# FINAL
# Spanaway Lake Watershed Scale Plan
# Quality Assurance Project Plan (QAPP)

Prepared for

Pierce County, Washington

April 2015

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Prepared for

Pierce County, Washington

Prepared by

Brown and Caldwell

April 2015

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# List of Abbreviations

| | |
|---|---|
| µg/L | microgram(s) per liter |
| BC | Brown and Caldwell |
| BIBI | Benthic Index of Biotic Integrity |
| °C | degree(s) centigrade |
| cfu | colony forming unit(s) |
| County | Pierce County |
| Cu | copper |
| DO | dissolved oxygen |
| DOC | dissolved organic carbon |
| EAP | Environmental Assessment Program |
| Ecology | Washington State Department of Ecology |
| EIM | Environmental Information Management database |
| EPA | U.S. Environmental Protection Agency |
| FC | fecal coliform |
| Fe | iron |
| $H_2SO_4$ | sulfuric acid |
| HDPE | high-density polyethylene |
| $HNO_3$ | nitric acid |
| ID | identifier |
| JBLM | Joint Base Lewis-McChord |
| LMP | Lake Management Plan |
| mg/L | milligram(s) per liter |
| mL | milliliter(s) |
| MQO | measurement quality objective |
| MS4 | municipal separate storm sewer system |
| $NH_3$ | ammonia |
| $NO_3$ | nitrate |
| NPDES | National Pollutant Discharge Elimination System |
| Permit | Washington State Phase I Municipal Stormwater Permit |
| PVC | polyvinyl chloride |
| QA | quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| RPD | relative percent difference |
| RSD | relative standard deviation |
| SM | Standard Method |
| SOP | standard operating procedure |
| SRP | soluble reactive phosphate or Ortho-phosphate |
| TKN | total Kjeldahl nitrogen |
| TN | total nitrogen |
| TOC | total organic carbon |
| TP | total phosphorus |
| TPCHD | Tacoma-Pierce County Health Department |
| TSS | total suspended solids |
| USGS | United States Geological Survey |
| WRIA | Water Resource Inventory Area |
| WSP | Watershed Scale Plan |
| Zn | zinc |

# Approval List: Spanaway Lake Watershed Scale Plan QAPP

This page consists of the Quality Assurance Project Plan (QAPP) approval signatures and dates, as required by Washington State Department of Ecology (Ecology) guidelines (Ecology, 2004). These signatures indicate both approval of the plan and commitment to support implementation of the procedures specified.

**Approved by:**

Signature:_______________________________________________ Date:__________

*Mike Milne, Brown and Caldwell Project Manager*

Signature:_______________________________________________ Date:__________

*Valerie Fuchs, Brown and Caldwell Data Quality Review*

Signature:_______________________________________________ Date:__________

*Tom Kantz, Pierce County Project Manager*

# Distribution List

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# Abstract

Stormwater discharges in unincorporated Pierce County (County) are covered by the Washington State Phase I Municipal Stormwater Permit (Permit), which became effective on August 1, 2013. Special Condition S5.C.5.c of the Permit requires watershed-scale stormwater planning. The Permit requires that the County submit a watershed-scale stormwater plan to the Washington State Department of Ecology (Ecology) by September 6, 2017. The watershed-scale stormwater plan should include a summary of results of the modeling and planning process, results of the evaluation of strategies under S5.C.5.c.iv(5), and an implementation plan and schedule developed pursuant to S5.C.5.c.iv(6).

Ecology approved the County's proposal to perform watershed-scale planning in the Spanaway Lake watershed on March 11, 2014. On April 1, 2014, the County sent Ecology a draft scope of work and schedule for developing a watershed-scale stormwater plan for the Spanaway Lake watershed. The County revised the scope of work in response to Ecology comments on the draft. Ecology approved the County's revised scope of work in a letter dated August 8, 2014.

Brown and Caldwell (BC) prepared this Quality Assurance Project Plan (QAPP) to guide collection of the data needed to develop the Spanaway Watershed Scale Plan (WSP). Data collection includes monitoring of flow, surface water quality, and groundwater quality. The WSP monitoring data will be used to assess existing conditions and calibrate a watershed model. The monitoring results may also be used to help identify potential stormwater management strategies.

Section 1

# Background

Stormwater discharges in unincorporated Pierce County (County) are covered by the National Pollutant Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit (Permit) issued by the Washington State Department of Ecology (Ecology). The current Permit became effective on August 1, 2013. Special Condition S5.C.5.c of the Permit requires a watershed-scale stormwater planning process to identify a stormwater management strategy or strategies that would result in hydrologic and water quality conditions that fully support "existing uses" and "designated uses, as those terms are defined in [Washington Administrative Code Section] 173-201A-020."

In March 2014, the County submitted to Ecology a draft scope of work and schedule for completing the watershed-scale planning process in accordance with Permit requirement S5.C.5.c.ii. Ecology provided comments in a letter dated May 14, 2014. On June 30, 2014, the County submitted a revised scope of work and schedule, which Ecology approved in a letter dated August 8, 2014.

Brown and Caldwell (BC) prepared this Quality Assurance Project Plan (QAPP) to guide collection of the data needed to develop the Spanaway Watershed Scale Plan (WSP). Data collection includes monitoring of flow, surface water and groundwater elevations, surface water quality, and groundwater quality. The monitoring results will be used to develop and calibrate an HSPF model of the watershed. BC will refine an existing MODFLOW model to provide groundwater flow and water quality data for use in the HSPF watershed model. The watershed model will be used to simulate existing, predevelopment, and future conditions in the WSP area and support evaluation of potential changes in hydrology and water quality resulting from alternative stormwater management strategies. BC is preparing a separate modeling plan to summarize the modeling approach, data sources, potential calibration parameters, methodology, and criteria. In general, BC will refine and update the existing U.S. Geological Survey (USGS) Chambers-Clover Groundwater Flow Model through grid refinement, higher-resolution data in key areas of the watershed (around Spanaway Lake and other surface water features), and updated model stress periods to coincide with HSPF model data sets. Hydraulic flux terms from MODFLOW will be extracted using a modified version of USGS's ZONEBUDGET to generate relevant input to HSPF. If sampling data suggest that groundwater is a key source term for nutrient transport, additional groundwater modeling will focus on simulating fate and transport using MODFLOW-MT3D.

The following paragraphs summarize the Spanaway Lake watershed characteristics relevant to the four Permit criteria. Figure 1-1 shows the Spanaway Lake watershed-scale stormwater planning area.

- **Drainage area:** Spanaway Creek, a 5.8-mile-long tributary of Clover Creek, is formed by springs and marshes and a tributary, Coffee Creek, within Joint Base Lewis-McChord (JBLM) and flows north through Spanaway Lake and Tule Lake and into Clover Creek at the northwest end of the watershed near the JBLM east boundary. Morey Creek splits from Spanaway Creek downstream of Spanaway Lake and joins Clover Creek downstream of the confluence of Spanaway Creek and Clover Creek.

  The Spanaway Lake watershed planning area upstream of the Clover Creek confluence has a drainage area of approximately 23.3 square miles. The planning area includes Spanaway Creek, Coffee Creek, Morey Creek, Spanaway Lake, and Tule Lake, and lands that drain into those water bodies. The watershed is located within Water Resource Inventory Area (WRIA) 12 and is part of the greater Chambers/Clover Creek drainage basin.

- **Jurisdiction:** About 67 percent of the watershed is under Pierce County jurisdiction. Morey Creek, Spanaway Lake, and the reach of Spanaway Creek downstream of the lake are within Pierce County's municipal separate storm sewer system (MS4) service area. Municipal stormwater discharges in this portion of the watershed are regulated by the Phase I Permits issued by Ecology to Pierce County and to the Washington Department of Transportation.

  The remaining 33 percent of the watershed is within JBLM. Stormwater discharges within JBLM are regulated under a municipal NPDES permit issued by the U.S. Environmental Protection Agency (EPA) Region 10.

- **Urban development and anadromous fish:** Urban development has affected the stream system in the Spanaway Lake watershed. Approximately 38,000 people live in the Spanaway Lake watershed. Residential and commercial land uses cover approximately 64 percent and 4 percent of the non-federal portion of the watershed, respectively (see Figure 1-2). Much of the area is served by onsite wastewater treatment systems. Pierce County's 2012 water quality report card cited low dissolved oxygen (DO) concentrations, high water temperatures, and low Benthic Index of Biotic Integrity (BIBI) scores in Spanaway Creek. Spanaway Lake has experienced toxic blue-green algae and fecal coliform (FC) levels above state water quality criteria. Morey Creek is on the state's 303(d) list due to low DO concentrations.

  Despite the substantial urban development in the watershed, Spanaway Creek has known distributions of cutthroat trout and coho salmon extending the entire length of the stream (Pierce County, 2005; U.S. Department of Transportation, 2003; Pierce Conservation District, 2003).

- **Future growth:** About two-thirds of the Spanaway Lake watershed is within Pierce County's jurisdiction and the remainder is within JBLM (see Figure 1-3). The northern portion of the watershed is in the Parkland/Spanaway/Midland unincorporated area, which is part of the Urban Growth Area for the City of Tacoma. The southeast portion of the Spanaway Lake watershed, about 5.4 square miles (23 percent of the area), is outside of the Tacoma Urban Growth Area, but within the Pierce County Comprehensive Urban Growth Area. According to the Pierce County Comprehensive Plan, the Parkland/Spanaway/Midland unincorporated area is expected to experience an urban population increase of nearly 10,000 people, or 16 percent, during 2000–22. The southeast region of the watershed includes portions of the Frederickson and Graham communities, which are expected to experience urban population increases of about 3,000 people (23 percent) and 1,500 people (89 percent), respectively.

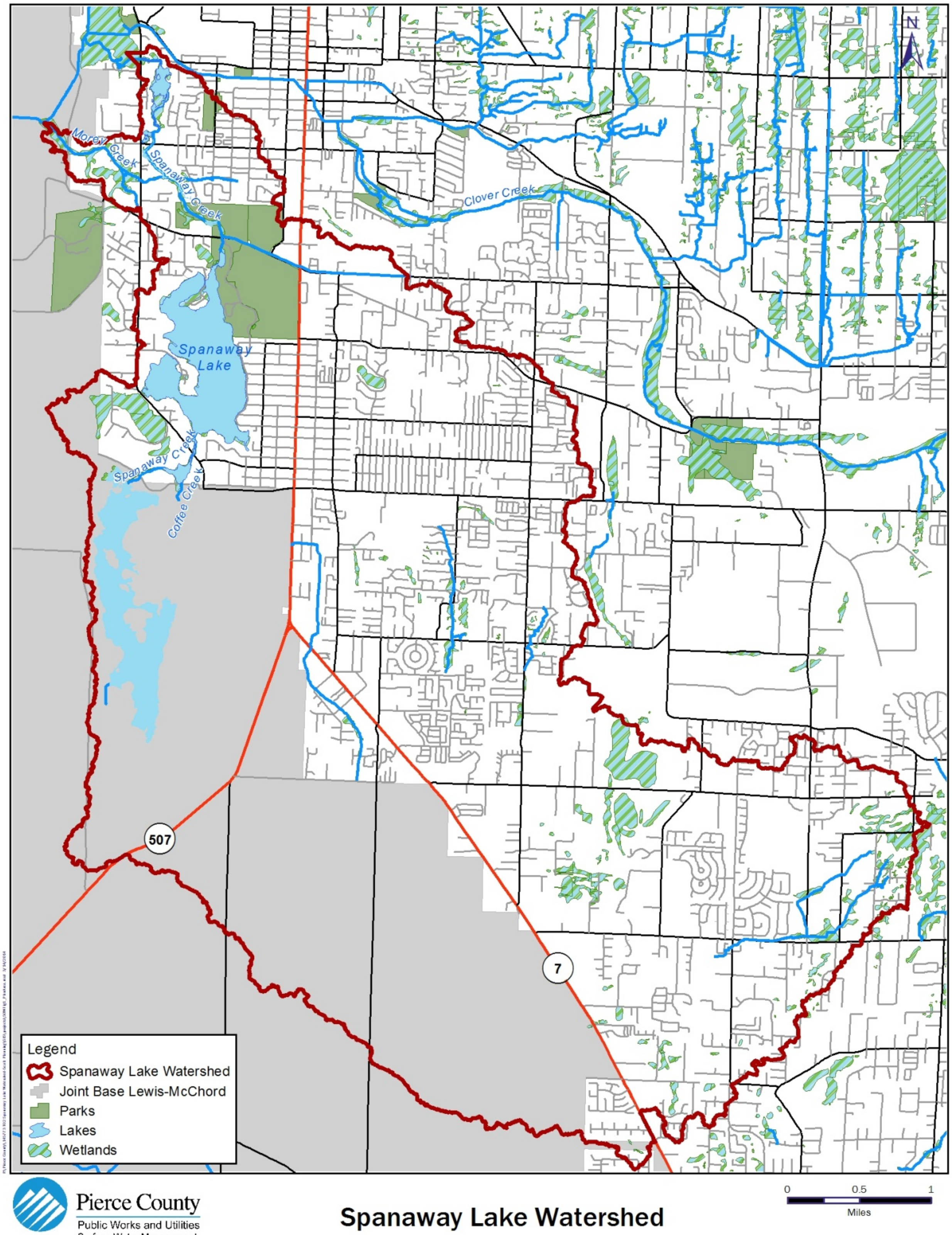


**Figure 1-1. Spanaway Lake watershed-scale stormwater planning area**

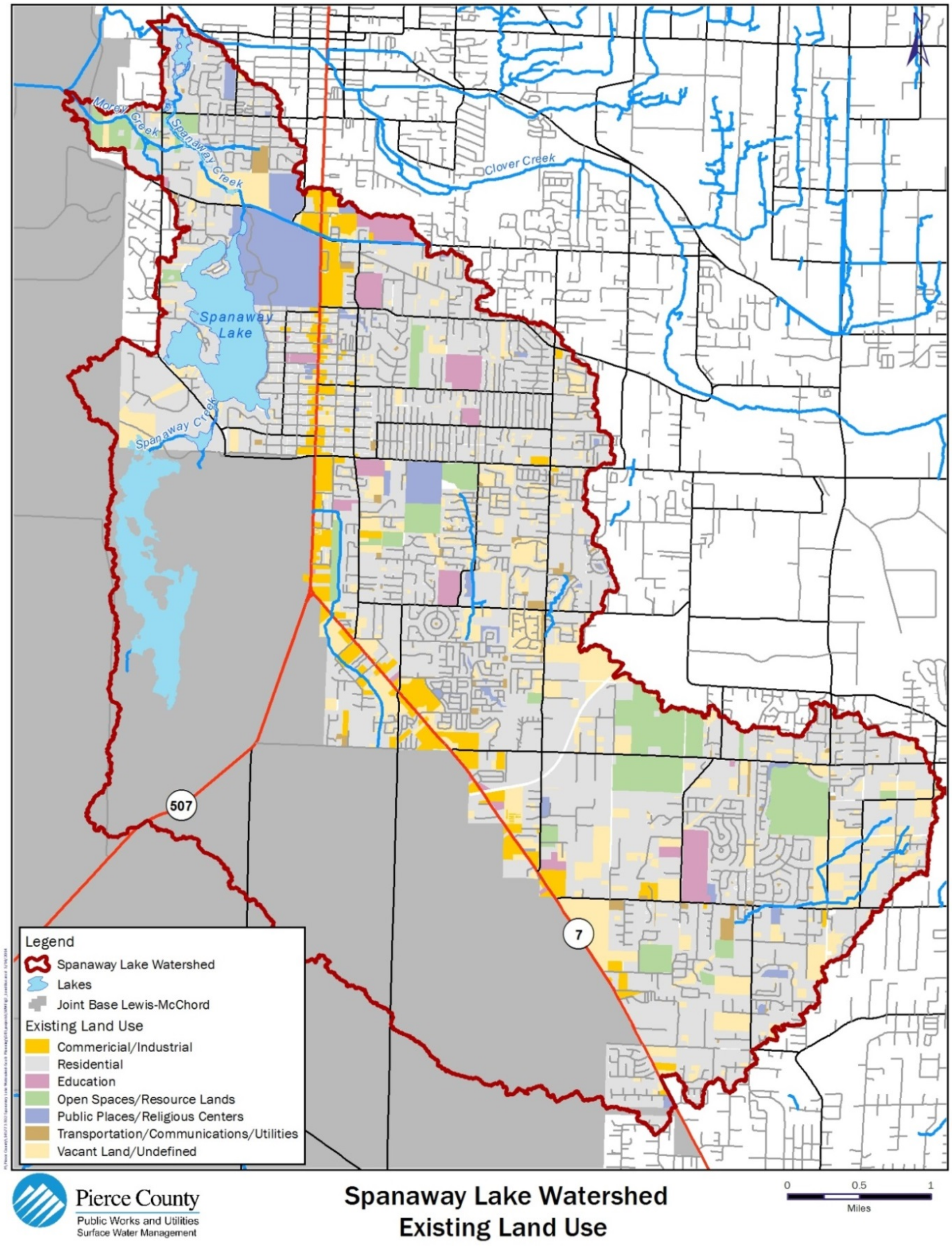


**Figure 1-2. Existing land use in Spanaway Lake watershed**

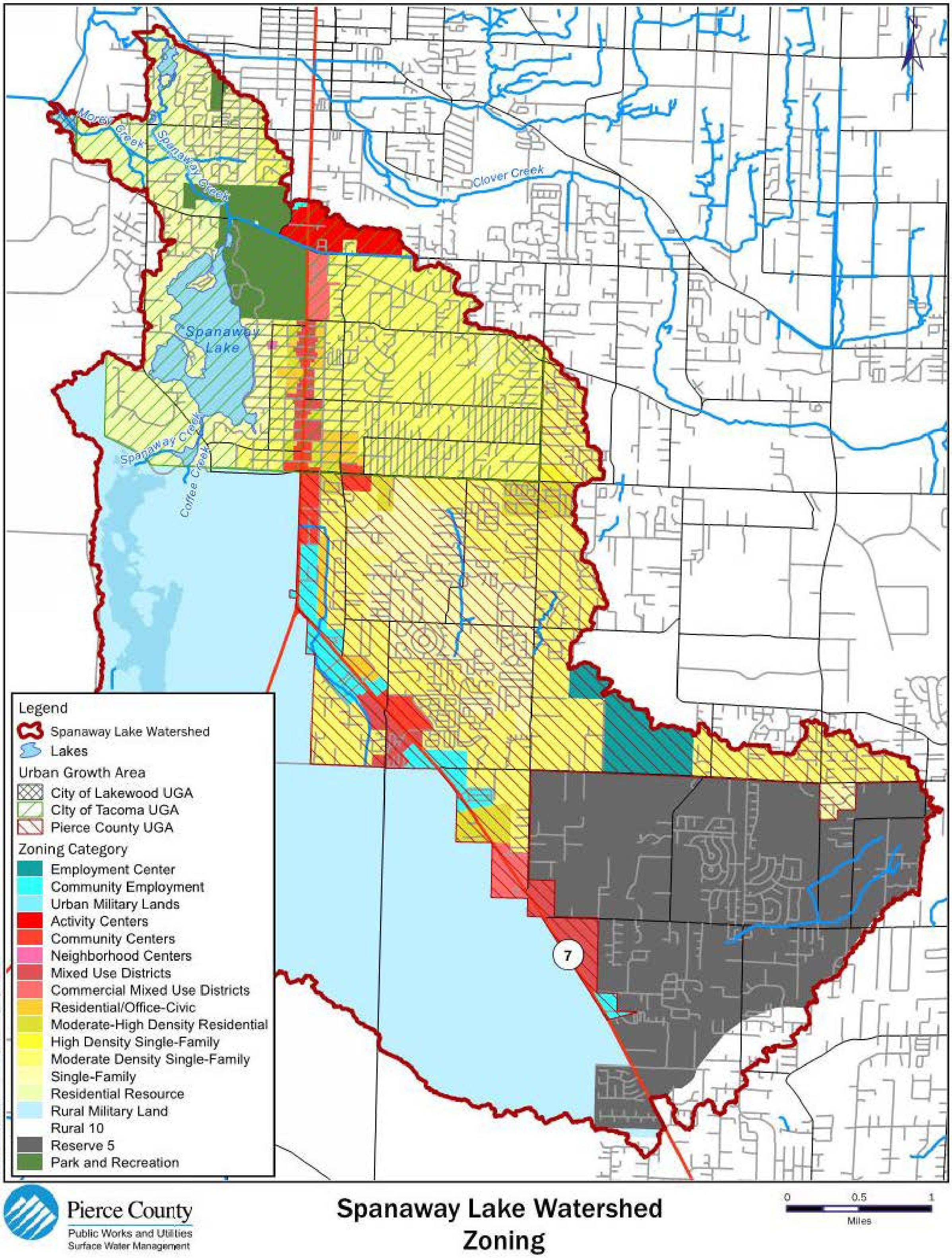


Figure 1-3. Zoning of Pierce County land in Spanaway Lake watershed

In addition to the WSP, the County is developing a Lake Management Plan (LMP) to improve water quality and protect beneficial uses in Spanaway Lake. The LMP is funded by a state budget allocation and County funds. Nutrient enrichment is the primary concern but fecal contamination is also a concern for the lake. The County is now monitoring surface water and groundwater around the lake in order to support development of the LMP. The LMP monitoring is being conducted under an Ecology-approved QAPP.

Section 2

# Project Description

This section describes the goal and objectives for the Spanaway WSP and summarizes the data needed to meet the project objectives.

## 2.1 Goal and Objectives

Stormwater discharges in Pierce County are covered by the Permit, which became effective on August 1, 2013. Ecology revised the Permit in August 2014. Special Condition S5.C.5.c of the Permit requires watershed-scale stormwater planning. The watershed-scale stormwater plan should include a summary of results of the modeling and planning process, results of the evaluation of strategies under S5.C.5.c.ii(5), and an implementation plan and schedule developed pursuant to S5.C.5.c.ii(6).

The goal and objectives for this project were developed based on a systematic planning process and the available budget. The goal is to develop a Spanaway Lake WSP in accordance with Special Condition S5.C.5.c.ii of the Permit. Monitoring is needed to support the following objectives:

- assess existing flow, water quality (temperature, FC bacteria, dissolved copper [Cu] and zinc [Zn]), and benthic conditions in Spanaway Creek and its key tributaries
- develop and calibrate an HSPF model to simulate existing, predevelopment, and future hydrology and water quality in the WSP area
- identify and help evaluate alternative stormwater management strategies for the WSP

Table 2-1 summarizes the key data gaps and lists the actions needed to fill in the data gaps in order to meet the project objectives.

Table 2-1. Data Gaps and Proposed Monitoring and Modeling Activities

| Data gap | Proposed monitoring and modeling activities |
|---|---|
| Limited information on surface water quality | • Collect water samples from the Spanaway Creek outlet (SW 1), Coffee Creek (SW 2), Spanaway Creek at 176th St. (WSP 1), Spanaway Creek at 138th St. (WSP 2), Spanaway Creek downstream of Tule Lake (WSP 3) and Morey Creek (WSP 4) during baseflow and wet weather conditions during 1 year. Analyze for dissolved Cu, dissolved Zn, and bacteria. Deploy temperature sensors to measure water temperature.<br>• Calibrate watershed-scale HSPF model to simulate temperature and pollutant washoff into creeks. |
| Limited flow data | • Collect continuous flow measurements in Coffee Creek just above the lake, Spanaway Creek just below the lake, Morey Creek, Spanaway Creek below the split, and Spanaway Creek below Tule Lake. Collect instantaneous flow measurements during a range of flow conditions in order to develop a stage-discharge relationship or rating table for each flow gage location.<br>• Calibrate a watershed-scale HSPF model to simulate baseflow and wet weather conditions. |

| Table 2-1. Data Gaps and Proposed Monitoring and Modeling Activities | |
|---|---|
| **Data gap** | **Proposed monitoring and modeling activities** |
| Limited information relevant to groundwater impacts on Spanaway Creek and its key tributaries | • Install six groundwater monitoring wells around watershed to complement LMP wells.<br>• Monitor groundwater levels to estimate flow direction.<br>• Collect core sediment samples during well drilling to support evaluation of contaminant fate and transport in the shallow groundwater system.<br>• Collect quarterly groundwater samples for 1 year. Analyze for dissolved Cu, dissolved Zn, and bacteria.<br>• Analyze samples from LMP wells for WSP parameters (Cu, Zn, bacteria).<br>• Refine existing MODFLOW model to simulate study area groundwater flow and provide the basis for the HSPF model.<br>• If groundwater monitoring data indicate that groundwater is an important pathway, develop MODPATH and MT3D models to simulate groundwater quality.<br>• Use the groundwater monitoring and modeling results to inform the HSPF model. |
| Limited data on benthic macroinvertebrates | • Collect and analyze benthic macroinvertebrate samples at Coffee Creek just above the lake, Spanaway Creek downstream of Spanaway Lake, Spanaway Creek below Bresemann Dam, and Morey Creek.<br>• Perform streambed and bank sediment particle size distribution analyses at Spanaway Creek just below the lake where benthic macroinvertebrates are sampled, as well as stream reaches downstream of Military Road that may be unsuitable for benthic sampling. Use the results to help interpret BIBI scores and support effective work analysis if necessary. (See Figure 5-1 for BIBI sampling locations). |

As noted in Section 1, the County is developing an LMP for Spanaway Lake. The LMP includes flow, surface water quality, and groundwater quality monitoring in and around the lake. Samples collected for the LMP will be analyzed for additional parameters (e.g., Cu and Zn) in order to enhance WSP development. In addition, creek and groundwater samples collected for the WSP will be analyzed for nutrients in order to facilitate development of the LMP.

## 2.2 Constraints on Study Design

The budget for developing the WSP is limited. Therefore, the County's monitoring and modeling activities focus on filling the key data gaps needed to assess current conditions, simulate future conditions, and evaluate alternative stormwater management strategies to support designated uses in the watershed.

The WSP scope of work calls for sampling each creek location three times during each of six storm events. Storm hydrographs in the WSP area could be elongated due to groundwater influence and detention in Spanaway Lake and the large wetland on JBLM. Sampling intervals during a storm event may need to be adjusted to avoid sampling in the dark or when the project lab will be unable to meet the holding time for one or more parameters.

The WSP scope of work also requires continuous flow monitoring at two locations on Spanaway Creek downstream of Military Road and one location on Morey Creek. However, in conjunction with the Lake Management Plan, continuous flow monitoring will be conducted at a total of five sites, as shown on Figure 5-1. To develop stage-discharge relationships, County staff will need to collect instantaneous flow measurements under a range of flow conditions and seasons at each location. Flow measurements are particularly needed for high flow events. The County WSP project manager will coordinate with the LMP and status and trends project managers in order to minimize staffing constraints for wet weather monitoring.

Permeable outwash soils cover most of the study area. Stormwater runoff from impervious surfaces is typically infiltrated through dry wells or infiltration basins. The existing data suggest that overland flow from shoreline areas is probably small compared to inflows from groundwater and Coffee Creek. Sampling of direct discharge from shoreline areas is impractical due to logistical and legal constraints. Therefore, stormwater loads from shoreline areas will be estimated using the HSPF model.

The WSP calls for collecting benthic macroinvertebrate samples from locations where channel conditions (e.g., low flow velocities, fine bottom sediments, invasive plants) could limit benthic populations. To aid in the interpretation of the benthic sampling results, each benthic sampling reach will be surveyed to estimate channel geometry and bottom sediment samples will be collected for particle size analysis.

## 2.3 A Summary of QAPP Sections

Section 2 describes the goal and objective for the Spanaway WSP and summarizes the data needed to meet the project objectives. Specifically, Table 2-1 lists the general monitoring and modeling activities to be performed for this study.

Section 3 identifies the members of the project team and the proposed project schedule. As noted in Section 3 below, County staff will perform most of the monitoring with limited support from BC staff. County staff will obtain the permits and approvals needed to install the groundwater monitoring wells and weather station. Two of the groundwater monitoring wells will be located on JBLM, and County staff will coordinate with JBLM to obtain permits and access to install those wells. County staff will also install continuous flow gauges on, Spanaway Creek at 138th Street upstream of Tule Lake (WSP 2), Spanaway Creek downstream of Tule Lake (WSP 3) and Morey Creek (WSP 4).

Section 4 describes the quality objectives for monitoring to support development of the Spanaway WSP. BC staff will review the monitoring data in light of these data quality objectives to ensure that project criteria are satisfied.

Section 5 describes the sampling design developed for this sampling and monitoring program and Section 6 describes the field sampling and measurement procedures. Section 7 describes the quality control measures that are integrated within the laboratory, field, and corrective actions of the Spanaway WSP monitoring program.

The monitoring results will be used together with existing information to assess existing conditions, calibrate a watershed model, and support identification of potential stormwater management strategies for the WSP. Because the monitoring results are not intended to determine compliance with a water quality standard or for selection between two clear alternative conditions, data quality will be evaluated based on performance and acceptance criteria. Sections 8, 9 and 10 of this QAPP discuss data management and data quality review procedures.

## Section 3

# Organization and Schedule

This section identifies the members of the project planning and monitoring team and the proposed project schedule.

## 3.1 Project Organization

Key project roles and responsibilities are as follows:

- **Pierce County project manager:** Mr. Tom Kantz of Pierce County Surface Water Management has overall responsibility for this project. He will supervise County monitoring staff as well as BC activities in support of this monitoring program. In addition, Mr. Kantz will be the County's primary point of contact for Ecology, citizen groups, and other stakeholders.
- **Pierce County modeling manager and groundwater monitoring team leader:** Ms. Shuhui Dun of Pierce County Surface Water Management will oversee the modeling for this project. She will review the modeling results based on quality objectives in the modeling plan. She is also responsible for the groundwater monitoring and field oversight of the drilling.
- **Pierce County monitoring team leader:** Ms. Carla Vincent of Pierce County Surface Water Management will direct and oversee the monitoring team collecting surface water (monthly continuous flow and temperature measurement), monthly and event water quality sampling, instantaneous flow measurements during a range of flow conditions for developing flow rating curves, benthic sampling and installation of water level and temperature monitoring equipment in the groundwater wells. Ms. Vincent will serve as the County's primary point of contact for AmTest Laboratories.
- **Pierce County surface water collection assistant:** Ms. Windy Kruse of Pierce County Surface Water Management will be assisting with surface water collection and in lake sampling for the LMP. Ms. Kruse is also the project manager for the LMP and assists with groundwater sampling and other monitoring activities. She will serve as the County's primary point of contact for Spectra Laboratories.
- **Consultant team project manager:** Mr. Michael Milne of BC is responsible for overseeing the consultant team's project performance to ensure contract compliance and to help accomplish program activities. Mr. Milne may also support Mr. Kantz with respect to coordination with Ecology, the County contract laboratory, the Tacoma-Pierce County Health Department (TPCHD), and other agencies and stakeholders.
- **Consultant team field activities manager:** Mr. Jon Turk, R.P.G., is responsible for overseeing all BC and subcontractor field personnel to ensure compliance with the QAPP. He will also coordinate sampling activities with County staff.
- **Consultant team project hydrologist:** Mr. Nathan Foged, P.E., is responsible for overseeing stream sediment sampling activities in coordination with County staff.
- **Data quality reviewer:** Dr. Valerie Fuchs of BC will review the monitoring results based on the measurement quality objectives for this project.
- **Surface water modeling task leader:** Ms. Colleen Doten of BC will use the data collected during this study to develop creek and lake water budgets and pollutant loads and provide information

on the estimated effects of watershed-scale stormwater management strategies based on the calibrated model.

- **Groundwater modeling task leader:** Mr. Jon Turk, R.P.G., of BC will use the groundwater data collected during this study to simulate groundwater flow and contaminant transport within the watershed to inform groundwater interactions in the surface water model.
- **Analytical laboratory:** Samples collected will be analyzed by the County's contract laboratories, Spectra Laboratories in Tacoma, Washington, and AmTest Laboratories in Kirkland, Washington. These laboratories have been accredited by the State of Washington for the analyses prescribed in this QAPP. The laboratory quality assurance (QA) officers, Marie Holt (Spectra) and Heidi Limmer (AmTest), are responsible for monitoring and documenting the quality of all work produced by their respective laboratories for this project, and for implementing corrective action should the need arise.
- **Stakeholders** include TPCHD, Pierce County Parks, shoreline residents, and recreational users of the lake.

## 3.2 Project Schedule and Budget

Field activities, including well installation, monitoring, and sampling, began in October 2014 and are estimated to end in October 2015. This timeline may be adjusted based on actual start dates in order to obtain 1 year of monthly samples. Data evaluation is projected to be conducted over approximately 14 to 16 months after monitoring is complete. Development of the WSP is anticipated to be conducted over an additional 8 to 10 months. The final WSP will be completed by September 1, 2017.

The source of funds for this project is the County budget. Pierce County is providing County staff and equipment to implement the monitoring program and paying for the sample analyses with the County's contract laboratory. To obtain the most value from the limited resources available, this QAPP prescribes a streamlined monitoring and modeling approach for developing the WSP.

## Section 4

# Quality Objectives

This section describes the quality objectives for monitoring to support development of the Spanaway WSP.

## 4.1 Decision Quality Objectives

The field data collection and data analyses activities described in this QAPP are designed to support development of the Spanaway Lake WSP. The data collected will be used to assess existing conditions, develop and calibrate a watershed model, and support development of potential stormwater management strategies. The data collected using the procedures and quality objectives outlined in this QAPP should be sufficient to assess existing conditions, calibrate a watershed model, and support development of stormwater management strategies. The results of the monitoring and evaluation activities described in this QAPP will contribute to the development of the WSP. In addition, the WSP may consider a wide range of other information such as stakeholder input, other regional and local studies, technical literature on the effectiveness of potential measures, costs, and funding,

## 4.2 Measurement Quality Objectives

Measurement quality objectives (MQOs) are the performance thresholds for a project (Lombard and Kirchmer, 2004). Tables 4-1 and 4-2, respectively, list the MQOs for field and laboratory measurements for the Spanaway WSP. Because WSP monitoring will be coordinated with LMP monitoring, Tables 4-1 and 4-2 also include the MQOs for the LMP. For field measurements, field equipment will be calibrated before and after each monitoring event per the equipment manufacturer's guidelines. The laboratory methods and reporting limits listed in Table 4-2 are appropriate for the expected range of results and the required level of sensitivity to meet project objectives. The laboratory QA procedures are documented in the *Spectra Laboratory Quality Assurance Manual* (Spectra Laboratories, 2013) and the *AmTest Laboratories Quality Manual* (AmTest Laboratories, 2012).

| Table 4-1. Measurement Quality Objectives for Field Measurements | | | |
|---|---|---|---|
| Parameter[a] | Method/ equipment | Precision (RPD[b]) | Accuracy (deviation or % deviation from true value) |
| Water temperature | YSI datasonde or other field meter, such as a YSI556 multi-parameter probe or Horriba U-22 | ≤10% | Parameters will be calibrated before and after each monitoring event according to the equipment manufacturer's specifications[d] |
| pH | | ≤10% | |
| DO | | ≤10% | |
| Conductivity[c] | | ≤10% | |

a. ORP and turbidity will be measured during well purging prior to groundwater sample collection and analysis.

b. RPD = relative percent difference.

c. For specific conductance (conductivity at 25 °C).

d. http://www.ysi.com/media/pdfs/069300-YSI-6-Series-Manual-RevJ.pdf.

| Table 4-2. Measurement Quality Objectives for Laboratory Analyses | | | | | |
|---|---|---|---|---|---|
| Parameter | Method/equipment | Precision: Field (relative standard deviation) | Precision: Lab (relative percent difference) | Accuracy (deviation or % deviation from true value) | Reporting limits or resolution |
| Water Samples (Creek and Groundwater)[a] | | | | | |
| Total Cu | EPA 200.8 | ≤ 10% | ≤20% | +/- 30% | 0.5 µg/L |
| Dissolved Cu | EPA 200.8 | ≤ 10% | ≤20% | +/- 30% | 0.5 µg/L |
| Total Zn | EPA 200.8 | ≤ 10% | ≤20% | +/- 30% | 0.5 µg/L |
| Dissolved Zn | EPA 200.8 | ≤ 10% | ≤20% | +/- 30% | 0.5 µg/L |
| FC | SM 9222D (membrane filter) | For duplicate pairs with mean [FC] >20 cfu 100 mL and >10 pairs, 50% of pairs ≤25% RSD and 90% of pairs ≤50% RSD[b] | ≤20% | n/a | 1 cfu/100 mL |
| Total Hardness | SM 2340B | ≤ 10% | ≤20% | +/- 25% | 0.2 mg/L |
| TSS | SM 2540D | ≤15% | ≤20% | +/- 25% | 1.0 mg/L |
| $NH_3$[c] | SM 4500-NH3-D | ≤10% | ≤20% | +/- 25% | 0.1 mg/L |
| TKN[c] | SM 4500-N-C | ≤10% | ≤20% | +/- 25% | 0.5 mg/L |
| $NO_3$[c] | Easy 1 Reagent | ≤10% | ≤20% | +/- 25% | 0.01 mg/L |
| TP[c] | SM4500-P E | ≤10% | ≤20% | +/- 25% | 0.01 mg/L |
| SRP[c] | SM4500-P E | ≤10% | ≤20% | +/- 25% | 0.005 mg/L |
| Alkalinity[c] | SM2320B | ≤10% | ≤20% | +/- 25% | 1 mg/L |
| Turbidity | EPA 180.1 | ≤10% | ≤20% | +/- 30% | 0.1 NTU |
| Chloride | SM 4500 CL-C | ≤10% | ≤20% | +/- 30% | 1 mg/L |
| Iron | EPA 200.8 | ≤10% | ≤20% | +/- 30% | 0.262 mg/L |

| Table 4-2. Measurement Quality Objectives for Laboratory Analyses | | | | | |
|---|---|---|---|---|---|
| Parameter | Method/equipment | Precision: Field (relative standard deviation) | Precision: Lab (relative percent difference) | Accuracy (deviation or % deviation from true value) | Reporting limits or resolution |
| Aquifer Core Sediment Samples | | | | | |
| Bicarbonate | SM 2320B | ≤ 10% | ≤12% | 79–121 | 10 µg/g |
| Calcium ($Ca^2$) | EPA 6010C | ≤ 10% | ≤28% | 40–161 | 2.5 µg/g |
| Chloride (Cl) | EPA 300/9056A | ≤ 10% | ≤25% | 80–120 | 10 µg/g |
| Magnesium ($Mg^2$) | EPA 6010C | ≤ 10% | ≤17% | 71–136 | 0.5 µg/g |
| Silicon (Si) | EPA 6010C | ≤ 10% | ≤35% | 25–150 | 2.5 µg/g |
| Sulfate ($SO_4$) | EPA 300/9056A | ≤ 10% | ≤29% | 76–121 | 10 µg/g |
| Potassium (K) | EPA 6010C | ≤ 10% | ≤26% | 37–163 | 5 µg/g |
| Total persulfate nitrogen (SO4-N)[c] | SM #20 SM4500-N C | ≤ 10% | ≤40% | 70–130 | 5 µg/g |
| TKN | SM 4500N C | ≤ 10% | ≤20% | 83–121 | 5 µg/g |
| $NH_3$[c] | SM 4500NH3B&C | ≤ 10% | ≤50% | 84–125 | 5 µg/g |
| $NO_3$[c] | EPA 9056 | ≤ 10% | ≤25% | 86–117 | 10 µg/g |
| TP[c] | SM 4500-P_B+E | ≤ 10% | ≤41% | 73–125 | 0.5 µg/g |
| Ferrous Iron | SM 3500 | ≤ 10% | ≤30% | 75-125 | 5 µg/g |
| Total Fe [Fe(0)+Fe(II)+Fe(III)] | EPA 6010C | ≤ 10% | ≤35% | 42–158 | 0.5 µg/g |
| TOC | SW 846 9060 | ≤ 10% | ≤30% | 72–124 | 0.05 % |
| Total Solids | SM 2540G | ≤ 10% | ≤15% | 90-110 | 1.0 µg/g |

a. *During the first round of groundwater sampling, samples will be analyzed for various major anions and cations as well using the same laboratory and analysis methods as the core sediment samples.*

b. *Duplicate bacteria results with means ≤20 cfu/100 mL will be evaluated qualitatively.*

c. *These parameters are not required for the WSP, but will be analyzed for WSP samples to support the LMP.*

Precision will be evaluated using field and laboratory duplicate samples. Table 4-3 summarizes the quality control (QC) procedures. Field duplicate results will be compared to indicate the combined effects of heterogeneity of the sampled media, variation in sampling methods, and analytical imprecision. Precision for field duplicates will be assessed based on their relative standard deviation (RSD), calculated as follows:

$$\% RSD = \frac{S}{\bar{X}} x\ 100$$

*Where,*

$\% RSD$ = relative standard deviation

$S$ = standard deviation of duplicate samples

$\bar{X}$ = mean of the duplicate samples

One laboratory duplicate sample will be analyzed for each analytical batch. Laboratory duplicate analyses will indicate imprecision due to sample splitting and analytical methods. Precision for lab replicates will be determined based on the relative percent difference (RPD) between duplicate samples, calculated as follows:

$$\% RPD = \frac{(S - D)}{(S + D)/2} x\ 100$$

*Where,*

$\% RPD$ = relative percent difference

$S$ = analytical result of sample of origin

$D$ = analytical results of the duplicate sample

Accuracy will be evaluated based on the % recovery of spiked samples:

$$\% R = \left[\frac{(Xs - Xo)}{Cs}\right] x\ 100\%$$

*Where,*

$\% R$ = % recovery

$Xs$ = spike sample result

$Xo$ = original sample result

Cs = known spike added concentration

For the in situ field measurements, the data quality will be assessed based on daily post-monitoring calibration checks. Field equipment will be calibrated before and after monitoring in accordance with the manufacturers' instructions.

Given the goal and objectives of collecting these data to support water budgets and contaminant load calculations and the use of the surface water and groundwater models to inform developing the WSP, these measurement quality objectives support the project objectives.

**Table 4-3. QC Samples, Types, and Frequency[a]**

| Media | Field | Laboratory | | | |
|---|---|---|---|---|---|
| | Duplicates | Check standards | Method blanks | Analytical duplicates | Matrix spikes |
| Groundwater | 1/quarter | 1/batch | 1/batch | 1/batch | 1/batch |
| Creek water | 1/sampling round | 1/batch | 1/batch | 1/batch | 1/batch |
| Aquifer core sediments | 1/sampling round | 1/batch | 1/batch | 1/batch | 1/batch |

*a. Field parameters (DO, pH, temperature, and conductivity) will be measured using equipment calibrated before and after each monitoring event according to the manufacturer's specifications. Duplicate measurements will be compared to assess precision.*

## 4.3 Representative Sampling

This monitoring program is designed to include sufficient sampling sites and sampling frequency to support the development of the watershed-scale model.

FC is often highly variable over time and space. Sampling variability can be reduced by strictly following standard procedures and collecting QC samples, but natural spatial and temporal variability can contribute greatly to the overall variability in the FC bacteria value. Available resources limit the number of bacteria samples that can be collected and analyzed.

The proposed sampling plan should meet the project data objectives and support the development of the watershed model needed for the WSP.

## 4.4 Completeness

EPA has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system (Lombard and Kirchmer, 2004). The goal for this study is to correctly collect and analyze 100 percent of the samples from each of the sites. It is possible that problems could prevent monitoring of all sites on all dates. Thus a completeness of 90 percent will be considered acceptable.

## 4.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Comparability will be achieved through use of standard techniques to collect and analyze representative samples, along with standardized data verification and reporting procedures. The field data collected will be compared to historical data and will be evaluated for appropriateness.

## Section 5

# Sampling Process Design

This section describes the sampling design developed for this sampling and monitoring program using the information discussed in the previous sections.

## 5.1 Overview

The goal of this project is to develop a WSP in accordance with Special Condition S5.C.5.c of the Permit. To obtain the information needed to support development of the WSP, the County will:

- monitor stream flow at five locations for 1 year
- perform 12 rounds of monthly sampling and 6 rounds of wet weather sampling at key surface water locations
- install six groundwater monitoring wells in the watershed upgradient of the lake
- collect core sediment samples of aquifer materials during drilling to evaluate major anions and cations in aquifer material
- perform 4 rounds of quarterly groundwater sampling and 12 rounds of groundwater elevation monitoring
- analyze the first round of groundwater samples for major anions and cations
- analyze all creek and groundwater samples for Cu, Zn, FC bacteria, hardness, and temperature
- perform one round of benthic macroinvertebrate sampling at four locations

In addition, the creek and groundwater samples collected for the WSP will be analyzed for nutrients in order to support the LMP effort. Field parameters (DO, pH, temperature, conductivity) will be measured to provide additional information about ambient water quality conditions at the time of sampling.

Figure 5-1 shows the proposed sampling locations along with the sample types. Table 5-1 shows the proposed sampling constituents for each monitoring location. Monitoring activities will be conducted in accordance with relevant Ecology standard operating procedures (SOPs) (http://www.ecy.wa.gov/programs/eap/quality.html).

The sub-sections below provide a detailed discussion of the proposed sampling and monitoring approach for each media type, including the sampling frequency for the selected analytes.

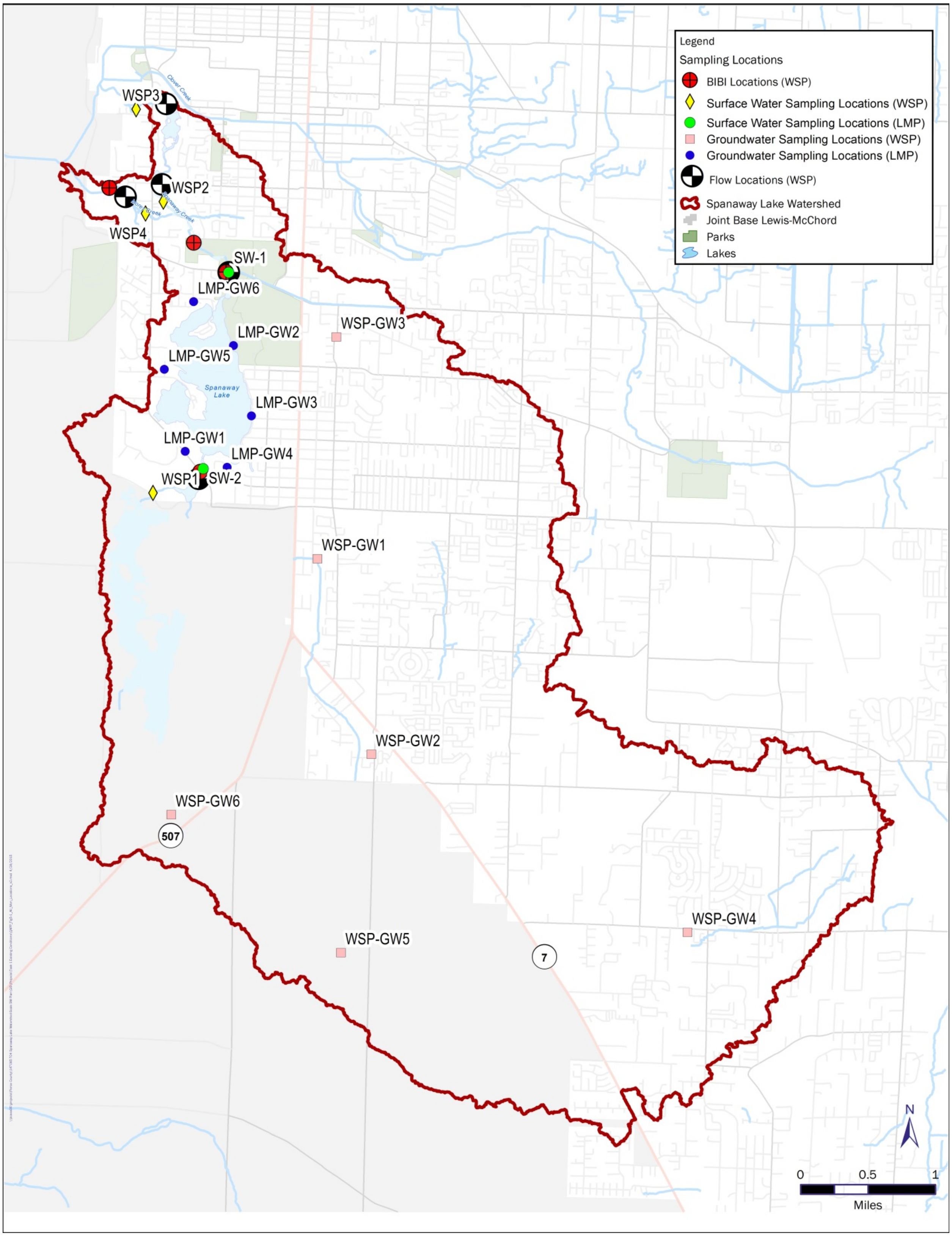


**Figure 5-1. Spanaway Lake proposed sampling locations**

**Table 5-1. Sampling Locations and Parameters***

| Sample type | Site ID | $NH_3$ | TKN | $NO_3$ | Total persulfate nitrogen | TP | SRP | Alkalinity | Fe | TOC | TSS | FC | Temperature[a] | pH[a] | DO[a] | Conductivity[a] | Turbidity[a] | Major anions and cations[b] | Total copper | Dissolved copper | Total zinc | Dissolved zinc | Hardness | BIBI | Chloride |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface water | SW-1 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| | SW-2 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| | WSP1 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | WSP2 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | WSP3 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | WSP4 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | Morey Creek | | | | | | | | | | | | | | | | | | | | | | | ✓ | |
| | Bresemann Dam | | | | | | | | | | | | | | | | | | | | | | | ✓ | |
| Groundwater | LMP_GW_1 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | LMP_GW_2 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | LMP_GW_3 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | LMP_GW_4 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | LMP_GW_5 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | LMP_GW_6 | X | X | X | | X | X | X | X | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | WSP_GW_1 | X | X | X | | X | X | X | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | WSP_GW_2 | X | X | X | | X | X | X | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | WSP_GW_3 | X | X | X | | X | X | X | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | WSP_GW_4 | X | X | X | | X | X | X | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | WSP_GW_5 | X | X | X | | X | X | X | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| | WSP_GW_6 | X | X | X | | X | X | X | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | X |
| Aquifer core sediments[b,c] | WSP_GW_1 | ✓ | ✓ | ✓ | ✓ | X | X | | ✓ | ✓ | | | | | | | | ✓ | | | | | | | |
| | WSP_GW_2 | ✓ | ✓ | ✓ | ✓ | X | X | | ✓ | ✓ | | | | | | | | ✓ | | | | | | | |
| | WSP_GW_3 | ✓ | ✓ | ✓ | ✓ | X | X | | ✓ | ✓ | | | | | | | | ✓ | | | | | | | |
| | WSP_GW_4 | ✓ | ✓ | ✓ | ✓ | X | X | | ✓ | ✓ | | | | | | | | ✓ | | | | | | | |
| | WSP_GW_5 | ✓ | ✓ | ✓ | ✓ | X | X | | ✓ | ✓ | | | | | | | | ✓ | | | | | | | |
| | WSP_GW_6 | ✓ | ✓ | ✓ | ✓ | X | X | | ✓ | ✓ | | | | | | | | ✓ | | | | | | | |

** WSP monitoring will be coordinated with LMP monitoring in order to promote efficiency. Therefore, this table lists the parameters to be monitored for the LMP as well as the WSP projects. Refer to the LMP QAPP for details specific to the LMP project.*

*✓ Denotes parameters to be monitored for the WSP project; X denotes parameters to be monitored for the LMP project.*

*a. These parameters will be monitored for groundwater during well-purging to determine when to begin groundwater sample collection. These parameters will also be monitored during creek sampling to provide supplementary information on ambient water quality. Surface water samples are also being analyzed for turbidity in the lab.*

*b. Major anions and cations will be analyzed during the first round of groundwater samples only and in the core sediment samples collected during drilling.*

*c. Core sediment samples collected from borings during well drilling will be collected from approximate depth interval of well screen.*

## 5.2 Surface Water Sampling from Creeks

Monthly grab samples will be collected at the six creek locations (including two LMP sites and four WSP sites) shown on Figure 5-1. All six locations will be also sampled during six wet weather events. Three grab samples will be collected at each location during each wet weather event. Samples will be analyzed for the parameters listed in Table 5-1. Table 5-2 provides a summary of the sample collection frequencies.

In addition to the constituents listed in Table 5-1, continuous temperature and flow measurements will also be collected at five surface water sampling locations. The County will use the existing gauge at SW-1 and newly installed flow gauges at SW-2, WSP2, WSP3, and WSP4. County staff will perform at least six instantaneous flow measurements over a range of flows at each of the gauged sites to develop the stage-discharge relationship for each site. The County will also collect continuous temperature data at each surface water sampling location.

## 5.3 Groundwater Sampling

The groundwater sampling will include the installation of six shallow (<70-foot) groundwater monitoring wells in the watershed (Figure 5-1). The proposed locations of these wells were selected based on review of regional groundwater data and a field investigation conducted by the County and BC staff. Well locations WSP_GW_1 through WSP_GW_6 were selected to: (1) capture the variation in hydrologic conditions of different geological settings that may influence seepage and groundwater movement; (2) provide data for areas of different development level; (3) reflect the impact of the onsite septic systems; and (4) use readily accessible locations that provide an approximate regular distribution along the presumed upgradient sides of the lake and surface water bodies.

The WSP wells will complement the LMP wells by providing data on groundwater flow direction and water quality in the watershed upgradient of the lakeshore area. WSP_GW_1 through WSP_GW_4 are scattered in the watershed, located on County property adjacent to County stormwater facilities south and southeast of the lake. WSP_GW_5 and WSP_GW_6 are located on JBLM along the south boundary of the watershed and upgradient of the large wetland complex that feeds Coffee Creek just upstream of the lake.

The wells are installed using sonic drilling technology by a licensed drilling contractor under the direction of a licensed hydrogeologist. After well installation, the ground surface and top of casing measuring points will be surveyed by a licensed surveyor. The wells will be developed to remove any fines entrained during construction.

The groundwater levels will be measured in the six groundwater wells on a monthly basis for 1 year. Groundwater discharge will be estimated using observed hydraulic gradients and an appropriate range in hydraulic conductivity based on sediment classification of the well lithological logging determined by observing of the drilling cores. The six groundwater wells will be sampled on a quarterly basis for 1 year and analyzed for the water quality constituents listed in Table 5-1. Table 5-2 provides a summary of the sample collection frequencies.

| Table 5-2. Sampling Frequencies | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample site | | Sample type | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| Creek: monthly | SW-1, SW-2, WSP 1, WSP 2, WSP 3, WSP 4 | Grab | 1x | 1x | 1x | 1x | 1x | 1x | 1x | 1x | 1x | 1x | 1x | 1x |
| Creek: wet weather events | SW-1, SW-2, WSP1, WSP2, WSP3, WSP4 | Grab | 6 events, 3 grab samples per event[a] | | | | | | | | | | | |
| Groundwater | LMP_GW_1, LMP_GW_2, LMP_GW_3, LMP_GW_4, LMP_GW_5, LMP_GW_6, WSP_GW_1, WSP_GW_2, WSP_GW_3, WSP_GW_4, WSP_GW_5, WSP_GW_6 | Grab (pump) | | 1x[b] | | | 1x[b] | | | 1x[b] | | 5.4 | 1x[b] | |
| Aquifer core sediments | LMP_GW_1, LMP_GW_2, LMP_GW_3, LMP_GW_4, LMP_GW_5, LMP_GW_6, WSP_GW_1, WSP_GW_2, WSP_GW_3, WSP_GW_4, WSP_GW_5, WSP_GW_6 | Grab or composite[c] | 1x | | | | | | | | | | | |

a. *Three grab samples will be taken at each site for 6 wet weather events.*

b. *Groundwater monitoring schedule is to be adjusted based on completion of wells. These locations will be sampled quarterly; however, the months within the quarter may vary depending on sampling start date. Groundwater levels will be measured monthly. The first round of groundwater samples will be analyzed for major anions and cations in addition to other parameters.*

c. *Aquifer core sediment samples will be taken from the borings during well installation, where the center of the well screen would be placed; if the sediments are very consistent in that area, a grab sample will be collected. If the sediments are diverse in the area around the center of the well screen, a composite sample will be collected.*

## 5.5 Benthic Sampling

The County will perform benthic macroinvertebrate sampling at four locations during 2015:

- Spanaway Creek at Spanaway Loop Road, just upstream of Spanaway Lake
- Spanaway Creek near Military Road, just downstream of the lake
- Spanaway Creek below Bresemann Dam
- Morey Creek

Benthic macroinvertebrate samples will be collected according to the Ecology SOP for collection of freshwater macroinvertebrate data in wadeable streams (Ecology, 2012a). Each location will be sampled once, during late summer.

## 5.6 Stream Sediment Sampling

The County will perform streambed pebble counts and sediment particle size distribution analyses at each benthic sampling site in order to help interpret benthic and hydrologic metrics. In addition, the data may be used to perform an effective work analysis deemed necessary, for correlation to benthic macroinvertebrate habitat at Spanaway Creek just below the lake where benthic macroinvertebrates are sampled, and in stream reaches downstream of Military Road that the County deems unsuitable for benthic sampling.

### 5.6.1 Pebble and Sediment Sampling

In gravel or cobble reaches, pebble counts will be performed using volumetric sampling to identify the particle size distribution of the armor layer. Pebble counts will be performed at five evenly spaced locations along the channel cross-section, to be selected by the project hydrologist. Pebble count protocols will follow the volumetric sampling methods of Bunte and Abt (2001).

In sandy or fine material reaches, grab samples will be taken using a Ponar sampler or similar handheld sampler. Sediment samples will be collected from five evenly spaced locations along the channel cross-section. The five subsamples will be combined in a stainless-steel mixing bowl to form one composite sample for laboratory analysis. The composite sediment samples will be delivered to the County laboratory for particle size analysis.

### 5.6.2 Sediment Depth Measurements

If unconsolidated fine sediment is observed at a sampling site, the field crew will use a survey rod to estimate the depth of fine sediment. The rod will be lowered until the top of the sediment layer is reached and the position of the top of the water column will be marked. The rod will then be forced down until resistance is met and the position of the top of the water column will be marked again. The difference between these water elevations will determine the depth of fine sediment layer. The rod will be forced down the sediment matrix by hand. The results will be used only as observational data to increase the understanding of sediment deposition within the creeks.

### 5.6.3 Bulk Sediment Samples

A bulk sediment sample will be collected below the armor layer for a subset of the pebble count sample locations, to be selected in the field. The depth of the armor layer will be assessed to estimate the depth at which fine sediments are contained in the voids of the sub-armor layer. These samples will be analyzed for particle size distribution. The results should help to improve understanding of sediment mobility in the study area.

### 5.6.4 Sampling Schedule and Development of Detailed Protocols

The pebble counts and sediment sampling will occur during the low flow period in late summer 2015. The detailed protocols to guide the field crew through pebble counts and sediment sampling will be further developed during spring 2015, including processes for identifying sample locations to represent the fluvial geomorphology and potential habitat characteristics of a site, determining sample volume and depth, and handling samples to minimize bias.

## 5.7 Practical Constraints and Logistical Problems

Logistical problems such as excessive precipitation during typically dry periods, scheduling conflicts, sample bottle delivery errors, vehicle or equipment problems, site access issues, or the limited availability of personnel or equipment, could interfere with sampling. Any circumstance that interferes with data collection and quality will be noted and discussed in the final report. As noted above, the project budget is limited so it may not be possible to perform additional monitoring should logistical problems arise.

Section 6

# Sampling and Measurement Procedures

This section describes the field sampling and measurement procedures. The methods selected for the sampling and monitoring program have performance characteristics that meet the MQOs for precision, bias, and sensitivity. Factors considered in developing this sampling and monitoring program include:

- definition of the water quality constituent and the form or forms to be measured (e.g., total phosphorus [TP] and soluble reactive phosphate [SRP])
- frequency of analysis and the number of samples to be analyzed per analytical batch
- size of sample available
- sample preservation and holding time requirements
- ability of the data to support model development.

The field activities will be supervised or performed by qualified BC or County staff. BC will retain a local drilling contractor, mobilize sonic drilling equipment, drill soil borings, construct monitoring wells, obtain well drilling permits, and submit logs as required by Ecology.

Field sampling will use methods consistent with Ecology's SOPs for sampling and field methodology (http://www.ecy.wa.gov/programs/eap/quality.html). Prior to each sampling round, field personnel will obtain the requisite sample bottles and field equipment, calibrate the equipment, review the sample locations shown on Figure 5-1, and obtain from the County project manager the keys needed to access the sample locations, such as a monitoring well or an encased datasonde. Field meters will be calibrated before and after each monitoring event per the equipment manufacturer's instructions (http://www.ysi.com/media/pdfs/069300-YSI-6-Series-Manual-RevJ.pdf).

The sample bottle handling procedures are provided in Sections 6.1 through 6.7. Table 6-3 lists the sample containers and preservation methods for each laboratory-analyzed water quality constituent.

The proposed sampling measurement procedures meet the data quality objectives for the project and to support watershed model development.

The sub-sections below summarize the field sampling procedures for each sampling media type. Field data sampling sheets are provided in Appendix A.

## 6.1 Creek Monitoring Procedures

Creek water sampling will be conducted at six locations, as shown on Figure 5-1 and as summarized in Tables 5-1 and 5-2. Ecology's SOP for stream sampling (Environmental Assessment Program [EAP] 034) will be used to guide the sampling (Ecology, 2012b). Table 6-1 summarizes the creek water sampling procedures.

The water samples will be obtained by a surface grab. A surface grab sample is collected at a discrete point in time and space. The sampler will collect individual grab samples facing upstream in order to minimize the contamination that would be caused by the sampler's presence. When collecting the sample, the sampler should place the container into the water with the opening facing downward to minimize collection of debris material from the surface layer. Creek water samples will be collected by immersing the appropriate sample bottle by hand or with an extension pole.

Due to varying sample container requirements, samples for different water quality constituents will be collected using slightly different methods. The grab sample for FC will be collected directly into a sterile specimen bottle. The sample bottles for nitrate plus nitrite and total suspended solids (TSS) analyses will be rinsed three times with creek water before the grab sample is collected. The sample bottles provided by the lab for ammonia ($NH_3$), total Kjeldahl nitrogen (TKN), and TP will contain preservatives. To avoid loss of preservatives, samples for those parameters will be collected using spare containers of the same type but without preservatives. The spare sample bottles will be used to collect sample water from the stream, and carefully fill the $NH_3$, TKN, and TP sample bottles. Prior to each sampling event, the spare container will be pre-cleaned by the laboratory and rinsed three times with creek water prior to sample collection, to avoid introducing sample residue from other sampling sites. Gloves will be worn during sample collection activities.

At each sampling location, the sample collector will record the following information on the field sheet:

- date, time, and name(s) of sampling personnel
- in situ field measurements (e.g., pH, DO)
- gage height
- number and type of samples collected to be submitted to laboratory (if needed)
- deviations from the protocols in the QAPP

At the beginning and end of each sample run, the weather/ambient temperature is recorded.

Table 6-1 presents the sampling procedures for creek water, and Table 6-3 presents measurement methods, sample containers, preservation, and holding times for each water quality constituent sampled by County staff.

**Table 6-1. Creek Water Sampling Procedures**

| Sample type and location | Equipment needed | Procedure for conducting the sampling[a] |
|---|---|---|
| SW-1, SW-2, WSP1, WSP2, WSP3, WSP4 | Continuous flow meter | • Continuous flow and temperature meters will be installed by County staff in accordance with equipment manufacturer's guidelines.<br>• The County will download data monthly and perform QC review |
| | Instantaneous flow meter | • Instantaneous flow measurements will be collected under a range of flow conditions at each location to develop stage-discharge relationships.<br>• Discharge measurements will be collected in accordance with relevant Ecology SOPs. |
| | Staff Gauge | • Staff gauges are installed at each surface water location.<br>• The gauge height will be recorded on the field sampling sheet. |
| | Extension pole | • Collect grab sample using an extension pole as necessary from upstream of the sampler's location<br>• If the sample bottle does not contain preservatives, rinse the bottle with creek water and then fill directly from creek<br>• If the sample bottle contains preservatives, use a pre-cleaned bottle of identical material provided by the laboratory without preservatives to collect the sample from the creek, and then pour into the sample bottle with preservative<br>• Place sample bottle(s) into cooler |

| Table 6-1. Creek Water Sampling Procedures | | |
|---|---|---|
| Sample type and location | Equipment needed | Procedure for conducting the sampling[a] |
| | Datasonde | • After collecting the water samples, use the probe to measure in situ water quality parameters, as listed in Table 5-1, and record readings on the Field Sheet (Appendix A)<br>• Calibrate per equipment manufacturer's instructions |

*a. Monitoring will follow applicable Ecology SOPs.*

After filling the bottles and placing them in a cooler, in situ water quality constituents will be measured. The water quality constituents will be measured by either placing the probe directly into the stream water or pumping the water through a flow-through cell. The in situ constituents measured will consist of temperature, pH, conductivity, and DO. Additionally, water levels at existing staff gauges will be recorded.

## 6.2 Groundwater Sampling Procedures

Prior to commencement of the groundwater sampling, monitoring wells will be installed. Summaries of these activities are provided below.

### 6.2.1 Monitoring Well Installation

Six shallow (<70-foot) groundwater monitoring wells are installed using sonic drilling at the locations shown on Figure 5-1.

The sonic drilling technique was chosen because it is well suited for drilling through the poorly sorted and unconsolidated glacial deposits of the region. As an additional benefit, sonic drilling produces a large amount of core material, which facilitates sample collection and lithological logging. Sonic drilling works by vibrating a drill head at high enough speeds to liquefy the material around the drill bit, enabling the drill to more easily penetrate into the surrounding material.

#### 6.2.1.1 Monitoring Well Construction

Each monitoring well will be constructed with a 2-inch-diameter, threaded schedule 40 polyvinyl chloride (PVC) riser pipe with a 0.010-inch factory-slotted screen fitted with pre-packed filter material. Screen lengths will be determined based on observed geologic conditions and may range from 10 to 20 feet in length, and will be documented as built. Bottom caps or end plugs will be installed at the bottom of each well. The screened intervals of the wells on JBLM property (WSP_GW_5 and WSP_GW_6) will be emplaced from approximately 5 feet above the groundwater table to approximately 20 feet below the water table. The screened intervals of all other wells (WSP_GW_1 through WSP_GW_4) will be emplaced from approximately 5 feet above the groundwater table to approximately 10 feet below the water table. Field adjustments to screened intervals of all wells may be necessary to account for different lithologies encountered during drilling. Additional filter material may be placed around, and up to 3 feet above, the screened PVC interval, and will consist of size 10 to 20 silica sand, or an equivalent sand size and type. A 3-foot bentonite seal will be emplaced on top of the filter sand, and cement/bentonite grout will be emplaced from near ground surface to the bentonite seal.

The wells on JBLM property (WSP_GW_5 and WSP_GW_6) will be completed 2 feet above the ground surface with metal casing and a locking cap that enclose and cover the well casing to prevent damage to, or unauthorized entry into, the monitoring well. No metal parts will be used for well completion except the security casing at the top of the well. All other wells (WSP_GW_1 through WSP_GW_4) will be completed flush with the ground surface.

#### 6.2.1.2 Monitoring Well Development

Each well will be developed using a 2-inch-diameter, impeller-driven, submersible pump. At least 24 hours will be allowed to elapse between the time of well installation and development to let the filter pack and well seal settle and cure. Development will consist of pumping water from all depths in the well screen to remove fines from the filter pack. Development will be considered complete when at least three to five well volumes have been purged and the water is visibly free of fine sediment.

#### 6.2.1.3 Sediment Sampling during Well Installation

Continuous sediment cores will be collected from the drilling rig during monitoring well installation. The cores will be observed and logged by a field geologist, and used to select the appropriate screen interval and describe the local geologic conditions. One sediment sample per well will be collected from the well screen interval for laboratory analysis of major anions and cations, total persulfate-N, TKN, ammonia-N ($NH_3$), nitrate-N ($NO_3$), TP, SRP, total iron [Fe(0)+Fe(II)+Fe(III)], and total organic carbon (TOC). For screen intervals where sediment type is consistent, a single grab sample will be collected. For intervals where sediment type is diverse, a composite sample will be collected. (See Table 5-1 for sampling locations and parameters.)

### 6.2.2 Groundwater Sampling

The first round of quarterly groundwater samples will be collected at least 72 hours after well development is complete. The second through fourth rounds of groundwater monitoring will be conducted at 3-month intervals starting from the date of the first sampling event. (See Table 5-2 for sampling frequencies.) The sub-sections below discuss the groundwater sampling procedures and a summary is provided in Table 6-2.

**Table 6-2. Groundwater Sampling Procedures[a]**

| Sample type and location | Equipment needed | Procedure for conducting the sampling |
|---|---|---|
| WSP_GW_1, WSP_GW_2, WSP_GW_3, WSP_GW_4, WSP_GW_5, WSP_GW_6 | Water level indicator | • Remove well cap and wait approximately 5 minutes for the water level to stabilize.<br>• Place water level indicator into the well and record depth to groundwater on the Groundwater Sampling Field Sheet (Appendix A).<br>• Record time and ambient weather conditions on the Groundwater Sampling Field Sheet (Appendix A). |
| | Multi-parameter water quality probe | • Use the meter probe for collecting field measurements from the purged groundwater.<br>• Calibrate the equipment per the equipment manufacturer's instructions.<br>• Set up meter probe assembly and remaining field equipment for groundwater sampling collection.<br>• Use the meter probe for monitoring temperature, pH, conductivity, and DO.<br>• Record these measurements on the Groundwater Sampling Field Sheet (Appendix A). |
| | Peristaltic pump | • Use the peristaltic pump for sampling wells with a shallower groundwater table (WSP_GW_1, WSP_GW_2, WSP_GW_3, WSP_GW_4)<br>• Use the peristaltic pump for purging well water.<br>• Insert pump tubing into well and purge the groundwater until representative groundwater is noted. (Withdraw groundwater at a rate of 0.3 liter per minute for approximately 20 minutes or until measured parameters of the discharge water stabilizes.)<br>• Record purging details, including time, purge volume, and water quality parameters on the Groundwater Sampling Field Sheet (Appendix A). (Note that purge volume is measured by collecting water in a carboy bottle.)<br>• Immediately after purging, collect sample water from the pump discharged water and place into applicable sample bottle (see Table 6-3). Record sample collection details on the Groundwater Sampling Field Sheet (Appendix A). |

| Table 6-2. Groundwater Sampling Procedures[a] | | |
|---|---|---|
| Sample type and location | Equipment needed | Procedure for conducting the sampling |
| | Proactive™ Stainless Steel Monsoon ® Sampling Pump | • Use the Proactive™ Stainless Steel Monsoon ® Sampling Pump for purging well water with a deeper water table (WSP_GW_5 and WSP_GW_6).<br>• Insert pump tubing into well and purge the groundwater until representative groundwater is noted. (Withdraw groundwater at a rate of 0.3 liter per minute for approximately 20 minutes or until measured parameters of the discharge water stabilizes.)<br>• Record purging details, including time, purge volume, and water quality parameters on the Groundwater Sampling Field Sheet (Appendix A). (Note that purge volume is measured by collecting water in a carboy bottle.)<br>• Immediately after purging, collect sample water from the pump discharged water and place into applicable sample bottle (see Table 6-3). Record sample collection details on the Groundwater Sampling Field Sheet (Appendix A). |

a. *For wells that have issues with high turbidity and suspended solids (turbidity values greater than 50 NTU), a modified sampling approach will be conducted. This modified sampling approach includes purging the well the day before sampling to allow the well to rest. The following day, the sample should be collected as normal. If, however, the turbidity values are greater than 50 NTU, a field filter should be applied to end of the tubing to collect the groundwater sample. Static Water Level*

The ground surface and top of casing measuring points will be surveyed by a licensed surveyor. Field personnel will measure water levels during each sampling/monitoring event using an electronic water level indicator. The measurements for all wells will be collected in as short a time period as possible prior to beginning the sampling event to obtain a “snapshot” of the whole study area, generally within a 4-hour period. The well cap will be removed, and an initial water level will be recorded. After allowing approximately 5 minutes for the water level to stabilize, a second water level measurement will be collected. If the second and initial water level measurements are within one-hundredth of a foot (0.01 foot), the water level in the well casing is assumed to be stable. If the difference is greater than 0.01 foot, an additional 5 minutes will be allowed to elapse. Measurements of the depth to groundwater will be accurate to the nearest 0.01 foot. The groundwater depth, time, and ambient weather conditions will be recorded on the Groundwater Sampling Field Sheet, as provided in Appendix A.

#### 6.2.2.1 Water Quality Parameters

Water quality parameters will be measured during purging and sampling using a multi-parameter water quality probe to assess the stabilization of flow from the well screen to the pump intake.

Water temperature, pH, conductivity, DO, turbidity, and water depth will be measured in the field. Water quality instruments will be calibrated at a minimum on a daily basis, change in temperatures of +/- 10 degrees centigrade (°C), or if weather conditions change (sun to rain, etc.), to account for barometric pressure and temperature effects on the probe sensors. All field measurement equipment, except water quality meter probes, will be cleaned prior to use at each sampling location using the decontamination procedures described in Section 6.5.

#### 6.2.2.2 Well Purging

Wells will be purged and sampled using uniform equipment configurations. Two types of pumps will be used for purging the well water, a peristaltic pump for the wells with a shallower groundwater table (WSP_GW_1, 2, 3, 4, and all the LMP wells) and a Proactive ™ Stainless Steel Monsoon ® Sampling pump for the wells with a deeper groundwater table (WSP_GW_5 and 6 ). Both pumps will be fitted with polyethylene or PVC tubing for use in purging and sampling. Purging details, including time, purge volume, and water quality parameters, will be recorded on the Groundwater Field Sampling Form (Appendix A). All equipment used for purging and sampling will be decontaminated prior to use at each location. New pump tubing or dedicated tubing will be used for each well and sampling event. Dedicated tubing will be used with wells where the peristaltic pump is used. Dedicated tubing will be replaced as needed. New tubing will be used for the submersible Proactive ™ Stainless Steel Monsoon ® Sampling pump.

Monitoring wells will be purged and sampled using low-flow techniques. This includes gently lowering the pump intake tubing to the approximate center of the well screen and withdrawing groundwater at a rate that does not induce drawdown (<0.33 foot based on EPA guidance for low flow sampling) of the water level (Puls et al., 1996). Groundwater quality parameters will be measured continuously and recorded every 5 minutes during purging to assess water quality parameter stabilization. Generally three or more consecutive measurements of pH within 0.2 pH unit, conductivity within 10 percent, and temperature within 1°C indicate adequate stability. A final set of water quality parameters will be recorded after purging and just prior to sampling. These final measurements will be reported as representative of the samples submitted for analysis.

#### 6.2.2.3 Sample Collection

Immediately after purging, field personnel will disconnect the tubing from the multi-parameter flow cell and collect a sample directly from the pump discharge line using the following procedures:

1. Slowly fill one sample bottle at a time, taking care not to agitate or overfill the bottle.
2. After the bottle has been filled, complete the label, as discussed in Section 6.5, and immediately place the bottle into a cooler with sufficient ice to maintain the temperature at or below 4°C.
3. Transfer all the samples to the laboratory, as discussed in Section 6.4, leaving enough time available for the laboratory to perform extractions and analyses within the specified holding times. This is especially important for the FC samples, which have a holding time of 48 hours.

As noted in the footnote of Table 6-2, for wells that have issues with high turbidity and suspended solids (turbidity values greater than 50 NTU), a modified sampling approach will be conducted. This modified sampling approach includes purging the well the day before sampling to allow the well to rest. The following day, the sample should be collected as normal. If, however, the turbidity values are greater than 50 NTU, a field filter should be applied to end of the tubing to collect the groundwater sample.

## 6.3 Field Supplies and Measurement Methods

The specific field equipment needed for conducting the sampling tasks described above is listed in Tables 6-1 through 6-3. This section provides a summary of the general field supplies that will be used for all of the sampling tasks. Table 6-3 provides a summary of the sample containers, and preservation and holding times.

Typical supplies include:

- antibacterial hand sanitizer or soap
- cooler(s)
- ice (regular, or blue ice blocks)
- tap water
- hip boots or waders (if applicable)
- chain-of-custody forms for use with accredited laboratory
- sample bottles, as listed in Table 6-3 below
- latex or nitrile gloves (for sites where bacteria level is known or suspected to be high)
- sample bottle labels

- sample field sheets (See Appendix A)
- camera
- mixing bowl
- mixing spoon

| Table 6-3. Laboratory Analysis Methods, Detection Limits, and Holding Times | | | | | |
|---|---|---|---|---|---|
| Parameter | Sample matrix | Method | Container | Preservative | Holding time |
| Water Samples (Creek and Groundwater) | | | | | |
| $NH_3$ | Water | SM 4500-NH3-D | 500 mL HDPE | Cool to 4°C | 28 days |
| TKN | Water | SM 4500-N-C | 500 mL HDPE | $H_2SO_4$, cool to 4°C | 28 days |
| $NO_3$ | Water | Easy 1 Reagent | 250 mL HDPE | Cool to 4°C | 48 hours |
| TP | Water | SM4500-P E | 125 mL clear HDPE | $H_2SO_4$,cool to 4°C | 28 days |
| SRP | Water | SM4500-P E | Aliquot from TSS bottle | Cool to 4°C | 48 hours [a] |
| Alkalinity | Water | SM2320B | 250 mL HDPE | Cool to 4°C | 14 days |
| Fe | Water | EPA 200.8 | 250 mL HDPE | $HNO_3$ | 6 months |
| TSS | Water | SM 2540D | 1 L HDPE (full volume analyzed) | Cool to 4°C | 7 days |
| FC | Water | SM9222D (membrane filter) | 250 mL glass/poly, autoclaved | Cool to 4°C | 30 hours |
| Total Cu | Water | EPA 200.8 | 250 mL HDPE | HNO3 | 6 months |
| Dissolved Cu | Water | EPA 200.8 | 250 mL HDPE | None required | 6 months* |
| Total Zn | Water | EPA 200.8 | 250 mL HDPE | HNO3 | 6 months |
| Dissolved Zn | Water | EPA 200.8 | 250 mL HDPE | None required | 6 months* |
| Total Hardness | Water | SM 2340B | 250 mL HDPE | HNO3 | 6 months |
| Turbidity | Water | EPA 180.1 | 250 mL HDPE | None required | 48 hours |
| Chloride | Water | SM 4500 CL-C | 250 mL HDPE | None required | 28 days |
| Major ions | Water | Various[b] | Various[b] | Various[b] | Various[b] |
| Aquifer Core Sediment Samples | | | | | |
| $NH_3$ | Sediment | SM 4500NH3B&C | Plastic | N/A | 28 days |
| TKN | Sediment | SM 4500N C | Plastic | N/A | 28 days |
| $NO_3$ | Sediment | EPA 9056 | Plastic | N/A | 28 days |
| Total persulfate nitrogen | Sediment | SM #20 SM4500-N C | Plastic | N/A | 28 days |
| TP | Sediment | SM 4500-P_B+E | Plastic | N/A | 28 days |
| SRP | Sediment | SM 4500-P E | Plastic | N/A | 28 days |
| Total Fe [Fe(0)+Fe(II)+Fe(III)] | Sediment | EPA 6010C | Plastic | N/A | 28 days |
| TOC | Sediment | SW 846 9060 | Glass | N/A | 7 days |

| Table 6-3. Laboratory Analysis Methods, Detection Limits, and Holding Times | | | | | |
|---|---|---|---|---|---|
| Parameter | Sample matrix | Method | Container | Preservative | Holding time |
| Major Anions and Cations | | | | | |
| Bicarbonate ($HCO_3$) | Sediment | SM 2320B | Plastic | N/A | 28 days |
| Calcium ($Ca^2$) | Sediment | EPA 6010C | Plastic | N/A | 28 days |
| Magnesium ($Mg^2$) | Sediment | EPA 6010C | Plastic | N/A | 28 days |
| Silicon (Si) | Sediment | EPA 6010C | Plastic | N/A | 28 days |
| Potassium (K) | Sediment | EPA 6010C | Plastic | N/A | 28 days |
| Chloride (Cl) | Sediment | EPA 300/9056A | Plastic | N/A | 28 days |
| Sulfate ($SO_4$) | Sediment | EPA 300/9056A | Plastic | N/A | 28 days |

a. *Samples for SRP analysis will be filtered in the laboratory.*

b. *For major anions and cations, container and holding times are analyte-specific and will vary for each analyte.*

## 6.4 Coordination with Laboratory

An integral part of this sampling and monitoring program is coordination with the laboratory. This coordination includes the following key features:

- **Obtaining the sampling bottles and labels:** Sample bottles, labels, and chain-of-custody forms will be obtained by the lab prior to each sampling event and will be cross-referenced with Table 6-3 by the field staff to ensure that all sample bottles and labels are present.
- **Obtaining correct sampling procedures regarding filtering:** The laboratory will provide guidance on collected filtered samples.
- **Scheduling sampling runs:** Field staff will confirm with the lab the delivery dates and times needed in order for samples to be processed and analyzed within the allowable holding times.
- **Storage of sample containers:** Field staff will confirm with the lab the proper storage of the sample bottles, including holding times (Table 6-3), to ensure adequate usability of the sample.
- **Completing chain-of-custody forms:** Chain-of-custody forms will be completed according to the procedures set forth by the lab and field staff.

## 6.5 Sample Handling and Documentation

Depending on the sampling type, specific procedures will be adhered to for proper sampling. These procedures include the following key features:

- **Decontamination of sampling equipment:** All sampling equipment will be properly decontaminated in accordance with Ecology's SOPs. Field meters will be decontaminated per the equipment manufacturers' instructions.
- **Disposing of waste from field operations:** Any waste generated from field operations will be properly disposed of.
- **Calibration of field equipment:** Field equipment will be calibrated before and after each monitoring event per the equipment manufacturer's guidelines. Calibration efforts will be recorded on the Field Data Sheets (Appendix A).

- **Proper labeling of samples:** All samples will be properly labeled with the correct site identifier (ID) and date using the laboratory-provided labels.
- **Field Data Sampling Sheets:** Field staff will complete Field Data Sampling Sheets at each sampling event (Appendix A). The field sheets will include the following information:
  - name of the project, location, sample ID(s), sample type, and field staff present
  - site and ambient weather conditions
  - date and time of sample collection
  - number of samples collected
  - instrument calibration procedures
  - field measurement results
  - identity of blind duplicate samples (described in Section 7)
  - any unusual circumstances that could affect interpretation of the data

## 6.6 Safety

Ensuring the safety of all field staff is a key feature of this sampling and monitoring program. Field staff is trained on safety preparedness and awareness, and will not conduct any sampling in unsafe conditions. Extra precautions will be taken to ensure proper boat safety techniques.

When collecting samples, gloves will be worn to avoid exposure to water contaminants. (If gloves are not worn, hands and anything they touch will be assumed to be contaminated after sampling.) In such cases, hands will be cleaned using antibacterial and phosphate-free soap or hand sanitizer after completing work at each sampling station or, at a minimum, after completing work at sampling stations with known high bacteria counts and before ingesting food or drink. Further field health and safety measures are available in the EAP Safety Manual (Ecology, 2009).

## 6.7 Aquatic Invasive Species Protocols

Field crew will follow the SOP on minimizing the spread of invasive species. The Spanaway WSP project study area is not in a region of extreme concern. Areas of extreme concern have, or may have, invasive species like New Zealand mud snails that are particularly hard to remove from equipment and are especially disruptive to native ecological communities. For more information, please see Ecology's website on minimizing the spread of invasive species at http://www.ecy.wa.gov/programs/eap/quality.html

Section 7

# Quality Control

Several QC measures are integrated within the laboratory, field, and corrective actions of the Spanaway WSP monitoring program, as discussed below.

## 7.1 Laboratory Quality Control

Analytical QC procedures will involve the use of four types of QC samples: check standards, laboratory duplicates, matrix spikes, and method blanks. The QC samples will be analyzed within each batch of field samples to provide an indication of the performance of the entire analytical system. Each type of QC sample will be analyzed at a minimum frequency of one per sample batch. A short summary of each of these types is provided below.

1. **Check standards** are used to verify that analytical precision is in control and that the level of bias due to calibration is acceptable. The lab will analyze check standards at a frequency of one per batch. If the results for check standards do not fall within established control limits, the measurement system will be recalibrated.
2. **Laboratory duplicates** are derived from a single sample, and are used to verify precision of the measurement system.
3. **Matrix spikes** are an aliquot of a sample to which a known amount of analyte is added at the start of the procedure. Matrix spike recoveries may provide an indication of bias due to interference from components of the sample matrix. Matrix spike duplicates will be used to estimate analytical precision at the concentration of the spiked samples.
4. **Method blanks** are standards prepared by the laboratory that contain none of the analytes of interest. A blank is run with each sample batch to document that the measurement system responds accurately to such samples.

## 7.2 Field

Field QC samples for this study will consist of 1 blind duplicate sample collected for every 10 field samples. Duplicate samples will be collected by filling two sets of sample bottles at a given location. Blind duplicates will be assigned fictitious sample names so that the laboratory is unaware that the samples are duplicates. The fictitious sample names and their actual locations will be cross-referenced on the field forms.

Datasondes and field meters will be calibrated according to manufacturer's recommendations and applicable Ecology SOPs (e.g., EAP033). Conductivity, DO, pH and temperature results will be accepted, qualified, rejected, or corrected, as appropriate.

## 7.3 Corrective Actions

Corrective actions will be taken when data quality falls outside of established MQOs established in this QAPP. A corrective action involves the following steps: discovery of a nonconformance to the QAPP, identification of the cause of the nonconformance, plan and schedule of corrections, and confirmation that the desired results were produced.

Field personnel are responsible for following all QC procedures and identifying and correcting nonconforming field data. Field personnel will notify the project manager or QA officer if they suspect that QC requirements for field methods cannot be met. Corrective actions will be identified and implemented as appropriate. Field personnel will document the nonconformance, corrective action, and results.

Corrective actions at the laboratory may be necessary because of equipment malfunction, nonconformance with internal QC standards, method blank contamination, failure of performance or system audits, or noncompliance with the QAPP. When measurement equipment or analytical methods fail QC standards, the problem will immediately be brought to the attention of the laboratory QA officer and assigned project manager in accordance with SOPs.

# Section 8
# Data Management Procedures

Data management includes carefully maintaining field and laboratory analytical data, from their production to their final use and archiving.

## 8.1 Field Data

Field data and events will be carefully recorded and maintained so the field crew or others who were not present can accurately describe events at a later date. Field data will be entered with permanent ink on the field data sheets provided in Appendix A. Mistakes will be crossed out and initialed by the field personnel making the correction. No entries will be erased. At the close of the project, all of the field data sheets will be archived in the Pierce County or BC archives.

## 8.2 Laboratory Analytical Data

The laboratories will provide analytical results to BC for all primary and QC samples. The hard-copy data package will be signed by the laboratory project manager and technician(s) who analyzed the samples. The laboratories will also provide the completed chain-of-custody forms and a narrative or cover letter that describes any problems with the analyses, corrective actions, changes to the analytical methods, an explanation of any data qualifiers, and all applicable QA/QC documentation. An electronic version of analytical results will also be provided in either a Microsoft Word or Excel format.

Section 9

# Data Review, Verification, and Validation

Once data have been recorded, they will be examined to ensure the following:

- data are consistent, correct, and complete, with no errors or omissions
- results for QC samples are included
- QC results show that acceptance criteria were met
- data qualifiers are assigned where necessary
- data described in the Sampling Design were obtained
- methods and protocols specified in the QAPP were followed

## 9.1 Field Data

Data acquired in the field will be reviewed following each sampling event to ensure that there are no omissions and ensure consistency with the QAPP. For example, after collecting a groundwater sample from a well, the field crew will review the field data sheet and sample bottle labels to verify that all water quality parameters were measured, the correct bottles were filled for the planned analyses, and planned QC samples were collected. When practicable, a second field crew member will peer-review chain-of-custody forms and field logs prior to submitting samples to the laboratory.

## 9.2 Laboratory Analytical Data

Prior to releasing the data to County staff or BC, the laboratory will perform several levels of data review, including analytical level (analyst), data section level (supervisor), and final quality review (laboratory QA officer). Immediately after receiving the data, BC will perform a data quality review to document the data quality, verify that adequate documentation is available, and determine whether the analytical data are usable and meet the measurement quality objectives.

## 9.3 Corrective Actions

Corrective actions will be taken when data quality falls outside of MQOs established in this QAPP. A corrective action involves the following steps: discovery of a nonconformance to the QAPP, identification of the cause of the nonconformance, plan and schedule of corrections, and confirmation that the desired results were produced.

Field personnel are responsible for following all QC procedures and identifying and correcting nonconforming field data. Field personnel will notify the project manager or QA officer if they suspect that QC requirements for field methods cannot be met. Corrective actions will be identified and implemented as appropriate. Field personnel will document the nonconformance, corrective action, and results.

Corrective actions at the laboratory may be necessary because of equipment malfunction, nonconformance with internal QC standards, method blank contamination, failure of performance or system audits, or noncompliance with the QAPP. When measurement equipment or analytical methods fail QC standards, the problem will immediately be brought to the attention of the laboratory QA officer and assigned project manager in accordance with SOPs.

## 9.4 Audits and Reports

The results from this sampling program will be used to support development of the watershed model, which will be used to develop the Watershed-Scale Stormwater Plan. The project manager will be responsible for verifying data completeness before use in the subsequent technical analyses that will be conducted for this project.

The NPDES permit requires that the County submit a Watershed-Scale Stormwater Plan to Ecology and include a summary of results of the modeling and planning process, results of the evaluation of strategies under S5.C.5.c.ii(5), and an implementation plan and schedule developed pursuant to S5.C.5.c.ii(6). This Watershed-Scale Stormwater Plan will include analyses of results that form the basis of conclusions and recommendations.

Section 10

# Data Quality (Usability) Assessment

The field lead or project manager will verify that all measurement and data quality objectives have been met. The field lead or project manager will make this determination by examining the data and all of the associated QC information. Existing data that will be used to support the project objectives will be evaluated to confirm that it is suitable for the purpose of this project. If the MQOs for the data have been met, the quality of the data should be useful for meeting project objectives. If the objectives have not been met (e.g., the percent RPD for sample replicates exceeds the MQO), the project manager will decide how to qualify the data and whether they can be used in the technical analysis. For the purposes of the sampling surveys, data that are qualified may still be usable for project objectives. If any sample results are non-detect, half the detection limit will be used for subsequent statistical analyses. The project manager will determine if the quality of the data is sufficient to meet project objectives. Documentation of the data quality and decisions on data usability will provide accuracy and transparency of the QA/QC procedures. The data quality assessment methods and results will be documented in individual project data files and summarized in the Watershed-Scale Stormwater Plan.

The project team will use the monitoring results to develop and calibrate an HSPF model of the watershed. The HSPF model will be calibrated to reflect the existing hydrologic conditions using the surface water monitoring results.

In addition, an existing groundwater model will be refined and calibrated using groundwater data collected for this study. The groundwater model will be used to inform the groundwater interactions in the HSPF model. The HSPF model will be designed to simulate existing, predevelopment, and future conditions in the WSP area and support evaluation of potential changes in hydrology and water quality resulting from alternative stormwater management strategies.

BC is preparing a separate modeling plan to summarize the modeling approach, data sources, potential calibration parameters, methodology, and criteria.

Section 11

# Limitations

This document was prepared solely for Pierce County in accordance with professional standards at the time the services were performed and in accordance with the contract between Pierce County and Brown and Caldwell dated December $6^{th}$, 2013. This document is governed by the specific scope of work authorized by Pierce County; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Pierce County and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

## Section 12

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# Appendix A: Field Data Sheets

This appendix contains examples of the field data sheets that will be used for this project:

- Creek Sampling Field Sheet
- Groundwater Sampling Field Sheet
- Aquifer Sediment Sampling Field Sheet

## SPANAWAY LAKE MANAGEMENT PLAN / WATERSHED SCALE PLAN

### Creek Sampling Field Sheet

**STATION INFORMATION**

| Sample Location | Location Description | Date | Time | Field Measurements | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Temp (°C) | pH (s.u.) | EC (mS) | D.O. (mg/L) | Stage (ft) | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

Comments:

**QA/QC Samples:** ______________________________

Personnel:

Weather:

Tasks completed (narrative of sampling event):

Deviations from QAPP:

**SPANAWAY LAKE MANAGEMENT PLAN/WATERSHED SCALE PLAN**
**Groundwater Sampling Field Sheet**

## WELL INFORMATION

Well ID: ____________________ Date: ________________
Well Diameter: ____________________ Time: ________________

Sample ID Number: ________________________________________
Sampler's Signature: ________________________________________

Depth to Water (ft btoc): ________________________________________
Total depth (ft btoc): ________________________________________
Well casing volume (gal.): ________________________________________
Total purge volume (gal): ________________________________________
Pump inlet depth (ft btoc): ________________________________________

## FIELD SAMPLING PARAMETERS:

| | Time | Est. Volume (gallons) | Temp ($^oC$) | Diss. Oxygen (DO) (mg/L) | pH (s.u.) | Conductivity (μS) | ORP (mV) | Color / Turbidity (for purging only) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
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| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Sample** | | | | | | | | |

## SAMPLE COLLECTION AND ANALYSIS

| Container | Color | Filtered/Raw | Perservative | Constituents & Analyses |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

**QA/QC Samples:** ________________________________________

Personnel: ________________________________________
Weather: ________________________________________
Tasks completed (narrative of sampling event): ________________________________________

Deviations from QAPP: ________________________________________

# SPANAWAY WATERSHED SCALE PLAN
## Aquifer Soil Sampling Field Sheet

**Boring ID** ______________________

| Sample ID | Depth Interval | Container | Date | Time | Sample Type | # of subsamples | Consituents and Analyses | Comments/Description |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Major ions: HCO3, Ca2, Cl, Mg2, Si, SO4, K | |
| | | | | | | | Nutrients: SO4-N, TKN, NH4, NO3, TP, PO4, Fe, TOC, DOC | |
| | | | | | | | | |
| | | | | | | | | |

QA/QC Samples: ______________________________

______________________________

______________________________

Personnel: ______________________________

Weather: ______________________________

Tasks completed (narrative of sampling event): ______________________________

______________________________

______________________________

______________________________

______________________________

Deviations from QAPP: ______________________________

______________________________

______________________________

______________________________

______________________________