LOST URBAN CREEKS

Springbrook Creek Watershed Final Water Quality Monitoring Report For 2019/2020 and 2020/2021



August 2022

A project of

PUGET SOUNDKEEPER®

In partnership with

UTB UNLEASH THE BRILLIANCE

SNO-KING WATERSHED COUNCIL

FORTERRA LAND FOR GOOD

King County Drainage District 1

Abbey Road GROUP

With support from

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Russell Family Foundation

river NETWORK connecting people saving rivers

National Park Services

Keta Legacy Foundation

Kent Community Foundation

Figure 1: UTB Intern conducting a Turbidity test

Introduction

The Lost Urban Creeks Project highlights streams in urban areas, streams that have a history of abuse and neglect. These creeks often flow through communities most impacted by pollution and social injustice, highlighting environmental inequities in our region. Many of these creeks used to support salmon but salmon and other species sensitive to pollution can no longer be found or are in decline in these urban waterways. They can even pose a human health threat to the communities around them.

In our project, we chose to examine the water quality of Springbrook Creek, which flows through South King County and historically supported healthy runs of Chinook salmon. Its headwaters are still so pure that the City of Renton uses its springs as a source for drinking water[1]. But as Springbrook Creek flows through developed areas of Kent and Renton, it is quickly surrounded by homes, businesses, parking lots and impervious surfaces that deliver pollution and sediment to the creek from stormwater runoff. The creek is also overrun in many placed by invasive species and in many areas lacks an adequate tree canopy to provide shade for the creek to improve water temperature conditions. Today no salmon are found in a watershed where they used to spawn. Some segments of the creek may pose a human health concern for the surrounding communities due to bacteria contamination.

Youth from Unleash the Brilliance (UTB), a unique youth mentoring program have been working with Puget Soundkeeper Alliance and other partners to restore the health of Springbrook Creek. UTB Youth have contributed over 3000 hours of paid work to protect clean water in Puget Sound. In the Lost Urban Creeks Project, they participate in the following activities along Springbrook Creek:

- **Monitoring Water Quality** – Regularly monitor water quality along the creek to document conditions and identify pollution.
- **Restoring Habitat** – Plan and conduct restoration work in the Black River Forest and new restoration efforts along Springbrook Creek. Doing regular clean-ups along the creek and surrounding region.
- **Building Community** – Many people live, work, and play near Springbrook Creek. UTB Youth engage community members in their work to improve the creek for everyone to enjoy.
- **Developing the Skills of the Youth** – Build environmental literacy to become future leaders, re-connecting to their education, and increasing their job skills.

This paper documents the results of two years of the water quality monitoring efforts in the Springbrook Creek that included the wet (Oct to Apr) and dry seasons (May to Sep) for 2019-2020 and 2020-2021. Our hope is to understand better the challenges for salmon to return to Springbrook Creek and the opportunities and potential for this watershed to achieve fishable, swimmable, and drinkable waters.

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[1] *The City of Renton has a groundwater water right for 1050 gallons per minute (gpm) from the infiltration (spring) area, but currently use only up to approximately 750 gpm. No water is returned to the creek. (Personal communication, Lauren Imhoff, Senior Program Specialist, City of Renton Public Works, Feb 19, 2021).*

Background

Springbrook Creek is a part of the Green-Duwamish River Watershed and is the largest sub-basin of the lower Green River Basin. It drains an area of about 15,763 acres[2]. Others have studied Springbrook Creek and its water quality in the past[3] and have provided a list of reasons explaining the decline in salmonid use, including riparian conditions, hydrology modification, sediment conditions, water quality, and land use. Springbrook Creek is also on a Washington State list[4] of impaired streams due to water quality violations for high temperatures and low dissolved oxygen levels at multiple locations[5]. This appears to be a chronic seasonal occurrence and is believed to be the result of low summer water flows, lack of adequate riparian vegetation and shade, and pollution[6]. Two other organizations are conducting water quality monitoring in the Springbrook Watershed. King County (2022) monitors one location (Station 317) in the lower watershed monthly and Drainage District No. 1 (2022) monitors nine locations in the middle and lower basin, twice a year (as well as four additional stations in the spring of 2021). In 2021, King County determined that Springbrook is rated as a stream with poor water quality on its Water Quality Index[7] (King County, 2022a).

More information can be found about the larger Green River Basin of which Springbrook is a part can be found at: https://kingcounty.gov/services/environment/watersheds/green-river.aspx.

Methods

Youth interns of the Lost Urban Creek Project were trained in July of 2019 and again in the summers of 2020 and 2021 by the Sno-King Watershed Council to conduct water quality monitoring of Springbrook Creek Watershed using methods established by the Alabama Water Watch and Global Water Watch (AWW/GWW) as well as those outlined in our LUC Quality Assurance Program Plan (QAPP) [8]. Each year, eight locations (see Appendix B) were monitored throughout the watershed for water and air temperature, pH, dissolved oxygen, specific conductance, turbidity, total dissolved solids, nitrates, and salinity. Weather and site conditions were noted, and garbage was collected at these sites. In addition, youth interns were trained in September 2020 in Global Water Watch Biomonitoring protocols and conducted sampling of six locations in the watershed (on Springbrook, Mill and Panther Creeks) to develop a Cumulative Index Value (CIV) of the benthic invertebrates

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[2] Kerwin, J. and Nelson (2020) WRIA 9 Habitat Limiting Factors and Reconnaissance Assessment for Salmon Habitat Report, Part3.3-2

[3] Ibid. Regular monitoring has taken place at one station on Springbrook near Longacres in Renton (KCM-0317) starting in 1996 and became monthly monitoring in 2004 under the King County Ambient and Wet Weather Streams Monitoring program. In addition, Drainage District #1 monitors several locations in the watershed twice a year 2008.

[4] State Department of Ecology's 303(d) list

[5] Kerwin, J. and Nelson (2020) P3.3-12.

[6] Harza (1995) in Kerwin, J. and Nelson (2020).

[7] The Water Quality Index (WQI) is based on several water quality parameters, which are used to create a single score between 1 (poor water quality) and 100 (good water quality) that can then be used to compare different waterbodies. Stations scoring 80 and above meet water quality standards and are of "low concern", scores 40 to 80 indicate "moderate concern", and water quality at stations with scores below 40 are of "high concern." For the most recent year of sampling (2021), Springbrook had a score of 26.

[8] Forterra NW & Puget Soundkeeper Alliance. (2020). Approved by EPA Region 10.

present in these stream locations. Sampling protocols are outlined in the LUC QAPP and the AWW/GWW Quality Assurance Program Plan[9].

Site locations were identified using a three-letter code for the name of the creek (e.g., SPR for Springbrook Creek, MIL for Mill Creek, and PAN for Panther Creek) and a number for the number of river miles the site was located from the mouth of the creek (e.g., SPR1.4 is at Springbrook Creek, 1.4 river miles from the mouth of the creek). The higher this number, the higher up in the watershed the site is located. See Appendix A for the full list of sites monitored in both years.

A YSI ProPlus multimeter and a LaMotte Water Quality Testing Kit were the main equipment used along with a turbidity tube and telescoping measuring rod. Equipment calibration, training, data collection and management are all detailed in the Lost Urban Creek Sampling plan. Biomonitoring used a kick net, a D-net, a Surber sampler (used variously at two sites in Mill Creek Earthworks Canyon Park, MIL5.3 and an adjacent site approximately 850 feet upstream above a sedimentation pond) and leaf packs were used at four additional sites (SPR3.0, SPR1.4, MIL0.8, & PAN0.0), which were placed in the stream a month prior to the assessment.

For basic water quality parameters, we visited sites monthly from September 2019 to September 2021 (both wet & dry Seasons)[10]. During the 2nd year of sampling (2020-2021), we modified some of the sites we visited to include additional sites on Mill Creek and add an upstream site on Panther Creek. Biomonitoring was only done in September 2020. Appendix A and B have the list of sample locations and map showing sites for each year that are included in this analysis (Results for additional sites sampled in the mid-basin of Springbrook Creek in the first year can be found in the 2021 Puget Soundkeeper Report but were excluded from this analysis). Sites were selected to see water quality variability along Springbrook, Mill, and Panther Creeks between upper and lower watershed stations (though an upper Panther Creek site provided this information only in the 2nd year of monitoring and the location of the
downstream Mill Creek Site differed between the two monitoring years).

Monitoring results were compared to Water Quality Standards for Surface Waters of the State of Washington's Administrative Code. See Chapter 173-201A WAC (WADOE, 2022)

Results

0Appendix A: Sample Locations**Error! Reference source not found.**Sites from which additional data discussed in the following sections are shown in the map in Appendix D. This data comes from King County or the Drainage District No. 1. Below,

Table *1* provides an overview of all data collected by the Lost Urban Creeks Project during both the wet and dry seasons in the Springbrook Creek Watershed.

During the wet season, most water quality parameters, such as water temperature, pH, Specific Conductance, etc., were well within the range that would allow salmon to survive but results for

[9] *Alabama Water Watch and Global Water Watch (AWW/GWW). (2019).*

[10] *The number of sites visited in September 2019 and November 2019 were limited (4 sites and 1 site, respectively).*

three parameters (highlighted in yellow) indicated that there were some concerns. During the dry season, which had lower rainfalls (except in September) and lower stream flows, water temperatures increased significantly with one site exceeding State temperature standard (MIL0.8) in May; six sites fell below State standards for dissolved oxygen, and two sites had high turbidity (consistently so at PAN0.0 throughout the dry season).

Table 1: Springbrook Creek Water Quality Data Review for the wet and dry season (2019-2021)

Year		Water Temp. (deg. C)	pH	DO (mg/L)	SPC (µs/cm)	Turbidity (NTU)	TDS (mg/L)	NO3-N (mg/L)	Garbage Collected (lbs)	Rainfall during visit (inches)	Flow (ft^3/s)
2019-2020	**Wet Season Mean (Average)***	9	7	8	144	<10	79	1.4	8	3.5	9.8
	Wet Season Minimum	6	6	2 (at PAN0.0 on Oct 2019)	66	<10	1	0.1	0	0 (in Oct, Nov, & Apr)	1
	Wet Season Maximum	17 (at MIL0.8 on Apr 2020)	8	13 (at MIL5.3 on Feb 2020)	253 (at SPR5.0 on Oct 2019)	40 (at PAN0.0 on Feb 2020)	199 (at SPR1.4 on Feb 2020)	4.5 (at SPR5.0 on Mar 2020)	92.0 (at MIL4.2)	1.96 (in Dec 2019)	99 (at MIL0.8 on Dec 2019)
2020-2021	**Wet Season Mean (Average)***	11.1	7.1	7.7	186.9	<10	114.4	1.3	6.7	3.8	9.5
	Wet Season Minimum	3.9	6.4	0.1 (at PAN0.0 in Oct 2020 and MIL2.0 in Sep 2020)	68	<10	44.2	0.5	3	0	1.38 (at MIL5.3 in Mar 2021)
	Wet Season Maximum	13.2 (at PAN0.0 in Apr 2021)	8.1	14.4	265.4 (at PAN0.0 in Apr 2021)	19 (at PAN0.0 in Oct 2020)	172.3 (at PAN0.0 in Apr 2021)	5.9 (at SPR5.0 in Dec 2020)	23 (at MIL4.8 in Oct 2021)	0.3	46.9 (MIL2.0 in Dec 2020)
2019-2020	**Dry Season Mean (Average)***	15.2	7.3	5	219.5	<10	143.5	1.5	3.3	1.2	4.7
	Dry Season Minimum	11.9 (at SPR5.0 on Sep 2020)	6.1	0.1 (at PAN0.0 on Aug 2020)	100.3 (at MIL4.2 on Jun 2020)	<10	65 (at MIL4.2 on Jun 2020)	0.57 (at MIL0.8 on Jun 2020)	0.5 (at SPR4.3 on Sep 2020)	0.01 (in May 2020)	0.05 (at MIL0.8 on Jul 2020)
	Dry Season Maximum	19.6 (at MIL0.8 on May 2020)	8.1	12.7 (at MIL5.3 on Aug 2020)	440.6 (at PAN0.0 on Aug 2020)	90 (at PAN0.0 on Aug 2020)	286.7 (at PAN0.0 on Aug 2020)	2.98 (at MIL5.3 on May 2020	94 (at MIL0.8 on Sep 2020)	0.57 (in Sep 2020)	15 (at MIL0.8 on Jun 2020)
2020-2021	**Dry Season Mean (Average)***	15.2	6.8	3.19	268.1	<10	155.3	0.7	2.9	0.4	3.8
	Dry Season Minimum	11.1	6.3	0.1 (at MIL3.2 in Jun 2021 and MIL2.0 in Sep 2021)	188.3	<10	2.41	0.3	0.5	0	0.19 (at MIL2.0 in Aug 2021)
	Dry Season Maximum	20.7 (at MIL3.2 on Jun 2021)	7.9	11.5	571.3	65	370.2	3.7	15.5	0.3	2.41 (at MIL2.0 in Jun 2021)
	Total								650		

**Geometric means taken from monthly precipitation data for Kent, WA (NOAA,2021) and monthly flow data from USGS Station 12113346 Springbrook Creek at Orillia, WA (USGS, 2021).*

For the purposes of comparison between the data from the two calendar years, the following data discussion will only cover the uppermost stations and stations closest to the mouth on each stream that were monitored in each year to simplify the comparison to one upstream and one downstream station on each creek. For Springbrook Creek, this includes SPR5.0 and SPR1.4 (these were monitored in both years). For Panther Creek, this includes PAN2.0 (monitored only in the 2nd year) and PAN0.0. And for Mill Creek, this includes MIL5.3 and MIL0.8 (only monitored in the 1st year) and MIL2.0 (only monitored in the 2nd year). Refer to the map in Appendix B. For discussion of results from other sample locations, which were all monitored in the first year, please refer to our previous report (Puget Soundkeeper Alliance, 2021).

1. Dissolved Oxygen (DO)

Based on new research, the Washington State standard for aquatic life (specifically the spawning, rearing and migration of salmon) was revised as of April 2022. Dissolved Oxygen in the water column should be at least 10 mg/L (represented by the dashed red line in the charts below). This standard was previously at least 8 mg/L or higher. From Figure 2 thru Figure 5 below the monitoring data shows that the lower stations on Springbrook, Panther and Mill Creek are consistently, with one exceptions (PAN0.0) in the second wet season, failing to meet State Water Quality standards for Dissolved Oxygen. Sampling results near the mouth of Panther Creek where it meets Springbrook Creek (PAN0.0) in Renton, indicates that this station has routinely some of the lowest dissolved oxygen levels in the entire Springbrook Basin, particularly in summer. This station is often very stagnant with very slow flows and excessive algal growth, as was site MIL2.0 during the 2020-2021 monitoring year. Between June and July of 2021 (the second dry season), even the upper Panther site (PAN2.0) and once the upper Mill Creek site (MILE5.3) also failed to meet Ecology's current dissolved oxygen standard.

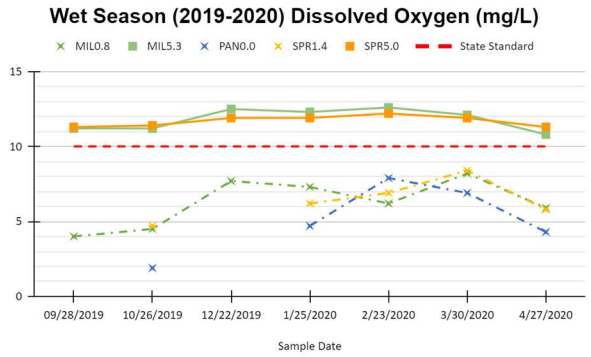

Figure 2: Wet Season Dissolved Oxygen for 2019-2020[11] (red dashed line is the current State standard)

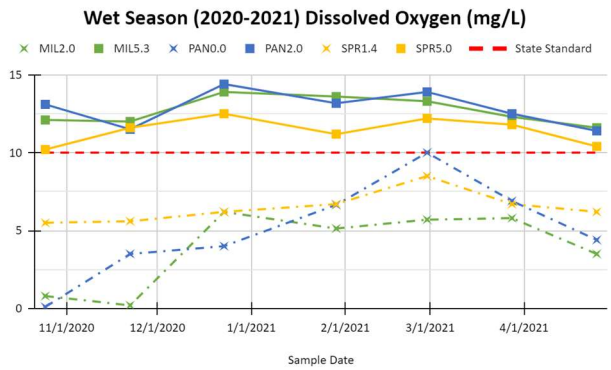

Figure 3: Wet Season Dissolved Oxygen for 2020-2021 (red dashed line is the current State standard)

[11] Points on the line graphs presented in this report represent monthly, discreet results and do not infer that data follows the line between sample dates. This is done for the readability of the graphs, but we do not have data to support the pattern shown by the line graph outside sample events.

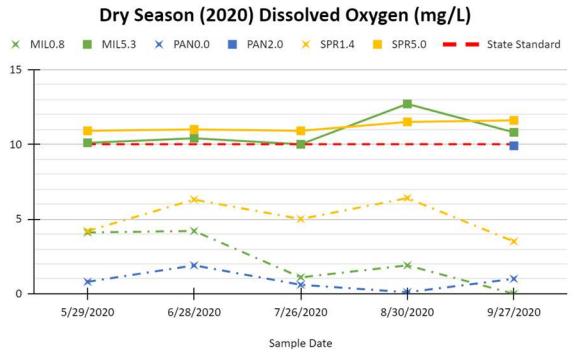

Figure 4: Dry Season Dissolved Oxygen for 2020 (red dashed line is the current State standard)

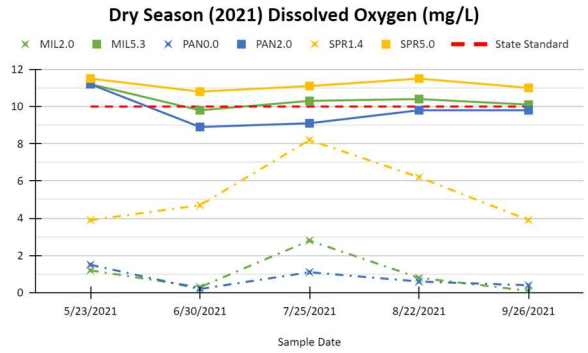

Figure 5: Dry Season Dissolved Oxygen for 2021 (red dashed line is the current State standard)

Drainage District No. 1 is also monitoring twice a year at nine stations in the middle and lower Springbrook Creek Basin (Springbrook, Mill, and Garrison Creeks) as well as three sites in Panther Creek in 2021. Table 2 provides an overview of their results for dissolved oxygen as compared to current State Standards.

Table 2: Drainage District Dissolved Oxygen monitoring results in Springbrook Creek Basin (2022)

	Wet Season (2020)*	**Dry Season (2020)***	**Wet Season (2021)****	**Dry Season (2021)***
Number of Samples Meeting State Standard	2	None monitored	2	1
Number of Samples Not Meeting State Standard	7		11	8

**Nine sites in Springbrook, Mill, & Garrison*
***13 sites (4 additional sites monitored on Panther Creek but their location is unknown)*

Monthly results from King County's monitoring of their one site (station 317), which is downstream from SPR1.4 showed that the highest results for dissolved oxygen at this lower creek site reach only as high as 8.2 mg/L during two of their monthly samples (in December 2020 and January 2021) and for all other readings did not meet even the previous States dissolved oxygen standard of 8 mg/L.

2. Temperature

The Washington State Temperature Limit for salmonid streams waters should always be ≤17.5 °C. During the wet seasons for both years, stream temperatures met the State water temperature standard. During the dry season for both years, we occasionally saw temperatures rise above the State standard as some of the lower stations. These were MIL0.8 and SPR1.4 in the first-year dry season and MIL2.0 and SPR1.4 in the second-year dry season. During the second-year dry season, a heat wave hit the area at the end of June 2021, in which area air temperatures reached 106°F (41°C). Monitoring was rescheduled to June 30th when cooler conditions returned but water temperatures were still the highest seen (20°C or higher) during the two years of monitoring work at all three of the lower sites (SPR1.4, MIL2.0 & PAN0.0).

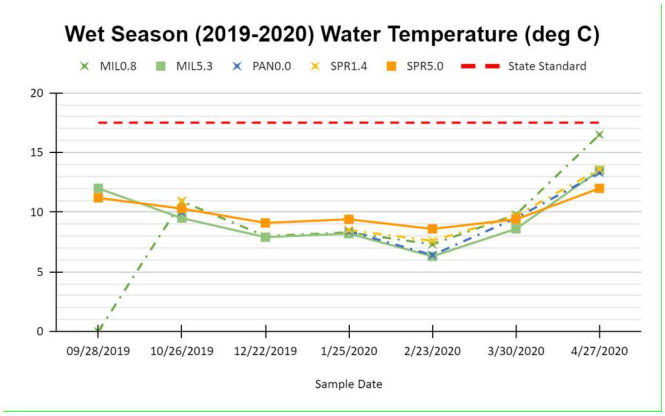

Figure 6: Wet Season Temperature for 2019-2020 (red dashed line is the current State standard)

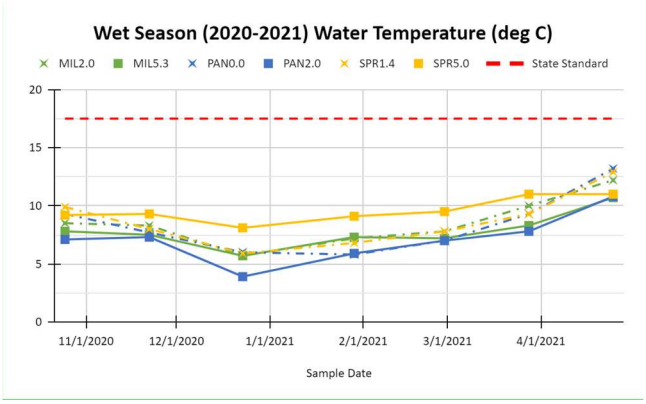

Figure 7: Wet Season Temperature for 2020-2021 (red dashed line is the current State standard)

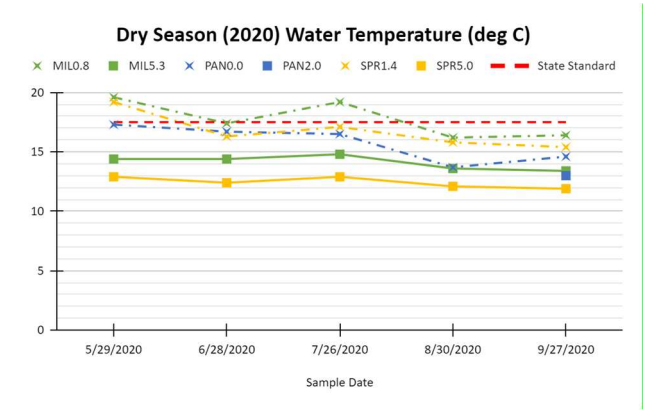

Figure 8: Dry Season Temperature for 2020 (red dashed line is the current State standard)

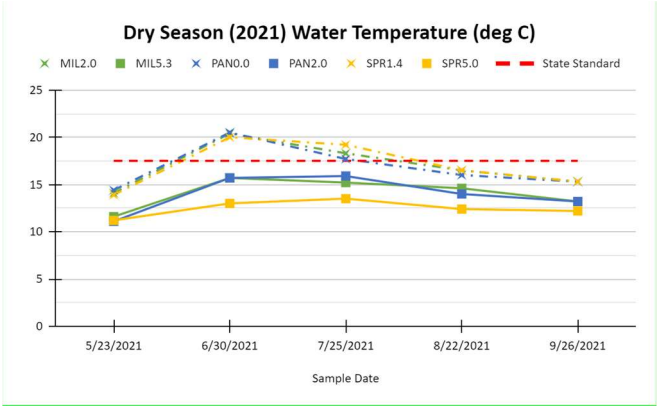

Figure 9: Dry Season Temperature for 2021 (red dashed line is the current State standard)

3. Specific Conductance

There is no state standard related to this water quality parameter, which is simply a measure of water's ability to conduct electricity. Conductivity is not a pollutant itself but serves as an indicator of the presence of pollutants. Conductivity of water is affected by the presence of dissolved substances in the water, including salts and heavy metals. Some of these substances are harmful to aquatic life and to humans, especially at high concentrations.

Over the two monitoring years, we saw that conductivity readings (SPC) tended to be higher in the dry season and during this time it was typically higher at the lower stations in the watershed (See

Table *1* and the figure below, which shows the 2nd dry season results demonstrating this dynamic). In the wet season for both years, the upper station on Springbrook Creek (SPR5.0) usually had the highest SPC values. This station is very close to the springs that form the source of the creek and may indicate the mineral inputs from groundwater that influence this site.

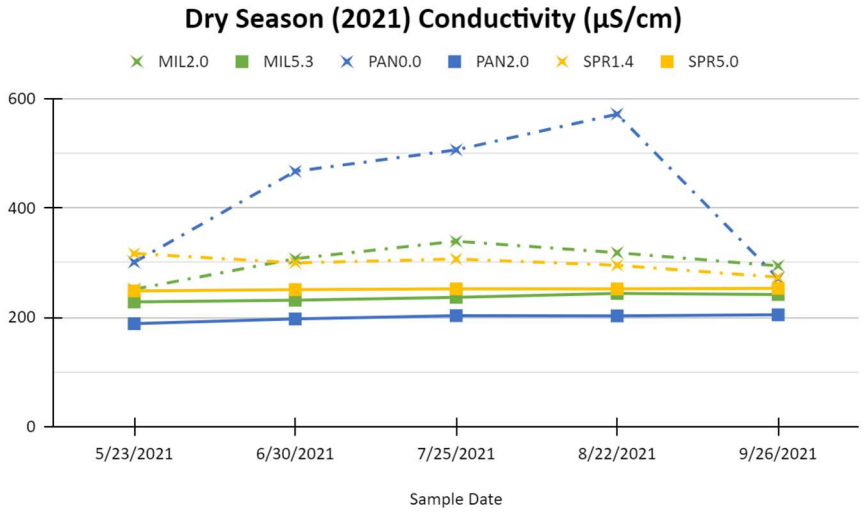

Figure 10: Specific Conductance in the 2nd Dry Season Monitoring

4. Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by suspended solids floating in the water and is measured in units called nephelometric turbidity units or "NTUs." Due to winter rains bringing more sediment into the creek, we might expect to see higher turbidity levels in the wet season. For Salmon and according to Washington State standards, turbidity should not be more than 5 NTU over the normal background level of turbidity (which for Springbrook Creek should be approximately 10 NTUs).

During both wet seasons, we saw occasional high turbidity levels in the lower stations, specifically PAN0.0 in both years and SPR1.4 and MIL0.8 in the first year (i.e., ≥15 NTU). During the dry seasons, when there are generally fewer rainfall events, we expect the waters of Springbrook to be clearer and have lower turbidity levels. Results showed that this was generally true for most sites except Panther Creek. PAN0.0 had consistently higher turbidity levels in both years than even its winter values. MIL0.8 also had somewhat elevated turbidity levels in August for the 2019-2020 monitoring year but MIL2.0, the lowest site on Mill Creek in the second (2020-2021) monitoring year often had similar or higher turbidity levels than Panther Creek's lowest station.

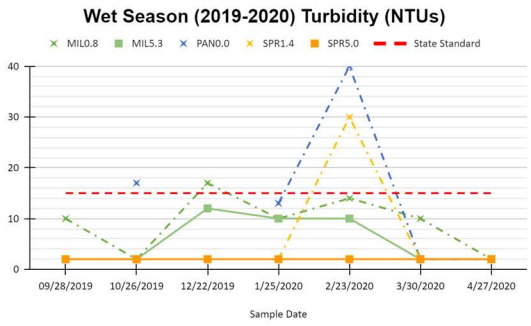

Figure 11: Wet Season Turbidity for 2019-2020

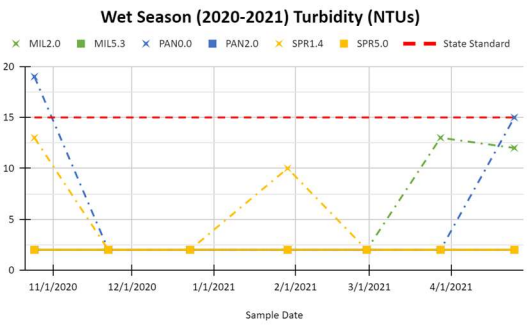

Figure 12: Wet Season Turbidity for 2020-2021

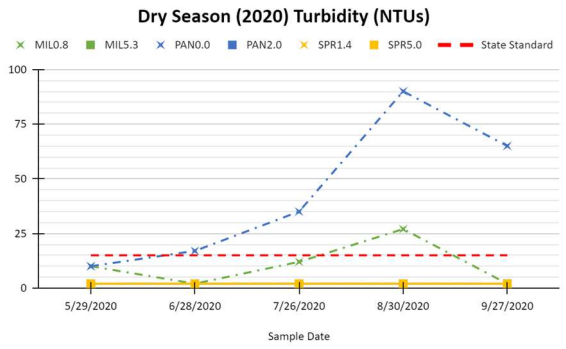

Figure 13: Dry Season Turbidity for 2020

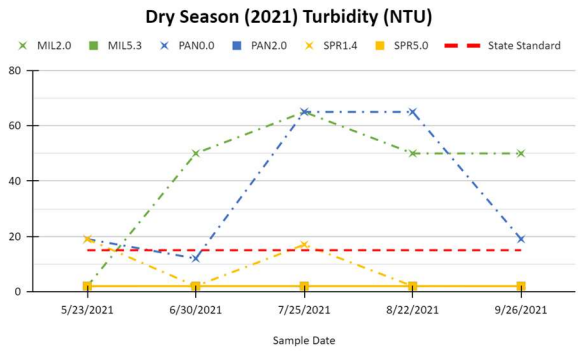

Figure 14: Dry Season Turbidity for 2021

5. Biomonitoring

Biological assessments were only conducted at five locations in the Springbrook watershed in the first year of monitoring (on September 5th 2020). Invertebrate species (bugs) living in the stream were sampled and counted to create a measurement of a stream's biological diversity based on the classifications and counting of three species groups (Group 1 species indicate good to excellent water quality; Group 2 species indicating fair water quality, and Group 3 indicate poor water quality). This information is used to calculate a *Cumulative Index Value* for the stream. A fuller discussion of this work can be found in the 2021 report (Puget Soundkeeper Alliance), but the results of this survey are including here, which indicate a deterioration in stream conditions in the lower areas of the Springbrook Watershed.

Figure 15: UTB Intern doing bioassessment

Table 3: Springbrook Creek Bioassessment Results

Site	Cumulative Index Value	Stream Quality Assessment
MIL5.3	28	Excellent
Upstream of MIL5.3, upstream of sedimentation pond	16	Fair
MIL0.8	8	Poor
SPR3.0	5	Poor
SPR1.4	4	Poor
PAN0.0	2	Poor

6. Garbage Collected

In the two years of the project 650 pounds of garbage was collected and removed at from the monitoring sites as well as other locations in the Springbrook Creek and lower Duwamish Watershed. The work was done in collaboration with the Kent Adopt-A-Spot program and the Cities of Kent and Renton's Public Works Departments picked up all garbage that was collected.

7. Fecal Bacteria

Bacteria sampling was not part of the Lost Urban Creeks Project between 2019-2021. Bacteria sampling was done by the Drainage District during and prior to the survey period. Their samples showed elevated fecal coliform bacteria concentrations at most of their stations in the middle and lower Springbrook Watershed. Under fecal coliform rules[12], exposure to waters containing fecal coliform concentrations with a geometric mean value of 100 colony-forming unit (CFU) per 100mL or higher is considered a health risk. These stations are listed as a 'Hot Spot' in the table below. A single result exceeding this 100 CFU level is considered a 'High Hit' and is highlighted with yellow in the table. In addition, a single sample obtained that exceeds 200 CFU per 100mL is also considered a health risk and these waters are also automatically considered a 'Hot Spot' (they are highlighted in red in the table below, which contains the full list of the Drainage District's results (2022) during the project period).

Table 4: Fecal Coliform Results from Drainage District No. 1 sample locations during the project period (To see the location of these sites in watershed, see the map in Appendix D)

	Sample Months					
Site	**Sep-2019**	**Nov-2020**	**May-2021**	**Sep-2021**	**Geomean**	**Result**
1-Springbrook	**410**	42	140	**950**	219	Hot Spot
2-Garrison	**225**	62	**352**		170	Hot Spot
3-Mill	**800**	32	**710**	**650**	330	Hot Spot
4-Mill	90	1	110	**750**	52	Hot Spot
5-Mill	130	16	12	10	22	High Hit*
6-Garrison	**300**	38	74	**850**	164	Hot Spot
7-Springbrook		96	78	**350**	138	Hot Spot
8-Springbrook	**300**	38	**208**	**48**	103	Hot Spot
9-Mill	50	76	90	140	83	High Hit

*Subsequently this site had a concentration of 460 CFU/100mL in Apr-2022, which would make this a Hot Spot site

King County's (2022b) monthly monitoring at Station 317 included 14 results between October 2019 and January 2021. The 2019-2020 winter geomean for fecal coliform was 78 CFU/100mL and the 2020 summer geomean was 216 CFU/100mL. In addition, five of the 14 results were over 200 CFU/100mL and confirm this location as a Hot Spot for bacteria contamination.

Discussion

Based on the two years of water quality monitoring conducted in the Lost Urban Creeks Project, which were evaluated against current State Standards (Ecology, 2022) that are based on requirements for salmon and the protection of human health, three water quality parameters indicate concerns in the Springbrook Creek Watershed. At certain stations, typically lower in the Springbrook Watershed, dissolved oxygen, turbidity, and temperature indicate poor water quality.

1. Dissolved Oxygen

For dissolved oxygen, this is very clear in both the wet and the dry season, where the lower stations in the basin regularly do not meeting State standards (i.e., dissolved oxygen levels are lower than the

[12] *This rule expired in December 2020 and was replaced with a standard based on E. coli concentrations.*

10 mg/L standard). Drainage District No. 1 (2022) monitoring during the same project period found that only one to two of their stations (both Mill Creek Stations in the middle and lower basin) met the State's standard and King County monthly data (2022b) at one station in the lower basin during the project period never met the current State standard.

Water temperature can impact dissolved oxygen levels (see discussion below) and high nutrient content in the water can also lead to low dissolved oxygen because nutrients encourage plant growth but as plants start to die off and are consumed by other organisms, this can cause oxygen to be removed from the water. Nitrate levels were generally between excellent (< 1 mg/L) and fair (between 3 to 5 mg/L) during the wet and dry seasons, but other forms of nitrogen were not tested, but King County (2022a) monthly nutrient data for Station 317 in 2021 is more comprehensive and the Water Quality Index score indicated that phosphorus is likely a concern in Springbrook[13].

Low and/or stagnant water flows and a lack of turbulence can also lower the dissolved oxygen in the creek, and this may be the case as much of the lower part of the watershed is quite flat and water flow was often slow to moderate. The Black River Dam/Pump Station and culverts (i.e., at Panther Creek and Highway 167) contributes to lower flows and potential stagnation in the lower basin as well. High levels of Iron bacteria found throughout the watershed but particularly in Panther Creek can also consume oxygen and may contribute to low levels. Other pollutants in stormwater that wash into the stream during the winter are likely also impacting dissolved oxygen levels as indicated by conductivity levels (see Figure 10), but this was beyond the scope of the current project to evaluate.

2. Temperature

For temperature, elevated temperatures occur only during summer but again exceedances of the State temperature standard took place primarily in the lower basin sites. This is a concern to any resident fish or young salmonids using the Springbrook Creek's lower reaches as a refuge during the summer. King County monthly results at Station 317 had no exceedances. The Drainage District, which samples only in spring and late summer, did not usually have exceedances but in 2019 when sampling took place in September, six out of their nine sites had exceedances of the temperature standard. Higher conductivity measurements also indicate potential problems in the lower basin particularly in the dry season.

The amount of oxygen dissolved in water is affected by water temperature, as warmer water has less oxygen. While water temperature was within acceptable ranges at many sites during the wet season, when salmon could be spawning in the creek, parts of the creek have limited to almost no riparian vegetation to provide shade to the water. Summer water temperatures at some of these lower watershed site in May and July of the first monitoring year and June and July of the second monitoring year exceeded the State Temperature Limit, which would be harmful to any resident salmonids and other sensitive species.

3. Turbidity

Turbidity followed the same pattern as oxygen levels with waters in the upper basin sites being relatively clear but becoming increasingly turbid as the streams progress downstream. This was

[13] *The Water Quality Index in 2021 for total nitrogen was 99 (low concern) while total phosphorus was 1 (high concern).*

particularly true during the dry season though occasionally SPR1.4, MIL0.8, and PAN0.0 had elevated turbidity in the first wet season and PAN0.0 had occasional higher turbidity in both wet seasons.

Water with high turbidity levels can clog fish gills of salmonids and suffocate them. High levels of conductivity and total dissolved solids also often correlate with high turbidity. The particles in highly turbid water also attach to other pollutants, such as metals and bacteria. Most Northwest creeks, urban or not, usually have near zero turbidity outside of rain events. High stormwater flows can bring in more pollution from the surrounding land to the creek or re-suspend the sediments in the creek. While there were six spikes in turbidity in the middle and lower Springbrook Creek stations the first wet season, in the second wet season, this only happened at PAN0.0. Conversely, during the dry season when we might expect lower turbidity, two sites frequently still had high turbidity (PAN0.0 from June through September in the first and second dry seasons & MIL0.8 in August of the first dry season and in July through September in the second dry season). Panther Creek turbidity was typically much higher in the dry season, and we speculate that this is caused by or worsened by high levels of iron bacteria that give an orange color to the water (see photos below).

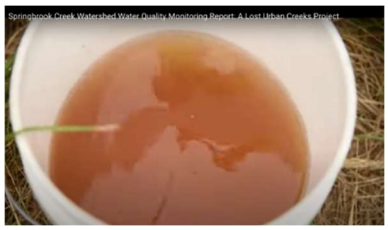

Figure 16 & Figure 17: During both dry seasons water at Panther Creek (PAN0.0) had high turbidity and an orange-color cause by iron bacteria (2019-2020 monitoring season)

4. Biomonitoring & Bacteria

Biomonitoring results at six locations in Springbrook, Mill and Panther Creeks from the first monitoring year showed very poor water quality in the lower basin sites of all three creeks when compared to two upper basin sites in Mill Creek that had fair to excellent results. This supports the other results that indicate a significant decline in the water quality the further you travel downstream in the watershed.

Bacteria data from the Drainage District for the project period indicated that seven of the nine regularly monitored sites in the middle and lower basins exceeded State bacteria standards and are considered bacteria Hot Spots for contamination. Only the most downstream and one middle basin Mill Creek Sites (Sites #5 and #9) had single, elevated high hits, though Site #5 in the middle basin should now be listed as a bacteria Hot Spot as well due to a high concentration result seen in April of 2022. King County monthly data during the project period also indicate that their station (the lowest in the watershed), is also a bacteria Hot Spot.

This indicates that there are potentially extensive health risks to any humans exposed to these waters. Bacteria sources causing contamination can come from either wildlife, pets, or humans. Wildlife and pet sources, while contributing to bacteria in the creek, are likely not the main sources of contamination in the middle and lower basin due to the limited residential and recreational areas

along the creek and the high level of commercial development in this area. The entire area is on a sanitary sewer and sewer main lines and side sewer lines lace the area. Leakages in this system could cause contamination. Additionally, contamination can come from homeless encampments without sanitation that exist in some areas along the creek.

5. Garbage

For garbage, as reported in our previous report (PSA, 2021), trash tends to accumulate most at those sites that offer easy access to the creek but are also less visible to the public, so that dumping of trash is less noticeable. PAN2.0 is a relatively inaccessible site but next to a busy road and seems to collect a large amount of trash from highway traffic as well as use debris from homeless populations. As was noted in our first report, garbage also appears to also accumulate where there is a lack of connectivity in the trail system and where there is a lack of trash receptacles, such as where the Springbrook Creek Trail ends in Renton on the border with the City of Kent.

Recommendations

Suggestions from the 2021 Puget Soundkeeper Report continue to be recommended. One recommendation relates to the need to develop a better understanding of specific areas of the creek where water quality declines:

- Evaluate nutrients impacts to Springbrook and identifying where oxygen levels consistently drop below State Standards.

Other recommendations are targeted to improving overall water quality to create better conditions for salmonids and sensitive species. These include:

- Evaluate how the operations of the Black River Pump Station can be changed to improve flows in the lower part of the watershed (particularly in regard to the Station Retrofit).
- Plant trees in areas of the creek lacking riparian vegetation to improve shading and help decrease water temperatures in the creek.
- Address water stagnation issues in lower Panther Creek by improving the culvert under State Route 167.
- Increased efforts to control stormwater flows through riparian and stream restoration and green stormwater infrastructure projects, which will help to filter out and/or biologically treat pollutants and sediment entering the creek.

Some recommendations related to addressing trash that gets into the creek:

- Give more attention to accessible but less visible areas of the creek, where trash is accumulating through programs like the Kent Adopt-A-Spot Program (with perhaps a program targeting commercial landowners to address trash accumulating on commercial sites).
- Extending the Springbrook trail system into the City of Kent (along Springbrook and Mill Creek) and provide amenities such as trash cans more frequently along the length of the trail.

In addition, based on data and information from King County and the Drainage District, new recommendations in this report try to address human health concerns caused by bacteria contamination and the need for a more comprehensive approach to the restoration of the entire

watershed to achieve more fishable, swimmable, and drinkable waters in Springbrook. These include:

- Investigate further to identify the source of bacteria inputs, such as adding a monitoring station(s) at an outfall upstream or other upstream sites and consider other source-tracking methods to identify where their bacteria is coming from such as bacteria DNA analysis.
- Develop a Springbrook Watershed Restoration Plan that involves all stakeholders that prioritizes restoration activities that are comprehensive for the entire watershed. This will have a more lasting impact over opportunistic and episodic restoration activities by different groups working separately. Individual projects (or at least their impacts on and implications for the restoration of the entire watershed) should be included together as part of a larger vision for Springbrook Creek that works to solve its chronic water quality health problems. These include, but may not be limited to, plans and projects such as:

    - Kent's Mill Creek Re-establishment Project,
    - Renton's proposed stream improvement projects (such as one to improve flow on Panther Creek),
    - King County's Black River Pump Station Retrofit Project, and
    - the Drainage District No 1's Planting Plan

Next Steps

The Lost Urban Creeks Project had hoped to participate in Kent's Mill Creek Re-establishment Project and successfully collected some baseline data in 2020-2021 but this project has been delayed. Instead, LUC continued regular monitoring into 2022 but switched to quarterly monitoring in Springbrook starting in October 2021 to allow the youth interns to visit other urban watersheds.

The 2021-2022 monitoring year includes two additional sites in Garrison Creek (another tributary to Springbrook in Kent) and monitoring sites on Longfellow Creek in West Seattle, and Des Moines, Barnes, Massey, and McSorley Creeks in Des Moines, Washington. Starting in October 2022, youth interns will continue quarterly monitoring in Springbrook Creek and select other comparison creeks for regular monitoring visits. In addition, in the summer of 2021, the project will introduce summer bacteria monitoring.

For more information about the Lost Urban Creeks Project, contact LUC@pugetsoundkeeper.org or find us on Instagram at @lost_urban_creeks.

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The following Unleash the Brilliance youth interns participating in monitoring, data entry, data analysis and presentations of the water quality monitoring effort in the Springbrook Watershed between 2019 and 2021: Adrian Maceda, Alana Biggers-Thomas, Alex Quirino, Ashley Jones, Atticus Shaw, Bless Graham, Cameron Kaiser, Chloe Trujillo, Cole Dozier, Danae Thomas, Donovan Thomas, Dylan Dozier, Emanuel Chavez, Hailey Davis, Hannah Park, Hyein Park, Imoleayo Alao, Jaelyn Patton, Jeremiah Bynum, Jonus Parrish, Joy Han, Kunati Sey Cruz, Lyla Chaudhary, Maximo "Max" David, Miguel Villasenor, Nick Varela, Noah Bagby, Quinn Tracy, Ruby Maceda, Shania Fleurine, Sharlene Pioquinto, Sydney Noel James, Taivion Gamble, and Yafet Amine.

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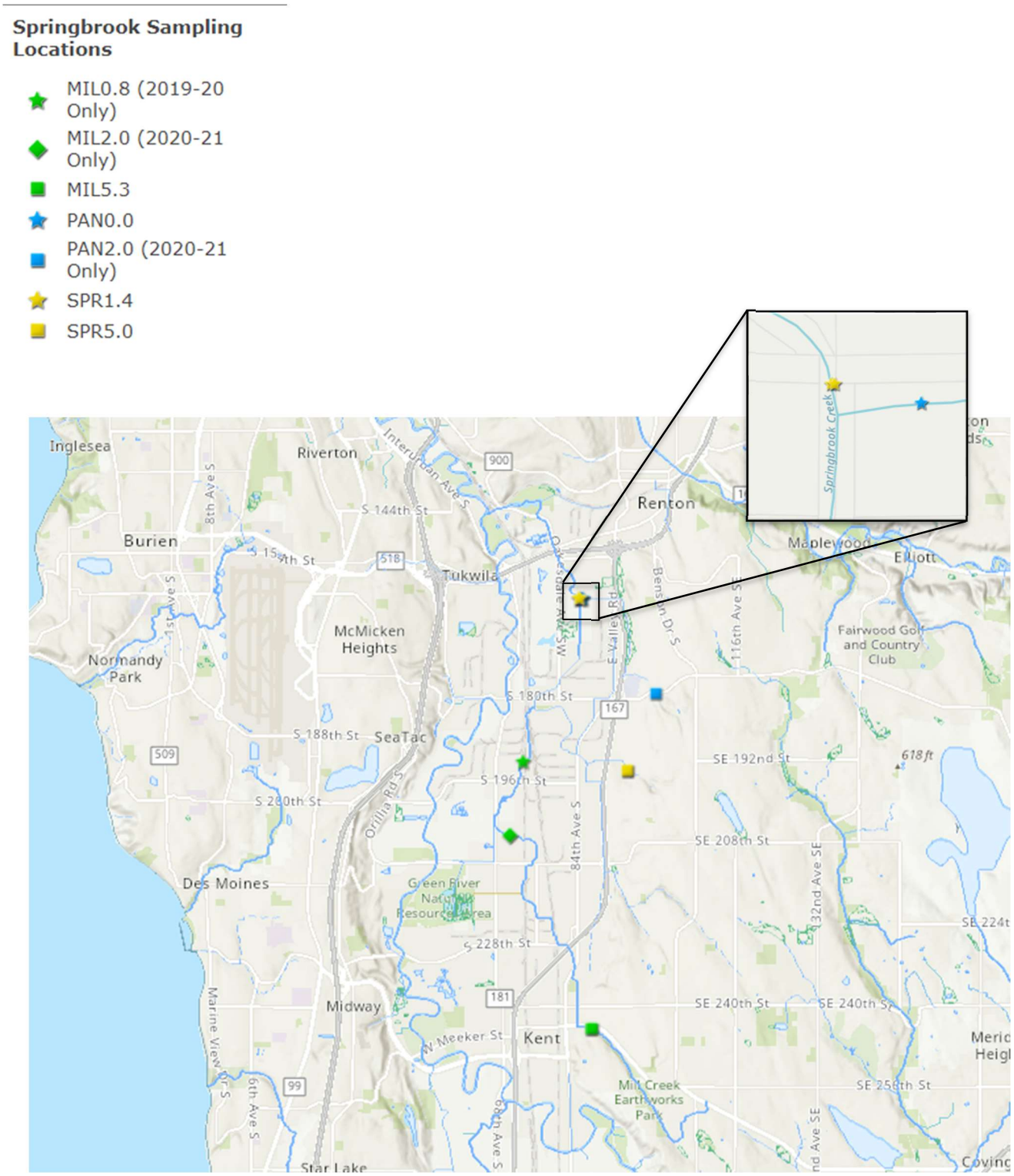
Water Resource Inventory Area (WRIA) 9 - Green/Duwamish and Central Puget Sound Watershed (December 2020).

Appendix A: Sample Locations

Locations for 2019-2020					
#	Site Code*	Site Name	Description	Latitude	Longitude
1	SPR1.4	Springbrook below Panther Creek - River Mile 1.4	Below confluence with Panther Creek	47.459	-122.2275
2	SPR3.0	Springbrook below Mill Creek - River Mile 3.0	Below Mill Creek Confluence - Facing Downstream	47.44088	-122.2392
3	SPR4.3	Springbrook below Garrison Creek - River Mile 4.3	Springbrook below Garrison	47.42986	-122.2257
4	SPR5.0	Springbrook - River Mile 5.0	Upper Springbrook Creek at Trout Farm – highest station	47.42852	-122.2150
5	MIL0.8	Lower Mill Creek - River Mile 0.8	Mill Creek – lowest station	47.43017	-122.2422
6	MIL4.2	Mill Creek - River Mile 4.2	Mill Creek near Ford Motor Co.	47.39606	-122.229
7	MIL5.3	Upper Mill Creek - River Mile 5.3	Upper Mill Creek – highest station	47.38282	-122.2246
8	PAN0.0	Lower Panther Creek - River Mile 0.0	Lower Panther Creek	47.45895	-122.2266
Locations for 2020-2021					
1	SPR1.4	Springbrook Creek - River Mile 1.4	Below confluence with Panther Creek	47.459	-122.22748
2	SPR5.0	Springbrook at Trout Farm - River Mile 5.0	Upper Springbrook Creek	47.42852	-122.21501
3	MIL2.0	Lower Mill Creek - River Mile 2.0	Lower Mill Creek	47.41708	-122.24568
4	MIL3.2	Middle Mill Creek - River Mile 3.2	Middle Mill Creek	47.40602	-122.24211
5	MIL4.8	Upper Mill Creek - River Mile 4.8	Upper Mill Creek	47.38688	-122.22809
6	MIL5.3	Upper Mill Creek - River Mile 5.3	Upper Mill Creek	47.38285	-122.22414
7	PAN0.0	Lower Panther Creek - River Mile 0.0	Lower Panther Creek	47.458940	-122.22709
8	PAN2.0	Panther Creek - River Mile 2.0	Upper Panther Creek	47.44212	-122.20759

**Site Codes consist of a 3-letter abbreviation for the name of the creek and a number representing the river miles to the mouth of the creek. For example, SPR5.0 is on Springbrook Creek 5 River Miles up from the mouth of the creek.*

Appendix B: Maps of sample locations



Appendix C: LUC Water Quality Data

Sample Date	Sample Time	Site Code	Precip. (inches)	Last Rain Date	Air Temp. (deg. C)	Temp. water (deg. C)	pH	DO (%)	DO (mg/L)	SPC (us/cm)	Turbidity (NTU)	TDS (mg/L)	NO3-N (mg/L)	Gauging station flow (ft3/s)
09/28/2019	14:50	MIL0.8	0.2	9/28/2019	14	NV	7	41	4		10			13.1
9/28/2019	11:27	MIL5.3	0.2	9/28/2019	11	12	7.4	104	11.2	97.3	2	63.7		0.74
09/28/2019	12:10	SPR5.0	0.2	9/28/2019	12	11.2	7.7	103	11.3	251.6	2	163.8		N/A
10/26/2019	13:44	PAN0.0	0.2	10/25/2019	11	10	7	17	1.9	180.7	17	17.65	0.07	N/A
10/26/2019	13:10	MIL0.8	0.2	10/25/2019	11	10.9	7	41	4.5	112.1	2	72.8	0.35	25.5
10/26/2019	13:59	SPR1.4	0.2	10/25/2019	11	10.96	7.1	42	4.7	150.6	2	96.85	0.7	N/A
10/26/2019	9:37	MIL5.3	0.2	10/25/2019	6	9.5	7.47	97	11.2	168.8	2	1.09	1.03	0.8
10/26/2019	10:58	SPR5.0	0.2	10/25/2019	8	10.3	7.5	100	11.4	253	2	165.1	1.85	N/A
12/22/2019	13:55	MIL0.8	1.96	12/21/2019	6	8	7.1	66	7.7	65.5	17	39	0.61	98.8
12/22/2019	12:00	SPR5.0	1.96	12/21/2019	6	9.1	7.2	104	11.9	200.5	2	130	4.13	N/A
12/22/2019	10:15	MIL5.3	1.96	12/21/2019	5	7.9	7	105	12.5	91.9	12	59.8	3.6	59
12/22/2019		PAN0.0	1.96	12/21/2019									NV	
12/22/2019		SPR1.4	1.96	12/21/2019									NV	
1/25/2020	13:39	PAN0.0	0.41	1/25/2020	11	8.4	6.9	40	4.7	148.2	13	96.2	1.17	N/A
1/25/2020	13:23	SPR1.4	0.41	1/25/2020	11	8.5	7	53	6.2	136	2	88.4	1.25	N/A
1/25/2020	14:40	MIL0.8	0.41	1/25/2020	11	8.3	7.3	62	7.3	118.9	10	77.35	0.9	62.3
1/25/2020	12:10	SPR5.0	0.41	1/25/2020	10	9.4	7.3	104	11.9	181	2	118.3	3.68	N/A
1/25/2020	10:23	MIL5.3	0.41	1/24/2020	11	8.2	7	105	12.3	99.5	10	66.3	2.3	40.7
2/23/2020	13.09	MIL0.8	0.28	2/23/2020	12	7.3	7.1	52	6.2	226.7	14	143.65	1.1	20.3
2/23/2020	13:35	SPR1.4	0.28	2/23/2020	7.1	7.6	7	57	6.9	229	30	198.5	1.5	N/A
2/23/2020	13:45	PAN0.0	0.28	2/23/2020	7	6.4	6.7	64	7.9	221.5	40	144.3	1.1	N/A
2/23/2020	11:45	SPR5.0	0.28	2/23/2020	8	8.6	7.5	105	12.2	228.9	2	148.9	3.2	N/A
2/23/2020	10:14	MIL5.3	0.28	2/22/2020	7.2	6.3	7.2	104	12.6	114.8	10	16.4	2.14	8.14
3/30/2020	14:19	PAN0.0	0.5	3/30/2020	8	9.5	6.9	61	6.9	198.3	2	128.7	1.8	N/A
3/30/2020	12:41	MIL0.8	0.5	3/30/2020	10	9.8	7	73	8.2	108/1	10	70.2	1.1	41.4
3/30/2020	13:00	SPR1.4	0.5	3/30/2020	8	9.7	7.1	74	8.4	128.6	2	83.9	1.6	N/A
3/30/2020	12:43	SPR5.0	0.5	3/30/2020		9.4	7.3	104	11.9	178.6	2	116.4	4.5	N/A
3/30/2020	11:41	MIL5.3	0.5	3/30/2020	8	8.6	7.2	104	12.1	95.8	2	62.4	1.9	7.77
4/27/2020	12:25	PAN0.0	0.3	4/25/2020	16	13.3	6.9	41	4.3	233.7	2	152.1	1.6	N/A
4/27/2020	11:59	SPR1.4	0.3	4/25/2020	16	13.6	6.9	66	5.8	179.1	2	116.4	1.4	N/A
4/27/2020	16:31	MIL0.8	0.3	4/25/2020	17	16.5	7.1	60	5.9	161.6	2	104.7	1.3	16.1
4/27/2020	14:11	MIL5.3	0.3	4/25/2020	16	13.5	7.5	103	10.8	146.8	2	95.6	3.0	2.98
4/27/2020	15:01	SPR5.0	0.3	4/25/2020	17	12	7.8	105	11.3	243	2	158	2.9	N/A
5/29/2020	12:14	MIL5.3	0.01	5/26/2020	13	14.4	7.8	99	10.1	221.6	2	144.3	2.98	0.85
5/29/2020	13:53	SPR5.0	0.01	5/26/2020	24	12.9	8.1	105	10.9	250.9	2	163.2	2.49	N/A
5/29/2020	14:43	MIL0.8	0.01	5/26/2020	25	19.6	7.16	45	4.1	259.5	10	169	1.2	4.81

Sample Date	Sample Time	Site Code	Precip. (inches)	Last Rain Date	Air Temp. (deg. C)	Temp. water (deg. C)	pH	DO (%)	DO (mg/L)	SPC (us/cm)	Turbidity (NTU)	TDS (mg/L)	NO3-N (mg/L)	Gauging station flow (ft3/s)
5/29/2020	15:09	SPR1.4	0.01	5/26/2020	25	19.2	7.1	45	4.2	300.3	2	194.4	1.78	N/A
5/29/2020	15:27	PAN0.0	0.01	5/26/2020	25	17.3	6.94	9	0.8	281.9	10	183.3	1.33	N/A
6/28/2020	13:30	MIL5.3	0.3	6/27/2020	19	14.4	7.5	102	10.4	131.4	2	85.2	1.39	2.43
6/28/2020	15:03	SPR5.0	0.3	6/27/2020	19	12.4	7.9	104	11	244.3	2	158.6	1.98	N/A
6/28/2020	16:18	MIL0.8	0.3	6/27/2020	20	17.4	6.9	44	4.2	103.9	2	67.6	0.57	15
6/28/2020	17:00	SPR1.4	0.3	6/27/2020	20	16.3	6.8	65	6.3	119	2	76.1	1.92	N/A
6/28/2020	17:09	PAN0.0	0.3	6/27/2020	20	16.7	6.9	20	1.9	237	17	154.1	1.52	N/A
7/26/2020	11:03	MIL5.3	0.02	7/22/2020	23	14.8	7.7	98	10	200.2	2	130	2.48	1.04
7/26/2020	11:56	SPR5.0	0.02	7/22/2020	25	12.9	7.9	103	10.9	252.6	2	164.5	2.42	N/A
7/26/2020	13:39	MIL0.8	0.02	7/22/2020	26	19.2	7	12	1.1	367.6	12	238.6	1.37	0.05
7/26/2020	12:31	SPR1.4	0.02	7/22/2020	26	17.1	7.1	52	5	306.7	2	199.6	1.66	N/A
7/26/2020	12:36	PAN0.0	0.02	7/22/2020	26	16.5	6.7	6	0.6	325.9	35	211.3	0.99	N/A
8/30/2020	10:17	MIL5.3	0.1	8/22/2020	20	13.6	7.86	103	12.7	235	2	152.8	1.96	0.91
8/30/2020	11:54	SPR5.0	0.1	8/22/2020	20	12.1	7.9	107	11.5	254.1	2	165.1	1.71	N/A
8/30/2020	12:29	MIL0.8	0.1	8/22/2020	19	16.2	7.3	19	1.9	366.1	27	237.9	1.05	0.18
8/30/2020	13:41	SPR1.4	0.1	8/22/2020	20	15.8	7.1	64	6.4	299.3	2	194.4	1.07	N/A
8/30/2020	14:01	PAN0.0	0.1	8/22/2020	20	13.7	6.6	1	0.1	440.6	90	286.7	1.3	N/A
9/27/2020	10:04	MIL5.3	0.57	9/25/2020	14	13.4	7.4	101	10.8	185.8	2	120.9	1.2	6.3
9/27/2020	10:56	SPR5.0	0.57	9/25/2020	17	11.9	7.8	106	11.6	250.4	2	162.5	1.5	N/A
9/27/2020	13:30	MIL0.8	0.57	9/25/2020	19	16.4	6.9	0	0	185.2	2	119.6	1.24	11.7
9/27/2020	11.32	SPR1.4	0.57	9/25/2020	17	15.4	7.1	34	3.5	183.6	2	119.6	0.8	N/A
9/27/2020	11:48	PAN0.0	0.57	9/25/2020	17	14.6	6.1	9	1	236.2	65	153.4	1.78	N/A
9/27/2020	11:13	PAN2.0	0.57	9/25/2020	16	13	7.7	92	9.9	192.7	2	124.8	1.27	N/A
10/25/2020	10:05	MIL5.3	0.1	10/24/2020	4	7.8	7.7	100	12.1	196	2	127.4	5.09	14.7
10/25/2020	12:09	MIL2.0	0.1	10/24/2020	8	8.5	6.7	7	0.8	153.3	2	99.5	1.12	5.66
10/25/2020	13:30	SPR1.4	0.1	10/24/2020	8	9.9	6.8	47	5.5	256.2	13	164.1	1.25	6.05
10/25/2020	13:41	PAN0.0	0.1	10/24/2020	8	9.3	6.6	1	0.1	226.5	19	146.9	1.83	N/A
10/25/2020	14:04	PAN2.0	0.1	10/24/2020	8	7.1	7.6	107	13.1	195.6	2	127.4	1.82	N/A
10/25/2020	14:30	SPR5.0	0.1	10/24/2020	9	9.2	7.9	105	10.2	252.2	2	163.8	3.93	N/A
11/22/2020	10:10	MIL5.3	0.1	11/20/2020	4.5	7.5	7.5	102	12	161.2	2	104.7	2.47	N/A
11/22/2020	11:52	MIL2.0	0.1	11/20/2020	6	8.3	6.7	1	0.2	171.4	2	111.8	1.96	N/A
11/22/2020	12:50	SPR5.0	0.1	11/20/2020	8	9.3	7.7	101	11.6	246	2	159.9	4.8	N/A
11/22/2020	13:56	PAN0.0	0.1	11/20/2020	7	7.7	6.5	29	3.5	176.4	2	114.4	1.63	N/A
11/22/2020	13:10	PAN2.0	0.1	11/20/2020	7	7.3	7.4	96	11.5	126.9	2	82.6	2.71	N/A
11/22/2020	13:47	SPR1.4	0.1	11/20/2020	7	8	6.9	46	5.6	164	2	106.6	1.6	N/A
12/23/2020	10:58	MIL5.3	0	12/21/2020	7.5	5.7	7.4	109	13.9	123	2	80	4.68	29.5

Sample Date	Sample Time	Site Code	Precip. (inches)	Last Rain Date	Air Temp. (deg. C)	Temp. water (deg. C)	pH	DO (%)	DO (mg/L)	SPC (us/cm)	Turbidity (NTU)	TDS (mg/L)	NO3-N (mg/L)	Gauging station flow (ft3/s)
12/23/2020	12:14	MIL2.0	0	12/21/2020	5	5.7	6.7	49	6.2	134.2	2	87.1	0.97	46.9
12/23/2020	12:39	SPR5.0	0	12/21/2020	6	8.1	7.7	104	12.5	223.1	2	145	5.85	N/A
12/23/2020	13:32	PAN0.0	0	12/21/2020	9	6	6.7	32	4	135.9	2	135.9	1.52	N/A
12/23/2020	12:57	PAN2.0	0	12/21/2020	5	3.9	7.2	109	14.4	68	2	44.2	1.26	N/A
12/23/2020	13:29	SPR1.4	0	12/21/2020	9	5.9	7	49	6.2	114.2	2	74.1	1.64	N/A
1/29/2021	12:40	MIL5.3	0.28	1/28/2021	10	7.3	7.7	112.7	13.6	162.7	2	106	2.98	Not Available
1/29/2021	14:01	MIL2.0	0.28	1/28/2021	10	7.2	6.9	42.5	5.13	219	2	142.4	0.95	19.5
1/29/2021	14:28	SPR5.0	0.28	1/28/2021	11	9.1	8	97.4	11.19	210	2	136.5	2.36	N/A
1/29/2021	14:50	PAN2.0	0.28	1/28/2021	8.5	5.9	7.8	104.2	13.17	100.5	2	65	2.2	N/A
1/29/2021	15:21	SPR1.4	0.28	1/28/2021	9	6.8	7	56.7	6.7	213.9	10	139.1	1.12	N/A
1/29/2021	15:22	PAN0.0	0.28	1/28/2021	9	5.8	7	53.1	6.65	188.1	2	122.2	1.35	N/A
2/28/2021	10:40	MIL5.3	0.03	2/27/2021	14	7.2	7.7	110.8	13.3	159	2	103.4	1.78	5.08
2/28/2021	11:41	MIL2.0	0.03	2/27/2021	12	7.8	6.9	47.1	5.7	231.4	2	150.8	0.92	20
2/28/2021	12:44	SPR5.0	0.03	2/27/2021	11.5	9.5	8.1	106.9	12.2	232.3	2	150.8	1.93	N/A
2/28/2021	13:11	PAN2.0	0.03	2/27/2021	12	7	7.8	115	13.9	105.8	2	68.3	2.45	N/A
2/28/2021	13:41	SPR1.4	0.03	2/27/2021	13.5	7.8	7	69.8	8.5	226.2	2	145.6	1.05	N/A
2/28/2021	13:58	PAN0.0	0.03	2/27/2021	13	7	7	82	10	189.6	2	122.9	1.49	N/A
3/28/2021	10:06	MIL5.3		3/28/2021	9	8.3	7.1	105	12.3	187.2	2	121.6	0.68	N/A
3/28/2021	11:36	MIL2.0		3/28/2021	8	10	6.9	51	5.8	253.3	13	164.5	1.12	N/A
3/28/2021	12:39	SPR5.0		3/28/2021	9.3	11	7.6	103	11.8	225.4	2	146.3	2.24	N/A
3/28/2021	13:40	PAN2.0		3/28/2021	8	7.8	7.4	105	12.5	113	2	74.1	0.51	N/A
3/28/2021	14:00	SPR1.4		3/28/2021	7	9.3	7.2	59	6.7	261.5	2	169.7	1.12	N/A
3/28/2021	14:17	PAN0.0		3/28/2021	7	9.3	6.9	60	6.9	227	2	147.6	0.86	N/A
4/25/2021	10:10	MIL5.3	0.2	4/24/2021	14.5	10.7	7.5	105	11.6	161.5	2	105.3	3.22	N/A
4/25/2021	11:35	MIL2.0	0.2	4/24/2021	15	12.2	6.4	32	3.5	128.8	12	83.5	0.6	N/A
4/25/2021	13:08	SPR5.0	0.2	4/24/2021	16	11	7.5	95	10.4	241	2	156.7	1.03	N/A
4/25/2021	13:39	PAN2.0	0.2	4/24/2021	16	10.8	7.3	103	11.4	137	2	89.1	0.79	N/A
4/25/2021	14:05	SPR1.4	0.2	4/24/2021	25	12.9	6.9	59	6.2	182.4	2	117.7	1.54	N/A
4/25/2021	14:15	PAN0.0	0.2	4/24/2021	25	13.2	6.9	42	4.4	265.4	15	172.3	2.53	N/A
5/23/2021	10:05	MIL5.3	0.01	5/22/2021	14	11.6	7.4	103	11.2	228	2	148.2	0.79	N/A
5/23/2021	11:30	MIL2.0	0.01	5/23/2021	17	14.1	6.9	11	1.2	251.2	2	163.2	0.55	N/A
5/23/2021	12:18	SPR5.0	0.01	5/23/2021	19	11.2	7.6	105	11.5	248.3	2	161.2	0.79	N/A
5/23/2021	12:57	PAN2.0	0.01	5/23/2021	15	11.1	7.7	103	11.2	188.3	2	122.2	0.57	N/A
5/23/2021	13:28	SPR1.4	0.01	5/23/2021	27	13.9	1.02	38	3.9	316.7	19	206.1	1.31	N/A
5/23/2021	13:40	PAN0.0	0.01	5/23/2021	27	14.4	6.8	14	1.5	300.6	19	195.7	0.8	N/A
6/30/2021	9:00	MIL5.3		6/14/2021	20	15.7	7.1	98	9.8	231.3	2	150.2	0.6	N/A
6/30/2021	10:35	MIL2.0		6/14/2021	21	20.4	6.9	3	0.3	307	50	198.25	1.48	N/A

Sample Date	Sample Time	Site Code	Precip. (inches)	Last Rain Date	Air Temp. (deg. C)	Temp. water (deg. C)	pH	DO (%)	DO (mg/L)	SPC (us/cm)	Turbidity (NTU)	TDS (mg/L)	NO3-N (mg/L)	Gauging station flow (ft3/s)
6/30/2021	11:31	SPR5.0		6/14/2021	21	13	7.5	102	10.8	250.6	2	163.2	1.36	N/A
6/30/2021	12:00	PAN2.0		6/14/2021	20	15.7	7.01	90	8.9	197	2	128.1	1.42	N/A
6/30/2021	12:33	SPR1.4		6/14/2021	25	20	7.2	52	4.7	299.5	2	195	2.17	N/A
6/30/2021	12:42	PAN0.0		6/14/2021	30	20.5	7.3	3	0.2	466.8	12	303.6	3.67	N/A
7/25/2021	10:02	MIL5.3			21	15.2	7.2	103	10.3	236.5	2	154.5	0.32	N/A
7/25/2021	11:26	MIL2.0			27	18.3	7.02	34	2.8	339	65	2.41	0.27	N/A
7/25/2021	12:56	SPR5.0			27	13.5	7.9	107	11.1	252	2	163.8	0.41	N/A
7/25/2021	13:19	PAN2.0			25	15.9	7.8	93	9.1	203	2	132	0.41	N/A
7/25/2021	13:48	SPR1.4			33	19.2	7.4	90	8.2	306.5	17	199.6	0.42	N/A
7/25/2021	14:02	PAN0.0			33	17.7	7.3	13	1.1	506	65	330.2	1.16	N/A
8/22/2021	10:11	MIL5.3	0		18	14.6	7	102	10.4	243.6	2	158.6	0.59	N/A
8/22/2021	11:45	MIL2.0	0		18	16.5	6.5	9	0.8	318.1	50	206.7	0.58	N/A
8/22/2021	13:15	SPR5.0	0		17	12.4	7.3	109	11.5	251.9	2	163.8	0.62	N/A
8/22/2021	13:37	PAN2.0	0		17	14	7.5	95	9.8	202.6	2	131.95	0.39	N/A
8/22/2021	14:00	SPR1.4	0		19	16.5	7.7	64	6.2	295.1	2	191.75	1.08	N/A
8/22/2021	14:17	PAN0.0	0		19	16	6.6	7	0.6	571.3	65	370.15	1.04	N/A
9/26/2021	10:12	MIL5.3	0.32	9/19/2021	17	13.2	7.2	97	10.1	241.6	2	157.3	0.53	N/A
9/26/2021	12:04	MIL2.0	0.32	9/19/2021	17	15.3	6.3	1	0.1	294	50	191.8	0.37	N/A
9/26/2021	13:20	SPR5.0	0.32	9/19/2021	18	12.2	7.3	103	11	252.9	2	163.8	0.57	N/A
9/26/2021	14:05	PAN2.0	0.32	9/26/2021	18	13.2	7.4	91	9.8	204.5	2	123.5	0.37	N/A
9/26/2021	14:42	SPR1.4	0.32	9/26/2021	18	15.3	7.1	39	3.9	273.3	2	177.5	1.25	N/A
9/26/2021	14:57	PAN0.0	0.32	9/26/2021	18	15.3	6.6	4	0.4	271.4	19	176.2	0.58	N/A

Appendix D: Map of Additional Monitoring Locations*

Drainage District Sites

- Site #1 - Springbrook
- Site 2 - Garrison
- Site #3 - Mill
- Site #4 - Mill
- Site #5 - Mill
- Site #6 - Garrison
- Site #7 - Springbrook
- Site #8 - Springbrook
- Site #9 - Mill

*King County Station 317 is the same location as Drainage District's Site #1