

LUMMI NATION WATER QUALITY MONITORING PROGRAM
QUALITY ASSURANCE/QUALITY CONTROL PLAN
Version 3.0

Water Resources Division
Natural Resources Department
Lummi Indian Business Council

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Lummi Nation Water Quality Monitoring QA/QC Plan Approval

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1. DISTRIBUTION LIST (A3)

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Recipients identified on this distribution list will be sent updated versions of this document or copies of minor change letters for this document immediately after they are approved. Recipients listed may also obtain the most current copy of the approved Quality Assurance Project Plan (QAPP) by contacting the Water Resources Manager or the Water Resources Specialist.

2. DOCUMENT ORGANIZATION

This document is organized following EPA Requirements for Quality Assurance Project Plans (EPA 2001) with the companion guidance document Guidance for Quality Assurance Project Plans (EPA 2002). Where a letter and number follow a section title (e.g., A3), they indicate the corresponding section in the EPA Requirements for Quality Assurance Project Plans (EPA 2001). “A1” (Title and Approval Sheet) and “A2” (Table of Contents) are not labeled.

3. PROJECT/TASK ORGANIZATION (A4)

The Lummi Nation Water Quality Monitoring Program is implemented and administered through the Water Resources Division (WRD) of the Lummi Natural Resources Department (LNR). The WRD is within the Environmental Program of the LNR. The WRD Manager is a direct report to the Environmental Program Director, who in turn is a direct report to the Executive Director of the LNR (Figure 1 presents an organizational chart for the LNR). The Natural Resources Commission provides policy direction to the Executive Director. The LNR is an administrative division of the Lummi Indian Business Council (LIBC), which is the elected governing body of the Lummi Nation. Neither the Natural Resources Commission nor LIBC are shown in Figure 1.

The Lummi Nation Water Quality Monitoring Program is implemented by a number of key staff members and contractors. Table 1 identifies these key personnel, provides contact information, identifies their roles and responsibilities with respect to the Lummi Nation Water Quality Monitoring Program, and identifies their relative positions within the organization. The three independent contractors identified in Table 1 perform tasks at the request of the Environmental Program Director.

The Quality Assurance Manager (QA Manager) is the Project Manager (Water Resources Manager). The Project Manager is not directly involved in data collection and management, but does supervise the Water Resources Specialist (Specialist) and evaluates and analyzes the data on an as-needed basis. Typically, the Specialist performs data evaluations and analysis. The organization is too small to provide for a completely independent QA Manager. The Specialist or contractors are responsible for performing regular Quality Assurance audits (audits) that the Project Manager evaluates for compliance with project goals. The Project Manager makes recommendations to the Environmental Program Director and/or the Executive Director who make decisions based upon data collected under the Lummi Water Quality Monitoring Program.

The Specialist is responsible for the Lummi Nation Water Quality Monitoring Program implementation and for maintaining the official, approved Quality Assurance Project Plan. Although the Specialist performs and/or assists in the water quality data collection, the Water Resources Technician (Technician) is the primary staff person assigned to perform the water quality monitoring and supporting activities including equipment maintenance and ensuring necessary supplies are fresh and available. The Technician is also a direct report to the

Specialist.

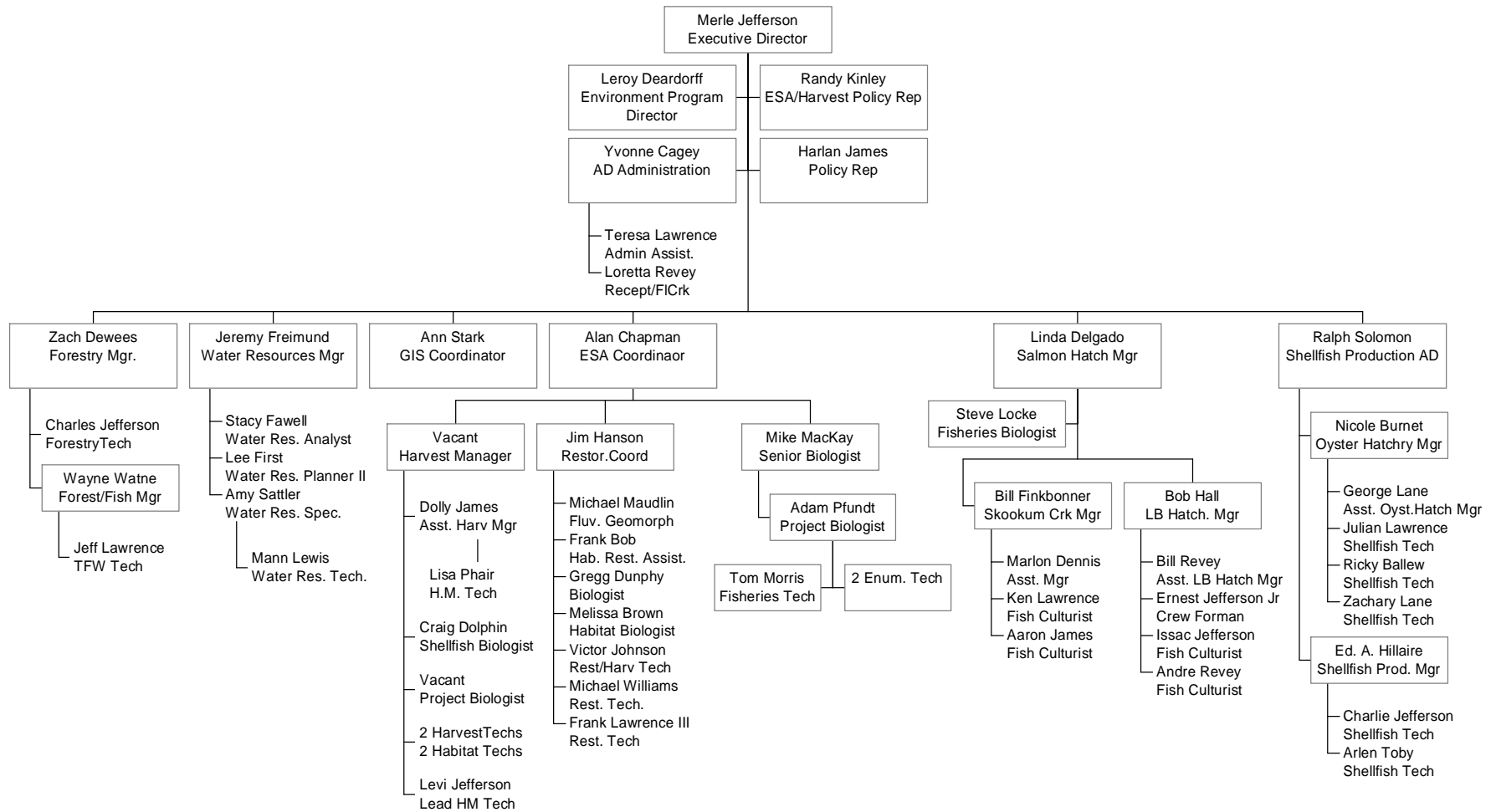


Figure 1. Lummi Natural Resources Department Organization Chart (September 2005).

Table 1. Key Personnel – Lummi Nation Water Quality Monitoring Program.

Name and Title	Organization	Telephone Numbers	Roles/Responsibilities	Reports To
Merle Jefferson, Executive Director, Natural Resources Department	LIBC Natural Resources Department	360-384-2225	Ensures that the Environmental Program Director has the resources necessary to fulfill the project oversight responsibilities associated with this project. Decision-maker.	Natural Resources Commission and the Lummi Indian Business Council
Leroy Deardorff, Environmental Program Director	LIBC Natural Resources Department	360-384-2272	Ensures that the Water Resources Manager has the resources necessary to fulfill the project management responsibilities associated with this project. Decision-maker.	Merle Jefferson, Executive Director, LIBC Natural Resources Department
Jeremy Freimund, P.H. Water Resources Manager	Water Resources Division of LIBC Natural Resources Department	360-384-2212	LIBC Project Manager – administers contracts, supervises Water Resources Specialist, and ensures quality assurance/quality control objectives and reporting requirements are achieved (QA Manager). Performs data analysis and evaluation as needed. Does not directly collect or manage data.	Leroy Deardorff, Environmental Program Director
Amy Sattler, Water Resources Specialist	Water Resources Division of LIBC Natural Resources Department	360-384-2233 extension 2712	Coordinates and supports work of the Water Resources Technician (including data collection when needed), maintains the official, approved QA Project Plan, ensures QA/QC protocols are followed or corrective action is taken, receives and reviews laboratory results, and manages surface and ground water database. Quality Assurance Officer.	Jeremy Freimund, Water Resources Manager
Mann Lewis, Water Resources Technician	Water Resources Division of LIBC Natural Resources Department	360-384-2358	Performs sample collection and analysis, transfers samples to the laboratory, maintains field data sheet, implements QA/QC protocols, calibrates and maintains equipment, ensures equipment is functional, ensures consumables are fresh and available, and performs data entry.	Amy Sattler, Water Resources Specialist

Table 1. Key Personnel – Lummi Nation Water Quality Monitoring Program.

Name and Title	Organization	Telephone Numbers	Roles/Responsibilities	Reports To
Andy Ross, LG, LHG, Water Resources Management and Planning contractor	Salix Environmental Services	--	Participates in the training of new members of the water quality monitoring program, participates in the evaluation of the quality of the collected data, provides database management support services.	Leroy Deardorff, Environmental Program Director
Anne Atkeson, Water Resources Management and Planning contractor	Anne E. Atkeson	--	Performs data entry, database management support, and QA/QC checks on data entry.	Leroy Deardorff, Environmental Program Director
Carol Bissell, Microbiologist Laboratory Supervisor	AVOCET Environmental Testing, Inc.	360-734-9033	Ensures that staff are available to receive water samples from Water Resources Technician or Water Resources Specialist, analyzes samples for bacteria, nutrients, metals, and hydrocarbons pursuant to the Washington State approved laboratory QA/QC plan, maintains laboratory certification in Washington State.	Leroy Deardorff, Environmental Program Director

4. PROBLEM DEFINITION/BACKGROUND (A5)

The mission of the Lummi Natural Resources Department is to enhance, manage, and protect natural resources into perpetuity for the benefit of the Lummi people in accordance with the policy and procedures of the Lummi Nation. The Lummi Water Resources Division of the Natural Resources Department is responsible for protecting, restoring, and managing Lummi Nation water resources, including the Lummi Indian Reservation (Reservation) shorelines, in accordance with the policies, priorities, and guidelines of the LIBC.

Pursuant to LIBC resolutions 90-88 and 92-43, the Water Resources Division of the Lummi Natural Resources Department is developing a Comprehensive Water Resources Management Program (CWRMP). Resolutions 90-88 and 92-43 directed that a comprehensive water resources management program be developed to ensure that the planning and development of Reservation water and land resources are safeguarded against surface and ground water degradation. The Nonpoint Source Management Program is an element of the CWRMP along with a wellhead protection program, a storm water management program, a stream and wetland management program, and a water quality standards program. An important milestone in the program development effort was achieved in January 2004 with the adoption of the Lummi Nation Water Resources Protection Code (Title 17 of the Lummi Code of Laws). The Lummi Nation Water Quality Monitoring Program is an important element of the CWRMP, and is comprised of a surface water quality monitoring component and a ground water quality monitoring component.

As described in the Lummi Nation Nonpoint Source Management Plan (LWRD 2002) and other documents developed as part of the Lummi Nation CWRMP (LWRD 1997, LWRD 1998, LWRD 2000, LWRD 2001), there are numerous threats to Lummi Nation Water¹.

The purpose of the surface water quality monitoring component is to establish the baseline conditions of waters on and flowing onto the Reservation, and to detect water quality problems. Information from the surface water quality monitoring program is used to evaluate compliance of waters flowing onto and within the Reservation with water quality criteria, evaluate fecal coliform contributions from on- and off-Reservation to shellfish harvest areas, and support the development and implementation of a water quality regulatory program on the Reservation, including the creation, adoption, and implementation of Water Quality Standards. The purpose of the ground water quality monitoring component is to protect ground water supplies from saltwater intrusion and ground water mining.

¹ Pursuant to 17.09.010 of the Lummi Code of Laws, Lummi Nation Water is all fresh and marine waters that originate or flow in, into, or through the Reservation, or that are stored on the Reservation, whether found on the surface of the earth or underground, and all Lummi Nation tribal reserved water rights.

Threats to Lummi Nation Water include contamination of surface waters from on- and off-Reservation sources that could damage resource rich Reservation tidelands, and/or adversely impact fisheries (e.g., closure of shellfish beds harvested for cultural, subsistence, and/or commercial purposes). On-Reservation commercial shellfish beds have been downgraded from “approved” to “restricted” in various amounts since 1996. The cause of the downgrades was attributed to contaminated Nooksack River water entering Portage Bay (DOH 1997). The presence of Nooksack River water in Portage Bay is common and evidenced through lowered salinities, salinity-based stratification, and/or color. In general, elevated fecal coliform bacteria levels in Portage Bay are associated with lower surface salinities.

Ground water resources on the Reservation are vulnerable to salt water intrusion. The majority of residential development has occurred along the marine shoreline placing the most vulnerable portion of aquifers at risk through direct pumping of ground water near marine shorelines. Currently ground water supplies over 95 percent of the potable water used on the Reservation.

The Lummi Indian Reservation (Reservation) is located along the western boundary of Whatcom County and includes the mouth of the Nooksack and Lummi rivers (Figure 3). The Lummi River is a former tributary of the Nooksack River that empties into Lummi Bay and only receives water from the Nooksack River when the Nooksack River flows are in excess of approximately 9,600 cubic feet per second (cfs). The Lummi River currently drains much of the area west of the Nooksack River in the vicinity of Ferndale, Washington. The Nooksack River drains most of western Whatcom County, including the developed lowlands. Both the Nooksack and Lummi river watersheds are under environmental pressures from rapid regional growth. The Lummi Nation has also entered a period of rapid economic development under self-governance. Growth on and near the Reservation requires that the Nation’s core environmental program prioritize the development of a regulatory infrastructure that allows for responsible growth while protecting tribal resources and the Reservation environment. The Lummi Reservation has approximately 38 miles of marine shoreline and approximately 10 miles of freshwater/estuarine shoreline along the Lummi and Nooksack rivers and deltas.

Due to the estuarine environment, nearly all of the watercourses in the Lummi River and Nooksack River floodplains are exposed to marine influences, which include the presence of saline water, salinity-based-stratification (stratification), and upstream flow during high tide. Most of the sample sites are tidally influenced (water level and/or salinity) and have variable water column profiles (e.g., stratified or well-mixed) and salinities. For most sample sites, the salinity and presence or absence of stratification cannot be predicted. In the Lummi Bay Watershed, salinity levels at surface water sample sites generally decrease as the wet season progresses and generally increase as the wet season ends and the dry season progresses.

Two (apparently separate) potable ground-water systems occur on the Reservation. One system is located in the northern upland area. This northern system appears to flow onto the Reservation from the north and drains to the west, south, and east. The second potable ground-water system is located in the southern upland area of the Reservation (Lummi Peninsula) and is

completely contained within the Reservation boundaries (LWRD 1997). The floodplain of the Lummi and Nooksack rivers, which contains a surface aquifer that is saline (Cline 1974), separates the two potable water systems. A third potable water system may exist on Portage Island, but information on the water quality and the potential yield of this system is limited and inconclusive.

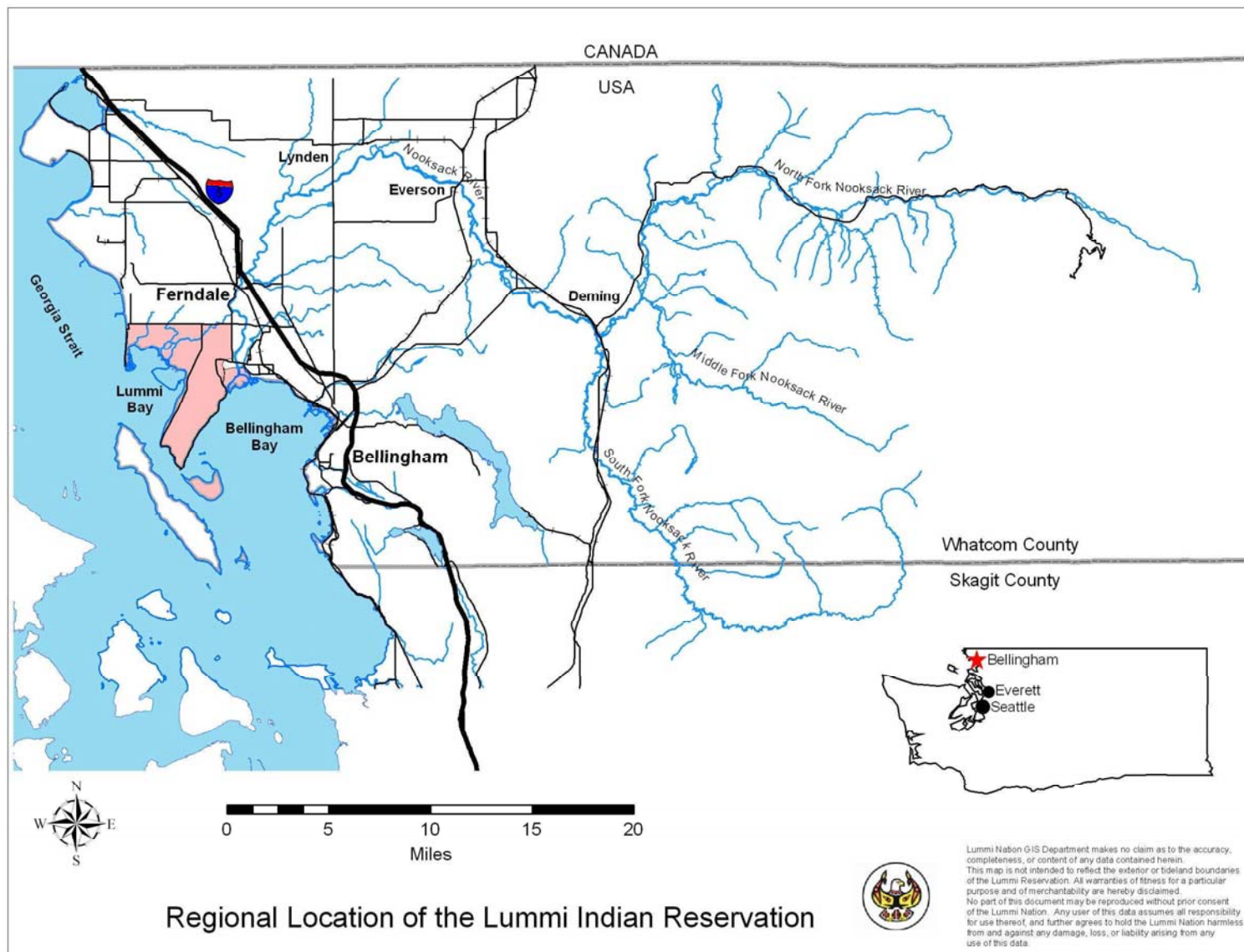


Figure 2. Regional Location of the Lummi Indian Reservation.

5. PROJECT DESCRIPTION (A6)

The purpose of the Lummi Nation Water Quality Monitoring Program is to monitor the quality of Lummi Nation water to establish baseline conditions and provide information to assist in managing surface water quality flowing onto and across the Reservation and to protect Reservation aquifers from saltwater intrusion.

Water quality is measured monthly or more frequently at forty-three surface water sites, as needed at four Washington Department of Health (DOH) sites (Figure 3 and Tables 2 and 3), and monthly or more frequently at twenty-eight ground water sites (Figure 4 and Table 4). The Lummi Nation Water Quality Monitoring Program is ongoing and is considered to be the core program that is complemented by other, shorter term or more intensive monitoring projects.

Historically, the number of sample sites in the program and other job duties has limited the ability of the Specialist and Technician to sample all of the sample sites each month. In addition, poor weather conditions can make sampling unsafe, especially for the samples that need to be collected by boat. The Water Quality Monitoring Program is currently being evaluated to determine the number and locations of sample sites to continue sampling and the parameters that will be measured. It is anticipated that the number of sample sites will be reduced. The evaluation process is scheduled for calendar year 2006 and will follow a systematic and documented planning process (Section 14 [B10]²).

Annual reports that summarize surface water quality conditions for that year and compare that year to previous years are provided to the EPA. These reports are to be delivered within 90 days of the end of the grant period and contain a hardcopy of the EPA funded data. Surface water quality data collection funded by EPA is scheduled for delivery to EPA in a STORET v.2 format by December 31, 2006 (Section 14 [B10] provides the primary explanation³).

5.1 Surface Water Quality

Forty-three sample sites (Figure 3) were chosen to characterize surface water quality on the Reservation. Six additional Washington Department of Health (DOH) sample sites (Figure 3) are sampled to provide logistical assistance to the DOH and also assist with achievement of program goals. Thirty-two of the Lummi sampling sites are accessible from land and various parameters are measured monthly by the Lummi Water Resources Division staff (Tables 2 and 3). During the late summer to early-winter period, "First Flush" sampling is conducted at many of these sample sites at variable intervals (daily to weekly) based upon precipitation and runoff levels

² A few other sections contain descriptions of, and/or references to the surface water quality program evaluation and revision. The other sections are 9 [B1], and 10 [B2, B3, B4]).

³ Many other sections contain descriptions of, and/or references to, the revised database. The other sections include this section and sections 6 [A7], 8 [A9], 9 [B1], 11 [B5, B6, B7], 15 [C1], and 18 [D2].

during the onset of the wet season. The remaining eleven Lummi sample sites are on Portage Island, in southern Portage Bay, in the Sandy Point Marina, and in Lummi Bay, and are all boat-accessible sites. These sample sites are targeted for monthly sampling, but unsafe weather conditions usually reduces the sample frequency. The Washington Department of Health (DOH) Sites are sampled as needed when DOH is unable to sample northern Lummi Bay.

Table 2 shows the surface water quality monitoring sampling schedule including conventional parameters measured. Table 3 shows the specific nutrients, metals, and hydrocarbons analyzed at an independent state or federally certified laboratory. Due to the costs of analyzing water quality samples for metals and petroleum hydrocarbons, these parameters are measured quarterly at two of the water quality monitoring sites (one fresh water site downstream from a petroleum oil refinery and one marine water site within a recreational boat marina). Similarly, due to cost considerations, nutrients are measured quarterly at only five of the surface water quality monitoring sites.

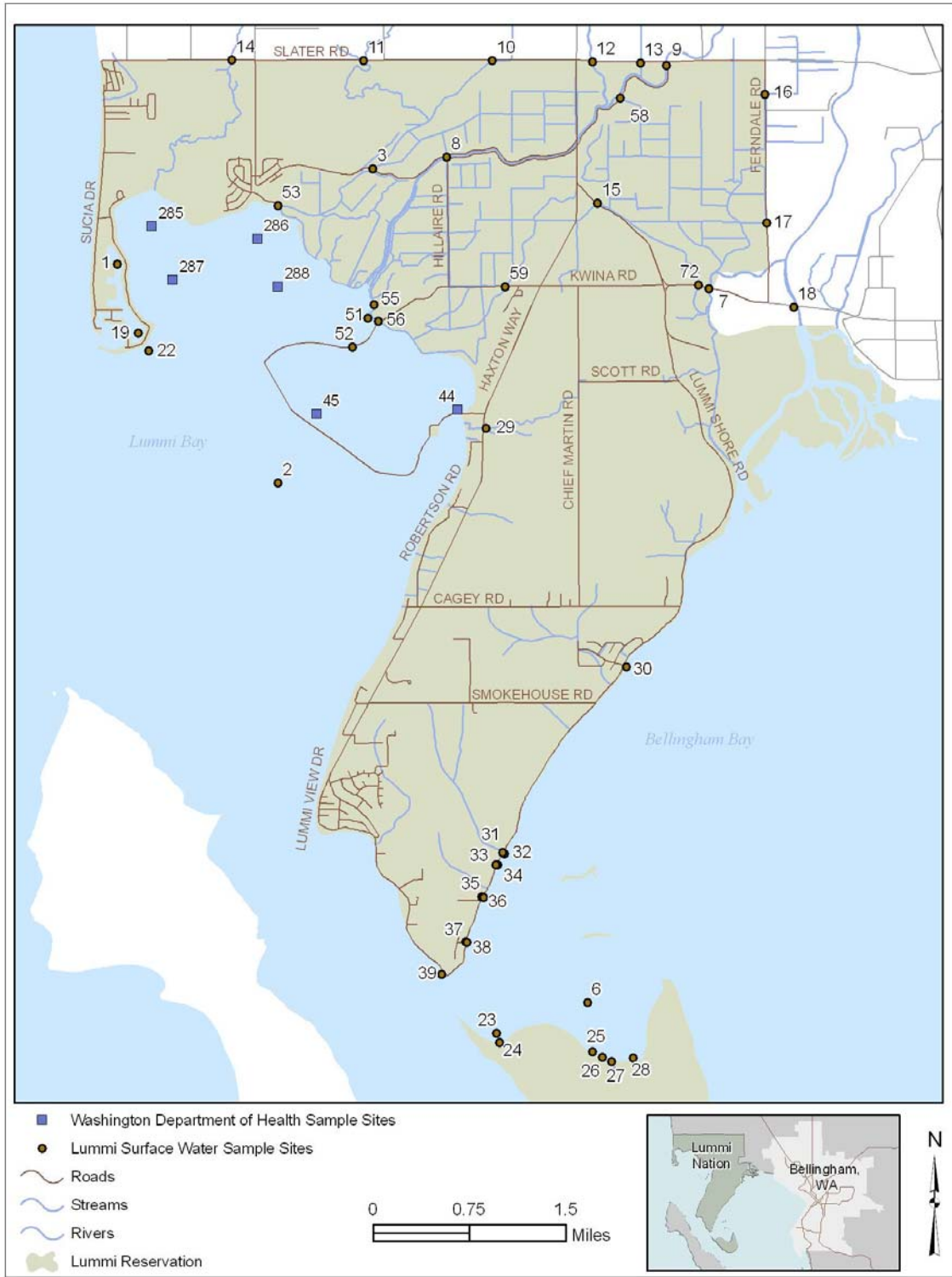


Figure 3. Surface water quality monitoring program sample site locations.

Table 2. Surface water quality monitoring site groups, conventional parameters, laboratory sample collection, and frequency.

Run Name	Sample Sites(s) Included	Conventional Parameters Measured At Each Sample Site	Laboratory Samples Collected At Each Sample Site	Measurement Frequency	Notes
Floodplain East (FPE)	15, 16, 17, 51, 52, 55, 56, 59, 72	Air temperature, salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), flow, pH, water level/depth, turbidity, and general observations.	Fecal Coliform, <i>E. coli</i> , and enterococcus	Monthly	Site 51 is measured in both the FPE and FPW runs.
Floodplain West (FPW)	3, 8, 9, 10, 11, 12, 13, 14, 51, 53, 58	Air temperature, salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), flow, pH, water level/depth, turbidity, and general observations.	Fecal Coliform, <i>E. coli</i> , and enterococcus	Monthly, First Flush	Site 51 is measured in both the FPE and FPW runs.
Lummi Bay Watershed First Flush	11, 10, 12, 13, 9, 58, 8, 3, 53, 51, 18 Time permitting: 14, 59, 15, 16, and 17	Salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), flow, pH, water level/depth, turbidity, and general observations.	Fecal Coliform, <i>E. coli</i> , and enterococcus	As needed based upon predicted and observed runoff during the onset of the rainy season.	Site 18 is part of Bellingham Bay. It is measured with the "Lummi Bay Watershed First Flush" because it has easy site access, which provides useful information on Bellingham Bay if collected on the first day of the first flush sampling. pH and turbidity are often not measured due to time constraints (i.e., the measurement can be time consuming, and

Table 2. Surface water quality monitoring site groups, conventional parameters, laboratory sample collection, and frequency.

Run Name	Sample Sites(s) Included	Conventional Parameters Measured At Each Sample Site	Laboratory Samples Collected At Each Sample Site	Measurement Frequency	Notes
					the First Flush sample run is often constrained for time due number of sites sampled during run and need for timely delivery of bacteria samples [within six hours from time of collection]).
Bellingham Bay Watershed First Flush	7, 18, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39	Salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), flow, pH, water level/depth, turbidity, and general observations.	Fecal Coliform, <i>E. coli</i> , and enterococcus	The day following the Lummi Bay First Flush sample run.	<p>Sites along Lummi Shore sampled from north to south or from south to north.</p> <p>Flow is only measured at upland sites along the Portage and Bellingham Bay shorelines.</p> <p>pH and turbidity are often not measured due to time constraints (i.e., the measurement can be time consuming, and the First Flush sample run is often constrained for time due number of sites sampled during run and need for timely delivery of bacteria samples [within six hours from time of collection]).</p> <p>Site 29 samples a relatively undeveloped Lummi Peninsula upland watershed and is used as a control site representing a watershed that is minimally affected by development.</p>
Marine Boat-Accessible (Marine)	1, 2, 6, 19, 22, 23, 24, 25, 26, 27, 28	Salinity-based stratification, water temperature, salinity, specific	Fecal Coliform, <i>E. coli</i> , and enterococcus	Monthly, as needed	Measure flow at the Portage Island sites (Sites numbered 24 through 28).

Table 2. Surface water quality monitoring site groups, conventional parameters, laboratory sample collection, and frequency.

Run Name	Sample Sites(s) Included	Conventional Parameters Measured At Each Sample Site	Laboratory Samples Collected At Each Sample Site	Measurement Frequency	Notes
		conductivity, current/flow direction, dissolved oxygen (DO), flow, pH, Secchi depth, water level/depth, turbidity, and general observations.			
Lummi Shore Road (LSR)	18, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39 Time permitting: 7, 29	Salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, flow, and general observations. Time permitting: Air temperature, dissolved oxygen (DO), pH, water level/depth, turbidity	Fecal Coliform, <i>E. coli</i> , and enterococcus	Monthly in coordination with the DOH sampling of Portage Bay.	Sometimes Site 18 is sampled at beginning and end of run if Portage Bay sampling occurs late in morning or afternoon. Sites along Lummi Shore sampled from north to south or from south to north. Flow is only measured at upland sites along the Portage and Bellingham Bay shorelines. The LSR sample run is often constrained for time due to the need to sample before or, at latest, during DOH sampling of Portage Bay. Site 29 samples a relatively undeveloped Lummi Peninsula upland watershed and is used as a reference site representing water minimally affected by development.

Table 2. Surface water quality monitoring site groups, conventional parameters, laboratory sample collection, and frequency.

Run Name	Sample Sites(s) Included	Conventional Parameters Measured At Each Sample Site	Laboratory Samples Collected At Each Sample Site	Measurement Frequency	Notes
Portage Bay DOH Support	18	Air temperature, salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), pH, water level/depth, turbidity, and general observations.	Fecal Coliform, <i>E. coli</i> , and enterococcus	Three times in one day the day before LSR sample run and DOH sampling of Portage Bay.	Samples are collected early in the day, mid-day, and afternoon. Due to time constraints the following may only be measured one of the three sample collection times: Air temperature, dissolved oxygen (DO), pH, water level/depth, turbidity
Lummi Bay Department of Health Boat-Accessible (Lummi Bay DOH Support)	DOH 285, DOH 286, DOH 287, DOH 288, DOH 44, DOH 45	Salinity-based stratification, water temperature, salinity, specific conductivity, current/flow direction, dissolved oxygen (DO), flow, pH, Secchi depth, water level/depth, turbidity, and general observations.	Fecal Coliform	As needed	Washington Department of Health (DOH) provides sample bottles and bacteria enumeration. Logistical difficulties can prevent DOH staff from sampling Lummi Bay (tidal window for access to marine sample sites in Portage and Lummi bays is narrow, particularly in the summer). In these circumstances, LNR staff collect bacteria samples and measure other water quality.

Table 3. Petroleum hydrocarbons, metals, and nutrients measured quarterly at selected sites.

Sample Site Number(s)	Group Name	Parameters	Frequency of Collection	Notes
1	Hydrocarbons	Diesel and Lube Oil range hydrocarbons.	Quarterly	Sample collected in 1 1-L amber bottle
	Metals	Arsenic, Copper, Mercury, Tin, Zinc, Hardness, and pH with the temperature of the water sample at the time of measurement.	Quarterly	Sample collected in 1 1-L amber bottle & 1 1-L plastic bottle
2, 3, 6, 9, 15	Nutrients	Alkalinity, Ammonia, Biochemical Oxygen Demand, Nitrate, Nitrite, Total Kjeldahl Nitrogen, Ortho Phosphate, Total Phosphorus, pH [with temperature at time of reading], Total Organic Carbon, Total Suspended Solids, Total Volatile Suspended Solids, and may include Iron, Sulfate, Chlorophyll <i>a</i> , Sulfide, Silicon	Quarterly	Samples collect in 3 1-L plastic bottles and 1 400-mL amber vial with a preservative. Nitrite and Nitrate are normally combined.
14	Hydrocarbons	Diesel and Lube Oil range hydrocarbons.	Quarterly, First Flush	Sample collect in 1 1-L amber bottle
	Metals	Chromium, Copper, Lead, Zinc, Hardness and pH with the temperature of the water sample at the time of measurement.	Quarterly, First Flush	Sample collected in 1 1-L amber bottle & 1 1-L plastic bottle

Information from all sample runs is used to establish baseline conditions and to evaluate compliance with water quality criteria. Some runs serve other purposes as well. For example, to determine if sources of fecal coliform bacteria in Portage Bay are local or due to the Nooksack River, data collected by the Washington Department of Health (DOH) in and around Portage Bay are analyzed in conjunction with the data collected as part of the “Lummi Shore Road” (LSR) sample run and the “Portage Bay DOH Support” sample run. The LSR sample run is scheduled to occur within a few hours prior to the DOH sampling of Portage Bay. At the latest, the sampling occurs concurrently with DOH sampling of Portage Bay. Similar to the LSR sample run, the data collected as part of the “Bellingham Bay Watershed First Flush” aid in determining fecal coliform sources over the Portage Bay shellfish beds.

The data collected under the “Floodplain East” (FPE) and “Floodplain West” (FPW) sample runs are used to establish baseline conditions for waters flowing onto the Reservation and through to Lummi Bay (all within the Lummi Reservation). Similar to the LSR sample run, the data collected as part of the FPE, FPW, and Lummi Bay First Flush sample runs aid in determining fecal coliform sources over the Lummi Bay shellfish beds.

The collection of water quality data along the Reservation boundary allows for evaluation of compliance of waters flowing onto the Reservation with water quality criteria. Water quality can also be evaluated along the length of the Lummi River floodplain waterbodies and their tributaries. This water quality information is used to help identify pollution sources in the Lummi Bay Watershed.

Data collected under the Boat-Accessible (Marine) sample run are used to establish baseline conditions about water quality in the Sandy Point Marina, Lummi Bay, Portage Bay, and the five (5) Portage Island fresh water discharges to Portage Bay. These data can also help identify sources of pollution.

The Lummi Bay DOH Support sample run is conducted to provide information about water quality in the northern portion of Lummi Bay assists in determining fecal coliform sources.

5.2 Ground Water Quality

Twenty-eight (28) sampling sites (Figure 4) have been selected to characterize the two major potable aquifer systems on the Reservation. Sample sites were selected to represent aquifer-wide conditions as practicable, but the spatial representativeness of these sampling points is limited by the lack of existing ground water wells in some parts of the Reservation – particularly along the interior of the Lummi Peninsula and the eastern part of the northern upland.

Table 4 shows the ground water quality monitoring sampling schedule including parameters measured. Wells are generally sampled monthly and more frequently if necessary. Factors affecting the frequency of sampling include changes in pump rate, changes in water level or chloride, and the pumping schedule of nearby wells.

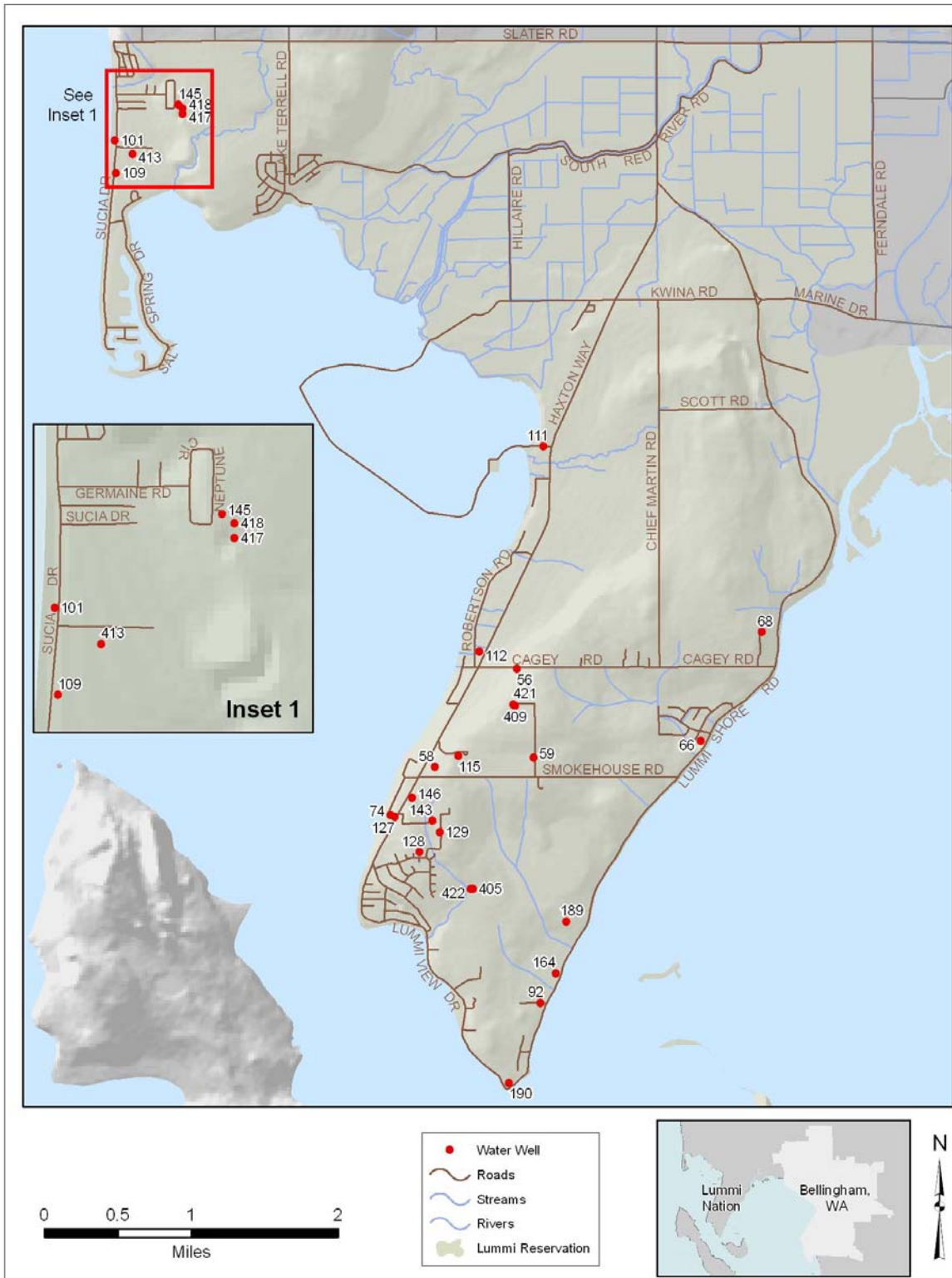


Figure 4. Ground water quality monitoring sample site locations.

Table 4. Ground water quality monitoring well types, parameters, and frequency.

Well Group	Wells Included	Well Number	Parameters Measured At Each Sample Site	Measurement Frequency
Domestic	R. Jefferson	112	Water level, chloride, temperature, specific conductivity.	Monthly
	C. Charles	74	Water level, chloride, temperature, specific conductivity.	Monthly
	Berg	143	Water level, chloride, temperature, specific conductivity.	Monthly
	Lewis/Boynton	190	Chloride, temperature, specific conductivity.	Monthly
	J. Adams	92	Chloride, temperature, specific conductivity.	Monthly
	Bewley	164	Water level.	Monthly
	M. Egawa	189	Water level, chloride, temperature, specific conductivity.	Monthly
	J. Finkbonner	109	Chloride, temperature, specific conductivity (water level infrequently)	Monthly
	T. Teeter	413	Water level, chloride, temperature, specific conductivity.	Monthly
	Skolrood (if becomes active)	101	Water level, chloride, temperature, specific conductivity.	Monthly
Potable Public Water Supply Wells	Balch	115	Water level, water use, chloride, temperature, specific conductivity.	Weekly or as needed.
	Horizon	58	Water level, water use, chloride, temperature, specific conductivity.	Weekly or as needed.
	Kinley Way (Kinley 1)	59	Water level, water use, chloride, temperature, specific conductivity.	Weekly or as needed.
	Kinley 2	409	Water level until operational. After operational, water level, water use, chloride, temperature, specific conductivity.	Monthly
	Kinley 3	421	Water level until operational. After operational, water level, water use, chloride, temperature, specific conductivity.	Monthly
	Mackenzie 2	129	Water level, water use, chloride, temperature, specific conductivity.	Weekly or as needed.
	Northwest Well 2 (NW2)	418	Water level until operational. After operational, water level, water use, chloride, temperature, specific conductivity.	Monthly
	West Shore	146	Water level, water use, chloride, temperature, specific conductivity.	Weekly or as needed.
Monitoring Wells	Hopkins	111	Water level	Monthly
	Cultee	56	Water level	Monthly
	Revey	127	Water level	Monthly
	Mackenzie 1	128	Water level	Monthly

Table 4. Ground water quality monitoring well types, parameters, and frequency.

Well Group	Wells Included	Well Number	Parameters Measured At Each Sample Site	Measurement Frequency
	Mackenzie 3	405	Water level	Monthly
	Mackenzie 4	422	Water level	Monthly
	Pierre	66	Water level	Monthly
	M.H. Cagey	68	Water level	Monthly
	Northwest Well 1 (NW1)	417	Water level	Monthly
Other Wells	Johnson	145	Water level, water use, chloride, temperature, specific conductivity, tank level, and discharge from manifold in tank. Flow rate and totalizer at all meters except M. Finkbonner (Nau) and Greg Finkbonner meters every time visit Johnson well. The latter two meters are measured monthly.	Weekly or more frequently for water quality, water level, and water use.

Water level, temperature, specific conductivity, and chloride concentration are measured at least monthly at each site, and well production is recorded from existing meters at the Lummi Water District water supply wells. Of primary importance are the chlorides, pumping rates, and water levels of the wells as these data indicate whether seawater intrusion is occurring or the potential for seawater intrusion is increasing. Based upon these data, measures can be implemented (e.g., reduce or curtail pumping) to address the potential for salt water intrusion.

The Kinley 2, Kinley 3, and NW 2 wells are in the process of being converted to public water supply wells. Once operational, the measured parameters and measurement frequency will be adjusted accordingly.

6. QUALITY OBJECTIVES AND CRITERIA (A7)

The overall performance standard for the water quality monitoring program is the collection of high-quality data sufficient to meet program goals. Data must be of sufficient quality (i.e., known precision, accuracy, bias, traceability, completeness, and representativeness) to support decisions based upon the water quality data. Standards for acceptance of equipment acclimation and stabilization, and acceptance criteria for quality control (QC) activities are listed in Sections 10 [B2, B3, B4] and 11 [B5, B6, B7] respectively. Quality control activities are designed to indicate data quality in the field and prompt corrective actions at that time. In addition, QC activities provide information necessary to assess and quantify data quality and comparability for data analysis.

As described previously, the water quality monitoring program is ongoing and is not designed to prove or disprove a specific hypothesis. The data are also used to assist in identifying and addressing actual and potential impairments of water quality, and for evaluation of water quality against regulatory criteria. Quality control activities are in place that allow for the reliability and usefulness of the data for evaluation of trends, impairment, and/or compliance with water quality criteria to be assessed.

Statistics for data quality indicators are not systematically calculated at this time. Instead they are calculated on an as-needed basis and specific to the question being asked. Calculation of these statistics will become routine with the implementation of the revised database (Section 14 [B10]) and surface water quality monitoring program. The specific formulas and approaches will be addressed during the systematic planning process used to revise the surface water quality monitoring program. Data quality indicators are briefly discussed below.

6.1 Precision

At least ten percent of all field measurements are duplicated in the field during each sample run, except for samples collected for analysis at a laboratory, well water level, and visual observations of water quality (e.g., flow direction). Duplication takes place at randomly selected locations and is recorded directly in the field log as a water quality duplicate.

Duplicate laboratory samples are not collected in the field, unless the amount of environmental variation needs to be documented or the laboratory requires duplication. Water levels in wells are not duplicated because of variability in water levels over very short time periods. However, water level measurements in wells are repeated two or three times to quantify water level variation. If a visual observation (e.g., current direction) changes during the period when water quality is being measured, it is noted in the field book.

6.2 Accuracy and Bias

In general, all field instruments are verified and/or calibrated against National Institute of Standards and Technology (NIST) traceable standards. The NIST traceable standards are used to calibrate the temperature-salinity-conductivity meters, pH meter, and turbidimeter; and to verify the accuracy of specific conductivity, salinity, water temperature, turbidity, pH, dissolved oxygen, and chloride measurements. If a meter will not properly calibrate, or the validation is not within acceptable levels, corrective actions are taken to determine and remedy the problem (Section 11 [B5, B6, B7]).

6.3 Representativeness

Representative water quality samples are measured and/or collected at every sample site (Section 10.1.6). If a sample is collected that is not representative of the sample site, the lack of representativeness is recorded along with an explanation in the field book.

For surface waters, the collection of a representative sample consists of collecting the sample from a portion of the waterbody that is characteristic and away from possible influences from the sampler(s). Representative portions are determined by visual means, measured water quality variation, and where samples have been collected historically. Shallow margins and uncharacteristic areas are avoided and the variability of salinity, specific conductivity, temperature, and dissolved oxygen is evaluated while the sample site is being measured. If variation is present, it is recorded in the field log. Variation can also be representative of water quality due to the variable nature of surface waters on the Reservation (see Section 9.1 [B1]). Where waters are stratified, laboratory samples are only collected for the upper stratum, unless the upper stratum is too thin. Care is taken to minimize disturbance of the water column when collecting samples and taking measurements when the waterbody is stratified.

Ground water samples are collected from water taps specifically located as close to the well as possible, prior to treatment, and after the source has been sufficiently flushed. Water quality data are only collected at wells that are in-use (i.e., water has not been sitting in the well casing for an extended period of time). The measurement of water level two or three times provides information about the representativeness of that water level measurement along with data about water use.

6.4 Comparability

Data quality can be assessed and quantified for all data collected over the period of record. Methods for collecting water quality data have not changed significantly since 1993, although different brands of meters or model types have been used over time, which is documented in the field log. The basic measures of accuracy, precision, and traceability have not changed since 1993 and provide for the ability to assess accuracy, precision, and traceability for data collected over the entire period of record. This information allows for both comparison of data collected

at different times within the program as well as comparison with non-program sources of data, assuming QC information is available for non-program sources of data.

6.5 Completeness

The goal is for all sample sites to be visited at least twelve times a year, and some more frequently (e.g., Sample Site 18 for DOH support and LSR sample runs, first flush sample runs). With the exception of more frequent sample runs, sampling events should be equally distributed throughout the year, but do not have to occur on specific days (except for DOH Support and LSR sample runs). Surface water sample sites are grouped into runs that provide spatially representative data that, if incomplete, can hinder interpretation of the data.

Data gaps may affect future analysis of baseline conditions, but do not immediately compromise the integrity of the monitoring because the monitoring is not attempting to answer a specific hypothesis. Data gaps that could have supported decisions are addressed on a case-by-case basis. Missing data may be due to staff turnover, resource constraints, equipment failure, corrective actions, and/or logistical problems (e.g., storms, tides). Corrective actions are undertaken to remedy conditions that create data gaps.

6.6 Sensitivity

The goal is to collect data with sufficient resolution (sensitivity) to establish baseline conditions and identify trends, evaluate water quality against criteria, evaluate fecal coliform contributions from on- and off-Reservation, support the development and implementation of a water quality regulatory program, and protect ground water supplies from salt water intrusion and ground water mining. Deficiencies in sensitivity will be evaluated and remedied for future monitoring.

7. TRAINING REQUIREMENTS AND CERTIFICATION (A8)

The LIBC Water Resources Manager position, which is also the Quality Assurance Manager for the Lummi Nation Water Quality Monitoring Program, requires a Master of Science degree in a related field. The current Water Resources Manager is certified as a Professional Hydrologist (American Institute of Hydrology No. 1595), has a Masters of Science degree in Watershed Management, and a Bachelors of Sciences degree in Zoology. A Master of Science degree is highly desired but not required for the LIBC Water Resources Specialist position, which is also the Water Quality Monitoring Program Manager. The current Specialist has a Masters of Sciences degree and a Bachelors of Sciences degree in Civil Engineering. The LIBC Water Resources Technician position requires a high school diploma or equivalent. The current Water Resources Technician has a high school diploma and is currently taking classes at a community college. The former Water Resources Specialist (now Salix Environmental Services), specifically trained the Specialist and the Technician on water quality data collection methods. Both the Specialist and Technician are required to successfully pass a proficiency examination to demonstrate their capabilities. Additional training requirements are identified in Table 5 below. These requirements can be completed prior to or during the employees' time in these positions. All of this information is retained in personnel files and supervisors are responsible for ensuring staff are qualified and trained.

Required	Desired
<ul style="list-style-type: none"> • Health Care (basic first aid, Cardiopulmonary Resuscitation [CPR]) • Computer Proficiency (word processing, spreadsheet, presentation, database) • Boat Use and Safety • Incident Command System/National Incident Management System (NIMS) • First Responder Awareness Training (Occupational Safety and Health Administration [OSHA]) • First Responder Operations Training (OSHA) • Hazardous Materials Technical Training (OSHA) • Electrical Hazards and Safety Training • Water Quality Sampling Methods • Stream Flow Measurement Methods • Ground Water Sampling Methods • Global Positioning System (GPS) applications. • Quality Assurance and Quality Control • Construction Site Storm Water Management (desired for Technician) • Construction Site Storm Water Inspection (desired for Technician) 	<ul style="list-style-type: none"> • Management and Supervision. • Geographic Information Systems (GIS) Applications • Project Design and Management • Environmental Regulations and Ethics

8. DOCUMENTS AND RECORDS (A9)

8.1 Quality Assurance Project Plan Distribution

The Water Resources Specialist is responsible for ensuring that the people listed on the Distribution List in Section 1 [A3] have the most current version of this Quality Assurance Project Plan (QAPP). Records will be maintained by the Water Resources Specialist that document substantial and minor version changes, and who was sent copies of minor change letters and/or revised QAPPs and when copies were distributed.

Substantial QAPP updates will be transmitted to the EPA Project Manager and EPA Quality Assurance Officer for approval as an entire document with identification and justification of changes. Major updates will result in a change in the number before the decimal point in the QAPP version number.

Minor updates to the QAPP will be transmitted to the EPA Project Manager and EPA Quality Assurance Officer for approval via a letter that identifies changes and justifications. Minor updates include correction of mistakes and non-substantial changes to the QAPP.

- Correction of mistake(s) and minor changes are tracked through use of a lower case letter at the end of the QAPP version number. The letters will start with “a” and proceed in alphabetical order (e.g., Version 3.0 to 3.0a).
- Non-substantial minor changes are tracked through use of a number following the decimal point in the QAPP version number. The numbers start with “1” and proceed in ascending order (e.g., Version 3.0 to 3.1).

8.2 Data Report Package

An annual water quality summary report is provided to the EPA Project Officer. The report includes graphical time-series analysis of water quality data for the reporting period as well as for the period of record, and a table of the surface water quality data for the reporting period. As described in Section 14 [B10], surface water quality data are scheduled to be provided to EPA in STORET v.2 compatible format by December 31, 2006.

8.3 Field Log Book

All measurements and samples collected are recorded in ink in a bound field log book (field book) in chronological order (Section 10.1.1). The field book has a hard plastic cover and Rite-in-the-Rain paper. Recorded information includes results of water quality measurements with the date, time, and sample site identification for each measurement, equipment used, calibrations, QC activities, problems, corrective actions, outcomes/resolutions, and other noteworthy observations. Units of measurement are always recorded with the measurement (which may be in the column header for the data entry table). The name(s) or initials of the person(s) performing the work, the date, and the weather conditions are also recorded for every sample run

in the field book. The date is recorded as the day/month/year using numeric values for the day and year and text for the month (e.g., 05Nov2005, 21July2004, 19April1999). Mistakes in the field book are crossed out with one line and the date of the correction and initials of the person(s) that made the correction recorded. A glossary is provided at the beginning or end of the field book to define abbreviations used in the field book. At the end of each day, information in the field log from that day is photocopied and stored chronologically in a three-ring binder kept in the office. The individual field books are labeled with either “Surface Water” or “Ground Water,” the period of record contained in the field book, and a unique and sequential number starting with one for the first field log used. The field book in use and those no longer in use are stored in the office. Archiving of field logs and copies of field logs is not anticipated at this time, but the procedures of the Lummi Records and Archives Department will be followed when field logs are archived.

8.4 Laboratory Results

The entire data reporting package from the laboratory is placed in chronological order in a three-ring notebook stored in the office. Archiving of laboratory records is not anticipated at this time, but the procedures of the Lummi Records and Archives Department will be followed when field logs are archived. Chain of custody forms are photocopied when samples are delivered to the Washington State certified independent contracted laboratory. These copies are placed with the associated photocopies of the field book pages.

8.5 Data Stored Electronically

All electronic data are stored on a network hard drive that is backed up nightly. Data from the entire period of record will be stored on the network hard drive (Section 14 [B10]). Removal and archiving of data are not anticipated at this time (i.e., data will be available for the entire period of record). During 2006, all of the existing water quality data collected as part of the surface water quality program will be exported and transmitted to the EPA for inclusion in the STORET v.2 database. All data collected in subsequent years will also be exported and transmitted to the EPA annually for inclusion in the STORET v.2 database.

9. SAMPLE PROCESS DESIGN (B1)

The Lummi Nation Water Quality Monitoring program was started in 1993 and is designed to achieve the following goals: provide high quality data sufficient to establish baseline conditions of Lummi Nation Water, to evaluate water quality compliance with water quality criteria, to evaluate fecal coliform contributions from on- and off-Reservation sources, to support the development of a water quality regulatory program, and to protect ground water supplies from saltwater intrusion and ground water mining. The program is ongoing and not intended to prove or disprove a hypothesis

9.1 Surface Water Quality Monitoring

The 43 surface water quality sample sites (Figure 3) were chosen to achieve program goals. Four to six additional Washington Department of Health (DOH) sample sites (Figure 3) are sampled to provide logistical assistance to the DOH and also assist with achievement of program goals. Table 2 and Table 3 list the sample runs, sites included in the run, parameters measured, samples collected, and frequency of sampling. Water quality is generally measured in situ for salinity, specific conductivity, water temperature, dissolved oxygen, and Secchi depth, and at the sample site immediately after sample collection for pH and turbidity. Samples for laboratory analysis are collected, labeled (site identifier, date, time, analysis, and collecting agency), placed on ice, and delivered to the laboratory using chain of custody procedures and the methods detailed in Section 11 [B2, B3, B4].

Thirty-two of the surface water quality sampling sites are accessible from land and the parameters identified in Table 2 and Table 3 are measured monthly by the Lummi Water Resources Division staff. During the late-summer to early-winter period, "First Flush" samples are collected at variable intervals (daily to weekly) based upon precipitation and runoff levels during the onset of the wet season. The timing and magnitude of the response to the beginning of the wet season varies considerably between sample sites. The eleven sample sites on Portage Island, in southern Portage Bay, in the Sandy Point Marina, and Lummi Bay are boat-accessible sites. These sample sites are targeted for monthly sampling, but foul weather usually reduces the sample frequency. The four to six Washington Department of Health (DOH) Sites are sampled as needed when DOH is unable to sample northern Lummi Bay.

Water quality on the Reservation is quite variable. As described previously, the Reservation is located in the estuary of the Nooksack River Basin and nearly all of the watercourses in the Lummi River and Nooksack River floodplains are exposed to marine influences, which include upstream flow of saline water during high tide and salinity-based-stratification. Most of the sample sites in the Lummi Bay watershed are tidally influenced (water level and/or salinity) and have variable water column profiles (e.g., stratified or well-mixed) and salinities. For most sample sites, the salinity and presence or absence of stratification cannot be predicted. Generally, salinity levels at surface water quality sample sites decrease as the wet season progresses and increase as the wet season ends and the dry season progresses.

The sample site distribution on the Reservation is dense in order to protect shellfish resources and capture spatial variability associated with estuarine environments. Temporal variability is also significant and is addressed through regular but essentially random sampling at the same location over long periods of time. The dense sampling network also provides some insight into the range of temporal variability as individual sample sites respond more or less quickly to environmental conditions. During the planned sample program evaluation in 2006 (Section 14 [B10]), the frequency of sampling will be evaluated.

“Essentially random sampling” means that the tides, season, and weather are not used to stratify sampling efforts. The exception to this is that for marine sampling to occur, sufficient water (i.e., tidal depth) is required to get to marine sample sites (Table 3). Additionally, the DOH Support and LSR sample runs are timed to occur with Washington Department of Health (DOH) sampling of Portage Bay. The DOH sampling is systematic random and conducted to determine the classification of shellfish growing waters under the NSSP. The DOH support and LSR sample runs are intended to provide context for the DOH sample results (e.g., bacteria levels in the Nooksack River, local uplands, salinity distributions).

As mentioned above, “First Flush” sampling is more frequent water quality sampling that occurs during the late-summer to early-winter period during the onset of the regional wet-season. Conditions that trigger first flush sampling are precipitation events likely to produce runoff during the beginning of the wet season in the Lummi Bay, Portage Bay, and Nooksack River watersheds. Determination of when to conduct First Flush sample runs is made based upon: 1) increases in Nooksack River discharge measured by the U.S. Geological Survey at Ferndale, Washington,⁴ 2) occurrence of lower salinities at sites along the Reservation boundary, 3) the onset of surface water flow at sites that dry out, and 4) the intensity and duration of the storm event. The timing and magnitude of the response at sample sites is variable and only predictable to the level that a response may occur. However, information indicating that water quality is or is not being affected by the onset of the wet season is useful. Climatic variation and the varied response of waterbodies dictates a flexible event-driven sample schedule that can result in daily to weekly sampling spanning a period of weeks to months.

Water quality sampling of DOH sites in Lummi Bay occurs as needed. Logistical difficulties can prevent DOH staff from sampling Lummi Bay (tidal window for access to marine sample sites in Portage and Lummi bays is narrow, particularly in the summer). In these circumstances, LNR staff collect bacteria samples and measure other water quality parameters. The northern portion of Lummi Bay is vulnerable to contamination because the major Lummi Bay tributaries empty into this part of Lummi Bay. In addition, the winds associated with precipitation events

⁴ Nooksack River flows in excess of about 9,600 cubic feet per second flow directly into the Lummi River through a damaged culvert at the head of the Lummi River. U.S. Geological Survey Station “USGS 12213100 Nooksack River at Ferndale, WA” available online at http://waterdata.usgs.gov/usa/nwis/uv?site_no=12213100.

are from the south, which can limit circulation in northern Lummi Bay and associated precipitation increases runoff from the contributing watersheds.

With the exception of marine sites where tides and weather may preclude sampling, sample site access is usually not a problem. When sites are inaccessible, the sample run is rescheduled. If an individual sample site cannot be accessed during a sample run, the reason for the inaccessibility is determined and remedied on-site or soon thereafter, if possible. If the site can no longer be accessed, it will be replaced (this has not occurred to date). If the regularly sampled site cannot be sampled, but the problem is temporary (i.e., a big hornet nest), the problem is remedied within a few days and a sample may be collected at that time. In general, sampling of individual sample sites without also sampling the other sample sites in the sample run is avoided because the measurements and analysis will not have the context of the other sampling sites. However, if the information is critical, a site will be sampled as soon as access is re-established with sampling of some or all of the other sites in the sample run. In addition, when the sample site is first determined to be inaccessible, a sample may be collected nearby if the area is part of the same waterbody and is representative of the designated sample site area. When this occurs, the sampling location is described in the field book and the data collected identified as suspect because the information/sample was not collected at the established sample site.

Critical information varies with the type of sample run. For example, bacteria, salinity, and flow information are critical for the Portage Bay DOH Support and LSR sample runs, as well as for the sample sites located and near Portage Island. All other data collection is critical in the sense that representative and complete data are required to meet the goals of the program. The program provides for flexibility in that measurements do not have to occur at specified times, but they do need to be collected in the groupings assigned (i.e., sample runs). Each sample run (except for first flush and the Lummi Bay DOH Support sample runs) should be performed twelve times a year and generally be equally distributed throughout the year.

The parameters measured/analyzed provide substantial information about water quality. For example, air and water temperature, specific conductivity, salinity, dissolved oxygen, pH, turbidity, Secchi depth, presence of salinity-based stratification, water level, flow or current direction, and flow (discharge) provide information to characterize the basic water chemistry, which provides insight into both the variation and the causes of variation of these parameters. Fecal coliform and *E. coli* are enumerated from the same plate to provide information about the presence of non-pathogenic bacteria (i.e., klebsiella) in fecal coliform counts and increase the comparability of the fecal coliform and *E. coli* results. Enterococcus is enumerated from the same sample bottle as fecal coliform and *E. coli* to provide information about enterococcus distributions. The nutrients measured (Tables 3 and 6) provide a relatively complete snap-shot of nutrient dynamics in a highly variable estuarine environment and concentrations can provide insight to the source of any contamination. Nitrogen and phosphorus levels and forms can vary considerably depending upon whether conditions are fresh, brackish, or marine, the time of year, and upland inputs. This variability requires considerable associated information (e.g., the rest of the nutrients measured) to assist with interpretation. Any measured parameter can also provide

insight about other biological or chemical processes that may be affected by water quality (e.g., metals may be dissolved in surface water or conditions are favorable for die-off of bacteria).

As previously mentioned, the measurements also provide information on regulatory compliance. Many of the parameters measured are associated with regulatory criteria (i.e., water temperature, dissolved oxygen, pH, bacteria, metals), which provides for evaluation of water quality against the criteria. The extent of these evaluations rarely include strict legal evaluations (i.e., citations, legal actions), but they guide follow-up actions to confirm and remedy the problem (Section 16 [C2]). As for bacteria, the EPA is advocating for the discontinuation of fecal coliform as a regulatory indicator bacteria. However, at this time all three bacteria will continue to be sampled because NSSP criteria are based on fecal coliform and there is no indication that this will change.

Metals and hydrocarbons are collected at Site 1 and Site 14 and the metals analyzed are based upon likely contributions and previous detections of metals from the Sandy Point Marina (Site 1), and from an oil refinery located immediately north of the Reservation (Site 14).

The numerical gaps in the sequential identification numbers for the surface water sites encountered in Figure 3 are for sites that are no longer sampled. Aside from the two discontinued sites in the Sandy Point Marina, and Site 4, all of these sites occur along the western shoreline of Portage Bay and were associated with a three-year intensive sampling program to characterize fecal coliform contributions from the local uplands (LWRD 1999).

The number of sample sites and laboratory analyzed parameters has increased over the years to provide for additional baseline information, and in response to potential and actual sources of pollution, primarily animal wastes indicated by bacteria.

Most of the expansion of the surface water quality monitoring program occurred in the mid- to late-1990s due to fecal coliform contamination of Portage Bay and the resultant downgrade of commercial shellfish beds classification from “approved” to “restricted” under the National Shellfish Sanitation Program (NSSP). These problems with Portage Bay prompted the increase in the number of sample sites in Lummi Bay and the Lummi Bay watershed to better characterize and protect that area. Lummi Bay contains significant shellfish resources and the watershed contains several dairy farms, two of which have been cited by the Washington Department of Ecology (Ecology) and/or the EPA for Clean Water Act violations.

When the surface water quality program was started in 1993, it consisted of eleven surface water sample sites numbered 1 through 11. With three exceptions (sample sites 3, 4 and 8), these sites are either located along the upland Reservation boundary or in marine waters. Site 3 and Site 8 were located approximately mid-way between the upland Reservation boundary and marine waters to obtain better spatial resolution of water quality at sites measured along the upland

Reservation boundary (i.e., sites 9, 10, and 11). Site 4 was located on the Nooksack River at the Slater Road Bridge⁵ (it was replaced by surface water quality sample site 18) and is currently sampled by the Washington Department of Ecology. The sites located along the Reservation boundary provide information about water quality flowing onto the Reservation, and the marine water sites were located to document background water quality in Portage Bay, Lummi Bay, and the Sandy Point Marina.

Over time more surface water quality sample sites were added to measure all remaining surface waterbodies flowing onto the Reservation (Sites numbered 12 through 18), to evaluate potential contamination from areas with no sewer systems at the south end of Sandy Point (Sites numbered 19 through 22, two of these sites have since been discontinued), to better characterize bacteria transport from the Nooksack River to Portage Bay including potential local contributions (Sites numbered 23 through 39), and to obtain more resolution within the Lummi Bay watershed (Sites numbered 15, 51, 52, 53, 55, 56, 59, and 72). The Floodplain East and Floodplain West sample runs divide the on-Reservation Lummi Bay watershed into two runs based upon the drainage network. Floodplain East captures the discrete drainage network of the eastern Lummi Bay watershed waters from the Reservation Boundary and hydrographic divide (Site 72) to Lummi Bay. The Floodplain West sample run captures the drainage network of the western Lummi Bay watershed from the Reservation Boundary to Lummi Bay. Sample sites 31 through 38 occur in pairs with a sample site located at the upland source (odd number) for upland discharges (i.e., inlet culverts to the beach/marine water) and in the marine water near to, but not under direct influence of the upland water discharge (even number).

The number of parameters analyzed by a laboratory has also increased over the course of the program. Bacteria sampling has expanded from enumerating one bacteria, usually Fecal coliform or occasionally *Escherichia coli* (*E. coli*) at a site to enumerating Fecal coliform, *E. coli*, and Enterococcus at each sample site. In addition, comprehensive nutrient samples are collected approximately four times per year at five of the sample sites and several metals are sampled four times per year at two sample sites. Initially no nutrient or metals analyses were performed. At selected sample sites, discharge is measured to allow for loading calculations, and at selected sample sites and times (e.g., during the onset of the rainy season) sampling frequency may be increased from the regular once-per-month to weekly or daily sampling (i.e., first flush sample runs).

⁵ Site 4 was never directly measured by Lummi Water Resources Division staff as part of the surface water quality monitoring program. Data from the site was obtained from the Washington Department of Ecology

9.2 Ground Water Monitoring

Twenty-eight (28) sampling sites (Figure 4) have been selected to characterize the two major potable aquifer systems on the Reservation. Table 4 lists the well group, wells included, well number, parameters measured, and measurement frequency. The number of wells sampled has increased over the years but the parameters measured have not increased. Wells were added as they were drilled and/or access was granted to obtain better spatial resolution of aquifer conditions. Water level, pumping status, temperature, specific conductivity, and chloride concentration are measured monthly or more frequently at each site (Table 4) and well production is recorded from existing meters at the Lummi Water District water supply wells. If a well is not sampled when scheduled, the well is sampled as soon as possible afterwards.

Sample sites were selected to represent aquifer-wide conditions as practicable, but the spatial representativeness of these sampling points is limited by the lack of existing ground water wells in some parts of the Reservation – particularly along the interior of the Lummi Peninsula and the eastern part of the northwestern upland.

The primary sources of variability are seasonal climate changes (i.e., wet season and dry season) and pumping regimes (which is typically related to season). This variability is addressed through frequent sampling (sub-monthly to monthly), performing multiple well water level measurements during sampling at each well, and recording the pumping rate and totalizer values (if metered) and pump status of the well at the time of measurement. Water quality is generally stable in the wells.

The chloride concentration, pumping rate and amounts, and water levels of the water supply wells provide critical information about aquifer condition, pumping regimes, and the need for protective measures, as these data indicate whether seawater intrusion is occurring, and/or if the likelihood of seawater intrusion is increased. For wells that are not used for water supply purposes (e.g., inactive), water level provides information about aquifer conditions.

10. WATER SAMPLING, SAMPLE HANDLING, AND WATER MEASUREMENT METHODS (B2, B3, B4)

Sampling methods, sample handling, and analytical methods for each parameter measured or sampled are described below. General practices that are independent of specific sampling and analysis methods are described first followed by practices specific to each type of measurement. The QC activities, equipment calibration and inspection, and supplies are described in Section 11 [B5, B6, B7].

10.1 General Information

Tables 2, 3, and 4 list parameters measured and sampling frequency at every sample site. Table 6 summarizes the sampling equipment, measurement method, sample holding container, method of sample preservation, and the maximum holding time for each of the measured parameters. Not listed in Table 6 is flow meter reading for ground water. “General Observations” are also not listed in this section because they are not a specific method. General and noteworthy conditions are observed during the time period the sampler is at a sample site and recorded as comments in the field book. Turbidity is not currently measured due to workload constraints and will be addressed during the evaluation and revision of surface water quality sampling described in Section 14 [B10].

Safety is not addressed in detail in this document. Use of safety protocols and equipment is required. No water quality measurement is worth risking injury or death. To ensure that hazards are identified and addressed requires an awareness of potential hazards and the ability to respond appropriately. The sampler must be aware of the environment, use common sense and training, and not exceed their abilities or limits. Protective equipment must always be used whenever hazardous materials are handled, stored, and transported, and/or when other hazardous conditions are present. The samplers always wear life jackets and have a minimum of two people when performing boat-based sampling. Whenever performing field work, the samplers always carry a cell phone with an extra battery and a 12 volt charger, sign out, providing the time of departure, the time of the scheduled return, a cell and/or contact phone number, and the general location of the field work.

Where a mild detergent is specified as a supply item, cleaning of equipment follows manufacturers instructions. In general, mild detergent is used for cleaning a dedicated surface, ground water bottles, and sampling equipment when necessary. Laboratory sample bottles are never cleaned by Lummi Water Resources Division staff and some water quality measurement equipment can be damaged by improper cleaning.

Table 6. Lummi Nation Water Quality Sampling Methods.

Parameter	Measurement Equipment ^A	Measurement Method ^B	Sample Holding Container	Method Sample Preservation ^C	Maximum Holding Time ^D
Air Temperature	Armored non-toxic liquid-in-glass thermometer graduated and readable to 1°F or 0.5°C increment.	Manufacturer's instructions Section 10.2.1.	N/A	N/A	Immediately
Chloride	Lamotte test kit, Model PSC-DR, Code 4503-DR	Direct Reading Titrator Method (Manufacturer's Instructions) Section 10.2.3. EPA 9253 SM 4500-Cl ⁻ C	Plastic bottle with screw top	None	28 days
Current and Flow Direction	N/A	Section 10.2.4	N/A	N/A	N/A
Dissolved Oxygen	Oxyguard Handy Mk III Portable DO meter OR Oxyguard Handy Gamma Portable DO meter	Manufacturers' Instructions Section 10.2.5. EPA 360.1 SM 4500-O G	Dedicated surface water one-liter wide-mouth plastic bottle with screw top when not measured in situ	N/A	Immediately
Enterococcus (surface water)	Laboratory with Enterolert Test Kit	Enterolert Test Procedure (ASTM D6503-99)	Sterile plastic bottle with screw top	Ice	24 hours
Coliform (total, fecal, <i>E. Coli</i>) (ground water)	Laboratory with presence/absence and membrane filtration capabilities	SM 92221B, F and/or SM 9221D	Sterile plastic bottle with screw top	Ice	24 hours
Fecal Coliform and <i>E. Coli</i> (surface water)	Laboratory with membrane filter enumeration capabilities	Membrane Filtration with elimination of rosolic acid. SM 9222D	Sterile plastic bottle with screw top	Ice	24 hours
Flow (Surface water discharge)	Variable, containers of known volume (1-L to 5-gallon), measuring tape, neutral buoyancy objects.	Section 10.2.6.	N/A	N/A	N/A
Nutrients					
<ul style="list-style-type: none"> • Alkalinity • Ammonia • Biochemical oxygen demand • Nitrate • Nitrite • Total Kjeldahl Nitrogen • Ortho-phosphate • Total phosphorus • pH • Total organic carbon • Total suspended 	<ul style="list-style-type: none"> • Laboratory • Laboratory • Laboratory • Laboratory • Laboratory • Laboratory • Laboratory • Laboratory • Laboratory • Laboratory • Laboratory 	<ul style="list-style-type: none"> • SM 2320B • EPA 350.1 • EPA 405.1 • EPA 353.2 • EPA 353.2 • EPA 351.2 • EPA 365.1 • EPA 365.1 • EPA 150.1 • EPA 415.1 • EPA 160.2 	<ul style="list-style-type: none"> • P, G • P, G • P, G • P, G • P, G • P, G • P, G • P, G • P, G • G, amber • P, G 	<ul style="list-style-type: none"> • Ice • Ice • Ice • Ice • Ice • Ice • Ice • Ice • None • Ice • Ice 	<ul style="list-style-type: none"> • 14 days • 14 days • 24 hours • 48 hours • 24 hours • 28 days • 48 hours • 28 days • Immediately • 28 days • 7 days

Table 6. Lummi Nation Water Quality Sampling Methods.

Parameter	Measurement Equipment ^A	Measurement Method ^B	Sample Holding Container	Method Sample Preservation ^C	Maximum Holding Time ^D
solids					
• Total volatile suspended solids	• Laboratory	• EPA 160.4	• P, G	• Ice	• 7 days
• Iron	• Laboratory	• SM 3111B	• P, G	• None	• 6 months
• Sulfate	• Laboratory	• EPA 300.0	• P, G	• Ice	• 28 days
• Chlorophyll <i>a</i>	• Laboratory	• SM 10200H	• P, G, opaque	• Ice	• 28 days
• Sulfide	• Laboratory	• EPA 376.2	• P, G	• Ice	• 7 days
• Silicon	• Laboratory	• EPA 200.7	• P, G	• None	• 6 months
Metals					
• Copper	• Laboratory	• SM 3111B	• P, G	• None	• 6 months
• Zinc	• Laboratory	• SM 3111B	• P, G	• None	• 6 months
• Tin	• Laboratory	• EPA 6020	• P, G	• None	• 6 months
• Arsenic	• Laboratory	• EPA 6020	• P, G	• None	• 6 months
• Mercury	• Laboratory	• EPA 245.2	• P, G	• None	• 28 days
• Chromium	• Laboratory	• EPA 6020	• P, G	• None	• 6 months
• Lead	• Laboratory	• EPA 6020	• P, G	• None	• 6 months
• pH	• Laboratory	• EPA 150.1	• P, G	• None	• Immediately
• Hardness	• Laboratory	• SM 2340A	• P, G	• None	• 6 months
Petroleum Hydrocarbons					
• Diesel Range plus	• Laboratory	• WTPH-DX	• G, amber	• Ice	• 28 days
• Heavy Oil Range	• Laboratory	• WTPH-DX	• G, amber	• Ice	• 28 days
pH	IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and temperature compensation probe	Manufacturer's Instructions Section 10.2.8. EPA 150.1 SM 4500-H ⁺ B	Wide-mouth dedicated plastic bottle and lid with ports for pH electrode and temperature probe	None	Immediately
Secchi Depth	Eight-inch diameter secchi disk marked alternately in black and white quadrants & measuring tape	Section 10.2.9.	None	In-situ	Immediately
Salinity (specific conductivity based)	WTW LF330 Meter With TetraCon 325 Probe OR YSI Model 30 Meter	Manufacturer's Instructions Section 10.2.2. SM 2520 B	One- liter wide-mouth plastic bottle with screw top when not measured in situ	N/A	Immediately
Specific Conductivity	WTW LF330 Meter With TetraCon 325 Probe OR YSI Model 30 Meter.	Manufacturers' Instructions Section 10.2.2. EPA 9050 SM 2510 A	One-liter wide-mouth plastic bottle with screw top when not measured in situ Plastic wide-mouth bottle with screw top	N/A	Immediately
Surface Water Level/Depth	4 ft. ruler, or sample wands marked in 1 ft. increments.	Section 10.2.10	N/A	N/A	N/A

Table 6. Lummi Nation Water Quality Sampling Methods.

Parameter	Measurement Equipment ^A	Measurement Method ^B	Sample Holding Container	Method Sample Preservation ^C	Maximum Holding Time ^D
Turbidity	Hach 2100 P portable turbidimeter	Manufacturer's Instructions Section 10.2.11. EPA 180.1 SM 2130 B	Wide mouth plastic bottle	None	Immediately
Water Temperature	WTW LF330 Meter With TetraCon 325 Probe OR YSI Model 30 Meter	Manufacturers' Instructions Section 10.2.2. EPA 170.1 SM 2550 B	One-liter wide-mouth plastic bottle with screw top when not measured in situ Plastic wide-mouth bottle with screw top	N/A	Immediately
Well Water Level	Waterline Envirotech electric 300 ft Olympic Well Probe	Manufacturer's Instructions Section 10.2.12.	None	N/A	N/A

P = Plastic container

G = Glass container

^A Where "Laboratory" is entered in this column, the sampling methods are described in Section 10.2.7. of this document.

^B "Section #" refers to sections in this document that describe sampling methods and "SM" refers to Standard Methods (APHA 2005).

^C Sample preservation methods listed are for the collection and delivery of samples to the laboratory by WRD staff and do not include sample preservation methods performed at the contracted laboratory.

^D Maximum holding times listed include sample preservation methods performed at the laboratory. All laboratory samples are delivered to the contracted laboratory within 8 hours of collection, preferably less.

10.1.1. Sample Tracking and Recording of Information in the Field Book

Every surface and ground water sample site has a unique identifier. Numbers are used to identify surface sample sites, and either numbers or names are used for ground water sample sites. Data are entered into the field book (Section 8.3) in a table format (Appendix A) where the sample site identifier is in the first column, and that row is used to record the time of sample collection, samples collected, measurements taken, and other observations. Prior to every sample run, the tables are written into the field book for data collection and QC activities. Appendix A contains the templates used to make the tables in the field book. The tables are checked after every QC activity and measurement, and after every sample run to ensure that all required information was collected or an explanation is recorded for why the information was not collected.

Where additional information needs to be recorded for a site or QC activity that is not included in the templates, the information is recorded in one of two ways.

- Empty rows below the row(s) being used for the current sample site are used to record information. The information is written across column lines so that it is clearly not data meant for the particular columns.
- A sequential number starting with “1” is written in a circle and placed adjacent to where the additional information is relevant, and, elsewhere on the page or on a subsequent page, (that is dated and initialed) the additional information is recorded with the same number within this circle.

The field book is also used to track all sample containers used for sample collection where analysis does not occur at the sample site.

- Where samples are collected for analysis at the laboratory, the sample site identifier and type of analysis is recorded in the field book with the date, time, and location of sample collection. This information and the agency collecting the data (i.e., L.I.B.C.) are recorded on the label of the sample container, and the chain of custody form.
 - Where the requested analyses are too numerous to fit directly into the data entry table, the analysis can be listed elsewhere in the field book and cross-referenced to the sample collected at a sample site.
 - When a sample site is sampled more than once during a day, the sample identifier is the sample site number followed by a letter starting with the letter “A” moving sequentially through the alphabet for each subsequent sample at that site on that day. This facilitates identification of samples collected at different times throughout a day.
- For all chloride samples, the sample location, date, and time are recorded on label tape on the bottle. The sample site, date, and time of the sample collection are recorded in the field book.

10.1.2. Corrective Actions

The goals of corrective actions are to solve the problem(s) at hand and to eliminate or reduce the occurrence of the problems. Problems with equipment detected during equipment use, calibration, and/or during QC activities result in actions to correct the problem (see parameter measurement methods later in this section and parameter QC activities in Section 11 [B5, B6, B7]). Corrective actions depend upon the parameter being measured. Generally, if the problem cannot be resolved on-site, the measurement is discontinued until the problem is identified, remedied, and reliable results obtained. For most parameters, backup equipment is available for use as described later in this section for each measurement. Problems with equipment and measurements, corrective actions, and outcomes/resolutions are recorded in the field book.

Problems that require corrective actions during sampling are categorized into three types: problems with the water being sampled, operator error, and equipment error/malfunction. One or all of these may be responsible for the problem(s) encountered. Steps to identify the specific causes of the problem vary between and within measurement types, but the general approach used to identify the source of a problem is to compare the sampling method against the manufacturer's instructions and the methods described later in this section, and follow troubleshooting steps in the equipment manual. Typical steps include repeating the measurement; re-collecting/measuring and analyzing the sample water; checking for fouling of probes or equipment; checking for poor connections or seals on equipment; checking battery condition; and measuring a calibration standard. If sampling protocols and the equipment manual are not adequate to solve the problem, the manufacturer and/or other people that perform the same or similar measurements are consulted, and additional materials such as the National Field Manual for the Collection of Water-Quality Data (USGS variously dated) and the most recent version of Standard Methods for the Examination of Water and Wastewater (APHA 2005) are used.

When the time required to perform corrective actions may preclude conducting a sample run, a determination is made on a case-by-case basis to: 1) continue the sample run without measuring the parameters requiring corrective actions, 2) to remedy the problem and conduct a portion of the sample run, or 3) to cancel the sample run. This decision is made in consultation with the Water Resources Specialist and/or the Water Resources Manager and documented in the field log. Primary factors that influence the decision are: the need for the data; the completeness of the data set for that parameter, sample site, and sample run; and whether data quality for the parameter(s) can be quantified or not. In limited circumstances, malfunctioning equipment can be used to measure specific conductivity, salinity, and/or water temperature, if the error can be quantified and calibration checks are performed with every measurement (Section 11 [B5, B6, B7]).

10.1.3. Suspect Data

Where data are marked as suspect in the field book, the reason that the data are suspect is also recorded and the data are not considered for entry into the database until the quality of the data are known. The final resolution of suspect data (i.e., data quality determination) is recorded in

the field book with the original suspect data that includes the initials of the person that recorded the information, the date it was recorded in the field book, the resolution, and the basis for the resolution (see Section 14 [B10]).

10.1.4. Sample and Standard Disposal Procedures

With two exceptions, all samples collected and measured on site and standards used during a sample run are disposed of at the place of use, taking care not to influence the water being sampled. The laboratory disposes of samples delivered to the laboratory. The titrated chloride samples and the zero oxygen standard are collected in bottles, labeled with the contents and date, and transported to a Hazardous Materials Disposal Site (which currently is Hazardous Waste Disposal in Bellingham, WA).

10.1.5. Sample Locations

Sample locations are shown in Figures 3 and 4 for surface and ground water sample sites, respectively. If a sample cannot be collected in the area where the sample is regularly collected, the location sampled and reason for the different location are described in the field book. The data are labeled in the field book as suspect due to a different location. When surface water is sampled at a location close to, but not at, an existing sample site, the sample site identifier is the numeric identification of the nearest sample site followed by the compass direction (eight point—north, northeast, east, southeast, south, southwest, west, northwest) from the nearest sample site to the sampling location, and the estimated distance from the nearest sample site in meters (e.g., a sample collected 20 m southeast of Site 32 would be Site 32SE20). The location sampled is also described with an explanation of why the location was sampled as a comment in the field book. If necessary, a plan-view schematic map may also be drawn in the field book to show the location of site(s) sampled.

Section 10.1.8. (Other Sampling) describes the method for recording sample site identifications and locations that are not part of, or near existing sample sites.

If the normal sampling location at a sample site cannot be regularly sampled, the sampling location will be moved and noted with the date and reason for the change in the field log and database. The GIS coverage that contains the sample site locations and descriptions will also be updated.

10.1.6. Representative Water Quality Sampling

Both surface and ground water sample site locations were selected where representative water quality can be measured. Representative water quality is obtained through a variety of methods described below and as described for each parameter in Section 10.2. Representative in this context includes both the method of sample collection and measurement, and the sequence of sample collection and measurement.

The tables that follow (Table 7 through Table 10) describe the sample sequence and steps required to obtain representative water quality samples and measurements for surface and ground water. The content of the surface water Tables 7 through 9 overlaps and the three are used in combination to guide surface water sampling. Table 7 provides an overview of the chronological order that sample types are collected and water quality parameters are measured. Table 8 provides more detail on the method used to ensure collection of a representative sample or parameter measurement at a site. Table 9 details how representative samples are collected and measured using a sampling wand and by-hand.

Table 7. Description of surface water sampling sequence.

Surface Water Sampling Sequence Description	
A.	Visual observation of sample site conditions and representative area. <ol style="list-style-type: none"> 1. Setup air temperature thermometer, observe current and flow direction, water level/depth, and waterbody condition throughout time at sample site.
B.	Bacteria samples are collected first in the top six inches of the water column, before any other water quality measurements are performed. Sample is collected in representative portion of waterbody.
C.	Metals and hydrocarbons are sampled in the upper portion of the waterbody immediately following collection of the bacteria.
D.	In situ measurements are performed for water temperature, salinity, specific conductivity, and dissolved oxygen, starting at the previously identified representative portion of the waterbody (area identified in Step A above). <ol style="list-style-type: none"> 1. Assess water quality variation at sample site and measure at representative location. If prior laboratory samples were collected from non-representative areas, consider discarding the samples. <ol style="list-style-type: none"> a. If samples discarded, record that and reason in the field book. b. If samples not discarded, record sample as suspect in the field book and why. c. Consider resampling if feasible. 2. Salinity is measured before dissolved oxygen. 3. If these parameters are measured in a container, the water sample is collected after nutrients have been sampled and before pH and turbidity.
E.	Nutrients samples are collected after salinity, specific conductivity, temperature, and dissolved oxygen have been measured. <ol style="list-style-type: none"> 1. This allows for targeting of the upper strata if it can be sampled discretely, and avoidance of areas with uncharacteristic (i.e., very localized) dissolved oxygen concentrations (e.g., very localized supersaturation due to benthic algae immediately below). 2. Lower strata are not sampled with containers and would require use of specialized devices to obtain discrete samples.
F.	Water samples for pH and turbidity are collected after in-situ measurements are made and are collected after nutrient samples are collected.
G.	Finally, Secchi depth, water level and/or depth, air temperature, and flow are measured and visual observations (e.g. flow direction) are recorded. <ol style="list-style-type: none"> 1. Visual observations are conducted during the entire period of time the sampler is at the sample site. If conditions change substantially (e.g., current direction reverses, tidal channel fills or empties) the changes are recorded in the field book.

Table 8. Description of methods to obtain representative surface water samples and measurements.

Surface Water Sampling Methods to Obtain Representative Measurements	
A.	<p>Determine where water quality will be sampled and measured based upon visual assessment of the waterbody and previous experience.</p> <ol style="list-style-type: none"> 1. Determine path of sample collection and placement of probe in the waterbody prior to collecting samples and performing measurements. 2. Avoid areas along margins, where debris accumulate, and other areas that are not characteristic of the waterbody at the sample site. 3. Select an area that minimizes disturbance to the waterbody (Item B below). 4. For wading sites, unless safety precludes wading into the water, avoid collecting samples along the shoreline where waves are breaking and washing across the beach. <ol style="list-style-type: none"> a. Sample seaward of debris and seaweed generally found in the water close to the shoreline. a. If samples are collected from within wave or debris zone, mark samples and measurements as suspect and why in the field book. b. Avoid areas of entrained air in the wave-wash zone. 5. Avoid areas disturbed by previous sample collection and measurement when collecting and performing subsequent samples and measurements, unless there are no other representative areas to collect samples. If the water column was disturbed by sampling and is no longer representative, record in field book. <ol style="list-style-type: none"> b. Subsequent samples should be at a different, but representative location at the sample site. c. If overall conditions at the sample site are stable, the disturbance will dissipate within a few minutes, and water quality is not likely to change from when sampling started, the disturbed location may be resampled after the disturbance has passed. If this approach is taken, record in field book. d. If subsequent samples cannot be relocated in space or at a slightly later time, consider sampling in the disturbed (non representative) location and mark data as suspect with reason why in the field book if data collected. e. If subsequent samples cannot be relocated in space or at a slightly later time, consider a complete re-sampling of the site at a later time in the sample run. If this approach is taken, record in field book. f. Consider sampling water in the disturbed location (A.5.d. above) and at a later time (A.5.e. above).
B.	<p>Minimize disturbance to waterbody when collecting samples and performing measurements</p> <ol style="list-style-type: none"> 1. Use wand to collect samples and place probes in water column unless unsafe or impractical. If wand not used, the same approach is used when sampling by hand (See Table 9 for sample collection and probe placement using a wand or by-hand). 2. Sample upstream/upgradient of any influences of the sampler. <ol style="list-style-type: none"> a. When sampling from the boat, sample water from near the bow while slowly moving forward over water that the boat has not previously come into contact with during the sample run. b. Sample outside of the zone of influence of the sampler(s) if the sample site requires wading. Water and sediments can be entrained by the movement of the sampler. 3. Avoid disturbance of the bed of the waterbody and other materials (e.g. plants, benthic algae) in the waterbody.
C.	<p>After bacteria, metals, and petroleum hydrocarbons are sampled, assess water quality variation in situ for the area identified in Step 1 above by gently moving probe to different areas of the waterbody over at least a minute, after the equipment has acclimated and stabilized.</p> <ol style="list-style-type: none"> 1. Measure in situ parameters at representative location. 2. If a representative location cannot be found, mark data and collected samples in field book as suspect due to non-representative water quality. <ol style="list-style-type: none"> a. Consider discarding previously collected samples. If so, record in field book with reason discarded and place a large "X" on the sample bottle label. b. If samples retained for analysis, record the sample as suspect and why in the field book and transcribe same information to laboratory results when available. c. Measure and record water quality and mark data as suspect because not representative in the field book. d. Consider not sampling nutrients. <ul style="list-style-type: none"> • If do not sample, record in field book with reason. • If do sample, record the sample as suspect and why in the field book and transcribe same information to laboratory results when available. 3. If a different area than was sampled for bacteria, metals, or petroleum hydrocarbons is found to be representative (i.e., it is likely that bacteria, metals, or petroleum hydrocarbon sample location(s) were not representative): <ol style="list-style-type: none"> a. Consider discarding previously collected samples. If so, record in field book with reason and place a large "X" on the sample bottle label. b. If samples retained for analysis, record the sample as suspect and why in the field book and transcribe same information to laboratory results when available.

c. Consider resampling for bacteria, metals, or petroleum hydrocarbons if feasible.

Table 9. Description of use of sampling wand or hands for sample collection and measurement.

Surface Water Sampling Use of Wand or Hands for Sample Collection and Measurement Description

Use sample wand for sample collection and probe placement unless impractical or unsafe.

A. Laboratory sample collection with a wand.

1. Do not rinse sample bottle unless specifically instructed to do so by the laboratory.
2. Rinse portion of wand to be submerged with distilled or deionized (DI) water prior to first use in the waterbody if able to do so without letting any of this water enter the waterbody.
3. Attach capped sample bottle to wand. Top of sample container should be at least several inches upstream/upgradient of every part of the sample wand (i.e., no sample water will touch any part of the wand before flowing into the container).
4. Select representative location based on previous experience and visual assessment to collect sample.
5. Determine the route of the sample container through the waterbody. Avoid areas where water column disturbance from prior sample collection and/or measurement may persist.
6. Label closed (never opened) and undamaged laboratory supplied sample containers with sample site identifier, date, time, analysis, and agency collecting the sample.
7. Open sample container. Do not place bottle or cap on ground and do not touch or allow any foreign materials to come into contact with bottle opening or threads, or the inside of the bottle cap.
8. Vertically* dip the sample bottle, opening first, into the water column and then in one motion, rotate the bottle in the direction of the current (upstream) or in the direction of bottle movement in still waters, so that trapped air can escape as the bottle fills in an upstream/upgradient arc. Bottle should be no deeper than six (6) inches below the water surface for bacteria and within the upper foot for other laboratory samples (except for nutrients if upper strata is targeted).
 - a. Ensure that bottle opening is always upstream/upgradient of wand (or hand for Procedure D below).
9. Continue the motion until bottle is nearly full then rotate the bottle to remove it vertically from the waterbody. If preservative is in the bottle, ensure that bottle is not overfilled.
10. If sample collected successfully, cap bottle and place upright in cooler with ice. If cannot be placed on ice immediately after collection, place bottle in sheltered area out of direct sunlight and place in cooler within a few minutes. Record sample collection in field book and on chain of custody form.
11. If sample not collected successfully, place an "X" on the label and collect another sample. Do not collect sample from waters that were disturbed during collection of the unsuccessful sample.
12. Always sample bacteria first, and metals and hydrocarbons before nutrients.

B. Non-laboratory sample collection with a wand.

1. Rinse sample container, cap, and threads with distilled or deionized water once and twice with sample water. Empty water through any ports in cap (dedicated pH container and cap) and loosely fitted cap to rinse threads.
2. Follow steps 2-8 of "A. Laboratory sample collection with a wand" above.
3. Continue the motion until three bottle volumes replaced then rotate the bottle to remove it vertically from the waterbody.
4. If sample collected successfully, cap bottle and place in a sheltered area where sampler can perform measurements immediately.
5. If sample not collected successfully, empty contents of the bottle, clean and rinse the bottle if necessary, and collect another sample. Do not collect sample from waters that were disturbed during collection of the unsuccessful sample.

C. Probe placement with a wand

1. Select representative location based on previous experience and visual assessment to collect sample.
2. Turn on meter, check for proper function.
3. Rinse portion of wand that may be submerged and probe with distilled or deionized water.
4. Suspend rinsed probe by cable below end of wand a sufficient distance to allow the probe to go from the surface of the waterbody to the bottom without immersing the wand.
 - a. At sites where this is not likely (i.e., conditions are such that the probe needs to be held in position, it cannot remain in the proper location by hanging from the wand), the probe must be placed so that it is at least several inches upstream or upgradient of the wand when measurements are performed.
 - b. Submergence and subsequent movement of the wand is done carefully to avoid disturbance to the waterbody.

5. Lower probe into waterbody, evaluate variability, and perform measurements while keeping wand out of waterbody, if possible.
 - a. Move probe gently and carefully through waterbody to minimize disturbance of the water column and not contact the bed or otherwise disturb the waterbody.
 - b. If the wand is lowered into the waterbody, evaluate for influence of the wand and record in field book if detected. If possible, sample a different representative location at the sample site. If water quality influences detected and cannot be avoided, record in log and label data as suspect due to influence of the wand.

D. Laboratory sample collection by hand (without a wand).

1. Do not rinse sample bottle unless specifically instructed to do so by the laboratory.
2. Rinse hands with distilled or deionized water and dry. For bacteria samples, wear gloves.
3. Hold capped sample bottle near base with hand.
4. Follow steps 4-12 of "A. Laboratory sample collection with a wand above"

E. Non-laboratory sample collection by hand (without a wand).

1. Rinse sample container, cap, and threads with distilled or deionized water once and twice with sample water. Empty rinse water through ports and loosely fitted cap to rinse threads.
2. Rinse hands with distilled or deionized water and dry. For bacteria samples, wear gloves.
3. Hold capped sample bottle near base with hand.
4. Follow steps 4-8 of "A. Laboratory sample collection by hand (without a wand)" above.
5. Continue the motion until three bottle volumes replaced then rotate the bottle to remove it vertically from the waterbody.
6. If sample collected successfully, cap bottle and place where can sample perform measurement immediately.
7. If sample not collected successfully, empty contents of the bottle, clean and rinse the bottle if necessary, and collect another sample. Do not collect sample from waters that were disturbed during collection of the unsuccessful sample.

F. Probe placement by hand (without a wand).

1. Select representative location based on previous experience and visual assessment to collect sample.
2. Turn on meter, check for proper function.
3. Suspend rinsed probe by cable so that the probe can go from the surface of the waterbody to the bottom without immersing the sampler's hand and/or arm.
 - a. At sites where this is not likely (i.e., conditions are such that the probe needs to be held in position, it cannot remain in the proper location without be held at or near the probe), the probe must be placed so that it is at least several inches upstream or upgradient of the samplers' hand and arm when measurements are performed.
 - b. Submergence and subsequent movement of the samplers' hand and arm is done carefully to avoid disturbance to the waterbody.
4. Lower probe into waterbody, evaluate variability, and perform measurement while keeping hand and arm out of waterbody, if possible.
5. Move probe gently and carefully through waterbody, minimize disturbance of the water column and do not contact the bed or otherwise disturb the waterbody.

G. Sample collection in extremely shallow waters. If the water at a sample site is too shallow to fully immerse a sample bottle, document in field book and use one of the following approaches, while minimizing disturbance of the bottom of the watercourse. Do not allow water that has potentially or actually contacted the bottle and/or that has flowed past the bottle opening to enter the bottle. When filling the bottle, be careful to not create a wave at the container opening that can bring water from downstream of the opening back to the opening, and also to not entrain bottom materials in the vicinity of the bottle opening.

1. For still waters, fill the bottle carefully by moving it slowly, opening-first, into the waterbody, and then slowly moving it so that the bottle fills (and ideally overflow rinses for non-laboratory samples). Only water that has not been disturbed by the sampling is collected. Disturbed water includes water that has come into contact with the sample bottle. Do not stop movement of the bottle during filling (unless the bottle can be filled only with water that cannot actually or potentially come into contact with the outside of the bottle prior to entering the bottle).
2. For moving waters, fill the bottle by carefully placing the bottle, opening first and pointed upstream, into the

waterbody and then lowering the bottom of the bottle so that the bottle can fill. Depending upon the flow, the bottle can remain stationary or be moved upstream.

3. Document in field log that sample suspect because water is too shallow to fully submerge sample bottle and properly collect sample.

Table 10. Ground water sample sequence and methods to obtain representative measurements.

Ground Water Sampling Description
<ol style="list-style-type: none">1. Determine pump status at sample site.<ol style="list-style-type: none">a. If pump is on, collect water quality samples prior to measuring water level.b. If pump is off, measure water level prior to collecting water quality information. Nonpumping water levels are preferred. <u>* If bacteria samples are collected, they must be collected before water level measurement.</u>2. Water quality sample collection.<ol style="list-style-type: none">a. Flush source from designated tap.b. For active wells adequate flushing is determined by stabilization of the temperature or three minutes, whichever is longer.c. For wells not pumped regularly, at least three casing volumes must be pumped prior to sample collection.d. Where well production is inadequate to flush the source as described above, flush source as much as possible and note sampling conditions in field log. Record data as suspect due to potentially incomplete flushing.e. For non-laboratory samples, use dedicated ground water hose for sample collection where possible. Note if well owner hose used in field log. <u>Do not use hose for collection of samples delivered to the contracted laboratory.</u> See procedure 6 “Laboratory samples” below.3. Record pump rate and totalizer from meter at time water quality sample collect.<ol style="list-style-type: none">a. If well is not pumping, record pump status and totalizer from meter at time of water level measurement.b. Monitor pumping rate if conducting pumping water level measurement. If different than that recorded for water quality sample collection, record pump rate and totalizer at time of water level measurement.4. Water level measurement<ol style="list-style-type: none">a. Do not measure water levels unless measurements can be performed safely.b. Use access tube if present.<ol style="list-style-type: none">i. If access tube is present and not used, note in field book and mark data as suspect because access tube not used.c. Measure water level at least twice.<ol style="list-style-type: none">i. If the two water level measurements are equal, no further measurements are required.ii. If the two water level measurements are not equal, measure water level a third time.iii. If water level is going to be measured regularly over a relatively short time period (5 to 30 minutes) at a well, and the pumping regime does not change, each water level measurement during that time does not have to be repeated two or three times.d. If pump is on during measurement, record pump rate and totalizer from the meter at the time of water level measurement.5. Always record pump rate and totalizer value at metered wells.6. Laboratory samples: Laboratory samples may be collected before or after other water quality measurement (and before water level measurement), but must occur after the source has been flushed<ol style="list-style-type: none">a. Remove hose and sterilize tap with bleach or propane torch*.b. Flush source again for at least one minute or as long as necessary to remove bleach. Wait several minutes

and, without touching tap or causing splashing of the tap, collect some water and determine if there is a bleach odor by waving air with hand from over bottle toward sampler's nose. Nose is not over bottle but is close to bottle. If no odor is present, allow tap to flush for one more minute before collecting sample.

- c. Label closed (never opened) and undamaged laboratory supplied sample containers with sample site identifier, date, time, analysis, and agency collecting the sample.
- d. Open bacteria sample container. Do not place bottle or cap on ground and do not touch or allow any foreign materials to come into contact with bottle opening or threads, or the inside of the bottle cap.
- e. Fill bottle to nearly full (approximately the shoulder of the bottle, or to the graduation near the top).
- f. If sample collected successfully, cap bottle and place upright in cooler with ice*. If cannot be placed on ice immediately after collection, place bottle in sheltered area out of direct sunlight and place in cooler within a few minutes. Record sample collection in field book and on chain of custody form.
- g. If sample not collected successfully, place an "X" on the label and collect another sample starting with Step 1 or 6 above, depending upon what went wrong. Record sample collection in field book and on chain of custody forms.
- h. Return tap to configuration prior to sample collection.

* **For chloride laboratory samples**, sterilization and storage with ice are not necessary. Absolutely, do not sterilize with bleach, unless complete removal of bleach can be verified prior to sample collection.

10.1.7. Use of New Equipment

When new equipment is purchased for use in the water quality monitoring program, the new equipment is used side-by-side with the existing equipment until the relationship between the results of each instrument can be established. However, this is not possible where new equipment replaces instruments that can no longer be used. All changes in equipment are recorded in the field log. Assessment of the relationship between each instrument is based to the extent possible on the results of side-by-side calibrations, field measurements, and QC activities.

10.1.8. Other Sampling

Other sampling not described in this QAPP may be conducted on an as-needed basis (e.g., follow-up sampling after a manure spill). In these instances, sampling methods will conform to the methods and QC activities specified in this document, or stricter methods, if necessary. Sampling may or may not occur at established sample sites. When sampling at new sample sites, the site location is recorded in the field log so that the sites can be re-visited and incorporated into the Geographical Information System (GIS) coverage of sample sites. Sample site identifiers for this type of sample site are the number “99” followed by a letter in alphabetical order starting with “A” for the first sample collected that day. If the same sample sites are sampled again as part of the same event (e.g., spill response), the same sample site identifier is used for each sample site for the duration of the event.

10.2. Parameter Specific Sampling Methods

In this section, parameter specific sampling methods are described. Lists of supplies to conduct sampling for each parameter include materials for all QC activities and calibrations. Except for turbidity, primary standards are not transported into the field. The needed supplies are stored securely in a locked cabinet and brought on the sampling run to minimize the time required to perform troubleshooting as part of any corrective actions.

10.2.1. Air Temperature

Air temperature is measured with a hand-held non-mercury liquid-in-glass thermometer. Air temperature is measured at a representative location in the immediate vicinity of the sample site.

The Water Resources Department owns three air temperature thermometers. Air temperature is not a critical measurement.

The equipment required to measure air temperature is listed in Table 11. The methods of air temperature measurement are described in Table 12. Table 6 contains summary information for air temperature measurement and Section 11.1 describes QC activities, equipment use, and maintenance.

Table 11. Equipment required to measure air temperature.

Supplies
<ul style="list-style-type: none">• Two (2) hand-held non-mercury liquid-in-glass thermometers (one spare).• Distilled or deionized water (for cleaning, if necessary)• NIST traceable reference thermometer in armor and in protective case.• Lint-free towels• Mild detergent (e.g., Alconox)• Sampling methods table and QC activity table

Table 12. Air temperature measurement using hand-held non-mercury liquid-in-glass thermometers.

Determination of Representative Air Measurement Location	Parameter Measurement	Acclimation/stabilization criteria	Problems/Corrective Actions
<ol style="list-style-type: none"> 1. Select representative location based on previous experience and assessment of representative climate at sample site. 2. Securely place dry and undamaged thermometer in a sheltered location several feet off the ground soon after arriving at the sample site. 3. Perform measurement at or near the end of the time at an individual site. 4. Dry thermometer and place in case. 	<p>Measure the temperature over a one-minute period.</p> <p>If <u>temperature not variable</u>, record temperature.</p> <p>If <u>temperature variable</u>, record average, range, and trend if present.</p>	<p>Temperature N/A</p>	<p>If equipment not functioning properly, discontinue measurement and take corrective actions. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. Record problem, corrective actions, and outcomes/resolutions in the field book.</p> <p>Identify and document suspect data as a result of equipment problems in field book.</p>

10.2.2. Specific Conductivity, Salinity, Water Temperature (WTW and YSI Meters)

The specific conductivity, salinity, and water temperature parameters are grouped because they are measured with one instrument at a sample site. Either a WTW LF 330 with TetraCon 325 probe (WTW) or a Yellow Springs Instruments (YSI) S-C-T Model 30 meter and probe (YSI probe is permanently attached to the YSI meter) are used to measure specific conductivity, salinity, and temperature in surface waters. The manufacturers’ instructions are followed for the respective meters. The Water Resources Division owns one YSI S-C-T Model 30 meter. A WTW LF 330 meter with a TetraCon 325 Probe and a YSI S-C-T Model 30 meter are available to the Water Resources Division from the Stock Assessment and Habitat Restoration divisions of the Lummi Natural Resources Department. Certified NIST traceable standards are used for non-zero calibration checks and equipment calibration.

The equipment required to measure specific conductivity, salinity, and water temperature is listed in Table 13. The method of sampling and measurement is described for surface water in Table 14 and for ground water in Table 15. Surface water should only be measured in a container when it is unsafe or impractical to perform in situ measurements. Container-based measurements are performed at the sample site and water samples are not retained for later analysis. Table 6 contains summary information for specific conductivity, salinity, and water temperature measurements and Section 11.2 describes QC activities, equipment use, and maintenance for the WTW LF 330 with TetraCon 325 probe (WTW) or a YSI S-C-T Model 30 meter and probe.

Table 13. Equipment required to measure specific conductivity, salinity, and water temperature.

Supplies
<ul style="list-style-type: none"> • User-Calibrated WTW LF 330 with TetraCon 325 probe or a Manufacturer calibrated YSI S-C-T Model 30 meter and probe • Bottle for probe storage (for WTW) • Fresh (not expired and unopened) 1,000 µS/cm certified NIST traceable standard • Fresh (not expired and unopened) 10,000 µS/cm certified NIST traceable standard • Fresh (not expired) 1,413 µS/cm certified NIST traceable single-use calibration standard • NIST traceable reference thermometer in armor and in protective case. • Distilled or deionized water • Two (2) dedicated one-liter wide-mouth plastic bottles for surface water or ground water sampling • Sample wand (surface water) • Dedicated ground water hose (ground water) • Mild detergent (e.g., Alconox) • Complete set of replacement batteries • Copy of equipment manual • Sampling methods tables and QC activity tables

Table 14. Surface water specific conductivity, salinity, and temperature measurements using either the WTW LF 330 meter with TetraCon 325 Probe or YSI S-C-T Model 30 meter and probe.

Determination of Representative Surface Water Measurement Location	Parameter Measurement	Acclimation/stabilization criteria	Problems/Corrective Actions
<p>In situ measurement:</p> <ol style="list-style-type: none"> Select representative location based on previous experience and visual assessment Turn on meter, check for proper function Rinse probe with DI water Place probe in representative portion of waterbody using sampling wand unless unsafe or impractical. Take care to minimize disturbance of the water when placing the probe and moving it in the water. Allow probe to acclimate/stabilize (no less than 60 seconds) If probe does not acclimate and/or stabilize at one location, determine if the environment, operator, and/or equipment is the reason. Take corrective actions if operator equipment is responsible for variation. If environment is variable, continue. Evaluate water quality variation of sampling area, determine if water body stratified based on salinity, ensure sampling representative area. If cannot sample representative area, document in field book and mark recorded results as suspect because site not representative. Perform measurement (described in next column). Rinse probe with DI water and store in DI water in a sheltered location out of direct sunlight. <p>Container based measurement:</p> <ol style="list-style-type: none"> Collect sample into dedicated surface water sample bottle using the procedure for “Non-laboratory sample collection with a wand” from Table 9 above. Follow steps 1-10 above, except replace step 4 with: Rinse probe once with distilled or DI water and twice with sample water. Insert probe into container, gently swirl probe but do not let rest on bottom or sides of container. 	<p>Measure and record temperature, salinity, and specific conductivity as described below. Stratification refers to salinity-based stratification.</p> <p>If water column is <u>not stratified</u> and measurement results are <u>within</u> acclimation/stabilization criteria.</p> <ul style="list-style-type: none"> Record the average of the last five (5) values in the field book. <p>If water column is <u>not stratified</u> and measurement results are <u>not within</u> acclimation/stabilization criteria due to variation of sample water.</p> <ul style="list-style-type: none"> Record the average and the range of the last five (5) values in the field book. If a trend is apparent, document in field book. Also record apparent and/or suspected causes of variation. <p>If water column is <u>stratified</u> and measurement results are <u>within</u> acclimation/stabilization criteria.</p> <ul style="list-style-type: none"> Record average of the last five (5) values in the field book for each strata. <p>If water column is <u>stratified</u> and measurement results are <u>not within</u> acclimation/stabilization criteria due to variation of sample water.*</p> <ul style="list-style-type: none"> Record the average and the range of the last five (5) values for each strata in the field book. If a trend is apparent, document in field book. Also record apparent and/or suspected causes of variation. <p>* Where salinity and specific conductivity are variable and the variation is predominantly vertical, measure the top and/or bottom strata as follows:</p> <ul style="list-style-type: none"> Top stratum, measure as close to the surface as practical. Bottom stratum, measure as close the bottom as practical without disturbing bed and avoid depressions and other areas in the bed where pockets of isolated water may occur. Record results and measurement locations near top and bottom in the field book. 	<p>Specific Conductivity Values within 3% range</p> <p>Salinity Values within 0.2 ppt range</p> <p>Temperature Values within 0.2 °C range.</p>	<p>If water quality values will not stabilize, determine if environment, operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. If problem not caused by environment, discontinue measurement until problem resolved and clearly mark sample run data collected up to time of problem as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.</p> <p>For container-based measurement: If temperature changing in one direction by more than 0.2°C (coming into equilibrium with atmospheric conditions), discard sample, repeat sample collection, and perform measurement before temperature changes more than 0.2 °C. If not possible to measure without small temperature change, perform measurement and flag data as suspect because of temperature change.</p>

Table 15. Ground water container-based specific conductivity, salinity, and temperature measurements using either the WTW LF 330 meter with TetraCon 325 Probe or YSI S-C-T Model 30 meter and probe.

Collection of Representative Ground Water Sample in Container	Parameter Measurement	Acclimation/ stabilization criteria	Problems/Corrective Actions
<ol style="list-style-type: none"> 1. Flush sample source for at least three minutes or until temperature stabilizes for regularly pumped wells (i.e., water supply wells). If the well is not regularly pumped, flush at least three casing volumes from the well. Use dedicated ground water hose where possible. 2. Rinse clean 1-L wide-mouth plastic sample container, threads, and cap once with DI water and twice with sample water. Empty rinse water through loosely fitted cap to rinse threads. Use only dedicated ground water sample bottles (labeled). 3. Fill the bottle so that it overflows and three bottle volumes of sample water have passed through the bottle. 4. Cap bottle and place in sheltered area to allow for measurement of sample water. 5. Turn on equipment, check for proper function 6. Rinse probe with DI water once and sample water twice. 7. Insert probe into container, gently swirl probe but do not let rest on bottom or sides of container. 8. Allow probe to acclimate and readings stabilize (no less than 60 seconds). 9. If probe does not acclimate and/or stabilize, take corrective actions and discontinue measurement until problem remedied. 10. Perform measurement (described in next column). 11. Rinse probe with DI water and store in DI water in a sheltered location out of direct sunlight. 	<p>Measure and record temperature and specific conductivity as described below.</p> <p>If measurement results are <u>within</u> acclimation/ stabilization criteria.</p> <ul style="list-style-type: none"> • Measure and record the average of the last five (5) stabilized values in the field book. <p>If measurement results are <u>not within</u> acclimation/ stabilization criteria due to variation of sample water <u>and the sample water is representative</u>.</p> <ul style="list-style-type: none"> • Record the average and the range of the last five (5) values in the field book. Record apparent and/or suspected causes of variation. 	<p>Specific Conductivity Values within 3% range</p> <p>Temperature Values within 0.2 °C range.</p>	<p>If water quality values will not stabilize, determine if sample water, operator error, and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark sample run data collected up to time of problem as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.</p>

10.2.3. Chloride

Chloride is measured using a direct-titrating Lamotte test kit, Model PSC-DR, Code 4503-DR. The test kit is used following the manufacturer's instructions. Chloride is measured in ground water and the analysis (titration) is typically not performed at the sample site. The titrations are usually performed at the end of the sample run. Dedicated 500-ml wide-mouth plastic bottles are used for chloride analysis. The date and sample identifier are recorded on waterproof label tape affixed to the bottle. If more than one sample is collected from a sample site in one day, the time of sample collection is also recorded on the bottle. Samples are securely stored between sample collection and measurement, and samples are not discarded until all of the QC activities associated with chloride analysis are performed and within acceptance criteria. If samples are not analyzed on the day collected, they are measured within 24 to 48 hours. The chloride sample inventory is checked weekly and chloride samples are analyzed within the 28-day holding time.

- When chloride analysis are not performed as part of the sample run, the results of the analysis are recorded in two places in the field book when they are performed. Stored samples in bottles are analyzed and the chloride results are recorded in the field book following format shown for Chloride QC activities in Appendix A on the day the analysis is performed. The results are then transcribed to the appropriate row and column for the date, time, and location that the chloride sample was collected. Any QC or other information affecting the result is recorded in both places.

The equipment required to sample and analyze chloride is listed in Table 16. The method of chloride sampling and measurement is described in Table 17. Table 6 contains summary information for chloride measurement and Section 11.3 describes QC activities, equipment use, and maintenance. Certified NIST traceable material is used with Class A glassware to prepare the 100 mg/l chloride standard.

The chloride waste is collected in a labeled (contents and date) and dedicated container and taken to a Hazardous Materials Disposal Site (which currently is Hazardous Waste Disposal in Bellingham, WA).

Table 16. Equipment required to measure chloride.

Supplies
<ul style="list-style-type: none">• Two (2) fresh Lamotte Chloride test kits (Model PSC-DR, Code 4503-DR). One kit is for backup and should be unopened. The kit intended for use should have sufficient reagents to perform chloride analysis on all samples collected. Each kit contains:• 15 ml of Chloride Reagent #1 (4504-E)• 60 ml of Chloride Reagent #2 (4505DR-H)• 15 ml of Phenolphthalein Indicator, 1% (2246-E)• 15 ml of Sulfuric Acid, 0.5N (6090-E)• 1 15-ml glass Titration Tube (0771)• 1 Direct Reading Titrator, 0-200 (0382)• Distilled or deionized water• Lint-free towels• Sufficient dedicated 500-ml plastic bottles to perform run, with a few extras• Chloride waste container• Label tape• Ground water hose• Fresh (not expired and within shelf life after opened) 1,000-mg/l certified NIST traceable chloride standard• Class A 20-ml volumetric pipette.• Class A 200-ml volumetric flask with stopper• Pipette pump• 50-ml beaker• Protective cover for 200-ml flask• Mild detergent (e.g., Alconox)• Safety goggles and gloves• Copy of manual for use of kit• Sampling methods table and QC activity table

Table 17. Ground water chloride sampling and measurement with a Lamotte Chloride test kits (Model PSC-DR, Code 4503-DR).

Collection of Representative Ground Water Sample in Container	Parameter Measurement	Acclimation/ Stabilization criteria	Problems/Corrective Actions
<ol style="list-style-type: none"> 1. Flush sample source for at least three minutes or until temperature stabilizes for regularly pumped wells (i.e., water supply wells). If the well is not regularly pumped, flush at least three casing volumes from the well. Use dedicated ground water hose where possible. 2. Rinse clean 500-ml wide-mouth plastic sample container, threads, and cap once with DI water and twice with sample water. Empty rinse water through loosely fitted cap to rinse threads. Use only dedicated chloride sample bottles (bottle labeled for ground water use). 3. Cross out all other sample identifiers on label or replace label tape. 4. Fill the bottle so that it overflows and three bottle volumes of sample water have passed through the bottle. 5. Label bottle with well name and/or number and date of collection. If more than one sample is collected at a sample site in one day, also record time of sample collection and label accordingly. 6. Cap bottle and securely store. 	<p>Measure and record chloride level as described below. Store all glassware on clean and dry lint-free towels when not in use. Note that the titrator is marked in units that are the equivalent of parts per million (ppm), which are the units used by the manufacturer (one ppm equals one mg/l of liquid).</p> <ol style="list-style-type: none"> 1. Rinse clean test tube and cap (not threaded, snap on) with DI once and sample water twice. 2. Overfill the test tube with three volumes of sample water and then pour off water until water level is at 15-ml index mark on test tube. <ul style="list-style-type: none"> • Additional water may be added from 500-ml sample bottle if necessary. • The bottom of the meniscus should align with the index mark. • Eliminate parallax error by rotating test tube until index mark can be lined up on itself and the closer portion of the mark hides the further portion of the index mark. 3. Add one drop of Phenolphthalein Indicator. If solution turns pink, add Sulfuric Acid one drop at a time, mixing after each drop, until pink color disappears. 4. Add 3 drops of Chloride Reagent #1. Cap and swirl to mix. Solution will turn yellow. 5. Fill the titrator to the zero mark with Chloride Reagent #2, rinse the tip with DI water, and then purge at least 20 ppm indicated Chloride Reagent #2 a half-graduation volume of liquid from the titrator and then refill the titrator to the zero mark. Each minor graduation on the titrator represents 4 ppm chloride. Discard purged material into chloride waste container. <ul style="list-style-type: none"> • Purge air bubbles from titrator when purging the liquid. 6. Use a white background when performing chloride titrations. Place titrator in cap of test tube and titrate sample until water turns from yellow to a light orange. Titrant is typically added in half-graduation increments of titrator volumes. This minor graduations on this Lamotte titrator were made to represent 4 ppm chloride. Using this relationship, record chloride concentration of sample in field book. <ul style="list-style-type: none"> • If dark orange is obtained, the endpoint has been overshoot. Record result and label as suspect due to color in the field book. Discard sample and start over with Step 1 above. 7. Discard analyzed sample into the chloride waste container. 8. Rinse the test tube with a small amount of DI water and discard of rinsate into chloride waste container. 9. Rinse test tube once with DI water and store upside down on lint-free towel for next measurement or dry with lint-free towel and place into kit if analysis is done. 10. Purge about a half-graduation volume of liquid from the titrator into the chloride waste container, rinse tip of titrator with DI water into chloride waste container, dry the tip, and place on lint-free towel for next measurement, or purge completely into chloride waste container and store in kit if analysis is done. 11. Do not discard chloride samples until all QC activities are completed for chloride analysis and all are within performance criteria. 	<p>Color: Endpoint color is light orange.</p> <p>General: No problems encountered during titration.</p>	<p>If endpoint color is not light orange, redo measurement. If that does not solve problem, determine if sample water, operator error, and/or equipment malfunction is the problem. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark sample run data collected up to time of problem as suspect, and why the data are suspect in the field book.</p> <p>If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.</p> <p>Securely store all chloride samples (both analyzed and not) until problem remedied. If measurement is unlikely to resume within 28 days of the collection of the oldest chloride sample, send samples to certified laboratory for analysis prior to expiration of holding time, using labels supplied by laboratory and chain-of-custody forms. Track and document sample container holding and transport in field book.</p>

10.2.4. Current and Flow Direction

The direction of the current or flow is based on a visual assessment of the waterbody at the sample site. No equipment is required. Table 18 lists the methods for determining and recording flow or current direction. Flow direction is measured in confined channels (e.g., Lummi River) and current direction is used for open waters (e.g., Portage Bay). There are no QC activities for this sampling method. Instead, the site is observed for the duration of time spent at the sample site and variation recorded.

Current direction is a visual observation of the flow direction in channel and open waters. When recording compass directions in open waters, the sampler records the direction abbreviation in capital letters preceded by a “from” or “to” as appropriate. If no current is evident, the sampler records “none evident” or “none” for that site. If the site is near the intersection of another waterbody (e.g., site 39), the sampler notes if water is flowing into or from the adjacent waterbody.

Table 18. Current and Flow direction measurement methods.

Collection of Representative Surface Water Sample in Container	Parameter Measurement	Acclimation/stabilization criteria	Problems/Corrective Actions
<ol style="list-style-type: none"> 1. When arrive at site and perform assessment for representativeness, note current/flow direction. 2. Observe current/flow direction while at sample site performing other measurements. <ul style="list-style-type: none"> ● Observe position and/or movement of plants or other submerged vegetation, air bubbles, sediment plumes, and other debris. ● For wading sites, take care to minimize water column disturbance and actively evaluate for water entrained by sampler. Avoid areas disturbed by the sampler to determine current direction. 3. At end of sampling at a site, record flow direction and variation, if present. 	<p>In channels:</p> <ul style="list-style-type: none"> ● Record flow as “downstream” or “ds” if flow is in downstream direction. ● Record flow as “upstream” or “us” if flow is in upstream direction. ● Record flow as “none evident” or “none” if flow is not evident. <p>In open waters:</p> <ul style="list-style-type: none"> ● Record direction of current as “from” one of the following eight points on the compass: North (N), Northeast (NE), East (E), Southeast (SE), South (S), Southwest (SW), West (W), Northwest (NW). ● Record current as “none evident” or “none” if flow is not evident. 	<p>N/A</p>	<p>N/A</p>

10.2.5. Dissolved Oxygen

Dissolved oxygen is measured in surface waters using either an Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter (DO meters). Dissolved oxygen is measured in surface waters in situ unless in situ measurements are unsafe or impractical. The Lummi Water Resources Department owns one of each of the two meters listed. Certified NIST traceable zero dissolved oxygen solutions are used for zero value calibration checks. After use, the zero dissolved oxygen solution is collected in a labeled (contents and date) and dedicated container, securely stored, and transported to a Hazardous Materials Disposal Site (which currently is Hazardous Waste Disposal in Bellingham, WA). Dissolved oxygen is measured after salinity.

The equipment required to measure dissolved oxygen is listed in Table 19. The methods of dissolved oxygen sampling and measurement are described in Table 20. Table 6 contains summary information for dissolved oxygen measurements and Section 11.5 describes dissolved oxygen QC activities, equipment use, and maintenance.

Table 19. Equipment required to measure dissolved oxygen.

Supplies
<ul style="list-style-type: none">• Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter.<ul style="list-style-type: none">◦ Meter is calibrated at beginning of sample run.• Small flat head screwdriver• Humidity information (www.kirotv.com/pinpointweather/index.html and www.outsideconnection.com).• Distilled or deionized water• Fresh (not-expired and within shelf life if opened) certified NIST traceable zero dissolved oxygen standard sufficient for QC activities and corrective actions (if single use packages are used, bring at least six).• Lint-free towels• Sample wand• Two (2) one-liter wide-mouth plastic bottle dedicated to surface water sampling• Mild detergent (e.g., Alconox)• Complete set of replacement batteries for the meter• Copy of manual for equipment• Sampling methods table and QC activity table
<p>Note: Supplies for changing membrane are not included because the meter cannot be used for at least several hours after the membrane has been changed.</p>

Table 20. Surface water dissolved oxygen measurements using either the Oxyguard Handy Mk III Portable Dissolved Oxygen Meter or an Oxyguard Handy Gamma Portable Dissolved Oxygen Meter.

Determination of Representative Surface Water Measurement Location	Parameter Measurement	Acclimation/ stabilization criteria	Problems/Corrective Actions
<p>In Situ Measurement:</p> <ol style="list-style-type: none"> Select representative location based on previous experience and visual assessment. Turn on meter, check for proper function. Adjust salinity to measured value (salinity needs to be measured before dissolved oxygen). Rinse probe with DI water. Place probe in representative portion of waterbody using sampling wand unless unsafe or impractical. Take care to minimize disturbance of the water when placing the probe and moving it in the water. Gently move probe slowly through water if water is not moving. Allow probe to acclimate/stabilize (no less than 60 seconds). If probe does not acclimate and/or stabilize at one location, determine if the environment, operator, and/or equipment is the source. Take corrective actions if operator or equipment is responsible for variation. If environment is variable, continue. Evaluate water quality variation of sampling area to ensure sampling representative area. If cannot sample representative area, document in field book and mark recorded results as suspect because site not representative. Perform measurement (described in next column). Rinse probe with DI water and store in a sheltered location out of direct sunlight. <p>Container based measurement:</p> <ol style="list-style-type: none"> Collect sample into dedicated surface water sample bottle using the procedure for “Non-laboratory sample collection with a wand” from Table 9 above. Follow steps 1-10 above, except replace step 5 with: Rinse probe with distilled or DI water once and sample water twice. Insert probe into container, gently swirl probe but do not rest on bottom or sides of container. Mark data as suspect because collected in a container 	<p>Measure and record dissolved oxygen as described below. Record both concentration and percent saturation. Stratification refers to salinity-based stratification.</p> <p>If water column is <u>not stratified</u> and measurement results are <u>within</u> acclimation/stabilization criteria</p> <ul style="list-style-type: none"> Record the average of the last five values in the field book. <p>If water column is <u>not stratified</u> and measurement results are <u>not within</u> acclimation/stabilization criteria due to variation of sample water.</p> <ul style="list-style-type: none"> Record the average and the range of the values in the field book. If a trend is apparent, document in field book. Also record apparent and/or suspected causes of variation. <p>If water column is <u>stratified</u> and measurement results are <u>within</u> acclimation/stabilization criteria.</p> <ul style="list-style-type: none"> Adjust the salinity to that of each strata and record average of the last five values in the field book for each strata. <p>If water column is <u>stratified</u> and measurement results are <u>not within</u> acclimation/stabilization criteria due to variation of sample water.*</p> <ul style="list-style-type: none"> Adjust the salinity to that of each strata, and record the average and the range of the values for each strata in the field book. If a trend is apparent, document in field book. Also record apparent and/or suspected causes of variation. <p>* Where salinity and specific conductivity are variable and the variation is predominantly vertical, measure the top and/or bottom strata as follows:</p> <ul style="list-style-type: none"> Top stratum, measure as close to the surface as practical. Bottom stratum, measure as close the bottom as practical without touching bed and avoid depressions and other areas in the bed where pockets of isolated water may occur. Record results and measurement locations near top and bottom in the field book. 	<p>Dissolved Oxygen Concentration: Values within 0.3 mg/l range</p> <p>Temperature: values within 0.2°C range.</p> <p>Note: Temperature is not recorded in the field book, it is used to help indicate probe acclimation.</p>	<p>Determine if operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark sample run data collected up to time of problem as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.</p> <p>Container-based measurement If temperature changes in one direction by more than 0.2°C (coming into equilibrium with atmospheric conditions), discard sample, repeat sample collection, and perform measurement before temperature changes more than 0.2 °C. If not possible to measure without small temperature change, perform measurement and flag data as suspect because of temperature change.</p>

10.2.6. Flow (Surface Water Discharge)

Surface water flow (discharge) measurements are made using a variety of techniques. Flow measurements in the surface water quality monitoring program are approximate quantifications and are not intended to be precise. Due to time constraints, current velocity meters (e.g., Price AA or Pigmy) are not used for flow measurement as part of the water quality monitoring program. Flow is only measured or estimated in confined channels.

The equipment required to measure flow is listed in Table 21. The methods of flow measurement are described in Table 22 for volumetric, Table 23 for neutral-buoyancy, and Table 24 for visual-assessment-based flow determinations. Two sample sites (29 and 31) also have staff gages. The water level on the staff gage is recorded for those sites as a comment and independent flow measurements may still occur at the two sites (independent flow measurements are made when practicable at Site 31). The method for measuring water level on staff gages is described in Table 25. Table 6 contains summary information for each flow measurement and Section 11.6 describes QC activities, equipment use, and maintenance.

The most accurate and feasible flow method is used at each site. If volumetric measurements are not feasible (i.e., there is not a free-fall of water), the neutral buoyancy method is used. Where there is not physical space to utilize the neutral buoyancy method, either the cross section is measured and flow rate visually estimated, or just the flow rate is visually estimated. Where present, staff gage levels are recorded immediately prior to the physical measurement/estimate of flow. Stage-discharge relations for these sites have been developed based on volumetric measurements of discharge.

Where surface waters discharge to marine waters, the fate of the water is recorded. Examples include:

- No flow across beach, water percolates into gravels within 2 ft. of culvert outlet
- Surface water discharge across beach.
- No flow at culvert outlet, emergence of water near shoreline on beach

Plan-view schematic maps drawn in the field book can be helpful to show surface flow conditions and where flow was sampled.

Table 21. Equipment required to measure flow.

Supplies
<ul style="list-style-type: none">• Stopwatch• Containers with marked known volumes (1-liter and 5-gallon total capacities)• Measuring tape (large open-reel type, not carpentry-type)• Ruler (generally three or more feet in length)• Neutral buoyancy objects• Squeegee (clean staff gage surface)• Shovel (create uniform channel on beach)• Mild detergent (e.g., Alconox)• Sampling methods table and QC activity table

Table 22. Volumetric flow measurement method.

Determination of Representative In Situ Surface Water Measurement Location	Parameter Measurement	Acclimation/stabilization criteria	Problems/Corrective Actions
<p>1. Evaluate sample site for free-fall of water where entire volume, or essentially all of flow can be captured in a container appropriately sized to flow.</p> <ul style="list-style-type: none"> ● If entire flow cannot be captured, consider neutral buoyancy method. 	<ol style="list-style-type: none"> 1. Using stopwatch, measure and record time to fill container to pre-determined volume marked on container. Check container for leaks. 2. Record time to fill volume and volume in field book as comment for sample site. <ul style="list-style-type: none"> ● Record estimated percentage of flow captured in container if do not capture entire flow. ● Use smaller containers for smaller flows, and larger container for larger flows. Fill container as full as possible, taking into consideration safety and ability to hold container in place. 3. Empty container and repeat step 2 more times (a total of three measurements). Use the same volume for all three measurements. 4. Record method of flow measurement and any factors that actually or potentially affected results (e.g., rapid filling of container made determination of precise water level very difficult). 	<p>Flow N/A</p>	<p>If equipment not functioning properly, discontinue measurement and take corrective actions. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. Record problem, corrective actions, and outcomes/resolutions in the field book. Identify and document suspect data as a result of equipment problems in field book.</p>

Table 23. Neutral buoyancy flow measurement method.

Determination of Representative In Situ Surface Water Measurement Location	Parameter Measurement	Acclimation/stabilization criteria	Problems/Corrective Actions
<p>1. Select area of uniform and suitable flow conditions and channel dimensions to measure flow.</p> <ul style="list-style-type: none"> ● If flow is across beach along Portage Bay shoreline, consider making channel in beach if feasible and conditions elsewhere are not suitable. 	<p>1. Measure and record average width and depth of channel, and length of channel used for velocity measurements as comment for sample site in field book.</p> <ul style="list-style-type: none"> ● If entire flow cannot be captured, estimate percentage of flow captured. <p>2. Using stopwatch, record time of neutral buoyancy object to travel specified length of channel. Repeat two more times (a total of three measurements).</p> <ul style="list-style-type: none"> ● A buoyant object may be used (i.e., small piece of foam) in shallow channels where the movement of neutral buoyancy objects would be hindered by the substrate and the travel of the buoyant object is not hindered by wind or other factors. <p>3. Record method of flow measurement and any factors that actually or potentially affected results (e.g., buoyant object used).</p>	<p>Flow N/A</p>	<p>If equipment not functioning properly, discontinue measurement and take corrective actions. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. Record problem, corrective actions, and outcomes/resolutions in the field book. Identify and document suspect data as a result of equipment problems in field book.</p>

Table 24. Visual Assessment flow measurement method.

Determination of Representative In Situ Surface Water Measurement Location	Parameter Measurement	Acclimation/stabilization criteria	Problems/Corrective Actions
<p>1. Select area of uniform and suitable flow conditions and channel dimensions to visually estimate flow.</p>	<p>If estimated flow is greater than an estimated three (3) gallons per minute (gpm):</p> <ol style="list-style-type: none"> 1. Measure and record average width and depth of channel as comment for sample site in field book. <ul style="list-style-type: none"> ● If entire flow not in a discrete channel, estimate percentage of flow captured (e.g., shallow flow across a beach in a reverse dendritic pattern with one primary distributary). 2. Record qualitative description of flow in field book for sample site. Terms used are near-still, very slow, slow, and fast. <p>If estimated flow is less than or equal to three (3) gpm*:</p> <ol style="list-style-type: none"> 1. Record estimate of flow as comment for sample site in field book that is either: <ul style="list-style-type: none"> ● An estimated five or more (5) minutes of flow needed to fill a one gallon milk jug. Record as “<<< 1 gpm.” ● An estimated one (1) to five (5) minutes of flow needed to fill a one gallon milk jug. Record as “<1 gpm.” ● An estimated twenty (20) seconds to one (1) minute of flow needed to fill one gallon milk jug. Record as “1-3 gpm.” ● No flow because site dry, isolated pools are present (no surface flow between pools), or for other waterbody conditions. Record as “no flow” with waterbody condition. 	<p>Flow N/A</p>	<p>N/A</p>

Table 25. Staff gage flow measurement method.

Determination of Representative In Situ Surface Water Measurement Location	Parameter Measurement	Acclimation/stabilization criteria	Problems/Corrective Actions
<ol style="list-style-type: none"> 1. Evaluate condition of staff gage, clean if necessary. <ul style="list-style-type: none"> ● Use caution to not move gage when cleaning area around staff gage and staff gage. 2. If gage damaged or otherwise not functioning properly, take corrective actions. 	<p>If water level <u>stable</u>:</p> <ol style="list-style-type: none"> 1. Measure and record water level indicated by the gage as comment for sample site in field book. <ul style="list-style-type: none"> ● Take measurement after water level has stabilized following cleaning. ● If there is ramping of water on the gage, record ramped water level, that there is ramping, and the amount in the field book. ● Record any other conditions that could affect water level. <p>If water level <u>not stable</u>:</p> <ol style="list-style-type: none"> 1. Measure and record average water level and range indicated by the gage as comment for sample site in field book. <ul style="list-style-type: none"> ● Record cause of water level variation. ● Record any other conditions that could affect water level. <p>If water level <u>below bottom of staff gage</u>:</p> <ol style="list-style-type: none"> 1. Record that water level below bottom of the gage as comment for sample site in field book. <ul style="list-style-type: none"> ● If practicable, measure and record distance between bottom of gage and water surface. ● Record any other conditions that could affect water level. 	<p>Flow N/A</p>	<p>If gage is damaged and/or not functioning properly, arrange for repairs or replacement of gage as soon as possible. The repairs or replacement need to occur the establishment of the accurate stage-discharge relationship. Document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved. Identify and document suspect data as a result of equipment problems in field book.</p>

10.2.7. Water Samples Collected for Analysis at a Laboratory

Laboratory samples are collected in containers prepared and provided by a laboratory following instructions provided by a laboratory certified by Washington State or the United States government (currently Avocet Environmental Testing, Inc., except for Washington Department of Health [DOH] sample sites). For laboratory analysis, fecal coliform, *E. coli*, enterococcus, nutrients, metals, and petroleum hydrocarbons are collected in surface waters and, occasionally, bacteria and chloride samples are collected from ground water. Other samples may be collected on an as-needed basis following instructions provided by the laboratory. The laboratory faxes and mails bacteria results to the Water Resources Specialist within two working days of sample delivery, and typically a fax with preliminary results arrives the next working day after sample delivery. Results of other requested analysis can be provided rapidly by the laboratory if needed.

The equipment required to collect laboratory samples is listed in Table 26 and the sampling method is described in Table 9 for surface water and Table 10 for ground. Please note that sampling methods in Table 9 and Table 10 are superseded by laboratory instructions if the laboratory instructions indicate a different method of sample collection. Table 6 contains summary information for laboratory methods and Section 11.7 describes QC activities, equipment use, and maintenance. Also note that rosolic acid is eliminated from the method for fecal coliform and *E. coli* to aid in the recovery of stressed organisms to reduce the bias of membrane filtration methods relative to multiple tube methods and obtain more accurate results. The DOH uses the multiple tube method.

Laboratory supplied bottles are inspected upon receipt from the laboratory and prominently marked with an “X” if the bottle cap is off or loose, or the cap or bottle is damaged. These bottles are either disposed of at the office if they are broken and do not contain hazardous materials, or they are returned to the laboratory. Laboratory supplied bottles are not rinsed prior to sample collection unless specifically indicated by the laboratory. All laboratory bottles are securely stored prior to and after use. After sample collection, sample bottles are stored upright in a cooler with ice with their lids screwed on tightly (unless instructions indicate otherwise or if only ground water chlorides are being collected) and packed to avoid breaking glass containers until delivery to the laboratory. The samplers avoid letting water from melting ice accumulate in the cooler. Samples shipped to the DOH Public Health Laboratory are packed with reusable ice blocks. Fecal coliform, *E. coli*, enterococcus, nutrients, metals, and petroleum hydrocarbon samples are delivered to the laboratory within 6 hours of sample collection (although on rare occasions, bacteria samples may be delivered to the laboratory after more than 6 hours have elapsed but before 24 hours have elapsed). If samples are not delivered to the laboratory within 6 hours of sample collection, it is recorded with the reason in the field log.

Samples must be collected successfully in order for the samples to be delivered to a laboratory.

Successful sampling means:

- Laboratory instructions followed.
- Bottle not contaminated by contact with samplers’ hands or foreign materials such as plants and substrate of waterbody.
- Cap not contaminated by contact with samplers’ hands or foreign materials.

In cases where conditions preclude successful sampling (e.g., the channel bottom will be disturbed) and a sample is desired, the sample is labeled as suspect in the field book due to the conditions of the sampling, and the laboratory results are also marked as suspect due to sampling conditions.

Samples for laboratory analysis are collected, labeled (site identifier, date, time, analysis, and collecting agency), stored, and delivered to the laboratory using chain of custody procedures. When a site is sampled more than once during a day, the sample identifier is the sample site number followed by a letter starting with the letter “A” moving sequentially through the alphabet for each subsequent sample at that site on that day. This facilitates identification of samples collected at different times throughout a day. For laboratory samples in surface waters, bacteria is always sampled first, and metals and hydrocarbons are sampled before nutrients.

In addition to the established laboratory sampling mentioned above, LNR also helps the Washington Department of Health (DOH) collect samples in and near the Reservation. The Washington Department of Health Public Health Laboratories (1610 NE 150th Street, Shoreline, Washington 98155-9701) supplies LNR with the sample bottles, sampling forms (used in conjunction with the field book), labels, shipping coolers, and pre-paid shipping forms. LNR sampling methods for bacteria collection, surface water temperature and surface water salinity (the only parameters that the DOH requires LNR staff to sample and measure) are in conformance with DOH requirements. Often LNR staff deliver the bacteria samples directly to DOH staff who either deliver or ship the samples to the Public Health Laboratory. If this does not occur, LNR ship the samples to the Public Health Laboratory using the shipping forms and coolers supplied by the DOH. Reusable ice blocks are used for shipping the bacteria samples.

Table 26. Equipment required to collect laboratory samples.

Supplies
<ul style="list-style-type: none"> • Unopened and undamaged laboratory supplied sample bottles, including one complete set of extra bottles for nutrient, metals, and hydrocarbons, and five to ten extra bottles for bacteria. • Two (2) sterile water bottles (for bacteria only, one for backup) • Chain of custody form and/or DOH sampling sheet • Sample wand • Cooler • Ice • Copy of laboratory instructions • Sampling methods table and QC activity table • Shipping cooler (DOH) • Reusable ice blocks (DOH) • Prepaid and labeled shipping form (DOH) • Bleach or plumbing torch with sparker for ground water bacteria sampling

10.2.8. pH

The pH of water is measured with a Model IQ150 Handheld pH/mV/Temperature meter (pH meter) with an ASI Model 35 Low Ionic Strength electrode and a Model T11 stainless steel temperature compensation probe following manufacturer's instructions. The pH is measured in surface waters by sampling the waterbody with a dedicated pH measurement container and measuring pH at the sample site immediately after sample collection. Occasionally, pH may be measured in situ (the meter is not waterproof and the cords are too short to measure representative water quality at most sites). Certified NIST traceable single-use pH 4, 7, and 10 buffers are used for calibration and calibration checks. Only one pH meter and probe are currently available for use within the Lummi Natural Resources Department. The electrode is replaced when the fill-solution level is low (the electrode is sealed).

The equipment required to measure pH is listed in Table 27. The sampling and measurement of pH is described in Table 28. Table 6 contains summary information for pH measurement and Section 11.8 describes QC activities, equipment use, and maintenance.

Table 27. Equipment required to measure pH.

Supplies
<ul style="list-style-type: none">• Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and Model T11 stainless steel temperature compensation probe• pH container with cap (has port for placement of probe)• Sample wand• Ten certified NIST traceable pH 7 buffer single use packets (includes two extra packets)• Six certified NIST traceable pH 10 buffer single use packets (includes two extra packets)• Four certified NIST traceable pH 4 buffer single use packets (includes two extra packets)• Distilled or deionized water• Electrode storage bottle• Electrode storage solution• Lint-free towels• Mild detergent (e.g., Alconox)• Sample wand• Complete set of replacement batteries for meter• Copy of equipment manual(s)• Sampling methods table and QC activity table

Table 28. Surface water pH measurement using Model IQ150 Handheld pH/mV/Temperature meter (pH meter) with meter with an ASI Model 35 Low Ionic Strength electrode (electrode) and temperature compensation probe (probe).

Collection of Representative Surface Water Sample	Parameter Measurement	Acclimation/stabilization criteria	Problems/Corrective Actions
<p>Container-based Measurements:</p> <ol style="list-style-type: none"> Select representative location based on previous experience and visual assessment to collect sample. Determine the route of the sample container through the waterbody. Avoid areas where water column disturbance from prior sample collection and/or measurement may persist. Rinse clean dedicated pH container, threads, and cap once with DI water and twice with sample water. Empty rinse water through ports and loosely fitted cap to rinse threads, without letting any water fall into the waterbody. Place capped container on sample wand so that opening is several inches above (upstream, upgradient) of all of the sample wand, unless use of a wand is unsafe or impractical. The dedicated surface water bottle may be used if the pH contain appears unstable on wand. Open container and vertically dip the sample bottle, opening first, into the water column and then in one motion, rotate the bottle in the direction of the current (upstream) or in the direction of bottle movement in still water, so that trapped air can escape as the bottle fills in an upstream/upgradient arc. Continue the motion until three bottle volumes replaced then rotate the bottle to remove it vertically from the waterbody. Cap bottle and place in sheltered area to allow for measurement of sample water. Turn on equipment, check for proper function. Set for automatic indication of when pH value is stable. Rinse electrode and probe with distilled or DI water once and sample water twice. Insert probe and electrode into port in cap on container (or into dedicated surface water bottle). Allow electrode and probe to acclimate and readings stabilize (no less than 60 seconds, sometimes several minutes for low ionic strength water). If electrode and probe do not acclimate and/or stabilize, take corrective actions and discontinue measurement until problem remedied. If cannot sample representative area, document in field book and mark recorded results as suspect because site not representative. Perform measurement (described in next column). Rinse electrode and probe with DI water, store electrode in electrode storage solution and probe in a sheltered location out of direct sunlight. <p>In Situ Measurement:</p> <ol style="list-style-type: none"> Place probe and electrode in close proximity using the procedure for "Probe Placement by hand" from Table 9 above. Follow steps 11-15 above. 	<p>Measure and record pH as described below.</p> <p>With automatic indication of stable pH used:</p> <ul style="list-style-type: none"> Record indicated stable pH value in the field book. <p>If automatic indication of stable pH not used and pH values within acclimation/stabilization criteria:</p> <ul style="list-style-type: none"> Measure and record the average of the last five stabilized values in the field book and why automatic indication of stability not used. <p>If automatic indication of stable pH not used and pH values are not within acclimation/stabilization criteria due to variation of sample water and the sample water is representative:</p> <ul style="list-style-type: none"> Record the average of the last five values and the range of the values in the field book and why automatic indication of stability not used. Record apparent and/or suspected causes of variation. 	<p>pH Meter automatically indicates when pH readings are stable.</p> <p>If automatic feature not working or disabled, pH values within 0.3 pH range.</p> <p>Temperature Values within 0.2 °C range</p>	<p>If water quality values will not stabilize, determine if environment, sample water, operator error, and/or equipment malfunction. If environment is variable, continue. Take corrective actions if operator equipment is responsible for variation. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark sample run data collected up to time of problem as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.</p> <p>Container-based Measurements:</p> <p>If temperature changing in one direction by more than 0.2°C (coming into equilibrium with atmospheric conditions), discard sample, repeat sample collection, and perform measurement before temperature changes more than 0.2°C. If not possible to measure without small temperature change, perform measurement and flag data as suspect because of temperature change.</p>

10.2.9. Secchi Depth

Secchi depth is measured with an eight-inch diameter disk marked alternately in black and white quadrants. A weight is attached to the bottom center of the disk and the disk is attached to a 1/8 inch diameter nylon cord that is 10 m long. The cord is marked in 0.5 m intervals. Secchi disk is the last physical measurement made at a sample site. Secchi depth is not measured where flow (surface water discharge) is measured. Only one Secchi disk is available for use within LNR.

The equipment required to measure Secchi depth is listed in Table 29. The method of Secchi depth measurement is described in Table 30. Table 6 contains summary information for Secchi depth measurement and Section 11.9 describes QC activities, equipment use, and maintenance.

Table 29. Equipment required to Secchi depth.

Supplies
<ul style="list-style-type: none">• Secchi disk with cord and weight• Two (2) measuring tapes (one extra)• Distilled or deionized water• Lint-free towels• Four (4) clothes pins (two backup)• Two (2) measuring tapes (one backup)• Mild detergent (e.g., Alconox)• Sampling methods table and QC activity table

Table 30. Surface water in situ Secchi depth measurements using the 8.5 inch diameter black and white Secchi Disk.

Determination of Representative In Situ Surface Water Measurement Location	Parameter Measurement	Acclimation/ stabilization criteria	Problems/Corrective Actions
<ol style="list-style-type: none"> 1. Select representative location based on previous experience and visual assessment. <ul style="list-style-type: none"> • Measure on the shady side of the boat. • Keep sun to back to minimize glare 2. Ensure that all components of Secchi disk firmly are attached and that the disk is clean. 3. Perform measurement. <ul style="list-style-type: none"> • Same person should perform measurement throughout sample run. • Ideally, measurement performed between 10:00 am and 2:00 pm. 4. Rinse submerged portions of equipment with DI water and store disk. 	<p>Measure and record Secchi depth as follows:</p> <ol style="list-style-type: none"> 1. Lower the Secchi disk from the shady side of the boat until it disappears. Do not use sunglasses. 2. Place clothes pin on cord at water surface when disk disappears. 3. Lower the Secchi disk a few inches and then raise the Secchi disk until it reappears. 4. Place second clothes pin on cord at water surface when disk re-appears. 5. Measure both depths to the nearest one (1) centimeter. 6. Record the Secchi depth as the average of the two depth measurements in the field book. 	<p>N/A</p>	<p>Fix equipment if broken.</p>

10.2.10. Surface Water Level/Depth

Surface water level and depth are estimated or measured for surface waters. Water level is not intended to be a precise representation of the waterbody, but rather a general representation for the location sampled. Depth measurements are made with 4 to 6-ft. rigid measuring devices. Surface water level estimated based upon visual assessment of the water surface. A metal ruler four (4) feet long graduated in 1/8-inch increments is used to measure depths up to four feet, and the sample wand (which is marked in 1 ft. increments) is used to measure depth sites deeper than four feet and at marine sample sites. The Water Resources Department owns two marked sample wands and one 4-ft. metal ruler.

Staff gage measurements are not depth measurements and are recorded as a comment for flow measurement (surface water level and depth are for the location sampled, which the staff gage may not represent). Water level estimates and depth measurements are made where they are representative of the portion of the waterbody being sampled and measured.

The equipment required to measure depth is listed in Table 31. The methods of surface water level estimates and depth measurements are described in Table 32 and Table 33, respectively. Table 6 contains summary information for depth measurement and Section 11.10 describes QC activities, equipment use, and maintenance.

Table 31. Equipment required to estimate surface water level or measure depth.

Supplies
<ul style="list-style-type: none">• 4-ft. rigid metal ruler.• Sample wand marked in at least 1-ft. increments.• Distilled or deionized water• Lint-free towels• Mild detergent (e.g., Alconox)• Sampling methods table and QC activity table

Table 32. Surface water level estimation method.

Determination of Representative In Situ Surface Water Measurement Location	Parameter Measurement	Acclimation/ stabilization criteria	Problems/Corrective Actions
<ol style="list-style-type: none"> 1. Select representative location based on previous experience and visual assessment when arrive at site. 2. Monitor water level during time at site. Near end of sampling at site, estimate water level. <ul style="list-style-type: none"> • Use area where horizontal separation between water and edge of vegetation is eliminated or minimal and edge of vegetation is representative. • If location sampled and/or depth is not representative of the waterbody, record representative water level and provide explanation (e.g., there is no flow in channel sampled stagnant pool) in field book. • If conditions change substantially during time at site (e.g., tidal channel fills or empties) the changes are recorded in the field book. 	<ol style="list-style-type: none"> 1. Estimate water level elevation as the vertical difference between the water surface elevation and the edge of vegetation along the edge of the waterbody. Estimate to nearest ½ of a foot. 2. Record estimated water level in field book as “VG ± vertical difference” except if the water level is at the edge of vegetation. In that case, record water level as “VG.” <ul style="list-style-type: none"> • VG stands for “edge of vegetation.” 3. Record conditions that could affect water level. 	<p>Surface Water Level N/A</p>	<p>N/A</p>

Table 33. Surface water depth measurement method.

Determination of Representative In Situ Surface Water Measurement Location	Parameter Measurement	Acclimation/stabilization criteria	Problems/Corrective Actions
<ol style="list-style-type: none"> 1. Select representative location based on previous experience and visual assessment. 2. Check equipment for proper function. 3. Monitor water level during time at site, near end of sampling at site, estimate water level. <ul style="list-style-type: none"> • If location sampled and/or depth is not representative of the waterbody, record representative water level and provide explanation (e.g., there is no flow in channel or sampled stagnant pool) in field book. • If conditions change substantially during time at site (e.g., tidal channel fills or empties) the changes are recorded in the field book. 	<p>If water level <u>stable</u>:</p> <ol style="list-style-type: none"> 1. Place metal ruler or sample wand into waterbody and measure depth. <ul style="list-style-type: none"> • Gently probe bottom of waterbody to ensure measurement representative. 2. Measure and record depth to nearest ½ of a foot with wand or nearest ¼ inch with rigid ruler and record in field book. <ul style="list-style-type: none"> • If water level is deeper than largest measurement wand can be used for, record depth as greater than maximum wand depth (e.g., > 6 ft). 3. Record any other conditions that could affect water level. <p>If water level <u>not stable</u>:</p> <ol style="list-style-type: none"> 1. Place metal ruler or sample wand into waterbody and measure depth. <ul style="list-style-type: none"> • Gently probe bottom of waterbody to ensure measurement representative. 2. Measure and record average depth to as close as practicable to the nearest ½ of a foot with wand or nearest ¼ inch with rigid ruler and the range of variation, record average and range in field book. <ul style="list-style-type: none"> • Record cause of water level variation. • If water level is deeper than largest measurement wand can be used for, record depth as greater than maximum wand depth (e.g., > 6 ft). 3. Record any other conditions that could affect water level. 	<p>Surface Water Depth: N/A</p>	<p>If equipment not functioning properly, discontinue measurement and take corrective actions. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. Record problem, corrective actions, and outcomes/resolutions in the field book. Identify and document suspect data as a result of equipment problems in field book.</p>

10.2.11. Turbidity

Turbidity is measured with a Hach 2100 P portable turbidimeter. The instrument is used and maintained following manufacturer's instructions. Turbidity is measured in surface waters by sampling the waterbody with a one-liter wide-mouth plastic bottle and then transferring a representative aliquot to a turbidity vial for measurement in the turbidimeter. Turbidity is measured immediately after sample collection, turbidity samples are not stored for later analysis.

If the Lummi Water Resources Division turbidimeter fails, another of the same model is available from the Salmon Stock Assessment Division of the Lummi Natural Resources Department. Formazin standards are not used for Turbidity calibrations. EPA approved AMCO CLEAR[®] or equivalent are used for primary and secondary standards.

The equipment required to measure turbidity is listed in Table 34. The method of turbidity sampling and measurement is described in Table 35. Table 6 contains summary information for turbidity measurement and Section 11.11 describes QC activities, equipment use, and maintenance.

Table 34. Equipment required to measure turbidity.

Supplies
<ul style="list-style-type: none">• Calibrated Hach 2100 P portable turbidimeter• Fresh, (not expired and within shelf life if opened) EPA approved polymer suspension primary calibration standards (<0.1, 20, 100, 800 NTU)• Fresh (not expired) EPA approved polymer suspension sealed secondary standards (0, 20, 100, 800 NTU)• Distilled or deionized water• 3 matched and indexed turbidity vials• Lint-free towels• Silicone oil• One-liter wide-mouth plastic bottle• Mild detergent (e.g., Alconox)• Sample wand• Complete set of replacement batteries• Copy of manuals for turbidimeter and standards• Sampling methods table and QC activity table

Table 35. Turbidity measurement of surface water with Hach 2100 P portable turbidimeter.

Collection of Representative Surface Water Sample in Container	Parameter Measurement	Acclimation/ stabilization criteria	Problems/Corrective Actions
<ol style="list-style-type: none"> 1. Turn on equipment, check for proper function. 2. Rinse an indexed and cleaned turbidity vial in good condition with DI water and store capped turbidity vial with meter. 3. Select representative location based on previous experience and visual assessment to collect sample. 4. Determine the route of the sample container through the waterbody. Avoid areas where water column disturbance from prior sample collection and/or measurement may persist. 5. Rinse clean 1L wide-mouth plastic sample container, threads, and cap once with DI water and twice with sample water. Empty rinse water through loosely fitted cap to rinse threads. 6. Place capped container on sample wand so that opening is several inches above (upstream, upgradient) of all of the sample wand, unless use of a wand is unsafe or impractical. 7. Open container and vertically dip the sample bottle, opening first, into the water column and then in one motion, rotate the bottle in the direction of the current (upstream) or in the direction of bottle movement in still water, so that trapped air can escape as the bottle fills in an upstream/upgradient arc. 8. Continue the motion until three bottle volumes are replaced then rotate the bottle to remove it vertically from the waterbody. 9. Cap bottle and place in sheltered area to allow for measurement of sample water as soon as possible after sample collection. 10. Rinse turbidity vial, cap, and threads with sample water twice, then overfill for three sample volumes, pour off water until water level at index line and cap vial. 11. When pouring off from the sampling container into the turbidity vial, gently and thoroughly mix sample but do not entrain or otherwise create air bubbles. 12. Rinse vial with DI water and then dry outside of turbidity vial with lint-free cloth 13. Place and wipe silicon oil onto sample vial. 14. Insert vial into instrument, thoroughly remove any condensation prior to placement of sample. If condensation occurs, check for condensation after sample measurement as described in next column. 15. Perform measurement. 	<p>Measure and record turbidity as described below.</p> <ol style="list-style-type: none"> 1. Align index mark on vial with index mark on meter. 2. Take five (5) continuous readings. 3. If <u>within acclimation/stabilization</u> criteria, record average of readings in field book. If condensation not present on vial*, discard sample water from vial, rinse vial, threads, and cap with DI water, and clean with mild detergent. Rinse at least twice with DI water after cleaning and cap for storage. Inspect for problems, discontinue use if glass scratched or light transmission likely to be affected. 4. If <u>not within acclimation/stabilization</u> criteria, determine if source of variation is sample water, operator error, and/or equipment. Take corrective actions if operator equipment is responsible for variation. If environment is variable, continue. 5. Ensure water sample thoroughly mixed and place in meter with index marks aligned. 6. Use “sample averaging” to measure turbidity* and record result along with use of sample averaging in the field book. If condensation not present on vial*, discard sample water from vial, rinse vial, threads, and cap with DI water, and clean with mild detergent. Rinse at least twice with DI water after cleaning and cap for storage. Inspect for problems, discontinue use if glass scratched or light transmission likely to be affected. <p>* Check for condensation when removing vial from instrument. If condensation present, remove it, ensure contents of vial well-mixed, and repeat measurement. Mark measurement just collected in field book as suspect due to condensation.</p>	<p>Turbidity Values within 10 % range.</p>	<p>Determine if operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark sample run data collected up to time of problem as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.</p>

10.2.12. Well Water Level

Well water level is measured with a Waterline Envirotech electric 300-ft. Olympic Well Probe directly in the well. The probe is custom and thinner than regular probes to allow passage within small diameter access tubes. The sensitivity of the meter can be adjusted and is set at mid-range.

Water level is indicated with a user-selectable sound or light. The cable is marked in 5-ft. increments that are used in conjunction with a measuring tape to obtain a water level. A key to the colors used to denote various depths on the cable is located on the body (reel) of the meter. The Lummi Water Resources Division owns two Waterline Envirotech 300-ft. Olympic Well probes, and one Solinst 300-ft. electric well probe is available for backup. The Solinst is generally similar to the other probes except that the probe is too large for use in access tubes and the depth is marked in 0.01 ft. increments on the cable.

The equipment required to measure well water level is listed in Table 36. The method of well water level measurement is described in Table 37. Table 6 contains summary information for well water level measurement and Section 11.12 describes QC activities, equipment use, and maintenance. Table 37 also applies to the Solinst probe, with the exception that the cable is marked to 0.01-ft. increments, eliminating the need to use the tape measure to get a water level elevation from the cable. A tape measure is still required to measure distances above and below the measuring point. The measuring point is the top of the casing, or the sanitary seal, whichever is greater, unless otherwise noted. When recording totalizer values, record the last printed digit(s) on the dial and mark as displayed on the dial, if present. Typically, a box encloses the last digit(s).

If the probe gets stuck or otherwise hung up in the well, perform the following:

- Gently tug on the probe several times.
- Do not pull hard, this can stretch the cord, which can create errors in subsequent water level measurements.
- Lower a bit more cable down the hole and then raise the cable again. May be able to “feel” how hard the probe is stuck. Take great care not to make the probe more stuck.
- If the probe is freed and anything more than gentle tugging was used to accomplish the removal, the probe cord needs to be evaluated for stretch, and if necessary, correction factors developed. Return probe to manufacturer for inspection and stretch evaluation.
- If the probe cannot be freed and the well site can be secured, leave the probe in the well overnight to try again the following day. If the site cannot be secured or two days of effort have not freed the probe, cut the cable, leaving about ten feet of extra cable and tie off the cable in the well so that it does not fall down the well. If the cable is cut, return instrument to manufacturer for repair.

Never use the well probe to measure the total depth of a well.

Table 36. Equipment required to measure Well Water Level.

Supplies
<ul style="list-style-type: none">• Waterline Envirotech Electric 300-ft. Olympic Well Probe• 2 tape measures (one for backup)• Screwdriver, flathead• Two crescent wrenches• One needle nose vise grip• Wire cutters• Fresh replacement battery for probe• Extra bolts and nuts (sizes encountered in field)• Dilute Bleach• Distilled or deionized water• Mild detergent (e.g., Alconox)• Lint-free towels• Sampling methods table and QC activity table

Table 37. Water well level measurement in wells with Waterline Envirotech Olympic Model 300.

Measurement of Representative Well Water Level	Parameter Measurement	Acclimation/ stabilization criteria	Problems/ Corrective Actions
<ol style="list-style-type: none"> 1. Examine previous water level measurements for that well to determine approximate water level. 2. Determine if pump active or not. Do not typically measure pumping water levels unless can be performed safely. 3. <u>If pump off</u>, measure water level. 4. <u>If pump is on</u> and is used to supply private domestic water to homes, often the pump will cycle off within ten minutes. If water quality measured at site, collect sample and analyze for water quality while pump is on. Wait for pump to turn off to perform well level measurement. Document in field log the approximate time before the measurement, that the pump automatically turned off, and the data are collected during "recovery." 5. <u>If pump is on</u>, collect water quality sample if that is part of sampling for the site. Then turn pump off with permission of well owner. Record pump rate prior to turning off pump and totalizer reading after pump turned off, and the time the pump turned off in the field log. Record switch and associated device settings in field log prior to turning off pump (typically as a comment). 6. After 10 minutes to 4 hours has elapsed, measure water level. Time that pump is off depends upon well owner's needs and is as long as practical for the owner. After water level measurement, return all switches and associated devices to position prior to turning off well. Measure pump rate and, if rate substantially different than prior to turning off pump, notify well owner and assist with corrective actions. 7. <u>If pump on</u> and cannot turn off pump, measure water level if can be performed safely. Record pump rate and totalizer reading at time of measurement. 8. Always record pump rate and totalizer value from metered wells. 	<p>Measure and record water level as described below.</p> <ol style="list-style-type: none"> 1. If access tube present, use it for water level measurement. <ul style="list-style-type: none"> ● If access tube present and not used, document in field book. 2. Lower probe into well in the immediate vicinity of the measuring point, playing out line and paying attention to the speed of the drop, weight of the line, and the amount of line down the well. If line hangs up or too much has been used (amount exceeds expected well depth) gently pull line back up (keeping cable off of the ground) until probe and line clear of where cable had hung up. Feel for obstructions and work past them when re-lowering the probe. If a particular depth(s) is the site of chronic hang ups, note in field log and well inventory. Consider installing access tube for chronic problems. If probe becomes stuck or water cannot be located in the well, take corrective actions and document in field log. 3. When water level detected, raise and lower probe several times about one foot above and one foot below water level to confirm detected water level representative. 4. Hold cable at measuring point and perform fine adjustments up and down with cable—pinch off cable at the measuring point when the water level is indicated. 5. Very slightly raise and lower cable to ensure water level location accurate. Then raise probe several inches and return cable at pinched position to measuring point. <ul style="list-style-type: none"> ● If pinched position is accurate water level elevation, record water level and time of measurement. ● If pinched position is not the water level, repeat process starting with Step 3 above. ● If water level falling or rising too rapidly, measure and record water level after fine adjustment. 6. Use tape measure to measure distance between where cable pinched and nearest mark (marks are 5 ft. apart). Redo measurement (start with Step 3) if cable moves relative to fingers at pinched point when using tape measure. Record water level as feet and inches to nearest 1/8th of an inch, pump status, pump rate (if well pumping and metered), and time (when pinched cable) in field book. 7. Record time that cable pinched as time of measurement, the water level (in feet and inches to the nearest 1/8 of an inch, and any additions or subtractions from the measuring point (e.g., access tube above top of sanitary seal), and pump status (and rate if pumping). 8. Repeat measurement starting with No. 3. <ul style="list-style-type: none"> ● Perform two total water level measurements if both water levels equal. ● Perform three total water level measurements if first two water level measurements are not equal. ● If water level is going to be measured regularly over a relatively short time period (5 to 30 minutes) and the pumping regime does not change, each water level measurement during that time does not have to be repeated two or three times. 	<p>Step 5 of Parameter Measurement.</p>	<p>If water cannot be found in well at expected location, determine if operator error or equipment problem (e.g., cable hung up). If confident that equipment and operator not at fault, slowly and carefully lower probe farther into well to locate water. Check often that probe is not hung up. Amount of cable out cannot exceed well depth.</p> <p>If equipment or operator error, remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark sample run data collected up to time of problem as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.</p> <p>If well probe becomes stuck in the well, follow directions in text at beginning of Well Water Level Section.</p>

11. QUALITY CONTROL ACTIVITIES, EQUIPMENT USE AND MAINTENANCE (B5, B6, B7)

This section discusses quality control (QC) activities, equipment testing, inspections, maintenance, and calibration by parameter or parameter group. QC activities are not presented for current/flow direction because it is a visual assessment without any equipment. Appendix A contains data entry tables for the QC activities required for specific conductivity, salinity, water temperature, dissolved oxygen, pH, chloride, and turbidity. Appendix B contains a copy of the chain of custody form used with the contracted Washington State certified laboratory. Appendix C contains a list of units and abbreviations used in this document.

Quality control activities are integral to equipment maintenance and calibration and provide information to the sampler and analyst about equipment condition and data reliability. The QC activities occur before, during, and after sample runs. Equipment operation is assessed at/during startup and during operation as specified in sampling methods in Section 10 [B2, B3, B4]. Equipment problems and/or failure to meet QC activity acceptance criteria initiates corrective actions.

The sampler can take corrective actions based on QC activities to ensure that measurements have a known accuracy, precision, and traceability. Where QC activities indicate a problem has occurred after measurements have been taken, the data are clearly labeled as suspect in the field book and measurement is discontinued until the problem is resolved. All problems, corrective actions, and outcomes/resolutions are documented in the field book. Whenever water quality measuring equipment is changed within a sample run, the full range of QC activities must be applied to the replacement equipment.

QC activities are performed in the field and not in the office. Calibrations of the WTW LF 330 meter with TetraCon 325 probe, Oxyguard dissolved oxygen meters, and pH meter take place outdoors. Primary calibration of the turbidimeter is performed indoors. Backup equipment is available for measurement of most parameters (Section 10.2)

Statistics such as bias, precision, and accuracy are not systematically calculated at this time. Instead they are calculated on an as-needed basis and specific to the question being asked. Calculation of these statistics will become routine with the implementation of the revised database (Section 14 [B10]) and the specific formulas and approaches will be addressed during the systematic planning process used to revise the surface water quality monitoring program. The Water Resources Manager (QA Manager) is responsible for ensuring QA/QC objectives are met and for “final acceptance” of validated and verified data. The process for “final acceptance” has been applied on a case-by-case basis and is an evaluation of the data quality (accuracy, precision, representativeness, completeness of data, QC activities, and problem resolutions) to determine if there is suitable quality and resolution for the decision being made. Development of a systematic “final acceptance” procedure is part of the scheduled database revision (Section 14 [B10]).

Because salinity is critical information to collect with bacteria samples, in extreme cases, the

WTW or YSI meters may be used to measure water quality even when they do not meet acceptance criteria. This will only occur if no other meters are available. As described in Section 11.2 below, if the error can be quantified, the meter may be used if calibration checks are performed with every sample measurement. The problem, reason for use of the sub-optimally functioning meter, and all QC activity information is recorded in the field log. All collected data are labeled as suspect due to poor QC performance. Corrective actions are taken so that this type of condition is not repeated.

Duplicates are recorded in the field log by writing “water quality duplicate” or “wq dup” with the sample site identifier in the Sample Site column of the data entry table. If additional accuracy information is desired for a particular parameter at a sample site, calibration checks should be run before and/or after the sample measurement at values in the range of the sample water. Record additional calibration checks in the field log with the reason performed.

All standards are certified National Institute of Standards and Technology (NIST) traceable, except the distilled or deionized water standards and the 100 mg/l chloride standard because it is prepared with distilled or deionized water. The 100-mg/l chloride standard is prepared from certified NIST traceable stock using Class A glassware. The reference thermometer is a 460-mm mercury-in-glass certified NIST traceable thermometer.

Where a mild detergent is specified as a supply item, cleaning of equipment follows manufacturers’ instructions. In general, mild detergent is used for cleaning dedicated water bottles and sampling equipment when necessary. Laboratory sample bottles are never cleaned by Lummi Water Resources Division staff and some water quality measurement equipment can be damaged by improper cleaning.

11.1. Air Temperature

Air temperature is measured in situ with an armored, non-toxic, liquid-in-glass thermometer. The range, accuracy, and readability of the equipment used for these measurements is summarized in Table 38.

The equipment is used and maintained following the manufacturer's instructions. The air temperature measurement QC activities and supplies are listed in Table 39.

The thermometer is checked for proper function before every measurement. QC activities (Table 40) performed before and after sample runs provide information necessary to quantify data quality and determine if equipment is functioning properly and suitable for use. All use, maintenance, QC activities, corrective actions, and outcomes/resolutions are recorded with the meter type(s) in the field log by the person using the equipment.

Table 38. Range, accuracy, and readability of equipment used to measure air temperature.

Equipment	Parameter	Range	Accuracy	Readability
Armored, non-toxic, liquid-in-glass thermometer	Temperature	-5 to 51°C or 20 to 51°F	± 1.0°C or ± 2.0°F	0.5°C or 2.0°F

Table 39. Air Temperature measurement equipment calibration and QC activity frequency, use, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
Calibration	N/A	N/A	N/A
Duplicate	--	At least 10 % of the samples in a run	<ul style="list-style-type: none"> • Air temperature thermometer • Distilled or deionized water (for cleaning, if necessary) • Mild detergent (e.g., Alconox) • Certified NIST traceable reference thermometer in armor and in protective case. • Lint-free towels • Sampling methods table and QC activity table
Accuracy Check	Pre Run	At beginning of sample run.	<ul style="list-style-type: none"> • Air temperature thermometer • Distilled or deionized water (for cleaning, if necessary) • Mild detergent (e.g., Alconox) • Certified NIST traceable reference thermometer in armor and in protective case. • Lint-free towels • Sampling methods table and QC activity table
	Post Run	At the end of sample run.	<ul style="list-style-type: none"> • Air temperature thermometer • Distilled or deionized water (for cleaning, if necessary) • Mild detergent (e.g., Alconox) • Certified NIST traceable reference thermometer in armor and in protective case. • Lint-free towels • Sampling methods table and QC activity table

Table 40. Air temperature quality control activities using the Armored non-toxic liquid-in-glass thermometer.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Duplicate	Measurement is performed twice at one sample site for at least 10% of the sample sites in every sample run.	N/A. Air temperature too variable.	N/A
Pre Run Accuracy Check	At beginning of sample run, record near-simultaneous temperature measurements with air temperature and reference thermometer.	Air Temperature Thermometer temperature $\pm 1.0^{\circ}\text{C}$ or $\pm 2.0^{\circ}\text{F}$	Determine if temperature deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. Store all chloride samples (both analyzed and not). Track and document sample container holding and transport in field book.
Post Run Accuracy Check	At end of sample run, record near-simultaneous temperature measurements with air temperature and reference thermometer.	Air Temperature Thermometer temperature $\pm 1.0^{\circ}\text{C}$ or $\pm 2.0^{\circ}\text{F}$	Determine if temperature deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark temperature values prior to the calibration check as suspect, and why the data are suspect in the field book. If the equipment is faulty replace it as soon as possible. Store all chloride samples (both analyzed and not). Track and document sample container holding and transport in field book.

11.2. Specific Conductivity, Salinity, Water Temperature

Specific conductivity, salinity, and temperature are measured in surface and ground waters with a WTW LF 330 meter with a TetraCon 325 Probe (WTW) or Yellow Spring Instruments (YSI) S-C-T Model 30 meter (YSI probe is permanently attached to the YSI meter). The WTW and YSI meters measure specific conductivity, salinity, and temperature in situ for surface waters. The specific conductivity and temperature of ground water are measured in one-liter plastic bottles used only for ground water with the WTW and YSI meters. The range, accuracy, and readability of the equipment used for these measurements are summarized in Table 41.

The equipment is used, calibrated, and maintained following the manufacturers' instructions. The WTW probe is stored in distilled or deionized water when not in use. The YSI probe is stored in the meter storage chamber. Calibration, maintenance, and QC activity frequency and supplies are listed in Table 42 for the equipment used to measure specific conductivity, salinity, and temperature.

Equipment is inspected for basic proper function (e.g., battery, correct conductivity cell value) before every use of the equipment. The QC activities (Table 43) performed before, during, and after sample runs provide information necessary to quantify data quality and determine if equipment is functioning properly and suitable for use. All use, maintenance, QC activities, corrective actions, and outcomes/resolutions are recorded with the meter type(s) in the field log by the person using the equipment.

The temperature of the distilled or deionized water or standard for QC activities is measured near-simultaneously with both the certified NIST traceable reference thermometer (reference thermometer) and probe. After salinity and specific conductivity of the distilled or deionized water have been measured, a clean and rinsed reference thermometer is placed into the container with the bulb at the same depth as the temperature sensing element of the probe.

- The reference thermometer temperature is measured and recorded after stabilization when the same temperature is observed during three rapid and consecutive viewings of the mercury column (within a few seconds of each other) without removing the thermometer from the sample bottle.
 - Parallax error is eliminated by blocking the reflection of the graduation mark in the mercury column with the graduation mark of the temperature being observed.
 - Ideally, the top of the mercury column in the thermometer should be within ½ inch of the top of the water surface.
- The temperature indicated by the probe is measured immediately after the reference thermometer is recorded. The temperature indicated by the probe is monitored during the time the reference thermometer is read and, if the meter temperature is variable, the reference thermometer measurements are repeated until the probe measurements are stable.
- If water temperature will not stabilize, record QC activity results as suspect due to variable temperature and take corrective actions. Record problems, corrective actions, and outcomes/resolutions in the field book.

The reference thermometer is never to be used to measure in situ water temperature. The

reference thermometer is only to be used in the field vehicle, must always be used with protective armor, and must be in the protective storage case whenever the thermometer is not being used for a temperature measurement.

Because salinity is critical information to collect with bacteria samples, in extreme cases, the WTW or YSI meters may be used to measure water quality if they do not meet acceptance criteria. If the error can be quantified, the meter may be used if calibration checks are performed with every sampling measurement and the resolution of the measurement is sufficient for the need for the data. The problem, reason for use of the sub-optimally functioning meter, and all QC activity information is recorded in the field log. All collected data are labeled as suspect due to poor QC performance. Corrective actions are taken so that this type of condition is not repeated.

Table 41. Range, accuracy, and readability of equipment used to measure specific conductivity, salinity, and/or water temperature.

Equipment	Parameter	Range	Accuracy	Readability
WTW LF330 Meter With TetraCon 325 Probe	Specific Conductivity	0.0-199.9 μ S/cm	$\pm 1\%$ of measured value or ± 1 digit with ambient temperature between 15°C and 35°C	0.1 μ S/cm
		0-1999 μ S/cm		1 μ S/cm
		0.00-19.99 mS/cm		0.1 mS/cm
		0.0-199.9 mS/cm		0.1 mS/cm
	0-500 mS/cm	1 mS/cm		
Salinity	0-70 ppt	$\pm 2\%$ of sample value or ± 1 digit at sample temperature between 15°C and 35°C	0.01 ppt.	
Temperature	-5°C to 99.9°C	0.1°C	0.1°C	
YSI S-C-T Model 30	Specific Conductivity	0-200 mS/cm (4 ranges)	0.5 % for each range	0.1 for each range
	Salinity	0-80 ppt	$\pm 2\%$ or ± 0.1 ppt.	0.1 ppt.
	Temperature	-5 to 95 °C	± 0.1 °C	0.1 °C
NIST Traceable Thermometer	Temperature	-1 to 51°C	± 0.1 °C	.05°C

Table 42. Specific conductivity, salinity, and water temperature measurement equipment calibration and QC activity frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
WTW Calibration	--	6 months or more frequent if necessary	<ul style="list-style-type: none"> • WTW LF330 meter and TetraCon 325 Probe • 2 Fresh (not expired) 1,413 $\mu\text{S}/\text{cm}$ certified NIST traceable single use calibration standard (one spare) • Distilled or deionized water • Bottle for probe storage • Lint-free towels • Mild detergent (e.g., Alconox) • Complete set of replacement batteries • Copy of equipment manual • Sampling methods tables and QC activity tables
YSI Calibration	--	N/A (calibrated by manufacturer)	N/A
Duplicate (WTW and YSI)	--	10 % of measurements in a sample run	<ul style="list-style-type: none"> • WTW LF330 meter and TetraCon 325 Probe and/or YSI S-C-T Model 30 meter • Bottle for probe storage • Two (2) dedicated one-liter wide-mouth plastic bottles for surface water or ground water sampling • Sample wand (surface water) • Dedicated ground water hose (ground water) • Mild detergent (e.g., Alconox) • Lint-free towels • Complete set of replacement batteries • Copy of equipment manual • Sampling methods tables and QC activity tables

Table 42. Specific conductivity, salinity, and water temperature measurement equipment calibration and QC activity frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
WTW Calibration Checks	Equipment	Immediately following calibration.	<ul style="list-style-type: none"> ● WTW LF330 meter and TetraCon 325 Probe ● 2 Fresh (not expired) 1,413 $\mu\text{S}/\text{cm}$ certified NIST traceable single use calibration standard (one spare) ● Distilled or deionized water ● Bottle for probe storage ● Mild detergent (e.g., Alconox) ● Lint-free towels ● Complete set of replacement batteries ● Copy of equipment manual ● Sampling methods tables and QC activity tables
WTW Calibration Checks (con't.)	Pre Run	Before sample run.	<ul style="list-style-type: none"> ● WTW LF330 meter and TetraCon 325 Probe ● Distilled or deionized water ● Bottle for probe storage ● Certified NIST Traceable reference thermometer ● Distilled or deionized water ● Two (2) dedicated one-liter wide-mouth plastic bottles for surface water or ground water sampling ● Lint-free towels ● Mild detergent (e.g., Alconox) ● Complete set of replacement batteries ● Copy of equipment manual ● Sampling methods tables and QC activity tables
	Post Run	At end of sample run.	

Table 42. Specific conductivity, salinity, and water temperature measurement equipment calibration and QC activity frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
	2-week	Every two weeks, before sample run.	<ul style="list-style-type: none"> • WTW LF330 meter and TetraCon 325 Probe • Distilled or deionized water • Bottle for probe storage • 2 Fresh (not expired and unopened) 1,000 $\mu\text{S}/\text{cm}$ certified NIST traceable standards (one spare) • 2 Fresh (not expired and unopened) 10,000 $\mu\text{S}/\text{cm}$ certified NIST traceable standards (one spare) • Certified NIST Traceable reference thermometer • Mild detergent (e.g., Alconox) • Lint-free towels • Complete set of replacement batteries • Copy of equipment manual • Sampling methods tables and QC activity tables
YSI Calibration Checks	Pre Run Zero	Before sample run.	<ul style="list-style-type: none"> • YSI S-C-T Model 30 meter • Distilled or deionized water • Certified NIST Traceable reference thermometer • Two (2) dedicated one-liter wide-mouth plastic bottles for surface water or ground water sampling • Mild detergent (e.g., Alconox) • Complete set of replacement batteries • Copy of equipment manual • Sampling methods tables and QC activity tables
	Post Run Zero	At end of sample run.	<ul style="list-style-type: none"> • YSI S-C-T Model 30 meter • Distilled or deionized water • Certified NIST Traceable reference thermometer • Two (2) dedicated one-liter wide-mouth plastic bottles for surface water or ground water sampling • Mild detergent (e.g., Alconox) • Complete set of replacement batteries • Copy of equipment manual • Sampling methods tables and QC activity tables

Table 42. Specific conductivity, salinity, and water temperature measurement equipment calibration and QC activity frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
	2-Week Calibration Check	Every two weeks, before sample run.	<ul style="list-style-type: none"> ● YSI S-C-T Model 30 meter ● Distilled or deionized water ● Bottle for probe storage ● 2 Fresh (not expired and unopened) 1,000 μS/cm certified NIST traceable standards (one spare) ● 2 Fresh (not expired and unopened) 10,000 μS/cm certified NIST traceable standards (one spare) ● Certified NIST Traceable reference thermometer ● Mild detergent (e.g., Alconox) ● Lint-free towels ● Complete set of replacement batteries ● Copy of equipment manual ● Sampling methods tables and QC activity tables
Continued use of sub-optimally functioning WTW or YSI	--	Extremely limited circumstances. No other meters must be available	<ul style="list-style-type: none"> ● WTW LF330 meter and TetraCon 325 Probe or YSI S-C-T Model 30 meter. ● Distilled or deionized water ● Bottle for probe storage ● 3 Fresh (not expired and unopened) 1,000 μS/cm certified NIST traceable standard (2 spares) ● 3 Fresh (not expired and unopened) 10,000 μS/cm certified NIST traceable standard (2 spares) ● Sample wand ● Two (2) dedicated one-liter wide-mouth plastic bottles for surface water sampling ● Certified NIST traceable reference thermometer ● Mild detergent (e.g., Alconox) ● Lint-free towels ● Complete set of replacement batteries ● Copy of equipment manual ● Sampling methods tables and QC activity table

Table 42. Specific conductivity, salinity, and water temperature measurement equipment calibration and QC activity frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
Cleaning of YSI probe cell		When cell appears dirty or when instrument results are not accurate or reproducible, but no less frequent than monthly	<ul style="list-style-type: none"> ● YSI S-C-T Model 30 meter (with probe cell) ● Distilled or deionized water ● Foaming acid tile cleaner ● Nylon brush supplied by YSI ● Lint-free towels ● Copy of equipment manual ● Sampling methods tables and QC activity tables

Table 43. Specific conductivity, salinity, and water temperature quality control activities using the WTW LF 330 meter with TetraCon 325 Probe and YSI S-C-T Model 30 meter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Duplicate	Measurement is performed twice at one sample site for at least 10% of the sample sites in every sample run.	<p>Specific Conductivity: Up to ± 1 % difference between duplicate values.</p> <p>Up to $\pm 2\%$ allowable difference if occasional and 30% of the sample run measurements, or the remainder are duplicated, whichever is smaller.</p> <p>Salinity: Up to $\pm 2\%$ of sample value or ± 0.1 ppt when salinity less than 5 ppt.</p> <p>Temperature: Up to a $\pm 0.1^\circ\text{C}$ difference between values.</p>	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to environmental variability by measuring specific conductivity over a few minutes at same location. If due to environmental variation, document in field log and repeat duplicate at a different sample site. 2. If parameter deviation not due to environmental variation, determine if parameter deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 3. If measurements continue (i.e., problem remedied), duplicate 30 % of measurements for that sample run, or all of the remaining sample sites, whichever is less. 4. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment), unless prior calibration of the equipment is documented. Reference or record the calibration information for the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used. Place a photocopy of the calibration of the replacement equipment with a photocopy of the corresponding field book pages in the binder used to store copies of the field books pages. On the photocopied calibration, record the date of water quality measurements for which the equipment was used and reference the original source of the calibration.

Table 43. Specific conductivity, salinity, and water temperature quality control activities using the WTW LF 330 meter with TetraCon 325 Probe and YSI S-C-T Model 30 meter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Pre Run Zero Calibration Check (Pre Run Zero)	<p>At the beginning of every sample run, measure specific conductivity and salinity of distilled or deionized water followed by temperature measurement against NIST traceable thermometer.</p> <p>Surface or ground water sample bottle is used for this activity.</p>	<p>Specific Conductivity: Less than 3 $\mu\text{S}/\text{cm}$.</p> <p>Salinity: Zero (0) ppt.</p> <p>Temperature: $\pm 0.1^\circ\text{C}$ difference between values.</p>	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to poor quality source water, operator error, and/or equipment. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Do not perform sample measurement until problem resolved. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 2. If different equipment is used to perform sample measurements, calibrate equipment and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment), unless prior calibration of the replacement equipment is documented. Reference or record the prior calibration information in the field book as well as the meter type, owner of the meter, and the reason a different meter is being used. Place a photocopy of the calibration of the replacement equipment with a photocopy of the corresponding field book pages in the binder used to store copies of the field books pages. On the photocopied calibration, record the date of water quality measurements for which the equipment was used and reference the original source of the calibration.
Post Run Zero Calibration Check (Post Run Zero)	<p>At the end of every sample run, measure specific conductivity and salinity of distilled or deionized water followed by temperature measurement against NIST traceable thermometer.</p> <p>Surface or ground water sample bottle is used for this activity.</p>	<p>Specific Conductivity: Less than 3 $\mu\text{S}/\text{cm}$.</p> <p>Salinity: Zero (0) ppt.</p> <p>Temperature: $\pm 0.1^\circ\text{C}$ difference between values.</p>	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to poor quality source water, operator error, and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. 2. If problem cannot be remedied at the time of occurrence, document problem, attempted corrective actions, and outcomes/resolution in the field book, and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible and ensure that replacement equipment is ready for use for next sample run. Do not perform sample measurements until problem resolved.

Table 43. Specific conductivity, salinity, and water temperature quality control activities using the WTW LF 330 meter with TetraCon 325 Probe and YSI S-C-T Model 30 meter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
2-Week Calibration Check (1,000 std and 10,000 std)	<p>Before a sample run at least once every two weeks, measure 1,000 $\mu\text{S}/\text{cm}$ and 10,000 $\mu\text{S}/\text{cm}$ certified NIST traceable standards.</p> <p>The 1,000 $\mu\text{S}/\text{cm}$ and 10,000 $\mu\text{S}/\text{cm}$ standards are 0.5 ppt and 5.6 ppt salinity, respectively.</p>	<p>Specific Conductivity: Up to $\pm 3\%$ difference between measurement and standard, deviations for both standards must be proportional and in same direction.</p> <p>Salinity: Up to a ± 0.2 ppt difference between measurement and standard.</p> <p>Temperature: $\pm 0.1^\circ\text{C}$ difference between duplicate values</p>	<ol style="list-style-type: none"> 1. Determine if specific conductivity deviation due to operator error and/or equipment. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved. 2. If different equipment is used to continue measurements, calibrate meter and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment), unless prior calibration of the replacement equipment is documented. Reference or record the prior calibration information in the field book as well as the meter type, owner of the meter, and the reason a different meter is being used. Place a photocopy of the prior calibration with a photocopy of the corresponding field book page in the binder used to store copies of the field books
Post Equipment Calibration Check ¹ (Post Cal Check)	<p>Measure and record specific conductivity of 1,413 $\mu\text{S}/\text{cm}$ certified NIST traceable calibration standard immediately after calibration followed by temperature measurement against NIST traceable thermometer.</p> <p>(WTW only)</p>	<p>Specific Conductivity: Up to $\pm 1\%$ difference between stated value of calibration standard and value of measurement following calibration.</p> <p>Salinity: Value recorded but not evaluated.</p> <p>Temperature: $\pm 0.1^\circ\text{C}$ difference between values.</p>	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to poor quality standard, operator error, and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. If the equipment is faulty, do not use it for water quality measurement, flag it and have it serviced and/or replaced as soon as possible. 2. Prepare replacement equipment for water quality measurements, including calibrations and all QC activities (i.e., QC activities for all parameters to be used on the replacement equipment), unless prior calibration of the replacement equipment is documented. Reference or record the calibration information for the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used. Place a photocopy of the calibration of the replacement equipment with a photocopy of the corresponding field book pages in the binder used to store copies of the field books pages. On the photocopied calibration, record the date of water quality measurements for which the meter was used and <u>reference the original source of the calibration.</u>

Table 43. Specific conductivity, salinity, and water temperature quality control activities using the WTW LF 330 meter with TetraCon 325 Probe and YSI S-C-T Model 30 meter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Continued Use Of Faulty Equipment	Depends upon problem. Generally, at least one calibration check is performed with each measurement, and duplicates are taken for every measurement. If behavior of equipment becomes very predictable, the frequency of accuracy and precision valuations can be reduced.	Precision and accuracy must be quantifiable and provide resolution necessary to detect differences at scale necessary (e.g., difference between fresh water and marine water).	Fix problems that created need for this type of measurement so that it does not recur. Document that measurement does not meet regular acceptance criteria, why data must still be collected, problems, corrective actions, QC measures, and outcomes/resolution in the field log. In addition, the data are clearly marked as suspect in the field book.
Cleaning of YSI probe cell	When cell appears dirty or when instrument results are not accurate or reproducible, but no less frequent than monthly, dip and agitate cell in an acid tile cleaning solution for 2-3 minutes and gently scrubbed with the supplied nylon brush.	Instrument results are accurate and reproducible as described by calibration checks above. Cell appears clean.	If cell regularly appears dirty more often than monthly or if lack of cell cleanliness causes inaccurate or irreproducible results more frequently than monthly, shorten the minimum frequency for cell cleanings accordingly.

¹ YSI can only be calibrated by the manufacturer.

11.3. Chloride

Chloride is measured in ground water using a direct titrating Lamotte test kit, Model PSC-DR, Code 4503-DR. The test kit utilizes a silver nitrate titration to quantify chloride. Chloride is measured in ground water collected in 500-ml plastic bottles used only for chloride analysis from taps that are as close to the well as possible and before any treatment. Sample bottles are labeled with the sample site name or number and date of sample collection. Time is also recorded on the label if more than one sample is collected from the same source during one day.

The range, accuracy, and readability of the equipment used for these measurements are presented in Table 44. The Lummi Water Resources Division has between three and four test kits at any time, one backup kit is taken into the field and two complete and unopened, unexpired test kits are kept at the office. Chloride samples are typically collected throughout the sample run (less than one day) and analyzed in a single chloride analysis run at the end of the sample run.

The equipment cannot be calibrated. The equipment is used and maintained following manufacturer's instructions. Maintenance and QC activity frequency and needed supplies are listed in Table 45 for chloride analysis. The titrated chloride samples are collected in bottles, labeled with the contents and date, and transported to a Hazardous Materials Disposal Site (which currently is Hazardous Waste Disposal in Bellingham, WA).

Equipment is inspected for basic proper function (e.g., sufficient reagents, glassware that is not broken) before each use. The QC activities (Table 46) performed during chloride analysis provide information necessary to quantify data quality and to determine if equipment is functioning properly and suitable for use. All use, maintenance, QC activities, corrective actions, and outcomes/resolutions are recorded with the meter type(s) in the field log by the person using the equipment.

The 100-mg/l chloride standard used for the 100-mg/l Accuracy Check QC activity is prepared from a certified NIST traceable 1,000-mg/l chloride standard. Using class A glassware the 1,000-mg/l chloride standard is diluted in distilled or deionized water to a 100 mg/l concentration by placing 20 ml of the standard with a 20-ml volumetric pipette into a 200-ml volumetric flask and adding distilled or deionized (DI) water to the 200 ml mark on the neck of the flask. All glassware, except the flask, is rinsed once with distilled or deionized water and twice with the certified NIST traceable 1,000-mg/l standard prior to using a pipette to transfer 20 ml of the 1,000-mg/l standard from a beaker into the flask. Pipette rinses consist of overfilling it, rinsing the tip (without drawing material into the pump) and completely purging it. The flask is rinsed three times with distilled or deionized water including the stopper prior to receiving 20 ml of the 1,000-mg/l chloride standard. After transferring the chloride standard, the pipette is rinsed with DI water twice and then used to transfer the remaining 20 to 40-ml of DI water to the flask when filling to the 200-ml reference mark. The preparation of the 100-mg/l standard and the materials used is documented in the field book with the date, name or initials of the preparer, materials used including the name, type, manufacturer, concentration, lot number, and expiration date of all non-zero standards used. The date of preparation of the 100-mg/l standard is recorded on label tape on the volumetric flask. The 100-mg/l standard is stored in the flask with a

protective cover, which is handled and stored in the same manner as a chloride sample.

Table 44. Range, accuracy, and readability of equipment used to measure chloride.

Equipment	Parameter	Range	Accuracy	Readability
Lamotte test kit, Model PSC-DR, Code 4503-DR	Chloride	0 – 400 mg/l (The capacity of the titrator is 0 to 200 mg/l. The titrator can be used more than once for an individual analysis, but for high chloride values, dilutions of 1:20 or 1:100 are recommended)	Not quantified by manufacturer. (Titrator is graduated in 4-mg/l increments).	2 mg/l

Table 45. Chloride measurement equipment calibration and QC activity frequency, use, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
Calibration	--	N/A	N/A
Duplicate	--	At least 10 % of the samples in a chloride analysis run.	<ul style="list-style-type: none"> • Two (2) fresh Lamotte Chloride test kits (Model PSC-DR, Code 4503-DR). One kit is for backup and should be unopened. The kit intended for use should have sufficient reagents to perform chloride analysis on all samples collected. • Distilled or deionized water • Lint-free towels • Sufficient dedicated 500-ml plastic bottle to perform run, with a few extras. • Chloride waste container • Label tape • Ground water hose. • Fresh (not expired) 100 mg/l standard prepared from certified 1,000 mg/l NIST traceable chloride standard • Protective cover for 200-ml flask • Mild detergent (e.g., Alconox) • Safety goggles and gloves • Copy of manual for use of kit. • Sampling methods table and QC activity table
Zero Accuracy Check (Blank)	--	Once during every chloride analysis run.	
100 mg/l Accuracy Check	Measurement of Standard (100 mg/l std)	Once during every chloride analysis run.	
	Preparation of Standard	As needed. Shelf life of 28 days.	<ul style="list-style-type: none"> • Distilled or deionized water • Lint-free towels • Label tape • Fresh (not expired and within shelf life after opened) 1,000 mg/l certified NIST traceable chloride standard • Class A 20-ml volumetric pipette. • Class A 200-ml volumetric flask with stopper • Pipette pump • 50-ml beaker • Protective cover for 200-ml flask • Mild detergent (e.g., Alconox) • Sampling methods table and QC activity table

Table 46. Chloride quality control activities using the LaMotte Chloride test kit, Model PSC-DR, Code 4503-DR.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Duplicate	Measurement is performed twice at one sample site for at least 10% of the sample.	Up to ± 4 mg/l difference between duplicate values.	<ol style="list-style-type: none"> 1. Determine if chloride deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark chloride values prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. Store all chloride samples (both analyzed and not). Track and document sample container holding and transport in field book. 2. If chloride measurements continue (i.e., problem remedied), duplicate thirty percent of measurements for that sample run, or all of the remaining samples, whichever is less. 3. If different (replacement) equipment is used to continue chloride measurements, apply all other QC activities to replacement equipment. Document new equipment, reason for new equipment, and all QC activities in field book. 4. If measurement is unlikely to resume within 28 days of the collection of the oldest chloride sample, send samples to certified laboratory for analysis prior to expiration of holding time, using labels supplied by laboratory and chain-of-custody forms. Track and document sample container holding and transport in field book.
Zero Accuracy Check (Blank)	<p>Once during every run, measure chloride concentration of distilled or deionized water.</p> <p>Ground water sample bottle is used for this activity.</p>	Chloride concentration less than or equal to 4 mg/l.	Same as "Duplicate" above.
100 mg/l Accuracy Check (100-mg/l std)	Once during every run, measure chloride content of 100-mg/l chlorides standard	<p>Chloride concentration between 90 to 110 mg/l.</p> <p>Ideally, chloride concentration should be between 96 to 104 mg/l</p>	Same as "Duplicate" above.

11.4. Current and Flow Direction

Current and flow direction are measured through visual assessment without use of equipment. There are no QC activities for current direction and flow.

11.5. Dissolved Oxygen

Dissolved oxygen is measured in surface waters with either an Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter (DO meters). The DO meters use the same model of probe, which is permanently attached to the meter. Both meters feature automatic temperature compensation with temperature sensors on the probe. Both meters also compensate for salinity, which is manually set with a dial (Mk III), or button (Gamma) on the face of the meter. The dissolved oxygen concentration (mg/L) and percent saturation are recorded for every measurement. Dissolved oxygen measurements are made directly in the surface waterbody after salinity has been measured. The range, accuracy, and readability of each meter are presented in Table 47.

The DO meters and probes are used, calibrated, and maintained following the manufacturers' instructions. The only deviation from manufacturers' instructions is that inspection of the membrane on the probe is more frequent and occurs before and after every sample run. If any fouling is evident the membrane is replaced. When the membrane is replaced, the probe may take several hours to acclimate and cannot be used for measurement during that time. Calibration, maintenance, and QC activity frequency and supplies are listed in Table 48. The used zero oxygen standard are collected in bottles, labeled with the contents and date, and transported to a Hazardous Materials Disposal Site (which currently is Hazardous Waste Disposal in Bellingham, WA). Humidity information is necessary for the calibration of the Oxyguard Gamma portable dissolved oxygen meter (when relative humidity is less than 50%, the meter is adjusted to 101% and if the relative humidity is greater than or equal to 50%, the meter is adjusted to 100%). Sample Calibration Check quality control activity results are recorded as comments for the site where the measurement and check occurred.

Equipment is inspected for basic proper function (e.g., battery, correct salinity settings) before each use. The QC activities (Table 49) performed before, during, and after sample runs provide information necessary to quantify data quality and determine if equipment is functioning properly and suitable for use. All use, maintenance, QC activities, corrective actions, and outcomes/resolutions are recorded with the meter type(s) in the field log by the person using the equipment.

Table 47. Range, accuracy, and readability of dissolved oxygen meters.

Equipment	Parameter	Range	Accuracy	Readability
Oxyguard Handy Mk III Portable Dissolved Oxygen meter	concentration	0 - 50 mg/l	< 1% of reading	0.1 mg/l
	percent saturation	0 - 600 % saturation	≤ 1% of reading	1 %
Oxyguard Handy Gamma Portable Dissolved Oxygen meter				

Table 48. Dissolved oxygen meter use and calibration frequency and supplies.

Activity	Sub-Activity	Frequency	Supplies
Calibration	--	<p>Before every sample run.</p> <p>During a sample run if part of a corrective action.</p>	<ul style="list-style-type: none"> • Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter. • Small flathead screwdriver • Lint-free disposable towels (e.g., Kimwipes) • Humidity information (www.kirotv.com/pinpointweather/index.html and www.outsideconnection.com). • Distilled or deionized water • Complete set of replacement batteries for the meter • Copy of manual for equipment • Sampling methods table and QC activity table
Probe Membrane Inspection and Replacement	--	<p>Inspection before and after every sample run.</p> <p>If DO meter has not been used for more than one week, inspect at least 24-hours before planned use of equipment.</p> <p>Meter cannot be used for a period (generally several hours) after membrane replaced.</p>	<ul style="list-style-type: none"> • Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter. • O-rings • Membranes • Electrolyte Solution • O-ring removal tool • Instruction sheet for replacement of membrane (placement of O-ring is not intuitive and is critical) • Distilled or deionized water • Lint-free disposable towels (e.g., Kimwipes) • Copy of manual for equipment • Sampling methods table and QC activity table

Table 48. Dissolved oxygen meter use and calibration frequency and supplies.

Activity	Sub-Activity	Frequency	Supplies
Duplicate	--	10 % of measurements in a sample run	<ul style="list-style-type: none"> • Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter. • Distilled or deionized water • Lint-free towels • Sample wand • Two (2) one-liter wide-mouth plastic bottle dedicated to surface water sampling • Complete set of replacement batteries for the meter • Mild detergent (e.g., Alconox) • Copy of manual for equipment • Sampling methods table and QC activity table
Air Calibration Checks	Pre Run Air	Immediately following calibration.	<ul style="list-style-type: none"> • Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter. • Lint-free disposable towels (e.g., Kimwipes) • Distilled or deionized water • Mild detergent (e.g., Alconox) • Complete set of replacement batteries for the meter • Copy of manual for equipment • Sampling methods table and QC activity table
	Sample Air	When sample water D.O. is beyond 90 to 110% saturation.	
	Mid Run Air	Half-way through sample run.	
	Post Run Air	At end of sample run.	
Zero Calibration Checks	Pre Run Zero	At beginning of sample run.	<ul style="list-style-type: none"> • Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter. • Fresh (not-expired and within shelf life if opened) certified NIST traceable zero dissolved oxygen standard sufficient for QC activities and corrective actions. If single use packages are used, bring at least six. • Distilled or deionized water • Lint-free towels • Mild detergent (e.g., Alconox) • Complete set of replacement batteries for the meter • Copy of manual for equipment • Sampling methods table and QC activity table • Safety goggles and gloves • Bottle for disposal of used zero dissolved oxygen standard
	Post Run Zero	At end of sample run.	

Table 49. Dissolved oxygen quality control activities using the Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Calibration	At the beginning of every sample run, use screwdriver to adjust the meter to read 100 or 101 % saturation (depending on the meter and the humidity) when the probe is in the air	Meter adjusts to exact value aimed for and stabilizes there.	If meter will not adjust and stabilize to desired value, determine if problem due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.
Duplicate	Measurement is performed twice at one sample site for at least 10% of the sample sites in every sample run.	Up to ± 1 % difference between duplicate values for percent saturation and concentrations greater than 10 mg/l. ± 0.1 mg/l for concentrations of less than or equal to 10 mg/l.	<ol style="list-style-type: none"> 1. Determine if dissolved oxygen deviation due to environmental variability by measuring dissolved oxygen over a few minutes at same location. If due to environmental variation, document in field log and repeat duplicate at a different sample site. 2. If parameter deviation not due to environmental variation, determine if parameter deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 3. If measurements continue (i.e., problem remedied), duplicate thirty percent of measurements for that sample run, or all of the remaining sample sites, whichever is less. 4. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment). Document the use of the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used.

Table 49. Dissolved oxygen quality control activities using the Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Equipment Air Calibration Check (Pre Run Air)	Immediately following calibration before sample run, perform air check (follow calibration procedures but do not adjust meter settings). Record both air check value and temperature.	Up to $\pm 1\%$ difference between calibration value and calibration check air check value.	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to operator error, and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Do not perform sample measurement until problem resolved. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible 2. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment). Document the use of the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used.

Table 49. Dissolved oxygen quality control activities using the Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Sample Calibration Check (Sample Air)	When dissolved oxygen of sample water is beyond the range of 90 to 110 percent saturation perform air check while at sample site. Record air check value and temperature.	Primarily informational measure, but if air check values not within 90 to 110 percent, take corrective actions.	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. If remedy includes recalibration of the meter, apply Pre Run Calibration, Pre Run Zero, and Duplicate QC measures again. Document recalibration and all other QC activities in the field book. If problem cannot be resolved, discontinue measurement until problem resolved. Clearly mark data collected prior to the Mid Run calibration as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 2. If corrective actions are only successful for a short period of time (i.e., the meter is recalibrated but fails this check at the next sample site), determine if parameter deviation due to operator error and/or equipment. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark data collected prior to the Sample Calibration Check as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 3. Discontinue measurement if equipment needs to be recalibrated more than once during the sample run. 4. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment). Document the use of the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used.

Table 49. Dissolved oxygen quality control activities using the Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Mid Run Calibration Check (Mid Run Air)	Half-way through a sample run perform air check. Record air check value and temperature.	Air check values between 90 and 110 percent.	<p>1. Determine if parameter deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. If remedy includes recalibration of the meter, apply Pre Run Calibration, Pre Run Zero, and Duplicate QC measures again. Document recalibration and all other QC activities in the field book. If problem cannot be resolved, discontinue measurement until problem resolved. Clearly mark data collected prior to the Mid Run calibration as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.</p> <p>2. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment). Document the use of the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used.</p>
Post Run Calibration Check (Post Run Air)	At the end of the sample run, perform air check. Record air check value and temperature.	Used to quantify instrument drift. If air check values not within 90 to 110 percent, take corrective actions.	<p>1. Determine if parameter deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book.</p> <p>2. If problem cannot be remedied at the time of occurrence, document problem, attempted corrected actions, and outcomes/resolution in the field book, and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible and ensure that replacement equipment is ready for use for next sample run. Do not perform sample measurement until problem resolved.</p>
Pre Run Zero Calibration Check (Pre Run Zero)	At the beginning of every sample run, measure percent saturation of certified NIST traceable zero dissolved oxygen solution. Record percent saturation and temperature.	Less than 5 percent saturation ^A	<p>1. Determine if parameter deviation due to poor quality standard, operator error, and/or equipment. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Do not perform sample measurement until problem resolved. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible</p> <p>2. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment). Document the use of the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used.</p>

Table 49. Dissolved oxygen quality control activities using the Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Post Run Zero Calibration Check (Post Run Zero)	At the end of every sample run measure percent saturation of certified NIST traceable zero dissolved oxygen solution. Record percent saturation and temperature.	Less than 5 percent saturation ^A	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to poor quality standard, operator error, and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. 2. If problem cannot be remedied at the time of occurrence, document problem, attempted corrected actions, and outcomes/resolution in the field book, and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible and ensure that replacement equipment is ready for use for next sample run. Do not perform sample measurement until problem resolved.

^A Use of a different certified NIST traceable zero dissolved oxygen standard is causing this QC activity to be rarely met. The previous standard used is no longer available and determination of the reason for elevated dissolved oxygen readings with replacement zero dissolved oxygen standards is currently underway. The deviations are documented in the field log and depending upon the outcome of the remedies, the QC activity to verify accuracy at low dissolved oxygen levels may have to be revised. The data collected during the time of poor zero dissolved oxygen calibration check performance are labeled as suspect in the field book. The standard has been identified as the problem and the equipment is otherwise performing to specification. A replacement standard is being investigated.

11.6. Flow (Surface Water Discharge)

Surface water flow measurements are not intended to be precise and are either physically based or a visual assessment. The equipment cannot be calibrated and duplicates are not performed. The physical methods involve taking the average of three velocity measurements (velocity is the only non-fixed variable, depth, width, and length are constant).

11.7. Samples Collected For Analysis At Certified Laboratory

A Washington State certified laboratory is contracted for enumeration of bacteria and analysis of nutrients, metals, and petroleum hydrocarbons (see Table 6 for list of analyses) for all sample sites, except for the Washington Department of Health (DOH) sample sites in northern Lummi Bay. The DOH Public Health Laboratory analyzes the bacteria samples collected for the Lummi Bay DOH Support sample run. Samples are collected in bottles supplied by the laboratory following instructions provided by the laboratory. The QC measures for the sample collection, handling, and transfer are specified by the laboratory. Lummi Water Resources Division QC practices in excess of laboratory QC requirements are the transfer of a sterile water from a laboratory supplied bottle to a sample bottle for bacteria enumeration.

Sufficient laboratory supplied sample bottles are securely stored in a locked cabinet at the office to allow for collection of at least 20 bacteria samples and four of each of the rest of nutrients, metals, and petroleum hydrocarbons listed in Table 6. Ten (10) laboratory supplied ground water chloride sample bottles are also securely stored in a locked cabinet at the office. The range, accuracy, and readability of laboratory measurements are not presented as they vary with the matrix and interfering compounds.

Equipment used for collection of samples to be analyzed at a laboratory is listed in Table 50. The contracted laboratory provides Practicable Quantification Limits (PQLs), known recovery, recovery limits, and duplicate differences for non-bacterial analysis, and growth response for a blank and each type of bacteria enumerated. The QC activity types, frequencies, acceptance criteria, and corrective actions are not presented because the laboratory is responsible for these activities. However, if PQLs or bacteria enumerations are not sufficient for necessary resolution (e.g., above associated criteria), corrective actions are taken with the laboratory to obtain sufficiently low PQLs. DOH data is discussed in Section 13 [B9].

Chain of custody protocols and forms are used to handle and track samples from field collection to delivery (by-hand or shipped) to the laboratory (Appendix B has a copy of the form for the contracted laboratory). The form is filled out while the sampler is in possession of the samples either during the sample run as information is recorded in the field book, or at the end of the sample run from information recorded in the field book. The DOH supplied sample sheet is used as the chain of custody form for the Lummi Bay DOH Support sample run. The chain of custody form for the contracted laboratory is photocopied at the laboratory, and the photocopy stored in the 3-ring binder used to store photocopies of field book sheets. Samples are securely stored during transport from the sample site to the laboratory. When samples are transferred to the laboratory or DOH staff, the sampler signs over the samples to the laboratory, who sign the form

upon receipt of the samples. If a different person than collected the samples delivers the samples to the laboratory, the transfer from the sampler to the delivery person is documented in the same manner as when the sample is delivered to and received by the laboratory. When the laboratory reports the results, a photocopy of the chain of custody form with laboratory sample tracking number is included.

Sterile water transfers are used for bacteria samples to determine if there is contamination in the preparation of the sterile water, sample transport, or sample processing. Sterile water provided by the contracted laboratory is transferred to a sample bottle in the field and recorded in the field book as such, but is marked as a regular sample on the bottle (a blind to the analyst). One sterile water sample is submitted to the laboratory for every sample run when bacteria samples are collected.

Temperature control standards are collected during the Lummi Bay DOH Support sample runs. This consists of filling a sample bottle with sample water at the beginning of the sample run, labeling it as a "Temperature Check" on the bottle, field book, and field sheet, and treating it as an actual sample for delivery to the Washington Department of Health Public Health Laboratory. DOH Public Health Laboratory staff evaluate the temperature control standard upon receipt.

Where duplicate bacteria samples are collected, it is to assess field variability rather than laboratory variability. Duplicate bacteria samples are not collected to quantify precision because of the inherent spatial and temporal variability associated with bacteria.

Table 50. Supplies and frequency of non-laboratory specified QC activities for collecting samples for delivery to the laboratory.

Activity	Sub-Activity	Frequency	Supplies
Chain Of Custody	--	For every sample collected at every sample site during a sample run.	<ul style="list-style-type: none"> • Chain of custody form
Sterile water transfer	--	Once during every sample run where bacteria samples are collected.	<ul style="list-style-type: none"> • Chain of custody form • Cooler • Ice • Two sterile water bottles (one for backup). • Sample bottle (to receive sterile water). • Copy of laboratory instructions • Sampling methods table and QC activity table
QC activity specified by laboratory	--	Determined by laboratory.	<ul style="list-style-type: none"> • Supplied by laboratory • Copy of laboratory instructions • Sampling methods table and QC activity table
Temperature control standard (Temperature Check)	--	One for every sample run at beginning of run.	<ul style="list-style-type: none"> • Extra sample bottle • Washington Department of Health sampling sheet • Sample wand • Cooler • Ice • Reusable ice blocks • Copy of laboratory instructions • Sampling methods table and QC activity table

11.8. pH

The pH of surface waters is measured at the sample site using a Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and temperature compensation probe (pH meter). The pH and the temperature measured by the pH meter are recorded for every measurement (this can assist with data interpretation). Surface water pH is usually measured in a 500-ml plastic bottle dedicated to pH measurement. This bottle has a screw top lid that can hold both the pH electrode and temperature probe suspended in the sample water. The pH measurement is made as soon as possible after sample collection from a sheltered environment (e.g., out of the sun and/or rain). Occasionally, pH is measured in-situ in surface water. The pH of ground water is infrequently measured and follows the general procedure as for surface water measured in the dedicated container. The range, accuracy, and readability of the pH meter is presented in Table 51.

The pH meter is used, calibrated, and maintained following manufacturer's instructions. Calibration, maintenance, and QC activity frequency and supplies are listed in Table 52. Single use packets of certified NIST traceable buffers are used for calibration and calibration checks. Most all sample sites typically have pH values above pH 7, but a few sites can have lower pH values, down to about 1 pH unit. Calibrations are performed at pH 7 and 10, and for the Equipment Calibration Check, pH 4, 7, and 10 buffers are measured. The pH electrode is polycarbonate, sealed, and gel-filled. The pH electrode is stored in KCl storage solution when not in use.

Equipment is inspected for basic proper function (e.g., battery, operating normally) before every use of the equipment. The QC activities (Table 53) performed before, during, and after sample runs provide information necessary to quantify data quality and determine if equipment is functioning properly and suitable for use. All use, maintenance, QC activities, corrective actions, and outcomes/resolutions are recorded with the meter type in the field log by the person using the equipment.

Table 51. Range, accuracy, and readability of pH meter.

Equipment	Parameter	Range	Accuracy	Readability
Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and temperature compensation probe	pH	2.00 to 12.00 pH units	± 0.01 pH units	0.01 pH units
	Temperature	0 to 100 °C	±0.5 °C	0.1 °C

Table 52. Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode (electrode) and temperature compensation probe (probe) use, maintenance, calibration frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
Calibration	--	<p>Before every sample run.</p> <p>During a sample run if part of a corrective action.</p>	<ul style="list-style-type: none"> • Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and temperature compensation probe • Two each fresh (not expired) certified NIST traceable pH 7 and 10 single-use buffer packets • Electrode storage bottle • Electrode storage solution (KCl) • Distilled or deionized water • Lint-free towels • Mild detergent (e.g., Alconox) • Sample wand • Complete set of replacement batteries for meter • Copy of equipment manual(s) • Sampling methods table and QC activity table
Duplicate	--	Duplicate at least 10% of measurements in a sample run.	<ul style="list-style-type: none"> • Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and temperature compensation probe • Electrode storage bottle • Electrode storage solution • Dedicated pH container • Distilled or deionized water • Lint-free towels • Mild detergent (e.g., Alconox) • Complete set of replacement batteries for meter • Copy of equipment manual(s) • Sampling methods table and QC activity table

Table 52. Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode (electrode) and temperature compensation probe (probe) use, maintenance, calibration frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
Calibration Checks	Pre Run Check	Immediately following calibration.	<ul style="list-style-type: none"> • Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and temperature compensation probe • Two each fresh (not expired) certified NIST traceable pH 4, 7 and 10 buffer single-use buffer packets • Distilled or deionized water • Electrode storage bottle • Electrode storage solution (KCl) • Lint-free towels • Mild detergent (e.g., Alconox) • Complete set of replacement batteries for meter • Copy of equipment manual(s) • Sampling methods table and QC activity table
	Mid Run Check	Half-way through sample run.	<ul style="list-style-type: none"> • Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and temperature compensation probe • Two fresh (not expired) certified NIST traceable pH 7 buffer single-use buffer packets • Electrode storage bottle • Electrode storage solution (KCl) • Distilled or deionized water • Lint-free towels • Mild detergent (e.g., Alconox) • Complete set of replacement batteries for meter • Copy of equipment manual(s) • Sampling methods table and QC activity table

Table 52. Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode (electrode) and temperature compensation probe (probe) use, maintenance, calibration frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
	Post Run Check	At end of sample run	<ul style="list-style-type: none"> • Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and temperature compensation probe • Two fresh (not expired) certified NIST traceable pH 7 buffer single-use buffer packets • Electrode storage bottle • Electrode storage solution (KCl) • Distilled or deionized water • Lint-free towels • Mild detergent (e.g., Alconox) • Complete set of replacement batteries for meter • Copy of equipment manual(s) • Sampling methods table and QC activity table

Table 53. pH quality control activities using the Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode (electrode) and temperature compensation probe (probe).

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Duplicate	Measurement is performed twice at one sample site for at least 10% of the sample sites for every sample run.	<p>Up to $\pm 1\%$ difference between duplicate values.</p> <p>Up to $\pm 2\%$ allowable difference if occasional and 30% of the total sample run measurements or the remainder of sample sites are duplicated, whichever is smaller.</p>	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to environmental variability by measuring specific conductivity over a few minutes at same location. If due to environmental variation, document in field log and repeat duplicate at a different sample site. 2. If parameter deviation not due to environmental variation, determine if parameter deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 3. If measurements continue (i.e., problem remedied), duplicate thirty percent of measurements for that sample run, or all of the remaining sample sites, whichever is less. 4. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment). Document the use of the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used.
Pre Run Calibration Check (Pre Run Check)	Immediately following every calibration of the meter and probe, measure pH and temperature of certified NIST traceable pH 4, 7, and 10 buffers.	± 0.2 pH units of the known value for the two buffers values used for calibration, and ± 0.4 pH for the third buffer (the buffer not used during calibration).	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 2. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities (i.e., QC activities for all parameters to be used on the replacement equipment). Document the use of the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used.

Table 53. pH quality control activities using the Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode (electrode) and temperature compensation probe (probe).

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Mid Run Calibration Check (Mid Run Check)	Half-way through a sample run, measure pH and temperature of certified NIST traceable pH 7 buffer.	± 0.2 pH units of buffer value.	<p>1. Determine if parameter deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. If remedy includes recalibration of the meter, apply Pre and Mid Run Calibration Checks and Duplicate QC measures again. Document recalibration and all other QC activities in the field book. If problem cannot be resolved, discontinue measurement until problem resolved. Clearly mark data collected prior to the Mid Run calibration as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible.</p> <p>2. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities. Document the use of the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used.</p>
Post Run Calibration Check (Post Run Check)	At end of every sample run measure pH and temperature of certified NIST traceable pH 7 buffer.	± 0.2 pH units of buffer value.	<p>1. Determine if parameter deviation due to operator error and/or equipment. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book.</p> <p>2. If problem cannot be remedied at the time of occurrence, document problem, attempted corrected actions, and outcomes/resolution in the field book, and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible and ensure that replacement equipment is ready for use for next sample run. Do not perform sample measurement until problem resolved.</p>

11.9. Secchi Depth

Secchi depth is measured with an eight-inch diameter disk marked alternately in black and white quadrants. A weight is attached to the bottom center of the disk and the disk is attached to a 1/8th inch nylon cord that is 10 m long marked in 0.5-m increments. Secchi depth is measured in situ at marine surface water quality sites. The Lummi Water Resources Division owns one secchi disk. The range, accuracy and readability are not presented because the method is not precise and range, accuracy, and readability vary with sea state and water clarity.

The secchi disk requires little maintenance except checking and fixing the attachment of the cord and weight, and cleaning of the disk. These actions are performed before and after every sample run, and the solid attachment of the weight is checked before every use. Table 54 lists the QC frequency and supplies needed for measurement. Table 55 lists the only QC activity for the secchi disk measurement.

Table 54. Secchi disk use, maintenance and calibration frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
Calibration	--	N/A	--
Duplicate	--	Duplicate at least 10% of measurements in a sample run.	<ul style="list-style-type: none"> • Secchi disk with cord and weight • Two (2) measuring tapes (one extra) • Distilled or deionized water • Lint-free towels • Four (4) clothes pins (two backup) • Two (2) measuring tapes (one backup) • Sampling methods table and QC activity table

Table 55. Secchi Depth quality control activities using the eight-inch diameter disk marked alternately in black and white quadrants.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Duplicate	Measurement is performed twice at one sample site for at least 10% of the sample sites in every sample run.	<p>Variable, both measurements as close as possible considering condition of sampling environment (i.e., sea-state, sunlight intensity).</p> <p>For example: In relatively clear and calm water, the difference between the duplicate values should be no more than 10 cm. In wavy waters with strong sunlight, the difference between the two duplicate values should be no more than 20 cm.</p>	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to environmental variability by measuring secchi depth over a few minutes at same location. If due to environmental variation, document in field log and repeat duplicate at a different sample site. 2. If parameter deviation not due to environmental variation, determine if parameter deviation due to operator error and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. Discontinue measurement until problem resolved and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 3. If measurements continue with current or replacement equipment (i.e., problem remedied), duplicate thirty percent of measurements for that sample run, or all of the remaining sample sites, whichever is less.

11.10. Surface Water Level/Depth

Surface water level estimates are made without equipment by visual assessment and depth measurements are made with either a 4-ft. metal ruler or a sample wand marked in 1-ft. increments. Surface water level estimates and depth measurements are not intended to be precise.

The equipment cannot be calibrated. The range, accuracy, and readability of the equipment used for depth measurements are presented in Table 56. QC activities and supplies are listed in Table 57 for surface water level and depth measurement.

The equipment is checked for proper function before every measurement. The QC activities (Table 58) during sample runs provide information necessary to quantify data quality and to determine if equipment is functioning properly and suitable for use. All use, maintenance, QC activities, corrective actions, and outcomes/resolutions are recorded with the meter type(s) in the field log by the person using the equipment.

Table 56. Range, accuracy, and readability of equipment used to measure water depth.

Equipment	Parameter	Range	Accuracy	Readability
5-ft. sample wand	Depth	0 to 5 ft.	± 0.5 ft.	0.5 ft.
6-ft. sample wand	Depth	0 to 6 ft.	± 0.5 ft.	0.5 ft.
4-ft. ruler	Depth	0 to 4 ft.	± 0.5 ft.	1/8 in.

Table 57. Surface water level and depth measurement equipment, QC activity frequency, use, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
Calibration	--	N/A	N/A
Duplicate	--	At least 10 % of measurements in a sample run	<ul style="list-style-type: none"> • Sample wand marked in at least 1 ft. increments, preferably 6 ft. • 4 ft. ruler • Distilled or deionized water • • Lint-free towels • Sampling methods table and QC activity table

Table 58. Water depth quality control activities using the sample wand or 4 ft. ruler.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Duplicate	Measurement is performed twice at one sample site for at least 10% of the sample.	<p>Wand: Up to a 0.5 ft. difference between duplicate values.</p> <p>Ruler: Up to ½ in. difference between duplicate values.</p>	<ol style="list-style-type: none"> 1. Determine if depth value deviation are due to waterbody, operator error, and/or the equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolutions in the field book. Discontinue measurement until problem resolved and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 2. If measurements continue (i.e., problem remedied), duplicate thirty percent of measurements for that sample run, or all of the remaining sample sites, whichever is less. 3. If different (replacement) equipment is used for depth measurements, apply all other QC activities to replacement equipment. Document new equipment, reason for new equipment, and all QC activities in field book.

11.11. Turbidity

Turbidity is measured with a Hach 2100 P portable turbidimeter. Surface water turbidity is measured at the site where the water sample was collected, and measurement occurs as soon as possible after sample collection. Table 59 lists the accuracy, range, and resolution of the turbidimeter.

The instrument is used and maintained following manufacturer's instructions. Calibration follows the strictest combination of instructions from both the equipment manufacturer and standards manufacturer. Formazin standards are not used for calibration or verification. EPA approved polymer suspensions are used. Calibration, maintenance, and QC activity frequency and supplies are listed in Table 60.

Equipment is inspected for basic proper function (e.g., battery, correct salinity settings) before every use of the equipment. The QC activities (Table 61) performed before, during, and after sample runs provide information necessary to quantify data quality and to determine if equipment is functioning properly and suitable for use. All use, maintenance, QC activities, corrective actions, and outcomes/resolutions are recorded with the meter type(s) in the field log by the person using the equipment.

Table 59. Range, accuracy, and readability of Hach 2100 P portable turbidimeter.

Equipment	Parameter	Range	Accuracy	Readability
Hach 2100 P Portable Turbidimeter	Turbidity	0.01 -1000 NTU (automatic)	± 2 % of reading plus stray light (stray light is <0.02 NTU)	Automatic decimal placement
		0 – 9.99 NTU (manual)		0.01 NTU
		0 – 99.9 NTU (manual)		0.1 NTU
		0 – 1000 (manual)		0.1 NTU from 0 to 999.9 NTU 1 NTU at 1,000 NTU

Table 60. Hach 2100 P portable turbidimeter use, maintenance and calibration frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
Calibration	--	Every three months, or more frequently if needed.	<ul style="list-style-type: none"> • Hach 2100 P portable turbidimeter • Fresh, (not expired and within shelf life if opened) EPA approved polymer suspension primary calibration standards (<0.1, 20, 100, 800 NTU) • Fresh (not expired) EPA approved polymer suspension sealed secondary standards (0, 20, 100, 800 NTU) • Distilled or deionized water • Indexed sample vial in good condition • Lint-free towels • Silicone oil • Mild detergent (e.g., Alconox) • Complete set of replacement batteries • Copy of manuals for meter and standards • Sampling methods table and QC activity table
Duplicate	--	Duplicate at least 10% of measurements in a sample run.	<ul style="list-style-type: none"> • Hach 2100 P portable turbidimeter • Indexed sample vial in good condition • Distilled or deionized water • Lint-free towels • Silicone oil • One-liter wide-mouth plastic bottle • Mild detergent (e.g., Alconox) • Sample wand • Complete set of replacement batteries • Copy of manuals for meter and standards • Sampling methods table and QC activity table
Calibration Checks	Equip. Cal. Check	Immediately following calibration.	<ul style="list-style-type: none"> • Calibrated Hach 2100 P portable turbidimeter • Fresh (not expired) EPA approved polymer suspension sealed secondary standards (0, 20, 100, 800 NTU)
	Pre Run Check	Before sample run.	

Table 60. Hach 2100 P portable turbidimeter use, maintenance and calibration frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
	Post Run Check	At end of sample run	<ul style="list-style-type: none"> • Distilled or deionized water • Lint-free towels • Silicone oil • Mild detergent (e.g., Alconox) • Sample wand • Complete set of replacement batteries • Copy of manuals for meter and standards • Sampling methods table and QC activity table

Table 61. Turbidity quality control activities using a Hach 2100 P portable turbidimeter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Duplicate	Measurement is performed twice at one sample site for at least 10% of the sample sites in every sample run.	Up to $\pm 2\%$ difference between duplicate values.	<ol style="list-style-type: none"> 1. Determine if turbidity value deviation are due to sample water, operator error, and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolutions in the field book. Discontinue measurement until problem resolved and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 2. If measurements continue (i.e., problem remedied), duplicate thirty percent of measurements for that sample run, or all of the remaining sample sites, whichever is less. 3. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities. Calibration is not necessary if prior calibration of the equipment is documented. Reference or record the prior calibration information for the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used. Place a photocopy of the calibration of the replacement equipment with a photocopy of the corresponding field book pages in the binder used to store copies of the field books pages. On the photocopied calibration, record the date of water quality measurements for which the equipment was used and reference the original source of the calibration.

Table 61. Turbidity quality control activities using a Hach 2100 P portable turbidimeter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Pre Run Calibration Check (Pre Run Check)	At the beginning of every sample run, measure turbidity of four certified NIST traceable sealed secondary standards (NTU values approximately 0, 20, 100, 800 NTU).	Up to ± 2 % difference between values for each standard.	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to sealed secondary standard, operator error, and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolutions in the field book. Do not perform sample measurement until problem resolved. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 2. If different (replacement) equipment is used to continue measurements, calibrate equipment and apply all other QC activities. Calibration is not necessary if prior calibration of the equipment is documented. Reference or record the prior calibration information for the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used. Place a photocopy of the calibration of the replacement equipment with a photocopy of the corresponding field book pages in the binder used to store copies of the field books pages. On the photocopied calibration, record the date of water quality measurements for which the equipment was used and reference the original source of the calibration.
Post Run Calibration Check (Post Run Check)	At the end of every sample run, measure turbidity of four certified NIST traceable sealed secondary standards (NTU values approximately 0, 20, 100, 800 NTU).	Up to ± 2 % difference between values for each standard.	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to secondary standard, operator error, and/or equipment malfunction. Remedy if possible and document problems, corrective actions, and outcomes/resolution in the field book. 2. If problem cannot be remedied at the time of occurrence, document problem, attempted corrected actions, and outcomes/resolution in the field book, and clearly mark data collected prior to the duplicate as suspect, and why the data are suspect in the field book. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible and ensure that replacement equipment is ready for use for next sample run. Do not perform sample measurement until problem resolved.

Table 61. Turbidity quality control activities using a Hach 2100 P portable turbidimeter.

Quality Control Activity	Frequency and Description of Activity	Acceptance Criteria	Corrective Action (presented in sequence)
Equipment Calibration, Calibration Check (Equip. Cal. Check)	Immediately following calibration, measure turbidity of the four certified NIST traceable sealed secondary standards used during the calibration (these are same vials used for all other calibration checks).	Up to $\pm 2\%$ difference between values for each standard.	<ol style="list-style-type: none"> 1. Determine if parameter deviation due to sealed secondary standard, operator error, and/or equipment. Remedy if possible and document problems, corrective actions, and outcomes/resolutions in the field book. Do not perform sample measurement until problem resolved. If the equipment is faulty, flag it and have it serviced and/or replaced as soon as possible. 2. Prepare replacement equipment for water quality measurements, including calibration and all QC activities. Document reason for use of replacement equipment and all calibration and QC measures in the field book. Calibration is not necessary if prior calibration of the equipment is documented. Reference or record the calibration information for the replacement equipment in the field book as well as the type, owner, and reason(s) different equipment is being used. Place a photocopy of the calibration of the replacement equipment with a photocopy of the corresponding field book pages in the binder used to store copies of the field books pages. On the photocopied calibration, record the date of water quality measurements for which the meter was used and reference the original source of the calibration.

11.12. Well Water Level

Well water level is measured with a Waterline Envirotech electric 300-foot Olympic Well Probe directly in the well. The probe is thinner than regular probes to allow passage within small diameter access tubes. The sensitivity of the meter can be adjusted and is set at mid-range. Water level is indicated with a user-selectable sound or light. The cable is marked in 5-foot increments. Depth is measured in feet and inches from the well measuring point. The Lummi Water Resources Division owns three water level meters, two Waterline Envirotech 300-foot Olympic Well probes, and one Solinst water level meter is available for backup. The Solinst meter is generally similar to the other probes except that the probe is too large for use in access tubes and the depth is marked in 0.02 foot increments. The water level meters are calibrated by the manufacturer and cannot be modified if the cable stretches. Instead, correction factors must be determined by the manufacturer to address stretch of the cable. Table 62 lists the accuracy, range, and resolution of the water level meter.

The water level meters are used and maintained following the manufacturers' instructions. Maintenance, QC activity frequency, and supplies are listed in Table 63. Very little maintenance is required, primarily keeping the probe clean, line clean, and checking the battery. If there is potential that the cable is stretched, the instrument must be returned to the manufacturer for determination of correction factors.

Equipment is inspected for basic proper function (e.g., battery, correct operation) before every use of the equipment. Quality control activities are not performed. Rapid changes in water levels preclude the use of duplicates and the method of water level measurement captures the variation of the water level. Only the manufacturer can evaluate and quantify the accuracy of the marked cord, which is performed whenever the cable could potentially or has actually been stretched.

All use, maintenance, problems, corrective actions, and outcomes/resolutions are recorded with the meter type(s) in the field log by the person using the equipment.

Table 62. Range, accuracy, and readability of well water level equipment.

Equipment	Parameter	Range	Accuracy	Readability
Waterline Envirotech electric 300-ft Olympic Well Probe	Well Water Level	0 to 300 ft.	± 1/8 in.	1/8 in.
Solinst electric water level meter	Well Water Level	0 to 300 ft.	± 0.02 ft	0.02 ft.

Table 63. Water level meters use, maintenance and calibration frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
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Table 63. Water level meters use, maintenance and calibration frequency, and needed supplies.

Activity	Sub-Activity	Frequency	Supplies
Return probe to manufacturer for inspection and stretch evaluation	--	As needed when a stretch in the cord is suspected.	<ul style="list-style-type: none"> • Waterline Envirotech Electric 300-ft. Olympic Well Probe <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> • Solinst water level meter

12. SUPPLIES AND CONSUMABLES (B8)

Critical supplies and consumables with acceptance criteria are listed in Table 64 below. The Water Resources Technician is responsible for ensuring that critical supplies and consumables are fresh, ready for use, and that a minimum two-month supply is always available. Supplies are purchased and delivered through the LIBC Purchasing Department and can usually be obtained within five working days after placement of the order. The Purchasing Department tracks and logs purchases and deliveries. Distilled or deionized (DI) water is readily available at stores on and adjacent to the Reservation. Equipment, supplies, and consumables are stored securely in locking cabinets at the Lummi Natural Resources Department office.

Supplies and consumables are inspected when received and corrective actions taken if they do not meet acceptance criteria. The inventory is checked monthly and materials ordered or discarded as needed. Hazardous materials (e.g., broken mercury thermometer, chloride analysis waste, zero dissolved oxygen standard) are securely stored in labeled (contents and date) and sealed containers, and transported to a Hazardous Materials Disposal Site (which currently is Hazardous Waste Disposal in Bellingham, WA). All other materials are disposed of at the place of use taking care to ensure that materials do not directly enter a waterbody (e.g., well vegetated areas away from waterbodies). All calibration and calibration check standards are disposed of after use, except for primary turbidity standards and the 1,000-mg/l chloride standard.

For consumables that are not single-use, the date that the container was first opened is written onto the container label with the initials of the person that opened the container. Replacement parts for meters are not kept in stock because, in most cases, only the manufacturer can perform repairs. Other complete equipment sets (i.e., meter and probe) are available within the Lummi Water Resources Division or from either the Salmon Stock Assessment or Habitat Restoration divisions of the Lummi Natural Resources Department.

Laboratory bottles are inspected upon receipt from the laboratory and prominently marked with an "X" if the bottle cap is off or loose, or the cap or bottle is damaged. These bottles are either disposed of at the office if they are broken and do not contain hazardous materials, or they are returned to the laboratory.

Table 64. Critical supplies and consumables with acceptance criteria.

Equipment and Parameter Category	Consumable & Supplies	Acceptance Criteria	Stocking Level	Responsible Party
Data Recording	Field Book	Permanently bound book with Rite-in-the-Rain paper.	Five minimum.	Water Resources Technician
	Pens	Ball point pens capable of writing on write-on-rain paper in any position.	Ten minimum.	Water Resources Technician
	Stopwatch with date, time, and countdown timer.	Time indicated by watch is accurate and watch is functional.	Two	Water Resources Technician
General	Sample Wand	Clean and not damaged	Two (2) minimum	Water Resources Technician
	Bleach	Fresh and container not damaged	Two (2), ½ gallon containers	Water Resources Technician
	One or two pint spray bottle	Clean and functional	Two (2) minimum	Water Resources Technician
	Alconox Detergent	Fresh and container not damaged	Two (2) one quart containers	Water Resources Technician
	Lint Free Towels (12 in. by 12 in. minimum size)	Clean and not damaged	6 boxes	Water Resources Technician
	Distilled or deionized water (DI Water)	Tested during zero calibration checks.	Four (4) to eight (8) gallons minimum, more if necessary.	Water Resources Technician
	Ice	Clean and fresh (do not allow water to accumulate in cooler)	As needed up to about 24 hours in advance.	Water Resources Technician
	Goggles	Clean and not damaged	Three	Water Resources Technician
	Gloves	Clean and not damaged	2 boxes with at least 25 pair. One box unopened.	Water Resources Technician
Sampling Containers for both laboratory and non-laboratory analysis.	1-L wide-mouth plastic bottle for surface water	Clean and not damaged	Five (5) minimum	Water Resources Technician
	1-L wide-mouth plastic bottle for ground water specific conductivity and temperature	Clean and not damaged	Five (5) minimum	Water Resources Technician
	500-ml wide-mouth plastic bottle for chloride	Clean and not damaged	Thirty (30) minimum.	Water Resources Technician
	Bottles for bacteria—Fecal coliform (Washington Department of Health supplied bottles)	Supplied by laboratory. Top must be securely in place and bottle not damaged. Label with analysis on bottle.	Twelve (12) minimum.	Water Resources Technician
	Bottles for bacteria—Fecal Coliform and <i>E. coli</i>	Discarded bottles have a prominent “X” placed across label and are either disposed of directly if broken and non-hazardous, or returned the laboratory.	Twenty (20) minimum.	Water Resources Technician
	Bottles for bacteria—Fecal coliform, <i>E. coli.</i> , and Enterococcus		Twenty (20) minimum. Two working days prior to sample run must have number required for run plus five extra.	Water Resources Technician

Table 64. Critical supplies and consumables with acceptance criteria.

Equipment and Parameter Category	Consumable & Supplies	Acceptance Criteria	Stocking Level	Responsible Party
	Sterile Water		Ten (10) minimum.	Water Resources Technician
	Chloride		Ten (10) minimum	Water Resources Technician
	Nutrient		Four complete sample bottle sets minimum. Two working days prior to sample run must have number required for run plus two extra sets.	Water Resources Technician
	Metals		Four complete sample bottle sets minimum. Two working days prior to sample run must have number required for run plus two extra sets.	Water Resources Technician
	Hydrocarbons		Four complete samples bottle sets minimum. Two working days prior to sample run must have number required for run plus two extra sets.	Water Resources Technician
Air Temperature	Armored non-toxic liquid-in-glass thermometer	Graduated and readable to 1°F or 0.5°C increment.	Two replacements	Water Resources Technician
Specific Conductivity, Salinity, Water Temperature with WTW LF 330 Meter and TetraCon 325 Probe. or YSI S-C-T Model 30 meter and probe (probe permanently attached to meter)	WTW LF 330 Meter or YSI S-C-T Model 30 meter and probe	Operating properly and passing QC activities.	One of either. Two additional meters (one of each type) are available for use from other divisions with LNR.	Water Resources Technician
	TetraCon325 Probe with 10 m. cord. (WTW Only)	Operating properly and passing QC activities.	None. Probe will be replaced and alternate meter and probe combination used in mean-time.	Water Resources Technician
	Certified NIST traceable reference thermometer	1. Certified NIST traceable 2. Construction details: mercury in glass, 460 mm length, total immersion, graduated in 0.1 °C increments 3. Clean and not damaged	Two	Water Resources Technician
	Metal armor for certified NIST traceable reference thermometer	Clean and not damaged	Two	Water Resources Technician
	Certified NIST traceable 1,413µS/cm calibration standard. (WTW Only)	1. Certified NIST traceable 2. Material not expired. Must be received with expiration date of material a minimum of six or more months from present date. 3. Single use container	Six (6) to ten (10) fresh single use containers.	Water Resources Technician

Table 64. Critical supplies and consumables with acceptance criteria.

Equipment and Parameter Category	Consumable & Supplies	Acceptance Criteria	Stocking Level	Responsible Party
	Certified NIST traceable 1,000 $\mu\text{S}/\text{cm}$ calibration check standards.	1. Certified NIST traceable 2. Material not expired. Must be received with expiration date of material a minimum of six or more months from present date.	Four (4) to eight (8) fresh one pint bottles.	Water Resources Technician
	Certified NIST traceable 10,000 $\mu\text{S}/\text{cm}$ calibration check standards.	1. Certified NIST traceable 2. Material not expired. Must be received with expiration date of material a minimum of six or more months from present date.	Four (4) to eight (8) fresh one pint bottles.	Water Resources Technician
	AA Batteries	Fresh and charged.	Eight (8) batteries (2 replacement sets).	Water Resources Technician
Chloride with LaMotte PSC DR Code 4503-DR	Lamotte Chloride test kit, Model PSC-DR, Code 4503-DR	1. Kit contains sufficient reagents and is in proper condition to perform at least ten chloride analysis.	Three (3) to Four (4), only one in use at any time	Water Resources Technician
	Certified NIST traceable 1,000-mg/l chloride standard	1. Certified NIST traceable 2. Material not expired. Must be received with expiration date of material a minimum of six or more months from present date. 3. Within opened shelf life (date opened recorded on bottle in pen).	Two 500-ml containers. One in use the other not opened.	Water Resources Technician
	Class A 20-ml volumetric pipette	Clean and not damaged	Three	Water Resources Technician
	Class A 200-ml volumetric flask with stopper	Clean and not damaged	Three	Water Resources Technician
	Pipette pump	Properly functioning and clean	Three	Water Resources Technician
	50-ml beaker	Clean and not damaged	Three	Water Resources Technician
	Label tape	Clean and not damaged	Three	Water Resources Technician
	Ground water hose	Clean and not damaged	Two	Water Resources Technician
Dissolved Oxygen with Oxyguard Handy Mk III Portable Dissolved Oxygen meter or Oxyguard Handy Gamma Portable Dissolved Oxygen meter.	Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or Oxyguard Handy Gamma Portable Dissolved Oxygen meter.	Operating properly and passing QC activities.	One extra meter available for use with WRD.	Water Resources Technician
	NIST traceable zero dissolved oxygen standard	1. Certified NIST traceable 2. Material not expired. Must be received with expiration date of material a minimum of six or more months from present date.	Two boxes of 25 single-use packets (one unopened spare) or two 500-ml containers (one unopened spare).	Water Resources Technician
	9-V batteries	Fresh and charged	Four (2) batteries (1 replacement for each meter).	Water Resources Technician
	Small flat-head screwdriver	Clean and not damaged	Two	Water Resources Technician
	Probe membranes	Clean and not damaged	At least ten (10)	Water Resources Technician

Table 64. Critical supplies and consumables with acceptance criteria.

Equipment and Parameter Category	Consumable & Supplies	Acceptance Criteria	Stocking Level	Responsible Party
	O-rings	Clean and not damaged	At least ten (10)	Water Resources Technician
	Electrolyte solution	Fresh, not expired, and within shelf life	At least two 100-ml bottles (one unopened spare)	Water Resources Technician
	Probe servicing tool	Clean and not damaged	Two	Water Resources Technician
Flow (surface water discharge)	One (1) liter container marked in 0.25 liter increments.	Clean and not damaged	Two	Water Resources Technician
	Five (5) gallon container marked in one-gallon increments.	Clean and not damaged	Two	Water Resources Technician
	Open Reel Measuring tape	Clean and not damaged	Two	Water Resources Technician
	Squeegee	Clean and not damaged	Two	Water Resources Technician
	Shovel	Clean and not damaged	Two	Water Resources Technician
Water Samples Collected for Analysis at a Laboratory	Bottles addressed under "Sampling Containers" above	--	--	--
	Chain of Custody forms and/or DOH sampling form	Clean and not damaged	Five (5)	Water Resources Technician
	Cooler(s)—in field vehicle sample transport	Clean and not damaged	Two (2)	Water Resources Technician
	Cooler(s)—sample shipment	Clean and not damaged	Two (2)	Water Resources Technician
	Reusable ice block	Clean, functional.	Variable. Size and type of block varies. Store sufficient blocks for two shipments of DOH samples, with one set always frozen.	Water Resources Technician
	Plumbing Torch and sparker	Clean and not damaged	Two (2), one un-used	Water Resources Technician
pH with Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and Model T11 stainless steel temperature compensation probe	Model IQ150 Handheld pH/mV/Temperature meter	Operating properly and passing QC activities.	One	Water Resources Technician
	ASI Model 35 Low Ionic Strength electrode and	Operating properly and passing QC activities.	One	Water Resources Technician
	Model T11 stainless steel Temperature Compensation Probe	Operating properly and passing QC activities.	One	Water Resources Technician
	KCl Electrode storage solution	Fresh (not expired) and within shelf life	Two (one unopened spare)	Water Resources Technician
	pH buffer 4	Fresh (not expired) single use packets	Two boxes of 25 packets	Water Resources Technician
	pH buffer 7	Fresh (not expired) single use packets	Two boxes of 25 packets	Water Resources Technician

Table 64. Critical supplies and consumables with acceptance criteria.

Equipment and Parameter Category	Consumable & Supplies	Acceptance Criteria	Stocking Level	Responsible Party
	pH buffer 10	Fresh (not expired) single use packets	Two boxes of 25 packets	Water Resources Technician
	Dedicated pH measurement container and cap	Clean and not damaged	Two	Water Resources Technician
	9-V batteries	Fresh and charged	Eight (one set of replacements)	Water Resources Technician
Secchi Depth	Secchi disk	8.5 inch diameter disk alternately marked in black and white quadrants. Weight and 10-m cord marked in 0.5-meter increments attached.	One	Water Resources Technician
	Clothes pins	Clean and not damaged	Five	Water Resources Technician
	Measuring tape	Clean and not damaged	Two	Water Resources Technician
Water Depth	Marked sample wand	Clean and not damaged	Two	Water Resources Technician
	4-ft. ruler	Clean and not damaged	One	Water Resources Technician
Turbidity with Hach 2100 P portable turbidimeter	Hach 2100 P portable turbidimeter	Operating properly and passing QC activities.	One. One other identical instrument available within LNR.	Water Resources Technician
	Certified EPA approved primary standards (0, 20, 100, 800 NTU)	Fresh, (not expired and within shelf life if opened) EPA approved polymer suspension primary calibration standards (<0.1, 20, 100, 800 NTU) (not Formazin).	Sufficient volume for three (3) calibrations.	Water Resources Technician
	Certified EPA approved sealed secondary standards	Fresh (not expired) EPA approved polymer suspension sealed secondary standards (0, 20, 100, 800 NTU)	One complete set. Replace at least 3 months prior to expiration.	Water Resources Technician
	Matched and indexed turbidity vials	Indexed, clean, and not damaged or scratched.	Three	Water Resources Technician
	Silicone Oil	Fresh (not expired) and within shelf life	Two (one spare unopened)	Water Resources Technician
	AA Batteries	Fresh and charged	Eight (one replacement set)	Water Resources Technician
Well Water Level with Waterline Envirotech Electric 300-ft. Olympic Well Probe	Waterline Envirotech Electric 300-ft. Olympic Well Probe	Operating properly and not stretched (unless stretch corrections determined by manufacturer)	Two	Water Resources Technician
	Measuring tape	Clean and not damaged	Two	Water Resources Technician
	Flat head screwdriver	Clean and not damaged	Two	Water Resources Technician
	Crescent wrench	Clean and not damaged	Two	Water Resources Technician
	Needle-nose vise grips	Clean and not damaged	Two	Water Resources Technician
	Wire cutters	Clean and not damaged	Two	Water Resources Technician
	Extra nuts and bolts	Clean and not damaged. In sizes encountered in field	Variable, at least three (3) of each size	Water Resources Technician

Table 64. Critical supplies and consumables with acceptance criteria.

Equipment and Parameter Category	Consumable & Supplies	Acceptance Criteria	Stocking Level	Responsible Party
	9-V battery	Fresh and charged	Two (one replacement)	Water Resources Technician

13. NON-DIRECT MEASUREMENTS (B9)

Non-direct measurements are used to assist with implementation of the water quality monitoring program, and to provide context for program data. Non-direct measurements include tidal height, Nooksack River discharge, and water quality data from the Washington Department of Health (DOH). Except for the staff-gage-based calculated discharges, these data are not entered into the water quality database. Data qualifiers provided by the sources are retained with the data. Acceptable levels of data quality vary with the type of information needed (e.g., preliminary discharge information that is subject to revision is acceptable for evaluating real-time Nooksack River discharge).

Predicted tidal information is generated by the Tides and Currents Pro software program. Actual tidal information is obtained from the National Oceanic and Atmospheric Administration (NOAA) Cherry Point (Station CHYW1 - 9449424) tide gage located along the Georgia Strait coast near Cherry Point north of the Reservation⁶. Nooksack River flow information is obtained from the U.S. Geological Survey gauging station located on the Nooksack River at Ferndale, Washington⁷. The DOH provides copies of the sampling sheets with the bacteria results within a few weeks of sample collection, and sooner via facsimile and phone if there is a problem with either sample collection or elevated fecal coliform levels.

14. DATA MANAGEMENT (B10)

All sampling and related data are recorded in a bound field book (Sections 8 [A9] and 10 [B2, B3, B4]) or on reports provided by the laboratory. Data are transferred from the field book to a computer database (Microsoft Access).

To eliminate transcription errors, once the information in the field books and laboratory reports is entered into the database, a hard copy of the entered data are printed and manually compared against the information recorded in the field book and on the laboratory report. Check marks are placed next to every entry on the hard copy printout from the database to document that the value was checked. The initials of the person performing the quality control work and the date are recorded on each page.

All hardcopy information is stored in the office of the Water Resources Specialist and Technician. Archiving these materials is not anticipated at this time, but the procedures of the Lummi Records and Archives Department will be followed when field logs are archived.

⁶ The National Data Buoy Center (National Oceanic and Atmospheric Administration) Station CHY1 – 9449424 is available online at http://www.ndbc.noaa.gov/station_page.php?station=chyw1.

⁷ U.S. Geological Survey Station “USGS 12213100 Nooksack River at Ferndale, WA” available online at http://waterdata.usgs.gov/usa/nwis/uv?site_no=12213100.

The QA/QC information for each measurement is accessible through the date, time, and the person sampling. Data are checked against calibration and QC activity data (including chain-of-custody) and labeled/coded according to its quality. Also recorded during the above data evaluation are the name of the person performing the task, the date and time of the evaluation, the database records evaluated, and the evaluation criteria.

- Data with poor QA/QC performance are not entered into the database, or are prominently coded as such. Suspect data are not entered into the database until data quality has been assessed and is sufficient for entry into the database. The data are coded as originally being suspect and may have other qualifiers based upon data quality.
- Where data are not recorded electronically in the database, it is noted that measurements were made but the results were too inaccurate, imprecise, or un-traceable for the database.
- Until the data have been reviewed and assessed as described above, including for transcription errors, the data are prominently marked as "Draft" and "Preliminary, Subject To Revisions."

All electronic data are stored on a network hard drive that is backed up nightly. Data from the entire period of record will be stored on this network hard drive. During 2006, all of the existing water quality data collected as part of the surface water quality program will be exported and transmitted to the EPA for inclusion in the STORET v.2 database. All data collected in subsequent years will also be exported and transmitted to the EPA for inclusion in the STORET v.2 database.

The Lummi Water Resources Division is currently evaluating its data management procedures both to reduce the turn around time between sample collection, sample analysis, reporting, data entry, and data analysis; and to meet new EPA criteria that requires that all water quality data collected using EPA grant funds be provided to the EPA for direct importation into the STORET v.2 database. Workload constraints have historically resulted in substantial delays between sample collection, analysis, and reporting and the subsequent steps of data entry, data quality analysis, and data analysis. To address these workload constraints, contractors have been hired to help perform some of the duties previously performed by just the Specialist and Technician (Table 1). In addition, a work group was formed to: 1) assess the existing database structure and existing water quality monitoring program in terms of the number and location of sample sites, and the parameters that are measured, and 2) to identify and take actions to implement a database management system that is stable, accessible, reliable, and cost effective. Part of this effort is to develop a database structure that is compatible with both STORET v.2 and is linked to the tribal Geographic Information System (GIS). The linkage to the GIS is intended to allow technical and management staff to select a sample site location on the GIS and be able to display photographs of the site and graphical and statistical presentations of water quality sample results for the location. The Water Resources Specialist has been assigned to lead this effort with a targeted date of full implementation by December 31, 2006.

15. ASSESSMENT AND OVERSIGHT (C1)

Table 1 lists the key personnel and their responsibilities. In summary, the person conducting the sampling (primarily the Water Resources Technician, but also the Water Resources Specialist) is responsible for performing all inspections, calibrations, and QC activities required for the parameters recorded and/or sampled during a sample run. The Water Resources Specialist is responsible for ensuring that required inspections, maintenance, calibrations, QC activities, and corrective actions are performed and documented. The Water Resources Technician and/or Specialist report this information to the Water Resources Manager, who ensures QA/QC objectives and reporting requirements are achieved.

Operator errors and equipment problems detected during calibration or in the field will initiate actions to correct the problem. Corrective actions depend upon the parameter being measured. Generally, if the problem cannot be resolved on-site, the measurement is discontinued until the problem is identified, remedied, and reliable results obtained. Problems with equipment and measurements are recorded in the field log along with corrective actions and outcomes/resolutions. The equipment may still be used in a limited capacity if the information provided is useful. In such instances, the condition of the instrument will be documented in the field log.

Data quality assessments are performed on an as-needed basis by the Water Resources Specialist or Manager⁸. The scheduled revision of the database includes provision for automated evaluation and assessment of sampling and QC activity data so that completeness, representativeness (at program scale), accuracy, precision, traceability, and comparability can be quantified immediately after the data have been entered and verified. It is anticipated that annual data quality reports will be generated by the Water Resources Manager and as-needed by the Water Resources Technician, Specialist, or Manager.

16. REPORTS TO MANAGEMENT (C2)

The Water Resources Technician and Specialist are responsible for evaluating sampling and QC data and reporting to the Water Resources Manager regularly and as-needed for problems. Problems include elevated fecal coliform counts, elevated chloride levels, and declining well water levels.

For example, the Water Resources Specialist reviews the bacteria results and data quality of bacteria results provided by laboratory and immediately alerts the Water Resources Manager if elevated levels of fecal coliform are detected. If the sample site location indicates that an

⁸ Workload constraints have prevented pro-active data quality assessments, other than the sampling methods and QC activities specified in Sections 10 [B2, B3, B4] and 11 [B5, B6, B7]. This is one reason the database structure and sampling program are being revised.

elevated pollutant level originates from off-Reservation, representatives from either the State Department of Ecology and/or the State Department of Agriculture are notified of the elevated count and requested to investigate possible sources. If the sample site location indicates that an elevated pollutant level originates on-Reservation, the Water Resources Division staff conduct a follow-up investigation.

The Water Resources Specialist prepares an annual water quality summary report that compares water quality for the previous year with historical water quality. These reports are reviewed and approved by the Water Resources Manager and the Environmental Program Director and the approved reports are transmitted to the Environmental Protection Agency.

The Water Resources Manager submits semi-annual (twice per year) progress reports to the EPA Project Officer that describe program status, problems, remedies, and schedules.

17. DATA REVIEW, VERIFICATION, VALIDATION (D1)

Data verification and validation are described in Section 14 [B10].

18. VERIFICATION AND VALIDATION METHODS (D2)

As described previously, water quality data are only entered into the field book if method and quality control activity criteria are met, or if data are entered that do not meet the method and QC activity criteria or are otherwise suspect, the data are clearly labeled as suspect along with the reason(s) in the field book. Suspect data are not entered into the database until data quality is known and acceptable for inclusion in the database. Once the quality of the suspect data are known, that information is recorded in the field book (with the initials of the person writing in the book and the date) with the suspect data, from which point the data may or may not be entered into the database.

The water quality sampler checks that all necessary information has been recorded for each sample site before leaving the sample site, and again at the end of the sample run. Any deficiencies are corrected and documented in the field book. The Water Resources Specialist reviews the sampling and QC activity data collected and recorded by the Water Resources Technician, and visa versa if the Specialist performs the sampling. Data are reviewed for completeness and identification of any problems. If required, additional information is recorded in the field book, with the dates additional information and initials of person entering it. Validation of the transcription from the field book or laboratory report to the database is described in Section 14.

Currently, additional data verification and validation is performed as needed according to the decision required. These as-needed evaluations include accuracy, precision, traceability, completeness, and representativeness. Acceptable levels of these data quality elements vary with the decision to be made, and in some cases, the collection of additional data are required. In

order for data to be used to support a decision, the data must be of sufficient quality and resolution when compared to the decision threshold(s) for a decision. As described earlier, quantification of data quality will be included with the upcoming revisions to the database and water quality monitoring program. It is also planned that when the revised database is implemented, recently collected data can be compared with the current and historic results from that and nearby sample sites to evaluate trends or anomalies.

The Water Resources Specialist is responsible for ensuring all QA/QC protocols are followed. Where problems are detected and not resolved through standard practices or are of a larger nature than the staff conducting water quality sampling typically address (e.g., the method is no longer providing acceptable results) the Water Resources Technician, Specialist, and Manager jointly develop an action plan to remedy the problem with clear roles, responsibilities, and timelines. The Water Resources Specialist is also responsible for quantifying or qualifying data quality to data users.

19. RECONCILIATION WITH USER REQUIREMENTS (D3)

The program is an ongoing program and is not designed to prove or disprove specific hypothesis. Uncertainty of the data are not currently calculated, but will start with the implementation of the revised database (Sections 14 [B10]) to increase the usability of the data. Currently, data limitations are presented to the data users with the data by the Water Resources Specialist. With the revised database, data limitations will be linked directly to the data with readily accessible explanations.

20. REFERENCES

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⁹ Several locations should be checked for updates because not all contain the most up-to-date versions. The following Internet Sites had up-to-date versions as of November 21, 2005: 1) <http://pubs.usgs.gov/twri/>, 2) <http://pubs.water.usgs.gov/twri9A>, 3) <http://water.usgs.gov/owq/FieldManual/>, and 4) <http://water.usgs.gov/pubs/>. The U.S. Geological Survey Publications Warehouse (<http://infotrek.er.usgs.gov/pubs/>) did not have up-to-date versions available as of November 21, 2005.

**APPENDIX A: DATA ENTRY TABLES FOR SAMPLING AND QUALITY CONTROL
ACTIVITIES USED IN THE FIELD LOG BOOK**

Data Entry Table: Surface Water Quality Sampling

The date, sampler(s) names or their initials (if they have been previously defined in the field book), weather conditions, and sample run name are recorded on the first page of the field book. Subsequent pages used for that sample run have the date, initials of the sampler, and weather conditions if they have changed. Note that flow and DO Sample Calibration Checks are recorded as comments for the site sampled. Fewer columns may be used if not all parameters are measured (e.g., Secchi depth is not measured during the LSR sample run). Duplicates are recorded in the field log by writing “water quality duplicate” or “wq dup” with the sample site identifier in the Sample Site column of the data entry table.

Surface Water Quality Data Entry Table

Shaded area not entered into field book, provided here for informational purposes	Column Layout														
Full Table Header Text	Sample Site Number or Name	Time of sample collection and/or measurement (24-hours)	Sample Identifier for Samples Collected for Analysis at a Laboratory	Air Temperature (°C)	Water Temperature (°C)	Salinity (ppt)	Specific Conductivity (µ S/cm or mS/cm)	Waterbody Stratified? Yes/No/ Where Water Quality sampled/ measured	Dissolved Oxygen concentration (mg/l) and percent saturation (%)	Water Level (narrative) or Depth (m)	Flow/ Current Direction	pH (pH units) with temperature (°C) recorded by Automatic Temperature Compensation Probe.	Turbidity (NTU)	Secchi Depth (m)	Comments
Abbreviated Table Header Text	Sample Site	Time	Lab ID	Air Temp. (°C)	Wtr. Temp. (°C)	Sal. (ppt)	Sp Cond. (xS/cm) where “x” is “µ” or “m” and recorded with data.	Strat? (Y/N/ Where)	DO conc. (mg/l) / sat (%)	WL/ Depth (m)	Flow/ Curr. Dir.	pH (pH units) / ATC Temp (°C)	Turb. (NTU)	Secchi Depth (m)	Comm.
Example Data (fictional)	31	14:10	31 Bacteria (A)	22.5	12.5	2.5	5.2 m	N	9.5 / 96	.75 m	downstream	7.5/18.0	15	--	Staff gage is 0.15 ft. No flow across beach.
	3	09:47	3 Bacteria 3 Nutrients (B)	15.2	10.5	0.0	152 µ	N	8.7 / 85	1.25 m	upstream	7.9/11.1	5.2	--	Translucent brown color.
	8	09:47	8 Bacteria (A)	17.5 avg 17.0 to 19.0	12.5	5.2	4.11 m	Y, Top (T)	8.5 / 90	VG – 0.3 m	downstream	7.3 (12.7)	150	--	Brown murky water
	8	09:47			12.5	22.5	23.5 m	Y, Bottom (B)	7.5 / 67						Sharp stratification boundary at 0.5 meters below water surface

(A) If only bacteria samples are collected, “bacteria” does not need to follow sample site number if column header indicates that only bacteria are being sampled and defines which bacteria will be enumerated.

(B) Analyses are typically grouped into bacteria, hydrocarbons, metals, and nutrients. The specific analyses requested are listed in the field book and are cross referenced with

the “Lab ID” column.

Data Entry Table: Ground Water Quality Sampling

The date, sampler(s) names or their initials (if they have been previously defined in the field book), weather conditions, and sample run name are recorded on the first page of the field book. Subsequent pages used for that sample run have the date, initials of the sampler, and weather conditions if they have changed. Duplicates are recorded in the field log by writing “water quality duplicate” or “wq dup” with the sample site identifier in the Sample Site column of the data entry table.

Ground Water Quality Data Entry Table

Shaded area not entered into field book, provided here for informational purposes	Column Layout									
Full Data Entry Table Header	Sample Site Number or Name	Time of sample collection and/or measurement (24-hours)	Sample Identifier for Samples Collected for Analysis at a Laboratory	Water Level (feet and inches)	Pump rate (cfm or gpm depending upon meter) if pump is on or pump status	Chloride (mg/l)	Water Temperature (°C)	Specific Conductivity (µ S/cm or mS/cm)	Totalizer value (either cfm or gpm depending upon meter)	Comments
Abbreviations used for Data Entry Table Header in field book	Sample Site	Time	Sample ID	Water Level	Pump rate/ status (units recorded with data)		Temp. (°C)	Sp Cond. (xS/cm) where “x” is “µ” or “m” and recorded with data.	Odometer	Comm.
Example Data (fictional)	74	14:20	74 (A)	125’ – 12.5”	off	40	10.5	347 µ	220447 f ³	
	145	13:11	--	130’ – 22.25”	off 10 minutes	--	--	--	--	
	56	08:42	--	--	5.2 cfm (“pump on” implicit with recording of rate).	56	10.5	287 µ	793582 f ³	

(A) If the specific analyses requested is not written here, provide cross reference to where listed in field book.

Data Entry Table: Specific Conductivity, Salinity, and Water Temperature Quality Control Activities

Specific conductivity, salinity, and water temperature measurements with the either a WTW LF 330 with TetraCon 325 probe (WTW) or a Yellow Springs Instruments (YSI) S-C-T Model 30 meter and probe (YSI).

The template for recording of QC activity information is contained within the text box below. Shaded areas are not written into the field book and *underlined italics* represent where the sampler enters information outside of the data entry table. Duplicates are not included because they are recorded in the data entry table as a duplicate.

Abbreviations for sample sources are presented as text in parenthesis. At a minimum, the date and name(s) or initials of the sampler(s) are written on the field book page with the QC activity information. Calibrations are recorded in the field book in the same general format.

Specific Conductivity, Salinity, Temperature QC Activities
 Equipment used: *Meter and probe name and model/type*
 Equipment operating properly at beginning of sample run? *yes/no*
 Cell Constant Value: *Value (WTW only)*
 Date of last calibration: *Date or "N/A" for YSI*

Shaded area not entered into field book, provided here for informational purposes	Column Layout					
Full Table Header Text	Sample Source	Reference Thermometer Identification and Sample Temperature (°C)	Sample Temperature (°C) Measured by Equipment	Sample Salinity (ppt) Measured by Equipment	Sample Specific Conductivity (µS/cm or mS/cm) Measured by Equipment	Comments
Abbreviated Table Header Text (can be used in lieu of full text).	Sample Source	Ref Therm ID Temp. (°C)	Temp. (°C)	Sal. (ppt)	Sp Cond. (xS/cm) where "x" is "µ" or "m" and recorded with data.	Comm
Minimum QC activities	Pre-run Zero					
	Post-Run Zero					
Additional QC Activities as necessary	Post Cal Check*A					
	1,000 std*B					
	10,000 std*C					

**A, *B, *C: Name, type, manufacturer, concentration, lot number, and expiration date of all standards used*

Problems, corrective actions, and outcomes/resolutions: *"yes" with full documentation or "none"*

Data Entry Table: Dissolved Oxygen Quality Control Activities

Dissolved oxygen measurements with either an Oxyguard Handy Mk III Portable Dissolved Oxygen meter, or an Oxyguard Handy Gamma Portable Dissolved Oxygen meter

The template for recording of QC activity information is contained within the text box below. *Underlined italics* represent where the sampler enters information. Duplicates and Sample Calibration Checks are not included because they are recorded in the data entry table. Abbreviations for sample sources are presented as text in parenthesis. At a minimum, the date and name(s) or initials of the sampler(s) are written on the field book page with the QC activity information.

DO QC Activities

Equipment Used: *Meter name and model/type*

Equipment operating properly at beginning of sample run? *yes/no*

Pre Run Air Calibration *dissolved oxygen value set meter to* (%) at *temperature value* (°C)

Pre Run Air Check *dissolved oxygen value* (%) at *temperature value* (°C)

Pre run zero Check *dissolved oxygen value* (%) at *temperature value* (°C)

Mid-Run Air Check *dissolved oxygen value* (%) at *temperature value* (°C)

Mid-Run Recalibration (*yes/no*)

If yes, Mid Run Air Calibration *dissolved oxygen value* (%) at *temperature value* (°C)

Post Run Air Check *dissolved oxygen value* (%) at *temperature value* (°C)

Post Run Zero Check *dissolved oxygen value* (%) at *temperature value* (°C)

Name, type, manufacturer, concentration, lot number, and expiration date of all standards used.

Problems, corrective actions, and outcomes/resolutions: *“yes” with full documentation* or *“none”*

Data Entry Table: pH Quality Control Activities

pH measurements with a Model IQ150 Handheld pH/mV/Temperature meter with an ASI Model 35 Low Ionic Strength electrode and temperature compensation probe.

The template for recording of QC activity information is contained within the text box below. Shaded areas are not written into the field book and *underlined italics* represent where the sampler enters information outside of the data entry table. Duplicates are not included because they are recorded in the data entry table as a duplicate. At a minimum, the date and name(s) or initials of the sampler(s) are written on the field book page with the QC activity information.

pH QC Activities
 Equipment Used: *Meter and probe name and model/type*
 Equipment operating properly at beginning of sample run? *yes/no*

Shaded area not entered into field book, provided here for informational purposes	Column Layout						
Full Table Header Text	Type of Activity (calibration or calibration check)	pH value of buffer used)	pH value indicated by meter	Temperature of buffer (°C)	Lot number of buffer used	Expiration date of buffer used	Comments
Abbreviated Table Header Text (can be used in lieu of full text).	Cal/Chk	Buffer pH	pH Value	Temp (°C)	Lot #	Exp. Date	Comm
Calibration	Calibration	7					
Calibration	Calibration	10					
Minimum QC activities	Pre Run Check	7					
Minimum QC activities	Pre Run Check	10					
Minimum QC activities	Pre Run Check	4					
Minimum QC activities	Mid Run Check	7					
Minimum QC activities	Post Run Check	7					

Name, type, manufacturer, buffer value, lot number, and expiration date of all buffers used.

Data Entry Table: Chloride Quality Control Activities

Chloride measurement with a direct titrating Lamotte test kit, Model PSC-DR, Code 4503-DR.

The template for recording of QC activity information is contained within the text box below. Shaded areas are not written into the field book and *underlined italics* represent where the sampler enters information outside of the data entry table. Duplicates are not included because they are recorded in the data entry table as a duplicate. At a minimum, the date and name(s) or initials of the sampler(s) are written on the field book page with the QC activity information.

The preparation of the 100-mg/l standard and the materials used is documented in the field book with the date, name or initials of the preparer, materials used including the name, type, manufacturer, concentration, lot number, and expiration date of all non-zero standards used. The date of preparation of the 100-mg/l standard is recorded on label tape on the volumetric flask. The 100-mg/l standard is stored in the flask with a protective cover, which is handled and stored in the same manner as a chloride sample.

Chloride QC Activities			
Equipment Used: <i>Kit name and model/type</i>			
Equipment operating properly at beginning of sample run? <i>yes/no</i>			
Shaded area not entered into field book, provided here for informational purposes	Column Layout		
Full Table Header Text	Sample Source	Chloride concentration (mg/l)	Comment
Abbreviated Table Header Text (can be used in lieu of full text).	Sample Source	Chl (mg/l)	Comment
Minimum QC activities	100-mg/l std		100-mg/l chloride standard prepared on <i>date</i> .
	Blank		
<i>Name, type, manufacturer, buffer value, lot number, and expiration date of all buffers used.</i>			
Problems, corrective actions, and outcomes/resolutions: <i>“yes” with full documentation or “none”</i>			

Data Entry Table: Turbidity Quality Control Activities

Turbidity measurements with a Hach 2100 P portable turbidimeter.

The template for recording of QC activity information is contained within the text box below. Shaded areas are not written into the field book and underlined italics represent where the sampler enters information outside of the data entry table. Duplicates are not included because they are recorded in the data entry table as a duplicate. At a minimum, the date and name(s) or initials of the sampler(s) are written on the field book page with the QC activity information. Calibrations are recorded in the field book using the same general format.

Where NTU values are presented in underlined italics in the data entry table in the text box, the actual values of the secondary standards (determined during calibration) should be entered. The actual values should be close to the values presented. NTU = Nephelometric Turbidity Unit.

Turbidity QC Activities							
Equipment Used: <u>Meter name and model/type</u>							
Equipment operating properly at beginning of sample run? <u>yes/no</u>							
Date of last calibration: <u>date</u>							
Shaded area not entered into field book, provided here for informational purposes	Column Layout						
	Full Table Header Text	Calibration Check Type	NTU value of secondary standard used	NTU value indicated by meter (NTU)	Lot number of secondary standard used	Expiration date of secondary standard used	Comments
Abbreviated Table Header Text (can be used in lieu of full text).	Check Type	Std NTU	Turbidity (NTU)	Lot #	Exp. Date	Comm	
Minimum QC activities	Pre Run Check	<u>0</u>					
		<u>10</u>					
		<u>100</u>					
		<u>800</u>					
	Post Run Check	<u>0</u>					
		<u>10</u>					
		<u>100</u>					
		<u>800</u>					
Additional QC Activities as necessary	Equip. Cal. Check	<u>0</u>					
		<u>10</u>					
		<u>100</u>					
		<u>800</u>					

Name, type, manufacturer, NTU value, lot number, and expiration date of all standards used
*A, *B, *C: Name, type, manufacturer, concentration, lot number, and expiration date of all standards used

APPENDIX B: SAMPLE CHAIN OF CUSTODY FORM

**APPENDIX C: UNITS FOR WATER QUALITY MEASUREMENTS AND OTHER
ABBREVIATIONS**

Units of measurement used in document.

°C	= Degrees Celsius
cf	= Cubic feet
cfm	= Cubic feet per minute
cfs	= Cubic feet per second
gpm	= Gallons per minute
°F	= Degrees Fahrenheit
ft	= Feet
in	= Inch
m	= Meter
cm	= Centimeter
mg/l	= Milligrams per liter (equivalent to parts per million)
NTU	= Nephelometric turbidity unit
%	= Percent (parts per hundred)
ppt	= Parts per thousand
mS/cm	= MilliSiemens per centimeter
µS/cm	= MicroSiemens per centimeter
L	= Liter
ml	= Milliliter

Other Abbreviations used in this document:

DI	= Distilled or deionized water
DO	= Dissolved oxygen
DOH	= Washington Department of Health
LIBC	= Lummi Indian Business Council
LNR	= Lummi Natural Resources Department
LWRD	= Lummi Water Resources Division
NIST	= National Institute of Standards and Technology
QC	= Quality control