LAUGHING JACOBS BASIN PLAN

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

The Laughing Jacobs Basin Plan describes and evaluates the natural and built conditions of the basin to identify opportunities to improve the basin's quality. Conceptual projects are developed from these opportunities satisfying the City of Sammamish's goal to use basin planning to allocate limited resources to address priority problems and opportunities.

The Laughing Jacobs Basin supports some of the few sphagnum-dominated peatland wetlands in King County and provides Lake Sammamish Kokanee with spawning areas. The headwaters of the basin begin at Beaver Lake and its tributaries; however, this region will be analyzed at a different time and is not discussed in this Basin Plan. Laughing Jacobs Creek connects a portion of the East Lake Sammamish Plateau and cascades down the hillside to its discharge location at Lake Sammamish. Sphagnum wetlands exist in the upper basin and contribute to the diversity of the basin's ecosystem. Lower reaches of the creek have historically supported kokanee spawning.

Public engagement and feedback identified aspects of the basin that present value to residents and areas where improvement is desired. A problems and opportunities assessment narrowed comments and concerns to specific attributes where improvements could benefit the basin. Potential solutions are proposed in the form of conceptual projects supported by hydrologic modeling efforts. Projects provide water quality improvements, benefits to native habitats, climate change resilience, and other environmental benefits. Projects are ranked in accordance with the City of Sammamish's Capital Improvement Project prioritization process. The total cost of the six proposed projects is approximately 2.7 million dollars. However, implementation of any of the projects will benefit the basin.

Proposed projects include:

- Construction of bioretention systems to treat stormwater runoff tributary to two sphagnum bogs,
- Installation of compact roadway stormwater treatment devices,
- Riparian vegetation restoration, and
- Engineered hyporheic zone augmentation.

ACRONYMS AND ABBREVIATIONS

Basin Plan	Laughing Jacobs Basin Plan
BMP	Best Management Practice
CARA	Critical Aquifer Recharge Area
Cascadia	Cascadia Consulting Group
CFS	Cubic Feet per Second
CIP	Capital Improvement Project/Capital Improvement Plan
City	City of Sammamish
CWA	Clean Water Act
Ecology	Department of Ecology
EPA	Environmental Protection Agency
ESA	Environmental Science Associates
Geosyntec	Geosyntec Consultants
GIS	Geographic Information System
GPM	Gallons per Minute
HOA	Homeowner’s Association
IMC	Issaquah Municipal Code
LID	Limited Impact Development
NPDES	National Pollutant Discharge Elimination System
PHS	Priority Habitats and Species
PVC	Polyvinyl Chloride
RM	River Mile
SAP/QAPP	Sampling and Analysis Plan/Quality Assurance Project Plan
SE	Southeast
SM	Standard Method
SMC	Sammamish Municipal Code
SMP	Shoreline Master Plan
SOP	Standard Operating Procedure
SSWMCP	Storm and Surface Water Management Comprehensive Plan
TAPE	Technology Assessment Protocol – Ecology

USDA	United States Department of Agriculture
USGS	United States Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WHPA	Wellhead Protection Area
WHPP	Wellhead Protection Plan
WWMH	Western Washington Hydrology Model

ACKNOWLEDMENTS

The City of Sammamish thanks the City of Issaquah for their collaboration and feedback with this basin planning effort.

1. INTRODUCTION

The City of Sammamish (City) uses basin planning to assess the physical and biological conditions of watersheds in the City and to develop solutions to mitigate identified issues. The NPDES Municipal Stormwater Permit requires the implementation of a stormwater planning program to inform and assist in the development of policies and strategies as water quality management tools to protect receiving waters. The City's comprehensive plan (City of Sammamish, 2018) and the *Storm and Surface Water Management Comprehensive Plan* (City of Sammamish, October 2016) both identify a goal to use basin planning to allocate limited resources to address priority problems and opportunities.

The Laughing Jacobs Basin drains approximately 4.1 square miles of area at the south end of the East Lake Sammamish Plateau. Most of the basin lies within the City; however, a portion of the lower basin extends into the City of Issaquah including the mouth of the Laughing Jacobs Creek which discharges to Lake Sammamish. Although Beaver Lake and areas tributary to Beaver Lake are the headwaters of the Laughing Jacobs Basin, these areas are not included in this Laughing Jacobs Basin Plan (Basin Plan); a separate planning effort will focus on these areas. The basin is depicted in Figure 1-1.

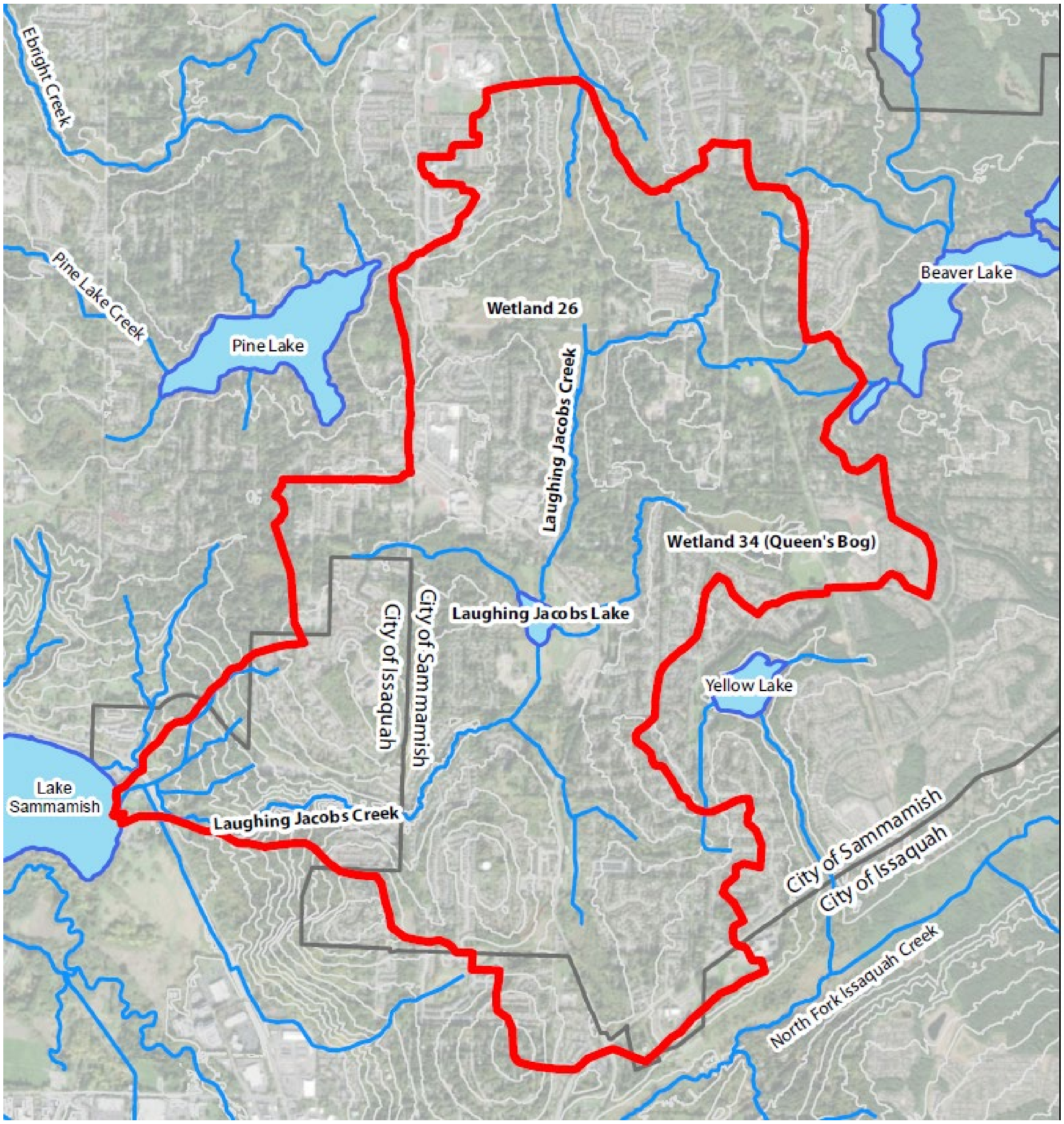


Figure 1-1. Laughing Jacobs Basin

The Laughing Jacobs Basin encompasses residential areas, schools, parks, and shopping centers that support the residents of both Sammamish and Issaquah. Unique species rely on the natural habitat of the basin, such as sphagnum moss and kokanee salmon. Sammamish and Issaquah partnered to identify ways to protect and repair the natural environment within the Laughing Jacobs Basin. Specifically, the Basin Plan was developed with the following objectives:

- Watershed characterization, including regulatory drivers, incorporating existing data, and providing new data from water quality monitoring, stream and wetland hydrology monitoring, geomorphic surveys, fish passages, basin and sub-basin delineation, and channel cross-sections;
- Public outreach, including community involvement via survey feedback and public meetings;
- Problems and opportunities identification, defining values and providing risk analysis;
- Targeted modeling and alternatives development, considering natural systems, linkages, and infrastructure;
- Capital Improvement Project (CIP) identification and prioritization; and
- Delivery of a final basin plan which provides a transparent documentation of processes, decisions, and proposed projects

The basin planning effort was operated as a series of Topic Areas outlined in the Project Management Plan (Appendix A). Topic Areas included watershed characterization, public outreach, water quality monitoring, problems and opportunities identification, modeling, project identification and prioritization, and conceptual design development. These efforts were compiled into this Basin Plan for presentation. The Laughing Jacobs Basin extends beyond the City of Sammamish into the City of Issaquah. This Basin Plan was developed in collaboration with the City of Issaquah to analyze the physical and biological conditions of the basin within both cities and to present opportunities beneficial to both cities.

2. WATERSHED SETTING

2.1 Background

Environmental Science Associates (ESA) drafted a memorandum to characterize physical, biological, and water quality conditions in the Laughing Jacobs Basin. This section highlights key points in ESA's memorandum, which is included in Appendix B.

2.2 Previous Studies

Previous studies have focused on the assessment and restoration of East Lake Sammamish tributary streams and the associated basin. The following are key studies listed in ESA's memorandum:

- Blueprint for the Restoration of Lake Sammamish Kokanee Tributaries (2014)
- Ecological Survey of "Late-Run" Kokanee in Lake Sammamish, 2016 (published 2017)
- City of Issaquah State of Our Waters (2011)
- City of Issaquah Stream and Riparian Areas Restoration Plan (2006)
- City of Sammamish Shoreline Master Program (SMP) Update, Final Shoreline Restoration Plan (2008)
- Lake Sammamish State Park Wetland, Stream, and Lakeshore Restoration Plan (2005)
- Final East Lake Sammamish Basin and Nonpoint Action Plan (1994)

2.3 Regulatory drivers

2.3.1 Surface Water

Surface water quality in the State of Washington is regulated by Washington Administrative Code (WAC) 173-201A (WAC, 2021a). Specific criteria for water quality standards based on designated use are outlined in WAC 173-201A-200. Laughing Jacobs Creek is a designated core summer salmonid habitat. The aquatic life temperature criterion for this use classification requires a 7-day average of the daily maximum of 16°C or less (WAC, 2021b).

Based on previous monitoring efforts further described in Section 2.7.1, Laughing Jacobs Basin Creek is listed under Clean Water Act (CWA) Section 303(d). Water bodies that are listed under CWA 303(d) are also known as Category 5 water bodies under Washington's Water Quality Assessment categories. A Category 5 water body is defined as a polluted water body that requires a water improvement project (Ecology, 2018).

2.3.2 Groundwater

Regulations exist which protect the integrity of the groundwater within the Laughing Jacobs Basin, which is a domestic water supply. Protection of groundwater is enforced through Wellhead Protection Areas (WHPAs) and Critical Aquifer Recharge Areas (CARAs).

WAC 246-290-135 Source Water Protection requires purveyors of water systems using groundwater sources to implement a Wellhead Protection Plan (WHPP). The WHPP must include the delineation of WHPAs for each well with a 1-, 5-, and 10-year time of travel boundary (WAC, 2021c).

Municipal codes for both the City of Sammamish and the City of Issaquah require establishment and protection of CARAs within the Laughing Jacobs Basin. CARAs are critical areas that must be protected such that the integrity of groundwater quality is conserved. Municipal codes require demonstration that contaminants will not enter the aquifer due to development activity. CARAs are regulated in the City of Sammamish under Sammamish Municipal Code (SMC) 21.03.020.X. Critical Aquifer Recharge Areas – Development Standards (SMC, 2021a) and CARAs are regulated in the City of Issaquah under Issaquah Municipal Code 13.29 Groundwater Quality Protection Standards (IMC, 2021).

2.3.3 City Ordinances and Plans

The City has plans and ordinances to help regulate development to mitigate adverse effects to environmentally sensitive areas. These include:

- **The Environmentally Critical Areas Ordinance (SMC Chapter 21.03.020)**, which provides standards for developments near wetlands, streams, and other fish and wildlife habitat areas, geologically hazardous areas, critical aquifer recharge areas, and frequently flooded areas. Since the ordinance was established, developments have implemented better measures to detain and treat stormwater runoff, which generally discharges to receiving waters within the Laughing Jacobs Basin (SMC, 2021b).

- **The Stormwater Capital Improvement Plan (CIP)**, which was adopted in 2016 through the passage of Resolution R2016-688. The CIP prioritizes stormwater projects and programs, including sequenced basin planning efforts, including for the Laughing Jacobs Basin plan (City of Sammamish, 2016a).

- **The Storm and Surface Water Management Comprehensive Plan (SSWMCP)**, which was also developed and adopted by the City in 2016. The SSMCP provides direction for management of the City's surface and stormwater system and elaborates on the City's general 2015 Comprehensive Plan (see below). It also provides framework through which the City ensures consistency with National Pollutant Discharge Elimination System (NPDES) permit requirements. Among its goals are using drainage basin planning to address priority problems and opportunities and promoting the recovery of Lake Sammamish Kokanee and other threatened or endangered salmonids (City of Sammamish, 2016b).

- **The City of Sammamish's Comprehensive Plan**, which includes goals and policies that are directly relevant to the management of surface water resources and stormwater infrastructure. These goals and policies, and the implementing framework provided by the 2016 SSWMCP, provide primary policy and planning direction for the City's basin planning efforts (City of Sammamish, 2018).

2.4 Physical Setting

2.4.1 Topography and Drainage Network

The Laughing Jacobs Basin begins on the southern side of the East Lake Sammamish Plateau, where Laughing Jacobs Creek gradually slopes before entering a steep bedrock-based ravine to the south. The creek has a series of waterfalls throughout the ravine. The topography then transitions to low gradient lake fringe topography.

The Laughing Jacobs Basin drainage network incorporates Laughing Jacobs Creek's mainstem channel, tributary streams, associated wetlands, and Laughing Jacobs Lake. The basin extends from the headwaters to the mainstem to the point where it enters Lake Sammamish.

2.4.2 Climate

Flows are influenced by the climate, which are typical of the Puget Sound Region with wet winters and dry summers. Accelerated climate change is expected to increase rainfall intensity and alter the seasons, which may change the timing of seasonal peaks and increase the magnitude of peak flows.

2.4.3 Geology

The Laughing Jacobs Basin is located within the Puget Lowland region, which is a broad, relatively low elevation area. The geology has been impacted by multiple glaciations, with the last glaciation, the Vashon Stade of the Fraser glaciation, having the most influence. The area generally has a mix of glacial and postglacial sediments over Tertiary bedrock. As glaciers retreat, they can leave behind low-lying areas that form lakes. These lakes often form into bog wetlands when they have conditions that allow the growth of sphagnum mosses.

The Laughing Jacobs Basin has landslide and earthquake hazards. A landslide hazard area and a landslide hazard drainage area are located in the area around the mainstem between Providence Point Place SE and East Lake Sammamish Parkway SE. A landslide hazard area is an area where landslides pose a direct hazard, whereas a landslide drainage area is an area where overland flows pose a threat due to its proximity to a landslide hazard area.

Groundwater withdrawals in Sammamish are generally managed by the Sammamish Plateau Water and Sewer District. The Laughing Jacobs Basin is located within the Plateau Zone of the Sammamish Plateau Water service, which draws its water from two aquifers, the Plateau Aquifer and the Issaquah Valley Aquifer. WHPAs have been mapped out and CARAs have been identified. The CARAs have critical recharging effects on the aquifers, and are susceptible to groundwater contamination, which affects the quality of potable water. Supply forecasts have revealed that there may not be sufficient supply of water for the predicted system if Sammamish Plateau Water does not expand its sources.

2.5 Land Cover and Built Environment

Prior to development, the dominant land cover type was late-stage coniferous forest with unique shrub-dominated areas likely occurring in the bog wetland areas. Development has replaced much of this land cover type with less mature and non-native plant communities as well as non-native vegetation. The two predominant land cover types in the Laughing Jacobs Basin are forest (48.2%) and developed (25.0%). Wetlands account for 5.5% of the land cover.

Within the City of Sammamish, the dominant land uses include lower intensity residential, publicly owned park lands, and protected open space. Other land uses include institutional use, moderate to higher intensity residential, and commercial and business uses. The majority of lots are owner-occupied, meaning any redevelopment that occurs will most likely be incremental. This will reduce the amount of forest cover and increase impervious cover, which would increase the peak flows and decrease the base flows of streams in the Laughing Jacobs Basin. Large tracts of undeveloped forest appear to be well protected, including three large parks: Sammamish State Park, Klahanie Park, and Beaver Lake Park. The three parks all have high functioning wetland and riparian areas.

Tabular summaries of both the land cover types and the built environment are detailed in Appendix B.

2.6 Surface Water and Floodplains

Flooding has been a problem in the past as uncontrolled runoff from developed areas and several landslides in the Laughing Jacobs Ravine have resulted in sedimentation leading to loss of channel conveyance in the lower reaches. Improvements in stormwater detention and conveyance have helped alleviate the problem in the lower basin, although localized flooding still occurs in some reaches.

Analysis of the City of Sammamish geographic information system (GIS) has identified a total of 32 wetlands within the Laughing Jacobs Basin, with the upper basin having the most wetland acreage. The types of wetlands found include riparian wetlands, depressional wetlands, and bogs. Bogs are wetlands that have formed from lakes that have been filled over millennia by plant growth and sedimentation. The peat present in bogs absorbs water, which can provide functions to the streams. One function is the ability to provide slow release of cool water to streams during the drier summer season and another is to prevent flooding.

Riparian buffer zones in the basin are generally well vegetated. ESA defined riparian areas as the 150-foot buffer on each side of a stream and analyzed these areas via GIS. Forested areas make up 57.5% of the riparian areas while developed areas make up 8.0% of the areas.

2.7 Water Quality Monitoring

2.7.1 Previous Efforts

The Laughing Jacobs Basin was previously studied as part of the *East Lake Sammamish Basin Plan and Nonpoint Action Plan* (King County, 1994). In that study, several development-related concerns were noted in the Laughing Jacobs sub-basin, including erosion and sediment deposition in stream channels, flooding over roads, and degraded water quality with nutrient and bacteria exceedances in surface water bodies. Several high-quality wetlands were also identified in the basin and were considered sensitive to human disturbance and fluctuations in water level.

King County has historically conducted water quality monitoring at several locations within the Laughing Jacobs Basin. The data are accessible through the Washington Department of Ecology's (Ecology's) Environmental Information Management System database (Ecology, 2019).

Based on data collected for these studies, Laughing Jacobs Creek is listed as an impaired water body under Clean Water Act (CWA) Section 303(d) for the following parameters (Ecology, 2016):

- Temperature (Listing ID 72595), based on data collected between 2006 and 2010;
- DO (Listing ID 47948), based on data from 2003 and 2004;
- Bacteria (Listing ID 15755), based on data from 1987 through 2012; and
- Bioassessment (Listing ID 70115), based on data 2006 through 2010.

2.7.2 Geosyntec's Monitoring Efforts

Geosyntec installed four monitoring stations: two within the Laughing Jacobs Creek and two within bogs. The four monitoring stations continuously logged temperature and water pressure, which was used with ambient air pressure to calculate water stages at the stations. Field measurements of stage, temperature, specific conductance, and pH were taken at each station and grab samples were taken at the bogs to measure for inorganic anions, metals, ammonia, carbonate, and bicarbonate. Monitoring methods are detailed in Section 4.

2.8 Fish Use

Most of Laughing Jacobs Creek is classified by WDNR as fish habitat in the Forest Practices Fish Habitat Water Type database. The species of fish include, but are not limited to, kokanee salmon, coho salmon, and cutthroat trout. A waterfall at River Mile (RM) 0.97 acts as a natural fish barrier that prevents kokanee salmon, coho salmon, and certain forms of cutthroat trout from traveling upstream.

Kokanee salmon are generally found in the lower reaches of Laughing Jacobs Creek from RM 0.2 to RM 0.8. Kokanee salmon are a non-anadromous form of sockeye salmon, meaning they spend their entire life in fresh water. The number of kokanee salmon that spawn in Laughing Jacobs Creek varies from year to year. Spawning season typically occurs from late October through January with most spawning occurring in November and December.

Puget Sound coho salmon have been documented from the mouth of Laughing Jacobs Creek to RM 0.97. Despite stable population trends, coho salmon may be threatened due to concerns of genetic, environmental, and habitat conditions. Adult coho salmon enter fresh water from mid-September to mid-November and spawn from mid-to-late October to mid-December. Spawning typically occurs from the mouth of Laughing Jacobs Creek to a point approximately 1,300 feet upstream.

Cutthroat trout exist in many forms within the Lake Sammamish/Lake Washington system and occur in most of the mainstem of Laughing Jacobs Creek. These forms include adfluvial, anadromous, and stream-resident forms. Adfluvial forms migrate between streams and lakes and are likely present downstream of the natural barrier waterfall on the mainstem at RM 0.97. Anadromous forms migrate between freshwater and saltwater and are likely present downstream of RM 0.97. Stream-resident cutthroat trout typically reside in low-velocity large pools or side channels and spawn in small tributary streams. Stream-resident forms have been documented throughout the mainstem of Laughing Jacobs Creek.

2.9 Wildlife

Wildlife in the Laughing Jacob Basin generally varies based on primary vegetation cover:

- **Urban matrix:** consists of a mix of buildings, asphalt, ornamental gardens, lawns, and shrubby/grassy areas with scattered, and includes the following species: European starlings, American robins, American crows, dark-eyed juncos, spotted towhees, house finches, house sparrows, black-capped chickadees, opossums, raccoons, deer mice, and Norway rats.

- **Deciduous tree cover:** includes a variety of songbirds and raptors, small mammals, deer, amphibians, and reptiles.

- **Coniferous tree cover:** includes ruby-crowned kinglets, Steller's jays, red-breasted nuthatches, pileated woodpeckers, vagrant shrews, and shrew-moles. Coniferous trees continue to provide cover for birds through the winter. These birds include black-capped chickadees, Steller's jays, American robins, and song sparrows.

- **Wetlands:** includes great blue herons, mallards, Canada geese, belted kingfishers, red-winged blackbirds, willow flycatchers, Bewick's wrens, Pacific treefrogs, and western terrestrial and common garter snakes. Riparian wetlands provide habitat for beavers, muskrats, and long-toed salamanders. Reed canary-grass dominated wetlands species include Canada geese, striped skunks, long-tailed weasels, creeping voles, Townsend's moles, vagrant shrews, Townsend's voles, and northwestern garter snakes. Red-tailed hawks and northern harriers may hunt for prey in these areas. Mallards, gadwalls, buffleheads, and other waterfowl are found in open water portions and may also use the emergent wetlands with the Laughing Jacobs Basin.

Priority Habitats and Species (PHS) that occur within or immediately adjacent to the Laughing Jacobs Basin include the Townsend's big-eared Bat, Yuma Myotis, and the Little Brown Bat. A review of PHS data also identified a Waterfowl Concentration on Lake Sammamish, immediately adjacent to the inlet of Laughing Jacobs Creek.

Evidence of beaver activity is occasionally observed within the basin. Beavers may improve or maintain healthy watersheds through the creation of their dams. Beaver dams have been shown to reduce velocity, promote channel building and floodplain reconnection, and increase aquifer and groundwater recharge, which can reduce summer stream temperatures. However, maintenance of culverts within the City has required periodic beaver and beaver dam removal to reduce flooding hazards.

2.10 Field Assessment

A field assessment was conducted using data collected from creek walks on April 29, April 30, and May 2, 2019 and a wetland conditions assessment conducted on July 8, 2019. Select stream reaches determined to be representative of the larger basin were walked and assessed for geomorphology and habitat conditions.

Daily streamflow data were obtained from King County Station 15C, which is located on Laughing Jacobs Creek by East Lake Sammamish Parkway. The measured streamflow at the King County gage on dates, April 29, 30, and May 2, 2019 was 1.7, 1.6, and 1.4 cubic feet per second (cfs), respectively (King County, 2019). The decrease in streamflow between April 30 and May 2 was observed as reaches of Laughing Jacobs Creek north of the Laughing Jacobs Lake were partially dry as was the west tributary to Laughing Jacobs Lake on May 2, 2019.

Laughing Jacobs Creek is partially located in developed areas and utilizes culverts to maintain conveyance of the mainstem through these areas. Washington Department of Fish and Wildlife (WDFW) has evaluated some of these culverts based on their potential to act as a barrier for fish migration; relevant assessments are included in Appendix B. In addition, ESA evaluated culverts that have not yet been classified by WDFW. ESA’s evaluation identified flooding potential near stream crossings due to limited freeboard, downstream erosion, and backwatering effects at some culverts.

Historic channelization of segments of Laughing Jacobs Creek has led to limited connectivity between the channel and floodplain areas. A segment of the creek channel immediately downstream of Laughing Jacobs Lake was straightened, likely for agricultural reasons, and discharges to a wetland. Straightening of this channel segment has likely increased the velocity of the water and decreased the residence time inside the wetland, impairing the wetland’s ability to improve water quality and detain flow.

Multiple bogs exist within the Laughing Jacobs Basin and provide a variety of functions to the health of the basin. The bogs have very deep layers of organic soil, which provide storage to prevent flooding as well as the ability to filter pollutants from stormwater. Vegetative cover and root systems provide additional filtration of pollutants from stormwater. Chemistry of bog complexes may be altered if the water quality influent to the bog changes. Historical agricultural activity and direct discharge of roadway runoff to the bog complex along SE 24th Street may have adversely affected the bog chemistry limiting the presence of native bog species. This is evident by the monoculture of Douglas' spirea covering most of the bog; however, a central portion of the bog remains dominated by bog-tolerant species. In contrast, Queen's Bog, a wetland that is drained by the East Tributary to Laughing Jacobs Basin, has a buffer of intact forest around most of its perimeter. Several bog-tolerant species are present within the wetland, including peat moss, which is a moss subclass that is very sensitive to hydrologic and chemical disturbance.

ESA determined the basin is near thresholds for degradation based on the percent of impervious area; however, the stream channel did not show signs of significant erosion. Review of available data revealed no significant increases in peak flow magnitudes, durations, and frequencies. This is attributed to several factors, including the presence of wetlands and the fact that riparian buffers have largely been excluded from development. Much of the mainstem of the channel has a slight gradient and great connectivity to flood plains except for some canyon reaches in the lower subbasin. Erosion observed was determined to likely be due to historic channelization and straightening for agricultural purposes.

3. PUBLIC OUTREACH

The following section summarizes the public outreach efforts led by Cascadia Consulting Group (Cascadia) utilized to shape this Basin Plan. Feedback from residents in Sammamish and Issaquah was essential to understanding primary concerns and the priority of enhancements within the basin. Outreach primarily occurred during two efforts, one in 2019 and one in 2021.

3.1 2019 Public Engagement

In 2019, the City engaged residents via survey and an open house in the first phase of the public involvement process. This process was designed to engage residents and provide them with ample opportunities to help identify projects related to natural areas, flooding, drainage, and stream restoration. Since the priority projects in the basin plan will shape neighborhoods for decades to come, it is important that they reflect community values.

Cascadia collaborated with City staff to design a public survey and plan an open house. Survey and open house goals were:

- Inform the public about the Laughing Jacobs Basin and basin planning process and build excitement and sense of ownership among the community for their watershed.
- Gather feedback on concerns, interests, and priorities for drainage, stormwater, and natural resources management in Laughing Jacobs Basin to inform the development of the basin plan.
- Identify priority projects that reflect community values and will help reduce flooding and preserve natural areas in the basin.
- Gather information about specific locations with standing water or flooding issues that priority projects could help address.

The following subsections summarize the structure and outcomes of the survey and open house. A memorandum from Cascadia, referred to as the Laughing Jacobs Basin Plan Public Engagement Summary (Public Engagement Memo), details the 2019 public engagement effort and is included in Appendix C.

3.1.1 Survey

Cascadia developed a survey and distributed to residents via paper copy and online using SurveyMonkey. The survey asked residents questions about their priorities for the Laughing Jacobs Basin, basin planning, and flooding or stormwater concerns. The survey is attached to the Public Engagement Memo included in Appendix C.

Cascadia used a list of addresses within the Basin boundary provided by the City to mail paper surveys, including the link to the online survey, in late April 2019. Surveys reached 3,063 residents in the Sammamish and Issaquah area. In the early stages of data analysis, Cascadia found that all respondents identified as homeowners. Cascadia reviewed data to better understand this result and realized that the addresses used were for property owners rather than property locations, indicating that home renters were generally excluded from the distribution. To address this issue and help ensure an equitable approach, Cascadia mailed 329 postcards with the online survey link in late June 2019 to property addresses that were different than the address listed for the property owner. Cascadia also made the paper and online surveys (on iPads) available for completion at the open house.

The online survey closed on July 12, 2019. The total number of survey respondents from both paper and online surveys was 465 (approximately 14 percent return rate). Out of this total, 170 surveys were completed online, and 295 surveys were returned in paper format, including those completed at the open house.

3.1.2 Open House

The City hosted an open house on June 13, 2019 to share information about the basin plan, preliminary results from the survey, and to gather more input from residents. Fifteen people attended the open house, which was fewer than desired, despite promotional and marketing efforts that included a postcard invitation sent to the same mailing list used in the paper survey as well as email announcements to a suite of community organizations and schools.

Attendees engaged with materials and questions presented at different stations using display boards. These stations were intended to generate an understanding of public priorities for basin improvements in different areas of the watershed. A copy of the display board results is included in the Public Engagement Memo in Appendix C for reference.

3.1.3 Engagement Analysis

The following analysis summarizes the compiled survey and open house results and presents associated graphical summaries, maps, and key themes. Note that results are presented in order of the open house stations to follow the logical story arc, and the corresponding survey questions are noted.

3.1.3.1 Priorities for Natural Area Preservation and Public Access

Station 2 asked open house attendees to indicate which locations they would recommend for natural area preservation, which would restrict public access, and which locations they would recommend keeping open for public access. This station corresponded to survey questions 2-4 (Q2-4).

Q2 asked respondents to indicate their preference for using potential projects to preserve natural area and restrict public access or to create opportunities for public use of open space. Respondents indicated their preferences using a 1-10 scale, with 1 indicating Full protection: No public access and 10 indicating No protection: Full public access.

The survey responses were well-distributed among the scale. A fair amount of people (13%) felt strongly about full protection compared to fewer people who preferred full public access (5%). However, overall, the mean response was found to be in the middle (mean=5.1). This indicates that while some people have strong preferences, a general balance between environmental preservation and human access to these spaces should be considered in the Laughing Jacobs Basin. Figure 3-1 shows the distribution and mean of responses.

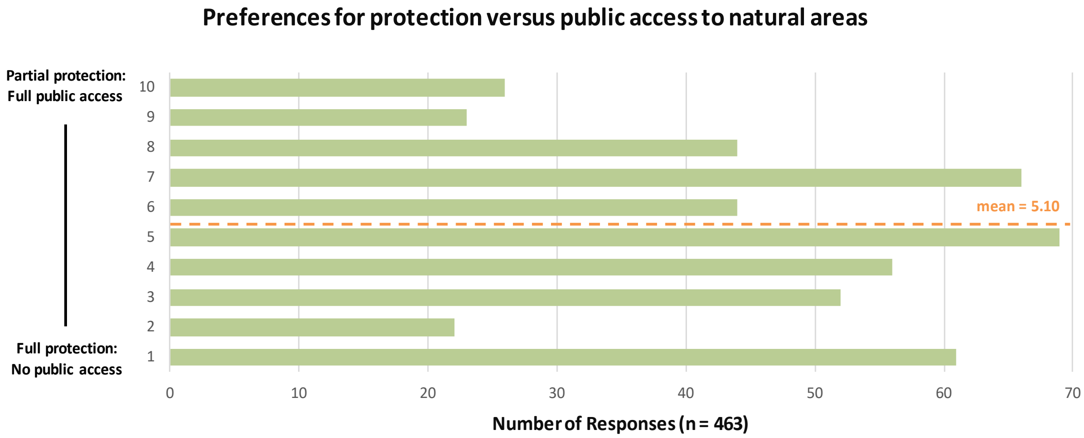


Figure 3-1. Public Access of Natural Areas

The survey asked respondents to identify specific areas where they thought public access should be restricted in an open-ended question format (Q3). Responses are grouped by common themes, summarized in Table 3-1.

The majority of people commented that public access should be restricted in areas where water systems such as lakes, wetlands, and shorelines were present. The next themes with the greatest number of responses were wildlife habitat and natural or sensitive areas. These data underscore that people support minimal human access to preserve naturally functioning ecosystems. Table 3-1 shows the themes and associated responses. In addition, some comments that reflect each theme are shown in italics and quotations.

Table 3-1. Restricted Public Access Comments

Theme	Number of Responses	Comments
Water Systems (e.g., lakes, wetlands, shorelines, streams). Responses mentioned: • Beaver Lake • Hazel Wolf Wetland • Klahanie Park • Laughing Jacobs Lake • Lake Sammamish • Queen's Bog	69	*"Ponds, streams and wetlands that have returning nesting for wildlife (ducks, frogs, mammals and reptiles)."* *"I think every development should have a wetland area that is restricted, yet surrounded by a trail open to general public."*
Wildlife Habitat	38	*"Any location where it is a critical habitat for an endangered or at-risk animal. In addition, we should protect and reduce access to locations where we are collecting and storing drinking water."*
Natural or Sensitive Areas • Existing natural areas with little to no access • Planted areas with dense, old, or native growth • Concern/mention of invasive species	36	*"Environmentally sensitive areas where the loss of habitat is threatened."* *"Wetlands, Shorelines, Streams. Especially remove invasive problem plants such as purple loosestrife, ivy, and many others."*
Hazardous/Dangerous Areas • Concerns for human safety due to unstable ground and natural hazards	8	*"Wetlands, rainwater basins, areas of danger due to floods/slides, or other hazards"*
Residential and/or Private Property Areas, specifically Rainbow Lake Ranch	8	*"New building should be restricted."*
Walking, Hiking, and Biking Trails	4	*"Limit hiking and preserve the protected areas."*

Other Responses that did not fit into a clear theme or included feedback that was not specific to the question are listed below: • All areas • Neutral as long as balance is achieved • Unsure or not familiar enough to answer the question • Desire for data and/or feedback from professionals (e.g., scientists) • Skepticism of previous/future development • Pine Lake School	26	*"I don't know enough to answer this. Overall I think there should be a balance between ensuring the health of the area and people enjoying them."*

3.1.3.2 Full Public Access

The survey asked respondents in an open-ended question format to identify specific areas where they thought public access should be maintained (Q4). We grouped these responses into common themes, summarized in Table 3-2.

The greatest number of responses fall under recreational and current public access areas. Many people felt that access to these areas enables people to appreciate nature and expressed that proper management to maintain good condition is important. Interestingly, the theme with the second most responses is water systems, which was the top priority in restricting public access. These conflicting preferences suggest that a balance needs to be met between these two approaches. Table 3-2 shows the themes and associated responses. In addition, some comments that reflect each theme are shown in italics and quotations.

Table 3-2. Full Public Access Responses

Theme	Number of Responses	Comments
Recreational and Current Public Access Areas Responses mentioned: • Areas with opportunities for environmental education • Duthie Hill • Klahanie • Lake Sammamish State Park • Soaring Eagle	105	*"Trails to appreciate nature and wetlands are important so we remember the beauty."* *"Natural areas that can tolerate trials for walking, bird watching, and other casual activities. But these areas need to be monitored for damage and closed if needed."* *"Keep current parks open to public. Where possible expand use of green spaces to light recreational use."* *"Areas with good educational value for kids."*
Water Systems (e.g., lakes, wetlands, shorelines, streams), specifically: • Beaver Lake • Evans Creek • Hazel Wolf Wetlands • Lake Sammamish • Laughing Jacobs Lake • Pine Lake • Yellow Lake	56	*"Each lake should have a viewing, fishing, swimming area, observation areas into wetlands to watch birds and animals, and new trails alongside water bodies."*
Forests, woods, and fields	6	*"Trails, scenic areas, wooded or shaded areas"*
Other Responses that did not fit into a clear theme or included feedback that was not specific to the question are listed below: • All areas • Neutral as long as balance is achieved • Unsure or not familiar enough to answer the question • Desire for data and/or feedback from professionals (e.g., scientists) • Skepticism of previous/future development • Highland upper areas	24	*"As long as we maintain a balance between the health of the environment and the community being able to access these areas, I'm happy."*

The map shown in Figure 3-2 illustrates locations that survey respondents and open house attendees identified as places to keep open for public access and areas that should be restricted for natural area preservation.

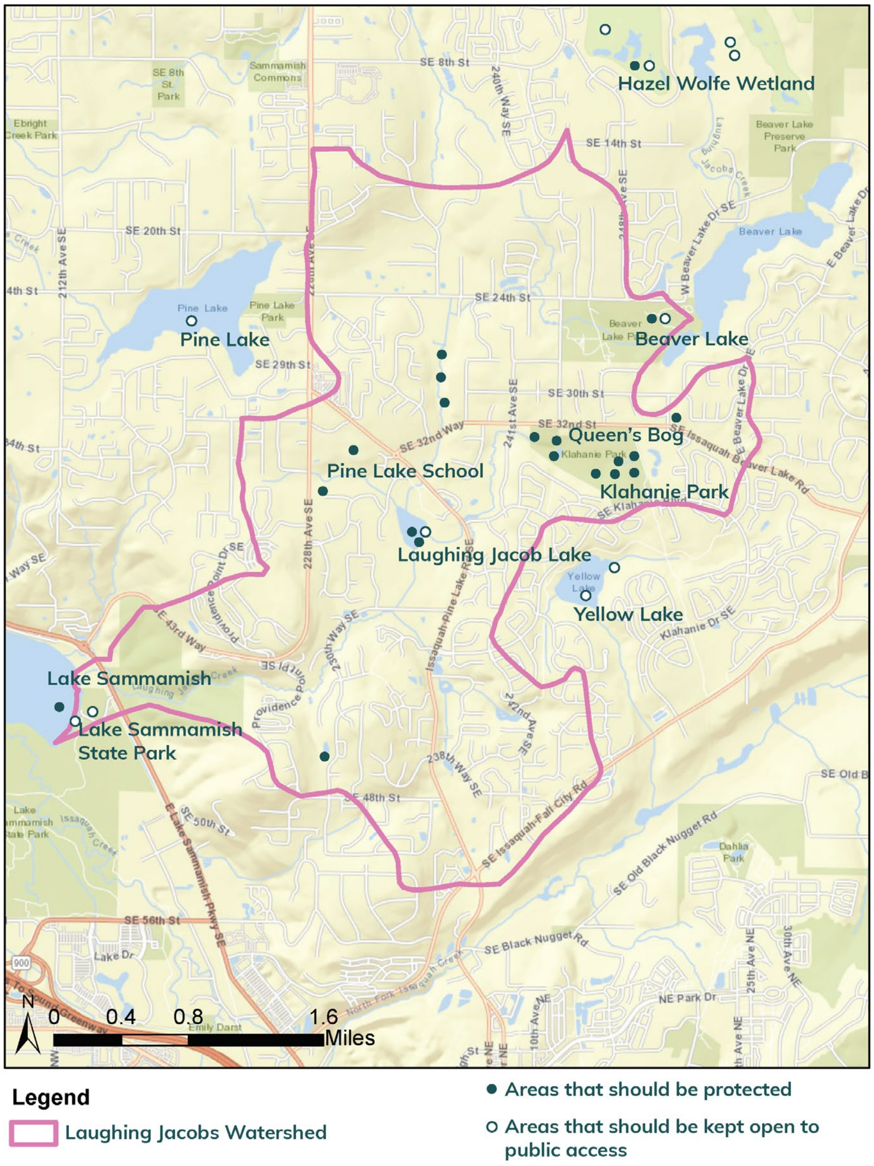


Figure 3-2. Natural Area Preservation and Public Access Areas

3.1.4 Recreational Activities in the Laughing Jacobs Basin

Q5 asked respondents how often in the last year they did a variety of recreational activities in the Laughing Jacobs Basin. The results are shown in Figure 3-3.

The online survey form did not require a response for each activity. As a result, some respondents provided input for some activities and left other categories blank; blank responses were not included in this analysis. The sample size represents respondents who provided an answer to at least one of the recreational activities. Figure 3-3 provides a summary of the distribution (n=452).

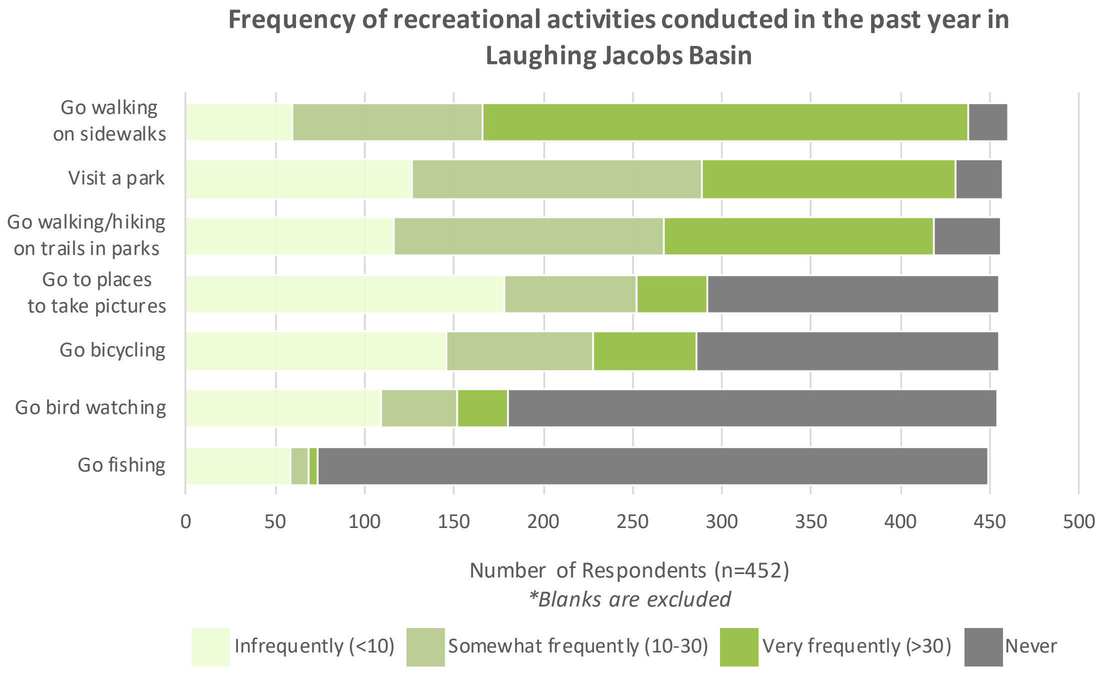


Figure 3-3. Frequency of Recreational Activities

Station 2 at the open house presented a simpler variation of this question, only asking which of the same recreational activities respondents had done in the last year in Laughing Jacobs Basin. The results are portrayed in Table 3-3.

Table 3-3. Activity Priorities.

Activity	Number of Stickers
Visit a park	6
Go walking on sidewalks	6
Go walking/hiking on trails in parks	8
Go fishing	2
Go bicycling	4
Go bird watching	2
Go to places to take pictures	3

The data indicate that walking or hiking on sidewalks and trails as well as visiting parks are the recreational activities with the most frequent participation among survey respondents and should be considered when prioritizing projects in the Laughing Jacobs Basin.

3.1.5 Identification of Drainage Issues

Station 3 asked attendees to identify any locations where they have seen flooding, large puddles, or other water issues in the basin. The corresponding survey questions Q6-10 asked respondents similar questions.

Responses to Q6 showed that 22 percent of respondents remembered seeing flooding or large puddles near their home or neighborhood in the last year (n=465). These responses present potential opportunities for drainage and flooding projects in this area. 65 percent of residents said they did not see any flooding or large puddles, while 13 percent of respondents could not remember instances in the last year as shown on Figure 3-4. These data show that the majority of residents in the Laughing Jacobs Basin do not know of or recall specific instances of drainage issues. However, it is important to note that the timing of public engagement during a relatively dry period during the year (May through July) may have skewed the data due to a cognitive bias toward the present (i.e., forgetting about problems that occurred in the past).

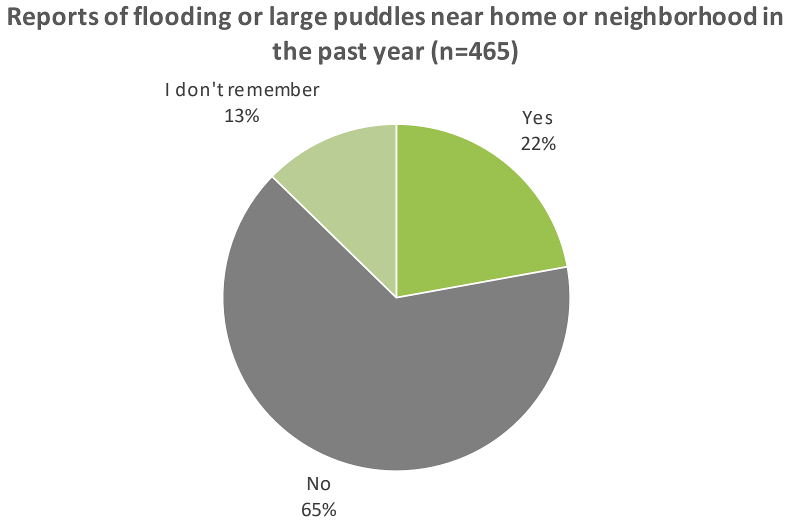


Figure 3-4. Flooding Survey Results

As for types of drainage issues (Q7) observed at each location, no survey respondents reported seeing flooding of an entire block. Some respondents answered "Other" for type of drainage issue and noted puddles in yards, on trails, or in ditches. Table 3-4 indicates the number of drainage issues identified by type. As the table indicates, survey respondents and open house attendees identified 95 total instances of drainage issues (Q8/Station 3). Specific geographic locations of approximately 10 drainage issues could not be determined due to missing or unintelligible information. These instances were excluded from the analysis.

Table 3-4. Drainage Issues Identified

Type of drainage issue	**Number of drainage issue instances identified**	**Percent of total drainage issues identified**
Flooding of an entire block	0	0%
Flooding in sections of the street	30	32%
Large puddle(s) in or next to the street	54	57%
Other: Puddle(s) in yards, trails, and ditches	11	12%
Total	95	

Q9 asked respondents to identify the date, month, or season when they could recall seeing the drainage issue. This question had an open-ended response. Table 3-5 lists the categories of responses and the corresponding number of responses. Months were categorized accordingly: Fall includes September, October, and November; Winter includes December, January, and February; and Spring includes March, April, and May. Since the seasonal definition was not provided in the survey, Table 3-5 shows the count of responses for individual months under its respective season.

Table 3-5. Drainage Issues by Month

Time	Number of responses
Rainy season	25
Fall	**24**
October	*4*
November	*2*
Winter	**45**
December	*1*
January	*2*
February	*4*
Spring	**9**
March	*2*
After snow	3
Year-round	1
2018	7
2019	7
Blank	20
Don't remember	3

Q10 asked how frequently the drainage issue occurs. Table 3-6 summarizes responses by type of drainage issue (n=95).

Table 3-6. Drainage Issues by Frequency

	Flooding in sections of the street		**Large puddle(s) in or next to the street**		**Puddle(s) in yards, trails, and ditches**	
Frequency	# of reported issues	% of total reported issues (n=95)	# of reported issues	% of total reported issues (n=95)	# of reported issues	% of total reported issues (n=95)
Once or twice / I don't remember*	13	14%	20	21%	3	3%
Three or four times	13	14%	15	16%	4	4%
Five or more times	4	4%	19	20%	4	4%
TOTAL	30	32%	54	57%	11	12%

**The categories "Once or twice" and "I don't remember" were grouped together to simplify the spatial display of information because there were few if any responses in the latter category.*

Maps of drainage issues were generated using the following steps:

- Survey responses filtered to create a new dataset with all respondents who identified one or more locations with a drainage problem.
- Researched each identified location using Google Maps to identify a corresponding parcel address. In cases where insufficient information was provided, assumptions were made to identify an approximate parcel address. For instance, if only one street was identified without an address or cross-street, we selected a parcel address in the central segment of the street.
- Mapped parcel addresses using an ArcGIS address locator created from the King County GIS Center Addresses dataset.
- Applied symbols to show the frequency and type of drainage events throughout the Laughing Jacobs Basin.

The resulting Figure 3-5 shows the locations of drainage problem (Q8) by level of severity (Q7) and frequency (Q10). Each drainage problem is represented by a shade of blue and graduated size of circle. As the legend in the map illustrates, darker shades of blue indicate a more severe drainage problem. The larger size of circle indicates a more frequent drainage problem. Additional maps showing a larger scale of each quadrant of the basin are included in the Public Engagement Memo in Appendix C.

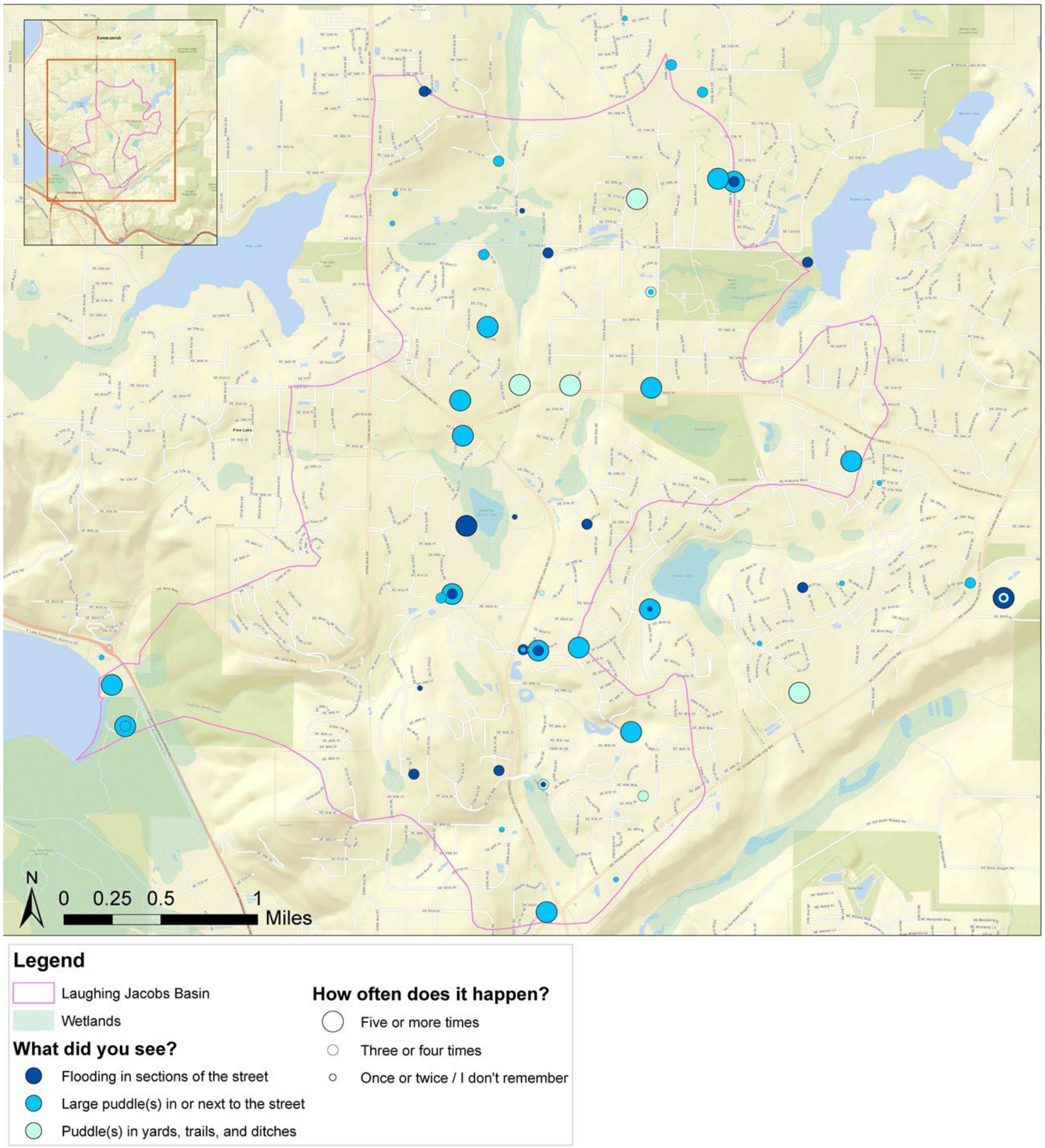


Figure 3-5. Flooding Summary Map

Several survey respondents and open house attendees requested follow-up contact from the City regarding the drainage issues they identified. Contact information and the drainage issues they identified are listed in the Public Engagement Memo in Appendix C.

3.1.6 Vision for the Future

Station 4 at the open house invited attendees to describe their vision for the future of the watershed in terms of what they would like to see more of and what they would like to see less of. Table 3-7 lists responses grouped by themes with the respective quantity of responses in parentheses. Responses that were the same or very similar are not repeated in the table. The data indicate that residents’ priorities for the future are for supporting walking and biking infrastructure and protecting water systems, which aligns with the recreational activities residents most engage in as well as their priorities for natural area protection of water systems. Residents strongly urged to slow the pace of dense development and the associated impacts. The few responses supporting less flooding in the future indicates that flooding and drainage issues are not a high priority for residents, which is similar to the findings noted in the section above.

Table 3-7. Future Priorities

More	Less
• Build sidewalks, trails and parks (8) o Connect trail/road system for pedestrians and mountain bikes o Make trail system more robust o Pipeline can be public trail • Protect lands along waterways (6) o Restore waterway vegetation o Widen setbacks from waterways o Have native growth protection easements • Stormwater and water quality (4) o Natural storm water ponds o Add rain gardens o Water quality treatment • Managed development (3) o Consider impact of large tracts of homes o Incentives to landowners for protection of sensitive areas o Have open space • Wildlife/habitat protection (2) o Protect/consider critters • Have wildlife corridors	• Development increasing density (5) o Decrease dense development o No more "pocket" developments (i.e., 4-6 houses in a small area) o Less in-fill o Encroachment of housing and roads • Impacts from development (3) o Cut down so many trees for development o Fewer cars o Less cumulative impacts • No more cheap construction (buildings that don't last) (2) • Flooding and water flow control (2) o Flow control on smaller projects o Flooding

3.1.7 Funding Priorities for Future Projects

Station 5 and Q1 asked respondents how they would divide funds for projects related to natural areas, flooding, drainage, and stream restoration out of $100 (n=454) for the following priorities:

- Protect new natural areas
- Continue managing existing protected natural areas (e.g. wetlands and stream buffers)
- Reduce flooding and improve drainage on roadways
- Install infrastructure to improve water quality of roadside runoff
- Install natural drainage systems (e.g., rain gardens)
- Restore streams and streambanks

The online survey had a validation feature that required the total to equate to $100. For paper surveys, validation was not possible, so in instances where the values did not equate to $100, we adjusted the sum to equal $100 and still captured the respondents' preferences the best.

The survey found that the top two priorities for funding were to: (1) continue managing existing protected natural areas and (2) protect new natural areas. In contrast, the two lowest priorities people wanted to fund were related to drainage and road infrastructure. These results are shown in Figure 3-6.

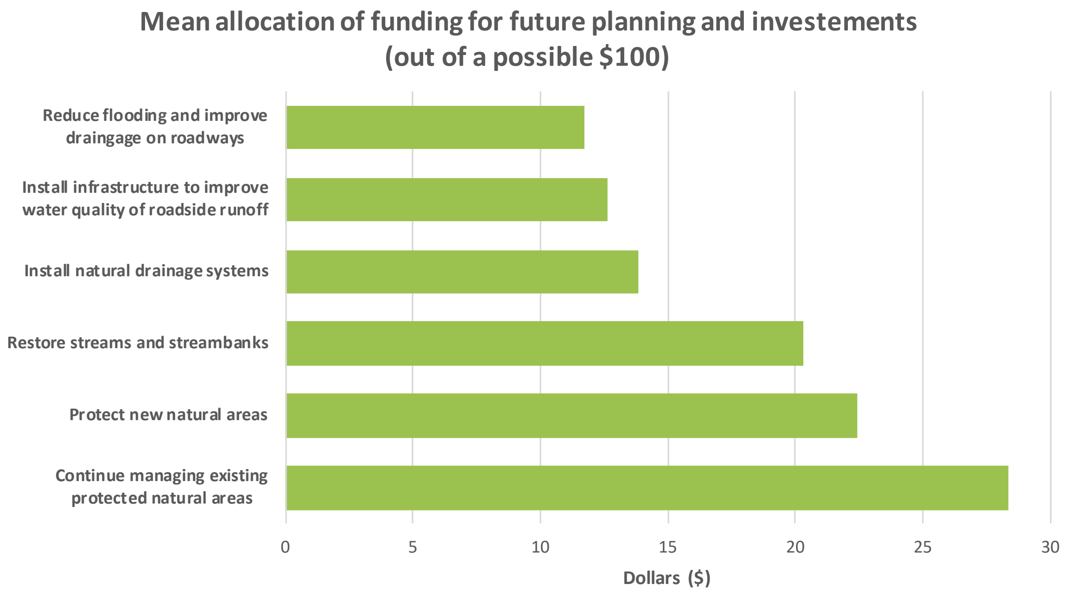


Figure 3-6. Funding Priorities out of $100

Station 5 asked a variation of this question to participants during the open house. Instead of asking how they would distribute $100 between these categories as in the survey, participants placed dots representing $20 next to each category they would want to invest in. Restoring streams and streambanks received the greatest number of dots during the open house. Categories that received the least were the same as those in the survey: reduce flooding and improve drainage on roadways and install infrastructure to improve water quality of roadside runoff. The open house results are displayed in Table 3-8.

Table 3-8. Funding Priorities Ranked

Priority	**Number of dots ($20 each) per category**
Continue managing existing protected natural areas	10
Protect new natural areas	10
Restore streams and streambanks	16
Install natural drainage systems	12
Install infrastructure to improve water quality of roadside runoff	5
Reduce flooding and improve drainage on roadways	5

Responses suggest that participants in both the survey and open house want to invest future funding in protecting and preserving natural areas and water systems rather than in improving road infrastructure. These priorities generally align with residents' priorities for preserving natural areas and waterways indicated in the previous sections above.

3.1.8 Demographic Questions

Q17 and Q18 asked respondents optional demographic questions about how long they have resided in Sammamish or Issaquah and whether they own or rent their home, respectively. Some respondents did not answer one or both questions. Any blank responses were not included in the data analysis. Responses are summarized in Figure 3-7 and Figure 3-8.

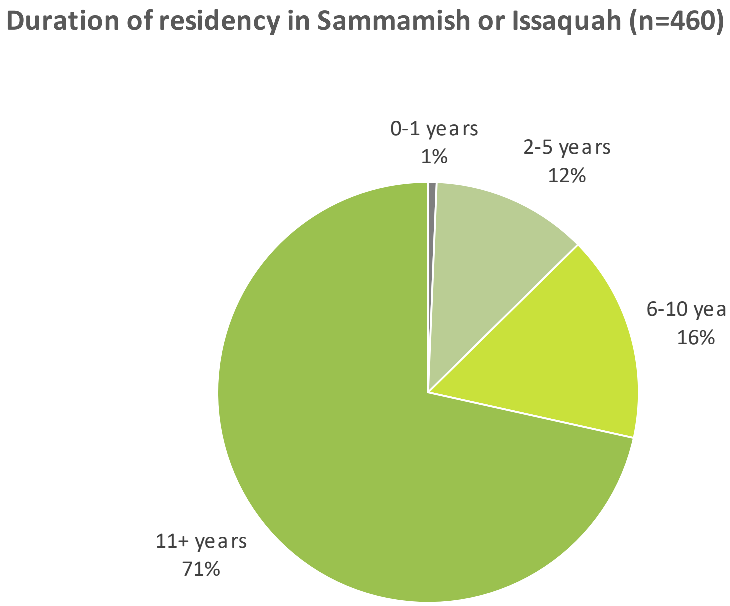


Figure 3-7. Duration of Residency

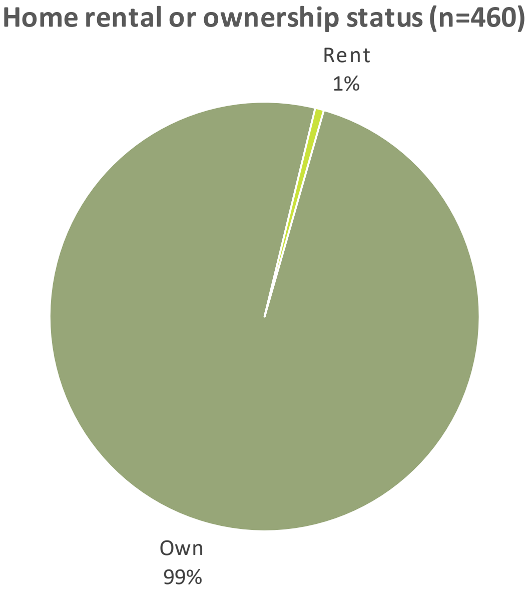


Figure 3-8. Home Ownership Status

3.1.9 Key Findings

The public engagement efforts in this first phase of the Laughing Jacobs Basin planning process revealed several key findings:

- Residents in the Laughing Jacobs Basin generally encourage striking a balance between environmental preservation and public access to sites for recreational purposes. This balance is especially important in areas with natural ecosystem functioning that also provide recreational benefits.

- In particular, residents identified wetlands, shorelines, and other water systems as a top priority for protection, restoration, and investment of public funds.

- Many residents frequently engage in walking/hiking on sidewalks and trails and visiting parks. Improving walking and biking infrastructure (e.g., sidewalk/trail connectivity) was the highest top priority for the future among open house attendees.

- The majority of residents do not know of or recall specific instances of flooding or water drainage issues. Investing in solutions to drainage issues is a low priority for most residents, given the suite of other ways to spend money in the basin. However, it is important to note that the timing of public engagement during a relatively dry period during the year (May through July) may have skewed the data due to a cognitive bias toward the present (i.e., forgetting about problems that occurred in the past).

- Residents at the open house strongly urged to slow the pace of dense development and the associated impacts.

- Improving road-related infrastructure, including runoff filtration, was a low priority for investment. This result may be more an indication of residents' aversion to development than a lack of concern for water quality, given that in other questions/stations, water quality and water systems emerged as a high priority among residents.

3.2 2021 Public Outreach Webinar

The City led a second public outreach effort on October 26, 2021 to provide an update of developments to residents. Geosyntec, Cascadia, and City staff led an online webinar describing additional efforts completed following the 2019 public engagement effort.

3.2.1 Promotional Communication

Promotional efforts to inform residents of the webinar began approximately two months prior to the event. These efforts included advertisements via:

- Laughing Jacobs Basin Plan webpage hosted on the City's website.
- City's Facebook, Instagram, Twitter, and Nextdoor social media platforms.
- E-newsletter to City residents.

3.2.2 Webinar Content

The webinar was presented virtually to attendees via Zoom. Speakers from Geosyntec, Cascadia, and the City took turns discussing sections relevant to their expertise. Content consisted of:

- Basin planning drivers;
- Purpose and goals of the Laughing Jacobs Basin Plan;
- A recap of the previous public engagement effort;
- A brief description of the watershed and habitats;
- Identification of opportunities within the basin;
- Proposed projects and prioritization; and
- Questions and answers.

Questions were submitted to the presenters within Zoom. The questions were read aloud to the audience and the speakers provided responses. The majority of questions pertained to clarifications of the scope of the project and integration with ongoing project. A copy of the presentation used for the webinar and a transcription of the questions and answers session is included in Appendix C.

4. HYDROLOGY AND WATER QUALITY MONITORING

4.1 Background

To generate a current understanding of water quality and hydrology conditions in the Laughing Jacobs Basin, monitoring activities were conducted throughout the study area. These activities were initially planned with the July 2019 submittal of a Sampling and Analysis Plan / Quality Assurance Project Plan (SAP/QAPP) for monitoring of the basin (Geosyntec, 2019). The purpose of these activities was to observe a representative selection of water quality and hydrologic conditions within the study area. A copy of the SAP/QAPP is included in Appendix D.

4.2 Monitoring Locations

Four locations were selected to monitor hydrologic conditions, water quality conditions, or both. Two monitoring stations were located within sphagnum bogs (Queen's Bog and Wetland 26/SE 24th Street Wetland Complex). Two additional monitoring stations were installed in Laughing Jacobs Creek, one along the mainstem and another on a smaller tributary. Ambient air pressure monitoring was conducted at the mainstem station on Laughing Jacobs Creek. The ambient air monitoring station collected barometric pressure data used with pressure transducer data from the continuous monitoring sensors to derive water level data. These locations were selected due to their representativeness of the basin's water quality and hydrologic conditions.

Monitoring stations were installed in August 2019 at the four different locations within Laughing Jacobs Basin. These locations include the following:

- Queen's Bog (Wetland 34)
- Southeast 24th Street Wetland Complex (Wetland 26)
- Two stations in Laughing Jacobs Creek (Mainstem of Laughing Jacobs Creek and Tributary to Laughing Jacobs Creek)

All monitoring stations are marked as green dots in Figure 4-1. The station in Laughing Jacobs Creek that also monitored ambient air is shown in Figure 4-1 as a green and black dot.

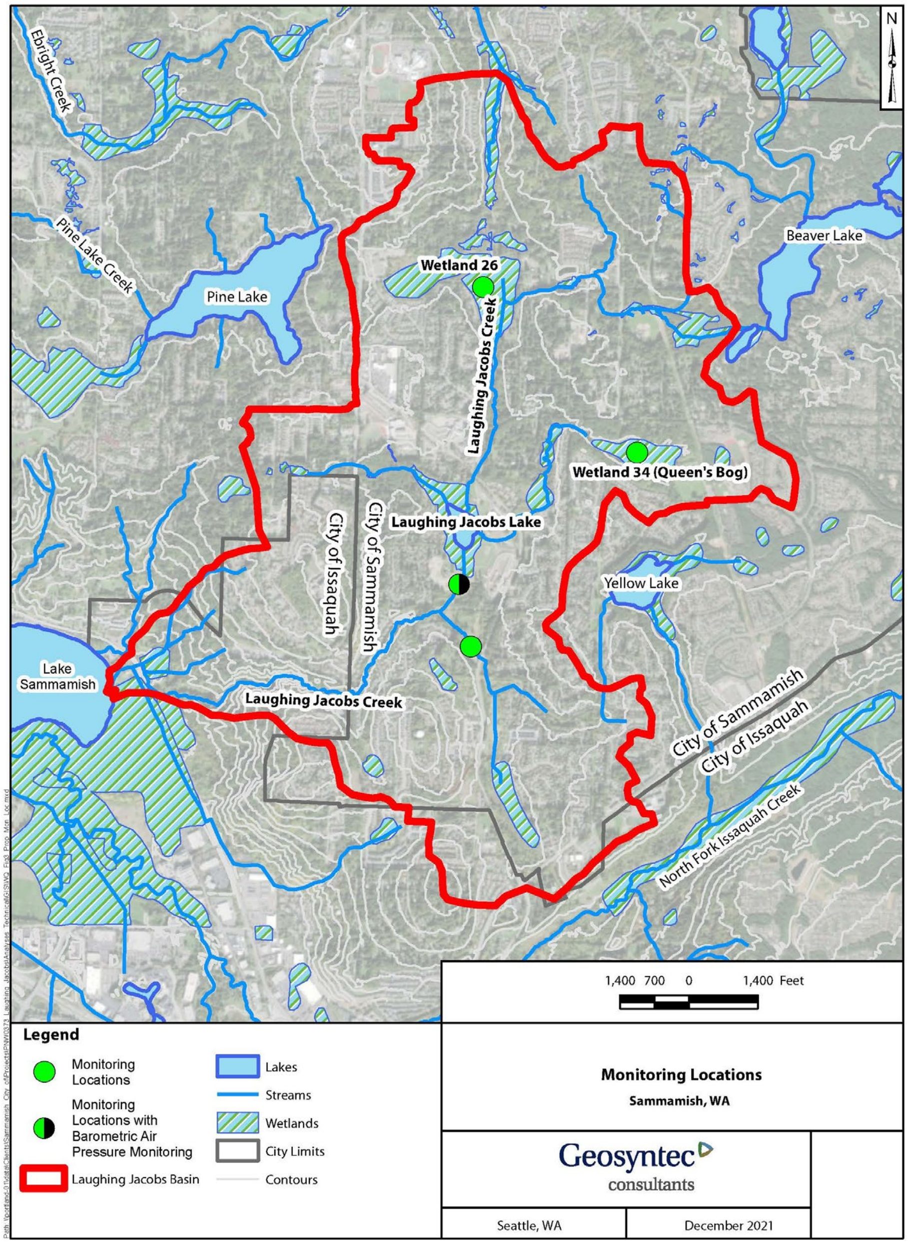


Figure 4-1. Monitoring Locations

Each of the four monitoring stations included a rigid wood and metal frame with a locked stilling well to house monitoring equipment, a staff plate for manual water level measurements, and a forked structure to insert into the ground for stability. Photographs of each location are provided in Figure 4-2.

Figure 4-2. Monitoring Stations

4.3 Monitoring Plan

Different parameters were monitored at each station depending on the type of location. All locations included continuous hydrologic monitoring (i.e., water level measurements) and field measured water quality parameters; wetland/bog stations included analytical water quality grab samples. The full list of monitoring parameters at each monitoring station are listed here in Table 4-1.

Table 4-1. Monitoring Parameters

Location Name	Parameters Monitored		
	Continuous Hydrology Monitoring	**Field Measurements**	**Water Quality Grab Samples**
Queen's Bog	Stage, Temperature	Stage, Temperature, Specific Conductance, pH	Inorganic Anions, Metals, Carbonate + Bicarbonate
Southeast 24th Street Bog	Stage, Temperature	Stage, Temperature, Specific Conductance, pH	Inorganic Anions, Metals, Ammonia, Carbonate + Bicarbonate
Laughing Jacobs Creek Mainstem	Stage, Temperature	Stage, Temperature, Specific Conductance, pH	None
Laughing Jacobs Creek Tributary	Stage, Temperature	Stage, Temperature, Specific Conductance, pH	None
Ambient Station (Co-located with the Laughing Jacobs Creek Mainstem)	Barometric pressure, Air temperature	None	None

Notes: Anions analysis included nitrate + nitrite, orthophosphate, sulfate, and chloride ions.
Alkalinity analysis included carbonate and bicarbonate ions.
Metals analyses included potassium, sodium, calcium, magnesium, and aluminum

Data were collected beginning in August of 2019 and ending in October of 2021. Continuous data were collected during this time with the exception of a few data gaps that are described in 4.4.2. Field measurements and grab samples were collected as part of site visits typically conducted every two months. The methodology of each type of monitoring (continuous hydrology monitoring, field measurements, and water quality grab samples) is described in the following sections.

4.3.1 Continuous Monitoring Equipment and Methodology

Continuous monitoring sensors for water level and temperature were installed at each of the four water monitoring stations. Staff plates were installed at each of the stations to validate the water level measurements provided by the sensors; these manual water level measurements were collected when field measurements were taken. Additionally, one sensor for measuring ambient air barometric pressure was deployed at the Mainstem Laughing Jacobs Creek location as a reference for the four water level sensors.

Water level and temperature readings were continuously monitored at 5-minute time steps using vanEssen TD-Diver DI801 pressure transducers. These sensors use the pressure differential created between the water above the sensor and the barometric sensor to determine the relative water level. The DI800 provides water level readings at a resolution of 0.03 cmH2O and an accuracy of ±0.5 cmH2O and temperature readings at a resolution of 0.01 °C and an accuracy of ±0.1 °C.

The pressure transducers were placed in stilling basins made of perforated PVC piping to protect the sensor. A rope or flexible metal wire was used to attach the sensor to the stilling basin. During data collection, the sensor was raised using the rope or wire and the readings were downloaded from the device. The continuous monitoring sensors were deployed in accordance with manufacturer instructions and in general accordance with Ecology's SOP EAP080, Version 2.1: Continuous Temperature Monitoring of Freshwater Rivers and Streams (included in Appendix D).

A USGS-style staff gauge was installed alongside each pressure transducer to allow manual measurements and calibration of sensor readings. The staff plates were installed in general accordance with Ecology's SOP EAP042, Version 1.2: Measuring Gage Height in Streams (included in Appendix D).

4.3.2 Field Measurements Methodology

Field measurements were recorded during the same periods at which grab samples were collected. Stage was measured using the USGS-style staff gauges shown in Figure 4-2. Temperature, specific conductance, and pH were measured using a Hanna HI991300 Portable Meter. A description of the field parameters is below:

- Stage: Stage was measured from the staff gauge and was used to validate the water level sensors.

- Temperature: Temperature was measured with the Hanna meter and was used to validate the temperature readings provided by the water level sensors.

- Specific Conductance: Specific conductance was measured with the Hanna meter; this value was compared to typical values obtained from literature.

- pH: pH was measured with the Hanna meter; this value was also compared to typical values obtained from literature.

4.3.3 Water Quality Grab Sampling Protocol

Periodic grab samples were collected at the two Sphagnum bog/wetland stations. Parameters were selected based on a review of previous studies on the chemistry of acid peatlands. Sphagnum bogs are characterized by low pH combined with low cation concentrations (Kulzer et al., 2001). Low pH in these types of wetlands is due to influence of slightly acidic rainwater combined with decomposition of sphagnum moss. Acidity is further buffered by soil minerals, of which aluminum appears to play an important role (Rocchio et al., 2014). In urbanized areas, eutrophication of wetlands from increased nutrient inputs can alter water chemistry and plant communities. The parameters in Table 4-2 were assessed via laboratory analysis.

Table 4-2. Water Quality Grab Sampling Parameters

Category	Parameters	Method	Justification
Inorganic anions	Nitrate + Nitrite, Chloride, Ortho-Phosphate, Sulfate	EPA 300.0	Evaluation of acid-forming chemistry. Evaluation of nutrient inputs.
Metals	Aluminum, Calcium, Magnesium, Sodium, Potassium	EPA 200.8	Cation chemistry and pH buffering.
Carbonate & Bicarbonate	-	SM 2320B	Hardness and Cation availability
Ammonia	-	SM 4500-NH3	Toxicity and eutrophication.

4.3.4 Quality Assurance

Analytical samples were collected using sampling containers with preservative, as necessary, and submitted to the laboratory for analysis within relevant holding times. Documentation and laboratory procedures generally followed the guidance outlined in the SAP/QAPP provided in Appendix D.

4.4 Monitoring Data Analysis

Between August 29, 2019 and August 12, 2021 (herein referred to as the "Period of Record"), hydrologic and water quality data were collected according to the methods described above. The data collected during the Period of Record are summarized and analyzed below.

4.4.1 Monitoring Site Visit Schedule

During the Period of Record, eleven site visits were conducted to collect hydrologic and water quality data approximately once every two months. The dates of site visits are listed below in Table 4-3.

Table 4-3. Data Collection Site Visits

Site Visit Date
08/29/2019
11/01/2019
12/30/2019
02/28/2020
06/17/2020
08/18/2020
10/27/2020
01/07/2021
03/31/2021
06/17/2021
08/12/2021

4.4.2 Hydrologic Monitoring Data

Hydrologic monitoring data were retrieved from the continuous sensors and the USGS-style staff gauges during each site visit. In general, continuous hydrologic data were collected during the Period of Record. However, sensors were programmed to not overwrite data once the internal storage was full; data gaps are attributed to periods in which storage of sensors was full before the next site visit. Despite these data gaps, sufficient coverage of hydrologic data was provided to allow for rigorous modeling and analysis. Data are presented and calibrated to the staff gauge in Section 6.2.4.

4.4.3 Water Quality Monitoring Data

Water quality samples were taken at all four monitoring locations. At the two creek locations, field measurements were recorded. At the two bog/wetland sites, field measurements were recorded, and representative samples were submitted for laboratory analysis. The results of these efforts are described below.

4.4.3.1 *Field Measurement Analysis*

Field measurements were taken at each site for pH, conductivity, and temperature. These measurements for each site visit are shown in Table 4-4.

Table 4-4. Field Parameters

Sampling Location	Date	pH [S.U.]			Conductivity [µS/cm]			Temperature [°C]		
		Mean	Standard Deviation	Number of Samples	Mean	Standard Deviation	Number of Samples	Mean	Standard Deviation	Number of Samples
Queen's Bog	8/29/2019	6.15	0.17	3	78	12.36	3	21.8	0.66	3
	11/1/2019	5.95	0.03	5	61	3.74	5	3.9	1.54	5
	12/30/2019	5.38	0.36	5	30	12.08	5	5.6	0.41	5
	2/28/2020	6.47	0.04	5	48	1.50	5	7.9	0.37	5
	6/17/2020	6.14	0.03	5	52	1.36	5	18.1	0.83	5
	8/18/2020	6.30	0.10	5	53	2.04	5	20.8	0.37	5
	10/27/2020	6.41	0.21	5	58	2.73	5	10.8	0.43	5
	1/7/2021	5.91	0.22	5	44	33.52	5	6.7	0.52	5
	3/31/2021	4.62	0.70	8	42	9.19	8	7.6	1.60	8
	6/17/2021	6.05	0.02	5	59	2.73	5	20.6	1.13	5
	8/12/2021	5.90	0.21	5	57	2.99	5	23.8	1.10	5
Wetland 26	8/29/2019	6.55	0.14	4	169	115.80	4	21.6	1.82	4
	11/1/2019	6.20	0.09	4	98	4.72	4	4.2	0.56	4
	12/30/2019	6.38	0.03	4	70	5.07	4	5.7	0.14	4
	2/28/2020	6.62	0.07	5	70	4.16	5	7.2	0.66	5
	6/17/2020	6.30	0.11	5	93	2.61	5	17.7	0.68	5
	8/18/2020	7.74	0.78	5	94	1.85	5	20.8	0.9	5
	10/27/2020	6.39	0.04	5	58	2.73	5	10.8	0.43	5
	1/7/2021	6.51	0.06	5	65	3.66	5	7.1	0.71	5
	3/31/2021	6.48	0.02	5	74	1.41	5	11.2	1.60	5
	6/17/2021	6.20	0.10	5	99	7.65	5	19.8	1.13	5
	8/12/2021	6.40	0.05	3	57	2.99	3	23.8	1.36	3

LJ Creek	8/29/2019	6.58	0	1	290	0	1	16.7	0	1
	11/1/2019	6.57	0	1	185	0	1	8.6	0	1
	12/30/2019	6.81	0	1	71	0	1	7.3	0	1
	2/28/2020	6.80	0	1	87	0	1	8.9	0	1
	6/17/2020	6.84	0	1	105	0	1	18.0	0	1
	8/18/2020	6.76	0	1	266	0	1	17.8	0	1
	10/27/2020	7.03	0	1	260	0	1	13.6	0	1
	1/7/2021	6.94	0	1	225	0	1	9.3	0	1
	3/31/2021	6.68	0	1	82	0	1	10.9	0	1
	6/17/2021	6.82	0	1	204	0	1	19.5	0	1
	8/12/2021	6.58	0	1	248	0	1	18.4	0	1
LJ Stream (2646)	8/29/2019	6.97	0	1	228	0	1	19.9	0	1
	11/1/2019	6.72	0	1	192	0	1	6.6	0	1
	12/30/2019	6.88	0	1	148	0	1	7.4	0	1
	2/28/2020	7.19	0	1	143	0	1	9.0	0	1
	6/17/2020	7.04	0	1	194	0	1	17.2	0	1
	8/18/2020	7.18	0	1	219	0	1	20.3	0	1
	10/27/2020	6.51	0	1	174	0	1	11.4	0	1
	1/7/2021	6.97	0	1	110	0	1	8.7	0	1
	3/31/2021	6.88	0	1	133	0	1	10.0	0	1
	6/17/2021	7.07	0	1	199	0	1	18.0	0	1
	8/12/2021	7.03	0	1	242	0	1	22.1	0	1

4.4.3.2 Laboratory Data Analysis

Water quality samples were submitted for laboratory analysis. Table 4-4 and Table 4-5 show the summary of these analyses for Queen's Bog and Southeast 24th Street Wetland Complex, respectively. The full laboratory data are provided in Appendix E.

Table 4-5. Summary of Water Quality Sampling Results for Queen's Bog

Sampling Location	Constituent	Unit	Median	Standard Deviation	Maximum	Minimum	Number of Non-Detects	Number of Samples
Queen's Bog	Alkalinity, Total (As CaCO3)	mg/L	14.6	4.95	21.9	2.5	1	11
	Aluminum	mg/L	0.38	0.41	1.40	0.10	1	7
	Calcium	mg/L	5.82	1.99	8.80	0.93	0	11
	Chloride	mg/L	2.99	0.93	4.57	1.6	0	11
	Magnesium	mg/L	1.88	0.52	2.68	0.66	0	11
	Nitrate (as N)+Nitrite (as N)	mg/L	0.1	0.07	0.301	0.1	5	7
	Nitrogen, Ammonia	mg/L	0.1	0.05	0.235	0.1	5	7
	Ortho-Phosphate (as P)	mg/L	0.2	0.00	0.2	0.2	7	7
	Potassium	mg/L	0.91	0.53	2.15	0.47	0	11
	Sodium	mg/L	3.20	0.83	4.75	1.83	0	11
	Sulfate	mg/L	0.514	0.50	1.71	0.3	4	11

Table 4-6. Summary of Water Quality Sampling Results for Southeast 24th Street Wetland Complex

Sampling Location	Constituent	Unit	Median	Standard Deviation	Maximum	Minimum	Number of Non-Detects	Number of Samples
Southeast 24th Street Bog	Alkalinity, Total (As CaCO3)	mg/L	29.2	57.47	224	11.7	0	11
	Aluminum	mg/L	0.28	0.43	1.46	0.17	0	7
	Calcium	mg/L	8.14	2.14	11.80	3.68	0	11
	Chloride	mg/L	5.44	2.52	11.8	2.31	0	11
	Magnesium	mg/L	3.17	0.83	3.69	1.30	0	11
	Nitrate (as N)+Nitrite (as N)	mg/L	0.1	0.03	0.189	0.1	6	7
	Nitrogen, Ammonia	mg/L	0.1	0.18	0.601	0.1	6	7
	Ortho-Phosphate (as P)	mg/L	0.2	0.00	0.2	0.2	7	7
	Potassium	mg/L	1.48	1.17	4.24	0.21	0	11
	Sodium	mg/L	5.76	1.42	8.56	2.88	0	11
	Sulfate	mg/L	1.76	2.69	9.07	0.3	1	11

The collected data were compared against historical data from the area. This comparison is shown for anions, cations, conventional parameters, and nutrients for both wetland sites in Figure 4-3, Figure 4-4, Figure 4-5, and Figure 4-6, respectively. Anions, conductivity, and nutrients were generally less than historical values. pH was slightly elevated above historical values. Cation concentrations were generally greater than historical values.

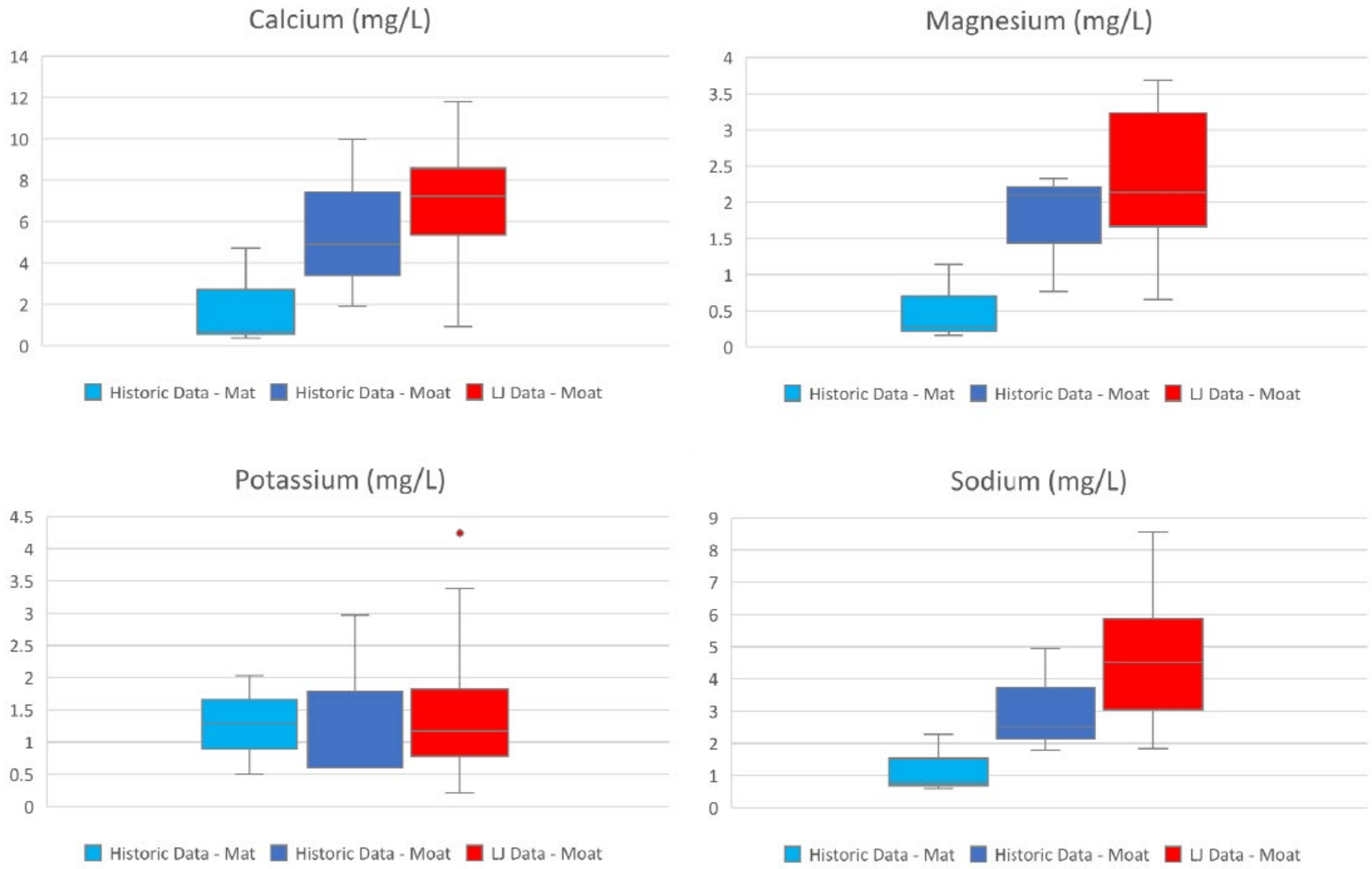


Figure 4-3. Anions Results for Queen's Bog and SE 24th Street Wetland Complex

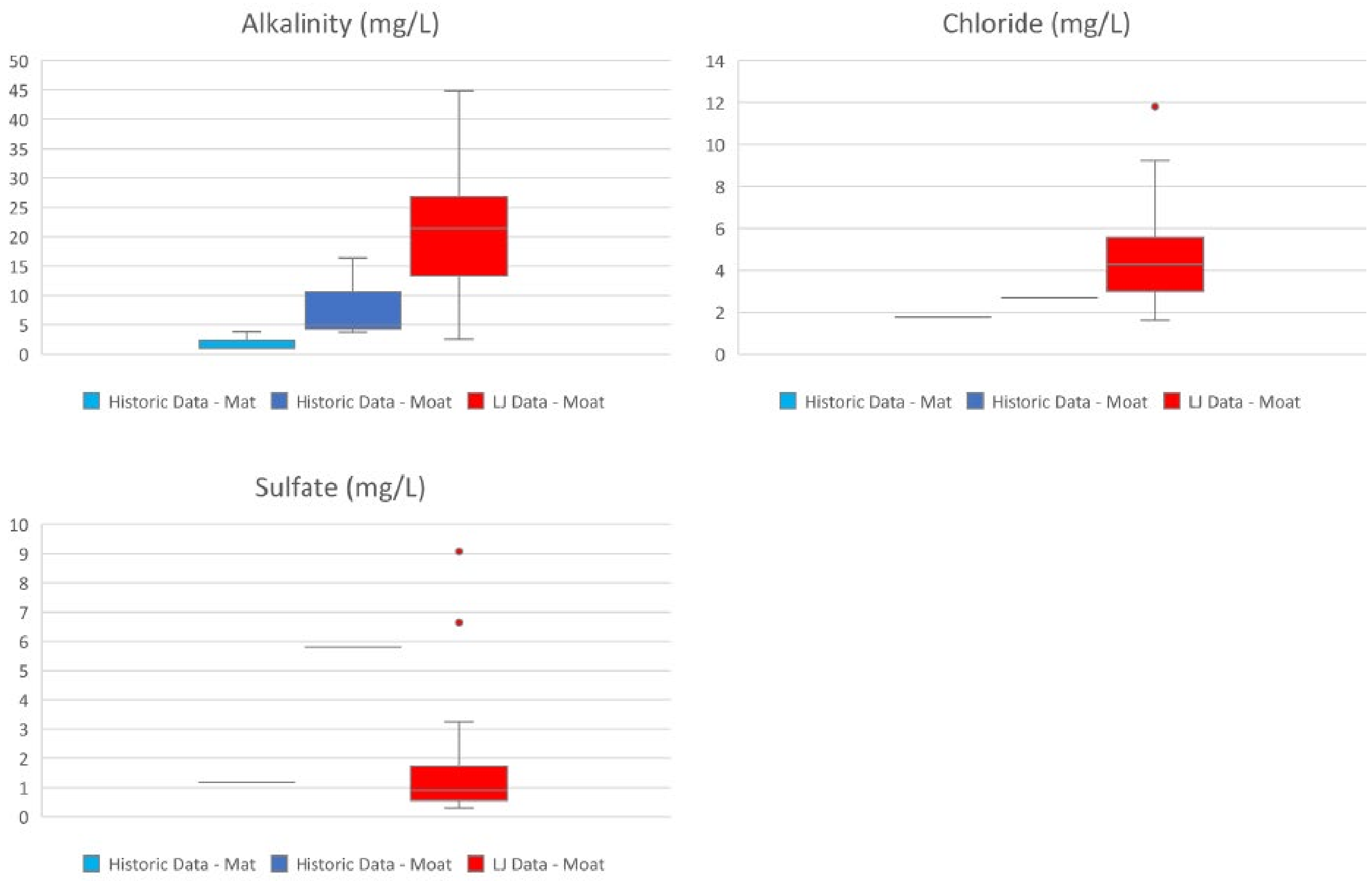


Figure 4-4. Cations Results for Queen’s Bog and SE 24th Street Wetland Complex

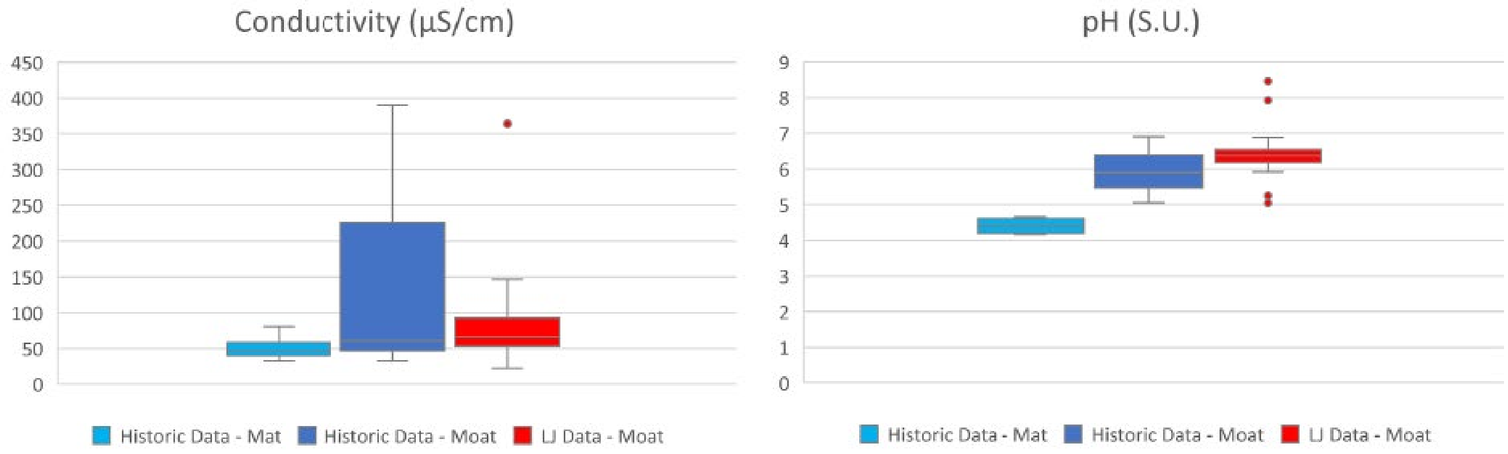


Figure 4-5. Conductivity and pH Results for Queen's Bog and SE 24th Street Wetland Complex

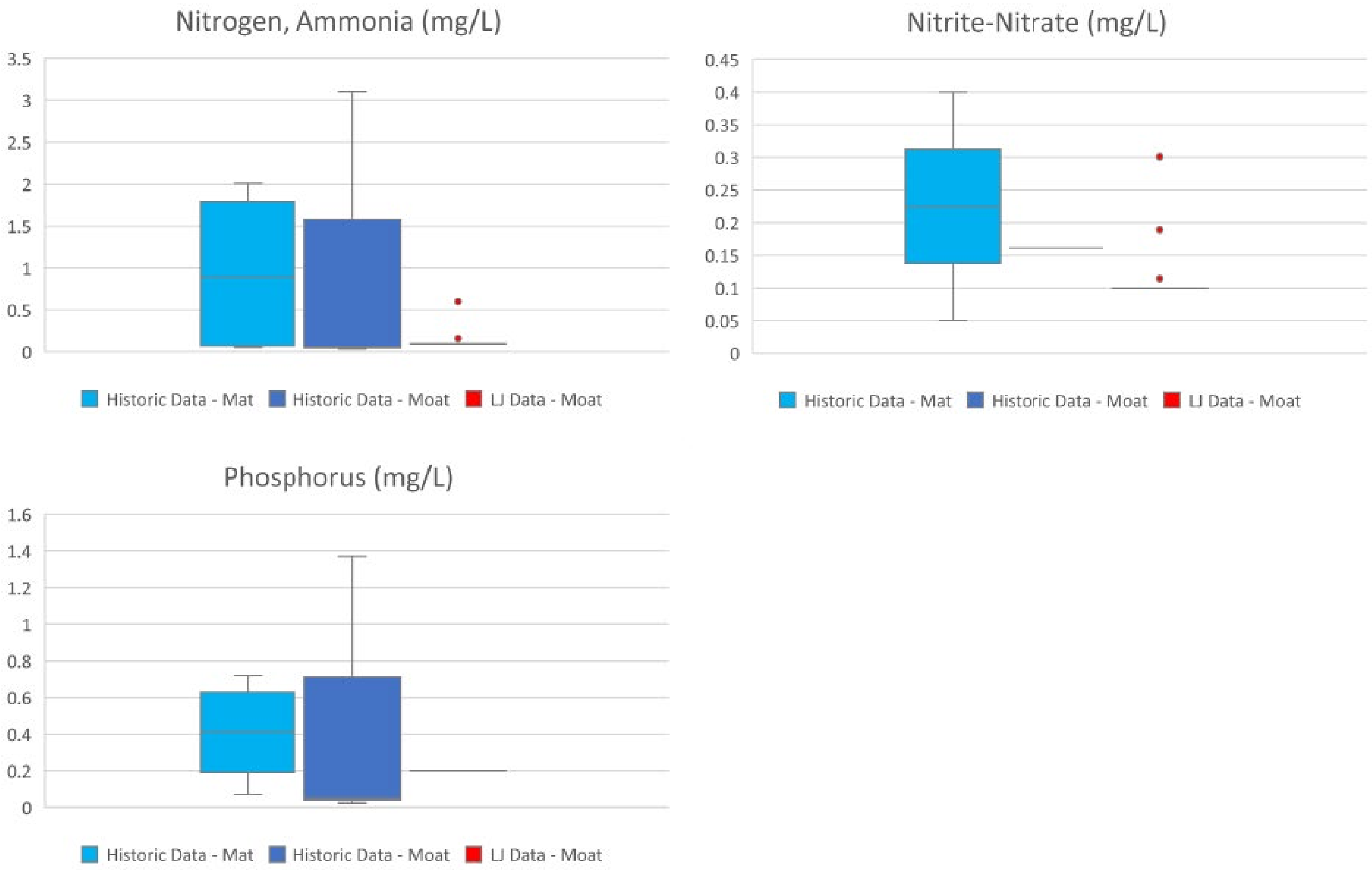


Figure 4-6. Nutrients Results for Queen's Bog and SE 24th Street Wetland Complex

5. BASIN PLAN ACTIONS

5.1 Identification of Problems and Opportunities

Problems and opportunities for improvement within the Laughing Jacobs Basin were identified from the watershed characterization, public input, water quality monitoring data, and internal workshops and site visits. These sources are described below.

5.1.1 Sources of Information

5.1.1.1 Watershed Characterization

A watershed characterization study was performed in Summer 2019 as described in Section 2. That effort characterized physical, biological and water quality conditions in the Laughing Jacobs Basin. That study found that the basin supports unique and rare natural habitats and important species. Critical habitat, such as wetlands and riparian buffers are intact, and forested conditions exist in most stream buffer areas. In addition, streams do not show appreciable erosion or downcutting. Habitat that supports salmonids was rated from fair to excellent. Sphagnum bog wetlands within the basin exhibit moderate to severe degradation as a result of excavation, fill, ditching, and untreated stormwater inputs.

5.1.1.2 Public Engagement

As described in Section 3, the City engaged residents to provide input on the basin plan through a survey and open house during May and June of 2019, respectively. Goals of the public engagement approach were to:

- Inform the public about the Laughing Jacobs watershed and basin planning process and build excitement and sense of ownership among the community for their watershed.
- Gather feedback on concerns, interests, and priorities for drainage, stormwater, and natural resources management in Laughing Jacobs Basin to inform the development of the basin plan.
- Identify priority projects that reflect community values and will help reduce flooding and preserve natural areas in the basin.

- Gather information about specific locations with standing water or flooding issues that priority projects could help address.

This effort found that residents generally encourage striking a balance between environmental preservation and public access to sites for recreational purposes. This balance is especially important in areas with natural ecosystem functioning that also provide recreational benefits. Residents identified wetlands, shorelines, and other water systems as a top priority for protection, restoration, and investment of public funds. The majority of residents do not know of or recall specific instances of flooding or water drainage issues. Investing in solutions to drainage issues is a low priority for most residents, given the suite of other ways to spend money in the basin. Improving road-related infrastructure, including runoff filtration, were low priorities for investment.

5.1.1.3 Water Quality Monitoring

Geosyntec monitored surface water quality in the watershed as described in Section 4. Findings indicate that overall water quality is good and stream flashiness is low. However, monitoring in bog areas indicates that water quality may be a contributor to wetland degradation. This is especially evident from measurements of neutral pH in the bogs. Sphagnum mosses and associated communities require a more acidic environment to thrive. Continued exposure to urban runoff is a likely contributor.

5.1.1.4 Internal Workshop

An internal workshop consisting of City staff and the consultant team was held in May 2019 to further evaluate potential issues. Areas of interest were identified based on concern by maintenance staff, previous resident feedback, and existing sources and studies.

Figure 5-1 depicts a “mind-map” of problems and opportunities identified during the workshop. Problems, or issues, are those items that were identified as potentially requiring attention within the basin. Opportunities are those items within the watershed that may be utilized to leverage improvements within the basin.

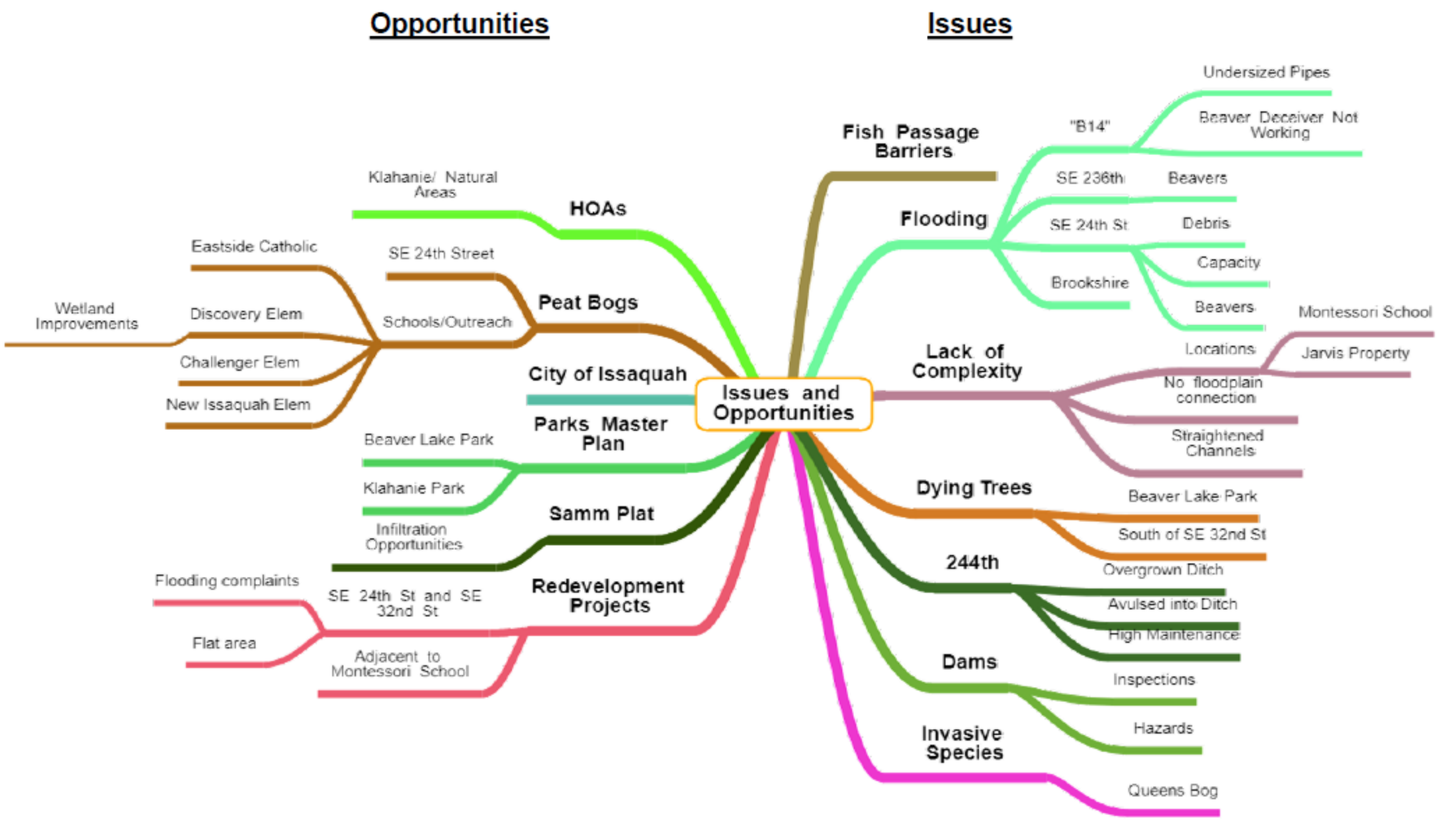


Figure 5-1. Problems and Opportunities Mind-Map

A concise list of the problems and opportunities from this workshop is listed below:

Problems:

- Fish Passage Barriers – Obstructions to natural fish passages impedes migratory patterns and decreases populations.
- Flooding – Flow impediments or blockages create flooding risks to roadways and properties.
- Lack of Complexity – Water features lacking natural complexity (e.g., straightened channels, no floodplain connection) increase the risk of erosive flow rates and the introduction of suspended solids into streams.
- Dying Trees – Dying trees may be associated with changes in water availability or water quality. Dying trees present fall hazards to citizens and property.
- Dams – Inspections and regular maintenance should be performed on dams to ensure failure risk and downstream hazards are mitigated.
- Invasive Species – Invasive species may threaten native species and reduce biodiversity in the ecosystem.

Opportunities:

- HOAs – Private groups may be utilized to provide additional assistance/feedback for basin improvements.
- Peat Bogs – Education and outreach programs may benefit from peat bog improvement/protection programs.
- City of Issaquah – Public partnerships may be leveraged to develop solutions that are beneficial to citizens of both public entities.
- Park Master Plan – Existing planned improvements may provide secondary improvements to the basin.

- Sammamish Plateau – Opportunities to increase infiltration in the basin footprint, particularly on the upgradient portion, may provide aquifer recharge while reducing runoff.

- Redevelopment Projects – Opportunities for redevelopment of existing infrastructure may be used to mitigate multiple areas of concern.

5.1.1.5 Field Investigation

Five sites were further investigated to visually identify problems and to discuss potential opportunities. Figure 5-2 shows the locations of these sites. A brief summary of the problems and opportunities identified for each site is as follows:

1. Jarvis Property/Lakeside Montessori – Figure 5-3
    - Problems: Vertical channel walls, flooding concerns of adjacent properties, and safety concerns due to vertical channel walls.
    - Opportunities: Restoration of natural channel geometry and infiltration considerations. Potential for public education and active stewardship through school. Ongoing design for Issaquah – Pine Lake Road widening.
2. Laughing Jacobs Creek – Figure 5-4
    - Problems: Temperature influences due to lack of large riparian vegetation, localized flooding due to culvert capacity, and water quality impacts from adjacent horse pasture.
    - Opportunities: Additional studies for Bacteria 303(d) violation. Streambank vegetation restoration/enhancement program.
3. Queen’s Bog – Figure 5-5
    - Problems: Sphagnum hills/islands, open water regions, possible deflating of bog mat, water quality concerns, and water level fluctuations/extended inundation.
    - Opportunities: Upstream modifications to reduce inflows and localized stormwater treatment of residential areas. Evaluate bog’s flow control function to reduce water level fluctuations. Incorporate solutions/designs in Klahanie Park Master Plan.
4. SE 24th Street Wetland Complex – Figure 5-6

  - Problems: Water level fluctuations, open water regions, drainage channel connection to bog, and residential and roadway runoff contributions.
  - Opportunities: Localized treatment of stormwater from contributing areas. Small property grant program for individual site LID retrofits. Policy revision to identify bog-friendly treatment strategies. Beaver dam controls.

5. South Fork – Figure 5-7
  - Problems: No substantial problems identified.
  - Opportunities: Potential for Klahanie HOA to retrofit existing storm systems and/or provide public education.

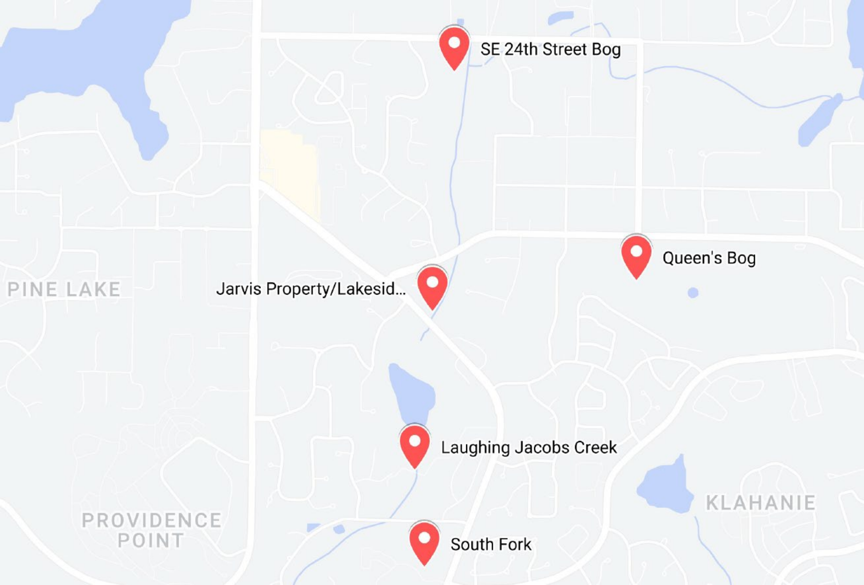


Figure 5-2. Field Investigation Sites: Overview

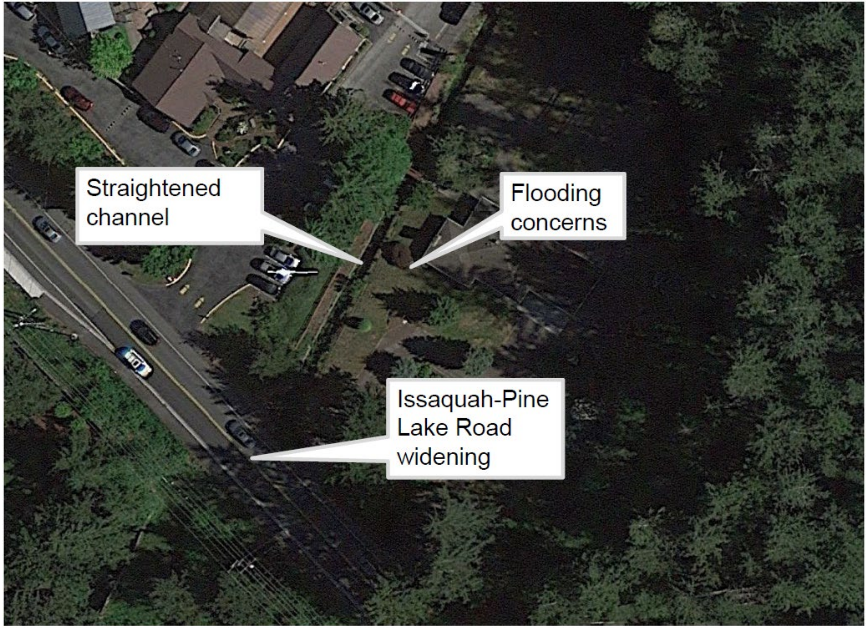


Figure 5-3. Field Investigation Sites: Jarvis Property/Lakeside Montessori

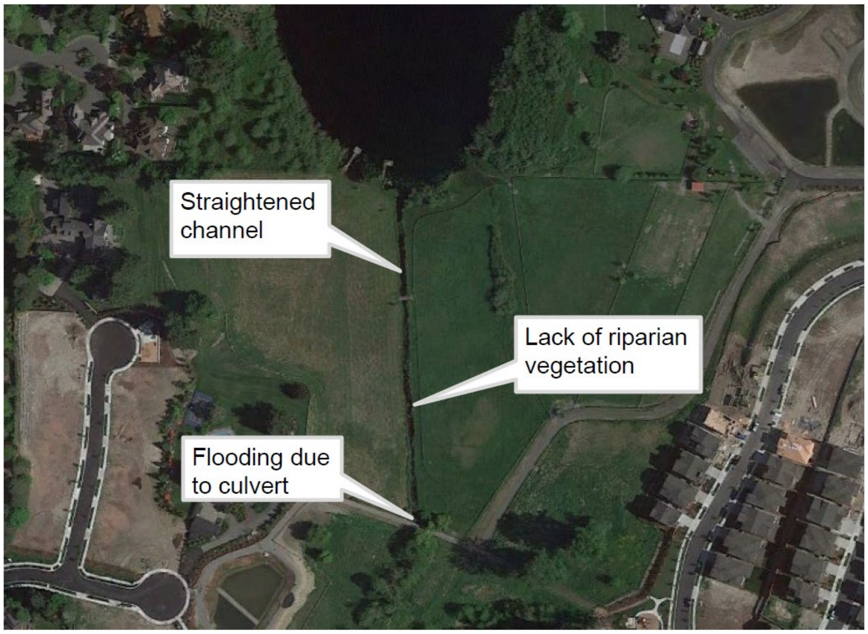


Figure 5-4. Field Investigation Sites: Laughing Jacobs Creek

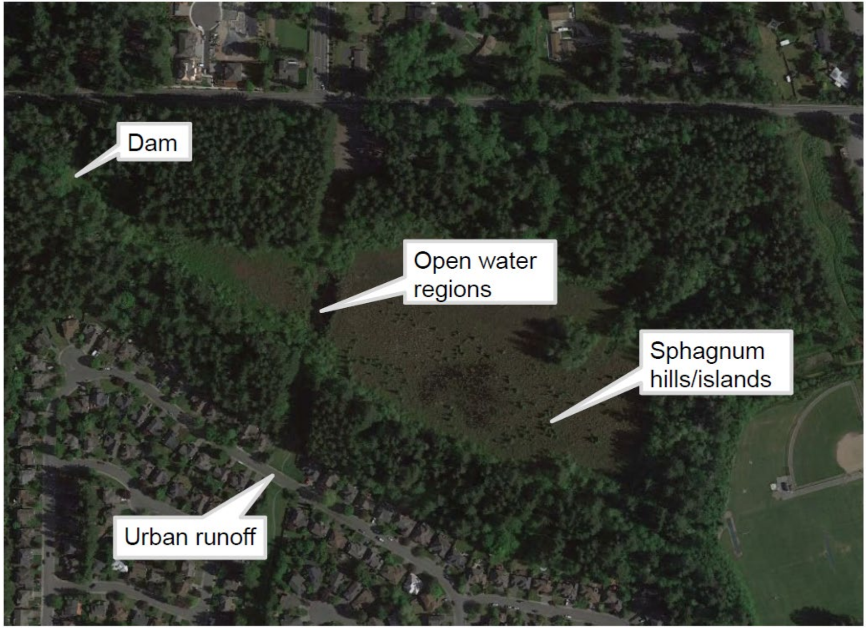


Figure 5-5. Field Investigation Sites: Queen's Bog

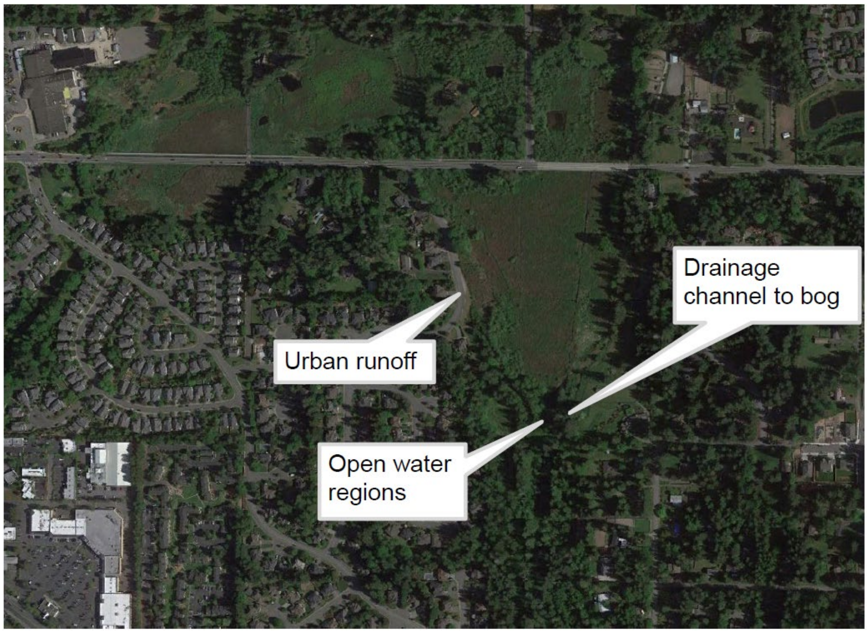


Figure 5-6. Field Investigation Sites: SE 24th Street Wetland Complex

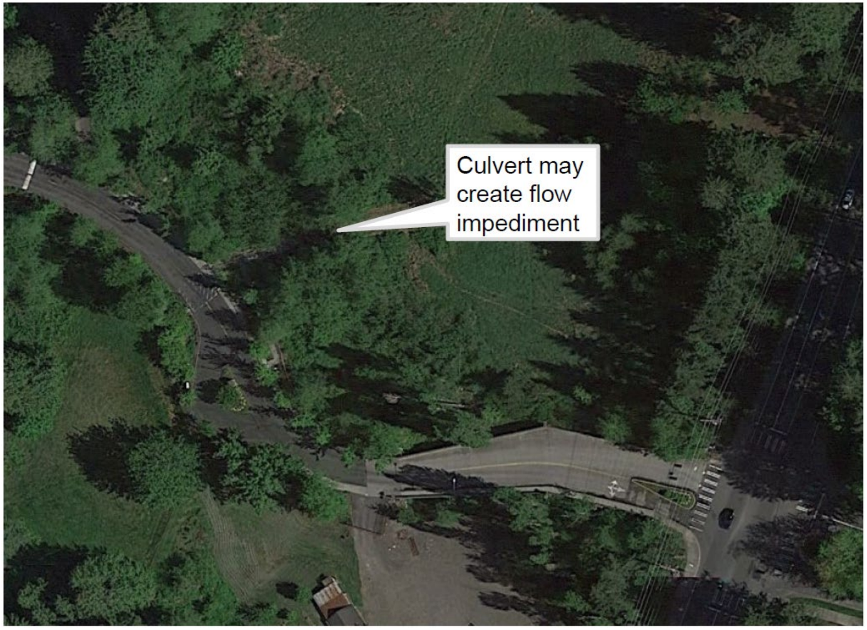


Figure 5-7. Field Investigation Sites: South Fork

5.1.2 Summary of Opportunities

A summary of the problems and improvement opportunities for the Laughing Jacobs Basin are presented in Table 5-1. This table summarizes the problems and opportunities identified during the workshop and identifies the applicability to the sites investigated during the field visit.

Table 5-1. Problems and Opportunities by Site

		Jarvis Property/Lakeside Montessori	Laughing Jacobs Creek	Queen’ s Bog	SE 24th Street Wetland Complex	South Fork
Problems	Fish Passage Barriers	✓	✓			
	Flooding	✓	✓	✓	✓	
	Lack of Complexity	✓	✓			
	Dying Trees					
	Dams			✓		
	Invasive Species			✓		
Opportunities	HOAs					✓
	Peat Bogs			✓	✓	
	City of Issaquah					
	Park Master Plan			✓		
	Sammamish Plateau	✓				
	Redevelopment Projects	✓	✓	✓		

5.1.2.1 Opportunity Analysis

1. Jarvis Property/Lakeside Montessori

The channel between the Jarvis Property and Lakeside Montessori provides several opportunities for improvement. This channel is a straightened reach approximately three feet deep with vertical walls. The proximity to a single-family home and a school presents flooding and safety concerns, see Figure 5-3.

Flooding and safety concerns at this reach may be lessened via restoration of natural channel geometry (i.e., sloped channel walls and meanders). Flooding risks may be further reduced using infiltration BMPs to reduce the quantity of stormwater in the channel. Limited space between the channel and nearby properties may limit changes to the channel geometry; however, a potential future design of the Issaquah-Pine Lake Road widening and culvert replacement project may be leveraged to increase downstream capacity and reduce potential surcharging of culverts that may lead to flooding. Improvements at this site may be utilized for public education and active stewardship through Lakeside Montessori or nearby Sunny Hills Elementary School.

2. Laughing Jacobs Creek

The reach of Laughing Jacobs Creek immediately downstream of Laughing Jacobs Lake displays several indicators of impacts due to urbanization and development. This segment is straightened and lacks riparian vegetation as demonstrated by Figure 5-4. Meanders in natural creeks function to reduce flow velocities and reduce streambank erosion. This straightened reach is more prone to flooding due to the lack of complexity coupled with a downstream culvert that may restrict flows. In addition, the lack of riparian vegetation subjects this reach to more streambank erosion potential and greater fluctuations in water temperature, which can have a direct impact on aquatic life. Property on either side of the creek is used as horse pastures which may be a pathway for bacteria to enter the stream.

Streambank restoration of the reach of Laughing Jacobs Creek described above may provide greater stability to aquatic life in the form of temperature regulation while reducing the potential for streambank erosion. Planting of dense, riparian vegetation along the banks of this reach could be a cost-effective solution to streambank stabilization. Water quality testing to determine impacts of bacteria on this reach may be conducted. However, removal of this reach from the 303(d) list for bacteria may not provide significant benefit due to the limited impact of this current listing.

3. Queen’s Bog

Vegetation encroachment and open water regions of Queen’s Bog indicate that degradation of the bog habitat may be occurring. Physical changes may be due to alterations in the input hydrology and influent water quality. Urbanization of the areas adjacent to Queen’s Bog has introduced runoff from nearby residential developments, parks, and roadways as seen in Figure 5-5. Sphagnum bogs are typically ombrotrophic (rainfall dominated) systems with little surface water inflow (Kulzer and others, 2001). As a result, water in sphagnum dominated bogs is acidic, contributing to unique moss species and other flora.

Urbanization of the surrounding area has resulted in greater runoff and altered water chemistry to which this bog was not previously exposed. Alterations to the bog for use as a detention facility (i.e., dam and outlet structures) have increased the retention volume and changed the hydroperiod of Queen’s Bog.

Restoration of Queen’s Bog hydrologic regime and water chemistry would require flow-control and water quality treatment of stormwater runoff from the contributing areas. Runoff may be reduced upstream of the bog using LID, flow-controlled retention or detention, and other similar practices. Generally, these practices reduce and distribute peaks of stormwater runoff over a greater period of time. In addition, LID and stormwater technologies may be utilized to improve the water quality of the bog by providing pretreatment of the influent stormwater. The Klahanie Park Master Plan may be leveraged to incorporate these flow reduction and pretreatment features such that a direct benefit is provided to the health of Queen’s Bog. In addition, localized treatment in residential areas may be utilized to provide benefit at a smaller scale.

4. Southeast 24th Street Wetland Complex

Similar to Queen’s Bog, open water regions and fluctuating water levels of the SE 24th Street Wetland Complex suggest a declining wellbeing of the bog and surrounding wetland. Water levels of sphagnum bogs are typically subject to small fluctuations; however, contributions of runoff from regions outside of the natural drainage basin may cause greater inflows and water level fluctuations. A drainage channel along the eastern edge of the bog may be directly associated with these fluctuations. In addition, the development of residential areas and roadways through and around the bog have altered the hydrology and contributing water quality of the bog. An aerial depiction of this bog and some of these problems is shown in Figure 5-6.

Localized stormwater treatment in the residential areas and along SE 24th Street may improve the contributing water quality to the SE 24th Street Wetland Complex. Small property grants may be leveraged by homeowners adjacent to the bog to install LID retrofits. In addition, improved stormwater treatment strategies are being developed by King County in the form of policy revisions. These revisions would more directly detail appropriate stormwater treatment strategies that may further protect and improve the health of bogs. Flooding in the general vicinity may be slightly mitigated by removal of beaver dams or other impediments the restrict outflow from the bog.

5. South Fork

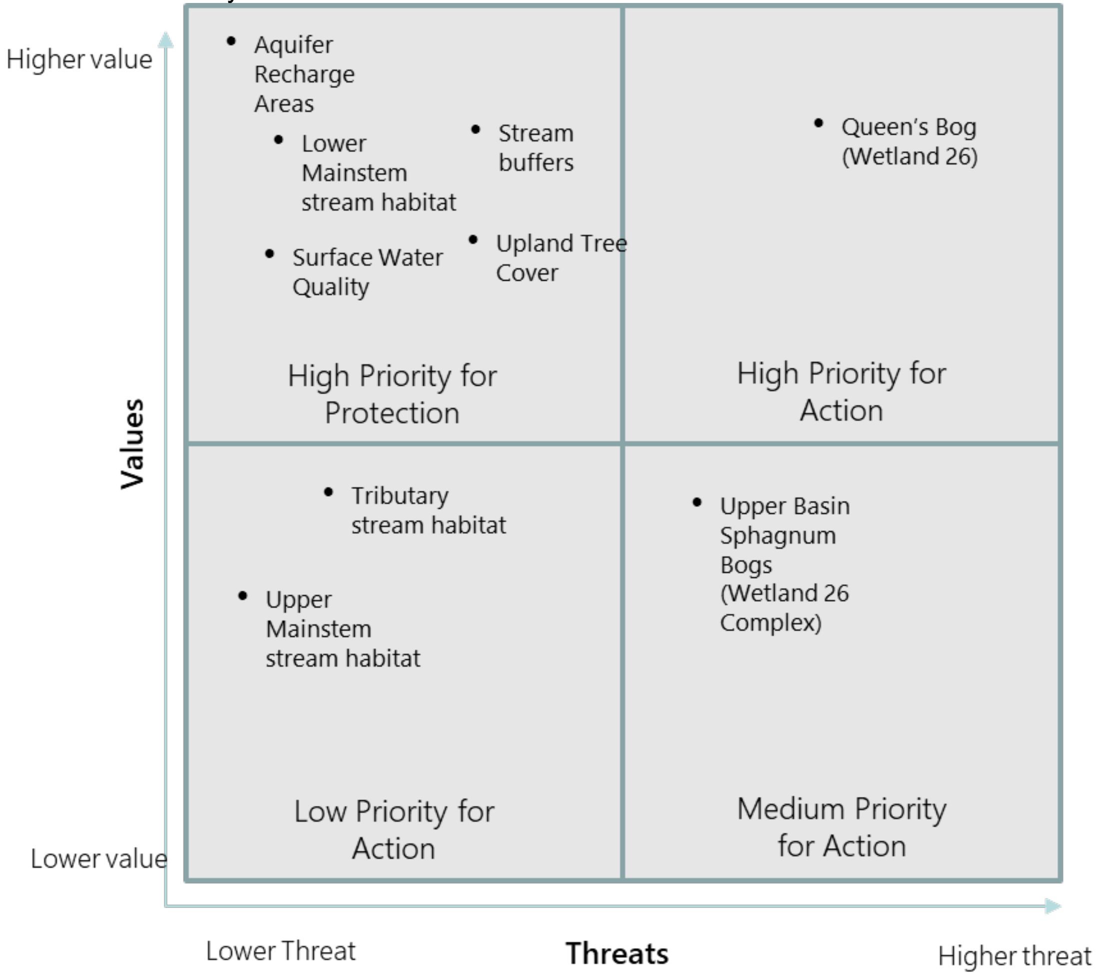
The South Fork of the Laughing Jacobs Creek appears in good health. Dense riparian vegetation and meanders in the creek resemble the natural state of the creek. A potential for flooding exists if culverts become blocked, as indicated in Figure 5-7. In addition, the health of this creek may be impacted by changing upstream conditions.

The lack of significant problems displayed at this creek may be maintained by increasing public recognition and education. The Klahanie Homeowner's Association may be leveraged to inform its residents of their impacts to downstream water bodies and best practices for maintaining the health of the watershed. In addition, retrofits of existing stormwater infrastructure should consider the impacts downstream (e.g., flow volumes, water quality, etc.).

5.1.3 Preliminary Risk Analysis

Opportunities identified throughout this process are subject to varying levels of risk. The risk associated is multifaceted; values added by the potential opportunity and threats faced without implementation of the opportunity are summarized in the matrix shown in Table 5-2.

Table 5-2. Risk Analysis Matrix



Resources within the basin are categorized based on their relative value (in terms of habitat, community priorities, or other functions), and the relative risk to each resource. Each quadrant of the matrix can be used to categorize how to address potential issues through the Basin Plan. Resources that are both high-value and high-risk are the highest priority for action. Resources that are lower in value are at a lower priority for action. Resources that are high-value, but low-risk are good candidates for projects that would preserve or protect those resources.

5.2 Proposed Actions

Actions were proposed to restore or protect resources of the Laughing Jacobs watershed. These actions were devised from the “High Priority for Protection,” “High Priority for Action,” and “Medium Priority for Action” risk categories presented in Table 5-2. The following sections identify actions relevant to the opportunities identified in Section 5.1.

5.2.1 Issaquah-Pine Lake Road Crossing Engineered Hyporheic Zone Augmentation

Treatment of surface water runoff from Issaquah-Pine Lake Road at the stream crossing identified in Figure 5-3 is proposed within the stream of Laughing Jacobs Creek using engineered hyporheic zones. Engineered hyporheic zones would be added using proposed engineered wood structures to provide instream water quality improvements while leveraging the potential roadway widening and culvert replacement project described in Section 5.1.2.

5.2.2 Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration

The downstream channel at Laughing Jacobs Lake is shallow and not shaded by riparian cover as identified in Figure 5-4 and described in Section 5.1.2. Planting of native riparian vegetation along this channel segment would shade the water and reduce temperatures due to direct sun exposure. Reduced temperatures would lessen temperature-specific burdens on aquatic life in this channel and the downstream Laughing Jacobs Creek (e.g., low dissolved oxygen levels). In addition to temperature benefits, riparian vegetation can provide cover for salmonids, increase benthic macroinvertebrate populations, and improve aesthetics.

5.2.3 Queen’s Bog Bioretention

A portion of the Klahanie neighborhood discharges stormwater runoff directly to Queen’s Bog, altering the natural hydrology and water chemistry of the bog. Sphagnum bogs, like Queen’s Bog, are typically ombrotrophic (rainfall dominated) and contain vegetation that needs acidic conditions to survive. Preliminary evidence described in Section 5.1.2 and depicted in Figure 5-5 suggests that the bog vegetation may be changing due to untreated stormwater and the altered hydrology of the system. Bioretention areas are proposed to reduce harmful constituents in stormwater runoff tributary to the bog.

5.2.4 Southeast 24th Street Wetland Complex Bioretention

The Southeast 24th Street wetland complex has been drastically altered by historic land use patterns including drainage for farming, filling in some locations, and bisecting by roads as depicted by Figure 5-6. Land cover changes related to logging, farming, and development altered the hydrologic regime and influent water quality. Vegetated bioretention areas are proposed to be installed to partially restore hydrology and water quality.

5.2.5 East Lake Sammamish Parkway Roadway Stormwater Treatment

Although not initially identified in Section 5.1.2, treatment of stormwater runoff from a segment of East Lake Sammamish Parkway located in Issaquah is proposed to enhance surface water quality and the habitat of lower Laughing Jacobs Creek. These resources are categorized as “High Priority for Protection” in Table 5-2.

Lower Laughing Jacobs Creek supports a native run of Lake Sammamish Kokanee Salmon, an important fish species whose population has declined by almost 95% from historic levels. The proposed treatment area includes a heavily trafficked section of East Lake Sammamish Road which crosses the creek near the discharge point to Lake Sammamish. Most runoff from this section is untreated before discharge to the creek. Ultra-dense BMPs would capture and treat as much roadway runoff as feasible given site constraints. Treatment of roadway runoff would improve water quality and reduce harmful effects to Kokanee and other salmonids.

5.2.6 Southeast 43rd Way Roadway Stormwater Treatment

Similar to the roadway stormwater treatment proposed at East Lake Sammamish, treatment of stormwater runoff from a segment of Southeast 43rd Way located in Issaquah is proposed to enhance surface water quality and the habitat of lower Laughing Jacobs Creek.

Southeast 43rd Way parallels Laughing Jacobs Creek for its entire length from the Sammamish Plateau to East Lake Sammamish Road and traffic loading is expected to increase in this area due to the development of a new Issaquah School District high school/elementary school campus in this area. Most runoff from this section is untreated before discharge to the creek. Ultra-dense BMPs would capture and treat as much roadway runoff as feasible given site constraints. Treatment of roadway runoff would improve water quality and reduce harmful effects to Kokanee and other salmonids.

5.3 Environmental Benefits

The environmental benefits of proposed actions were evaluated based on their contributions to restore or improve identified watershed functions. For purposes of this study, watershed functions were broadly defined to include historic, existing, or potential ecosystem benefits and services provided by the Laughing Jacobs watershed. These include nutrient cycling, water quality improvement, benefits to populations of plants and animals, carbon storage, erosion control, resilience to climate change, and wetland buffer improvements. Environmental benefits of the proposed actions are described below.

1. Issaquah-Pine Lake Road Crossing Engineered Hyporheic Zone Augmentation
    - Water Quality Improvement – Porous media in the hyporheic zone will function to remove pollutants via filtration and sorption.
    - Benefits to Populations of Plants and Animals – Removal of pollutants from surface water, particularly those associated with roadway runoff, can improve habitats for plants and animals. Pre-spawn mortality of salmon is hypothesized to decrease when roadway pollutants are removed from runoff.
    - Climate Change Resilience – Subsurface flows cool water and offset ambient air and stormwater runoff temperature increases of stream flows.
    - Opportunity for Pilot Study – Engineered hyporheic zone augmentation is an emerging strategy to remove 6PPD-quinone, a toxic chemical found in vehicle tires, from roadway stormwater runoff.
2. Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration
    - Erosion Control – Establishment of riparian vegetation stabilizes channel banks and reduces the potential for erosion.
    - Climate Change Resilience – Riparian vegetation shades water within the channel and reduces temperature fluctuations associated with sunlight exposure.
    - Wetland Buffer Improvement – Flooding and flashiness associated with large storm events is lessened due to the natural vegetation barrier. This reduces the impact of flooding on nearby wetlands.
3. Queen’s Bog Bioretention

  - Nutrient Cycling – Fertilizer laden runoff from yards and gardens may contribute nutrients atypical to sphagnum bogs. Bioretention systems function to reduce the nutrient load via sorption to the bog.
  - Water Quality Improvement – Water quality is improved by removal of harmful surface water pollutants including heavy metals and nutrients.
  - Benefits to Populations of Plants and Animals – Stormwater treatment protects the native population of sphagnum moss and the organisms that rely on the bog's unique ecosystem.
  - Carbon Storage – Sphagnum bogs provide a substantial carbon storage ability. Protection of these resources permits the sequestration of carbon from the atmosphere via natural means.
  - Resilience to Climate Change – Carbon storage within the sphagnum moss provides a natural solution to the ongoing need for carbon sequestration.

4. Southeast 24th Street Wetland Complex Bioretention
   - Nutrient Cycling – Fertilizer laden runoff from yards and gardens may contribute nutrients atypical to sphagnum bogs. Bioretention systems function to reduce the nutrient load via sorption to the bog.
   - Water Quality Improvement – Water quality is improved by removal of harmful surface water pollutants including heavy metals and nutrients.
   - Benefits to Populations of Plants and Animals – Stormwater treatment protects the native population of sphagnum moss and the organisms that rely on the bog's unique ecosystem.
   - Carbon Storage – Sphagnum bogs provide a substantial carbon storage ability. Protection of these resources permits the sequestration of carbon from the atmosphere via natural means.
   - Resilience to Climate Change – Carbon storage within the sphagnum moss provides a natural solution to the ongoing need for carbon sequestration.
5. East Lake Sammamish Parkway Roadway Stormwater Treatment
   - Water Quality Improvement – Treatment of runoff reduces the presence of roadway pollutants in stormwater (e.g., oils and grease, heavy metals, compounds associated with tire wear, turbidity).

   - Benefits to Populations of Plants and Animals – Removal of pollutants from surface water, particularly those associated with roadway runoff, can improve habitats for plants and animals. Pre-spawn mortality of salmon is hypothesized to decrease when roadway pollutants are removed from runoff.

6. Southeast 43rd Way Roadway Stormwater Treatment
   - Water Quality Improvement – Treatment of runoff reduces the presence of roadway pollutants in stormwater (e.g., oils and grease, heavy metals, compounds associated with tire wear, turbidity).
   - Benefits to Populations of Plants and Animals – Removal of pollutants from surface water, particularly those associated with roadway runoff, can improve habitats for plants and animals. Pre-spawn mortality of salmon is hypothesized to decrease when roadway pollutants are removed from runoff.

6. MODELING

Hydrologic models were developed to assess stormwater treatment options at Queen's Bog, Southeast 24th Street Wetland Complex, and roadway segments of East Lake Sammamish Parkway and Southeast 43rd Way. Conceptual hyporheic zone implementation downstream of the Issaquah-Pine Lake Road culvert replacement was not modeled.

6.1 Modeling Methodology

Three modeling approaches were used to analyze the locations of interest in the Laughing Jacobs Basin. These approaches included reviewing and analyzing monitoring data collected by Geosyntec between August 2019 and March 2021, sizing bioretention stormwater BMPs for the bog and wetland complex, and conceptual placement of BMPs for the roadway areas described above. Note, modeling was not conducted for the conceptual hyporheic zone.

6.1.1 Data Collection

Monitoring stations were installed in August 2019 to collect water level and temperature data at Queen's Bog, Southeast 24th Street Wetland Complex, and two locations in Laughing Jacobs Creek. In addition, water quality sampling at Queen's Bog and Southeast 24th Street Wetland Complex began in August 2019. Data collection and water quality sampling continued through August 2021. Monitoring and sampling locations are depicted in Figure 4-1.

6.1.2 Bog/Wetland BMP Sizing Approach

For Queen's Bog and Southeast 24th Street Wetland Complex, key outlet points were identified for drainage areas that do not currently receive water quality treatment (such as bioretention or similar systems). Locations of existing water quality BMPs were recorded from Storm Bandit, the City of Sammamish's online stormwater GIS database (City of Sammamish, 2021). A total of five outfalls were identified for each bog/wetland that currently do not receive water quality treatment prior to discharge to the bog.

Drainage areas were delineated to each outfall and are shown on Figure 6-1 and Figure 6-2 for Queen's Bog and Southeast 24th Street Wetland Complex, respectively. For Southeast 24th Street Wetland Complex, two outfalls to the wetland already receive some level of stormwater treatment and are excluded from the bioretention sizing analysis (Outfalls 2 and 4 in Figure 6-2).

#	Area (acres)
1	8.26
2	6.39
3	7.20
4	8.10
5	25.66

Figure 6-1. Queen’s Bog Drainage Areas

#	Area (acres)
1	13.05
3	1.28
5	7.46
6	3.66
7	2.98

Figure 6-2. SE 24th Street Bog Drainage Areas

Drainage areas and imperviousness of the catchment area tributary to each outfall were determined and are summarized in Table 6-1 for Queen's Bog and Table 6-2 Southeast 24th Street Wetland Complex.

Table 6-1. Queen's Bog Land Use Types for Drainage Areas

Sampling Location	Area Type	Outfall 1	Outfall 2	Outfall 3	Outfall 4	Outfall 5	Overall
Queen's Bog	Roadways, Moderate Slope *(acres)*	1.04	0.59	0.72	2.18	3.12	7.65
	Rooftops, Flat *(acres)*	1.98	1.19	1.53	0.99	2.43	8.12
	Driveways, Moderate Slope *(acres)*	0.54	0.40	0.51	0.36	1.24	3.05
	Sidewalks, Moderate Slope *(acres)*	0.48	0.34	0.37	0.65	0.14	1.98
	Lawn, Moderate Slope, Soil Group C *(acres)*	4.02	3.08	1.94	2.77	18.72	30.53
	Forest, Moderate Slope, Soil Group C *(acres)*	-	-	-	-	-	-
	Forest, Flat, Saturated *(acres)*	0.19	0.80	2.13	1.13	-	4.25
	Total Impervious Area *(acres)*	4.04	2.52	3.13	4.18	6.93	20.80
	Total Drainage Area *(acres)*	8.26	6.39	7.20	8.10	25.66	55.61

Table 6-2. Southeast 24th Street Wetland Complex Land Use Types for Drainage Areas

Sampling Location	Area Type	Outfall 1	Outfall 2	Outfall 3	Outfall 4	Outfall 5	Overall
Southeast 24th Street Bog	Roadways, Moderate Slope *(acres)*	0.23	0.47	0.36	0.78	0.51	2.35
	Rooftops, Flat *(acres)*	0.71	-	1.34	0.44	0.12	2.61

Driveways, Moderate Slope *(acres)*	1.09	-	0.31	0.73	0.52	2.65
Sidewalks, Moderate Slope *(acres)*	0.01	0.14	0.08	0.22	0.10	0.55
Lawn, Moderate Slope, Soil Group C *(acres)*	6.00	-	2.87	0.50	1.23	10.60
Forest, Moderate Slope, Soil Group C *(acres)*	5.00	0.68	2.50	1.00	0.50	9.68
Forest, Flat, Saturated *(acres)*	-	-	-	-	-	-
Total Impervious Area *(acres)*	2.04	0.61	2.09	2.17	1.25	8.16
Total Drainage Area *(acres)*	13.05	1.28	7.46	3.66	2.98	28.43

Following drainage area delineation, parameters were input into the Western Washington Hydrology Model (WWHM) to determine the size of bioretention areas needed to treat at least 91% of runoff volume from a long-term, continuous simulation for each outfall drainage area. A minimum water quality treatment volume of 91% was utilized for consistency with Section 6.2.1 of the King County Surface Water Design Manual (King County, 2016).

WWHM utilizes a local precipitation factor to scale precipitation timeseries data from a rain gauge to the location of interest. Locations in Sammamish were assigned a precipitation factor of 1.167 to scale the data from a rain gauge near the Seattle-Tacoma International Airport. Additionally, the model accepts categorical land-use types input by the user (e.g., steep roadways, flat lawn with well-drained soil, saturated forest, etc.), and analyzes runoff while performing hydrologic routings from these drainage areas based on the historical local precipitation. Models utilized a precipitation timeseries comprised of data from October 1948 to September 2009 (i.e., the default timeseries available in WWHM).

Conceptual bioretention areas were created in WWHM for each of the ten drainage areas identified in Table 6-1 and Table 6-2. Dimensions of the bioretention areas were determined by performing multiple model-runs while iterating on bioretention dimensions. Iterations were considered complete once a long-term runoff treatment volume of 91% or greater was achieved. Results from this analysis are provided in Section 6.3.

6.1.3 Conceptual Roadway StormFilter® Sizing Approach

Segments of East Lake Sammamish Parkway and Southeast 43rd Way identified in Figure 6-3 represent heavily trafficked areas. Roadway runoff from these areas is not currently treated prior to discharge to Laughing Jacobs Creek. Recent roadway improvements in the vicinity of the drainage area identified along Southeast 43rd Way have provided treatment benefits to a portion of this runoff; however, additional benefits may be realized via proactive BMP installation.

Figure 6-3. Roadway Drainage Areas

Public right-of-way along both roadway segments is limited and existing infrastructure obstructs the extent of construction possible without disturbances to the roadway and surrounding areas. As such, Contech StormFilters® were identified as a stormwater treatment practice that would provide ample stormwater treatment from these roadways while limiting disturbances. StormFilters® are typically installed in catch basin structures such that additional routing is not necessary; further, retrofits of existing catch basin structures may facilitate the installation of StormFilters®.

Contech StormFilter® cartridge quantities were calculated as prescribed by the Washington state Technology Assessment Protocol – Ecology (TAPE) guidelines for StormFilters® with ZPG media (Ecology, 2017). As such, the off-line water quality design flow rate was determined using a WWHM model with timeseries data from October 1948 to September 2009. For each roadway segment, the average subcatchment area was calculated, and the land use was identified as summarized in Table 6-3.

Table 6-3. Roadway Drainage Areas

Location	Land Use	Average Drainage Area *(sq. feet)*	Average Drainage Area *(acres)*
East Lake Sammamish Parkway	Roads/Flat	7,375	0.17
Southeast 43rd Way	Roads/Moderate Slope	13,027	0.30

StormFilters® are available in three heights: 12 inches, 18 inches, and 27 inches. TAPE guidelines state a design flow rate of 1 gallon per minute (gpm) per square foot (ft2) of media surface (Ecology, 2017). The design flow rate for each of the StormFilter® models is provided in Table 6-4. Note, cartridge flow rate corresponds to StormFilter® ZPG Media; StormFilters® with PhosphoSorb Media operate at a design flow rate of 1.67 gpm/ft2. Cartridge quantities may be modified to correspond to the selected media.

Table 6-4. StormFilter® Design Flow Rates per Cartridge

Parameter	Cartridge Type #1	Cartridge Type #2	Cartridge Type #3
Effective Cartridge Height (inches)	12	18	27
ZPG Cartridge Flow Rate (gpm/cartridge)	5	7.5	11.3

The number of StormFilter® cartridges for each of the three available models was determined for the average drainage area for each roadway segment. A ratio of StormFilter® cartridge quantity to drainage area was determined from this calculation and applied to the drainage area of each subcatchment. The resultant calculation provides the quantity of StormFilter® cartridges for each subcatchment necessary to satisfy the TAPE sizing criteria.

6.2 Water Balance Results

To assess the effects of urbanization on the hydrology of Queen's Bog, a simple water balance model was developed. A water balance is a conceptual model of the hydrologic cycle that accounts for inputs (e.g., rainfall) and outputs (e.g., discharge) to estimate the hydrologic response of a system.

6.2.1 Model Setup

The water balance developed for Queen's Bog was used to estimate the water surface elevation changes over time under existing conditions and under pre-development conditions. This water balance used the following equation.

$$P - ET + Q_I - Q_O = \Delta s$$

Where:

P = Precipitation
ET = Evapotranspiration
Q_I = Inflow
Q_O = Outflow
Δs = Change in storage

The model was run for a calibration period of approximately two years and then for the historical period used by WWHM. The calibration period was used to adjust modeling parameters and the historical period was used to evaluate the effects of development on the bog.

6.2.1.1 Meteorological Data

Precipitation and evapotranspiration data were acquired from nearby weather stations; sources are summarized in Table 6-5. Data were obtained for time periods coincident with the calibration period.

Table 6-5. Meteorological Data

Parameter	Data Source	Site
Rainfall	King County Hydrologic Information Center	Sammamish Plateau Rain Gage
Evapotranspiration	Washington State University AgWeatherNet	Woodinville

6.2.2 Stage-Storage-Discharge

Stage-storage-discharge relationships were estimated from as-built design drawings of the bog outlet structure (Lowe Enterprises Northwest, 1989). The overflow elevation was adjusted based on field observations of the staff plate when the bog was discharging. The existing stage-storage-discharge relationship is shown in Table 6-6.

Table 6-6. Stage-Storage-Discharge Relationship

Stage	Head	Area	Storage	Discharge
(feet, gage height)	*(feet, outlet)*	*(acres)*	*(acre-feet)*	*(cfs)*
0	0.00	17.6	0.0	0.0
1.64	0.00	18.2	0.0	0.0
1.69	0.05	18.2	0.0	0.1
1.74	0.10	18.3	0.0	0.3
1.89	0.25	18.4	4.5	1.0
2.14	0.50	18.5	9.0	2.8
2.64	1.00	19.0	18.0	7.7
3.14	1.50	19.5	28.0	13.5
3.64	2.00	20.0	36.4	43.0
4.14	2.50	20.5	48.0	58.5
4.64	3.00	21.5	56.0	62.5
5.64	4.00	23.0	76.0	71.0
6.64	5.00	25.0	98.0	80.0

6.2.3 Inflow

Daily runoff (inflow to the bog) was calculated from precipitation using the curve number method (USDA, 2004) which accounts for soil moisture storage of various soil types. The curve number method is described by the following set of equations.

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}\ S = \frac{1000}{CN} - 10 I_a = 0.2\,S$$

Where:

Q = Runoff *(inches)*
P = Precipitation *(inches)*
S = Potential maximum soil retention after runoff begins *(inches)*
CN = Curve number
I_a = Initial abstraction *(inches)*

The curve number served as the main calibration parameter for this analysis.

6.2.4 Calibration

Water surface elevation in Queen’s Bog was measured continuously between August 29, 2019, and August 12, 2021. Data were downloaded and validated according to procedures specified in the Laughing Jacobs Basin Sampling and Analysis Plan/Quality Assurance Project Plan (Appendix D). During periodic site visits, field staff performed manual readings of water surface elevations using the staff plate installed in the bog. Readings are shown in Table 6-7.

Table 6-7. Staff Plate Readings, Queen’s Bog

Time of Simulation	Staff Plate Height *(feet)*	Approximate Elevation [feet NAVD]
8/29/2019 15:30	0.55	396.5
11/1/2019 11:58	1.17	397.1
12/30/2019 12:19	1.85	397.8
2/28/2020 11:30	1.76	397.7
6/17/2020 11:42	1.76	397.7

Time of Simulation	Staff Plate Height *(feet)*	Approximate Elevation [feet NAVD]
8/18/2020 10:44	0.77	396.7
10/27/2020 14:14	0.89	396.9
1/7/2021 12:33	2.20	398.2
3/31/2021 9:20	1.89	397.9
6/17/2021 11:37	1.49	397.5
8/12/2021 11:05	0.40	396.4

Manual readings were used to correct monitoring data to provide a continuous record of water surface elevations in Queen's Bog. This record is shown in Figure 6-4.

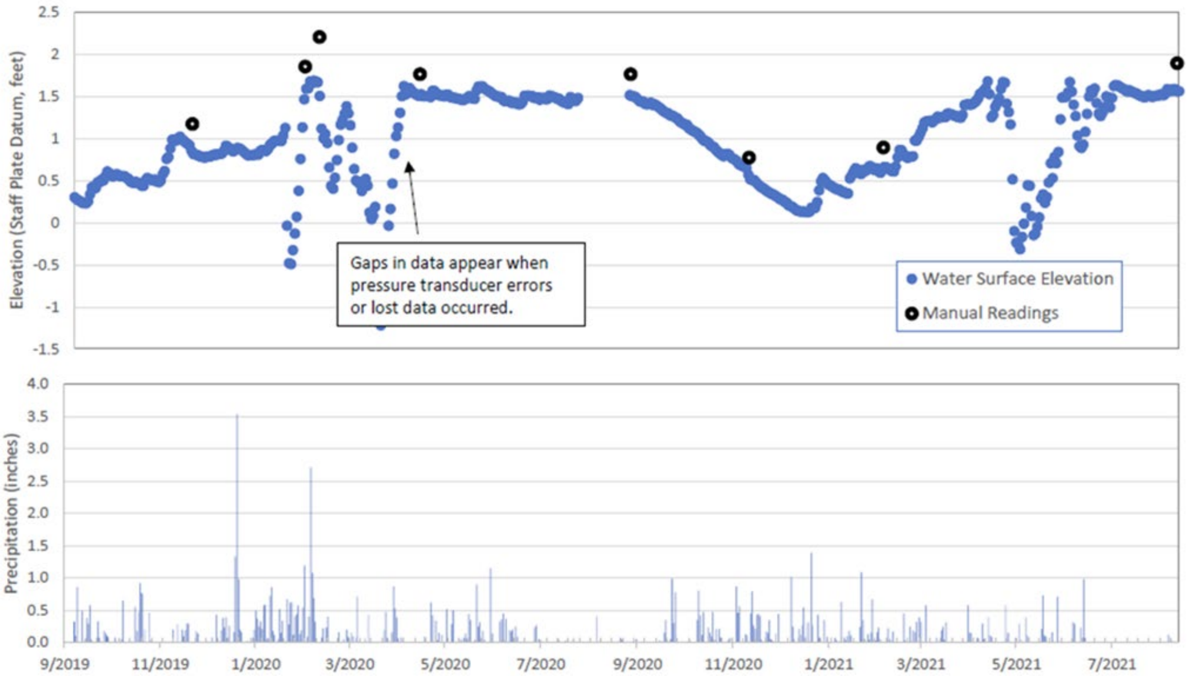


Figure 6-4. Measured Water Surface at Queen's Bog

Using the corrected water surface elevation record, the runoff curve number was adjusted until agreement between modeled and measured data was achieved. The selected curve numbers were 78 for typical conditions, and 81 for antecedent rainfall conditions. Antecedent rain thresholds were assumed to be more than 3-inches of rainfall in the previous 5 days. The calibration results, which were completed in March 2021, are shown in Figure 6-5.

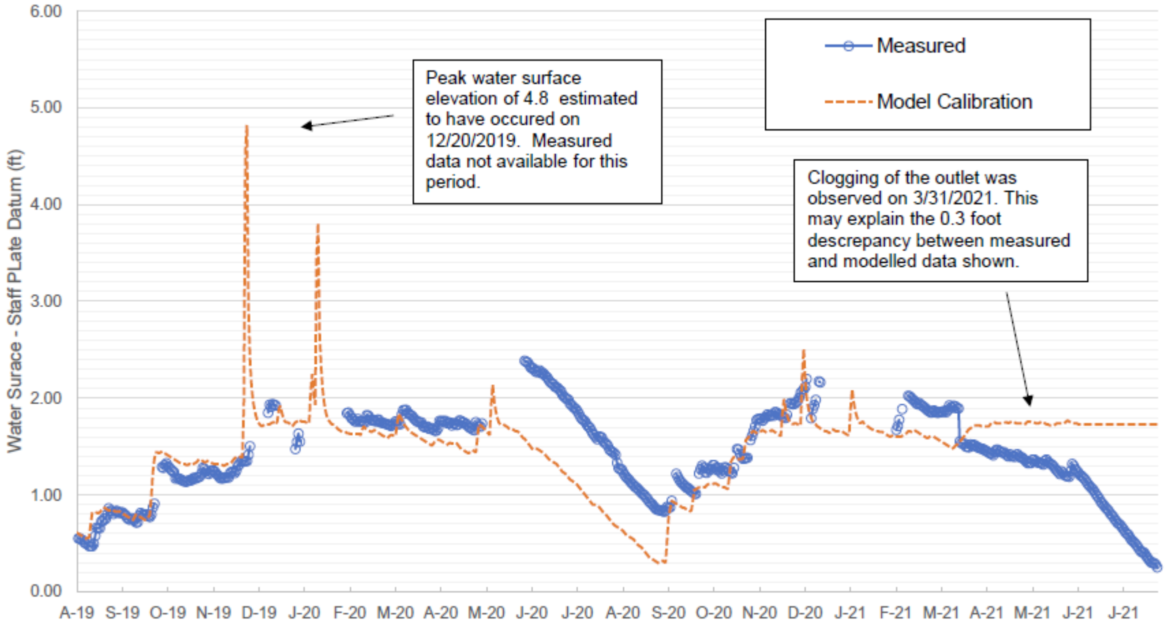


Figure 6-5. Water Balance Calibration

6.2.5 Historical Model

A model simulation was performed using the WWHM historical dataset. The rainfall and evapotranspiration records from WWHM were used. This simulation consisted of three scenarios: 1) existing conditions with treatment facilities, 2) existing conditions without treatment facilities, and 3) pre-development conditions.

The existing conditions scenario used the same watershed and stage-storage-discharge parameters in the calibration model. For the pre-development scenario, the following adjustments were made:

- Watershed curve numbers were adjusted to reflect a forested condition. The selected curve numbers were 55 for typical conditions, and 75 for antecedent rainfall conditions. Antecedent rain thresholds were assumed to be more than 3-inches of rainfall in the previous 5 days.

- The discharge relationship was changed to reflect conditions before the existing outlet structure was built. Historical outlet controls were assumed to be the normal depth in a trapezoidal channel with a bottom width of 12 feet. These dimensions were measured from the topography contained in the Queen's Bog outlet as-built drawings (Lowe Enterprises Northwest, 1989).

The results of a simulation period from the WWHM model corresponding to September 2007 to September 2009 are shown in Figure 6-6.

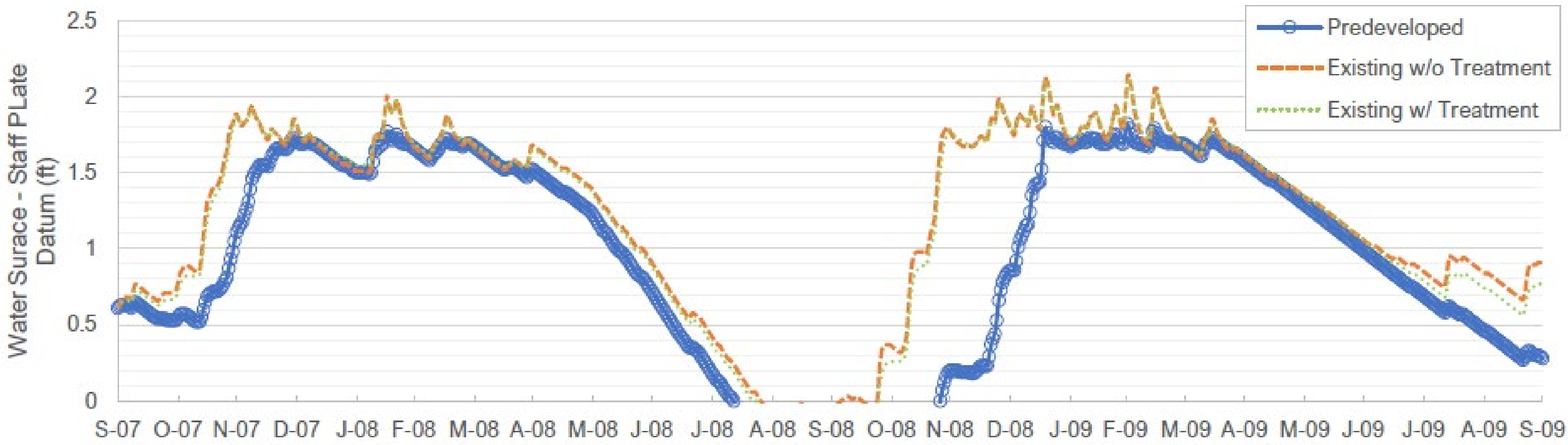


Figure 6-6. Historical Model WWHM Simulation

6.2.6 Water Balance Results

Modeled average water surface elevations are shown in Table 6-8. Results indicate that the existing conditions scenario results in water surface elevations approximately one foot higher in the winter months and approximately 0.5 feet higher in the summer months. Maximum water surface elevations are about two to four feet higher in the existing conditions scenario than in the pre-development scenario.

Table 6-8. Modeled Average Water Surface Elevation of Queen's Bog

Month of Simulation	**Pre-Development Scenario**		**Existing Conditions Scenario**	
	Average *(feet)*	**Maximum *(feet)***	**Average *(feet)***	**Maximum *(feet)***
Jan	0.64	1.74	1.64	3.51
Feb	0.73	2.03	1.60	3.78
Mar	0.74	1.77	1.55	3.41
Apr	0.66	1.94	1.47	3.52
May	0.51	1.58	1.32	2.78
Jun	0.36	1.33	1.18	2.70
Jul	0.24	1.12	0.97	1.64
Aug	0.14	0.88	0.76	2.44
Sep	0.08	0.65	0.64	2.33
Oct	0.11	2.63	0.75	6.01
Nov	0.28	2.02	1.27	4.00
Dec	0.49	2.29	1.55	4.92

Average monthly runoff (i.e., inflow) and outflow at Queen's Bog are shown in Table 6-9. Both runoff and outflow are much higher in the existing conditions scenario than the pre-development scenario, with the largest differences occurring during November, December, and January. During the summer months, the pre-development results suggest that the bog received little to no inflow or outflow.

Table 6-9. Modeled Runoff (Inflow) and Outflow at Queen's Bog

Month of Simulation	Pre-Development Scenario		Existing Conditions Scenario	
	Runoff [acre-feet]	Outflow [acre-feet]	Runoff [acre-feet]	Outflow [acre-feet]
Jan	1.00	0.01	28.92	29.73
Feb	1.04	0.21	16.47	18.11
Mar	0.29	0.05	8.26	8.64
Apr	0.22	0.10	5.71	5.02
May	0.01	0.00	1.42	0.66
Jun	0.00	0.00	2.32	1.12
Jul	0.00	0.00	0.17	0.00
Aug	0.00	0.00	2.94	0.84
Sep	0.00	0.00	3.06	0.60
Oct	2.12	0.41	15.11	8.24
Nov	2.84	0.30	38.77	31.20
Dec	1.31	0.24	31.17	30.30

The water balance suggests that the hydrology of Queen's Bog has been affected by development, both in terms of inundation depth and duration, as well as the total volume of water that passes through the bog. These factors may correlate to alterations in the characteristics of the bog.

6.3 Bog/Wetland Bioretention Sizing Results

The results of conceptual bioretention sizing for Queen's Bog and Southeast 24th Street Wetland Complex are provided below.

6.3.1 Queen's Bog

An iterative process of sizing each bioretention area in WWHM to meet, or exceed, a long-term treatment volume of 91% was conducted. The results of this process are shown in Table 6-10.

Table 6-10. Queen's Bog Bioretention Area Sizing

Outfall Number	**Total Drainage Area** ***(acres)***	**Bioretention Area** ***(sq. feet)***	**Bioretention Dimensions Length** ***(feet)*** **by Width** ***(feet)***	**Water Quality Volume Treated** *(percent of long-term runoff volume)*
1	8.26	1,250	50 x 25	91.1
2	6.39	1,000	50 x 20	93.8
3	7.20	1,250	50 x 25	93.4
4	8.10	1,500	50 x 30	92.9
5	25.66	2,500	50 x 50	91.2

Bioretention areas were sized to treat the drainage area tributary to the discharge location indicated in Figure 6-1. Placement upgradient of the discharge location was not considered for modeling; however, bioretention area footprints may be optimized if not placed at the discharge location.

6.3.2 Southeast 24th Street Bog

An iterative process of sizing each bioretention area in WWHM to meet, or exceed, a long-term treatment volume of 91% was conducted. The results of this process are shown in Table 6-11.

Table 6-11. Southeast 24th Street Bog Bioretention Area Sizing

Outfall Number	**Total Drainage Area** ***(acres)***	**Bioretention Area** ***(sq. feet)***	**Bioretention Dimensions Length** ***(feet)*** **by Width** ***(feet)***	**Water Quality Volume Treated** *(percent of long-term runoff volume)*
1	13.05	500	50 x 20	91.1
3	1.28	200	20 x 10	94.3
5	7.46	800	40 x 20	92.7
6	3.66	800	40 x 20	94.7
7	2.98	400	20 x 20	92.2

Bioretention areas were sized to treat the drainage area tributary to the discharge location indicated on Figure 6-2. Placement upgradient of the discharge location was not considered for modeling; however, bioretention area footprints may be optimized if not placed at the discharge location.

6.4 Conceptual Roadway StormFilter® Sizing Results

The conceptual StormFilter® cartridge sizing for subcatchments identified along East Lake Sammamish Parkway and Southeast 43rd Way is summarized below.

Table 6-12 presents the off-line water quality flow rates determined using WWHM for the average drainage area of each roadway segment and the number of StormFilter® cartridges needed to satisfy the design flow rate requirement. Note, StormFilter® quantities are rounded up to the nearest whole number.

Table 6-12. StormFilter® Sizing for Average Drainage Area

Location	**Off-line Water Quality Flow Rate**		**StormFilter® Cartridge Quantities**		
	(cfs)	*(gpm)*	**12-inch Model**	**18-inch Model**	**27-inch Model**
East Lake Sammamish Parkway	0.02	8.2	2	2	1
Southeast 43rd Way	0.04	16.2	4	3	2

The non-rounded StormFilter® quantities for the average drainage area were used to calculate the StormFilter® quantities by subcatchment. Subcatchments correspond to those labeled in Figure 6-3. Results for East Lake Sammamish Parkway and Southeast 43rd Way are provided in Table 6-13 and Table 6-14, respectively.

Table 6-13. East Lake Sammamish Parkway StormFilter® Cartridge Quantities

Subcatchment ID	**Drainage Area**		**StormFilter® Cartridge Quantities**		
	[ft^2]	**[ac]**	**12-inch Model**	**18-inch Model**	**27-inch Model**
0	12,957	0.30	3	2	2
1	29,438	0.68	7	5	3
2	7,859	0.18	2	2	1
3	7,923	0.18	2	2	1
4	6,745	0.15	2	2	1
5	7,698	0.18	2	2	1
6	7,602	0.17	2	2	1
7	7,349	0.17	2	2	1
8	3,653	0.08	1	1	1
9	1,771	0.04	1	1	1
10	3,621	0.08	1	1	1
11	5,192	0.12	2	1	1
12	16,769	0.38	4	3	2
13	5,580	0.13	2	1	1
14	6,815	0.16	2	2	1
15	6,540	0.15	2	1	1
16	6,561	0.15	2	1	1
17	6,543	0.15	2	1	1
18	6,583	0.15	2	1	1
19	6,507	0.15	2	1	1
20	3,328	0.08	1	1	1
21	1,625	0.04	1	1	1
22	3,371	0.08	1	1	1
23	4,981	0.11	2	1	1

Table 6-14. Southeast 43rd Way StormFilter® Cartridge Quantities

Subcatchment ID	**Drainage Area**		**StormFilter® Cartridge Quantities**		
	[ft^2]	**[ac]**	**12-inch Model**	**18-inch Model**	**27-inch Model**
0	17,928	0.41	5	3	2
1	4,186	0.10	2	1	1
2	6,547	0.15	2	2	1
3	7,532	0.17	2	2	1
4	9,804	0.23	3	2	2
5	3,976	0.09	1	1	1
6	4,354	0.10	2	1	1
7	4,055	0.09	2	1	1
8	4,790	0.11	2	1	1
9	3,417	0.08	1	1	1
10	11,643	0.27	3	2	2
11	8,914	0.20	3	2	1
12	7,112	0.16	2	2	1
13	72,242	1.66	18	12	8
14	5,588	0.13	2	1	1
15	3,987	0.09	1	1	1
16	53,587	1.23	14	9	6
17	13,865	0.32	4	3	2
18	14,432	0.33	4	3	2
19	16,253	0.37	5	3	2
20	6,336	0.15	2	2	1
21	6,037	0.14	2	1	1

7. PRIORITIZATION AND PROJECT DEVELOPMENT

7.1 Prioritization

Sites identified with opportunities for improvement in Section 5.2 were prioritized using metrics from the City of Sammamish that City Council established through adoption of Resolution (R2016-688; City of Sammamish, 2016a). The City's Capital Improvement Project (CIP) Prioritization ranks projects based on five criteria: (i) environmental benefit, (ii) facility/maintenance improvements, (iii) safety, (iv) population benefitted, and (v) time-sensitive opportunity.

7.1.1 CIP Prioritization Criteria

Each criterion presents a question to the reviewer which returns a quantitative value based on the response.

Environmental Benefit (30 Points)

Question: What is the project's ability to protect, restore, or improve natural watershed function(s)?

Scoring:

	Points		
Large Area	15	25	30
Small Area	10	20	25
	1	2	3+
	Number of Watershed Functions		

Facilities and Maintenance (25 Points)

Question 1: Does the project repair or build/retrofit stormwater facilities to address current or projected impacts of growth and climate change? (15 Points)

Scoring 1:

Number of Impacts Addressed	Points
0	0
1	5
2	10
3+	15

Question 2: Will this project provide a long-term, cost-savings solution to an on-going maintenance problem? (10 Points)

Scoring 2:

	Points
No	0
No, but costs are reduced	5
Yes, minor maintenance issue	5
Yes, permanently resolves	10

Safety (25 Points)

Question: Does the project address a safety risk?
Scoring:

Frequency	High	Medium Priority (5-15 Points)	High Priority (25 Points)
	Low	Low Priority (0 Points)	Medium Priority (10-20 Points)
		Minor Safety Impact	Severe

Population Benefited (10 Points)

Question: How many citizens does the project benefit?
Scoring:

Number of Citizens Benefited	Points
<5	0
5-50	5
>50	10

Time-Sensitive Opportunity (10 Points)

Question: Can the project take advantage of an opportunity that might not otherwise exist?

Scoring:

	Points
No link to other projects, City must fund project entirely	0
Moderate chance of leveraging other funding, some partnering opportunities	5
Project may not happen without this opportunity	5

7.1.2 Project Prioritization

Project prioritization was completed by City staff in August 2021. Table 7-1 presents a scoring matrix that summarizes the prioritization.

Table 7-1. Project Prioritization Matrix

Project	Environmental Benefit (30)	Facility/Maintenance Improvements (25)	Safety (25)	Population Benefited (10)	Time-Sensitive Opportunity (10)	Total (100)
Queen’s Bog Bioretention	30	15	0	10	10	65
SE 24th Street Wetland Complex Bioretention	25	10	0	10	0	45
Issaquah-Pine Lake Road Crossing Engineered Hyporheic Zone Augmentation	20	5	0	10	10	45
SE 43rd Way Roadway Stormwater Treatment	20	5	0	10	5	40
East Lake Sammamish Parkway Roadway Stormwater Treatment	20	5	0	10	0	35
Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration	25	0	0	10	0	35

7.2 Conceptual Design

Schematics were prepared for the six projects identified to provide a visual depiction of the proposed design. Siting of proposed infrastructure was intentionally omitted from these designs to provide future flexibility in advancement and funding of these projects. A planning-level cost estimate was produced to accompany each design to give an estimated magnitude of cost for the project. Key benefits, challenges, capital costs, and annual operations and maintenance costs are provided in Table 7-2.

Table 7-2. Conceptual Design Summary

Project	Benefits	Challenges	Costs	
			Capital	Annual O&M
Queen’s Bog Bioretention	Protects the rare ecosystem present in Queen’s Bog Provides a pleasant aesthetic for citizens to enjoy Uses existing open space to reduce development impacts to surrounding area	Existing pipeline right of way Potential utility conflicts	$545k (5 systems)	$10.3k (5 systems)
SE 24th Street Wetland Complex Bioretention	Would improve water quality and hydrology in the SE 24th Street wetland complex	Siting of bioretention areas Possible utility conflicts	$197k (5 systems)	$3.8k (5 systems)
Issaquah-Pine Lake Road Crossing Engineered Hyporheic Zone Augmentation	Provides water quality benefits to downstream reaches Reduces water temperature of creek Can be paired with IPL Road widening project to reduce capital cost Grant opportunities may offset costs	Relatively new practice – no established design guidance Long-term maintenance costs unknown	$64k	$1k
SE 43rd Way Roadway Stormwater Treatment	Provides stormwater treatment to roadway runoff not currently treated	Limited working area in ROW	$38k (per catch basin)	$400 (per catch basin)

Project	Benefits	Challenges	Costs	
			Capital	Annual O&M
	Requires minimal existing infrastructure for installation	Lack of curb and gutter may contribute high sediment levels to catch basins		
East Lake Sammamish Parkway Roadway Stormwater Treatment	Provides stormwater treatment to roadway runoff not otherwise treated Requires minimal existing infrastructure for installation	Limited working area in right of way Wetlands adjacent to roadway in some areas	$38k (per catch basin)	$400 (per catch basin)
Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration	Reduced exposure to sunlight results in decreased water temperature in channel and downstream to support aquatic life Provides pleasant aesthetic for residents	Property and maintenance agreements	$163k	$1.4k

Conceptual design cut sheets are provided in Appendix F.

7.3 Implementation

Conceptual project designs require further design development and funding before projects may be implemented. Funding may be achieved via means internal and/or external to the City. Projects demanding timely attention may seek funding by the City as capital improvement projects; however, external partnerships and organizations should be considered for funding opportunities. External funding sources may include nonprofits, educational organizations, county and state grants, and many others. Further, funding for all projects is not necessary to provide benefit to the basin; implementation of any of the proposed projects will provide benefits to the health of the basin. Once funding is secured, projects may be designed further and sited for construction.

8. CONCLUSION

The Laughing Jacobs Basin supports unique and somewhat rare natural habitats, such as sphagnum-dominated peatland (bog) wetlands, as well as unique species, such as the imperiled late-run Lake Sammamish Kokanee. These elements are present despite substantial single- and multi-family residential and commercial development within the basin. While development has occurred, critical areas such as wetlands and riparian buffers have generally been excluded from development and thus are relatively intact.

Although basin-wide impervious surfaces are at or near thresholds for degradation, the basin generally does not show significant stream channel erosion and downcutting or increased peak flow magnitudes, durations, and frequencies. This lack of a significant negative ecological response to development is likely due to several factors, including the prevalence of several wetlands and wetland complexes within the basin combined with the presence of Laughing Jacobs Lake. These elements can serve to mitigate hydrologic and water quality effects.

It is anticipated that pressure for future intensification of land use is generally low, and that changes would occur incrementally over many years. However, past land use activities and infrastructure development have degraded wetland areas, with key alterations including fill (and excavation cut) for roadway and utility crossings, discharge of untreated (or undertreated stormwater), and ditching with linear swales intended to facilitate drainage. Current degradation provides an opportunity for wetland restoration, including a focus on water quality enhancement, additional canopy and shading, and improvement of habitat functions.

Water quality monitoring and sampling, hydrologic modeling, and citizen feedback helped shape the conceptual projects proposed to address these opportunities. Environmental benefits attributed to the projects include water quality improvement, climate change resilience, and carbon storage among others. A rough order of magnitude estimate shows a total cost of approximately 2.7 million dollars. The use of grants, other external funding sources, and incremental City financing may provide a viable, cost-effective means to implementing these projects. While implementation of each of the proposed projects is ideal, any number of these projects may provide substantial benefit to the health of the Laughing Jacobs Basin.

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APPENDIX A

Project Management Plan

Prepared for

City of Sammamish
801 228th Ave. SE
Sammamish, WA 98075

Project Management Plan

Laughing Jacobs Basin Plan

Prepared by

Geosyntec consultants
engineers | scientists | innovators

520 Pike Street, Suite 2600
Seattle, Washington 98101

Project Number: PNW0373

22 March 2019

DRAFT

TABLE OF CONTENTS

LIST OF APPENDICES

1. PROJECT PURPOSE AND OBJECTIVES

The purpose of the Laughing Jacobs Basin Plan is to characterize current physical, biological, and water quality conditions in the basin and to identify projects and programs that will benefit the basin and local residents. This plan will balance the high value features of the basin, while addressing drainage concerns. The result will be an adoptable basin plan that reflects the community's values, while providing actionable recommendations which focus limited City of Sammamish (City) resources to where they are needed most.

The specific project objectives are:

- Watershed characterization, including regulatory drivers, incorporating existing data, and providing new data from water quality monitoring, stream and wetland hydrology monitoring, geomorphic surveys, fish passages, basin and sub-basin delineation, and channel cross-sections;
- Solicit public feedback and community involvement via survey feedback and public meetings;
- Problems and opportunities identification, defining values and providing risk analysis;
- Targeted modeling and alternatives development, considering natural systems, linkages, and infrastructure;
- Capital Improvement Project (CIP) identification and prioritization; and
- Delivery of a final basin plan which provides a transparent documentation of processes, decisions, and proposed projects

2. PROJECT ORGANIZATION

The Laughing Jacobs Basin Plan will be managed and operated as a series of Topic Areas. Each Topic Area will be directed by a Topic Area Lead who will utilize support staff from the three consultant teams to accomplish project objectives and produce deliverables. The Basin Planning Core Team will function to provide collaboration and representation of consultant teams from the three project managers, each representing the three consultant teams. The Consultant Project Manager will manage the Plan and provide work products to the City Project Manager. The project organization chart, identifying staff and responsibilities is shown in Figure 1. Additional information on roles and responsibilities is provided in Section 2.1 below.

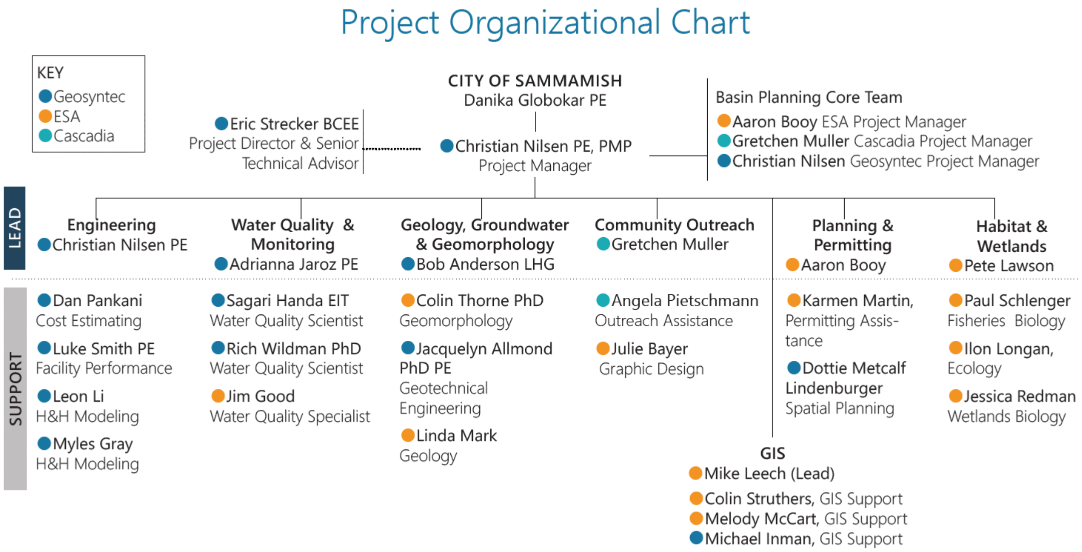


Figure 1. Project Organization Chart

2.1 Roles and Responsibilities

The roles and responsibilities of key staff are presented below in Table 1.

Table 1. Roles and Responsibilities

Role	Name	Responsibilities
City Project Manager	Danika Globokar	▪ Reviews and approves work. Provides project direction and guidance. ▪ Makes decisions related to day-to-day project execution. ▪ Elevates project issues to City Management as needed.

City Project Director	Tawni Dalziel	▪ Oversees City Project Manager. ▪ Ensures project conforms with City-wide stormwater goals and objectives.
City Public Works Maintenance Lead	Dan Johnson	▪ Provides input to City Project Manager on known stormwater infrastructure and maintenance issues. ▪ Provides feedback to City Project Manager on developed CIPs maintenance needs, or alternative solutions.
City Stakeholder PMs	Shelby Perrault, Jed Ireland	▪ Manage concurrent projects within the City; Klahanie Park Master Plan and Issaquah-Pine Lake Rd, respectively. ▪ Coordinate with City Project Manager to communicate status of their projects, hear about Laughing Jacobs Basin Plan project, and integrate recommendations as possible.
City of Issaquah Lead	Allen Quynn	▪ Represents City of Issaquah interests ▪ Provides input to City Project Manager ▪ Reviews work products as needed
Consultant Project Manager	Christian Nilsen, Geosyntec	▪ Leads consultant team. ▪ Coordinates project execution with subconsultants. ▪ Controls consultant budget and schedule. ▪ Elevates project issues to Project Director as necessary.
Consultant Project Director	Eric Strecker, Geosyntec	▪ Oversees Consultant Project Manager. ▪ Ensures project conforms to Quality Assurance Plan.

Basin Planning Core Team	Christian Nilsen, Geosyntec Aaron Booy, ESA Gretchen Muller, Cascadia	▪ Primary points of contact for the City. ▪ Oversee day-to-day project execution within respective firms. ▪ Provide advice and direction for the project. ▪ Responsible for invoicing and budget control.
Topic Area Leads	Christian Nilsen, Adrianna Jarosz, Bob Anderson, Gretchen Muller, Aaron Booy, Pete Lawson, Mike Leach	• Coordinates technical work for Topic Area • Performs senior review on interim and final work products • Ensures that the quality control plan is followed

3. SCHEDULE

The Laughing Jacobs Basin Plan will extend from March 2019 through December 2020. An overview of the schedule is presented in Table 2. A detailed schedule has been prepared by the Consultant Project Manager in Microsoft Project and will be maintained for the duration of the project. The schedule is subject to change upon approval by the City Project Manager.

Table 2. Schedule Overview

Task	Performance Period
Task 1. Project Management	March 2019 – December 2020
Task 2. Watershed Characterization	March 2019 – August 2019
Task 3. Public Outreach Support	March 2019 – April 2020
Task 4: Water Quality Monitoring	May 2019 – December 2020
Task 5: Problems and Opportunities Identification	May 2019 – June 2019

Task 6: Modeling	September 2019 – January 2020
Task 7: Project Identification and Prioritization	October 2019 – November 2019
Task 8: Conceptual Design	November 2019 – June 2020
Task 9: Basin Plan Report	June 2020 – December 2020

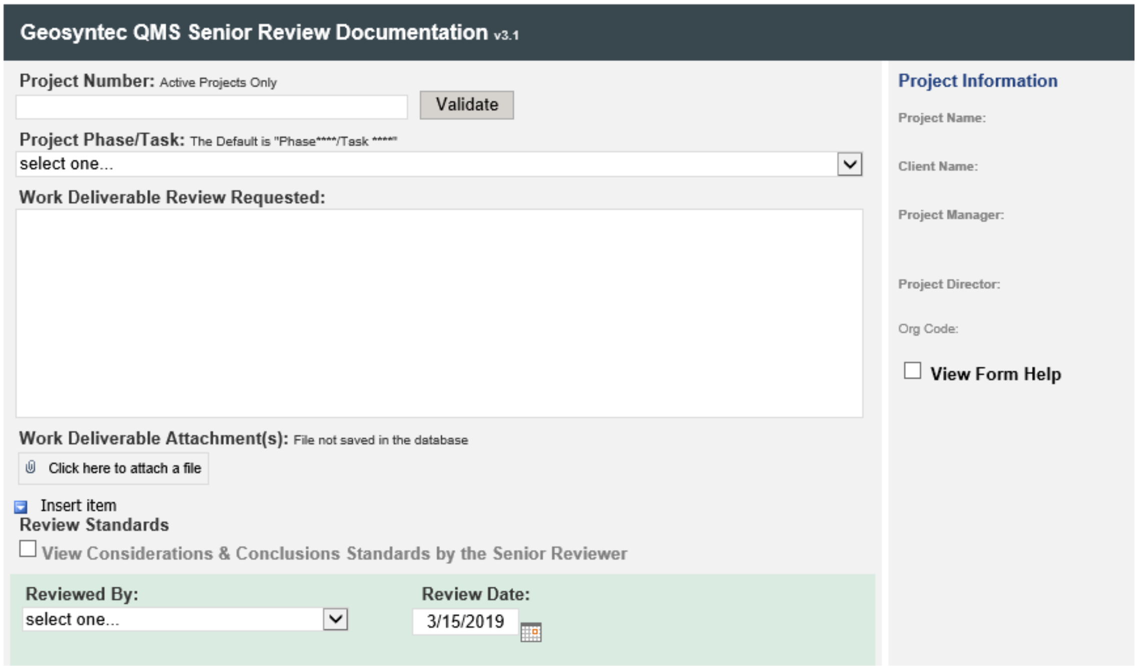
4. QUALITY CONTROL

4.1 Quality Control and the Role of Quality Management

Quality control is the implementation of activities identified as a component of a broader quality management plan. Each consultant company on the Laughing Jacobs team has an established quality management plan specific to the company's services. Peer and senior reviewers of work products will adhere to their organization's individual quality management process.

The role of the project quality control plan is to specify a framework for ensuring that quality management processes are being implemented for work products delivered to the City.

For example, Geosyntec's Quality Management Plan specifies the use of an internal Quality Management System (QMS) for both peer review and senior review. See Figure 2. A copy of Geosyntec's Quality Management Plan can be provided to the City upon request.



Geosyntec QMS Senior Review Documentation v3.1

Project Number: Active Projects Only

Validate

Project Phase/Task: The Default is "Phase****/Task ****"

select one...

Work Deliverable Review Requested:

Work Deliverable Attachment(s): File not saved in the database

Click here to attach a file

Insert item

Review Standards

☐ View Considerations & Conclusions Standards by the Senior Reviewer

Reviewed By: select one...

Review Date: 3/15/2019

Project Information

Project Name:

Client Name:

Project Manager:

Project Director:

Org Code:

☐ View Form Help

Figure 2. Example Quality Control Documentation from the Geosyntec Quality Management System

4.2 Project Quality Control Plan

Work products will undergo a tiered review process to ensure technically-sound deliverables of known and documented quality. In agreement with induvial organizations' quality management processes, the project quality control plan consists of the following steps:

4.2.1 Interim Work Products

Interim work products will undergo the following quality control steps:

1) Peer Review Technical reviewers within Topic Areas will provide initial peer review of interim work products. This review will include the use of appropriate documentation for modeling and technical work products.

2) Senior Review	Interim work products will be provided to Topic Area Leads for review. Topic Area Leads will be responsible for following the applicable quality management plan of their home organization.
3) Consultant PM Review	The Consultant Project Manager will review deliverables for consistency and will verify that applicable quality control has been documented. The Consultant PM will then deliver interim work products to the City Project Manager.
4) City Review	The City Project Manager will coordinate review with City staff and compile comments into one unified set. Comments and revisions will then be delivered to the consultant project manager.

4.2.2 Final Work Products

Final work products will undergo the following quality control steps:

1) Revised Work Product	Consultant Project Manager will distribute City comments to applicable Topic Area Leads for revision and response to comments.
2) Senior Review	Topic Area Leads will provide review of final work products and will document that quality control procedures were followed.
3) Consultant PM Review	The Consultant Project Manager will review final work products and will verify that applicable quality control has been documented. The Consultant PM will then deliver final work products to the City Project Manager.
4) Delivery to City	The City will receive consistent final work products with known and documented quality.

5. COMMUNICATION

5.1 Project SharePoint Site

Geosyntec will establish a centralized project SharePoint site consisting of a document library, project schedule, contact information, and announcements. This site will be regularly updated to communicate major milestones, schedule changes, and other relevant information.

5.2 Lines of Communication for Substantive Issues

In general, lines of communication should follow the organization chart shown in Figure 1 for substantive project issues. Substantive issues are defined as those issues that are not related to the day-to-day execution of the project scope of work. These include adjustments to project scope, schedule, and budget. The Consultant Project Manager will be the primary point of contact for the consultant team and the City Project Manager will be the primary point of contact for the City.

5.3 Lines of Communication for Day-to-Day Issues

Communications about day-to-day project execution are not required to go through formal lines of communication. Relevant decisions, scheduling of scoped activities, and other routine issues can be communicated directly with relevant team members. The Consultant Project Manager and relevant Topic Area Leads should be included in routine email communication.

6. STAKEHOLDER REGISTER

Project success will be subject to effectively engaging stakeholders through the project, based on their needs, interests, and potential impact. A detailed public outreach plan will be developed in Task 3. As a parallel effort, the project stakeholder register will be updated throughout the project to document the identification and engagement of internal and external stakeholders. The stakeholder register will be included as a standalone document on the project SharePoint site and will be updated as needed. The initial stakeholder register is shown in Table 3.

Table 3. Stakeholder Register

Stakeholder Category	Group/Department	Contact
Residents	Basin Residents	Developed through Public Outreach
	Citywide Residents	Developed through Public Outreach
	Individual Residents	Karen Herring
Internal City Stakeholders	City Council	All Members
	Parks	Anjali Meyer, Shelby Perrault
	Maintenance	Dan Johnson
	Inspection	Jeff Dickinson, Jim Kreig
	Development Review/Planning	Stephen Noeske
	Capital Projects	Andrew Zagars, Jed Ireland
	Transportation Master Plan	Doug McIntyre
	Sammamish Youth Board	Lynn Handlos
City of Issaquah	Parks and Recreation	Jennifer Fink, Chante Floreani
	New and Redevelopment	Doug Schlepp
	Communications	Autumn Monahan
Other Governmental Organizations	Sammamish Plateau Water	Jay Regenstreif
	Issaquah School District – Outreach/Maintenance	Dawn Wallace

Table 3. Stakeholder Register

Stakeholder Category	Group/Department	Contact
	Beaver Lake Management District	Tawni Dalziel
	Snoqualmie Tribe	McKenna Sweet-Dorman, David Steiner
	Kokanee Work Group	David St. John, Tawni Dalziel
	Washington State Department of Ecology	TBD
	King County	TBD
Non-Government Organizations	Sammamish Stormwater Stewards	Sharon Steinberg
	Kempton Downs Homeowners Association	TBD
	Klahanie Homeowners Association	Bonnie Anderson
	Trout Unlimited	David Kyle
	Master Builders Association	TBD

Appendix A

Detailed Scope of Work

Task 1	Project Management
1.1	**Project coordination** Project coordination will include communications with the City of Sammamish (City) Project Manager and the consultant team; scheduling and oversight of the various project activities; and budget and schedule tracking and oversight, including preparation of monthly invoices and progress reports. Consultant will develop a master project schedule. Throughout the project, Consultant will maintain and update the master schedule, updating the City and project team as necessary.
1.2	**Project charter and project management plan** Consultant will develop a project charter prior to the kick-off meeting in coordination with the City. Upon approval of the project charter Consultant will develop a project management plan (PMP) specific to the Laughing Jacobs Basin project. Subconsultant leads and topic area leads will be allocated time to review The PMP will contain the following sections: Schedule Budget Quality Control Plan Communication Plan Stakeholder Register
1.3	**Project meetings** A project kick-off meeting will be held with key Consultant team members and City staff. The Consultant Project Manager will develop the agenda, prepare and provide copies of all necessary materials; take notes and provide a meeting summary. Consultant will hold bi-weekly phone calls with consultant team and City Project Manager to discuss project progress, upcoming events and tasks, and any potential issues and remedies. Time is allocated for as-needed coordination calls with the consultant team.

Task Assumptions	2 hours are allocated for the kick-off meeting. 3 members of the Consultant team will participate. Bi-weekly phone calls will last for a maximum of 1-hour 20 hours of as-needed team coordination time is included.
Items Provided by the City	Project charter template. One set of comments on Project Charter One set of comments on Project Management Plan
Task 1 Deliverables	Monthly invoices Monthly progress reports delivered with invoices Master project schedule in Microsoft Project format Project charter Draft and final Project Management Plan Meeting agenda and meeting notes
2	**Watershed Characterization**
2.1	**Data Review** Consultant will review relevant information and data to evaluate existing conditions and summarize future conditions, identify data gaps, inform field investigations, and guide community involvement plan. The data will be reviewed in the context of identifying: Current and future regulatory drivers involving surface water, lakes, and wetlands; groundwater recharging and wellhead protection; fish and wildlife habitat protection; and geological hazards; Previous water quality monitoring locations and constituents; Present drainage patterns and modeled flows to understand how and where is surface and stormwater routed through the basin; Location and condition of existing stormwater facilities; Land use and characteristics in Laughing Jacobs Basin to evaluate current zoning, development and how future development may affect stormwater routing, hydrology, and stream habitat; Surface and subsurface geologic conditions, including landslides and erosion hazard areas, to evaluate how geology affects surface and subsurface flow, infrastructure, or habitat; Historic drainage complaints to identify flooding and erosion problem areas; and Natural areas, such as lakes, wetlands, streams, and riparian areas that require preservation or provide beneficial surface water functions.
2.2	**Stream and Geomorphic Evaluation**

	In order to characterize basin instream and geomorphic conditions, a field assessment will occur in representative accessible stream reaches. Within these reaches, primarily qualitative assessment techniques will be used to evaluate the following elements: General riparian vegetation conditions (type, size and maturity, prevalence of invasive species, relative canopy density, and approximate width of vegetation corridor adjacent to stream channel); Evidence of instream and hillslope erosion processes (incision, aggradation, and landslides); Approximate limits of perennial flow (if feasible, and subject to verification in late summer); Stream channel widths, gradients, and location/description fish passage barriers; Aquatic habitat conditions including general stream morphology (pools and riffles) and presence of large woody debris; Approximate locations of riparian wetlands, where noted, at a reconnaissance level – does not include data plots or formal delineations; Location, type, and size of stormwater outfalls, pipes, and groundwater seeps; Potential non-point pollution sources; General stream substrate conditions, including substrate size and relative embeddedness to characterize stream conditions and allow for estimates of Manning's roughness coefficients for future hydraulic models. Observed wildlife activity (e. g. presence of beaver dams, other wildlife or signs observed); General stream channel geometry estimates for input into future hydraulic models, if needed; Description and habitat conditions within stream mouth and delta, if accessible (if not, aerial photographs may be used as a substitute); and Photographs of existing conditions to be used for analysis and basin plan report. Field assessment of in-stream conditions will be completed only in accessible reaches, and will target lower reaches of Laughing Jacobs Creek (near the stream mouth and at E Lake Sammamish Parkway crossing; at the mapped natural fish passage barrier; downstream of 230th Way SE; and downstream of SE 42nd Street), middle reaches of Laughing Jacobs Creek and tributaries around Laughing Jacobs Lake; and upper reaches north of SE 32nd Street and into Beaver Lake Park (but not extending into the Beaver Lake Basin). Field assessment of stream and geomorphic conditions will be completed by a stream biologist and geomorphologist over four days.
2.3	**Upland Assessment** In addition to review and synthesis of existing data through subtask 2.1, overall biological and physical characteristics in the rest of the project area (outside the stream corridors) will be documented through targeted field visits by the team wetland ecologist, stormwater engineer, and/or technical leads(s) to identified wetlands, open spaces, road networks, and drainage flow patterns.

	The upland assessment will be completed to verify and further detail on-the-ground conditions at identified key upland and critical area locations within the basin, filling in identified gaps and furthering understanding from subtask 2.1 efforts. Field assessment of upland conditions will be completed over four days and will be coordinated with subtask 2.2 and 2.4 evaluation to ensure that the upland assessment activities are completed efficiently and provide integrated information on the basin's natural environment, drainage infrastructure, and overall surface and groundwater resource conditions.
2.4	**Groundwater Evaluation** Consultant will perform a desktop evaluation of groundwater resources and constraints in the Laughing Jacobs basin. The following information will be reviewed under this task: Critical Aquifer Recharge Areas Wellhead Projection Plan Surface and subsurface geology maps Local and regional groundwater planning efforts
2.5	**Spatial Analysis** Relying on key existing geospatial data sets identified in subtask 2.1 and additional evaluation and assessment completed in subtasks 2.2, 2.3. and 2.5, the consultant team will complete spatial analysis and generate condition summary matrices and basin exhibits. Assembly and analysis of geospatial information by the Consultant team will be primarily focused on tabular review of input data layers provided by the City or available from other identified sources. Preparation of the map/exhibit folio for the basin study area will be limited to a maximum of five exhibits to be determined in coordination with the City during Task 2 efforts. Each exhibit theme will display related geospatial data to support the Watershed Characterization memo; for example, exhibit themes could include: surface waters & storm drainage infrastructure; channel geomorphology & surficial geology; wetlands/wildlife habitats; existing land use/land cover; etc.
2.6	**Watershed Characterization Memo** Consultant will develop a draft watershed characterization technical memorandum that summarizes information developed in Task 2.
Assumptions	Preparation of the map/exhibit folio for Task 2 will be limited to a maximum of 6 exhibit themes to be determined in coordination with the City during task 2 efforts. City Project Manager will coordinate comments from other city staff to deliver one set of unified comments to be addressed. Consultant will address comments during Task 9. Documents will be delivered in electronic format.

Items Provided by the City	Project charter template. One set of comments on Project Charter One set of comments on Project Management Plan
Task 2 Deliverables	Draft Watershed Characterization TM Photolog of field activities delivered as an appendix to TM
3	**Public Outreach Support**
3.1	**Public Involvement Plan** Consultant will prepare a Public Involvement Plan (PIP) in consultation with the City and Consultant team that includes: public outreach goals and objectives key messages stakeholder identification detailed strategies and tactics by target audience, and engagement timeline.
3.2	Survey and Stakeholder Briefing Support Consultant will: Develop a survey to inform community priorities and preferences. Support the City for one (1) meeting/briefing with the City Council Prepare for and attend a stakeholder meeting with Sammamish Plateau Water and Sewer District Provide key messages, talking points, and anticipated Q&A for stakeholder outreach and City Council engagement Develop a stakeholder outreach slide deck and project one-page summary flyer
3.3	**Public Meetings** In consultation with the City and Consultant team, Consultant will design and implement up to two (2) public meetings, aligned to coincide with key project milestones and opportunities for the public to provide input. Public Meeting activities will include: Development of meeting plans that describe goals and objectives, format, roles and responsibilities, key messages and planning timeline Coordinate and schedule meetings Design communication materials for each open house, including up to ten (10) display boards Design two (2) mailer/postcards for each open house event

	Prepare meeting announcements via US mail, local online publications, and on the project website Hold up to one (1) pre-public meeting prep session for each public meeting with key City and Consultant team staff Develop display boards for each public meeting Provide meeting supplies and basic materials such as sign-in sheets, nametags, comment forms, directional signage and agendas Staff public meetings including setup, registration and break down Collect and coordinate comments using Salesforce outreach and correspondence tracking software Prepare public meeting summaries
Task Assumptions	One round of review/one set of comments for each deliverable Up to two (2) Consultant staff will attend public meeting prep sessions Up to two (2) Consultant staff will attend public meetings
Items Provided by the City	One set of comments on PIP The City will pay directly for all venue rental fees and printing costs associated with public meeting notifications and meeting materials Project website hosting. The City will coordinate stakeholder meetings
Task 3 Deliverables	Deliverables under this task are: Task 3.1 Draft and final Public Involvement Plan Task 3.2 Public Involvement survey (conducted via email, online) PowerPoint slide deck for City Council and/or Mayor's Office PowerPoint slide deck for stakeholder briefing meetings Summary of survey findings One project flyer Up to two (2) web updates (one (1) draft and one (1) final per update) Development of comprehensive web updates at key project milestones Task 3.3 Two (2) public meeting plans, one for each (two (2) drafts, one (1) final of each) Attendance of up to two (2) Consultant staff at public meeting prep sessions, up to one (1) meeting per public meeting Attendance of up to two (2) Consultant staff at two (2) public meetings Two (2) public meeting summaries, one for each (two (2) drafts, one (1) final) Up to ten (10) total display boards, five (5) for each public meeting event (two (2) drafts and one (1) final) Two (2) postcards/mailers for public meetings, one (1) for each (two (2) drafts and one (1) final)
4	**Water Quality Monitoring**

4.1	**Sampling and Analysis Plan and QAPP** A Sampling and Analysis Plan (SAP) will be developed for monitoring. The SAP will include: • Discussion of previous investigations and previously collected data • Establishment of sampling objectives • Sampling design: sample locations, parameters/analytes of concern and methods • Field procedures and equipment • Notetaking protocols • Sample handling and custody procedures • Sample documentation The Quality Assurance Monitoring Plan (QAPP) will include the following components: • Identification of members of the QAPP team and assigned responsibilities • Schedule of tasks and project timetable • Data Quality Objectives (DQOs) • Quality controls requirements for field measurements and lab analysis • Methodology for data validation and usability
4.2	**Water Level Station Deployment** Up to 5 monitoring sites consisting of continuously logging pressure transducers will be deployed in the Laughing Jacobs Basin. Data from the pressure transducers will be downloaded periodically by field staff.
4.3	**Ongoing water quality sampling** Consultant will conduct ongoing water quality sampling in the Laughing Jacobs Basin. Specific parameters to be sampled will be identified in Task 4.1. For budgeting purposes assumed parameters are: • conventional parameters (pH, DO, temperature, turbidity, TSS), • nutrients (phosphorus, nitrogen) and • bacteria (fecal coliform, e. coli). Parameters required specialized laboratory methods, such as specific organics (PCB's, phthalate, etc) are not included.
4.4	**Reporting** Data collected will be summarized and delivered to the City at the conclusion of the project.

Task Assumptions	• City will secure necessary access agreements, coordinate with property owners, and coordinate with City of Issaquah as necessary to allow Consultant access to monitoring locations. • Monitoring equipment will be leased to the City of the duration of the project • Consultant will address and incorporate one round of comments in each annual monitoring report. • City Project Manager will coordinate comments from other city staff to deliver one set of unified comments to be addressed. • Documents will be delivered in electronic format. • Continuously logging monitoring equipment will be owned by consultant and will be leased to the City for the duration of the project. The total lease amount over the life of the project will be capped at the purchase price of the equipment.
Task 4 Deliverables	• Final SAP/QAPP • Monitoring report delivered at conclusion of project
5	**Problems and Opportunities Identification**

5.1	**Initial opportunities workshop**
	Consultant will lead an internal workshop consisting of consultant core team, select topic area leads, and City Staff. This workshop will synthesize information gathered from Tasks 2-4 and develop a preliminary list of potential problems and opportunities to be addressed.
	The following information will be incorporated:
	• Existing Sources and Studies
	    o Beaver dam locations
	    o Climate change
	    o Dam stability
	    o Flooding
	    o Regulatory environment
	    o Groundwater
	• Public Input
	    o Community values
	    o Stakeholder values
	    o Ongoing planning efforts
	• Watershed Characterization
	    o Erosion and Sedimentation
	    o Fisheries and aquatic habitat
	    o Wetland functions and values
	    o Water Quality
	Meeting results and decisions made will be summarized in a meeting summary to be delivered to participants.

5.2	**Field investigation** Consultant will perform a "windshield survey" of identified opportunities and problems to gather additional information about potential approaches. Consultant will prepare field notes and photographs as appropriate.
5.3	**Risk Analysis** Consultant will identify values and threats associated with preliminary opportunities and will perform a high-level risk analysis. Opportunities will be classified into risk categories to be used in project identification.
5.4	**Reporting** Consultant will prepare a brief technical memorandum summarizing information developed in Task 5.
Task Assumptions	• Consultant will address and incorporate one round of comments in the Task 5 memorandum. • City Project Manager will coordinate comments from other city staff to deliver one set of unified comments to be addressed. Comments will be incorporated in Task 9. • Documents will be delivered in electronic format.
Items Provided by the City	• Coordination, scheduling and venue for initial opportunities workshop • Attendance at field investigation and any access agreements
Deliverables	• Workshop agenda, meeting notes • Draft Problems and Opportunities TM
6	**Hydrologic and Hydraulic Modeling**
6.1	**Refine modeling approach** Based on information developed in previous tasks, consultant will develop a refined modeling approach to answer specific questions regarding identified problems, opportunities and potential solutions. Consultant will develop a brief technical memo that outlines specific needs and models to be developed.
6.2	**Hydrologic Modeling** Hydrologic modeling will focus on establishing existing and future rainfall-runoff relationships that will inform design of potential solutions. Time has been allocated for this task to perform continuous simulation modeling using the standard parameterization

	of the Western Washington Hydrology Model (WWHM) of select locations of the Laughing Jacobs Basin. Data will be developed from existing sources to be provided by the City or available for public download from other sources. If recommended during task 6.1, the publicly available Puget Sound Stormwater Heatmap may be used for data extraction or to augment existing data sources. These data include: • Slopes • Hydrologic Soil Groups • Landcover • Land use • Subwatershed boundaries
6.4	**Water Balance Evaluation** Time is allocated for development and implementation of a spreadsheet-based water balance to assess long term functions of wetland areas. Information to be developed in this task may include stage-storage relationships, soil infiltration, evapotranspiration, and rainfall.
6.6	**Modeling Memo** Consultant will prepare a draft modeling memorandum documenting assumptions, methodology and results from modeling tasks.
Task Assumptions	• The modeling approach will be refined based on the specific needs associated with proposed opportunities and projects. • Budget may be reallocated between subtasks of Task 6 at the direction of the City Project Manager upon recommendations in Task 6.1. • The refined approach (to be agreed to by City and Consultant) will form the basis of understanding for this task. • Not all sub-tasks may be utilized. • Hydraulic Modelling and Drainage Network modeling will not be performed unless identified as a need in task 6.1. If needed, the Consultant will allocate budget from other modeling tasks in coordination with the City.
Items Provided by the City	• One set of comments on Draft Modeling TM
Task 6 Deliverables	• Draft Modeling Approach TM • Modeling files and spatial data developed during Task 6

7	**Project Identification and Prioritization**
7.1	**Initial projects work session** Consultant will lead an internal workshop consisting of consultant core team and City Staff. This workshop will be used to present initial projects identified by the consultant and solicit feedback regarding feasibility, potential refinements, and additional solutions to consider. The range of initial projects is expected to include: • Capital projects • Operations and maintenance projects • New technologies • Programmatic solutions, including policy recommendations • Restoration and preservation, including habitat restoration • Additional or continued monitoring Information developed during this work session will be used to develop initial project descriptions and begin project prioritization.
7.2	**Prioritization of projects** Consultant will evaluate and rank projects using the prioritization framework developed above. An initial set of inputs (e.g., population affected, benefits, etc) will be developed, and used to develop an initial prioritization. Inputs related to costs will be developed at a high level to be refined during conceptual design. The initial prioritized list will be submitted to the City for comment and review. The final prioritized list will incorporate comments from the City along with more detailed cost information developed in Task 8.
Task Assumptions	• Consultant will address and incorporate one round of comments on the project prioritization inputs. Comments will be incorporated in Task 9. • City Project Manager will coordinate comments from other city staff to deliver one set of unified comments to be addressed. Consultant will address comments during Task 9.
Items Provided by the City	• Coordination, scheduling and venue for initial projects work session
Task 7 Deliverables	• Workshop agenda, meeting notes • Initial prioritized list of projects
8	**Conceptual Design**

8.1	**Initial sizing and layout** Consultant will perform initial sizing and layout of identified projects. Time is allocated for additional modeling runs to perform sizing of projects that treat or detain stormwater, affect stream power or sediment transport, or improve surface flooding. Initial sizing and layout of projects will be presented to the City for informal comment and review.
8.2	**Conceptual design development** Conceptual designs and planning-level cost estimates will be developed for proposed priority projects. Conceptual designs will include plan schematics with sufficient detail to support the development of City Capital Improvement Plans, Permit Applications, and Grant Applications. Maps will be produced to identify locations and connections to existing infrastructure, outfall locations, or other spatial locations. Planning-level costs estimates will include capital costs, engineering, permitting, regular operations and management, annual maintenance, and major maintenance activities. Conceptual designs will be delivered in the form of cut-sheets for proposed projects. These will include maps, conceptual schematics and planning-level costs. To the extent possible, the Puget Sound Stormwater Pollution Reduction Tool may be used to estimate project performance or estimate life-cycle costs.
8.3	**Basis of design memo** Consultant will prepare a draft basis of design memorandum documents assumptions, calculations, and other information used to prepare conceptual designs.
Task Assumptions	• Up to seven (7) projects will be brought to the conceptual design level. • Initial sizing and layout will be delivered in a PowerPoint slide deck. Comments from initial sizing and design will not be addressed in Task 8.1 but will be incorporated into the approach for Task 8.2. • Consultant will address and incorporate one round of comments in the basis of design memorandum. Comments will be incorporated in Task 9. • City Project Manager will coordinate comments from other city staff to deliver one set of unified comments to be addressed. Comments will be incorporated in Task 9. • Documents will be delivered in electronic format.
Items Provided by the City	• One set of comments on draft project cut-sheets. • One set of comments on basis of design memo.

Task 8 Deliverables	• Initial sizing and layout PowerPoint slide deck • Draft and final project cut-sheets • Draft basis of design memo
6	**Basin Plan Report**
10.1	**Draft and Final Report** Consultant will compile a basin plan report utilizing technical memoranda developed in previous tasks. Time is allocated for specific sections to be developed under this task: • Executive Summary • Introduction • Summary of Watershed Characterization • Summary of Public and Stakeholder Participation • Opportunities Identification • Project Prioritization • Conceptual Design • Implementation Plan • Conclusion • Appendices o Watershed Characterization o Modeling Appendix The implementation section will be developed around: 1) anticipated funding sources, and 2) key project partners / stakeholders. The implementation plan will identify key project benefits (including multiple benefits), anticipated outcomes, and opportunities to adaptively manage plan implementation based on alternative future scenarios (including climate change, growth, and funding streams).
10.2	**GIS Exhibits** Time is allocated for development of additional GIS exhibits to support the final basin plan report. Up to six (6) revised or additional exhibits will be developed under this task for inclusion in the final report.
Task Assumptions	• Consultant will address and incorporate up to two rounds of comments. • City Project Manager will coordinate comments from other city staff to deliver one set of unified comments for each round. • Draft and final documents will be delivered in electronic formats.
Task 10 Deliverables	• Initial Draft, Revised Draft, and Final report

APPENDIX B
Watershed Characterization

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206.789.9658 phone
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esassoc.com

draft memorandum

date August 23, 2019

to Danika Globokar, P.E., City of Sammamish Public Works

cc Christina Nilsen, P.E., Geosyntec Consultants

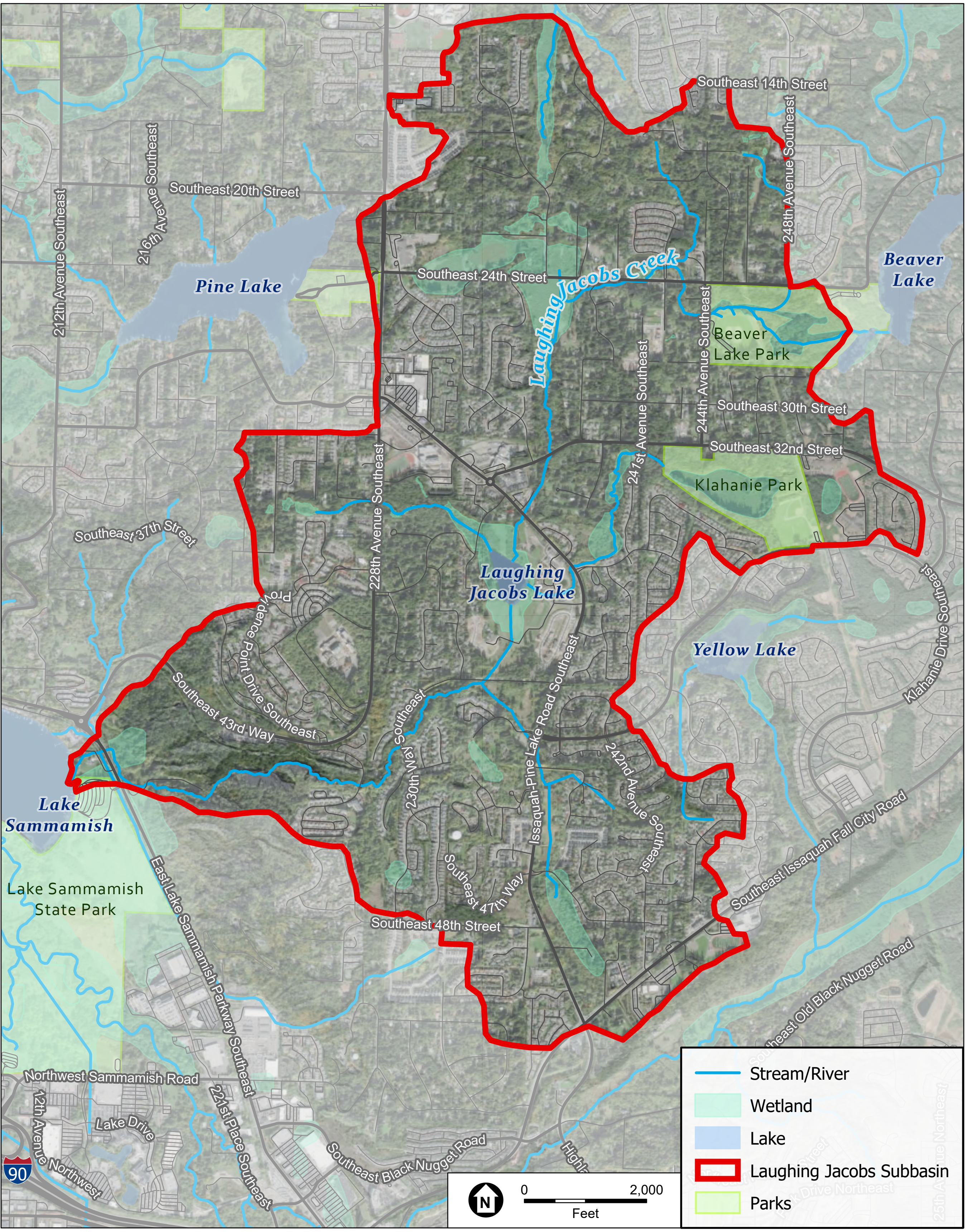
from Pete Lawson, Linda Mark, and Aaron Booy, ESA; and Christian Nilsen, Geosyntec Consultants

subject Draft Watershed Characterization for Laughing Jacobs Basin

Introduction

This memorandum is part of a planning effort being conducted by the City of Sammamish (City) in the Laughing Jacobs Basin. The Laughing Jacobs Basin is a watershed located on the southwest portion of Lake Sammamish, with the majority of the basin within the City while the lower portions of the basin, adjacent to the lake, are in the City of Issaquah. The purpose of the memorandum is to characterize current physical, biological, and water quality conditions in the Laughing Jacobs Basin. Content presented in this memorandum will be included as the future *Basin Characterization* chapter of the Laughing Jacobs Basin Plan Report.

The Laughing Jacobs Basin covers an area of approximately 4.1 square miles at the south end of the East Lake Sammamish Plateau (Figure 1); most of the basin is in the City, with a significant portion of the lower basin extending into the City of Issaquah, including the reaches of Laughing Jacobs Creek from River Mile (RM) 1.1 to the mouth of the stream within Lake Sammamish State Park. Although Beaver Lake and areas that drain to Beaver Lake are the headwaters for the Laughing Jacobs Basin, they are not included in the Laughing Jacobs Basin Plan, as the City is conducting a separate planning effort for this area.



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SOURCE: City of Sammamish, 2019; ESA, 2019.

City of Sammamish Laughing Jacobs Basin Plan

Figure 1
Overview Map of the Laughing Jacobs Basin

The primary riverine feature in the basin is Laughing Jacobs Creek, which has numerous tributary streams and is associated with a number of wetlands, including sphagnum bog wetlands. The following sections present background information, describe the regulatory drivers, characterize the watershed setting of the basin, and present the results of a field reconnaissance/site visit to evaluate the geomorphic, instream, riparian, and wetland habitat conditions in the basin.

Background

The following sections place the current evaluation into a larger context. They present information on previous studies and documents relevant to the current Laughing Jacobs Basin planning effort and describe the regulatory drivers for the plan, including applicable City of Sammamish and Washington state regulations.

Previous Studies

Numerous previous studies have been completed, focusing on the assessment and restoration of East Lake Sammamish tributary streams and the associated basin. The following provides a brief summary of key studies conducted to date:

- **Blueprint for the Restoration of Lake Sammamish Kokanee Tributaries (2014):** Completed by the Lake Sammamish Kokanee Work Group, this restoration plan uses best available science to identify and prioritize restoration projects and other actions focused on recovery of the native kokanee salmon population in Lake Sammamish. Laughing Jacobs Creek is identified as a “Category One Stream” for restoration, with rerouting and restoration of the lower stream reaches (from Han Jenson Park to the mouth) the primary restoration focus. The Kokanee Work Group is a partnership between local jurisdictions, agencies, tribes, community groups, and other kokanee advocates that was formed in 2007. The Blueprint is available online: https://www.kingcounty.gov/services/environment/animals-and-plants/salmon-and-trout/kokanee/kokanee-workgroup.aspx.

- **Ecological Survey of “Late-Run” Kokanee in Lake Sammamish, 2016 (published 2017):** Prepared by the Lake Sammamish Kokanee Work Group with technical support from King County Department of Natural Resources and Parks (DNRP), the study examines the recent status of the Lake Sammamish kokanee population and conservation efforts. The report is available online: https://your.kingcounty.gov/dnrp/library/2017/kcr2866/kcr2866-txt.pdf.

- **City of Issaquah State of Our Waters (2011):** This report was prepared by the City of Issaquah’s Public Works Engineering Department and Resource Conservation Office consistent with stream and surface water management objectives. The report details results of stream water quality monitoring conducted between 2009 and 2010 under an aquatic resource monitoring program. The report provides water quality data for reaches of Laughing Jacobs Creek below East Lake Sammamish Parkway and above the parkway. Water quality reported between 1998 and 2010 identified frequent exceedances of dissolved oxygen parameters for both monitored reaches, as well as exceedances for fecal coliform within the downstream reach. The report is available online: https://www.issaquahwa.gov/DocumentCenter/View/925.

- **City of Issaquah Stream and Riparian Areas Restoration Plan (2006):** This plan was prepared by The Watershed Company to support the City of Issaquah in identifying streams and associated riparian areas in need of restoration across the City. Three restoration opportunities were identified along the lower reaches of Laughing Jacobs Creek, all within Lake Sammamish State Park (immediately upstream of East Lake Sammamish Parkway in Hans Jenson Group Camp and downstream along the outlet channel). The plan is available online: https://www.issaquahwa.gov/index.aspx?NID=1046.

- **City of Sammamish Shoreline Master Program (SMP) Update, Final Shoreline Restoration Plan (2008):** Prepared by ESA Adolfson for the City as part of the Comprehensive SMP Update, this plan provides programmatic recommendations for restoring the shorelines of the City, including Lake Sammamish at the bottom of Laughing Jacobs Basin and Beaver Lake, at the headwaters of Laughing Jacobs Creek (and outside of the study area for this memo). The plan is available online: https://www.sammamish.us/government/departments/community-development/shoreline-master-plan-2011/.

- **Lake Sammamish State Park Wetland, Stream, and Lakeshore Restoration Plan (2005):** Prepared by the Watershed Company for Washington State Parks, the plan focuses on the identification of restoration opportunities for all critical habitats across the State Park. For areas at the bottom of Laughing Jacobs Basin, the plan calls for significant restoration of the extensive wetland extending south of the boat ramp and parking area; however, this earlier plan does not identify the currently conceptualized re-route of Laughing Jacobs Creek through this wetland. The plan is available online at: https://parks.state.wa.us/DocumentCenter/View/11225/02-Wetland-Stream-Lakeshore-Restoration-Plan-PDF.

- **Final East Lake Sammamish Basin and Nonpoint Action Plan (1994):** Prepared by the Issaquah/East Lake Sammamish Watershed Management Committee (lead effort by King County, with support from other stakeholders including the City of Issaquah), this plan provides an assessment of all drainages from the overall East Lake Sammamish Basin, and establishes recommendations consistent with the overall goals of: (1) reducing health and safety problems, (2) protecting the value of water bodies, and (3) reducing nonpoint pollution. The plan provides specific actions for mitigating effects of development, much of which has been subsequently built consistent with first King County and now Sammamish standards. The plan is available online at: https://your.kingcounty.gov/dnrp/library/1994/kcr910-01.pdf.

Regulatory Drivers

Surface Water

Water Quality Standards

Water quality standards for surface waters are dictated by the Washington Administrative Code (WAC) 173-201A. WAC 173-201A-200 dictates the criteria for temperature, dissolved oxygen, turbidity, total dissolved gas, pH, and bacteria, depending on the aquatic life and recreational use of the water body. In addition, general criteria for water supply and miscellaneous uses are described in this section of the WAC.

303(d) Impaired Waters

The State of Washington Department of Ecology (Ecology) assigns all waters in the state (except on tribal reservation land) to a numerical category ranging from 1 to 5, where Category 1 meets water quality criteria and the increasing numerical category indicates decreasing water quality. Water bodies in which water quality criteria are not persistently attained or where well-documented narrative evidence indicates impairment of a designated use by a pollutant are placed in Category 5. Water bodies placed in Category 5 are submitted to the U.S. Environmental Protection Agency (EPA) as 303(d)-listed water bodies. 303(d) is a section of the Clean Water Act that authorizes the EPA to assist states in listing impaired waters and developing Total Maximum Daily Loads (TMDLs) for these water bodies. TMDLs establish a maximum pollutant level in the water body that must be attained to restore water quality.

WAC 173-201A-200 defines the designated uses for protection in fresh surface waters of the state. Laughing Jacobs Creek is classified as core summer salmonid habitat, where the key identifying characteristics are summer (June 15–September 15) salmonid spawning or emergence, or adult holding; use as important summer rearing habitat by one or more salmonids; or foraging by adult and subadult native char. Other common characteristic aquatic life uses for waters in this category include spawning outside of the summer season, rearing, and migration by salmonids. The aquatic life temperature criteria for this use classification is a 7-day average of the daily maximum temperatures (7-DADMax) of 16°C or less.

Groundwater

Wellhead Protection Areas

Wellhead protection areas (WHPAs) in Washington must be delineated for each well used by a water system for domestic supply as part of a required wellhead protection program (WHPP). WHPPs are required under WAC 246-290-135 Source Water Protection. A WHPA must be delineated for each well with a 1-, 5-, and 10-year time of travel boundary marked using recognized methods, such as guidance from the Washington State Department of Health or the EPA.

Critical Aquifer Recharge Areas

Critical Aquifer Recharge Areas (CARAs) within the Laughing Jacobs Basin must be established to abide by municipal codes established by the City of Sammamish and the City of Issaquah. These CARAs are critical areas that must be protected such that the integrity of groundwater quality is conserved. The City of Sammamish provides development standards for developments located within CARAs under Sammamish Municipal Code (SMC) 21A.50.280 Critical Aquifer Recharge Areas – Development Standards. The City of Issaquah provides development and protection standards for CARAs under Issaquah Municipal Code 13.29 Groundwater Quality Protection Standards. Both regulations require demonstration that contaminants will not enter the aquifer caused by the development activity.

City Ordinances and Plans

Environmentally Critical Areas Ordinance

Required under the Washington State Growth Management Act (GMA), the City regulates wetlands, streams, and other fish and wildlife habitat areas, geologically hazardous areas, critical aquifer recharge areas, and frequently flooded areas through the Environmentally Critical Areas Ordinance (SMC Chapter 21A.50). Standards for the protection of these resources as new development, expansions, and redevelopment occur is integral to the City's approach for managing natural areas and water resources. Standards for critical areas are also established for the City of Issaquah.

The Environmentally Critical Areas Ordinance works to:

(1) Restrict inappropriate development activities within resource areas.

(2) Require buffers and/or setbacks around wetlands, streams, and landslide hazard areas.

(3) Implement development standards to ensure that adjacent development avoids indirect impacts.

(4) Require mitigation for unavoidable impacts.

Generally, within the Laughing Jacobs Basin and throughout the City, stormwater runoff from developed areas eventually discharges to receiving waters, including tributary streams and wetlands. Development built before current standards were in place for stormwater management and critical areas typically discharges undetained and/or untreated stormwater, with facilities and outfalls located within wetlands and/or immediately adjacent stream and wetland buffers. In comparison, newer developments have implemented measures to detain and treat runoff, and facilities have been located farther away from wetlands and streams.

Stormwater Capital Improvement Plan (2017 – 2022)

In 2016, the City adopted a Stormwater Capital Improvement Plan (CIP) for a 6-year period from 2017 to 2022. The Stormwater CIP was passed by Resolution R2016-688, and identified stormwater components of planned City Transportation Improvement Projects, as well as prioritized stormwater projects and programs. Prioritization of sequenced basin planning efforts is a key aspect of the Stormwater CIP, with this Laughing Jacobs Basin planning effort identified for completion in 2020. Other prioritized project types include culvert fish passage improvements, stormwater conveyance tightlines, and facility retrofit projects. A programmatic fund is also established for projects "to mitigate the negative effects of the beaver population and beaver dams in the City."

Storm and Surface Water Management Comprehensive Plan

The Storm and Surface Water Management Comprehensive Plan (SSWMCP) was developed and adopted by the City in 2016, and is the "functional document that provides direction for management of the City's surface and stormwater system" aimed at meeting community and City goals for health and sustainability. The SSWMCP elaborates on goals of the City's general 2015 Comprehensive Plan (detailed below), steering the City to achieve its overall objectives of environmental and community health in protection and management of water resources. The plan also provides the primary framework through which the City ensures consistency with National Pollutant Discharge Elimination System (NPDES) permit requirements. The following are goals of the SSWMCP:

- **Goal 1 (G.1)** – Comprehensively evaluate and address problems related to the existing stormwater system and manage storm and surface water systems to ensure longevity of assets.
- **Goal 2 (G.2)** – Use drainage basin planning to allocate limited resources to address priority problems and opportunities.
- **Goal 3 (G.3)** – Promote surface and stormwater education and outreach.
- **Goal 4 (G.4)** – Promote the recovery of Lake Sammamish kokanee and other threatened or endangered salmonids.

- **Goal 5 (G.5)** – Prepare a multiyear list of Capital Improvement Projects that address the City's storm and surface water priorities.
- **Goal 6 (G.6)** – Promote City-wide compliance with storm and surface water regulations.
- **Goal 7 (G.7)** – Coordinate surface and stormwater management services with neighboring jurisdictions.
- **Goal 8 (G.8)** – Develop storm and surface water rates and charges based on present and future revenue needs.

Along with these goals and presenting the detailed stormwater management program, the SSWMCP provides an overview of existing natural resources and infrastructure conditions across the City, anticipated future conditions, and recommendations for moving forward.

Sammamish Comprehensive Plan

The City's Comprehensive Plan (developed and adopted in 2015; most recently amended in 2018) includes goals and policies that are directly relevant to the management of surface water resources and stormwater infrastructure. These goals and policies, and the implementing framework provided by the 2016 SSWMCP, provide primary policy and planning direction for all of the City's basin planning efforts.

The primary goals and associated policies for surface and stormwater management are included in the Environmental Conservation, Utility, and Capital Facilities elements:

- **Environmental Conservation Goals EC.2, EC.3, and EC.5** focus on protecting surface water, groundwater, wetlands, and other natural resources from degradation, recognizing that these resources serve the community and enhance the quality of life.

- **Utility Goal UT.6** encourages water conservation and the protection of water quality.

- **Capital Facilities Goal CF.4** directs the City and other utility agencies to design and locate capital facilities so as to support the environment and achieve sustainability.

Watershed Setting

This section identifies ecosystem components and key ecological attributes for the watershed. It describes their current status, including physical, biological, and chemical aspects of the natural environment and the current land use and land cover.

Physical Setting

Topography and Drainage Network

The drainage network in the Laughing Jacobs Basin includes the mainstem channel, tributary streams, and several lakes, ponds, and associated wetlands, including sphagnum bog wetlands. For the purposes of this characterization, the basin was divided into three subbasins, based on geomorphic and hydrologic characteristics: the Lower Subbasin, the Middle Subbasin, and the Upper Subbasin (Table 1; Figure 2). Most of the stream reaches within the basin are classified by the Washington Department of Natural Resources (WDNR) as fish habitat in the Forest Practices Fish Habitat Water Type dataset (WDNR, 2006).

Table 1. Subbasin Characteristics in the Laughing Jacobs Basin

Laughing Jacobs Subbasin	Subbasin Area (acres)	Associated Streams and WDNR Stream Typing
Lower Subbasin	356.5	Lower Mainstem Laughing Jacobs Creek (Type F)
Middle Subbasin	1,318.6	Middle Mainstem Laughing Jacobs Creek (Type F), Laughing Jacobs Lake (Type F), South Tributary, West Tributary, East Tributary (Type F)
Upper Subbasin	931.7	Upper Mainstem Laughing Jacobs Creek (Type F)

Upper Subbasin

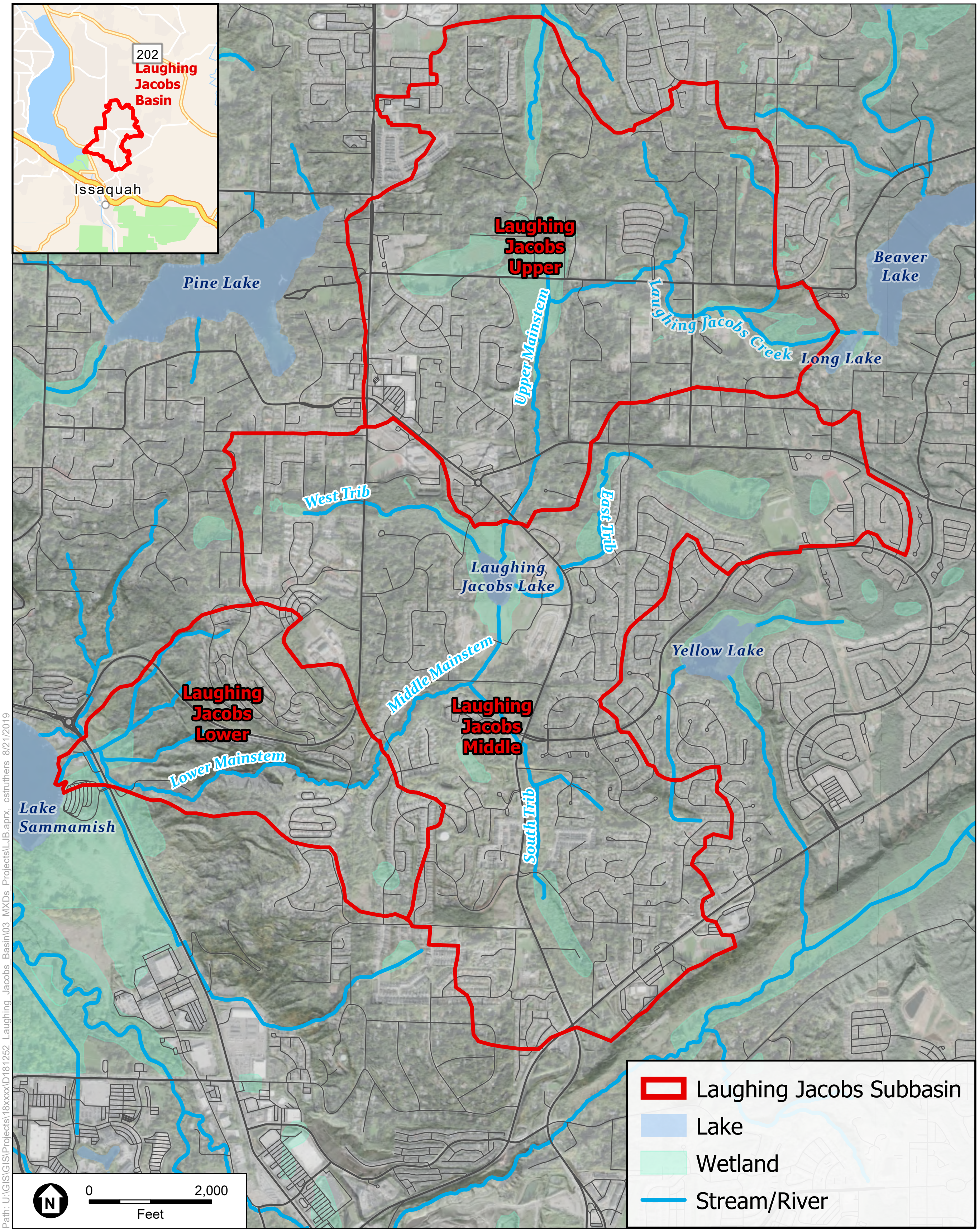
The Upper Subbasin contains the headwaters of the basin, including Beaver Lake and Long Lake, which are outside the area addressed by the Laughing Jacobs Basin Plan, as well as the upper mainstem of Laughing Jacobs Creek and a very large bog wetland complex along SE 24th Street. The topography in the Upper Subbasin ranges from a low elevation of 360 feet (NAVD 88) in the Laughing Jacobs upper mainstem, just upstream of Issaquah-Pine Lake Road, to a high of 550 feet on the Highcroft development on the northeast subbasin plateaus (Figure 3).

Middle Subbasin

The Middle Subbasin includes Laughing Jacobs Lake, a portion of the mainstem north of the lake, two tributaries to the lake (the East Tributary and the West Tributary), and the mainstem south of the lake, where it flows through a low gradient plateau. A wetland complex, including bog wetlands, surrounds the lake, including a portion of the tributary streams listed above. Another large bog wetland, the Queens Bog, serves as the headwaters for the East Tributary. Approximately 2,000 feet downstream of the lake, the South Tributary joins the mainstem. The South Tributary drains several large wetlands and stormwater ponds in the south portion of the subbasin. The topography in the subbasin ranges from a low elevation of approximately 340 feet in the downstream mainstem to a high of approximately 590 feet.

Lower Subbasin

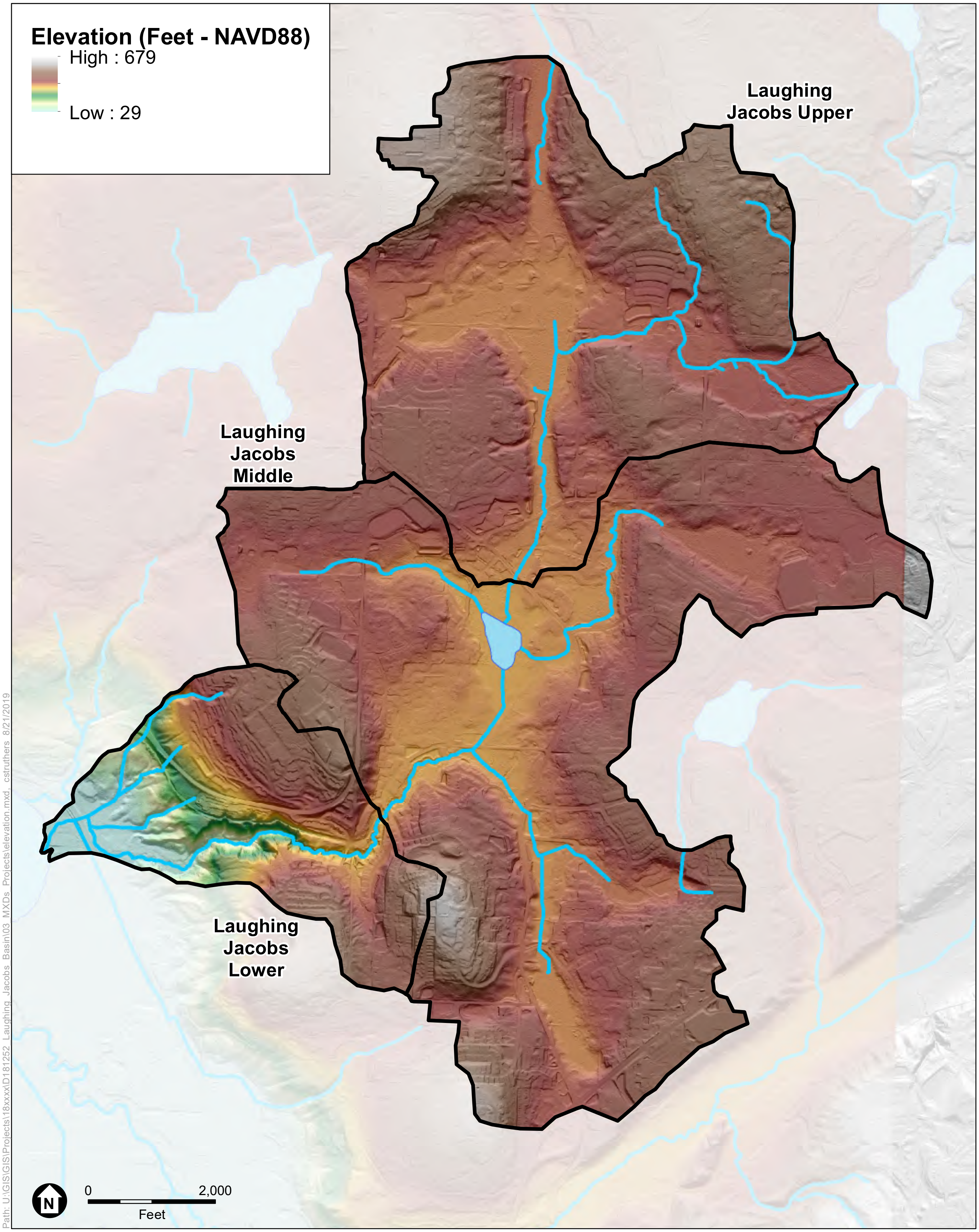
The Lower Subbasin is characterized by a steep bedrock-based ravine in the upper portion that transitions to a low gradient lake fringe topography at the mouth. Anadromous fish use is confined to only this subbasin, due to the presence of a natural fish barrier in the upper portion of the subbasin. The topography in the subbasin ranges from a low elevation of approximately 32 feet at the confluence of Laughing Jacobs Creek and Lake Sammamish to a high of approximately 570 feet on the top of the large hill in the southwest portion of the basin.



SOURCE: City of Sammamish, 2019; ESA, 2019.

City of Sammamish Laughing Jacobs Basin Plan

Figure 2
Subbasins, Streams, and Wetlands in the Laughing Jacobs Basin



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SOURCE: City of Sammamish, 2019;
King County, 2016

Laughing Jacobs Basin

Figure 3
Topography in the Laughing Jacobs Basin

Climate

Historic Conditions

The climate in the Laughing Jacobs Basin is typical of the Puget Sound region, characterized by wet winters and dry summers, with the wettest months generally occurring between October and March. Average rainfall in the City is around 62 inches per year based on data reported in the weather atlas for Sammamish (Weather Atlas, 2019). Rainfall and stormwater runoff are the primary sources of flow in Laughing Jacobs Creek; groundwater is a secondary source, supplying water to the stream that has infiltrated into the ground from rainfall or runoff and emerged as seepage. Snowmelt is infrequent.

The Aleutian Low, a low pressure weather cell centered in the Gulf of Alaska, is largely responsible for interannual and interdecadal variations in climatic characteristics of the Pacific Northwest region. The El Nino Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) are two important factors affecting climatic patterns in the Pacific Northwest (Mantua et al., 1997). El Nino conditions are characterized by warmer, drier winters while the opposite condition, La Nina, is characterized by cooler and wetter winter conditions (Redmond and Koch, 1991). In general, the PDO is a persistent climatic pattern that oscillates between warm and cool phases. The warm phase of the PDO has a similar effect as El Nino on climate of the Pacific Northwest (warm, dry winters), and the cool phase of the PDO is similar to La Nina (cooler, wetter winters) (Mantua et al., 1997).

Future Conditions

Increases in rainfall intensity and altered seasonal precipitation patterns are anticipated within the next several decades due to accelerated climate change. Climate change in the overall Snoqualmie Basin has been modeled extensively by the University of Washington Climate Impact Group and the National Oceanic and Atmospheric Administration (Yang et al., 2015; Climate Impacts Group, 2015). Predicted effects include increases in the magnitude of peak flows, changes in the timing of seasonal flow peaks, prolonged and persistent low flows, reductions in summer flows, and increased stream temperatures. These effects could further degrade water quality within streams and wetlands –with the potential for higher loads of polluted runoff during winter storm events, and higher surface water temperatures during summer months, and could further strain threatened salmon populations (including kokanee and juvenile coho rearing in the lower basin), drinking water supplies, and unique wetland bog vegetation communities. The magnitude of climate change impacts on habitat, flooding, and other local concerns is uncertain.

Geologic Setting

The Laughing Jacobs watershed is in the eastern Puget Lowland region, which is a broad, relatively low elevation area bounded by the Olympic Mountains to the west and the Cascade Range to the east. In general, glacial and postglacial sediments overlie Tertiary bedrock within the Laughing Jacobs watershed (Booth et al., 2012). These glacial sediments were left behind by glaciers that advanced six or more times within the last 2 million years. The current surficial geology is most influenced by the last glaciation, the Vashon Stade of the Fraser glaciation, which reached its maximum extent approximately 17,000 years ago before receding north (Porter and Swanson, 1998).

The geology of the Laughing Jacobs Basin, as mapped and described in Booth et al. (2012), is shown in Figure 4a, and the geologic units are described in Table 2. The different types of glacial sediments have varying levels of permeability, which affect their ability to infiltrate water and produce runoff. For example, Vashon Stade advance outwash deposits (Qva) are very permeable and infiltrate very well, but in contrast, Vashon till (Qvt) is generally less permeable and is susceptible to runoff, and deposits of pre-Fraser glaciation age (Qpf) do not infiltrate well and are prone to producing runoff. Seeps or perched groundwater may occur where more permeable layers, including Qva or Vashon Stade recessional outwash deposits (Qvr), overlie Qvt or Qpf or other less permeable layers.

Most of the mapped wetland areas in Figure 2 overlie areas mapped as Vashon Stade recessional outwash deposits, Stage 3 (Qvr(3)). Many of the largest wetlands, such as Laughing Jacobs Lake, are located within mapped wetland deposits (Qw) that generally overlie Qvr(3) (Figure 4a). A few smaller wetlands overlie other geologic units.

As glaciers retreat, they can leave behind blocks of ice, which melt to form small kettle lakes; or, they can leave behind other low-lying areas that form lakes. Bog wetlands often form in these lakes, which can have conditions conducive to the growth of sphagnum mosses around the perimeter of the lakes. The sphagnum moss in turn creates acidic conditions that are conducive to the growth of other bog plants.

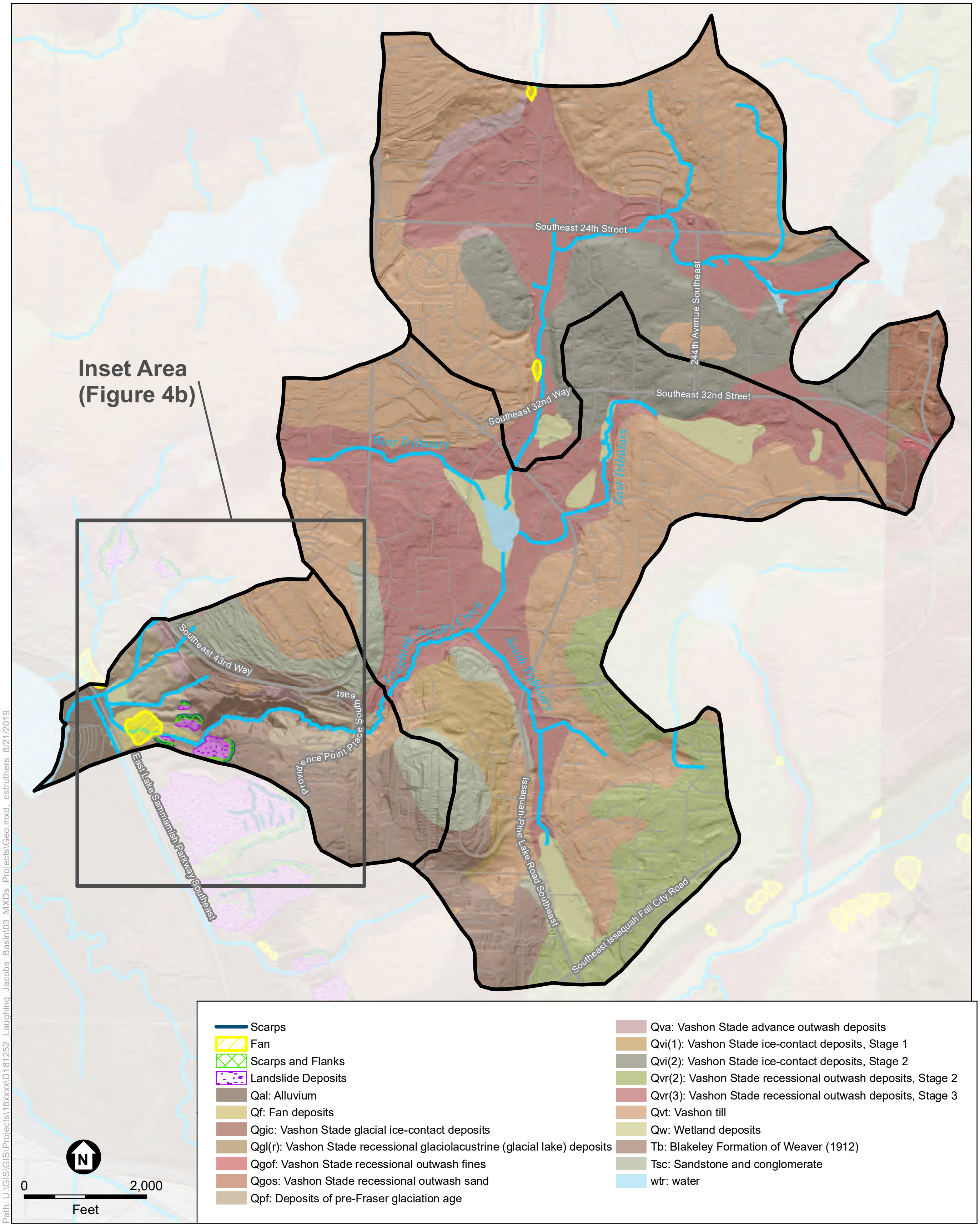
Landslide Hazards

Both planning-level and detailed landslide information is available for the Laughing Jacobs watershed. The City maps both a landslide hazard area and landslide hazard drainage area in the vicinity of the middle reach of the lower mainstem of Laughing Jacobs Creek, generally between Providence Point Place SE and East Lake Sammamish Parkway SE (City of Sammamish, 2019; Figure 4b). Landslide hazard areas are defined as "*those areas in the City of Sammamish potentially subject to risk of mass movement due to a combination of geologic, topographic, and hydrologic factors. These areas are typically susceptible to landslides because of a combination of factors including: bedrock, soil, slope gradient, slope aspect, geologic structure, groundwater, or other factors*" (City of Sammamish, 2019a). Landslide hazard drainage areas are critical drainage areas "*where overland flows pose a significant threat to health and safety because of their close proximity to a landslide hazard area*" (City of Sammamish, 2019a). These landslide hazard areas are generally located in the steepest part of the watershed and include the area where Laughing Jacobs Creek passes through a steep-sided ravine.

Washington Geological Survey provides detailed landslide inventory mapping (beginning 2017) which includes the Laughing Jacobs watershed (Washington Geological Survey, 2019; Figure 4b). This mapping contains landslides mapped using light detection and ranging (LiDAR) data, according to the mapping protocol of Slaughter et al. (2017). Data layers include landslide deposits, scarps and flanks, scarps, and fans. Shallow susceptibility and deep susceptibility mapping is not available for the Laughing Jacobs watershed.

The Laughing Jacobs watershed contains four mapped landslides within the basin area, none of which have been field-verified (Washington Geological Survey, 2019; Figure 4b). All four mapped landslides are in the general vicinity of the middle reach of the Lower Subbasin and are mapped as being prehistoric (older than 150 years). Three of the landslides are mapped with low confidence and one is mapped with moderate confidence.

Four prehistoric fans are mapped within the study area, none of which have been field-verified (Washington Geological Survey, 2019; Figure 4b). Two fans are mapped with low confidence in the lower portion of the middle reach of the Lower Subbasin just above East Lake Sammamish Parkway SE. One fan is mapped with moderate confidence adjacent to Laughing Jacobs Creek upper mainstem just upstream of SE 32nd Way, and one fan is mapped at the north boundary of the watershed with moderate confidence.



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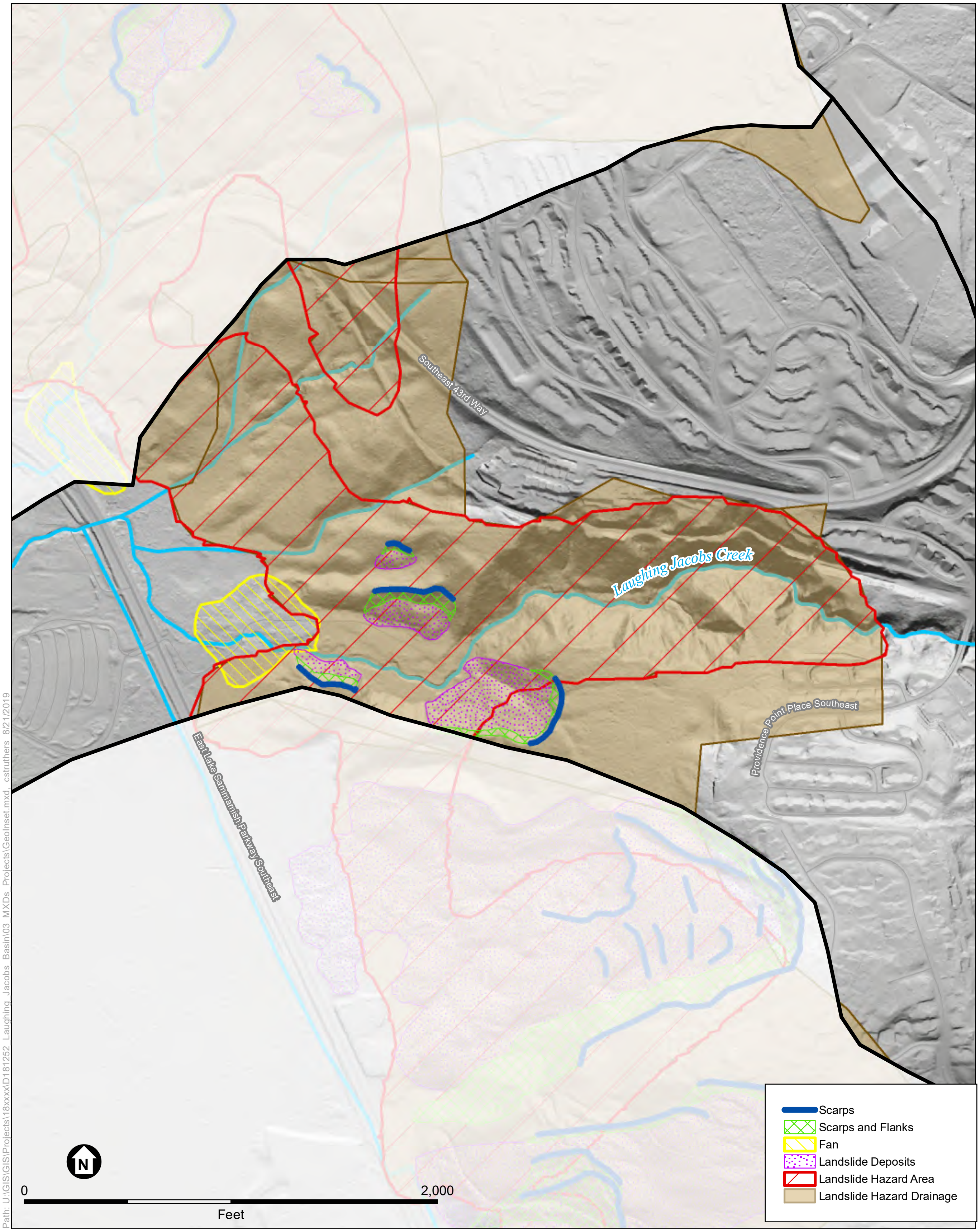
SOURCE: City of Sammamish, 2019; Washington Geological Survey, 2019;
Booth et al., 2012 (USGS Scientific
Investigations Map 3211);
Dragovich et al., 2007 (far eastern portion of map)

Laughing Jacobs Basin

Figure 4a
Geology of the Laughing Jacobs Basin



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SOURCE: City of Sammamish, 2019;
Washington Geological Survey, 2019;

Laughing Jacobs Basin

Figure 4b
Geology of the Laughing Jacobs Basin (Landslide Hazards)

Table 2. Geologic Map Units along Laughing Jacobs Creek

Geologic Unit Abbreviation	Name (Age)	Brief Description
Qw	Wetland deposits (Holocene)	Peat and alluvium deposits that are poorly drained and intermittently wet.
Qal	Alluvium (Holocene)	Moderately sorted sandy silt, pebbly sand, and cobble gravel deposited along major stream channels and locally including similar sediments adjacent to Lake Sammamish.
Qf	Fan deposits (Holocene)	Diamict, sand, cobbles, and boulders deposited where streams emerge from confining valleys, located along shores of Lake Sammamish. Qf contact is gradational with Qal.
Qvr(3)	Recessional outwash deposits (Pleistocene)	Vashon Stade recessional outwash deposits - Stage 3. These are moderately to well-sorted stratified sand and gravel deposits, with less common silty sand and silt.
Qvi(2)	Ice-contact deposits Stage 2 (Pleistocene)	Ice-contact deposits in the Laughing Jacobs Lake area along the southern meltwater channel. These deposits are similar to Qvr, but they contain a much higher percentage of silt mixed with granular sediments.
Qvt	Till (Pleistocene)	Glacial till that is a compact diamict composed of glacially transported and deposited subrounded to well-rounded clasts, which forms an undulating surface varying from a few meters to tens of meters thick.
Qpf	Undifferentiated sedimentary deposits of pre-Fraser glaciation age (Pleistocene)	Deposits that underlie Vashon-age deposits, including silt, clay, sand, and gravel.
Tb	Blakeley Formation of Weaver (1912) (Tertiary)	Coarse-grained and medium-grained sandstone, conglomerate, tuffaceous sandstone, airfall tuff, and minor siltstone, fresh to highly weathered bedrock. Massive to well-bedded.

From Booth et al. (2012).

Earthquake Hazards

The Laughing Jacobs Basin is located at the northern front of the Seattle Fault Zone, a west-trending thrust fault system. The Seattle Fault Zone is moving northward due to deflection from the Cascadia Subduction Zone (Johnson, et al., 1994). The structure of the Seattle Fault Zone is still under investigation by researchers, however, a Magnitude 7 to 7.5 earthquake likely occurred around 900–930 AD, causing uplift of around 6 m (20 feet) (Bucknam et al., 1992).

Earthquakes can cause a loss of soil through liquefaction, which can cause landslides and damage structures. King County produces a liquefaction susceptibility map, which shows low susceptibility to liquefaction for most of the Laughing Jacobs Basin, with the exception of the area adjacent to Lake Sammamish (King County, 1999a).

Groundwater Conditions

Groundwater in Sammamish is managed by the Sammamish Plateau Water and Sewer District (Sammamish Plateau Water). The Sammamish Plateau Water service areas are divided into two zones, the Plateau Zone and the Cascade View Zone. The Laughing Jacobs Basin is solely encompassed within the Plateau Zone. The Plateau Zone is supplied by two aquifers, the Plateau Aquifer and the Issaquah Valley Aquifer; five wells draw from the Plateau Aquifer and three wells draw from the Issaquah Valley Aquifer. Figure 5 depicts the public supply withdrawal wells within the Laughing Jacobs Basin and the surrounding areas.

Wellhead Protection Areas

A Wellhead Protection Area (WHPA) is the surface and subsurface area surrounding a well through which potential contaminants are likely to pass and reach the well (City of Sammamish, 2007). Boundaries are formed indicating the WHPA such that a protection area is formed to reduce the possibility of potential contamination and detrimental effects to water quality. WHPAs are defined spatially based on the travel time for a potential contaminant to travel from the point of infiltration to the point of discharge at the well. Figure 6 shows the 1-year, 5-year, and 10-year WHPAs within or near the Laughing Jacobs Basin.

Aquifer Recharge

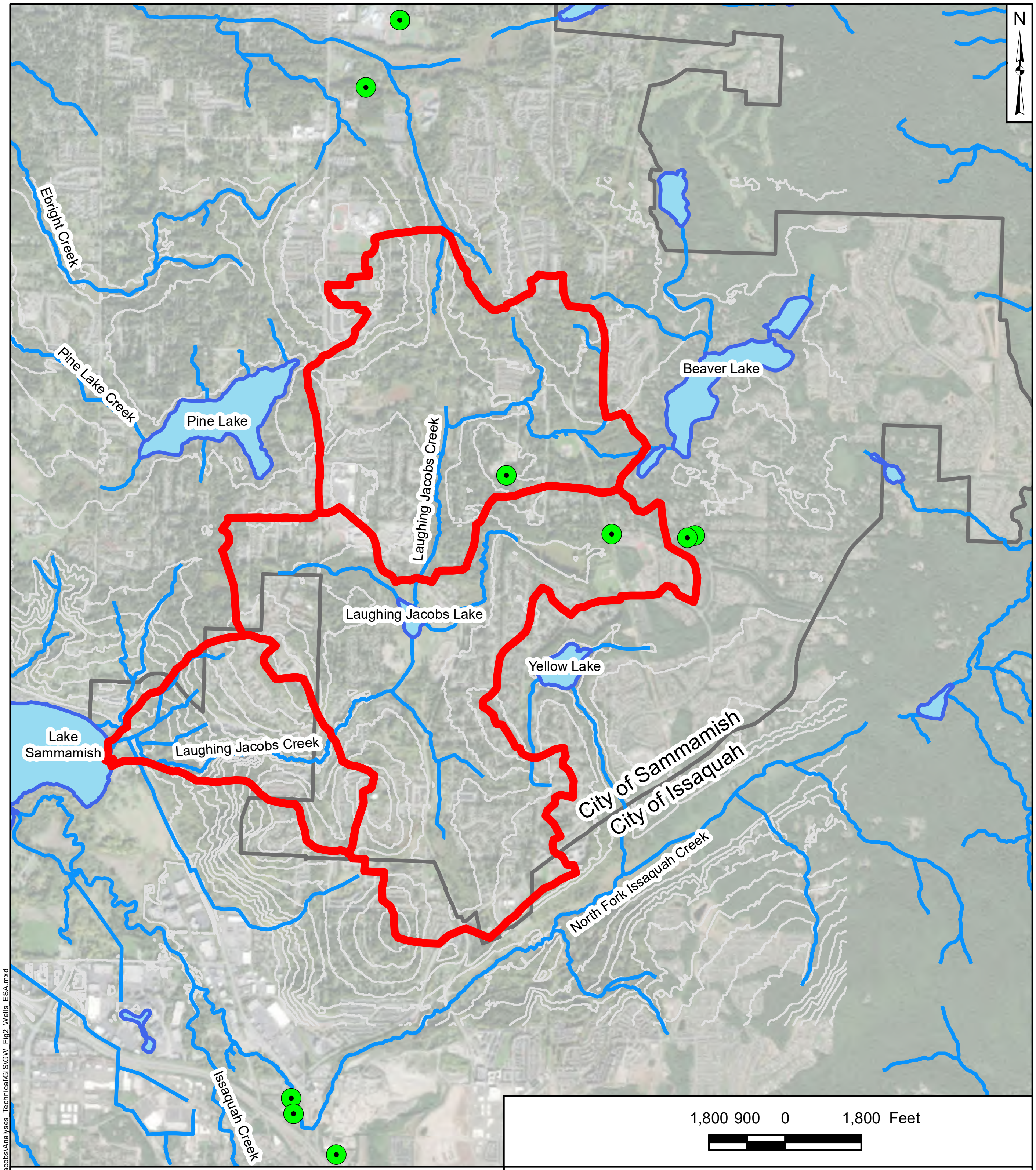
An aquifer must be recharged to continue to supply water without significant draw down. Aquifers are typically recharged via infiltration of surface water, lateral flow, or injection wells. Surface water infiltrates aquifers via direct infiltration of stormwater through porous soils or through water bodies in which a greater pressure is present at the water-soil interface, allowing water to drain in the downward direction. As development occurs in the basin, greater risk of contamination to the aquifer may arise. Areas of concern have been identified as high, medium, and low susceptibility to groundwater contamination and are presented in Figure 7.

Critical Aquifer Recharge Areas

Critical Aquifer Recharge Areas (CARAs) have a critical recharging effect on aquifers used for potable water. The geologic conditions of CARAs are associated with infiltration rates that create a high potential for contamination of groundwater resources or contribute significantly to the replenishment of groundwater (SMC, 2019a). These areas are divided into three classes based on their proximity to WHPAs:

- Class 1 CARA – mapped areas within the 1- or 5-year capture zone of a WHPA.
- Class 2 CARA – mapped areas within the 10-year capture zone of a WHPA.
- Class 3 CARA – mapped areas outside WHPAs that are identified as high aquifer susceptibility areas based on characteristics of surficial geology and soil types.

Development within CARAs is subject to the development standards outlined by the SMC. This code requires infiltration of 75 percent of on-site stormwater generated from the proposed land development project, limitations on activities that may impair the quality of groundwater, special regulation on facilities handling and storing hazardous waste, and a list of prohibited uses or activities based on the CARA class (SMC, 2019b). Figure 8 shows the CARAs within and adjacent to the Laughing Jacobs Basin (Note, there are no Class 3 CARAs in the area).



Legend

● Supply Wells

🟥 Laughing Jacobs Basin

🟦 Lakes

— Streams

▢ City Limits

— Contours

Supply Wells in the Laughing Jacobs Basin

Sammamish, WA

Geosyntec
consultants

Seattle, WA

22-Aug-2019

Figure

5

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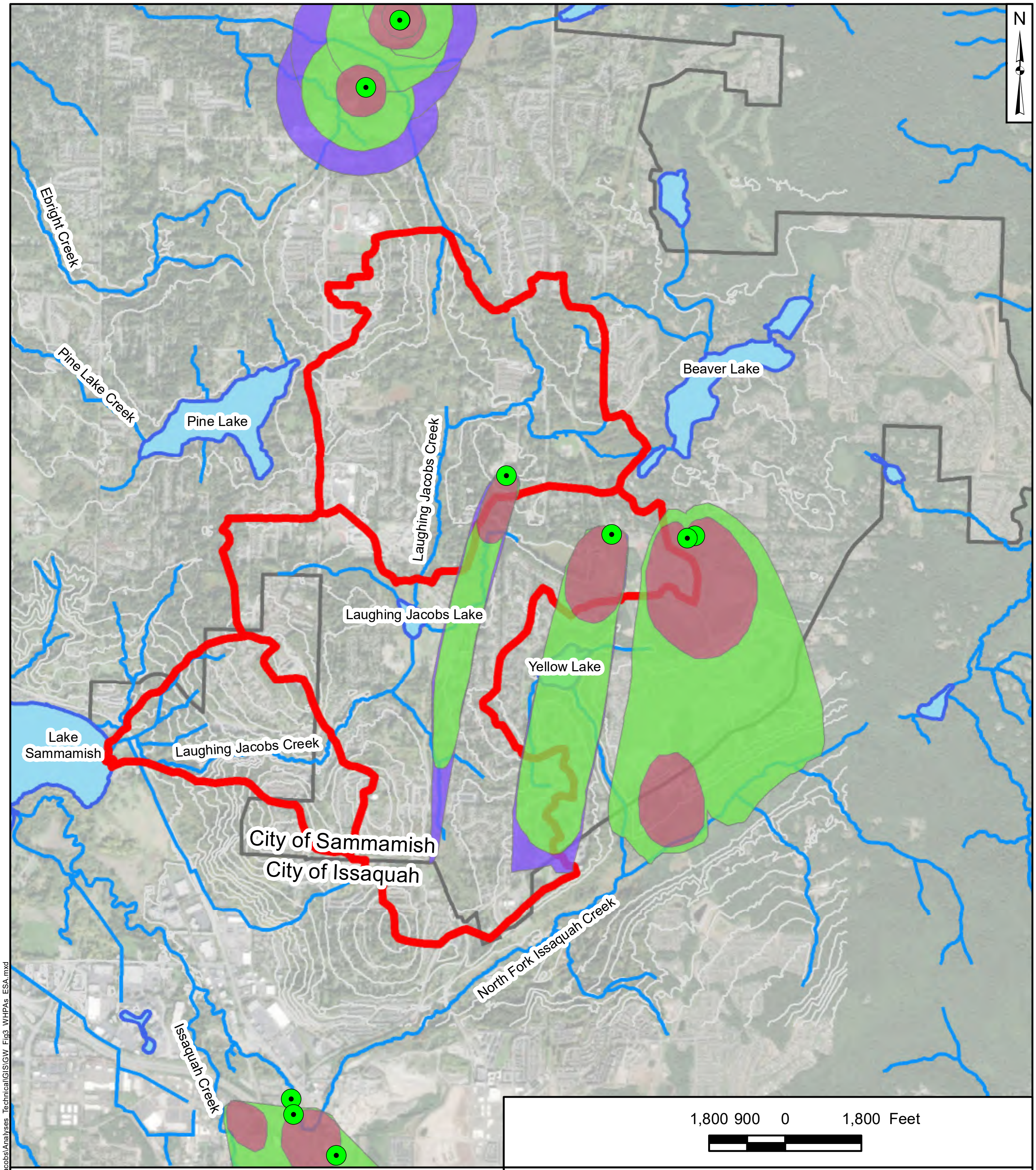

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● Supply Wells

🟥 1-Year WHPA

🟩 5-Year WHPA

🟪 10-Year WHPA

▭ Laughing Jacobs Basin

🟦 Lakes

— Streams

▭ City Limits

— Contours

Wellhead Protection Areas (WHPAs)
in the Laughing Jacobs Basin

Sammamish, WA

Geosyntec
consultants

Seattle, WA

22-Aug-2019

Figure

6

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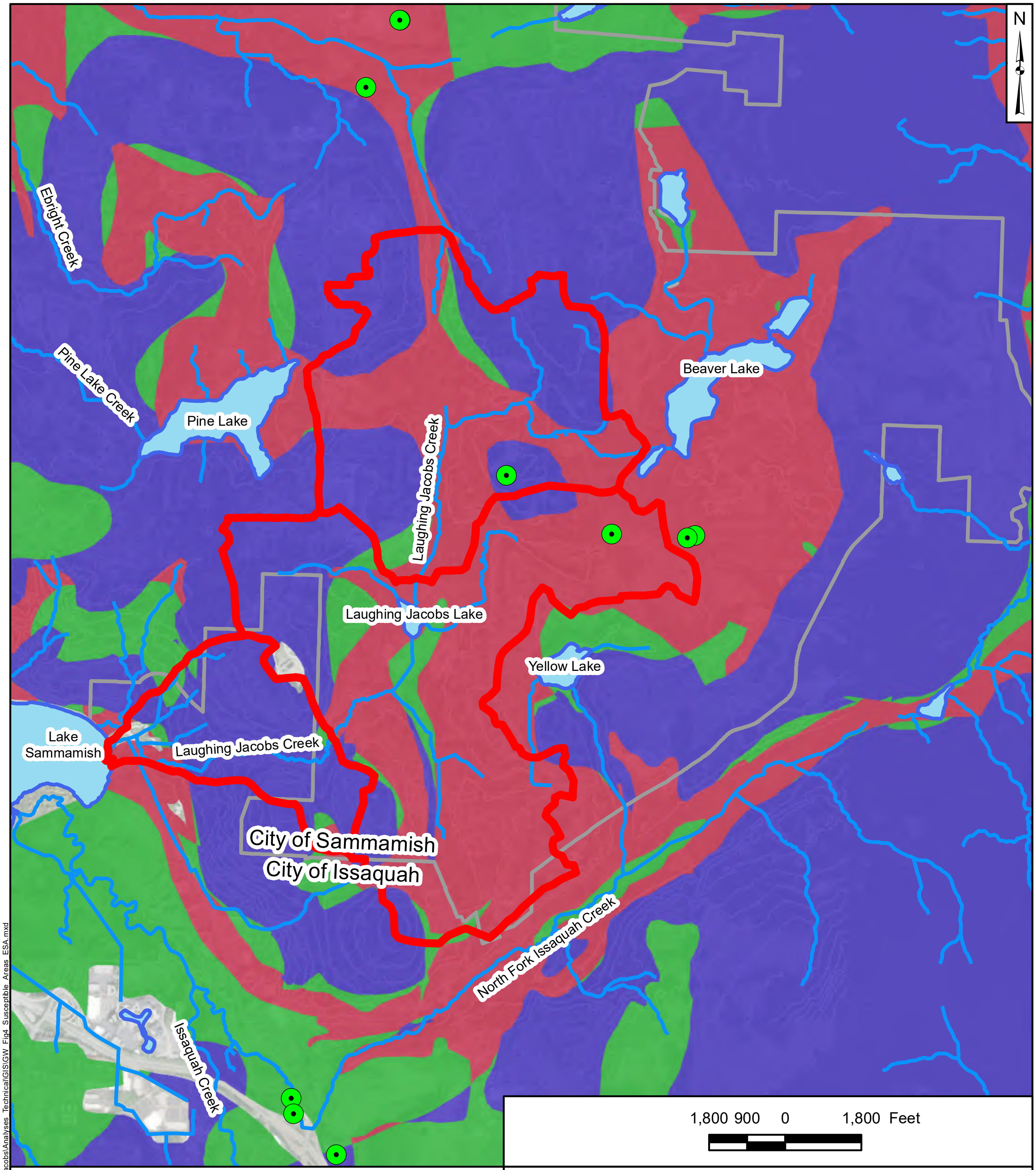

Legend

- ● Supply Wells
- 🟥 Laughing Jacobs Basin
- 🟦 Lakes
- Streams
- ▭ City Limits
- Contours
- 🟥 High Susceptibility to Groundwater Contamination
- 🟩 Medium Susceptibility to Groundwater Contamination
- 🟦 Low Susceptibility to Groundwater Contamination

Areas Susceptible to Groundwater Contamination in the Laughing Jacobs Basin

Sammamish, WA

Geosyntec consultants

Seattle, WA

22-Aug-2019

Figure

7

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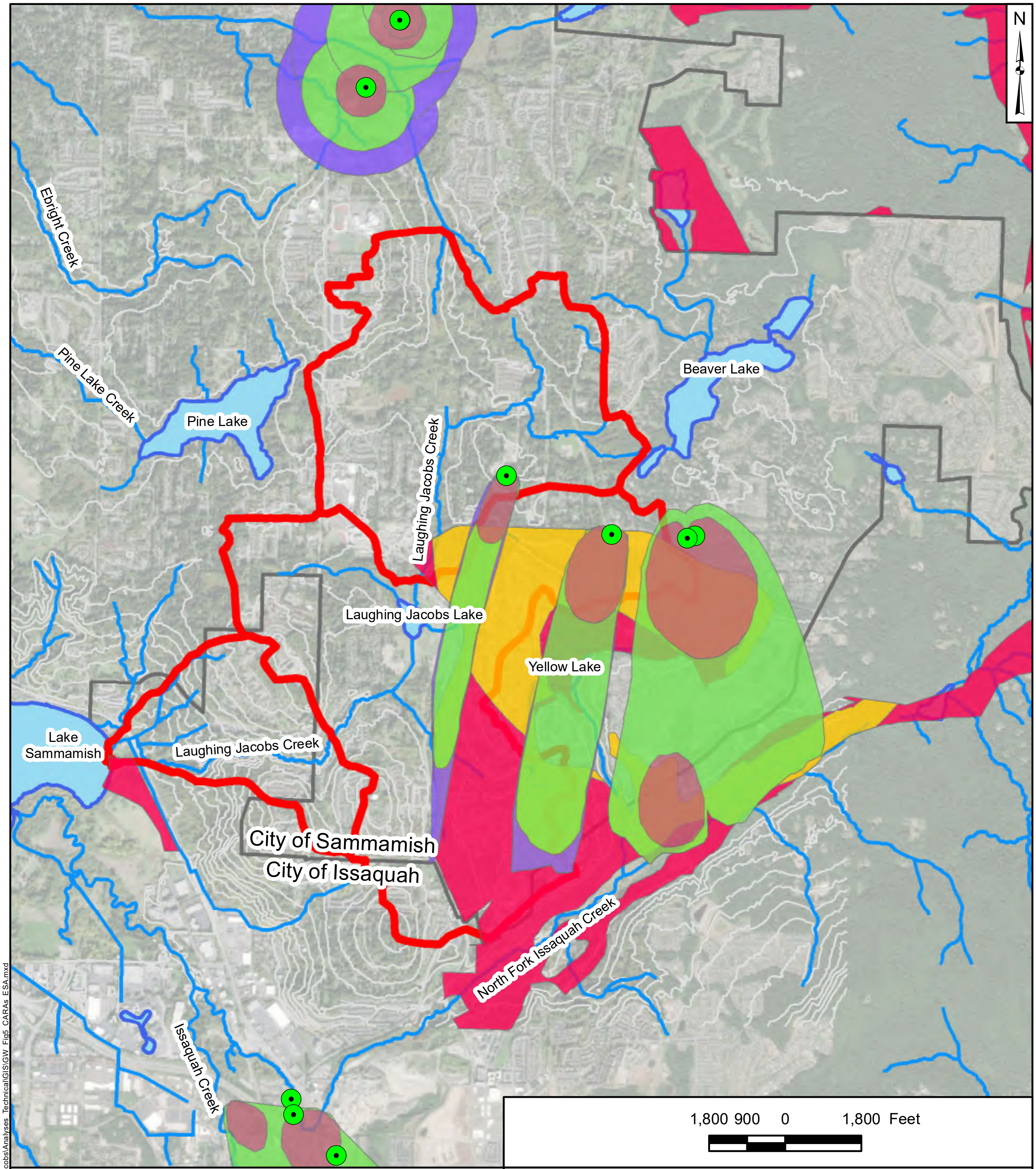

Legend

- ● Supply Wells
- 🟫 1-Year WHPA
- 🟩 5-Year WHPA
- 🟪 10-Year WHPA
- 🟥 Laughing Jacobs Basin
- ☐ City Limits
- 🟨 Class 1 CARA
- 🟥 Class 2 CARA
- 🟦 Class 3 CARA
- 🟦 Lakes
- — Streams
- — Contours

Critical Aquifer Recharge Areas (CARAs) in the Laughing Jacobs Basin

Sammamish, WA

Geosyntec consultants

Seattle, WA

22-Aug-2019

Figure

8

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Groundwater Planning Strategies

Sammamish Plateau Water's *2018 Water Comprehensive Plan* details the approaches to which a water supply strategy will be implemented for the service area.

Groundwater Supply

Supply forecasts do not show a sufficient supply of water for the predicted system needs in the next 10 years if Sammamish Plateau Water's sources are limited to the Plateau and Cascade View zone groundwater supplies. Regional sources have been identified and supply via the existing Cascade South Regional Connection will be provided to supplement the 10-year planning period demand for the Plateau Zone, and supply via the existing Cascade North Regional Connection will be provided to supplement the 20-year planning period demand for the Cascade View Zone (CHS Engineers, 2018).

Water Level Monitoring

A record of groundwater and surface water levels has been created by Sammamish Plateau Water with records dating back to 1990. This ongoing database collects water levels from 56 wells in the Lower Issaquah Valley, Sammamish Plateau, and Cascade View and one surface water level on North Fork Issaquah Creek in the Lower Issaquah Valley. These data are used to determine the quantity of available groundwater, analyze impacts of changing variables (i.e., climate, water use, and land use changes) on the water levels, calibrate existing groundwater models, evaluate groundwater gradients and flow patterns, and provide data for water rights and management decisions (CHS Engineers, 2018).

Aquifer Storage and Recovery

The Aquifer Storage and Recovery (ASR) program is a permitted process of injecting surplus water provided during the winter months into the aquifers in an approach to recharge the aquifers. Ecology recently granted an extension to continue the ASR program in the Plateau Zone, with the exception that operational testing will be limited to Zone III and Zone IV wells and will exclude Zone II wells (CHS Engineers, 2018).

Reclaimed Water

The use of reclaimed water has been considered to alleviate the dependence on Sammamish Plateau Water's groundwater wells. This process would use reclaimed water to replace some of the non-potable water demand (e.g., school and park irrigation). Recent studies have assessed the feasibility, but no specific plans have been developed for the use of reclaimed water for non-potable demands in the area (CHS Engineers, 2018).

Land Cover and Built Environment

Land Cover

Like the rest of the Puget Sound region, the dominant pre-development land cover of the Laughing Jacobs Basin was late-stage coniferous forests prior to settlement, with unique shrub-dominated areas likely occurring in the large bog wetland areas. Much of the original forest vegetation has since been replaced by less mature and non-native plant communities and non-vegetated artificial surfaces (e.g., roads, parking lots, and buildings) driven by widespread land development and human activities.

Based on a geographic information system (GIS) analysis of high-resolution land cover data (WDFW, 2015), the land cover within the Laughing Jacobs Basin is dominated by two land cover types: forest and developed (Table 3). Forest land cover includes deciduous, coniferous, and mixed forest, while developed land cover includes buildings, roadways, and other types of impervious surfaces. Forest land cover accounts for 48 percent of land cover in the overall basin, while forest cover in the subbasins ranged from 57 percent (Lower Subbasin) to 39 percent (Upper Subbasin). Developed land accounted for 25 percent of land cover in the overall basin and showed an inversely proportional relationship to forest cover within the three subbasins, as the subbasin with the highest percentage of developed land cover (28% in Middle Subbasin) had the lowest percentage of forest cover. Likewise, the subbasin with the lowest percentage of developed land cover (22% in Lower Subbasin) had the lowest amount of forest cover.

Urban development alters rainfall-runoff relationships and increases the “flashiness” (higher peaks, lower base flows) of the hydrologic regime for a given stream (Booth, 1991; Booth and Jackson, 1997; Konrad et al., 2005). The most common changes to the hydrologic regime observed in streams with urbanizing catchments include reductions in dry season base flow and increases in wet season peak flows. Increases in impervious area, storm drain systems, and overall changes in land cover result in runoff being delivered more quickly to streams. This increases the magnitude of the peak flows and reduces opportunity for storage and infiltration. Hydrologic impacts driven by urbanization are related to decreases in ecological productivity and biodiversity in aquatic systems (Konrad et al., 2005).

Table 3. Land Cover Analysis for Laughing Jacobs Subbasins (Percent of Total Cover)

	Subbasin			
Land Cover Type	**Laughing Jacobs Lower (%)**	**Laughing Jacobs Middle (%)**	**Laughing Jacobs Upper (%)**	**Basin-Wide (%)**
Developed	22.3	29.7	23.0	25.0
Forest	56.5	38.9	49.3	48.2
Bare Dirt	1.9	3.7	3.0	2.8
Herbaceous/Grass	11.2	17.4	10.8	13.1
Shrub	3.0	3.5	3.1	3.2
Water	0.3	1.4	0.5	0.7
Unclassified	0.8	1.5	1.5	1.3
Wetland	4.0	3.9	8.7	5.5
Total	**100.0**	**100.0**	**100.0**	**100.0**

Other primary land cover types include grass and herbaceous land cover, which includes both landscaped lawns and grass fields, such as patches of non-native grasses such as reed canarygrass. This land cover type accounts for approximately 13 percent of the overall basin, with higher percentages (17%) in the more developed Middle Subbasin and lesser percentages (11%) in the two other subbasins.

Wetlands account for approximately 6 percent of the overall basin, with the highest percentages (9%) in the Upper Subbasin, which contains Queens Bog and the SE 24th Street wetland complex. The shrub and bare dirt land cover types each accounts for approximately 3 percent of the overall basin, while the combined water land cover type and the unclassified land cover types account for just 2 percent of the overall basin area.

Klein (1979) suggested that the initial threshold of degradation of stream water quality was approximately 15 percent effective impervious area (EIA), while Schueler et al. (2009) reported that the threshold was 10 to 20 percent (EIA). Holland et al. (2004) also reported that the adverse changes in physical, sediment, and water quality variables could be detected at 10 to 20 percent EIA. In general, the thresholds for biotic measures (including fish and macroinvertebrate diversity and abundance) range from 3.6 to 15 percent EIA, while the chemical water quality tended to have higher impact levels with thresholds ranging from 7.5 to 50 percent EIA (Brabec et al., 2002).

Booth et al. (2002) examined the role of impervious surface area and forest cover for protecting aquatic resources, and identified the following elements for effective protection:

- Clustered developments that protect half or more of the forest cover, preferably in headwater areas and around streams and wetlands to maintain intact riparian buffers.
- A maximum of 20 percent total impervious area, and substantially less effective impervious area through the widespread reinfiltration of stormwater (Konrad and Burges, 2001).
- On-site detention, realistically designed to control flow durations (not just peaks).
- Riparian buffer and wetland protection zones that minimize road and utility crossings as well as overall clearing.
- No construction on steep or unstable slopes.

Land Use

Within the City, the Laughing Jacobs Basin is predominantly built-out consistent with established Comprehensive Plan Land Use Designations and zoning. Dominant land uses include lower intensity residential, publically owned park lands, and protected open space. Other land uses include institutional uses (primarily schools), moderate to higher intensity residential uses, and areas of commercial and business uses (Table 4). Detailed descriptions of existing land use patterns are provided by subbasin in the *Detailed Assessment* section of this memorandum.

Zoning for the City of Sammamish was most recently updated in April 2016, with zoning designations consistent with the designations established by the City's Comprehensive Plan (City of Sammamish, Amended 2018). Zoning for the City of Issaquah was most recently updated in November 2018, with the effective Comprehensive Plan Land Use designations adopted in October 2017 (City of Issaquah, 2017).

Table 4. Zoning Designations for Laughing Jacobs Subbasins (Percent of Total)

City of Sammamish Zoning	Subbasin			Basin-Wide (%)
	Laughing Jacobs Lower (%)	Laughing Jacobs Middle (%)	Laughing Jacobs Upper (%)	
R-1	0%	7%	20%	11%
R-4	7%	31%	57%	37%
R-6	16%	38%	9%	25%
R-8	0%	1%	1%	1%
R-12	0%	<0.5%	<0.5%	<0.5%
R-18	0%	0%	2%	<1%
CB	0%	0%	2%	<1%

City of Sammamish Zoning	Subbasin			Basin-Wide (%)
	Laughing Jacobs Lower (%)	Laughing Jacobs Middle (%)	Laughing Jacobs Upper (%)	
Right-of-Way / Unzoned	5%	11%	9%	10%
Within Issaquah	73%	11%	-	15%
W/in Unincorporated King County	-	1%	-	<0.5%
Total	**100.0**	**100.0**	**100.0**	**100.0**

Future Development

The large majority of lands across the Laughing Jacobs Basin are consistent with the City of Sammamish's established Comprehensive Plan Land Use Element and adopted zoning designations. One of the last large (20+ acre) privately owned properties within the basin was just developed – this property surrounds Laughing Jacobs Lake in the Middle Subbasin, with formerly agricultural areas currently being developed with detached single-family residences (consistent with underlying lower density residential zoning). Similarly, all areas within the City of Issaquah are built-out consistent with established Comprehensive Plan Land Use designations and adopted zoning.

In limited areas of the basin, an older (40+ year old) pattern of larger lot residential platting remains, with detached single-family homes occurring on 1+ acre lots. In these areas, underlying zoning could allow for platting of lots to an approximately 1/4-acre size. Areas include portions of the Middle Subbasin north of Queens Bog and SE 32nd Street and a smaller area to the west of 228th Avenue SE in the vicinity of SE 35th Street. Areas also include portions of the Upper Subbasin west of Beaver Lake Park and south of SE 24th Street, as well as around the north limits of the subbasin surrounding 238th Avenue SE, SE 18th Street, SE 18th Place, and 245th / 233th Avenue SE. In these areas, the larger residential lots are predominantly built with homes, and the residential structures are typically assessed as "Good" or better by King County assessor data (King County Department of Assessments, 2019). In addition, lots are predominantly owner-occupied, so are not assembled under common ownership. Because of this existing pattern, platting and redevelopment in these areas will most likely occur incrementally. Over time, redevelopment will likely result in reduced forest cover and increases in total impervious cover.

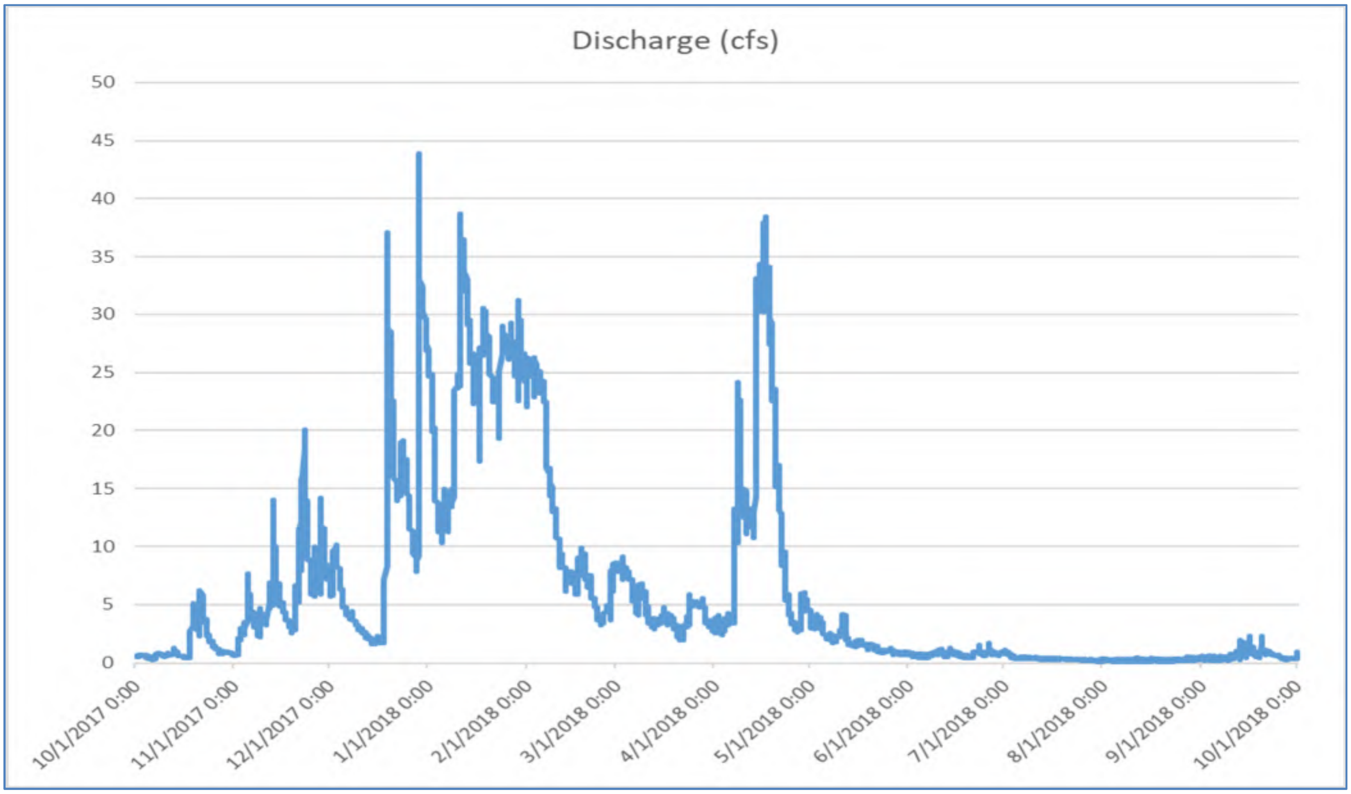
Large tracts of undeveloped forest generally appear to be well protected across the basin. For these areas, protection is provided through public ownership and designation as park/open space land, or by development limitations regarding critical areas. The three large parks within the basin (Lake Sammamish State Park, Klahanie Park, and Beaver Lake Park) all have high-functioning wetland and riparian areas that help maintain ecological processes. Future improvements are being considered within Klahanie Park through the ongoing Klahanie Park Master Plan.

Surface Water and Floodplains

Hydrology

The surface water hydrology of the Laughing Jacobs Basin is governed by rainfall rates, vegetative conditions (e.g., forest, shrub, or emergent vegetation), surface geology (permeability of surficial geologic units), topography, and land development. In the last full water year (October 1, 2017 to September 30, 2018), mean monthly flows at the King County gage at RM 0.25 varied between 0.25 cubic feet per second (cfs) in August, to 23.72 cfs in January (King County, 2019b). Over this time period, the instantaneous minimum flow was 0.10 cfs (August), and the instantaneous maximum flow was 46.83 cfs (December). The mean monthly flow was less than 1.0 cfs for all 4 summer months (June through September). The hourly flow for this water year is shown in Figure 9. For comparison, the hourly discharge over the entire period of record (1991 through 2018) is shown in Figure 10.

Figure 9. Hourly Discharge for the 2017–2018 Water Year in the Laughing Jacobs Basin



From 1992 through 2015, annual peak flows in Laughing Jacobs Creek ranged from 21 cfs to 181 cfs, with an average of 64 cfs (King County, 2017). Annual mean flow for this period ranged from 2.1 cfs to 11 cfs, with an average of 5.8 cfs.

A more useful analysis of high flow describes flow-frequency estimates. These estimates were developed from King County gaging data for Laughing Jacobs Creek at East Lake Sammamish Parkway (Gage 15C) with a period of record from 1991–2018. Estimates were calculated using guidance from Bulletin 17-C (England et al., 2019) and Mastin et al. (2017). Table 5 and Figure 11 present the results of the analysis, with confidence intervals. The calculated 2-year, 10-year, and 50-year floods are estimated at 51 cfs, 108 cfs, and 171 cfs, respectively. Appendix A contains the annual peak flow frequency analysis details.

The frequency of high-flow events may be increasing in the short-term. However, these events do not appear to be occurring over a longer seasonal pattern, and the degree of flashiness does not show obvious signs of change over time (King County, 2017).

Figure 10. Daily Discharge in Laughing Jacobs Creek for 1991–2018 Water Years

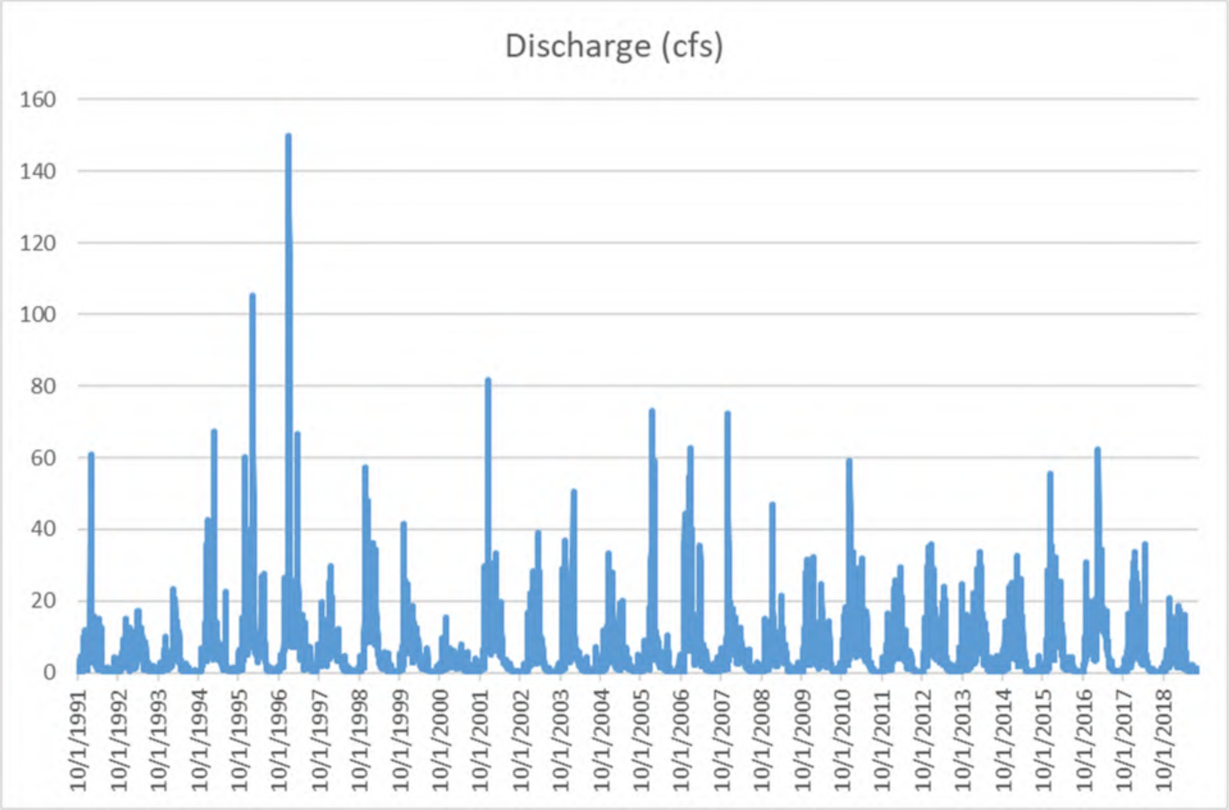
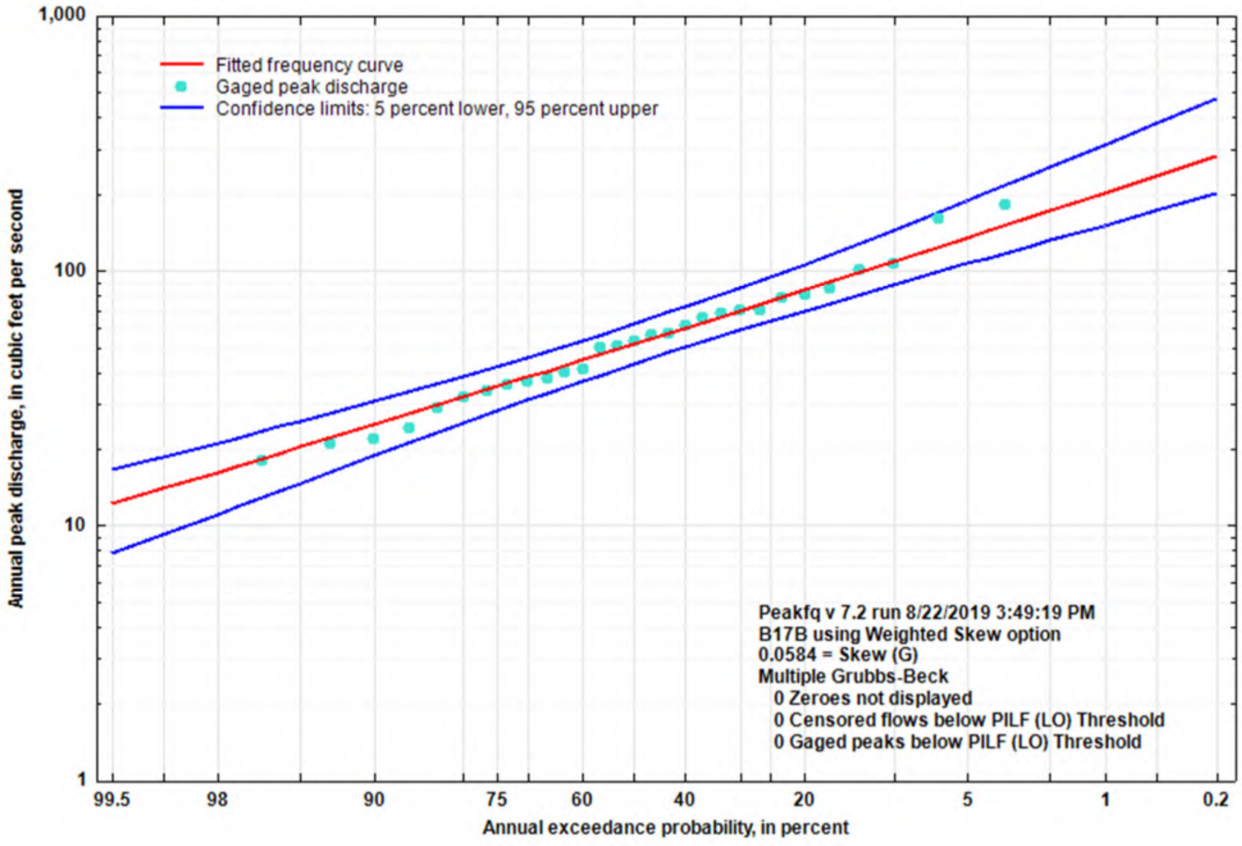


Table 5. Flood Frequency Estimates for Laughing Jacobs Creek at E Lake Sammamish Parkway

Return Period	Exceedance Probability	Estimate (cfs)	Confidence Interval (cfs)	
			5% Lower	95% Upper
1.5-year	0.6667	40.2	32.9	48.0
2-year	0.5000	51.4	43.0	61.6
5-year	0.2000	83.8	69.5	106.0
10-year	0.1000	108.4	87.8	144.2
25-year	0.0400	143.1	112.1	202.5
50-year	0.0200	171.4	130.9	253.3

Figure 11. Flood Frequency Estimates for Laughing Jacobs Creek at East Lake Sammamish Parkway



Flooding

In the past, uncontrolled runoff from developed areas has resulted in the delivery of excessive hillslope sediment to the channel that contributed to flooding. Flooding was exacerbated by a loss of channel conveyance due to sediment from several landslides in the Laughing Jacobs ravine that settled in the flat lower reaches (Issaquah/ELSWMC, 1994). Improved stormwater conveyance and detention in the subsequent years have generally alleviated flooding problems in the lower basin, although localized flooding occurs in some reaches around many of the associated wetlands, particularly where development has encroached on these water bodies (such as near the intersection of SE 24th Street and 244th Avenue SE).

Dams

Ecology regulates dams that store 10 acre-feet of water or more. Ecology's Dam Safety Office conducts plan reviews, construction inspections, and periodic inspections of existing dams to ensure their proper operation and maintenance. Dams that are assessed to pose a hazard to human life upon failure are required to have an approved Emergency Action Plan (EAP). The City owns three qualifying dams in the Laughing Jacobs watershed, all within the Klahanie neighborhood. These dams are listed in Table 6.

Table 6. Information on Dams in Laughing Jacobs Basin

Facility Name	Dam Type	Length (feet)	Height (feet)	Structural Height (feet)	Hazard	Emergency Action Plan	Last Inspection Date	Inspection Frequency (years)
Klahanie stormwater detention dam no. 1	Earth fill	200	9	10	Significant: 1-6 lives at risk	Yes	7/16/2015	5
Klahanie stormwater detention dam no. 2	Earth fill	75	3	6	Significant: 1-6 lives at risk	Yes	7/16/2015	5
Queens Bog dam	Earth fill	140	9	12	Low: no lives at risk	No		0

Water Quality

Ecology has listed Laughing Jacobs Creek in *Category 5 - Polluted Waters/303(d) List of Threatened and Impaired Water Bodies* for fecal coliform, stream temperature, dissolved oxygen, and bioassessment (Ecology, 2019). For all four parameters, the listing applies to the mainstem of Laughing Jacobs Creek, from the mouth up to and including Laughing Jacobs Lake.

The Ecology Category 5 listing for bioassessment in Laughing Jacobs Creek, an indicator of degraded biological integrity, was based on scores for the Benthic Index of Biotic Integrity (B-IBI) (0–40 scale) that represents biologic conditions from fair to very poor. The B-IBI scores were 28 in 2006, 30 in 2007, 24 in 2008, 32 in 2009, and 16 in 2010 (Ecology, 2019). A more recent B-IBI sample from August 2018 scored 57 on a 1 to 100 scale, indicating fair biologic condition (Puget Sound Stream Benthos, 2019).

Laughing Jacobs Creek is classified as a Category 5 for dissolved oxygen in the current Ecology 303(d) listing (Ecology, 2019). Adequate concentrations of dissolved oxygen in fresh water streams are critical for the survival of salmonids (Carter, 2005). Reduced levels of dissolved oxygen (<9.5 mg/L) can affect the growth and development of different life stages of salmon, including eggs, alevins, and fry, as well as the swimming, feeding, and reproductive ability of juveniles and adults. Under extreme conditions, low dissolved oxygen concentrations can be lethal to salmonids. Based on the available dissolved oxygen data from 1998 to 2010, state water quality standards were exceeded in 96 percent (45 of 47) of upstream samples and 86 percent (25 of 29) of downstream samples (City of Issaquah, 2011). However, low dissolved appears to be a natural condition in this basin, associated with the numerous large wetlands and lakes in the basin headwaters.

In addition to the 303(d) listings, other sources and classes of pollutants can negatively affect aquatic life in streams. Roadways and parking lots are impervious and accumulate a mixture of contaminants, including the dissolved forms of copper and zinc. These constituents present in roadway runoff are toxic to the sensory systems of fish, specifically impairing the ability of salmon to detect odors, which in turn impedes predator detection and avoidance, social interaction, prey detection, orientation, and homing, all of which can affect the survival, distribution, and reproductive success of individual fish. As part of an ongoing monitoring program of aquatic resources, the City of Issaquah (2011) measured dissolved copper at levels above the water quality standard one time out of 13 samples (8% of the samples), with the sample exceeding the standard taken after an extended period of dry weather (first flush). Two of the 13 samples (15%) dissolved copper levels were above the fisheries sublethal limit. Additionally, three of the 13 samples (23%) were at or above the fisheries sublethal limit for dissolved zinc.

Historically, this stream also has a high phosphorus content and sediment loads, which originated from active landslides in the lower reaches of the creek (the upper portions are underlain by bedrock) (King County, 1990a).

Stream Temperature

Stream temperature influences the behavior, growth, metabolism, and habitat utilization of fish and other aquatic organisms. Most fish have specific suitable and preferred water temperature ranges, and exhibit distinct responses to increasing or decreasing water temperatures within and outside of these preferred ranges. In general, decreasing water temperatures result in decreased feeding and metabolic rates and a corresponding decrease in growth, while increasing temperatures tend to result in an increase in all three of these rates (assuming there is an adequate food supply). However, growth is substantially reduced near either end of the suitable temperature range, either because the metabolic rate is too low at low temperatures or all available energy is used for maintenance at high temperatures. Salmon, trout, and other cold-water fish species tend to have narrower overall suitable temperature ranges, as well as narrow preferred temperature ranges, than warm- or cool-water species and are typically sensitive to relatively small temperature changes. Water temperature also influences egg incubation rates and the corresponding emergence timing for fry.

The entire mainstem of Laughing Jacobs Creek, from the mouth up to and including Laughing Jacobs Lake, is cited on the Ecology 303(d) list for repeated exceedances of the stream temperature criteria (King County stream gage data *in* Ecology, 2019). Table 7 provides details on the frequency and magnitude of exceedances for the period of 2006 through 2010. Over this time period, Laughing Jacobs Creek averaged 78 days where aquatic life temperature standards were exceeded, equating to 21 percent of the overall 5-year time period. A similar trend of exceedances has occurred in recent years as well (King County, 2019b).

Table 7. Water Quality Temperature Exceedances in Laughing Jacobs Creek from 2006 through 2010 at King County Stream Gage

Year	Number of Days in Exceedance of the 7-day Mean of Daily Maximum Values (16°C)	Percent of Year Daily Maximum Value Exceeded	Maximum 7-day Exceedance Temperature (°C)
2006	95	26	19.99
2007	75	21	19.09
2008	50	14	18.88
2009	101	28	21.52
2010	71	19	19.84
Totals 2006–2010	**392**	**21**	**21.52**

Temperature data from June 1996 through 2018 (Table 8), collected by King County at the stream gage just upstream of East Lake Sammamish Parkway, was evaluated for exceedances of high temperature and indicates that based on average daily temperatures, the temperature regime of Laughing Jacobs Creek exceeds thresholds for properly functioning conditions, particularly for rearing or migrating salmonids in the summer months.

Table 8. Water Quality Temperature Exceedances in Laughing Jacobs Creek from 1996 to 2018 at King County Stream Gage

Daily Mean Stream Temperature Degree Threshold (°C)	Number of Days Exceeded	Average Days Per Year Threshold Exceeded
20	10	0.4
18	111	4.9
16	979	43.5

Wetlands, Vegetation, and Riparian Conditions

Wetlands

Wetland conditions were examined throughout the basin and based on a review of existing reports, GIS analysis, interpretation of aerial photographs, and observations made during a site visit on July 8, 2019. Additionally, the wetlands visited during the site visit were rated and categorized using the Washington State Wetland Rating System for Western Washington (Hruby, 2014) to evaluate likely wetland ecological functions. The abundance and relative wetland areas for the subbasins of the Laughing Jacobs Creek basin are summarized below.

The City GIS layer identified a total of 32 wetlands within the Laughing Jacobs Basin (Table 9). Half of all identified wetlands in the Laughing Jacobs Basin were in the Upper Subbasin, which also had the most wetland acreage, representing approximately 9 percent of the subbasin area. Although the Middle Subbasin had approximately three times the number of acreage and number of wetlands than did the Lower Subbasin, the actual percentage of wetlands in the two subbasins is almost identical (4.0 versus 3.9%), based on the much larger size of the Middle Subbasin.

Table 9. Wetland Summary for the Laughing Jacobs Basin.

Subbasin	Wetland Area (acres)	Subbasin Area (acres)	Percent of Subbasin with Wetland	Number of Wetlands	Average Wetland Size (acres)
Lower Laughing Jacobs Subbasin	14.2	356.5	4.0	4	3.6
Middle Laughing Jacobs Subbasin	51.1	1318.6	3.9	12	4.3
Upper Laughing Jacobs Subbasin	81.4	931.7	8.7	16	5.1
Total	**146.7**	**2606.7**	**5.6**	**32**	**4.6**

Multiple types of wetlands are present within the basin, including riparian wetlands, depressional wetlands, and bogs. Wetland vegetation types include forested, emergent, and scrub-shrub. As bogs are a unique and relatively rare, and multiple bogs are present within the basin, more detail on these features are provided below.

Bogs

Bogs are a type of wetland that are relatively rare on the landscape of Western Washington and are wetland systems that are thousands of years old. Bogs have been referred to under a variety of classification systems in scientific studies; however, they generally include wetland areas that are acidic (with a pH of 5 or lower) and have low levels of nutrients available for plant growth (Ecology, 2014). In the 2001 report on Western Washington bogs prepared by King County (and other contributors), Queens Bogs and other bog wetland areas of the East Lake Sammamish Plateau landscape were described interchangeably as "Sphagnum-dominated peatland" and/or "acid peatland" bogs, an indication of their low pH and dominant presence of sphagnum mosses throughout the ground layer of vegetation (King County, 2001).

Such sphagnum-dominated peatland bogs are the only places where certain plant species specifically adapted to such conditions are typically found. Minor changes in hydrology or water quality can cause major changes in the plant community – a circumstance that has been occurring over the last decades for the bogs within the Laughing Jacobs Basin. Bogs, and their associated acidic peat environment, provide habitat for unique species of plants and animals; bog soils are typically very spongy, with continuous cover of mosses (typically sphagnum mosses). Other unique bog-adapted plant species include bog cranberry, bog laurel, Labrador tea, sphagnum moss, the carnivorous Pacific Sundew, and many others. This special plant community supports an assemblage of insects, birds and other wildlife that rely on wetlands for foraging, sanctuary, and breeding habitat.

Bogs, including those in the basin, began as lakes that were filled in over millennia by plant growth and sedimentation. The peat soil in bogs is usually very deep; for example, the peat in Queens Bog is estimated to be greater than 45 meters deep, and the system is over 9,000 years old (unpublished WDNR research data, to be published in 2021). King County has the largest number of identified bogs of any county in Washington, and numerous bogs occur on the Sammamish Plateau. Bogs provide some functions at a higher level than other wetlands, such as providing a slow release of cool water to streams during hot summer months. The deep peat soils in bogs absorb water like a sponge and provide an excellent source of dry season water for nearby streams. This same characteristic allows bogs to provide for downstream flood control during the rainy season.

Riparian Areas

Riparian buffers provide a suite of important ecological functions needed for properly functioning riverine and terrestrial habitats. Healthy riparian areas support fish and wildlife species by both providing habitat directly and by creating and maintaining key physical, biological, and chemical ecological processes that create and maintain habitat.

Riparian buffers are the transition zone between streams and upland terrestrial habitat. Riparian buffers offer a variety of ecological functions, such as: (1) providing shade to the stream in summer; (2) stabilizing the stream bank; (3) providing nutrient input to aquatic organisms; (4) serving as a source of large woody debris to create in-stream habitat; (5) assisting with flood retention; (6) supporting nutrient cycling, sediment and pollutant filtration, and carbon sequestration; (6) providing complex wildlife habitat; and (7) allowing an area for stream channel migration (WDFW, 2018; Knutson and Naef, 1997). Stream riparian ecosystems generally include the upland corridors adjacent to the stream banks that that directly contribute organic matter or large wood to the active channel, as well as active floodplain areas, riverine wetlands, and steep slopes that provide wood and sediment to streams via landslides or sloughing (Gregory et al., 1991; Naiman et al., 1998).

Within riparian areas, wetlands play an important role in providing wildlife habitat, as wildlife use is generally greater than in other habitats because the major life requirements for many species are present in the wetlands (Oakley et al., 1985). According to the Washington Department of Fish and Wildlife (WDFW), stream riparian ecosystems are designated as priority habitats "in part because wildlife occurs more often and in greater variety" in these areas than in other habitat types (WDFW, 2018).

Habitat for many upland and aquatic species, including salmonid species that rely on lower reaches of Laughing Jacobs Creek, rely on the physical and biological processes and functions provided by riparian corridors. Along with habitat functions, riparian corridors provide important functions for flood control, groundwater recharge and summer baseflow maintenance, and maintenance of water quality and temperature (MEA, 2005 as cited in WDFW, 2018).

In the Laughing Jacobs Basin, most wetlands are located within the riparian area (defined in the GIS analysis as a 150-foot buffer) of a stream or lake. Of the approximately 148 acres of mapped wetland area within the Laughing Jacobs Basin, approximately 113 acres of wetland overlap (either partially or totally) with the riparian buffer of a stream, equating to approximately 81 percent of all wetlands within the basin (Table 10). On a subbasin scale, the relationship ranges from a low of 69 percent of wetland area in the Middle Subbasin to a high of 93 percent of wetland area in the Upper Subbasin.

Table 10. Relationship Between Wetlands and Riparian Areas in Laughing Jacobs Basin

Subbasin and *Water Body*	Total Wetland Acreage	Total Acreage of Wetlands Intersecting Stream Buffer	Total Number of Wetlands Intersecting Stream Buffer	Total Acreage of Wetlands Completely Outside Stream Buffer	Total Number of Wetlands Completely Outside Stream Buffer	Percent of Total Wetland Area Associated with Streams
Lower Laughing Jacobs	**14.2**	**11.12**	**3**	**3.08**	**1**	**78.3**
Lower Mainstem		*11.12*	*3*			
Middle Laughing Jacobs		**56.81**	**7**	**26.14**	**5**	**68.5**
East Tributary		*10.58*	*2*			
Laughing Jacobs Lake		*30.87*	*1*			
South Tributary		*13.35*	*1*			
West Tributary		*2.00*	*3*			
Upper Laughing Jacobs		**80.24**	**8**	**6.36**	**8**	**92.7**
Upper Mainstem		*65.04*	*3*			
Other Areas		*15.20*	*5*			
TOTALS		**148.16**	**18**	**35.58**	**14**	**80.6**

Another factor in the functionality of riparian buffer is the type of land cover within this area. In Western Washington, pre-developed riparian areas consisted of a mix of habitat types, dominated by mature forest, but also including shrub and wetlands habitat, depending on location, topography, and other factors. Under existing conditions, the forest land cover type still dominates, representing by far the largest land cover type in buffers basin-wide (approximately 58% of all riparian areas), while wetlands (15%) and grass (13%) also are well represented (Table 11). Conversely developed land cover types, which approximate impervious surface, are present in only 8 percent of the basin-wide buffers.

The buffer condition varies substantially by subbasin and by drainage (Table 11). For example, in the Middle Subbasin, the forested land cover type in the buffer of the West Tributary is 79 percent, while it is only 31 percent in the South Tributary buffer. When analyzing riparian cover with the three subbasins, the Lower Subbasin has the best riparian conditions (most forest and least developed area), followed by the Upper Subbasin and the Middle Subbasin. This pattern reflects subbasin-wide land cover conditions (see Table 3) and is likely due to historical and current development and growth patterns, which are in turn linked to the presence/absence of other regulated critical areas (e.g., wetlands and steep slopes).

It should be noted that in the buffer condition analysis, a uniform buffer distance of 150 feet from each side of the stream was applied in GIS. However, in some cases, the actual regulated buffer distances per the City of Sammamish Critical Areas Code are less than the 150 feet. If the regulated buffer distances were applied, the amount of forested land cover in the buffer would likely increase, while the amount of developed land cover in the buffer would likely decrease. Furthermore, the land cover analysis does not differentiate between the quality of a single land cover type. For example, an immature deciduous forest with an understory of invasive species and a mature coniferous forest with a well-developed understory of native shrubs are both classified simply as forest, even though there is a significant difference in the habitat quality and degree of riparian function these two types provide.

Table 11. Percent of Land Cover Types Within Riparian Buffers by Subbasin and Water Body

Subbasin and *Water Body*	Land Cover Types by Percent of Riparian Buffer Area (Within 150-feet of Stream)								
	Developed	**Forest**	**Bare Dirt**	**Grass**	**Shrub**	**Water**	**Unclassified**	**Wetland**	**Total**
Laughing Jacobs Lower	**4.8**	**77.9**	**0.9**	**4.1**	**1.9**	**0.1**	**0.5**	**9.8**	**100.0**
Lower Mainstem	4.9	78.4	1.6	5.7	2.6	0.2	0.5	6.2	100.0
Other	4.7	77.3	0.3	2.4	1.1	0.1	0.4	13.7	100.0
Laughing Jacobs Middle	**10.8**	**46.7**	**2.5**	**23.3**	**3.5**	**2.8**	**1.1**	**9.3**	**100.0**
East Tributary	11.1	35.7	3.6	18.9	2.6	1.4	0.6	26.2	100.0
Middle Mainstem	6.6	50.0	3.4	32.9	3.5	1.8	1.6	0.0	100.0
Other	26.8	45.2	2.7	20.2	4.0	0.3	0.8	0.0	100.0
South Tributary	9.3	31.2	1.0	35.1	4.8	5.1	1.5	12.0	100.0
Upper-Mid Mainstem	1.6	33.9	4.5	39.6	6.4	13.9	0.1	0.0	100.0
West Tributary	7.5	79.4	1.1	4.6	2.3	2.1	1.0	1.9	100.0
Laughing Jacobs Upper	**7.3**	**54.4**	**2.7**	**7.8**	**1.8**	**0.2**	**0.9**	**24.8**	**100.0**
Other	5.2	55.5	1.8	7.5	1.9	0.1	0.3	27.8	100.0
Upper Mainstem	9.1	53.5	3.5	8.1	1.7	0.4	1.4	22.4	100.0
Basin-Wide Average	**8.0**	**57.5**	**2.2**	**12.8**	**2.5**	**1.2**	**0.8**	**15.0**	**100.0**

Fish Use

Kokanee Salmon

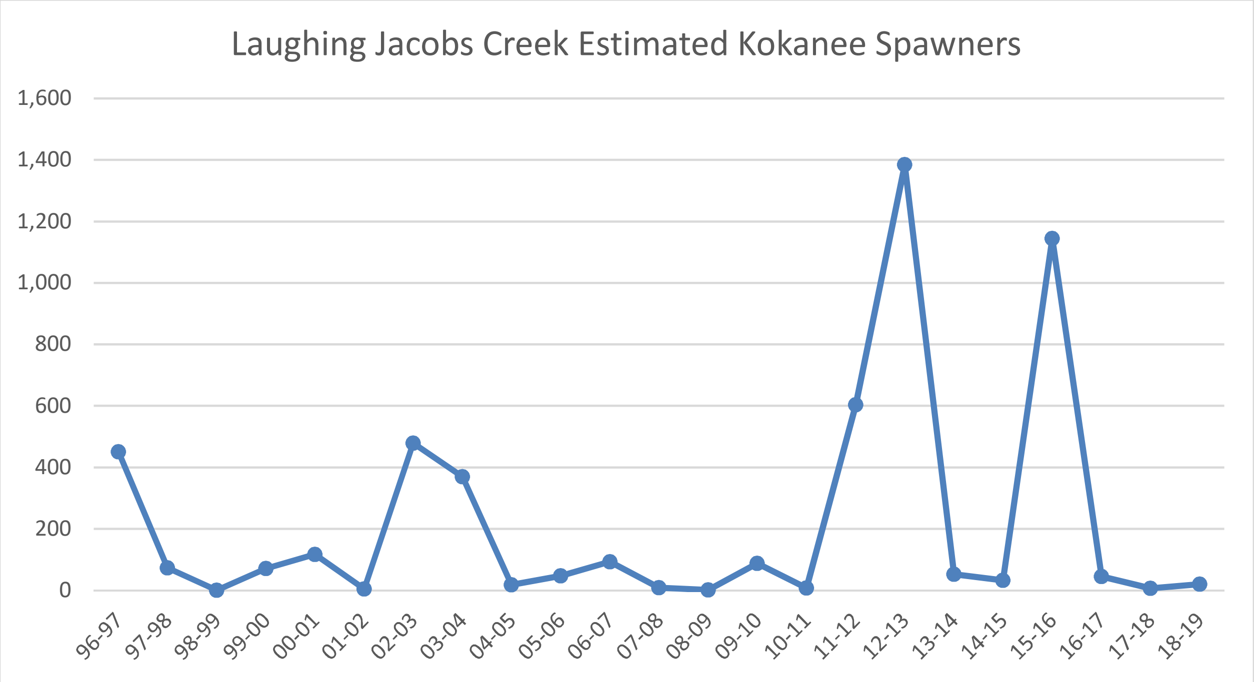
Kokanee salmon, which remain in fresh water their entire life, are the non-anadromous form of sockeye salmon (Ricker, 1938). In Washington, only Lake Washington, Lake Sammamish, and Lake Whatcom contain native kokanee salmon populations and no native sockeye salmon runs (Burgner, 1991). Sockeye salmon are usually anadromous; they migrate to sea, usually in the spring of their second year after 1 or 2 years in a nursery lake, and grow to maturity in the Pacific Ocean, followed by spawning in their natal stream (Foerster, 1968).

Kokanee salmon were present in the Lake Washington/Lake Sammamish Basin historically and are known to be native (Seeb and Wishard, 1977; Crawford, 1979; Hendry, 1995; King County DNR, 2000). Currently, kokanee salmon in the Sammamish River/Lake Sammamish Basin can be separated into three races based on different spawn timing and location (Berge and Higgins, 2003): (1) a group of early-run kokanee salmon spawning from August through September in Issaquah Creek (at the south end of Lake Sammamish), now extirpated; (2) a group of middle-run kokanee spawning from late September through November in the larger Sammamish River tributaries, thought to likely be effectively extinct; and (3) late-entry kokanee salmon that spawn from October through January in the Sammamish River and Lake Sammamish tributaries that spawn in late fall (October through January) in tributaries of Lake Sammamish.

Ostergaard (1996) described eight streams along the east and south shores of Lake Sammamish that historically supported native early-run kokanee salmon; however, under current conditions the vast majority of spawning is late-entry kokanee in just four primary streams: Laughing Jacobs, Lewis, Ebright, and Pine Lake creeks (LSKWG, 2014, 2017).

In most brood years, the spawning numbers have been lower in nearby Laughing Jacobs Creek than in Lewis or Ebright creeks but higher than in Pine Lake Creek. King County DNRP has regularly conducted spawning surveys in the Lake Sammamish tributaries, including Laughing Jacobs Creek (Berge and Higgins, 2003; J. Bower, personal communication). As shown in Figure 12, in the 23 brood years from 1996–1997 to 2018–2019, kokanee escapement in Laughing Jacobs Creek has ranged from 0 in 1998–1999 to 1,384 fish (7-day stream-life estimate) in 2012–2013 (LSKWG, 2014; J. Bower, personal communication) and has averaged 222 fish. However, over this period, the number of returning late-run Lake Sammamish kokanee spawners has dropped below 150 spawners for 17 of 23 brood years, including critically low numbers in the last 3 brood years (through 2018–2019) of 45, 7, and 20 fish, respectively. Spawning in Laughing Jacobs Creek has been observed to occur from late October through January, with a peak spawning time of November and December. Kokanee spawning ranges from the East Lake Sammamish Trail (RM 0.1) upstream to a large plunge pool downstream of the natural barrier falls at RM 0.97 (see discussion in the *Lower Subbasin Geomorphic and Instream Habitat* section). The primary spawning reach for kokanee in Laughing Jacobs Creek is upstream of the East Lake Sammamish Parkway from the King County stream gage (RM 0.2) up through the east end of the East Lake Sammamish State Park (approximately RM 0.8). King County estimates that approximately 70 to 80 percent of all spawning occurs in this area, with the majority of remaining spawners downstream of this reach, in the stream segment parallel to the East Lake Sammamish Trail (J. Bower, personal communication).

Figure 12. Estimated Number of Kokanee Spawners in Laughing Jacobs Creek from 1996–1997 to 2018–2019



Coho Salmon

Despite recent stable trends and population abundances near historic levels in some systems, Puget Sound coho salmon remains a candidate species for listing because of concerns over current genetic, environmental, and habitat conditions (Weitkamp et al., 1995). Coho salmon inhabiting the tributaries that flow into Lake Sammamish are managed as part of the Lake Washington/Sammamish Tributaries stock. Coho salmon are distributed throughout the accessible reaches of these tributaries, with very limited straying into this drainage from surrounding systems (WDF et al., 1993).

Adult coho enter fresh water from mid-September to mid-November, and spawning occurs mostly from mid- to late October to mid-December (Williams et al., 1975; WDF et al., 1993). This stock is considered to be a mixture of native and introduced non-native stocks (WDF et al., 1993).

Coho salmon have been documented in Laughing Jacobs Creek, with documented spawning occurring from near the mouth to a point approximately 1,300 feet upstream, and documented presence extending to the barrier falls at RM 0.97. Spawning coho have been observed in the reach adjacent to East Lake Sammamish Parkway SE in recent years (J. Bower, personal communication). Laughing Jacobs Creek provides important, albeit somewhat degraded, habitat for coho salmon.

Coastal Cutthroat Trout

Resident cutthroat trout exhibit several life histories, even within the Lake Sammamish/Lake Washington system. These include strict stream-resident forms, adfluvial forms, and anadromous forms. Resident cutthroat trout generally spawn in small tributary streams. Large woody debris and in-stream structures provide valuable habitat for cutthroat trout. Adult cutthroat typically reside in low-velocity large pools or side-channels, while the young cutthroat reside in side channels, riffles, backwater areas, and in upper tributaries of small rivers. Cutthroat trout use a variety of habitat types during their complex lifecycle. They spawn in small tributary streams, and use slow-flowing backwater areas and low velocity pools and side channels for rearing young and escaping spring high flows. Good forest canopy cover, in-stream woody debris, and abundant supplies of insects are crucial for young cutthroat survival.

Cutthroat trout occur in most of the mainstem of Laughing Jacobs Creek. Adfluvial or anadromous forms are likely present downstream of the natural barrier falls on the mainstem at RM 0.97, while cutthroat trout upstream of the falls are limited to smaller resident cutthroat trout, with a distribution extending up to near SE 24th Street of the mainstem (WDFW, 2019a,b). Where there is no blockage to upstream migration, it is common to see a mixture of resident and adfluvial life history forms, with residents typically found in the upper or headwater reaches. Adfluvial cutthroat trout have been a popular game fish in Lake Sammamish for many years.

Other Fish Species

The National Marine Fisheries Service (NMFS) designated Puget Sound Chinook salmon as threatened in March 1999 (NMFS, 1999). Summer/fall Chinook salmon in Lake Sammamish are managed as part of the Lake Washington summer/fall Chinook salmon stock. The natural spawning population of the Lake Washington-Issaquah stock is located primarily below the Issaquah Hatchery rack and is dependent on hatchery production (WDF et al., 1993). Spawn timing begins in late September and peaks in October, similar to other Chinook salmon stocks in south Puget Sound (WDF et al., 1993). Laughing Jacobs Creek has documented Chinook presence in the lower reaches, below the East Lake Sammamish Trail (WDFW, 2019a,b) based on occasional sightings of the species (J. Bower, personal communication). However, Chinook use is likely confined to episodic drop-ins of small numbers of juvenile Chinook salmon originating in Issaquah Creek. No spawning of Chinook salmon is known to occur within the Laughing Jacobs Basin.

River lamprey are a federal species of concern and is anadromous and parasitic in both fresh and marine waters. However, little is known about the freshwater life of river lamprey. River lampreys have been identified in Lake Sammamish (WDFW file records, Mill Creek); however, the spawning and ammocoete (larval lamprey) rearing areas for this species in Lake Sammamish are unknown. Based on habitat requirements, it is likely that there is the potential for river lamprey use of Laughing Jacobs Creek, downstream of the natural barrier at RM 0.97.

Largemouth bass, a non-native Priority Species (WDFW, 2019b), potentially occur in the lower reaches of Laughing Jacobs Creek. However, most largemouth bass in Lake Sammamish are located near the lake’s north and south ends (Pflug, 1981). Smallmouth bass, also a non-native Priority Species, are far more abundant in the Lake Washington/Lake Sammamish Basin than largemouth bass. These fish prefer rocky substrates, mature at age 3 or 4, and spawn in the spring. They spawn and rear along much of the Lake Sammamish shoreline adjacent to the mouth of Laughing Jacobs Creek (Pflug, 1981).

Other native fish species in the Lake Sammamish watershed are peamouth, chub, largescale sucker, mountain whitefish, and one or more species of sculpin. Numerous (24) species of nonnative fish also occur in the watershed including brown bullhead, black crappie, and pumpkinseed sunfish (Kerwin, 2001).

Wildlife

The description of wildlife in the Laughing Jacob Basin can be organized by relevant primary vegetation cover types (as opposed to the land use cover types mentioned previously). These cover types, defined below, have specific wildlife associations.

Urban Matrix

Urban matrix is the second-most abundant cover type in the Laughing Jacob Basin, after forest. It consists of a mix of buildings, asphalt, ornamental gardens, lawns, and shrubby/grassy areas with scattered trees. Naturally occurring trees within this cover type are deciduous (such as bigleaf maple) and generally 20 to 40 feet tall. Dominant shrubs are Himalayan blackberry, Scot's broom, and a variety of ornamental species. Grassy areas that are not mowed are dominated by non-native pasture grasses. Wildlife species present in the urban matrix cover type are adapted to a variety of conditions. Characteristic species include European starlings, American robins, American crows, dark-eyed juncos, spotted towhees, house finches, house sparrows, black-capped chickadees, opossums, raccoons, deer mice, and Norway rats.

Deciduous Tree Cover

The deciduous tree cover type consists of mostly deciduous trees (Oregon ash, black cottonwood, and bigleaf maple) with an understory of swordfern, salal, Himalayan blackberry, and salmonberry. Trees in this cover type are generally more than 40 feet tall, and some cottonwoods reach more than 150 feet in height. Deciduous tree cover is scattered throughout the Laughing Jacobs Basin and includes both riparian and upland areas. Forested wetlands are included in the wetland cover type. Wildlife species associated with the deciduous tree cover type include a variety of songbirds and raptors, small mammals, deer, and a few species of amphibians and reptiles. Deciduous trees and shrubs provide nesting habitat, cover, and forage for songbirds such as warbling vireos, orange-crowned warblers, song sparrows, spotted towhees, black-throated gray warblers, and black-headed grosbeaks. Deciduous areas along streams also provide habitat for beavers. Large cottonwoods present in this cover type are particularly important as potential perch and nest sites for raptors, such as red-tailed hawks and bald eagles. Amphibians and reptiles expected to occur in the deciduous tree cover type include common garter snakes and possibly ensatinas (a type of salamander).

Coniferous Tree Cover

The coniferous tree cover type consists of mostly coniferous trees (Douglas fir, western red cedar, and western hemlock), with an understory of swordfern, low Oregon grape, Himalayan blackberry, and English ivy. Trees in this cover type are generally 40 to 80 feet tall. Within the overall basin, coniferous tree cover occurs as small and large patches in upland areas, as well as in riparian habitat. Wildlife species characteristic of the coniferous tree cover type include ruby-crowned kinglets, Steller's jays, red-breasted nuthatches, pileated woodpeckers, vagrant shrews, and shrew-moles. During winter, coniferous trees provide important cover for a variety of birds, such as black-capped chickadees, Steller's jays, American robins, and song sparrows.

Wetlands

The wetlands cover type varies considerably in vegetation cover and includes bogs, forested, shrub, and emergent habitats. Wildlife species characteristic of wetlands within the Laughing Jacobs Basin include great blue herons, mallards, Canada geese, belted kingfishers, red-winged blackbirds, willow flycatchers, Bewick's wrens, Pacific treefrogs, and western terrestrial and common garter snakes. Riparian wetlands provide foraging habitat for beavers and muskrats, and breeding habitat for long-toed salamanders. Reed canarygrass-dominated wetlands provide habitat for Canada geese, striped skunks, long-tailed weasels, creeping voles, Townsend’s moles, vagrant shrews, Townsend’s voles, and northwestern garter snakes. Red-tailed hawks and northern harriers may hunt for prey (e.g., garter snakes and small mammals) in such areas. Wetlands with open water portions provide habitat for mallards, gadwalls, buffleheads, and other waterfowl, which may also use the emergent wetlands within the Laughing Jacobs Basin.

Priority Habitats and Species

A review of WDFW (2019b) indicated that the following priority Priority Habitats and Species (PHS) species occur within, or immediately adjacent to, the Laughing Jacobs Basin:

- Townsend's Big-eared Bat
- Yuma Myotis
- Little Brown Bat

In addition, PHS data identified a Waterfowl Concentration on Lake Sammamish, immediately adjacent to the inlet of Laughing Jacobs Creek.

Beaver

The American beaver is the largest rodent in North America and is found statewide, wherever suitable habitat exists. Adult beaver typically weigh between 45 and 60 pounds and are 3 to 4 feet long (Hall and Cannon, 2013); they can live up to 20 years in the wild (Singleton and Taylor, 2010) but more commonly live 5 to 10 years (WDFW, 2011). Beavers are territorial and reproduce only where there is available habitat, which restricts beaver population growth. On average, 1 mile of stream can support up to two colonies (Hawley-Yan, 2016).

Beavers are “ecosystem engineers” in that they are among the few species besides humans that can significantly change the geomorphology, and consequently affect both the hydrological characteristics and biotic properties, of the landscape. This can improve heterogeneity and both habitat and species diversity at a landscape scale (Rosell et al., 2005). For example, beaver dams add complexity to streams and rivers while slowing water velocity. The ponds behind these dams store water that is slowly released during low-flow conditions. In addition, beaver ponds can also increase groundwater recharge and retention, store sediment, and increase riparian habitat.

These changes shift plant and invertebrate communities and increase habitat for waterfowl, amphibians, and mammals. The slow-moving water also provides refuge for fish including juvenile coho salmon, with studies showing beavers can have a positive effect on the density, survival, and production increase to both coho salmon (ODFW, 2005) and steelhead (Bouwes et al., 2016). The slow water, abundance of invertebrates, and increased aquatic vegetation provide opportunities for young fish to forage while requiring less energy. While these effects may vary depending on the size and location of a dam, the benefits are manifold.

Beaver are keystone species in riverine and riparian ecosystems because of the role that they play in building complexity into these systems. Through dam-building and forested buffer management, beaver can improve or maintain healthy watersheds in the following ways:

- Beaver dams impound and reduce stream velocity during storm events, create wetlands, and retain flow to reduce storm-water run-off and increase water retention, which can improve downstream water quality (Bergstrom, 1985; Johnston and Naiman, 1987).
- Aggradation of sediment behind beaver dams promotes channel building and floodplain reconnection, which further augments subsurface flow for riparian vegetation and can repair incised streams (Butler and Malanson, 2005; Janzen and Westbrook, 2011).
- Beaver dams increase aquifer and groundwater recharge (Bergstrom, 1985; Johnston and Naiman, 1987). Together, these benefits reduce summer stream temperatures and increase available stream nutrients (Lowry, 1993; Rosell et al., 2005).
- Beaver ponds provide direct fish and wildlife habitat and more diverse vegetation (Hall and Cannon, 2013; Rosell et al., 2005).

Although no detailed information on the distribution of beaver within the Laughing Jacobs Basin is available, evidence of beaver activity is occasionally observed within the basin, including during the field evaluation portion of the Watershed Characterization. Several culverts in the City have required beaver dam removal and/or beaver removal, and beaver deterrence measures (e.g., beaver deceiver) have been installed on several culvert crossings.

Detailed Assessment

The following sections summarize the methodology and results of additional field work performed as a finer-scale analysis of the conditions of riparian and wetlands conditions, as well as detailed analysis of geomorphic and instream habitat. The results are reported by subbasin, as is more detailed information on land cover and the built environment.

Methodology

Field Methodology

Physical and biological conditions in the Laughing Jacobs Basin were evaluated during creek walks on April 29, 30, and May 2, 2019. Assessment of wetland conditions occurred on July 8, 2019, with focus on wetland areas associated with Laughing Jacobs Creek and tributaries and areas where existing stormwater facilities are contiguous with or immediately adjacent to wetlands.

The stream corridor was accessed periodically at road crossings and other similar access points to provide a broad overview of the physical and biological conditions of the creek. Evaluations included qualitative observations of geomorphic, aquatic, and riparian habitat, and wetland/upland conditions.

Geomorphic Conditions

The geomorphic assessment, conducted concurrently with the habitat and riparian assessment, consisted of walking selected stream reaches within the basin, deemed as representative of the larger basin conditions. Observations were made on basic fluvial geomorphology conditions, including:

- Bankfull width
- Approximate stream gradient
- Vertical creek stability (incising, aggrading, or stable)
- Visible evidence of erosion and deposition
- General stream morphology
- Large wood abundance
- Connection to floodplain
- Streambank conditions (natural, armored, eroding)
- Streambed material (fines, sand, gravel, cobble)
- Substrate embeddedness

Instream Habitat and Riparian Conditions

The habitat assessment consisted of walking selected stream reaches within the basin, deemed as representative of the larger basin conditions. Data on habitat conditions within the streams assessed were collected primarily through qualitative observations, although quantitative habitat measurements were collected for certain habitat elements. Those habitat elements where field measurements were recorded include:

- Channel width (wetted and bankfull widths)
- Maximum wetted pool depth
- Average wetted pool depths
- Channel slope using a clinometer

The following habitat elements were also assessed in the field, with qualitative notes and written descriptions that characterize the stream and riparian conditions:

- Channel morphology (relative amount of pools, riffles, and runs/glides)
- Dominant and subdominant substrate type throughout reach
- Relative embeddedness (high, medium, or low)
- Presence of suitable spawning gravels throughout reach
- Riparian zone width, density, and composition throughout reach
- Presence of wetlands adjacent to stream or in floodplain throughout reach
- Presence of large woody debris and small woody debris throughout reach
- Channel shape (e.g., trapezoidal or rectangular) throughout reach
- Bank condition, including signs of active erosion or scour, presence of undercut banks, and extent and nature of stream armoring throughout reach

Wetland and Upland Conditions

The assessment of wetland and upland conditions in the basin provides an indication of the overall biological and physical characteristics outside of stream corridors. Targeted field visits were completed by a wetland ecologist and watershed scientist from Environmental Science Associates (ESA), along with the City project manager. The upland assessment activity was completed to verify and further detail on-the-ground conditions at identified key upland, wetland, and stormwater facility locations within the basin, filling in identified gaps and furthering understanding from the stream assessment. Each of the large wetland areas, including the historic bogs around Laughing Jacobs Lake, Queens Bog, and the 24th Avenue SE complex, were visited and a functional assessment of habitat, water quality, and hydrologic functions was completed. The assessment also focused on conditions surrounding existing stormwater facilities adjacent or within wetland areas, and conditions where wetlands extended to road rights-of-way.

Stream Hydrology

The mean flows during the 3 days of the field reconnaissance, as measured at the King County gage, were 1.7, 1.6, and 1.4 cfs on April 29, April 30, and May 2, 2019, respectively (King County, 2019). Although no visible change was observed over this time period in flow levels downstream of Laughing Jacobs Lake, the East Tributary to Laughing Jacobs Lake and several reaches of the upper reaches of the upper mainstem (adjacent to SE 24th Street and below the headwaters in Klahanie Park) went partially dry between April 30 and May 2.

Upper Subbasin Assessment

Land Cover and Built Environment

Land use patterns in the Upper Subbasin are built out to the west of the mainstem Laughing Jacobs Creek and to the south of SE 24th Street. This area, extending above Issaquah-Pine Lake Road, includes the highest intensity development anywhere in the subbasin, with commercial retail uses anchored around the QFC grocery store. The Madison Sammamish Apartment development at 230th Lane SE is immediately east of this and adjoins the Sunny Hills Elementary School campus. The remainder of this area is built-out with detached single-family neighborhoods, all at approximately four units per acre (consistent with R-4 zoning). These neighborhoods were platted in the 1990s.

The portion of the Upper Subbasin to the east of the mainstem, between SE 32nd Street to the south and SE 24th Street to the north, shows an older pattern of larger lot residential platting, with detached single-family homes on 1-acre lots. The south portion of this area, closer to SE 32nd Street, is actually within the Middle Subbasin and drains south toward Queens Bog. Significant forest cover remains across this neighborhood, which extends east to the basin boundary. All of this area is zoned R-4, so some amount of residential short platting is anticipated in the foreseeable future. Because of the existing pattern of many owner-occupants, platting and redevelopment in this area will most likely occur incrementally (as has been the case in recent years, with only a handful of short plats apparent from review in King County iMap). That said, over time redevelopment will likely result in reduced forest cover and increases in total impervious cover.

To the north of SE 24th Street in the northeast portion of the Upper Subbasin, one larger residential subdivision was built-out in the early 2000s (the Laurels neighborhood at 242nd Ave SE). Otherwise, the upper limits of the subbasin surrounding 238th Ave SE, SE 18th Street, SE 18th Place, and 245th / 233th Avenue SE occur on large (1+ acre) residential lots, consistent with a platting pattern from 40 or more years ago. These lots generally occur at a density that is below City zoning, such that short plats could likely occur in the future. In all of these areas, the larger residential lots are predominantly built with homes, and the residential structures are typically assessed as “Good” or better by King County assessor data. In addition, lots are predominantly owner-occupied, so are not assembled under common ownership. Because of this existing pattern, platting and redevelopment in these areas will most likely occur incrementally. That said, over time redevelopment will likely result in reduced forest cover and increases in total impervious cover.

Geomorphic and Instream Habitat

The upper mainstem reach of Laughing Jacobs Creek extends from the headwaters down to where Issaquah-Pine Lake Road SE crosses Laughing Jacobs Creek. The headwaters of Laughing Jacobs Creek flow over glacial till and recessional outwash deposits, which are a source of stream gravels and sand (Figure 4a; Booth et al., 2012). The headwaters also drain finer-grained glacial ice-contact deposits. The stream is seasonal with the middle reaches going dry between April 30 and May 2, 2019.

Upstream of 224th Avenue SE in Beaver Lake Park, Laughing Jacobs Creek emerges from Long Lake, the second in a chain of lakes below Beaver Lake, on the upstream end of Beaver Lake Park. Upstream of 244th Avenue SE, in Beaver Lake Park, Laughing Jacobs Creek is wide (bankfull width to approximately 31 feet) and appears to widen even farther upstream, up to nearly 50 feet in places (Photo 1 [photos are presented in Appendix B]). In this area, streambanks are low and gentle, and the creek is well connected to its floodplain. The gradient is gradual (less than 1% slope) and is dispersed over a wide area, including rooted trees through the forest in the park, which appear to be dying from regular inundation. The cause of the wide flow-path was not determined, but stream bed substrate (sand to 4-inch cobbles, with an average gravel diameter of about 1.5 inches) is dispersed throughout. One possible explanation is the deposition of sediment in the low-gradient reach from high flows originating in Long Lake mobilizing upstream sediment. During low flows, the 244th Avenue SE culvert backwaters the creek for about 40 feet upstream, which encourages the deposition of fine sediment in this area, including an area dominated by spawning-gravel sized materials near where the stream emerges from the forest.

A 3-foot diameter pre-cast culvert (WDFW Site ID 920035, see Appendix C for details) under 244th Avenue SE is classified by WDFW (2019c) as having unknown barrier status. The roadway crossing over the stream appears to have been replaced relatively recently; however, this work was conducted over the top of the culvert crossing, which does not appear to have been altered.

Immediately downstream of the 244th Avenue SE culvert, water is pooled, and the substrate is fine (silt/sand) with few gravels (Photo 2). Below the ponded area, natural streambanks are about 1.5 feet tall and the creek transitions to pool-riffle morphology for a short distance before entering a series of two inline ponds (approximately 60 by 80 feet). After flowing through the ponds, the creek flows north through the backyards of numerous residences, with a riparian zone consisting of a mix of forested, shrub, lawn, ornamental plantings, and developed land.

The mainstem flows north under SE 24th Street through a 5-foot-wide by 2-foot-high pre-cast concrete box culvert (WDFW Site ID 920034, see Appendix C for details), which is classified by WDFW (2019c) as having unknown barrier status. During the site visit, the freeboard was 0.2 foot at both the inlet and outlet (the culvert has slight negative slope). The culvert is partially full of channel material, primarily cobble, with a maximum water depth of 1.4 feet at the culvert inlet. The structure appears to be backwatering the stream, as the channel upstream of the inlet is fully wetted upstream, to a width of 6 to 8 feet. This crossing could present a flooding problem, based on the limited freeboard under low-flow/no-flow conditions, although no scour was observed at the inlet or outlet during the site visit.

Immediately downstream of the small pool at the culvert outlet, the stream was dry on May 2, 2019, with a bankfull width on the order of 9 to 10 feet and a slope of approximately 2 percent. This reach appears to be vertically stable, with moderately sloped banks and a substrate dominated by sand and small gravel, with a smaller amount of large gravel and cobbles. The riparian understory of willow, salmonberry, and vine maple provides shade and cover to the stream channel, as does the deciduous forest comprising the overstory.

The next road crossing downstream is the culvert crossing of 242nd Avenue SE. Between this area and 242nd Avenue SE, the stream flows through a vine maple and salmonberry-dominated riparian wetland, with a combination of pool-riffle morphology and uniform glide habitat. There is minor erosion of the natural streambanks upstream and downstream of the 242nd Avenue SE culvert. Large wood in the stream is largely absent, although there are small amounts of small wood. Floodplain connectivity is generally moderate to good. Upstream of the culvert, substrate is finer, with sand to small gravels upstream of the culvert and minor amounts of silt.

A large two-cell stormwater pond, associated with the Laurels development, is located north of the stream, just downstream of 242nd Avenue SE. The pond discharges into another pond, which is physically connected to the stream and has wetland characteristics. Stormwater from another constructed pond on the northeast side of the 242nd Avenue SE and SE 24th Street intersection also discharges to the stream on the left bank in the vicinity of the stormwater wetlands. The reach downstream of 242nd Avenue SE has an understory of willow, salmonberry, and vine maple, which provides shade and cover to the stream channel, as does the deciduous forest comprising the overstory. Prior to the stream crossing back to the south side of SE 24th Street, it enters a large scrub-shrub wetland dominated by willow. This wetland appears to have piped connections with a stream channel/ditch on the south side of the roadway, which also appears to receive stormwater runoff from several catch basins. The ditched portion of the stream, essentially stagnant during the site visit, runs for about 250 feet on the south side of SE 24th Street and is confined (4-feet-wide) and entrenched approximately 4 feet and is completely lined with heavy riprap.

Two stream crossings were noted in this reach. The first, to the east, is a round culvert (WDFW Site ID 920032, see Appendix C for details), classified by WDFW (2019c) as having unknown barrier status. The second is a box culvert crossing from the wetland to near the driveway on the south side of the roadway (at 24007 SE 24th Street) that has not been evaluated by WDFW. Both culverts appear to drain the general wetland area, which may serve as a flood retention area, as no defined channels were observed in the vicinity of the inlet locations. At the east terminus of the roadside ditch, near the outlet of the box culvert, a 36-inch-diameter corrugated metal pipe (CMP) crosses under a driveway at 24007 SE 24th Street. This structure has not been evaluated by WDFW; however, based on the large size and limited length (15 feet), it is unlikely that it is a fish passage barrier. Downstream of the driveway, the channel is entrenched approximately 4 to 5 feet, and some bare banks are present, although major signs of active erosion are absent. Stream substrate is sand to 3-inch cobbles, with a median size of about 1 inch near the culvert, and fining to sand to 2-inch gravel with a median size of half-inch gravel farther downstream. The stream slope is approximately 4 percent upstream of the 239th Avenue SE. Riparian conditions are comprised of medium-age mixed forest, with a native understory of salmonberry and swordfern. A few pieces of large wood and a moderate amount of small wood are present within the reach. This portion of the stream was almost completely dry between April 30, 2019 and May 2, 2019.

At 239th Avenue SE, the stream flows under the roadway through three parallel 4-foot-diameter round corrugated steel culverts. WDFW has classified this crossing (WDFW Site ID 920031, see Appendix C for details) as a total fish barrier based on culvert slopes (WDFW, 2019c). A large amount of brush and woody debris is present at the culvert outfall.

The 300 feet of stream downstream of 239th Avenue SE and extending to a private road crossing south of SE 24th Street has a bankfull width of approximately 9 to 10 feet and a stream gradient of about 1.5 percent, as the stream flows through mature mixed native riparian forest (Photo 3). This reach appears to have incised previously and has approximately 3-foot-tall banks with poor floodplain connectivity, but it does not appear to be actively incising now. There is some minor erosion of natural banks. The creek has pool-riffle morphology, with only small amounts of woody debris. Bed material in this area is generally sand or granules to 3-or 4-inch cobbles with a median size of approximately one-half-inch gravel. The gravel has low embeddedness.

The stream crosses under the private driveway located 300 feet east of 239th Avenue SE through a box culvert, which has not been assessed for fish passage by WDFW (2019c). Immediately downstream of the driveway, the stream enters the 24th Avenue sphagnum bog wetland (Photo 4). Although the stream reaches in the bog were not examined, aerial photos from 1936 indicate the bog area was previously drained by a series of linear excavated channels that now serve as the mainstem stream channel and several tributaries that join the mainstem in the wetland. The historic channelization extends downstream to Issaquah-Pine Lake Road.

The stream flows through the bog to a point approximately 800 feet south of where the mainstem enters the bog. Here, the wide wetland floodplain (up to 700 feet wide) becomes more confined within an 80-foot-wide valley, with bog habitat transitioning to forested riparian wetlands. From this point, flow was present in the stream to Laughing Jacobs Creek downstream to SE 32nd Way, bankfull width is approximately 9 feet, and the stream is confined due to 3 to 4 feet of channel incision, which severely limits floodplain connectivity (Photo 5). Although incised, the stream banks show signs of only minor bank erosion. Stream slope varies from about 1 to 2 percent. Bed materials range from sand to 3-inch-diameter cobbles with low embeddedness.

Riparian conditions are good, with 120 to over 200 vertical feet of mature conifers (primarily western red cedar and Douglas fir) on both banks providing almost complete canopy closure. Overhanging vegetation, primarily vine maple, provides some overhead cover. The stream displays pool-riffle channel morphology, combined with reaches of uniform depth (0.5- to 1.0-feet-deep) run habitat. Several pools with a depth of between 1 and 2 feet were noted. Although large wood is not plentiful, there are several larger logs (approximately 1.5 to 2 feet in diameter) both within and spanning the entrenched channel. In addition, a single 3- to 4-foot-diameter conifer, with rootwad attached, has fallen in the stream and collected several other pieces of large wood to form a jam.

Within the confined reach upstream of SE 32nd Way, the stream flows through the front yard of a single residence at 23622 SE 32nd Way in a trapezoidal-shaped channel. Although the stream is approximately 15 to 20 feet from the residence in a grass yard, the residents have planted native streamside shrubs to enhance the riparian condition. Stream substrate is excellent in this reach, consisting of well-sorted small and large gravel. The stream crosses under the driveway to the residence, in dual 24-inch diameter CMP culverts, which have not been evaluated by WDFW for fish passage (WDFW, 2019c).

The stream crosses under SE 32nd Way in 6.5-foot by 5.-foot corrugated aluminum squash culvert (WDFW Site ID 920029, see Appendix C for details) that is 100 percent passable (WDFW, 2019c). Downstream of SE 32nd Way, the stream has a bankfull width of approximately 26 feet (Photo 6). The stream appears to be stable and bank erosion was not observed. Morphology downstream is primarily a glide, although some riffles and pools are present. Small stream-side riparian wetlands are present downstream of the culvert. Low, gradual banks provide floodplain access, and there are some high flow channels. Stream substrate is generally silt and sand with a few gravels smaller than three-quarters of an inch in diameter, with a median grain size of sand. Riparian habitat for the reach extending from SE 32nd Way to a point approximately 600 feet downstream is fair and consists of moderate-aged mixed forest, extending from 50 to 100 feet from the streambanks. Some overhanging vegetation, primarily bigleaf maple and vine maple, provides instream cover.

From SE 32nd Way, the stream flows south, where it crosses under Issaquah-Pine Lake Road SE between 234th Avenue SE and SE 36th Lane. The crossing (WDFW Site ID 920028, see Appendix C for details) consists of a 4.5-foot wide by 3-foot corrugated steel squash culvert that is considered a total fish passage barrier (0% passable) due to slope (WDFW, 2019c). Immediately upstream of the crossing for a distance of approximately 240 feet, the stream is channelized between a residence and the Lakeside Montessori School (Photo 7). Here, the banks consist of vertical riprap/concrete, and the stream is entrenched approximately 3 feet with a 9-foot-wide bankfull width. The stream has a substantial amount of aquatic vegetation within the wetted channel, which consists of uniform, 1-foot-deep run morphology. Slopes upstream and downstream of the culvert are approximately 1 percent or less. Erosion was not observed upstream of Issaquah-Pine Lake Road SE at this location, and stream substrate consists of granules to 2-inch gravels.

Riparian and Wetland Conditions

Two large wetland areas are mapped within the Upper Subbasin: the wetlands within Beaver Lake Park, and the wetland complex occurring to the north and south of SE 24th Street.

The depressional wetland area within Beaver Lake Park occurs near the headwaters of Laughing Jacobs Creek. The wetland slopes slightly from the west to the east along the alignment of the upper mainstem of the stream (Photo 8). In addition to overflow from the stream, hydrological inputs include precipitation and a high groundwater table. The wetland has been bisected by a powerline corridor and associated trail. The east and west portion of the wetland were likely connected before fill was placed to support the powerline corridor. Water flows through a culvert under the trail and into the west portion of the wetland. Based on an analysis of aerial imagery, it appears that inundation occurs to the east of the culvert, resulting in an area of open water and emergent cover. The remainder of the wetland is forested and dominated by species such as western red cedar and Oregon ash. The outflow enters Laughing Jacobs Creek, which flows through an area of mowed lawn, before being piped under 224th Avenue SE.

The shrub-dominated, depressional wetland complex along SE 24th Street (Photo 9) has been documented as a bog by the 1990 King County Wetland Inventory (King County, 1990b). The wetland is bisected by SE 24th Street, as well as several access roads and driveways. Based on an analysis of aerial photos, several ditches have been dug through the wetland and the area appears to have been used for agriculture purposes in the past. Additionally, stormwater outfalls into the wetland are mapped as occurring in several areas along SE 24th Street (Storm Bandit, 2019). Past agricultural pollutants, in addition to current pollutants from the roadway, have likely changed the chemistry of the water so the wetland now supports fewer bog species. This is supported by the large monoculture of Douglas' spirea that covers most of the bog. However, the central portion of the bog was observed as being dominated by bog-tolerant species such as bog cranberry, bog laurel, and Labrador tea, as recently as December 2017 (ESA, 2018).

Both of these wetland complexes provide a moderate to high water quality function as they both are largely vegetated with plants that persist throughout the year and aid in filtering out pollutants. Additionally, the uptake of dissolved phosphorus and toxic compounds is highest when soils are high in organic content (Mitsch and Gosselink, 1993), such as those present in bogs. These wetlands also provide a high hydrologic function as they store water during times of high flow and reduce or prevent flooding downstream. Both wetland areas also provide moderate habitat function. However, the habitat function of the bog is slightly higher due to the structural diversity of the wetland, which optimizes the potential for breeding areas, escape, cover, and food production (Hruby, 2014).

Middle Subbasin

Land Cover and Built Environment

Land use patterns are generally built-out consistent with underlying zoning in the Middle Subbasin. The large majority of this subbasin is built out with lower density detached single-family residential. To the east of Issaquah-Pine Lake Road and to the south of Queens Bog, the subbasin includes a large portion of the Klahanie Neighborhood, a large residential development built in the late 1980s at a density of approximately four to six dwelling units per acre (majority of zoning is R-6). Farther south along Issaquah-Pine Lake Road surrounding the South Tributary, areas outside of the large wetland corridor also support residential neighborhoods, platted at densities consistent with underlying zoning ranging from R-4 to R-12. A larger property, to the southwest of the Issaquah-Pine Lake Road / SE 42nd Street Intersection, was developed in the early 2000s as the Jacobs Creek Condominium community. This is a clustered development, with a series of attached condo structures grouped in one portion of the property and a large majority retained as vegetated open space (including stream corridors around the convergence of the South Tributary with Laughing Jacobs Creek).

Immediately around Laughing Jacobs Lake, construction and full buildout of the Meadow Leaf residential subdivision is currently underway. This large residential subdivision is one of the most recent to break ground within the City of Sammamish, with approximately 5,000 square foot detached single-family residential lots grouped near Issaquah-Pine Lake Road. Significant other portions of the property have been retained as native growth / open space tracts around the lake, and some portions of the large property are maintaining the previously rural residential character. Some ongoing livestock agriculture is still occurring (all of the property around the lake was formerly a horse farm).

Immediately west of Laughing Jacobs Lake, larger lot detached single-family residential is associated with the Sammamish Highlands and Kempton Downs neighborhoods, platted in the late 1970s and late 1980s, respectively. Lots in these neighborhoods are generally more than 15,000 square feet in size, with underlying zoning at R-1 (the City of Sammamish's lowest residential density) and R-4. Pine Lake Middle School is to the north of these neighborhoods (between Issaquah-Pine Lake Road and 228th Avenue SE). The school and associated athletic and parking lot facilities are sited on the north portion of the property, maintaining a large forested corridor associated with the tributary stream that drains to the west side of Laughing Jacobs Lake.

Across 228th Avenue SE to the west, a portion of Issaquah's jurisdiction extends north into the Middle Subbasin, which is primarily developed with the clustered Providence Point neighborhood (which extends into the lower subbasin) as well as the Sammamish Christian School campus. Farther north along the west side of 228th Avenue SE, City of Sammamish zoning is R-4. Over the last decade, a previous pattern of approximately 1- to 3-acre lots in this neighborhood have been platted into smaller detached single-family residential homes. Some additional opportunity for short platting appears to be present in this area, especially between 225th Avenue SE and 228th Avenue SE.

To the east of Laughing Jacobs Lake and to the north of the Klahanie neighborhood, predominant land uses are Klahanie Park (including Queens Bog and the surrounding forested buffer open space), Beaver Lake Middle School, and Challenger Elementary School. For both the City-owned park and the Issaquah School District campus properties, large areas of undeveloped forested open space remain.

Geomorphic and Instream Habitat Conditions

Middle Mainstem

The middle mainstem reach of the Middle Subbasin extends from Issaquah-Pine Lake Road SE downstream to near the Laughing Jacobs Creek culvert crossing under Providence Point Place SE. The creek flows through recessional outwash deposits and then through wetland deposits in the vicinity of Laughing Jacobs Lake before flowing again through recessional outwash deposits, which are a source of stream gravels and sand (Figure 4a; Booth et al., 2012). It also drains areas of glacial till, ice-contact deposits, and recessional outwash deposits, amongst others (Figure 4a; Booth et al., 2012).

Downstream of the Issaquah-Pine Lake Road SE culvert, bankfull widths are on the order of 10.5 to 12 feet. Some bank erosion occurs immediately downstream of the culvert, where there are incised, steep banks and erosion has undercut tree roots (Photo 10). Morphology downstream of the culvert is pool-riffle and only small amounts of large wood are present. Once outside of the culvert influence, streambanks are approximately 2 feet tall and provide some floodplain connectivity (Photo 11). Stream substrate is generally pebble to up to 6-inch cobbles with a median diameter of about 1 inch. Embeddedness is generally low. A second culvert conveys the creek downstream of the Issaquah-Pine Lake Road SE culvert. Substrate below this lower culvert is generally sand to three-quarter-inch gravel, with low to moderate embeddedness. Prior to entering Laughing Jacobs Lake, the stream flows through a large wetland complex on the northeast side of the lake.

Laughing Jacobs Lake has a surface area of approximately 8 acres and is surrounded on the north and west sides by large wetland complexes. No control structure is present at the lake outlet, which drains to a 10- to 12-foot-wide straight channel flowing 600 feet due south through a wetland that constitutes the 200-foot-wide riparian zone on either side of the stream and consists of a reed canarygrass monoculture. Pond lily is also present within the channel, which due to channelization completely lacks habitat heterogeneity with continuous run-type habitat and no large wood.

Based on a review of 1936 historic aerial photographs, the 1,350 linear foot reach of stream between the lake outlet and SE 42nd Street was dredged and channelized sometime prior to 1936, likely for agricultural drainage. Furthermore, the northernmost 600 feet of this reach was again relocated slightly to the east, to its present location, sometime between 1936 and 1998. The channelization was likely conducted to improve drainage and reduce flooding risk in the agricultural fields that were historically present.

At a private driveway 600 feet south of the lake outlet, a culvert is present that has not been inventoried by WDFW (2019c) and should be evaluated for fish passage status. Downstream of the driveway to SE 42nd Street, the reach is still channelized, but has a narrow (10 to 20 feet on each bank) riparian zone of 15- to 30-foot -high willows and alders that provide some stream shading, although the understory consists mostly of reed canarygrass, which also dominates most of the riparian area. A moderate aged mixed forest riparian zone is present within 250 feet of SE 42nd Street. The channel is trapezoidal with uniform depth run habitat and water depths of 1 to 2 feet. Some pieces of small wood were present, but large wood was sparse to absent.

The stream crossing under SE 42nd Street (WDFW Site ID 920026, see Appendix C for details) consists of twin round metal pipes and has been assessed by WDFW as having unknown barrier status (WDFW, 2019c) (Photo 12). In the vicinity of the crossing, the stream typically has a bankfull width on the order of approximately 12 to 13 feet, but was approximately 17 feet downstream of the SE 42nd Street culvert. The creek has a gentle gradient in this reach, typically less than 1 percent, and is generally a slow-moving glide or run (Photo 13). Upstream of the SE 42nd Street culvert, the reach is incised with a poor connection to its floodplain due to channelization. The connection to the floodplain is generally better downstream of the SE 42nd Street culvert. Large wood is present in minor amounts and is typically less than 4 inches in diameter. One small wetland was observed near the pedestrian bridge next to the road.

Streambanks are composed of natural materials. Just upstream of the SE 42nd Street culvert, the creek has a sandy bed with some gravels up to approximately 1 inch in diameter. Immediately downstream of the SE 42nd Street culvert, the stream is partially impounded by a small beaver or debris dam, which has caused deposition and a silty streambed in the impounded area downstream of the culvert. Other evidence of beaver activity (chewed stump, etc.) was also observed. The channel had a 1- to 2-foot uniform wetted depth with very soft sediments comprised of silt and organic material up to 2 feet deep. Both live and dead willows are growing both adjacent to and within the stream channel, which also had reed canarygrass and blackberry on the banks and within the riparian areas. A large wetland complex, vegetated primarily with reed canarygrass, is present just downstream of SE 42nd Street at the confluence of the South Tributary and the mainstem. The wetland extends downstream of the mainstem for several hundred feet and upstream along the South Tributary for approximately 900 feet.

The lower portion of the middle mainstem, in the vicinity of 230th Way SE, has a bankfull width on the order of approximately 15 feet and a gentle gradient typically less than 1 percent. The culvert crossing (WDFW Site ID 920025, see Appendix C for details) is a large bottomless half pipe, which is fully fish passable (WDFW, 2019c) (Photo 14). Two years ago, there was a beaver dam on the upstream side of the 230th Way SE culvert, although it is no longer present (personal communication, Danika Globokar, City of Lake Sammamish, April 29, 2019). This reach appears to be stable and only minor erosion of the natural streambanks was observed. Upstream of the crossing, the stream flows through a broad (50-foot-wide) valley bottom reed canarygrass wetland that extends several hundred feet upstream of the crossing (Photo 15). The valley bottom wetland shows signs (dead trees and wrack) indicating at least somewhat frequent overbank inundation.

There is pool-riffle morphology immediately downstream of the SE 230th Way SE culvert, with high quality spawning habitat, but it transitions back to glide morphology shortly downstream (Photo 16). There is very little wood, and it is generally small wood less than 2 inches in diameter. In this area, the stream is well connected to its floodplain; banks are generally 1 to 2 feet high. There are two minor high water channels shortly downstream of the 230th Way SE culvert. Bed material generally ranges from sand to small gravels up to approximately three-quarters of an inch in diameter. Gravels are approximately 50 percent embedded in sand. An exception to this is that coarser cobbles up to 8 inches in diameter are present immediately downstream of the 230th Way SE culvert.

The lowest portion of the reach, between 230th Way SE and Providence Point Place SE, was not examined because of access issues. However, it appears that between these two crossings, the gradient transitions from very flat to slightly steeper moving downstream, with channel morphology changing from wetland-type glide and run habitat closer to 230th Way SE to slightly steeper (1% slope) pool and riffle habitat near Providence Point Place SE. The culvert under Providence Point Place SE was recently replaced with a new large, bottomless half pipe that is fully fish passable, although this crossing does not appear on the WDFW (2019c) fish passage inventory.

West Tributary

The West Tributary in the Middle Subbasin is intermittent. It emerges from a wetland near the western watershed boundary and flows across mapped recessional outwash deposits, which are a source of sand and gravel, and then across wetland deposits into the northwest corner of Laughing Jacobs Lake (Figure 4a; Booth et al., 2012). The West Tributary also drains areas of glacial till. Observations below are from the vicinity of 228th Avenue SE and SE 35th Street. Bankfull width in the vicinity of the 228th Avenue SE culvert is on the order of 2.5 to 3 feet with a steeper stream slope (2–3%) upstream of the roadway (Photo 17) and more gradual stream slope (less than 1%) downstream of the roadway (Photo 18).

Based on the small size of the stream channel and the amount of vegetation in the channel, this upper segment flows on an irregular basis. Shortly downstream of the culvert, the creek splits into four distinct braided channels, then a little farther downstream converges to one channel within a wetland with a bankfull width on the order of 1 to 3 feet. All of these channels were dry on April 30, 2019. This reach appears to be stable. The creek morphology is generally pool-riffle and minor small wood is present. The creek has good floodplain access, with natural banks on the order of 6-inches-tall. Bed material ranges from sand to 3-inch cobbles, with half-inch gravel being dominant.

Although the reach between 228th Avenue SE and 234th Avenue SE was not examined, aerial photographs and observations from near the two roadways indicate that at a minimum, the stream flows through a wetland for a large portion of the stream length, including the 600 feet immediately upstream of 234th Avenue SE. There was not a discernable channel through this wetland, which was broad and likely provides some flood storage during large storm events. The culvert conveying the stream under 234th Avenue SE has not been inventoried by WDFW, but is nonetheless a fish passage barrier due to the small 12-inch diameter concrete pipe. A large standpipe overflow structure is located along the toe of the road prism, approximately 30 feet south of the culvert inlet.

The cross culverts discharge flow into the large wetland complex on the east side of 234th Avenue SE. It appears that no defined channel is downstream; rather, sheet flow enters the large wetland complex northwest of Laughing Jacobs Lake, providing hydrology to the wetland until the dispersed flow enters the lake as either surface water or groundwater.

East Tributary

The East Tributary in the Middle Subbasin is intermittent, originating from Queens Bog and flowing east and south, before discharging into Laughing Jacobs Lake. It is unclear if this feature was present prior to 1936, as no channel is visible in historic aerial photos and no outlet to the bog is apparent. Currently, the headwaters are located in the large wetland, Queens Bog, in Klahanie Park and flows across wetland deposits, then flows downstream across recessional outwash deposits which are a source of gravel and sand to join Laughing Jacobs Lake in an area of wetland deposits (Figure 4a; Booth et al., 2012). The East Tributary also drains areas of glacial till and ice-contact deposits.

Queens Bog, a high quality wetland, also detains City stormwater from adjacent areas. An 8-foot-diameter standpipe with a debris rack (birds nest) controls the flow of water from Queens Bog west into the upper reaches of the stream (Photos 19 and 20). Although the barrier status of this crossing has not been assessed by WDFW (2019c), the structure is a barrier due to the standpipe. Between the standpipe and 241st Avenue SE, the East Tributary is shallow and wide (ranging from 10 to 20 feet) just downstream of the outlet and not well defined in places, with angular cobbles in places and (Photo 21). Upstream of 241st Avenue SE, the channel narrows some to a bankfull width of 9 to 10 feet and the channel becomes more confined.

The culvert under 241st Avenue SE has not been assessed by WDFW (2019c) and the barrier status is unknown. Downstream of 241st Avenue SE, the stream is more confined and has an average bankfull width of approximately 9 feet. The slope is estimated to be approximately 1 to 2 percent. In this vicinity, the creek has pool-riffle morphology and has a low amount of small wood. The creek has good floodplain connectivity with 6-inch-tall, natural, gentle streambanks. Bed material generally ranges from sand up to one-and-a-half-inch gravel, with minor silt. Gravel is approximately 50 percent embedded in sand.

Farther downstream, immediately upstream of Issaquah-Pine Lake Road SE, the East Tributary has a very low (less than 1%) gradient and is ponded, forming an open water wetland with organic matter and silt deposition in the ponded area. This wetland appears to be associated with the stream for at least 1,000 feet upstream of the road crossing and is present along most of the stream length from 241st Avenue SE to Issaquah-Pine Lake Road SE. The stream channel upstream of Issaquah-Pine Lake Road SE is generally aggrading because of its ponded nature. Large wood amounts are low and the wood that is present is generally smaller than 3 inches in diameter. Streambanks are gradual. A stormwater pond adjacent to SE 37th Place discharges via a pipe on the left bank of the stream, near the culvert inlet. The East Tributary is entirely piped from the east side of Issaquah-Pine Lake Road SE downstream to the lake. This culvert is a complete fish passage barrier, due to length alone, although it does not appear on the WDFW (2019c) fish passage inventory.

South Tributary

The headwaters for the seasonal South Tributary in the Middle Subbasin are a series of three open-water wetlands /stormwater ponds on the east side of Issaquah-Pine Lake Road SE between SE Klahanie Boulevard to the north and extending south of 238th Way SE (Photo 22). In the vicinity of SE Klahanie Road, the stream crosses Issaquah-Pine Lake Road SE in a culvert, then flows northeast through a large wetland complex prior to entering the mainstem Laughing Jacobs Creek, just downstream of SE 42nd Avenue.

The culvert under Issaquah-Pine Lake Road SE (WDFW Site ID 920027, see Appendix C for details), which drains the large wetland/ stormwater pond and discharges into a defined channel, is classified as a partial fish passage barrier (33% passable) based on WDFW (2019c) professional judgement. The inlet of the road culvert, enclosed by a makeshift wire screen, passively regulates the level of the wetland pond and can dewater the stream when pond levels drop below the culvert inlet level in the summer months. A second culvert, under an abandoned road, is located approximately 10 feet downstream of the road culvert outlet. The fish barrier status of this pipe has not been evaluated.

As described above, historical aerial photographs from 1936 indicate that the South Tributary was completely channelized at some point prior to 1936, likely for agricultural drainage. In addition, none of the three large open-water wetlands currently present on the east side of Issaquah-Pine Lake Road SE and now serving as the headwaters of the West Tributary, were present in 1936. Instead, the channelized stream extended upstream (south) in this location, originating in agricultural fields near the present-day location of 238th Way SE.

The uppermost headwaters of the South Tributary are in glacial till and wetland deposits, while the majority of the South Tributary flows across recessional outwash deposits before joining the mainstem (Figure 4a; Booth et al., 2012). Downstream of Issaquah-Pine Lake Road SE, bankfull width is on the order of approximately 8 feet and the stream gradient is less than 1 percent (Photo 23). This reach is stable and is primarily a glide that flows for approximately 900 feet through a wetland. Large wood is generally absent, although some small wood is present. Streambanks are natural with an accessible floodplain, and dense native shrub vegetation is present adjacent to the stream, providing overhead cover. Substrates in this reach are primarily fine sediments and organic matter, with some scattered cobbles and gravel.

Riparian and Wetland Conditions

Middle Mainstem

Wetlands within this portion of the subbasin are limited to an emergent wetland area at the downstream end of Laughing Jacobs Lake (Photo 24). The middle mainstem of Laughing Jacobs Creek flows north to south, from the lake, through the wetland, and into a forested area on the south side of SE 42nd Street. The stream north of SE 42nd Street is highly channelized and appears to have been ditched. The surrounding wetland and upland areas are primarily maintained lawn.

Because of the channelization of the stream within the wetland, water likely rapidly flows through the system. Because of the low residence time in the wetland, as well as a lack of impoundment of water, the wetland has little opportunity to improve water quality or detain flow. Additionally, because most of this wetland is mowed lawn with little species diversity, structural diversity, or habitat features, it also exhibits a low habitat function.

No additional wetlands are mapped within this subbasin. Downstream of SE 42nd Street, basin topography is at a higher gradient, which can impede the formation of depressional wetlands; however, smaller, riverine wetlands along the mainstem may exist.

West Tributary

The West Tributary begins within a forested wetland area on the east side of 223rd Avenue SE. Water flows from west to east and into a large wetland associated with Laughing Jacobs Lake. Most of the wetland area within this subbasin is part of this wetland complex. The West Tributary flows through the wetland from the northwest to the southeast, and into the northeast extent of the lake. The wetland includes forested, scrub-shrub, and emergent cover. Forested portions of the wetland are dominated by Sitka spruce. Native roses, willows, and Douglas' spirea are the dominant vegetation in the shrub class; according to the East Lake Sammamish Basin and Nonpoint Action Plan (Issaquah/ELSWMC, 1994), the scrub-shrub portion of the wetland has bog-like characteristics with Sphagnum moss. Dominant emergent vegetation includes small-fruited bulrush, lady fern, and rush. Duckweed is present in inundated portions of the wetland (King County, 1990a).

Residential developments are adjacent to its northwestern and southwestern sides, and 234th Avenue S bisects the wetland and separates it from Laughing Jacobs Lake. A stormwater facility, associated with Pine Lake Middle School, is upslope and approximately 250 north of the northern extent of the wetland. Based on the City's stormwater mapping, it appears that water from the stormwater pond is released into the wetland buffer and/or wetland at the northeastern extent of the wetland (Storm Bandit, 2019). Other stormwater outfalls into the wetland are mapped as occurring along 234th Avenue S and from the residential developments on the southwest side of the wetland.

The wetland has a high water quality function based on the presence of persistent vegetation that can aid in the filtering of pollutants. Additionally, because of the presence of bog species, soils in the wetland are assumed to be largely organic, which also contributes to a high water quality function. A high water quality function is valuable to the subbasin based on the proximity of development as well as the stormwater inputs. This wetland area also has a high hydrologic function based on its size. The area of the basin is comparable to the area of the wetland (less than 10 times) and, therefore, the wetland has the ability to slow and store water before it enters downstream area that likely have flooding problems. The habitat function of the wetland is also high because it exhibits a high diversity of vegetation structures, hydroperiods, and habitat features.

East Tributary

The headwaters to the East Tributary begin in Queens Bog, within Klahanie Park. The East Tributary flows west to east through the bog, which contains most of the wetland area in this subbasin. The East Tributary is culverted under 241st Avenue SE. On the east side of 241st Avenue SE, the stream flows southwest through two additional wetlands before joining Laughing Jacobs Lake.

Queens Bog is a depressional wetland that includes primarily scrub-shrub and emergent cover (Photo 25). Several bog-tolerant shrub species occur within the wetland including bog laurel, Labrador tea, and bog cranberry. Emergent species present include soft rush and dulichium. Peat moss also occurs in the wetland (King County, 1990a). According to the East Lake Sammamish Basin and Nonpoint Action Plan, this moss subclass is very sensitive to hydrologic and chemical disturbance (Issaquah/ELSWMC, 1994). A gas line bisects the wetland near its western extent and has formed an area of open water through the trenched area.

The bog has an intact forested buffer dominated by Douglas fir around most of its perimeter. However, residential developments are immediately adjacent to the buffer to the southwest; and a park, transmission line corridor, and school are adjacent to the east. Based on the City's stormwater mapping, two stormwater outfalls on the south side of the bog convey stormwater from the residential development into the bog. Two additional drainage easements are mapped on the southwest side of the bog. However, no pipes or flow are mapped. An additional stormwater detention area is east of the bog within Klahanie Park (Storm Bandit, 2019). However, during the site visits, no connection between this site and the bog was observed. City stormwater mapping further supports this.

Similar to other bogs in the area, the presence of organic soils, coupled with high vegetative cover, contributes to the wetland having a high water quality function. A high water quality function is valuable to the subbasin based on the proximity of development as well as the stormwater inputs. The bog also has a high hydrologic function because comparably, the area of the basin is relatively small to the area of the wetland (less than 10 times) and, therefore, can help reduce flooding problems downstream. The bog also provides a moderate habitat function; it provides structural diversity and habitats that could provide cover. However, because of its location in a highly developed landscape, connections to other high quality habitats are limited.

The two wetlands downstream of Queens Bog were both included in the King County Wetlands Inventory (King County, 1990b). The northern wetland is described as exhibiting primarily scrub-shrub cover. Dominant shrub species include cascara, willow, and Douglas spirea. Labrador tea, a common bog species, is also listed. However, the report does not identify this wetland as a bog. The wetland to the south is also classified as a scrub-shrub wetland with cascara and Douglas spirea. Other noted wetland species include twinberry, small-fruited bulrush, and reed canarygrass. A small area of open water is located in the southern extent of this wetland. The East Tributary runs north to south through the two wetlands. A forested corridor dominated by Douglas fir and upland shrubs separates them.

The wetlands are bordered by high-density residential development to the east, west, and south, and SE 32nd Street to the north. One stormwater outfall is mapped as discharging into the east side of the northern wetland from 41st Avenue SE. An additional outfall discharges from 41st Avenue SE into the southern wetland. It also appears that stormwater collected along 239th Avenue SE, a residential street to the west, also discharges to the southern wetland. Additionally, the East Tributary is mapped as flowing through a stormwater pond, immediately upstream of the Issaquah Pine Lake Road SE crossing. During the site visit, however, a large fill berm was observed surrounding the wetland area. Based on site conditions, a review of mapped topography, and an analysis of aerial photos, it is unlikely that a hydrologic connection exists between the wetland and the stormwater pond.

Both wetlands are almost completely covered by persistent vegetation, which can help remove pollutants. Vegetation present is also multistructural and includes scrub-shrub, emergent, and some tree species. This, coupled with several hydrologic regimes present, provides habitat for various species and results in a higher habitat function.

South Tributary

Most of the wetland area within the South Tributary is associated with a wetland at its headwaters. The wetland is a depressional wetland that exhibits both forested and scrub-shrub cover. Western red cedar and willows are dominant species in most of the wetland. An open water area at the north portion of the wetland contains some aquatic bed cover, primarily duckweed and yellow pond lily. Other species observed include small-fruited bulrush.

The wetland (Photo 26) is bordered by Issaquah Pine Lake Road SE to the southwest, 238th Way SE to the northwest, residential development to the northeast, and SE Issaquah–Fall City Road to the southeast. A private east-west driveway bisects the middle of the wetland. Based on a review of aerial imagery, it appears that most of the wetland is inundated throughout the year. However, more inundation appears to occur north of the private drive. This is supported by the large amount of down wood visible throughout the wetland. The wetland buffer is narrow and is primarily disturbed by roads and residences. Based on the City's stormwater mapping, four stormwater outfalls discharge to this wetland, all north of the private drive. Two of the outfall discharge into the open water area to the north. This area is mapped as a stormwater pond, suggesting that the wetland may have been excavated in this area to support additional stormwater storage.

The South Tributary flows through the wetland, is culverted under 238th Way SE, and enters a large vegetated swale. Neither the City nor King County map any wetland in this area. However, large wetland areas dominated by reed canarygrass can be seen throughout the stream alignment, until the stream reaches a pond south of SE 44th Street.

Because of the high inundation observed, it appears that this wetland likely has a high hydrologic function and can assist in holding back floodwaters to residences downstream during times of high flow. The wetland also provides a water quality function as it is covered largely with persistent vegetation. The wetland provides a moderate habitat function; it provides structural diversity and habitat features such as snags and down wood. However, similar to other wetlands in proximity to a developed landscape, connections to other high quality habitats are limited.

Lower Subbasin

Land Cover and Built Environment

Land use patterns in the Lower Subbasin are predominantly built-out consistent with underlying zoning. The large majority of this subbasin is densely forested open space, with large properties owned and managed by (from downstream to upstream) Washington State Parks, WDNR, and as native growth protection tracts associated with surrounding residential development. Within the City of Issaquah, the privately owned areas are predominantly within the Providence Point residential neighborhood, which was developed with a clustered development approach (attached single-family / townhouse structures grouped in portions of the larger property, with surrounding open space). This neighborhood was constructed in the mid-1990s, and the overall density per Issaquah's Single Family Small Lot zoning designation is 7.26 dwelling units per acre. Residential uses within the City of Sammamish portion of the Lower Subbasin were platted as detached single-family lots in the early 2000s (Highland Ridge development) and the early 2010s (Tremont development). These developments are consistent with underlying R4 (4 residential units per acre) and R-6 (6 residential units per acre) zoning.

Geomorphic and Instream Habitat Conditions

Upper Reach of Lower Mainstem

The upper reach of the lower mainstem of Laughing Jacobs Creek extends from near the Laughing Jacobs Creek culvert crossing under Providence Point Place SE downstream to a natural fish passage barrier falls at RM 0.9. While Laughing Jacobs Creek flows across mapped recessional outwash deposits in the uppermost portion of this reach, the underlying geology soon transitions to till, deposits of pre-Fraser glaciation age, and then to bedrock (Blakeley Formation) as it flows through a ravine (Figure 4a; Booth et al., 2012). This reach is unique due to its steep slope and confinement as it flows into and through the ravine. Bankfull width is variable and is on the order of 15 to 30 feet. This reach generally steepens as it flows downstream; it generally has pool-riffle morphology downstream of the Providence Point Place SE culvert, then steepens to step-pool and then bedrock morphology with multiple waterfalls (Photo 27). Several falls, consisting of steep bedrock chutes, are present above the larger barrier falls (see details below), ranging in gradient from approximately 15 to 25 percent. Much of the channel in this reach is bare bedrock with numerous step pools (Photo 28). Large wood is abundant, with some jams of channel-engaged wood and also some channel-spanning logs that have lodged in the narrow canyon reaches. Wood that appears to have been in place for a long period (based on lack of bark and coloration) is forming additional pocket pools in places. Overhanging vegetation is prevalent within this stream reach, primarily western red cedar, vine maple, and salmonberry. High quality riparian conditions are present, as the riparian zone is 200 feet or greater in width and is dominated by mature conifer overstory with mature western red cedars of up to 30 to 36 inches in diameter. The understory is also well developed, with native shrubs and little to no invasive species.

Where streambed sediment is present, it is mostly gravel with some pebbles and sand. There is potential for sediment delivery to the creek due to uprooting trees and mass wasting on the steep ravine walls; however, in general, the steep ravine slopes are well vegetated, which helps to reduce erosion and sediment delivery to the stream. In the upper part of the reach, the creek has a developed, accessible floodplain, but once the creek enters the ravine and becomes bedrock dominated, the floodplain is not well developed.

At the lower end of this stream reach, a natural fish passage barrier (WDFW Site ID 892023, see Appendix C for details) is present, consisting of a series of mostly vertical waterfalls, carved into the bedrock, with sections of high gradient sheet flow with stream gradients far exceeding 20 percent (WDFW, 2019c). The largest of the falls is approximately 30 feet high and lacks a plunge pool, with water falling directly onto boulders and large wood.

Middle Reach of Lower Mainstem

The middle reach of the lower mainstem of Laughing Jacobs Creek extends from the impassable barrier falls at RM 0.9 to the stream crossing of the East Lake Sammamish Parkway SE and is almost entirely within Lake Sammamish State Park. This reach starts in bedrock (Blakeley Formation) in the ravine, and then transitions to flowing across fan deposits as it flattens and approaches East Lake Sammamish Parkway SE (Figure 4a; Booth et al., 2012). The lower portion of this reach has been impacted by a previous stream reroute that placed the stream adjacent to East Lake Sammamish Parkway SE.

In the upper portions of this reach, downstream of the impassable barrier falls at RM 0.9, the gradient gradually flattens, with some bedrock-formed pools present that represent the upstream extent of anadromous fish use (J. Bower, personal communication). Farther downstream, in the middle portions of this reach, one or more high-flow channels are present. Bankfull width in this reach varies; measurements ranged from approximately 27 feet to approximately 51 feet including both the main channel and high flow channel. The stream slope is approximately 3 percent. This reach of the stream is stable to aggrading and is characterized by riffles with some pools. There are moderate amounts of large wood, especially compared to downstream reaches (Photo 29). The creek is well connected to the floodplain, especially on the right bank where streambanks are lower (about 1 foot tall). Streambanks are natural, and minor erosion is present in some locations along the left bank. Streambed material ranges from sand up to 5-inch diameter cobbles, but is dominated by rounded 1- to 3-inch diameter material and low embeddedness, with somewhat coarser sediment (2-inch to 5-inch cobbles) in the vicinity of a several log jams.

The habitat quality was documented with a stream survey of approximately 290 linear feet of stream in a reach between the park pedestrian bridge and a natural barrier falls at RM 0.9. Table 12 summarizes the results of the survey, and the survey form is provided as Appendix D. This reach represents high-quality fish habitat with a stable stream; un-armored stream banks; an unconfined channel that has high-flow channels in some locations; morphological heterogeneity (riffles and pools); well-developed riparian conditions which overhang the channel providing both shade and cover for fish; moderate amounts of large wood, including several jams, that provide both cover for fish and invertebrate habitat; and well-sorted substrate that includes small gravel, large gravel, and cobbles. The riparian zone is dominated by mature western red cedar and bigleaf maple, with a well-developed understory of native shrubs that overhang the stream banks, providing cover and refugia for fish. In addition, fringe wetlands are present on floodplain benches that have formed along portions of the stream. The stream is unconfined in this location and in places, the stream's bankfull width is up to 50 feet wide, as compared to 12 feet in the confined reaches downstream.

There were an equal number (seven) of pool and riffle habitat units in the surveyed reach, with riffles constituting 69 percent of the habitat area and pools 31 percent (Table 9). The pools consisted of lateral scour pools, as well as mid-channel large wood formed plunge pools, with water drops of up to 2 feet and plunge pool depths of up to 1.6 feet.

Table 12. Measured Stream Habitat Components in Lower Laughing Jacobs Creek

Habitat Parameter	Result
Slope (%)	3
Bankfull Width (Feet)	27 to 51
Pool:Riffle Ratio (by Number of Features)	1 to 1
Pool:Riffle Ratio (by Area)	1 to 2.2
Large Wood Frequency[a] (Pieces per 1,000 Feet)	45
Small Wood Frequency[b] (Pieces per 1,000 Feet)	27
Average Maximum Pool Depth (Feet)	1.0
Average Pool Tailout Depth (Feet)	0.3
Average Pool Area	118
Dominant Substrate	Cobble
Sub-Dominant Substrate	Large Gravel
Substrate Embeddedness	Moderate

[a] Defined as a piece of wood, at least partially engaged with the active channel, that is greater than 10 feet in length and greater than 1.0 feet in diameter.

[b] Defined as a piece of wood that does not meet the requirements for large wood, but is greater than 6 feet in length and greater than 0.4 feet in diameter.

The fish habitat description above is indicative of conditions upstream of a fish-passable pedestrian bridge in the Hans Jensen Group Area (within Lake Sammamish State Park). The reach from the bridge to a point approximately 400 feet downstream still contains well-sorted gravels, riffles, and pools; however, riparian conditions are considerable poorer than upstream with few trees (shrubs are dominant) and more prevalence of invasive plant species, such as blackberry.

Upstream of the parkway, the stream has been straightened and channelized along the east side of the parkway, where it flows from south to north with a stream gradient of about 1 percent. Approximately 50 percent of the banks in this reach have riprap armoring (Photo 30). Although this bank armoring has led to some downcutting of the stream, signs of severe erosion are minimal. Less severe bank erosion is present in some localized areas without bank armoring. Where the creek banks are armored, the creek’s connection to its floodplain is limited, although it has a better connection to its floodplain in unarmored sections. Habitat morphology is present in the form of plunge pools and scour pools, formed by the occasional large wood piece or small jam present in the reach; however, run habitat is also present where habitat complexity is lacking. Stream substrate consists of cobbles and gravels, with some areas of suitable salmonid spawning habitat at the tailouts of pools. Although the riparian condition is fair, the width of the left bank riparian buffer is limited to approximately 50 feet, due to the presence of East Lake Sammamish Parkway SE. A moderate amount of invasive species (e.g., Himalayan blackberry and English ivy) is also present in the buffer.

A restoration feasibility study of lower Laughing Jacobs Creek, that seeks to improve the middle and lower reaches of the stream, is currently being conducted by Washington Trout. The study will evaluate options for improving the quality and quantity of fish habitat, including improving fish passage at the East Lake Sammamish Parkway SE culvert, a potential realigning of the stream on public property, and the addition of habitat features, such as bank softening, spawning gravels, pool formation, and wood placement (LSKWG, 2014).

Lowest Reach of Lower Mainstem

The lowest reach in the lower mainstem of Laughing Jacobs Creek extends from East Lake Sammamish Parkway SE downstream to the mouth of Laughing Jacobs Creek where it enters Lake Sammamish; this area is mapped as alluvium (Figure 4a; Booth et al., 2012). At the mouth of the stream, just north of the boat launch at Lake Sammamish State Park, a small delta has formed, composed primarily of approximately 1-inch diameter gravel (Photo 31). The lower-most reaches are on private property, and have limited riparian vegetation and some bank armoring that has led to a moderate level of entrenchment. Bed material generally varies from sand to 3-inch cobbles and is partially embedded in the vicinity of the East Lake Sammamish Parkway SE crossing and fines downstream to a mixture of fines, sand, and minor gravel. At the upstream end of the private property reach, the abutments of a private driveway bridge have been undermined, resulting in the application of large riprap to protect the bridge. The East Lake Sammamish Trail Bridge is immediately downstream of the East Lake Sammamish Parkway SE culvert. The corrugated steel squash culvert crossing under East Lake Sammamish Parkway SE (WDFW Site ID 920054, see Appendix C for details) is classified as a 0 percent passable fish barrier due to a steep slope (2.7%) (WDFW, 2019c) adjacent to a second parallel culvert conveying Many Springs Creek, classified as a partial fish passage barrier (WDFW Site ID 920058).

Riparian and Wetlands Conditions

Several small riparian wetlands are present upstream of the steep bedrock middle reach, approximately 100 to 200 feet downstream of Providence Point Place SE. Several riparian wetlands are also present in the well-forested lower gradient reaches within the Hans Jensen Group Area. These wetlands are likely inundated during large stormflows and provide some amount of flood storage and hydrologic roughness.

Outside of the City boundary, a large wetland complex is located within Lake Sammamish State Park. The wetland mosaic is bordered by Lake Sammamish to the north and northwest and State Park lands to the west. Commercial developments border the wetland mosaic to the east, NW Sammamish Road lies to the south, and East Lake Sammamish Parkway SE is adjacent to the northeast edge of the wetland. Another wetland lies to the northeast side of the parkway, suggesting that the two wetlands were likely connected before the development of the parkway. Laughing Jacobs Creek flows between these two wetlands within a roadside ditch along the northeast side of East Lake Sammamish Parkway, before crossing under the parkway through a culvert. The stream then enters a private parcel where it flows to the southwest and into Lake Sammamish. Issaquah Creek meanders to the northwest through the wetland complex, before meeting with Lake Sammamish. King County interactive mapping (iMap) maps an additional unnamed creek flowing through the wetland, north of Issaquah Creek (King County, 2019c).

According to the King County Wetland Inventory (1990b), the wetland mosaic exhibits forested, scrub-shrub, emergent, and aquatic bed classes. Based on the 1994 inventory and analysis of aerial imagery, forested areas are primarily located along the shoreline and are dominated by western red cedar and red alder. Shrub cover is primarily located along Issaquah Creek. Dominant shrubs species within the wetland include red-osier dogwood, Pacific ninebark, and willow species. Emergent cover is interspersed throughout the forest and shrub classes, and also occurs along the lakeshore. Dominant emergent species include small-fruited bulrush, rush species, ladyfern, and broadleaf cattail. The aquatic bed class is located within the lake, near the shoreline and is primarily yellow pond lily (Photo 32).

To improve salmonid habitat, a study is currently in the design phase that would reroute the lower reach of Laughing Jacobs Creek away from the private parcel, and instead into the wetland mosaic at Lake Sammamish State Park. All flow would be rerouted away the roadside ditch along the parkway and through a new culvert under the parkway. The stream would then travel through the wetland in a naturalized, meandering channel. A floodplain bench would be excavated through the wetland to provide refuge and cover for salmonids, and native riparian plants would be installed along the length of the constructed channel (AMEC, 2011; LSKWG, 2014).

Conclusions

The Laughing Jacobs Basin supports unique and somewhat rare natural habitats, such as sphagnum-dominated peatland (bog) wetlands, as well as unique species, such as the imperiled late-run Lake Sammamish Kokanee. These elements are present despite substantial single- and multi-family residential and commercial development within the basin, particularly in the 25 years since the previous Basin Plan was prepared. While development has occurred, critical areas such as wetlands and riparian buffers have generally been excluded from development and thus are relatively intact, with forested conditions in over half of the streams buffer areas. Effective impervious areas within a watershed can lead to degradation of stream hydrology, aquatic and terrestrial habitats, and degrade water quality. Although basin-wide impervious surfaces, as indicated by developed land cover types, are at or near thresholds for degradation as discussed in the scientific literature, the basin generally does not show significant stream channel erosion and downcutting or increased peak flow magnitudes, durations, and frequencies.

This lack of a significant negative ecological response to development is likely due to a number of factors, including the prevalence of several wetlands and wetland complexes within the basin, including some complexes over 20 acres and a predominance of riparian wetlands, combined with the presence of Laughing Jacobs Lake. These elements can all serve to mitigate hydrologic and water quality effects. Furthermore, the geology and topography of the streams in the basin, which with the exception of the canyon reaches in the Lower Subbasin, are generally low gradient with streams having relatively good connections to the floodplains. In the several areas where slight to moderate downcutting was observed, channel degradation is likely related to historic (>80 years) stream channelization and straightening for agricultural drainage purposes.

Although a natural fish passage barrier, in the form of a waterfall, limits anadromous salmonid access to the lower mile of the stream, the habitat that is accessible ranges in quality from fair to excellent, with the reaches upstream of the East Lake Sammamish Parkway offering high-quality spawning and rearing habitat, which will be further improved by an ongoing restoration effort. Much of the stream network upstream of the barrier also offers good quality spawning and rearing habitat, which is utilized by resident cutthroat trout. Excessive peak flows, and associated streambed erosion, do not appear to be limiting factors for anadromous fish in the basin; however, low summer stream flows, which contribute to high summertime temperatures, are conditions that are present in the basin and could have effects on salmonids. However, the timing of high temperature and low flows would primarily affect coho salmon in the lower reaches and cutthroat trout in the upper reaches, as the timing of kokanee utilization of Laughing Jacobs Creek occurs later in the fall when streamflows have increased and stream temperatures have dropped. Furthermore, the temperature regime may be a natural phenomenon due to the presence of Laughing Jacobs Lake and numerous open-water wetlands in the basin.

Laughing Jacobs Basin supports land use patterns that are predominantly built-out consistent with established Comprehensive Plan Land Use Designations and zoning (under jurisdictions of both the City of Sammamish and the City of Issaquah). Dominant land uses in the basin include lower intensity residential, publically owned park lands, and protected open space. Based on a review of current land use patterns that shows limited areas where existing lot size could result in subdivision and associated intensification of use, it is anticipated that pressure for future intensification of land use is generally low, and that changes would occur incrementally over many years. Within this established pattern of use, the majority of large wetland areas (including the full extent of Queens Bog) are protected either as designated native growth protection areas, or as publically owned open space lands. However, past land use activities and infrastructure development have degraded these wetland areas, with key alterations including fill (and excavation cut) for roadway and utility crossings, discharge of untreated (or undertreated stormwater), and ditching with linear swales intended to facilitate drainage. Current degradation provides an opportunity for wetland restoration, including a focus on water quality enhancement, additional canopy and shading, and improvement of habitat functions.

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Appendix A –Annual Peak Flow Frequency Analysis for Laughing Jacobs Creek

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.002.000
  Version 7.2        Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                    08/22/2019 15:57

                         --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  -
C:\Users\jprock\Desktop\LJ_Peak_Flow_Analysis\PEAK.TXT

                         specifications -
C:\Users\jprock\Desktop\LJ_Peak_Flow_Analysis\PKFQWPSF.TMP

                      Output file(s):
                         main -
C:\Users\jprock\Desktop\LJ_Peak_Flow_Analysis\PEAK.PRT



  ***  User responsible for assessment and interpretation of the following analysis
 ***

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.001.001
  Version 7.2        Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                    08/22/2019 15:57

                   Station - 12010000  LAUGHING JACOBS MOUTH


                     TABLE 1 - INPUT DATA SUMMARY

                Number of peaks in record            =       29
                Peaks not used in analysis           =        0
                Gaged peaks in analysis              =       29
                Historic peaks in analysis           =        0
                Beginning Year                       =     1992
                Ending Year                          =     2019
                Historical Period Length             =       28
                Skew option                          =   WEIGHTED
```

```
                Regional skew                        =   -0.070
                     Standard error                  =    0.424
                     Mean Square error               =    0.180
                Gage base discharge                  =      0.0
                User supplied high outlier threshold =   --
                User supplied PILF (LO) criterion    =   --
                Plotting position parameter          =     0.00
                Type of analysis                       BULL.17B
                PILF (LO) Test Method                      MGBT
                Perceptible Ranges               =   Not Applicable
                Interval Data                    =   Not Applicable


    TABLE 2 - DIAGNOSTIC MESSAGE AND PILF RESULTS


    WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE.                  0.0
    WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.       223.7
  **WCF164W-HISTORIC PERIOD IGNORED.    28.0
  **WCF233W-EXPECTED PROB OUT OF RANGE AT TAB PROB.   0.00000   0.00000
    WCF002J-CALCS COMPLETED.  RETURN CODE =  2


                       Kendall's Tau Parameters

                                        MEDIAN   No. of
                       TAU    P-VALUE    SLOPE   PEAKS
               ---------------------------------------
    GAGED PEAKS     -0.067      0.626     -0.542    29


1


  Program PeakFq           U. S. GEOLOGICAL SURVEY           Seq.001.002
  Version 7.2        Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                    08/22/2019 15:57

                    Station - 12010000  LAUGHING JACOBS MOUTH


     TABLE 3 - ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

                          FLOOD BASE                LOGARITHMIC
                  ----------------------  -------------------------------
                             EXCEEDANCE                STANDARD
                   DISCHARGE PROBABILITY     MEAN     DEVIATION     SKEW
                  -------------------------------------------------------
 SYSTEMATIC RECORD       0.0     1.0000     1.7138      0.2495      0.192
```

```
 BULL.17B ESTIMATE       0.0     1.0000     1.7138      0.2495      0.058

 BULL.17B ESTIMATE OF MSE OF AT-SITE SKEW     0.1879



 TABLE 4 - ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE
PROBABILITIES

   ANNUAL                         <-- FOR BULLETIN 17B ESTIMATES -->
EXCEEDANCE  BULL.17B SYSTEMATICLOG VARIANCE     CONFIDENCE INTERVALS
PROBABILITY ESTIMATE   RECORD      OF EST.    5% LOWER   95% UPPER

   0.9950      12.2      13.1         ----            7.7         16.5
   0.9900      13.9      14.8         ----            9.2         18.5
   0.9500      20.3      20.8         ----           14.6         25.6
   0.9000      24.9      25.1         ----           18.7         30.7
   0.8000      31.9      31.8         ----           25.1         38.4
   0.6667      40.2      39.8         ----           32.9         48.0
   0.5000      51.4      50.8         ----           43.0         61.6
   0.4292      57.0      56.3         ----           47.8         68.7
   0.2000      83.8      83.4         ----           69.5        106.0
   0.1000     108.4     109.2         ----           87.8        144.2
   0.0400     143.1     146.8         ----          112.1        202.5
   0.0200     171.4     178.4         ----          130.9        253.3
   0.0100     201.8     213.4         ----          150.5        310.6
   0.0050     234.5     252.0         ----          170.9        374.9
   0.0020     281.5     309.2         ----          199.4        472.0
1

  Program PeakFq           U. S. GEOLOGICAL SURVEY             Seq.001.003
  Version 7.2         Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                     08/22/2019 15:57

                   Station - 12010000  LAUGHING JACOBS MOUTH


                       TABLE 5 - INPUT DATA LISTING


    WATER       PEAK   PEAKFQ
     YEAR      VALUE    CODES  REMARKS
     1992       18.0
     1992       65.0
     1993       21.0
     1995       50.0
     1995       85.0
     1997      160.0
     1997      181.0
```

```
      1999       70.0
      2000       53.0
      2000       29.0
      2002      101.0
      2002       37.0
      2004       56.0
      2004       57.0
      2005       34.0
      2006       78.0
      2008      107.0
      2008       22.0
      2009       61.0
      2011       68.0
      2011       36.0
      2013       41.0
      2013       32.0
      2014       38.0
      2016       70.0
      2017       51.0
      2017       81.0
      2018       40.0
      2019       24.0


         Explanation of peak discharge qualification codes

        PeakFQ    NWIS
         CODE     CODE   DEFINITION

           D        3    Dam failure, non-recurrent flow anomaly
           G        8    Discharge greater than stated value
           X       3+8   Both of the above
           L        4    Discharge less than stated value
           K      6 OR C  Known effect of regulation or urbanization
           H        7    Historic peak

           -  Minus-flagged discharge -- Not used in computation
                 -8888.0 -- No discharge value given
           -  Minus-flagged water year -- Historic peak used in computation
```

1

```
                   Station - 12010000  LAUGHING JACOBS MOUTH
```

```
  TABLE 6 - EMPIRICAL FREQUENCY CURVES -- WEIBULL PLOTTING POSITIONS

   WATER     RANKED   SYSTEMATIC     B17B
    YEAR   DISCHARGE    RECORD     ESTIMATE
    1997      181.0     0.0333      0.0333
    1997      160.0     0.0667      0.0667
    2008      107.0     0.1000      0.1000
    2002      101.0     0.1333      0.1333
    1995       85.0     0.1667      0.1667
    2017       81.0     0.2000      0.2000
    2006       78.0     0.2333      0.2333
    1999       70.0     0.2667      0.2667
    2016       70.0     0.3000      0.3000
    2011       68.0     0.3333      0.3333
    1992       65.0     0.3667      0.3667
    2009       61.0     0.4000      0.4000
    2004       57.0     0.4333      0.4333
    2004       56.0     0.4667      0.4667
    2000       53.0     0.5000      0.5000
    2017       51.0     0.5333      0.5333
    1995       50.0     0.5667      0.5667
    2013       41.0     0.6000      0.6000
    2018       40.0     0.6333      0.6333
    2014       38.0     0.6667      0.6667
    2002       37.0     0.7000      0.7000
    2011       36.0     0.7333      0.7333
    2005       34.0     0.7667      0.7667
    2013       32.0     0.8000      0.8000
    2000       29.0     0.8333      0.8333
    2019       24.0     0.8667      0.8667
    2008       22.0     0.9000      0.9000
    1993       21.0     0.9333      0.9333
    1992       18.0     0.9667      0.9667
1



 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      29


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)
```

```
For the station below, the following records were ignored:

FINISHED PROCESSING STATION:  12010000       KINGCLAUGHING JACOBS MOUTH


For the station below, the following records were ignored:

FINISHED PROCESSING STATION:
```

Appendix B – Photo Appendix

Photo 1. Laughing Jacobs Creek flows wide and shallow through the downstream end of Beaver Lake Park.

Photo 2. Stream is ponded downstream of 244th Avenue SE culvert.

Photo 3. Creek flowing through mature mixed native riparian forest between 239th Avenue SE and 238th Private Road.

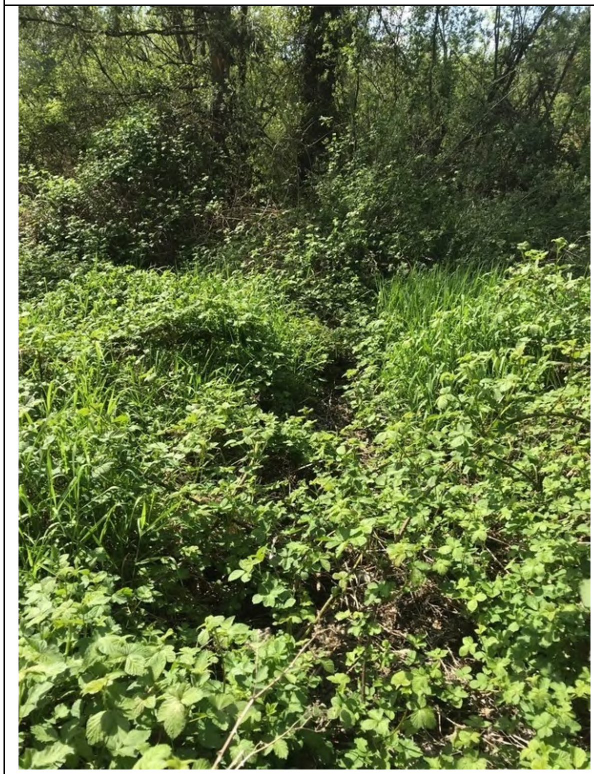


Photo 4. Creek just downstream of private driveway (238th Private Road).

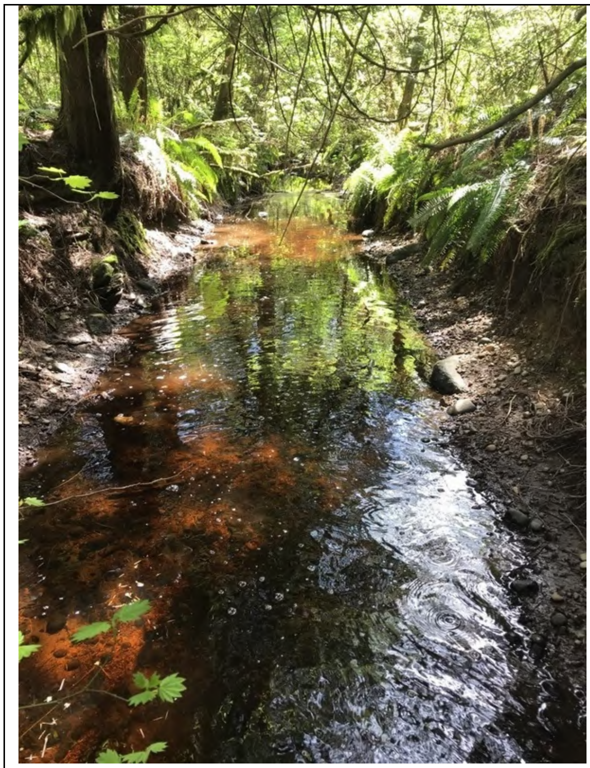


Photo 5. The creek upstream of SE 32nd Way has been artificially straightened and is confined due to three to four feet of channel incision which severely limits floodplain connectivity.

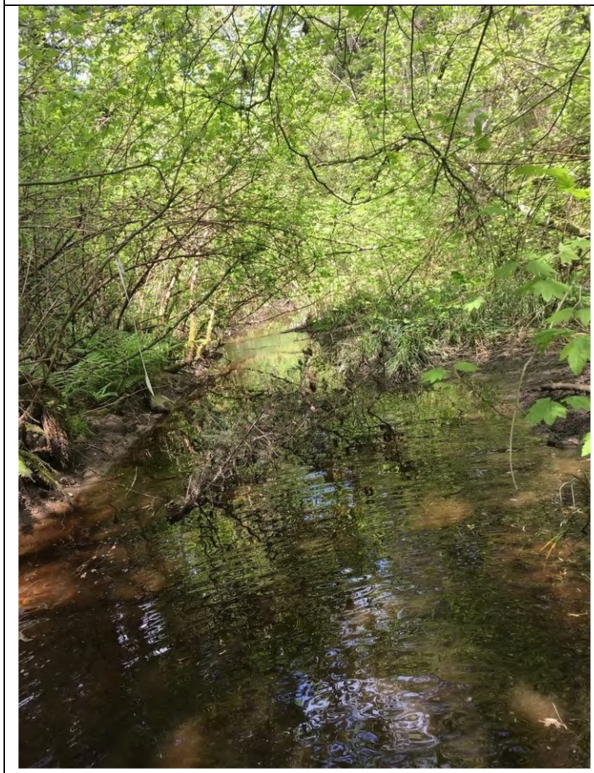


Photo 6. Downstream of SE 32nd Way, the creek widens and shallows and has low, gradual banks with good floodplain access.

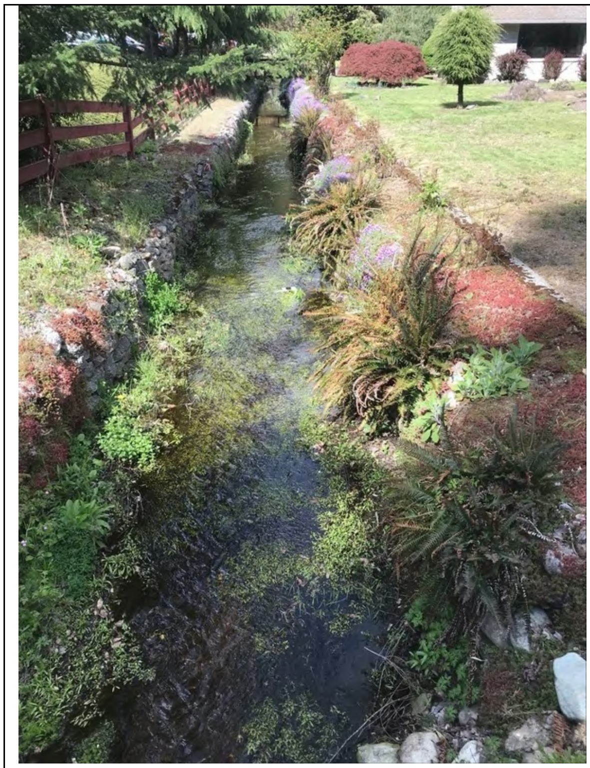


Photo 7. Immediately upstream of the Issaquah-Pine Lake Road SE culvert, the creek is channelized and has armored banks between a residence and the Lakeside Montessori School.

Photo 8. Wetland at Beaver Lake Park.

Photo 9. View of bog wetland that constitutes a large portion of the SE 24th Street wetland complex.

Photo 10. Immediately downstream of the Issaquah-Pine Lake Road SE culvert, the creek is incised with tall, steep banks and erosion has undercut tree roots.

Photo 11. Laughing Jacobs Creek downstream of the Issaquah-Pine Lake Road SE culvert and outside of its influence.

Photo 12. View of downstream side of culverts under SE 42nd Street.

Photo 13. View upstream from near SE 42nd Street culvert.

Photo 14. 230th Way SE culvert crossing, looking upstream.

Photo 15. Former beaver pond location immediately upstream of 230th Way SE culvert.

Photo 16. Laughing Jacobs Creek downstream of 230th Way SE culvert.

Photo 17. West Tributary upstream of 228th Avenue SE on April 30, 2019.

Photo 18. West Tributary downstream of 228th Avenue SE on April 30, 2019.

Photo 19. An eight-foot-diameter standpipe with a debris rack (birds nest) controls the flow of water from Queens Bog west into the upper reaches of the stream.

Photo 20. Headwaters of East Tributary at Klahanie Park wetlands; trail crossing is a fish passage barrier.

Photo 21. East Tributary upstream of 241st Avenue SE.

Photo 22. Upstream of Issaquah-Pine Lake Road SE, the South Tributary headwaters are a series of three open-water wetlands/stormwater ponds connected by culverts and water control structures.

Photo 23. South Tributary below Issaquah-Pine Lake Road SE, looking downstream.

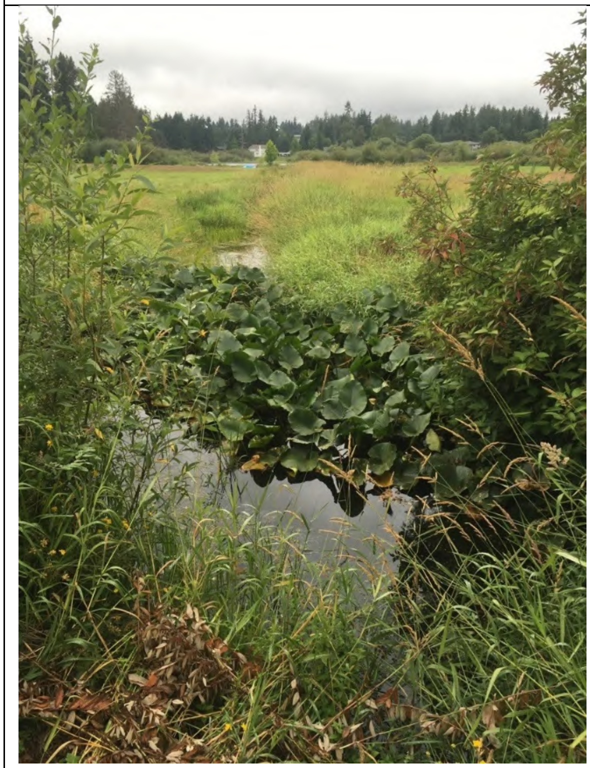


Photo 24. Looking north at Laughing Jacobs Lake at emergent wetland along mainstem outlet.

Photo 25. View of Queens Bog.

Photo 26. View of open-water wetland serving as the headwaters to the South Tributary.

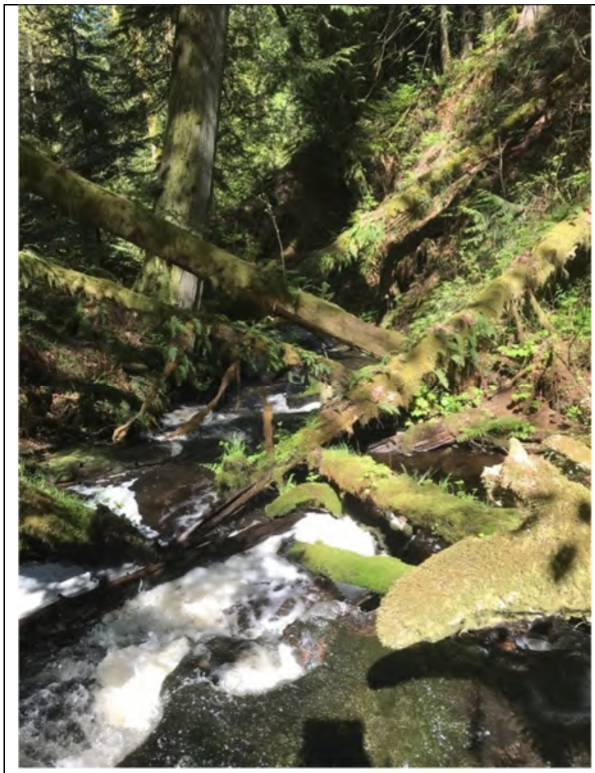


Photo 27. Upper Reach of the Lower Mainstem downstream of the Providence Point Place SE culvert.

Photo 28. Bedrock reach of the Upper Reach of the Lower Mainstem.


Photo 29. This reach has moderate amounts of large wood, especially when compared to downstream reaches.


Photo 30. The channel in this reach has been straightened and approximately fifty percent of the banks in this reach have riprap armoring.

Photo 31. Laughing Jacobs Creek entering Lake Sammamish.

Photo 32. View looking north at Lake Sammamish aquatic bed wetland immediately south of Laughing Jacobs Creek mouth.

Appendix C – WDFW Fish Passage and Diversion Screening Inventory Database Reports

Washington Department of
Fish and Wildlife

Fish Passage & Diversion Screening Inventory Database
Report Cover Sheet

The following report is extracted from the Washington Department of Fish and Wildlife's (WDFW) Fish Passage and Diversion Screening Inventory Database (FPDSI). WDFW makes every attempt to keep these reports in sync with FPDSI; however, the dynamic nature of the data and workflows associated with maintaining the database may result in short-term differences.

Users are encouraged to contact WDFW to discuss appropriate use of the data and how we can assist with fish passage barrier removal or inventory. Please visit the Fish Passage web site for contact information at: https://wdfw.wa.gov/species-habitats/habitat-recovery/fish-passage/about

Disclaimers:

- Data presented here represent a snapshot observation of conditions in a dynamic environment that is subject to change. Fish passage data are also collected from a variety of agencies and sources. Therefore, WDFW makes no guarantee concerning the data's content, accuracy, completeness, or the results obtained from use of the data. WDFW assumes no liability for the data represented here.
- These data are not an attempt to provide you with an official agency response as to the impacts of your project on fish and wildlife.
- Note that some fish passage features, habitats or species may occur in areas not currently known to the WDFW Fish Passage division, and may not be reflected in this database. A lack of data does not necessarily indicate that a feature, habitat, or species are not present.
- Unauthorized attempts to alter or modify these data are strictly prohibited.
- Bankfull width measurements included in these reports should not be used for fish passage crossing design. They are solely for assessment purposes.
- The barrier status reported in this document is based on the swimming abilities of adult salmonids. Passabilities are a qualitative value, and should not be interpreted as a quantitative calculation. Please see page 1-4 of the Fish Passage Inventory, Assessment and Prioritization Manual for further clarification: https://wdfw.wa.gov/publications/02061
- EXIF data presented with Image Reports may be erroneous due to camera battery failures and resetting of camera clock functions.

Abbreviations:

Most abbreviations in this report are defined in the Quick Reference Tables of the Fish Passage Inventory, Assessment, and Prioritization Manual. Additional commonly used abbreviations are defined as follows:

NFB = no potential salmonid use, **BB** = both banks, **LB** = left bank looking downstream, **RB** = right bank looking downstream, **US or U/S** = upstream, **DS or D/S** = downstream, **WSDrop** = water surface drop, **BFW** = bankfull width, **OHW** = ordinary high water, **SLW** = scour line width, **CMP** = corrugated metal pipe, Q_{fp} = fish passage flow, **V&D** = Velocity and Depth, **ROW** = Right of Way

The FPDSI database often uses default values such as '**-99.99**' or '**-999**' to represent null values.

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 601582

Project FBRB

Geographic Coordinates

Latitude (WGS 84):	47.6084563
Longitude (WGS 84):	-122.0727512
East (HARN 83):	1,252,447.3
North (HARN 83)	833,589.2

Waterbody

Stream:	Ebright Cr
Tributary To:	Lake Sammamish
WRIA:	08.0149
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Mapped

General Location

Road Name:	otpath; L Sammamish Pk
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	County
Name:	King County

PI Species

☑ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☑ Coho
☑ Steelhead
☑ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Site Comments

Print Date: 4/22/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID:	**601582**				
Latitude:	**47.6084563**	Stream:	**Ebright Cr**	WRIA:	**08.0149**
Longitude:	**-122.0727512**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Data Source WDFW

Field Crew: Barrett;Burns

Review Date: 4/12/2016

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.2	RND	CST	0.91	0.91	11.10	0.08	NO	0.00		No	0	0.72
2.2	RND	PCC	0.91	0.91	10.10	0.24	NO	0.00		No	0	3.18

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 2.69

Culvert/Stream Width Ratio: 0.34

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 2.00

Assessment Results

Barrier:	Yes	Passability (%):	33	Method:	Other
Reason:	Other	Fishway Present:	No	Recheck:	

Comments

Last segment of 2.2 detached - grade break. Culvert 1.2 33% passable depth barrier at time of assessment - likely 0% passable during low flow. Culvert 2.2 33% passable slope barrier.

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Unknown	Rearing (sq m):		**PI Total**	

Print Date: 4/22/2019

WDFW Fish Passage and Diversion Screening Inventory Database
Image Report - Active

Site ID:	**601582**				
Latitude:	**47.6084563**	Stream:	**Ebright Cr**	WRIA:	**08.0149**
Longitude:	**-122.0727512**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Image Name: 601582_1.jpg, Date/Time: 09/13/2014 00:20

Image Name: 601582_2.jpg, Date/Time: 09/13/2014 00:21

Print Date: 4/22/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 892023

Project CITY

Geographic Coordinates

Latitude (WGS 84):	47.565851369
Longitude (WGS 84):	-122.039691317
East (HARN 83):	1,260,298.2
North (HARN 83)	817,889.2

Waterbody

Stream:	Laughing Jacobs Cr
Tributary To:	Lake Sammamish
WRIA:	08.0166
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Biological

General Location

Road Name:	
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type: Other

Name:

PI Species

☑ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☑ Coho
☑ Steelhead
☑ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☐ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☑ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Site Comments

Print Date: 4/17/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Natural Barrier Assessment Report

Site ID:	**892023**				
Latitude:	**47.565851369**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.039691317**	Trib To:	**Lake Sammamish**	River Mile:	**-999.99**

Data Source: WDFW

Field Crew: Dwight;Romero;Stygar

Survey Date: 8/1/2012

Site Name:

Type: Waterfall

Fishway Present: No

Dimensions

Waterfall Height (m):	9.1	Stream Length (m):	-999	Gradient (%):	-99.99
Plunge Pool Depth (m):	0	Channel Width (m):	-999.99		

Species Blocked

- Coho
- Sockeye
- Sea Run Cutthroat
- Winter Steelhead

Status

Barrier Criteria: Physical

Barrier: Yes

Blockage: Total

Comments

Mostly vertical falls with sections of high gradient sheet flow. No plunge pool, water drops onto boulders and LWD.

Print Date: 4/17/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920025 **Project** CITY

Geographic Coordinates

Latitude (WGS 84):	47.56704679
Longitude (WGS 84):	-122.03383513
East (HARN 83):	1,261,752.3
North (HARN 83)	818,297.0

Waterbody

Stream:	Laughing Jacobs Cr
Tributary To:	Lake Sammamish
WRIA:	08.0166
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	230 Way SE
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	City
Name:	City of Sammamish

PI Species

☐ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☐ Coho
☐ Steelhead
☐ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Site Comments

Beaver dam crossing channel immediately upstream of pipe. 9.1m high falls downstream (892023) preclude anadromous access.

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID: **920025**

Latitude:	**47.56704679**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.03383513**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Data Source WDFW

Field Crew: Ingram;Stygar

Review Date: 7/23/2012

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.1	RND	SPS	5.69	5.69	32.50	0.19	NO	0.00		Yes	0	0.34

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 5.54

Culvert/Stream Width Ratio: 1.03

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 10.00

Assessment Results

Barrier:	No	Passability (%):	100	Method:	Level A
Reason:	N/A	Fishway Present:	No	Recheck:	

Comments

Large woody debris anchored inside of pipe with rebar. Pipe beveled at both ends.

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Yes	Rearing (sq m):		**PI Total**	

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database
Image Report - Active

Site ID: **920025**

Latitude:	**47.56704679**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.03383513**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Associated Features

☑ Culvert	☐ Dam	☐ Natural Barrier	☐ Diversion
☐ Non-Culvert Xing	☐ Other	☐ Fishway	

Image Name: 920025_1.JPG, Date/Time: 07/23/2012 09:27

Image Name: 920025_2.JPG, Date/Time: 07/23/2012 09:29

Image Name: 920025_3.JPG, Date/Time: 07/23/2012 09:43

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920026

Project CITY

Geographic Coordinates

Latitude (WGS 84):	47.56991952
Longitude (WGS 84):	-122.02848357
East (HARN 83):	1,263,093.6
North (HARN 83)	819,319.2

Waterbody

Stream:	Laughing Jacobs Cr
Tributary To:	Lake Sammamish
WRIA:	08.0166
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	42nd St
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	City
Name:	City of Sammamish

PI Species

☐ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☐ Coho
☐ Steelhead
☐ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Site Comments

Standpipe overflow system associated with crossing; minor contributing flows from roadside ditch. 9m high waterfall downstream.

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID: **920026**

Latitude:	**47.56991952**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.02848357**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Data Source WDFW

Field Crew: Ingram;Stygar

Review Date: 7/23/2012

Culvert Details								Level A Parameters				
ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.2	RND	OTH	0.91	0.91	29.60	0.20	NO	0.00		No	0	-0.51
2.2	RND	OTH	0.91	0.91	30.70	0.29	NO	0.00		No	0	-0.16

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 4.58

Culvert/Stream Width Ratio: 0.40

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 2.50

Assessment Results

Barrier:	Unknown	Passability (%):	Unknown	Method:	Level A
Reason:	evel B Require	Fishway Present:	No	Recheck:	

Comments

Boulder headwall at upstream end. Some sandbagging along channel at downstream end. Level B recheck required to asses passability.

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Yes	Rearing (sq m):		**PI Total**	

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Image Report - Active

Site ID:	**920026**				
Latitude:	**47.56991952**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.02848357**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Image Name: 920026_1.JPG, Date/Time: 07/23/2012 10:26

Image Name: 920026_2.JPG, Date/Time: 07/23/2012 11:02

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920027

Project CITY

Geographic Coordinates

Latitude (WGS 84):	47.56741105
Longitude (WGS 84):	-122.02513338
East (HARN 83):	1,263,902.8
North (HARN 83)	818,388.3

Waterbody

Stream:	unnamed
Tributary To:	Laughing Jacobs Cr
WRIA:	08
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	Issaquah Pine Lake Rd
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	City
Name:	City of Sammamish

PI Species

☐ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☐ Coho
☐ Steelhead
☐ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Issaquah Pine Lake Rd near the entrance to Jacobs Cr Condominiums.

Site Comments

Several tie-ins with stormwater management systems.

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID: **920027**

Latitude:	**47.56741105**	Stream:	**unnamed**	WRIA:	**08**
Longitude:	**-122.02513338**	Tributary To:	**Laughing Jacobs Cr**	Fish Use Potential:	**Yes**

Data Source WDFW

Field Crew: Ingram;Stygar

Review Date: 7/23/2012

Culvert Details								Level A Parameters				
ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.1	RND	OTH	0.84	0.84	38.40	0.63	NO	0.00		No	0	0.05

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 3.92

Culvert/Stream Width Ratio: 0.21

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 4.50

Assessment Results

Barrier:	Yes	Passability (%):	33	Method:	Professional Judgment
Reason:	Undersized	Fishway Present:	No	Recheck:	

Comments

0.84m SST at downstream end, 0.46m PCC at upstream end. Several generations of overflow pipes found draining pond into stormwater management systems. Boulder headwall at downstream end. Beaver deciever device at upstream end (pond).

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Yes	Rearing (sq m):		**PI Total**	

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Image Report - Active

Site ID:	**920027**				
Latitude:	**47.56741105**	Stream:	**unnamed**	WRIA:	**08**
Longitude:	**-122.02513338**	Tributary To:	**Laughing Jacobs Cr**	Fish Use Potential:	**Yes**

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Image Name: 920027_1.JPG, Date/Time: 07/23/2012 11:53

Image Name: 920027_2.JPG, Date/Time: 07/23/2012 12:06

Image Name: 920027_3.JPG, Date/Time: 07/23/2012 12:06

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920028

Project CITY

Geographic Coordinates

Latitude (WGS 84):	47.57744423
Longitude (WGS 84):	-122.0259296
East (HARN 83):	1,263,777.1
North (HARN 83)	822,051.4

Waterbody

Stream:	Laughing Jacobs Cr
Tributary To:	Lake Sammamish
WRIA:	08.0166
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	Issaquah-Pine Lake Rd
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	City
Name:	City of Sammamish

PI Species

☐ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☐ Coho
☐ Steelhead
☐ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Issaquah-Pine Lake Rd next to Lake side kindegarten.

Site Comments

Retaining walls both sides of stream channel at upstream end of pipe funneling flows into upstream end of pipe.

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID:	**920028**				
Latitude:	**47.57744423**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.0259296**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Data Source WDFW

Field Crew: Ingram;Stygar

Review Date: 7/23/2012

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.1	SQSH	CST	1.40	0.95	20.20	0.01	NO	0.10	Outlet	No	0	3.17

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 3.82

Culvert/Stream Width Ratio: 0.37

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 3.00

Assessment Results

Barrier:	Yes	Passability (%):	0	Method:	Level A
Reason:	Slope	Fishway Present:	No	Recheck:	

Comments

Stacked stone headwall at upstream end of pipe. Small pond at downstream end of pipe, no plunge pool.

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Yes	Rearing (sq m):		**PI Total**	

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database
Image Report - Active

Site ID: **920028**

Latitude: **47.57744423**
Stream: **Laughing Jacobs Cr**
WRIA: **08.0166**

Longitude: **-122.0259296**
Tributary To: **Lake Sammamish**
Fish Use Potential: **Yes**

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Image Name: 920028_1.JPG, Date/Time: 07/23/2012 13:41

Image Name: 920028_2.JPG, Date/Time: 07/23/2012 13:43

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920032

Project CITY

Geographic Coordinates

Latitude (WGS 84):	47.588013735
Longitude (WGS 84):	-122.018050063
East (HARN 83):	1,265,795.9
North (HARN 83)	825,868.9

Waterbody

Stream:	Laughing Jacobs Cr
Tributary To:	Lake Sammamish
WRIA:	08.0166
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	SE 24th St
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	City
Name:	City of Sammamish

PI Species

☐ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☐ Coho
☐ Steelhead
☐ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Site Comments

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID:	**920032**				
Latitude:	**47.588013735**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.018050063**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Data Source WDFW

Field Crew: Ingram;Stygar

Review Date: 7/24/2012

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.1	RND	OTH	0.76	0.76	-999.90	0.00	NO	0.00		No	0	-99.99

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): -99.99

Culvert/Stream Width Ratio: -99.99

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 1.00

Assessment Results

Barrier:	Unknown	Passability (%):	Unknown	Method:	Level A
Reason:	nsufficient Data	Fishway Present:	No	Recheck:	

Comments

Crosses the street to a collection box, 90 degree turn. Ties in with storm management system. Downstream end has a mangled trash rack. Unable to shoot due to change in material and connection with city storm water system. Upstream is PCC, dowstream CAL.

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Yes	Rearing (sq m):		**PI Total**	

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database
Image Report - Active

Site ID: **920032**

Latitude:	**47.588013735**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.018050063**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion


Image Name: 920032_1.JPG, Date/Time: 07/24/2012 13:04


Image Name: 920032_2.JPG, Date/Time: 07/24/2012 13:05

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920033

Project CITY

Geographic Coordinates

Latitude (WGS 84):	47.588613854
Longitude (WGS 84):	-122.016893148
East (HARN 83):	1,266,085.6
North (HARN 83)	826,082.2

Waterbody

Stream:	Laughing Jacobs Cr
Tributary To:	Lake Sammamish
WRIA:	08.0166
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	242nd Ave
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	City
Name:	City of Sammamish

PI Species

☐ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☐ Coho
☐ Steelhead
☐ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Site Comments

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID: **920033**

Latitude: **47.588613854** Stream: **Laughing Jacobs Cr** WRIA: **08.0166**

Longitude: **-122.016893148** Tributary To: **Lake Sammamish** Fish Use Potential: **Yes**

Data Source WDFW

Field Crew: Ingram;Stygar Review Date: 7/24/2012

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.1	OTH	SPS	-99.99	-99.99	31.40	0.00	NO	0.00		Yes	0	1.50

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 3.96

Culvert/Stream Width Ratio: -99.99

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 5.00

Assessment Results

Barrier: No Passability (%): 100 Method: Level A

Reason: N/A Fishway Present: No Recheck:

Comments

Believed to be a SQSH over 5m wide, but unable to verify due to the amount and type of bedload material inside pipe. 2/3 filled in with artificial boulders. Heavily overgrown with blackberries and other shrubs growing mid channel.

Potential Habitat Gain

Survey Type: Spawning (sq m): Length (m):

Significant Reach: Yes Rearing (sq m): **PI Total**

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Image Report - Active

Site ID:	**920033**				
Latitude:	**47.588613854**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.016893148**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Associated Features

☑ Culvert ☐ Dam ☐ Natural Barrier ☐ Diversion

☐ Non-Culvert Xing ☐ Other ☐ Fishway

Image Name: 920033_1.JPG, Date/Time: 07/24/2012 13:53

Image Name: 920033_2.JPG, Date/Time: 07/24/2012 13:53

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920034 **Project** CITY

Geographic Coordinates

Latitude (WGS 84):	47.588121678
Longitude (WGS 84):	-122.015519038
East (HARN 83):	1,266,421.2
North (HARN 83)	825,896.2

Waterbody

Stream:	Laughing Jacobs Cr
Tributary To:	Lake Sammamish
WRIA:	08.0166
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	SE 24th St
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type: City

Name: City of Sammamish

PI Species

☐ Sockeye	☐ Chinook	☐ Sea Run Cutthroat
☐ Pink	☐ Coho	☑ Resident Trout
☐ Chum	☐ Steelhead	☐ Bull Trout

Associated Features

☑ Culvert	☐ Dam	☐ Natural Barrier	☐ Diversion
☐ Non-Culvert Xing	☐ Other	☐ Fishway	

Location/Directions

Site Comments

Cyclone fence crossing channel immediately upstream of culvert.

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID: **920034**

Latitude:	**47.588121678**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.015519038**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Data Source WDFW

Field Crew: Ingram;Stygar

Review Date: 7/25/2012

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.1	BOX	PCC	1.51	0.61	17.10	0.00	NO	0.00		No	0	-0.53

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 3.96

Culvert/Stream Width Ratio: 0.38

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 2.50

Assessment Results

Barrier:	Unknown	Passability (%):	Unknown	Method:	Level A
Reason:	evel B Require	Fishway Present:	No	Recheck:	

Comments

Level B required during flows. Level B is not in project scope due to only resident fish use. Roadside surface water management drains entering at downstream end of pipe. Cement retaining wall with cyclone fencing on top defining sidewalk elevation.

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Yes	Rearing (sq m):		**PI Total**	

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920035 **Project** CITY

Geographic Coordinates

Latitude (WGS 84):	47.586540377
Longitude (WGS 84):	-122.014161707
East (HARN 83):	1,266,745.0
North (HARN 83)	825,313.0

Waterbody

Stream:	Laughing Jacobs Cr
Tributary To:	Lake Sammamish
WRIA:	08.0166
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	SE 244th Ave
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	City
Name:	City of Sammamish

PI Species

☐ Sockeye
☐ Pink
☐ Chum

☐ Chinook
☐ Coho
☐ Steelhead

☐ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Site Comments

Fence at downstream of pipe catching debris moving through system creating a backup point. Beaver Lake Park ball fields at upstream end of pipe.

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID: **920035**

Latitude:	**47.586540377**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.014161707**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Data Source WDFW

Field Crew: Ingram;Stygar

Review Date: 7/25/2012

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.1	RND	PCC	0.91	0.91	15.50	0.00	NO	0.00		No	0	-0.06

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 3.90

Culvert/Stream Width Ratio: 0.23

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 2.00

Assessment Results

Barrier:	Unknown	Passability (%):	Unknown	Method:	Level A
Reason:	evel B Require	Fishway Present:	No	Recheck:	

Comments

Determined that Level B analysis is required during time of flows, but out of scope of project due to resident only fish use. Stacked stone and concrete headwall at upstream and downstream end of pipe.

Potential Habitat Gain

Survey Type:		Spawning (sq m):		Length (m):	
Significant Reach:	Yes	Rearing (sq m):		**PI Total**	

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Image Report - Active

Site ID:	**920035**				
Latitude:	**47.586540377**	Stream:	**Laughing Jacobs Cr**	WRIA:	**08.0166**
Longitude:	**-122.014161707**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Image Name: 920035_1.JPG, Date/Time: 07/25/2012 08:51

Image Name: 920035_2.JPG, Date/Time: 07/25/2012 08:52

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920058

Project CITY

Geographic Coordinates

Latitude (WGS 84):	47.566594727
Longitude (WGS 84):	-122.053557158
East (HARN 83):	1,256,880.8
North (HARN 83)	818,227.4

Waterbody

Stream:	unnamed
Tributary To:	Laughing Jacobs Cr
WRIA:	08.0164
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Biological

General Location

Road Name:	Lake Sammamish Pkwy
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	City
Name:	City of Issaquah

PI Species

☑ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☑ Coho
☐ Steelhead
☑ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Next to Laughing Jacobs Cr.(WRIA 08.0166) and joins around 5m DS at East Lake Sammamish Trail bridge (810690).

Site Comments

Stream channel was rerouted and was originally a tributary to Lake Sammamish and is now a tributary to Laughing Jacobs Cr. Juvenile Coho observed. Boulder armor on US LB.

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID: **920058**

Latitude: **47.566594727** Stream: **unnamed** WRIA: **08.0164**

Longitude: **-122.053557158** Tributary To: **Laughing Jacobs Cr** Fish Use Potential: **Yes**

Data Source WDFW

Field Crew: Dwight;Romero Review Date: 8/8/2012

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.1	BOX	CPC	1.83	1.22	31.10	0.13	NO	0.00		No	0	1.38

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 2.65

Culvert/Stream Width Ratio: 0.69

Plunge Pool

Length (m): 0.00

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 3.00

Assessment Results

Barrier: Yes

Passability (%): 33

Method: Level A

Reason: Slope

Fishway Present: No

Recheck:

Comments

Potential Habitat Gain

Survey Type: RSFS

Spawning (sq m): 716

Length (m): 1,837

Significant Reach: Yes

Rearing (sq m): 2,200

PI Total 19.60

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Habitat Survey Summary Report

Site ID: **920058**

Latitude: **47.566594727** Longitude: **-122.053557158** WRIA: **08.0164**

Stream: **unnamed** Tributary To: **Laughing Jacobs Cr** PI Total: **19.60**

Survey Type RSFS

Spreadsheet File(s):

920058.xls;920058A.xls;920058A1.xls;920058B.xls;920058Add.xls

Downstream Survey

Date: 10/9/2012 Crew: Dwight;Romero Length (m): 233

Downstream Comments:

DS habitat is low gradient riffle and pool through residential landscaping. Channel is very uniform in width and has bank armor in many places. Low instream cover, very little canopy. Channel substrates are mostly gravel.

Upstream Survey

Date: 10/9/2012 Crew: Dwight;Romero Length (m): 1,837

Upstream Comments:

Mixed deciduous canopy, conifers at upper reaches. Lower reach braids through reed canary grass. Channel has been re-routed to confluence with Laughing Jacobs. Upper reaches flow from forested ravine North of 43rd Way. Gradient increases in upper reaches

Potential Habitat Gain

Lineal (m): 1,837

Spawning Area (sq m): 716

Rearing Area (sq m): 2,200

Distribution
- ● Anadromous
- ○ Resident Only
- ○ Unknown

Gain Direction (Resident Only)

Potential Species Benefit

- ☑ Sockeye / Kokanee
- ☐ Pink
- ☐ Chum
- ☐ Chinook
- ☑ Coho
- ☐ Steelhead
- ☑ Searun Cutthroat
- ☑ Resident Trout
- ☐ Bull Trout

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Barrier Priority Index Report

Site ID: **920058**

Stream unnamed **Trib To** Laughing Jacobs Cr **WRIA** 08.0164

Habitat (H) Estimatiom Method RSFS

	B	H	M	D	C	Species PI
Sockeye	0.67	287	2	1	2	6.93
Pink			2		2	0.00
Chum			2		2	0.00
Coho	0.67	735	2	2	2	3.75
Chinook			2		2	0.00
Steelhead	0.67	1,379	2	3	2	2.20
Searun Cutthroat	0.67	1,379	2	1	2	3.42
Resident Trout	0.67	2,198	1	1	2	3.30
Dolly/Bull Trout					2	0.00
					TOTAL PI	**19.60**

B = proportion of fish passage improvement (1, 0.67, 0.33).

H = potential habitat gain (square meters), spawning habitat for sockeye, pink and chum, rearing habitat for the rest.

M= mobility modifier (anadromous = 2, resident = 1).

D = stock condition modifier (critical = 3, depressed = 2, not 2 or 3 = 1).

C= repair cost modifier (<$100K = 3, $100K - $500K = 2, >$500K = 1).

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database
Image Report - Active

Site ID: **920058**

Latitude:	**47.566594727**	Stream:	**unnamed**	WRIA:	**08.0164**
Longitude:	**-122.053557158**	Tributary To:	**Laughing Jacobs Cr**	Fish Use Potential:	**Yes**

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Image Name: 920058_1.JPG, Date/Time: 08/08/2012 15:14

Image Name: 920058_2.JPG, Date/Time: 08/08/2012 14:45

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Site Description Report

Site ID 920108

Project FBRB

Geographic Coordinates

Latitude (WGS 84):	47.608436896
Longitude (WGS 84):	-122.072439054
East (HARN 83):	1,252,524.1
North (HARN 83)	833,580.6

Waterbody

Stream:	Ebright Cr
Tributary To:	Lake Sammamish
WRIA:	08.0149
River Mile:	-999.99
Fish Use Potential:	Yes
FUP Criteria:	Physical

General Location

Road Name:	ake Sammamish Parkw
Mile Post:	-999.99
County:	King
WDFW Region:	4

Owner

Type:	City
Name:	City of Sammamish

PI Species

☑ Sockeye
☐ Pink
☐ Chum
☐ Chinook
☑ Coho
☑ Steelhead
☑ Sea Run Cutthroat
☑ Resident Trout
☐ Bull Trout

Associated Features

☑ Culvert
☐ Non-Culvert Xing
☐ Dam
☐ Other
☐ Natural Barrier
☐ Fishway
☐ Diversion

Location/Directions

Site Comments

Upstream channel re-enforced with concreted boulders to protect road surface.

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level A Culvert Assessment Report

Site ID: **920108**

Latitude:	**47.608436896**	Stream:	**Ebright Cr**	WRIA:	**08.0149**
Longitude:	**-122.072439054**	Tributary To:	**Lake Sammamish**	Fish Use Potential:	**Yes**

Data Source WDFW

Field Crew: Barrett;Burns

Review Date: 4/12/2016

Culvert Details / **Level A Parameters**

ID	Shape	Material	Span	Rise	Length	WDIC	Apron	WSDrop	Location	Countersunk	Backwater	Slope (%)
1.2	RND	PCC	0.76	0.76	18.30	0.18	NO	0.00		No	0	1.58
2.2	RND	PCC	0.76	0.76	18.30	0.09	NO	0.00		No	0	1.31

All dimensions in meters

Channel Description

Toe Width (m):

Average Width (m): 5.20

Culvert/Stream Width Ratio: 0.29

Plunge Pool

Length (m): -999.99

Max Depth (m): -99.99

OHW Width (m): -999.99

Road

Fill Depth (m): 2.50

Assessment Results

Barrier:	Yes	Passability (%):	67	Method:	Level A
Reason:	Slope	Fishway Present:	No	Recheck:	

Comments

Left bank pipe receiving majority of flows at 4/12/2016 visit. 0.41 cms.

Potential Habitat Gain

Survey Type:	RHA	Spawning (sq m):	-999	Length (m):	-999
Significant Reach:	Yes	Rearing (sq m):	-999	**PI Total**	

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Level B Culvert Assessment Report

Site ID: 920108

Reference Point

Elevation (m): 100.00 Location: Upstream Invert LB

Drainage Basin

Basin Area (sq mi): 1.48 Basin Precipitation (in): 47.20

Culvert Elevations

Culvert ID	Corrugation	USIE (m)	USCBE (m)	DSIE (m)	DSCBE (m)
1.2	Concrete	100.00	-999.99	99.65	99.83
2.2	Concrete	99.99	-999.99	99.77	99.89

Downstream Control

X-Section

Station	Top LB	Toe LB	Bed 1	Bed 2	Bed 3	Toe RB	Top RB
Distance (m)	0.00	1.00	1.50	2.00	2.50	3.10	3.80
Elevation (m)	100.83	100.01	99.99	99.96	99.96	99.95	100.56

Downstream Control Water Surface Elevation (m) 100.09

Downstream Control OHW Surface Elevation (m) -999.99

---

15 Meters Downstream of Downstream Control

Water Surface Elevation (m): 99.90 Dominant Channel Substrate: Gravel

---

Results

Velocity (m/sec): -99.99 Depth (m): -99.99

Print Date: 4/18/2019

WDFW Fish Passage and Diversion Screening Inventory Database

Habitat Survey Summary Report

Site ID: **920108**

Latitude: **47.608436896** Longitude: **-122.072439054** WRIA: **08.0149**

Stream: **Ebright Cr** Tributary To: **Lake Sammamish** PI Total:

Survey Type

Spreadsheet File(s):

920108_RHA.xlsx

Downstream Survey

Date: 4/20/2016 Crew: Engeness;Visser Length (m): -999

Downstream Comments:

There is a barrier (601582) present just downstream of target site, but it is scheduled to be replaced. Water quality appears good with several decent pools present. Rip rap present in a couple spots. BFW = 2.68. Gradient = 3%.

Upstream Survey

Date: 4/20/2016 Crew: Engeness;Visser Length (m): -999

Upstream Comments:

Water quality appears good with a couple pools. Small man made present pond on RB. Occasional armoring with rip rap on small sections by house. Step-pool / pool-riffle regime present. Steep valley walls at upstream portion of reach.

Potential Habitat Gain

Lineal (m): -999

Spawning Area (sq m): -999

Rearing Area (sq m): -999

Distribution

● Anadromous

○ Resident Only

○ Unknown

Gain Direction (Resident Only)

Potential Species Benefit

☑ Sockeye / Kokanee

☐ Pink

☐ Chum

☐ Chinook

☑ Coho

☑ Steelhead

☑ Searun Cutthroat

☑ Resident Trout

☐ Bull Trout

Print Date: 4/18/2019

Appendix D – Laughing Jacobs Creek Stream Survey Form for the Middle Reach of Lower Subbasin

Habitat Survey Data Form for a Reach of Laughing Jacobs Creek located Between East Lake Sammamish Parkway and the Barrier Falls at RM X.97. Survey Conducted April 29, 2019

Station	Habitat Type		Dominant Substrate	Sub-Dom. Substrate	Embeddedness	Pool Measurements (feet)					Wood Count		Bank Armor, Revetments and Bank Erosion	Comments/ Notes
(Hip Chain Read (feet))	Pool, Riffle, Other (P, R, O)	Riffle Length	Size Class 1-7	Size Class 1-7	Low, Med., or High	Max Depth	Tailout Depth	Wetted Width	Wetted Length	Pool Area	LWD Tally (>1 foot dia, 10-ft length)	SWD Tally (>4-in diam, 6-ft length)		
0	R	68.0	6	5	M						3	2		Braided
68.0	P		6	5	M	0.5	0.3	8.0	11.0	88		2		
79.0	R	22.0	6	5	M						1			
101.0	P		6	5	M	0.6	0.3	9.0	14.0	126				
115.0	R	42.0	6	5	M						1	1		
157.0	P		5	4	M	1.0	0.3	8.0	8.0	64	1			LWD scour pool on right bank
165.0	R	7.0	6	5	M									
172.0	P		5	6	M	1.3	0.4	8.0	9.0	72	1			
181.0	R	33.0	5	6	M									
214.0	P		6	5	M	0.9	0.4	9.0	18.0	162				LWD scour pool on left bank
232.0	R	6.0	6	5	M									
238.0	P		5	6	M	0.9	0.3	7.0	7.0	49	3			Mid-channel scour pool with wood
245.0	R	22.0	6	5	M						1			
267.0	P		5	6	M	1.6	0.4	11.0	24.0	264	2	3		LWD Jam and plunge pools
291.0	END													

Substrate Codes

1	Bedrock	
2	Silt/organic (<2 mm)	
3	Sand (2-4 mm)	to 0.15 inch
4	Small Gravel (4-25 mm)	to 1 inch
5	Large Gravel (25-74 mn	to 3 inches
6	Cobble (74-300 mm)	to 12 inches
7	Boulder (> 300 mm)	> 12 inches

APPENDIX C

Public Outreach Materials

rTO: City of Sammamish
FROM: Cascadia Consulting Group
RE: Laughing Jacobs Basin Plan Public Engagement Summary - DRAFT
DATE: July 24, 2019

INTRODUCTION

The following memo summarizes the results of the 2019 Laughing Jacobs Basin Plan public engagement with residents in Sammamish and Issaquah on behalf of the City of Sammamish ("the City"). The Laughing Jacobs Basin Plan will be an update on the current health of the basin and will recommend priority areas and actions for the City to invest its resources to reduce flooding and preserve natural areas. In 2019, the City engaged residents through a survey and an open house in the first phase of the longer public involvement process designed to engage residents and provide them with ample opportunities to help identify projects related to natural areas, flooding, drainage, and stream restoration. There will be additional engagement opportunities planned for the spring of 2020. Since the priority projects in the basin plan will shape neighborhoods for decades to come, it is important that they reflect community values.

Cascadia collaborated with City staff to design a public survey and plan an open house. Survey and open house goals included to:

- Inform the public about the Laughing Jacobs watershed and basin planning process and build excitement and sense of ownership among the community for their watershed.
- Gather feedback on concerns, interests, and priorities for drainage, stormwater, and natural resources management in Laughing Jacobs Basin to inform the development of the basin plan.
- Identify priority projects that reflect community values and will help reduce flooding and preserve natural areas in the basin.
- Gather information about specific locations with standing water or flooding issues that priority projects could help address.

Survey

Cascadia first developed an online survey through SurveyMonkey as well as a paper version of the survey. The survey asked residents questions about the following topics:

- Question 1 (Q1): How would you divide $100 of funds for projects related to natural areas, flooding, drainage, and stream restoration out of the list of priorities provided?
- Question 2 (Q2): How would you rank your preference for using potential projects to preserve more natural area and restrict public access or create more opportunities for public use of open space?
- Question 3 (Q3): List any specific areas where you think public access should be restricted.
- Question 4 (Q4): List any specific areas where you think public access should be maintained.
- Question 5 (Q5): How often in the last year have you engaged in the following recreational activities in the Laughing Jacobs Basin (list provided)?
- Questions 6-10 (Q6-10): Have you seen flooding or large puddles near your home or neighborhood in the last year? If so, characterize what you saw, where it was located, what time of year it happened, and how frequently it happens.
- Questions 11-16 (Q11-16) repeated Q6-10 to give respondents opportunities to identify and characterize additional locations where they have seen flooding or large puddles near their home or neighborhood.
- Questions 17-18 (Q17-18) How long have you lived in Sammamish or Issaquah and do you own or rent your home?

Cascadia used a list of addresses within the basin provided by the City to mail paper surveys, including the link to the online survey, in late April. These reached 3,063 residents in the Sammamish and Issaquah area. In the early stages of data analysis, we found that all respondents identified as homeowners. We reviewed our data to better understand this result and realized that the addresses we had used were for the property owners rather than the property locations, indicating that home renters were generally excluded from the distribution. To address this issue and help ensure an equitable approach, Cascadia mailed 329 postcards with the online survey link in late June to property addresses that were different than the address listed for the property owner. Cascadia also made the paper and online surveys (on iPads) available for completion at the open house.

The online survey closed on July 12, 2019. The total number of survey respondents from both paper and online surveys was 465 (approximately 14 percent return rate). Out of this total, 170 surveys were completed online and 295 surveys were returned in paper format, including those completed at the open house. For paper surveys, the City provided hardcopy responses to Cascadia and Cascadia manually entered responses into the online survey database. All online surveys were automatically entered into the survey database. A copy of the survey is included in Appendix A of this memo for reference.

Open House

The City hosted an open house on June 13, 2019 to share information about the basin plan and preliminary results from the survey and to gather more input from residents. Fifteen people attended the open house, which was fewer than desired, despite promotional and marketing efforts that included a postcard invitation sent to the same mailing list used in the paper survey as well as email announcements to a suite of community organizations and schools. One factor that may have affected attendance was that the City hosted an open house two days prior, on June 11, for the Klahanie Parks Master Plan, which may have attracted a similar audience as the Laughing Jacobs Basin Plan and made them less likely to attend a second community meeting in a single week.

Attendees engaged with materials and questions presented at different stations using display boards. A copy of the display board results is included in Appendix B of this memo for reference. Some of the questions were variations of those asked in the survey and others were distinct to gather additional information that was not suitable to a survey format. There were five stations, which are listed below with their corresponding survey questions, if applicable:

- Station 1: Where do you live in the watershed?
- Station 2: What do you care about in your neighborhood?
    - Public access vs. natural area protection (Survey Q2-4)
    - Activities people engage in (Survey Q5)
- Station 3: Where are the water hotspots in the watershed? (Q6-16)
- Station 4: What is your vision for the future?
- Station 5: How should we spend our money? (Survey Q1)

Note that the order of the open house stations does not correspond to the order of the survey questions. This was intentional to facilitate an effective user engagement. The open house stations were ordered in a way that created a story arc or narrative about the Laughing Jacobs basin and basin plan as the attendees navigated through the stations. In contrast, the survey questions were ordered using best practices for survey design that emphasize consideration of tendency toward decision fatigue and avoidance of complex thinking.

ANALYSIS

The following analysis summarizes the compiled survey and open house results and presents associated graphical summaries, maps, and key themes. Note that the results are presented in order of the open house stations to follow the logical story arc, and the corresponding survey questions are noted.

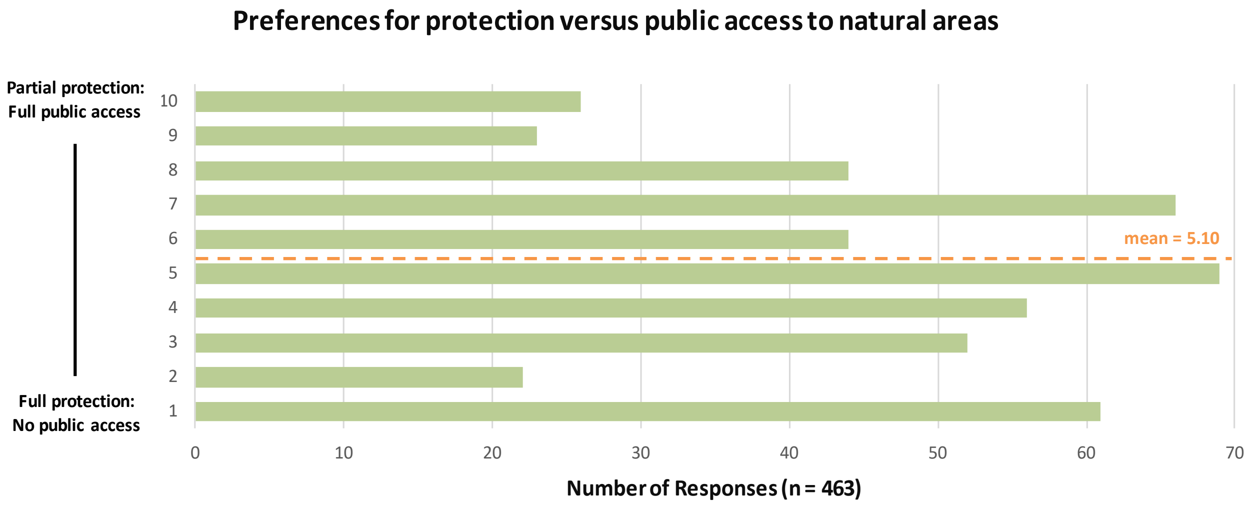
There are no results to present from Station 1 because these display boards were intended to provide information about characteristics of a watershed and specifically the Laughing Jacobs watershed as well as the basin planning process. This station was not designed to gather feedback from to inform the basin planning process. See Appendix B for the photo of the display board with residents' approximate location of residency from the open house.

Priorities for Natural Area Preservation and Public Access (Station 2/Q2-4)

Station 2 asked open house attendees to indicate which locations they would recommend for natural area preservation, which would restrict public access, and which locations they would recommend to keep open for public access. This station corresponded to survey questions 2-4 (Q2-4).

Q2 asked respondents to indicate their preference for using potential projects to preserve natural area and restrict public access or to create opportunities for public use of open space. Respondents indicated their preferences using a 1-10 scale, with 1 indicating *Full protection: No public access* and 10 indicating *No protection: Full public access*.

The survey responses were well-distributed among the scale. A fair amount of people (13%) felt strongly about full protection compared to fewer people who preferred full public access (5%). However, overall, the mean response was found to be in the middle (mean=5.1). **This indicates that while some people have strong preferences, a general balance between environmental preservation and human access to these spaces should be considered in the Laughing Jacobs plan.** The chart below shows the distribution and the average of responses:



The survey asked respondents to identify specific areas where they thought public access should be restricted in an open-ended question format (Q3). We grouped these responses by common themes, summarized in the table below. Comments that included specific locations (e.g., Beaver Lake) were grouped under an umbrella theme (e.g., Water Systems). Individual responses were coded into more than one theme, as applicable.

The majority of people commented that public access should be restricted in areas where water systems such as lakes, wetlands, and shorelines were present. The next themes with the greatest number of responses were wildlife habitat and natural or sensitive areas. This data underscores that people support minimal human access to preserve naturally functioning ecosystems. The table below shows the themes and associated responses. In addition, some comments that reflect each theme are shown in italics and quotations.

Theme:	Number of Responses:	Comments:
Water Systems (e.g., lakes, wetlands, shorelines, streams). Responses mentioned: • Beaver Lake • Hazel Wolf Wetland • Klahanie Park • Laughing Jacobs Lake • Lake Sammamish • Queen's Bog	**69**	*"Ponds, streams and wetlands that have returning nesting for wildlife (ducks, frogs, mammals and reptiles)."* *"I think every development should have a wetland area that is restricted, yet surrounded by a trail open to general public."*
Wildlife Habitat	**38**	*"Any location where it is a critical habitat for an endangered or at-risk animal. In addition, we should protect and reduce access to locations where we are collecting and storing drinking water."*
Natural or Sensitive Areas • Existing natural areas with little to no access • Planted areas with dense, old, or native growth • Concern/mention of invasive species	**36**	*"Environmentally sensitive areas where the loss of habitat is threatened."* *"Wetlands, Shorelines, Streams. Especially remove invasive problem plants such as purple loosestrife, ivy, and many others."*
Hazardous/Dangerous Areas • Concerns for human safety due to unstable ground and natural hazards	**8**	*"Wetlands, rainwater basins, areas of danger due to floods/slides, or other hazards"*
Residential and/or Private Property Areas, specifically Rainbow Lake Ranch	**8**	*"New building should be restricted."*
Walking, Hiking, and Biking Trails	**4**	*"Limit hiking and preserve the protected areas."*
Other Responses that did not fit into a clear theme or included feedback that was not specific to the question are listed below: • All areas • Neutral as long as balance is achieved	**26**	*"I don't know enough to answer this. Overall I think there should be a balance between ensuring the health of the area and people enjoying them."*

Theme:	Number of Responses:	Comments:
- Unsure or not familiar enough to answer the question - Desire for data and/or feedback from professionals (e.g., scientists) - Skepticism of previous/future development - Pine Lake School		

Full Public Access

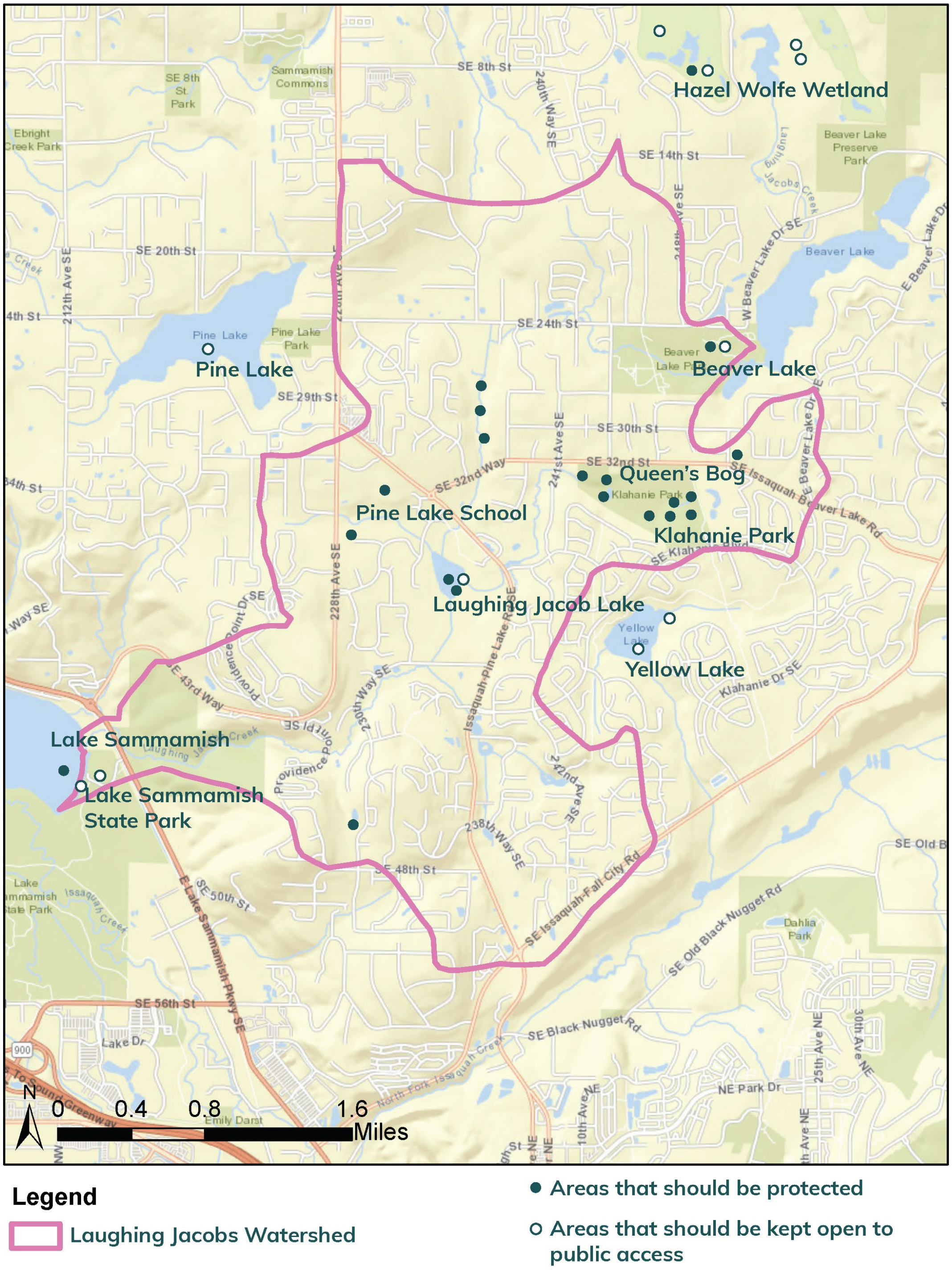
The survey asked respondents in an open-ended question format to identify specific areas where they thought public access should be maintained (Q4). We grouped these responses into common themes, summarized in the table below. Comments that included specific locations (e.g., Lake Sammamish State Park) were grouped under an umbrella theme (e.g., Recreational and Current Public Access Areas). Individual responses were coded into more than one theme, as applicable.

The greatest number of responses fall under recreational and current public access areas. Many people felt that access to these areas enables people to appreciate nature and expressed that proper management to maintain good condition is important. Interestingly, the theme with the second most responses is water systems, which was the top priority in restricting public access. **These conflicting preferences suggest that a balance needs to be met between these two approaches.** The table below shows the themes and associated responses. In addition, some comments that reflect each theme are shown in italics and quotations.

Theme:	Number of Responses:	Comments:
Recreational and Current Public Access Areas Responses mentioned: - Areas with opportunities for environmental education - Duthie Hill - Klahanie - Lake Sammamish State Park - Soaring Eagle	**105**	*"Trails to appreciate nature and wetlands are important so we remember the beauty."* *"Natural areas that can tolerate trials for walking, bird watching, and other casual activities. But these areas need to be monitored for damage and closed if needed."* *"Keep current parks open to public. Where possible expand use of green spaces to light recreational use."* *"Areas with good educational value for kids."*
Water Systems (e.g., lakes, wetlands, shorelines, streams), specifically: - Beaver Lake - Evans Creek - Hazel Wolf Wetlands - Lake Sammamish - Laughing Jacobs Lake - Pine Lake - Yellow Lake	**56**	*"Each lake should have a viewing, fishing, swimming area, observation areas into wetlands to watch birds and animals, and new trails alongside water bodies."*
Forests, woods, and fields	**6**	*"Trails, scenic areas, wooded or shaded areas"*

Theme:	**Number of Responses:**	**Comments:**
Other Responses that did not fit into a clear theme or included feedback that was not specific to the question are listed below: • All areas • Neutral as long as balance is achieved • Unsure or not familiar enough to answer the question • Desire for data and/or feedback from professionals (e.g., scientists) • Skepticism of previous/future development • Highland upper areas	**24**	*"As long as we maintain a balance between the health of the environment and the community being able to access these areas, I'm happy."*

The following map illustrates locations that survey respondents and open house attendees identified as places to keep open for public access and areas that should be restricted for natural area preservation.



Recreational Activities in the Laughing Jacobs Basin (Station 2/Q5)

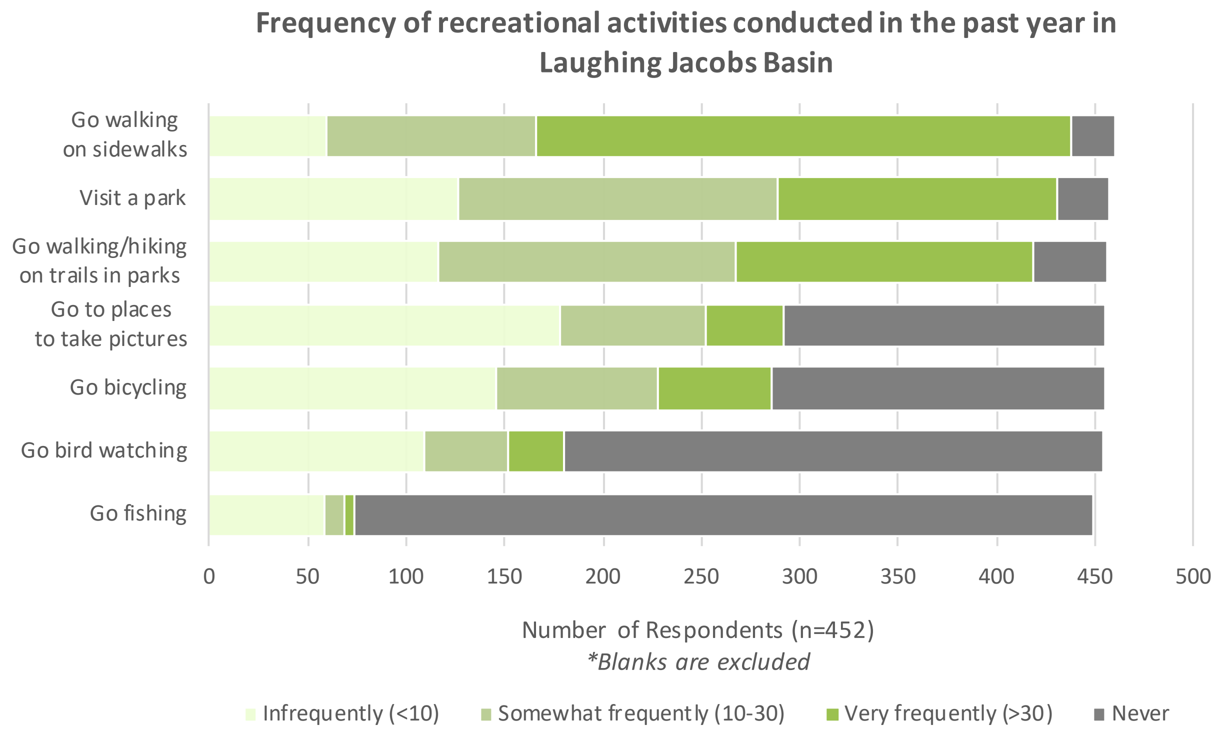
Q5 asked respondents how often in the last year they did the following recreational activities in the Laughing Jacobs Basin:

- Visit a park
- Go walking on sidewalks
- Go walking/hiking on trails in parks
- Go fishing
- Go bicycling
- Go bird watching
- Go to places to take pictures

People responded to each recreational activity with the following frequency scale:

- Never
- Infrequently (less than 10 times per year)
- Somewhat frequently (10 to 30 times per year)
- Very frequently (more than 30 times per year)

The online survey form did not require a response for each activity. As a result, some respondents provided input for some activities and left other categories blank; blank responses were not included in our analysis. The sample size represents respondents who provided an answer to at least one of the recreational activities. The chart below provides a summary of the distribution (n=452):



Station 2 at the open house presented a simpler variation of this question, only asking which of the same recreational activities respondents had done in the last year at in Laughing Jacobs Basin. The results are portrayed in the following table:

Activity	**Number of stickers**
Visit a park	**6**
Go walking on sidewalks	**6**
Go walking/hiking on trails in parks	**8**
Go fishing	**2**
Go bicycling	**4**
Go bird watching	**2**
Go to places to take pictures	**3**

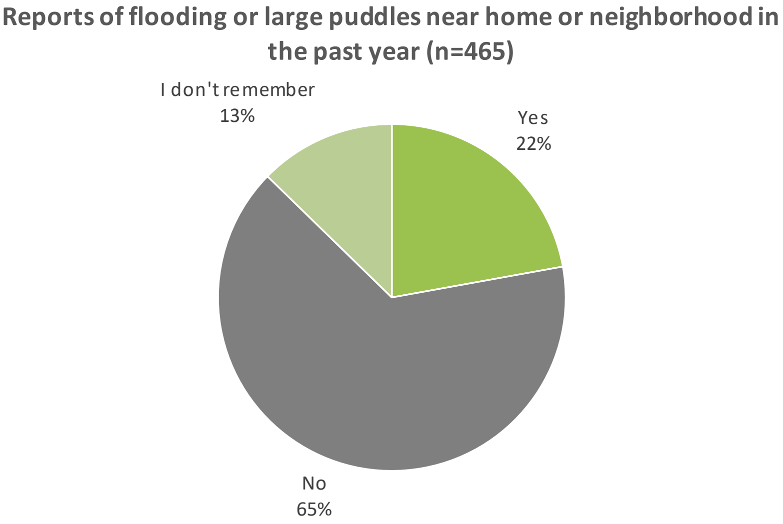
The data indicates that walking or hiking on sidewalks and trails as well as visiting parks are the recreational activities with the most frequent participation among survey respondents and should be considered when prioritizing projects in the Laughing Jacobs basin.

Identification of Drainage Issues (Station 3/Q6-10)

Station 3 asked attendees to identify any locations where they have seen flooding, large puddles, or other water issues in the basin. The corresponding survey questions 6-10 asked respondents similar questions:

- Q6: Do you remember seeing flooding or large puddles near your home or neighborhood in the last year?
- Q7: If yes, what did you see?
    - Large puddle(s) in or next to the street
    - Flooding in sections of the street
    - Flooding of an entire block
    - Other (please describe)
- Q8: Where did you see it? Please list the address or nearest street intersection.
- Q9: When did it happen? Please list the date(s), month, or season.
- Q10: How often does it happen? How many times have you seen this in the past year?
    - Once or twice
    - Three or four times
    - Five or more times
    - I don't remember

Responses to Q6 showed that 22 percent of respondents remembered seeing flooding or large puddles near their home or neighborhood in the last year (n=465). These responses present potential opportunities for drainage and flooding projects in this area. 65 percent of residents said they did not see any flooding or large puddles, while 13 percent of respondents could not remember instances in the last year. **This data shows that the majority of residents in the Laughing Jacobs basin do not know of or recall specific instances of drainage issues. However, it is important to note that the timing of public engagement during a relatively dry period during the year (May through July) may have skewed the data due to a cognitive bias toward the present (i.e., forgetting about problems that occurred in the past).**



As for types of drainage issues (Q7) observed at each location, no survey respondents reported seeing flooding of an entire block. Some respondents answered "Other" for type of drainage issue and noted puddles in yards, on trails, or in ditches. The following table indicates the number of drainage issues identified by type. As the table indicates, survey respondents and open house attendees identified 95 total instances of drainage issues (Q8/Station 3). Specific geographic locations of approximately 10 drainage issues could not be determined due to missing or unintelligible information. These instances were excluded from the analysis.

Type of drainage issue	**Number of drainage issue instances identified**	**Percent of total drainage issues identified**
Flooding of an entire block	0	0%
Flooding in sections of the street	30	32%
Large puddle(s) in or next to the street	54	57%
Other: Puddle(s) in yards, trails, and ditches	11	12%
Total	95	

Q9 asked respondents to identify the date, month, or season when they could recall seeing the drainage issue. This question had an open-ended response. The table below lists the categories of responses and the corresponding number of responses. We categorized months into the seasons accordingly: Fall includes September, October, and November; Winter includes December, January, and February; and Spring includes March, April, and May. Since the seasonal definition was not provided in the survey, the table shows the count of responses for individual months under its respective season.

Time	**Number of responses**
Rainy season	25
Fall	**24**
October	*4*
November	*2*
Winter	**45**
December	*1*
January	*2*
February	*4*
Spring	**9**
March	*2*
After snow	3
Year-round	1
2018	7
2019	7
Blank	20
Don't remember	3

Q10 asked how frequently the drainage issue occurs. The following table summarizes responses by type of drainage issue (n=95).

	Flooding in sections of the street		**Large puddle(s) in or next to the street**		**Puddle(s) in yards, trails, and ditches**	
Frequency	# of reported issues	% of total reported issues (n=95)	# of reported issues	% of total reported issues (n=95)	# of reported issues	% of total reported issues (n=95)
Once or twice / I don't remember*	13	14%	20	21%	3	3%
Three or four times	13	14%	15	16%	4	4%
Five or more times	4	4%	19	20%	4	4%
TOTAL	30	32%	54	57%	11	12%

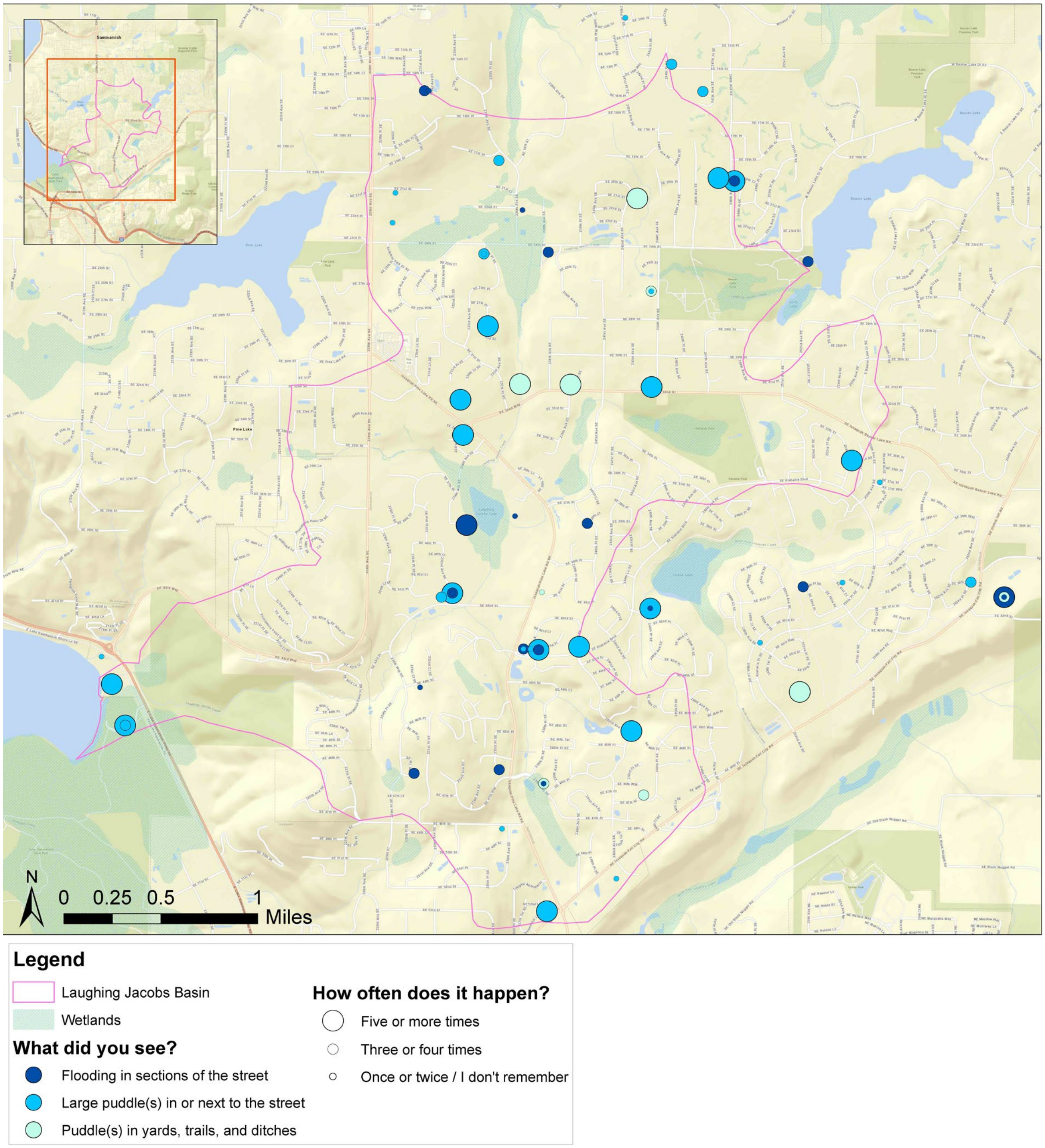
**The categories "Once or twice" and "I don't remember" were grouped together to simplify the spatial display of information because there were few if any responses in the latter category.*

Maps of drainage issues were generated using the following steps:

- Filtered survey responses to create a new dataset with all respondents who identified one or more locations with a drainage problem.
- Researched each identified location using Google Maps to identify a corresponding parcel address. In cases where insufficient information was provided, assumptions were made to identify an approximate parcel address. For instance, if only one street was identified without an address or cross-street, we selected a parcel address in the central segment of the street.

- Mapped parcel addresses using an ArcGIS address locator created from the King County GIS Center Addresses dataset.
- Applied symbols to show the frequency and type of drainage events throughout the Laughing Jacobs Basin.

The resulting map below shows the locations of drainage problem (Q8) by level of severity (Q7) and frequency (Q10). Each drainage problem is represented by a shade of blue and graduated size of circle. As the legend in the map illustrates, darker shades of blue indicate a more severe drainage problem. The larger size of circle indicates a more frequent drainage problem. Additional maps showing a larger scale of each quadrant of the basin are included in Appendix C.



Several survey respondents and open house attendees requested follow-up contact from the City regarding the drainage issues they identified. Contact information and the drainage issues they identified are listed in Appendix D.

Vision for the Future (Station 4)

Station 4 in the open house invited attendees to describe their vision for the future of the watershed, in terms of what they would like to see more of and what they would like to see less of. The table below lists responses grouped by themes with the respective number of responses in parentheses. Responses that were the same or very similar are not repeated in the table. **The data indicates that resident's priorities for the future are for supporting walking and biking infrastructure and protecting water systems,** which aligns with the recreational activities residents most engage in as well as their priorities for natural area protection of water systems. Residents strongly urged to slow the pace of dense development and the associated impacts. **The few responses supporting less flooding in the future indicates that flooding and drainage issues are not a high priority for residents,** which is similar to the findings noted in the section above.

More	Less
▸ Build sidewalks, trails and parks (8) • Connect trail/road system for pedestrians and mountain bikes • Make trail system more robust • Pipeline can be public trail ▸ Protect lands along waterways (6) • Restore waterway vegetation • Widen setbacks from waterways • Have native growth protection easements ▸ Stormwater and water quality (4) • Natural storm water ponds • Add rain gardens • Water quality treatment ▸ Managed development (3) • Consider impact of large tracts of homes • Incentives to landowners for protection of sensitive areas • Have open space ▸ Wildlife/habitat protection (2) • Protect/consider critters • Have wildlife corridors	▸ Development increasing density (5) • Decrease dense development • No more "pocket" developments (i.e., 4-6 houses in a small area) • Less in-fill • Encroachment of housing and roads ▸ Impacts from development (3) • Cut down so many trees for development • Fewer cars • Less cumulative impacts ▸ No more cheap construction (buildings that don't last) (2) ▸ Flooding and water flow control (2) • Flow control on smaller projects • Flooding

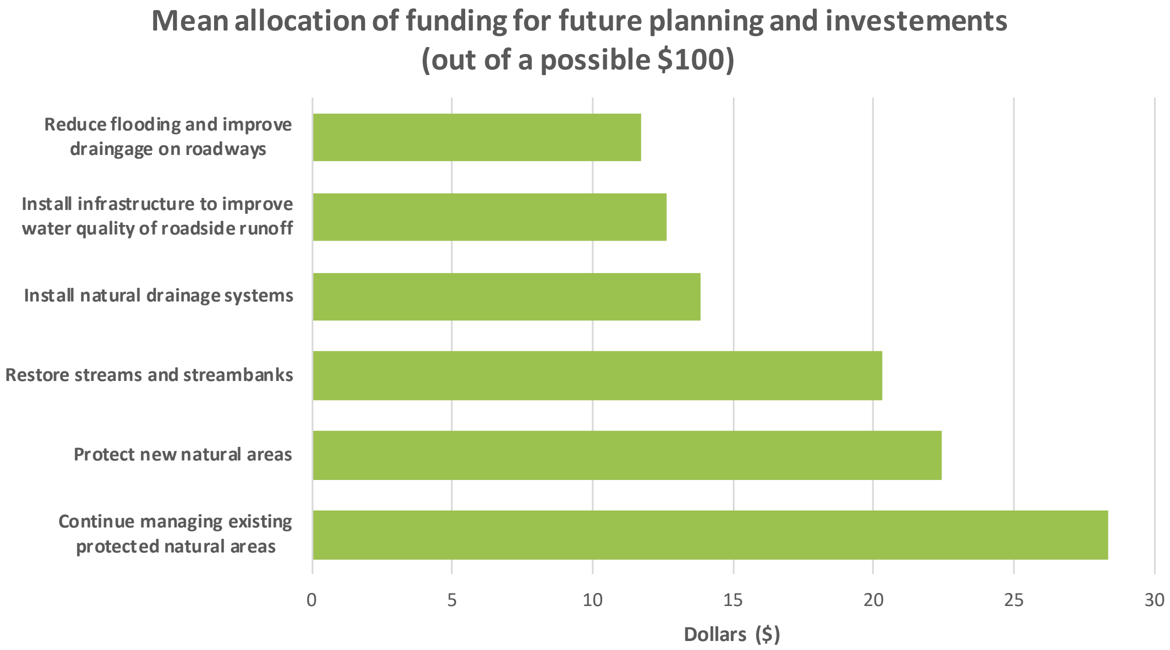
Funding Priorities for Future Projects (Station 5/Q1)

Station 5 and Q1 asked respondents how they would divide funds for projects related to natural areas, flooding, drainage, and stream restoration out of $100 (n=454) for the following priorities:

- Protect new natural areas
- Continue managing existing protected natural areas (e.g. wetlands and stream buffers)
- Reduce flooding and improve drainage on roadways
- Install infrastructure to improve water quality of roadside runoff
- Install natural drainage systems (e.g., rain gardens)
- Restore streams and streambanks

The online survey had a validation feature that required the total to equate to $100. For paper surveys, validation was not possible, so in instances where the values did not equate to $100, we adjusted the money to equal $100 and still capture the respondent's preferences the best. This approach is illustrated in the following example:

Priority	Respondent's Answer	Answers Entered After Adjustments
Protect new natural areas	$5	$6
Continue managing existing protected natural areas	$25	$26
Reduce flooding and improve drainage on roadways	$5	$6
Install infrastructure to improve water quality of roadside runoff	$23	$25
Install natural drainage systems (e.g., rain gardens)	$10	$11
Restore streams and streambanks	$25	$26
Total	**$93**	**$100**



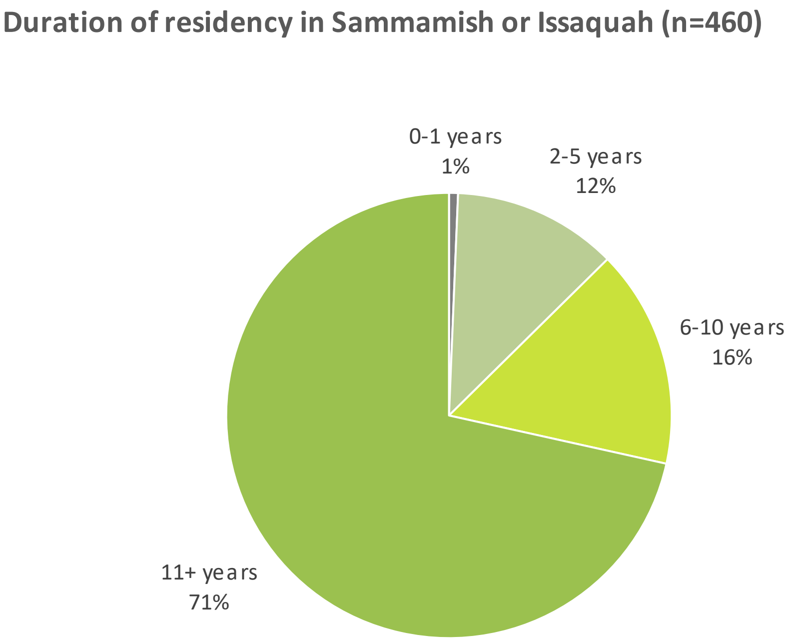
Station 5 asked a variation of this question to participants during our open house. Instead of asking how they would distribute $100 between these categories as in the survey, participants placed dots representing $20 next to each category they would want to invest in**. Restoring streams and streambanks received the greatest number of dots during the open house. Categories that received the least were the same as those in the survey: (1) reduce flooding and improve drainage on roadways, (2) install infrastructure to improve water quality of roadside runoff.** The open house results are portrayed in the following table:

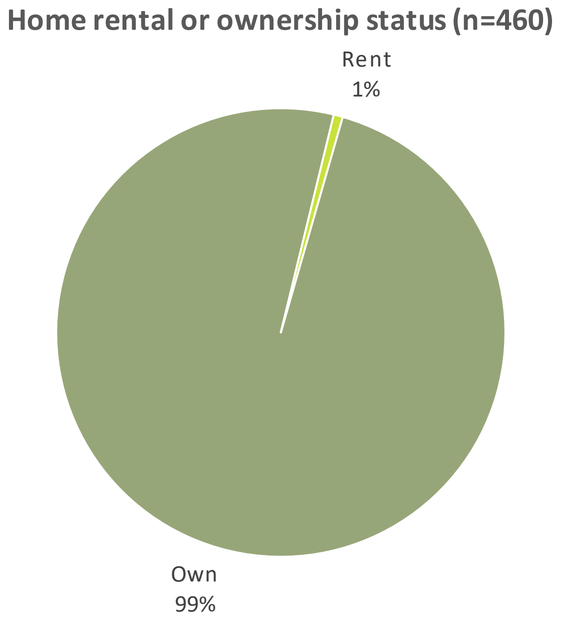
Priority	Number of dots ($20 each) per category
Continue managing existing protected natural areas	10
Protect new natural areas	10
Restore streams and streambanks	16
Install natural drainage systems	12
Install infrastructure to improve water quality of roadside runoff	5
Reduce flooding and improve drainage on roadways	5

Responses indicate that participants in both the survey and open house want to invest future funding in protecting and preserving natural areas and water systems rather than in improving road infrastructure. These priorities generally align with resident's priorities for preserving natural areas and waterways indicated in the previous sections above.

Demographic Questions (Q17-18)

Q17 and Q18 asked respondents optional demographic questions about how long they have resided in Sammamish or Issaquah and whether they own or rent their home, respectively. Some respondents did not answer one or both questions. Any blank responses were not included in our data analysis. Responses are summarized in the graphs below:





While these graphs show that the majority of survey participants have resided in this area for 11 years or more and are homeowners. We compared this information with Census data about the cities of Sammamish and Issaquah. As of 2017, 88 percent of households across both cities have lived in their home for three years or longer.[1] This percentage may increase if it included households that have moved between homes in the past two years but have stayed within the cities of Sammamish or Issaquah. This data suggests that the duration of residency among survey participants appears to be representative of the population at large. The homeownership rate across Sammamish and Issaquah was 76 percent in 2017, which is less than the rate of survey respondents. This discrepancy may be partially attributable to some home renters receiving notice of the survey later than the rest of the sample, as described above, and having approximately 1.5 weeks to complete the online survey compared to over 3 weeks for the rest of the sample.

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[1] U.S. Census Bureau, 2013-2017 American Community Survey 5-Year Estimates, Table B25038: Tenure by year householder moved into unit.

CONCLUSION

The public engagement efforts in this first phase of the Laughing Jacobs Basin planning process revealed several key findings:

- Residents in the Laughing Jacobs basin generally encourage striking a balance between environmental preservation and public access to sites for recreational purposes. This balance is especially important in areas with natural ecosystem functioning that also provide recreational benefits.
- In particular, residents identified wetlands, shorelines, and other water systems as a top priority for protection, restoration, and investment of public funds.
- Many residents frequently engage in walking/hiking on sidewalks and trails and visiting parks. Improving walking and biking infrastructure (e.g., sidewalk/trail connectivity) was the highest top priority for the future among open house attendees.
- The majority of residents do not know of or recall specific instances of flooding or water drainage issues. Investing in solutions to drainage issues is a low priority for most residents, given the suite of other ways to spend money in the basin. However, it is important to note that the timing of public engagement during a relatively dry period during the year (May through July) may have skewed the data due to a cognitive bias toward the present (i.e., forgetting about problems that occurred in the past).
- Residents at the open house strongly urged to slow the pace of dense development and the associated impacts.
- Improving road-related infrastructure, including runoff filtration, were low priorities for investment. This result may be more an indication of residents' aversion to development than a lack of concern for water quality, given that in other questions/stations, water quality and water systems emerged as a high priority among residents.

Given these key findings, we recommend the following considerations for the Laughing Jacobs Basin planning process moving forward:

- **Allocate more resources toward identifying projects that address high-priority issues for residents** (i.e., water system protection and walking/biking infrastructure). Focusing future public engagement on these types of projects would help convey to residents that their priorities were heard and incorporated into the basin plan.
- **Carefully characterize and communicate about drainage and water quality improvement projects that could be perceived as supporting or being related to development**. Focusing on the connection to water quality and avoiding road-related messaging is advised to overcome residents' strong negative associations with development.
- **Aim to strike a balance of proposed projects in the basin plan that support preservation of natural areas and opportunities for public access to nature for recreational purposes.** Clearly communicating about this goal of achieving a balance would be useful to speak to residents' preferences.

APPENDIX A: PUBLIC SURVEY

Priorities when planning for our future

1. The plan will recommend projects related to natural areas, flooding, drainage, and stream restoration. **If you had $100 to spend on these projects,** **how would you divide the funds?**

$	Protect new natural areas
$	Continue managing existing protected natural areas (e.g. wetlands and stream buffers)
$	Reduce flooding and improve drainage on roadways
$	Install infrastructure to improve water quality of roadside runoff
$	Install natural drainage systems (e.g., rain gardens)
$	Restore streams and streambanks
$100	**TOTAL BUDGET**

2. When we preserve natural areas, we can provide more protection by keeping people out of these areas. **The plan will recommend projects to preserve more natural area without public access and/or create more opportunities for public use of open space. Which would you like to see more of?**

1	2	3	4	5	6	7	8	9	10

←Full protection: No public access

Partial protection: Full public access←

3. **Are there specific areas where public access should be restricted? If so, please list them.**

4. **Are there specific natural areas that should be kept open to public access? If so, please list them.**

5. Over the past year, how often did you do in the following things in the Laughing Jacobs Basin?

	Never	Infrequently (less than 10 times per year)	Somewhat frequently (10 to 30 times per year)	Very Frequently (more than 30 times per year)
Visit a park	○	○	○	○
Go walking on sidewalks	○	○	○	○
Go walking/hiking on trails in parks	○	○	○	○
Go fishing	○	○	○	○
Go bicycling	○	○	○	○
Go bird watching	○	○	○	○
Go to places to take pictures	○	○	○	○

Reducing flooding and managing stormwater

6. We want to know about areas that tend to flood or have large puddles when it rains. **Over the last year, do you remember seeing any flooding or large puddles near your home or neighborhood?**

__ **Yes**, I have seen flooding or large puddles.

__ **No**, I haven't seen flooding or large puddles. (*Skip to question 17 on the next page.)*

__ **I don't remember.** *(Skip to question 17 on the next page.)*

Flooding or Puddles Location #1 Please provide as much detail as you remember.

7. What did you see?

☐ Large puddle(s) in or next to the street
☐ Flooding in sections of the street
☐ Flooding of an entire block
☐ Other (please describe) ____

8. **Where did you see it?** Please list the address or nearest street intersection.

9. **When did it happen?** Please list the date(s), month, or season.

10. **How often does it happen?** How many times have you seen this in the past year?

☐ Once or twice
☐ Three or four times
☐ Five or more times
☐ I don't remember

Flooding or Puddles Location #2 Please provide as much detail as you remember.

11. What did you see?

☐ Large puddle(s) in or next to the street
☐ Flooding in sections of the street
☐ Flooding of an entire block
☐ Other (please describe) ____

12. **Where did you see it?** Please list the address or nearest street intersection in the space below.

13. **When did it happen?** Please list the date(s), month, or season in the space below.

14. **How often does it happen?** How many times have you seen this in the past year?

- ☐ Once or twice
- ☐ Three or four times
- ☐ Five or more times
- ☐ I don't remember

15. If there are more areas where you have seen flooding or large puddles, please describe below.

____

____

____

____

16. If you would like City staff to contact you about the problems you described, please provide your contact information:

Your Name: ____
Email Address:______________________________________
Phone Number:______________________________________

Demographic information

17. How long have you lived in Sammamish or Issaquah?

- ☐ 0-1 years
- ☐ 2-5 years
- ☐ 6-10 years
- ☐ 11 or more years

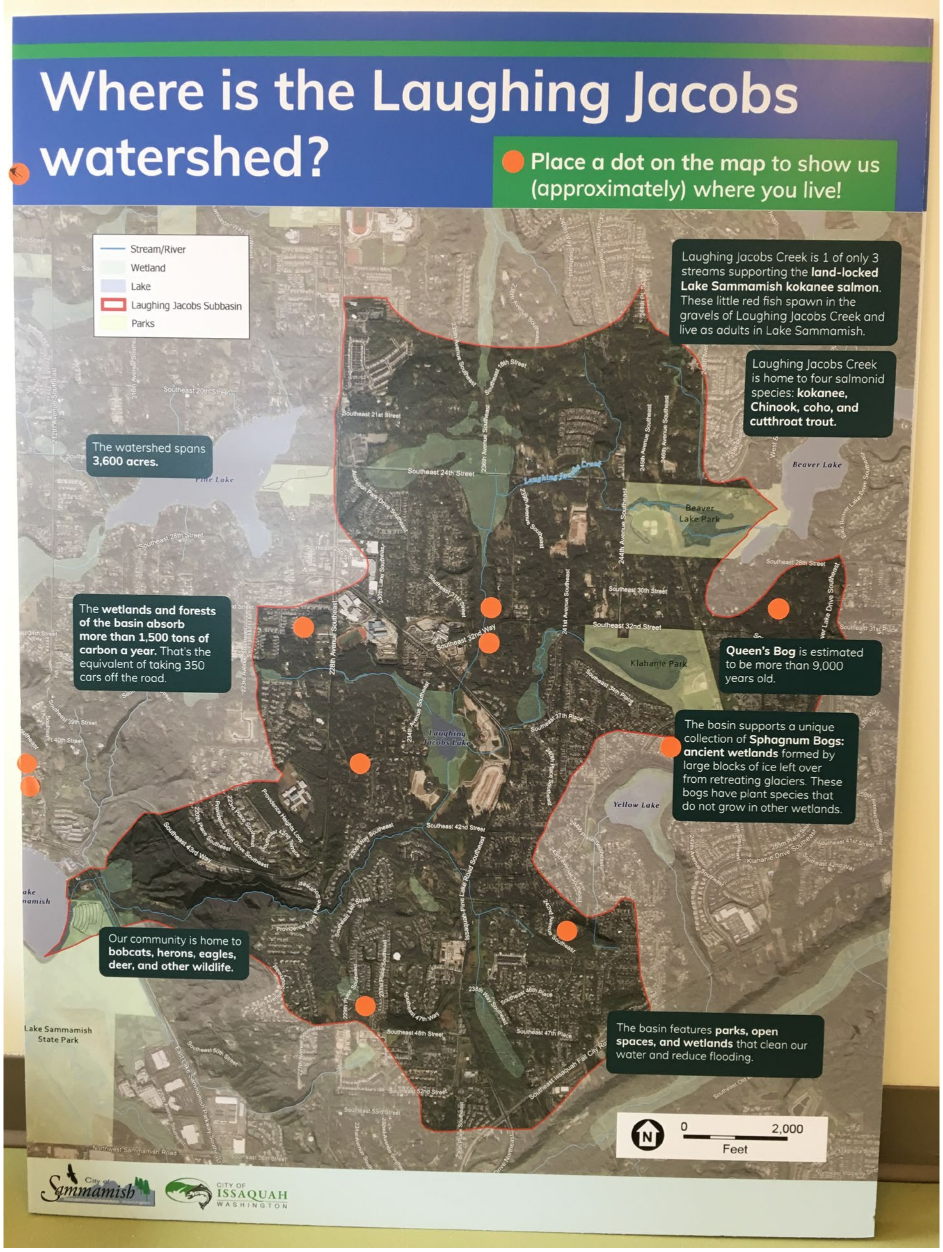
18. Do you own or rent your home in Sammamish or Issaquah?

- ☐ Own
- ☐ Rent

Thank you for providing your input. If you would like to receive email alerts with future project updates, please sign up by visiting: www.sammamish.us/laughingjacobs.

APPENDIX B. OPEN HOUSE DISPLAY BOARD RESULTS

Station 1



Where is the Laughing Jacobs watershed?

● Place a dot on the map to show us (approximately) where you live!

Laughing Jacobs Creek is 1 of only 3 streams supporting the **land-locked Lake Sammamish kokanee salmon**. These little red fish spawn in the gravels of Laughing Jacobs Creek and live as adults in Lake Sammamish.

Laughing Jacobs Creek is home to four salmonid species: **kokanee, Chinook, coho, and cutthroat trout.**

The watershed spans **3,600 acres.**

The wetlands and forests of the basin absorb more than 1,500 tons of carbon a year. That's the equivalent of taking 350 cars off the road.

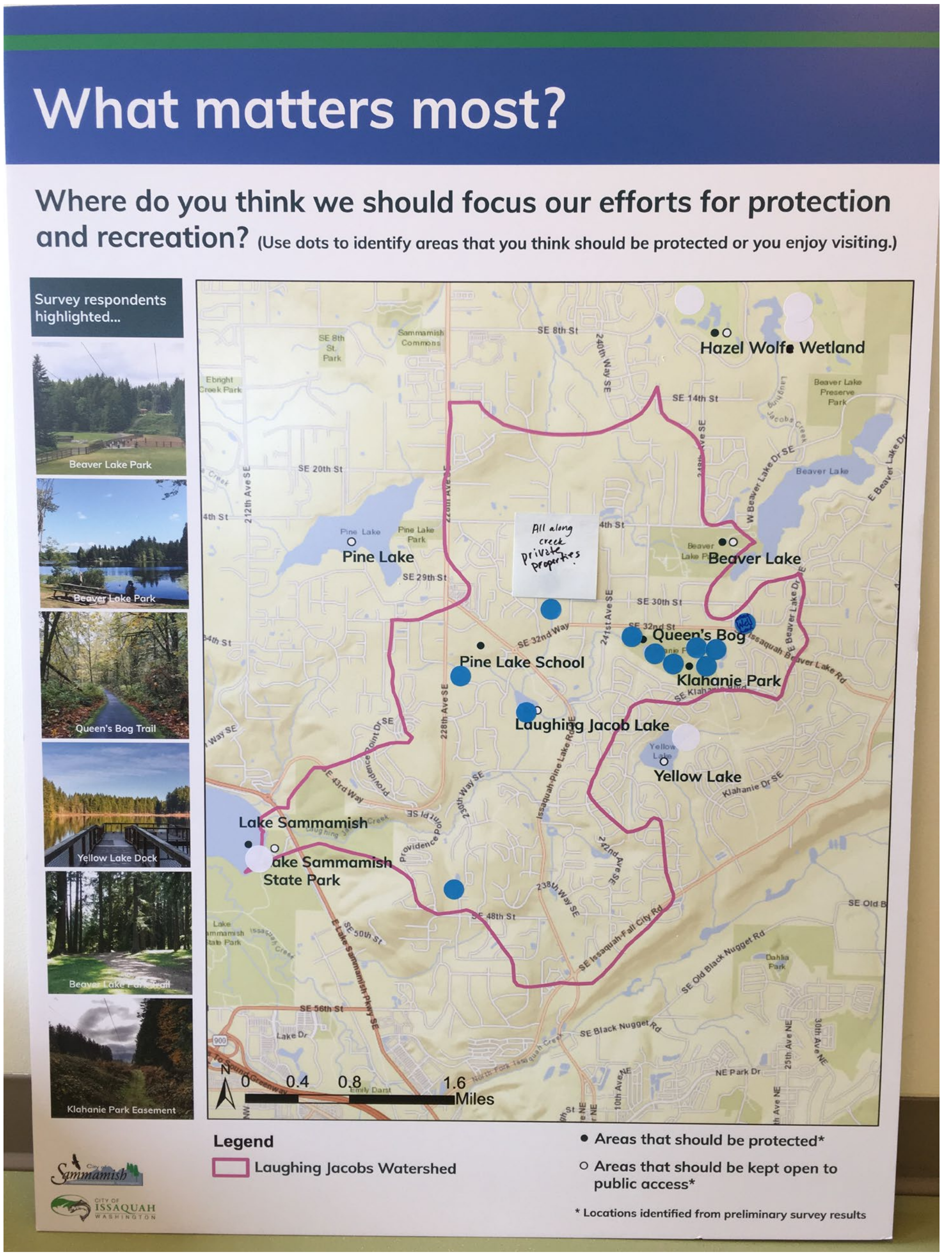
Queen's Bog is estimated to be more than 9,000 years old.

The basin supports a unique collection of **Sphagnum Bogs: ancient wetlands** formed by large blocks of ice left over from retreating glaciers. These bogs have plant species that do not grow in other wetlands.

Our community is home to **bobcats, herons, eagles, deer, and other wildlife.**

The basin features **parks, open spaces, and wetlands** that clean our water and reduce flooding.

Station 2



What matters most?

Where do you think we should focus our efforts for protection and recreation? (Use dots to identify areas that you think should be protected or you enjoy visiting.)

Survey respondents highlighted...

Beaver Lake Park

Beaver Lake Park

Queen's Bog Trail

Yellow Lake Dock

Beaver Lake Park Trail

Klahanie Park Easement

All along creek private properties

Legend

▭ Laughing Jacobs Watershed

● Areas that should be protected*

○ Areas that should be kept open to public access*

* Locations identified from preliminary survey results

Station 2 (continued)

We value our watershed...

Survey respondents identified a number of ways in which they **frequently enjoy** our watershed. **How do you most frequently use the natural areas in your community?** Place a dot in each relevant block.

Go walking on sidewalks

Go hiking on trails in the park

Visit a park

Go bicycling

Go places to take pictures

Go birdwatching

Go fishing

Write your own!

Survey responses

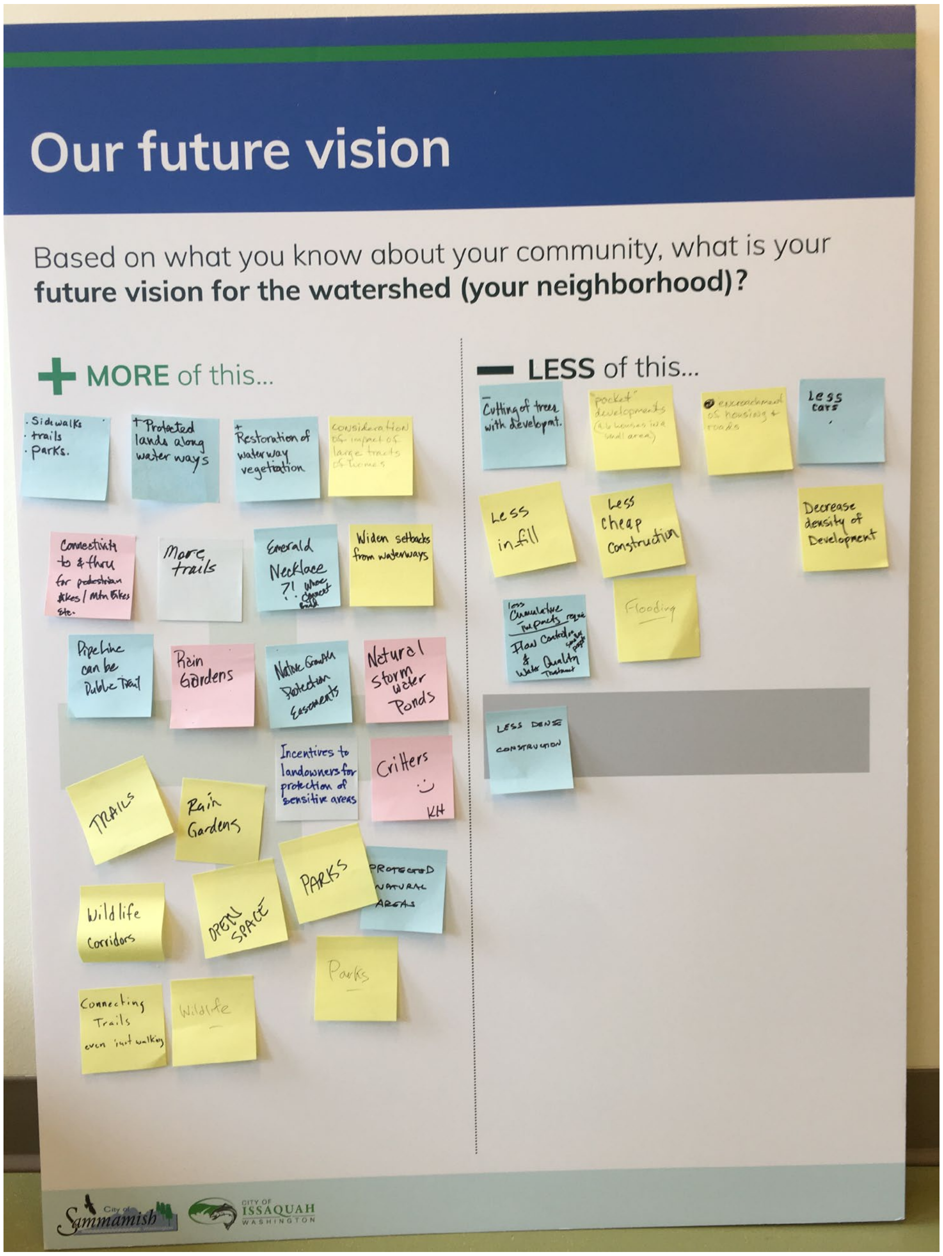
🟩 Frequently
🟦 Sometimes
⬛ Infrequently
⬜ Never

City of Sammamish

City of Issaquah Washington

Station 3 – Flooding locations consolidated and displayed in Appendix C.

Station 4



Our future vision

Based on what you know about your community, what is your **future vision for the watershed (your neighborhood)?**

+ MORE of this...

- Sidewalks
- trails
- parks.

+ Protected lands along water ways

+ Restoration of waterway vegetation

consideration of impact of large tracts of homes

Connectivity to & thru for pedestrian bikes / mtn bikes etc.

More trails

Emerald Necklace ?! where connect [illegible]

Widen setbacks from waterways

Pipeline can be Public Trail

Rain Gardens

Native Growth Protection Easements

Natural storm water Ponds

Incentives to landowners for protection of sensitive areas

Critters :) KH

TRAILS

Rain Gardens

PARKS

PROTECTED NATURAL AREAS

Wildlife corridors

OPEN SPACE

Parks

Connecting Trails even just walking

Wildlife

— LESS of this...

– Cutting of trees with developmt.

"pocket" developments (lots of houses in a small area)

encroachment of housing + roads

Less cars

Less infill

Less cheap construction

Decrease density of Development

less Cumulative Impacts [illegible] Flow Control & Water Quality Treatment

Flooding

LESS DENSE CONSTRUCTION

Station 5

How would you invest?

If we gave you $100 to spend on natural areas, flooding improvements, and stream restoration, **how would you spend it?**

One dot = $20. Use your dots to let us know how you would prioritize investments in your local watershed.

Continue managing existing protected natural areas

Protect new natural areas

Increasingly difficult to obtain land. Damage difficult to undo. Time is of the essence

Restore streams and streambanks

Install natural drainage systems

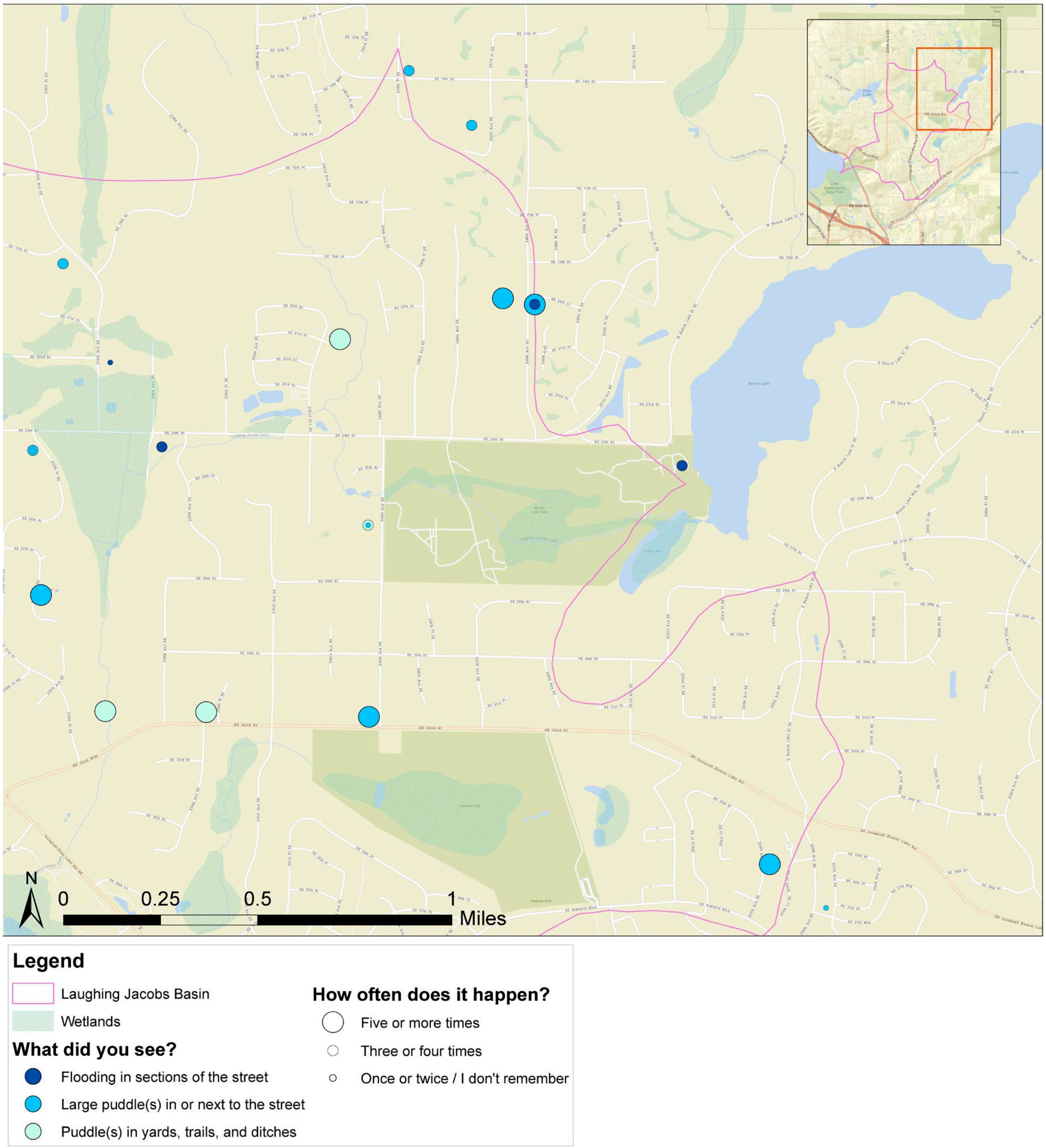
Install infrastructure to improve water quality of roadside runoff

Reduce flooding and improve drainage on roadways

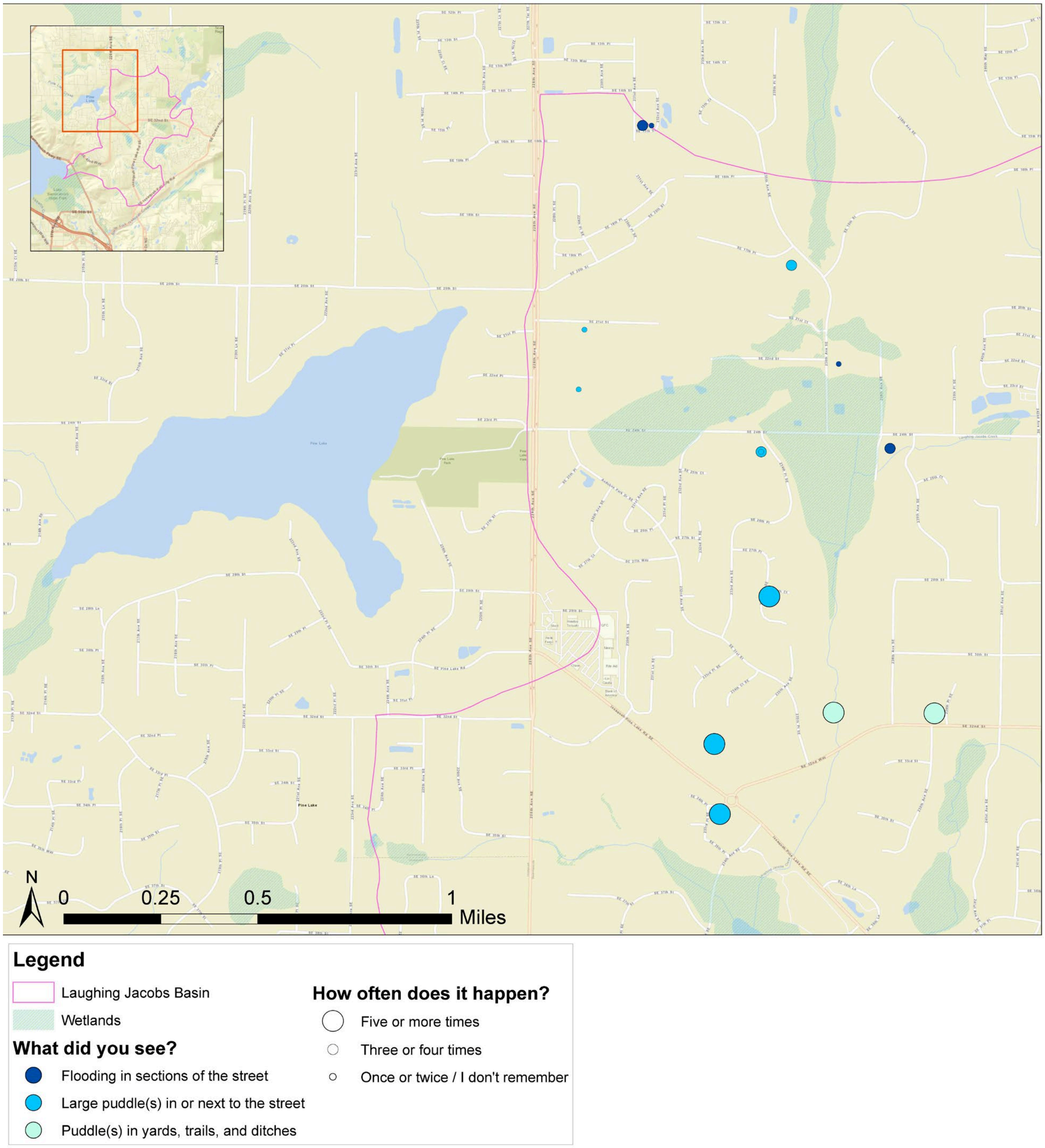
Benefits all Sammamish residents

APPENDIX C. BASIN QUADRANT MAPS OF DRAINAGE PROBLEMS

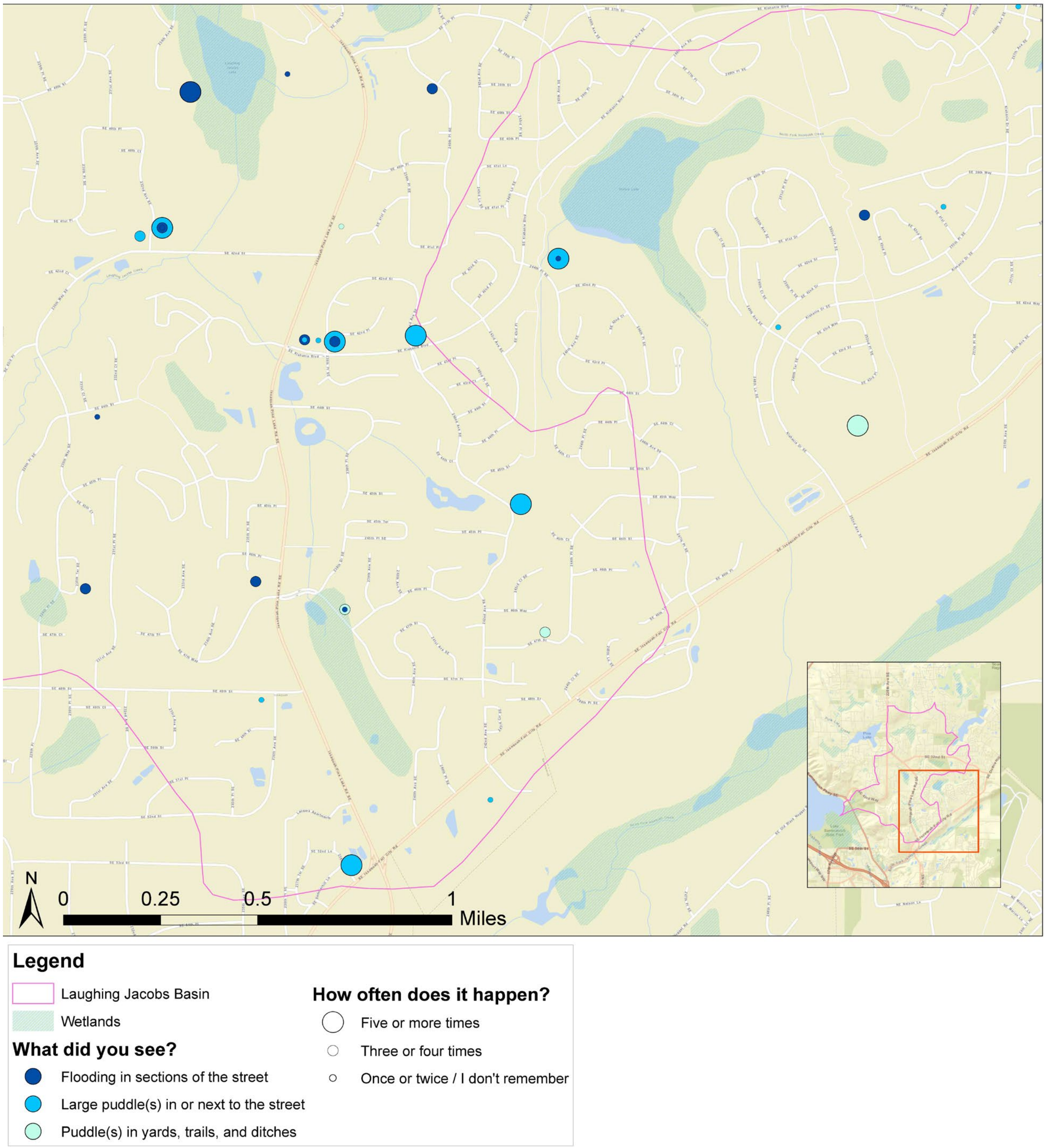
Northeast Basin



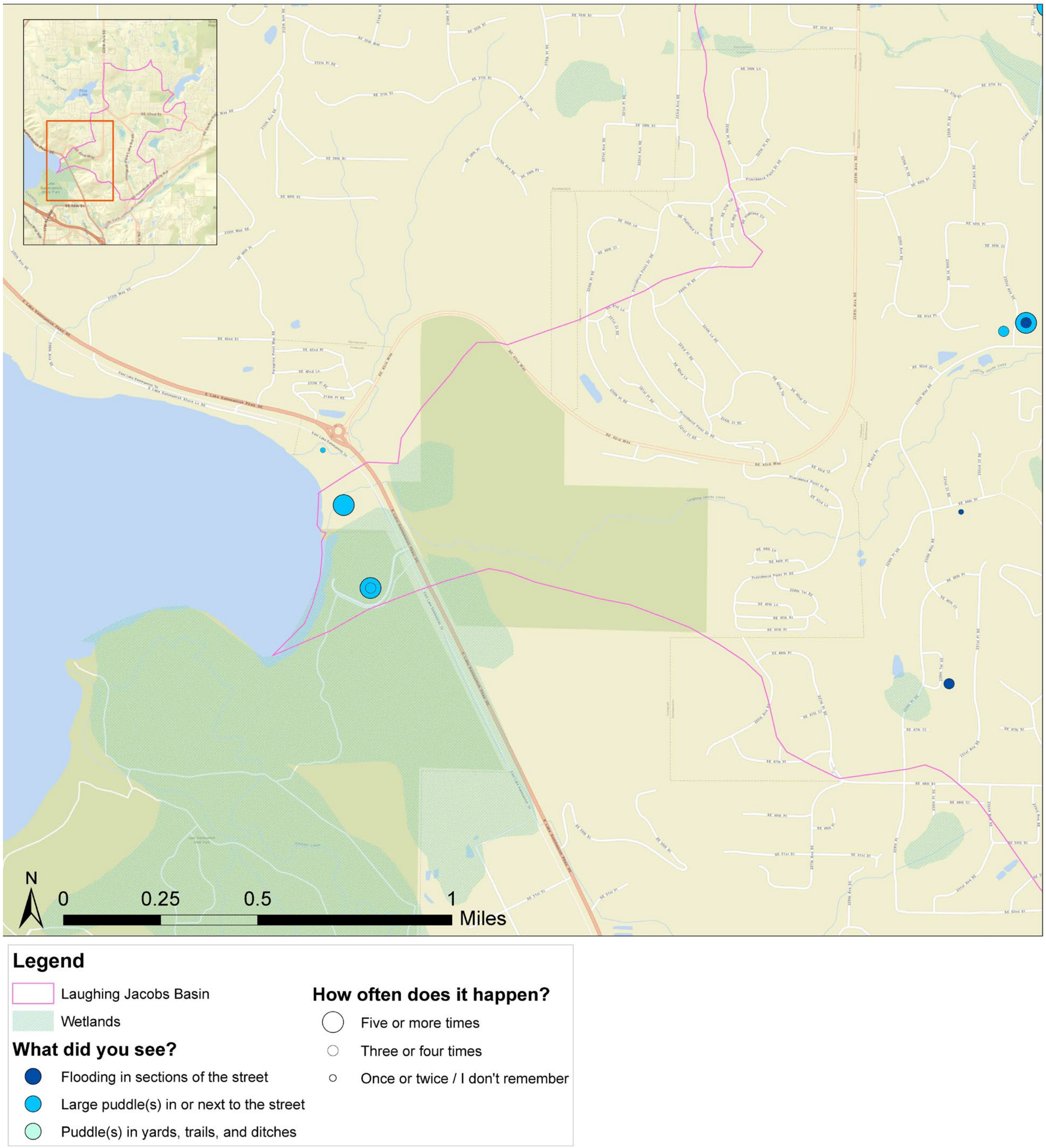
Northwest Basin



Southeast Basin



Southwest Basin



APPENDIX D. RESIDENTS REQUESTING FOLLOW-UP CONTACT

The following table lists the individuals and contact information for survey respondents and open house attendees who requested follow-up contact regarding drainage issues they identified.

Name	Email	Phone	Drainage Issue*
Survey respondents			
Gary Brenner	joannengary@comcast.net	425-417-4749	Large puddle(s) in/next to street during rainy/winter season, 3-4 times in past year, Location: Approx. 32nd and Issaquah-Pine Lake Road where school and new high-density development is located.
Hao Liu	harryliuziqi@gmail.com	Not provided	1) Large puddle(s) in or next to the street during fall, 5+ times in past year Location: SE Klahanie Blvd/239th PL SE 2) Large puddle(s) in or next to the street during fall, 5+ times in past year Location: Issaquah-Pine Lake Road SE/SE Issaquah-Fall City Road
Steve Cristallo	stevecristallo@gmail.com	206-972-3810	Large puddle(s) in or next to the street during heavy rains, 5+ times in past year Location: SE 42nd St. between Issaquah Pine Lake Road and 232nd Ave SE
Melanie Jacobs	melanie@conjury.com	Not provided	1) Flooding in sections of the street during rainy season, 3-4 times in past year (although better this year) Location: Walkway around Klahanie/along Fall City Road 2) Other: Across walking path, 3-4 times in past year Location: Across from Fall City turn-off
Barry Bersch	bjb0425@comcast.net	Not provided	Other: Beaver dam blocked, garbage blocked in 2018, 3-4 times in past year Location: Brookshire pond Other: My driveway! Inches to 1.5 submerged, usually November and December Location: Not provided
Open House Attendees			
Roger Smith	rogerhartsmith@outlook.com	425-557-7795	Easement to west of 230th Pl. SE needs clearing Location: 4017 230th Pl. SE
Kent Treen	Kent.treen@mail.com	425-516-1425	Location: 1825 ELSP SE**
Karen Herra**	Slopewatcher@hotmail.com	425-837-9024	23684 SE 32nd W**

*More details regarding drainage issues were captured in the survey than at the open house.

**Information may be inaccurate due to difficulty reading handwriting of open house attendees.

APPENDIX E. ADDITIONAL ENGAGEMENT MATERIALS

Public Survey Postcard

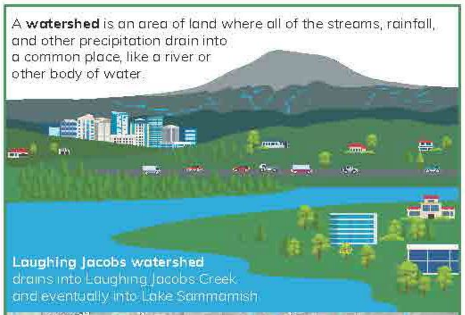
City of Sammamish
801 228th Ave SE
Sammamish, WA 98075

PRSRT STD
ECRWSS
U.S. POSTAGE
PAID
EDDM RETAIL

Planning for our future begins today!

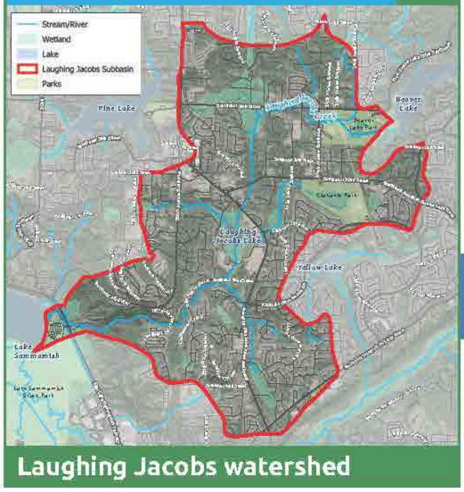
Please take our short survey...

Current Resident



A **watershed** is an area of land where all of the streams, rainfall, and other precipitation drain into a common place, like a river or other body of water

Laughing Jacobs watershed drains into Laughing Jacobs Creek and eventually into Lake Sammamish



Laughing Jacobs watershed

Planning for our future begins today!

Hello, Neighbor!

Did you know that you live near the Laughing Jacobs watershed? The Laughing Jacobs watershed has parks, open spaces, and important wetlands that help reduce flooding and clean our water.

The City of Sammamish is identifying priority projects that help reduce flooding and preserve natural areas in your neighborhood, and we need your help! Puget Sound is one of the fastest growing regions in the nation, and we want to make sure that the priority projects we select reflect community values.

We want to understand what you care about and pinpoint locations with standing water or flooding issues. Please tell us what you want for your community's future.

Take the short online survey by May 17th:

www.surveymonkey.com/r/LaughingJacobs

Your thoughts are very valuable to us.
Thank you for participating in this important survey!

For more information, please contact:
Danika Globokar at (425) 295-0516 or dglobokar@sammamish.us
Sign up to receive email alerts with future project updates by visiting:

www.sammamish.us/laughingjacobs

Open House Postcard

Planning for our future together…

Hello, Neighbor!

The City of Sammamish is identifying **priority projects that help reduce flooding and preserve natural areas in your neighborhood**, and we need your help. We would like to share what we've heard so far and get your feedback.

Join us at the **community open house** to:

- **Let us know your priorities and ideas for your neighborhood.**
- **Learn more about the future of your local watershed.**
- **Hear what we've learned from your neighbors about local needs and values.**
- **Chat one-on-one with the project team.**

Join us!

June 13th, 2019
5:30 PM to 7:30 PM

Beaver Lake Middle School, Commons/Lunchroom
25025 SE 32nd Street
Issaquah, WA 98029

On-site parking is available.

We're excited to see you there!

Can't come but still want your voice to be heard?
Please take the **community survey** online at:
www.surveymonkey.com/LaughingJacobs

For more information, please contact:
Danika Globokar at (425) 295-0516
or dglobokar@sammamish.us

www.sammamish.us/laughingjacobs

Website Update

Join us for a community open house to plan for the future of your neighborhood!

Visit www.sammamish.us/laughingjacobs to learn more.

JUNE 13th
5:30 to 7:30 PM

Beaver Lake Middle School
25025 SE 32nd Street
Issaquah, WA 98029
On-site parking available

Open House Press Release

The City of Sammamish is identifying priority projects that help reduce flooding and preserve natural areas in the Laughing Jacobs watershed, which spans southern Sammamish and northern Issaquah. The watershed is a valuable feature in the community and environment, with parks, open spaces, and important wetlands that naturally help clean water and reduce flooding. Sammamish and Issaquah are some of the fastest-growing cities in the region, and more housing, buildings, and roads can threaten the watershed's health. A smart plan for the Laughing Jacobs watershed is essential to make sure our communities grow in a way that works with the environment to reduce flooding and protect natural areas.

Resident feedback is important to make sure the priority projects in the plan reflect what residents care about most. Throughout May, the City will continue gathering initial input through a public survey. Next month, residents will have the opportunity to share their priorities for the Laughing Jacobs Basin plan at a community open house. At the open house, residents can share priorities and ideas for their neighborhood, learn more about the future of their local watershed, hear what has been learned about local needs and values from the survey, and chat one-on-one with the project team.

The open house will be held on Thursday, June 13, from 5:30 to 7:30 pm at Beaver Lake Middle School located at 25025 SE 32nd Street in Issaquah. There will be stations set up where residents can learn about the basin plan and share input. Parking is available on-site.

More information about the basin plan can be found at the project website: https://www.sammamish.us/laughingjacobs.

Open House Factsheet

Planning for our future starts today

The Laughing Jacobs watershed spans about 3,600 acres across the communities of southern Sammamish and northern Issaquah.

The watershed has parks, open spaces, and important wetlands that clean our water and help reduce flooding. It is also home to bobcats, herons, eagles, deer, and other wildlife.

Why is it important to plan for the future of the Laughing Jacobs watershed?

Sammamish and Issaquah are two of the fastest-growing cities in the region. With this growth comes more buildings and roads, which can threaten the watershed's health.

Healthy watersheds reduce flooding and provide clean water. They also provide access to natural areas, which can reduce stress among those who live and work nearby.

✓ A **smart plan** is essential to ensure our communities grow in a way that works with the environment to reduce flooding and protect natural areas.

We need your help to plan for the future!

You know the Laughing Jacobs watershed best—it's where you live, work, and play. The priority projects in the plan will shape your neighborhoods for decades to come, so we want to make sure that the ones the city selects reflect community values and address locations with standing water or flooding issues.

We will be soliciting input from the Laughing Jacobs community throughout the project timeline below

PROJECT TIMELINE

To learn more about the project, please visit:
www.sammamish.us/laughingjacobs

Community Open House

June 13th, 2019
Beaver Lake Middle School

AGENDA

5:30 PM Open House Begins

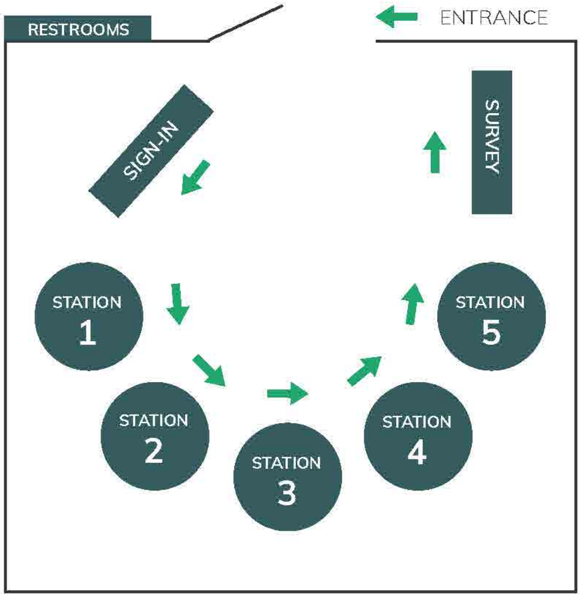
5:45 PM Welcome and Opening Statement

6:00 PM Visit Stations

7:30 PM Open House Adjourns

Visit each of the five stations to learn more about the Laughing Jacobs watershed and participate in the community dialogue that is shaping its future.

TODAY'S OPEN HOUSE LAYOUT



Station 1: What is happening in the Laughing Jacobs watershed?
Learn what a watershed is, what makes the Laughing Jacobs watershed special, and what the basin planning process is all about.

Station 2: What do you care about in your neighborhood?
Review initial community preferences for outdoor recreation and natural area preservation. Share what you like to do for fun outdoors and places that are important to you in the watershed.

Station 3: Where are the water hotspots in the watershed?
Identify and review locations where flooding and standing water issues occur in your neighborhood

Station 4: What is your vision for the future?
Contribute ideas for what you would like to see more or less of in the watershed (your neighborhood) in the future.

Station 5: How should we spend our money?
Review initial community feedback about what to focus on for planning. Share how you would prioritize investments in natural areas, flooding improvements, and stream restoration.

To learn more about the project, please visit:
www.sammamish.us/laughingjacobs

Laughing Jacobs Basin Plan Public Engagement Webinar

10.26.2021

Presented By:

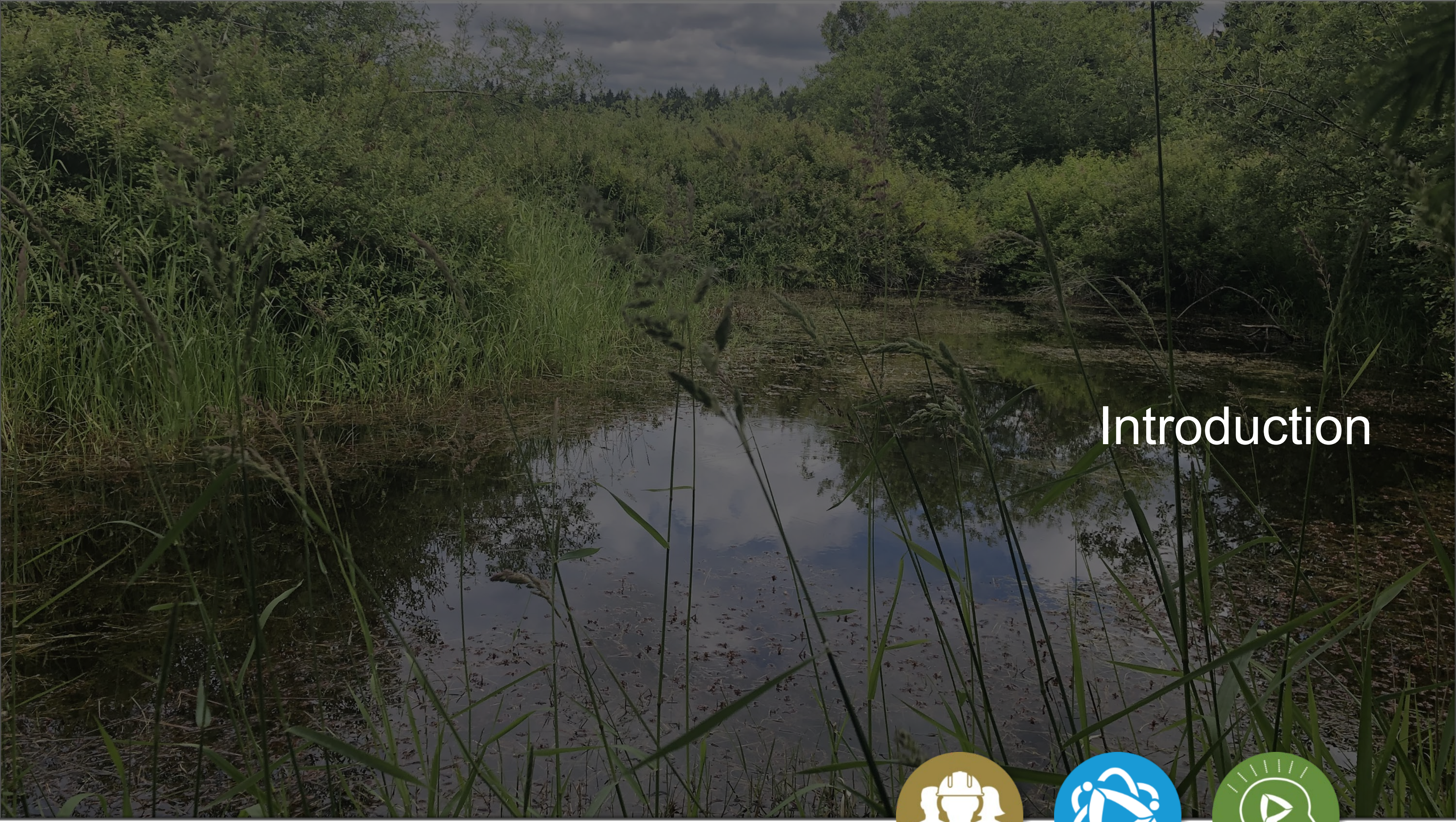
Toby Coenen, City of Sammamish

Christian Nilsen, Geosyntec Consultants

Gretchen Muller, Cascadia Consulting

Geosyntec consultants

City of Sammamish Washington



Introduction

Agenda and Goals for Webinar

- Introduction
- Project Overview
- Prior Public Engagement – What we heard
- Watershed Description – What we learned
- Projects – What we identified
- Next Steps – Where we go from here
- Q&A

Webinar Overview – Plan for Q&A

Designated Q&A during the presentation

Please use the Q&A function in Zoom to submit your questions during the presentation

Tech Support

Brent Edgar - IT support

- Contact him if you have **any issues** with **Zoom**

☎ **Call:** (206) 390-8378

✉ **Email:** brent@cascadiaconsulting.com

Project Team

City of Sammamish

Toby Coenen

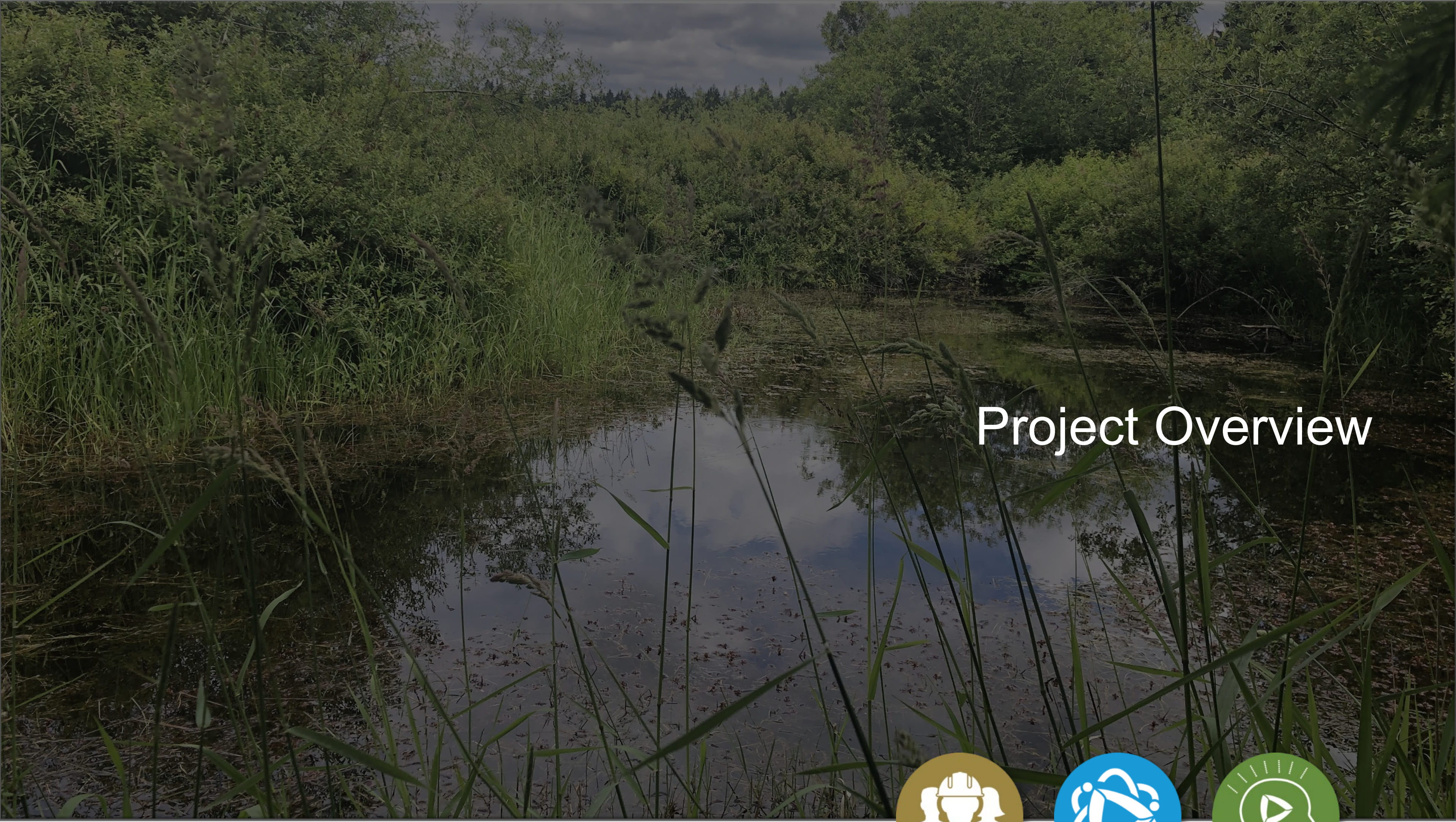
Cascadia Consulting

Gretchen Muller

Geosyntec Consultants

Christian Nilsen

Joel Prock



Project Overview

Project Overview

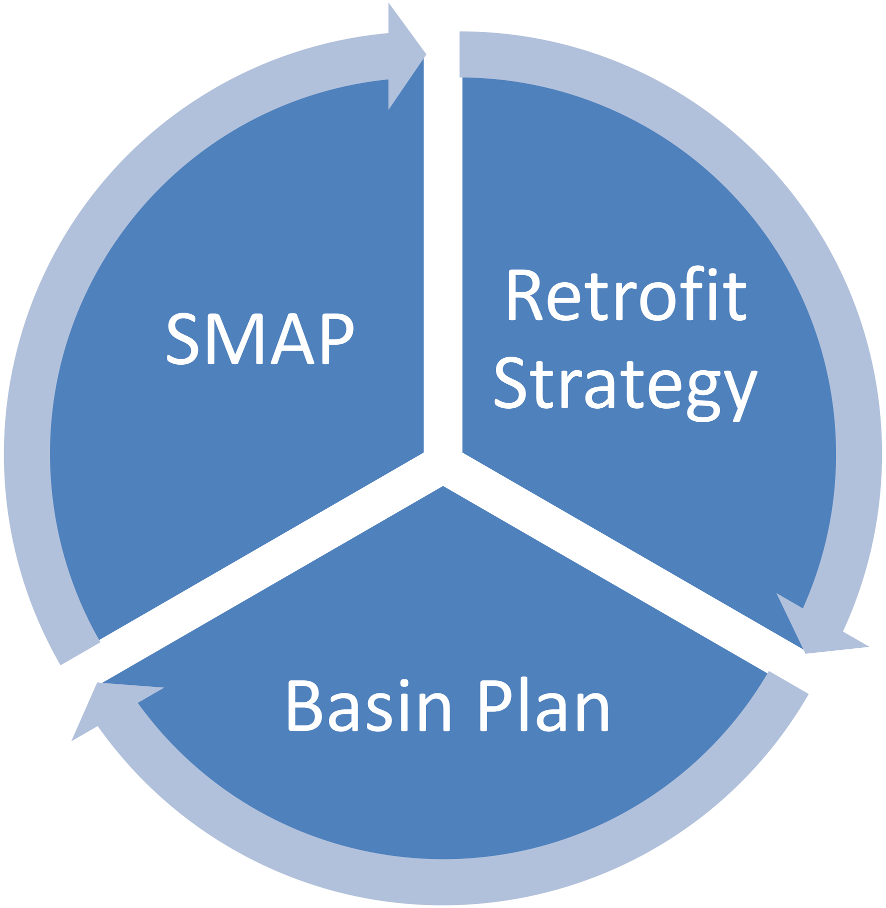
Why Basin Planning?

- *City of Sammamish Storm and Surface Water Management Comprehensive Plan*
  Goal 2 (G.2) - *Use basin planning to allocate limited resources to address priority problems & opportunities.*
- *NPDES Municipal Stormwater Permit*
  Special Condition 5 (S5.C.1) - *Implement a Stormwater Planning program to inform and assist in the development of policies and strategies as water quality management tools to protect receiving waters*

Project Overview

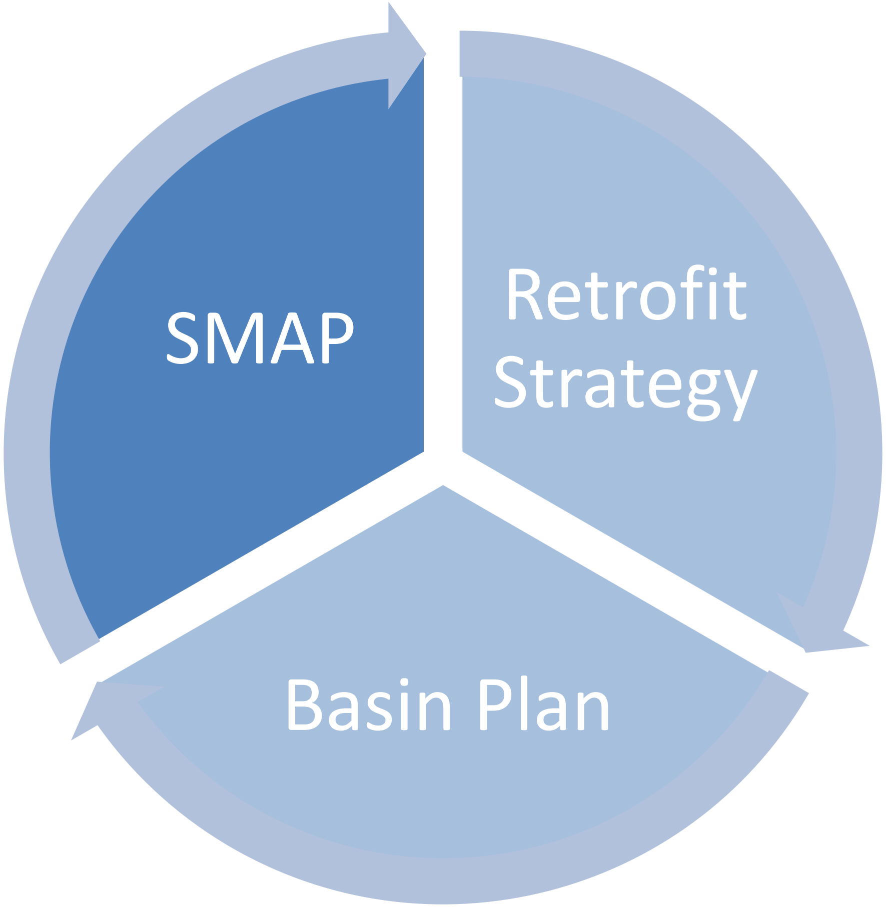
Geosyntec consultants

Relationship to Other Current Stormwater Program Efforts



Project Overview

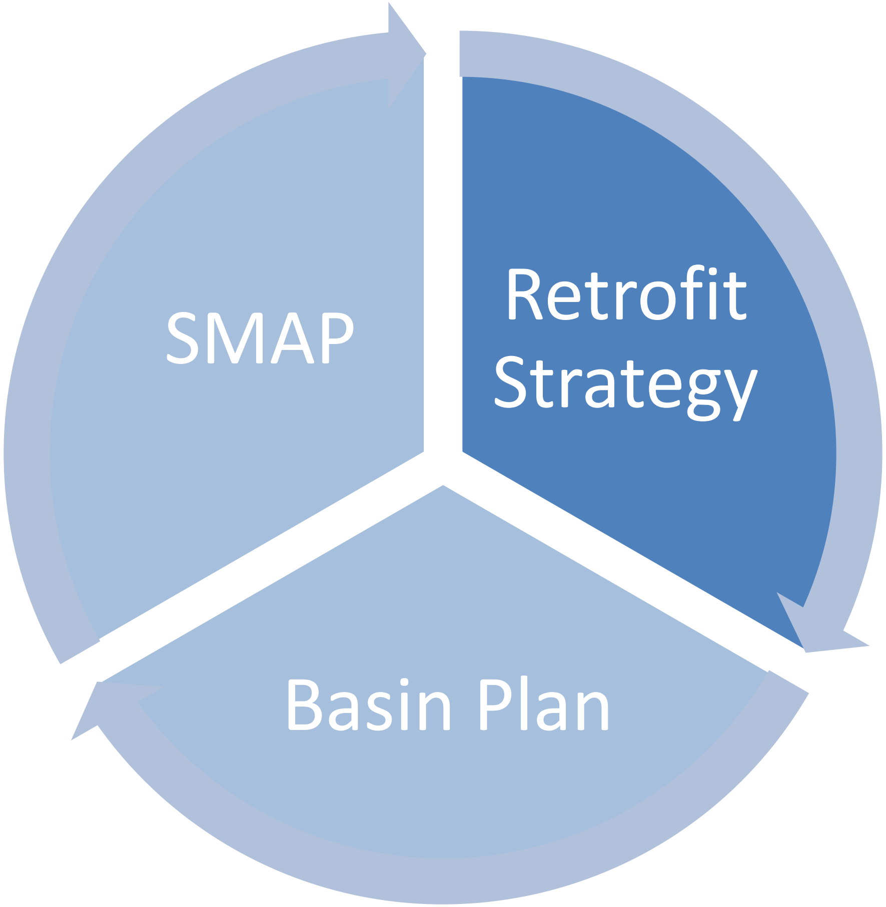
Geosyntec consultants



SMAP

- *Stormwater Management Action Planning*
- NPDES Requirement
- Elements
  - Receiving Water Assessment
  - Basin Prioritization
  - Action Plan

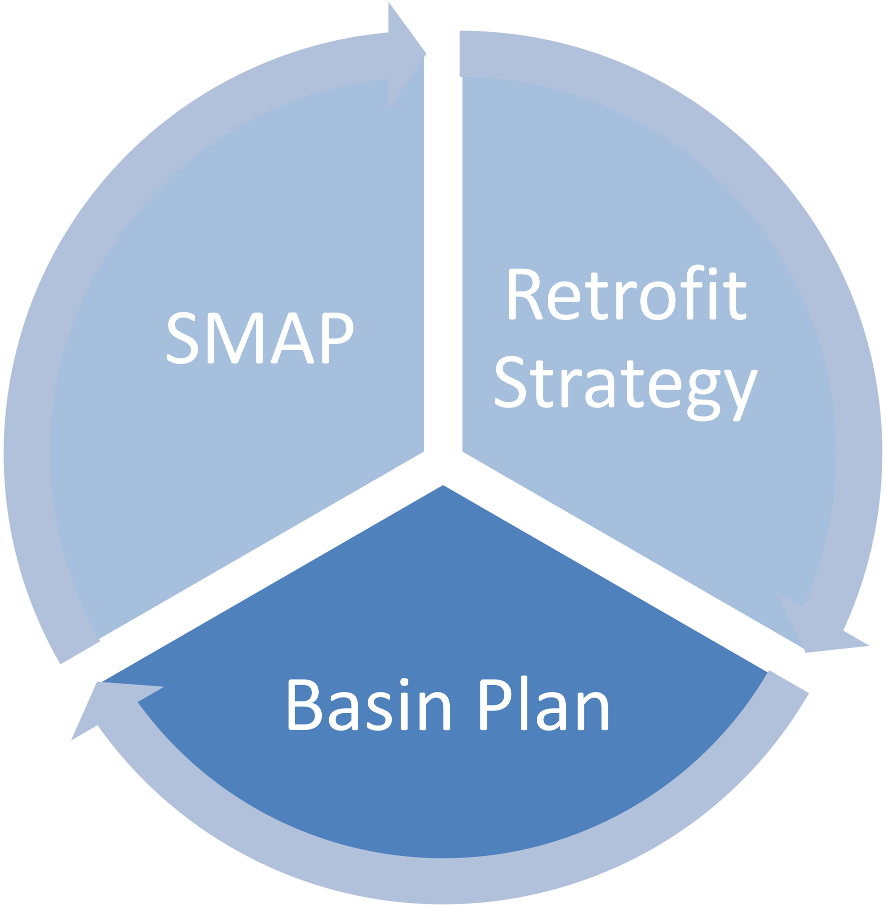
Project Overview



Retrofit Strategy

- *City of Sammamish Retrofit Strategy and Guidance Manual*
- Completed in Anticipation of NPDES Requirements
- Elements
  - Focus on addressing collective impacts from *existing development*.
  - *Process* to identify, evaluate and prioritize sub-watershed retrofit potential

Project Overview



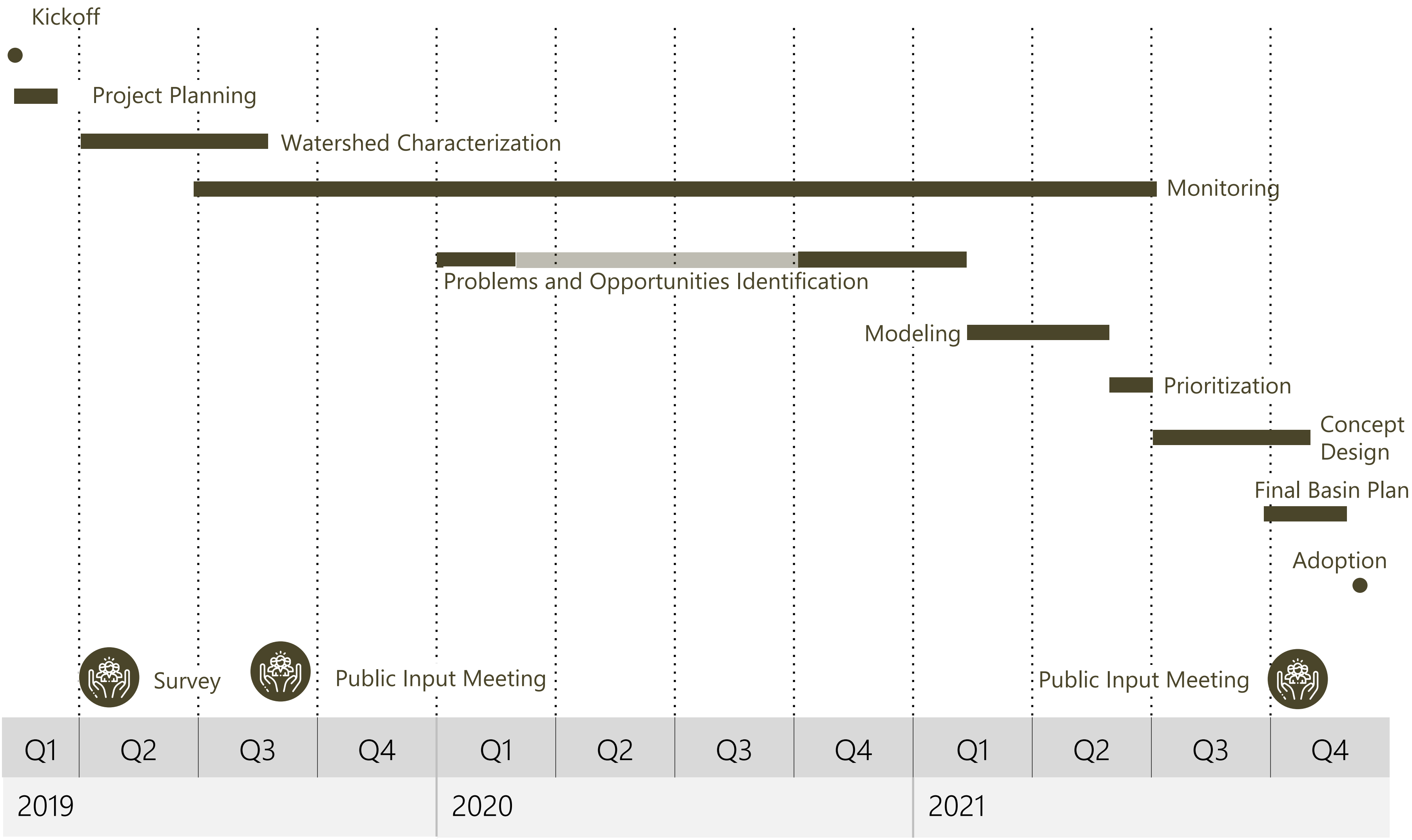
Basin Plan

- Long-term goal of developing a plan for each unique basin within Sammamish

Project Purpose

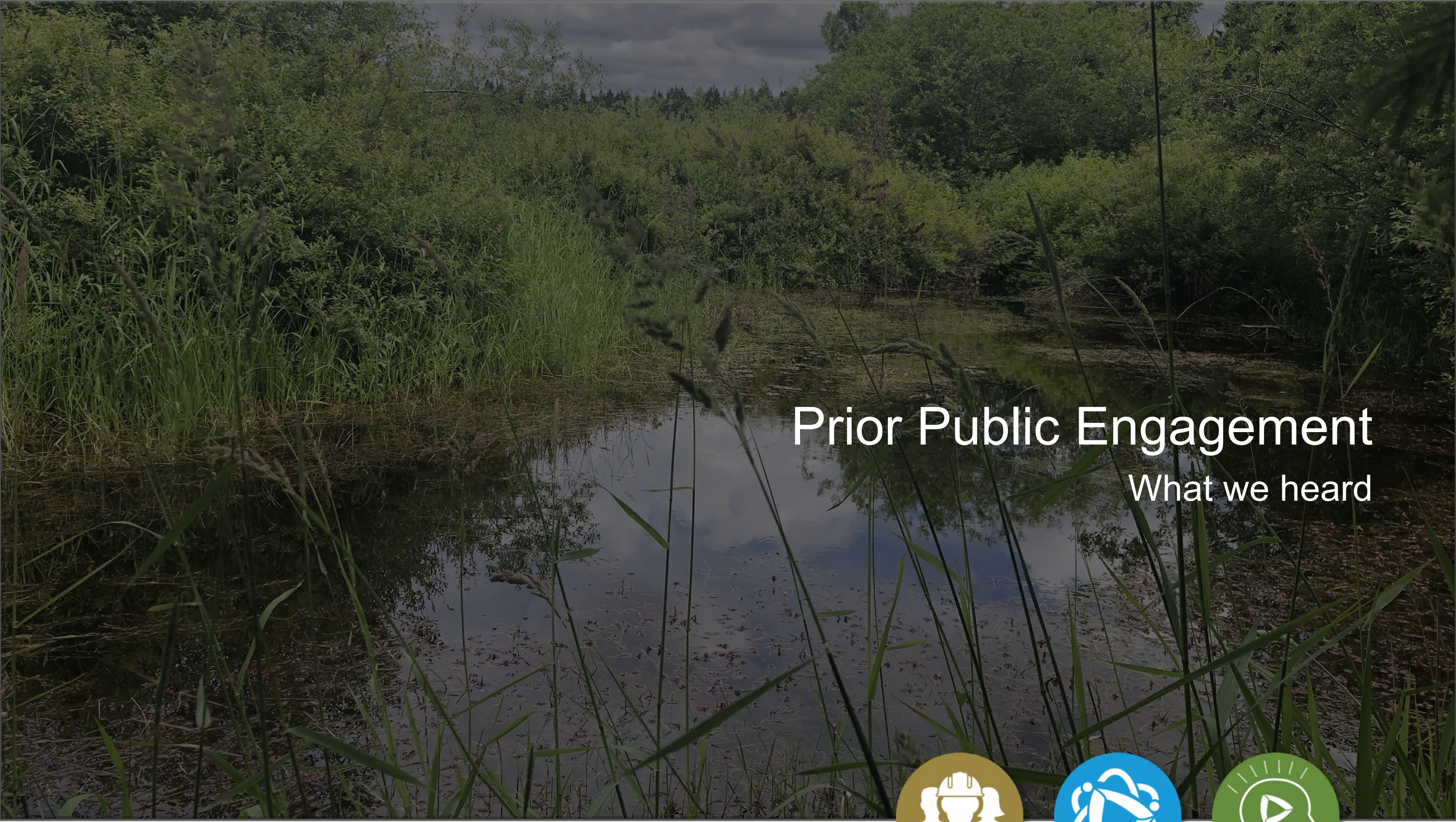
1. Characterize current physical, biological, and water quality conditions.
2. Identify projects and programs that will benefit the basin and residents.

Project Timeline



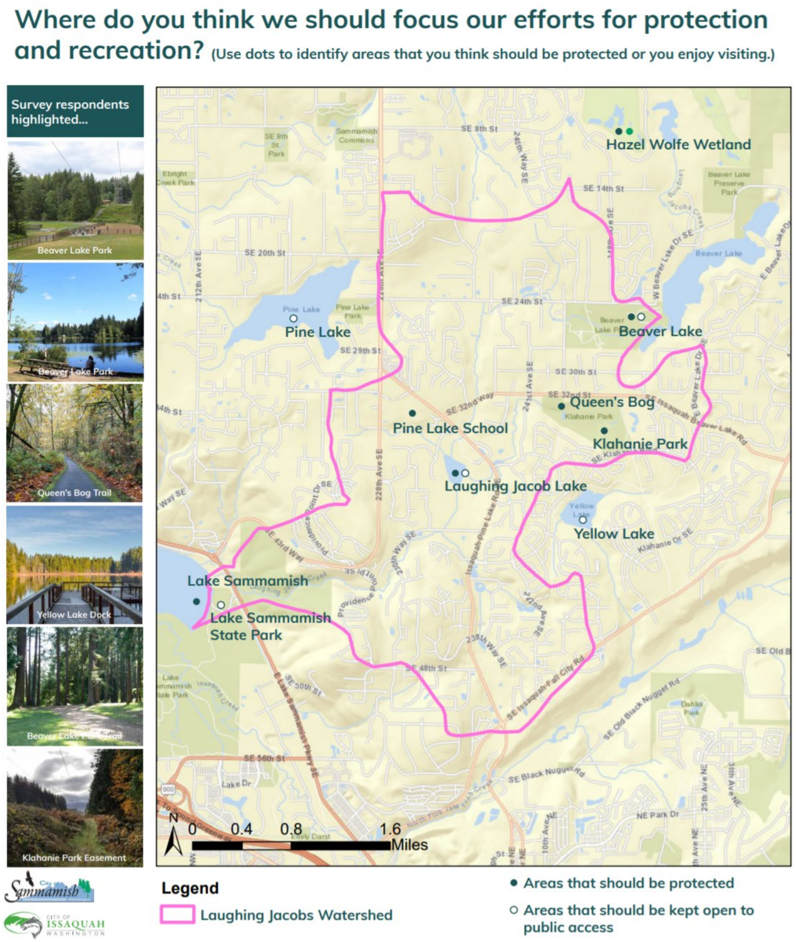
Prior Public Engagement

What we heard



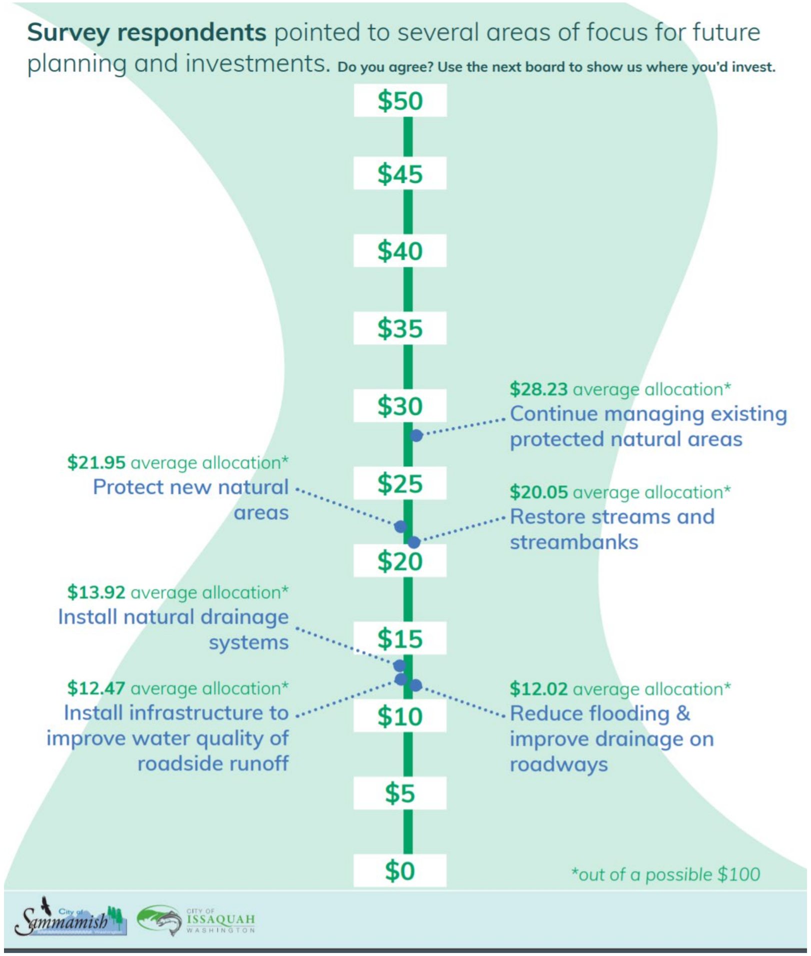
Prior Public Engagement

- Online and Postcard Survey
  - May - July 2019
  - 463 Responses
- In-person Open House
  - July 2019



Where do you think we should focus our efforts for protection and recreation? (Use dots to identify areas that you think should be protected or you enjoy visiting.)

Prior Public Engagement



Survey respondents pointed to several areas of focus for future planning and investments. **Do you agree? Use the next board to show us where you'd invest.**

*out of a possible $100

Residents in the Laughing Jacobs basin generally:

- Encourage striking a balance between environmental preservation and public access.
- Identified wetlands, shorelines, and other water systems as a top priority for protection, restoration, and investment of public funds.

Watershed Characterization

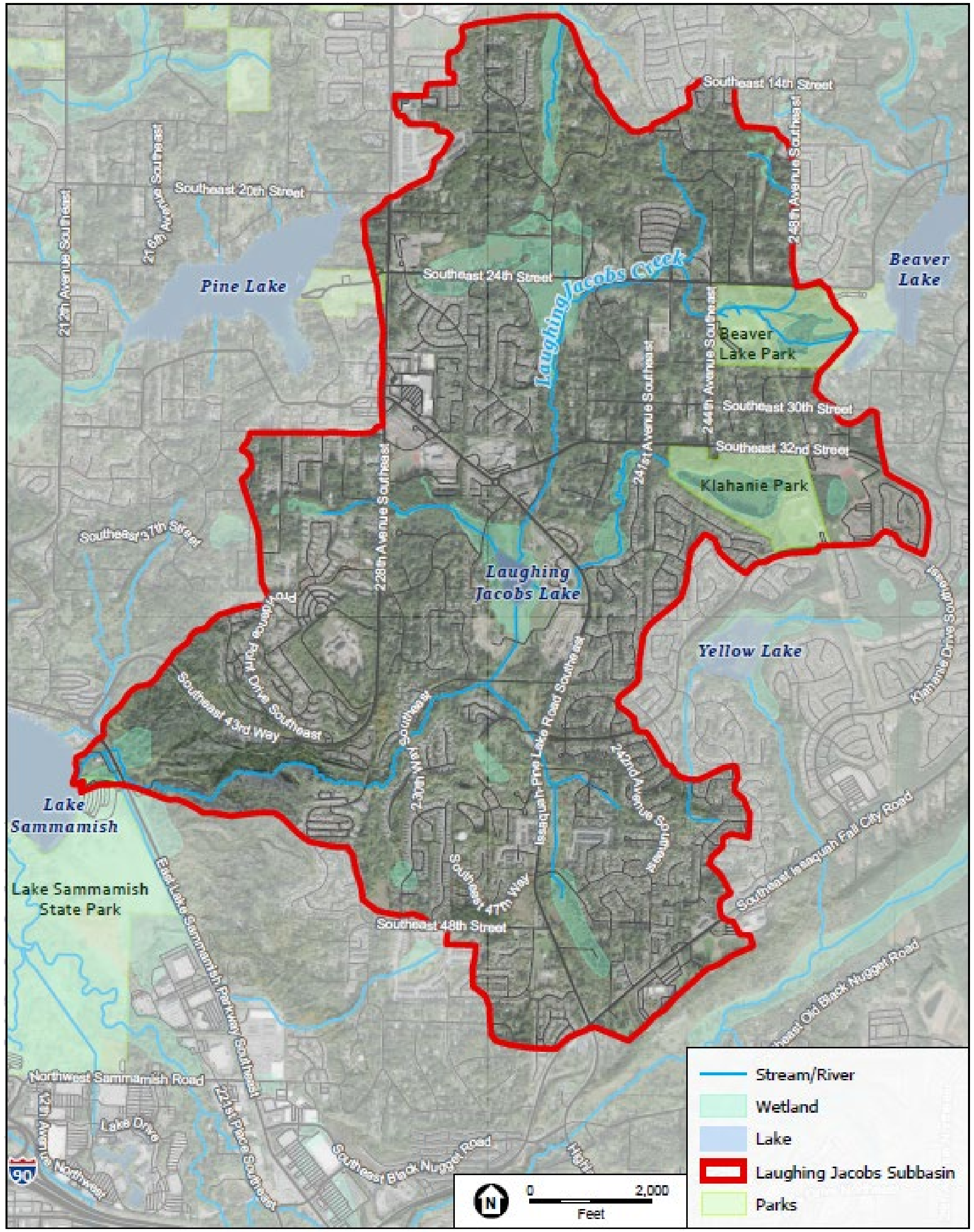
What we learned

Watershed Characterization

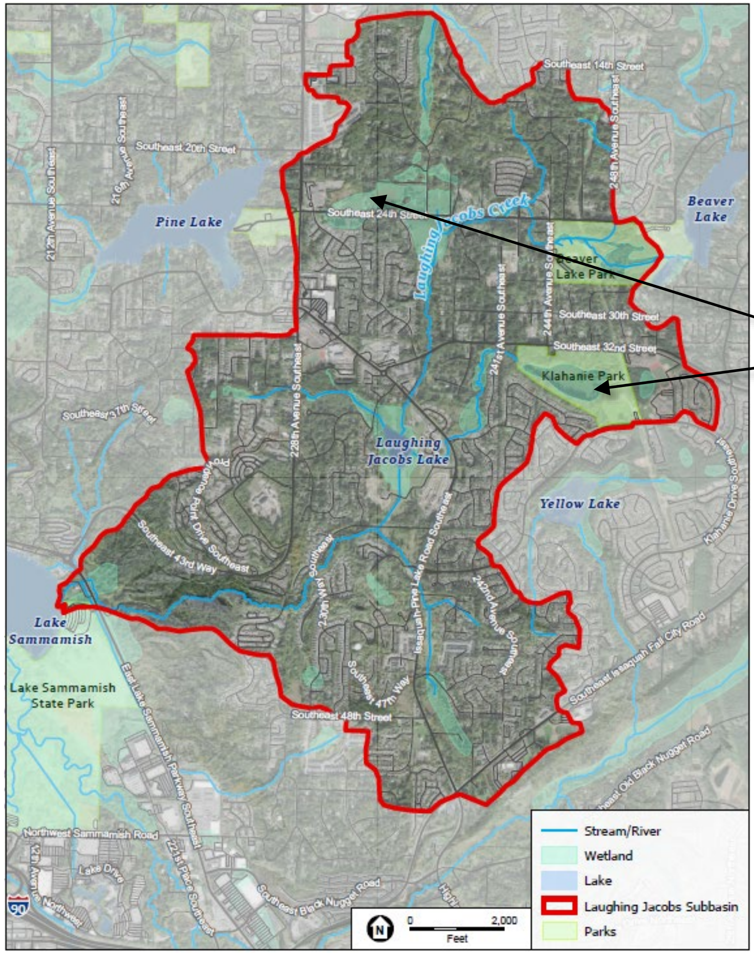
- Water quality and stream habitat is good
- The basin supports some rare natural habitats
- Critical areas such as wetlands and riparian buffers are relatively intact

The Laughing Jacobs Watershed

Geosyntec consultants

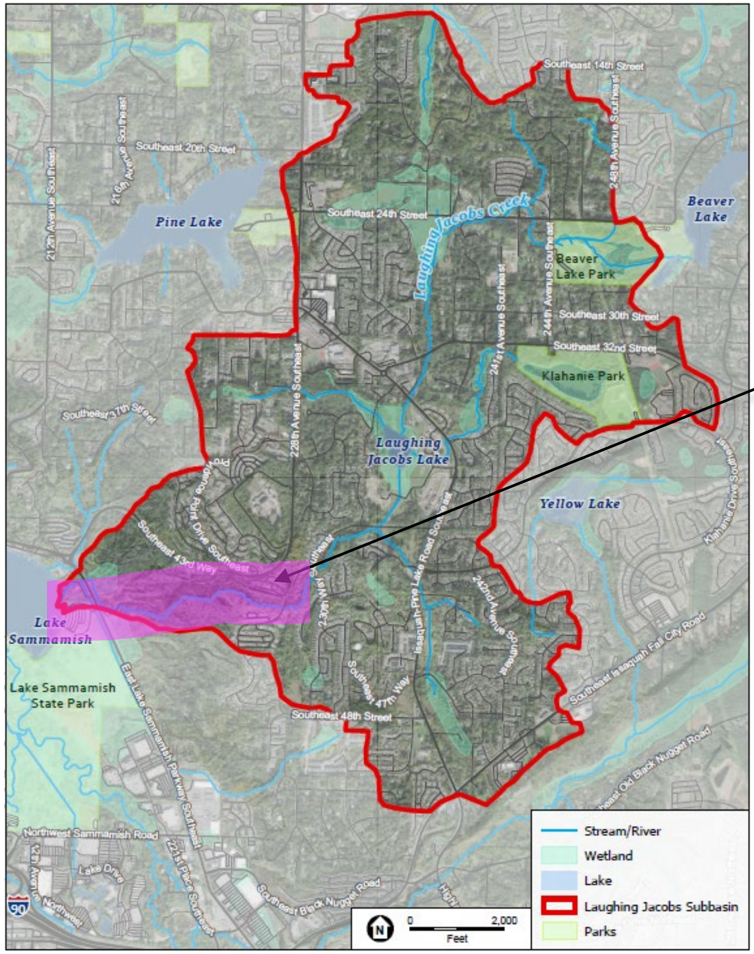


The Laughing Jacobs Watershed

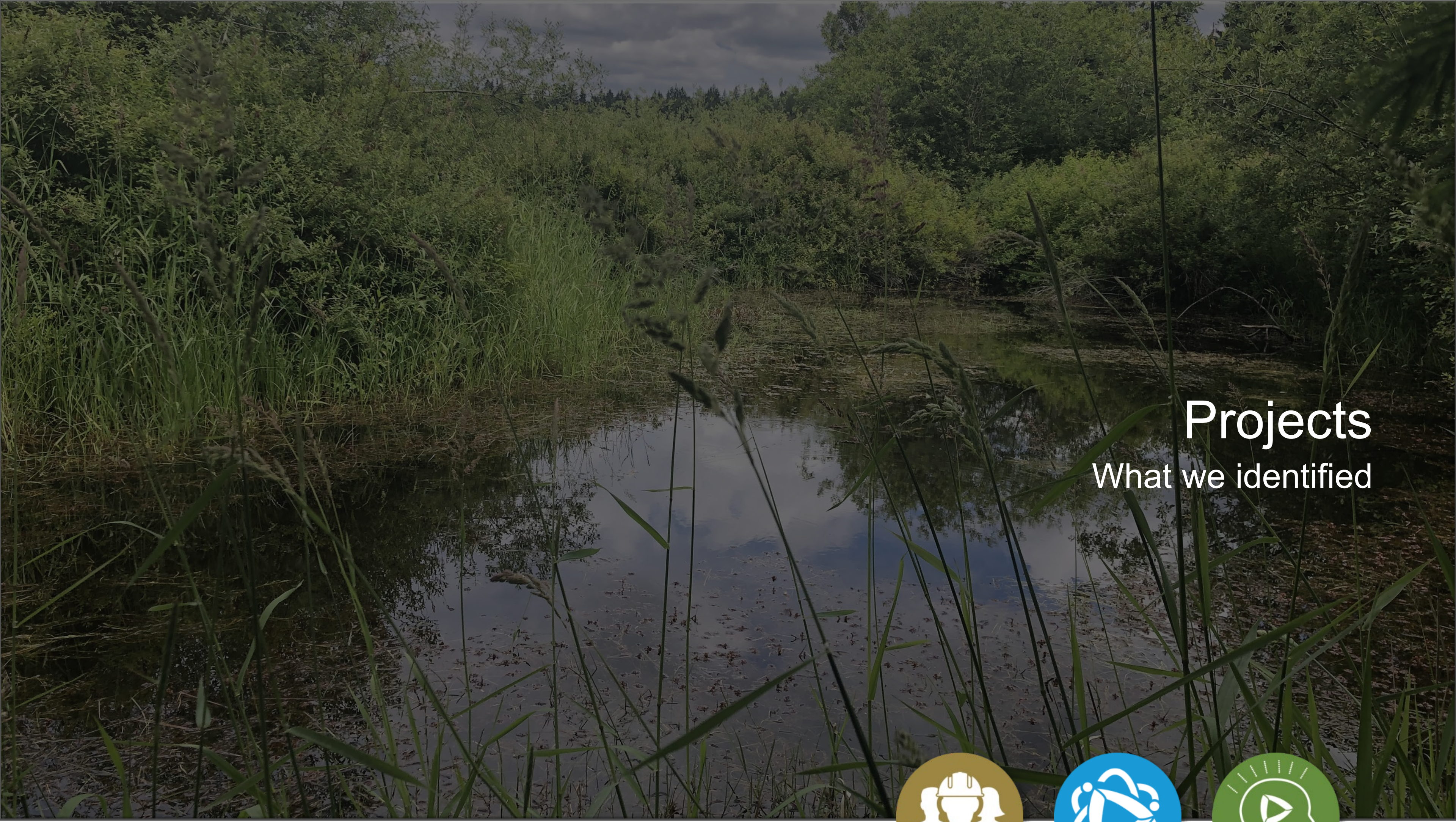


Sphagnum Bogs

The Laughing Jacobs Watershed



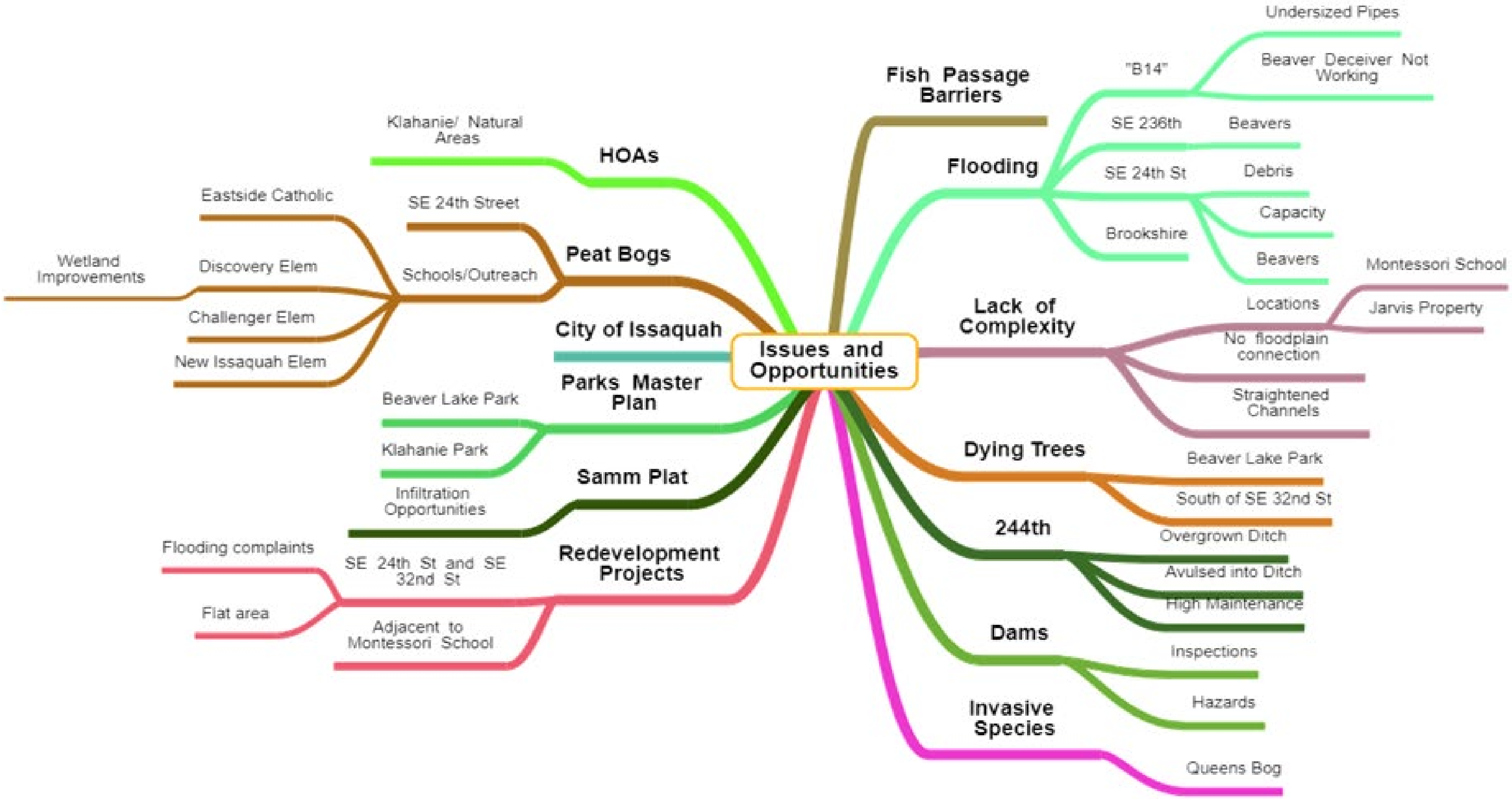
Kokanee Habitat



Projects

What we identified

Identification of Opportunities



Issues and Opportunities

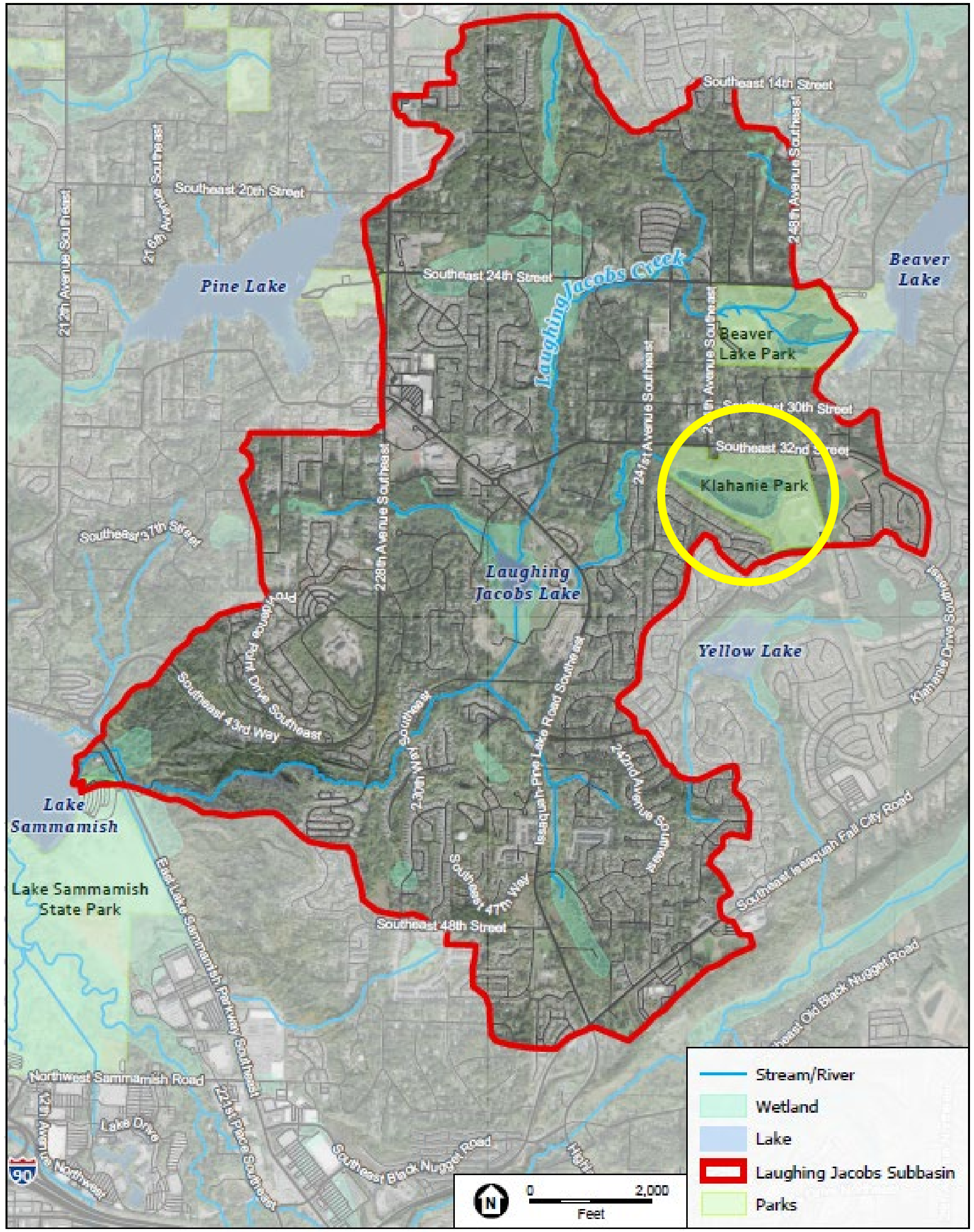
- **HOAs**
  - Klahanie/ Natural Areas
- **Peat Bogs**
  - SE 24th Street
  - Schools/Outreach
    - Eastside Catholic
    - Discovery Elem
      - Wetland Improvements
    - Challenger Elem
    - New Issaquah Elem
- **City of Issaquah**
- **Parks Master Plan**
  - Beaver Lake Park
  - Klahanie Park
- **Samm Plat**
  - Infiltration Opportunities
- **Redevelopment Projects**
  - SE 24th St and SE 32nd St
    - Flooding complaints
    - Flat area
  - Adjacent to Montessori School
- **Fish Passage Barriers**
- **Flooding**
  - "B14"
    - Undersized Pipes
    - Beaver Deceiver Not Working
  - SE 236th
    - Beavers
  - SE 24th St
    - Debris
    - Capacity
    - Beavers
  - Brookshire
- **Lack of Complexity**
  - Locations
    - Montessori School
    - Jarvis Property
  - No floodplain connection
  - Straightened Channels
- **Dying Trees**
  - Beaver Lake Park
  - South of SE 32nd St
- **244th**
  - Overgrown Ditch
  - Avulsed into Ditch
  - High Maintenance
- **Dams**
  - Inspections
  - Hazards
- **Invasive Species**
  - Queens Bog

Project Ranking Criteria

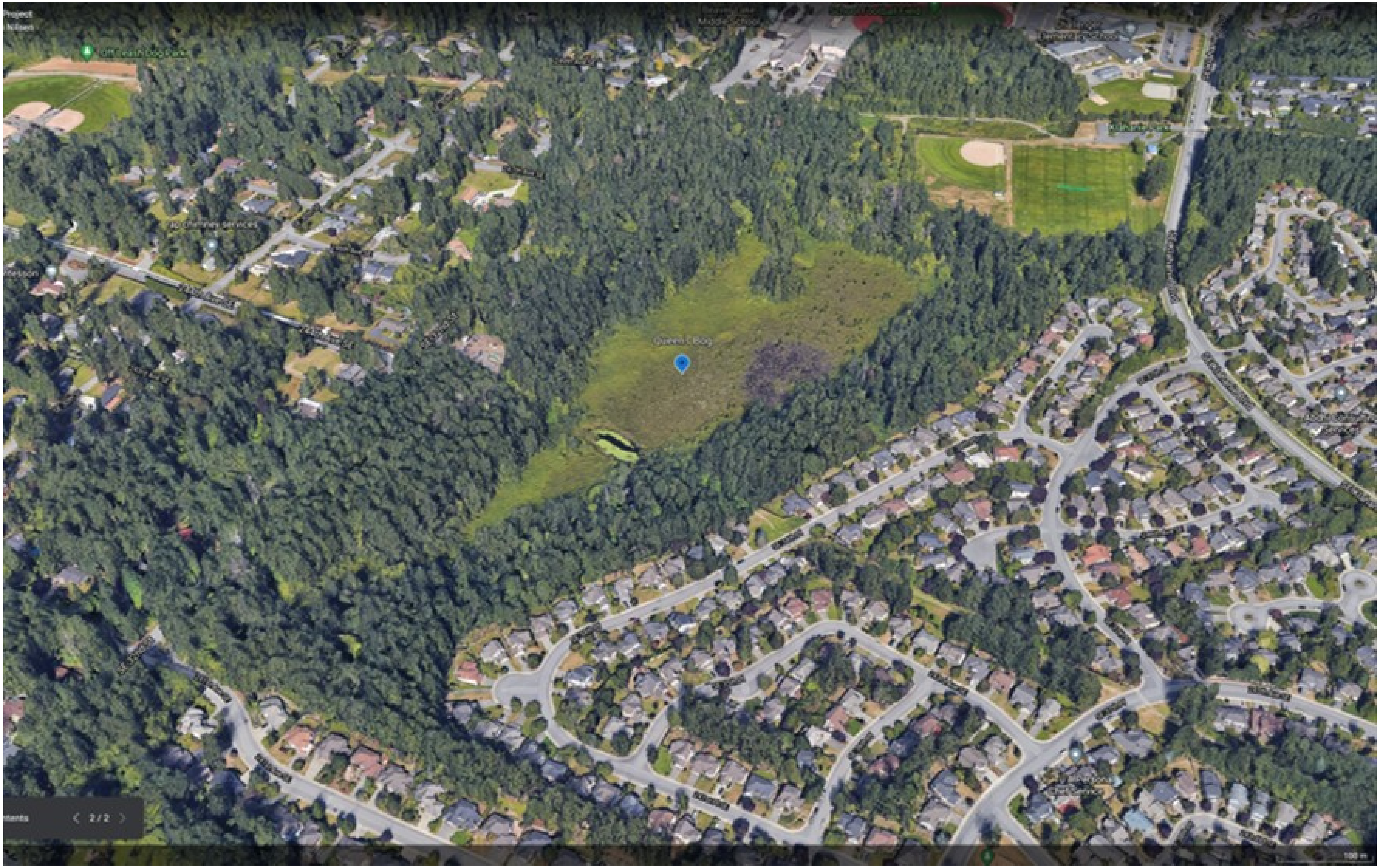
Stormwater CIP Priority Criteria

Criterion	Maximum Score	Considerations
Environmental Benefit	30	What is the project's ability to protect, restore, or improve natural watershed function(s)
Facility and Maintenance Improvements	25	Does the project repair or build/retrofit stormwater facilities to address current or projected impacts of growth and climate change? Will this project provide a long-term, cost-savings solution to an on-going maintenance problem?
Safety	25	Does the project address a safety risk?
Population	10	How many citizens does the project benefit?
Time-Sensitive Opportunity	10	Can the project take advantage of an opportunity that might not otherwise exist?
Total	100	

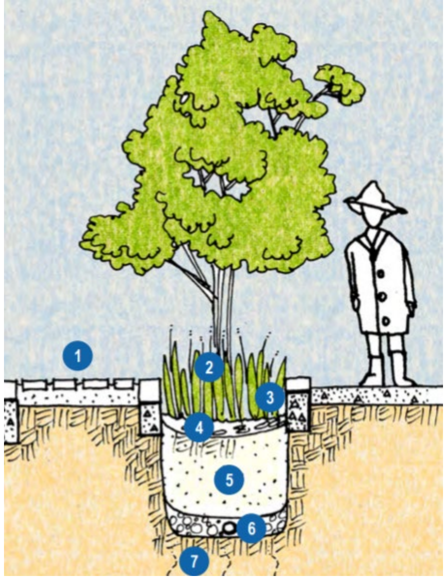
Proposed Project 1: Queens Bog Bioretention



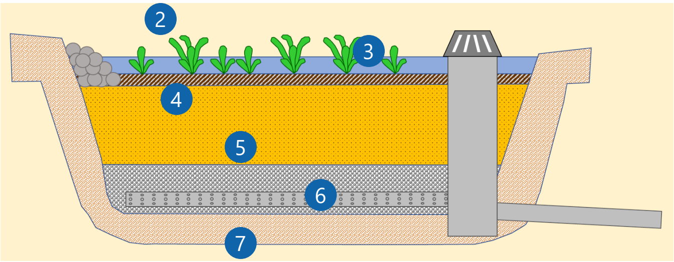
Proposed Project 1: Queens Bog Bioretention



Proposed Project 1: Queens Bog Bioretention



1. Sidewalk or trail
2. Vegetation
3. Intermittent ponding
4. Plant roots help maintain infiltration
5. Specialized bioretention mix
6. Optional underdrain where needed
7. Infiltration where feasible



Benefits:

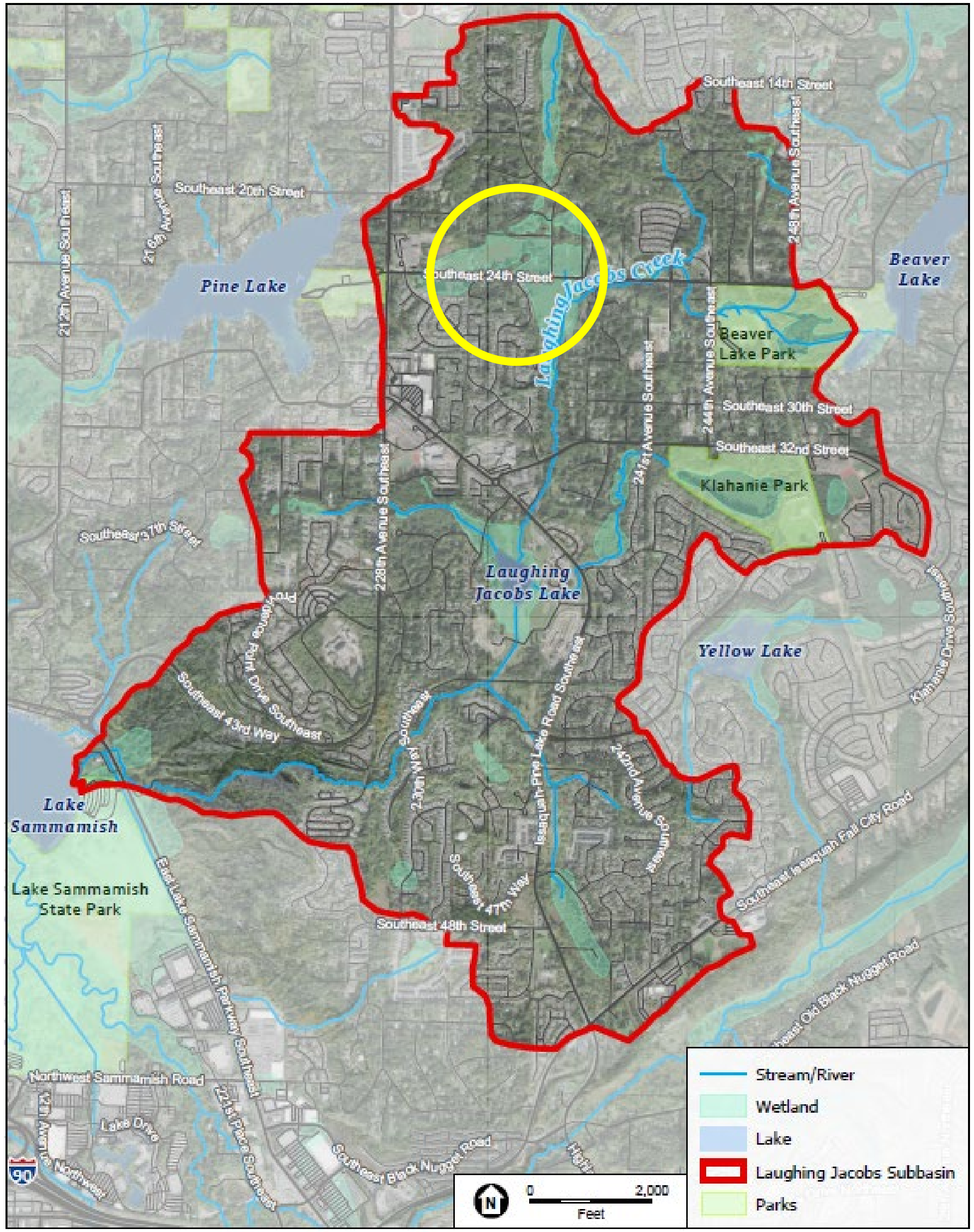
- Protects the rare ecosystem present in Queens Bog
- Provides a pleasant aesthetic for citizens to enjoy
- Uses existing open space to reduce development impacts to surrounding area

Capital Improvement Project Prioritization Scoring

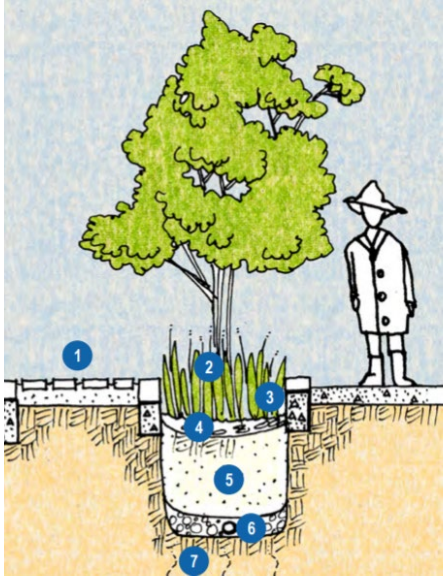
Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity	**TOTAL**
30/30	15/25	0/25	10/10	10/10	**65/100**

Proposed Project 2: SE 24th Street Wetland Complex Bioretention

Geosyntec consultants



Proposed Project 2: SE 24th Street Wetland Complex Bioretention



1. Sidewalk or trail
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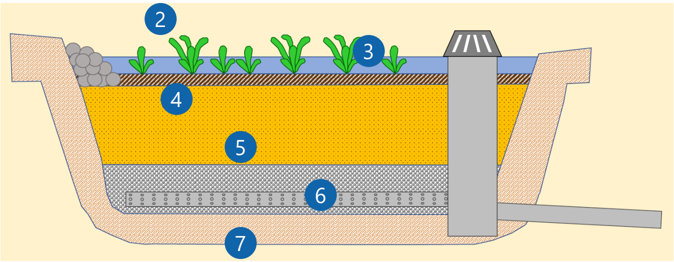
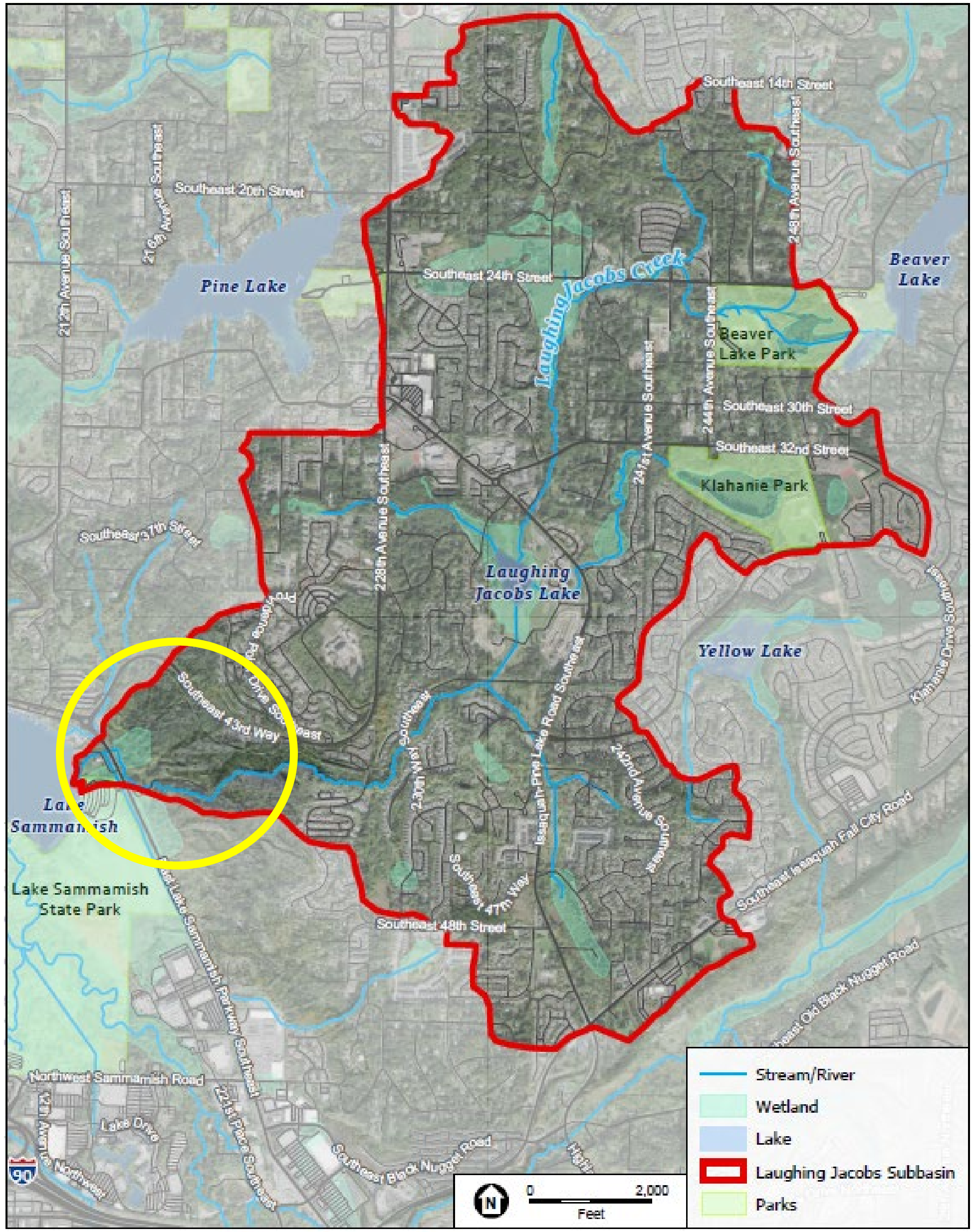


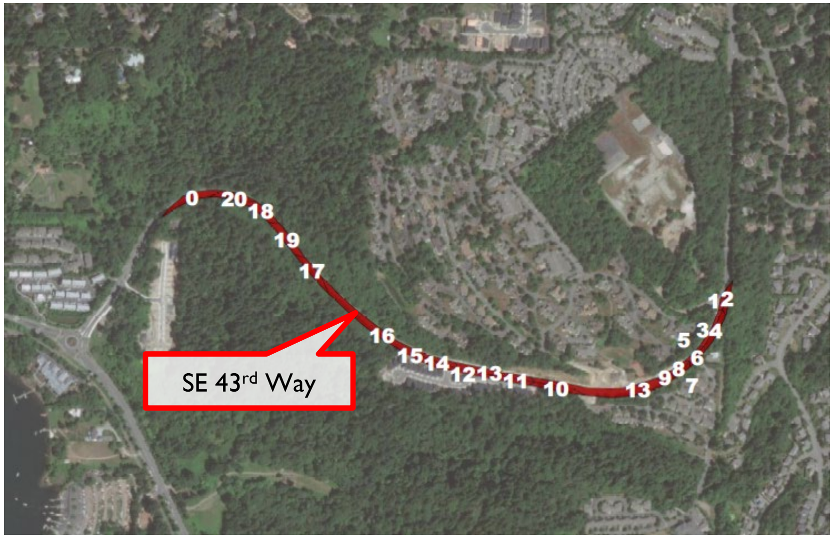
Benefits:

- Improves water quality and hydrology in the SE 24th Street wetland complex

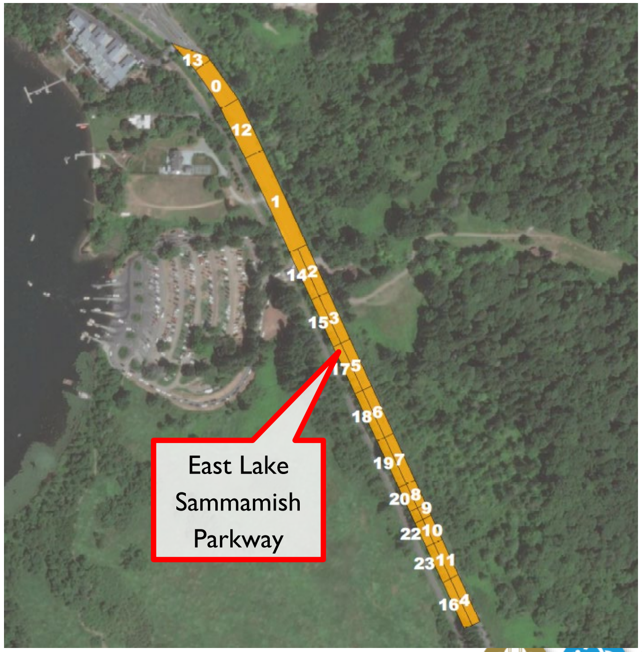
Capital Improvement Project Prioritization Scoring					
Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity	**TOTAL**
25/30	10/25	0/25	10/10	0/10	**45/100**

Proposed Projects 3&4: Roadway Stormwater Treatment





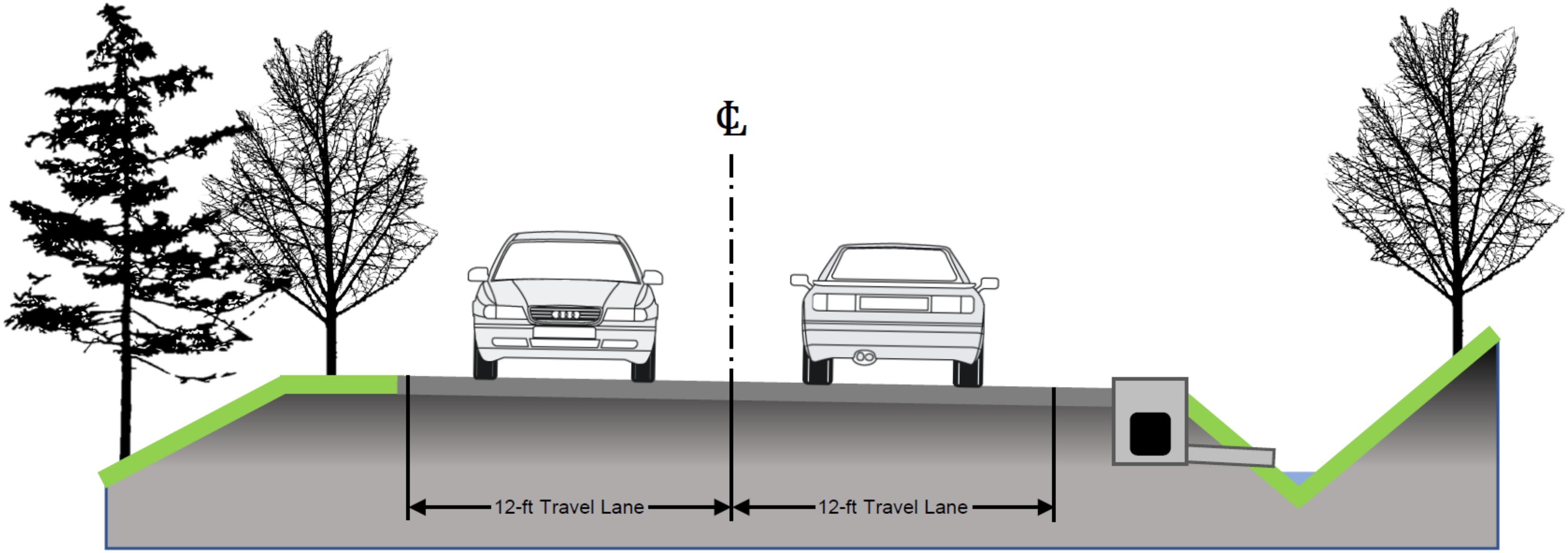
SE 43rd Way



East Lake Sammamish Parkway

Proposed Projects 3&4: Roadway Stormwater Treatment

Geosyntec consultants



Benefits:

- Provides stormwater treatment to roadway runoff not currently treated
- Requires minimal existing infrastructure for installation

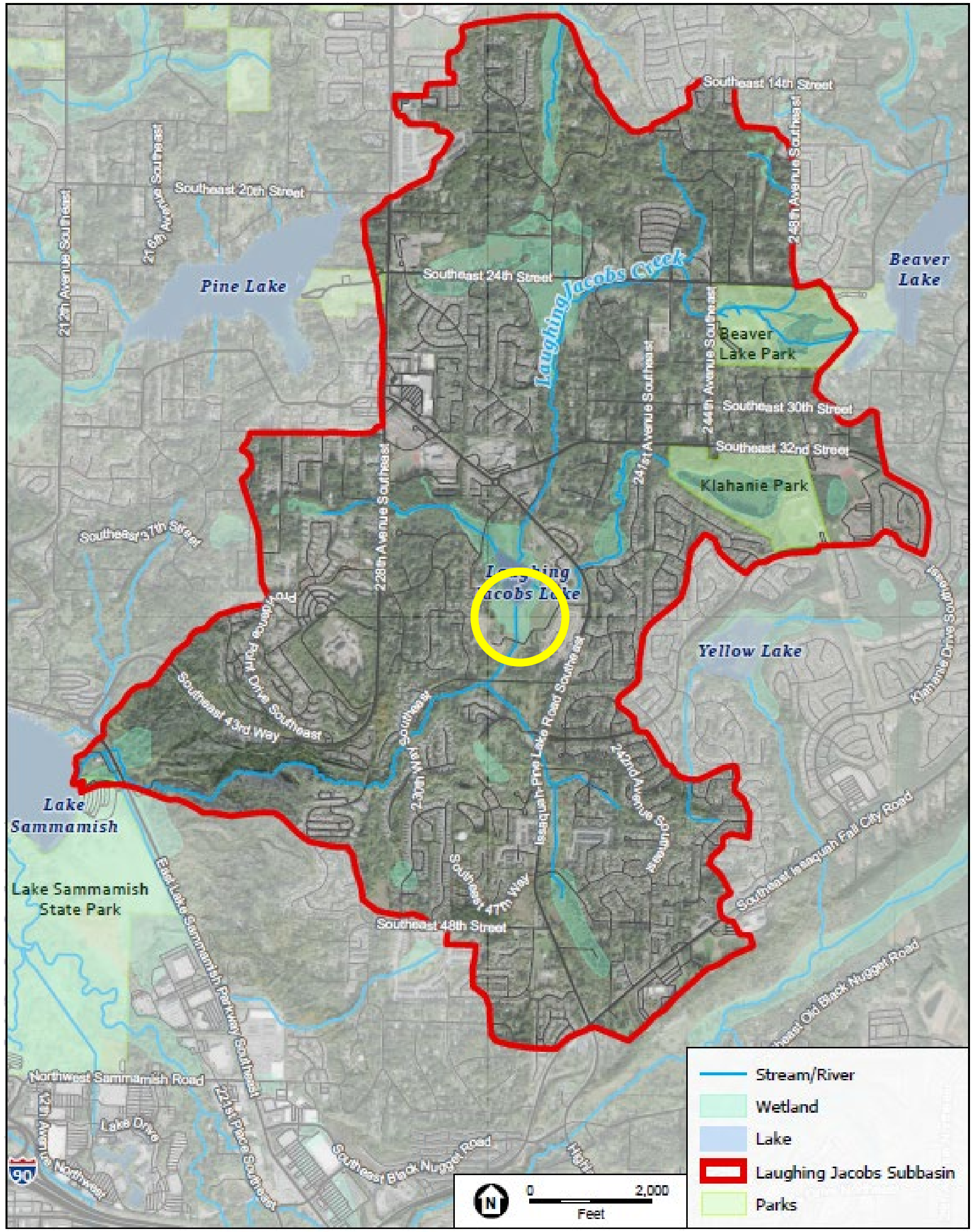
Capital Improvement Project Prioritization Scoring

Location	Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity	**TOTAL**
SE 43rd Way	20/30	5/25	0/25	10/10	5/10	**40/100**
E Lk Sammamish Pkwy	20/30	5/25	0/25	10/10	0/10	**35/100**

Graphic components sourced from https://www.graphicsfuel.com/2017/10/vector-tree-silhouettes-pack/

Proposed Project 5: Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration

Geosyntec consultants



Laughing Jacobs Lake

Project Area:
Laughing Jacobs
Downstream Channel

Proposed Project 5: Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration

Before

After

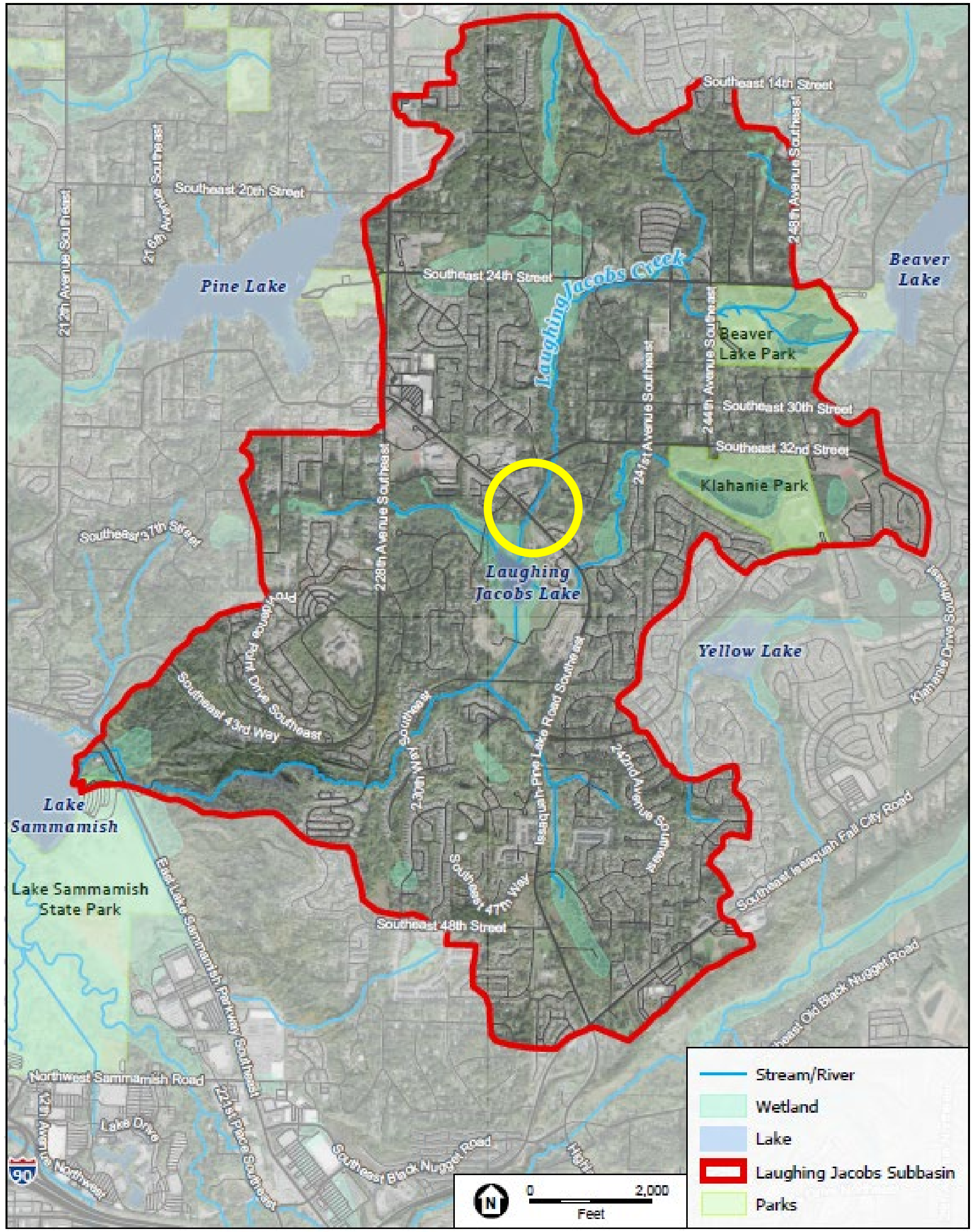
Benefits:

- Reduced exposure to sunlight results in decreased water temperature in channel and downstream to support aquatic life
- Provides pleasant aesthetic for residents

Capital Improvement Project Prioritization Scoring					
Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity	**TOTAL**
25/30	0/25	0/25	10/10	0/10	**35/100**

Proposed Project 6: Issaquah-Pine Lake Rd Crossing Engineered Hyporheic Zone Augmentation

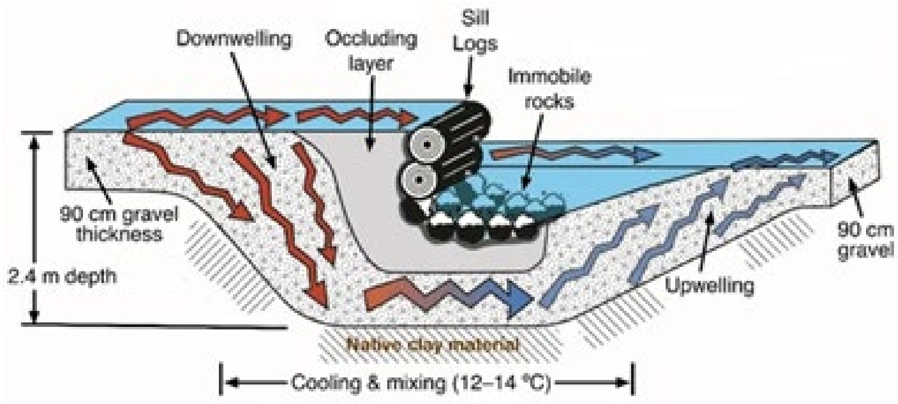
Geosyntec consultants



Project Area:
Laughing Jacobs Creek
downstream of IPL Rd

Proposed Project 6: Issaquah-Pine Lake Rd Crossing Engineered Hyporheic Zone Augmentation

Geosyntec consultants



Benefits:

- Provides water quality benefits to downstream reaches
- Reduces water temperature of creek
- Can be paired with IPL Road widening project to reduce capital cost
- Grant opportunities may offset costs

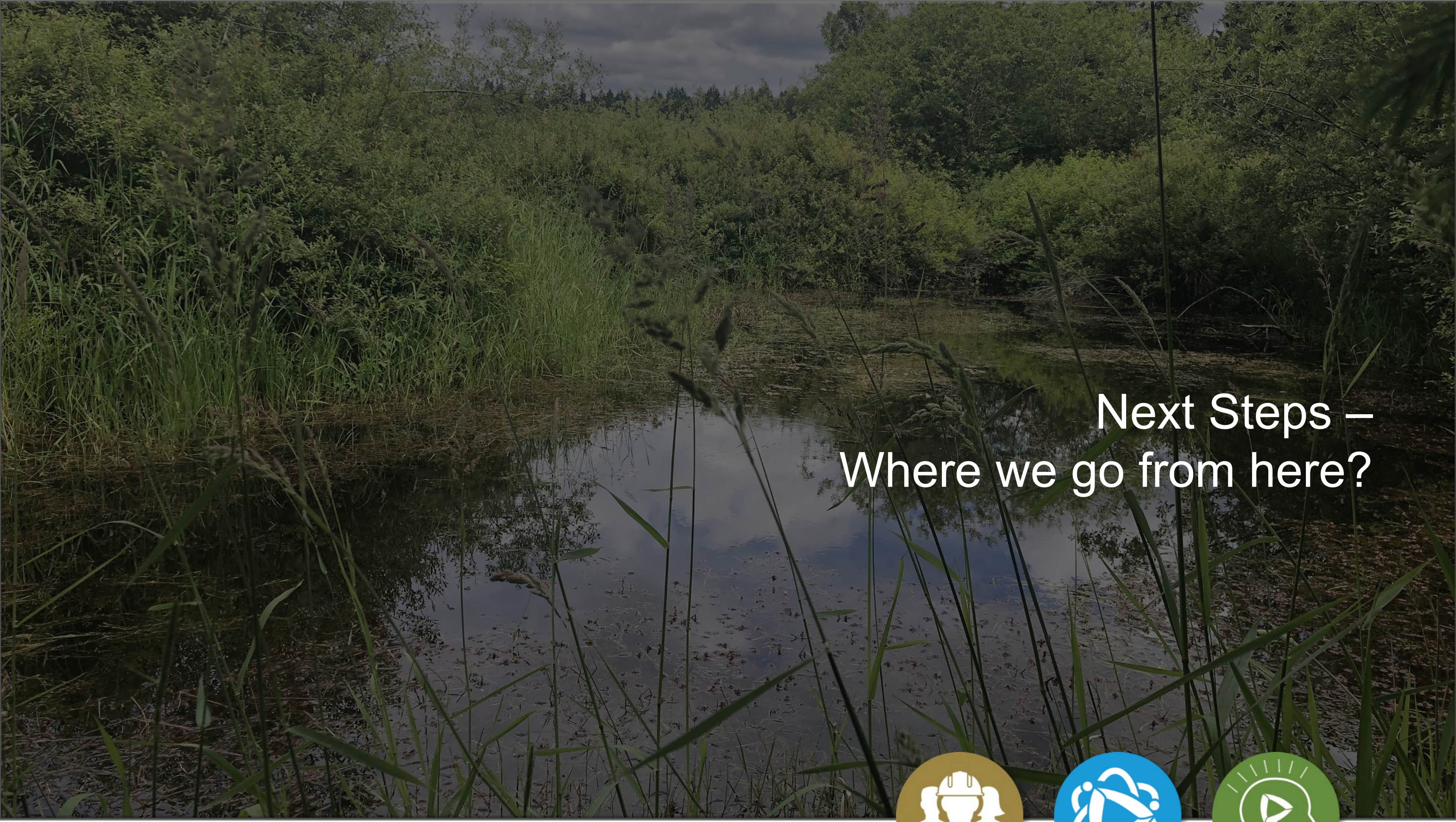
Capital Improvement Project Prioritization Scoring

Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity	**TOTAL**
20/30	5/25	0/25	10/10	10/10	**45/100**

Graphic sourced from Bakke, P., Hrachovec, M., & Lynch, K. (2020). Hyporheic Process Restoration: Design and Performance of an Engineered Streambed. https://doi.org/10.3390/w12020425

CIP Prioritization Summary

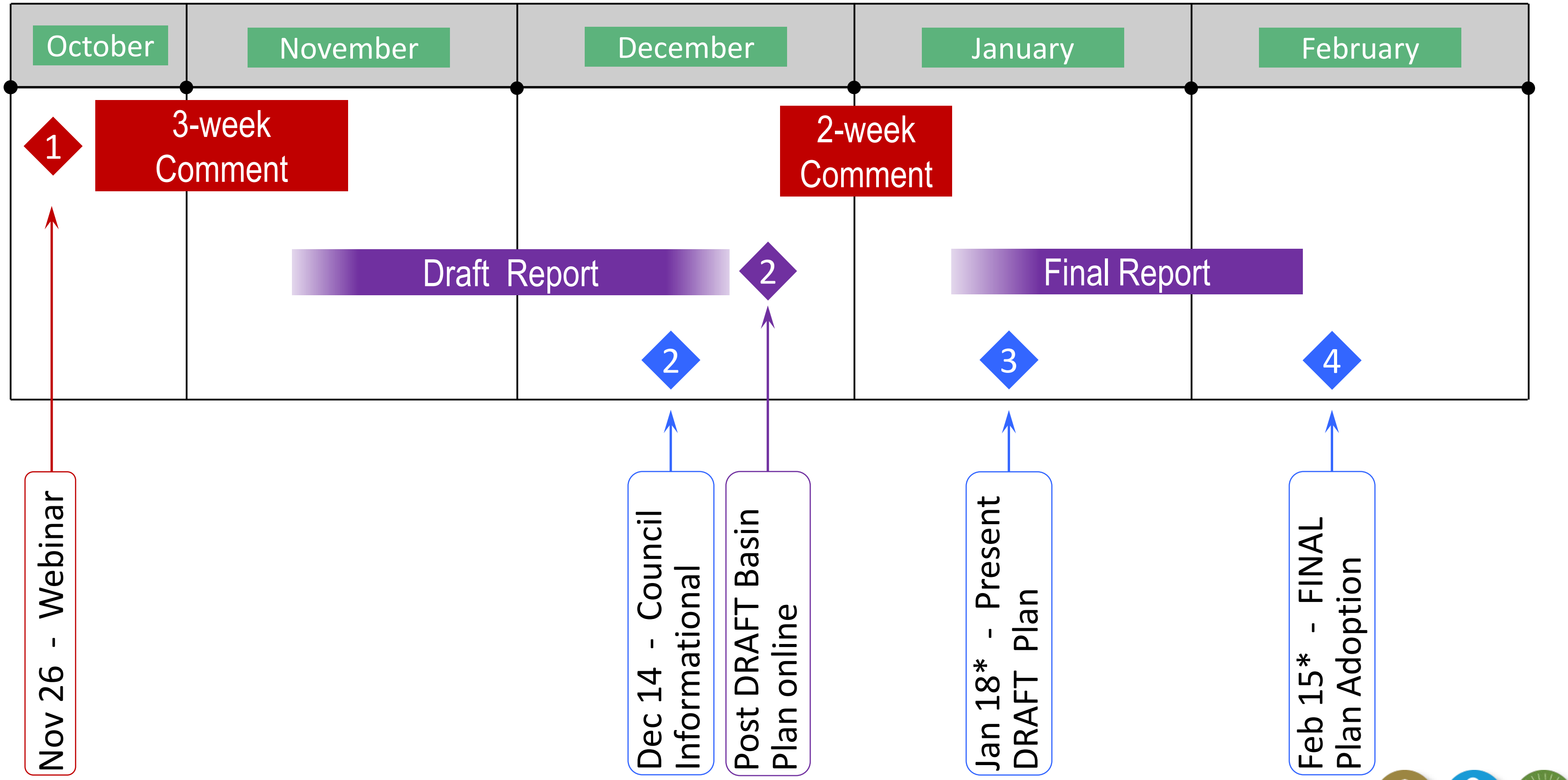
	Capital Improvement Project Prioritization Scoring					
Project	Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity	**TOTAL**
1. Queens Bog Bioretention	30/30	15/25	0/25	10/10	10/10	**65/100**
2. SE 24th Street Wetland Complex Bioretention	25/30	10/25	0/25	10/10	0/10	**45/100**
3. SE 43rd Way Roadway Stormwater Treatment	20/30	5/25	0/25	10/10	5/10	**40/100**
4. East Lake Sammamish Parkway Roadway Stormwater Treatment	20/30	5/25	0/25	10/10	0/10	**35/100**
5. Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration	25/30	0/25	0/25	10/10	0/10	**35/100**
6. Issaquah-Pike Lake Road Crossing Engineered Hyporheic Zone Augmentation	20/30	5/25	0/25	10/10	10/10	**45/100**



Next Steps – Where we go from here?

Next Steps

- Additional input from public
- Drafting Basin Plan
- Council consideration and adoption



October

November

December

January

February

1

3-week Comment

Draft Report

2

2-week Comment

Final Report

2

3

4

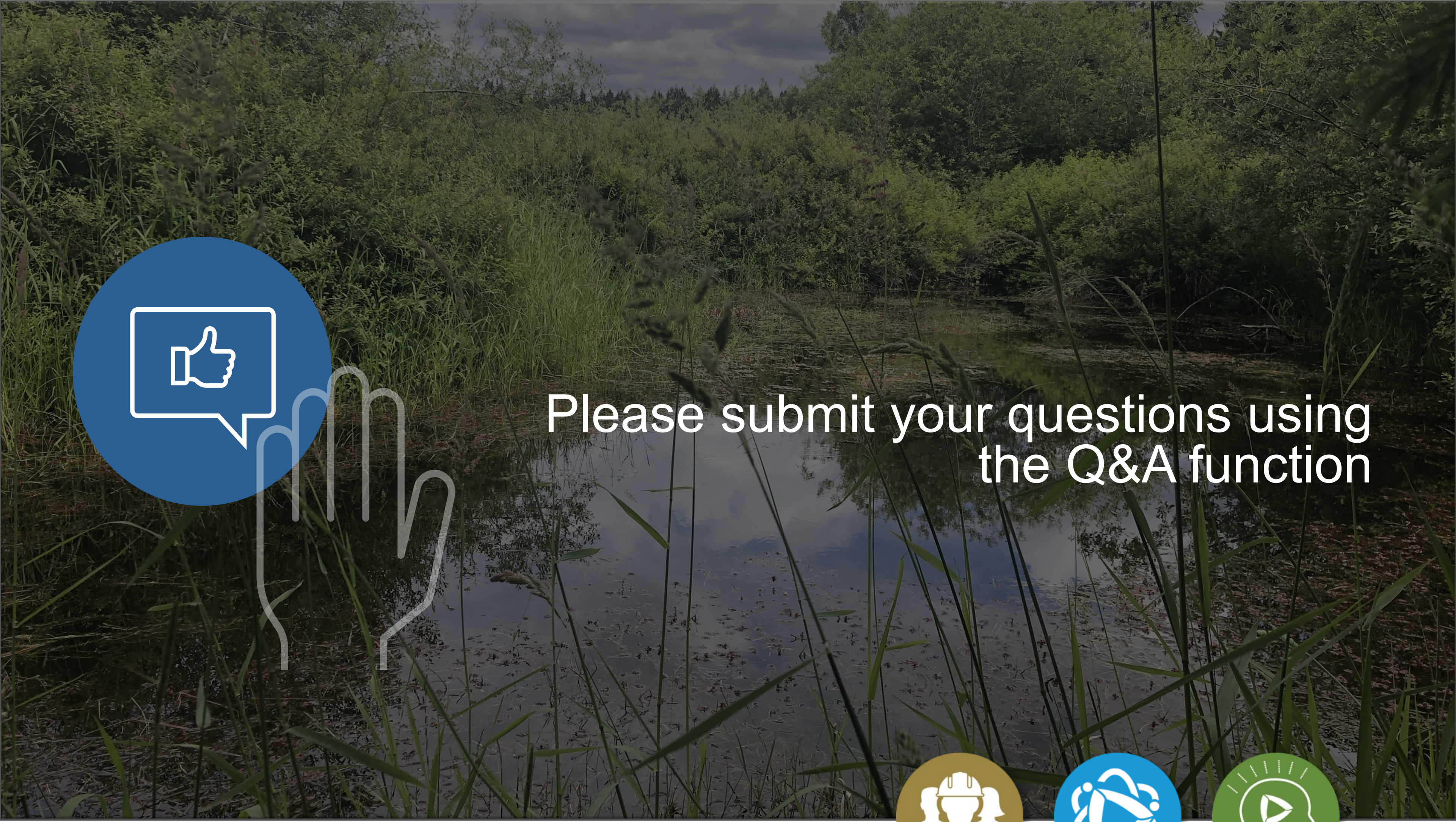
Nov 26 - Webinar

Dec 14 - Council Informational

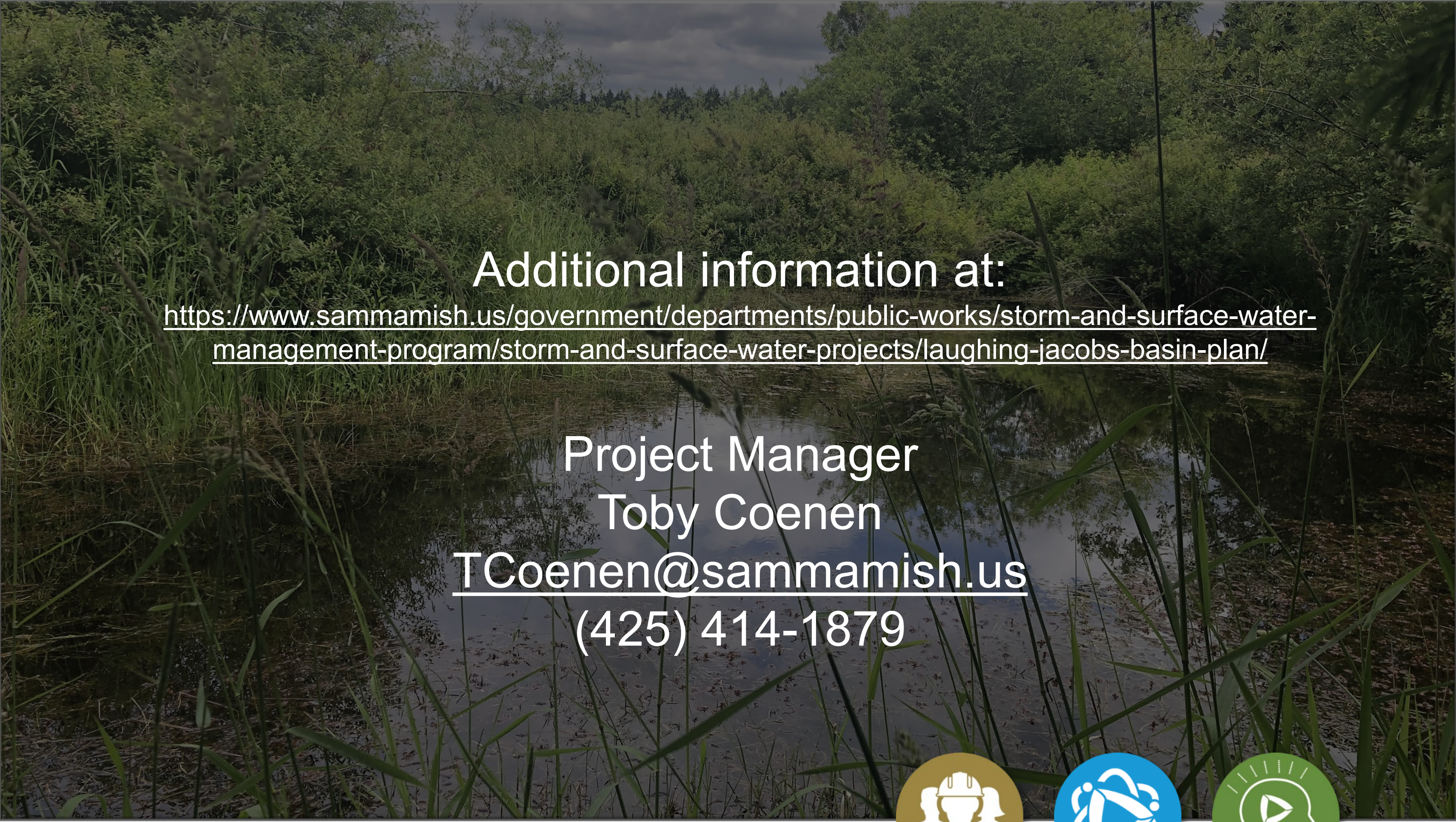
Post DRAFT Basin Plan online

Jan 18* - Present DRAFT Plan

Feb 15* - FINAL Plan Adoption



Please submit your questions using the Q&A function



Additional information at:

https://www.sammamish.us/government/departments/public-works/storm-and-surface-water-management-program/storm-and-surface-water-projects/laughing-jacobs-basin-plan/

Project Manager
Toby Coenen
TCoenen@sammamish.us
(425) 414-1879

Thank you for joining!

Laughing Jacobs Webinar – Q&A Transcript

Gretchen (Cascadia)

Subbasin drained into the the thought there was that Beaver Lake Subbasin drained into laughing Jacobs Basin.

Gretchen (Cascadia)

Can you clarify that?

Toby (City of Sammamish)

Sure, yes it does.

Toby (City of Sammamish)

Beaver Lake technically is part of the Laughing Jacobs Basin.

Toby (City of Sammamish)

The outlet flows.

Toby (City of Sammamish)

East, I think one of the plans showed.

Toby (City of Sammamish)

That fairly clearly.

Toby (City of Sammamish)

Decision was made early on to segregate the lake in the upstream area from the overall basin plan.

Toby (City of Sammamish)

The thinking was that there's a significant subset of issues and concerns and responses unique to the lake, as well as some of the upstream wetland areas that really it really didn't play well with the.

Toby (City of Sammamish)

You know, the downstream areas that we're looking.

Toby (City of Sammamish)

Yeah, so we wanted to tackle those as two discrete efforts.

Toby (City of Sammamish)

And you know, that's the approach we've taken since.

Toby (City of Sammamish)

But yeah, to the Bills comment, that's absolutely Bartel.

Toby (City of Sammamish)

Laughing Jacobs Basin, so there will be a separate plan is to take away.

OK.

Gretchen (Cascadia)

Thank you Toby. The next question is also comments. Last question here, but it's about project #4.

Gretchen (Cascadia)

And point of clarification about.

Gretchen (Cascadia)

Uhm, relocating, laughing laughing.

Gretchen (Cascadia)

Jacobs away from East Lake Sammamish Parkway.

Gretchen (Cascadia)

If you could clarify that, please to be Christian.

Toby (City of Sammamish)

Right that come.

Toby (City of Sammamish)

A little more Intel on that.

Toby (City of Sammamish)

Trout Unlimited is sponsoring a project to essentially replace the culvert of Laughing Jacobs Creek under under the Parkway as well.

Toby (City of Sammamish)

As is Bill noted kind of straightening out the the channel and getting it away from the boat dock to the extent that.

Toby (City of Sammamish)

And as well as getting it away.

Toby (City of Sammamish)

From the Parkway.

Toby (City of Sammamish)

We have talked to Dave Kyle about that.

Toby (City of Sammamish)

We're kind of familiar with their plans, and we've also one thing that we really haven't touched on here tonight.

Toby (City of Sammamish)

There's been a fair amount of coordination with the city of Issaquah.

Toby (City of Sammamish)

There are partners in this.

Toby (City of Sammamish)

We do have an interlocal agreement.

Toby (City of Sammamish)

To kind of spells out, you know the input.

Toby (City of Sammamish)

What have you?

Toby (City of Sammamish)

The projects that we did recommend, I think Christian you might be able to shed some light on this, but we generally stayed away from that segment where the stream.

Toby (City of Sammamish)

Will be relocated.

Toby (City of Sammamish)

And our efforts are more confined to the South of the roundabout.

Christian (Geosyntec)

Yeah, we.

Christian (Geosyntec)

We took their preliminary plans into account when we.

Christian (Geosyntec)

Laid out in those two areas where where these would go.

Christian (Geosyntec)

And so this these.

Christian (Geosyntec)

Two proposed projects would work well with.

Christian (Geosyntec)

The the planned Restoration project that T is doing.

Gretchen (Cascadia)

Great thank you both to being Christian and we've got a comment in here from Barbara.

Gretchen (Cascadia)

Would it be helpful to consider that peat bogs store more carbon than all other vegetation types in the world combined?

Toby (City of Sammamish)

I'm going to hand that to Christian, I think.

Toby (City of Sammamish)

He knows that.

Christian (Geosyntec)

Yeah, thanks for mentioning that I should have mentioned that.

Christian (Geosyntec)

In my in my overview.

Christian (Geosyntec)

That came up at the first public meeting that that was.

Christian (Geosyntec)

That was something people really valued about these P box systems.

Christian (Geosyntec)

Is that over the the the hundreds and thousands of years that they exist?

Christian (Geosyntec)

They they build up this layer of of of carbon and they're really this.

Christian (Geosyntec)

This great sink for carbon.

Christian (Geosyntec)

And so not only do they provide resilience for water systems, but they also provide resilience for for climate too.

Christian (Geosyntec)

And that's that's the reason one of the reasons why we really.

Christian (Geosyntec)

The Wanted to find projects that would really benefit these.

Christian (Geosyntec)

These unique spiking bonds

Gretchen (Cascadia)

Great, thanks Christian.

Gretchen (Cascadia)

And then we've got a comment in here from Bill would be good.

Gretchen (Cascadia)

You included a generic stormwater treatment to start breaking down pollutants that head of fish use.

Gretchen (Cascadia)

Some owners are not being too successful based on pre spawned mortality and utilizing watershed areas.

Gretchen (Cascadia)

The latest source identified is from car tires.

Gretchen (Cascadia)

Many researchers have zeroed down on specific immediate remedies.

Gretchen (Cascadia)

That would tie into your retrofit elements.

Gretchen (Cascadia)

Comments on that Christian or to be?

Yeah, there's I've.

Toby (City of Sammamish)

Got a couple and I know Christian will certainly have some as well.

Toby (City of Sammamish)

Well, you know, in a broader sense.

Toby (City of Sammamish)

You're very right we.

Toby (City of Sammamish)

The city is undertaking a number of you know what would seem to be unrelated.

Toby (City of Sammamish)

You know that ultimately, will I think, pay dividends and fish habitat, and you know source control is a big one.

Toby (City of Sammamish)

We are in the coming year going to be developing a source control program.

Toby (City of Sammamish)

The city is beginning to pay.

Toby (City of Sammamish)

It continues, I should say, with efforts to, you know, on the operation and maintenance side of existing facilities and we're really trying to ramp up our vigilance in terms of policing those to make sure that they're operating properly.

Toby (City of Sammamish)

I think what we've found a lot of times is, you know, we can have all the systems in the world, but if they aren't properly functioning.

Toby (City of Sammamish)

Yeah, the plugin removal just isn't there, so that's another area and.

Toby (City of Sammamish)

Only the.

Toby (City of Sammamish)

Another broader overview of approach that we're taking is a.

Toby (City of Sammamish)

You know we're updating our storm code in the coming year.

Toby (City of Sammamish)

Now, the primary focus of this is going to be adoption of the you know latest stormwater manual as well as a city addendum, and we've already been kind of circling little things that we want to include.

Toby (City of Sammamish)

And there they are geared.

Toby (City of Sammamish)

Not specific to this, I'm not at a position to talk about those at the moment, obviously, but.

Toby (City of Sammamish)

We are.

Toby (City of Sammamish)

It's acutely aware of where we're headed here, and I know in terms of you know, tyre compound.

Toby (City of Sammamish)

You know, that's obviously everybody is aware of how detrimental that is to you know, couple in particular, I think, and sakayan you know there's.

Toby (City of Sammamish)

Growing research on some of the effective strategies aimed at that.

Toby (City of Sammamish)

I know Christian had some thoughts on, you know where we might might be.

Toby (City of Sammamish)

Able to employ.

Christian (Geosyntec)

Yeah, the the tire compounds and the prespawn mortality issue is is really interesting.

Christian (Geosyntec)

It's something we've been following for a while.

Christian (Geosyntec)

Uh, this consignment in it's called 6 PPD quinone and it was not identified.

Christian (Geosyntec)

Prior to a year ago.

Christian (Geosyntec)

There there's some really good work that researchers at.

Christian (Geosyntec)

UW and Wash State University have done there.

Christian (Geosyntec)

They really played Detective and they really narrowed it down to this contaminant that causes mortality in in coho before they can make it up to their their spawning grounds.

Christian (Geosyntec)

There's it's an emerging contaminant, which means that that there's still a lot of unanswered questions about the sources and the fate and transport of it, but preliminary data is showing that the stormwater treatments that exist now.

Christian (Geosyntec)

Can prevent the the toxics from causing cope, respond mortality, and the mechanisms behind that are still being researched, but the the good news is that existing bioretention like the the the.

Christian (Geosyntec)

Two projects that we have around Queens Bog area.

Christian (Geosyntec)

Those have been shown to prevent.

Christian (Geosyntec)

Uh, cope, respond mortality, and similarly the the treatment mechanisms that we have in the roadways.

Christian (Geosyntec)

Those are going to be.

Christian (Geosyntec)

The same sort of mechanisms that those bioretention areas employ so.

Christian (Geosyntec)

Like I said, there's there's a lot of emerging science on it, and we'll probably know a little bit more about that specific compounds.

Christian (Geosyntec)

When it gets closer to design, but I'm fairly confident that.

Christian (Geosyntec)

The the treatments that we have employed here would also address 6 PPD quinone.

Christian (Geosyntec)

One final thing is that that engineered Hyper Exone.

Christian (Geosyntec)

Project that's that project has been under a pilot study with Seattle Public Utilities.

Christian (Geosyntec)

For two to three years, they have one on Thornton Creek and they have one on tail.

Christian (Geosyntec)

Creek and the same researchers that are studying coho prespawn mortality are also studying this.

Christian (Geosyntec)

Uhm, this novel structure that that causes this this hyper rate zone and so.

Christian (Geosyntec)

Hopefully we'll get some.

Christian (Geosyntec)

More data about that and how that can prevent Co priest on mortality.

Christian (Geosyntec)

It's looking like it it it may, but again, it's an emerging contaminant.

Christian (Geosyntec)

There's emerging science, and there's still.

Christian (Geosyntec)

Some questions to be answered.

Christian (Geosyntec)

And hopefully by the time we get to to to design, we'll have a little.

Christian (Geosyntec)

Bit more information about that.

Gretchen (Cascadia)

Excellent, thanks so much, Christian.

Gretchen (Cascadia)

We've got another comment or question in here from Mary.

Gretchen (Cascadia)

What about treatment trains required for stagnant Boggs, Glony existing stormwater facility has some but not current code adopted.

Toby (City of Sammamish)

Well, that's a very good point.

Toby (City of Sammamish)

They you know Klahanie was developed.

Toby (City of Sammamish)

You know the master plan in the 70s and you know the manual that a lot of that was based on was dates to 19.

Toby (City of Sammamish)

78 I believe.

Toby (City of Sammamish)

In 1990, you know some of the more recent divisions.

Toby (City of Sammamish)

Were you know followed that?

Toby (City of Sammamish)

Yeah, the the water quality treatment does not employ the you know conventional treatment train.

Toby (City of Sammamish)

The series of different mechanisms that are have been found to benefit stagnant logs and particularly the big part of that is you know trying to maintain.

Toby (City of Sammamish)

The pH levels of.

Toby (City of Sammamish)

The runoff trying to maintain that acidic quality.

Toby (City of Sammamish)

Uhm, there has been some.

Toby (City of Sammamish)

You know, discussions within King County and I know they continue to wrestle with the best approach to it.

Toby (City of Sammamish)

You know and right now they are the only ones that have a financial treatment standard for treatment or stagnant logs.

Toby (City of Sammamish)

The Department of Ecology.

Toby (City of Sammamish)

He doesn't specifically identify that as a targeted pollutant removal treatment level, if you will.

Toby (City of Sammamish)

So it it does fall to King County to really kind of be in charge of that one, if you will, and they've done some interesting research.

Toby (City of Sammamish)

You know, getting down to specific gravel sources within standard sand filters and that the thing to identify the best approach.

Toby (City of Sammamish)

So I'm you know confident that that will continue to.

Toby (City of Sammamish)

Kind of circling back to.

Toby (City of Sammamish)

You know the klahanie development.

Toby (City of Sammamish)

In particular.

Toby (City of Sammamish)

That's one reason why we identified.

Toby (City of Sammamish)

A series of.

Toby (City of Sammamish)

Projects within the basin to capture runoff from.

Toby (City of Sammamish)

I'm not sure what division that is, uh, a second element is the park adjacent to it?

Toby (City of Sammamish)

Kind of on the you know, I guess would be the southeasterly corner.

Toby (City of Sammamish)

There's a significant stormwater detention facility there that I know the park Master Plan anticipates making significant upgrades to with an eye toward, you know, protecting the bog.

Toby (City of Sammamish)

And then finally our retrofit plan, you know, is it a good vehicle with which we can, you know, make some of those changes so?

Toby (City of Sammamish)

It's definitely on our radar.

Toby (City of Sammamish)

You know, it's like a lot of things.

Toby (City of Sammamish)

It's we're not going to get it built.

Toby (City of Sammamish)

Today or tomorrow.

Toby (City of Sammamish)

But you know, we're setting in motion to, you, know the the Legos.

Toby (City of Sammamish)

If you will.

Toby (City of Sammamish)

To, you know, build the build the Fort so.

Gretchen (Cascadia)

Excellent so B. Next question from Diane here on Project #3 this across school district plans on building a high school in elementary school on the Old Providence Heights property.

OK.

Gretchen (Cascadia)

This will include widening 43rd and 228. There will be additional. There will be additional roadway, stormwater and additional water cascading down.

Gretchen (Cascadia)

The laughing Jacobs creep. Have you factored in the impact of this development which is scheduled to break ground in spring of 2022?

Toby (City of Sammamish)

We have the.

Toby (City of Sammamish)

City of Issaquah actually asked the city of Sammamish that the schools, as you know, are within the the city of Issaquah.

Toby (City of Sammamish)

And I know our.

Toby (City of Sammamish)

Consultants have picked up all the design documents associated with that just to get their arms around.

Toby (City of Sammamish)

What what this thing is going to look like?

Toby (City of Sammamish)

But the city of Issaquah is ask the city of Sammamish to kind of partner in reviewing this, so that you know, we're kind of all on the same page if you will with respect to.

Toby (City of Sammamish)

Traffic and stormwater, and through that we've been able to, you know, offer some comments and insights and and you know the indication that we've seen is.

Toby (City of Sammamish)

Issaquah staff is paying close attention to this, you know.

Toby (City of Sammamish)

Ultimately they have the permitting.

Toby (City of Sammamish)

Authority for the.

Toby (City of Sammamish)

Uhm, you know for the development.

Toby (City of Sammamish)

Uhm, they adhere to the Department of Ecology standards we use is Sammamish, you know, adhere to the King County standards.

Toby (City of Sammamish)

So ultimately King County develops standards that are substantially equivalent to ecology.

Toby (City of Sammamish)

Some kind of a potato potato thing if you will, but you know, there's some slight differences in terms of you know how those things will manifest themselves.

Toby (City of Sammamish)

That's good, you know.

Toby (City of Sammamish)

We're confident that this was like I said, they're paying attention.

Toby (City of Sammamish)

To it and.

Toby (City of Sammamish)

They are doing everything within their power to.

Toby (City of Sammamish)

You know, make sure that these things are addressed.

Toby (City of Sammamish)

I don't know if in reviewing those plans, Joel or Christian, if either of you had any.

Toby (City of Sammamish)

Observations and specifics that you've seen.

Christian (Geosyntec)

And yeah, I I'll mention that the the school district has a separate process that they're going through or they identify the environmental impacts and how they're going to mitigate for them.

Christian (Geosyntec)

That's that's still, I believe in process we.

Christian (Geosyntec)

Have a a.

Christian (Geosyntec)

Pretty good idea where it's going to go.

Christian (Geosyntec)

But the the.

Christian (Geosyntec)

The Long story short, I guess is that the the project will be self mitigating in terms of CVA, so they will be complying with all all of the environmental and stormwater issues on their site and so there there shouldn't be any additional stormwater impacts from from the project.

Christian (Geosyntec)

Now there will be additional.

Christian (Geosyntec)

Traffic, and that's going to be a.

Christian (Geosyntec)

That'll be, UM.

Christian (Geosyntec)

That's part partly the reason why we specified the types of treatments that we did at that site, because it is does drain to the the spawning area in lapping Jacobs Creek and.

Christian (Geosyntec)

There will be.

Christian (Geosyntec)

Additional traffic impacts we know so, so these projects.

Christian (Geosyntec)

Are intended to help.

Christian (Geosyntec)

Reduce the the.

Christian (Geosyntec)

The chemicals that are running off off the the road from that additional traffic, but in terms of other impacts on the site.

Christian (Geosyntec)

Our assumption in the basin plan has been that that those will be taken care of by the the school district as part of their project.

Gretchen (Cascadia)

Excellent, thanks to being Christian.

Gretchen (Cascadia)

Got time for a couple more questions here.

Gretchen (Cascadia)

We've got one from Barbara.

Gretchen (Cascadia)

If these bogs are protected, is there a way to?

Gretchen (Cascadia)

Get federal funds.

Toby (City of Sammamish)

I'm not explicit to that.

Toby (City of Sammamish)

You know the designation as a A sphagnum bog.

Toby (City of Sammamish)

You know the protections are really, you know what we employ or implement.

Toby (City of Sammamish)

Rather as a city.

Toby (City of Sammamish)

Some you know in the area around it, the area is privately owned.

Toby (City of Sammamish)

Portion of it, so there's a limitation there.

Toby (City of Sammamish)

We can pursue federal funds for any number of projects, and most often those are actually through the state we've generally found.

Toby (City of Sammamish)

Stormwater projects in general that we have a little better work locally with with King County in particular, and you know some of the state sources of revenue that.

Toby (City of Sammamish)

Uhm, yeah, that's a good question.

Toby (City of Sammamish)

I mean, we're always.

Toby (City of Sammamish)

Always looking.

Toby (City of Sammamish)

The corollary to that.

Toby (City of Sammamish)

In the city of Sammamish, there's no such thing as free money, because you know federal money does oftentimes come with some pretty significant you know strings attached, and it's you know it.

Toby (City of Sammamish)

We need a certain sized project to to justify sometimes that additional work necessary.

Toby (City of Sammamish)

Instead of yeah, we're we are looking, you know these.

Toby (City of Sammamish)

Are the types of.

Toby (City of Sammamish)

Things that they want to be in.

Christian (Geosyntec)

A funny thing about sphagnum bogs.

Christian (Geosyntec)

I mentioned that there are.

Christian (Geosyntec)

There are these.

Christian (Geosyntec)

Isolated systems that are primarily rainwater fed, and they're really important habitat.

Christian (Geosyntec)

But what that means since they're isolated, is that they're not connected to an unnavigable water, which is how the federal government.

Christian (Geosyntec)

It's it's what they use to regulate wetlands under the Clean Water Act.

Christian (Geosyntec)

And since they're not since they're isolated systems, historically they haven't had the same protection that other wetlands have because they don't have this this federal desert.

Christian (Geosyntec)

That's that's kind of.

Christian (Geosyntec)

Changed now within the within the state that we do know that these are important things.

Christian (Geosyntec)

But what that means is, is that it's it's not technically a water of the US, it, so it could be a water of the.

Christian (Geosyntec)

State, but not a water of the US.

Christian (Geosyntec)

Uhm, but I will add that if there's.

Christian (Geosyntec)

It there might not be.

Christian (Geosyntec)

Federal support for for funding.

Christian (Geosyntec)

But I've there's a lot of interested.

Christian (Geosyntec)

Funders that are really interested in in these types of systems.

Christian (Geosyntec)

And with stormwater, so I'm sure that there are other sources of funding that that the city can explore.

Gretchen (Cascadia)

Excellent thank you.

Gretchen (Cascadia)

Both Toby and Christian.

Gretchen (Cascadia)

Final question of the night is from Mary.

Gretchen (Cascadia)

Are there areas identified with flooding currently?

Gretchen (Cascadia)

Or fast flows.

Gretchen (Cascadia)

With storm surges for peak events or and or multi day and longer duration flows.

Toby (City of Sammamish)

Yes, yes, there certainly are.

Toby (City of Sammamish)

You know one of the.

Toby (City of Sammamish)

Common comments that we heard in the initial.

Toby (City of Sammamish)

Public open house process.

Toby (City of Sammamish)

You know there's a fair amount of nuisance flooding around, and a lot of that is more related to, you know, just condition the storm drains and what have you.

Toby (City of Sammamish)

There's invariably seasonal flooding similar to what we saw this weekend in some areas.

Toby (City of Sammamish)

It just leaves plugging up drains.

Toby (City of Sammamish)

And that type of thing.

Toby (City of Sammamish)

More systemic problems if you go downstream of lapping.

Toby (City of Sammamish)

Jacobs lake.

Toby (City of Sammamish)

This is covered under SE 42nd St for example, which is, I think by most objective measures, undersized not to convey. You know current storm levels.

Toby (City of Sammamish)

Uhm, I think he's undersized.

Toby (City of Sammamish)

You know to convey historic storm levels, and that tends to back up water into left Jacobs, like.

Toby (City of Sammamish)

Similarly, the preliminary design work that has been done on.

Toby (City of Sammamish)

Issaquah Pine Lake Rd.

Toby (City of Sammamish)

You know the culverts identified.

Toby (City of Sammamish)

There are all much bigger than the ones that exist now.

Toby (City of Sammamish)

And we've mentioned this Quad Pine Lake Rd a couple times here I want.

Toby (City of Sammamish)

To be real clear that.

Toby (City of Sammamish)

As far as that project moving forward, that's nothing that's going to happen in the next couple of years.

Toby (City of Sammamish)

It's a, you know, that's a capital project and know that runs through a separate group, and this transportation plan needs to be implemented for that.

Toby (City of Sammamish)

That gets legs, but you know these are significant elements of that project, so.

Toby (City of Sammamish)

But yeah, to your point Mary, there's a, you know, the science behind sizing, culverts and estimating runoff.

Toby (City of Sammamish)

All of that has evolved.

Toby (City of Sammamish)

A lot over the last 30 years since I've been in.

Toby (City of Sammamish)

And really, when you look at them, you know how we size them now versus how we size them 30 years ago.

Toby (City of Sammamish)

Yeah, I think you could make an argument that a number of them are undersized under capacity.

Toby (City of Sammamish)

But that in general is the primary source of flooding.

Toby (City of Sammamish)

You know there's just, you know, under capacity culverts, in, in and of itself you know periodic inundation isn't problematic.

Toby (City of Sammamish)

Unless you're dealing with, for example, Queens bond.

Toby (City of Sammamish)

So you know the the wetland area around laughing chickens leg.

Toby (City of Sammamish)

If that gets wet you know a few times a year that's.

Toby (City of Sammamish)

You know it's a wet Meadow that's you know that's.

Toby (City of Sammamish)

Functioning as it's intended.

Toby (City of Sammamish)

I don't know if you have anything further to.

Toby (City of Sammamish)

Add to that Christian.

Christian (Geosyntec)

I guess I'll just add until you know more about this, but the the city.

Christian (Geosyntec)

It did do a analysis of climate change effects and how that's going to change runoff patterns, and that's being incorporated.

Christian (Geosyntec)

I believe into the the retrofit plan.

Christian (Geosyntec)

Do I have that right?

Toby (City of Sammamish)

Right?

Christian (Geosyntec)

So so the this the city has been also looking at what they can do in infrastructure more generally to address climate change issues.

Gretchen (Cascadia)

Excellent, and with that that actually concludes our Q&A for the night. It's over at 7:00 o'clock here and so.

Gretchen (Cascadia)

I'm going to.

Gretchen (Cascadia)

Turn it back over to Toby for closing remarks.

Toby (City of Sammamish)

No, thank you.

Toby (City of Sammamish)

You know, I appreciate.

Toby (City of Sammamish)

The questions we've we've got a couple links here with information not expecting you to jot down that web link, obviously.

Toby (City of Sammamish)

But if you do, Google Laughing Jacobs Basin plan, Sammamish, you will come to the project page.

Toby (City of Sammamish)

It's got my contact information there as well.

Toby (City of Sammamish)

You have my phone, phone and email are both available there.

Toby (City of Sammamish)

That's going to be the easiest, smoothest way to reach me.

Toby (City of Sammamish)

Before we sign off, I want to thank our consulting team.

Toby (City of Sammamish)

These guys have been in this for years.

Toby (City of Sammamish)

As I noted, and it's been a pleasure to work with them.

Toby (City of Sammamish)

But most importantly, I do want to thank the residents that took some time out this evening to, you know, share their concerns and interests and you know, just let you folks know that we appreciate hearing.

Toby (City of Sammamish)

From you and.

Toby (City of Sammamish)

We're looking forward to.

Toby (City of Sammamish)

You know, continuing the dialogue so.

Toby (City of Sammamish)

Thank you and.

Toby (City of Sammamish)

We'll sign off for the night.

Christian (Geosyntec)

And I went ahead and put the.

Christian (Geosyntec)

The link in the chat.

Christian (Geosyntec)

That that way you don't have to type it in, you can just.

Grab that.

Gretchen (Cascadia)

Fine, thank you everybody.

Gretchen (Cascadia)

Have a good night.

Toby (City of Sammamish)

Thank you.

Christian (Geosyntec)

Thank you.

APPENDIX D

Quality Assurance Project Plan

DRAFT SAMPLING AND ANALYSIS PLAN (SAP)/ QUALITY ASSURANCE PROJECT PLAN (QAPP)

Laughing Jacobs Basin Water Quality Monitoring 2019-2020

Prepared for

City of Sammamish
Department of Public Works
801 228th Ave SE
Sammamish, WA 98075

Prepared by

Geosyntec Consultants, Inc.
520 Pike Street, Suite 2600
Seattle, WA 98101

Project PNW0373

July 25, 2019

Sampling and Analysis Plan (SAP)/ Quality Assurance Project Plan (QAPP)

Laughing Jacobs Basin Water Quality Monitoring 2019-2020

Approvals Page

Prepared for

City of Sammamish
Department of Public Works
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Project Number: PNW0373

July 25, 2019

ACRONYMS AND ABBREVIATIONS

7-DADMax	7-day Average of the Daily Maximum
AIS	Aquatic Invasive Species
B-IBI	Benthic Index of Biotic Integrity
CIP	Capitol Improvement Project
CFU	Colony Forming Units
CWA	Clean Water Act
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
ESA	Environmental Science Associates
MDL	Method Detection Limit
mg/L	Milligrams per Liter
mL	Milliliter
MPN	Most Probable Number
MQO	Measurement Quality Objectives
NTU	Nephelometric Turbidity Unit
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
TDG	Total Dissolved Gases
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION

This document presents a combined Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) for the Laughing Jacobs Basin in the cities of Sammamish and Issaquah. It describes the sampling, analysis, and quality assurance/quality control (QA/QC) methods that will be utilized during water quality monitoring to support the Laughing Jacobs Basin Plan. The monitoring is scheduled to commence in the summer of 2019. This work will be performed by Geosyntec Consultants on behalf of the City of Sammamish (City).

Results from this monitoring will be used to understand watershed characteristics and to inform potential projects to be utilized for watershed characterization, identification of problems and opportunities, and identification of Capital Improvement Projects (CIPs) within the cities of Sammamish and Issaquah.

2. BACKGROUND

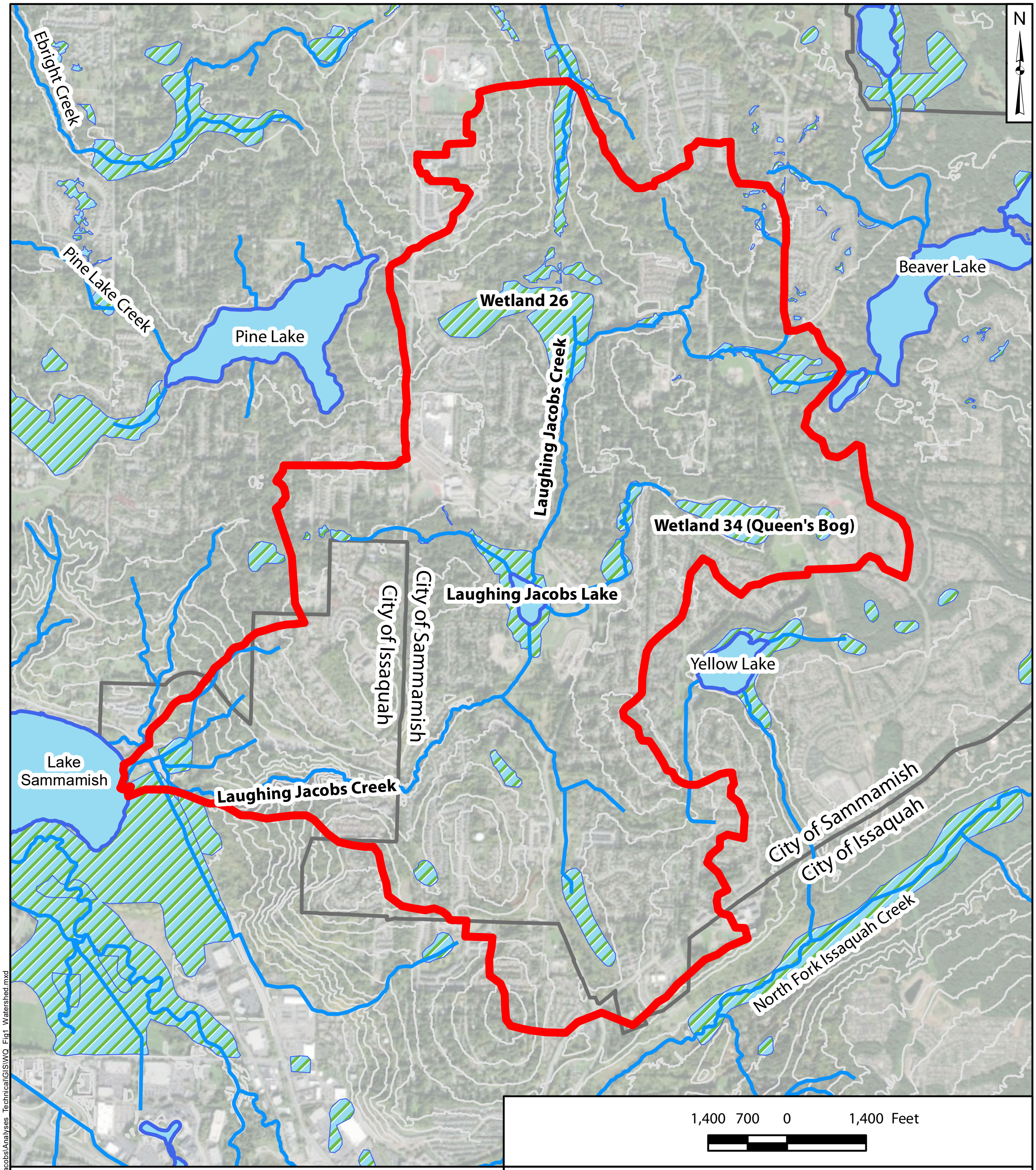
2.1 Study Area

The Laughing Jacobs Basin drains approximately 2,600 acres of the southern portion of the City of Sammamish, as wells as a northern portion of the City of Issaquah in Washington (Figure 1). The basin is located within the greater Lake Washington/Cedar/Sammamish Watershed (Washington Water Resource Inventory Area (WRIA) 8) (Ecology, 2019a).

The basin headwaters originate in the upland plateau within the City of Sammamish. On the upland area, hills of till and bedrock are dissected by a broad valley, generally floored in gravelly ice-contact sediments. The basin contains one lake (Laughing Jacobs Lake), numerous wetland complexes, including sphagnum bog wetlands (Wetlands 26 and 34 [also referred to as Queen’s Bog]), and is drained by Laughing Jacobs Creek and five smaller streamsThe creek flows southwest from the Sammamish Plateau to a steep canyon reach, ultimately discharging to Lake Sammamish in Issaquah.

Wetland 26 lies at the headwaters of the Laughing Jacobs Creek system and provides seasonal storage and release of stormwater to the creek. The 1994 King County *East Lake Sammamish Basin and Nonpoint Action Plan* (King County, 1994) describes Wetland 26 as a 37-acre number-one-rated wetland that consisted of three vegetative subclasses. In particular, the northeastern corner of the wetland was identified as a subclass that is extremely sensitive to hydrologic change. The remainder of the wetland was historically tilled and ditched for agricultural use. Additionally, Queen’s Bog was identified as a number-1-rated 17.5-acre wetland with four vegetative subclasses, one of which was considered very sensitive to hydrologic and chemical disturbances. At the time, the wetland was extensively developed on the southern and eastern perimeters, and a gas line bisected the wetland from north to south (King County, 1994).

Although Beaver Lake and areas that drain to Beaver Lake are the headwaters for Laughing Jacobs Basin, they are excluded from the Laughing Jacobs Basin Plan and therefore are not included in this monitoring plan.



Legend

- 🟥 Laughing Jacobs Basin
- 🟦 Lakes
- Streams
- ▨ Wetlands
- ☐ City Limits
- Contours

Laughing Jacobs Basin

Sammamish, WA

Geosyntec
consultants

Seattle, WA

23-Jul-2019

Figure

1

Path: Z:\Clients\Sammamish City of\Projects\PNW0373 Laughing Jacobs\Analyses Technical\GIS\WQ Fig1 Watershed.mxd

2.2 Previous Monitoring

The Laughing Jacobs Basin was previously studied as part of the *East Lake Sammamish Basin Plan and Nonpoint Action Plan* (King County, 1994). In that study, several development-related concerns were noted in the Laughing Jacobs sub-basin, including erosion and sediment deposition in stream channels, flooding over roads, and degraded water quality with nutrient and bacteria exceedances in surface water bodies. Several high-quality wetlands were also identified in the basin and were considered sensitive to human disturbance and fluctuations in water level.

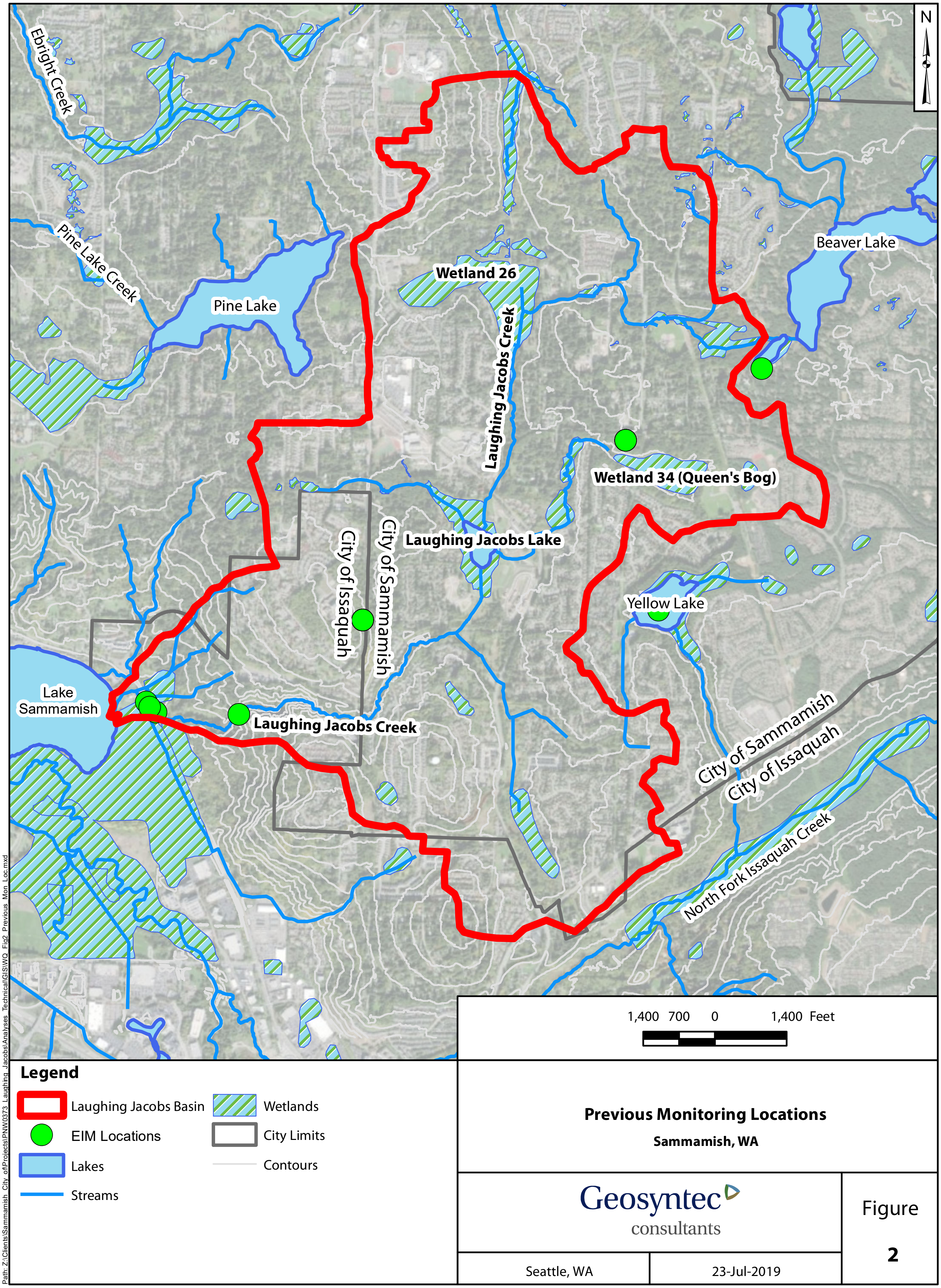
King County has historically conducted water quality monitoring at several locations within the Laughing Jacobs basin (see Figure 2). The data are accessible through Ecology's Environmental Information Management System database (Ecology, 2019b). A summary of the data is provided in Appendix A.

Based on data collected for these studies, Laughing Jacobs Creek is listed as an impaired water body under Clean Water Act (CWA) section 303(d) for the following parameters (Ecology, 2016):

- Temperature (Listing ID 72595), based on data collected between 2006 and 2010;
- DO (Listing ID 47948), based on data from 2003 and 2004;
- Bacteria (Listing ID 15755), based on data from 1987 through 2012; and
- Bioassessment (Listing ID 70115), based on data 2006 through 2010.

Water bodies that are listed under CWA 303(d) are also known as Category 5 water bodies under Washington's Water Quality Assessment categories. A Category 5 water body is defined as a polluted water body that requires a water improvement project (Ecology, 2018).

No recent water quality monitoring has been completed in Laughing Jacobs Lake, Wetland 26 or Queen's Bog.



Previous Monitoring Locations

Sammamish, WA

Geosyntec
consultants

Seattle, WA

23-Jul-2019

Figure

2

Path: Z:\Clients\Sammamish City of\Projects\PNW0373 Laughing Jacobs\Analyses Technical\GIS\WQ Fig2 Previous Mon Loc.mxd

3. MONITORING DESIGN

3.1 Water Quality Monitoring Team

The Water Quality Monitoring Team is led by the City of Sammamish working in partnership with consultants from Geosyntec Consultants (Geosyntec). The laboratory analysis will be performed by Fremont Analytical, Inc. located in Seattle, Washington. Members of the Water Quality Monitoring Team and associated responsibilities are outlined in Table 1. Water Quality Monitoring Team staff may be added or replaced as needed.

Table 1. Water Quality Monitoring Team

Organization	Role	Name	Responsibilities
City of Sammamish (Client)	City Project Manager	Danika Globokar, PE	• Reviews and approves consultant work. • Provides overall project direction and guidance. • Makes decisions related to day-to-day project execution. • Elevates project issues to City Management as needed.
Geosyntec (Consultant)	Consultant Project Manager	Christian Nilsen, PE	• Leads consultant team. • Controls consultant budget and schedule. • Escalates project issues to Geosyntec Project Director as needed.
	Consultant Project Director & Senior Technical Advisor	Eric Strecker, BCEE	• Oversees Consultant Project Manager. • Provides technical expertise.
	Water Quality & Monitoring Task Lead	Adrianna Jarosz, PE	• Coordinates technical work for water quality monitoring task. • Performs peer-review on interim and final work products. • Ensures that protocols are followed in accordance with the SAP/QAPP.
	Water Quality Scientist	Rich Wildman, PhD	• Project support staff. • Set up monitoring stations. • Conduct water quality monitoring and sample collection. • Assist with data management and reporting. • Perform QA/QC procedures for field data.
	Water Quality Scientist	Joel Prock	

Organization	Role	Name	Responsibilities
Fremont Analytical (Laboratory)	Laboratory Project Manager	Brianna Barnes	• Performs analyses on water quality samples. • Ensures that laboratory QA/QC procedures are performed.

3.2 Proposed Monitoring Locations and Parameters

Four new water quality monitoring locations in the basin are proposed, as shown in Figure 3. Two monitoring stations will be located within sphagnum bogs (Queen's Bog and Wetland 26). Two additional monitoring stations will be in Laughing Jacobs Creek, one at an upstream and one at a downstream location. A fifth ambient air monitoring location has also been identified for collecting barometric pressure data; ambient air pressures will be used for calculating water levels in conjunction with pressure transducer data from the continuous monitoring sensors[1].

Table 2 provides a summary of locations and parameters. Each of these are discussed in detail in the sections below.

Table 2. Proposed Monitoring Locations and Parameters

Location Number	Location Name	Parameters Monitored		
		Continuous Monitoring Sensors	Field Measurements	Grab Samples
1	Queen's Bog	Stage, Temperature	Stage, Temperature, Specific Conductance, pH	Inorganic Anions, Metals, Ammonia, Carbonate + Bicarbonate
2	Wetland 26			
3	Laughing Jacobs Creek Upstream			None
4	Laughing Jacobs Creek Downstream			None
5	Ambient Station	Barometric pressure, Air temperature	None	None

Notes: Anions analysis will include nitrate + nitrite, orthophosphate, sulfate, and chloride ions.
Alkalinity analysis will include carbonate and bicarbonate ions.
Metals analyses will include potassium, sodium, calcium, magnesium and aluminum

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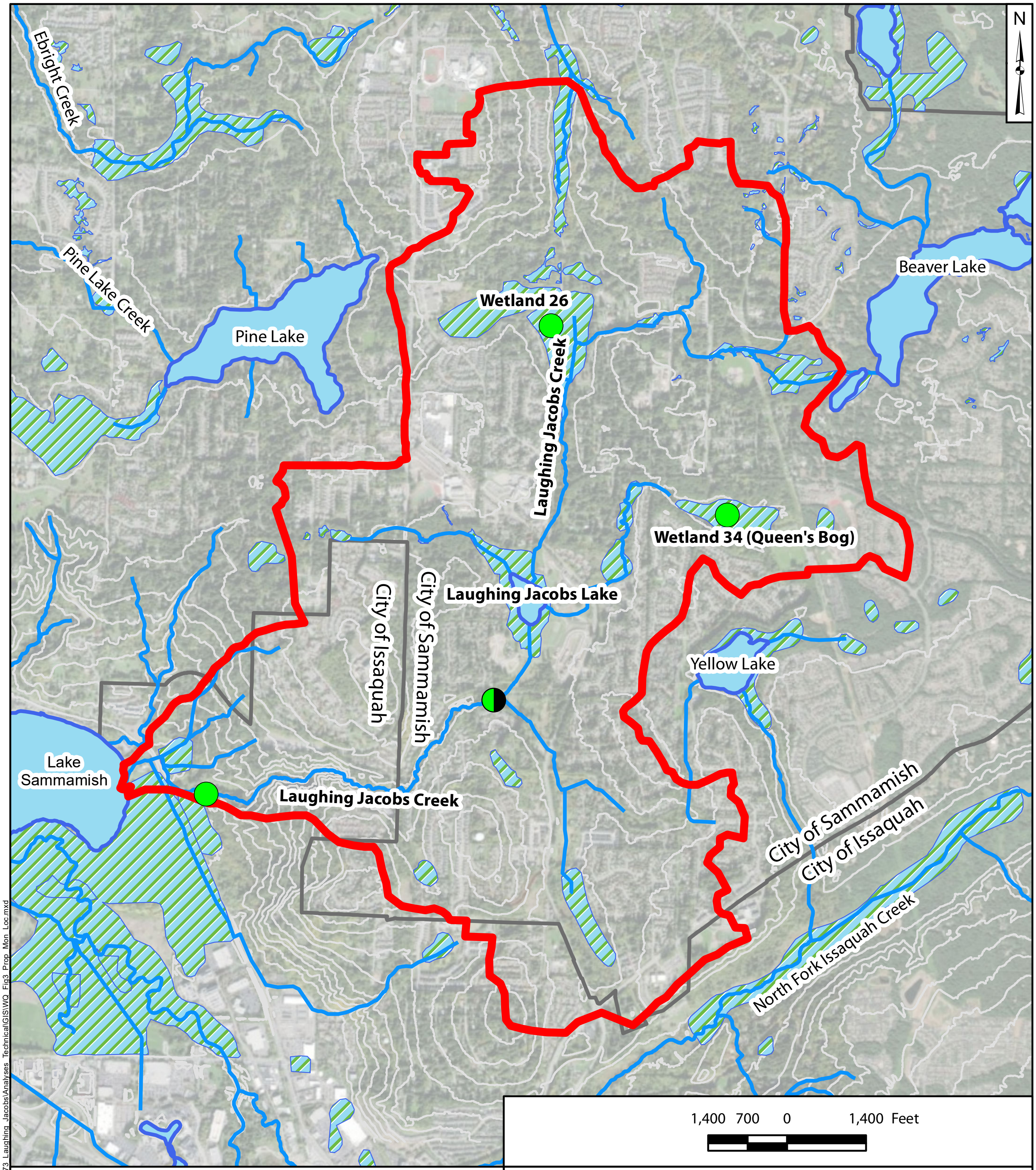
[1] King County will also be conducting a separate monitoring program, outside the scope of this SAP/QAPP, for assessing additional parameters including B-IBI within Laughing Jacobs Creek. The approximate location of the two B-IBI monitoring locations are shown in Figure 3.



Legend

●	Proposed Monitoring Locations	🟦	Lakes
◐	Proposed Monitoring Locations with Barometric Air Pressure Monitoring	—	Streams
🟥	Laughing Jacobs Basin	▨	Wetlands
		☐	City Limits
		—	Contours

Note: Proposed monitoring locations are approximate and are subject to change upon evaluation of field conditions.

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Proposed Monitoring Locations

Sammamish, WA

Geosyntec
consultants

Seattle, WA

25-Jul-2019

Figure

3

3.2.1 Continuous Monitoring

Continuous monitoring sensors for water level and temperature will be installed at a total of four water monitoring stations. Staff plates will be installed at each of the stations to validate the water level measurements provided by the sensors; these manual water level measurements will be collected when field measurements are taken as described in Section 3.2.3. Additionally, one sensor for measuring ambient air barometric pressure will be deployed at a fifth location as a reference for the four water level sensors. Additionally, one sensor for measuring ambient air barometric pressure will be deployed at a fifth location as a reference for the four water level sensors.

Water level and temperature readings will be continuously monitored at 5-minute time steps using vanEssen TD-Diver DI801 (or equivalent) pressure transducers. Four sensors will be deployed in the monitoring locations depicted on Figure 3 and one barometric sensor will be deployed nearby to allow for pressure adjustment due to atmospheric pressure. These sensors use the pressure differential created between the water above the sensor and the barometric sensor to determine the relative water level. The DI800 provides water level readings at a resolution of 0.03 cmH_2O and an accuracy of ±0.5 cmH_2O and temperature readings at a resolution of 0.01 °C and an accuracy of ±0.1 °C. More information, including the DI800 product manual, is provided in Appendix B.

The pressure transducers will be placed in stilling basins made of perforated PVC piping used to protect the sensor. A rope or flexible metal wire will be used to attach the sensor to the stilling basin. During field data collection, the sensor will be raised using the rope or wire and the readings will be downloaded from the device. The continuous monitoring sensors will be deployed in accordance with manufacturer instructions (see Appendix B) and in general accordance with Ecology's *SOP EAP080, Version 2.1: Continuous Temperature Monitoring of Freshwater Rivers and Streams* (Appendix C).

A USGS-style staff gauge will be installed alongside each pressure transducer to allow manual measurements and calibration of sensor readings. An example installation is shown in Figure 4. The staff plates will be installed in general accordance with Ecology's *SOP EAP042, Version 1.2: Measuring Gage Height in Streams* (Appendix C).

Figure 4. Example monitoring station showing staff gauge and stilling well installation.

3.2.2 Water Quality Grab Sampling

Periodic grab samples will be collected at the two Sphagnum bog wetland stations. Proposed parameters have been selected based on a review of previous studies on the chemistry of acid peatlands. Sphagnum bogs are characterized by low pH combined with low cation concentrations (Kulzer et al. 2001). Low pH in these types of wetlands is due to influence of slightly acidic rainwater combined with decomposition of sphagnum moss. Acidity is further buffered by soil minerals, of which aluminum appears to play an important role (Rocchio et al. 2014). In urbanized areas, eutrophication of wetlands from increased nutrient inputs can alter water chemistry and plant communities. The parameters in Table 3 are proposed for grab sampling.

Table 3. Grab Sampling Parameters

Category	Parameters	Method	Justification
Inorganic anions	Nitrate + Nitrite, Chloride, Ortho-Phosphate, Sulfate	EPA 300.0	Evaluation of acid-forming chemistry. Evaluation of nutrient inputs.
Metals	Aluminum, Calcium, Magnesium, Sodium, Potassium	EPA 200.8	Cation chemistry and pH buffering
Carbonate & Bicarbonate	-	SM 2320B	Hardness and Cation availability

Category	Parameters	Method	Justification
Ammonia	-	SM 4500-NH_3	Toxicity and eutrophication.

3.2.3 Field Measurements

Field measurements will be recorded during the same periods at which grab samples are collected. Stage will be measured using the staff gauges described in Section 3.2.1. Temperature, specific conductance, and pH will be measured using a Hanna HI991300 Portable Meter. A description of the field parameters is below:

- Stage: Stage will be measured from the staff gauge and used to validate or calibrate the water level sensors.
- Temperature: Temperature will be measured with the Hanna meter and will be used to validate or calibrate the temperature readings provided by the water level sensors.
- Specific Conductance: Specific conductance will be measured with the Hanna meter; this value will be compared to typical values obtained from literature.
- pH: pH will be measured with the Hanna meter; this value will be compared to typical values obtained from literature.

3.3 Proposed Monitoring Schedule

Proposed monitoring is expected to begin in August 2019. Field monitoring visits are scheduled to occur on an approximately bimonthly basis during which field measurements, grab sampling, and continuous monitoring sensor data downloads will be conducted. A tentative schedule is provided in Table 4.

Table 4. Proposed Monitoring Schedule

Date*	Activity
August 1, 2019	Installation of water level meters, barometric air sensor, staff plates, and supporting equipment (e.g., posts, perforated PVC, etc.)
September 2019	Site visit: continuous monitoring data download, grab sampling, and field measurements
November 2019	
January 2020	
March 2020	
May 2020	
July 2020	
September 2020	

November 2020	
December 2020	Decommissioning of monitoring stations

*All dates are approximate and are subject to change given time or accessibility conflicts.

4. FIELD EQUIPMENT

The following section details the field equipment that will be needed to execute this SAP/QAPP. Personnel using field instruments are expected to read and be thoroughly familiar with the instruction manuals for all field instruments and equipment.

4.1 Field Equipment Checklist

A checklist of recommended field equipment needed to complete this water quality monitoring effort is included in Appendix B.

5. FIELD METHODOLOGY

5.1 Safety

Safety is of the utmost importance when collecting field measurements and samples. Access to sampling locations may become hazardous depending on weather conditions, accidents, construction, or other situational dangers. The presence of animals, suspicious persons, or poisonous plants may also limit accessibility. Field staff should follow their internal safety plans and immediately report any issues to the Water Quality and Monitoring Task Lead.

Proper clothing should be worn based on the field work to be performed. Gloves should be worn to avoid exposure to potential water contaminants and to prevent cross-contamination between monitoring locations.

5.2 Continuous Monitoring Sensor Data Download Procedures

Continuous monitoring sensor data will be downloaded periodically by field staff during visits to each of the four monitoring stations. Data from the barometric pressure sensor will also be downloaded during these monitoring events. Manufacturer's instructions for sensor data downloads are provided in Appendix B.

5.3 Surface Water Field Measurement Procedures

Field measurements for temperature, specific conductivity, and pH will be conducted at each of the four monitoring stations using handheld water quality meters. Field measurements will be collected in general accordance with Ecology's *SOP EAP108, Version 1.10: Collecting In Situ Water Quality Data* (Appendix C).

5.3.1 Equipment Calibration

Calibration of handheld water quality meters used in the field will be calibrated in accordance with manufacturer instructions (Appendix B).

5.3.2 Equipment Decontamination

Handheld water quality meters and associated field equipment will be decontaminated with a phosphate-free detergent, rinsed with distilled water, and dried between monitoring locations. Consumables will be designated to one monitoring location and will be disposed of between locations.

Proper decontamination procedures will assist with meeting the project data quality objectives and reduce the likelihood of spreading invasive species (see discussion in Appendix A).

5.4 Surface Water Sample Collection Procedures

Surface water samples will be collected from the monitoring locations in general accordance with Ecology's *Stream Sampling Protocols for the Environmental Monitoring and Trends Section* (Appendix C). Sample containers, preservation and holding times have been specified by the lab and are outlined in Table 5.

5.5 Potential Challenges and Contingencies

5.5.1 Logistical Problems

Field planning prior to each monitoring event should address potential logistical challenges. This may include having backup plans for malfunctioning monitoring equipment, having spare containers in case of accidental breakage of lab bottles, and evaluating how to adhere to sample holding times (Table 5). Any encountered logistical problems should be discussed with the Water Quality and Monitoring Task Lead and addressed so as to minimize impacts to the monitoring scope of work.

5.5.2 Practical Constraints

Monitoring location accessibility may be impacted by weather or other extenuating circumstances. Field staff should abide by the safety plans and use good judgement during field work. The presence of hazards limiting the monitoring effort should be communicated to the Water Quality and Monitoring Task Lead. In the presence of unavoidable hazards, a monitoring location may be skipped. If a hazard is a permanent condition, relocation of the station may be evaluated.

5.5.3 Schedule Limitations

For the safety of the field personnel, monitoring fieldwork will only be performed during daylight hours. During winter months with shorter daylight hours, this may mean that field days in the winter are cut short and the work is continued the next feasible day.

Table 5. Sampling Containers, Preservation, QC samples and Holding Times

Sample Matrix	Analytical Parameter	Analytical Method	Number of Sample Containers	Sample Volume	Sample Container Material	Preservative	Field Duplicates	Temperature Blanks	Holding Time
Surface Water	Ammonia	SM 4500-NH_3	1	500 mL	Polyethylene	H_2SO_4	1 per 10 samples	1 per sample cooler	28 days
	Orthophosphate	EPA 300.0	1	1 L	Polyethylene	None			48 hours
	Nitrate + Nitrite	EPA 300.0							28 days
	Sulfate	EPA 300.0							
	Chloride	EPA 300.0							
	Alkalinity	SM 2320B							
	Aluminum	EPA 200.8	1	250 mL	Polyethylene	HNO_3			6 months
	Calcium	EPA 200.8							
	Magnesium	EPA 200.8							
	Sodium	EPA 200.8							
	Potassium	EPA 200.8							

6. FIELD DOCUMENTATION

6.1 Field Notebook and Forms

Field procedures will be documented in either a field notebook or in designated field forms. The notes will specify the monitoring locations, field measurements, observations and sample collection details. Deviations from the protocols outlined in this SAP/QAPP will be recorded in the field notes.

Hardcopy documentation of the data, such as field notebooks and forms, will be kept and maintained by the Water Quality and Monitoring Task Lead.

6.2 Photographs

Photographs should be taken at each location during each sampling event to document site conditions. Additionally, observations that seem out of the ordinary should be photographed and reported to the Water Quality & Monitoring Team Lead.

6.3 Sample Labeling

The sample label will include the sampling location name, the date, the time, analytes of interest, bottle preservatives (if any), and the initials of the sample collector.

Every sample will have a unique identification number associated with it. Each sample set will have the unique identification number written or printed on each bottle set using waterproof labels and indelible ink.

Samples will be labeled in accordance with the following naming convention:

Sample Location-Date

The date format to be used is *MMDDYYYY*.

6.4 Field Duplicates

A duplicate sample should be collected in either a side by side manner or immediately following the initial sample. This sample represents the total variability due to sample collection and laboratory analysis.

Duplicate samples will be named using the following convention:

Sample Location-Date-Dup

At least one duplicate sample will be collected for every 10 samples.

6.5 Temperature Blanks

Samples should be packed into coolers as soon as possible after collection. Temperature should be maintained below 4 degrees Celsius using ice. A temperature blank should be present in each cooler. The temperature blank will be submitted with the samples, and temperature will be measured in the blank to confirm proper chilling.

6.6 Chain of Custody

Chain of custody procedures will be followed for samples throughout the collection, handling and analysis process. A chain of custody form will accompany each set of samples delivered to the analytical laboratory. Each person who has custody of the samples will sign the chain of custody form and ensure that the samples are not left unattended unless properly secured.

7. LABORATORY DOCUMENTATION AND PROCEDURES

7.1 Laboratory Accreditation

Fremont Analytical is the laboratory selected for sample analyses. This laboratory is a Washington-accredited environmental laboratory for the target analyses; the laboratory accreditation has been confirmed by verifying the presence of the requested analytes in the Ecology Lab Search database entry for Fremont Analytical (Ecology, 2019c).

7.2 Laboratory Procedures

The laboratory measurement methods are listed in Table 6. This table includes the sample matrix, total number of anticipated samples, the analytical method approved by Ecology under the Laboratory Accreditation, and the Method Detection Limit (MDL) for each analyte. Special method modifications are not anticipated for the analytes outlined in this section however, if special method modifications are necessary (e.g., very high concentrations of an analyte that require atypical dilution procedures), these modifications will be clearly recorded and documented in the deliverables from the laboratory.

7.3 Laboratory Deliverables

Laboratory electronic data deliverables (EDDs) will be sent directly to Christian Nilsen (CNilsen@geosyntec.com) of Geosyntec. EDDs will include a copy of the chain of custody document, analytical results, and accompanying QA documentation from the laboratory.

Table 6. Laboratory Measurement Methods

Analyte	Number of Samples	MDL[1]	MRL[2]	Sample Preparation Method
Ammonia by SM 4500-NH$_3$ – *Surface Water Samples*				
Ammonia	8 total; collected bimonthly [09/2019 – 12/2020]	0.0109 mg/L	0.1 mg/L	Preliminary Distillation
Anions by EPA Method 300.0 – *Surface Water Samples*				
Nitrate + Nitrite	8 total; collected bimonthly [09/2019 – 12/2020]	0.000967 mg/L	0.1 mg/L	N/A
Orthophosphate	8 total; collected bimonthly [09/2019 – 12/2020]	0.00502 mg/L	0.2 mg/L	N/A
Sulfate	8 total; collected bimonthly [09/2019 – 12/2020]	0.00461 mg/L	0. 3mg/L	N/A
Chloride	8 total; collected bimonthly [09/2019 – 12/2020]	0.00242 mg/L	0.1 mg/L	N/A
Alkalinity by SM 2320B – *Surface Water Samples*				
Alkalinity	8 total; collected bimonthly [09/2019 – 12/2020]	1.25 mg/L	2.5 mg/L	N/A
Total Metals by EPA Method 200.8 – *Surface Water Samples*				
Aluminum	8 total; collected bimonthly [09/2019 – 12/2020]	21.8 ug/L	100 ug/L	ICP-MS Digestion
Calcium	8 total; collected bimonthly [09/2019 – 12/2020]	10.6 ug/L	100 ug/L	ICP-MS Digestion
Magnesium	8 total; collected bimonthly [09/2019 – 12/2020]	8.48 ug/L	100 ug/L	ICP-MS Digestion
Sodium	8 total; collected bimonthly [09/2019 – 12/2020]	10.3 ug/L	100 ug/L	ICP-MS Digestion
Potassium	8 total; collected bimonthly [09/2019 – 12/2020]	9.53 ug/L	500 ug/L	ICP-MS Digestion

[1] MDL = Method Detection Limit

[2] MRL = Method Reporting Limit

8. DATA MANAGEMENT

8.1 Data Assessment and Validation Procedures

Reports generated in the field and laboratory will be included as an appendix to the draft and final versions of the Water Quality Sampling Report.

The task lead will assure validation of the analytical data. The laboratory generating analytical data for this project will be required to submit results that are supported by sufficient backup and QA/QC data to enable the reviewer to determine the quality of the data. Validity of the laboratory data will be determined based on the objectives outlined in Appendix A. Data validity will also be determined based upon the sampling procedures and documentation outlined in this Sampling Plan. Upon completion of the review, the task lead will be responsible for assuring development of a QA/QC report on the analytical data. Data will be stored and maintained according to the standard procedures of the laboratory.

8.1.1 Performance Audits

Performance audits are an integral part of an analytical laboratory's SOPs and are available upon request.

8.1.2 Corrective Actions

If the QC audit detects unacceptable conditions or data, the project manager will be responsible for developing and initiating corrective action. The task lead will be notified if the nonconformance is significant or requires special expertise. Corrective action may include the following:

- Reanalyzing the samples, if holding time criteria permit;
- Resampling and analyzing;
- Evaluating and amending sampling and analytical procedures; and
- Accepting data and acknowledging level of uncertainty or inaccuracy by flagging the data.

8.2 Data Storage

Analytical data obtained from the laboratory, field notes, and other relevant documentation produced as part of this study will be stored on a secure cloud platform. This platform will be maintained by Geosyntec and made available to select staff from the City of Sammamish, Geosyntec, and ESA. All relevant data will be added to the draft and final version of the Water Quality Sampling Report as an appendix.

8.3 Data Reporting

Following completion of the monitoring program, a draft and final Water Quality Sampling Report will be prepared documenting monitoring efforts and data.

9. REFERENCES

King County, 1994. *Final East Lake Sammamish Basin Plan and NonPoint Action Plan.* King County (Lead Agency), Surface Water Management Division and Issaquah/East Lake Sammamish Watershed Management Committee. December.

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APPENDIX A

Supplementary Information

1. OVERVIEW

This appendix provides supplementary information for the SAP/QAPP document.

2. PREVIOUS WATER QUALITY STUDIES

Table 1 details previous water quality studies that have occurred in the Laughing Jacobs Basin.

Table 1. Previous Water Quality Studies

EIM Location ID	**08L070**	**KC_T_15c**	**KCM-A670**	**08LAK3879gr**	**08LAK3879**
Location Name	Laughing Jacobs Creek Near Mouth	Laughing Jacobs Creek at E Lk Samm Pkwy	Laughing Jacobs Creek - A670	Laughing Jacobs Creek	E Lake Sammamish Subbasin 3879
Location Description	About 100 yds North of the entrance of the Lake Sammamish State Park - Boat Ramp parking area off Rail-to-Trail bridge.	Laughing Jacobs Creek at E Lake Sammamish Pkwy	LAUGHING JACK CREEK/LAUGHING JACOBS CREEK/LAUGHING JACOBS CR ONE QUARTER MILE S OF SE 43RD WY ONE LK SAMM PARKWAY S	Laughing Jacobs Creek at Hans Jensen Youth Camp	Off E Lk Samm Pkwy in hans Jensen Youth Camp
Location Setting	Stream/River - channeled, flowing water	Stream/River - channeled, flowing water	Stream/River - channeled, flowing water	Stream/River - channeled, flowing water	Stream/River-Riffle: bottom of shallow, fast-moving section of stream/river
Lat, Long	47.56593633, -122.0528961	47.5653799, -122.0521202	47.565655, -122.05262	47.56535026, -122.045569	47.56535026, -122.045569
Associated EIM Studies	AMS001E: Routine ambient monitoring. To collect long-term water quality data from a state-wide network of stations. Thirteen conventional constituents are measured monthly at 84 stations. Metals are measured bi-monthly at some stations during some years. (http://www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html) AMS004: General environmental study. Collect diel continuous water and air temperatures statewide at most of Ecology's Ambient Stream Monitoring Stations (June - September). The data may be used to evaluate compliance with state water quality standards and interpret a station's monthly temperature data.	KC STREAM CONT TEMP: Routine ambient monitoring. Component of continuous hydrologic monitoring program of streams and rivers in King County.	KCstrm-1: Routine ambient monitoring. The streams and rivers program is designed to monitor the larger streams in King County that can be impacted by the wastewater collection, conveyance and treatment system (those with pipe crossings and/or wastewater facilities adjacent to the streams) and is very closely coordinated with the Major Lake Assessment Program. Sampling sites are primarily located in streams identified as the emergency overflow sites for King County Wastewater Facilities and are typically located at the stream mouth.	B-IBI Recalibration: This project will develop standardized monitoring tools and an ecosystem indicator which are two key Puget Sound Partnership goals. The key outcomes are (1) updated list of sensitive and tolerant taxa derived from empirical testing of data collected from Puget Sound lowlands; (2) a recalibration of the Puget Lowland Benthic Index of Biotic Integrity; (3) a cross-walk to reconcile data collection protocols; (4) application of EPA's Biological Condition Gradient framework to guide development of a freshwater ecosystem indicator; and (5) expanded analytical capabilities of the existing Puget Sound Stream Benthos database.	Ambient Monitoring: Routine ambient monitoring. King County Water and Land Resources Division collects annual benthic macroinvertebrate samples from approximately 150 stream locations within the Greater Lake Washington (WRIA 8) and Green-Duwamish River watersheds (WRIA 9). Between 2014 and 2016 we are adding up to 40 stream locations within the Snoqualmie watershed (WRIA 7). This sampling helps to characterize existing aquatic macroinvertebrate conditions, detect differences in biological condition between sub-basins, and identify changing trends over time. A random, probabilistic sampling design was used for site selection. KC AmBug: Routine ambient monitoring. King County Water and Land Resources Division collects annual benthic macroinvertebrate samples from approximately 150 creeks within the Greater Lake Washington (WRIA 8) and Green-Duwamish River watersheds (WRIA 9). This sampling helps to characterize existing aquatic macroinvertebrate conditions, detect differences in biological condition between sub-basins, and identify changing trends over time. A random, probabilistic sampling design was used for site selection.
Date Range	10/1/2003 - 9/19/2005	1/1/2011 - 1/1/2016	10/14/2014 - 12/12/2017	8/30/2011	8/16/2006 - 8/12/2014
Sample Sources	Outdoor air; Fresh/Surface water	Fresh/Surface Water	Fresh/Surface Water		Freshwater Taxonomy
Matrix Sampled	Air/Gas; Water	Water	Water	Solid/Sediment	Solid/Sediment
Number of Parameters	15: Ammonia, Barometric pressure, DO, DO (% saturation), Fecal coliform, Flow, Freshwater Quality Index, Nitrite-Nitrate, Ortho-Phosphate, pH, Phosphorus, Specific Conductivity, Temp (air), Temp (water), Total persulfate nitrogen, Total phosphorus, TSS, Turbidity	0	15: Alkalinity, Ammonia as N, Conductivity, DO, Fecal coliform, Nitrite, Nitrate, Nitrogen, Ortho, Phosphate, pH, Silica, Temp, water, Total persulfate nitrogen, Total phosphorus, TSS, Turbidity	1: Number of individual organisms	1: Number of individual organisms
Number of Samples/ Measurements	506	3	105	55	7
Number of Results Records	180		541		248
Time Series Data	716	242716: Temp, water			0

3. WATER QUALITY CRITERIA

3.1 Designated Uses

Chapter 173-201A of the Washington Administrative Code (WAC) specifies designated uses and water quality standards for surface waters in Washington State. Designated uses for Laughing Jacobs Creek are summarized in Table 2. Because Laughing Jacobs Creek is a feeder stream to Lake Sammamish, the use designations for the creek are considered the same as lake water uses (WSL, 2019a).

As identified in Table 2, Laughing Jacobs Creek is designated as a core summer salmonid habitat. Notably, Lake Sammamish and its feeder streams provide a habitat for a native population of kokanee salmon (*Oncorhynchus nerka*). The declining kokanee population in recent decades is attributed, in part, to urbanization within the watershed. Substantial residential development has occurred in the basin within the past 25 years, with additional re-development projects anticipated as the City of Sammamish continues to transition from rural to urban densities.

The key identifying characteristics of core summer salmonid habitat are: summer (June 15 - September 15) salmonid spawning or emergence, or adult holding; use as important summer rearing habitat by one or more salmonids; or foraging by adult and subadult native char. Other common characteristic aquatic life uses for waters in this category include spawning outside of the summer season, rearing, and migration by salmonids (WSL, 2019a).

Table 2: Designated Uses for Laughing Jacobs Creek

Category	Designated Uses
Aquatic Life	• Core summer salmonid habitat
Recreation	• Primary contact recreation
Water Supply	• Domestic water supply • Industrial water supply • Agricultural water supply • Stock watering • Wildlife habitat
Miscellaneous	• Fish harvesting • Commerce and navigation • Boating • Aesthetics

3.2 Applicable Water Quality Criteria

The applicable water quality criteria are discussed in this section and are summarized in Table 3. The designated uses of the water bodies in the Laughing Jacobs Basin are described in Section 3.1.

Table 3. Applicable Water Quality Criteria

Water Quality Parameter	Category/Use	Numeric Criteria	Source
Temperature	Aquatic Life: Core Summer Salmonid Habitat	≤ 16°C (60.8°F) for the 7-DADMax	WAC 173-201A-200 Table 200 (1)(c)
Dissolved Oxygen	Aquatic Life: Core Summer Salmonid Habitat	≥ 9.5 mg/L for the 1-day minimum	WAC 173-201A-200 Table 200 (1)(d)
Turbidity	Aquatic Life: Core Summer Salmonid Habitat	≤ 5 NTU with background ≤ 50 NTU ≤ 10% increase with background > 50 NTU	WAC 173-201A-200 Table 200 (1)(e)
Total Dissolved Gases	Aquatic Life: Core Summer Salmonid Habitat	≤ 110% of saturation at any point of sample collection	WAC 173-201A-200 Table 200 (1)(f)
pH	Aquatic Life: Core Summer Salmonid Habitat	6.5 – 8.5, with a human-caused variation within the above range of less than 0.2 units	WAC 173-201A-200 Table 200 (1)(g)
Bacteria	Recreation: Primary Contact Recreation	Fecal coliform: Geometric mean ≤ 100 colonies/100 mL, and ≤ 10% of samples > 320 colonies/100 mL* *E. coli:* Geometric mean ≤ 100 colonies/100 mL, and ≤ 10% of samples > 200 colonies/100 mL	WAC 173-201A-200 Table 200 (2)(b)
Toxic, radioactive, or deleterious material	General Criteria: Aquatic Life, Recreation, Water Supply, Miscellaneous	Concentrations below those which have the potential to adversely affect public health.	WAC 173-201A-260 (2)(a)
Aesthetic values		Should not be impaired by presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.	WAC 173-201A-260 (2)(b)

*Allowance of fecal coliform analysis to evaluate bacteria will expire on Dec 31, 2020.

3.2.1 Temperature

The temperature criteria for Laughing Jacobs Creek requires that the 7-day average of the daily maximum temperatures (7-DADMax) is less than 16°C (60.8°F) based on the beneficial use designations for the creek and contributing water features (WSL, 2019b). The 7-DADMax for any individual day is calculated by averaging that day's maximum temperature with the maximum temperatures for each of the three days prior and the three days after that date (Ecology, 2018).

3.2.2 Dissolved Oxygen

Sufficient levels of dissolved oxygen (DO) are required for kokanee survival. The Ecology numeric water quality standards for DO are expressed as a 1-day minimum. (Ecology, 2018). The applicable DO criteria for Laughing Jacobs Creek is a lowest 1-day minimum of 9.5 mg/L (WSL, 2019b).

3.2.3 Turbidity

Criteria state turbidity shall not exceed 5 NTU over background when the background is 50 NTU or less; or a 10 percent increase in turbidity when the background turbidity is more than 50 NTU (WSL, 2019b).

3.2.4 Total Dissolved Gases

Total dissolved gases (TDG) are measured in percent saturation. Gas supersaturation has the potential to impact fry survival and development. For core summer salmonid habitat, the TDG shall not exceed 110 percent saturation at any point of sample collection (WSL, 2019b).

3.2.5 pH

Measurement of pH is expressed as the negative logarithm of the hydrogen ion concentration. Water quality pH is assessed using either time series (continuous) or discrete (instantaneous/grab) sample event data. Time series monitoring data are preferable as it shows how the pH of a waterbody changes throughout the day (Ecology, 2018). Based on the use category, pH shall be within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 units (WSL, 2019b).

3.2.6 Bacteria

The bacteria criteria are intended to protect human health during recreational water contact in fresh waters. Historically, fecal coliform organism levels have been used to determine compliance with bacteria criteria. Organism levels can be expressed as colony forming units (CFU) or most probable number (MPN).

The freshwater recreation-based standard states that fecal coliform levels must not exceed a geometric mean value of 100 CFU/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 CFU/100 mL.

The use of coliform organism levels to determine bacteria compliance in fresh water will expire on December 31, 2020 and will be replaced by *E. coli* (WSL, 2019b). The presence of *E. coli* is indicative of fecal pollution and the possible presence of enteric pathogens. *E. coli* is a bacterium and is a common inhabitant of the intestinal tract of warm-blooded animals. The measurement of *E. coli* organism levels is a better bacterial indicator than fecal coliform analysis and can continue to be used for determining bacteria compliance into the future. The water criteria states that *E. coli* organism levels within an averaging period must not exceed a geometric mean value of 100 CFU or MPN per 100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained within the averaging period exceeding 320 CFU or MPN per 100 mL (WSL, 2019b).

3.2.7 Toxic Substances

WAC 173-201A-240 lists the water quality parameters known to be toxic to aquatic life and human health. Copper, zinc, and ammonia are toxic substances that may significantly impair the quality of water bodies.

Dissolved copper affects survival, growth, behavior, osmoregulation, and sensory function in salmonids. It is a potent neurotoxicant that directly damages the sensory capabilities of salmonids even at low concentrations. It can also cause adverse health effects in humans. The water criterion for copper based on human health is 1.3 mg/L; the criterion for aquatic life is dependent on hardness (WSL, 2019c).

Salmonids exhibit increased mortality rates in response to increased zinc concentrations (City of Issaquah, 2011). The human health criterion for zinc in freshwater is 1 mg/L (Ecology, 2018). The aquatic life zinc criterion is based on hardness and must be calculated (WSL, 2019c).

Ammonia toxicity rises with pH and temperature due to the increasing fraction of unionized ammonia that occurs with increasing pH and increasing temperature. Ammonia toxicity is also reported to increase when DO concentrations decrease (City of Issaquah, 2011). Ammonia is considered a toxic substance by the Washington Administrative Code; The water quality criteria calculation for freshwater ammonia concentration requires sample values for temperature and pH collected during the same sampling event (WSL, 2019c).

4. QUALITY OBJECTIVES

4.1 Data Quality Objectives

The overall data quality objective (DQO) is to collect representative samples and measurements indicative of water quality within the Laughing Jacobs basin.

4.2 Measurement Quality Objectives

Measurement quality objectives (MQOs) describe acceptable levels of error and variability in measurement processes and measured results. Indicators of data quality include precision, accuracy, sensitivity, bias, representativeness, comparability and completeness.

4.2.1 Precision

Precision is a measure of the reproducibility of data under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average value. For duplicate measurements, precision can be expressed as the relative percent difference (RPD). Five to ten percent field duplicates will be collected. A five to ten percent duplicate frequency will be carried out for laboratory samples.

Precision will be expressed as the relative percent difference (% RPD) between duplicate samples.

$$RPD\ (\%) = \frac{(x_1 - x_2)}{\left(\frac{x_1 + x_2}{2}\right)} \times 100 \qquad \text{where} \qquad x_1 = measurement\ of\ first\ parameter$$

$$x_2 = measurement\ of\ second\ parameter$$

A smaller RPD indicates more precise measurements. An RPD of 15% will be considered acceptable.

4.2.2 Accuracy

Accuracy is the measure of error between the reported test results and the true sample concentration. True sample concentration is never known due to analytical limitations and error. Consequently, accuracy is inferred from the recovery data from spiked samples.

Because of difficulties with spiking samples in the field, the laboratory will spike samples. The laboratory shall perform sufficient spike samples of a similar matrix to allow for computation of accuracy. For analyses of less than five samples, matrix spikes may be performed on a batch basis. Perfect accuracy is 100 percent recovery.

4.2.3 Bias

Bias is defined as the difference between the sample population mean and the true value of the parameter being measured. Bias is usually addressed by calibrating field and laboratory instruments, and by analyzing laboratory control samples, matrix spikes, and/or standard reference materials. Bias will be assessed by the laboratory based on analysis of method blanks.

4.2.4 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance, such as the method detection limit (MDL) or the measurement resolution. Targets for acceptable sensitivity of all field and lab measurements are listed in the main report.

4.2.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. This goal is achieved through the use of standard techniques to collect and analyze representative samples, along with standardized data verification and reporting procedures. Deviations from the protocols outlined in this SAP/QAPP will be investigated and documented.

4.2.6 Representativeness

Representativeness is a measure of how closely the results reflect the actual concentration of the chemical parameters in the medium sampled. Sampling procedures—as well as sample-handling protocols for storage, preservation, and transportation—are designed to preserve the representativeness of the samples collected. Proper documentation will confirm that protocols are followed. This helps to assure sample identification and integrity.

Laboratory method blanks will be run in accordance with established laboratory protocols to ensure samples are not contaminated during sample preparation in the laboratory.

4.2.7 Completeness

Completeness is the percentage of valid measurements or data points obtained, as a proportion of the number of measurements or data points planned for the project. Completeness is affected by such factors as sample bottle breakage and acceptance/non-acceptance of analytical results. To be considered complete, the data set must contain all Quality Control check analyses verifying precision and accuracy for the analytical protocol.

Completeness is then determined by the following:

$$Completeness\ (\%) = \frac{(Number\ of\ Valid\ Measurements)}{(Total\ Number\ of\ Measurements\ Planned)} \times 100$$

A target of 95% completeness will be considered acceptable. Any instances of variances will be investigated and documented.

5. INVASIVE SPECIES EVALUATION

Special care must be taken to prevent the spread of aquatic invasive species (AIS). AIS represent a threat to King County's native ecosystems (King County, 2016).

New Zealand mud snails, *Potamopyrgus antipodarum*, are freshwater invaders from New Zealand. They were first found in the United States in 1987. New Zealand mud snails have been in King County since at least 2009. They have since been discovered in Lake Washington tributaries and may also be present in the Laughing Jacobs Creek basin (King County, 2016).

These mud snails are a non-native species that have no natural predators, parasites, or diseases to control their populations in North America. They have little or no nutritional value to fish or other species. Studies have indicated that New Zealand mud snails can alter the chemistry of streams, disrupt the natural food chain, and drive out native stream insects.

New Zealand mud snails can multiply quickly and can easily be transported to new areas by people, wildlife and equipment. Once they are present in a stream or lake, it is impossible to get rid of them without seriously harming native species present.

Natural resource agencies throughout the western United States are concerned that these animals could further harm threatened or endangered salmon runs. In Washington, these mollusks are a "prohibited" species and their transport is prohibited by law (WSL, 2019d). In other words, it is illegal to carry them accidentally via muddy boots, tires, or fishing gear.

An identification guide for the New Zealand mud snails is provided in Attachment A. If any New Zealand mud snails are located during the completion of this monitoring, Attachment A will be referenced for adequate reporting of the findings to Ecology.

King County has published gear decontamination protocols to prevent the spread of New Zealand mud snails via wading gear and other sampling equipment. Gear and equipment decontamination protocols should be conducted in accordance with Ecology's *Standard Operating Procedure (SOP) EAP070, Version 2.2: Minimize the Spread of Invasive Species* (Attachment A).

6. REFERENCES

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ATTACHMENT A

New Zealand Mud Snail Information

DEPARTMENT OF
ECOLOGY
State of Washington

Standard Operating Procedure
EAP070, Version 2.2

Minimize the Spread of Invasive Species

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Purpose of this document

The Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures to Minimize the Spread of Invasive Species
Version 2.2

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Date – 2/21/2018

EAP070

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SIGNATURES ON FILE

SOP Revision History

Revision Date	Revision number	Summary of changes	Section	Reviser(s)
05/15/2009	1.0	Initial draft, formatting	All	Jenifer Parsons
11/ 2009		Add boat information		Keith Seiders
11/10/09		Revise to apply to all sampling		Jenifer Parsons
11/24/09		Review		Dave Hallock
01/04/10		Keith's comments		Jenifer Parsons
01/29/10		Address comments from committee		Jenifer Parsons
03/23/2010	1.0	Cover Page		Bill Kammin
02/13/12	2.0	Draft revision to combine moderate and extreme concern SOPs and to comply with Invasive Species Council SOP	All	Jenifer Parsons
04/30/2012		Change approval date	Cover	Bill Kammin
01/29/2016	2.1	Minor edits, update links	All	Jen Parsons
02/21/2018	2.2	Update links, minor edits	All	Jenifer Parsons

Table of Contents

Environmental Assessment Program

Standard Operating Procedures to Minimize the Spread of Invasive Species

1.0 Purpose and Scope

1.1 Environmental ethics and Washington law prohibit the transportation of all aquatic plants, animals, and many noxious weeds.. Specifically, it is a misdemeanor to "transport aquatic plants on any state or public road, including forest roads" or to "knowingly import, move within the state, or export" animals.

1.2 This document is the Environmental Assessment Program (EAP), Standard Operating Procedure (SOP) to minimize the risk of spreading any organisms, especially aquatic invasive species (AIS), within or between waterbodies or other field sites as a result of fieldwork, reconnaissance activities or other operations.

1.3 This SOP combines and implements the prevention and control measures identified in Ecology's Hazard Analysis and Critical Control Point (HACCP) Plans for conducting operations in Areas of Extreme Concern and Areas of Moderate Concern.

1.4 This SOP supersedes the Washington Invasive Species Council SOP "Reducing Accidental Introductions of Invasive Species." It covers all points considered in that protocol and is more stringent in some areas.

2.0 Applicability

2.1 This SOP covers all field operations.

2.2 These procedures also apply to contractors operating under contract to EAP. They don't apply to other organizations conducting joint field work with EAP.

3.0 Definitions

3.1 AIS – Aquatic Invasive Species: any freshwater or marine species that is not native to an ecosystem and whose introduction does or is likely to cause economic, human health, or environmental harm.

3.2 Areas of Extreme Concern –Areas of the state documented as having established Aquatic Invasive Species (AIS) that are considered to be a particular environmental or economic threat and hard to remove from sampling equipment, such as areas with New Zealand mudsnail (NZMS) populations. Most equipment and sampling gear used in these areas must undergo rigorous inspection and decontamination procedures to prevent accidental introductions to other waters. GIS layers of these areas are available for staff here http://awwecology/sites/itsoi/bsds/GIS/metadata/SitePages/environmentThemes.aspx, and images of the maps are on the EAP Field Training SharePoint site at http://teams/sites/EAP/Pages/FieldTraining.aspx. These layers are publically available through Ecology's website at ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/GIS-data#e

3.3 Areas of Moderate Concern –Areas of the state not documented as having established NZMS or other species of extreme concern. These areas may have other invasive species, including plants, animals, fish, invertebrates, and pathogens that should not be spread.

3.4 Decontamination – a method used to kill invasive species that may be lodged in or on equipment. These include drying, hot water wash, freezing and chemical treatments.

3.5 Ecology – Washington State Department of Ecology.

3.6 EAP – Environmental Assessment Program.

3.7 HACCP – Hazard Analysis and Critical Control Point. This is a systematic analysis tool used to identify the risks and the preventative procedures needed to significantly reduce the spread of aquatic species from our sampling equipment and operations.

3.8 Invasive Species – any organism that is not native to an ecosystem and whose introducation does, or is likely to cause, economic, human health, or environmental harm.

3.9 New Zealand mudsnail – This AIS from New Zealand has been spreading across North America since its introduction in the late 1980s. They are very small (<1/8 inch), and just one individual is capable of producing 230 juveniles per year. They are easily transported into uninfected waters by hitchhiking on waders or other aquatic equipment. They are considered an environmental and economic threat to the state (Washington Invasive Species Council, 2008).

3.10 Noxious weed – a plant included on the State Noxious Weed List. They are invasive, non-native plants that are a threat to the natural resources, ecology, and economy of Washington State. The list of noxious weeds and information about the State Noxious Weed Control Board is available at www.nwcb.wa.gov.

3.11 Equipment – This means all equipment that contacts water, sediment, plants, or the ground during site access, reconnaissance, and sample collection. Such equipment includes but is not limited to: wading boots or shoes, samplers, ropes, nets, boats, trailers, vehicles, anchors, chain, water and sediment grab samplers, cables, probes, multi-probes, flow measuring or gaging devices, and others.

3.12 Felt-soled waders – waders with any sort of fibrous surface affixed to the sole. They require decontamination because of their ability to trap and hold mud, vegetation, and moisture.

4.0 Personnel Qualifications/Responsibilities

4.1 Field operations require training specified in EAP's Field Safety Manual (Ecology, 2010) such as First Aid, CPR, and Defensive Driving, as well as training in field gear cleaning methods specified in EAP Procedure #1-15.

5.0 Equipment and Supplies

5.1 The following may be required, depending on the equipment used in sampling and the decontamination method being used:

5.1.1 Clean water supply (free of mud and debris)

5.1.2 Scrub brushes and bucket.

5.1.3 Hose adapters for flushing outboard boat motors.

5.1.4 Hand tools for attaching hoses or taking apart equipment if necessary.

5.1.5 If decontamination is required:

5.1.5.1 Treatment chemicals if that is the decontamination method to be used, along with a backpack sprayer, squirt bottle, tub, buckets, bags or other method to apply, contain, and transport chemicals.

5.1.5.2 Thermometer to monitor temperature of treatment if using hot water for decontamination.

5.1.5.3 Watch to monitor treatment times

5.1.5.4 Adequate supply of hot water if that is the decontamination method used.

6.0 Procedures

6.1.1 Note: a two-page procedure summary is at the end of this document

6.2 Planning - Prior to Conducting Field Work and During Field Work

6.2.1 **Determine if the field activity is located within an Area of Extreme Concern** by checking the current maps. GIS layer files and metadata are on the Ecology GIS intranet page at http://awwecology/sites/itsoi/bsds/GIS/metadata/SitePages/environmentThemes.aspx. Layer files can also be accessed on the GIS O drive in the environment folder as Areas_of_Extreme_Concern.lyr. Images of the maps are available in the EAP Field Training SharePoint site, http://teams/sites/EAP/Pages/FieldTraining.aspx. They are publically available on Ecology's website at ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/GIS-data#e.

If so, the extra decontamination step (section 6.2.1.2) will need to be followed for all equipment that contacted aquatic sediment, aquatic vegetation, amphibians or fish. (Note: felt-soled wading boots must be decontaminated no matter where they are used).

6.2.2 **Use equipment which can be easily inspected and cleaned** to both avoid spreading invasive species and reduce impacts to planned field schedules. If possible, bring extra sets of "back up" field equipment in case cleaning and decontamination (if required) can't be done in the field prior to arrival at a new sampling site. Where feasible, especially when working in areas of extreme concern, dedicate gear to be used only in that waterbody.

6.2.3 *Note: wading gear has been implicated in the spread of New Zealand mudsnails and other AIS as well as fish, amphibian, and plant diseases. Felt soles can be particularly problematic because of their tendency to stay moist for long periods. The laces and eyelets of lace-up wading boots can also be problem spots because they are difficult to clean. To the extent possible, consider using non-felt soles and boot-foot waders.* Because of these risks from felt-soled waders, they must go through the decontamination step (section 6.2.1.2) in all parts of the state.

6.2.4 Conduct field activities to **minimize contact between equipment and potential sources of invasive species**, particularly aquatic plants, sediment, amphibians and fish. This can include the following:

6.2.4.1 Sample from least to most contaminated areas, for example, sample upstream to downstream or from areas of less weed growth to dense weed growth.

6.2.4.2 Minimize wading and avoid running boats onto sediment.

6.2.4.3 Avoid getting plants, sediment, and fish or amphibians inside boats or other sampling gear.

6.2.4.4 Use a catch pan underneath dredges, etc., to keep potential AIS off boat decks and out of bilges.

6.2.4.5 Avoid driving or walking through areas of mud and high weed growth

6.3 After Field Work

6.3.1 Inspect, clean and if working in an area of extreme concern, decontaminate equipment – this step is divided into two parts:

6.3.1.1 ***First – inspect, clean and drain all equipment***

6.3.1.1.1 **Inspect and clean** all equipment that contacted (terrestrial or aquatic) soil, vegetation, or water. Remove any visible vertebrates, invertebrates, plants, algae or sediment. If necessary, use a scrub brush, and rinse with clean water either from the site or brought for that purpose. Continue this process until the equipment is clean. Be sure to clean the scrub brush as well. **Drain** all water in bilges, samplers or other equipment that could hold water from the site. Flush areas that can't be seen with clean water until the rinse water is clean. Information on cleaning boats and motors is in Attachment B.

6.3.1.1.2 Do the initial treatment (scrubbing and rinsing) before leaving the sampling site (if possible). If cleaning after leaving the field site, ensure that no debris will leave the equipment and potentially spread invasive species during transit or cleaning. Acceptable interim sites for cleaning include: Ecology OC or Regional Offices, commercial car wash businesses, or other facilities (e.g. WSDOT shops), provided drains do not lead to surface waters. A table with commercial car wash locations is available to Ecology employees on the Field Training SharePoint site at http://teams/sites/EAP/Pages/FieldTraining.aspx.

6.3.1.2 ***Second – decontaminate felt-soled waders and, in areas of extreme concern, equipment that contacted aquatic sediment, aquatic vegetation, amphibians or fish.***

6.3.1.2.1 **Wipe smooth surfaced sampling equipment that can be easily and fully wiped down until dry**. The equipment must be smooth enough so there are no cracks or crevices that could harbor a sand-grain-sized juvenile New Zealand mudsnail while being wiped dry.

6.3.1.2.2 **Use one of the decontamination treatments from Attachment A for all other equipment**. For additional information on cleaning boats and motors, see Attachment B.

6.3.1.2.3 Decontamination treatments should take place where the procedure can be carried out effectively and safely. Keep in mind that wash and rinse water must not drain to surface water, and all chemicals must be disposed of to a sanitary sewer.

6.4 Relaxing Requirements

6.4.1 Equipment should be cleaned whenever leaving a field site. However, decontamination procedures as described in this SOP need not be followed under the following circumstances.

6.4.2 Documented exceptions:

6.4.2.1 If procedures in this SOP are not workable for a particular project, exceptions may be documented and approved following QAPP guidance.

6.4.3 Moving short distances:

6.4.3.1 If moving by foot within the same watershed, equipment may be used without following procedures in this SOP. Keep in mind to work from upstream to down whenever possible. Procedures laid out in this SOP must be followed when leaving the area.

6.4.4 Sampling by boat:

6.4.4.1 When transiting by boat to different sites within a waterbody, procedures detailed in this SOP may not be necessary. However, when boating from site to site, don’t move water, sediment, organisms, nor vegetation on sampling gear, boat props, etc. Leaving the waterbody requires implementing this SOP.

6.4.5 Float Planes

6.4.5.1 In marine systems, the pontoons of float planes should not represent a problem and special cleaning should not be required unless motoring through weedy areas, in which case they should be visually inspected before taking off. Amphibious planes (with wheels) should be avoided because they are more likely to catch and transport material. The use of float planes and helicopters in freshwater is not covered in this SOP and should be explicitly addressed in the project QAPP; however, float planes should not be used between waterbodies with invasive plant species.

7.0 Equipment storage

7.1 When moving between field sites, and upon returning from the field, **store gear in a manner to facilitate drying**. For example, boots and waders should be stored on a drying rack until dry, not left in a gear bag; open hatches and leave out drain plugs on boats.

8.0 Special Considerations for Construction and Restoration Projects

8.1 Avoid moving weed infested gravel, rock, and other fill material to relatively weed-free locations. Gravel and fill should come from weed-free sources. Inspect gravel pits and fill sources to identify weed-free sources.

8.2 Identify and remove existing noxious weeds in areas of construction to avoid contaminating construction equipment

8.3 Minimize ground-disturbing activities

8.4 Use only certified weed-free straw and mulch for erosion control

9.0 Quality Control and Quality Assurance Section

9.1 Follow the procedures of this SOP.

10.0 Safety

10.1 Follow all EA Program Safety Manual procedures. Take precautions if using hot water for decontamination to avoid burns.

10.2 Material Safety Data Sheets (MSDSs) for all chemicals used in EAP field sampling or analytical procedures can be found at the following SharePoint link: http://teams/sites/EAP/QualityAssurance/ChemicalSafetyDataSheets/Forms/AllItems.aspx.

Also, binders containing MSDSs can be found in all field vehicles, vessels, Ecology buildings, or other locations where potentially hazardous chemicals may be handled. EAP staff following Ecology SOPs are required to familiarize themselves with these MSDSs and take the appropriate safety measures for these chemicals.

11.0 References and Related Documents

11.1 Ecology, 2016. Environmental Assessment Program Safety Manual. Olympia, WA. 168 pp.

11.2 Ecology, 2018. Chemical hygiene plan and hazardous material handling plan. Olympia, WA.

11.3 Washington Invasive Species Council. Invaders at the Gate: Washington Invasive Species Council 2008 Strategic Plan. www.invasivespecies.wa.gov/documents/InvasiveSpeciesStrategicPlan.pdf

11.4 10.4 Reducing Accidental Introductions of Invasive Species: State Agency Field Work Protocols

www.invasivespecies.wa.gov/documents/invasive%20species%20prevention%20protocol.pdf

11.5 Environmental Assessment Program Policy on Minimizing the Spread of Aquatic Organisms. EAP Procedure 1-15. *(Requires all EAP field work to follow approved procedures for minimizing the spread of aquatic organisms.*)

11.6 RCW 77.15.290: Unlawful transportation of fish or wildlife — Unlawful transport of aquatic plants — Penalty.

11.7 Washington Weed Laws: links to three laws pertaining to noxious weed and quarantine laws www.nwcb.wa.gov/ab_weedlaws.htm

Attachment A – Decontamination treatment options

Decontamination employs chemicals, freezing, drying, or hot water. While chemical treatments can be used, they are not generally recommended for most equipment, boats, and trailers. The effects of chemical treatments on some equipment have yet to be researched. Several of the chemicals contain ammonia compounds that could contaminate ammonia samples. Also, chemical treatments need to address safe and environmentally sound storage, handling, and disposal of the chemicals.

The treatment options listed in Table A-1 utilize temperature (heat or cold) or chemicals to ensure that contaminants such as New Zealand mudsnails that may have been missed during the initial treatment will be killed. At this time, hot water or drying are the recommended treatments for large equipment such as boats and boat trailers. Additional information about hot water sources and treatment methods is provided in Figure A-1 on the next page.

Table A-1. Options for decontaminating equipment that has contacted sediment, aquatic vegetation, amphibians or fish in areas of extreme concern.

Treatment	Concentration or temperature	Exposure Time	comments
hot water wash or soak (**see Figure A-1**)	60° C (140° F)	5 minutes for felt-soled boots and nets; 10 sec for all other equipment	Ensure all parts of the equipment reach temperature for the full exposure time
	49° C (120° F)	10 minutes for felt-soled boots and nets; 5 minutes for other equipment	Ensure all parts of the equipment reach temperature for the full exposure time
cold	-4° C	4 hours minimum	Time starts after the equipment reaches -4 °C
drying	low humidity, in sunlight is best	48 hours	Time starts after the equipment is thoroughly dry
Formula 409 Antibacterial All-Purpose Cleaner[1]	100% (full strength)	10 minutes	Follow proper procedures for storage and handling.
Green Solutions High Dilution 256[2]	3.1% or higher	10 minutes	Follow proper procedures for storage and handling.
Quat 128	4.60%	10 minutes	Follow proper procedures for storage and handling.
Hydrogen peroxide[3]	30,000 ppm (3%)	15 minutes	Spray on until soaked, then keep damp for contact time (cover or place gear in a dry bag)
Virkon Aquatic®	2%	20 minutes	Must soak (not spray on) Follow proper procedures for storage and handling[4]

[1] Must be antibacterial (make sure it has quaternary ammonia, otherwise it is ineffective)

[2] Corrosive; read the MSDS and use with caution (replaced Sparquat 256).

[3] May be corrosive; read the MSDS and follow safety precautions

[4] Rinse gear after soak to prolong life. Solution degrades, lasts up to 7 days, best if mixed fresh

Note: All chemicals must be disposed of to a sanitary sewer.

Figure A-1 Sources and methods for treating equipment with hot water

Hot Water Sources

- Hot tap water is available at EAP's OC in the Skookum Bay. (Note: Tap water at the Spills Program washdown bay by the HQ loading dock can be used for rinsing, but it is not hot enough to meet decontamination requirements.)
- A hot water pressure washer is available at EAP's OC (special training required).
- Other facilities may have hot water, such as Ecology's regional offices, WSDOT shops, and local government maintenance facilities.
- A portable hot water heater is available at the OC. The system uses propane to power an on-demand heater. It may be difficult to maintain 60° C with this equipment in the field. It is recommended to use the wask/soak times for 49° C (Table A-1) to ensure proper decontamination when using the portable hot water heater.
- Car washes can be used for rinsing and cleaning, but are not an option for decontamination: the water is not hot enough to kill aquatic organisms.

Treating Equipment with Hot Water

- Wear appropriate personal protection equipment to prevent burns to self and others.
- Avoid or protect parts of equipment that might be damaged by hot water.
- Ensure that the water is at least 60° C at the discharge side of whatever's being treated.
- Flush for at least 10 seconds for all equipment except felt soles and nets; 5 minutes for felt-soled boots and nets at 60° C (10 minutes at 49°C)
- After treatment, ensure equipment drains and dries before re-stowing equipment.

Attachment B – Additional Cleaning Information

Use one of the decontamination options in Table A1 if needed.
HOT WATER is preferred for decontaminating boating equipment at this time.

Felt Soled Waders

Felt soles can trap aquatic organisms and hold moisture that can sustain them for long periods.

1. First, rinse and brush soles to remove visible mud and debris.
2. Then use one of the treatment options in Table A-1.
3. Hot water, freezing or drying are recommended because they are effective against the widest variety of species and don't involve chemicals.
4. If hot water, freezing, or drying are not possible, choose a different option from Table A-1. Hydrogen peroxide is inexpensive, readily available, and relatively innocuous to humans and the environment; however, its effectiveness at killing organisms besides New Zealand mudsnails is not clear.

Hydrolabs

Cleaning recommendations for Hydrolabs that are deployed in areas of Extreme Concern and contact aquatic sediment or vegetation

1. Follow procedures in section 6.2.1.2.1 (wipe smooth surfaces until clean and dry). Decontaminate any parts of the hydrolab that can't be wiped clean of sand grain-sized particles using one of the methods listed in Table A-1
2. Parts of the hydrolab that can not withstand those methods (the probes) should be soaked in the low pH buffer solution (pH 4) overnight. (PH 4 buffer is the recommended storage solution.)

Boat Trailers

1. Flush all interior and exterior surfaces of trailers, wheels, and tires until clean. Interior surfaces are the inside of the trailer's metal tube framing.

Boat Hulls: Exterior and Interior

1. Remove gear as needed (e.g. deck mat, dip nets, net anchors, boat anchor and line, ropes) to provide access to all areas of the boat to allow for effective cleaning.
2. Wash down the boat working from bow to stern, and top to bottom. Flush all nooks and crannies to get at all areas where aquatic species may have gotten into. Wash all boat-related gear.
3. Wash all bilge areas where accessible using hot water, working from bow to stern. However, do not flush the bilge of the jet sled with hot water because of the fuel tank located there.
4. Raise bow of boat for effective draining of water and muck that gets into bilge. Work all of the bilge water, sediment, and muck out of drain on transom.

5. Flush all interior and exterior thru-hull pipes and screens. These may be located on the bottom of the hull, on the transom, or inside the hull (e.g. Skookum's strainers for washdown pumps and engine cooling system). Try backflushing bilge pumps by introducing water into the bilge pump discharge port (on transom or hull exterior) and check to see if water flows through the bilge pump and into the bilge.
6. If using hot water or chemicals on inflatable boats, ensure that such treatments won't damage the boat's material or adhesives

Boat Engines: Propeller and Jet Pump

Boat engines pump ambient water through them for cooling and can pick up and harbor unwanted material – which may be transported to another waterbody. While most boat engines have fine-mesh screens (~2 mm) that can prevent debris from getting into the engine, sand and mud particles may pass through. Jet-pump engines operating in shallow waters often move sediment and fine debris through the cooling passages, so more effort is needed to clean jet-pump engines. The external parts of engines can also collect weeds or other debris, especially propellers and other parts submerged in the water. Clean external parts of engines to remove all visible debris. Clean internal parts of engines by flushing with water as described below.

- Some engines have an adaptor that accepts garden hoses (electrofisher, jet sled, and Whaler #2). Connect hose or adaptor and run water through the engine. Check to ensure that water is reaching and running from the cooling water pump intake areas.
- Some engines need the "ear muff" type flushing adaptor (many smaller engines): Connect hose to adaptor and attach adaptor to the engine. Turn on water. Start engine and let run at idle speed.
- Some engines have no flushing adaptor (some smaller engines): Mount the engine so that the lower unit can be submerged in a large container (e.g. 18 gallon tote) filled with water. Start engine and let run at idle speed.

NOTE that all engines can be run while being flushed with cold water. However, running some engines while flushing with hot water could damage the engine, so DO NOT run engines while flushing with hot water. The exception to this is the electrofishing boat's outboard engine and generator – these may be run while flushing with hot water (monitor temperature for possible overheating condition). Many engines can be flushed with hot water as long as the engine is not run at the same time.

Table B-1 at the end of this section shows all of EAP's boat engines, their location, and the method needed for flushing each engine (electric motors excluded).

Electrofishing Boat: Fish Tank, Outboard, Generator, Pumps, and Plumbing Systems

Fish Holding Tank (Live Well)

1. Remove all standpipes and screens to get at trapped muck.
2. Wash interior thoroughly using scrub brush, and hot water (60° C; 140° F).
3. Soak and scrub all standpipes and screens with hot water.
4. Let washwater and muck drain out of tank through transom.
5. Flush the fish tank fill pump and its plumbing with hot water for five minutes. To do this, remove access cover located inside live well on starboard side aft. Place hose through access and into tall stand pipe. Hot water will flush through the fish tank fill plumbing and pump, and out through the hull intake. While flushing, turn on fish tank fill pump for five seconds to stir out any debris. <u>Do not run fish tank fill pump for extended period of time, because this could burn up pump.</u>
6. Decontaminating the recirculation pump can be skipped. The recirculation pump has been decommissioned and no longer in use. If the recirculation system becomes operational in the future follow these procedures: once fish tank and fish tank pump are thoroughly cleaned, fill fish tank with 4” of hot water and operate the recirculation pump for five minutes to help flush system of debris. If needed, remove and clean aerator (sprinkler) heads located in upper corners of live well.

Outboard Engine

1. Use 13mm socket and ratchet to unscrew and remove water intake bolt located on the lower jet unit, near jet pump bearing zerk fitting (see pictures 2A-2C below). Next, hand screw outboard flushing adapter to lower jet unit. Do not over tighten adapter to lower jet unit; finger tight is okay. Attach water hose to outboard flushing adapter.
2. Turn on water supply with the outboard engine off. Water will begin to spill out lower jet unit and seams.
3. Turn on “Outboard Cranking Battery” selector located on stern (ensure water is on and spilling out of jet unit).
4. Turn outboard engine on, and run at idle speed. Outboard ignition key is located on throttle control box, port side of diver’s console. Note: <u>Do not run the outboard above idle speed. Throttle controller should be in neutral position.</u> Ensure idle lever is all the way down, do not increase RPMs.
5. With the outboard engine on, water will discharge from the lower jet unit, seams, and indicator pilot hole located on starboard side of engine. At this point, water is flushing through entire cooling system.
6. Once flushing is complete, turn off outboard engine. Next, turn off “Outboard Cranking Battery” selector located on stern.
7. Turn off water, and disconnect hose and adapter from lower jet unit.

8. Replace water intake bolt on lower jet unit.
9. **Note**: If flushing the outboard engine with hot water, you may notice grease seeping out from "Excess-Grease Exit Hose" (see picture 2A), this is normal. If grease seeps out, apply an adequate amount of grease using electrofishing boat grease gun. Pump enough grease to just fill the exit hose.

Generator

1. Unscrew "Generator Raw Water Strainer" located on the port side of dirver's console (see picture 3A below). Remove mesh strainer from strainer cup. Rinse out debris from strainer and strainer cup. Ensure not to lose strainer cup o-ring during rinsing. After rinsing is complete, replace mesh strainer back into strainer cup, and attach strainer cup to port side of driver's console – do not bend edges of mesh strainer while attaching to driver's console.
2. Next, use 11/16" open end wrench to unscrew "Generator Test Water" fitting pipe plug located on the base of generator cover, port side aft (see pictures 3B-3C). Next, hand screw generator flushing adapter into "Generator Test Water" fitting. Do not over tighten; finger tight is okay. Attach water hose to the generator flushing adapter.
3. Turn on water supply with the generator off (do not run generator at this point). Water will back flush plumbing through generator strainer and out through hull intake. Flush for several minutes.
4. Once the plumbing from the hull intake through generator strainer has been flushed, the generator can now be started. Turn the main battery selector located on port side of driver's console to battery 1 or 2 (see picture 3A). Ensure water is spilling out of hull intake before starting generator. Turn on generator ignition key located on driver's console. Once the generator is started, water will flush the cooling system from the raw water pump, through the heat exchanger, and out the exhaust located on the transom. Continue flushing system for several minutes.
5. Once flushing is complete, turn off the generator. Leave the adapter and hose attached to the "Generator Test Water" fitting, with the water on. Proceed to flush washdown pump.

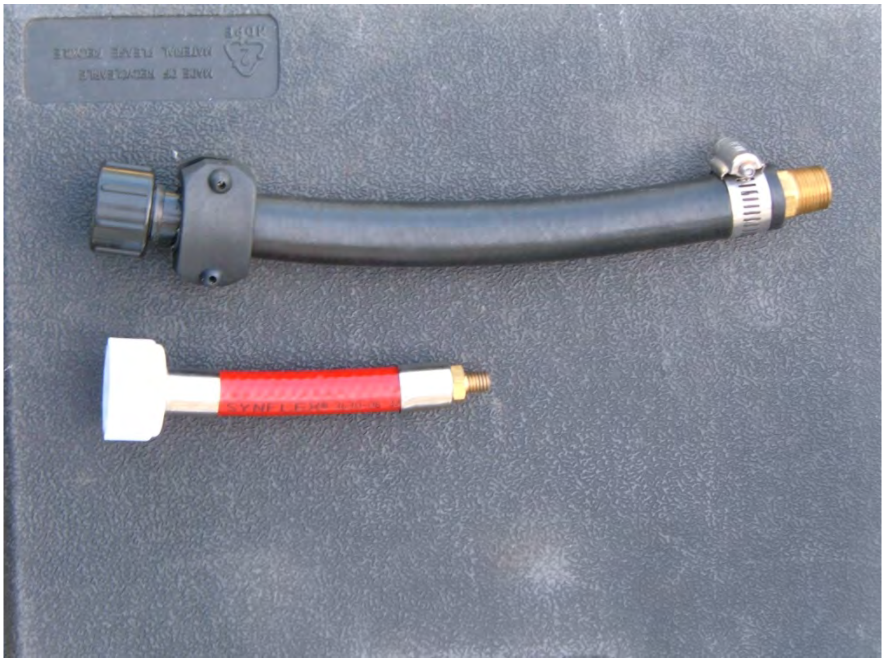
Washdown Pump

1. Follow steps 1 – 4 from generator section above. As the water back-flushes through generator strainer and out hull intake, it's also priming the wash down pump.
2. Turn main battery selector to either battery 1 or 2 (see picture 3A). Next, turn generator ignition key to the accessories position. Turn on the washdown pump switch located on driver's console. Remove washdown hose/spray nozzle from access port located on the starboard side of driver's console.
3. Spray washdown hose to flush washdown pump and internal plumbing.
4. Once flushing is complete, turn off washdown pump switch. Next, turn generator ignition key off. Turn off main battery selector.
5. Turn off water supply, disconnect hose and adaptor from "Generator Test Water" fitting.

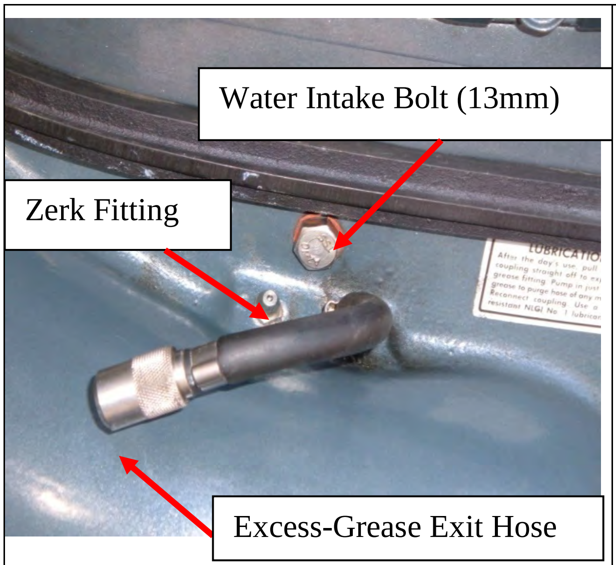
6. Replace pipe plug in the “Generator Test Water” fitting located at the base of generator cover, port side aft. Finger tighten pipe plug, then ¾ turn with 11/16” open end wrench to snug down. Do not over tighten the brass pipe plug because it is prone to stripped threads.

Nets and Related Gear

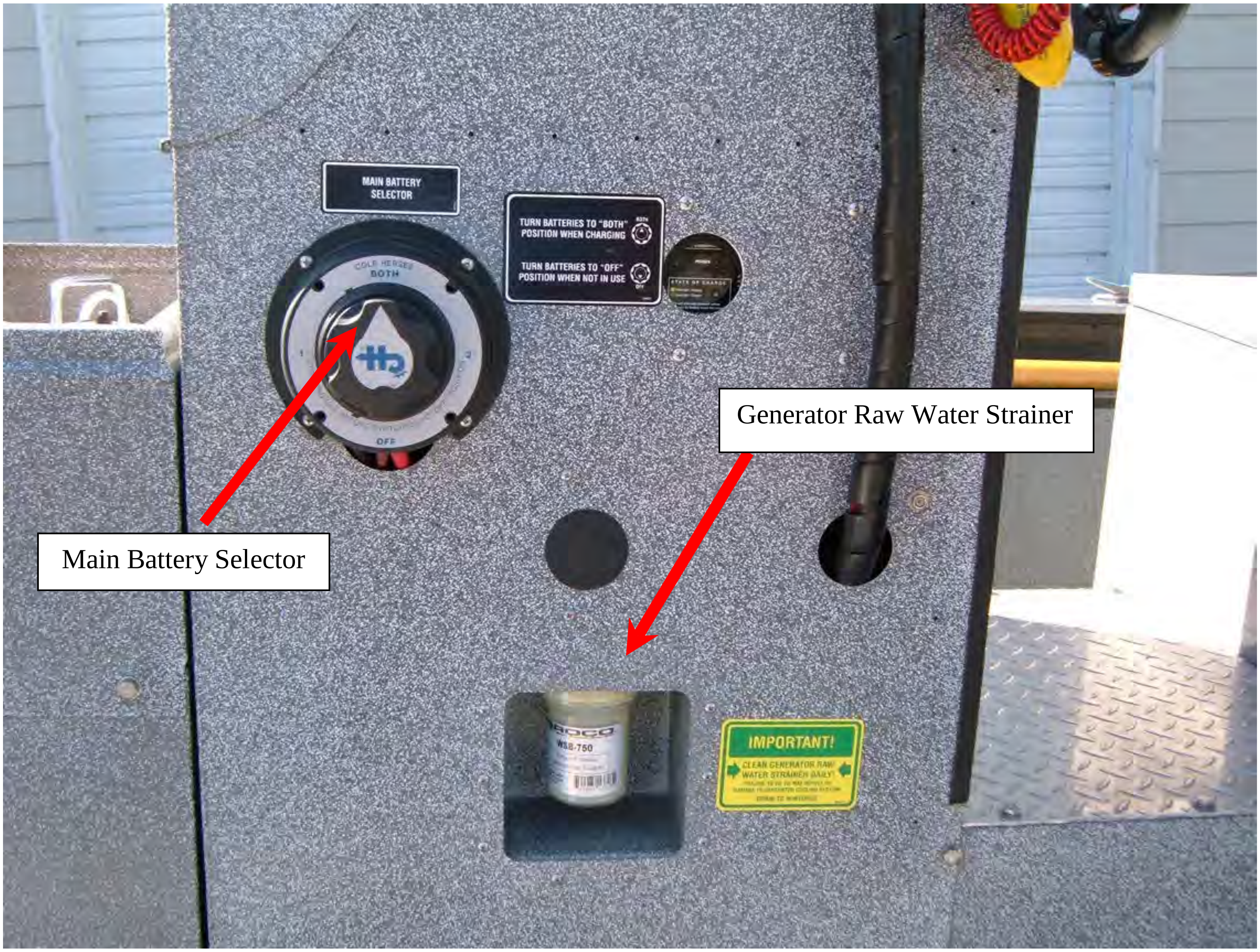
1. Clean weeds off the net and attached gear while retrieving in order to reduce loading the boat with weed fragments.
2. When ashore at the boat launch, find a way to hang nets and manually pick off all weeds from mesh, lead line, and float line. For gillnets, hang 30-50 foot sections of net at a time between the truck and boat and gather the cleaned section into a clean tub. Repeat for the rest of the net.
3. Clean other nets and gear (e.g. beach seines, fyke net, dip nets, and trawl nets) similarly to gill nets.
4. Ensure that floats, anchors, and anchor line are cleaned of all visible foreign material.
5. After adequately hand-picking and cleaning nets and related gear, one of the treatments in Table A-1 is required. Preferably a hot water soak.
6. If unable to clean while in the field, nets and gear can be cleaned upon return to the OC - provided they are not being used in another waterbody.
7. NOTE: chemical treatments may damage nets so testing should be done before using chemicals.



1A. Large black hose adapter for flushing electrofishing boat generator. Small red hose adapter for flushing electrofishing boat outboard engine.

	
2A. Outboard excess-grease exit hose, zerk fitting and water intake bolt. Located on port side of jet unit.	**2B.** Water intake bolt has been removed, and outboard flushing adapter has been attached.

2C. Outboard flushing adapter attached to lower jet unit. Ready to turn on water supply and flush outboard system.



3A. Generator raw water strainer and main battery selector are located on port side of diver's console.

Generator Test Water Fitting and Pipe Plug

3B. Generator raw water flushing connection (i.e. Generator Test Water Fitting). Located on the base of generator cover, port side aft.

3C. Pipe plug has been removed, and generator flushing adapter has been attached.

3D. Generator flushing adapter is attached. Ready to turn on water supply and flush generator and washdown pump systems.

Table B-1. Boat Engine Information for Cleaning to Minimize Spread of Aquatic Species. (1/28/10).

Boat Name and Type	Engine Information	Location	Flushing Method
Skookum Almar “Sounder” 26’x8.5’	Volvo-Penta 200HP Diesel Model AD 41/DP 2002	OC main engine on boat	Ear Muffs
Large Whaler 20' “Outrage” Boston Whaler	Evinrude 150 HP 2-cycle Model E150FPXEE Serial # G04651401 Tag # E120972 (12/98)	ERO main engine on boat	Ear Muffs
Large Whaler 20' “Outrage” Boston Whaler	Evinrude 5 HP 4-cycle Model E15FRLED Serial # G04070374 Tag# E117261	ERO spare engine on boat	Ear Muffs
Electro-Fisher Smith-Root SR-18 18'	Yamaha 115 HP 4-cycle Model F115TJRC Serial #68VL1070897J Tag # E133353 2007	OC main engine on boat	Hose connection and adaptor Generator also uses hose connection and adaptor
Whaler #1 ("old") 17' “Montauk” Boston Whaler	Evinrude 70 HP 2-cycle Model E70TLED Serial # G03842907 Tag # E116488 Feb-95	OC main engine on boat	Ear Muffs
Whaler #1 ("old") 17' “Montauk” Boston Whaler	No motor on boat as of 1/12/09	OC	n/a
Whaler #2 ("new") 17' “Montauk” Boston Whaler	Evinrude 90 HP 2-cycle Model E-TEC Serial # 05227247 Tag # new 2008	OC main engine on boat	Hose connection
Jet Sled Wooldridge 16 Xtra Plus (16.5')	Evinrude 115/80 HP 2-cycle Model E-TEC Serial # 05250809 Tag # E135285 2008	OC main engine on boat	Hose connection and adaptor

Table B-1 (continued). Boat Engine Information for Cleaning to Minimize Spread of Aquatic Species.

Boat Name and Type	Engine Information	Location	Flushing Method
McKee Craft	Honda 90 HP 4-cycle	CRO	Hose connection
16'	Model	main engine	
	Serial # BEB…a7…1007464 ?	on boat	
	Tag # E135305		
Jon Boat	OMC 8HP 2-cycle	OC	Flushing Tub
Valco P-14'	#1 (in red lettering)		
	Model E8REV	on floor caddy	
	Serial # G04323535		
	Tag # E118561		
	1997		
Little Jon	Evinrude 6HP 2-cycle	OC	Flushing Tub
Grumman	#3 (in white ? lettering)	on floor caddy	
Model 1237	Model E6RETB		
	Serial # BO8967546		
	Tag # E121292		
AVON 1	Honda 5 HP 4-cycle	CRO	Hose connection
Roll-Up inflatable	Model ??	location?	
2.85	Serial #		
9'x4'9"	Tag #		
	2005		
AVON 2	Evinrude 6 HP 2-cycle	**location**	Flushing Tub
Roll-Up inflatable	#2 (in white lettering)	**unknown**	
2.85	Model E6RERE		
9'x4'9"	Serial # B09048443		
	Tag #E115547		
	Jun-94		
No Boat Assigned	Evinrude 6 HP 2-cycle	OC	Flushing Tub
	#1 (in white lettering)	on floor caddy	
	Model E6R…?		
	Serial # B8984343		
	Tag # E114122		
No Boat Assigned	OMC 8HP 4-cycle	OC	Ear Muffs
	#2 (in red lettering)	on upright stand	
	Model E8REVR		
	Serial # H09363061		
	Tag # E119579		
	1997		

Appendix

Summary of Field Gear Cleaning and Decontamination Procedure

Prior to field work:

- Check if the sampling will take place in an area of extreme concern – maps at this link: http://teams/sites/EAP/Pages/FieldTraining.aspx OR ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/GIS-data#e.
- Plan field activities to minimize contact between equipment and potential sources of invasive species, particularly aquatic plants and sediment.

After conducting field work:

- **Inspect and clean** all equipment. Remove any visible soil, vegetation, vertebrates, invertebrates, aquatic plants, algae or sediment. If necessary, use a scrub brush and rinse with clean water either from the site or brought for that purpose. Continue this process until the equipment is clean. **Drain** all water in bilges, samplers or other equipment that could harbor water from the site. This step should take place before leaving the sampling site or at an interim site. If cleaning after leaving the sampling site, ensure that no debris will leave the equipment and potentially spread invasive species during transit or cleaning.
- **Additional Requirements for felt-soled waders used anywhere in the state and equipment that contacted sediment, aquatic vegetation, amphibians or fish in areas of extreme concern**:
  - **Smooth surfaced sampling equipment that can be easily and fully wiped down – wipe until dry**. The equipment must be smooth enough so there are no cracks or crevices that could harbor a sand-grain-sized juvenile New Zealand mudsnail while being wiped dry.
  - **For all other equipment, use one of the decontamination treatments found in the table below**. Conduct decontamination where the procedure can be carried out effectively and safely. Wash and rinse water must not drain to surface water, and all chemicals must be disposed of to a sanitary sewer.

Equipment Storage:

- **Dry** – Between field sites and upon returning from the field, when cleaning and decontamination requirements are complete store gear to facilitate drying.

Table. Decontamination Options

Treatment	**Concentration or temperature**	**Exposure Time**	**Comments**
hot water wash or soak	60° C (140° F)	5 minutes for felt-soled boots and nets; 10 seconds for all other equipment	Ensure all parts of the equipment reach temperature for the full exposure time.
	49° C (120° F)	10 minutes for felt-soled boots and nets; 5 minutes for other equipment	Ensure all parts of the equipment reach temperature for the full exposure time
cold	-4° C	4 hours minimum	Time starts after the equipment reaches -4 °C.
drying	low humidity, in sunlight is best	48 hours	Time starts after the equipment is thoroughly dry.
Formula 409 All-Purpose Cleaner[1]	100% (full strength)	10 minutes	Follow proper procedures for storage and handling.
Green Solutions High Dilution 256[2]	3.1% or higher	10 minutes	Follow proper procedures for storage and handling.
Quat 128	4.60%	10 minutes	Follow proper procedures for storage and handling.
Hydrogen peroxide[3]	30,000 ppm (3%)	15 minutes	Spray on until soaked, then keep damp for contact time (cover or place gear in a dry bag).
Virkon Aquatic®	2%	20 minutes	Must soak (not spray on) Follow proper procedures for storage and handling.[4]

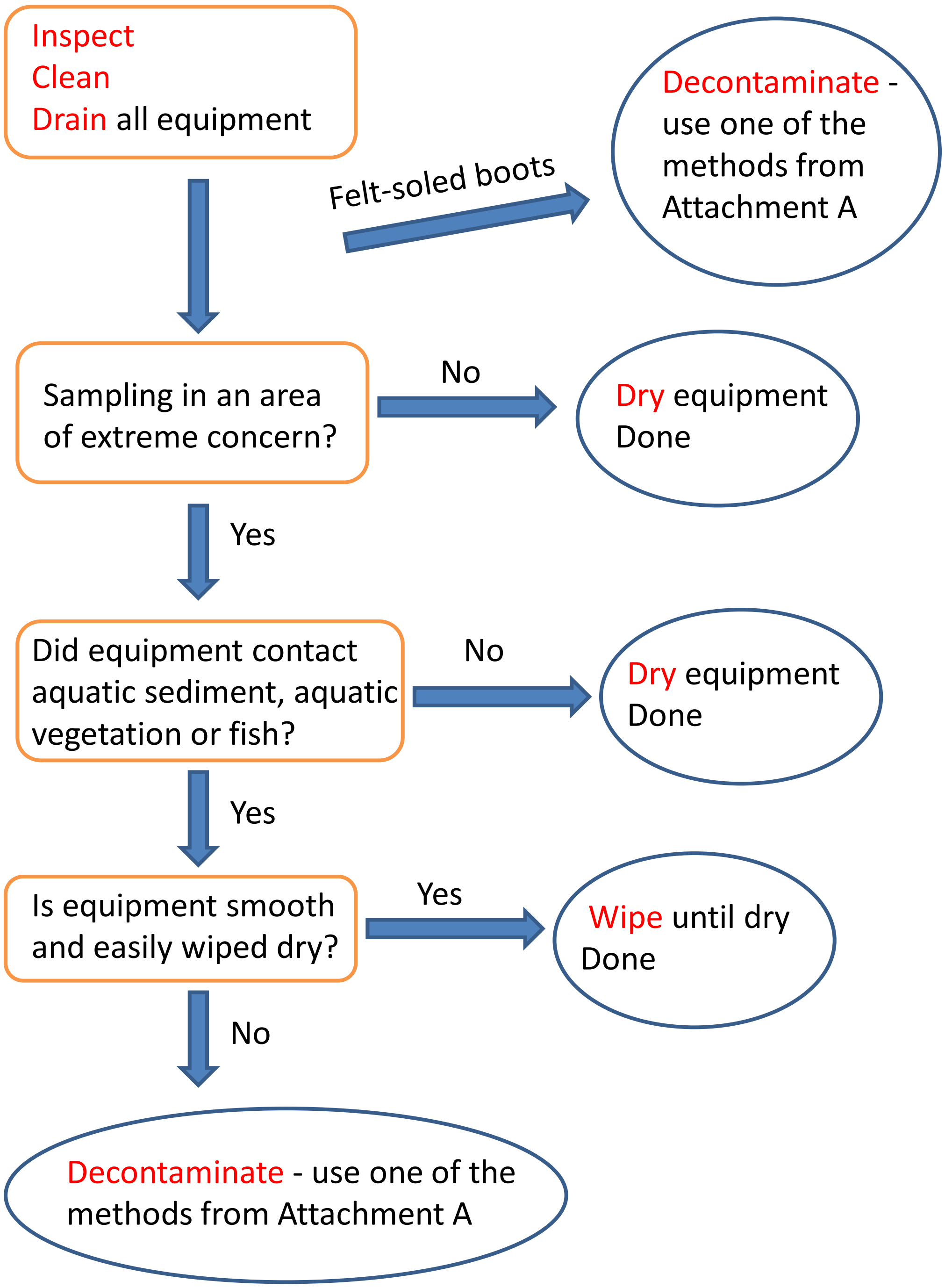
[1] Must be antibacterial (make sure it has quaternary ammonia, otherwise it is ineffective).

[2] Corrosive; read the MSDS and use with caution (replaced Sparquat 256).

[3] May be corrosive; read the MSDS and follow safety precautions.

[4] Rinse gear after soak to prolong life. Solution degrades, lasts up to seven days, best if mixed fresh.

Summary Flow Chart



APPENDIX B

Field Equipment Information

[Available upon request]

APPENDIX C

Water Quality Monitoring Standard Operating Procedures (SOPs)

DEPARTMENT OF
ECOLOGY
State of Washington

Standard Operating Procedure
EAP080, Version 2.1

Continuous Temperature Monitoring of Freshwater Rivers and Streams

April 2018

Publication No. 18-03-205

Publication information

This Standard Operating Procedure (SOP) is available on the Washington State Department of Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1803205.html.

The Activity Tracker Code for this document is 10-196.

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Eastern Regional Office, Spokane	(509) 329-3400

Purpose of this document

The Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures for Continuous Temperature Monitoring of Freshwater Rivers and Streams.

Version 2.1

Author – William J. Ward
Date –

Reviewers: Dan Sherratt and Dave Hallock

QA Approval - William R. Kammin, Ecology Quality Assurance Officer
Date – 10/26/2011

EAP080

APPROVED: 10/26/2011

Recertified: 2/27/15
Updated and Recertified: 3/25/2015
Updated and Recertified: 3/25/2018

Signatures on File

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
4/12/10		First draft updating and incorporating existing 2003 Continuous Temperature Protocols with the 2008 TMDL SOP.	All	W. Ward
		Draft addressing Dan Sherratt and Dave Hallock comments	All	W. Ward
		Draft addressing James Kardouni comments	All	W. Ward
	1.0	Final draft		
10/26/2011	1.0	Editorial cleanup	All	B. Kammin
3/25/15	2.0	Minor editorial updates and recertified	All	W. Ward
3/25/2015	2.0	QA approval	All	B. Kammin
3/25/2018	2.1	Minor editorial updates	5, 6, & 10	W. Ward
3/25/2018		Recertified	All	T. Gries

Environmental Assessment Program

Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams.

1.0 Purpose and Scope

This Standard Operating Procedure (SOP) details a methods used by the Department of Ecology (Ecology) to collect continuous temperature monitoring data. It may also contain methods that other entities would find useful for their monitoring work.

The scope of the continuous temperature monitoring program currently focuses on summer (June-September) stream temperatures, but will be expanded to year-round as resources allow.

The intended purpose of the continuous temperature monitoring program is to collect diel stream temperature data that may be used to expand the interpretation of a station's ambient monitoring results and to determine its compliance with state water quality standards. The continuous temperature results are assessed using Ecology's policy for identifying impairments under the federal Clean Water Act (Section 303(d)), which requires stream temperature to be measured on consecutive days in order to apply the criterion.

2.0 Applicability

The Standard Operating Procedures (SOP) will be followed for the installation and maintenance of continuous temperature ambient monitoring stations. These protocols reflect in part those outlined in the TFW Stream Temperature Survey Manual (Schuett-Hames et al., 1999), Continuous Temperature Sampling Protocols for the Environmental Monitoring and Trends Section (https://fortress.wa.gov/ecy/publications/summarypages/0303052.html) (Ward, 2003), Measuring Stream Temperature with Digital Data Loggers (USFS, 2005), and Standard Operating Procedures for continuous temperature monitoring of fresh water rivers and streams conducted in a Total Maximum Daily Load (TMDL) project for stream temperature (Bilhimer and Stohr, 2008).

3.0 Definitions

3.1 7DAD*Max*, 7-day average of the daily maximum temperature
3.2 *EAP*, Ecology's Environmental Assessment Program
3.3 *EIM*, Ecology's Environmental Information Management database for environmental data
3.4 *EPA*, US Environmental Protection Agency
3.5 *GIS*, Geographical Information System

3.6 *GPS*, Global Position System
3.7 *NIST*, National Institute of Standards and Technology
3.8 *PST*, Pacific Standard Time
3.9 *PDT*, Pacific Daylight savings Time
3.10 *QAPP*, Quality Assurance Project Plan

4.0 Personnel Qualifications/Responsibilities

4.1 Field operations require training specified in EAP's Field Safety Manual (Ecology, 2016), such as First Aid, CPR, and Defensive Driving.

4.2 Typical Job Class performing SOP: Natural Resource Scientist 1/2/3, Environmental Engineer 1/2/3/4/5, Environmental Specialist 1/2/3/4/5, Administrative Intern 1/2/3.

5.0 Equipment, Reagents, and Supplies

5.1 *General Field Equipment:*

5.1.1 See Attachment A for a list of the typical equipment and supplies that may be used to deploy temperature loggers.

5.2 *Specialized Field Equipment*[1].

5.2.1 Rebar Pounder (see design specifications in Attachment B)
5.2.2 PVC Shade Device (see design specifications in Attachment B)
5.2.3 Onset Tidbit$^{©}$ v2 Temp Logger, (#UTBI-001), +/- 0.2°C
5.2.4 Onset Hobo$^{©}$ Water Temp Pro v2, (#U22-001), -20°C to +50°C, +/- 0.2C
5.2.5 Onset StowAway Tidbits$^{©}$, -5°C to +37°C model, +/- 0.2°C (no longer available)
5.2.6 Onset StowAway Tidbits$^{©}$, -20°C to +50°C model, +/- 0.4°C (no longer available)
5.2.7 Spirit-filled thermometer or long-line thermistor with an accuracy of +/-0.2ºC
5.2.8 PC communication cables or optic shuttles specific for each instrument type

6.0 Summary of Procedure

6.1 *Pre-Deployment Run Preparation*

6.1.1 <u>Assemble equipment</u>. Use a checklist to ensure that all of the necessary preparation tasks, equipment, supplies, and safety gear are completed (See Attachment A for the Continuous Temperature Sampling Checklist).

6.1.2 <u>Calibration Checks</u>. All temperature loggers must be calibration checked both pre- and post-study to document instrument accuracy specifications.

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[1] The specialized equipment listed does not represent an endorsement by Ecology. Other equipment may be used if it meets the project QA/QC requirements for accuracy and reliability.

6.1.2.1 The calibration checks are done using test-bath temperatures that bracket the intended monitoring range (near 20 and 0ºC). The bath temperatures must be verified with a NIST traceable or calibrated reference thermistor, thermocouple, or thermometer (NIST thermometer)[2]. *Note: This procedure is also used to determine correction factors (if required) for the field thermistor and thermometer measurements.*

6.1.2.2 A calibration-check test-bath method that can maintain a constant temperature is essential to obtain excellent test results. The one described below has worked very well for us. In addition, we have also had great success utilizing a 20-gallon aquarium with a two-bay Hatch Box design and a recirculation pump.

6.1.2.3 Place one open cooler half full of water overnight in a walk-in cooler or room that has a constant air temperature near 0ºC and two coolers (setup similarly) in a room with a temperature near 20ºC. *Note: Test baths done in rooms that have the target temperature ensure stable bath temperatures and the overall quality of the test.*

6.1.2.4 Program the temperature loggers for the test start time and up to a five-minute logging interval (a one- to two-minute interval is preferred). String the loggers together to facilitate their transfer into each water bath.

6.1.2.5 Put the programmed temperature loggers in the near 0 ºC test bath overnight.

6.1.2.6 Twenty minutes before the start of the test, place the NIST thermometer in the water bath oriented to easily view the scale increments. Then, gently stir the water to help ensure a uniform water temperature.

6.1.2.7 Gently stir the water bath again a few minutes before test and just after reading and recording the NIST thermometer temperature.

6.1.2.8 Record 10 relatively constant and consecutive NIST thermometer comparison measurements on the Calibration Check Form (See Attachment C1 for blank form and Attachment C2 for an example of a used form) when the logger records the water bath temperature. If the logger has a two-minute sampling interval, it may take twenty minutes to obtain the 10 NIST measurements.

6.1.2.9 Dewater and transfer the strings of temperature loggers, thermometers, and thermistor probes to one of the room temperature (near 20ºC) water baths. Gently stir the transition water bath and allow the loggers to soak there for several minutes. Then transfer them to the other room temperature water bath for a few minute soak. *Note: this two-step process helps minimize the temperature changes in the final water bath.*

6.1.2.10 Repeat the process noted above to obtain ten relatively constant NIST thermometer comparison measurements the final water bath.

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[2] All NIST reference thermistors, thermocouples, and thermometers, used for this test, need to have an annual three-point (near 0, 10, 20°C) calibration check against the Lacey Operations Center NIST or be sent in for an Accredited Calibration Certificate.

6.1.2.11 Download the temperature loggers as soon as possible after the test to shut them off and minimize battery life impacts.

6.1.2.12 Calculate the mean absolute value of the difference between the temperature logger measurements and the NIST thermometer for each water bath with spreadsheet software or by hand. Water-temperature loggers that have a mean difference greater than 0.2°C in one or both water baths have failed the test and cannot be used unless they pass a follow-up test.

6.1.3 Launch temperature loggers. Adjust the computer clock settings to Pacific Standard Time (PST) and also make sure that it will not automatically adjust to Daylight Savings Time (DST). Then adjust the clock time to the atomic clock (e.g., https://www.time.gov). These necessary steps ensure that all the data will be in PST year-round and that all loggers will monitor at exactly the same time.

6.1.4 Program the temperature loggers for a delayed launch that starts at least one hour before the first planned deployment time of the season and at a 30- (or 15-) minute monitoring interval (on the hour and half hour).

6.2 *Stream temperature logger site selection methods*

6.2.1 Deploy temperature loggers in the active and well-mixed part of the stream (or as close as possible to it) to ensure representative temperatures (based on flow volume) are recorded throughout the entire deployment period. The preferred location in these areas is against an instream landmark or other submerged structure that can help hide the logger and minimize the loss to vandalism or high-flow events and also where direct sunlight may be avoided. *Note: avoid deployment locations near popular swimming holes and fishing access points where there is a much higher chance of logger discovery and loss to vandalism.*

6.2.2 Ideal deployment locations are typically at the upstream outside edge or downstream inside edge of the river bends or in the middle of riffles of low flow and wadeable streams (see Figure 1 below).

6.2.3 Temperature logger locations should never be in eddies or pools or locations where these conditions may develop during low flows. In addition, locations just downstream of tributaries, stream-side wetland areas, point-source discharges, and potential hillside groundwater seeps should also be avoided because these conditions may seasonally bias the recorded temperatures. Consider locations either on the opposite side of the stream or upstream of these conditions.

6.2.4 Deployment depth locations should not be on the stream bottom where the loggers may record groundwater inflow, but deep enough that they do not become exposed to air during a low-flow period. The basic deployment location depth goal is six (6) inches (<0.5 ft) off the stream bottom in smaller streams and wadeable locations and, if possible, at about one half of the water depth in the large streams (Schuett-Hames et al., 1999). *Note: Locating temperature loggers near the stream bottom may be necessary in small streams to ensure that the logger remains submerged during low flows.*

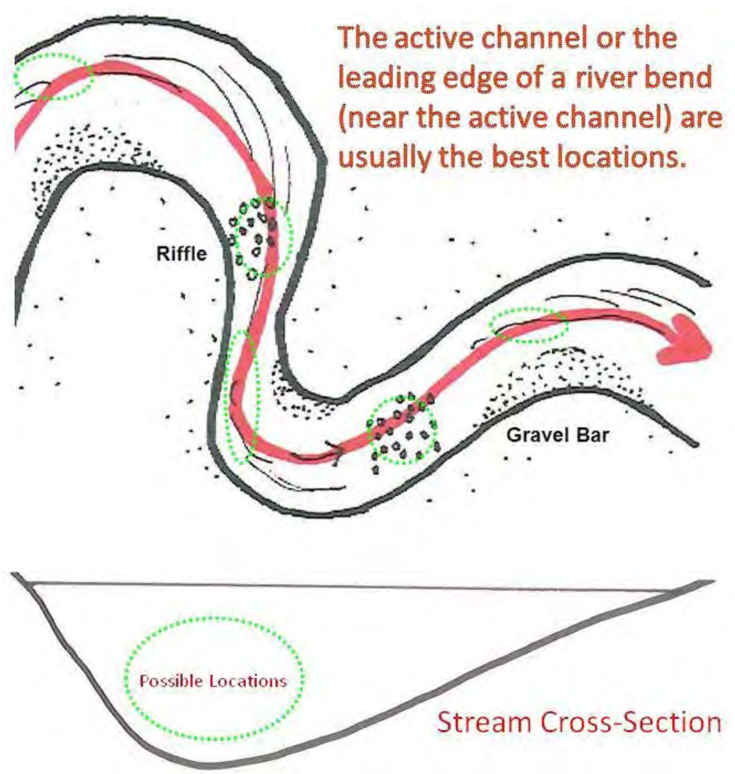

Figure 1. Potential Temperature Logger Deployment Locations

6.2.5 The representativeness of the temperature logger deployment location should be verified by measuring several points in and near the vicinity of the logger and the temperature of the well-mixed part of the stream. If the stream can be easily waded, then a simple cross sectional temperature survey could also be done. Review the survey results, and consider another deployment location, if necessary, to help ensure that the logger will record representative results.

6.3 *Stream temperature logger deployment options*

6.3.1 Record the water-temperature-logger serial numbers on the survey form. (See Attachment D1 for blank form and Attachment D2 for an example).

6.3.2 Pre-assemble the water-temperature logger with a camouflage-painted PVC shade device cover (See fig.2 below and design in Attachment B) that helps hide the logger and prevent any bias from indirect solar radiation.

6.3.3 Avoid low-flow and direct-sunlight temperature logger deployment locations. If the temperature logger needs to be deployed in these locations, then a white PVC shade cover must be used to prevent any solar-biased temperature results (USFS, 2005).

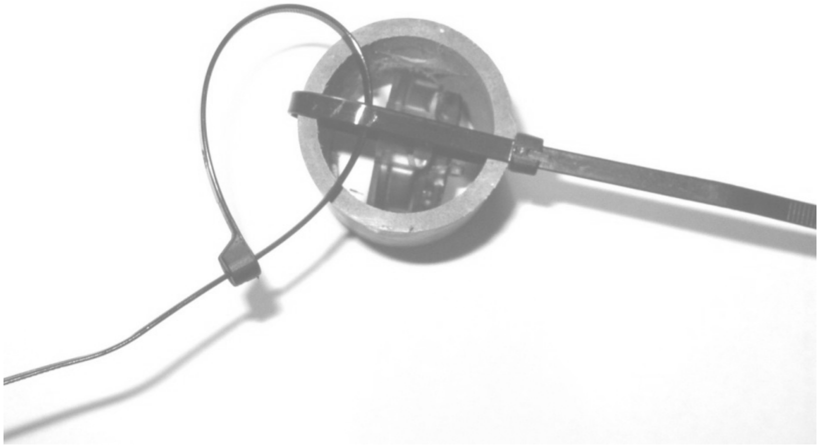

Figure 2. Assembled Temperature Logger and PVC Cover

6.3.4 Place a thermometer or thermistor as close as possible to the identified deployment location and record the measurement after the logger has been deployed. Consider one the use of one of the following deployment methods:

6.3.5 <u>Rebar Deployments.</u> This option is typically used in small- and medium-sized streams to create a suitable temperature logger attachment location in or as near as possible to the active part of the stream. In most cases, this method is best used against the active-part-of-the-stream side of a large landmark rock or log.

6.3.6 Choose a two-to-three-foot length of rebar that can be driven deep enough into the streambed to stay in place during high streamflow events and provide an attachment location that is six inches to one-half of the expected total stream depth during the seasonal low-flow period.

6.3.7 Insert the rebar into the open end of the rebar pounder and use a 4# engineering hammer (or an alternative) to hammer the rebar into the streambed by striking the heavy steel head of the pounder. Hammer all but eight inches of the rebar into the streambed[3].

6.3.8 Leave the rebar pounder on the rebar, and document the water-temperature logger location with photographs.

6.3.9 Remove the rebar pounder and attach the temperature logger assembly to the rebar about 6 inches off the bottom (or mid-water depth) with a cable tie. *Note: In fast-flowing locations an additional cable tie should be attached to the rebar just above the temperature logger assembly attachment point to prevent its loss should the second cable tie loosen on the rebar (or attach the assembly using a small gage wire).*

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[3] If a mid-stream depth is desired, then leave more rebar exposed.

6.3.10 Large Rock, Tree Root, or woody debris deployments. This option uses existing instream structures such as large rocks or boulders, woody debris, or roots that are located in or extend into the desired location in the active part of the stream. Attach the water-temperature logger to these structures with cable ties or wire, or to cable or heavy wire that may be used to create the location near the base of these structures.

6.3.11 Photographs of the location using a visual marker (such as the rebar pounder, hammer handle, nearby flagging, or pointing with a finger) are essential to help relocate loggers installed by this method.

6.3.12 Anchor deployments. This option can be used where stable large woody debris is not available or where near-surface bedrock or other consolidated sediments prohibit rebar use. The basic approach is to attach the water-temperature-logger assembly to a heavy weight (i.e., rock, brick, concrete block, wadded up piece of chain, or rebar) that may be set in the desired water-temperature-logger location.

6.3.13 It is also advisable that the heavy object be cabled or chained to something on the nearest bank (or other stable instream structure) to prevent loss during a possible high flow event (*Note: rusty chain use may deter logger loss to vandalism more than a shiny cable*). The heavy weight may be encouraged into the desired deployment location using a stick or boat hook (or similar device). *Note: this is not considered a viable option in locations with a significant groundwater inflow.*

6.3.14 Streamside or pile deployments. A long protective PVC or metal pipe housing may be used to establish a deployment location along deep rivers or at wildly fluctuating streams. The pipe can be fastened to a piling, pier, or anchored to large rocks and trees on the stream bank with the lower end extended into the active part of the stream. The upper end of the pipe should be secured with a threaded or locking cap to discourage casual vandalism. The lower end of the pipe should be perforated to allow streamflow around the logger and also be blocked with a diagonal bolt (or similar device) to prevent logger loss out that end. The logger in a protective cover needs to be kept at the lower pipe end with a weighted cord, length of PVC pipe, or any other method that also allows retrievals and deployments to be made through the upper capped end (see Figure 3 example below).

6.3.15 Buoy or dock deployments. This option may be useful where no pilings are available or where a string of thermistors is desired to monitor stratified conditions. One issue with this type of deployment option is the high vandalism potential. This potential increases dramatically when establishing a new floating structure, so it is best to use existing structures if permission can be obtained.

6.3.16 Aquatic Invasive Species. Clean all field equipment that contacted water following procedures in Parsons, et al., (EAP070) and Ward, et al., (EAP071).

Figure 3. Deployment method using a length of PVC pipe

6.4 *Air temperature logger deployment methods*

6.4.1 Use temperature loggers that can record the maximum expected temperature for the deployment location. If you are locating loggers in an area where the summer air temperatures can exceed 100ºF (37ºC), then use an air thermistor that has the higher temperature range setting.

6.4.2 Record the air-temperature-logger serial numbers on the survey form.

6.4.3 Pre-assemble the air-temperature logger with a PVC shade device cover. The pre-assembly should be done before beginning the process to install the logger (See Figure 2 above).

6.4.4 These temperature loggers need to be located within the same microclimate of the water logger. Ideal locations are one to three meters into the riparian zone (Schuett-Hames et al., 1999) and about four to eight feet above the ground (USFS, 2005). Avoid placing them in areas that are not representative of streamside conditions at your location or where they will be severely impacted from solar radiation. The north side of a shrub or tree trunk should work well in most locations, especially those with limited streamside vegetation choices[4].

6.4.5 One air-temperature logger should be deployed near every water-temperature-logger location. However, if the vegetation and streamside conditions are similar, then one air-temperature logger may be used to cover several nearby water-temperature loggers. *Note: Air loggers deployed for Total Maximum Daily Load studies (*Bilhimer and Stohr, 2008) *must be within approximately 0.5 mile of the most distant water logger.*

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[4] Do not use weeping willows, as they can secrete fluid during hot weather and create error in the air temperature results.

6.5 *Documentation Procedures*

6.5.1 Record all the field data and deployment location information on the Continuous Temperature Station Survey Form (See example in Attachment D-1) or by a similar method. Be sure to note the station number and name, temperature logger ID numbers, and air- and water-temperature measurements, and any other useful narrative observations, especially those useful for finding the location (e.g. – “upstream of largest boulder on right bank”).

6.5.2 Also, record all observation times in PST (or note when they are DST, so they may be converted to PST later), and use a timepiece that has been calibrated to the atomic clock (or use the cell-phone time).

6.5.3 Further, draw a map and describe the general area, noting the temperature-logger locations, logger installation technique, and any landmark references such as a unique rock, log, root, flagging, or tree (See example in Attachment D-2). *Note: if possible, draw the map with north being toward the page top or denote the direction of north on the drawing*.

6.5.4 Take upstream and downstream photographs of the water-temperature-logger location that includes useful and easily identifiable landmark tree(s), flagging, or boulder. It is also important that the photographs include some visual marker (such as the rebar pounder, hammer handle, or pointing with a finger) to use along with the information on the survey form to help relocate and retrieve it in the future (See Fig 4 below).

6.5.5 Measure and record: the total water depth (water depth), distance from the logger to the streambed (height), distance from water surface to the logger (deployment depth), and the stream temperature on the survey form.

Figure 4. Photo showing the water-temperature-logger deployment location.

6.5.6 Record the temperature logger GPS coordinate location (or note the logger location on an accurate map and determine the coordinates later).

6.6 *Mid-deployment checks*

6.6.1 If possible, periodically visit the temperature-logger location during the deployment period to get mid-deployment temperature-check data and to make sure that it remains submerged and in a representative location. If the logger needs to be moved or is missing and needs to be replaced, then take the appropriate action and enter new remarks and notes on the survey form. *Note: consider taking replacement loggers and deployment equipment along when doing these checks to help expedite to process.*

6.7 *Retrieval Procedures*

6.7.1 Measure and record the stream temperature and surface depth of the water-temperature logger (retrieval depth), and record the results on the field form. Also, measure and record the distance from the streambed up to the logger, and note any differences between the result and what was recorded during deployment.

6.7.2 If the stream may be easily waded, then also consider doing a cross-sectional survey of the stream temperature. The survey results may help determine if the stream-temperature logger measured representative temperatures and show any cross-sectional temperature differences.

6.7.3 Remove all rebar, cement blocks, or other deployed equipment at the end of the study.

6.7.4 Aquatic Invasive Species. Clean all field equipment that contacted water following the procedures in Hallock, et al., 2010 (EAP070).

6.8 *Downloading Procedures*

6.8.1 Gently clean the temperature loggers with a soft wet cloth to remove any biofouling or sediment that may affect its ability to communicate optically during the downloading process. The preferred method is to use water and a soft cloth or soft-bristled brush. Note: avoid using any method that can scratch the logger optic communication area.

6.8.2 Set the computer clock to atomic clock time for the Pacific Time Zone before downloading any temperature loggers. Then follow the manufacturer’s downloading procedures, and save the data in text files that may be opened in Excel or another type of spreadsheet software.

7.0 Records Management

7.1 Continuous Temperature Survey Forms are used to document the deployment and retrieval information for a station. Filled-out field forms are organized and stored in binders to use for long-term recordkeeping.

7.2 Use Ecology's FMU Access® Data Logger Database developed by Dave Hallock, to manage, store, export, and upload data summaries to Ecology's Environmental Information Management System (EIM). *Note: the database is available to interested agencies and organizations upon request.*

8. 0 Quality Control and Quality Assurance Section

8.1 *Temperature Logger Post-Deployment Accuracy Check.* Verify the accuracy of the retrieved temperature loggers by conducting a post-deployment calibration check (Refer to Calibration Check procedure, 6.1.2, above).

8.1.1 If the mean absolute value of the temperature difference for a logger in each water bath, compared against the NIST certified thermometer, is equal to or less than the manufacturer stated accuracy (i.e. usually ±0.2°C for a water-temperature logger or ±0.4°C for an air temperature logger), then a second check should be performed.

8.1.2 If a second calibration check result confirms a consistent bias above the stated accuracy, then the raw data should be adjusted by the mean difference of the pre- and post-calibration check results to correct for the logger bias (Schuett-Hames et al., 1999).

8.2 *Data Proofing Procedures.* Data from temperature loggers that met the calibration-check accuracy requirement are proofed and QC checked using *Ecology's FMU Access® Data* Logger Database. This database allows the information recorded on the Continuous Temperature Data Report Form (deployment/retrieval times and temperatures) and available climatic and flow data to be used to proof, edit, run automated QC checks, store, summarize, report, and export the finalized data (to text files, Microsoft® Excel, or to Ecology's Environmental Information Management (EIM) system Excel template).

8.2.1 *Note: all identified anomalous data may be omitted from the data set, provided that the justification remark(s) is inserted on the station Continuous Temperature Station Survey Form and in the electronic record for the data. Similarly, all explainable climatic caused data spikes (i.e. - rain events) should also be noted in these same two records.*

8.2.2 All data will be assigned a measurement accuracy value based on the pre- and post-deployment calibration check results.

9.0 Safety

Safety is the primary concern when deploying temperature loggers. Proper fieldwork safety procedures are outlined in the Environmental Assessment Program Safety Manual (Ecology, 2016). A minimum of two people are required when streams are waded. One can deploy the stream temperature loggers, and the other can assist from shore. If streamside hazards such as high flow, weather, and debris make the temperature logger deployment dangerous, then an alternate location, different deployment method, or different deployment time should be considered.

9.1 Material Safety Data Sheets (MSDSs) for all chemicals used in EAP field sampling or analytical procedures can be found at the following SharePoint link: http://teams/sites/EAP/QualityAssurance/ChemicalSafetyDataSheets/Forms/AllItems.aspx.

Also, binders containing MSDSs can be found in all field vehicles, vessels, Ecology buildings, or other locations where potentially hazardous chemicals may be handled. EAP staff following Ecology SOPs are required to familiarize themselves with these MSDSs and take the appropriate safety measures for these chemicals.

10.0 References

10.1. Bilhimer, D. and Stohr, A., 2008. Standard Operating Procedures for Continuous Temperature Monitoring of Freshwater Rivers and Streams Conducted in a Total Maximum Daily Load (TMDL) Project for Stream Temperature, Version 2.2. Washington State Department of Ecology, SOP Number EAP044. ecology.wa.gov/Quality.

10.2. Dunham J., G. Chandler, B. Rieman, and D. Martin, 2005. Measuring Stream Temperature with Digital Data Loggers: A User’s Guide. U.S.D.A. Forest Service Rocky Mountain Research Station. General Technical Report RMRS-GTR-150WWW. 16 p.

10.3. Environmental Assessment Program, 2016. Environmental Assessment Program Safety Manual.

10.4. Hallock, D. 2010. Standard Operating Procedures to Minimize the Spread of Invasive Species from Areas of Extreme Concern. EAP070. https://fortress.wa.gov/ecy/publications/SummaryPages/1803201.html.

10.5. Schuett-Hames, D., A. E. Pleus, E. Rashin, and J. Matthews, 1999. TFW Monitoring Program Method Manual for the Stream Temperature Survey. Washington State Department of Natural Resources and NW Indian Fisheries Commission publication #TFW-AM9-99-005.

10.6. Ward, W., 2003. Continuous Temperature Sampling Protocols for the Environmental Monitoring and Trends Section. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/publications/summarypages/0303052.html.

Attachment A

This Attachment contains the checklist used to prepare for temperature logger deployments.

Continuous Temperature Sampling Checklist

Pre-Deployment Preparation

_____ Determine Number of Stations
_____ Determine Deployment Equipment Needs
_____ Obtain or Make Deployment Equipment
_____ Check Calibration of:
_____ • Temperature Loggers
_____ • Thermometer
_____ • Thermistor
_____ Plan Deployment Schedule
_____ Schedule Field Assistance
_____ Program Temperature Loggers
_____ Make Motel Reservations
_____ Fill out Field Work Plan and Contact Person Designation Form
_____ Gas Van

Van/Safety Equipment

_____ Tire Chains
_____ Yellow Hazard Beacon
_____ Flashlight
_____ Tool Chest
_____ Jumper Cables
_____ Flares/Reflectors
_____ First Aid Kit
_____ Foil Blanket
_____ Orange Vests
_____ 2 Gallons Drinking Water
_____ Hand Towels
_____
_____

Sampling Equipment and Supplies

_____ Programmed Temperature Loggers
_____ Continuous Temperature Survey Forms
_____ Thermometer
_____ Thermistor
_____ Compass
_____ Maps
_____ Watch
_____ Camouflaged PVC Pipe
_____ Cable Ties
_____ Rebar Pounder
_____ 3/8 inch x 2 – 3 Ft. Rebar Pieces
_____ 4# Hammer
_____ Several lengths of Chain or cable
_____ Pyramid Blocks
_____ Small Wire Cutters
_____ 6’ Pole W/Hook
_____ Knife
_____ Hand Trimmer
_____ Machete
_____ Survey Flagging
_____ Digital Camera
_____ Duct Tape

Personal Gear

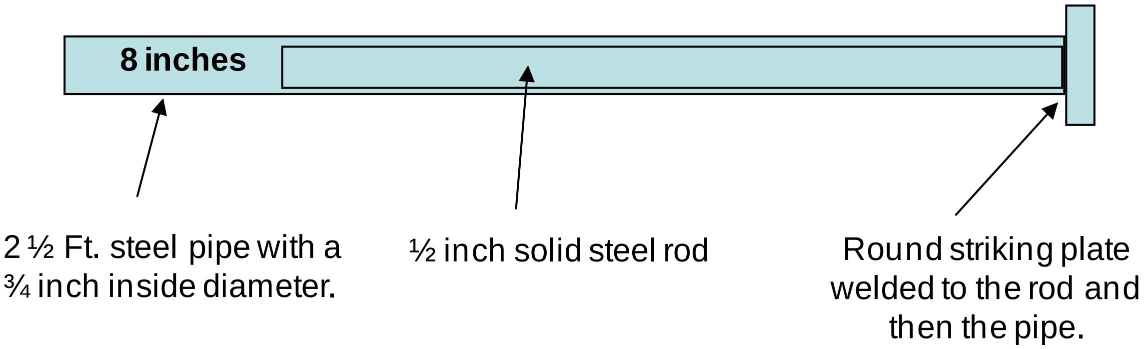
_____ Rain Gear
_____ Knee Boots
_____ Waders
_____ Watch
_____ Gloves
_____ Extra Clothing
_____ Hat
_____
_____
_____

Attachment B

This attachment contains the design specifications for the equipment that is made “in-house.” These designs have been created to meet specific needs for past field studies and can be modified as needed. The equipment to make these includes: power saws, drill press, and other hand tools. The rebar pounder is manufactured by a contracted welder.

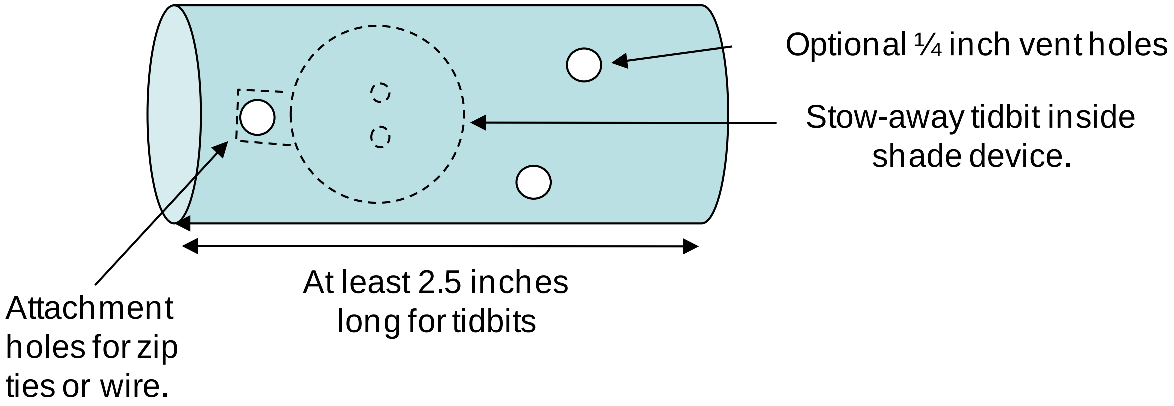
Rebar Pounder Design

Used to drive #4 (½ inch) rebar sections (2-4ft in length) into the streambed to establish an instream thermistor attachment location. The rebar is inserted in the hollow end and a heavy hammer is used to pound on the striking plate.

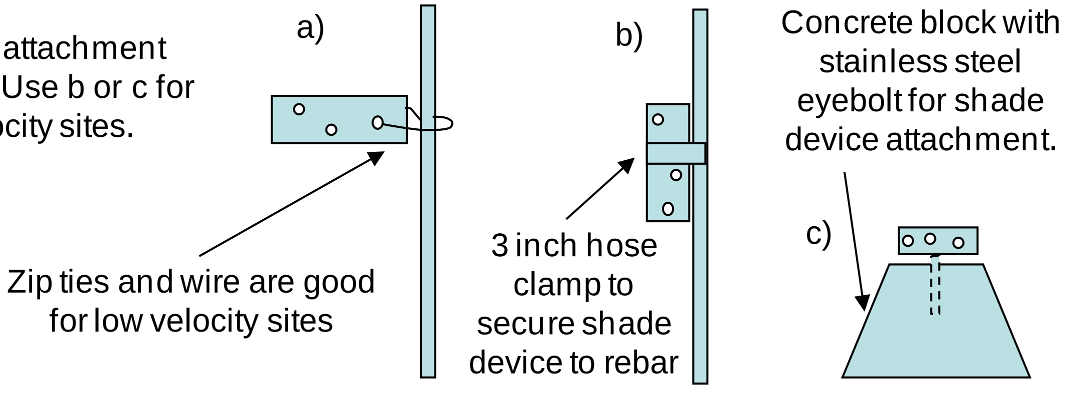


PVC Shade Device

This is typically made from 1.5 inch (inside diameter) PVC pipe. It should completely cover the thermistor to prevent solar radiation absorption. This design may be used for both instream and air thermistors.



Possible attachment options. Use b or c for high velocity sites.



Attachment C.

C-1. Temperature Logger Calibration Check Form – Blank Form.

C-2. Temperature Logger Calibration Check Form – Filled Out Form.

C-1. Temperature Logger Calibration Check Form – Blank Form.

Date: __________

Temperature Logger Calibration Check Form

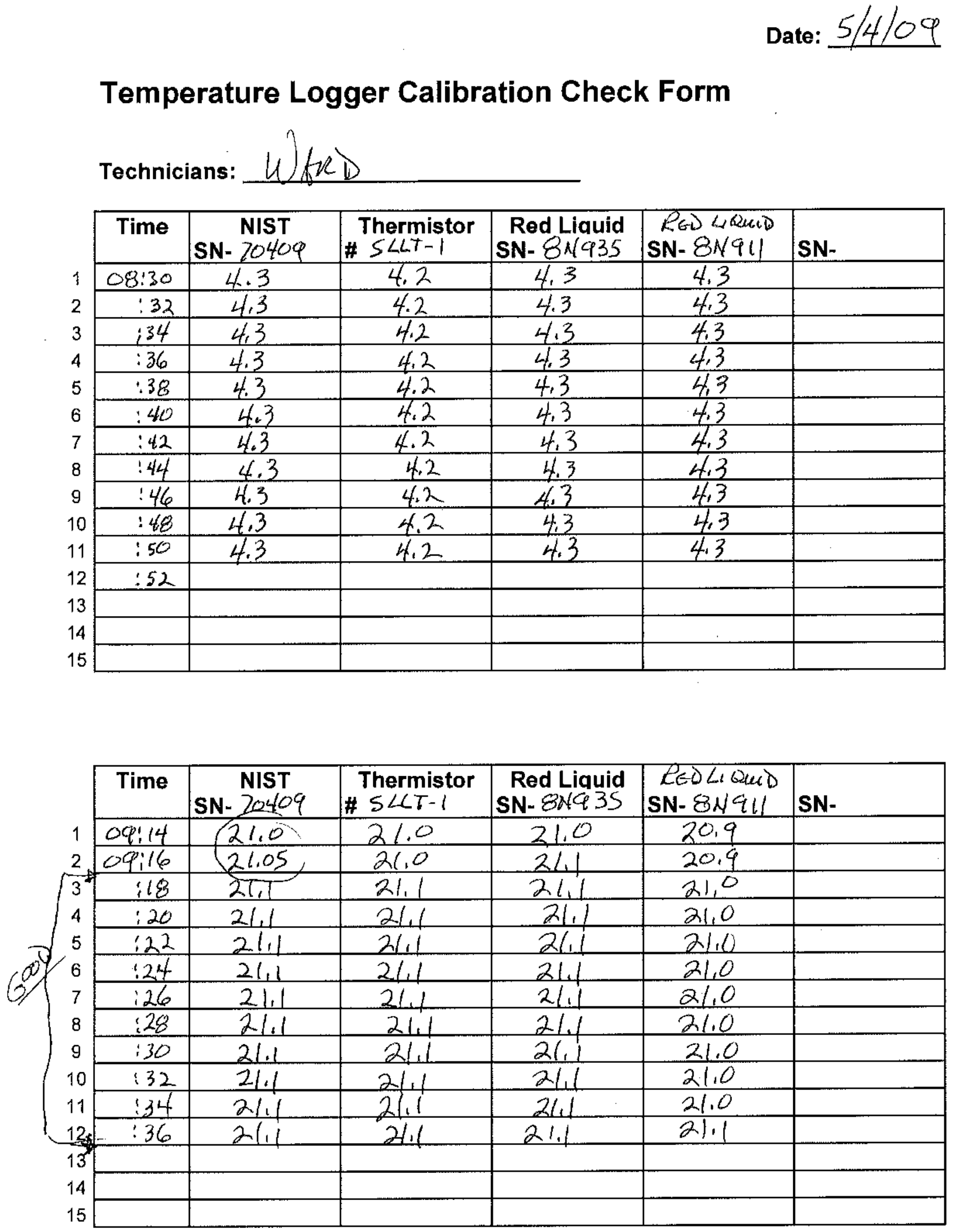
Technicians:

____

	Time	NIST SN-	Thermistor #	Red Liquid SN-	SN-	SN-
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

	Time	NIST SN-	Thermistor #	Red Liquid SN-	SN-	SN-
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

C-2. Temperature Logger Calibration Check Form - Filled Out Form.



Date: 5/4/09

Temperature Logger Calibration Check Form

Technicians: WJRD

	Time	NIST SN- 70409	Thermistor # SLLT-1	Red Liquid SN- 8N935	RED LIQUID SN- 8N911	SN-
1	08:30	4.3	4.2	4.3	4.3	
2	:32	4.3	4.2	4.3	4.3	
3	:34	4.3	4.2	4.3	4.3	
4	:36	4.3	4.2	4.3	4.3	
5	:38	4.3	4.2	4.3	4.3	
6	:40	4.3	4.2	4.3	4.3	
7	:42	4.3	4.2	4.3	4.3	
8	:44	4.3	4.2	4.3	4.3	
9	:46	4.3	4.2	4.3	4.3	
10	:48	4.3	4.2	4.3	4.3	
11	:50	4.3	4.2	4.3	4.3	
12	:52					
13						
14						
15						

	Time	NIST SN- 70409	Thermistor # SLLT-1	Red Liquid SN- 8N935	RED LIQUID SN- 8N911	SN-
1	09:14	21.0	21.0	21.0	20.9	
2	09:16	21.05	21.0	21.1	20.9	
3	:18	21.1	21.1	21.1	21.0	
4	:20	21.1	21.1	21.1	21.0	
5	:22	21.1	21.1	21.1	21.0	
6	:24	21.1	21.1	21.1	21.0	
7	:26	21.1	21.1	21.1	21.0	
8	:28	21.1	21.1	21.1	21.0	
9	:30	21.1	21.1	21.1	21.0	
10	:32	21.1	21.1	21.1	21.0	
11	:34	21.1	21.1	21.1	21.0	
12	:36	21.1	21.1	21.1	21.1	
13						
14						
15						

GOOD

Attachment D

This section contains a blank and filled out example of the Continuous Temperature Survey Form that should be used for Ambient Monitoring - continuous temperature logger deployments. The form must be printed on waterproof paper and all completed ones need to be organized and stored in binders for archival purposes.

D-1. Blank Survey Form

D-2. Filled-out Survey Form

D-1. Blank Survey Form

Continuous Temperature Survey Form

Station #: ____________ **Station Name:** ______________________________ **Samplers:** __________________________

Interval Frequency 00:30

Water Temperature Logger

I.D. # ____________________

Water Depth _______ **ft** **Deployment Depth** _______ **ft**

Height (Abv Bottom) _______ **ft** **Retrieval Depth** _______ **ft**

Air Temperature Logger

I.D. # ____________________

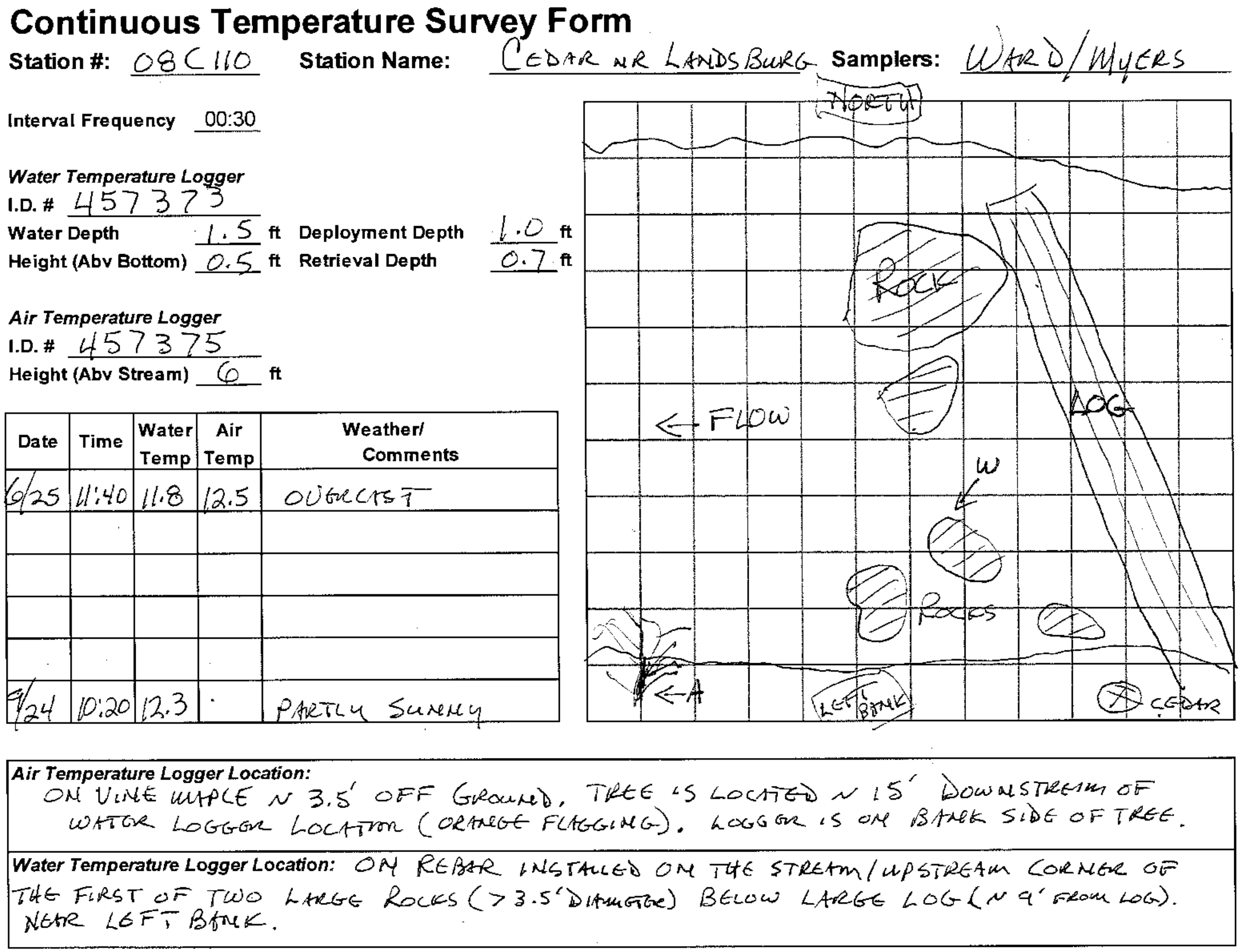
Height (Abv Stream) _______ **ft**

Date	Time	Water Temp	Air Temp	Weather/ Comments

Air Temperature Logger Location:

Water Temperature Logger Location:

D-2. Filled-out Survey Form



Continuous Temperature Survey Form

Station #: 08C110 **Station Name:** CEDAR NR LANDSBURG **Samplers:** WARD/MYERS

Interval Frequency 00:30

Water Temperature Logger
I.D. # 457373
Water Depth 1.5 **ft** **Deployment Depth** 1.0 **ft**
Height (Abv Bottom) 0.5 **ft** **Retrieval Depth** 0.7 **ft**

Air Temperature Logger
I.D. # 457375
Height (Abv Stream) 6 **ft**

Date	Time	Water Temp	Air Temp	Weather/ Comments
6/25	11:40	11.8	12.5	OVERCAST
9/24	10:20	12.3	.	PARTLY SUNNY

Air Temperature Logger Location: ON VINE MAPLE ~ 3.5' OFF GROUND, TREE IS LOCATED ~ 15' DOWNSTREAM OF WATER LOGGER LOCATION (ORANGE FLAGGING). LOGGER IS ON BANK SIDE OF TREE.

Water Temperature Logger Location: ON REBAR INSTALLED ON THE STREAM/UPSTREAM CORNER OF THE FIRST OF TWO LARGE ROCKS (> 3.5' DIAMETER) BELOW LARGE LOG (~ 9' FROM LOG). NEAR LEFT BANK.

DEPARTMENT OF
ECOLOGY
State of Washington

Standard Operating Procedure
EAP042, Version 1.2

Measuring Gage Height of Streams

December 2018
Publication 18-03-232

Purpose of this document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication information

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Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Measuring Gage Height of Streams

Version 1.2

Author – James R. Shedd
Date – 10/11/2018

Reviewer – Tyler Burks
Date – 10/15/2018

QA Approval - Arati Kaza, Ecology Quality Assurance Officer
Date – 10/07/2008

EAP042

APPROVED: October 7, 2008
RECERTIFIED: October 19, 2018

SIGNATURES ON FILE

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
08/10/2015	1.1	Updated reference and link to EAP Safety Manual	9.0	Jim Shedd
08/10/2015	1.1	Made grammatical and formatting adjustments, rephrased language throughout document.		Jim Shedd
08/10/2015	1.1	Recertified	All	B. Kammin
10/16/2018	1.2	Made grammatical and formatting adjustments, rephrased language throughout document.	All	Jim Shedd
10/16/2018	1.2	Clarified/updated definitions and described more succinctly the purpose and execution of procedures. Updated Equipment, Reagents, and Supplies section.	3.0, 5.0, 6.0	Jim Shedd
10/16/2018	1.2	Added missing QA/QC section. Inserted citation to Standard Operating Procedure EAP082.	8.0	Jim Shedd
10/16/2018	1.2	Inserted reference to Standard Operating Procedure EAP082. Updated reference to EAP Safety Manual.	10.0	Jim Shedd
10/16/2018	1.2	Added title to main page and brief description of back page of Logger Note Form.	Appendix	Jim Shedd
12/14/2018	1.2	Formatting and accessibility updates.	All	Ruth Froese

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for determining the stage of a stream using a staff gage, wire-weight gage, laser level, weighted measuring tape (tape down), and crest-stage gage.

2.0 Applicability

2.1 This procedure is followed when determining or verifying the gage height of a stream.

3.0 Definitions

3.1 Gage Datum —The term datum in the context of this SOP refers to the base or the 0.00 ft. elevation plane to which all reference marks, reference points, and water surface elevations are determined. At EAP flow monitoring stations the datum is set below the elevation of zero flow and maximum scour.

3.2 Gage Height — Often this term is used interchangeably with stage. However gage height is more appropriately used to indicate the water surface observed on a particular indices. (Rantz et al., 1975).

3.3 Stage — The height of the water surface above a datum (Rantz et al., 1975).

3.4 Primary Gage Index — The primary gage index is the base gage for the station, directly referenced to the recording gage. The primary gage index is the most stable and reliable gage at a site. All other gages at a station are considered secondary gage indices.

3.5 Secondary Gage Index — Secondary gage indexes are used to confirm the primary gage index. The secondary gage is used to estimate the value of the primary gage if the primary gage is damaged or missing.

3.6 Recording Gage — Typically, an automated bubbler, pressure transducer, or radar gage measures and records the stage to an electronic data logger maintaining a continuous record of stage through a specified period of time. The bubbler or transducer is calibrated to match the primary gage index.

3.7 Reference Mark — A reference mark is a permanent marker of known elevation above the datum, installed in the ground or on a stable structure in the vicinity of the gauging station.

3.8 Reference Point — A reference point is a marker above the zero datum from which gage height can be determined.

3.9 Levels — Also known as differential leveling, levels are a specific set of procedures conducted with surveying instruments to check that reference marks, reference points, and all gage indices used to determine gage height are set correctly to the gage datum.

3.10 Control — The physical features of a stream that control the relationship between stage and discharge at a gage site.

3.11 Point of Zero Flow — Stage at which water ceases to flow over the control. The point of zero flow is the lowest point on the control.

4.0 Personnel Qualifications/Responsibilities

4.1 Personnel using this SOP should have training and field experience in making stream gage site visits, recording and documenting pertinent data.

5.0 Equipment, Reagents, and Supplies

5.1 Copies of the standard Ecology Stream Gage Logger Notes (Attachment A) for recording times, gage readings, and actions taken while at the gage site, are kept in a suitable field notebook. These forms are usually printed on Rite in the Rain™ paper for outdoor durability.

5.2 A laser level instrument emits a laser beam illuminating a horizontal plane of known elevation. The laser beam elevation is used to determine water surface elevation.

5.3 A stadia rod, placed vertically on the wetted bottom of a stream channel reflects the laser beam emitted from the laser level instrument. Observations of the height of the laser beam reflection on the stadia rod and the intersection of the water surface on the rod allows determination of the water surface gage height.

5.4 A circular bubble level attaches to the stadia rod to ensure the stadia rod remains vertical while measuring laser beam and water heights.

5.5 A crest stage gage (csg) allows for determination of peak flow stages at EAP monitoring gages.

5.6 An engineer’s tape measure is used to measure the high-water mark on a crest-stage gage.

5.7 A weighted measuring tape is used for measuring vertical distance to the water surface from a reference point of known elevation above the wetted channel.

6.0 Summary of Procedure

6.1 Establishing Gage Datum — The stage or water surface elevation at a stream-gauging site and the elevations of all reference marks, reference points, and gages used to determine stage are relative to a common datum. At most stations, a datum is arbitrarily assigned corresponding to the elevation of the primary gage index. Primary gages are installed such that the assumed zero point of the primary gage is below the point of zero flow and expected scour of the channel.

6.1.1 Movement of the structures supporting the primary gage disturbs the datum. Periodic leveling surveys (levels) check the relative position of the primary gage against reference marks and points of known elevation.

6.1.2 Levels are run at a minimum of every three years or as soon as possible after unresolved discrepancies between gage observations or movement of gage structures, reference marks, or reference points are suspected.

6.1.3 When the primary gage has moved, the gage is recalibrated to the datum and/or relocated to the proper elevation when possible.

6.1.4 In some applications, relocation of the gage is not possible. The ways in which these circumstances are handled with respect to the existing datum are presented in the following discussions of each type of gage (sections 6.3 – 6.7).

6.2 Placement of Gages — Primary and secondary gages are placed collectively in the gage pool, subject to the same station control, and as close in proximity as possible to the recording gage.

6.2.1 Gages are not placed separately in stream sections regulated by different controls, as channel dynamics and geometry are not the same. Stage fluctuates at different rates and magnitudes, relative to changes in discharge in stream segments served by different controls.

6.3 Determining Stage Height by Observing a Staff Gage — A vertical standing staff gage consists of a singular or a successive series of porcelain enameled steel plates mounted to a secure structure. Most staff plates used by the Washington State Department of Ecology are graduated in 0.02 feet increments. Staff-gage observations are recorded to 0.01 feet resolution.

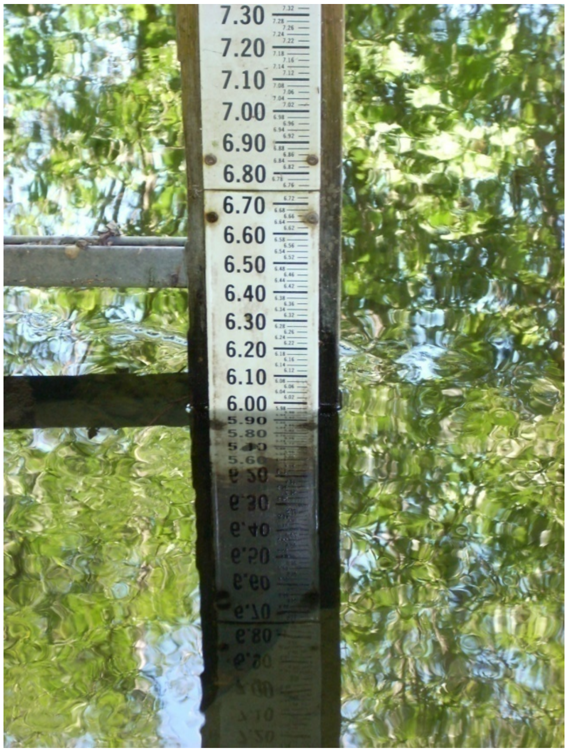

Figure 1. A typical Ecology staff gage with 0.02 feet increments. (Photo by Washington Dept. of Ecology)

6.3.1 In many locations, the water level may surge against the staff-gage structure, causing the water surface to fluctuate or bounce on the staff gage. If the water level fluctuates on the staff, read the average level, and note the reading with the range of water level fluctuation (uncertainty), i.e. 4.16 +/-0.04, where 4.16 is the best deciphered center of the peaks and troughs of the waves, and +/- 0.04 is the range of the peaks and troughs.

6.3.2 In situations where the fluctuation is excessive, use a makeshift stilling well. A good makeshift stilling well consists of a five-gallon bucket with the bottom cut out and a cut up the side to permit spreading of the bucket walls to surround the staff-gage structure. Open the bucket walls and wrap around the staff gage with the bottom of the bucket walls at a depth of 0.5 to 1 feet. This should calm the water around the staff gage enough to obtain a more reliable reading.

6.3.3 Take the necessary time to obtain the most accurate observation. Record the water surface fluctuation or bounce in the stream gage logger notes as an indicator of uncertainty for future analysis.

6.3.4 Record the date, time, the staff-gage observation, and the uncertainty on the stream gage logger notes or appropriate discharge measurement form.

6.3.5 In situations when the staff-gage elevation changes due to movement or damage, reposition the staff plate to the original elevation.

6.3.6 If repositioning the staff plate is not possible and the datum is tied to the original elevation of the staff gage, either discontinue use of the staff gage as the primary gage index and establish a new primary gage index relative to the existing datum, or establish a new datum adjusting related records and document accordingly.

6.4 Determining Stage Height Using a Wire Weight Gage — Wire-weight gages are stage-height-measuring instruments typically attached to a bridge railing or parapet over a stream. The gage is housed in a locked protective covering.

Figure 2. Wire Weight Gage (photo courtesy Rickly Hydrological Company)

6.4.1 The basic parts of a wire-weight gage include a drum wrapped with a single layer of cable and a weight attached to the end of the cable. A readable disc, graduated in tenths and hundredths of a foot is attached to the side of the drum. A Veeder counter, reading in whole feet is also included.

6.4.2 One complete turn of the drum represents one foot of vertical movement of the weight.

6.4.3 A threading sheave guides the cable to and from the drum. A pawl-and-ratchet mechanism holds the weight in place at any desired elevation.

6.4.4 A moveable check bar is mounted at the front of the instrument. When moved to the forward position, the weight rests on the check bar. The check bar, moved to the forward position, is the reference point for the wire-weight gage.

6.4.5 *Operating a wire-weight gage* — Open the wire-weight-gage house. Move the check bar forward so it rests in position under the weight.

6.4.6 While grasping the drum crank handle, disengage the pawl, and lower the weight until it touches but does not fully rest on the check bar.

6.4.7 Read the interval at the pointer on the graduated disc. The numbered hash marks correspond to tenths and five-hundredths-of-a-foot graduations (e.g. 38.45, 38.50, 38.55, etc.). The small hash marks correspond to one-hundredth-foot increments (e.g. 38.51). Record the CHECK BAR value on the Stream Gage Logger Notes in the space provided.

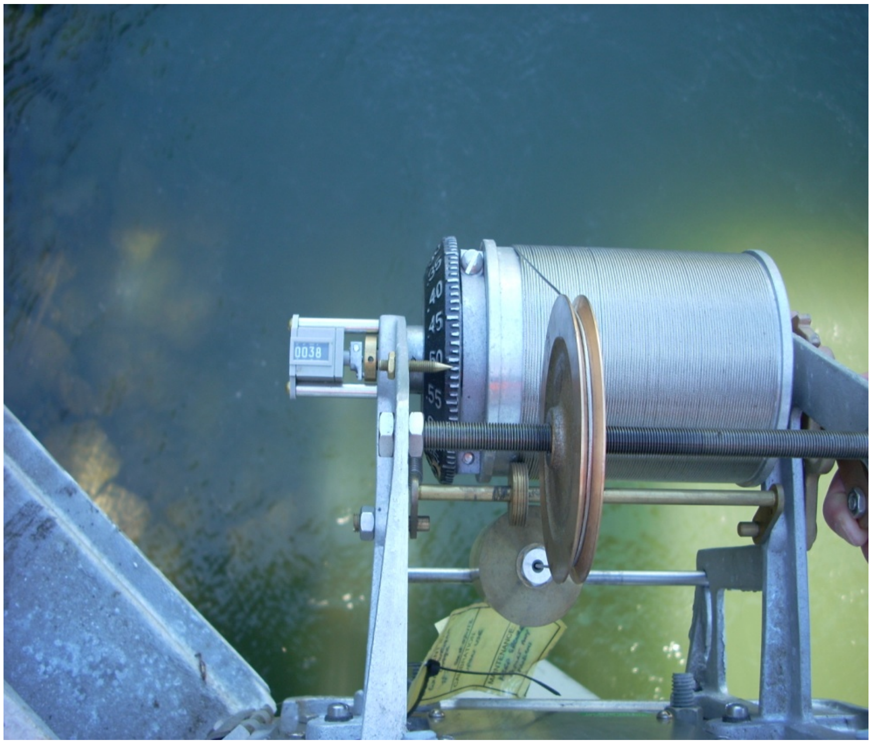

Figure 3. Prior to and after obtaining gage height, lower weight to check bar, and record this value to notes. (Photo by Washington Dept. of Ecology)

6.4.8 The check-bar value as read on the counter and disc should remain the same at all times. The station description notes should include the check-bar elevation and the latest date levels were run to establish or confirm the elevation.

6.4.9 If the check-bar value does not match, perform the following inspections: Make sure the check bar is set correctly. Check that the cable is wrapped on the drum properly, and the threading sheave is positioned properly, directly above the wrap on the drum. Make sure the graduated disc does not slip (caused by loose clutch screws). Check the Veeder counter for proper operation. Occasionally, the counter is not synchronized with the graduated disc and will not turn over to the next whole foot in synchronization with the disc.

6.4.10 If the check-bar value is satisfactory, slide the bar back, and slowly lower the weight to the water surface. The weight should only touch the water surface enough to form a distinct “V” shape on the water surface.

6.4.11 Read the Veeder counter and disc as previously described. Record the stage height in the WIRE WEIGHT space on the Stream Gage Logger Note form. Wind in the weight.

Confirm the check-bar elevation and reengage the pawl before closing and locking the wire-weight gage enclosure.

6.4.12 The best conditions to read a wire-weight gage is when current moves slowly under the weight with no wind. Stage-height observations can be difficult in higher velocities when surface waves are present. Attempt to discern the average surface elevation of the peaks and troughs of the waves. Conversely, it is sometimes difficult to determine when the weight touches the water surface if the water is quiescent. Windy conditions cause the cable to bow, resulting in underreporting of the water surface (Rantz, et, al., 1975).

6.4.13 Document difficulties encountered in reading a wire-weight gage. Quantifying errors in reading wire-weight gages can prove difficult; however, noting the potential for error without necessarily quantifying them is still useful in records and measurement evaluations.

6.4.14 Use secondary gage indices as a cursory check of the relative accuracy of the wire-weight gage. If there is indication that the position of the gage has changed, run a set of levels as soon as possible to verify the elevation of the gage.

6.4.15 The datum typically will not change when relocating a wire-weight gage. Using station reference marks, reset the gage and adjust mechanically to calibrate the check bar relative to the established datum.

6.5 Determining Stage Height Using a Laser Level

6.5.1 Laser levels are useful instruments to determine stage height, particularly in areas where staff gages are not practical. The laser level, a portable device mounted on a permanently installed structure or pad of known elevation emits a laser beam on a level plane.

Figure 4. Laser level mounted on laser level pad. (Photo by Washington Dept. of Ecology)

6.5.2 Determine stage height by measuring the difference between the known laser beam elevation and the water-surface elevation. Confirm the elevation of the laser level with the use of reference marks placed near the laser level pad.

Figure 5. Reference mark placed near laser level is used to confirm elevation of laser level beam. (Photo by Washington Dept. of Ecology)

6.5.3 *Confirmation of Laser Beam Elevation* — At the time of installation, run levels to establish the elevation of the laser level pad relative to the station datum.

6.5.4 The laser beam elevation consists of the elevation of the pad plus the difference between the laser beam plane and the bottom of the laser level instrument mounted on the pad. It is important to distinguish between the elevation of the pad and the laser beam plane. The pad elevation remains the same until disturbance of the pad occurs and the elevation changes. The beam elevation is variable depending on the manufacturer dimensions of the particular laser level model used. All reference-mark and water-surface elevations are noted and calculated with reference to the beam elevation.

6.5.5 In the immediate vicinity of the laser pad, three reference marks are installed and levels run to establish their respective elevations. The reference marks are placed in locations where a stadia rod is used with the laser level to verify elevations.

6.5.6 The elevations of the reference marks and the last date levels were run to confirm their elevations and are included in the station description.

6.5.7 To confirm the laser-beam elevation, place the laser level on the pad and power up the instrument. Most instruments will self-level if the surface upon which it is placed is close to level. The pads are installed at or near level, so unless the pad has been disturbed or the laser level is malfunctioning, the instrument should self-level.

6.5.8 Place the stadia rod on one of the reference marks. Using a circular bubble level as a guide, hold the rod as vertical as possible.

Figure 6. A circular bubble level is used to vertical the stadia rod. (Photo by Washington Dept. of Ecology)

6.5.9 With the laser level powered on and set at level, rotate the device until the laser beam intersects the stadia rod.

6.5.10 Read the rod to the one-hundredth of a foot resolution. The center of the laser light dot projected on the rod is the point at which the stadia rod is read. If the same model of laser level is used for each observation, the rod reading should be the same at each of the three exclusive reference marks.

Figure 7. The center of the bright red laser light dot projected on the rod is the point at which the stadia rod is read. (Photo by Washington Dept. of Ecology)

6.5.11 To check the elevation of the reference marks, compare the rod reading of the laser beam at each reference mark to the established rod reading value for that respective mark. Record the established rod reading for each reference mark in the station description notes. Record the established rod reading and the observed rod reading for each laser level reference mark in the appropriate space on the Stream Gage Logger Notes form.

6.5.12 If the laser elevation cannot be confirmed at a given reference mark, check the other reference marks. If the measured elevations of those reference marks match known elevations, assume the unconfirmed reference mark has been disturbed, but the position of the laser level has not changed.

6.5.13 If the rod readings of the other marks do not match, assume the laser has been disturbed and the (previously established) laser elevation is no longer valid.

6.5.14 If the laser elevation is no longer valid, check the differences in elevation between individual reference marks if possible. If these differences remain the same as shown by previous levels, it can be concluded until subsequent levels are run, the reference marks have not moved and only the laser level pad has been disturbed. If this is the case, assign a temporary elevation to a new position of the laser level based on the established elevations of the reference marks. The water surface elevation can be measured based on the new laser beam elevation. Consider this water surface elevation an estimate until levels are run. In most circumstances, the water surface elevation can be checked against secondary gages.

6.5.15 When the laser beam elevation shifts or reference marks move, run a new set of levels as soon as possible.

6.5.16 The datum typically will not change when relocating the laser level pad. Other reference marks at or near the station are tied to the datum elevation and used to reset the laser level at a datum relative elevation.

6.5.17 *Measuring Water Surface Elevation with Laser Level* — After confirming the laser level beam elevation, measure the water surface elevation.

6.5.18 The stadia rod handler stands the rod vertically on a solid, steady section of substrate in the calmest water practical in the gage pool subject to the station control. Place the rod as close to the primary and recording gage as possible.

Figure 8. Hold the rod perpendicular on solid substrate in calm water. (Photo by Washington Dept. of Ecology)

6.5.19 The instrument person rotates the laser level toward the stadia rod until the laser beam illuminates on the rod. Read the illuminated point on the rod and record in the Stream Gage Logger notes under LASER: STADIA ROD READING. Note any uncertainty in reading the laser illumination on the stadia rod (i.e. rod reading +/- *n* ft.)

6.5.20 Observe and record the water surface level on the stadia rod in the Stream Logger Gage notes under WATER SFC. ROD READING. Note fluctuations or bounce of the water surface against the stadia rod.

6.5.21 *Calculating Water Surface Elevation* — Subtract the WATER SFC. ROD READING from the LASER: STADIA ROD READING to give the DIFFERENTIAL and enter this value in the space provided on the Stream Gage Logger Notes. The differential is the difference in elevation between the laser beam plane and the water surface.

6.5.22 Subtract the DIFFERENTIAL from the LASER BEAM ELEVATION to give STAGE HEIGHT. Enter this value in the space provided on the Stream Gage Logger Notes.

Table 1. Example of calculation of stage from laser level readings on Stream Gage Logger Note form. (Washington Dept. of Ecology form)

LASER: STADIA ROD READING	**6.25**				
- WATER SURFACE, ROD READING	**0.34**				
= DIFFERENTIAL, LASER TO WATER SFC	**5.91**				
LASER BEAM ELEVATION	**11.90**				
- DIFFERENTIAL	**5.91**				
= STAGE	**5.99**				

6.6 Determining Stage Height by Tape Down

6.6.1 Measuring stage height by tape down involves lowering a weighted measuring tape to the water surface from a reference point. The reference point usually consists of a stainless steel washer secured to a bridge railing.

6.6.2 The degree of accuracy and reliability of tape downs in determining stage height is generally inferior to the other methods described in this document. Only use tape downs as a secondary gage.

6.6.3 Fiberglass tapes are light with a wide surface area and prone to errors even in light wind conditions. Fiberglass tapes tend to stretch over time causing biases in tape down measurements. Like the wire-weight gage, it can prove difficult to determine stage height when surface waves are present or conversely when water is extremely calm. When waves are present, try to determine the average water surface elevation between the peaks and troughs.

6.6.4 *Measuring Tape Down from Reference Point* — Locate the reference point. Lower the weighted tape to the water surface. The weight should only touch the water surface enough to form a distinctive "V" shape on the water surface.

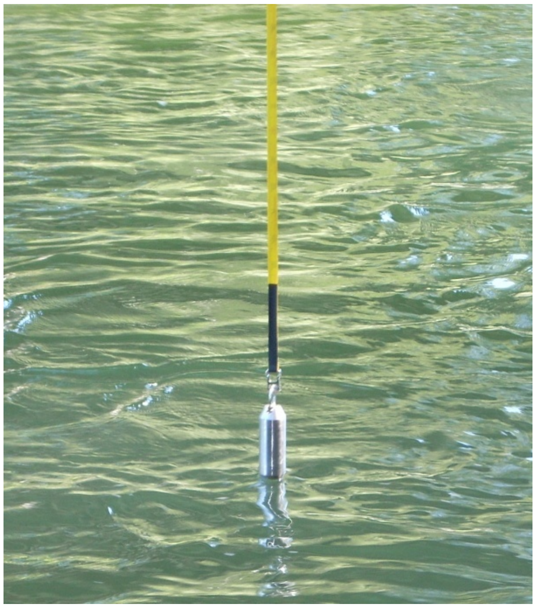

Figure 9. Tape down weight touching water surface. (Photo by Washington Dept. of Ecology)

6.6.5 Read the tape at the edge of the reference point to one-hundredth of a foot. Enter this value under TAPE DOWN in the space provided in the Stream Gage Logger notes. Note any difficulties reading the tape caused by wind or wave action.

6.6.6 Because the weight is attached to the end of the fiberglass tape, a correction factor is applied to the reference point reading. This correction factor is usually written in permanent marker on the tape housing. Enter this value under CORR. FACTOR in the Stream Gage Logger Notes.

6.6.7 *Calculating Water Surface Elevation* — Add the correction factor to the tape down and enter the sum to CORRECTED TD in both spaces provided in the Stream Gage Logger Notes.

6.6.8 Enter the reference-point elevation in the space labeled TD RP ELEVATION on the note form.

Subtract the corrected tape down from the reference point elevation to give the water surface elevation. Enter this value under = WS ELEV@TD on the note form.

Table 2. Example of calculation of stage from tape down readings on Stream Gage Logger Note form.

TAPE DOWN	**16.32**				
CORR. FACTOR	**0.37**				
CORRECTED TD	**16.69**				
TD RP ELEVATION:	**25.33**				
CORRECTED td	**16.69**				
=WS ELEV@TD	**8.64**				

6.6.9 The datum typically will not change when a tapedown reference point is relocated. Using station reference marks, reset the reference point relative to the established datum.

6.6.10 Include the reference mark elevations and the last date of levels in the station description notes.

6.7 Determining Peak Stage with Crest Stage Gage

6.7.1 The stage measurement equipment and methods previously described are designed to determine stage instantaneously. Crest-stage gages provide a valuable record of peak stages after the occurrence of high flows. The gage is reliable and relatively simple to install and operate (Rantz, et, al., 1975).

6.7.2 Crest-stage gages consist of a four-foot long, two-inch diameter galvanized pipe capped on both ends with a wooden staff contained in the pipe. The bottom pipe cap consists of an arrangement of six quarter-inch intake holes. The top cap has a small vent hole. The wooden staff rests on a bolt extending through the bottom of the pipe. The extension of the bolt on the outside of the pipe also serves as a reference point.

6.7.3 The bottom cap contains granulated cork. As water rises in the pipe, the cork floats on the water. When the water reaches its peak and begins to recede, the cork sticks to the wooden staff, marking the crest of the high-water event.

6.7.4 At a site visit subsequent to a high-flow event, remove the top cap from the crest-gage pipe. Carefully pull out the wooden staff. Measure from the bottom of the staff to the high-water mark with an engineer’s tape measure.

6.7.5 Clean the cork from the wooden staff to avoid confusion with subsequent high water marks. Rinse residual cork from the inside of the pipe. Replace the granulated cork in the bottom cap. Return the wooden staff into the pipe so that it rests on the bolt. Replace the top cap hand-tight. Be aware of the nail at the top of the staff for flush fit with the cap, and keep the staff vertical in the pipe.

6.7.6 *Calculating Crest Stage* — Record the high water mark in the space HWM ____ FT ON STICK on the back of the Stream Gage Logger Notes form (Appendix A). Record the elevation of the reference point in the space REF ELEV____ FT adjacent to the high-water-mark entry.

6.7.7 Add the high-water mark and the reference-mark elevation, and enter the sum under =HWM ELEV____FT. on the Stream Gage Logger Notes form. This value is the crest-stage height.

6.7.8 The datum typically will not change when relocating a crest-stage gage. Using station reference marks, reset the gage reference point relative to the established datum.

6.7.9 Include the reference mark elevations and the last date of levels in the station description notes.

7.0 Records Management

7.1 <u>Field Note Forms Archives</u>

7.1.1 All original field note forms including levels notes, stream-gage-logger notes, and discharge measurement notes are stored in a central locations at Ecology Headquarters, regional, and field offices.

7.1.2 All discharge measurement notes will contain the handwritten original primary gage observations associated with a particular discharge measurement.

7.1.3 Streamgage logger notes contain written stage-height observations of all primary and secondary gages at a site.

7.1.4 Levels notes contain the original notes of gauging site surveys as well as calculations of reference marks and reference point elevations.

7.2 <u>Stage Records in Hydstra Database</u>

7.2.1 All primary and secondary gage observations are recorded and stored electronically to a Hydstra® database.

7.2.2 Stage height observations associated with discharge measurements are stored in the Gaugings Database within Hydstra®.

8.0 Quality Control and Quality Assurance

8.1 The EAP addresses variability in gage height observations by paying close attention to the amount of fluctuation or bounce in the water surface against the observed gage index. In doing so the true gage height is more accurately determined. Variability in gage height observation can influence the application of data shifts in the stage data record to correct for instrument drift (Shedd, Springer, 2012) and subsequently impact stage record error. Variability in gage height can also affect discharge measurement quality which in turn affects the certainty of ratings.

8.2 All discharge measurements including gage height determinations are peer reviewed.

8.3 In addition, all streamflow records including primary and secondary gage height entries to the Hydstra® database undergo comprehensive review by EAP senior staff at the conclusion of each water year.

8.4 EAP flow monitoring stations include at least one independent secondary gage index in addition to the primary gage index. Field staff use the secondary gage as a check of the relative accuracy of the primary gage.

8.5 If the gages do not reasonably and consistently match each other nor result in close determinations of stage, levels are run as soon as possible to resolve the discrepancy and reset the gage indices to the station datum.

9.0 Safety

9.1 Personal Flotation Devices are required for persons working in or near streams.

9.2 All EAP safety policies are followed when obtaining stage heights. Refer to the EAP Safety Manual (EAP, 2017) for further information about working in and around streams.

9.3 Always consider the safety and traffic situations when obtaining gage heights from a bridge, and take appropriate actions including suspension of the activity if unsafe conditions exist. Consult the EAP Safety Manual (EAP, 2017) for further guidance regarding bridge safety.

9.4 When operating laser levels, do not stare into the beam or direct the beam at other persons. Check the path of the beam to ensure there is no danger of inadvertently pointing the beam at people in the vicinity.

10.0 References

10.1 Environmental Assessment Program, 2017. Environmental Assessment Program Safety Manual, March 2017. Washington State Department of Ecology, Olympia, WA.

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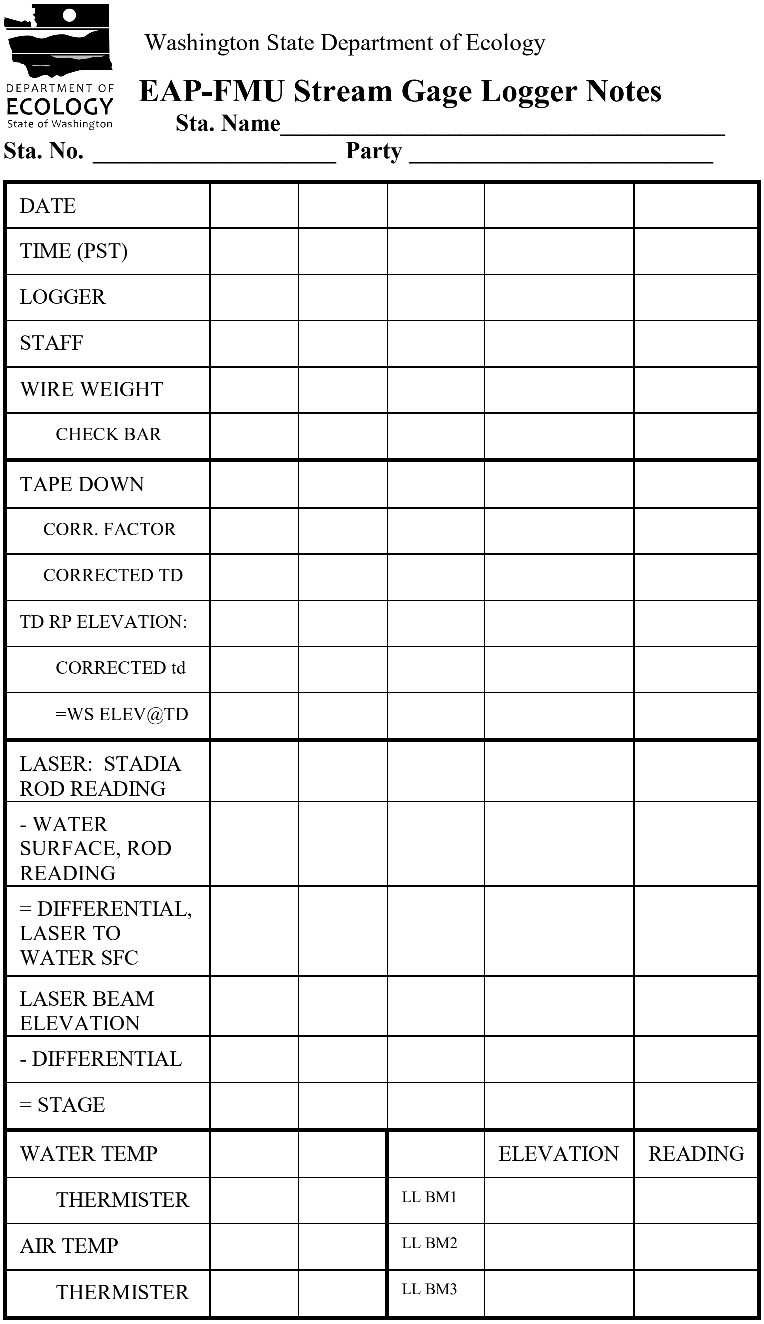
11.0 Attachment A

Front page view of EAP-FMU Stream Gage Logger Notes. Rite-in-the-Rain ™ field form



DEPARTMENT OF ECOLOGY
State of Washington

Washington State Department of Ecology

EAP-FMU Stream Gage Logger Notes

Sta. Name____________________________________

Sta. No. ____________________ **Party** _________________________

DATE					
TIME (PST)					
LOGGER					
STAFF					
WIRE WEIGHT					
CHECK BAR					
TAPE DOWN					
CORR. FACTOR					
CORRECTED TD					
TD RP ELEVATION:					
CORRECTED td					
=WS ELEV@TD					
LASER: STADIA ROD READING					
- WATER SURFACE, ROD READING					
= DIFFERENTIAL, LASER TO WATER SFC					
LASER BEAM ELEVATION					
- DIFFERENTIAL					
= STAGE					
WATER TEMP				ELEVATION	READING
THERMISTER			LL BM1		
AIR TEMP			LL BM2		
THERMISTER			LL BM3		

Back page view of EAP-FMU Stream Gage Logger Notes. Rite-in-the-Rain ™ field form
These notes populated by field staff to indicate routine station checks were performed as well as address station condition at time of station visit.

Batt V _________ Min ________ Max ____________

Reset Stats Y/N Batt replaced Y/N

GOES Time OK Y/N

Data downloaded Y/N .NEW file erased Y/N

Desiccant condition _______________ Changed Y/N

CSG checked Y/N

HWM ________ ft on stick + Ref Elev __________ ft

= HWM Elev _____ ft. Cleaned Y/N

Added cork Y/N

Remarks:

DEPARTMENT OF
ECOLOGY
State of Washington

Standard Operating Procedure EAP108, Version 1.10

Collecting In Situ Water Quality Data

February 2019
Publication 19-03-206

Purpose of this document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication Information

This SOP is available on the Department of Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1903206.html.

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Standard Operating Procedures for Collecting In Situ Water Quality Data

Author – Jenny Wolfe
Date –

Reviewers – Dan Dugger, Bill Ward, Glenn Merritt, Meghan Rosewood-Thurman and Brian Engeness
Date –

QA Approval – Tom Gries, Acting Ecology Quality Assurance Officer
Date –

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
1/4/17	1.1	Added Footers, updated references	All	Meghan Rosewood-Thurman
1/10/17	1.2	Updated glossary, general edits	All	Meghan Rosewood-Thurman
1/20/17	1.3	Updated Glossary, general edits	All	Meghan Rosewood-Thurman
1/26/17	1.4	Updated References, general edits	All	Meghan Rosewood-Thurman
1/30/17	1.5	3.10 removed bold 3.11 replaced PSAT definition 3.13 spelling of Protocol 3.16 re-wrote definition for µS/cm 5.4 Labeled soaker bottle in Fig 2 6.0 edited cites 6.1.1.2 reference Figure 2 6.3.1.1 Added Figure 4 and ref. to it 6.3.1.2 ref. to Figure 4 6.3 Renumbered Fig to 5; referenced it 10.13 Added cite: WOW. 2004	3.0 5.0 6.0 10.0	Glenn Merritt
2/13/17	1.6	Added Reviewers	Signature Page	Meghan Rosewood-Thurman
2/16/17	1.7	Removed drafted dates	Signature Page	Meghan Rosewood-Thurman
12/11/17	1.8	Replaced Tin Foil with User Manual Changed frequency of calibration Changed frequency of calibration Changed frequency of calibration Removed BOD procedure Changed frequency of probe check	5.13 6.1.1 6.1.2 6.1.3 6.1.3.1 6.5	Brian Engeness
12/21/17	1.9	Added new citation of SOP EAP127 Referenced citation of EAP127 Removed sentence	10.8 6.1.3 6.1.3.1	Brian Engeness
12/28/17	1.10	Updated Footers, general edits	All	Meghan Rosewood-Thurman
8/7/18	1.10	Minor edits and format changes for recertification	All	Tom Gries

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program's (EAP) Standard Operating Procedure (SOP) for measuring in situ water quality in rivers and streams for the Watershed Health Monitoring (WHM) program. It includes procedures for both of the WHM protocols. The Narrow Protocol is typically accomplished by wading upstream. The Wide Protocol is typically accomplished by floating on rafts. This SOP is also used in the Ambient Biological Monitoring Program.

1.2 In situ water quality is measured with a multi-parameter probe and includes: temperature, specific conductivity, pH, dissolved oxygen (DO) and oxygen percent saturation (PSAT).

2.0 Applicability

2.1 This SOP contributes to both of the WHM protocols: Narrow and Wide.

2.2 This SOP is used in conjunction with several others to complete a data collection event (DCE) for the WHM program.

3.0 Definitions

3.1 DCE: The Data Collection Event is the sampling event for the given protocol. Data for a DCE are indexed using a code which includes the site ID followed by the year, month, day, and the time (military) for the start time of the sampling event. For example: WAM06600-000222-DCE-YYYY-MMDD-HH:MM. One DCE should be completed within one working day, lasting 4-6 hours, on average.

3.2 DI: Deionized water.

3.3 DO: Dissolved Oxygen. The concentration of dissolved oxygen in a water sample. Reported in mg/L.

3.4 EAP: Environmental Assessment Program

3.5 Ecology: The Washington State Department of Ecology

3.6 Index station: Index station: The distinct point location mapped by the site coordinates obtained from the Washington Master Sample List. The index station is called "X" and is generally located at major transect F; however the point may occur at any elevation in the stream between transects A and K.

3.7 LDO: Luminescent dissolved oxygen; dissolved oxygen values are measured by pulses of LED light.

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

3.9 Narrow protocol: The set of Watershed Health Monitoring SOPs that describe data collection at wadeable sites with an average bankfull width of less than 25 m at the index station.

3.10 pH: a measure of hydrogen ion concentration; a measure of the acidity or alkalinity of a solution. Aqueous solutions at 25°C with a pH less than seven are acidic, while those with a pH greater than seven are basic or alkaline.

3.11 PSAT (% sat): Percent saturation of oxygen is calculated as the percentage of dissolved oxygen relative to that concentration which occurs when completely saturated at the ambient temperature, pressure, and salinity (WOW 2004).

3.12 QAMP: Quality Assurance Monitoring Plan. The QAMP for WHM is Cusimano et al. (2006). An updated version is in early stages of development.

3.13 Site: A site is defined by the coordinates provided to a sampling crew and the boundaries established by the protocol's site layout method (Hartman, 2017 (SOP EAP105) for the Wide Protocol; Merritt, 2017 (SOP EAP106) for the Narrow Protocol). Typically, a site is centered on the index station and equal in length to 20 times the average of 5 bankfull width measurements. Sites cannot be longer than 2 km nor shorter than 150 m. Narrow protocol sites range from 150 m to 500 m long. Wide Protocol sites are at least 500 m long and up to 2 km long. The most downstream end of a site coincides with major transect A; the most upstream end coincides with major transect K.

3.14 Specific Conductivity: Electrical conductivity is a measure of water's ability to conduct electricity, and therefore a measure of ionic activity and content. It is the reciprocal of specific resistivity. Specific conductivity is conductivity adjusted to 25˚ C (reported in µS/cm at 25˚ C). This is what most field conductivity meters report.

3.15 Thalweg station or transect: One of one hundred (100) equidistant measurement locations in the thalweg, across the length of a site. For example the thalweg stations at/above each major transect are named as follows:

- A0, A1, A2, A3, A4, A5, A6, A7, A8, A9,
- B0. B1, B2, B3, B4, B5, B6, B7, B8, B9,
- C0, C1, C2, C3, C4, C5, C6, C7, C8, C9,
- …
- J0, J1, J2, J3, J4, J5, J6, J7, J8, J9, and
- K0.

3.16 µS/cm: micro-Siemens per centimeter, the unit that we use for measurement of electric conductance.

3.17 WHM: Watershed Health Monitoring, a status and trends monitoring program within the Environmental Assessment Program at the Washington State Department of Ecology.

3.18 Wide protocol: The set of WHM SOPs that describes the sample and data collection at non-wadeable sites or sites wider than 25 m bankfull width. It is an abbreviated version of the Narrow Protocol and is typically accomplished by use of rafts.

4.0 Personnel Qualifications/Responsibilities

4.1 This SOP pertains to all Natural Resource Scientists, Environmental Specialists, Interns and Technicians in Ecology's EA Program, as well as any other qualified staff collecting and entering data for WHM.

4.2 This method is performed by 1 or more persons, at every site, at the beginning and end of the DCE. Daily quality control (QC) checks precede and follow sampling. Other QC tasks are required less frequently than daily. Staff performing this method must have been trained.

4.3 All field staff must comply with the requirements of the EA Safety Manual (Ecology, 2017). Have a full working knowledge of the procedures in Chapter 1 'General Field Work,' especially the sections 'Working in Rivers and Streams,' and 'Fall Protection'. When sampling from a boat, one person onboard must be a qualified boat operator and all persons onboard must be familiar with Chapter 3 of the EA Safety Manual, 'Boating.'

4.4 All field staff must have completed the annual WHM program field training and be familiar with the set of SOPs, that when combined, describe a full DCE for the WHM program.

4.5 All field staff must be familiar with the WHM electronic data recording method described in SOP EAP 125 (Janisch, 2017).

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

4.7 All field staff must comply with SOP EAP070 (Parsons et al., 2016) 'Minimizing the Spread of Invasive Species'.

5.0 Equipment, Reagents, and Supplies

5.1 Field tablet, electronic field forms

5.2 HQ40d Calibration Form (Appendix)

5.3 HQ40d Portable Multi-Parameter Meter (Figure 1)

5.4 PHC28101 IntelliCAL pH Ultra Electrode (Figure 2)

5.5 LDO101 IntelliCAL Standard Dissolved Oxygen Probe (Figure 2)

5.6 CDC401 IntelliCAL Standard Conductivity Probe (Figure 2)

5.7 Hach “Singlet” Single-Use pH Buffers; 4.01, 7.00, 10.01

5.8 Thermo Scientific Orion Pure Water pH Buffer; 6.97

5.9 Hach IntelliCAL™ 2.44M KCl PHC281 filling solution for pH probe

5.10 Ricca Chemical Conductivity/TDS Standard; 100 µmho/cm

5.11 De-ionized water (DI) to rinse equipment

5.12 Lab tissues (e.g., Kim-wipes®)

5.13 Hach HQ40d Multi-Parameter User Manual

5.14 4 AA batteries

5.15 500ml plastic beaker

5.16 DO grab sample (Winkler) supplies

5.17 Funnel tube surface sampler

5.18 BOD bottle with glass stopper and plastic cap

5.19 Manganous sulfate monohydrate reagent bottle with 2 mL disposable transfer pipette

5.20 Alkali-iodine-azide reagent bottle with 2 mL disposable transfer pipette

5.21 Access gear (boats, or waders and boots). This should be pre-cleaned to avoid the spread of invasive species. See SOP EAP070 (Parsons et al., 2016) for more information.

Figure 1. HQ40d Multi-Parameter Meter

Figure 2. PHC28101 IntelliCAL pH Ultra Electrode, CDC401 IntelliCAL Standard Conductivity Probe, and LDO101 IntelliCAL Standard Dissolved Oxygen Probe.

6.0 Summary of Procedure

The following methods were derived, in part, from Status and Trends Monitoring for Watershed Health and Salmon Recovery. Draft Field Data Collection Protocol: Narrow Streams (Merritt and Hartman 2013) and Collection, Processing, and Analysis of Stream Samples (Ward 2012).

6.1 Meter Calibration and Pre-Sampling Calibration Accuracy Check

6.1.1 **Calibrate the pH electrode** at the beginning of the work week and after every two or three days if using the probe daily. Each time calibrating, use new packets of the color coded Hach single use calibration buffers. Ensure that the temperatures of the buffers are 15˚ C or higher (but not above 30˚C). Conduct a 3-point calibration with pH 4.01, 7.00, and 10.01 calibration buffers according to instructions provided in the user's manual (Hach, 2010a).

6.1.1.1 Ensure that the pH electrode is full of IntelliCAL™ 2.44M KCl PHC281 solution. If needed, top off the probe fill chamber with filling solution (Figure 3).

Figure 3. Close-up of electrolyte filling hole on pH probe

6.1.1.2 Before removing the electrode from the soaker bottle (Figure 2), unscrew the bottle base from the bottle cap. This will ensure that electrolyte is not suctioned out of the probe. Remove the bottle cap and put the bottle aside where it will not spill or become contaminated.

6.1.1.3 Thoroughly rinse the electrode with DI water prior to calibration and in between buffers. Be sure to shake off excess water.

6.1.1.4 Let the pH electrode equilibrate in each calibration buffer for at least one minute before taking a reading. Ensure the electrolyte filling-hole is open for an accurate measurement.

6.1.1.5 Stir the electrode gently during calibration. Do not rest the electrode on the bottom or sides of the container.

6.1.1.6 After calibrating, measure the pH QC 7 buffer and compare the result to the true value of the buffer based on the buffer temperature. Record the buffer true value and measured value on the Calibration Form (Appendix). If the measured value is within 0.10 units, then proceed with sampling, if not then recalibrate and try again. Perform this accuracy check before and after the DCE.

6.1.1.7 Occasionally, clogs may form in the filling solution for the PHC281 pH probe. When this happens, it can cause inaccurate and unstable pH readings. It may be necessary to clear the pH reference junction in the tip of the probe using the following procedure:

6.1.1.7.1 Attach the probe soaker bottle to the tip of the probe and seal the cap.

6.1.1.7.2 Unplug the probe fill hole and pull the probe soaker bottle with slight pressure to suction at least ½ inch of the filling solution out of the probe.

6.1.1.7.3 Refill the probe through the fill hole.

6.1.1.7.4 Repeat this process if you find additional clogs. If clogs continue, it may be necessary to replace all the filling solution in the probe with fresh filling solution.

6.1.2 **Calibrate the conductivity probe** using 100 µS/cm Ricca Chemical Conductivity/TDS buffer. Follow the calibration instructions provided in the user's manual (Hach, 2010c). Perform calibration at the beginning of the work week before the site visit and after every two or three days if the probe is being used daily.

6.1.2.1 Use DI water and a cotton swab to scrub the contacts inside the tip of the probe.

6.1.2.2 Thoroughly rinse the probe with DI water and shake off excess prior to calibration.

6.1.2.3 After calibrating, measure the conductivity buffer and compare the result to the known value. Record this measurement on the Calibration form (Appendix). If the conductivity measurement is not within 10 µS/cm, then recalibrate. Perform this accuracy check before and after the DCE

6.1.3 **Calibrate the LDO probe** at the beginning of the work week before the site visit and after every two or three days if the probe is being used daily. Follow the calibration instructions as outlined in the Environmental Assessment Program's SOP EAP127 (Hoselton, 2018).

6.1.3.1 Do not calibrate in direct sunlight since this can cause temperature fluctuations, which will hinder the calibration process.

6.2 General Considerations and Cautions

6.2.1 Never compromise your personal safety or that of field partners. Always plan ahead to avoid falling and drowning hazards.

6.2.2 In situ measurements should be one of the first tasks you complete. It is also one of the last tasks at a DCE (the second set of measurements). Record time (military) and location (thalweg transect). Measurements should *always* be taken within the boundaries of the site (between transects A0 and K0) at the beginning and end of the data collection event. When rafting, collect the first sample near the top of the site (upstream) and collect the end sample from near the bottom of the site (downstream). When wading collect start and end samples from the same station as each other, normally the index station.

6.2.3 Choose a sample location that is representative of the site. This location should be relatively deep and non-turbulent. If possible, sample near the thalweg or predominant downstream current. Avoid back eddies and side channels.

6.2.4 To avoid sample contamination, measure parameters before other crew members enter the stream and make sure not to disturb sediment from the stream bed.

6.2.5 If sampling on foot, face upstream while obtaining each in situ measurement.

6.2.6 If sampling from a boat, avoid gas and oil contamination. Measure from near the bow while the boat is pointed upstream.

6.3 Measurements

6.3.1 Measure temperature, conductivity, pH and dissolved oxygen (mg/L, PSAT) at the beginning of the DCE.

6.3.1.1 Thermally equilibrate the pH electrode. Collect a sample of stream water with the 500 mL beaker (Figure 4) and place it in a shallow, calm, edge section of the stream. Unplug the pH electrode fill hole and carefully remove the pH electrode soaker bottle. Place the pH electrode upright in the beaker and let it sit for 3-5 minutes. Be sure that you do not submerge the pH electrode past the electrode filling solution hole.

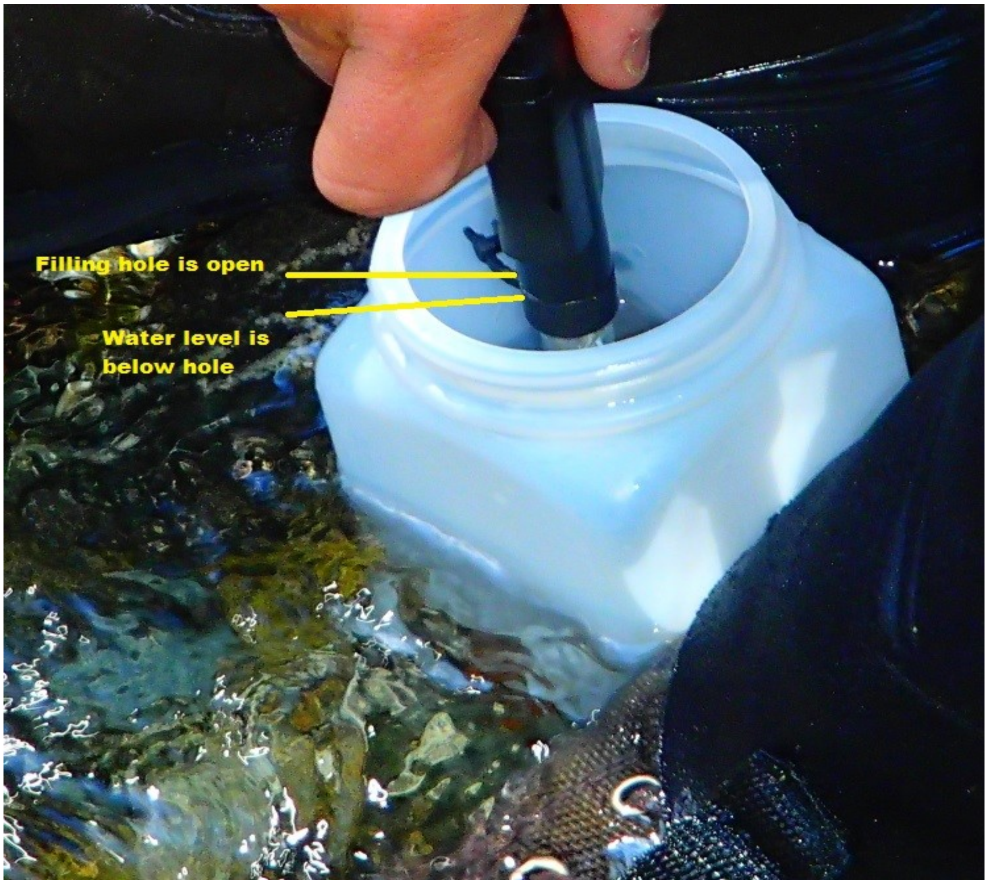


Figure 4. Measuring pH at equilibrated temperature and outside of streamflow.

6.3.1.2 Protect the pH electrode from flow-induced error. Measuring pH in flowing water can be problematic so do not place the electrode directly into the stream. Instead, re-fill the beaker with fresh, well-mixed stream water and measure from that (Figure 4). Keep the filled beaker partly submerged in stream water while taking the measurement in order to measure close to ambient stream temperature.

6.3.1.3 Measure pH in the contained water. Gently stir the pH sample with the pH electrode for several seconds while obtaining a stable sample measurement. Repeat this process until consecutive stable readings are within 0.02 pH units and the millivolts (Mv) readings are within 0.1 Mv of each other. On the field tablet, navigate to the *Chemistry Page.* Select "Get Time" button to record the time of the in situ measurements. Record the station ID (nearest transect) and record pH to the nearest hundredth (Figure 3).

6.3.1.4 Once you have recorded a stable stream pH value (Figure 5), plug the fill hole, rinse the pH probe with DI water and replace it in the soaker bottle. Make sure there is enough clean filling solution in the soaker bottle to cover the pH bulb (about ½ full). Detach the pH probe and connect the LDO and conductivity probes.

6.3.1.5 Thermally equilibrate the LDO and conductivity probes. Find a spot in the stream where the water is well mixed but not overly turbulent. Hold the LDO and conductivity probes so that they are just below the surface of the water, and completely immersed. Let them sit for 3-5 minutes.

6.3.1.6 Measure four parameters in flowing water. On the *Chemistry* sampling page (Figure 5), record temperature (˚ C, nearest tenth), specific conductivity (µS/cm at 25˚ C, nearest tenth), dissolved oxygen (mg/L, nearest tenth), and oxygen percent saturation (nearest tenth). Temperature should be measured using the LDO probe (for consistency).

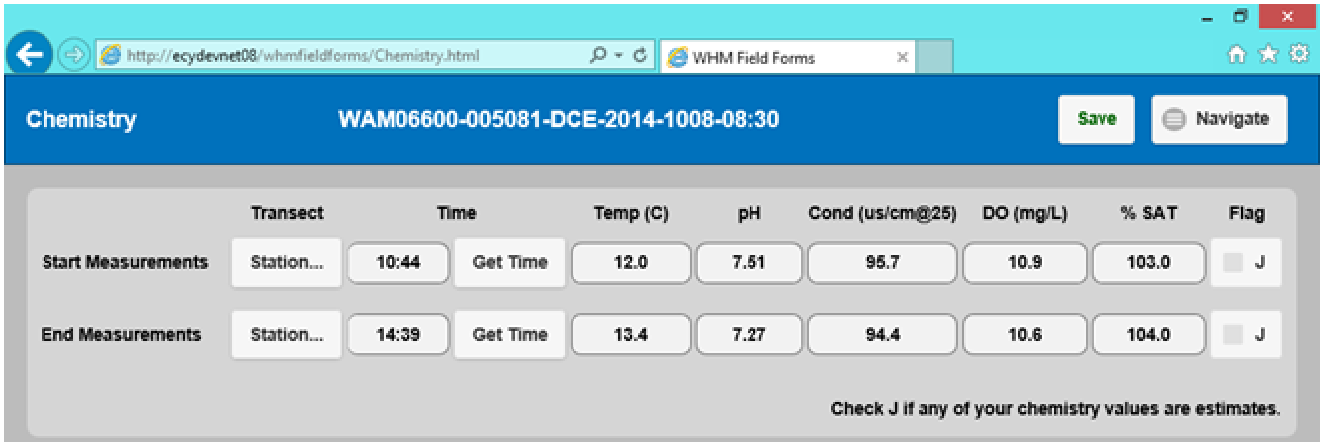
6.3.2 At the end of the DCE, re-measure temperature, specific conductivity, pH and dissolved oxygen (mg/L, PSAT). Record these values (Figure 5).

6.3.2.1 Repeat steps 6.3.1.1 through 6.3.1.6.

6.4 <u>Pre and Post-Sampling Accuracy Check</u>

6.5 Before starting the DCE and after completing the DCE, recheck the accuracy of the Hach meter and electrodes. Follow the calibration accuracy check procedures outlined in section 6.1.Verify that the buffers fall within the specified ranges: pH within 0.1 pH units, conductivity within 10µS/cm, DO water saturated air between 97.5% and 102.5%.

6.5.1 If the measured value of the QC solution is within the specified range then record this information on the calibration form. If it is outside the specified range then recalibrate **and resample** if possible. If the in situ pH or conductivity measurement does not meet the QC criteria, then collect and ship a water sample for the failing measurement as outlined in SOP EAP095 (Hartman, 2017)



Chemistry **WAM06600-005081-DCE-2014-1008-08:30**

	Transect	Time		Temp (C)	pH	Cond (us/cm@25)	DO (mg/L)	% SAT	Flag
Start Measurements	Station...	10:44	Get Time	12.0	7.51	95.7	10.9	103.0	☐ J
End Measurements	Station...	14:39	Get Time	13.4	7.27	94.4	10.6	104.0	☐ J

Check J if any of your chemistry values are estimates.

Figure 5. Top half of the chemistry page. Record measurements at the beginning and end of the DCE.

7.0 Records Management

7.1 Refer to SOP EAP125 (Janisch, 2017) which describes the process for validating, loading, and committing completed WHM electronic field forms to the WHM database.

8.0 Quality Control and Quality Assurance Section

8.1 Once monthly during July, August, September, and October, check the accuracy of the oxygen probe. Collect a Winkler sample as soon as possible following the initial calibration and prior to the first Data Collection Event. Subsequent Winkler samples should be collected immediately before and after monthly calibrations. For an accurate comparison, Winkler samples should be collected at the same station and time as the corresponding in situ DO reading. Winkler samples are collected and analyzed according to Ward and Mathieu (2013).

8.1.1 In situ DO readings are required to be within 1 mg/L of the average value from the paired Winkler samples. Verify that the meter measures to within 1 mg/L of the Winkler sample average, if it does not then recalibrate the probe and notify the project lead so that data entered from relevant prior sites can be recorded as suspect.

8.2 At the start and end of the field season, compare the measurements from the temperature probe against measurements of an NIST thermometer. Verify that the probe measures to within 1˚ C of the NIST thermometer in a cold water bath and to within 1˚ C of the NIST thermometer in a warm water bath. If it does not, then use a different probe that does meet these criteria.

8.3 QA/QC is discussed in the Quality Assurance Monitoring Plan (Cusimano et al, 2006), which is in the process of being updated.

9.0 Safety

9.1 All field staff must comply with the requirements of the EAP Safety Manual, especially Chapter 1 ‘General Field Work,’ which includes special circumstances like fall protection and working in rivers and streams. Sampling from a boat requires one person onboard to be a qualified boat operator and all persons onboard must be familiar with Chapter 3 of the EAP Safety Manual, ‘Boating.’

9.2 For further field health and safety measures refer to the EAP Safety Manual (Ecology, 2017).

10.0 References

10.1 Cusimano, R., G. Merritt, R. Plotnikoff, C. Wiseman, C. Smith, and WDFW. 2006. Status and Trends Monitoring for Watershed Health and Salmon Recovery: Quality Assurance Monitoring Plan. https://fortress.wa.gov/ecy/publications/SummaryPages/0603203.html

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LDO10103, LDO10105, LDO10110, LDO10115 or LDO10130. Edition 1 (11/210). DOC022.53.80021. Hach Company, Loveland Colorado.

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10.12 Ward, W.J., 2016. Collection, Processing, and Analysis of Stream Samples, Version 1.5. Washington State Department of Ecology, Olympia, WA. SOP Number EAP034. www.ecology.wa.gov/programs/eap/quality.html.

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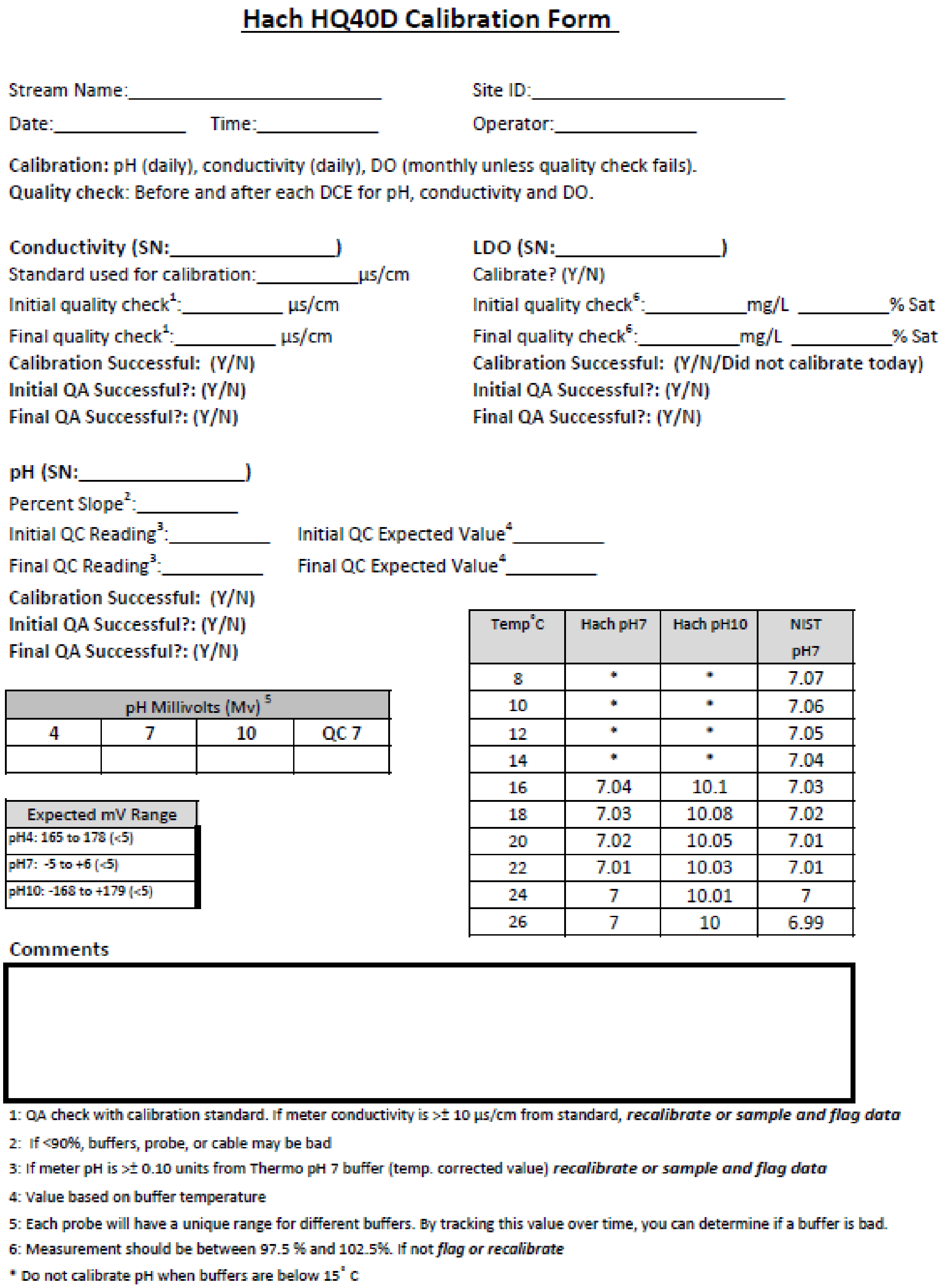
10.14 WOW. 2004. Water on the Web - Monitoring Minnesota Lakes on the Internet and Training Water Science Technicians for the Future - A National On-line Curriculum using Advanced Technologies and Real-Time Data. University of Minnesota-Duluth, Duluth, MN 55812. [Internet page, accessed 1-30-2017]
http://www.waterontheweb.org/under/waterquality/oxygen.html

11.0 Appendix A – Calibration Form



Hach HQ40D Calibration Form

Stream Name:______________________ Site ID:______________________

Date:__________ Time:__________ Operator:__________

Calibration: pH (daily), conductivity (daily), DO (monthly unless quality check fails).

Quality check: Before and after each DCE for pH, conductivity and DO.

Conductivity (SN:______________)

Standard used for calibration:__________µs/cm

Initial quality check[1]:__________ µs/cm

Final quality check[1]:__________ µs/cm

Calibration Successful: (Y/N)

Initial QA Successful?: (Y/N)

Final QA Successful?: (Y/N)

LDO (SN:______________)

Calibrate? (Y/N)

Initial quality check[6]:__________mg/L __________% Sat

Final quality check[6]:__________mg/L __________% Sat

Calibration Successful: (Y/N/Did not calibrate today)

Initial QA Successful?: (Y/N)

Final QA Successful?: (Y/N)

pH (SN:______________)

Percent Slope[2]:__________

Initial QC Reading[3]:__________ Initial QC Expected Value[4]__________

Final QC Reading[3]:__________ Final QC Expected Value[4]__________

Calibration Successful: (Y/N)

Initial QA Successful?: (Y/N)

Final QA Successful?: (Y/N)

pH Millivolts (Mv) [5]			
4	7	10	QC 7

Expected mV Range
pH4: 165 to 178 (<5)
pH7: -5 to +6 (<5)
pH10: -168 to +179 (<5)

Temp°C	Hach pH7	Hach pH10	NIST pH7
8	*	*	7.07
10	*	*	7.06
12	*	*	7.05
14	*	*	7.04
16	7.04	10.1	7.03
18	7.03	10.08	7.02
20	7.02	10.05	7.01
22	7.01	10.03	7.01
24	7	10.01	7
26	7	10	6.99

Comments

1: QA check with calibration standard. If meter conductivity is >± 10 µs/cm from standard, ***recalibrate or sample and flag data***

2: If <90%, buffers, probe, or cable may be bad

3: If meter pH is >± 0.10 units from Thermo pH 7 buffer (temp. corrected value) ***recalibrate or sample and flag data***

4: Value based on buffer temperature

5: Each probe will have a unique range for different buffers. By tracking this value over time, you can determine if a buffer is bad.

6: Measurement should be between 97.5 % and 102.5%. If not ***flag or recalibrate***

* Do not calibrate pH when buffers are below 15° C

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Stream Sampling Protocols for the Environmental Monitoring and Trends Section

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WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Stream Sampling Protocols for the Environmental Monitoring and Trends Section

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Table of Contents

List of Tables

Abstract

This document describes the sample collection, shipment, and analysis procedures used by the Washington State Department of Ecology, Environmental Monitoring and Trends Section staff to collect water quality information at long-term stream monitoring stations.

Although it is intended as a guidance manual for staff doing the field sampling, it may also be useful to individuals who would like to know more about Ecology protocols.

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Introduction

This document describes the procedures for sample collection, shipment, and analysis used by the Environmental Monitoring and Trends Section staff involved in long-term stream monitoring. Although it is intended as a guidance manual for staff doing the field sampling, it may also be useful to individuals who would like to know more about Ecology protocols.

Ecology has operated a long-term river and stream monitoring program since 1970. Prior to 1970, data were collected by other agencies under a variety of sampling schemes. The current program consists of monthly water quality monitoring for 14 conventional parameters (See Tables 1 and 2 below) at approximately 80 stations within the state. The goals of the program are to provide:

- Water quality information that can be used to characterize past and current conditions.
- Data that can be used to refine and verify total maximum daily load (TMDL) models or help evaluate other site-specific water quality issues.
- Data from a representative sample of rivers and stream segments for the evaluation of impairment of beneficial uses and the detection of violations of state water quality standards.

The program consists of both long-term and basin monitoring stations. Long-term stations are monitored every year to track water quality changes over time (trends), assess inter-annual variability, and collect current water quality information. These stations are generally located near the mouths of major rivers and below major cities. However, some long-term stations were deliberately located upstream of major cities and downstream of where major streams enter the state to monitor background conditions.

Basin stations are typically monitored for one year (although they may be re-visited every five years) to collect current water quality information. These stations are selected to support Ecology's basin approach to water quality management and to address site-specific water quality issues. Further details may be found in Ehinger (1995).

The sampling network is divided into four runs (roughly conforming to Ecology's Eastern, Central, Northwest, and Southwest Regions) of three or four days duration. At the end of a sampling day, samples are shipped via commercial carrier to the Manchester Environmental Laboratory for chemical and bacteriological analyses.

Table 1. Parameters Measured in the Field

Variable	**Method**	**Resolution**
Temperature	Thermistor	0.1°C
pH	Glass electrode	0.1 unit
Dissolved oxygen	Winkler titration	0.1 mg/L
Specific conductivity	Electrode	1 µmhos/cm (µS/cm)
Barometric pressure	Aneroid barometer	0.02 inches Hg

Table 2. Parameters Measured at the Laboratory

Variable	**Method**	**Reference**	**Practical Quantitation Limit**
Ammonia-N (NH_3)	Automated phenate	EPA 350.1/ SM 4500-NH_3 H	0.01 mg/L
Enterococci	Membrane filter	EPA 1600	1 colony/100 mL
Fecal coliform	Membrane filter	SM 16-909C	1 colony/100 mL
Nitrate + Nitrite ($NO_3^- + NO_2^-$)	Colormetric	EPA 353.2/ SM 4500-NO_3^-I	0.01 mg/L
Orthophosphate, Dissolved	Colormetric	EPA 365.3/ SM 4500-P G	0.01 mg/L
Total Persulfate Nitrogen (TPN)	Colormetric	SM 4500-N^-B	0.01 mg/L
Total Phosphorus (TP)	Colormetric	EPA 365.3/ SM 4500-P I	0.01 mg/L
Total Suspended Solids	Weighed Filter	EPA 160.2/ SM 2540D	1 mg/L
Turbidity	Nephelometric	SM 2130	1 NTU
EPA = *Environmental Protection Agency Method* SM = *Standard Methods for the Examination of Water and Wastewater*, 20th Edition.			

Run Preparation

Each run schedule is compiled at least a month before the beginning of the water year (October 1) following selection of the basin stations. Also compiled are the sample bottle delivery and pickup schedules, and run directions based on the run schedule.

Usually, one run is scheduled per week for four weeks each month, although periodic schedule changes may be necessary to accommodate holidays. The first run typically starts on the first Monday of the month. The usual run order is Central, Eastern, Northwest, and Southwest.

Samplers usually prepare for a run at least two weeks in advance. A checklist (Appendix A) is used to ensure that all of the necessary tasks, sampling equipment, supplies, sample containers, and safety gear have been dealt with or loaded in the van. *Note: Run sample bottles are delivered the to the bottle storage room by the lab courier the Wednesday before the scheduled run. The lab courier should be contacted if they are not there or the order is incorrect.*

Samplers must complete and submit the Field Sampling Notification Form (Appendix B) and Contact Person Designation Form (Appendix C) along with the Run Directions to the section secretary before beginning a run. This information enables family and program staff to call a sampler in case of an emergency or conduct a search if there was a mishap. If plans change (lodging, cell phone number, etc.) the sampler must contact a supervisor or to the section secretary to update the information. Also, if the sampler fails to check in with the contact person, then the contact person needs to notify the supervisor to begin efforts to locate the sampler. *Note: Van cell phones need to be kept on during work hours to allow the lab courier or other staff to get shipment information or to discuss other program related needs.*

Following a run, malfunctioning equipment needs to be taken to the boat shed for repair. Failure to maintain equipment may result in unsafe sampling conditions and lost sampling opportunities.

Pre-Run Procedure (Morning of First Day)

- Turn on the cell phone.
- Check the van oil and fluids.
- Calibrate the van barometer using the wet lab (OS-31) barometer (See Barometric Pressure on page 9).
- Check the calibration of the thermistor with an alcohol thermometer.
- Flush the filter apparatus with 10% HCl solution[1] and rinse with deionized water.
- Rinse the DO sample bucket with deionized water.
- Select an empty BOD bottle from the DO sample box, record its number on the Field Data Report from (Appendix F), place it in the DO sample bucket, and replace the bucket lid.
- Acid wash a dedicated 1-L nutrient collection bottle with 10% HCl solution, triple rinse with deionized water, and place it in one of the bottle holders attached to the DO sample bucket. Also place a clean 1-L sample bottle in the other attached bottle holder.
- Place a bacteria sample bottle in the flow-orienting bacteria sampler.
- Change the pH and conductivity standards.
- Soak the conductivity probe in deionized water for at least 30 minutes before calibrating. Calibrate the meter and store the probe in tap or deionized water (Do not store the probe with the pH electrode).
- Record the conductivity meter calibration and other pertinent observations on the Meter Calibration Log Form (Appendix D).
- Change pH probe solution.
- Calibrate pH meter and store the probe in the pH 7 standard or tap water (Do not store the probe in deionized water).
- Re-calibrate the pH probe a second time after arriving at the first sample station to insure that it has warmed up.
- Record the second pH calibration on the Meter Calibration Log Form.

---

[1] The 10% HCl solution should be changed in advance of a run. Prepared solution is stored in an acid cabinet located in the hazardous chemical storage room (OL-14). The old solution may be discarded down the drain. All appropriate safety measures need to be used if more solution must be prepared. The Cleaning Room (OL-16) sink is the best location to use for this process because an emergency shower/eyewash station is located in the room in case there is a mishap. Also, add the concentrated hydrochloric acid to the measured amount of distilled water. Never add water to concentrated hydrochloric acid. The reaction with water generates enough heat to boil water instantly; the water expands explosively and can splatter acid. When adding acid to the water, the heat is absorbed by the relatively (to the quantity of acid) large mass of water.

Sampling Procedure

Safety is the primary concern when collecting samples. Since most sample sites are located on highway bridges, road and pass conditions should always be check the before departure (especially in winter). If roadside hazards, weather, accidents, on-going construction, new bridge, etc. make sample collection dangerous, then skip that station. Note the reason on the Field Data Report Form and notify your supervisor of the hazard when you return to the office. If the hazard is a permanent condition, relocation of the station may be necessary. Review Ecology's Safety Program Manual periodically to assist with these safety determinations.

Sample collection involves three to five of the following steps:

1. Temperature is measured in situ with a long-line thermistor.

2. Dissolved oxygen (DO), turbidity, pH, and conductivity samples are collected simultaneously with a DO sample bucket with two attached 1-L bottles. Water for the Winkler titration is collected directly into a BOD bottle mounted inside the bucket. Also collected in the bucket is water for the turbidity sample, and for pH and conductivity analysis. One of the two 1-L bottles attached to the DO sample bucket has been acid-washed and collects water to be processed for nutrient analyses. The other 1-L sample bottle collects the total suspended solids sample.

3. Fecal coliform and enterococci samples are collected with the flow-orienting bacteria sampler and an autoclaved bottle.

4. Stream stage height measurements are obtained from a reference point (RP) by using a weighted measuring tape, a USGS weighted wire gage, or a staff gage.

5. Metal samples are collected using the metals sampler and specially prepared Teflon bottle. If metal sampling is necessary, refer to Metals on page 20.

A typical sampling routine consists of the following procedure:

1. Lower the thermistor probe into the water and allowed one to two minutes for it to equilibrate. If conditions allow, complete steps two and three while the temperature reading stabilizes.

2. If called for, measure the stage height and record the measurement in the Yellow Flow Book. Also, record the weighted measuring tape correction factor or check bar measurements. *Note: The keys to the gage houses and wire weight gage boxes are located on the key chain stored in the van.*

3. Remove the lids to the 1-L bottles attached to the DO sample bucket and lower it to the water surface, taking care to not dislodge bridge debris into the bottles. Then lower the bucket rapidly into the water until it has completely submerged to a depth of at least 0.3 meters to minimize sampling of surface film. Retrieve the bucket when the bubbles from the vent tube

stop (bucket is full). A swift current may take the bucket downstream before it completely fills. If so, pull the bucket from the water, allow it to swing upstream, and then drop it back into the water. This step may need to be repeated a few times until the bucket is full. Retrieve the bucket, taking care to not dislodge bridge debris into the bottles. Replace the bottle lids.

4. Memorize or record the water temperature and retrieve the thermistor.

5. Fit the bacteria sample bottle into the fecal coliform sampler. Remove the aluminum foil covered stopper and place it where contamination to the stopper can be avoided. Lower the sampler in the thalweg (mid-channel) of the river or stream to water surface, taking care to not dislodge bridge debris into the bottle. When the sampler touches the water allow the fin to orient it in the current with the bottle upstream. Then lower the bottle rapidly into the water until it has completely submerged to minimize sampling of surface film. Retrieve the filled bottle taking care to not dislodge bridge debris into it. Before the foil-covered stopper is replaced, pour out a little of the sample to establish the water level at the bottle shoulder.

6. Return to the van with the samples and sampling gear.

Field Processing

Field processing fulfills two essential purposes:

- To prepare individual sample bottles for shipment to the lab;
- To preserve (fix) the DO sample, and
- To measure specific conductivity, pH, and barometric pressure.

Typical field processing consists of the following procedure:

1. After returning to the van, label the fecal coliform/enterococci sample with the appropriate sample tag and place it in a cooler of ice. Reload the sampler with an empty fecal coliform/entrococci sample bottle and set it aside for the next station.

2. Remove the 1-L bottles from the DO sample bucket and set them aside in the van. Then carefully remove the bucket lid and set it aside in the van. Next, pull out the BOD bottle and set the DO sample bucket aside in the van. If necessary, tap the side of the BOD bottle to dislodge any air bubbles clinging inside. Insert a glass stopper in the bottle and discard the displaced water. Remove the stopper and fix the sample by adding approximately two milliliters of manganous sulfate solution followed by two milliliters of alkaline-azide solution using the disposable pipettes reserved for each solution. Add these reagents by immersing the tip of the pipette into the sample before injecting them into the solution (avoids splashing and entraining air bubbles in the reagent stream). Replace the stopper and mix the contents by inverting the bottle a few times. Add a few milliliters of deionized water around the stopper to form a water seal and cover the bottle top with a plastic cap. Place the fixed DO sample in the sample box. *Note: The DO samples are titrated after the completion of the run (See Dissolved Oxygen on page 15*).

3. Record the temperature and BOD bottle number on the Field Data Report Form (Appendix F).

4. Remove the cap from an empty 500mL general chemistry (turbidity) sample bottle and place the bottle in the sink bottle holder. Empty the previous sample water from the pH and specific conductivity measurement cups and rinse the cups and probes with deionized or sample water. Gently agitate the sample water in the DO sample bucket and fill the sample bottle and over fill the measurement cups. Cap the turbidity sample and set it aside.

5. Turn on the pH[2] and conductivity meters and allow them a few minutes to stabilize before recording the measurements on the Field Data Report Form. Check meter calibration if the pH measurement equals 8.5 or higher or equals 6.5 or less by measuring the 6.97 low ionic strength buffer. Record the reading(s) on the Field Data Report Form and if necessary, recalibrate meter. *Note: Always record the pH as soon as the meter gives a stable measurement (sample pH changes with time).*

---

[2] The pH meter should notify and hold (beep and display freezes) when it has a stable measurement (see meter instrument manual).

6. Open a 125mL preserved nutrient bottle (contains two milliliters of sulfuric acid) and set it in the sink bottle holder. Avoid contact with the acid. Agitate the 1-L nutrient sample and pour approximately 100 mL of the sample into the 125mL bottle. Cap the 125mL bottle and agitate it to insure that the acid gets mixed into the sample.

7. Turn on the filter pump and put the intake hose in the remaining 1-L nutrient sample. Be sure the filtration apparatus has been rinsed with deionized water and has a new filter. Allow the filtered sample water to run through the filter apparatus for 10-15 seconds to ensure that the deionized water has been purged from it. Then fill a 125-mL amber bottle (no preservative) with filtered sample water to the bottle shoulder, and cap it. Remove the intake hose from the 1-L nutrient sample bottle and the rinse hose exterior with deionized water. Then put the hose in deionized water and allow the pump to flush the interior of the filter apparatus with deionized water for 10-15 seconds. Cap the bottle and set it aside.

8. Record barometric pressure and any other measurements on the Field Data Report Form. Also note any site or weather observations.

9. Label the sample bottles with the appropriate sample tags and place them in ice in a cooler.

10. Remove and discard the used filter from the filter apparatus, rinse the inside of the apparatus with deionized water, and insert a new filter. Wet the new filter with deionized water to keep it in place and reassemble the filter apparatus. Then turn on the filter pump and allow the pump to flush the apparatus with deionized water for 10-15 seconds.

11. Rinse the inside of the stainless DO sample bucket with DI water and discard the rinse water.

12. Select an empty BOD bottle from the DO sample box, record its number on the Field Data Report Form (Appendix F), place it in the stainless DO sample bucket, and replace the bucket lid.

13. Rinse the used nutrient sample bottle with deionized water and pour the 10% acid solution from the spare bottle into the newly rinsed bottle. Cap it, shake it, and set it aside in the sink to soak until the next station. Rinse the empty 1-L nutrient sample bottle three times with deionized water, cap it, and place it in one of the bottle holders attached to the DO sample bucket. Also place a clean 1-L sample bottle in the other holder. *Note: The dedicated nutrient sample bottles are used at alternating sites.*

14. If required, check pH meter calibration (See pH on page 25).

Quality Assurance / Quality Control Samples

Stations for Quality Assurance / Quality Control (QA/QC) samples are selected at random prior to the water year. Two field blank stations and ten field replicate/field split stations are selected per year per run. The result is that one QA sample station is assigned per run for each month.

Following are the three types of QA/QC samples that are collected and submitted blind to the lab.

Field Blanks

Field blanks consist of deionized water processed as actual samples. Field blank results are expected to be below the method reporting limit. High results may indicate sample contamination. No fecal coliform/entrococci or DO samples, or pH or temperature measurements are necessary because they can not be correlated with contamination.

Field Replicates

These consist of repeating the entire sampling procedure about 20 minutes after initial station samples have been collected. The sample results include variability due to short-term in-stream processes, sample collection and processing, and laboratory analysis.

Field Splits

These consist of splitting samples from a single sampling event (usually the field replicate sample) that requires any field processing. The split samples eliminate the in-stream and isolate the field processing and laboratory variability. This includes DO, specific conductivity, pH, turbidity, and total and filtered nutrient samples. The total suspended solids, temperature, and fecal coliform/entrococci samples are not processed in the field and are excluded from these analyses. Adding a second BOD bottle to the DO sample bucket collects the split DO sample.

Quality Assurance / Quality Control
Sampling Procedures

Field Blank Samples

Fill the DO sample bucket and the acid-rinsed 1-L sample bottle with deionized water. Then go through the normal process of obtaining the total nutrient, filtered nutrient, and turbidity samples. Also fill the conductivity cup and record the measurement. Do not collect fecal coliform /enterococci, Total Suspended Solid, and DO samples or take pH or Temperature measurements. Label the bottles with the appropriate QA_-1 tags, place them in ice in a cooler, and note the time and conductivity measurement on the Field Data Report Form.

Field Replicate Samples

Put an additional DO bottle in the DO sample bucket and collect a second set of samples from the sample site. Go through the normal sampling process and label these samples with the appropriate QA_-1 tags (Also do Field Split samples).

Field Split Samples

Split the collected total nutrient, filtered nutrient, and turbidity samples (samples that require field processing) and label these samples with the appropriate QA_-2 tags. Do not split the total suspended solids and fecal coliform samples or record the temperature, pH, conductivity, or barometric pressure. The second DO sample collected during the field replicate sampling is processed as a split sample.

Sample Preservation and Shipment

After collection, samples need to be placed in a cooler containing enough ice to keep them cool (below 4˚C) until all samples are collected. On hot days, two coolers may be necessary.

At the end of the day, samples are shipped to the SeaTac Airport[3], to the Olympia Greyhound Bus Station, or delivered to Lacey by the sampler. The lab courier picks them up at the pre-arranged location and delivers them to the lab. The courier must be notified immediately if the pick-up location changes or if the samples cannot arrive before the courier's pickup time. If the courier cannot be reached then contact someone in the Freshwater Monitoring Unit or Environmental Monitoring and Trends Section who can verify that the courier receives the message. The short holding times for the bacteria and orthophosphate samples make timely deliveries imperative (See Table 3). *Note: Samples shipped via air need to be transferred to a single cooler and packed with cold gel ice (use frozen gel ice that has been stored in another cooler of ice). Coolers containing samples being shipped on Greyhound or delivered to Lacey only need to be drained and repacked with enough ice to keep them cool.*

Table 3. Sample: Container, Preservation, and Holding Times

Variable	Container	Preservation	Holding Time
Turbidity	500 mL wide-mouth poly	Cool to <4˚C	48 hours
Suspended Solids	1000 mL wide-mouth poly	Cool to <4˚C	7 days
Fecal coliform, Enterococci	500 mL glass/polypropylene autoclaved bottle[2]	Cool to <4˚C	24 hours
Total Phosphorus, Total Nitrogen, Nitrate + Nitrite, Ammonia	125 mL clear wide-mouth poly	Acidify with H_2SO_4 to pH<2 and cool to <4˚C	28 days
Dissolved Orthophosphate	125 mL amber wide-mouth poly	Filter in field and cool to <4˚ C	48 hours
Hardness	125 mL narrow-mouth poly	Acidify with H_2SO_4 to pH<2 and cool to <4˚C	6 months
Low Level Total Metals	500 mL Teflon FEP bottle	Acidify with HNO_3 to <2 pH and cool to <4˚C	6 months
Low Level Total Mercury	500 mL Teflon FEP bottle	Acidify with HNO_3 to <2 pH and cool to <4˚C	28 days
Low Level Dissolved Metals	500 mL Teflon FEP bottle	Filter, acidify with HNO_3 to <2 pH and cool to <4˚C	6 months

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[3] Air shipments are usually shipped via overnight air freight. Always get a copy of the shipping invoice.

Methods and Procedures

Barometric Pressure

Method - Field measurement
Holding Time - NA
Detection Limit - NA
Precision - 0.02 inches Hg

Overview

Barometric pressure is measured with an aneroid barometer. The barometric pressure measurement is used in conjunction with other variables to determine the percent saturation of dissolved oxygen in water. See Dissolved Oxygen Method Overview for more a more complete discussion.

Equipment

- Aneroid Barometer w/ .02" scale
- Mercury Barometer

Calibration

Prior to departing on the run take the aneroid barometer from the van to OS-31 (Wet Lab) to calibrate it against the mercury barometer. The adjustment screw for calibration is located on the back of the barometer.

Mercury Barometer Reading

Gently tap the glass tube and then turn the adjusting screw on the bottom of the barometer until the mercury just touches the white pointer, as viewed through the reservoir glass. Raise the vernier to the top of the mercury meniscus. Read the mercury scale in inches (to refine the estimate of the last digit read the two numbers that line up with the vernier).

The reading on the mercury barometer must be adjusted for temperature and gravity variation. Read the thermometer attached to the barometer and look up the correction in the table located in the manila holder attached to the hood. For our latitude (46˚N) at 20˚C (71˚F) the gravity correction is + 0.004 and the temperature correction is - 0.109. The combined correction factor for the mercury barometer at 71˚F is - 0.105 inches of mercury.

Aneroid Barometer Adjustment

Adjust the aneroid barometer to the corrected mercury barometer reading with the adjustment screw located on the front or back of the instrument. Hold the aneroid barometer upright and gently tap the glass while making the adjustment to assure proper alignment of the black pointer.

Field Measurement

The barometric pressure is read by sighting down the measurement pointer with the barometer near eye level. The measurement is recorded to the nearest 0.01 of an inch on the Field Data Report Form. *Note: Typical readings are between 27 and 30 inches.*

Conductivity

Method - Field measurement
Holding Time - NA
Detection Limit - NA
Precision - 1 µmhos/cm @ 25˚C

Overview

Conductivity is measured with a meter. Conductivity measures of the ability of the water sample to carry an electrical current. It is dependent upon the concentration and type of dissolved (ions) and the water temperature. The conductivity meter standardizes the measurement to 25˚C (i.e. specific conductivity) for data comparison.

Equipment

- Conductivity meter and probe
- Deionized water
- 99-109 µmhos/cm NIST Traceable Calibration Standard
- Plastic sample container
- Deionized water squirt bottle
- pH/Conductivity log form

Calibration

Soak the conductivity probe in deionized or tap water for at least 30 minutes. Replace the conductivity standard. Make sure that the meter is set to read in the non-linear function (nLF) mode for temperature compensation and the reference temperature for the meter is set at 25˚C. Follow the instrument manual to adjust the cell constant.

Sample Collection

Conductivity levels are measured on a sub sample of the water from the DO sample bucket.

Sample Measurement

Rinse the conductivity sample cup and conductivity probe with deionized water or sample water. Then agitate the water in the DO sample bucket and over fill the sample cup. Turn the meter "ON" and let the meter equilibrate. Record the conductivity measurement on the Field Data

Report Form. *Note: The meter displays to the nearest tenth, so in most cases, the measurement needs to be rounded to the nearest whole number. If the tenths digit > .5, round up, < .5, round down, and when = .5 always round to the nearest even number. For example, 103.5 would be rounded to 104 and 62.5 would be rounded to 62.*

Quality Control Check

The conductivity meter is calibrated each morning as part of run preparation and checked using the calibration standard after the last station of the day. The results are recorded on the Meter Calibration Log Form (Appendix A). If the meter will not calibrate properly or if the end-of-the-day check is off by more than five µmhos/cm then see *Troubleshooting* below. Also, be sure to code the data with a "J", note meter problems on the form, and report the problem to your supervisor when you return.

Meter\Probe Storage

Rinse probe with deionized water and store dry.

Troubleshooting

If you suspect an inaccurate measurement or the conductivity measurement is not within 5 µmhos/cm of the standard then do the following.

1. Make sure the meter is in the non-linear function (nLF) mode for temperature compensation.

2. Change the conductivity standard. This is an easily contaminated solution. A small quantity of deionized water or even a single drop of pH buffer can have a noticeable impact on the standard.

3. Check the battery and probe connection.

4. Recalibrate the meter. Note this recalibration in the comment portion of the Field Data Report Form.

5. Check the previous conductivity sample and if necessary, revise the recorded measurement.

If these steps do not work, then review the troubleshooting section in the meter instruction manual. If you can not fix the problem, then fill out an equipment problem report form when you return from the run and place it and the defective equipment on the boat shed electronic repair bench.

Dissolved Oxygen

Method - Standard Methods for the Examination of Water and Wastewater. 20th Edition, No:4500-O C. Winkler Method, Azide Modification[4].
Holding time - up to 4 days
Detection Limit - 0.1 mg/L
Precision - 0.1 mg/L
Limitations - ferrous iron/L should be < 1 mg/L in water sample.

Overview

Dissolved oxygen (DO) is the amount of oxygen dissolved in a water sample. The amount varies directly in response to changes in atmospheric pressure and water temperature. The higher the atmospheric pressure the higher the oxygen solubility in water and the higher the DO concentration. The opposite is true with temperature, the higher the temperature the lower the solubility and saturation concentration of oxygen in water. DO is one of the major factors that determine the type of biological communities that inhabit an aquatic system. The addition of organic or inorganic material that exerts an oxygen demand through respiration and biodegradation lowers the DO concentration and can facilitate the growth of nuisance organisms.

Equipment

- Stainless steel sampling bucket (similar to design presented in Figure 4500-0:1 of the 20th Edition of Standard Methods)
- Rope
- DO box
- BOD bottles, 300 mL
- Plastic BOD bottle water seal caps
- Manganous sulfate solution
- Alkali-iodate-azide reagent
- 2 mL pipettes
- Deionized water squirt bottle
- Deionized water
- 10% HCl

Cleaning

The DO sample bucket and BOD bottles are rinsed with deionized water after each run. BOD bottles are stored upside down in the DO box to keep dust out and promote drying. The sample bucket is stored with at least 3 cm of deionized water standing in the bottom of the bucket.

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[4] This is a slight modification of azide modification method presented in the 20th edition of Standard Methods, which calls for the addition of 1 mL of manganous sulfate and azide instead of 2 mL. The excess reagents are accounted for by using 203mL volumetric flasks rather than 201mL flasks.

Field Preparation

Record the BOD bottle number(s) on the Field Data Report Form (Appendix F). Rinse the sampling bucket, top, and filler tubes with deionized water. Place the BOD bottle into the sampling bucket. Orient the top of the sampling bucket to insure that a filler tube is inserted into the BOD bottle and fitted into place

Sample Collection

The water sample should be taken from the main part of the channel or thalweg where possible. Lower the sample bucket to the water surface. Then lower the bucket rapidly into the water until it has completely submerged to minimize sampling of surface film. Retrieve the bucket when the bubbles from the vent tube stop (bucket is full). A swift current may take the bucket downstream before it completely fills. If so, pull the bucket from the water, allow it to swing upstream, and then drop it back into the water. This step may need to be repeated a few times until the bucket fills. Retrieve the filled bucket, taking care to not dislodge bridge debris into it.

Field Processing

At the van, carefully remove the top from the sampling bucket by standing on the bucket feet and pulling on the top. Remove the BOD bottle. Try to avoid contamination of the water remaining in the sampler. If necessary, tap the side of the BOD bottle to dislodge any air bubbles clinging inside. Insert a glass stopper in the bottle and carefully discard the displaced water. Remove the stopper and fix the sample by adding approximately two milliliters of manganous sulfate solution followed by two milliliters of alkaline-azide solution using the disposable pipettes reserved for each solution. Add these reagents by immersing the tip of the pipette in the water before injecting them into the solution (avoids splashing and entraining air bubbles in the reagent stream). Replace the stopper and mix the contents by inverting the bottle a few times. Add a few milliliters of deionized water around the stopper to form a water seal and cover the bottle top with a plastic cap. Place the fixed DO sample in the sample box.

Laboratory Analysis

Equipment

- Graduated burette, 25 mL w/ 3-way stopcock
- Volumetric burette, 10 mL w/ 3-way stopcock
- Erlenmeyer flasks, 1000 mL
- Magnetic stirrer
- Stirring bars
- 203 mL Volumetric flask
- Concentrated sulfuric acid
- Aqueous starch solution
- Sodium thiosulfate, 0.025 M
- Potassium bi-iodate, 0.025 M
- Liquinox soap

Cleaning

Thoroughly wash and rinse glassware using Liquinox soap and water before every analysis.

Titration Procedure

Note: It is important to dilute the chemicals going into the sink during the following process with a continuous stream of tap water to prevent damage to the building plumbing.

1. Put on the plastic apron and Nitrile gloves.

2. Remove the plastic caps from the BOD bottles.

3. Pour off the water seal and invert the bottle several times to mix the floc.

4. Allow the floc to settle into the lower half of the bottle while rinsing needed flasks, flasks, and stirrers.

5. Put on the face shield.

6. Remove the glass stoppers.

7. Remove the bottle-top dispenser containing sulfuric acid from the acid storage cabinet and make sure its volume adjustment is set to 2 ml.

8. Add 2 mL of sulfuric acid to each sample and put the acid bottle back into the cabinet.

9. Re-stopper the bottles and invert them several times over the sink until the precipitate has completely dissolved.

10. Fill a 203 mL volumetric flask with a portion of a DO sample and transfer the sample to an Erlenmeyer flask.

11. Empty any the sodium thiosulfate from the volumetric burette.

12. Agitate the sodium thiosulfate storage bottle and loosen the plastic lid.

13. Open the volumetric burete stopcock. Then lower and raise the sodium thiosulfate storage bottle above and below the stopcock a few times to help flush the buret.

14. Fill the burete until sodium thiosulfate escapes from the top nipple.

15. Slide a stir bar into the flask containing a sample and place the flask on the magnetic stirrer.

16. Turn the stirrer on and titrate the sample, using the automatic burete with 0.025 N sodium thiosulfate until it turns to a pale yellow color.

17. Add 1 to 2 mL of the starch solution and continue titrating the sample until the purple color just disappears to establish the titration end point[5]. Record the measurement on the Field Data Report Form. *Note: The titration end point should be sharp and distinct, if it is not, see trouble shooting section below.*

Check the titration end points of questionable samples by adding a drop or two of bi-iodate into the flask. If the end point is correct, the purple color should reappear. If more than 1 or two drops of bi-iodate are required then the end point was overrun. Back-titrate the sample with the bi-iodate standard (1 drop = 0.05 mg/L) and correct the final value. Record the titration volume in the proper column on the Field Data Report Form. If the value is in between 0.1 mL marks on the burette, round the even numbers down and the odd numbers up (e.g., 10.25 to 10.2 and 10.35 to 10.4). After all titrations are completed, refill the burette, clean up all spills, and put away all equipment in clean working order.

Sodium Thiosulfate Normality Check

After the first sample has been titrated to its end point, add 10 mL of the bi-iodate standard[6] to the sample and re-titrate. Repeat this procedure on the first sample of the third day of the run or when an additional amount of sodium thiosulfate has been added to the burete fill bottle. Record the volume of the sodium thiosulfate needed for each normality check on the Field Data Report Form and on sheet of paper located on the clipboard next to the titration station. The average of the two normality checks is entered into the correction factor field when entering the field data into the ambient database. These checks should be very close, within 0.2 mL. If they are not, then run several more until you have three very close readings.

Trouble Shooting

Problem: Floc remains in BOD bottle after the addition of sulfuric acid.
Solution: Agitate again and allow 5-6 minutes for the precipitate to dissolve. If the floc still has not dissolved then add small amounts of sulfuric acid until floc is completely dissolved.

Problem: Slight blue or purple flakes or specks that resist titration, or the end point is not clear (mushy).
Solution: Replace starch solution.

Problem: End point is over run by a large volume (> 5 drops of bi-iodate must be added for blue color to reappear).
Solution: Titrate a 50-mL sample remaining in the BOD bottle. Use the following formula to calculate PPM DO. PPM DO = volume sodium thiosulfate x 203mL/50mL

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[5] The volume of sodium thiosulfate used to titrate 203 mL of each sample equals the PPM of dissolved oxygen in the water.

[6] The automatic volumetric buret measures out the 10mL bi-iodate standard above the 3-way stopcock (no standard needs to be between the stopcock and buret tip). Air should be trapped in and below the stopcock and a drop of sample in the tip when dispensing the 10ml of standard.

References

SM 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition, American Public Health Association, Washington D.C.

Mason, C.F., 1981. Biology of Freshwater Pollution, Longman Inc. New York, NY. 250 pp.

Reed, G.K. and R.D. Wood. 1976. Ecology of Inland Waters and Estuaries, 2nd Edition, D. Van Nostrand, New York, NY. 485 pp.

Fecal Coliform and Enterococci Bacteria

Fecal Coliform Method - Standard Methods for the Examination of Water and Wastewater. 20th Edition. No: 9222D 24 hour Membrane Filter (MF) method.
Enterococci Method - EPA 1600 24 hour MF method.
Holding Time - 24 hours
Detection Limit - 1 colony per 100 mL
Precision - 1 colony per 100 mL
Limitations - highly turbid waters

Overview

There are many potential disease-causing microorganisms that remain viable in freshwater. It is impractical, both with respect to time and money to test ambient water samples individually for the presence of all potential vectors. The practical approach is to test the water samples for the presence of indicator organisms. Fecal coliform bacteria concentration is currently used as the preferred indicator organism in Washington State. However, enterococci are being proposed as a replacement indicator. Fecal coliform and enterococci bacteria are present within the intestinal tract of warm-blooded animals and remain viable in freshwater for a variable period of time.

Equipment

- ♦ Rope
- ♦ 250 mL autoclaved bacteria sample bottles[7]
- ♦ Fecal coliform sampler

Sample Collection

Care should be used at all times to avoid contamination of the inside of the sample bottle, or the foil covered silicon stopper or bottle cap. Also, the sample needs to be placed in ice in a cooler as soon as possible after collection.

Fit the bacteria sample bottle into the fecal coliform sampler. Remove the aluminum foil cover stopper and place it where contamination can be avoided. Lower the sampler in the thalweg

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[7] 500 ml sample bottles may be necessary if both fecal coliform and enterococci tests are conducted.

(mid-channel) of the river or stream to water surface, taking care to not dislodge bridge debris into the bottle. When the sampler touches the water allow the fin orient it in the current with the bottle upstream. Then lower the bottle rapidly into the water until it has completely submerged to minimize sampling of surface film. Retrieve the filled bottle taking care to not dislodge bridge debris into it. Before the foil-covered cap is replaced, pour out a little of the sample to establish the water level at the bottle shoulder.

Field Processing

No field processing is required. Label the sample bottle with the appropriate tag and place it in ice in a cooler.

Metals

Dissolved Metals Method – Modified version of EPA 200.8 Method (Using inductive coupled plasma (ICP) – mass spectrometry (MS))
Total Recoverable Metals Method – EPA 202.2 Method (Hotplate Assisted Digestion) and a modified version of EPA 200.7 Method (ICP).
Total Mercury Method – EPA 245.7 Method (Free Bromide Digestion) and EPA 245.1 Method (Cold Vapor Absorbance)
Holding Time – Mercury 28 days, all the rest 6 months
Detection Limit – Refer to Table 6., Page 119, Manchester Lab Users Manual, Fifth Edition (Oct. 2000)

Overview

The long-term river and stream monitoring of ambient metals by the program was most extensive in the early and mid 1990s.

Equipment

- Stainless steel metals sampler
- Rope
- 500ml Teflon bottles
- Small Teflon vials containing 5 ml Concentrated Nitric Acid
- 125 ml narrow mouth poly bottle containing H_2S0_4 preservative (hardness sample bottle)
- Disposable 0.45 micron cellulose nitrate filter unit (precleaned Nalgene #450-0045, type S)
- Hand pump for filter unit

Sample Collection

Water samples are collected as single grabs using the stainless steel metals sampler and a 500ml Teflon bottle. Care must be used at all times to avoid contaminating the inside of the sample bottle with debris or ambient air. Also, samples need to be placed in ice in a cooler as soon as possible after collection.

The sample collection procedures are as follows:

1. Invert the Teflon bottle sample bottle, remove the cap, and let the deionized water empty out of the bottle.
2. Replace the cap, as soon as the bottle has emptied, to minimize ambient air contamination.
3. Fit the sample bottle into the stainless steel metals sampler.
4. Completely loosen the lid and attach the sampler lid clamp while keeping the lid on the bottle.
5. Remove the lid from the attached hardness sample collection container.
6. Lower the sampler in the thalweg (mid-channel) of the river or stream to the water surface, taking care to not dislodge bridge debris into the bottle or the attached hardness sample container.
7. Allow the sampler to orient itself in the current with the metals sample bottle upstream. Then lower the sampler rapidly into the water until it has completely submerged to minimize sampling of surface film. *Note: At about 25 cm under the water surface, the sampler should automatically raise the bottle lid and allow the bottle to fill.*
8. Retrieve the filled bottle taking care to not dislodge bridge debris.
9. Loosen the sampler lid clamp while keeping the lid on the bottle and tighten the bottle cap.
10. Cap and remove the filled sample bottle from the sampler, place it in the ziploc bag it shipped in, empty the hardness sample collection container, and repeat steps 1-8 to obtain a second metals sample.
11. Cap the second metals sample.
12. Pour approximately 100 mL of the sample collected in the attached hardness sample collection container into a 125 mL hardness sample bottle. Cap and agitate the hardness sample bottle to insure that the acid gets mixed into the sample. *Note: Avoid contact with the acid.*
13. Return to the van with the samples and sampling gear.

14. Label the hardness sample and place the sample in ice in a cooler.

15. Rinse the hardness sample collection container attached to the metals sampler with deionized water and recap it.

Field Processing

Dissolved Metals

1. Remove the disposable filter unit from its ziploc bag.

2. Attach the hand pump hose to the filter unit.

3. Loosen the tape on one side of the top of the filter unit.

4. Remove the cap from one of the filled sample bottles and empty the contents into the filter unit. *Note: Avoid touching or contaminating the inside of the filter unit.*

5. Cap the used sample bottle and set it aside.

6. Draw a vacuum on the filter unit by squeezing the hand pump.

7. Filter as much of the sample as possible (at least half).

8. Empty the deionized water from an unused Teflon bottle and place the cap over the opening.

9. Remove the bottom of the filter apparatus containing the filtered sample, remove the cap from the top of the unused sample bottle (do not set the cap down) and fill the bottle with the filtered sample.

10. Carefully add the nitric acid from a Teflon vial to the sample and screw the cap on tight.

11. Label the sample with the appropriate Dissolved Metals sample tag and place it into its original ziploc bag along with the empty (capped) Teflon vial.

12. Then put the bagged filtered sample along with the empty Teflon bottle into the larger ziploc bag that contained the filter unit.

Total Recoverable and Total Mercury

1. Remove the cap from the second sample bottle (do not set the cap down)

2. If necessary, gently squeeze the side of the sample to liberate about 5 ml of sample to make room for the Nitric acid.

3. Carefully add the Nitric acid from a Teflon vial to the sample and screw the cap on tight.

4. Label the sample with the appropriate Total Metals sample tag(s).
5. Place the sample in its original ziploc bag along with the empty (capped) Teflon vial and put them in the larger filter unit ziploc bag already containing the dissolved metals sample.
6. Eliminate air from the ziploc bags, fold the larger bag in half, put tape around the outside of the bag, and place the bagged samples on ice in a cooler.

Nutrients

Methods:

Ammonia - Standard Methods for the Examination of Water and Wastewater. 20th Edition, No:SM4500-NH3 H Ammonia (phenate) Method by Colormetric Flow Injection Analysis.

Total Persulfate Nitrogen - Standard Methods for the Examination of Water and Wastewater. 20th Edition, No:4500-N B Method by Colormetric Flow Injection Analysis.

Nitrate + Nitrite - Standard Methods for the Examination of Water and Wastewater. 20th Edition, No:4500 -NO3 I Method by Colormetric Flow Injection Analysis.

Total Phosphorus - Standard Methods for the Examination of Water and Wastewater. 20th Edition, No: 4500- P I Method by Colormetric Flow Injection Analysis.

Ortho Phosphate - Standard Methods for the Examination of Water and Wastewater. 20th Edition, No:4500- P G Method by Colormetric Flow Injection Analysis.

Holding Times:	Ammonia -------------------	28 Days
	Total Persulfate Nitrogen	28 Days
	Nitrate + Nitrite -----------	28 Days
	Total Phosphorus ----------	28 Days
	Ortho Phosphate -----------	48 Hours

Reporting Limits:	Ammonia -----------------------	0.01 mg/L
	Total Persulfate Nitrogen -------	0.01 mg/L
	Nitrate + Nitrite -----------------	0.01 mg/L
	Total Phosphorus ----------------	0.01 mg/L
	Ortho Phosphate -----------------	0.003 mg/L

Precision: See current Water Year Report for summary of latest QA data.

Overview

Nitrogen and phosphorus are the nutrients that most often limit aquatic algae growth in freshwater. When phosphorus is limiting, an increase in concentration can result in increased algal production, which can have aesthetic and ecological impacts. The typical phosphorus concentration of many of Washington's rivers and streams is very low, often less than 0.01 mg/L, which makes them especially susceptible to increases in phosphorus input.

Equipment

- Stainless steel DO sample bucket
- One 1-L poly bottle
- Rope
- Peristaltic pump
- Tubing (silicon)
- Filter apparatus (stand, polyethylene mesh support screen, under- and over-drain support,
- O-ring, wing nuts)
- Filters, cellulose acetate 0.45 µm pore size
- Deionized water squirt bottle
- Bottles, 125mL, brown poly (w/o preservative)
- Bottles, 125mL, clear poly (w/H_2S0_4 preservative)
- Deionized water
- 10% HCl
- Cleaning brush (toothbrush)

Cleaning

Contamination of the sampling equipment or sample bottles can result in an overestimate of phosphorus concentration. Cleanliness and standardized procedures are essential when collecting nutrient samples, particularly from oligotrophic streams. If soap is needed to clean the equipment, use "Liquinox". Other soaps usually contain trace amounts of phosphorus.

Acid-Washing of Nutrient Sample Collection Bottles

About 500 mL of 10% HCl is transferred from one 1-L poly nutrient sample bottle to the other. The acid-rinsed bottle is triple rinsed with deionized water and placed in the bottle holder attached to the DO sample bucket. The nutrient sample bottle containing the 10% HCl is shaken and set aside to soak. This process is repeated between each sampling event.

Filter Apparatus

The filter apparatus should be acid-washed before each run. Loosen the wing nuts and remove upper filter holder. Scrub the inside of both the upper and lower filter supports and the polyethylene screen with a brush. Then rinse the apparatus with deionized water, reassemble, and cycle 10% HCl solution through it *(Start by placing the tubing from the pump in the 1-L* *bottle containing the 500ml of HCl and set the bottle under the filter outlet. Turn the pump on. After about 30 seconds remove the hose from the acid and let the tubing purge itself of the remaining acid).* Then rinse the apparatus for 30 seconds with deionized water.

Set up the apparatus for filtering *(Loosen the wing nuts and remove the top of the apparatus. Insert a 0.45 µm cellulose nitrate filter on the filter holder. Prevent leaking by making sure the O-ring is in place. Wet the new filter with deionized water and reassemble the filter apparatus).* Then turn on the filter pump and flush the apparatus with deionized water for 10-15 seconds).

Sample Collection and Processing

The nutrient samples are collected in the 1-L acid-washed bottle attached to the DO sample bucket.

Open a 125 mL preserved nutrient bottle (contains two milliliters of sulfuric acid) and set it in the sink bottle holder. Avoid contact with the acid. Agitate the 1-L nutrient sample and pour approximately 100 mL of the sample into the 125 mL bottle. Cap and agitate the 125 mL bottle to insure that the acid gets mixed into the sample.

Turn on the filter pump and put the intake hose in the 1-L nutrient sample. Be sure the filtration apparatus has been rinsed with deionized water and has a new filter (See cleaning above). Allow the filtered sample water to run through the filter for 10-15 seconds to ensure that the deionized water has been purged from the apparatus. Then fill the bottle to the shoulder, and cap it. Remove the inlet hose from the 1-L nutrient sample bottle and the rinse hose exterior with deionized water. Next put the hose in the deionized water and allow the pump to flush the filter apparatus for 10-15 seconds.

Label the sample bottles with the appropriate sample tags and place them in the ice in a cooler.

pH

Method - Field measurement
Holding Time - NA
Detection Limit - NA
Precision - assumed 0.1 pH units

Overview

The pH of a water sample is defined as the negative logarithm of hydrogen ion activity. pH values range from 0 to 14, 0 being highly acidic, 14 being highly alkaline and 7 neutral. Each pH unit represents a tenfold change in the hydrogen ion activity. Natural waters usually fall within the pH range of 4 to 9, with Washington waters typically being from 6.5 to 8.5. The pH measurements made by the Freshwater Monitoring Unit are used in the calculation of ammonia toxicity and to determine if waters are in compliance with state pH standards.

Equipment

- pH meter
- pH probes (2)
- 1 M electrode filling solution (probe specific)
- Deionized water
- low ionic strength pH 4 buffer
- low ionic strength pH 6.97 buffer
- low ionic strength pH 9.27 buffer
- Plastic pipette
- Deionized water squirt bottle
- Sample container
- 10% HCl
- Meter Calibration Log Form (Appendix B)

Calibration

Remove the storage cap on the pH probe. Rinse off all salt deposits with deionized water. Replace the pH electrode filler solution in the probe using the plastic pipette. Refill the probe with the correct (1 M KCl) reference solution. Soak the pH probe in tap water for at least thirty minutes before calibration. Replace the buffers. Follow instrument manual for a two-buffer calibration.

Re-calibrate the pH probe a second time after arriving at the first sample station to insure that it has warmed up.

If the meter fails to calibrate properly soak the probe for one minute in 10% HCl solution, then in deionized water. Recalibrate the meter. If calibration fails again, refer to the troubleshooting section.

Sample Collection

The pH levels are measured on a sub-sample of the water from the DO sample bucket.

Sample Measurement

Rinse the pH sample cup with deionized water or sample water. Then agitate the water in the DO sample bucket and over fill the sample cup. Place the pH probe in the sample, taking care to not submerge the probe fill hole. Turn the meter on and let it notify and hold on a stable reading (denoted by the word “ready” on the meter display and also signaled by an audible beep). Press the measure button and allow the meter to notify and hold on a stable reading a second time. *Note: A small amount of drift is normal. If the drift is >0.1, the first reading was probably premature.* Record the measurement on the Field Data Report Form to the nearest 0.01 pH units.

Quality Control

The calibration of the pH meter is checked against the 6.97 buffer three times a day: immediately after obtaining the first measurement of the day, at the midway point of a sampling day, and after the last station of the day. The process of checking the calibration is as follows: rinse the probe with deionized water, place it in the 6.97 buffer, and proceed as if the buffer were a typical water sample. The results are recorded on the Meter Calibration Log Form (Appendix D) and the Field Data Report Form (Appendix F). If the pH is not within 0.1 of the true pH, then recalibrate the meter. If the meter will not calibrate properly then refer to **Troubleshooting** below. Also, be sure to note meter problems on the forms and report them to your supervisor when you return.

pH Meter\Probe Storage

At the end of the day, fill the probe protective cap about half full of electrode reference solution and secure the cap to the electrode. Cover the fill hole with the protective sleeve or the rubber plug (depends upon electrode). During freezing weather store the meter, probe, and buffer in a heated room.

Troubleshooting

If you suspect an inaccurate measurement, the reading drifts, or the meter takes longer than 90 seconds to notify and hold on a stable reading then check the meter calibration after doing one or more of the following:

1. Change the pH buffer and pH probe solutions.

2. If there is a slow response or the reading drifts, then alternately soak the probe in 10% HCl and deionized water several times for one to two minute intervals.

3. If the reading drifts, then alternately soak the probe in household ammonia and pH4 buffer several times for up to five-minute intervals. Since the ammonia can be a problem for the conductivity probe and other equipment, you should do this process outside the van.

4. Refer to meter instrument manual and perform self-test.

5. Refer to probe manual and review the troubleshooting section. Replace the probe if this does not fix the problem.

6. If you can not fix the problem, then fill out an equipment problem report form when you return from the run and place it and the defective equipment on the boat shed electronic repair bench.

Stream Stage Height

Reference Point Measurement

A reference point is a fixed point or datum on the bridge or other structure from which a measurement can made to the surface of the water under all flow conditions. The distance from this reference point to the water surface is measured with a weighted fiberglass measuring tape. The weighted tape is lowered to the water surface just to the point were the wake forms distinctive "V" behind the weight. The distance from the reference point to the water surface is recorded to the nearest 0.01 foot.

Wire Weight Gage

Measuring stage height with a wire weight gage is similar to using a reference point. A wire weight gage is a self-contained weighted measuring device that is permanently attached to the bridge. A wire weight gage is more accurate than the weighted fiberglass tape and the reference point for a wire weight gage is within the gage box itself. The first step is to move the check bar forward. Then drop the weight down until it touches the check bar, and record this number. Next move the check bar back and lower the weight to the water surface to a point where the wake from the water passing by the weight forms a slight distinctive "V" shape. Record the measurement and retrieve the weight. *Note: Both of these measurements are recorded to the 0.01-foot.*

Staff Gage

A Staff Gage is a graduated measuring device securely fixed to a permanent structure in the streambed from which stage height can be read directly to the 0.01 foot.

Continuous Stage Height Recorder

Some of the continuous stage-height recorders, located by the ambient stations are operated by the USGS. Current stage height can be read from the metal tape in the gage house or, with some models, by pressing a button next to the LCD display.

Suspended Solids

Method - Standard Methods for the Examination of Water and Wastewater. 20th Edition,
No: 2540 D. Total Suspended Solids dried at 103-105°C.
Holding Time - 7 days
Detection Limit - 1 mg/L
Precision - 1 mg/L

Overview

Total suspended solids (TSS) refers to the material retained on a standard glass filter after filtration and heating to 103-105˚C. TSS is a direct measurement of the concentration of suspended material present in a water sample.

Equipment

1-L poly bottle

Sample Collection

The water sample for TSS determination is collected in a 1-L poly bottle attached to the DO sample bucket.

Field Processing

The water sample for TSS determination does not require any field processing. The sample bottle is tagged and placed in a cooler of ice.

Temperature

Overview

Temperature is a major factor that influences the metabolism and structure of the biological communities in rivers and streams. Stream temperature can be influenced by many factors including: discharge (flow), stream gradient, depth, stream cover, water color, time of day, season, stream segment, intensity of solar radiation, and human activities. Temperature is inversely related to dissolved oxygen levels. As temperature levels increase the solubility of oxygen decreases. This relationship become more important as temperatures rises. Metabolism of most species within an aquatic community increases with temperature resulting in a higher oxygen demand for respiration. Increased demand for oxygen combined with reduced availability can lead to displacement of all but the least sensitive species. Possibly just as important as the relationship between temperature and dissolved oxygen is the effect temperature can have on the toxicity of various pollutants.

Equipment

- Thermistor with attached probe (50 meter)
- Alcohol thermometer 1 - 50˚C

Calibration

Check the calibration of the thermistor before departing on a run by placing the probe and the thermometer in a bottle of tap or deionized water. Allow at least two minutes for them to equilibrate. Record the meter and thermometer readings on the Meter Calibration Log Form. Also note the correction factor for the thermistor on the form.

Measurement

The thermistor probe is lowered at the thalweg (mid channel) of the sampling location to about .03 meters below the water surface. Turn the meter on and allow the probe to equilibrate. Record the temperature. *Note: Do not apply the correction factor prior to entering a result on the Field Data Report Form. The correction factor is applied when entering the result into the database.*

References

SM 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition, American Public Health Association, Washington D.C.

Mason, C.F., 1981. Biology of Freshwater Pollution, Longman Inc. New York, NY. 250 pp.

Reed, G.K. and R.D. Wood. 1976. Ecology of Inland Waters and Estuaries, 2nd Edition, D. Van Nostrand, New York, NY. 485 pp.

Turbidity

Method - Standard Methods for the Examination of Water and Wastewater.
20th Edition, No: 2130 B. Nephelometric Method
Holding time - 48 hours
Detection Limit - 0.5 NTU
Precision - 0.5 NTU

Overview

Turbidity is often thought of as a decrease in water clarity and is a measurement of the ability of the water sample to scatter or absorb light. Turbidity increases with the concentration of suspended matter in the water and the light refracting or light absorbing characteristics of the suspended material. The Nephelometric method for turbidity determination measures the amount of light scattered at an angle perpendicular to the light source. This method compares the light scattering ability of a water sample to known standards. The results are expressed in NTU (Nephelometric Turbidity Units).

Sample Collection

The water sample for turbidity determination is taken from a sub-sample of the water in the DO sample bucket.

Field Processing

The water sample for turbidity determination is obtained from the remaining water in the DO sample bucket. Gently agitate the sample water in the DO sample bucket and fill a 500 mL sample bottle to the bottle shoulder. Cap and tag the sample, and place it in ice in a cooler.

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Appendix A

Freshwater Ambient Run Checklist

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Freshwater Run Checklist

Type	C	E	NW	SW
250 mL unpres. nutr (brown)	23	24	28	24
250 mL pres. nutr. (clear)	23	24	28	24
500 mL (general)	23	24	28	24
1000 mL (TSS)	23	24	28	24
250 mL FC/Enterococcus	23	24	28	24
Acid (metals)	5	5	5	5
500 mL Teflon (metals)	5	5	5	5
Metal Filters Units	5	5	5	5
Hardness	5	5	5	5

Pre-Run Preparation

___ Hotel Reservations
___ Sample Tags
___ Field Data Report Forms
___ Meter Calibration Log Form
___ Yellow Flow Book
___ Field Sampling Notification Form[1]
___ Contact Person Designation Form[1]
___ Run Directions[1]
___ Gas Van

Meters/Instruments

___ pH Meter
___ Conductivity Meter
___ Thermistor
___ Alcohol Thermometer
___ Barometer

Standards

___ pH 6.97 & 9.15 Low Ionic Strength Buffers
___ pH Probe Solution
___ Conductivity Standards

Sampling Equipment & Supplies

___ Deionized Water
___ Stainless D.O. Bucket Sampler
___ Fecal Coliform Sampler
___ Metals Sampler
___ Ropes 1 @ 35 ft. & 2 @ 75 ft.
___ D.O. Sample Box
___ D.O. Reagents
___ Pipettes
___ Ice Chests
___ 250 mL 10% HCl
___ Filters
___ Filter Apparatus
___ Weighted Measuring Tape
___ USGS Keys
___ Fiberglass Tape

Van/Safety Equipment

___ Yellow Hazard Beacon
___ Flashlight
___ Tool Chest
___ Tire Chains
___ Jumper Cables
___ Flares or Reflectors
___ First Aid Kit
___ Foil Blanket
___ Orange Vests
___ 2 Gallons Drinking Water
___ Hand Towels

Personal Gear

___ Rain Gear
___ Sun Glasses
___ Watch
___ Gloves
___ Knee Boots
___ Extra Clothing

___ Hat
___ Map/Gazetteer
___ Sample Tags
___ Field Data Report Forms
___ Meter Calibration Log Form
___ Yellow Flow Book

Pre-Departure Preparation

___ Check Road Conditions
___ Acid Wash D.O. Bucket & Filtering Apparatus
___ Calibrate Barometer
___ Change pH Probe Solution
___ Change pH & Conductivity standards
___ Check Thermistor Calibration[2]
___ Calibrate pH meter[2]
___ Calibrate Conductivity Meter[2]

[1] Clip together and turn in to Section Secretary
[2] Enter observations on Meter Calibration Log Form

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Appendix B

Field Sampling Notification Form

Field Sampling Notification Form

Name(s): ____

Vehicle description: _____________________ License #: ______________

Cell Phone Number: ________________________

Date/Time of Departure _______________________________

Estimated Date/Time of Return: ________________________

Sampling "Run" or station list: Describe here or attach separate sheet if preferred:

Run/Station	Location
_____________________	_______________________________________
______________________	_______________________________________
______________________	_______________________________________
______________________	_______________________________________

Driving directions: (attach separate sheet if preferred)

See Attached

Lodging Plan:

Date	Hotel/Motel	Phone
________	____	____________
________	____	____________
________	____	____________

ADD:

- A *Float Plan* if you are planning to use a boat.
- A *Contact Person* form if you are travelling overnight or returning after hours (except this is not required when using a float plane if the pilot files a flight plan with the FAA).

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Appendix C

Contact Person Designation Form

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Contact Person Designation Form

Date: ______________________

Sampler's Name: _________________________________

Contact Person: _______________________________ Phone: ___________________

In case of emergency, Contact Person will call:

Name: ___________________________________ Phone: _____________________

Name: ___________________________________ Phone: _____________________

Name: ___________________________________ Phone: _____________________

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Appendix D

Meter Calibration Log Form

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Run: ______ Date: ________

Meter Calibration Log Form

Cond Meter#: ______ Cell Const. Initial.: ______ Final: ______ Standard: ______ µmhos /cm Meter: ______ µmhos /cm

pH Meter #: ______ pH Probe #: ______

Thermistor #: ______ Thermistor: ______ °C Thermometer: ______ °C Correction: ______

DAY 1

Low Ionic Strength pH Value vs. Temp. °C

	7	**10**
10	7.01	9.27
15	6.99/7.00	9.23
20	6.98	9.19

Slope ______ 92-102%
mv @ pH 7 ______ ± 30 mv
mv @ pH 4/10 ______ Difference between mv @ pH7 160-180
Response Time ______ < 90 seconds
Time of Day ______

	true pH	meter	time of day		
QA Check #1	______	______	______	Recalibrated	Y / N
QA Check #2	______	______	______	Recalibrated	Y / N
QA Check #3	______	______	______	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard: ______ µmhos/cm Meter: ______ µmhos/cm

DAY 2

Cell Const.Init.: ______ Final: ______ Standard: ______ µmhos/cm Meter: ______ µmhos/cm

Slope ______ 92-102%
mv @ pH 7 ______ ± 30 mv
mv @ pH 4/10 ______ Difference between mv @ pH7 160-180
Response Time ______ < 90 seconds
Time of Day ______

	true pH	meter	time of day		
QA Check #1	______	______	______	Recalibrated	Y / N
QA Check #2	______	______	______	Recalibrated	Y / N
QA Check #3	______	______	______	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard: ______ µmhos/cm Meter: ______ µmhos/cm

DAY 3

Cell Const.Init.: ______ Final: ______ Standard: ______ µmhos/cm Meter: ______ µmhos/cm

Slope ______ 92-102%
mv @ pH 7 ______ ± 30 mv
mv @ pH 4/10 ______ Difference between mv @ pH7 160-180
Response Time ______ < 90 seconds
Time of Day ______

	true pH	meter	time of day		
QA Check #1	______	______	______	Recalibrated	Y / N
QA Check #2	______	______	______	Recalibrated	Y / N
QA Check #3	______	______	______	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard: ______ µmhos/cm Meter: ______ µmhos/cm

DAY 4

Cell Const.Init.: _________ Final: _________ Standard: ________ µmhos/cm Meter: _________ µmhos/cm

Slope	_________	92-102%
mv @ pH 7	_________	± 30 mv
mv @ pH 4/10	_________	Difference between mv @ pH7 160-180
Response Time	_________	< 90 seconds
Time of Day	_________	

	true pH	meter	time of day		
QA Check #1	_________	_______________	_________	Recalibrated	Y / N
QA Check #2	_________	_______________	_________	Recalibrated	Y / N
QA Check #3	_________	_______________	_________	Recalibrated	Y / N

If meter pH is not within 0.10 pH units of true value in pH 7 buffer, then recalibrate & re-read sample.

Conductivity Standard: ________ µmhos/cm Meter: ____________ µmhos/cm

Appendix F

Field Data Report Form

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WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

FIELD DATA REPORT FORM

Y M M D D
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SURVEY .... SAMPLER .... PAGE ....OF ....

STATION NO.	STATION NAME	TIME	TEMP °C	DO mg/L	DO #	pH	TRUE pH METER	COND. µMHOS/CM	BAROMETRIC PRESSURE in. Hg	*	STAGE HEIGHT	CHK BAR OR WT LNGTH ADDITION	COMMENTS

WEATHER:

ADDITIONAL COMMENTS:

ECY 040-2-41 (Rev. 3/01)

* 1 = WWG 2 = Staff 3 = GH 4 = Tape Down 5 = Other (Specify above)

APPENDIX E

Analytical Laboratory Data

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Geosyntec Seattle
Christian Nilsen
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs (Sammamish)
Work Order Number: 1908413

September 09, 2019

Attention Christian Nilsen:

Fremont Analytical, Inc. received 2 sample(s) on 8/30/2019 for the analyses presented in the following report.

Ammonia by SM 4500 NH3 E

Ion Chromatography by EPA Method 300.0

Total Metals by EPA Method 200.8

Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD/ELAP Certification #L17-135, ISO/IEC 17025:2005
ORELAP Certification: WA 100009-007 (NELAP Recognized)

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)
Work Order: 1908413

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
1908413-001	Wetland_26	08/29/2019 11:50 AM	08/30/2019 11:18 AM
1908413-002	Queens_Bog	08/29/2019 2:50 PM	08/30/2019 11:18 AM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **1908413**
Date: **9/9/2019**

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **1908413**
Date Reported: **9/9/2019**

Client: Geosyntec Seattle
Collection Date: 8/29/2019 11:50:00 AM
Project: Laughing Jacobs (Sammamish)
Lab ID: 1908413-001
Matrix: Water
Client Sample ID: Wetland_26

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 25690		Analyst: SS
Chloride	9.24	0.500	D	mg/L	5	9/3/2019 5:09:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	9/3/2019 3:14:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L	1	9/3/2019 3:14:00 PM
Sulfate	0.347	0.300		mg/L	1	9/3/2019 3:14:00 PM
Total Metals by EPA Method 200.8				Batch ID: 25684		Analyst: WC
Aluminum	1,460	100		µg/L	1	9/3/2019 2:52:01 PM
Calcium	3,680	100		µg/L	1	9/3/2019 2:52:01 PM
Magnesium	1,300	100		µg/L	1	9/3/2019 2:52:01 PM
Potassium	3,380	500		µg/L	1	9/3/2019 2:52:01 PM
Sodium	7,540	100		µg/L	1	9/3/2019 2:52:01 PM
Total Alkalinity by SM 2320B				Batch ID: R53736		Analyst: WF
Alkalinity, Total (As CaCO3)	11.7	2.50		mg/L	1	9/6/2019 3:40:22 PM
Ammonia by SM 4500 NH3 E				Batch ID: R53683		Analyst: SS
Nitrogen, Ammonia	0.601	0.100		mg/L	1	9/5/2019 9:40:00 AM

Client: Geosyntec Seattle

Collection Date: 8/29/2019 2:50:00 PM

Project: Laughing Jacobs (Sammamish)

Lab ID: 1908413-002

Matrix: Water

Client Sample ID: Queens_Bog

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 25690		Analyst: SS
Chloride	2.99	0.100		mg/L	1	9/3/2019 3:37:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	9/3/2019 3:37:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L	1	9/3/2019 3:37:00 PM
Sulfate	0.379	0.300		mg/L	1	9/3/2019 3:37:00 PM
Total Metals by EPA Method 200.8				Batch ID: 25684		Analyst: WC
Aluminum	1,400	100		µg/L	1	9/3/2019 2:57:35 PM
Calcium	8,800	100		µg/L	1	9/3/2019 2:57:35 PM
Magnesium	2,680	100		µg/L	1	9/3/2019 2:57:35 PM
Potassium	817	500		µg/L	1	9/3/2019 2:57:35 PM
Sodium	2,700	100		µg/L	1	9/3/2019 2:57:35 PM
Total Alkalinity by SM 2320B				Batch ID: R53736		Analyst: WF
Alkalinity, Total (As CaCO3)	15.1	2.50		mg/L	1	9/6/2019 3:40:22 PM
Ammonia by SM 4500 NH3 E				Batch ID: R53683		Analyst: SS
Nitrogen, Ammonia	0.160	0.100		mg/L	1	9/5/2019 9:40:00 AM

Work Order: 1908413
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ammonia by SM 4500 NH3 E

Sample ID: **MB-R53683** SampType: **MBLK** Units: **mg/L** Prep Date: **9/5/2019** RunNo: **53683**
Client ID: **MBLKW** Batch ID: **R53683** Analysis Date: **9/5/2019** SeqNo: **1062682**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100									

Sample ID: **LCS-R53683** SampType: **LCS** Units: **mg/L** Prep Date: **9/5/2019** RunNo: **53683**
Client ID: **LCSW** Batch ID: **R53683** Analysis Date: **9/5/2019** SeqNo: **1062683**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	1.94	0.100	2.000	0	97.2	85	115				

Sample ID: **1908413-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **9/5/2019** RunNo: **53683**
Client ID: **Wetland_26** Batch ID: **R53683** Analysis Date: **9/5/2019** SeqNo: **1062685**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.603	0.100						0.6007	0.452	30	

Sample ID: **1908413-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **9/5/2019** RunNo: **53683**
Client ID: **Wetland_26** Batch ID: **R53683** Analysis Date: **9/5/2019** SeqNo: **1062686**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	2.54	0.100	2.000	0.6007	97.1	80	120				

Sample ID: **1908413-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **9/5/2019** RunNo: **53683**
Client ID: **Wetland_26** Batch ID: **R53683** Analysis Date: **9/5/2019** SeqNo: **1062687**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	2.56	0.100	2.000	0.6007	97.9	80	120	2.543	0.609	20	

Work Order: 1908413
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-25690** SampType: **MBLK** Units: **mg/L** Prep Date: **9/3/2019** RunNo: **53640**
Client ID: **MBLKW** Batch ID: **25690** Analysis Date: **9/3/2019** SeqNo: **1061882**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Nitrate (as N)+Nitrite (as N)	ND	0.100									
Ortho-Phosphate (as P)	ND	0.200									
Sulfate	ND	0.300									

Sample ID: **LCS-25690** SampType: **LCS** Units: **mg/L** Prep Date: **9/3/2019** RunNo: **53640**
Client ID: **LCSW** Batch ID: **25690** Analysis Date: **9/3/2019** SeqNo: **1061883**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.762	0.100	0.7500	0	102	90	110				
Nitrate (as N)+Nitrite (as N)	1.53	0.100	1.500	0	102	90	110				
Ortho-Phosphate (as P)	1.37	0.200	1.250	0	110	90	110				
Sulfate	3.78	0.300	3.750	0	101	90	110				

Sample ID: **1908413-002ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **9/3/2019** RunNo: **53640**
Client ID: **Queens_Bog** Batch ID: **25690** Analysis Date: **9/3/2019** SeqNo: **1061886**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	2.99	0.100						2.993	0.201	20	
Nitrate (as N)+Nitrite (as N)	ND	0.100						0		20	
Ortho-Phosphate (as P)	ND	0.200						0		20	H
Sulfate	0.437	0.300						0.3790	14.2	20	

Sample ID: **1908413-002AMS** SampType: **MS** Units: **mg/L** Prep Date: **9/3/2019** RunNo: **53640**
Client ID: **Queens_Bog** Batch ID: **25690** Analysis Date: **9/3/2019** SeqNo: **1061887**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	3.90	0.100	0.7500	2.993	121	80	120				ES
Nitrate (as N)+Nitrite (as N)	1.52	0.100	1.500	0.05600	97.9	80	120				

Work Order: 1908413
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **1908413-002AMS** SampType: **MS** Units: **mg/L** Prep Date: **9/3/2019** RunNo: **53640**
Client ID: **Queens_Bog** Batch ID: **25690** Analysis Date: **9/3/2019** SeqNo: **1061887**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	1.23	0.200	1.250	0	98.0	80	120				H
Sulfate	3.92	0.300	3.750	0.3790	94.3	80	120				

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **1908413-002AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **9/3/2019** RunNo: **53640**
Client ID: **Queens_Bog** Batch ID: **25690** Analysis Date: **9/3/2019** SeqNo: **1061888**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	3.98	0.100	0.7500	2.993	132	80	120	3.903	2.08	20	ES
Nitrate (as N)+Nitrite (as N)	1.57	0.100	1.500	0.05600	101	80	120	1.524	2.97	20	
Ortho-Phosphate (as P)	1.27	0.200	1.250	0	101	80	120	1.225	3.29	20	H
Sulfate	3.99	0.300	3.750	0.3790	96.3	80	120	3.916	1.92	20	

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 1908413
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-25684** SampType: **MBLK** Units: **µg/L** Prep Date: **9/3/2019** RunNo: **53621**
Client ID: **MBLKW** Batch ID: **25684** Analysis Date: **9/3/2019** SeqNo: **1061602**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	ND	100									
Calcium	ND	100									
Magnesium	ND	100									
Potassium	ND	500									
Sodium	ND	100									

Sample ID: **LCS-25684** SampType: **LCS** Units: **µg/L** Prep Date: **9/3/2019** RunNo: **53621**
Client ID: **LCSW** Batch ID: **25684** Analysis Date: **9/3/2019** SeqNo: **1061603**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	1,050	100	1,000	0	105	85	115				
Calcium	1,030	100	1,000	0	103	50	150				
Magnesium	984	100	1,000	0	98.4	50	150				
Potassium	1,050	500	1,000	0	105	50	150				
Sodium	1,010	100	1,000	0	101	50	150				

Sample ID: **1908422-001DDUP** SampType: **DUP** Units: **µg/L** Prep Date: **9/3/2019** RunNo: **53621**
Client ID: **BATCH** Batch ID: **25684** Analysis Date: **9/3/2019** SeqNo: **1061605**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	1,650	100						1,602	2.82	30	
Calcium	33,700	100						34,040	1.02	30	E
Magnesium	4,720	100						4,747	0.610	30	
Potassium	23,500	500						23,210	1.23	30	E
Sodium	69,900	100						73,150	4.59	30	E

NOTES:

E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 1908413
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **1908422-001DMS** SampType: **MS** Units: **µg/L** Prep Date: **9/3/2019** RunNo: **53621**
Client ID: **BATCH** Batch ID: **25684** Analysis Date: **9/3/2019** SeqNo: **1061606**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	3,510	100	1,250	1,602	152	70	130				S
Calcium	35,000	100	1,250	34,040	75.2	50	150				E
Magnesium	6,460	100	1,250	4,747	137	70	130				ES
Potassium	25,300	500	1,250	23,210	165	50	150				ES
Sodium	70,500	100	1,250	73,150	-211	50	150				ES

NOTES:

S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect (Al, K, Na, Zn).
S - Outlying spike recovery(ies) observed. A duplicate analysis was performed and recovered within range (Mg).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **1908422-001DMSD** SampType: **MSD** Units: **µg/L** Prep Date: **9/3/2019** RunNo: **53621**
Client ID: **BATCH** Batch ID: **25684** Analysis Date: **9/3/2019** SeqNo: **1061607**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	3,520	100	1,250	1,602	154	70	130	3,505	0.563	30	S
Calcium	34,700	100	1,250	34,040	53.4	50	150	34,980	0.783	30	E
Magnesium	6,350	100	1,250	4,747	128	70	130	6,460	1.77	30	E
Potassium	25,600	500	1,250	23,210	190	50	150	25,280	1.25	30	ES
Sodium	71,400	100	1,250	73,150	-137	50	150	70,520	1.29	30	ES

NOTES:

S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect (Al, K, Na, Zn).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 1908413
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R53736** SampType: **MBLK** Units: **mg/L** Prep Date: **9/6/2019** RunNo: **53736**
Client ID: **MBLKW** Batch ID: **R53736** Analysis Date: **9/6/2019** SeqNo: **1063614**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R53736** SampType: **LCS** Units: **mg/L** Prep Date: **9/6/2019** RunNo: **53736**
Client ID: **LCSW** Batch ID: **R53736** Analysis Date: **9/6/2019** SeqNo: **1063615**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	104	2.50	100.0	0	104	80	120				

Sample ID: **1908413-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **9/6/2019** RunNo: **53736**
Client ID: **Wetland_26** Batch ID: **R53736** Analysis Date: **9/6/2019** SeqNo: **1063617**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	10.7	2.50						11.70	8.65	20	

Sample Log-In Check List

Client Name: **GEO1**
Work Order Number: **1908413**
Logged by: **Carissa True**
Date Received: **8/30/2019 11:18:00 AM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Courier

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☐ No ☑ Not Required ☐
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >0°C to 10.0°C* Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☐ No ☑

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☑ No ☐ NA ☐

Person Notified: Christian Nilsen
Date: 8/30/2019
By Whom: Carissa True
Via: ☑ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding: COC signature
Client Instructions: Provided

19. Additional remarks:

Item Information

Item #	Temp ºC
Cooler 1	5.1
Sample 1	5.0
Temp Blank 1	5.4

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 8/29/2019 **Page:** 1 **of:** 1

Laboratory Project No (internal): 1908413

Project Name: Laughing Jacobs (Sammamish)

Project No: PNW0373

Special Remarks:

Client: Geosyntec

Address: 520 Pike St., Suite 2600

City, State, Zip: Seattle, WA 98101

Telephone: 206-496-1475

Fax: N/A

Collected by: J. Prock/S. Welsh

Location: Sammamish, WA

Report To (PM): Christian Nilsen

PM Email: cnilsen@geosyntec.com

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	VOCs (EPA 8260 / 624)	GX/BTEX	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM 2320 B)	Ammonia (SM 4500-NH3)			Comments
1 Wetland_26	8/29/19	1150	W										1	T	1		1	1			
2 Queens_Bog	8/29/19	1450	W										1	T	1		1	1			
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					

***Matrix:** A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

****Metals (Circle):** MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag [✓ Al] As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl U V Zn

*****Anions (Circle):** Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide [✓ O-Phosphate] Fluoride [✓ Nitrate+Nitrite]

Turn-around Time:

☒ Standard

☐ 3 Day

☐ 2 Day

☐ Next Day

Same Day ______ *(specify)*

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above and that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished	Date/Time	Received	Date/Time
x		x	8/30/19 1118
x		x	

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COC 1.2 - 2.22.17

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 8/29/2019 **Page:** 1 **of:** 1

Laboratory Project No (internal): 1908413

Project Name: Laughing Jacobs (Sammamish)

Special Remarks:

Client: Geosyntec

Project No: PNW0373

Address: 520 Pike St., Suite 2600

Collected by: J. Prock / S. Welsh

City, State, Zip: Seattle, WA 98101

Location: Sammamish, WA

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

Telephone: 206-496-1475

Report To (PM): Christian Nilsen

Fax: N/A

PM Email: cnilsen@geosyntec.com

Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	VOCs (EPA 8260 / 624)	GX/BTEX	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) / Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM 2320B)	Ammonia (SM 4500-NH3)			Comments
1 Wetland_26	8/29/19	1150	W										1	T	1		1	1			
2 Queens_Bog	8/29/19	1450	W										1	T	1		1	1			
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag [✓ Al] As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl U V Zn

***Anions (Circle): Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide [✓ O-Phosphate] Fluoride [✓ Nitrate+Nitrite]

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above and that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Turn-around Time:

☒ Standard
☐ 3 Day
☐ 2 Day
☐ Next Day
Same Day ______ (specify)

Relinquished x Date/Time 8/30/19 1118

Received x Date/Time 8/30/19 1118

Relinquished x Date/Time

Received x Date/Time

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COC 1.2 - 2.22.17

Page 1 of 2

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info@fremontanalytical.com

Geosyntec Seattle
Christian Nilsen
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs (Sammamish)
Work Order Number: 1911021

November 08, 2019

Attention Christian Nilsen:

Fremont Analytical, Inc. received 2 sample(s) on 11/1/2019 for the analyses presented in the following report.

Ammonia by SM 4500 NH3G
Ion Chromatography by EPA Method 300.0
Total Metals by EPA Method 200.8
Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD/ELAP Certification #L17-135, ISO/IEC 17025:2005
ORELAP Certification: WA 100009-007 (NELAP Recognized)

CLIENT:	Geosyntec Seattle
Project:	Laughing Jacobs (Sammamish)
Work Order:	1911021

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
1911021-001	LJ_Queens_110119	11/01/2019 12:25 PM	11/01/2019 4:19 PM
1911021-002	LJ_Wet_26_110119	11/01/2019 1:25 PM	11/01/2019 4:19 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **1911021**

Date: **11/8/2019**

CLIENT: Geosyntec Seattle

Project: Laughing Jacobs (Sammamish)

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers & Acronyms

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Client: Geosyntec Seattle
Collection Date: 11/1/2019 12:25:00 PM
Project: Laughing Jacobs (Sammamish)
Lab ID: 1911021-001
Matrix: Water
Client Sample ID: LJ_Queens_110119

Ion Chromatography by EPA Method 300.0

Batch ID: 26377 Analyst: SS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Chloride	2.98	0.100		mg/L-dry	1	11/4/2019 6:17:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L-dry	1	11/4/2019 6:17:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L-dry	1	11/4/2019 6:17:00 PM
Sulfate	0.751	0.300		mg/L-dry	1	11/4/2019 6:17:00 PM

Total Metals by EPA Method 200.8

Batch ID: 26384 Analyst: TN

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Aluminum	413	100		µg/L	1	11/6/2019 2:40:42 PM
Calcium	6,310	100		µg/L	1	11/6/2019 2:40:42 PM
Magnesium	2,240	100		µg/L	1	11/6/2019 2:40:42 PM
Potassium	2,070	500		µg/L	1	11/6/2019 2:40:42 PM
Sodium	3,200	100		µg/L	1	11/6/2019 2:40:42 PM

Total Alkalinity by SM 2320B

Batch ID: R55185 Analyst: WF

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Alkalinity, Total (As CaCO3)	21.9	2.50		mg/L	1	11/8/2019 1:06:19 PM

Ammonia by SM 4500 NH3G

Batch ID: 26407 Analyst: SS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Nitrogen, Ammonia	ND	0.100		mg/L	1	11/6/2019 4:35:00 PM

Analytical Report

Work Order: **1911021**
Date Reported: **11/8/2019**

Client: Geosyntec Seattle
Collection Date: 11/1/2019 1:25:00 PM
Project: Laughing Jacobs (Sammamish)
Lab ID: 1911021-002
Matrix: Water
Client Sample ID: LJ_Wet_26_110119

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 26377		Analyst: SS
Chloride	5.44	0.400	D	mg/L	4	11/5/2019 10:45:00 AM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L-dry	1	11/4/2019 6:40:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L-dry	1	11/4/2019 6:40:00 PM
Sulfate	6.64	0.300		mg/L-dry	1	11/4/2019 6:40:00 PM
Total Metals by EPA Method 200.8				Batch ID: 26384		Analyst: TN
Aluminum	278	100		µg/L	1	11/6/2019 2:45:16 PM
Calcium	8,890	100		µg/L	1	11/6/2019 2:45:16 PM
Magnesium	3,570	100		µg/L	1	11/6/2019 2:45:16 PM
Potassium	2,200	500		µg/L	1	11/6/2019 2:45:16 PM
Sodium	5,960	100		µg/L	1	11/6/2019 2:45:16 PM
Total Alkalinity by SM 2320B				Batch ID: R55185		Analyst: WF
Alkalinity, Total (As CaCO3)	22.4	2.50		mg/L	1	11/8/2019 1:06:19 PM
Ammonia by SM 4500 NH3G				Batch ID: 26407		Analyst: SS
Nitrogen, Ammonia	ND	0.100		mg/L	1	11/6/2019 4:56:00 PM

Work Order: 1911021
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ammonia by SM 4500 NH3G

Sample ID: **LCS-26407** SampType: **LCS** Units: **mg/L** Prep Date: **11/6/2019** RunNo: **55123**
Client ID: **LCSW** Batch ID: **26407** Analysis Date: **11/6/2019** SeqNo: **1095294**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.508	0.100	0.5000	0	102	72.7	119				

Sample ID: **MB-26407** SampType: **MBLK** Units: **mg/L** Prep Date: **11/6/2019** RunNo: **55123**
Client ID: **MBLKW** Batch ID: **26407** Analysis Date: **11/6/2019** SeqNo: **1095295**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100									

Sample ID: **1911021-001CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/6/2019** RunNo: **55123**
Client ID: **LJ_Queens_110119** Batch ID: **26407** Analysis Date: **11/6/2019** SeqNo: **1095297**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100						0		30	

Sample ID: **1911021-001CMS** SampType: **MS** Units: **mg/L** Prep Date: **11/6/2019** RunNo: **55123**
Client ID: **LJ_Queens_110119** Batch ID: **26407** Analysis Date: **11/6/2019** SeqNo: **1095298**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.365	0.100	0.5000	0	73.0	28.3	149				

Sample ID: **1911021-001CMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/6/2019** RunNo: **55123**
Client ID: **LJ_Queens_110119** Batch ID: **26407** Analysis Date: **11/6/2019** SeqNo: **1095299**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.362	0.100	0.5000	0	72.4	28.3	149	0.3650	0.825	30	

Work Order: 1911021
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-26377** SampType: **MBLK** Units: **mg/L** Prep Date: **11/4/2019** RunNo: **55086**
Client ID: **MBLKW** Batch ID: **26377** Analysis Date: **11/4/2019** SeqNo: **1094202**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Nitrate (as N)+Nitrite (as N)	ND	0.100									
Ortho-Phosphate (as P)	ND	0.200									
Sulfate	ND	0.300									

Sample ID: **LCS-26377** SampType: **LCS** Units: **mg/L** Prep Date: **11/4/2019** RunNo: **55086**
Client ID: **LCSW** Batch ID: **26377** Analysis Date: **11/4/2019** SeqNo: **1094203**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	1.44	0.100	1.500	0	96.2	90	110				
Nitrate (as N)+Nitrite (as N)	2.90	0.100	3.000	0	96.5	90	110				
Ortho-Phosphate (as P)	2.53	0.200	2.500	0	101	90	110				
Sulfate	6.76	0.300	7.500	0	90.1	90	110				

Sample ID: **1910485-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/4/2019** RunNo: **55086**
Client ID: **BATCH** Batch ID: **26377** Analysis Date: **11/4/2019** SeqNo: **1094205**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	24.3	1.00						24.07	0.992	20	D
Nitrate (as N)+Nitrite (as N)	ND	1.00						0		20	D
Ortho-Phosphate (as P)	ND	2.00						0		20	DH
Sulfate	20.7	3.00						20.59	0.436	20	D

Sample ID: **1910485-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **11/4/2019** RunNo: **55086**
Client ID: **BATCH** Batch ID: **26377** Analysis Date: **11/4/2019** SeqNo: **1094206**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	40.6	1.00	15.00	24.07	110	80	120				DE
Nitrate (as N)+Nitrite (as N)	28.5	1.00	30.00	0.6900	92.7	80	120				D

Work Order: 1911021
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **1910485-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **11/4/2019** RunNo: **55086**
Client ID: **BATCH** Batch ID: **26377** Analysis Date: **11/4/2019** SeqNo: **1094206**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	24.5	2.00	25.00	0	98.2	80	120				DH
Sulfate	89.3	3.00	75.00	20.59	91.7	80	120				D

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **1910485-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/4/2019** RunNo: **55086**
Client ID: **BATCH** Batch ID: **26377** Analysis Date: **11/4/2019** SeqNo: **1094207**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	40.5	1.00	15.00	24.07	110	80	120	40.55	0.123	20	DE
Nitrate (as N)+Nitrite (as N)	28.5	1.00	30.00	0.6900	92.7	80	120	28.49	0.0351	20	D
Ortho-Phosphate (as P)	24.9	2.00	25.00	0	99.6	80	120	24.54	1.42	20	DH
Sulfate	89.8	3.00	75.00	20.59	92.3	80	120	89.33	0.547	20	D

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Work Order: 1911021
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **LCS-26384** SampType: **LCS** Units: **µg/L** Prep Date: **11/5/2019** RunNo: **55109**
Client ID: **LCSW** Batch ID: **26384** Analysis Date: **11/5/2019** SeqNo: **1094889**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	1,080	100	1,000	0	108	85	115				
Magnesium	1,070	100	1,000	0	107	50	150				
Potassium	1,050	500	1,000	0	105	50	150				
Sodium	1,090	100	1,000	0	109	50	150				

Sample ID: **MB-26384** SampType: **MBLK** Units: **µg/L** Prep Date: **11/5/2019** RunNo: **55109**
Client ID: **MBLKW** Batch ID: **26384** Analysis Date: **11/6/2019** SeqNo: **1095043**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	ND	100									
Calcium	ND	100									
Magnesium	ND	100									
Potassium	ND	500									
Sodium	ND	100									

Sample ID: **LCS-26384** SampType: **LCS** Units: **µg/L** Prep Date: **11/5/2019** RunNo: **55109**
Client ID: **LCSW** Batch ID: **26384** Analysis Date: **11/6/2019** SeqNo: **1095044**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	1,210	100	1,000	0	121	50	150				

Sample ID: **1911024-001BDUP** SampType: **DUP** Units: **µg/L** Prep Date: **11/5/2019** RunNo: **55109**
Client ID: **BATCH** Batch ID: **26384** Analysis Date: **11/6/2019** SeqNo: **1095046**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	621	100						637.1	2.53	30	
Calcium	21,400	100						21,570	0.608	30	
Magnesium	12,000	100						12,160	1.60	30	
Potassium	6,090	500						5,942	2.50	30	

Work Order: 1911021
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **1911024-001BDUP** SampType: **DUP** Units: **µg/L** Prep Date: **11/5/2019** RunNo: **55109**
Client ID: **BATCH** Batch ID: **26384** Analysis Date: **11/6/2019** SeqNo: **1095046**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Sodium	19,700	100						19,980	1.62	30	E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **1911024-001BMS** SampType: **MS** Units: **µg/L** Prep Date: **11/5/2019** RunNo: **55109**
Client ID: **BATCH** Batch ID: **26384** Analysis Date: **11/6/2019** SeqNo: **1095047**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	2,270	100	1,250	637.1	131	70	130				S
Calcium	22,700	100	1,250	21,570	89.4	50	150				
Magnesium	13,600	100	1,250	12,160	118	70	130				E
Potassium	7,490	500	1,250	5,942	123	50	150				
Sodium	21,400	100	1,250	19,980	114	50	150				E

NOTES:
S - Outlying spike recovery(ies) observed. A duplicate analysis was performed and recovered within range (Al).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **1911024-001BMSD** SampType: **MSD** Units: **µg/L** Prep Date: **11/5/2019** RunNo: **55109**
Client ID: **BATCH** Batch ID: **26384** Analysis Date: **11/6/2019** SeqNo: **1095048**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	2,250	100	1,250	637.1	129	70	130	2,273	0.898	30	
Calcium	22,900	100	1,250	21,570	110	50	150	22,690	1.12	30	
Magnesium	13,200	100	1,250	12,160	85.5	70	130	13,630	2.98	30	E
Potassium	7,420	500	1,250	5,942	118	50	150	7,486	0.836	30	
Sodium	21,600	100	1,250	19,980	132	50	150	21,410	1.03	30	E

Work Order: 1911021
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R55185** SampType: **MBLK** Units: **mg/L** Prep Date: **11/8/2019** RunNo: **55185**
Client ID: **MBLKW** Batch ID: **R55185** Analysis Date: **11/8/2019** SeqNo: **1096653**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R55185** SampType: **LCS** Units: **mg/L** Prep Date: **11/8/2019** RunNo: **55185**
Client ID: **LCSW** Batch ID: **R55185** Analysis Date: **11/8/2019** SeqNo: **1096654**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	104	2.50	100.0	0	104	94.3	116				

Sample ID: **1911021-002BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/8/2019** RunNo: **55185**
Client ID: **LJ_Wet_26_110119** Batch ID: **R55185** Analysis Date: **11/8/2019** SeqNo: **1096656**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	23.4	2.50						22.43	4.23	20	

Fremont Analytical

Sample Log-In Check List

Client Name: **GEO1**

Work Order Number: **1911021**

Logged by: **Clare Griggs**

Date Received: **11/1/2019 4:19:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☐ No ☐ Not Required ☑
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >0°C to 10.0°C * Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☐ No ☑

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified: Date:

By Whom: Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person

Regarding:

Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Cooler	2.4
Sample	5.1
Temp Blank	1.8

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 11/1/2019 **Page:** 1 **of:** 1

Laboratory Project No (internal): 1911021

Project Name: Laughing Jacobs (Sammamish)

Project No: PNW0373

Collected by: J. Prock / S. Welsh

Location: Sammamish, WA

Report To (PM): Christian Nilsen

PM Email: cnilsen@geosyntec.com

Special Remarks:

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

Client: Geosyntec

Address: 520 Pike St., Suite 2600

City, State, Zip: Seattle, WA 98101

Telephone: 206-496-1475

Fax: N/A

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	VOCs (EPA 8260 / 624)	GX/BTEX	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM-2320B)	Ammonia (SM 4500-NH3)			Comments
1	LS_Queens_110119	11/1/19	1225	W										1	T	1		1	1			
2	LS_Wet_26_110119	11/1/19	1325	W										1	T	1		1	1			
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

***Matrix:** A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

****Metals (Circle):** MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag [✓ Al] As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl U V Zn

*****Anions (Circle):** Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide [✓ O-Phosphate] Fluoride [✓ Nitrate+Nitrite]

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above and that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Turn-around Time:

☒ Standard
☐ 3 Day
☐ 2 Day
☐ Next Day
Same Day ______ (specify)

Relinquished x Date/Time 11/1/19 1619
Received x Kayla [illegible] Date/Time 11/1/19 16:19

Relinquished x Date/Time
Received x Date/Time

www.fremontanalytical.com

Fremont Analytical

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info@fremontanalytical.com

Geosyntec Seattle
Joel Prock
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs (Sammamish)
Work Order Number: 1912473

January 07, 2020

Attention Joel Prock:

Fremont Analytical, Inc. received 2 sample(s) on 12/30/2019 for the analyses presented in the following report.

Ammonia by SM 4500 NH3G

Ion Chromatography by EPA Method 300.0

Total Metals by EPA Method 200.8

Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD/ELAP Certification #L17-135, ISO/IEC 17025:2005
ORELAP Certification: WA 100009-007 (NELAP Recognized)

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)
Work Order: 1912473

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
1912473-001	LJ_Queens_123019	12/30/2019 12:35 PM	12/30/2019 5:37 PM
1912473-002	LJ_Wet_26_123019	12/30/2019 1:05 PM	12/30/2019 5:37 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **1912473**

Date: **1/7/2020**

CLIENT: Geosyntec Seattle

Project: Laughing Jacobs (Sammamish)

I. SAMPLE RECEIPT:

Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:

Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:

Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **1912473**
Date Reported: **1/7/2020**

Client: Geosyntec Seattle
Collection Date: 12/30/2019 12:35:00 PM
Project: Laughing Jacobs (Sammamish)
Lab ID: 1912473-001
Matrix: Water
Client Sample ID: **LJ_Queens_123019**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 26984		Analyst: SS
Chloride	1.60	0.100		mg/L	1	12/31/2019 7:56:00 PM
Nitrate (as N)+Nitrite (as N)	0.301	0.100		mg/L	1	12/31/2019 7:56:00 PM
Ortho-Phosphate (as P)	ND	0.200		mg/L	1	12/31/2019 7:56:00 PM
Sulfate	0.897	0.300		mg/L	1	12/31/2019 7:56:00 PM
Total Metals by EPA Method 200.8				Batch ID: 26985		Analyst: CO
Aluminum	262	100		µg/L	1	1/2/2020 4:38:59 PM
Calcium	5,820	200		µg/L	1	1/2/2020 4:38:59 PM
Magnesium	1,680	100		µg/L	1	1/2/2020 4:38:59 PM
Potassium	2,150	500		µg/L	1	1/2/2020 4:38:59 PM
Sodium	3,230	200		µg/L	1	1/2/2020 4:38:59 PM
Total Alkalinity by SM 2320B				Batch ID: R56345		Analyst: WF
Alkalinity, Total (As CaCO3)	15.6	2.50		mg/L	1	12/31/2019 3:20:32 PM
Ammonia by SM 4500 NH3G				Batch ID: 27007		Analyst: SS
Nitrogen, Ammonia	ND	0.100		mg/L	1	1/7/2020 11:05:00 AM

Analytical Report

Work Order: **1912473**
Date Reported: **1/7/2020**

Client: Geosyntec Seattle
Collection Date: 12/30/2019 1:05:00 PM
Project: Laughing Jacobs (Sammamish)
Lab ID: 1912473-002
Matrix: Water
Client Sample ID: **LJ_Wet_26_123019**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 26984		Analyst: SS
Chloride	3.92	0.200	D	mg/L	2	12/31/2019 9:51:00 PM
Nitrate (as N)+Nitrite (as N)	0.189	0.100		mg/L	1	12/31/2019 10:14:00 PM
Ortho-Phosphate (as P)	ND	0.200		mg/L	1	12/31/2019 10:14:00 PM
Sulfate	3.25	0.300		mg/L	1	12/31/2019 10:14:00 PM
Total Metals by EPA Method 200.8				Batch ID: 26985		Analyst: CO
Aluminum	220	100		µg/L	1	1/2/2020 4:44:34 PM
Calcium	7,740	200		µg/L	1	1/2/2020 4:44:34 PM
Magnesium	3,170	100		µg/L	1	1/2/2020 4:44:34 PM
Potassium	2,400	500		µg/L	1	1/2/2020 4:44:34 PM
Sodium	5,400	200		µg/L	1	1/2/2020 4:44:34 PM
Total Alkalinity by SM 2320B				Batch ID: R56345		Analyst: WF
Alkalinity, Total (As CaCO3)	22.4	2.50		mg/L	1	12/31/2019 3:20:32 PM
Ammonia by SM 4500 NH3G				Batch ID: 27007		Analyst: SS
Nitrogen, Ammonia	ND	0.100		mg/L	1	1/7/2020 11:10:00 AM

Work Order: 1912473
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ammonia by SM 4500 NH3G

Sample ID: **MB-27007** SampType: **MBLK** Units: **mg/L** Prep Date: **1/3/2020** RunNo: **56454**
Client ID: **MBLKW** Batch ID: **27007** Analysis Date: **1/7/2020** SeqNo: **1124347**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100									

Sample ID: **LCS-27007** SampType: **LCS** Units: **mg/L** Prep Date: **1/3/2020** RunNo: **56454**
Client ID: **LCSW** Batch ID: **27007** Analysis Date: **1/7/2020** SeqNo: **1124348**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.423	0.100	0.5000	0	84.6	72.7	119				

Sample ID: **1912475-001CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **1/3/2020** RunNo: **56454**
Client ID: **BATCH** Batch ID: **27007** Analysis Date: **1/7/2020** SeqNo: **1124352**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	7.57	0.100						12.65	50.3	30	RE

NOTES:

R - High RPD due to high analyte concentration. In this range, high RPD's may be expected.
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **1912475-001CMS** SampType: **MS** Units: **mg/L** Prep Date: **1/3/2020** RunNo: **56454**
Client ID: **BATCH** Batch ID: **27007** Analysis Date: **1/7/2020** SeqNo: **1124353**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	>1.5ppm	0.100	0.5000	12.65	-2,530	28.3	149				SE

NOTES:

S - Analyte concentration was too high for accurate spike recovery(ies).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **1912475-001CMSD** SampType: **MSD** Units: **mg/L** Prep Date: **1/3/2020** RunNo: **56454**
Client ID: **BATCH** Batch ID: **27007** Analysis Date: **1/7/2020** SeqNo: **1124354**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.645	0.100	0.5000	12.65	-2,400	28.3	149	0	200	30	SE

Work Order: 1912473
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ammonia by SM 4500 NH3G

Sample ID: **1912475-001CMSD**		SampType: **MSD**			Units: **mg/L**		Prep Date: **1/3/2020**			RunNo: **56454**			
Client ID: **BATCH**		Batch ID: **27007**					Analysis Date: **1/7/2020**			SeqNo: **1124354**			
Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual		

NOTES:

S - Analyte concentration was too high for accurate spike recovery(ies).

E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 1912473
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-26984** SampType: **MBLK** Units: **mg/L** Prep Date: **12/31/2019** RunNo: **56368**
Client ID: **MBLKW** Batch ID: **26984** Analysis Date: **12/31/2019** SeqNo: **1122960**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Nitrate (as N)+Nitrite (as N)	ND	0.100									
Ortho-Phosphate (as P)	ND	0.200									
Sulfate	ND	0.300									

Sample ID: **1912473-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **12/31/2019** RunNo: **56368**
Client ID: **LJ_Queens_123019** Batch ID: **26984** Analysis Date: **12/31/2019** SeqNo: **1122969**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	1.52	0.200						1.554	1.95	20	D
Nitrate (as N)+Nitrite (as N)	0.254	0.200						0.2600	2.33	20	D
Ortho-Phosphate (as P)	ND	0.400						0		20	D
Sulfate	1.10	0.600						1.104	0.181	20	D

Sample ID: **1912473-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **12/31/2019** RunNo: **56368**
Client ID: **LJ_Queens_123019** Batch ID: **26984** Analysis Date: **12/31/2019** SeqNo: **1122970**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	2.95	0.200	1.500	1.554	92.9	80	120				D
Nitrate (as N)+Nitrite (as N)	2.84	0.200	3.000	0.2600	86.1	80	120				D
Ortho-Phosphate (as P)	2.06	0.400	2.500	0.05800	80.0	80	120				D
Sulfate	7.60	0.600	7.500	1.104	86.6	80	120				D

Sample ID: **1912473-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **12/31/2019** RunNo: **56368**
Client ID: **LJ_Queens_123019** Batch ID: **26984** Analysis Date: **12/31/2019** SeqNo: **1122972**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	2.89	0.200	1.500	1.554	89.1	80	120	2.948	1.99	20	D
Nitrate (as N)+Nitrite (as N)	2.76	0.200	3.000	0.2600	83.5	80	120	2.844	2.85	20	D

Work Order: 1912473
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **1912473-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **12/31/2019** RunNo: **56368**
Client ID: **LJ_Queens_123019** Batch ID: **26984** Analysis Date: **12/31/2019** SeqNo: **1122972**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	2.01	0.400	2.500	0.05800	77.9	80	120	2.058	2.56	20	DS
Sulfate	7.30	0.600	7.500	1.104	82.6	80	120	7.596	3.95	20	D

NOTES:
S - Outlying spike recovery(ies) observed. A duplicate analysis was performed and recovered within range.

Sample ID: **LCSRR-26984** SampType: **LCS** Units: **mg/L** Prep Date: **1/2/2020** RunNo: **56368**
Client ID: **LCSW** Batch ID: **26984** Analysis Date: **1/2/2020** SeqNo: **1122944**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.710	0.100	0.7500	0	94.7	90	110				
Nitrate (as N)+Nitrite (as N)	1.44	0.100	1.500	0	95.9	90	110				
Ortho-Phosphate (as P)	1.18	0.200	1.250	0	94.0	90	110				
Sulfate	3.84	0.300	3.750	0	102	90	110				

Work Order: 1912473
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **LCS-26985** SampType: **LCS** Units: **µg/L** Prep Date: **1/2/2020** RunNo: **56367**
Client ID: **LCSW** Batch ID: **26985** Analysis Date: **1/2/2020** SeqNo: **1122959**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	1,040	100	1,000	0	104	85	115				
Calcium	1,030	200	1,000	0	103	50	150				
Magnesium	1,040	100	1,000	0	104	50	150				
Potassium	1,020	500	1,000	0	102	50	150				
Sodium	1,050	200	1,000	0	105	50	150				

Sample ID: **1912480-001CDUP** SampType: **DUP** Units: **µg/L** Prep Date: **1/2/2020** RunNo: **56367**
Client ID: **BATCH** Batch ID: **26985** Analysis Date: **1/2/2020** SeqNo: **1122964**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	408	100						434.0	6.10	30	
Calcium	24,200	200						25,040	3.34	30	
Magnesium	3,000	100						3,049	1.55	30	
Potassium	5,100	500						5,271	3.21	30	
Sodium	12,900	200						13,190	2.03	30	

Sample ID: **1912480-001CMS** SampType: **MS** Units: **µg/L** Prep Date: **1/2/2020** RunNo: **56367**
Client ID: **BATCH** Batch ID: **26985** Analysis Date: **1/2/2020** SeqNo: **1122966**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	7,040	100	5,000	434.0	132	70	130				S
Calcium	30,200	200	5,000	25,040	103	50	150				E
Magnesium	9,890	100	5,000	3,049	137	70	130				S
Potassium	11,500	500	5,000	5,271	125	50	150				
Sodium	19,400	200	5,000	13,190	125	50	150				

NOTES:

S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect.

E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 1912473
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **1912480-001CMSD** SampType: **MSD** Units: **µg/L** Prep Date: **1/2/2020** RunNo: **56367**
Client ID: **BATCH** Batch ID: **26985** Analysis Date: **1/2/2020** SeqNo: **1122968**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	7,020	100	5,000	434.0	132	70	130	7,038	0.219	30	S
Calcium	31,100	200	5,000	25,040	121	50	150	30,190	2.92	30	E
Magnesium	10,100	100	5,000	3,049	141	70	130	9,893	2.29	30	S
Potassium	11,900	500	5,000	5,271	132	50	150	11,500	3.34	30	
Sodium	20,100	200	5,000	13,190	138	50	150	19,440	3.16	30	

NOTES:

S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect.

E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **MB-26985** SampType: **MBLK** Units: **µg/L** Prep Date: **1/2/2020** RunNo: **56395**
Client ID: **MBLKW** Batch ID: **26985** Analysis Date: **1/3/2020** SeqNo: **1123403**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	ND	100									
Calcium	ND	200									
Magnesium	ND	100									
Potassium	ND	500									
Sodium	ND	200									

Work Order: 1912473
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs (Sammamish)

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R56345** SampType: **MBLK** Units: **mg/L** Prep Date: **12/31/2019** RunNo: **56345**
Client ID: **MBLKW** Batch ID: **R56345** Analysis Date: **12/31/2019** SeqNo: **1122598**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R56345** SampType: **LCS** Units: **mg/L** Prep Date: **12/31/2019** RunNo: **56345**
Client ID: **LCSW** Batch ID: **R56345** Analysis Date: **12/31/2019** SeqNo: **1122599**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	101	2.50	100.0	0	101	94.3	116				

Sample ID: **1912434-002BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **12/31/2019** RunNo: **56345**
Client ID: **BATCH** Batch ID: **R56345** Analysis Date: **12/31/2019** SeqNo: **1122601**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	65.0	2.50						68.25	4.88	20	

Fremont *Analytical*

Sample Log-In Check List

Client Name: **GEO1** Work Order Number: **1912473**

Logged by: **Clare Griggs** Date Received: **12/30/2019 5:37:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☐ No ☐ Not Required ☑
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >0°C to 10.0°C* Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified: Date:

By Whom: Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person

Regarding:

Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Cooler	3.6
Sample	2.2
Temp Blank	2.1

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical
3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 12/30/2019 **Page:** 1 **of:** 1

Laboratory Project No (internal): 1912473

Client: Geosyntec

Address: 520 Pike St., Suite 2600

City, State, Zip: Seattle, WA 98101

Telephone: 206-496-1475

Fax: N/A

Project Name: Laughing Jacobs (Sammamish)

Project No: PNW0373

Collected by: J. Prock/S. Welsh

Location: Sammamish, WA

Report To (PM): Joel Prock

PM Email: jprock@geosyntec.com

Special Remarks:

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	VOCs (EPA 8260 / 624)	GX/BTEX	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) / Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM-2320B)	Ammonia (SM-4500-NH3)			Comments
1	LJ_Queens_123019	12/30/19	1235	W										1	T	1		1	1			
2	LJ_Wet_26_123019	12/30/19	1305	W										1	T	1		1	1			
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

***Matrix:** A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

****Metals (Circle):** MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag [✓ Al] As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl U V Zn

*****Anions (Circle):** Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide [✓ O-Phosphate] Fluoride [✓ Nitrate+Nitrite]

Turn-around Time:

☒ Standard

☐ 3 Day

☐ 2 Day

☐ Next Day

Same Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above and that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished x Date/Time 12/30/19 SW 17:37

Received x Date/Time 12/30/19 1737

Relinquished x Date/Time

Received x Date/Time

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Geosyntec Seattle
Joel Prock
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs
Work Order Number: 2002486

March 06, 2020

Attention Joel Prock:

Fremont Analytical, Inc. received 2 sample(s) on 2/28/2020 for the analyses presented in the following report.

Ammonia by SM 4500 NH3G

Ion Chromatography by EPA Method 300.0

Total Metals by EPA Method 200.8

Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD/ELAP Certification #L17-135, ISO/IEC 17025:2005
ORELAP Certification: WA 100009-007 (NELAP Recognized)

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs
Work Order: 2002486

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2002486-001	Queens_02282020	02/28/2020 11:36 AM	02/28/2020 3:00 PM
2002486-002	Wet26_02282020	02/28/2020 12:21 PM	02/28/2020 3:00 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2002486**
Date: **3/6/2020**

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers & Acronyms

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **2002486**
Date Reported: **3/6/2020**

Client: Geosyntec Seattle
Collection Date: 2/28/2020 11:36:00 AM
Project: Laughing Jacobs
Lab ID: 2002486-001
Matrix: Water
Client Sample ID: Queens_02282020

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 27642		Analyst: SS
Chloride	4.39	0.200	D	mg/L	2	2/28/2020 8:02:00 PM
Nitrate (as N)+Nitrite (as N)	0.114	0.100		mg/L	1	2/28/2020 9:57:00 PM
Ortho-Phosphate (as P)	ND	0.200		mg/L	1	2/28/2020 9:57:00 PM
Sulfate	1.52	0.300		mg/L	1	2/28/2020 9:57:00 PM
Total Metals by EPA Method 200.8				Batch ID: 27632		Analyst: CO
Aluminum	ND	100		µg/L	1	3/2/2020 4:10:35 PM
Calcium	5,230	200		µg/L	1	3/2/2020 4:10:35 PM
Magnesium	1,980	100		µg/L	1	3/2/2020 4:10:35 PM
Potassium	1,580	500		µg/L	1	3/2/2020 4:10:35 PM
Sodium	4,750	200		µg/L	1	3/2/2020 4:10:35 PM
Total Alkalinity by SM 2320B				Batch ID: R57805		Analyst: WF
Alkalinity, Total (As CaCO3)	14.1	2.50		mg/L	1	3/5/2020 10:50:23 PM
Ammonia by SM 4500 NH3G				Batch ID: 27681		Analyst: SS
Nitrogen, Ammonia	ND	0.100		mg/L	1	3/4/2020 3:33:00 PM

Client: Geosyntec Seattle
Project: Laughing Jacobs
Lab ID: 2002486-002
Client Sample ID: **Wet26_02282020**

Collection Date: 2/28/2020 12:21:00 PM

Matrix: Water

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 27642		Analyst: SS
Chloride	4.68	0.200	D	mg/L	2	2/28/2020 9:34:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	2/28/2020 10:20:00 PM
Ortho-Phosphate (as P)	ND	0.200		mg/L	1	2/28/2020 10:20:00 PM
Sulfate	2.63	0.300		mg/L	1	2/28/2020 10:20:00 PM
Total Metals by EPA Method 200.8				Batch ID: 27632		Analyst: CO
Aluminum	278	100		µg/L	1	3/2/2020 4:58:49 PM
Calcium	9,200	200		µg/L	1	3/2/2020 4:58:49 PM
Magnesium	3,690	100		µg/L	1	3/2/2020 4:58:49 PM
Potassium	1,480	500		µg/L	1	3/2/2020 4:58:49 PM
Sodium	6,500	200		µg/L	1	3/2/2020 4:58:49 PM
Total Alkalinity by SM 2320B				Batch ID: R57805		Analyst: WF
Alkalinity, Total (As CaCO3)	29.2	2.50		mg/L	1	3/5/2020 10:50:23 PM
Ammonia by SM 4500 NH3G				Batch ID: 27681		Analyst: SS
Nitrogen, Ammonia	ND	0.100		mg/L	1	3/4/2020 3:39:00 PM

Work Order: 2002486
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ammonia by SM 4500 NH3G

Sample ID: **MB-27681** SampType: **MBLK** Units: **mg/L** Prep Date: **3/4/2020** RunNo: **57800**
Client ID: **MBLKW** Batch ID: **27681** Analysis Date: **3/4/2020** SeqNo: **1154301**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100									

Sample ID: **LCS-27681** SampType: **LCS** Units: **mg/L** Prep Date: **3/4/2020** RunNo: **57800**
Client ID: **LCSW** Batch ID: **27681** Analysis Date: **3/4/2020** SeqNo: **1154302**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.438	0.100	0.5000	0	87.6	72.7	119				

Sample ID: **2002486-001CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **3/4/2020** RunNo: **57800**
Client ID: **Queens_02282020** Batch ID: **27681** Analysis Date: **3/4/2020** SeqNo: **1154304**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.300						0		30	D

Sample ID: **2002486-001CMS** SampType: **MS** Units: **mg/L** Prep Date: **3/4/2020** RunNo: **57800**
Client ID: **Queens_02282020** Batch ID: **27681** Analysis Date: **3/4/2020** SeqNo: **1154305**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	1.56	0.300	1.500	0	104	28.3	149				D

Sample ID: **2002486-001CMSD** SampType: **MSD** Units: **mg/L** Prep Date: **3/4/2020** RunNo: **57800**
Client ID: **Queens_02282020** Batch ID: **27681** Analysis Date: **3/4/2020** SeqNo: **1154306**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	1.38	0.300	1.500	0	92.0	28.3	149	1.557	12.1	30	D

Work Order: 2002486
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-27642** SampType: **MBLK** Units: **mg/L** Prep Date: **2/28/2020** RunNo: **57727**
Client ID: **MBLKW** Batch ID: **27642** Analysis Date: **2/28/2020** SeqNo: **1152730**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Nitrate (as N)+Nitrite (as N)	ND	0.100									
Ortho-Phosphate (as P)	ND	0.200									
Sulfate	ND	0.300									

Sample ID: **LCS-27642** SampType: **LCS** Units: **mg/L** Prep Date: **2/28/2020** RunNo: **57727**
Client ID: **LCSW** Batch ID: **27642** Analysis Date: **2/28/2020** SeqNo: **1152732**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.713	0.100	0.7500	0	95.1	90	110				
Nitrate (as N)+Nitrite (as N)	1.44	0.100	1.500	0	95.7	90	110				
Ortho-Phosphate (as P)	1.27	0.200	1.250	0	101	90	110				
Sulfate	3.56	0.300	3.750	0	95.0	90	110				

Sample ID: **2002486-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **2/28/2020** RunNo: **57727**
Client ID: **Queens_02282020** Batch ID: **27642** Analysis Date: **2/28/2020** SeqNo: **1152734**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	4.34	0.200						4.388	1.05	20	D
Nitrate (as N)+Nitrite (as N)	ND	0.200						0		20	D
Ortho-Phosphate (as P)	ND	0.400						0		20	D
Sulfate	1.63	0.600						1.660	1.82	20	D

Sample ID: **2002486-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **2/28/2020** RunNo: **57727**
Client ID: **Queens_02282020** Batch ID: **27642** Analysis Date: **2/28/2020** SeqNo: **1152735**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.97	0.200	1.500	4.388	105	80	120				D
Nitrate (as N)+Nitrite (as N)	3.00	0.200	3.000	0.1680	94.4	80	120				D

Work Order: 2002486
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2002486-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **2/28/2020** RunNo: **57727**
Client ID: **Queens_02282020** Batch ID: **27642** Analysis Date: **2/28/2020** SeqNo: **1152735**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	2.39	0.400	2.500	0.09200	91.8	80	120				D
Sulfate	8.67	0.600	7.500	1.660	93.5	80	120				D

Sample ID: **2002486-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **2/28/2020** RunNo: **57727**
Client ID: **Queens_02282020** Batch ID: **27642** Analysis Date: **2/28/2020** SeqNo: **1152736**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.96	0.200	1.500	4.388	105	80	120	5.966	0.168	20	D
Nitrate (as N)+Nitrite (as N)	2.98	0.200	3.000	0.1680	93.6	80	120	3.000	0.803	20	D
Ortho-Phosphate (as P)	2.41	0.400	2.500	0.09200	92.9	80	120	2.386	1.17	20	D
Sulfate	8.64	0.600	7.500	1.660	93.1	80	120	8.674	0.370	20	D

Work Order: 2002486
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-27632** SampType: **MBLK** Units: **µg/L** Prep Date: **3/2/2020** RunNo: **57729**
Client ID: **MBLKW** Batch ID: **27632** Analysis Date: **3/2/2020** SeqNo: **1153029**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	ND	100									
Calcium	ND	200									
Magnesium	ND	100									
Potassium	ND	500									
Sodium	ND	200									

Sample ID: **LCS-27632** SampType: **LCS** Units: **µg/L** Prep Date: **3/2/2020** RunNo: **57729**
Client ID: **LCSW** Batch ID: **27632** Analysis Date: **3/2/2020** SeqNo: **1153030**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	1,030	100	1,000	0	103	85	115				
Calcium	1,020	200	1,000	0	102	50	150				
Magnesium	1,010	100	1,000	0	101	50	150				
Potassium	1,030	500	1,000	0	103	50	150				
Sodium	1,030	200	1,000	0	103	50	150				

Sample ID: **2002472-001CDUP** SampType: **DUP** Units: **µg/L** Prep Date: **3/2/2020** RunNo: **57729**
Client ID: **BATCH** Batch ID: **27632** Analysis Date: **3/2/2020** SeqNo: **1153032**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	4,470	100						4,240	5.39	30	
Calcium	33,600	200						34,490	2.63	30	E
Magnesium	7,040	100						7,182	2.00	30	
Potassium	2,560	500						2,527	1.21	30	
Sodium	12,500	200						12,810	2.73	30	

NOTES:

E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 2002486
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2002472-001CMS** SampType: **MS** Units: **µg/L** Prep Date: **3/2/2020** RunNo: **57729**
Client ID: **BATCH** Batch ID: **27632** Analysis Date: **3/2/2020** SeqNo: **1153033**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	11,100	100	5,000	4,240	137	70	130				S
Calcium	40,200	200	5,000	34,490	115	50	150				E
Magnesium	13,800	100	5,000	7,182	132	70	130				S
Potassium	9,070	500	5,000	2,527	131	50	150				
Sodium	19,200	200	5,000	12,810	127	50	150				

NOTES:

S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect (Al, Mg)

E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2002472-001CMSD** SampType: **MSD** Units: **µg/L** Prep Date: **3/2/2020** RunNo: **57729**
Client ID: **BATCH** Batch ID: **27632** Analysis Date: **3/2/2020** SeqNo: **1153034**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	11,200	100	5,000	4,240	139	70	130	11,090	0.697	30	S
Calcium	39,200	200	5,000	34,490	94.8	50	150	40,230	2.51	30	E
Magnesium	14,100	100	5,000	7,182	138	70	130	13,780	2.32	30	S
Potassium	9,220	500	5,000	2,527	134	50	150	9,067	1.70	30	
Sodium	19,900	200	5,000	12,810	141	50	150	19,160	3.71	30	

NOTES:

S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect (Al, Mg)

E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 2002486
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R57805** SampType: **MBLK** Units: **mg/L** Prep Date: **3/5/2020** RunNo: **57805**
Client ID: **MBLKW** Batch ID: **R57805** Analysis Date: **3/5/2020** SeqNo: **1154373**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R57805** SampType: **LCS** Units: **mg/L** Prep Date: **3/5/2020** RunNo: **57805**
Client ID: **LCSW** Batch ID: **R57805** Analysis Date: **3/5/2020** SeqNo: **1154374**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	103	2.50	100.0	0	103	94.3	116				

Sample ID: **2002486-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **3/5/2020** RunNo: **57805**
Client ID: **Queens_02282020** Batch ID: **R57805** Analysis Date: **3/5/2020** SeqNo: **1154376**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	13.6	2.50						14.14	3.51	20	

Sample Log-In Check List

Client Name: **GEO1**
Work Order Number: **2002486**
Logged by: **Carissa True**
Date Received: **2/28/2020 3:00:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☐ No ☐ Not Required ☑
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >2°C to 6°C * Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified:
Date:
By Whom:
Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:
Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Cooler 1	1.3
Sample 1	5.8
Temp Blank 1	4.3

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Geosyntec Seattle
Joel Prock
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs
Work Order Number: 2006318

June 24, 2020

Attention Joel Prock:

Fremont Analytical, Inc. received 2 sample(s) on 6/17/2020 for the analyses presented in the following report.

Ammonia by SM 4500 NH3G

Ion Chromatography by EPA Method 300.0

Total Metals by EPA Method 200.8

Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD/ELAP Certification #L17-135, ISO/IEC 17025:2005
ORELAP Certification: WA 100009-007 (NELAP Recognized)

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs
Work Order: 2006318

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2006318-001	LJ_Queens_06172020	06/17/2020 11:41 AM	06/17/2020 5:06 PM
2006318-002	LJ_Wet26_06172020	06/17/2020 12:21 PM	06/17/2020 5:06 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2006318**

Date: **6/24/2020**

CLIENT: Geosyntec Seattle

Project: Laughing Jacobs

I. SAMPLE RECEIPT:

Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:

Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:

Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **2006318**
Date Reported: **6/24/2020**

Client: Geosyntec Seattle
Collection Date: 6/17/2020 11:41:00 AM
Project: Laughing Jacobs
Lab ID: 2006318-001
Matrix: Water
Client Sample ID: LJ_Queens_06172020

Ion Chromatography by EPA Method 300.0

Batch ID: 28726 Analyst: SS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Chloride	2.99	0.200	D	mg/L	2	6/19/2020 11:06:00 AM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	6/18/2020 6:22:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L	1	6/19/2020 8:20:00 PM
Ortho-Phosphate (as P)	ND	0.200	Q	mg/L	1	6/18/2020 6:22:00 PM
Sulfate	0.514	0.300		mg/L	1	6/18/2020 6:22:00 PM

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria

Total Metals by EPA Method 200.8

Batch ID: 28767 Analyst: CO

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Aluminum	112	100		µg/L	1	6/24/2020 11:42:47 AM
Calcium	6,510	200		µg/L	1	6/23/2020 8:29:10 PM
Magnesium	1,880	100		µg/L	1	6/23/2020 8:29:10 PM
Potassium	911	500		µg/L	1	6/24/2020 11:42:47 AM
Sodium	3,630	200		µg/L	1	6/23/2020 8:29:10 PM

Total Alkalinity by SM 2320B

Batch ID: R60081 Analyst: WF

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Alkalinity, Total (As CaCO3)	21.4	2.50		mg/L	1	6/24/2020 3:42:00 PM

Ammonia by SM 4500 NH3G

Batch ID: 28774 Analyst: SS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Nitrogen, Ammonia	ND	0.100		mg/L	1	6/23/2020 10:59:00 AM

Analytical Report

Work Order: **2006318**
Date Reported: **6/24/2020**

Client: Geosyntec Seattle
Collection Date: 6/17/2020 12:21:00 PM
Project: Laughing Jacobs
Lab ID: 2006318-002
Matrix: Water
Client Sample ID: LJ_Wet26_06172020

Ion Chromatography by EPA Method 300.0

Batch ID: 28726 Analyst: SS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Chloride	3.94	0.200	D	mg/L	2	6/19/2020 11:29:00 AM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	6/18/2020 7:54:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L	1	6/19/2020 8:43:00 PM
Ortho-Phosphate (as P)	ND	0.200	Q	mg/L	1	6/18/2020 7:54:00 PM
Sulfate	0.911	0.300		mg/L	1	6/18/2020 7:54:00 PM

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria

Total Metals by EPA Method 200.8

Batch ID: 28767 Analyst: CO

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Aluminum	528	100		µg/L	1	6/24/2020 11:48:21 AM
Calcium	11,800	200		µg/L	1	6/23/2020 8:34:43 PM
Magnesium	3,540	100		µg/L	1	6/23/2020 8:34:43 PM
Potassium	596	500		µg/L	1	6/24/2020 11:48:21 AM
Sodium	5,600	200		µg/L	1	6/23/2020 8:34:43 PM

Total Alkalinity by SM 2320B

Batch ID: R60081 Analyst: WF

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Alkalinity, Total (As CaCO3)	44.8	2.50		mg/L	1	6/24/2020 3:42:00 PM

Ammonia by SM 4500 NH3G

Batch ID: 28774 Analyst: SS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Nitrogen, Ammonia	ND	0.100		mg/L	1	6/23/2020 11:20:00 AM

Work Order: 2006318
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R60081** SampType: **MBLK** Units: **mg/L** Prep Date: **6/24/2020** RunNo: **60081**
Client ID: **MBLKW** Batch ID: **R60081** Analysis Date: **6/24/2020** SeqNo: **1202875**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R60081** SampType: **LCS** Units: **mg/L** Prep Date: **6/24/2020** RunNo: **60081**
Client ID: **LCSW** Batch ID: **R60081** Analysis Date: **6/24/2020** SeqNo: **1202876**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	103	2.50	100.0	0	103	94.3	116				

Sample ID: **2006318-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **6/24/2020** RunNo: **60081**
Client ID: **LJ_Queens_06172020** Batch ID: **R60081** Analysis Date: **6/24/2020** SeqNo: **1202878**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	21.4	2.50						21.45	0	20	

Work Order: 2006318
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ammonia by SM 4500 NH3G

Sample ID: **MB-28774** SampType: **MBLK** Units: **mg/L** Prep Date: **6/23/2020** RunNo: **60027**
Client ID: **MBLKW** Batch ID: **28774** Analysis Date: **6/23/2020** SeqNo: **1201549**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100									

Sample ID: **LCS-28774** SampType: **LCS** Units: **mg/L** Prep Date: **6/23/2020** RunNo: **60027**
Client ID: **LCSW** Batch ID: **28774** Analysis Date: **6/23/2020** SeqNo: **1201550**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.461	0.100	0.5000	0	92.2	74.1	109				

Sample ID: **2006318-001CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **6/23/2020** RunNo: **60027**
Client ID: **LJ_Queens_06172020** Batch ID: **28774** Analysis Date: **6/23/2020** SeqNo: **1201552**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100						0		30	

Sample ID: **2006318-001CMS** SampType: **MS** Units: **mg/L** Prep Date: **6/23/2020** RunNo: **60027**
Client ID: **LJ_Queens_06172020** Batch ID: **28774** Analysis Date: **6/23/2020** SeqNo: **1201553**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.315	0.100	0.5000	0	63.0	38.8	131				

Sample ID: **2006318-001CMSD** SampType: **MSD** Units: **mg/L** Prep Date: **6/23/2020** RunNo: **60027**
Client ID: **LJ_Queens_06172020** Batch ID: **28774** Analysis Date: **6/23/2020** SeqNo: **1201554**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.322	0.100	0.5000	0	64.4	38.8	131	0.3150	2.20	30	

Work Order: 2006318
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-28726** SampType: **MBLK** Units: **mg/L** Prep Date: **6/18/2020** RunNo: **59967**
Client ID: **MBLKW** Batch ID: **28726** Analysis Date: **6/18/2020** SeqNo: **1200348**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Nitrate (as N)+Nitrite (as N)	ND	0.100									
Ortho-Phosphate (as P)	ND	0.200									
Sulfate	ND	0.300									

Sample ID: **LCS-28726** SampType: **LCS** Units: **mg/L** Prep Date: **6/18/2020** RunNo: **59967**
Client ID: **LCSW** Batch ID: **28726** Analysis Date: **6/18/2020** SeqNo: **1200349**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.716	0.100	0.7500	0	95.5	90	110				
Nitrate (as N)+Nitrite (as N)	1.43	0.100	1.500	0	95.5	90	110				
Ortho-Phosphate (as P)	1.18	0.200	1.250	0	94.2	90	110				
Sulfate	3.64	0.300	3.750	0	97.2	90	110				

Sample ID: **2006318-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **6/18/2020** RunNo: **59967**
Client ID: **LJ_Queens_06172020** Batch ID: **28726** Analysis Date: **6/18/2020** SeqNo: **1200351**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	3.15	0.100						3.156	0.317	20	E
Nitrate (as N)+Nitrite (as N)	ND	0.100						0		20	
Sulfate	0.516	0.300						0.5140	0.388	20	

NOTES:

E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2006318-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **6/18/2020** RunNo: **59967**
Client ID: **LJ_Queens_06172020** Batch ID: **28726** Analysis Date: **6/18/2020** SeqNo: **1200352**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	3.97	0.100	0.7500	3.156	109	80	120				E
Nitrate (as N)+Nitrite (as N)	1.44	0.100	1.500	0.06200	92.0	80	120				

Work Order: 2006318
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2006318-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **6/18/2020** RunNo: **59967**
Client ID: **LJ_Queens_06172020** Batch ID: **28726** Analysis Date: **6/18/2020** SeqNo: **1200352**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	1.05	0.200	1.250	0.03500	81.0	80	120				
Sulfate	3.90	0.300	3.750	0.5140	90.2	80	120				

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2006318-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **6/18/2020** RunNo: **59967**
Client ID: **LJ_Queens_06172020** Batch ID: **28726** Analysis Date: **6/18/2020** SeqNo: **1200353**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	3.98	0.100	0.7500	3.156	110	80	120	3.973	0.151	20	E
Nitrate (as N)+Nitrite (as N)	1.45	0.100	1.500	0.06200	92.7	80	120	1.442	0.691	20	
Ortho-Phosphate (as P)	1.14	0.200	1.250	0.03500	88.1	80	120	1.047	8.15	20	
Sulfate	3.99	0.300	3.750	0.5140	92.8	80	120	3.895	2.48	20	

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **MB-28739** SampType: **MBLK** Units: **mg/L** Prep Date: **6/19/2020** RunNo: **60003**
Client ID: **MBLKW** Batch ID: **28739** Analysis Date: **6/19/2020** SeqNo: **1201142**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	ND	0.200									

Sample ID: **LCS-28739** SampType: **LCS** Units: **mg/L** Prep Date: **6/19/2020** RunNo: **60003**
Client ID: **LCSW** Batch ID: **28739** Analysis Date: **6/19/2020** SeqNo: **1201143**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	1.18	0.200	1.250	0	94.5	90	110				

Work Order: 2006318
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2006310-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **6/19/2020** RunNo: **60003**
Client ID: **BATCH** Batch ID: **28739** Analysis Date: **6/19/2020** SeqNo: **1201145**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	ND	0.400						0		20	DH

Sample ID: **2006310-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **6/19/2020** RunNo: **60003**
Client ID: **BATCH** Batch ID: **28739** Analysis Date: **6/19/2020** SeqNo: **1201146**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	1.86	0.400	2.500	0	74.4	80	120				DSH

NOTES:
S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect (o-phosphate).

Sample ID: **2006310-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **6/19/2020** RunNo: **60003**
Client ID: **BATCH** Batch ID: **28739** Analysis Date: **6/19/2020** SeqNo: **1201147**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	1.98	0.400	2.500	0	79.3	80	120	1.860	6.35	20	DSH

NOTES:
S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect (o-phosphate).

Work Order: 2006318
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-28767** SampType: **MBLK** Units: **µg/L** Prep Date: **6/23/2020** RunNo: **60035**
Client ID: **MBLKW** Batch ID: **28767** Analysis Date: **6/23/2020** SeqNo: **1201710**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	ND	100									
Calcium	ND	200									
Magnesium	ND	100									
Potassium	ND	500									
Sodium	ND	200									

Sample ID: **LCS-28767** SampType: **LCS** Units: **µg/L** Prep Date: **6/23/2020** RunNo: **60035**
Client ID: **LCSW** Batch ID: **28767** Analysis Date: **6/23/2020** SeqNo: **1201711**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	1,030	100	1,000	0	103	85	115				
Calcium	1,160	200	1,000	0	116	50	150				
Magnesium	1,020	100	1,000	0	102	50	150				
Potassium	1,040	500	1,000	0	104	50	150				
Sodium	1,090	200	1,000	0	109	50	150				

Sample ID: **2006280-001CDUP** SampType: **DUP** Units: **µg/L** Prep Date: **6/23/2020** RunNo: **60035**
Client ID: **BATCH** Batch ID: **28767** Analysis Date: **6/23/2020** SeqNo: **1201713**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	1,230	100						1,170	4.88	30	
Calcium	42,600	200						41,710	2.16	30	E
Magnesium	16,000	100						15,780	1.22	30	
Potassium	4,640	500						4,421	4.90	30	
Sodium	153,000	200						147,700	3.77	30	E

NOTES:

E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 2006318
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2006280-001CMS** SampType: **MS** Units: **µg/L** Prep Date: **6/23/2020** RunNo: **60035**
Client ID: **BATCH** Batch ID: **28767** Analysis Date: **6/23/2020** SeqNo: **1201714**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	7,130	100	5,000	1,170	119	70	130				
Calcium	48,800	200	5,000	41,710	141	50	150				E
Magnesium	20,900	100	5,000	15,780	103	70	130				
Potassium	11,100	500	5,000	4,421	134	50	150				
Sodium	151,000	200	5,000	147,700	66.0	50	150				E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2006280-001CMSD** SampType: **MSD** Units: **µg/L** Prep Date: **6/23/2020** RunNo: **60035**
Client ID: **BATCH** Batch ID: **28767** Analysis Date: **6/23/2020** SeqNo: **1201715**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	6,490	100	5,000	1,170	106	70	130	7,133	9.39	30	
Calcium	49,000	200	5,000	41,710	146	50	150	48,750	0.525	30	E
Magnesium	21,100	100	5,000	15,780	107	70	130	20,920	0.920	30	
Potassium	9,910	500	5,000	4,421	110	50	150	11,120	11.6	30	
Sodium	154,000	200	5,000	147,700	130	50	150	151,000	2.11	30	E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Fremont Analytical

Sample Log-In Check List

Client Name: **GEO1**
Work Order Number: **2006318**
Logged by: **Clare Griggs**
Date Received: **6/17/2020 5:06:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☑ No ☐ Not Present ☐
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >2°C to 6°C * Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☑ No ☐ NA ☐ H2SO4
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified:
Date:
By Whom:
Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:
Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Cooler	1.8
Sample	2.3

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Client: Geosyntec
Address: 520 Pike St., Suite 2600
City, State, Zip: Seattle, WA 98101
Telephone: 206-496-1475
Fax: N/A

Date: 6/17/2020 Page: 1 of: 1
Project Name: Laughing Jacobs
Project No: PNW0373
Collected by: J. Prock / S. Welsh
Location: Sammamish, WA
Report To (PM): Joel Prock
PM Email: jprock@geosyntec.com

Laboratory Project No (internal): 2006318

Special Remarks: Bottle provided w/ NaOH instead of H_2SO_4; use unpreserved bottle for Ammonia.

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	VOCs (EPA 8260 / 624)	GX/BTEX	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) / Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM-2320B)	Ammonia (SM-4500-NH3)			Comments
1	LJ-Queens_06172020	6/17/20	1141	W										1	T	1		1	1			Take Ammonia from unpreserved bottle.
2	LJ-Wet26_06172020	6/17/20	1221	W										1	T	1		1	1			" "
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag [✓ Al] As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl U V Zn

***Anions (Circle): Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide [✓ O-Phosphate] Fluoride [✓ Nitrate+Nitrite]

Turn-around Time:
☒ Standard
☐ 3 Day
☐ 2 Day
☐ Next Day
Same Day ______ *(specify)*

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above and that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished x Date/Time ~~2:56~~ SW 14:36 06/17/2020
Received x Date/Time 6/17/2020 1706

Relinquished x Date/Time
Received x Date/Time

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Geosyntec Seattle
Joel Prock
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs
Work Order Number: 2008242

August 26, 2020

Attention Joel Prock:

Fremont Analytical, Inc. received 3 sample(s) on 8/18/2020 for the analyses presented in the following report.

Ammonia by SM 4500 NH3G
Ion Chromatography by EPA Method 300.0
Total Metals by EPA Method 200.8
Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Original

Date: *08/26/2020*

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs
Work Order: 2008242

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2008242-001	LJ-Queens-08182020	08/18/2020 10:56 AM	08/18/2020 1:56 PM
2008242-002	LJ_Wet26_08182020	08/18/2020 11:35 AM	08/18/2020 1:56 PM
2008242-003	LJ_Dup_08182020	08/18/2020 11:35 AM	08/18/2020 1:56 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2008242**
Date: **8/26/2020**

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers & Acronyms

WO#: **2008242**
Date Reported: **8/26/2020**

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below LOQ
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
U - Not detected above the LOD

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DL - Detection Limit
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
LOD - Limit of Detection
LOQ - Limit of Quantitation
MB or MBLANK - Method Blank
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **2008242**
Date Reported: **8/26/2020**

Client: Geosyntec Seattle
Project: Laughing Jacobs
Lab ID: 2008242-001
Client Sample ID: **LJ-Queens-08182020**

Collection Date: 8/18/2020 10:56:00 AM
Matrix: Water

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 29412		Analyst: SS
Chloride	2.51	0.100		mg/L	1	8/19/2020 2:00:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	8/19/2020 2:00:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L	1	8/25/2020 9:20:00 PM
Ortho-Phosphate (as P)	ND	0.200	Q	mg/L	1	8/19/2020 2:00:00 PM
Sulfate	ND	0.300		mg/L	1	8/19/2020 2:00:00 PM

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Total Metals by EPA Method 200.8				Batch ID: 29405		Analyst: CO
Aluminum	579	100		µg/L	1	8/24/2020 2:27:06 PM
Calcium	7,370	200		µg/L	1	8/24/2020 2:27:06 PM
Magnesium	2,100	100		µg/L	1	8/19/2020 8:49:37 PM
Potassium	805	200		µg/L	1	8/24/2020 2:27:06 PM
Sodium	2,300	200		µg/L	1	8/24/2020 2:27:06 PM
Total Alkalinity by SM 2320B				Batch ID: R61360		Analyst: WF
Alkalinity, Total (As CaCO3)	14.6	2.50		mg/L	1	8/25/2020 10:13:35 AM
Ammonia by SM 4500 NH3G				Batch ID: 29406		Analyst: SS
Nitrogen, Ammonia	ND	0.100		mg/L	1	8/19/2020 10:33:00 AM

Client: Geosyntec Seattle
Collection Date: 8/18/2020 11:35:00 AM
Project: Laughing Jacobs
Lab ID: 2008242-002
Matrix: Water
Client Sample ID: **LJ_Wet26_08182020**

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
Ion Chromatography by EPA Method 300.0				Batch ID: 29412		Analyst: SS
Chloride	6.60	0.400	D	mg/L	4	8/19/2020 2:00:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	8/19/2020 2:00:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L	1	8/25/2020 9:43:00 PM
Ortho-Phosphate (as P)	ND	0.200	Q	mg/L	1	8/19/2020 2:00:00 PM
Sulfate	0.351	0.300		mg/L	1	8/19/2020 2:00:00 PM

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
Total Metals by EPA Method 200.8				Batch ID: 29405		Analyst: CO
Aluminum	173	100		µg/L	1	8/24/2020 2:32:40 PM
Calcium	8,390	200		µg/L	1	8/24/2020 2:32:40 PM
Magnesium	3,460	100		µg/L	1	8/19/2020 8:55:11 PM
Potassium	1,310	200		µg/L	1	8/24/2020 2:32:40 PM
Sodium	6,510	200		µg/L	1	8/24/2020 2:32:40 PM
Total Alkalinity by SM 2320B				Batch ID: R61351		Analyst: WF
Alkalinity, Total (As CaCO3)	35.8	2.50		mg/L	1	8/24/2020 10:26:37 AM
Ammonia by SM 4500 NH3G				Batch ID: 29406		Analyst: SS
Nitrogen, Ammonia	ND	0.100		mg/L	1	8/19/2020 10:38:00 AM

Analytical Report

Work Order: **2008242**
Date Reported: **8/26/2020**

Client: Geosyntec Seattle
Collection Date: 8/18/2020 11:35:00 AM
Project: Laughing Jacobs
Lab ID: 2008242-003
Matrix: Water
Client Sample ID: LJ_Dup_08182020

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**

Ion Chromatography by EPA Method 300.0

Batch ID: 29412 Analyst: SS

Chloride	6.58	0.400	D	mg/L	4	8/19/2020 2:00:00 PM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	8/19/2020 2:00:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L	1	8/25/2020 10:06:00 PM
Ortho-Phosphate (as P)	ND	0.200	Q	mg/L	1	8/19/2020 2:00:00 PM
Sulfate	0.356	0.300		mg/L	1	8/19/2020 2:00:00 PM

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria

Total Metals by EPA Method 200.8

Batch ID: 29405 Analyst: CO

Aluminum	156	100		µg/L	1	8/24/2020 2:38:14 PM
Calcium	8,910	200		µg/L	1	8/24/2020 2:38:14 PM
Magnesium	3,600	100		µg/L	1	8/19/2020 9:00:45 PM
Potassium	1,350	200		µg/L	1	8/24/2020 2:38:14 PM
Sodium	6,620	200		µg/L	1	8/24/2020 2:38:14 PM

Total Alkalinity by SM 2320B

Batch ID: R61351 Analyst: WF

Alkalinity, Total (As CaCO3)	35.8	2.50		mg/L	1	8/24/2020 10:26:37 AM

Ammonia by SM 4500 NH3G

Batch ID: 29406 Analyst: SS

Nitrogen, Ammonia	ND	0.100		mg/L	1	8/19/2020 11:12:00 AM

Work Order: 2008242
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R61351** SampType: **MBLK** Units: **mg/L** Prep Date: **8/24/2020** RunNo: **61351**
Client ID: **MBLKW** Batch ID: **R61351** Analysis Date: **8/24/2020** SeqNo: **1230844**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R61351** SampType: **LCS** Units: **mg/L** Prep Date: **8/24/2020** RunNo: **61351**
Client ID: **LCSW** Batch ID: **R61351** Analysis Date: **8/24/2020** SeqNo: **1230845**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	102	2.50	100.0	0	102	99.6	108				

Sample ID: **2008242-001CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/24/2020** RunNo: **61351**
Client ID: **LJ-Queens-08182020** Batch ID: **R61351** Analysis Date: **8/24/2020** SeqNo: **1230847**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	17.6	2.50						17.55	0	20	

Sample ID: **MB-R61360** SampType: **MBLK** Units: **mg/L** Prep Date: **8/25/2020** RunNo: **61360**
Client ID: **MBLKW** Batch ID: **R61360** Analysis Date: **8/25/2020** SeqNo: **1230959**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R61360** SampType: **LCS** Units: **mg/L** Prep Date: **8/25/2020** RunNo: **61360**
Client ID: **LCSW** Batch ID: **R61360** Analysis Date: **8/25/2020** SeqNo: **1230960**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	102	2.50	100.0	0	102	99.6	108				

Work Order: 2008242
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **2008242-001CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/25/2020** RunNo: **61360**
Client ID: **LJ-Queens-08182020** Batch ID: **R61360** Analysis Date: **8/25/2020** SeqNo: **1230962**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	15.1	2.50						14.62	3.28	20	

Work Order: 2008242
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ammonia by SM 4500 NH3G

Sample ID: **MB-29406** SampType: **MBLK** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61252**
Client ID: **MBLKW** Batch ID: **29406** Analysis Date: **8/19/2020** SeqNo: **1228740**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100									

Sample ID: **LCS-29406** SampType: **LCS** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61252**
Client ID: **LCSW** Batch ID: **29406** Analysis Date: **8/19/2020** SeqNo: **1228741**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.463	0.100	0.5000	0	92.6	74.1	109				

Sample ID: **2008163-001EDUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61252**
Client ID: **BATCH** Batch ID: **29406** Analysis Date: **8/19/2020** SeqNo: **1228743**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	6.06	0.100						1.326	128	30	RE

NOTES:
R - High RPD observed. The method is in control as indicated by the LCS.
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2008163-001EMS** SampType: **MS** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61252**
Client ID: **BATCH** Batch ID: **29406** Analysis Date: **8/19/2020** SeqNo: **1228744**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	9.12	0.100	0.5000	1.326	1,560	38.8	131				SE

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 2008242
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ammonia by SM 4500 NH3G

Sample ID: **2008163-001EMSD** SampType: **MSD** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61252**
Client ID: **BATCH** Batch ID: **29406** Analysis Date: **8/19/2020** SeqNo: **1228745**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	8.54	0.100	0.5000	1.326	1,440	38.8	131	9.123	6.61	30	SE

NOTES:

S - Analyte concentration was too high for accurate spike recovery(ies).

E - Estimated value. The amount exceeds the linear working range of the instrument.

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-29412** SampType: **MBLK** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61311**
Client ID: **MBLKW** Batch ID: **29412** Analysis Date: **8/19/2020** SeqNo: **1229905**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Nitrate (as N)+Nitrite (as N)	ND	0.100									
Ortho-Phosphate (as P)	ND	0.200									
Sulfate	ND	0.300									

Sample ID: **LCS-29412** SampType: **LCS** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61311**
Client ID: **LCSW** Batch ID: **29412** Analysis Date: **8/19/2020** SeqNo: **1229906**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.725	0.100	0.7500	0	96.7	90	110				
Nitrate (as N)+Nitrite (as N)	1.45	0.100	1.500	0	96.5	90	110				
Ortho-Phosphate (as P)	1.25	0.200	1.250	0	100	90	110				
Sulfate	3.61	0.300	3.750	0	96.3	90	110				

Sample ID: **2008249-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61311**
Client ID: **BATCH** Batch ID: **29412** Analysis Date: **8/19/2020** SeqNo: **1229908**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	8.38	0.100						8.374	0.131	20	E
Nitrate (as N)+Nitrite (as N)	0.202	0.100						0.2020	0	20	
Ortho-Phosphate (as P)	ND	0.200						0		20	
Sulfate	3.88	0.300						3.876	0.0774	20	

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2008249-001AMS** SampType: **MS** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61311**
Client ID: **BATCH** Batch ID: **29412** Analysis Date: **8/19/2020** SeqNo: **1229909**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	9.20	0.100	0.7500	8.374	110	80	120				E

Work Order: 2008242
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2008249-001AMS** SampType: **MS** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61311**
Client ID: **BATCH** Batch ID: **29412** Analysis Date: **8/19/2020** SeqNo: **1229909**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrate (as N)+Nitrite (as N)	1.61	0.100	1.500	0.2020	93.7	80	120				
Ortho-Phosphate (as P)	1.04	0.200	1.250	0	83.0	80	120				
Sulfate	7.71	0.300	3.750	3.876	102	80	120				

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2008249-001AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **8/19/2020** RunNo: **61311**
Client ID: **BATCH** Batch ID: **29412** Analysis Date: **8/19/2020** SeqNo: **1229910**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	9.22	0.100	0.7500	8.374	113	80	120	9.200	0.239	20	E
Nitrate (as N)+Nitrite (as N)	1.64	0.100	1.500	0.2020	95.9	80	120	1.608	1.97	20	
Ortho-Phosphate (as P)	1.19	0.200	1.250	0	95.4	80	120	1.037	14.0	20	
Sulfate	7.79	0.300	3.750	3.876	104	80	120	7.712	1.01	20	

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **LCS-29470** SampType: **LCS** Units: **mg/L** Prep Date: **8/25/2020** RunNo: **61378**
Client ID: **LCSW** Batch ID: **29470** Analysis Date: **8/25/2020** SeqNo: **1231256**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	1.23	0.200	1.250	0	98.6	90	110				

Sample ID: **MB-29470** SampType: **MBLK** Units: **mg/L** Prep Date: **8/25/2020** RunNo: **61378**
Client ID: **MBLKW** Batch ID: **29470** Analysis Date: **8/25/2020** SeqNo: **1231259**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	ND	0.200									

Work Order: 2008242
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2008322-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/25/2020** RunNo: **61378**
Client ID: **BATCH** Batch ID: **29470** Analysis Date: **8/25/2020** SeqNo: **1231269**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	ND	0.200						0		20	H

Sample ID: **2008322-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **8/25/2020** RunNo: **61378**
Client ID: **BATCH** Batch ID: **29470** Analysis Date: **8/25/2020** SeqNo: **1231270**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	0.807	0.200	1.250	0	64.6	80	120				SH

NOTES:
S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect.

Sample ID: **2008322-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **8/25/2020** RunNo: **61378**
Client ID: **BATCH** Batch ID: **29470** Analysis Date: **8/25/2020** SeqNo: **1231271**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Ortho-Phosphate (as P)	0.905	0.200	1.250	0	72.4	80	120	0.8070	11.4	20	SH

NOTES:
S - Outlying spike recovery(ies) observed. A duplicate analysis was performed with similar results indicating a possible matrix effect.

Work Order: 2008242
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-29405** SampType: **MBLK** Units: **µg/L** Prep Date: **8/19/2020** RunNo: **61259**
Client ID: **MBLKW** Batch ID: **29405** Analysis Date: **8/19/2020** SeqNo: **1228940**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	ND	100									
Calcium	ND	100									
Magnesium	ND	100									
Potassium	ND	500									
Sodium	ND	100									

Sample ID: **LCS-29405** SampType: **LCS** Units: **µg/L** Prep Date: **8/19/2020** RunNo: **61259**
Client ID: **LCSW** Batch ID: **29405** Analysis Date: **8/19/2020** SeqNo: **1228941**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	993	100	1,000	0	99.3	85	115				
Calcium	991	100	1,000	0	99.1	50	150				
Magnesium	1,030	100	1,000	0	103	50	150				
Potassium	939	500	1,000	0	93.9	50	150				
Sodium	997	100	1,000	0	99.7	50	150				

Sample ID: **2008234-005ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **8/19/2020** RunNo: **61259**
Client ID: **BATCH** Batch ID: **29405** Analysis Date: **8/19/2020** SeqNo: **1228943**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	ND	100						0		30	
Calcium	56,700	100						52,730	7.28	30	E
Magnesium	48,500	100						45,970	5.35	30	E
Potassium	456,000	500						421,300	7.88	30	E
Sodium	606,000	100						553,200	9.05	30	E

NOTES:

E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 2008242
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2008234-005AMS** SampType: **MS** Units: **µg/L** Prep Date: **8/19/2020** RunNo: **61259**
Client ID: **BATCH** Batch ID: **29405** Analysis Date: **8/19/2020** SeqNo: **1228944**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	5,930	100	5,000	38.09	118	70	130				
Calcium	63,500	100	5,000	52,730	216	50	150				ES
Magnesium	55,500	100	5,000	45,970	190	70	130				ES
Potassium	473,000	500	5,000	421,300	1,030	50	150				ES
Sodium	596,000	100	5,000	553,200	849	50	150				ES

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2008234-005AMSD** SampType: **MSD** Units: **µg/L** Prep Date: **8/19/2020** RunNo: **61259**
Client ID: **BATCH** Batch ID: **29405** Analysis Date: **8/19/2020** SeqNo: **1228945**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	6,270	100	5,000	38.09	125	70	130	5,933	5.54	30	
Calcium	62,300	100	5,000	52,730	191	50	150	63,540	2.03	30	ES
Magnesium	53,300	100	5,000	45,970	147	70	130	55,460	3.95	30	ES
Potassium	465,000	500	5,000	421,300	873	50	150	472,700	1.66	30	ES
Sodium	602,000	100	5,000	553,200	984	50	150	595,700	1.13	30	ES

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Fremont Analytical

Sample Log-In Check List

Client Name: **GEO1** Work Order Number: **2008242**

Logged by: **Claire Anderson** Date Received: **8/18/2020 1:56:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☑ No ☐ Not Present ☐
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >2°C to 6°C * Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified: ____ Date: ____

By Whom: ____ Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person

Regarding: ____

Client Instructions: ____

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample 1	4.8
Temp Blank 1	0.1

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 8/18/2020 Page: 1 of: 1

Laboratory Project No (internal): 2008242

Project Name: Laughing Jacobs

Project No: ~~AN3~~ SF PNW0373

Collected by: J. Prock / S. Welsh

Location: Sammamish, WA

Report To (PM): Joel Prock

PM Email: jprock@geosyntec.com

Special Remarks:

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

Client: Geosyntec

Address: 520 Pike St., Suite 2600

City, State, Zip: Seattle, WA 98101

Telephone: 206-496-1475

Fax: N/A

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	VOCs (EPA 8260 / 624)	GX/BTEX	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM-2320B)	Ammonia (SM-4500-NH3)			Comments
1	LJ-Queens-08182020	8/18/20	1056	W										1	T	1		1	1			
2	LJ-Wet26_08182020	8/18/20	1135	W										1	T	1		1	1			
3	LJ-Dup-08182020	8/18/20	1135	W										1	T	1		1	1			
4																						
5																						
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag [✓ Al] As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl U V Zn

***Anions (Circle): Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide [✓ O-Phosphate] Fluoride [✓ Nitrate+Nitrite]

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above and that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished x Joel Prock Date/Time 8/18/2020 1337

Received x Date/Time 8/18/20 @ 1356

Relinquished x Date/Time

Received x Date/Time

Turn-around Time:

☒ Standard
☐ 3 Day
☐ 2 Day
☐ Next Day
Same Day ______ *(specify)*

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Geosyntec Seattle
Joel Prock
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs
Work Order Number: 2010453

November 03, 2020

Attention Joel Prock:

Fremont Analytical, Inc. received 2 sample(s) on 10/27/2020 for the analyses presented in the following report.

Ammonia by SM 4500 NH3G
Ion Chromatography by EPA Method 300.0
Total Metals by EPA Method 200.8
Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Original

Date: *11/03/2020*

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs
Work Order: 2010453

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2010453-001	LJ_Queens_10272020	10/27/2020 2:25 PM	10/27/2020 5:17 PM
2010453-002	LJ_Wet26_10272020	10/27/2020 3:00 PM	10/27/2020 5:17 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2010453**
Date: **11/3/2020**

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers & Acronyms

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Client: Geosyntec Seattle
Project: Laughing Jacobs
Lab ID: 2010453-001
Client Sample ID: **LJ_Queens_10272020**

Collection Date: 10/27/2020 2:25:00 PM

Matrix: Water

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 30222		Analyst: SS
Chloride	2.90	0.200	D	mg/L	2	10/30/2020 10:01:00 AM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	10/29/2020 6:01:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L	1	10/29/2020 6:01:00 PM
Sulfate	1.18	0.300		mg/L	1	10/29/2020 6:01:00 PM
Total Metals by EPA Method 200.8				Batch ID: 30210		Analyst: CO
Aluminum	380	100		µg/L	1	11/3/2020 11:08:23 AM
Calcium	4,900	200		µg/L	1	11/3/2020 11:08:23 AM
Magnesium	1,520	100		µg/L	1	11/3/2020 11:08:23 AM
Potassium	1,130	200		µg/L	1	11/3/2020 11:08:23 AM
Sodium	2,540	200		µg/L	1	11/3/2020 11:08:23 AM
Total Alkalinity by SM 2320B				Batch ID: R63087		Analyst: TN
Alkalinity, Total (As CaCO3)	12.7	2.50		mg/L	1	11/3/2020 12:28:13 PM
Ammonia by SM 4500 NH3G				Batch ID: 30256		Analyst: SS
Nitrogen, Ammonia	0.235	0.100		mg/L	1	11/2/2020 1:28:00 PM

Analytical Report

Work Order: **2010453**
Date Reported: **11/3/2020**

Client: Geosyntec Seattle
Collection Date: 10/27/2020 3:00:00 PM
Project: Laughing Jacobs
Lab ID: 2010453-002
Matrix: Water
Client Sample ID: LJ_Wet26_10272020

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 30222		Analyst: SS
Chloride	5.70	0.500	D	mg/L	5	10/30/2020 10:24:00 AM
Nitrate (as N)+Nitrite (as N)	ND	0.100		mg/L	1	10/29/2020 6:24:00 PM
Ortho-Phosphate (as P)	ND	0.200	H	mg/L	1	10/29/2020 6:24:00 PM
Sulfate	9.07	0.300		mg/L	1	10/29/2020 6:24:00 PM
Total Metals by EPA Method 200.8				Batch ID: 30210		Analyst: CO
Aluminum	213	100		µg/L	1	11/3/2020 11:14:22 AM
Calcium	7,640	200		µg/L	1	11/3/2020 11:14:22 AM
Magnesium	2,790	100		µg/L	1	11/3/2020 11:14:22 AM
Potassium	1,170	200		µg/L	1	11/3/2020 11:14:22 AM
Sodium	5,520	200		µg/L	1	11/3/2020 11:14:22 AM
Total Alkalinity by SM 2320B				Batch ID: R63087		Analyst: TN
Alkalinity, Total (As CaCO3)	24.5	2.50		mg/L	1	11/3/2020 12:28:13 PM
Ammonia by SM 4500 NH3G				Batch ID: 30256		Analyst: SS
Nitrogen, Ammonia	ND	0.100		mg/L	1	11/2/2020 1:33:00 PM

Work Order: 2010453
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R63087** SampType: **MBLK** Units: **mg/L** Prep Date: **11/3/2020** RunNo: **63087**
Client ID: **MBLKW** Batch ID: **R63087** Analysis Date: **11/3/2020** SeqNo: **1266228**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R63087** SampType: **LCS** Units: **mg/L** Prep Date: **11/3/2020** RunNo: **63087**
Client ID: **LCSW** Batch ID: **R63087** Analysis Date: **11/3/2020** SeqNo: **1266229**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	103	2.50	100.0	0	103	99.6	108				

Sample ID: **2010453-002CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/3/2020** RunNo: **63087**
Client ID: **LJ_Wet26_10272020** Batch ID: **R63087** Analysis Date: **11/3/2020** SeqNo: **1266232**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	23.5	2.50						24.50	4.08	20	

Work Order: 2010453
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ammonia by SM 4500 NH3G

Sample ID: **LCS-30256** SampType: **LCS** Units: **mg/L** Prep Date: **11/2/2020** RunNo: **63068**
Client ID: **LCSW** Batch ID: **30256** Analysis Date: **11/2/2020** SeqNo: **1265808**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.474	0.100	0.5000	0	94.8	74.1	109				

Sample ID: **MB-30256** SampType: **MBLK** Units: **mg/L** Prep Date: **11/2/2020** RunNo: **63068**
Client ID: **MBLKW** Batch ID: **30256** Analysis Date: **11/2/2020** SeqNo: **1265814**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100									

Sample ID: **2010453-002BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **11/2/2020** RunNo: **63068**
Client ID: **LJ_Wet26_10272020** Batch ID: **30256** Analysis Date: **11/2/2020** SeqNo: **1265824**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	ND	0.100						0		30	

Sample ID: **2010453-002BMS** SampType: **MS** Units: **mg/L** Prep Date: **11/2/2020** RunNo: **63068**
Client ID: **LJ_Wet26_10272020** Batch ID: **30256** Analysis Date: **11/2/2020** SeqNo: **1265828**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.509	0.100	0.5000	0	102	38.8	131				

Sample ID: **2010453-002BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **11/2/2020** RunNo: **63068**
Client ID: **LJ_Wet26_10272020** Batch ID: **30256** Analysis Date: **11/2/2020** SeqNo: **1265831**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrogen, Ammonia	0.501	0.100	0.5000	0	100	38.8	131	0.5090	1.58	30	

Work Order: 2010453
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-30222** SampType: **MBLK** Units: **mg/L** Prep Date: **10/29/2020** RunNo: **63062**
Client ID: **MBLKW** Batch ID: **30222** Analysis Date: **10/29/2020** SeqNo: **1265739**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Nitrate (as N)+Nitrite (as N)	ND	0.100									
Ortho-Phosphate (as P)	ND	0.200									
Sulfate	ND	0.300									

Sample ID: **LCS-30222** SampType: **LCS** Units: **mg/L** Prep Date: **10/29/2020** RunNo: **63062**
Client ID: **LCSW** Batch ID: **30222** Analysis Date: **10/29/2020** SeqNo: **1265740**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.732	0.100	0.7500	0	97.6	90	110				
Nitrate (as N)+Nitrite (as N)	1.46	0.100	1.500	0	97.6	90	110				
Ortho-Phosphate (as P)	1.18	0.200	1.250	0	94.2	90	110				
Sulfate	3.69	0.300	3.750	0	98.4	90	110				

Sample ID: **2010453-002CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **10/29/2020** RunNo: **63062**
Client ID: **LJ_Wet26_10272020** Batch ID: **30222** Analysis Date: **10/29/2020** SeqNo: **1265743**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	6.35	0.100						6.346	0.0630	20	E
Nitrate (as N)+Nitrite (as N)	ND	0.100						0		20	
Ortho-Phosphate (as P)	ND	0.200						0		20	H
Sulfate	9.06	0.300						9.066	0.0110	20	

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2010453-002CMS** SampType: **MS** Units: **mg/L** Prep Date: **10/29/2020** RunNo: **63062**
Client ID: **LJ_Wet26_10272020** Batch ID: **30222** Analysis Date: **10/29/2020** SeqNo: **1265744**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	7.13	0.100	0.7500	6.346	104	80	120				E

Work Order: 2010453
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2010453-002CMS** SampType: **MS** Units: **mg/L** Prep Date: **10/29/2020** RunNo: **63062**
Client ID: **LJ_Wet26_10272020** Batch ID: **30222** Analysis Date: **10/29/2020** SeqNo: **1265744**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Nitrate (as N)+Nitrite (as N)	1.39	0.100	1.500	0.07000	88.0	80	120				
Ortho-Phosphate (as P)	1.09	0.200	1.250	0	87.3	80	120				H
Sulfate	12.9	0.300	3.750	9.066	101	80	120				

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2010453-002CMSD** SampType: **MSD** Units: **mg/L** Prep Date: **10/29/2020** RunNo: **63062**
Client ID: **LJ_Wet26_10272020** Batch ID: **30222** Analysis Date: **10/29/2020** SeqNo: **1265745**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	7.18	0.100	0.7500	6.346	112	80	120	7.128	0.783	20	E
Nitrate (as N)+Nitrite (as N)	1.44	0.100	1.500	0.07000	91.4	80	120	1.390	3.60	20	
Ortho-Phosphate (as P)	1.15	0.200	1.250	0	92.2	80	120	1.091	5.53	20	H
Sulfate	13.1	0.300	3.750	9.066	107	80	120	12.87	1.49	20	

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 2010453
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2010455-001CDUP** SampType: **DUP** Units: **µg/L** Prep Date: **10/29/2020** RunNo: **62975**
Client ID: **BATCH** Batch ID: **30210** Analysis Date: **10/29/2020** SeqNo: **1264042**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	334	100						317.7	5.00	30	
Calcium	32,500	200						29,950	8.15	30	E
Magnesium	9,400	100						9,070	3.61	30	
Potassium	7,880	200						7,519	4.66	30	
Sodium	54,100	200						51,290	5.27	30	E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2010455-001CMS** SampType: **MS** Units: **µg/L** Prep Date: **10/29/2020** RunNo: **62975**
Client ID: **BATCH** Batch ID: **30210** Analysis Date: **10/29/2020** SeqNo: **1264043**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	4,940	100	5,000	317.7	92.5	70	130				
Calcium	37,000	200	5,000	29,950	141	50	150				E
Magnesium	13,700	100	5,000	9,070	93.5	70	130				
Potassium	12,400	200	5,000	7,519	97.3	50	150				
Sodium	56,600	200	5,000	51,290	106	50	150				E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2010455-001CMSD** SampType: **MSD** Units: **µg/L** Prep Date: **10/29/2020** RunNo: **62975**
Client ID: **BATCH** Batch ID: **30210** Analysis Date: **10/29/2020** SeqNo: **1264044**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	5,050	100	5,000	317.7	94.6	70	130	4,943	2.07	30	
Calcium	35,900	200	5,000	29,950	120	50	150	37,010	2.98	30	E
Magnesium	13,400	100	5,000	9,070	86.2	70	130	13,740	2.70	30	
Potassium	12,100	200	5,000	7,519	91.8	50	150	12,380	2.25	30	
Sodium	54,900	200	5,000	51,290	72.4	50	150	56,610	3.06	30	E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 2010453
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-30210** SampType: **MBLK** Units: **µg/L** Prep Date: **10/29/2020** RunNo: **62975**
Client ID: **MBLKW** Batch ID: **30210** Analysis Date: **10/29/2020** SeqNo: **1265851**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	ND	100									
Calcium	ND	200									
Magnesium	ND	100									
Potassium	ND	200									
Sodium	ND	200									

Sample ID: **LCS-30210** SampType: **LCS** Units: **µg/L** Prep Date: **10/29/2020** RunNo: **62975**
Client ID: **LCSW** Batch ID: **30210** Analysis Date: **10/29/2020** SeqNo: **1265854**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Aluminum	1,050	100	1,000	0	105	85	115				
Calcium	1,020	200	1,000	0	102	50	150				
Magnesium	994	100	1,000	0	99.4	50	150				
Potassium	1,030	200	1,000	0	103	50	150				
Sodium	1,060	200	1,000	0	106	50	150				

Fremont Analytical

Sample Log-In Check List

Client Name: **GEO1** Work Order Number: **2010453**

Logged by: **Clare Griggs** Date Received: **10/27/2020 5:17:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐

4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☑ No ☐ Not Present ☐

6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐

7. Were all items received at a temperature of >2°C to 6°C * Yes ☑ No ☐ NA ☐

8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐

12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐

15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☐ No ☑

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified: Date:

By Whom: Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person

Regarding:

Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample	1.8

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 10/27/2020 **Page:** 1 **of:** 1

Laboratory Project No (internal): 2010453

Project Name: Laughing Jacobs

Project No: PNW0373

Collected by: J. Prock / S. Welsh

Location: Sammamish, WA

Report To (PM): Joel Prock

PM Email: jprock@geosyntec.com

Special Remarks:

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

Client: Geosyntec/Sammamish

Address: 520 Pike St., Suite 2600

City, State, Zip: Seattle, WA 98101

Telephone: 206-496-1475

Fax: N/A

Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	VOCs (EPA 8260 / 624)	GX/BTEX	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM-2320B)	Ammonia (SM-4500 NH3)			Comments
1 LJ-Queens-10272020	10/27/20	1425	W										1	T	1		1	1			
2 LJ-Wet26-10272020	10/27/20	1500	W										1	T	1		1	1			
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					

***Matrix:** A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

****Metals (Circle):** MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag [✓ Al] As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl U V Zn

*****Anions (Circle):** Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide [✓ O-Phosphate] Fluoride [✓ Nitrate+Nitrite]

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above and that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished x Date/Time 10/27/2020 17:05

Received x Date/Time 10/27/20 1717

Relinquished x Date/Time

Received x Date/Time

Turn-around Time:
- ☒ Standard
- ☐ 3 Day
- ☐ 2 Day
- ☐ Next Day
- Same Day ______ *(specify)*

www.fremontanalytical.com

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Seattle, WA 98103
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F: (206) 352-7178
info@fremontanalytical.com

Geosyntec Seattle
Joel Prock
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs
Work Order Number: 2101098

January 14, 2021

Attention Joel Prock:

Fremont Analytical, Inc. received 2 sample(s) on 1/7/2021 for the analyses presented in the following report.

Ion Chromatography by EPA Method 300.0
Total Metals by EPA Method 200.8
Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Original

Date: *01/14/2021*

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs
Work Order: 2101098

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2101098-001	LJ_Queens_010721	01/07/2021 12:35 PM	01/07/2021 3:27 PM
2101098-002	LJ_Wet26_010721	01/07/2021 1:22 PM	01/07/2021 3:27 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers & Acronyms

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria (<20%RSD, <20% Drift or minimum RRF)
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **2101098**
Date Reported: **1/14/2021**

Client: Geosyntec Seattle

Collection Date: 1/7/2021 12:35:00 PM

Project: Laughing Jacobs

Lab ID: 2101098-001

Matrix: Water

Client Sample ID: LJ_Queens_010721

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 30986		Analyst: SS
Chloride	1.83	0.100		mg/L	1	1/8/2021 8:07:00 PM
Sulfate	1.71	0.300		mg/L	1	1/8/2021 8:07:00 PM
Total Metals by EPA Method 200.8				Batch ID: 31010		Analyst: CO
Calcium	4,330	200		µg/L	1	1/12/2021 8:56:46 PM
Magnesium	1,350	100		µg/L	1	1/12/2021 8:56:46 PM
Potassium	1,170	200		µg/L	1	1/12/2021 8:56:46 PM
Sodium	1,890	200		µg/L	1	1/12/2021 8:56:46 PM
Total Alkalinity by SM 2320B				Batch ID: R64599		Analyst: WF
Alkalinity, Total (As CaCO3)	12.2	2.50		mg/L	1	1/11/2021 4:32:33 AM

Analytical Report

Work Order: **2101098**
Date Reported: **1/14/2021**

Client: Geosyntec Seattle
Project: Laughing Jacobs
Lab ID: 2101098-002
Client Sample ID: **LJ_Wet26_010721**

Collection Date: 1/7/2021 1:22:00 PM

Matrix: Water

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 30986		Analyst: SS
Chloride	2.31	0.100		mg/L	1	1/8/2021 8:30:00 PM
Sulfate	2.83	0.300		mg/L	1	1/8/2021 8:30:00 PM
Total Metals by EPA Method 200.8				Batch ID: 31010		Analyst: CO
Calcium	5,490	200		µg/L	1	1/12/2021 9:01:20 PM
Magnesium	1,870	100		µg/L	1	1/12/2021 9:01:20 PM
Potassium	1,500	200		µg/L	1	1/12/2021 9:01:20 PM
Sodium	2,880	200		µg/L	1	1/12/2021 9:01:20 PM
Total Alkalinity by SM 2320B				Batch ID: R64599		Analyst: WF
Alkalinity, Total (As CaCO3)	12.7	2.50		mg/L	1	1/11/2021 4:32:33 AM

Work Order: 2101098
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R64599** SampType: **MBLK** Units: **mg/L** Prep Date: **1/11/2021** RunNo: **64599**
Client ID: **MBLKW** Batch ID: **R64599** Analysis Date: **1/11/2021** SeqNo: **1299257**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R64599** SampType: **LCS** Units: **mg/L** Prep Date: **1/11/2021** RunNo: **64599**
Client ID: **LCSW** Batch ID: **R64599** Analysis Date: **1/11/2021** SeqNo: **1299258**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	102	2.50	100.0	0	102	99.6	108				

Sample ID: **2101054-001CDUP** SampType: **DUP** Units: **mg/L** Prep Date: **1/11/2021** RunNo: **64599**
Client ID: **BATCH** Batch ID: **R64599** Analysis Date: **1/11/2021** SeqNo: **1299260**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	559	2.50						563.5	0.873	20	

Work Order: 2101098
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-30986** SampType: **MBLK** Units: **mg/L** Prep Date: **1/8/2021** RunNo: **64607**
Client ID: **MBLKW** Batch ID: **30986** Analysis Date: **1/8/2021** SeqNo: **1299544**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Sulfate	ND	0.300									

Sample ID: **LCS-30986** SampType: **LCS** Units: **mg/L** Prep Date: **1/8/2021** RunNo: **64607**
Client ID: **LCSW** Batch ID: **30986** Analysis Date: **1/8/2021** SeqNo: **1299545**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.699	0.100	0.7500	0	93.2	90	110				
Sulfate	3.54	0.300	3.750	0	94.5	90	110				

Sample ID: **2101105-001ADUP** SampType: **DUP** Units: **mg/L** Prep Date: **1/8/2021** RunNo: **64607**
Client ID: **BATCH** Batch ID: **30986** Analysis Date: **1/8/2021** SeqNo: **1299557**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	93.7	10.0						92.60	1.18	20	D
Sulfate	36.8	30.0						37.00	0.542	20	D

Sample ID: **2101105-001AMS** SampType: **MS** Units: **mg/L** Prep Date: **1/8/2021** RunNo: **64607**
Client ID: **BATCH** Batch ID: **30986** Analysis Date: **1/8/2021** SeqNo: **1299558**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	169	10.0	75.00	92.60	102	80	120				D
Sulfate	373	30.0	375.0	37.00	89.6	80	120				D

Work Order: 2101098
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2101105-001AMSD** SampType: **MSD** Units: **mg/L** Prep Date: **1/8/2021** RunNo: **64607**
Client ID: **BATCH** Batch ID: **30986** Analysis Date: **1/8/2021** SeqNo: **1299559**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	169	10.0	75.00	92.60	102	80	120	168.8	0.296	20	D
Sulfate	377	30.0	375.0	37.00	90.6	80	120	372.9	1.04	20	D

Work Order: 2101098
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-31010** SampType: **MBLK** Units: **µg/L** Prep Date: **1/12/2021** RunNo: **64637**
Client ID: **MBLKW** Batch ID: **31010** Analysis Date: **1/12/2021** SeqNo: **1300171**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	200									
Magnesium	ND	100									
Potassium	ND	200									
Sodium	ND	200									

Sample ID: **LCS-31010** SampType: **LCS** Units: **µg/L** Prep Date: **1/12/2021** RunNo: **64637**
Client ID: **LCSW** Batch ID: **31010** Analysis Date: **1/12/2021** SeqNo: **1300172**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	1,090	200	1,000	0	109	50	150				
Magnesium	991	100	1,000	0	99.1	50	150				
Potassium	1,070	200	1,000	0	107	50	150				
Sodium	1,020	200	1,000	0	102	50	150				

Sample ID: **2101032-001EDUP** SampType: **DUP** Units: **µg/L** Prep Date: **1/12/2021** RunNo: **64637**
Client ID: **BATCH** Batch ID: **31010** Analysis Date: **1/12/2021** SeqNo: **1300177**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	15,500	200						15,690	1.46	30	
Magnesium	5,020	100						5,077	1.21	30	
Potassium	6,750	200						6,965	3.10	30	
Sodium	7,060	200						7,280	3.10	30	

Sample ID: **2101032-001EMS** SampType: **MS** Units: **µg/L** Prep Date: **1/12/2021** RunNo: **64637**
Client ID: **BATCH** Batch ID: **31010** Analysis Date: **1/12/2021** SeqNo: **1300178**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	20,000	200	5,000	15,690	86.3	50	150				
Magnesium	9,630	100	5,000	5,077	91.0	70	130				

Work Order: 2101098
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2101032-001EMS** SampType: **MS** Units: **µg/L** Prep Date: **1/12/2021** RunNo: **64637**
Client ID: **BATCH** Batch ID: **31010** Analysis Date: **1/12/2021** SeqNo: **1300178**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	11,500	200	5,000	6,965	91.1	50	150				
Sodium	11,700	200	5,000	7,280	89.2	50	150				

Sample ID: **2101032-001EMSD** SampType: **MSD** Units: **µg/L** Prep Date: **1/12/2021** RunNo: **64637**
Client ID: **BATCH** Batch ID: **31010** Analysis Date: **1/12/2021** SeqNo: **1300179**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	19,800	200	5,000	15,690	81.4	50	150	20,000	1.23	30	
Magnesium	9,720	100	5,000	5,077	92.8	70	130	9,626	0.933	30	
Potassium	11,600	200	5,000	6,965	93.0	50	150	11,520	0.826	30	
Sodium	12,300	200	5,000	7,280	101	50	150	11,740	4.83	30	

Sample Log-In Check List

Client Name: **GEO1**
Work Order Number: **2101098**
Logged by: **Clare Griggs**
Date Received: **1/7/2021 3:27:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☑ No ☐ Not Present ☐
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >2°C to 6°C * Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified:
Date:
By Whom:
Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:
Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample	5.6

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 1/7/2021, Page: 1 of: 1

Laboratory Project No (internal): 2101098

Special Remarks:

Project Name: Laughing Jacobs

Project No: PNW0373

Collected by: J. Prock / S. Welsh

Location: Sammamish, WA

Report To (PM): Joel Prock

PM Email: jprock@geosyntec.com

Client: Geosyntec

Address: 520 Pike St., Suite 2600

City, State, Zip: Seattle, WA 98101

Telephone: (206)-496-1475

Fax: N/A

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM-2320B)				Comments
1	LS_Queens_010721	1/7/21	1235	W	2									1	T	1		1				
2	LS_Wet26-010721	1/7/21	1322	W	2									1	T	1		1				
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time:

☒ Standard ☐ Next Day

☐ 3 Day ☐ Same Day

☐ 2 Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x	Joel Prock	1/7/2021 1514	x Claire Anderson	Claire Anderson	1/7/21 1527
x			x		

COC 1.3 - 11.06.20

www.fremontanalytical.com

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F: (206) 352-7178
info@fremontanalytical.com

Geosyntec Seattle
Joel Prock
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs
Work Order Number: 2103540

April 08, 2021

Attention Joel Prock:

Fremont Analytical, Inc. received 2 sample(s) on 3/31/2021 for the analyses presented in the following report.

Ion Chromatography by EPA Method 300.0

Total Metals by EPA Method 200.8

Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs
Work Order: 2103540

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2103540-001	LJ_Queens_033121	03/31/2021 10:38 AM	03/31/2021 3:52 PM
2103540-002	LJ_Wet26_033121	03/31/2021 1:48 PM	03/31/2021 3:52 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2103540**
Date: **4/8/2021**

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers & Acronyms

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Client: Geosyntec Seattle
Project: Laughing Jacobs
Lab ID: 2103540-001
Client Sample ID: **LJ_Queens_033121**

Collection Date: 3/31/2021 10:38:00 AM
Matrix: Water

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 31913		Analyst: SS
Chloride	3.46	0.200	D	mg/L	2	4/8/2021 10:56:00 AM
Sulfate	ND	0.600		mg/L	1	4/8/2021 1:47:00 AM
Total Metals by EPA Method 200.8				Batch ID: 31852		Analyst: EH
Calcium	930	200		µg/L	1	4/2/2021 9:43:33 PM
Magnesium	655	100		µg/L	1	4/2/2021 9:43:33 PM
Potassium	749	200		µg/L	1	4/5/2021 12:57:05 PM
Sodium	1,830	200		µg/L	1	4/2/2021 9:43:33 PM
Total Alkalinity by SM 2320B				Batch ID: R66400		Analyst: LB
Alkalinity, Total (As CaCO3)	ND	2.50		mg/L	1	4/7/2021 5:05:04 PM

Analytical Report

Work Order: **2103540**
Date Reported: **4/8/2021**

Client: Geosyntec Seattle
Project: Laughing Jacobs
Lab ID: 2103540-002
Client Sample ID: **LJ_Wet26_033121**

Collection Date: 3/31/2021 1:48:00 PM
Matrix: Water

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 31913		Analyst: SS
Chloride	4.76	0.200	D	mg/L	2	4/8/2021 11:19:00 AM
Sulfate	1.76	0.600		mg/L	1	4/8/2021 2:10:00 AM
Total Metals by EPA Method 200.8				Batch ID: 31852		Analyst: EH
Calcium	5,700	200		µg/L	1	4/2/2021 9:48:06 PM
Magnesium	2,140	100		µg/L	1	4/2/2021 9:48:06 PM
Potassium	211	200		µg/L	1	4/5/2021 1:02:39 PM
Sodium	4,520	200		µg/L	1	4/2/2021 9:48:06 PM
Total Alkalinity by SM 2320B				Batch ID: R66400		Analyst: LB
Alkalinity, Total (As CaCO3)	22.0	2.50		mg/L	1	4/7/2021 5:05:04 PM

Work Order: 2103540
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R66400** SampType: **MBLK** Units: **mg/L** Prep Date: **4/7/2021** RunNo: **66400**
Client ID: **MBLKW** Batch ID: **R66400** Analysis Date: **4/7/2021** SeqNo: **1335909**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R66400** SampType: **LCS** Units: **mg/L** Prep Date: **4/7/2021** RunNo: **66400**
Client ID: **LCSW** Batch ID: **R66400** Analysis Date: **4/7/2021** SeqNo: **1335910**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	101	2.50	100.0	0	101	99.1	105				

Sample ID: **2103540-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **4/7/2021** RunNo: **66400**
Client ID: **LJ_Queens_033121** Batch ID: **R66400** Analysis Date: **4/7/2021** SeqNo: **1335912**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50						0		20	

Work Order: 2103540
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-31913** SampType: **MBLK** Units: **mg/L** Prep Date: **4/7/2021** RunNo: **66445**
Client ID: **MBLKW** Batch ID: **31913** Analysis Date: **4/8/2021** SeqNo: **1336837**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Sulfate	ND	0.600									

Sample ID: **LCS-31913** SampType: **LCS** Units: **mg/L** Prep Date: **4/7/2021** RunNo: **66445**
Client ID: **LCSW** Batch ID: **31913** Analysis Date: **4/8/2021** SeqNo: **1336838**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.700	0.100	0.7500	0	93.3	90	110				
Sulfate	3.47	0.600	3.750	0	92.6	90	110				

Sample ID: **2103540-002BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **4/7/2021** RunNo: **66445**
Client ID: **LJ_Wet26_033121** Batch ID: **31913** Analysis Date: **4/8/2021** SeqNo: **1336847**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.07	0.100						4.764	6.16	20	E
Sulfate	1.77	0.600						1.818	2.73	20	

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2103540-002BMS** SampType: **MS** Units: **mg/L** Prep Date: **4/7/2021** RunNo: **66445**
Client ID: **LJ_Wet26_033121** Batch ID: **31913** Analysis Date: **4/8/2021** SeqNo: **1336848**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.89	0.100	0.7500	4.764	151	80	120				ES
Sulfate	5.34	0.600	3.750	1.818	93.8	80	120				

NOTES:
S - Analyte concentration was too high for accurate spike recovery(ies).
E - Estimated value. The amount exceeds the linear working range of the instrument.

Work Order: 2103540
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2103540-002BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **4/7/2021** RunNo: **66445**
Client ID: **LJ_Wet26_033121** Batch ID: **31913** Analysis Date: **4/8/2021** SeqNo: **1336849**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.89	0.100	0.7500	4.764	150	80	120	5.894	0.102	20	ES
Sulfate	5.38	0.600	3.750	1.818	94.9	80	120	5.336	0.747	20	

NOTES:

S - Analyte concentration was too high for accurate spike recovery(ies).

E - Estimated value. The amount exceeds the linear working range of the instrument.

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-31852** SampType: **MBLK** Units: **µg/L** Prep Date: **4/1/2021** RunNo: **66322**
Client ID: **MBLKW** Batch ID: **31852** Analysis Date: **4/2/2021** SeqNo: **1334004**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	200									
Magnesium	ND	100									
Potassium	ND	200									
Sodium	ND	200									

Sample ID: **LCS-31852** SampType: **LCS** Units: **µg/L** Prep Date: **4/1/2021** RunNo: **66322**
Client ID: **LCSW** Batch ID: **31852** Analysis Date: **4/2/2021** SeqNo: **1334005**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	844	200	1,000	0	84.4	50	150				
Magnesium	948	100	1,000	0	94.8	50	150				
Potassium	1,060	200	1,000	0	106	50	150				
Sodium	998	200	1,000	0	99.8	50	150				

Sample ID: **2103510-001BDUP** SampType: **DUP** Units: **µg/L** Prep Date: **4/1/2021** RunNo: **66322**
Client ID: **BATCH** Batch ID: **31852** Analysis Date: **4/2/2021** SeqNo: **1334009**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	200						0		30	
Magnesium	349	100						352.7	0.980	30	
Potassium	26,000	200						25,280	2.99	30	E
Sodium	63,500	200						62,650	1.27	30	E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2103510-001BMS** SampType: **MS** Units: **µg/L** Prep Date: **4/1/2021** RunNo: **66322**
Client ID: **BATCH** Batch ID: **31852** Analysis Date: **4/2/2021** SeqNo: **1334010**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	5,120	200	5,000	0	102	50	150				

Work Order: 2103540
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2103510-001BMS** SampType: **MS** Units: **µg/L** Prep Date: **4/1/2021** RunNo: **66322**
Client ID: **BATCH** Batch ID: **31852** Analysis Date: **4/2/2021** SeqNo: **1334010**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Magnesium	5,180	100	5,000	352.7	96.5	70	130				
Potassium	33,900	200	5,000	25,280	173	50	150				ES
Sodium	73,700	200	5,000	62,650	220	50	150				ES

NOTES:
S - Outlying spike recovery observed.
E - Estimated value. The amount exceeds the linear working range of the instrument.

Sample ID: **2103510-001BMSD** SampType: **MSD** Units: **µg/L** Prep Date: **4/1/2021** RunNo: **66322**
Client ID: **BATCH** Batch ID: **31852** Analysis Date: **4/2/2021** SeqNo: **1334011**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	5,280	200	5,000	0	106	50	150	5,122	2.94	30	
Magnesium	4,880	100	5,000	352.7	90.6	70	130	5,176	5.84	30	
Potassium	32,000	200	5,000	25,280	134	50	150	33,910	5.88	30	E
Sodium	69,500	200	5,000	62,650	137	50	150	73,660	5.83	30	E

NOTES:
E - Estimated value. The amount exceeds the linear working range of the instrument.

Fremont Analytical

Sample Log-In Check List

Client Name: **GEO1** Work Order Number: **2103540**

Logged by: **Carissa True** Date Received: **3/31/2021 3:52:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☑ No ☐ Not Present ☐
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >2°C to 6°C * Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified: Date:
By Whom: Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:
Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample 1	0.1

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 3/31/2021 **Page:** 1 **of:** 1

Laboratory Project No (internal): 2103540

Project Name: Laughing Jacobs

Project No: PNW0373

Collected by: J. Prock / S. Welsh

Location: Sammamish, WA

Report To (PM): Joel Prock

PM Email: jprock@geosyntec.com

Special Remarks:

Sample Disposal: ☐ Return to client ☐ Disposal by lab (after 30 days)

Client: Geosyntec

Address: 520 Pike St, Suite 2600

City, State, Zip: Seattle, WA 98101

Telephone: 206-496-1475

Fax: N/A

Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM 2320B)				Comments
1 LJ_Queens-033121	3/31/21	1038	W	3									X	T	X		X				
2 LJ_Wet26-033121	3/31/21	1348	W	3									X	T	X		X				
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					

***Matrix:** A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, SW = Storm Water, WW = Waste Water

****Metals (Circle):** MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl V Zn

*****Anions (Circle):** Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time:

☒ Standard ☐ Next Day

☐ 3 Day ☐ Same Day

☐ 2 Day ____ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x	Joel Prock	3/31/2021 1521	x	Carter Johnson	3/31/21 @ 1552

Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x			x		

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Geosyntec Seattle
Joel Prock
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs
Work Order Number: 2106327

June 28, 2021

Attention Joel Prock:

Fremont Analytical, Inc. received 2 sample(s) on 6/17/2021 for the analyses presented in the following report.

Ion Chromatography by EPA Method 300.0

Total Metals by EPA Method 200.8

Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

Date: *06/28/2021*

CLIENT:	Geosyntec Seattle
Project:	Laughing Jacobs
Work Order:	2106327

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2106327-001	LJ-Queens-061721	06/17/2021 11:45 AM	06/17/2021 2:30 PM
2106327-002	LJ-Wet26-061721	06/17/2021 12:46 PM	06/17/2021 2:30 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2106327**
Date: **6/28/2021**

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

I. SAMPLE RECEIPT:
Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:
Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:
Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **2106327**
Date Reported: **6/28/2021**

Client: Geosyntec Seattle
Collection Date: 6/17/2021 11:45:00 AM
Project: Laughing Jacobs
Lab ID: 2106327-001
Matrix: Stormwater
Client Sample ID: **LJ-Queens-061721**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 32751		Analyst: SS
Chloride	4.57	0.200	D	mg/L	2	6/23/2021 10:01:00 AM
Sulfate	ND	0.600		mg/L	1	6/22/2021 7:03:00 PM
Total Metals by EPA Method 200.8				Batch ID: 32702		Analyst: EH
Calcium	4,090	200		µg/L	1	6/23/2021 6:46:20 PM
Magnesium	1,650	100		µg/L	1	6/22/2021 10:20:42 PM
Potassium	470	200		µg/L	1	6/25/2021 4:05:17 PM
Sodium	3,450	200		µg/L	1	6/25/2021 4:05:17 PM
Total Alkalinity by SM 2320B				Batch ID: R68246		Analyst: TN
Alkalinity, Total (As CaCO3)	11.4	2.50		mg/L	1	6/28/2021 10:41:39 AM

Analytical Report

Work Order: **2106327**
Date Reported: **6/28/2021**

Client: Geosyntec Seattle
Collection Date: 6/17/2021 12:46:00 PM
Project: Laughing Jacobs
Lab ID: 2106327-002
Matrix: Stormwater
Client Sample ID: **LJ-Wet26-061721**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 32751		Analyst: SS
Chloride	5.72	0.500	D	mg/L	5	6/23/2021 10:24:00 AM
Sulfate	1.15	0.600		mg/L	1	6/22/2021 8:35:00 PM
Total Metals by EPA Method 200.8				Batch ID: 32733		Analyst: EH
Calcium	9,800	200		µg/L	1	6/24/2021 2:42:05 PM
Magnesium	3,290	100		µg/L	1	6/22/2021 9:13:55 PM
Potassium	668	200		µg/L	1	6/25/2021 4:27:30 PM
Sodium	5,760	200		µg/L	1	6/25/2021 4:27:30 PM
Total Alkalinity by SM 2320B				Batch ID: R68246		Analyst: TN
Alkalinity, Total (As CaCO3)	31.1	2.50		mg/L	1	6/28/2021 10:41:39 AM

Work Order: 2106327
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R68246** SampType: **MBLK** Units: **mg/L** Prep Date: **6/28/2021** RunNo: **68246**
Client ID: **MBLKW** Batch ID: **R68246** Analysis Date: **6/28/2021** SeqNo: **1378089**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R68246** SampType: **LCS** Units: **mg/L** Prep Date: **6/28/2021** RunNo: **68246**
Client ID: **LCSW** Batch ID: **R68246** Analysis Date: **6/28/2021** SeqNo: **1378090**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	91.0	2.50	100.0	0	91.0	90.5	114				

Sample ID: **2106304-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **6/28/2021** RunNo: **68246**
Client ID: **BATCH** Batch ID: **R68246** Analysis Date: **6/28/2021** SeqNo: **1378103**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	53.1	2.50						52.26	1.65	20	

Work Order: 2106327
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-32751** SampType: **MBLK** Units: **mg/L** Prep Date: **6/22/2021** RunNo: **68156**
Client ID: **MBLKW** Batch ID: **32751** Analysis Date: **6/22/2021** SeqNo: **1375655**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Sulfate	ND	0.600									

Sample ID: **LCS-32751** SampType: **LCS** Units: **mg/L** Prep Date: **6/22/2021** RunNo: **68156**
Client ID: **LCSW** Batch ID: **32751** Analysis Date: **6/22/2021** SeqNo: **1375656**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.731	0.100	0.7500	0	97.5	90	110				
Sulfate	3.72	0.600	3.750	0	99.1	90	110				

Sample ID: **2106327-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **6/22/2021** RunNo: **68156**
Client ID: **LJ-Queens-061721** Batch ID: **32751** Analysis Date: **6/22/2021** SeqNo: **1375658**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	4.84	0.100						4.851	0.330	20	E
Sulfate	ND	0.600						0		20	

Sample ID: **2106327-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **6/22/2021** RunNo: **68156**
Client ID: **LJ-Queens-061721** Batch ID: **32751** Analysis Date: **6/22/2021** SeqNo: **1375659**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.72	0.100	0.7500	4.851	115	80	120				E
Sulfate	3.78	0.600	3.750	0.3000	92.7	80	120				

Work Order: 2106327
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2106327-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **6/22/2021** RunNo: **68156**
Client ID: **LJ-Queens-061721** Batch ID: **32751** Analysis Date: **6/22/2021** SeqNo: **1375660**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	5.71	0.100	0.7500	4.851	114	80	120	5.715	0.123	20	E
Sulfate	3.75	0.600	3.750	0.3000	92.1	80	120	3.776	0.638	20	

Work Order: 2106327
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-32702** SampType: **MBLK** Units: **µg/L** Prep Date: **6/18/2021** RunNo: **68097**
Client ID: **MBLKW** Batch ID: **32702** Analysis Date: **6/21/2021** SeqNo: **1374224**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	200									
Magnesium	ND	100									

Sample ID: **2106303-001ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **6/18/2021** RunNo: **68097**
Client ID: **BATCH** Batch ID: **32702** Analysis Date: **6/21/2021** SeqNo: **1374227**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Magnesium	2,770	100						2,742	0.863	30	

Sample ID: **2106303-001AMS** SampType: **MS** Units: **µg/L** Prep Date: **6/18/2021** RunNo: **68097**
Client ID: **BATCH** Batch ID: **32702** Analysis Date: **6/21/2021** SeqNo: **1374228**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	14,100	200	5,000	7,583	131	50	150				
Magnesium	8,380	100	5,000	2,742	113	70	130				

Sample ID: **2106303-001AMSD** SampType: **MSD** Units: **µg/L** Prep Date: **6/18/2021** RunNo: **68097**
Client ID: **BATCH** Batch ID: **32702** Analysis Date: **6/21/2021** SeqNo: **1374231**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	13,400	200	5,000	7,583	116	50	150	14,150	5.56	30	
Magnesium	7,630	100	5,000	2,742	97.8	70	130	8,376	9.29	30	

Sample ID: **LCS-32702** SampType: **LCS** Units: **µg/L** Prep Date: **6/18/2021** RunNo: **68097**
Client ID: **LCSW** Batch ID: **32702** Analysis Date: **6/22/2021** SeqNo: **1374501**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	1,000	200	1,000	0	100	50	150				

Work Order: 2106327
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **LCS-32702** SampType: **LCS** Units: **µg/L** Prep Date: **6/18/2021** RunNo: **68097**
Client ID: **LCSW** Batch ID: **32702** Analysis Date: **6/22/2021** SeqNo: **1374501**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Magnesium	986	100	1,000	0	98.6	50	150				

Sample ID: **2106303-001ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **6/18/2021** RunNo: **68097**
Client ID: **BATCH** Batch ID: **32702** Analysis Date: **6/22/2021** SeqNo: **1374503**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	6,200	200						6,047	2.51	30	

Sample ID: **MB-32733** SampType: **MBLK** Units: **µg/L** Prep Date: **6/22/2021** RunNo: **68117**
Client ID: **MBLKW** Batch ID: **32733** Analysis Date: **6/22/2021** SeqNo: **1374531**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	200									
Magnesium	ND	100									

Sample ID: **LCS-32733** SampType: **LCS** Units: **µg/L** Prep Date: **6/22/2021** RunNo: **68117**
Client ID: **LCSW** Batch ID: **32733** Analysis Date: **6/22/2021** SeqNo: **1374532**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	1,030	200	1,000	0	103	50	150				
Magnesium	971	100	1,000	0	97.1	50	150				

Sample ID: **2106353-001CDUP** SampType: **DUP** Units: **µg/L** Prep Date: **6/22/2021** RunNo: **68117**
Client ID: **BATCH** Batch ID: **32733** Analysis Date: **6/22/2021** SeqNo: **1374534**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	38,600	200						36,700	5.09	30	EQ
Magnesium	10,400	100						9,585	8.23	30	

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2106353-001CDUP** SampType: **DUP** Units: **µg/L** Prep Date: **6/22/2021** RunNo: **68117**
Client ID: **BATCH** Batch ID: **32733** Analysis Date: **6/22/2021** SeqNo: **1374534**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual

NOTES:
Q - Indicates an analyte with a continuing calibration that does not meet established acceptance criteria

Sample ID: **2106353-001CMS** SampType: **MS** Units: **µg/L** Prep Date: **6/22/2021** RunNo: **68117**
Client ID: **BATCH** Batch ID: **32733** Analysis Date: **6/22/2021** SeqNo: **1374535**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	42,300	200	5,000	36,700	112	50	150				E
Magnesium	14,700	100	5,000	9,585	103	70	130				

Sample ID: **2106353-001CMSD** SampType: **MSD** Units: **µg/L** Prep Date: **6/22/2021** RunNo: **68117**
Client ID: **BATCH** Batch ID: **32733** Analysis Date: **6/22/2021** SeqNo: **1374536**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	41,200	200	5,000	36,700	89.5	50	150	42,300	2.71	30	E
Magnesium	13,800	100	5,000	9,585	84.8	70	130	14,720	6.26	30	

Sample ID: **MB-32790** SampType: **MBLK** Units: **µg/L** Prep Date: **6/25/2021** RunNo: **68236**
Client ID: **MBLKW** Batch ID: **32790** Analysis Date: **6/25/2021** SeqNo: **1377761**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	ND	200									
Sodium	ND	200									

Sample ID: **LCS-32790** SampType: **LCS** Units: **µg/L** Prep Date: **6/25/2021** RunNo: **68236**
Client ID: **LCSW** Batch ID: **32790** Analysis Date: **6/25/2021** SeqNo: **1377762**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	1,030	200	1,000	0	103	50	150				

Work Order: 2106327
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **LCS-32790** SampType: **LCS** Units: **µg/L** Prep Date: **6/25/2021** RunNo: **68236**
Client ID: **LCSW** Batch ID: **32790** Analysis Date: **6/25/2021** SeqNo: **1377762**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Sodium	1,100	200	1,000	0	110	50	150				

Sample ID: **2106327-001ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **6/25/2021** RunNo: **68236**
Client ID: **LJ-Queens-061721** Batch ID: **32790** Analysis Date: **6/25/2021** SeqNo: **1377764**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	448	200						469.6	4.74	30	
Sodium	3,410	200						3,454	1.30	30	

Sample ID: **2106327-001AMS** SampType: **MS** Units: **µg/L** Prep Date: **6/25/2021** RunNo: **68236**
Client ID: **LJ-Queens-061721** Batch ID: **32790** Analysis Date: **6/25/2021** SeqNo: **1377765**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	5,670	200	5,000	469.6	104	50	150				
Sodium	8,520	200	5,000	3,454	101	50	150				

Sample ID: **2106327-001AMSD** SampType: **MSD** Units: **µg/L** Prep Date: **6/25/2021** RunNo: **68236**
Client ID: **LJ-Queens-061721** Batch ID: **32790** Analysis Date: **6/25/2021** SeqNo: **1377766**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	5,210	200	5,000	469.6	94.9	50	150	5,668	8.37	30	
Sodium	8,130	200	5,000	3,454	93.6	50	150	8,521	4.65	30	

Fremont *Analytical*

Sample Log-In Check List

Client Name: **GEO1**
Work Order Number: **2106327**
Logged by: **Gabrielle Coeuille**
Date Received: **6/17/2021 2:30:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? Yes ☐ No ☐ Not Present ☑
   (Refer to comments for Custody Seals not intact)
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >2°C to 6°C * Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified:
Date:
By Whom:
Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person
Regarding:
Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample 1	4.9

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical
3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Date: 6/17/2021 **Page:** 1 **of:** 1
Laboratory Project No (internal): 2106327
Special Remarks:
Project Name: Laughing Jacobs
Project No: PNW0373
Collected by: JP/SW
Location: Sammamish, WA
Report To (PM): Joel Prock
PM Email: jprock@geosyntec.com
Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

Client: Geosyntec
Address: 520 Pike St, Suite 2600
City, State, Zip: Seattle, WA 98101
Telephone: 206-496-1475
Fax: N/A

	Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM-2320B)				Comments
1	LJ_Queens_061721	6/17/21	1145	SW	2									X	T	X		X				
2	LJ_Wet26-061721	6/17/21	1246	SW	2									X	T	X		X				
3																						
4																						
5																						
6																						
7																						
8																						
9																						
10																						

***Matrix:** A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, [✓ SW = Storm Water], WW = Waste Water

****Metals (Circle):** MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl V Zn

*****Anions (Circle):** Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time:
☒ Standard ☐ Next Day
☐ 3 Day ☐ Same Day
☐ 2 Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

Relinquished (Signature) x Print Name Joel Prock Date/Time 6/17/2021 1425
Received (Signature) x Print Name Date/Time 6/17/21 1430
Relinquished (Signature) x Print Name Date/Time
Received (Signature) x Print Name Date/Time

3600 Fremont Ave. N.
Seattle, WA 98103
T: (206) 352-3790
F: (206) 352-7178
info@fremontanalytical.com

Geosyntec Seattle
Joel Prock
520 Pike St., Suite 2600
Seattle, WA 98101

RE: Laughing Jacobs
Work Order Number: 2108174

August 24, 2021

Attention Joel Prock:

Fremont Analytical, Inc. received 3 sample(s) on 8/12/2021 for the analyses presented in the following report.

Ion Chromatography by EPA Method 300.0
Total Metals by EPA Method 200.8
Total Alkalinity by SM 2320B

This report consists of the following:

- Case Narrative
- Analytical Results
- Applicable Quality Control Summary Reports
- Chain of Custody

All analyses were performed consistent with the Quality Assurance program of Fremont Analytical, Inc. Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical.

Sincerely,

Brianna Barnes
Project Manager

DoD-ELAP Accreditation #79636 by PJLA, ISO/IEC 17025:2017 and QSM 5.3 for Environmental Testing
ORELAP Certification: WA 100009 (NELAP Recognized) for Environmental Testing
Washington State Department of Ecology Accredited for Environmental Testing, Lab ID C910

CLIENT: Geosyntec Seattle
Project: Laughing Jacobs
Work Order: 2108174

Work Order Sample Summary

Lab Sample ID	Client Sample ID	Date/Time Collected	Date/Time Received
2108174-001	LJ_Queens_081221	08/12/2021 11:18 AM	08/12/2021 3:04 PM
2108174-002	LJ_Wet26_081221	08/12/2021 12:03 PM	08/12/2021 3:04 PM
2108174-003	LJ_Dup_081221	08/12/2021 11:18 AM	08/12/2021 3:04 PM

Note: If no "Time Collected" is supplied, a default of 12:00AM is assigned

Case Narrative

WO#: **2108174**

Date: **8/24/2021**

CLIENT: Geosyntec Seattle

Project: Laughing Jacobs

I. SAMPLE RECEIPT:

Samples receipt information is recorded on the attached Sample Receipt Checklist.

II. GENERAL REPORTING COMMENTS:

Results are reported on a wet weight basis unless dry-weight correction is denoted in the units field on the analytical report ("mg/kg-dry" or "ug/kg-dry").

Matrix Spike (MS) and MS Duplicate (MSD) samples are tested from an analytical batch of "like" matrix to check for possible matrix effect. The MS and MSD will provide site specific matrix data only for those samples which are spiked by the laboratory. The sample chosen for spike purposes may or may not have been a sample submitted in this sample delivery group. The validity of the analytical procedures for which data is reported in this analytical report is determined by the Laboratory Control Sample (LCS) and the Method Blank (MB). The LCS and the MB are processed with the samples and the MS/MSD to ensure method criteria are achieved throughout the entire analytical process.

III. ANALYSES AND EXCEPTIONS:

Exceptions associated with this report will be footnoted in the analytical results page(s) or the quality control summary page(s) and/or noted below.

Qualifiers:

* - Flagged value is not within established control limits
B - Analyte detected in the associated Method Blank
D - Dilution was required
E - Value above quantitation range
H - Holding times for preparation or analysis exceeded
I - Analyte with an internal standard that does not meet established acceptance criteria
J - Analyte detected below Reporting Limit
N - Tentatively Identified Compound (TIC)
Q - Analyte with an initial or continuing calibration that does not meet established acceptance criteria
S - Spike recovery outside accepted recovery limits
ND - Not detected at the Reporting Limit
R - High relative percent difference observed

Acronyms:

%Rec - Percent Recovery
CCB - Continued Calibration Blank
CCV - Continued Calibration Verification
DF - Dilution Factor
DUP - Sample Duplicate
HEM - Hexane Extractable Material
ICV - Initial Calibration Verification
LCS/LCSD - Laboratory Control Sample / Laboratory Control Sample Duplicate
MCL - Maximum Contaminant Level
MB or MBLANK - Method Blank
MDL - Method Detection Limit
MS/MSD - Matrix Spike / Matrix Spike Duplicate
PDS - Post Digestion Spike
Ref Val - Reference Value
REP - Sample Replicate
RL - Reporting Limit
RPD - Relative Percent Difference
SD - Serial Dilution
SGT - Silica Gel Treatment
SPK - Spike
Surr - Surrogate

Analytical Report

Work Order: **2108174**
Date Reported: **8/24/2021**

Client: Geosyntec Seattle
Collection Date: 8/12/2021 11:18:00 AM
Project: Laughing Jacobs
Lab ID: 2108174-001
Matrix: Stormwater
Client Sample ID: **LJ_Queens_081221**

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 33447		Analyst: SS
Chloride	4.27	0.200	D	mg/L	2	8/24/2021 10:16:49 AM
Sulfate	ND	0.600		mg/L	1	8/24/2021 10:16:49 AM
Total Metals by EPA Method 200.8				Batch ID: 33350		Analyst: EH
Calcium	7,240	200		µg/L	1	8/14/2021 12:45:18 AM
Magnesium	2,310	100		µg/L	1	8/14/2021 12:45:18 AM
Potassium	750	200		µg/L	1	8/17/2021 1:23:37 AM
Sodium	3,660	200		µg/L	1	8/17/2021 1:23:37 AM
Total Alkalinity by SM 2320B				Batch ID: R69237		Analyst: TN
Alkalinity, Total (As CaCO3)	16.3	2.50		mg/L	1	8/13/2021 2:08:35 PM

Client: Geosyntec Seattle

Project: Laughing Jacobs

Lab ID: 2108174-002

Client Sample ID: **LJ_Wet26_081221**

Collection Date: 8/12/2021 12:03:00 PM

Matrix: Stormwater

Analyses	**Result**	**RL**	**Qual**	**Units**	**DF**	**Date Analyzed**
Ion Chromatography by EPA Method 300.0				Batch ID: 33447		Analyst: SS
Chloride	11.8	0.500	D	mg/L	5	8/24/2021 10:16:49 AM
Sulfate	ND	1.20	D	mg/L	2	8/24/2021 10:16:49 AM
Total Metals by EPA Method 200.8				Batch ID: 33350		Analyst: EH
Calcium	8,140	200		µg/L	1	8/14/2021 12:23:02 AM
Magnesium	1,630	100		µg/L	1	8/14/2021 12:23:02 AM
Potassium	4,240	200		µg/L	1	8/17/2021 1:12:29 AM
Sodium	8,560	200		µg/L	1	8/17/2021 1:12:29 AM
Total Alkalinity by SM 2320B				Batch ID: R69237		Analyst: TN
Alkalinity, Total (As CaCO3)	32.5	2.50		mg/L	1	8/13/2021 2:08:35 PM

Client: Geosyntec Seattle

Collection Date: 8/12/2021 11:18:00 AM

Project: Laughing Jacobs

Lab ID: 2108174-003

Matrix: Stormwater

Client Sample ID: LJ_Dup_081221

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
Ion Chromatography by EPA Method 300.0				Batch ID: 33447		Analyst: SS
Chloride	4.41	0.200	D	mg/L	2	8/24/2021 10:16:49 AM
Sulfate	ND	0.600		mg/L	1	8/24/2021 10:16:49 AM
Total Metals by EPA Method 200.8				Batch ID: 33350		Analyst: EH
Calcium	6,660	200		µg/L	1	8/14/2021 12:50:52 AM
Magnesium	2,170	100		µg/L	1	8/14/2021 12:50:52 AM
Potassium	631	200		µg/L	1	8/17/2021 1:29:11 AM
Sodium	3,480	200		µg/L	1	8/17/2021 1:29:11 AM
Total Alkalinity by SM 2320B				Batch ID: R69237		Analyst: TN
Alkalinity, Total (As CaCO3)	15.3	2.50		mg/L	1	8/13/2021 2:08:35 PM

Work Order: 2108174
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Alkalinity by SM 2320B

Sample ID: **MB-R69237** SampType: **MBLK** Units: **mg/L** Prep Date: **8/13/2021** RunNo: **69237**
Client ID: **MBLKW** Batch ID: **R69237** Analysis Date: **8/13/2021** SeqNo: **1402251**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	ND	2.50									

Sample ID: **LCS-R69237** SampType: **LCS** Units: **mg/L** Prep Date: **8/13/2021** RunNo: **69237**
Client ID: **LCSW** Batch ID: **R69237** Analysis Date: **8/13/2021** SeqNo: **1402252**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	97.6	2.50	100.0	0	97.6	88.3	113				

Sample ID: **2108139-001EDUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/13/2021** RunNo: **69237**
Client ID: **BATCH** Batch ID: **R69237** Analysis Date: **8/13/2021** SeqNo: **1402254**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Alkalinity, Total (As CaCO3)	36.3	2.50						36.28	0.00979	20	

Work Order: 2108174
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **MB-33447** SampType: **MBLK** Units: **mg/L** Prep Date: **8/20/2021** RunNo: **69444**
Client ID: **MBLKW** Batch ID: **33447** Analysis Date: **8/24/2021** SeqNo: **1406976**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.100									
Sulfate	ND	0.600									

Sample ID: **LCS-33447** SampType: **LCS** Units: **mg/L** Prep Date: **8/20/2021** RunNo: **69444**
Client ID: **LCSW** Batch ID: **33447** Analysis Date: **8/24/2021** SeqNo: **1406977**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.722	0.100	0.7500	0	96.3	90	110				
Sulfate	3.62	0.600	3.750	0	96.6	90	110				

Sample ID: **2108271-001BDUP** SampType: **DUP** Units: **mg/L** Prep Date: **8/20/2021** RunNo: **69444**
Client ID: **BATCH** Batch ID: **33447** Analysis Date: **8/24/2021** SeqNo: **1406993**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	148	10.0						152.9	2.92	20	D
Sulfate	ND	60.0						61.80	10.2	20	D

Sample ID: **2108271-001BMS** SampType: **MS** Units: **mg/L** Prep Date: **8/20/2021** RunNo: **69444**
Client ID: **BATCH** Batch ID: **33447** Analysis Date: **8/24/2021** SeqNo: **1406994**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	223	10.0	75.00	152.9	93.3	80	120				D
Sulfate	374	60.0	375.0	61.80	83.2	80	120				D

Work Order: 2108174
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Ion Chromatography by EPA Method 300.0

Sample ID: **2108271-001BMSD** SampType: **MSD** Units: **mg/L** Prep Date: **8/20/2021** RunNo: **69444**
Client ID: **BATCH** Batch ID: **33447** Analysis Date: **8/24/2021** SeqNo: **1406995**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	224	10.0	75.00	152.9	94.7	80	120	222.9	0.448	20	D
Sulfate	374	60.0	375.0	61.80	83.3	80	120	373.9	0.0267	20	D

Work Order: 2108174
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **MB-33350** SampType: **MBLK** Units: **µg/L** Prep Date: **8/13/2021** RunNo: **69242**
Client ID: **MBLKW** Batch ID: **33350** Analysis Date: **8/14/2021** SeqNo: **1402549**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	200									
Magnesium	ND	100									

Sample ID: **LCS-33350** SampType: **LCS** Units: **µg/L** Prep Date: **8/13/2021** RunNo: **69242**
Client ID: **LCSW** Batch ID: **33350** Analysis Date: **8/14/2021** SeqNo: **1402550**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	1,130	200	1,000	0	113	50	150				
Magnesium	1,040	100	1,000	0	104	50	150				

Sample ID: **2108174-002ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **8/13/2021** RunNo: **69242**
Client ID: **LJ_Wet26_081221** Batch ID: **33350** Analysis Date: **8/14/2021** SeqNo: **1402552**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	7,950	200						8,145	2.41	30	
Magnesium	1,590	100						1,629	2.51	30	

Sample ID: **2108174-002AMS** SampType: **MS** Units: **µg/L** Prep Date: **8/13/2021** RunNo: **69242**
Client ID: **LJ_Wet26_081221** Batch ID: **33350** Analysis Date: **8/14/2021** SeqNo: **1402553**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	13,800	200	5,000	8,145	114	50	150				
Magnesium	6,940	100	5,000	1,629	106	70	130				
Potassium	5,110	200	5,000	2,306	56.1	50	150				
Sodium	6,580	200	5,000	4,285	45.9	50	150				S

NOTES:

S - Analyte concentration was too high for accurate spike recovery(ies).

Work Order: 2108174
CLIENT: Geosyntec Seattle
Project: Laughing Jacobs

QC SUMMARY REPORT

Total Metals by EPA Method 200.8

Sample ID: **2108174-002AMSD** SampType: **MSD** Units: **µg/L** Prep Date: **8/13/2021** RunNo: **69242**
Client ID: **LJ_Wet26_081221** Batch ID: **33350** Analysis Date: **8/14/2021** SeqNo: **1402554**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	14,000	200	5,000	8,145	118	50	150	13,830	1.55	30	
Magnesium	6,890	100	5,000	1,629	105	70	130	6,935	0.585	30	
Potassium	5,160	200	5,000	2,306	57.1	50	150	5,110	1.01	30	
Sodium	6,960	200	5,000	4,285	53.6	50	150	6,581	5.64	30	

Sample ID: **MB-33350** SampType: **MBLK** Units: **µg/L** Prep Date: **8/13/2021** RunNo: **69242**
Client ID: **MBLKW** Batch ID: **33350** Analysis Date: **8/17/2021** SeqNo: **1403540**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	ND	200									
Sodium	ND	200									

Sample ID: **LCS-33350** SampType: **LCS** Units: **µg/L** Prep Date: **8/13/2021** RunNo: **69242**
Client ID: **LCSW** Batch ID: **33350** Analysis Date: **8/17/2021** SeqNo: **1403543**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	1,000	200	1,000	0	100	50	150				
Sodium	1,080	200	1,000	0	108	50	150				

Sample ID: **2108174-002ADUP** SampType: **DUP** Units: **µg/L** Prep Date: **8/13/2021** RunNo: **69242**
Client ID: **LJ_Wet26_081221** Batch ID: **33350** Analysis Date: **8/17/2021** SeqNo: **1403545**

Analyte	Result	RL	SPK value	SPK Ref Val	%REC	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Potassium	4,950	200						4,237	15.6	30	
Sodium	8,830	200						8,564	3.01	30	

Fremont Analytical

Sample Log-In Check List

Client Name: **GEO1**

Work Order Number: **2108174**

Logged by: **Clare Griggs**

Date Received: **8/12/2021 3:04:00 PM**

Chain of Custody

1. Is Chain of Custody complete? Yes ☑ No ☐ Not Present ☐
2. How was the sample delivered? Client

Log In

3. Coolers are present? Yes ☑ No ☐ NA ☐
4. Shipping container/cooler in good condition? Yes ☑ No ☐
5. Custody Seals present on shipping container/cooler? (Refer to comments for Custody Seals not intact) Yes ☑ No ☐ Not Present ☐
6. Was an attempt made to cool the samples? Yes ☑ No ☐ NA ☐
7. Were all items received at a temperature of >2°C to 6°C * Yes ☑ No ☐ NA ☐
8. Sample(s) in proper container(s)? Yes ☑ No ☐
9. Sufficient sample volume for indicated test(s)? Yes ☑ No ☐
10. Are samples properly preserved? Yes ☑ No ☐
11. Was preservative added to bottles? Yes ☐ No ☑ NA ☐
12. Is there headspace in the VOA vials? Yes ☐ No ☐ NA ☑
13. Did all samples containers arrive in good condition(unbroken)? Yes ☑ No ☐
14. Does paperwork match bottle labels? Yes ☑ No ☐
15. Are matrices correctly identified on Chain of Custody? Yes ☑ No ☐
16. Is it clear what analyses were requested? Yes ☑ No ☐
17. Were all holding times able to be met? Yes ☑ No ☐

Special Handling (if applicable)

18. Was client notified of all discrepancies with this order? Yes ☐ No ☐ NA ☑

Person Notified:

Date:

By Whom:

Via: ☐ eMail ☐ Phone ☐ Fax ☐ In Person

Regarding:

Client Instructions:

19. Additional remarks:

Item Information

Item #	Temp ºC
Sample	3.8

* Note: DoD/ELAP and TNI require items to be received at 4°C +/- 2°C

Fremont Analytical

3600 Fremont Ave N.
Seattle, WA 98103
Tel: 206-352-3790
Fax: 206-352-7178

Chain of Custody Record & Laboratory Services Agreement

Client: Geosyntec
Address: 520 Pike St, Suite 2600
City, State, Zip: Seattle, WA 98101
Telephone: 206-496-1475
Fax: —

Date: 8/12/2021 **Page:** 1 **of:** 1
Project Name: Laughing Jacobs
Project No: PNW0373
Collected by: JP/SW
Location: Sammamish, WA
Report To (PM): Joel Prock
PM Email: jprock@geosyntec.com

Laboratory Project No (internal): 21-08174
Special Remarks:

Sample Disposal: ☐ Return to client ☒ Disposal by lab (after 30 days)

Sample Name	Sample Date	Sample Time	Sample Type (Matrix)*	# of Cont.	VOCs (EPA 8260 / 624)	BTEX	Gasoline Range Organics (GX)	Hydrocarbon Identification (HCID)	Diesel/Heavy Oil Range Organics (DX)	SVOCs (EPA 8270 / 625)	PAHs (EPA 8270 - SIM)	PCBs (EPA 8082 / 608)	Metals** (EPA 6020 / 200.8)	Total (T) | Dissolved (D)	Anions (IC)***	EDB (8011)	Alkalinity (SM2320B)				Comments
1 LJ_Queens-081221	8/12/21	1118	SW	2									X	T	X		X				
2 LJ_Wet26-081221	8/12/21	1203	SW	2									X	T	X		X				
JP 3 ~~LJ_Dup-081221~~																					
4 LJ_Dup-081221	8/12/21	1118	SW	2									X	T	X		✓				
5																					
6																					
7																					
8																					
9																					
10																					

*Matrix: A = Air, AQ = Aqueous, B = Bulk, O = Other, P = Product, S = Soil, SD = Sediment, SL = Solid, W = Water, DW = Drinking Water, GW = Ground Water, [✓ SW = Storm Water], WW = Waste Water

**Metals (Circle): MTCA-5 RCRA-8 Priority Pollutants TAL *Individual:* Ag Al As B Ba Be [✓ Ca] Cd Co Cr Cu Fe Hg [✓ K] [✓ Mg] Mn Mo [✓ Na] Ni Pb Sb Se Sr Sn Ti Tl V Zn

***Anions (Circle): Nitrate Nitrite [✓ Chloride] [✓ Sulfate] Bromide O-Phosphate Fluoride Nitrate+Nitrite

Turn-around Time:
☒ Standard ☐ Next Day
☐ 3 Day ☐ Same Day
☐ 2 Day ______ (specify)

I represent that I am authorized to enter into this Agreement with Fremont Analytical on behalf of the Client named above, that I have verified Client's agreement to each of the terms on the front and backside of this Agreement.

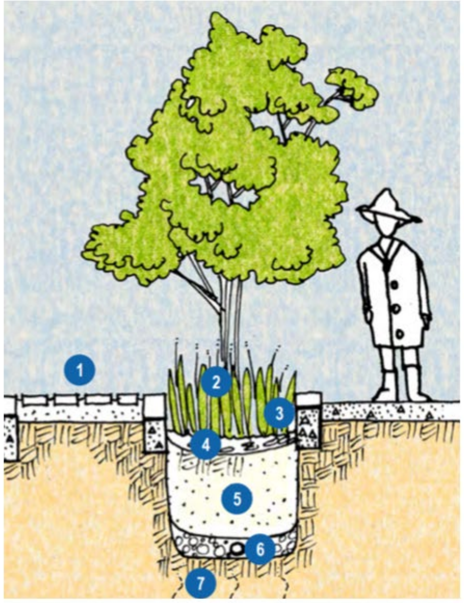
Relinquished (Signature)	Print Name	Date/Time	Received (Signature)	Print Name	Date/Time
x	Joel Prock	8/12/21 1338	x	AlanaBasn	8/12/21 15:04
Relinquished (Signature) x	Print Name	Date/Time	Received (Signature) x	Print Name	Date/Time

COC 1.3 - 11.06.20

www.fremontanalytical.com

APPENDIX F
Conceptual Designs

Conceptual Design: Queen's Bog Stormwater Treatment



① Sidewalk or trail

② Vegetation

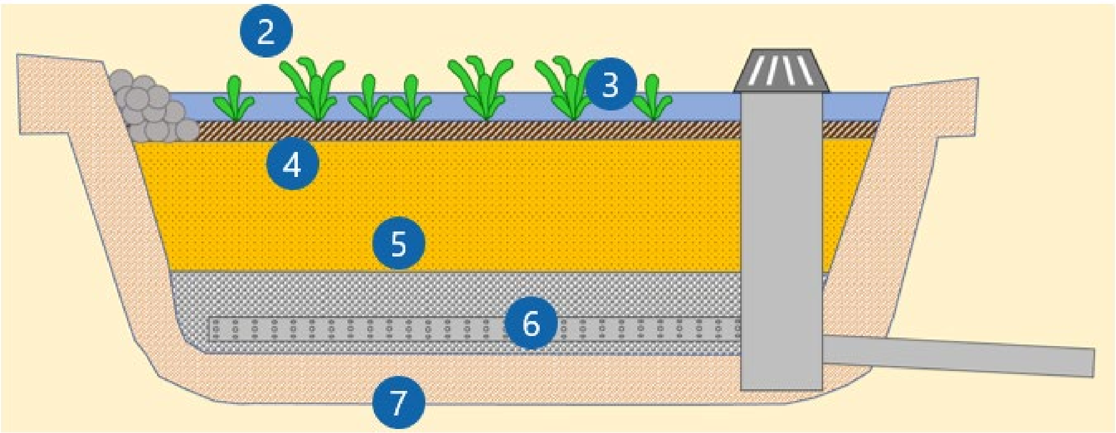
③ Intermittent ponding

④ Plant roots help maintain infiltration

⑤ Specialized bioretention mix

⑥ Optional underdrain where needed

⑦ Infiltration where feasible



Capital Improvement Project Prioritization Scoring

Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity
30/30	15/25	0/25	10/10	10/10

Conceptual Design: Queen's Bog Stormwater Treatment, Cont.

Project Description

Queen's Bog is one of Sammamish's most valued Sphagnum Bogs. It is an example of a unique habitat type rarely found in the region. A portion of the Klahanie neighborhood discharges stormwater runoff directly to the bog, altering the natural hydrology and water chemistry of the bog. Sphagnum bogs, like Queens Bog, are typically ombrotrophic (rainfall dominated) and contain vegetation that needs acidic conditions to survive. Preliminary evidence suggests that the bog vegetation may be changing due to untreated stormwater and the altered hydrology of the system. Up to five systems of bioretention cells would be installed to reduce harmful constituents in stormwater runoff tributary to the bog. Specific locations would be identified during design. Initial analysis shows the surface area of each bioretention systems would range from 1,000 to 2,500 square feet.

Benefits

- Protects the rare ecosystem present in Queens Bog
- Provides a pleasant aesthetic for citizens to enjoy
- Uses existing open space to reduce development impacts to surrounding area

Challenges

- Existing pipeline right of way
- Potential utility conflicts

Capital Cost (5 systems): $679k

Annual O&M Cost (5 systems): $12.7k

Conceptual Design: Queen's Bog Stormwater Treatment, Cont.

Assumptions/Considerations

- Easements and coordination with property owners may be required.
- Bioretention areas sized to provide 91% long-term capture; this sizing standard applies to development and redevelopment projects. As a water quality improvement project, a capture threshold is not required.
- A location is not proposed to provide future flexibility in project siting. Detailed siting would occur as part of design.
- Siting within the natural gas pipeline would require coordination with the pipeline owner and may necessitate additional constraints.

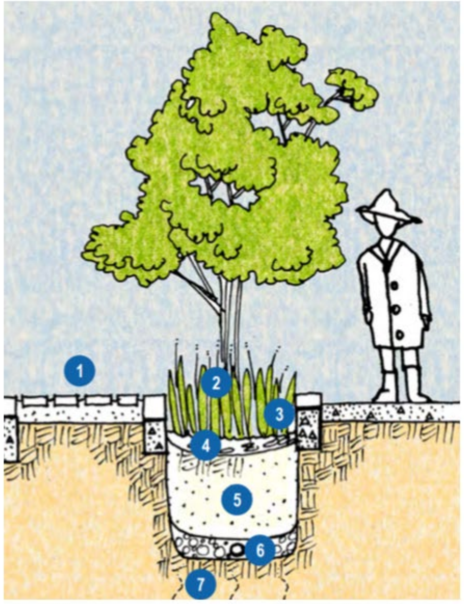
Planning Level Cost Estimate

Capital Costs					
	Outfall 1	**Outfall 2**	**Outfall 3**	**Outfall 4**	**Outfall 5**
Bioretention Area (SF)	1,250	1,000	1,250	1,500	2,500
Construction Cost[1] ($44/SF)	$54,688	$43,750	$54,688	$65,625	$109,375
Design Cost[1] ($11/SF)	$13,750	$11,000	$13,750	$16,500	$27,500
Subtotal	$68,438	$54,750	$68,438	$82,125	$136,875
Washington State Sales Tax (10%)	$6,844	$5,475	$6,844	$8,213	$13,688
Permitting (5%)	$3,422	$2,738	$3,422	$4,106	$6,844
Contingency (50%)	$34,219	$27,375	$34,219	$41,063	$68,438
Total Capital Cost	$113,000	$91,000	$113,000	$136,000	$226,000

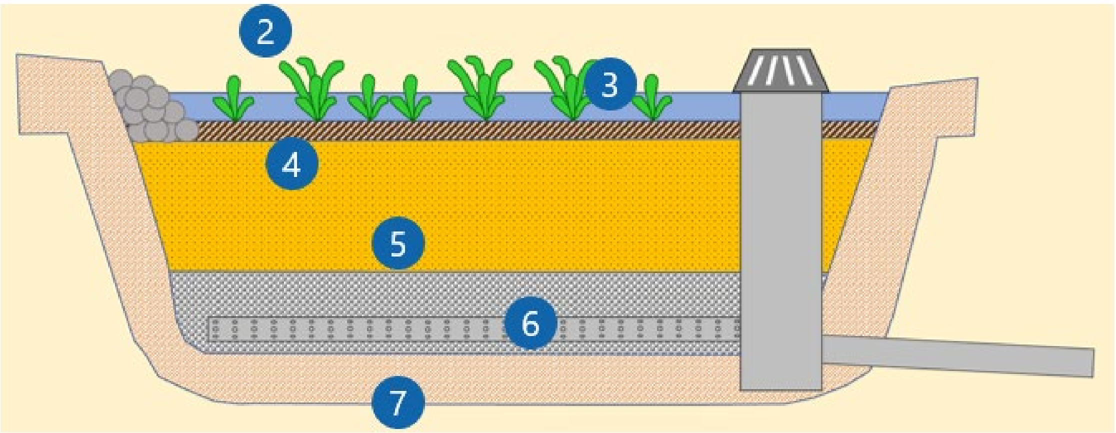
O&M Costs					
30-Year Present Value O&M Cost[1] ($50.05/SF)	$63,000	$51,000	$63,000	$76,000	$126,000
Average Annual O&M Cost	$2,100	$1,700	$2,100	$2,600	$4,200

[1] Construction, design, and O&M costs for bioretention facilities were obtained from the 2013 report titled "Case Study for Applying SUSTAIN to a Small Watershed in the Puget Lowland" prepared by Herrera Environmental Consultants, Inc. for the Department of Ecology, State of Washington. These costs were increased by 25% to account for rising construction costs.

Conceptual Design: SE 24th Street Wetland Complex Stormwater Treatment



1. Sidewalk or trail
2. Vegetation
3. Intermittent ponding
4. Plant roots help maintain infiltration
5. Specialized bioretention mix
6. Optional underdrain where needed
7. Infiltration where feasible



Capital Improvement Project Prioritization Scoring

Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity
25/30	10/25	0/25	10/10	0/10

Conceptual Design: SE 24th Street Wetland Complex Stormwater Treatment, Cont.

Project Description

The SE 24th Street wetland complex has been drastically altered by historic land use patterns including drainage for farming, filling in some locations, and bisecting by roads. Land cover changes related to logging, farming, and development have altered the hydrologic regime and influent water quality. Bioretention cells are proposed to be installed to partially restore hydrology and water quality. Up to five bioretention systems would be installed. Bioretention areas would be planted with appropriate vegetation. Specific locations proposed would be identified during design. Initial analysis shows the surface area of each bioretention systems would range from 200 to 800 square feet.

Benefits	**Challenges**
Would improve water quality and hydrology in the SE 24th Street wetland complex	Siting of bioretention areas Possible utility conflicts
Capital Cost (5 systems): $248k	**Annual O&M Cost (5 systems): $4.8k**

Conceptual Design: SE 24th Street Wetland Complex Stormwater Treatment, Cont.

Assumptions/Considerations

- Easements and coordination with property owners may be required.
- Bioretention areas sized to provide 91% long-term capture; this sizing standard applies to development and redevelopment projects. As a water quality improvement project, a capture threshold is not required.
- Siting of specific features would be conducted during design.

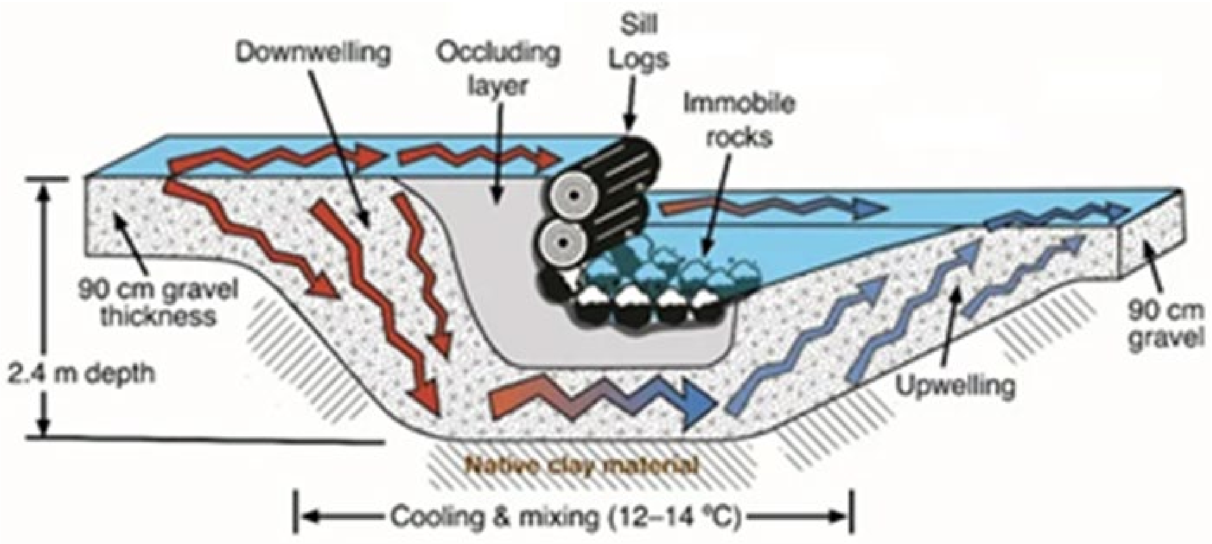
Planning Level Cost Estimate

Capital Costs					
	Outfall 1	**Outfall 3**	**Outfall 5**	**Outfall 6**	**Outfall 7**
Bioretention Area (SF)	500	200	800	800	400
Construction Cost[1] ($44/SF)	$22,000	$8,800	$35,200	$35,200	$17,600
Design Cost[1] ($11/SF)	$5,500	$2,200	$8,800	$8,800	$4,400
Subtotal	$27,500	$11,000	$44,000	$44,000	$22,000
Washington State Sales Tax (10%)	$2,750	$1,100	$4,400	$4,400	$2,200
Permitting (5%)	$1,375	$550	$2,200	$2,200	$1,100
Contingency (50%)	$13,750	$5,500	$22,000	$22,000	$11,000
Total Capital Cost	$46,000	$19,000	$73,000	$73,000	$37,000

O&M Costs					
30-Year Present Value O&M Cost[1] ($50.05/SF)	$26,000	$11,000	$41,000	$41,000	$21,000
Average Annual O&M Cost	$900	$400	$1,400	$1,400	$700

[1] Construction, design, and O&M costs for bioretention facilities were obtained from the 2013 report titled “Case Study for Applying SUSTAIN to a Small Watershed in the Puget Lowland” prepared by Herrera Environmental Consultants, Inc. for the Department of Ecology, State of Washington. These costs were increased by 25% to account for rising construction costs.

Conceptual Design: Issaquah-Pine Lake Road Crossing Engineered Hyporheic Zone Augmentation

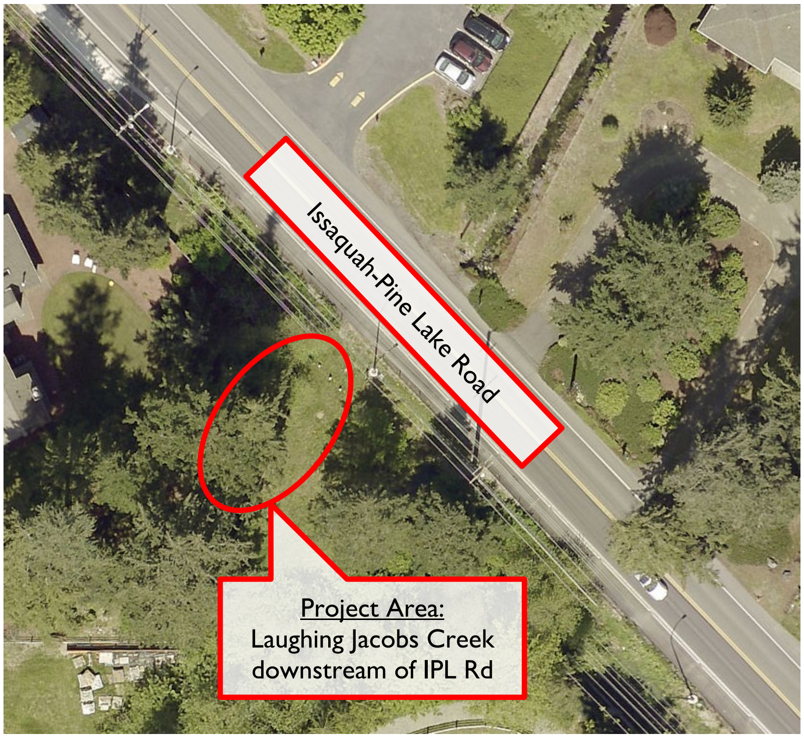


Graphic sourced from Bakke, P., Hrachovec, M., & Lynch, K. (2020). Hyporheic Process Restoration: Design and Performance of an Engineered Streambed. https://doi.org/10.3390/w12020425

Capital Improvement Project Prioritization Scoring

Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity
20/30	5/25	0/25	10/10	10/10

Conceptual Design: Issaquah-Pine Lake Road Crossing Engineered Hyporheic Zone Augmentation, Cont.



Project Description

This project would take advantage of proposed stream improvements related to the widening of Issaquah-Pine Lake (IPL) Road. Engineered hyporheic zones would be added using proposed engineered wood structures to provide instream water quality improvements. This project would add engineered media and controls that would direct a portion of the flow through the hyporheic zone of the stream channel. This project would utilize lessons learned from pilot studies by Seattle Public Utilities and others in Thornton Creek, where the concept has been successfully demonstrated. Studies suggest that engineered hyporheic zones can provide reduction of contaminants typically present in roadway runoff, while helping to lower stream temperature.

Benefits

- Provides water quality benefits to downstream reaches
- Reduces water temperature of creek
- Can be paired with IPL Road widening project to reduce capital cost
- Grant opportunities may offset costs

Challenges

- Relatively new practice – no established design guidance
- Long-term maintenance costs unknown

Capital Cost: $80k (additional cost to planned roadway project)

Annual O&M Cost: $2k (additional cost to planned roadway project)

Conceptual Design: Issaquah-Pine Lake Road Crossing Engineered Hyporheic Zone Augmentation, Cont.

Assumptions/Considerations

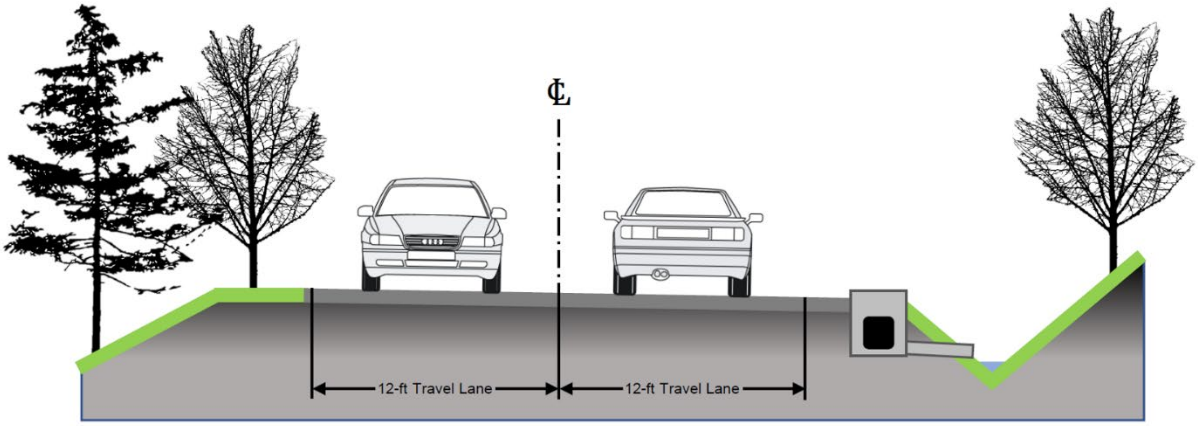
- Easements and coordination with property owners may be required.
- One engineered hyporheic zone would be constructed in the Laughing Jacobs Creek reach immediately downstream of Issaquah-Pine Lake Road.
- Costs developed based on engineering judgement. Actual costs may vary.

Cost Estimate

Capital Costs				
Line Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Mobilization	%	10%	1	$2,992
Water Pollution/Erosion Control	%	5%	1	$1,496
SPCC Plan	LS	$625	1	$625
Clearing & Grubbing	SY	$6	300	$1,875
Excavation	CY	$31	167	$5,219
Sheet Piling	SF	$31	450	$14,063
Sill Logs	EA	$19	6	$113
6" River Stone	CY	$88	34	$2,975
#8 Gravel	CY	$50	67	$3,350
Low-Permeability Clay	CY	$50	34	$1,700
Subtotal				$34,407
Washington State Sales Tax			10%	$3,441
Construction Contingency			50%	$17,203
Construction Subtotal				$55,051
Engineering Design			25%	$13,763
Design Contingency			10%	$5,505
Permitting			10%	$5,505
Total Capital Cost				$80,000

O&M Costs				
Line Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Labor	Hr	$94	12	$1,125
Incidentals	%	10%	1	$113
Annual O&M Cost (2021 Dollars)				$2,000

Conceptual Design: SE 43rd Way Roadway Stormwater Treatment



Capital Improvement Project Prioritization Scoring

Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity
20/30	5/25	0/25	10/10	5/10

Conceptual Design: SE 43rd Way Roadway Stormwater Treatment, Cont.

Project Description

Lower Laughing Jacobs Creek supports a native run of Lake Sammamish Kokanee Salmon, an important fish species whose population has declined by almost 95% from historic levels. SE 43rd Way parallels the creek for its entire length from the Sammamish Plateau to East Lake Sammamish Road. Most runoff from this section is untreated before discharge to the creek. This project proposes to retrofit roadway drainages with Contech® StormFilter Catch Basins, or similar ultra-dense BMPs. Facilities would be designed to capture and treat as much of the roadway runoff as feasible given site constraints. Treatment of roadway runoff would improve water quality and reduce harmful effects to Kokanee and other salmonids.

Benefits

- Provides stormwater treatment to roadway runoff not currently treated
- Requires minimal existing infrastructure for installation

Challenges

- Limited working area in ROW
- Lack of curb and gutter may contribute high sediment levels to catch basins

Capital Cost (per catch basin): $47k

Annual O&M Cost (per catch basin): $500

Conceptual Design: SE 43rd Way Roadway Stormwater Treatment, Cont.

Assumptions/Considerations

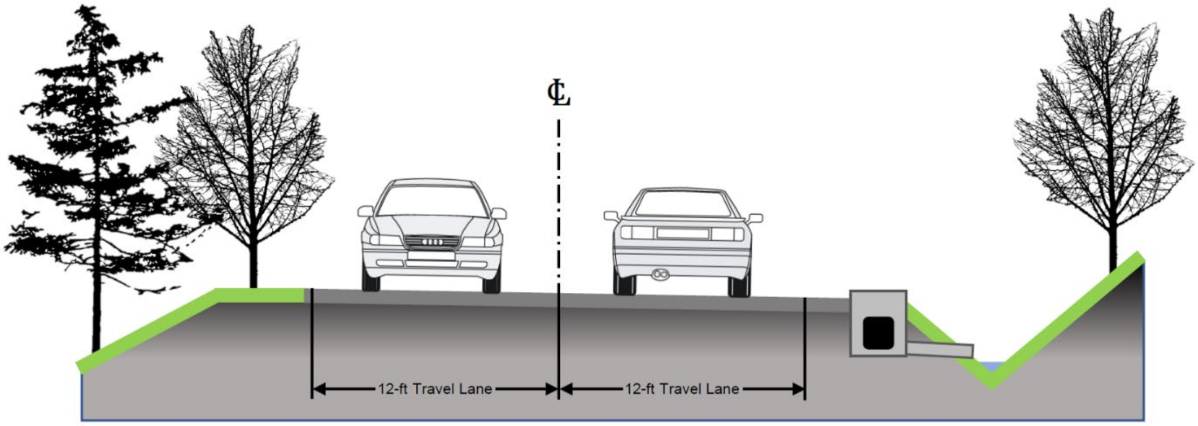
- Siting of StormFilter Catch Basins would be completed at a later stage in the design process.
- The quantity of StormFilter Catch Basins installed along SE 43rd Way would be determined at a future stage. The City of Sammamish may determine the number of units to be installed upon determination of costs and benefits provided.
- Estimates assume 27” StormFilter cartridges.
- Costs developed based on engineering judgement and estimates from similar projects. Actual costs may vary.

Planning Level Cost Estimate

Capital Costs				
Line Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Mobilization	%	10%	1	$1,756
Water Pollution/Erosion Control	%	5%	1	$878
SPCC Plan	LS	$625	1	$625
Earthwork	CY	$31	10	$313
2 Cartridge StormFilter Catch Basin	EA	$16,250	1	$16,250
Stormwater Pipes	LF	$38	10	$375
Subtotal				$20,197
Washington State Sales Tax			10%	$2,020
Construction Contingency			50%	$10,098
Construction Subtotal				$32,315
Engineering Design			25%	$8,079
Design Contingency			10%	$3,232
Permitting			10%	$3,232
Total Capital Cost				$47,000

O&M Costs				
Line Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Labor	Hr	$94	2	$188
Cartridges	EA	$125	2	$250
Incidentals	%	10%	1	$44
Annual O&M Cost (2021 Dollars)				$500

Conceptual Design: East Lake Sammamish Parkway Roadway Stormwater Treatment



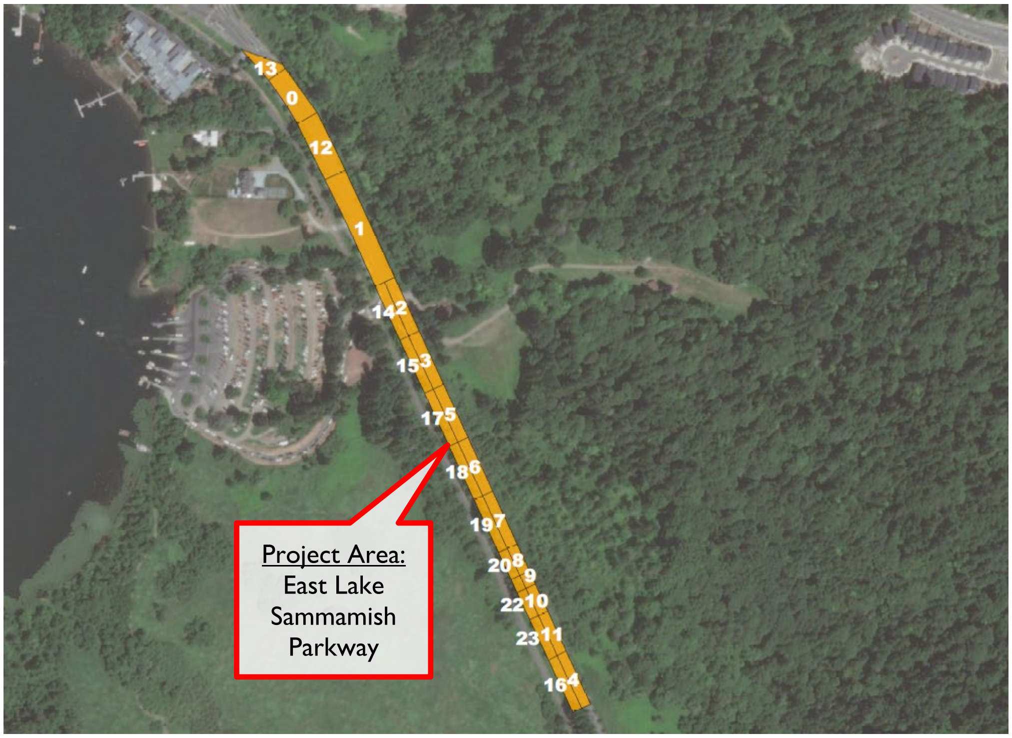
Capital Improvement Project Prioritization Scoring

Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity
20/30	5/25	0/25	10/10	0/10

City of Sammamish Washington

Geosyntec consultants

Conceptual Design: East Lake Sammamish Parkway Roadway Stormwater Treatment, Cont.



Project Description

Lower Laughing Jacobs Creek supports a native run of Lake Sammamish Kokanee Salmon, an important fish species whose population has declined by almost 95% from historic levels. The indicated project area includes a heavily trafficked section of East Lake Sammamish Road which crosses the creek near the discharge point to Lake Sammamish. Most runoff from this section is untreated before discharge to the creek. This project proposes to retrofit roadway drainages with Contech® StormFilter Catch Basins, or similar ultra-dense BMPs. Facilities would be designed to capture and treat as much of the roadway runoff as feasible given site constraints. Treatment of roadway runoff would improve water quality and reduce harmful effects to Kokanee and other salmonids.

Benefits

- Provides stormwater treatment to roadway runoff not otherwise treated
- Requires minimal existing infrastructure for installation

Challenges

- Limited working area in right of way
- Wetlands adjacent to roadway in some areas

Capital Cost (per catch basin): $47k

Annual O&M Cost (per catch basin): $500

Conceptual Design: East Lake Sammamish Parkway Roadway Stormwater Treatment, Cont.

Assumptions/Considerations

- Siting of StormFilter Catch Basins would be completed at a later stage in the design process.
- The quantity of StormFilter Catch Basins installed along East Lake Sammamish Parkway would be determined at a future stage. The City of Sammamish may determine the number of units to be installed upon determination of costs and benefits provided.
- Estimates assume 27” StormFilter cartridges.
- Costs developed based on engineering judgement and estimates from similar projects. Actual costs may vary.

Planning Level Cost Estimate

Capital Costs				
Line Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Mobilization	%	10%	1	$1,756
Water Pollution/Erosion Control	%	5%	1	$878
SPCC Plan	LS	$625	1	$625
Earthwork	CY	$31	10	$313
2 Cartridge StormFilter Catch Basin	EA	$16,250	1	$16,250
Stormwater Pipes	LF	$38	10	$375
Subtotal				$20,197
Washington State Sales Tax			10%	$2,020
Construction Contingency			50%	$10,098
Construction Subtotal				$32,315
Engineering Design			25%	$8,079
Design Contingency			10%	$3,232
Permitting			10%	$3,232
Total Capital Cost				$47,000

O&M Costs				
Line Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Labor	Hr	$94	2	$188
Cartridges	EA	$125	2	$250
Incidentals	%	10%	1	$44
Annual O&M Cost (2021 Dollars)				$500

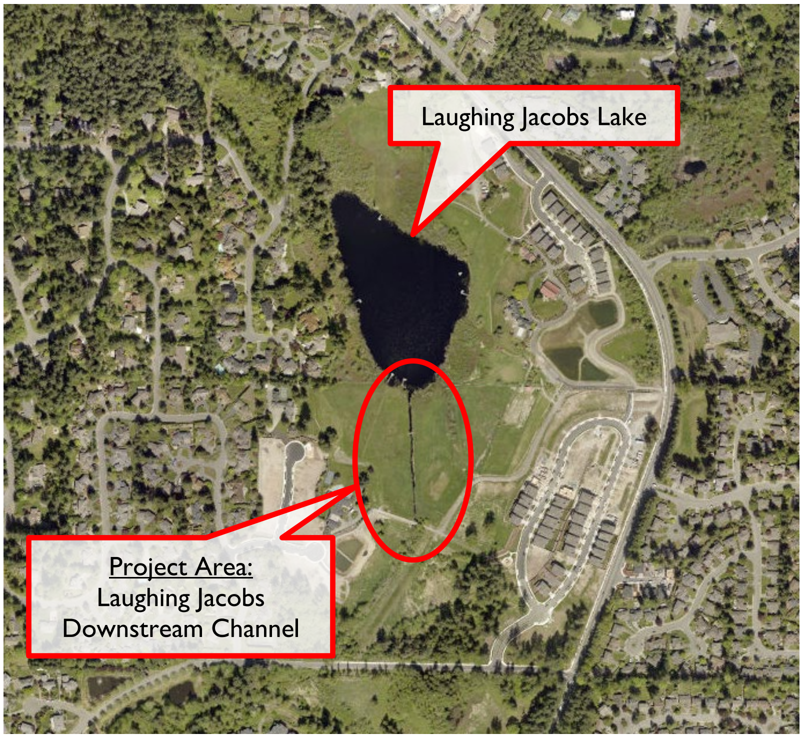
Conceptual Design: Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration

Existing

Proposed

Capital Improvement Project Prioritization Scoring				
Environmental Benefit	Facility/ Maintenance Improvements	Safety	Population Benefitted	Time-Sensitive Opportunity
25/30	0/25	0/25	10/10	0/10

Conceptual Design: Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration, Cont.



Project Description

The downstream channel at Laughing Jacobs Lake is shallow and not shaded by riparian cover. Small channels, such as this reach, are most susceptible to temperature changes, which will likely be exacerbated by climate change. Temperature data collected at this reach from August 2019 to August 2021 indicate an exceedance of the Washington Water Quality Temperature Standard of 16.0ºC during summer months by 0.7ºC to 2.5ºC. This stream is considered by Ecology to provide core summer salmonid habitat.

Planting of native riparian vegetation along this channel segment would shade the water and reduce temperatures due to direct sun exposure. Reduced temperatures would lessen temperature-specific burdens on aquatic life in this channel and the downstream Laughing Jacobs Creek (e.g., low dissolved oxygen levels). In addition to temperature benefits, riparian vegetation can provide cover for salmonids, increase benthic macroinvertebrate populations, and improve aesthetics.

Benefits	**Challenges**
• Reduced exposure to sunlight results in decreased water temperature in channel and downstream to support aquatic life • Provides pleasant aesthetic for residents	• Property and maintenance agreements
Capital Cost: $204k	**Annual O&M Cost: $1.7k**

Conceptual Design: Laughing Jacobs Lake Downstream Channel Native Vegetation Restoration, Cont.

Assumptions/Considerations

- Easements and coordination with property owners may be required.
- Native species would be planted in accordance with the City Critical Areas ordinance.
- Before project approval, a planting plan would be developed by a licensed landscape architect specifying plant species, quantities, locations, size, spacing, and density. Estimated costs reflect planning level detail based on preliminary information. Actual costs may vary.

Planning Level Cost Estimate

Capital Costs				
Line Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Mobilization	%	10%	1	$10,063
Water Pollution/Erosion Control	%	5%	1	$5,031
SPCC Plan	LS	$625	1	$625
Grubbing/Soil Prep	SY	$6	2000	$12,500
Landscaping	SY	$44	2000	$87,500
Subtotal				$115,719
Washington State Sales Tax			10%	$11,572
Construction Contingency			50%	$57,859
Construction Subtotal				$185,150
Permitting			10%	$18,515
Total Capital Cost				$204,000

O&M Costs				
Line Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**
Labor	Hr	$94	16	$1,500
Incidentals	%	10%	1	$150
Annual O&M Cost (2021 Dollars)				$1,700