP SWM_RM_003. Basic information is also covered in the user’s manual.

11.2 Using a Hydrolab® for unattended deployments is complex and highly variable and will be covered in training. Basic information is covered in the user’s manual. Note: If a Hydrolab® being used for an unattended deployment is equipped with a Clark Cell for measuring DO, it is best to place it in an area around 1 cubic foot per second of water flow.

11.3 After using any Hydrolab® make sure to clean it following the procedures in 6.1.2 and note and communicate any deficiencies to the custodian.

11.4 Short-term Storage (1 day to 3 months)

11.5 If not already completed, clean the Hydrolab® following procedures in 6.1.2. Keep a minimal amount of tap water or pH 4 buffer (about ½ inch) in the calibration cup. A clear pH 4 buffer without red dye is recommended for Hydrolabs® equipped with a rhodamine sensor. Do not use any other type of water unless it’s the only water available.

11.6 Long-term storage (over 3 months)

11.7 Follow section 6.3 procedures. In addition, remove external batteries, but do not remove the lithium battery which powers the Hydrolabs® internal time clock. Equipment Protection (Theft)
11.8 Hydrolabs® deployed in small creeks and clear rivers are easily seen. To avoid problems with theft and vandalism, hide them carefully. If possible, deploy Hydrolabs® upstream or downstream of public access areas, private property, or places where boaters and swimmers can see them. Under overhanging vegetation or behind instream rocks and fallen trees are often good places to hide them, as long as water circulation is not limited.

11.9 Do not use large floats or anchors in smaller streams; they attract attention. Instead, note where the Hydrolab® is and cover it as much as possible while maintaining good water flow past the sensors. Small cement blocks work well as anchors. If the Hydrolab® is deployed in a large river, floats, line, and larger anchors may be necessary. See an experienced Hydrolab® user for further details.

11.10 If you cannot find a Hydrolab® and suspect theft is the cause, notify your project manager and/or supervisor. It may be necessary to contact purchasing or risk management to obtain a replacement.

11.13 Equipment and/or calibration problems will be discussed with team members and documented in an electronic log.

11.14 Calibration forms and any field forms will be stored electronically or in hardcopy form by the project manager in a designated location.

11.15 If the Hydrolab®(s) are used for a deployment, the log files created will be downloaded from the Hydrolab® and stored in electronic format in a location designated by the project manager.
12.0 **Records Management**

12.1 Calibration records and field observations and measurements are either stored on the Surveyor, on hard copy field forms or more routinely in project specific electronic field forms.

12.2 Calibration records are kept in instrument-specific binders in the lab space.

12.3 Field observations and measurement data are transferred to the network for verification and WISKI database import. Detailed instruction for database import is found in guidance outside this SOP.

12.4 Guidance for archival of records can be found at https://team/depts/spw/AO/Records/default.aspx

13.0 **Quality Control and Quality Assurance**

13.1 Hydrolabs® should be calibrated before each use and then checked against standards after each use. Post checking against standards should be completed following the procedures in the calibrations section. The difference being that the Hydrolab® should only be used to measure the standards not calibrate to them. All calibration and post use data should be recorded in a field form (paper or electronic) and stored in a location designated by the project manager.

13.2 In addition to calibration prior to use and post checks after use, intermediate checks can be conducted. These checks will differ if the Hydrolab® is being used for discrete measurements or has been deployed.

13.3 Intermediate checks for a deployed Hydrolab® should include:

13.4 Checks with another Hydrolab® or equivalent hand-held meter over the expected range of the parameter being measured. At a minimum, one intermediate check should be completed for a short deployment (one week or less).
The number of intermediate check measurements will be dictated by the length of deployment and the requirements described in the associated Quality Assurance Project Plan.

Upon retrieval of the deployed Hydrolab®, field staff should check measurement with another Hydrolab® or equivalent hand-held meter.

This field check regime will provide a minimum of three checks per deployment and help identify if instrument drift occurs.

Additional quality checks for discrete or deployed use will be dealt with on a project by project basis in the Quality Assurance Project Plan.

Specific measurement quality objectives should also be developed in the QAPP. At a minimum the following objectives are recommended for post and intermediate checks:

<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>$&lt; \text{ or } = +0.25$</td>
<td>$&gt; +0.25$ and $&lt; \text{ or } = +0.5$</td>
<td>$&gt; +0.5$</td>
</tr>
<tr>
<td>Conductivity</td>
<td>$\mu S/cm$</td>
<td>$&lt; \text{ or } = +5%$</td>
<td>$&gt; +5%$ and $&lt; \text{ or } = +15%$</td>
<td>$&gt; +15%$</td>
</tr>
<tr>
<td>Temperature</td>
<td>°C</td>
<td>$&lt; \text{ or } = \pm 0.2$</td>
<td>$&gt; \pm 0.2$ and $&lt; \text{ or } = \pm 1.0$</td>
<td>$&gt; \pm 1.0$</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>mg/L</td>
<td>$&lt; \text{ or } = \pm 0.3$</td>
<td>$&gt; \pm 0.3$ and $&lt; \text{ or } = \pm 1.0$</td>
<td>$&gt; \pm 1.0$</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>% saturation</td>
<td>$&lt; \text{ or } = +5%$</td>
<td>$&gt; +5%$ and $&lt; \text{ or } = +10%$</td>
<td>$&gt; +10%$</td>
</tr>
</tbody>
</table>

When traveling from site to site, make sure the Hydrolab® sensors are kept moist so they don’t dry out and become inaccurate. It is recommended to only use tap water in the calibration cup to keep the sensors moist. If site water is all that is available, make sure to change it out with tap water as soon as possible.

If collecting data in an area of known concern for New Zealand mudsnails, inspect and clean the equipment between stations. Remove any visible soil, vegetation, vertebrates, invertebrates, aquatic plants or algae. If necessary, use a brush to clean the equipment housing. Follow other applicable invasive decontamination procedures.

Although Hydrolab® equipment is robust and made for heavy field use, it should be handled with care at all times. This is especially true when removing and replacing the calibration cup and sensor guard.
14.0 Safety

14.1 Persons involved with collection of field measurements 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.

14.2 Staff are provided appropriate PPE to minimize hazards. Teams of two should be considered especially for sites where data are gathered on larger streams/rivers during moderate to high flow events.

14.3 Washington State Department of Labor and Industries requires that employers provide a safe work environment through communicating hazards and providing adequate training.

14.4 Required safety training, inclusive of General Field Safety, Chemical Hygiene, Hazwoper, Roadway Safety, and Swiftwater awareness have been identified by position.

15.0 References

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 mudsnail (*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 mudsnails (see https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=1008 and/or 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 Mudsnails

New Zealand mudsnails 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 mudsnails, 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: https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=1008
- 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>
<thead>
<tr>
<th>Treatment</th>
<th>Concentration or temperature</th>
<th>Exposure Time</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>hot water wash or soak</td>
<td>60° C (140° F)</td>
<td>5 min for felt-soled boots and nets; 10 sec for all other equipment</td>
<td>Ensure all parts of the equipment reach temperature for the full exposure time</td>
</tr>
<tr>
<td>hot water wash or soak</td>
<td>49° C (120° F)</td>
<td>10 min for felt-sole boots and nets; 5 min for other equipment</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 minimum</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>Formula 409 All-Purpose Cleaner¹</td>
<td>100% (full strength)</td>
<td>10 min</td>
<td>Follow proper procedures for storage and handling.</td>
</tr>
<tr>
<td>sparquat 256²</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 peroxide³</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 handling⁴</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. Individual Field Sample Data Qualifiers
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<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>Result is non-detect</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>Method Specific Hold Time Not Met</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>Method Specific Hold Temperature Not Met Upon Receipt From Laboratory</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>Method Specific Hold Temperature Is Unknown At Time of Receipt From Laboratory</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>$\text{RPD} = \frac{(X_1 - X_2)}{((X_1 + X_2)/2)} \times 100%$</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</td>
<td>J</td>
<td>Matrix Spike and/or matrix spike duplicate recoveries are outside acceptance limits;</td>
</tr>
<tr>
<td>Outside of Acceptance Limits</td>
<td></td>
<td>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;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>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</td>
<td>U</td>
<td>Standard reference material recovery above acceptance limits; sample result is non-</td>
</tr>
<tr>
<td>Limits, Sample Result is Non-Detect</td>
<td></td>
<td>detect and data is not impacted</td>
</tr>
<tr>
<td>Standard Reference Material Recoveries Are Outside Acceptance</td>
<td>REJ</td>
<td>Standard reference material recoveries are outside acceptance limits; sample is</td>
</tr>
<tr>
<td>Limits</td>
<td></td>
<td>unusable</td>
</tr>
</tbody>
</table>

$X_1 =$ sample result  
$X_2 =$ duplicate result
<table>
<thead>
<tr>
<th>Quality Control Condition</th>
<th>Data Qualifier</th>
<th>Data Qualifier Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Laboratory Method Blank Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Target Analyte Was Detected In Associated Method Blank</strong></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><strong>Surrogate Recoveries Were Outside Acceptance Limits</strong></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 Associated Field Blank</td>
<td>J</td>
<td>Target analyte was detected in the field blank; sample result is an estimate</td>
</tr>
<tr>
<td>Target Analyte Was Detected In Associated Trip Blank</td>
<td>J</td>
<td>Target analyte was detected in the trip blank; sample result is an estimate</td>
</tr>
<tr>
<td><strong>Field Sample Duplicate Actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fecal coliform or E.coli field duplicate Means are &lt; 20 Colonies and RSD is &gt; 50%</td>
<td>J</td>
<td>Field Duplicate RSD &gt; ± 50% and &lt; ± 75%; sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>RSD= (StDev/mean) *100%</td>
<td></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 an estimate</td>
</tr>
<tr>
<td></td>
<td>REJ</td>
<td>Field Duplicate RSD &gt;± 75%; sample result is rejected</td>
</tr>
<tr>
<td>Fecal coliform or E.coli field duplicate Means are &gt; 20 Colonies and RSD is &gt; 50%</td>
<td>J</td>
<td>Field Duplicate RSD &gt; ± 20% and &lt; ± 50%; sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>RSD= (StDev/mean) *100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UJ</td>
<td>Sample result is non-detect. Field Duplicate RSD &gt; ± 20% and &lt; ± 50%; sample result is an estimate</td>
</tr>
<tr>
<td></td>
<td>REJ</td>
<td>Field Duplicate RSD &gt;± 50%; sample result is rejected</td>
</tr>
</tbody>
</table>