Water Quality and Invertebrate Analysis of Richards Creek, North Cowichan B.C.

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Executive Summary

An environmental monitoring project was conducted at Richards Creek as a part of the RMOT 306 Environmental Monitoring class in the Bachelors of Natural Resource Protection program at Vancouver Island University. Four sites from Richards Creek were chosen for sampling, the choice of site locations was based on the locations previously chosen in the long-term monitoring program of Richards Creek to maintain continuity of data. Sampling occurred on October 26, 2022 and November 16, 2022. The staggering of sampling events was implored to acquire data that would reflect low flow and high flow occurrences in the stream. Much lower than anticipated rainfall occurred between the time of sampling event 1 and sampling event 2, resulting in little difference in stream water levels; the staggering of sampling events did however show result in very different outcomes of each sampling event. Sites 1 to 4 were tested for general water quality and hydrology parameters and analyzed at VIU laboratories. Many of the general water quality results from VIU laboratories such as conductivity, alkalinity, pH, dissolved oxygen, and hardness indicated Richards Creek to generally meet the BC water quality guidelines; however a trend becomes apparent in both the VIU laboratory results as well as the ALS data, which shows Site 4 to consistently vary from the water quality guidelines. Nitrate and Phosphate results from VIU laboratory analysis indicate that Richards Creek is Nitrogen limited, concurring with data received from ALS which gives evidence of the eutrophication of Richards Creek. Samples from Sites 2, 3 and 4 were sent to ALS laboratories for testing of general water quality, total metals, and anions and nutrient concentrations. General water quality parameters concurred with VIU laboratory analysis results for conductivity, pH and hardness. Total metals analysis of samples sent to ALS showed no metal concentrations which exceeded the BC water quality guidelines, making this year of sampling an outlier to previous year, which showed persistent unacceptable concentrations of Aluminum. Anion and nutrient results from ALS laboratories indicated the continuing eutrophication of Site 4, also seen in previous years of monitoring. The invertebrates collected saw a significant drop in abundance numbers between phase 1 and 2. This is likely due to the unseasonal low flow and low temperatures that occurred. However, the invertebrate collection of phase 1 saw record high numbers compared to previous years, with overall site assessment average being higher in site 1 and 2. Site 3 saw an improved site assessment average rating during phase 2 compared to both of the other sites, with the site's invertebrate health improving with a lower water level. Overall the stream health based on the invertebrates collected is rated marginal to acceptable, with site 2 out performing both sites 1 and 3 in both phases.

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1.0 Introduction

The following proposal is an outlined plan on the process and purpose of a detailed assessment of Richards Creek in North Cowichan, BC. Richards creek is located in the Northeastern parts of the Cowichan Valley, originating from Crofton Lake and ending as it enters Somenos Lake. The assessment of Richards Creek took place between October 26th and November 30th, 2022 and incorporated a variety of tests and measurements including water quality, hydrology measurements and stream invertebrate health. The instream tests took place at four different sites within Richards Creek. The study was replicated twice, once during a low flow period (October 26th), and once during a high flow period (November 30th); The staggered testing method created a more dynamic testing environment to give a broader view of the general stream health. Richards Creek has been monitored and tested since 2008 at identical sites as those chosen in this project, to maintain continuity in the ongoing long term data collection project. Conducting this stream assessment provided an in-depth analysis into the current status and health of Richards Creek.

Figure 1: Map of Richards creek including sample sites. (Richards et al. 2021)

1.1 Background

Richards creek is approximately 9.5 km long with 132 m of elevation loss, it flows from the south end of Crofton Lake into Somenos Lake. Somenos Lake and Somenos Creek are an important and productive tributary to the lower Cowichan River (DFO. 2008). In 2000 the Municipality of North Cowichan terminated Crofton's residential water supply coming from Crofton Lake. Without the demand for year-round supply of water, Crofton Lake outflow was able to be increased to create additional salmon and trout rearing grounds, as well as new habitat for the other organisms and animals inhabiting

Richards Creek. The project of increasing flow was completed in 2008, resulting in an additional 765m^2 of new rearing grounds and 3 km of year-round residential cutthroat trout habitat. The augmentation of flow was documented to be 700-800% greater than historic levels (Habitat Conservation Trust Foundation. 2008).

1.2 Environmental Concerns

The region surrounding Richards Creek is primarily occupied by agricultural land, which may result in high levels of nutrient loading; nutrient loading or run-off may be magnified due to the low gradient and low flow in the summer season. Richards Creek crosses four roads; the crossing at Herd Road is a bridge, Richards Trail and Escarpment Way are box culverts and the fourth road crossing is a logging road on Mount Richards with a traditional culvert. This may be of concern if the culverts act as an impassable barrier for fish. The road crossings may lead to increased turbidity and a change in pH and salinity due to road run-off. Road crossings can also be a leading factor in flooding due to debris and beaver dams getting caught at the inlet, creating impassable blockages. There are also a series of small private culverts for driveway crossings, which can also lead to impassable barriers and flooding. Richards Creek has received several human interventions such as creek rerouting, dredging and culvert maintenance.

2.0 Project Objectives

The objective of this report is to compile and analyze the data collected from samples taken from Richards Creek on October 26, 2002 and November 17, 2022. Data collected from the 4 sites on the two sampling events were analyzed and compared with the findings of previous assessments of Richards Creek carried out by RMOT 306 students of previous years (2008-2021). To maintain continuity with previous years of monitoring, the same 4 sites, as historically tested in this long-term monitoring program, were chosen for sampling. Water quality and stream invertebrates samples were extracted from Richards Creek and analyzed at the Vancouver Island University laboratory facilities in Nanaimo, BC. separate water quality samples were sent to be analyzed at *Australian Laboratory Services (ALS)* in Vancouver, BC. By compiling and interpreting this data it can further contribute to the long-term monitoring program as well as provide relevant information on the limiting factors affecting Richards Creek for the Department of Fisheries and Oceans Canada and the Municipality of North Cowichan.

3.0 Environmental Sampling and Analytical Procedures

To carry on with past assessments in the long-term environmental monitoring of Richards Creek, the assessment of four sites that have been monitored annually since 2008 has been completed. These four sites were analyzed consistently with past practices, continuing the vital environmental monitoring for salmonid rearing streams by VIU students. To highlight the importance to the integrity of past reports of Richards

Creek, it is essential to maintain prior assessment location, interval, and protocol to be able to determine environmental trends and alterations.

3.1.1 Sampling Program

Each of the four sites have been chosen because of their defining features that include substrate, flow, and distance to stream headwater. Ease of access for safety reasons was also a defining factor for each one of these sites since much of the creek goes through private property.

The four site locations underwent designated environmental monitoring procedures that included water quality, and biodiversity analysis. All sites were visited on October 12, 2022, to conduct a preliminary assessment.

3.1.2 Locations and Habitat Characteristics

Richards Creek is located in North Cowichan, BC within the Somenos Basin. The creek is roughly 9.5 kilometers in length, starting from Crofton Lake and ending at Somenos Lake. The four samples were collected within a 5 kilometer stretch of the creek from Site 1 to Site 4. The sites can be found on the map (Figure 1) at Escarpment Way (Site 1), the end of Rice Road (Site 2), Richards Trail (Site 3), and Herd Road bridge (Site 4).

Site 1 is located just off of Escarpment Way, 100m from Osbourne Way (UTM 10N 452538m E, 5409437m N) (Figure 1). Sampling took place above the box culvert that passes underneath Escarpment Way which was recently cleaned/dredged after the

2021 November flood. The riparian area surrounding the creek was dense with thick overgrowth from small to large shrubs, giving the area lots of shade throughout the summer (Figure 2). The substrate was observed to mainly contain silt and sand with some small pebbles. There was one deeper pool observed on the downstream side of the culvert, likely a result of the November 2021 dredging (Figure 3). The stream level was low and had a relatively slow flow rate.

Figure 2: Site 1 Escarpment Way above new culvert (Bell 2022)

Figure 3: Site 1 Escarpment Way below culvert, with deeper pool (Bell 2022)

Site 2 is located at the end of Rice Road (UTM 10N 451941m E, 5408533m N) (Figure 1), 50 meters northeast down into a dense, wooded gully primarily occupied by ferns and maple trees. This site is the most isolated and requires a short walk as it is shrouded by an overgrown path. There is a large riparian area on both sides of the stream. This riparian area contains deciduous and coniferous trees of various sizes and a multitude of small plants (Figure 4). There is also a large circular cement structure with a deconstructed wooden structure next to the overgrown site - there is a possibility it may have been used as a well site (Figure 5). The substrate at Site 2 mainly consisted of small cobbles to fine silt with a slow flow.

Figure 4: Site 2 End of Rice Road dense riparian area (Bell 2022)

Figure 5: Site 2 End of Rice Road with some old structures (Bell 2022)

Site 3 is located on Richards Trail Road, one kilometer from Herd Road (UTM 10N 451326m E, 5408805m N) (Figure 1). Sampling took place above the box culvert that passes beneath Richards Trail (Figure 6). The riparian area above the culvert is small yet dense with many deciduous trees, large shrubs and saplings. The water level was low and had a slow flow rate. Below the culvert, the riparian area starts to disperse more as it enters farmland where it is quite open with much less vegetation along the stream bank. The substrate at Site 3 consists of small to large cobbles with medium size boulders on either side.

Figure 6: Site 3 Richards Trail Road above the culvert (Bell 2022)

Site 4 is located underneath the bridge on Herd Road that crosses Richards Creek (UTM 10N 450283m E, 5407657m N) (Figure 1). Site 4 is accessed along the north side of the bridge down a slight hill with thick ivy and blackberry bushes. This location is surrounded by a marshy riparian area with little to no shade cover for a large portion of the creek. The water is noticeably green, having algae present on the surface for most of the area with minimal surface flow (Figure 7). It was difficult to determine the exact depth of the water at this site due to safety concerns. It was not possible to conduct some of the assessments at this site.

Figure 7: Site 4 underneath Herd Road Bridge with visibly green water (Bell 2022)

3.1.3 Sampling Frequency

Two sets of samples were collected from these four locations over the duration of the project. Samples were collected during two separate sampling events, the first on October 26, 2022 and the second on November 16, 2022. All four sites had water and samples taken, with Sites 1-3 having invertebrate sampling completed. Invertebrate sampling was not completed at Site 4 due to limited water visibility and unknown depth creating a possible safety hazard.

3.2 Methods

3.2.1 Water Quality Sampling

Proper quality assurance and quality control measures were in place to help ensure accurate results were obtained. These included using protocols from the “Ambient Freshwater and Effluent Sample Manual” published by the BC government (Province of BC 2013). At Sites 1, 2, and 3 water samples were collected mid-stream, while standing downstream of the sample location. At Site 4, the water sample was collected from the bank of the creek, due to safety concerns. One sample was collected from each site for analysis at the VIU laboratory. At Sites 2, 3, and 4, three extra samples were taken for analysis by ALS laboratories. The VIU sample bottles were filled and rinsed three times in the creek before collecting the sample. The ALS sample bottles were sterile and did not need to be rinsed prior to collecting the samples. The sample bottles were held below the surface of the water to help ensure no contaminants entered the sample from the surface of the creek. Samples were then placed in a cooler with ice for transport to the VIU laboratory. Altogether, these protocols helped reduce any chances of contamination of the samples. As well, both a trip blank and a field blank were prepared and analyzed with the samples.

3.2.2 Hydrology

The stream depth was measured using a meter stick placed in the water at multiple locations at each sample site, the deepest location was the one noted. Then, the wet bank width was measured with a tape measure across the stream at the water's surface from bank to bank. The velocity was measured by using a ping-pong ball and a meter stick. A stopwatch was started as the ping pong ball was dropped in the stream, when the ping-pong ball reached the end of the meter stick the timer was stopped. This was done 3 times at Sites 1, 2, and 3, and an average was calculated for each site. The average discharge at each site was calculated by multiplying the depth, width and velocity together and then multiplying by the substrate coefficient, 0.8 for rocky bottom streams or 0.9 for mud bottomed streams.

3.2.3 Field Measurements

Temperature, pH, and dissolved oxygen were measured in the field. To measure the pH, the pH meter was placed in the water at the sample site and a pH reading was given. For testing the temperature and dissolved oxygen, a YSI meter was used. The YSI meter was placed in the water, calibrated, and approximately one minute was allowed at each site to allow for a true and accurate reading for temperature and dissolved oxygen.

3.2.4 VIU Laboratory testing

Once transported to the VIU lab the samples were tested for multiple different water quality parameters within 24 hours of the samples being taken. Conductivity, turbidity, total alkalinity, hardness, nitrates, and reactive phosphorus were all tested for. For conductivity, a conductivity meter was used by placing the probe in the sample and moving it in a mixing motion until the reading becomes stable. Turbidity, nitrates and phosphorus were all analyzed through the use of spectrophotometry. Hardness was measured using a HACH hardness drop test kit, and Alkalinity was analyzed through visual endpoint titration of the sample. The exact methods and equipment used for all the lab procedures used were provided in handouts at each station by the VIU RMOT lab department.

3.3 Stream Invertebrate Sampling and Analysis

3.3.1 Invertebrate Sampling Collection

Stream invertebrate sampling was conducted using Pacific Streamkeepers' procedures (Province of BC 2000) at Sites 1-3 during both phases of testing. Using a Hess sampler, 3 replicate samples of invertebrates were collected at each site from turbulent riffles. The sampler was placed in the stream and the substrate in the sampler was agitated for one minute for each sample taken. The Hess sampler received a thorough rinse to ensure all invertebrates were collected in the collection cup. The samples received a quick sort in the field to remove any larger debris and were preserved in 70% ethanol solution. The samples were then placed in a cooler with ice packs and transported to the VIU laboratory. Once in the lab, the samples were sorted and counted using a dissecting microscope by Family and Order. Invertebrate survey field data sheets were completed for each site and then the sorted invertebrates were noted on the sheet in the lab. Abundance, density, water quality assessments, diversity, overall site assessment rating, and the Shannon-Weiner Diversity index were all calculated, and an overall assessment of stream health was given.

3.3.2 VIU Laboratory Analysis

The Invertebrate samples that were collected on October 26 and November 16 were examined at the VIU laboratory the same day to avoid decomposition of the invertebrates. The samples were then emptied into a tray and collected by using tweezers and placed into a petri dish. Once all the invertebrates were collected from the trays, the petri dishes were analyzed through a dissecting microscope to get a precise identification of each individual organism. The individuals were then recorded on data sheets and categorized by Family and Order when possible.

3.3.3 Quality Assurance / Quality Control

Throughout the course of the collection process, two students took triplicate samples at each site to avoid human error influencing the outcome of the data. The bottles that contained the samples were pre cleaned and labeled with the location, date, collector and sample number. The Hess sampler was also rinsed out and cleaned after every sample was collected to avoid cross contamination between sites. To ensure and preserve the quality of the invertebrates collected, an ethanol solution was added. To acquire accurate data, sampling was first taken downstream, moving upstream to reduce the disturbance of the stream and obtain a precise population count for each site. Quality control was accomplished by taking samples from similar substrates at each location and ensuring all math calculations were double checked.

4.0 Results and Discussion

4.1 Field Measurements

Field measurements taken included dissolved oxygen, pH, and temperature. Dissolved oxygen and temperature were gathered at the same time using the same device. pH was taken separately but at the same location within the site and during the same site visit. These measurements are shown in table 1 below.

Table 1. Richards Creek: Field Results from sampling event 1 and 2, 2022.

Field Day 1: October 26, 2022			
Sample Site	**pH**	**DO mg/L**	**Temp (c)**
Site 1	6.9	11.39	8.5
Site 2	7.2	11.69	8.1
Site 3	7.5	11.73	7.8
Site 4	7.9	1.24	7.9
Field Day 2: November 16, 2022			
Sample Site	**pH**	**DO mg/L**	**Temp (c)**
Site 1	6.8	9.98	4.4
Site 2	6.8	12.27	4.6
Site 3	6.6	12.47	3.5
Site 4	8.7	2.09	3.5

4.1.1 Dissolved Oxygen

Dissolved oxygen (DO) levels were relatively consistent from Sites 1 through 3, with Site 4 showing a significant but expected departure from the prior sites. The above results were reflected in both site visits. The first field days measurements showed the most consistency with DO fluctuating by 0.34 mg/L between Sites 1 and 3. DO then plummeted by 10.5 mg/L at Site 4. The second field days measurements were less consistent where Site 1 measured over 2 mg/L less than Sites 2 and 3, where the former sites were only 0.2 mg/L apart. Similar to the October 26 measurements, Site 4 showed over 10 mg/L reduction in DO. Further comparisons between the October 26th and November 16th visits show Site 1 decreasing in DO from 11.39 mg/L to 9.98 mg/L, whereas Sites 2 to 4 showed an increase in DO by 0.58 mg/L, 0.74 mg/L, and 0.85 mg/L, respectively. Trends across DO measurements from past reports occur where Site 4 is consistently significantly lower than the sites before it (Figure 8 and 9). Notable discrepancies exist where 2009 through 2011 showed Site 4's DO rise significantly in the later site visits compared to Sites 1 to 3 (Anderson et al. 2009, Brooks et al. 2010, Dorey et al. 2011).

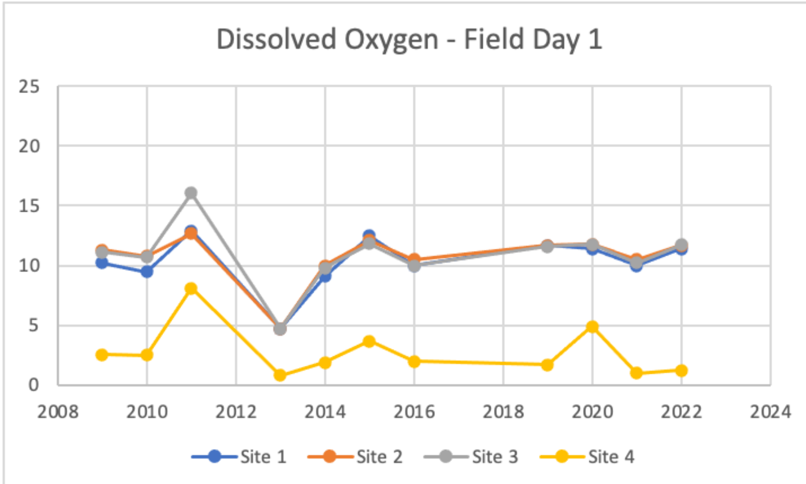

Figure 8. Richards Creek: Dissolved Oxygen trends; Field Day 1. 2009-2022.

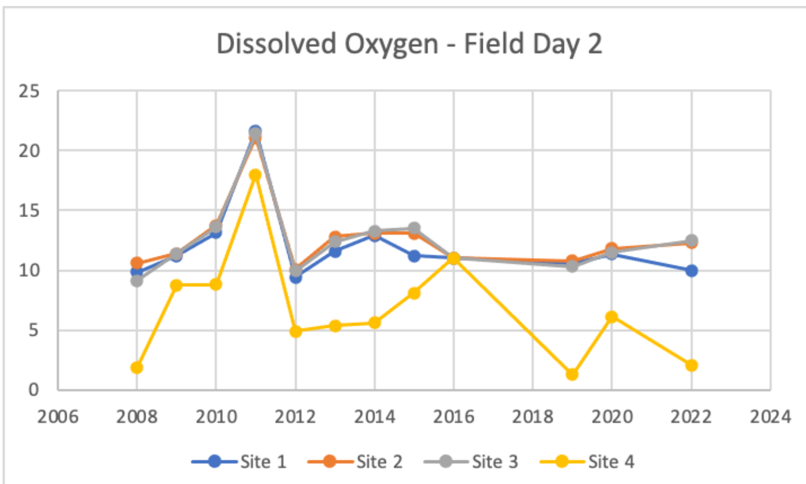

Figure 9. Richards Creek: Dissolved Oxygen trends; Field Day 2. 2008-2022.

Sites 1 to 3 show DO levels that meet the BC Water Quality Guidelines to support all life stages including buried embryo / alevin (Province of BC WQG). The one exception to this is Site 1's November measurement, of which is 1 mg/L lower than the minimum guideline for buried embryo / alevin. Site 4 is below all criteria for BC Water Quality Guidelines minimum DO to support healthy fish populations and are well below levels required to support most organisms (Province of BC).

4.1.2 pH

pH raised slightly as the stream neared Somenos Lake. This was seen consistently in the first field days readings where the pH gains 1 unit from Sites 1 to 4. The second field day trends similarly however the pH remains at 6.8 from sites 1 and 2, lowers to 6.6 at Site 3 before gaining to a pH of 8.7 at Site 4, gaining nearly 2 units from Site 1 to 4. These values fit within the pH ratings of most freshwater sources, that is a pH of 6 - 9, and within the BC Water Quality Guidelines of 6.5 - 9 (Province of BC WQG). Despite meeting the BC Water Quality Guidelines, it should be noted that an increase of 2 pH between these sites represents a change in acidity of 100 times. Past reports on Richards Creek show pH tests occurring as field measurements or lab analysis. Those reports that included pH field measurements showed similar pH readings, all falling within the same threshold of 6 – 9, with exception to the November 2010 Site 1 reading of 5.38, October 2011 site 1 at 5.89, November 2012 Site 4 at 5.1 (Figure 10 and 11).

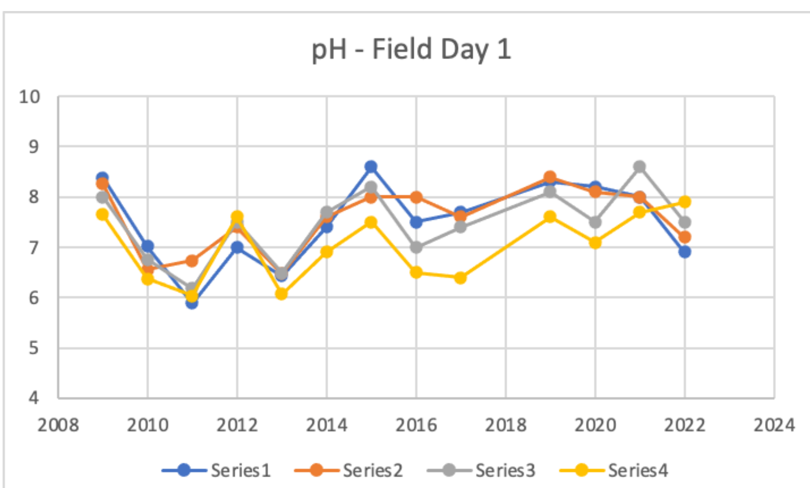

Figure 10. Richards Creek: pH trends; Field Day 1. 2009-2022

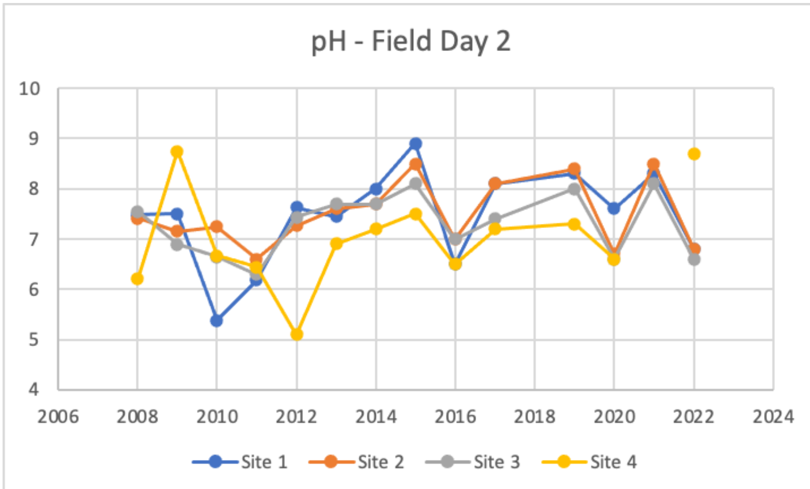

Figure 11. Richards Creek: pH trends; Field Day 2. 2008-2022

Where difference occurs is that past trends have the pH decrease downstream (Brown et al. 2008, Anderson et al. 2009, Brooks et al. 2010, Dorey et al. 2011, Coopsie et al. 2012). This inverse in trend is highlighted in Figures 10 and 11 above.

4.1.3 Temperature

Stream temperature lowered 0.6 to0.9 of a degree from Sites 1 to 4 in the October and November respective measurements. No trends were observed that highlighted any contrasts from this study to past reports on temperature at these same sites (Figures 12 and 13). Overall the temperatures averaged 8.0 in October and 4.0 in November, both reflecting the drop in average air temperature. This drop in temperature can be attributed to the unusual cold weather the region experienced at the time of the November sampling event. The temperatures of 3.5 at Sites 3 and 4 in November fall below the threshold of 4 degrees for optimum incubating habitat of salmon (Province of BC WQG).

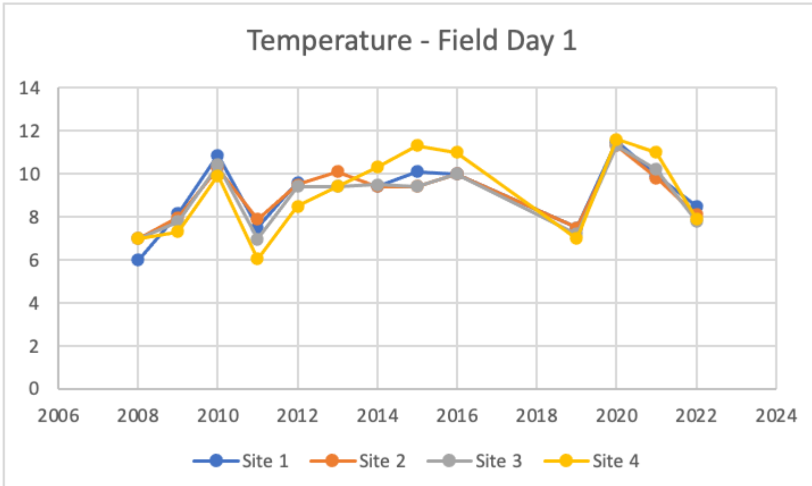

Figure 12. Richards Creek: Temperature trends; Field Day 1. 2008-2022

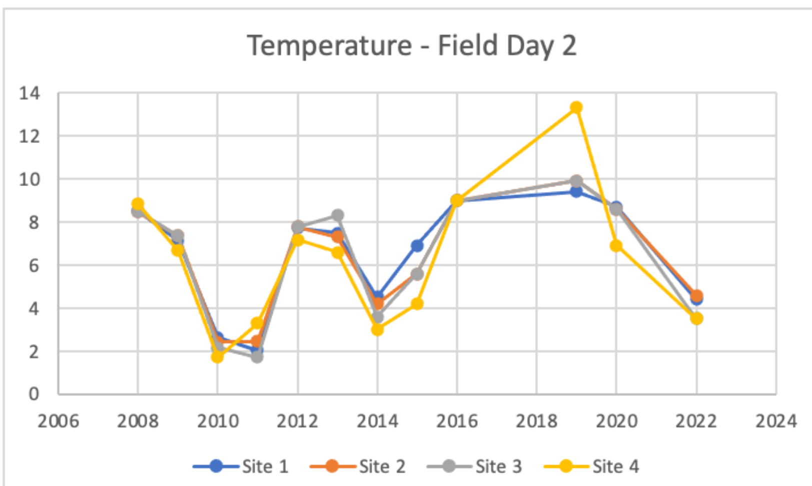

Figure 13. Richards Creek: Temperature trends; Field Day 2. 2008-2022

4.1.4 Stream Dimensions

Stream depth and wet bank width lowered from the October to the November measurements. This was unexpected where in previous years the second sample would usually provide a deeper, wider stream due to the seasonal rainfall. 2020's measurements for instance show a 30% gain in width and averaged doubling of stream depth from the October to November measurements (Evans et al. 2020).

Table 2. Richards Creek: Field Measurements, 2022.

Field Day 1: October 26, 2022				
Sample Site	**Depth (cm)**	**Wet Bank Width (cm)**	**Avg Velocity (m/s)**	**Avg. Discharge (m^3/s)**
Site 1	11	440	0.32	0.14
Site 2	40	430	0.13	0.18
Site 3	34	300	0.15	0.12
Site 4	-	~ 600	-	-
Field Day 2: November 16, 2022				
Sample Site	**Depth (cm)**	**Wet Bank Width (cm)**	**Avg Velocity (m/s)**	**Avg. Discharge (m^3/s)**
Site 1	5	110	0.16	0.0080
Site 2	38	270	0.04	0.033
Site 3	27	280	0.04	0.024
Site 4	-	~ 600	-	-

4.1.5 Stream Velocity and Discharge

Stream velocity was measured at all sites using the ping-pong ball method. A ping pong ball was dropped in the stream and the time it took for it to move 2m downstream was measured with a stopwatch. As expected, the velocity decreased as the sample sites moved further downstream. As well, the velocities during the second sampling day were less than those from the first. This can be seen in table 2. The average discharge was calculated by multiplying the stream depth, wet bank width, average velocity and the appropriate substrate coefficient together. The average stream discharge diminished significantly between the two sampling periods due to lack of rain.

4.2 VIU Water Quality Laboratory Analysis

The two field days included samples taken from each site that were then analyzed in the VIU lab. The first field day included a field blank while the follow up field day included a field and trip blank, these lab results are shown below in Table 3. The parameters analyzed from these samples were turbidity, conductivity, hardness, alkalinity, nitrate, and phosphorus content, with the field and trip blanks receiving pH testing in the lab.

Table 3. Richards Creek: VIU Lab Results, 2022.

October 26, 2022 Samples				
Parameters	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Turbidity (NTU)	1.54	1.02	1.08	10.6
Conductivity (µS/cm)	68	96	106	128
Hardness (mg/L $CaCO_3$)	37	45	52	60
Alkalinity (mg/L)	21.2	18	14	41.2
Nitrate (mg/L NO_3^-)	0.12	0.16	0.45	0.16
Phosphorous (mg/L PO_4^{3-})	0.1	0.04	0.06	0.19

October 26, 2022 Samples				
Parameters	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Turbidity (NTU)	1.54	1.02	1.08	10.6
Conductivity (μS/cm)	68	96	106	128
Hardness (mg/L $CaCO_3$)	37	45	52	60
November 16, 2022 Samples				
Parameters	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Turbidity (NTU)	2.14	1.16	1.01	3.72
Conductivity (μS/cm)	153	185	197	208
Hardness (mg/L $CaCO_3$)	60	76	84	100
Alkalinity (mg/L)	96	59	51	42
Nitrate (mg/L NO3-)	0.18	2.17	0.38	1.82
Phosphorous (mg/L PO43-)	0.02	0.05	0.05	0.25

4.2.1 Conductivity

Conductivity measurements showed a gain as the stream moved from Sites 1 through 4. This trend existed in both the October and November samples, with the October measurements ranging from 68 to 128 (μS/cm), and November surpassing this range with a conductivity of 153 to 208 (μS/cm). This near doubling in conductivity readings is peculiar where the region's rainfall subsided after the October samples were taken. This peculiarity is because a rise in conductivity is caused by a higher concentration of ions that is usually the result of rain (Province of BC WQG). However, this increase in conductivity could be a sign of an increase in effluent, potentially from a source other than rainwater. As the temperature dropped, road de-icing salts used regionally can correlate with this rise in conductivity (Figures 14 and 15). Prior project conductivity readings show a variety of trends. The 2014 through 2017, then 2020, and 2021 studies showed the mean conductivity lower in the later measurements than those the month prior (Aikman et al. 2014, Der et al. 2015, George et al. 2016, Bull et al. 2017, Evans et al. 2020, Richards et al. 2021). An opposite trend shows the mean conductivity slightly higher in the later months as seen in the 2010 through 2013, and 2019 studies (Brooks et al. 2010, Dorey et al. 2011, Coopsie et al. 2012, Seibert et al. 2013, Danielson et al. 2019).

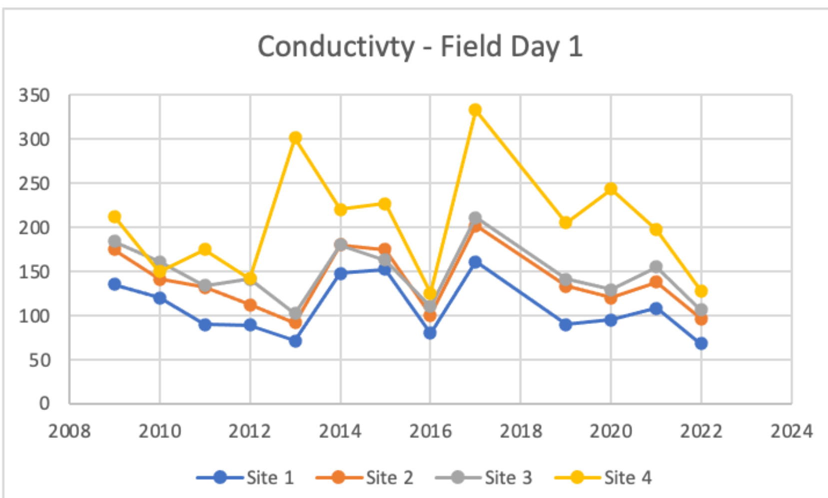

Figure 14. Richards Creek: Conductivity trends; Field Day 1. 2009-2022

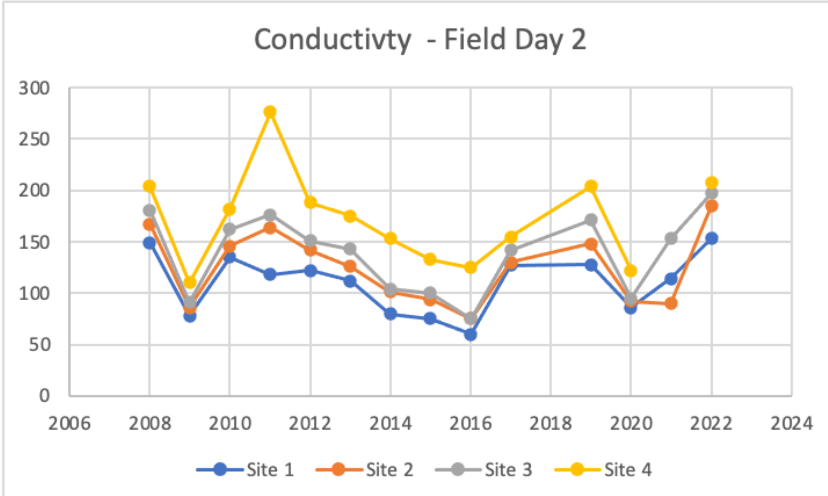

Figure 15. Richards Creek: Conductivity trends; Field Day 2. 2008-2022

Though no water quality guidelines exist for conductivity, these measurements give important values from which additional tests are required to perform.

4.2.2 Turbidity

Turbidity was found to be decreasing from site 1 to 3 during both sampling events. Unsurprisingly, site 4 was very turbid on both occasions due to lack of water movement. Sites 1, 2, and 3 all had greater turbidity during the second round of sampling. However, site 4 was found to be less turbid on the second round, most likely due to the fact that there was some very slow water movement at site 4 during the second round of testing. Overall, the average turbidity was greater during the second round of testing, this could be due to continued dry conditions, with little precipitation between sampling events. When compared to past data, the turbidity this year is below the average turbidity for 2009-2020 (Figure 16), With the turbidity being under 50 NTUs the acceptable limit under the Guidelines for Interpreting Water Quality Data is a change of 5 NTUs from the baseline (Province of BC WQG). Using the average turbidity as the baseline, we can see that the turbidity at site 4 is above threshold levels. High turbidity shows a correlation to having a poor riparian area. A healthy riparian area is able to filter out sediments and particles before they enter the water from runoff, without a healthy riparian area the runoff is able to enter the water system with all the sediment it is carrying. These high levels of turbidity are harmful to fish populations, as it makes it hard for them to respirate, and decreases their overall fitness.

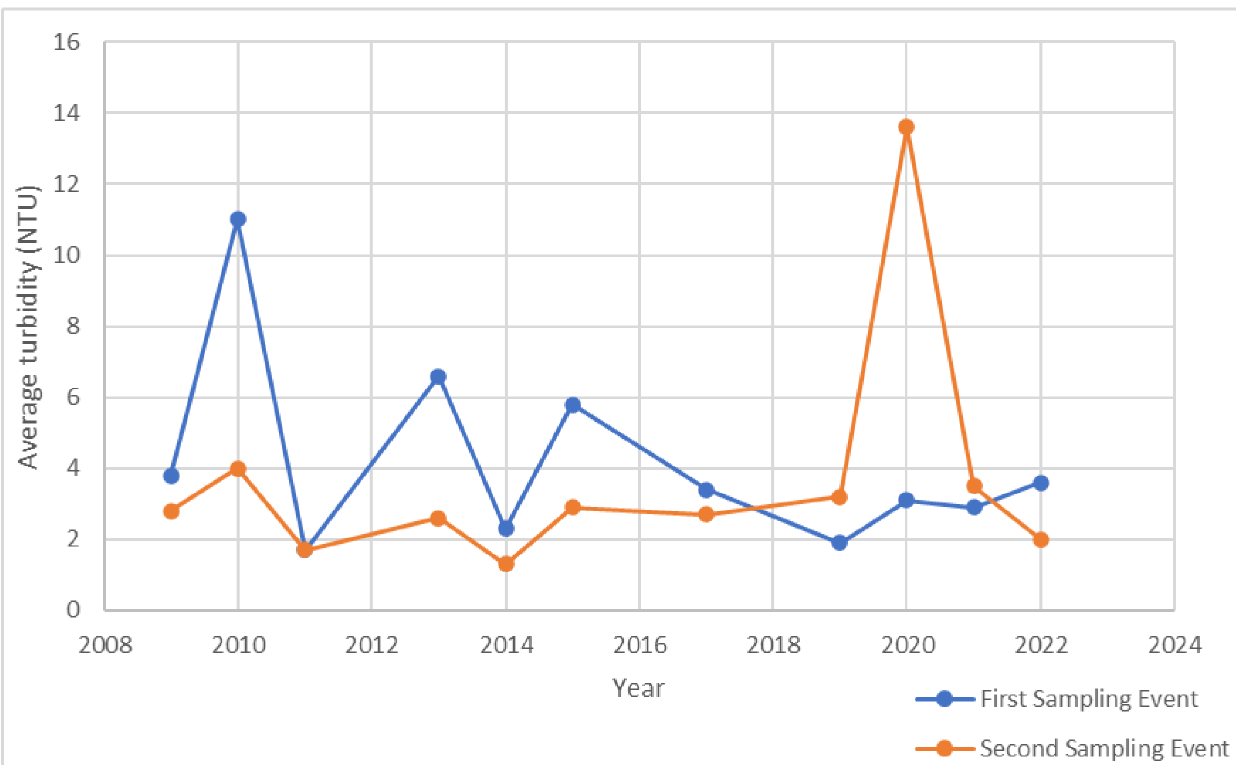

Figure 16. Data compiled from 2009-2022 illustrating the trend of average turbidity in Richards Creek.

4.2.3 Alkalinity

The alkalinity increased substantially from the first sampling event to the second in sites 1 – 3. Site 4 had almost the same alkalinity during both phases of sampling. Sites 1 and 4 during the first round of sampling showed low sensitivity to acidification, and sites 2 and 3 have moderate sensitivity (Province of BC WQG). During the second round of sampling, all 4 sites showed alkalinity levels that made them have low sensitivity to acidification.

The average alkalinity of Richards Creek during the first round of sampling was 23.6 mg/L, which is a good level to ensure the stream has a low sensitivity to acid inputs, and not to be overly hard with high concentrations of carbonates, bicarbonates and hydroxides. However, during the second round of testing, the alkalinity was significantly higher with the average being 62 mg/L. High alkalinity causes the system to have very low sensitivity to acidic inputs. Additionally, it causes the water to have a high concentration of carbonates, bicarbonates and hydroxides, potentially being harmful to fish populations.

The average alkalinity during the first round of sampling was below the average alkalinity of the system from 2008-2021 (Figure 17). In the second phase of sampling, the alkalinity was found to be well above the average alkalinity from 2008-2021, which was 32.5 mg/L. This high alkalinity in the second round of testing could be caused by little to no precipitation and cold temperatures which caused the roads in the area to have salt sprayed on them. The salt could then enter the system near all the road crossings, causing the alkalinity to increase.

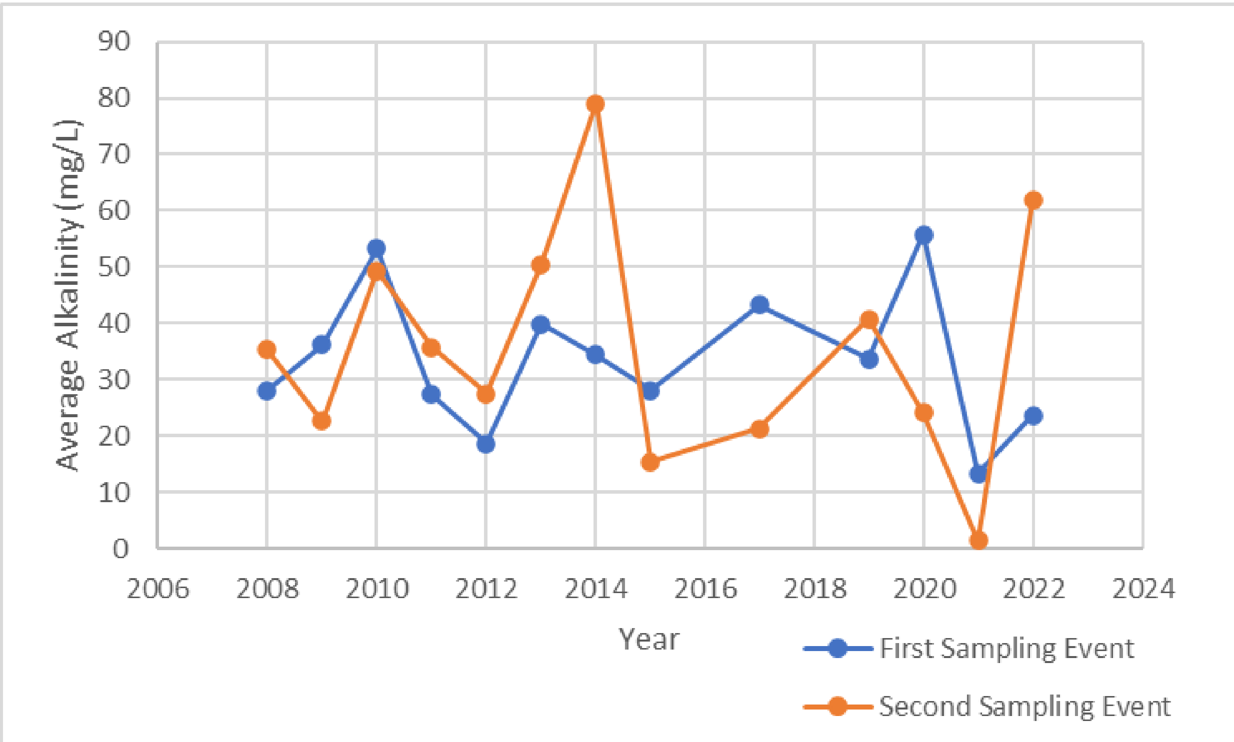

Figure 17. Data compiled from 2008-2022 illustrating the trend of average alkalinity in Richards Creek.

4.2.4 Hardness

During both sampling events the hardness increased as the sample locations moved downstream. In the first round of sampling, the hardness was 37 - 60 mg/L ($CaCO_3$). During the second round of sampling, the hardness increased with it being 60 - 100 mg/L ($CaCO_3$) from as it increased from sights 1 through 4. The average hardness of the stream almost doubled between the two sampling events going from 48.5 mg/L ($CaCO_3$) during the first phase to 80 mg/L ($CaCO_3$) during the second. During the first round of testing the water was found to be soft, with the values being almost all less than 60 mg/L ($CaCO_3$) (Province of BC WQG). During the second round of testing, the average hardness was found to be in the optimal range of 80 - 100 mg/L ($CaCO_3$). Hardness relates to the amount of calcium and magnesium in the stream, and is often affected by mining and effluent entering the water body (Province of BC WQG). During the first sampling event the average hardness was found to be below the average from 2008-2021, which is 68.3 mg/L ($CaCO_3$)(Figure 18). However, during the second round of sampling, the hardness was found to be approximately 20 mg/L ($CaCO_3$) above the average hardness from 2008-2021 (Figure 18). In most years there is greater rainfall between the two sampling events, which result in greater stream flow and flushing. As such, in most previous sample years the second sampling event is less hard. With the lack of rainfall between the sampling events this year, the reverse is observed, and the stream was found to be harder during the second sample event. The elevated results from the second sampling event could also be a result of the road salt being applied to the roads in close proximity to the stream. As well, sight 4 may have seen an increase in hardness due to effluent and runoff entering the system from the nearby construction waste disposal site.

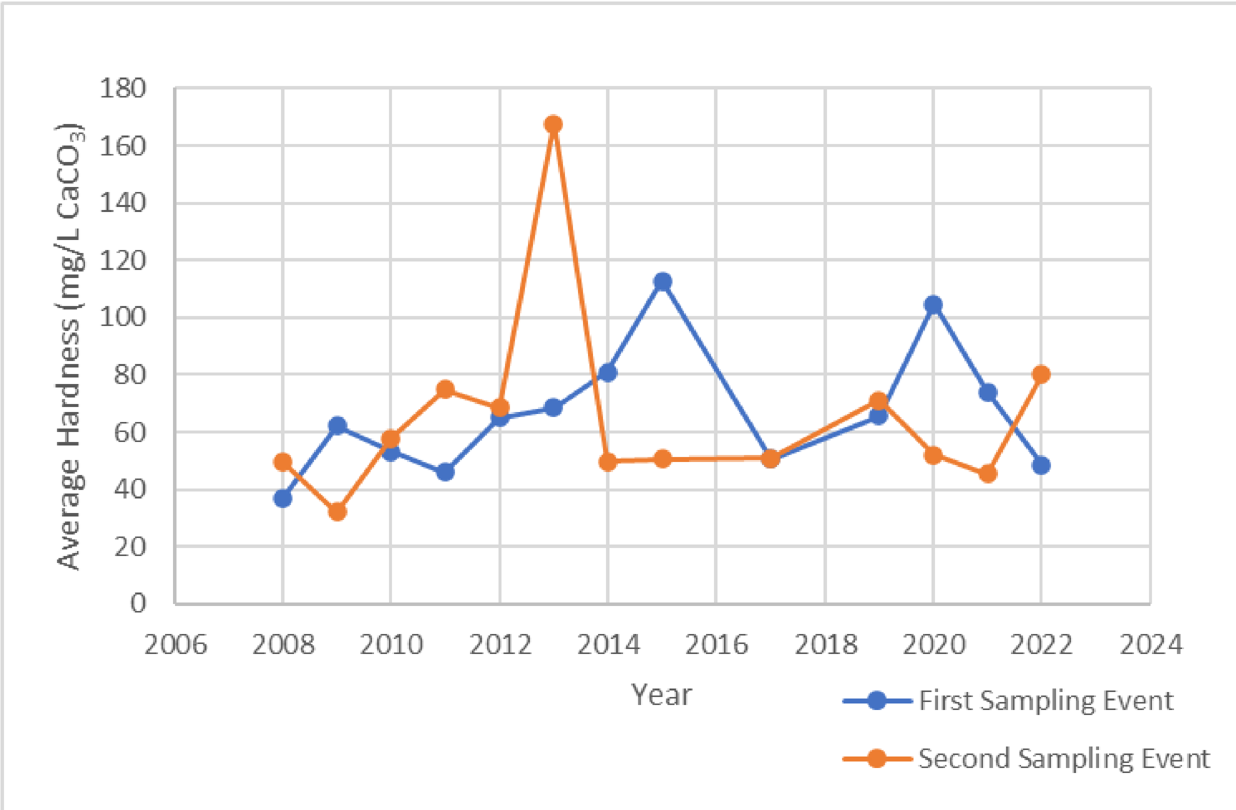

Figure 18. Data compiled from 2008-2022 illustrating the trend of average hardness in Richards Creek.

4.2.5 Nitrate and Phosphate

The Nitrate and Phosphate levels of the Richards Creek samples were determined in VIU laboratory facilities. The results from VIU laboratories differed from ALS laboratory results for Nitrate and Phosphate concentrations. ALS results showed much lower levels of Nitrate and Phosphate in each site compared to the analysis conducted at VIU. The differentiation in lab analysis results is most likely the result of lab equipment calibration issues or human error, because of the conflict in results the data was analyzed and interpreted separately and possible error in either the ALS or VIU results was noted.

VIU laboratory analysis results for Nitrate and Phosphate levels were used to calculate the ratios of Nitrogen (N) to Phosphorus (P) for each site and further used to identify any deviation from the optimal growth conditions of 16N:1P, the Redfield Ratio; this information is summarized in Table 4 below.

Table 4. Nitrate and Phosphate concentrations of Sites 1-4 of Richards Creek, and deviation of each site from the Redfield Ratio.

Sampling Event	Site	N (Nitrate mg/l)	P (Phosphate mg/l)	Ratio N:P (Redfield 16N:1P)
Event 1	1	0.12	0.10	6:5
	2	0.16	0.04	4:1
	3	0.45	0.06	7.5:1
	4	0.16	0.19	2:2.4
Event 2	1	0.18	0.02	9:1
	2	2.17	0.05	43.4:1

	3	0.38	0.05	7.6:1
	4	1.82	0.25	7.3:1

Results from Sites 1 – 4 of the first sampling event show Nitrate is well below the BC water quality guidelines; Nitrate levels in sampling event 2 do become close to the long-term chronic toxicity guideline of 3.0 mg/l, as Site 2 reaches 2.17 mg/l. Comparison of Nitrate to Phosphate ratios in Richards Creek to the Redfield Ratio does indicate the system is Nitrogen limited. Nitrate is the most accessible form of Nitrogen for plants growth, Nitrate in the right concentrations is integral to healthy aquatic plant growth but in excess has the potential to deteriorate a freshwater aquatic system. Excess Nitrate can contribute to advanced proliferation of aquatic plants and algal growth, creating a monoculture of aquatic life hence destroying diversity and contributing to accelerated eutrophication. Nitrate typically exists naturally in most surface waters at concentrations of approximately 0.3 mg/l, in the absence of anthropogenic sources (BCRIC). Anthropogenic sources of Nitrate are agricultural runoff, industrial effluent, and sewage treatment plant effluent (BCRIC).

There are no water quality guidelines for Phosphate set out in the BC water quality guidelines. VIU laboratory analysis of Phosphate does however follow the trend seen in many of the other nutrient samples which can be used as supporting data for the general assessment of the stream sites. Phosphate concentrations in Site 4 were the highest, increasing from sampling event 1 to 2. ALS data shows a more in depth analysis of organic and reactive forms of Phosphorus in Richards Creek.

4.2.6 Blank Results

The trip and field blanks underwent the same lab testing as the stream samples with addition to a lab pH test as the stream samples pH were tested in situ. Blank results (Table 5) were as expected, reflecting the distilled water source. Turbidity measurements show slight inconsistency but can be attributed to minimal contaminants on the surface of the test vessel which were not cleaned off as thoroughly as in other tests. Conductivity and pH were below detectable limits. The hardness results of 1 represent a detectable limit, where the test showed early signs of reaction before any antagonistic chemicals were added.

Table 5. Richards Creek: Blank Sample VIU Lab Results, 2022.

October 26, 2022							
Blanks	**Turbidity**	**Conductivity**	**Hardness**	**Alkalinity**	**Nitrate**	**Phosphorous**	**pH**
Field Blank	0.14	BDL	1	0.4	0.02	0.03	BDL
November 16, 2022							
Trip Blank	0.25	BDL	1	1.2	0.1	0.03	BDL
Field Blank	0.14	BDL	1	1.2	0.11	0.03	BDL

4.3 ALS Water Quality Laboratory Analysis

A set of water quality samples taken from sites 2 – 4 from each sampling event were sent to ALS to be analyzed for concentration of anions, nutrients, and total metals. The results of the ALS tested parameters were compared with the British Columbia Water Quality Guidelines.

4.3.1 General Water Quality

Three general water quality guidelines were analyzed from the samples taken from Richards Creek and sent to ALS laboratories, including conductivity, pH and hardness. Conductivity from the first sampling event was determined to be 100 μS/cm, 110 μS/cm and 128 μS/cm in Sites 2, 3 and 4, respectively; In the second sampling event conductivity was found to be 195 μS/cm, 204 μS/cm and 211μS/cm at Sites 2, 3 and 4, respectively. As the BC water quality guidelines do not specify any specific criterion for conductivity, this data may be used to support other parameter trends (BCRIC). It should be noted that coastal streams in BC typically experience conductivity of ≤ 100 μS/cm (BCRIC). In sampling event 1, many of the values for conductivity correspond with the parameters for coastal streams, the conductivity increased substantially in the second sampling event; the increase from sampling event 1 to 2 is likely the effects of the light rainfall which transpired between sampling events which created runoff into the stream introducing ions into the stream.

The hardness resulting from ALS lab analysis for sampling event 1 was 38.5 mg/l (CaCO3), 43.3 mg/l (CaCO3) and 49.2 mg/l (CaCO3) for Sites 2, 3 and 4, respectively; the hardness determined from sampling event 2 was 74.8 mg/l (CaCO3), 79.0 mg/l (CaCO3) and 79.3 mg/l (CaCO3) in Sites 2, 3 and 4, respectively. Water with a hardness of 60 mg/l or less is considered soft, and water with a hardness of 120 mg/l or higher is considered hard (BCRIC). Water samples from Richards Creek indicate the water is generally “soft” although hardness does increase from the first to second sampling event. Water categorized as harder typically decreases the toxicity of metals (BCRIC). The increase in hardness from sampling event 1 to 2 correlated with the trend seen in total metals, which may have acted to decrease the potential toxicity of any metals which increased in concentrations from sampling event 1 to 2.

The pH of Richards Creek from the ALS samples was found to be 7.56, 7.60 and 7.21 in sampling event 1, in Sites 2, 3 and 4, respectively. In the second sampling event pH was found to be 7.53, 7.56 and 6.90 in Sites 2, 3 and 4, respectively. The water quality guideline for aquatic life is a range of pH from 6.5 to 9.0 (BCRIC). The pH levels for Sites 2 to 4 of each sampling event were within the water quality guideline parameters, testing as slightly basic in all sites with the exception of Site 4 in sampling event 2. Slight changes are seen from sampling event 1 to 2, the greatest change in pH from sampling event 1 to 2 was seen in Site 4. Site 4 becomes slightly acidic at a pH of 6.90 in sampling event 2. The decrease in pH follows the same trend seen across the ALS results from Richards Creek. Although the decrease in pH of site 4 should be noted, it is still within the guidelines parameters for freshwater aquatic life, and well above the lethal acidic levels, which are stated in the BC water quality guidelines as 4.5 pH (BCRIC).

4.3.2 Total Metals

A majority of the parameters tested for by ALS in regard to the concentrations of total metals in the samples provided from Richards Creek fell under the minimum detection limit of the equipment used at the ALS laboratories; the remainder of the parameters were found to be within the British Columbia Approved Water Quality Guidelines.

Although no metals reach levels of acute or chronic toxicity, an apparent trend remains constant in all of the total metals found in the Richards Creek samples. The concentration of total metals was highest in Site 4 and increased, in many cases doubling, in the second sampling event. This trend could be the result of a multitude of factors. The primary anthropogenic source for many of the metals found in Site 4, is industrial effluent, the closest source of this form of effluent would be the North Cowichan Municipal dumping yard for construction waste which is located at a slightly higher elevation directly West of Site 4 of Richards Creek. Other sources such as agricultural land bordering Richards Creek upstream from Site 4 may also be a contributing factor. The stagnant nature of Site 4 as a result of very low flow rate, may also contribute to the accumulation of toxins at the site. The increase in concentrations from sampling event 1 to sampling event 2 is most likely the consequence of increased rainfall producing greater effluent runoff into Richards Creek.

The data from Richards Creek accumulated over the long-term monitoring program exhibits varying results for metal concentrations that exceeded the water quality guidelines. The generally reoccurring metals recorded in past samplings which exceeded the water quality guidelines were Aluminum (Al), Iron (Fe), Zinc (Zn), Copper

(Cu), and Calcium (Ca). The most prevalent reoccurring metal throughout the long-term monitoring was Aluminum. Aluminum exceeded the water quality guidelines in almost every year of monitoring from 2009-2021. As this year of sampling yielded no metals which exceeded the water quality guidelines, it can be seen as an outlier. Although it should be noted that Aluminum levels in Site 4 of this sampling year were 0.0570 mg/l and 0.0834 mg/l in sampling events 1 and 2, respectively. The water quality guideline for Aluminum is a maximum of 0.050 mg/l dissolved Al in a system with pH $\geq$ 6.5; The data provided by ALS labs is for total metals, this includes all metals dissolved in water as well as those bound to particles. The portion of dissolved metals in total metals water is most likely not its entirety (not 100%), hence the ratio of dissolved metals to those bound by particles is unknown. This makes it impossible to determine if Aluminum exceeds the guideline in this year of data or not.

4.3.3 Anions and Nutrients

Both results for Nitrate and Phosphate from ALS were lower than those tested at VIU, indicating a possible testing error or testing accuracy issue with one of the testing systems. Nitrogen levels, including total organic Nitrogen and Ammonia, Nitrate and Nitrite were all found to be within the approved BC water quality guidelines.

Phosphorus is the most limiting nutrient in an aquatic environment. Phosphorus loading in freshwater environments leads to prolific harmful algal growth, further deteriorating aquatic habitats and is the leading contributing factor in eutrophication (VIU). Orthophosphate is the form of Phosphorus most readily accessible by plants for uptake in the process of photosynthesis, thus the most integral form of Phosphorus to plants in growth (BCRIC). Orthophosphate and total Phosphorus concentration in the samples taken from Sites 2, 3 and 4 all indicated Richards Creek to be a eutrophic system. The BC water quality guidelines categorize the trophic level of a freshwater system into 3 categories: a system with <10 µg/l P yield is considered oligotrophic, 10-25 µg/l P yield is considered mesotrophic, and >25 µg/l P yield as eutrophic (BCRIC). The levels of total Phosphorus found in sampling event 1 for Sites 2, 3 and 4 were 0.0090 mg/l, 0.0135 mg/l and 0.0854 mg/l respectively; the levels of Phosphorus in sampling event 3 detected in Sites 2, 3 and 4 were 0.0077 mg/l, 0.0142 mg/l, and 0.137 mg/l respectively. All the levels detected from both sampling events were well above the threshold of a eutrophic system, concurring with the data collected at VIU laboratory on the levels of Phosphate and Nitrate. The levels of total Phosphorus also follow the trend seen in total metals; Site 4 in sampling event 2 has a drastically increased level of Phosphorus in comparison to the other sites tested in the second and first sampling events. Comparing the data of total Phosphorus from the second event of this year of sampling to the previous years of second sampling events, a trend forms (see Figure 19).

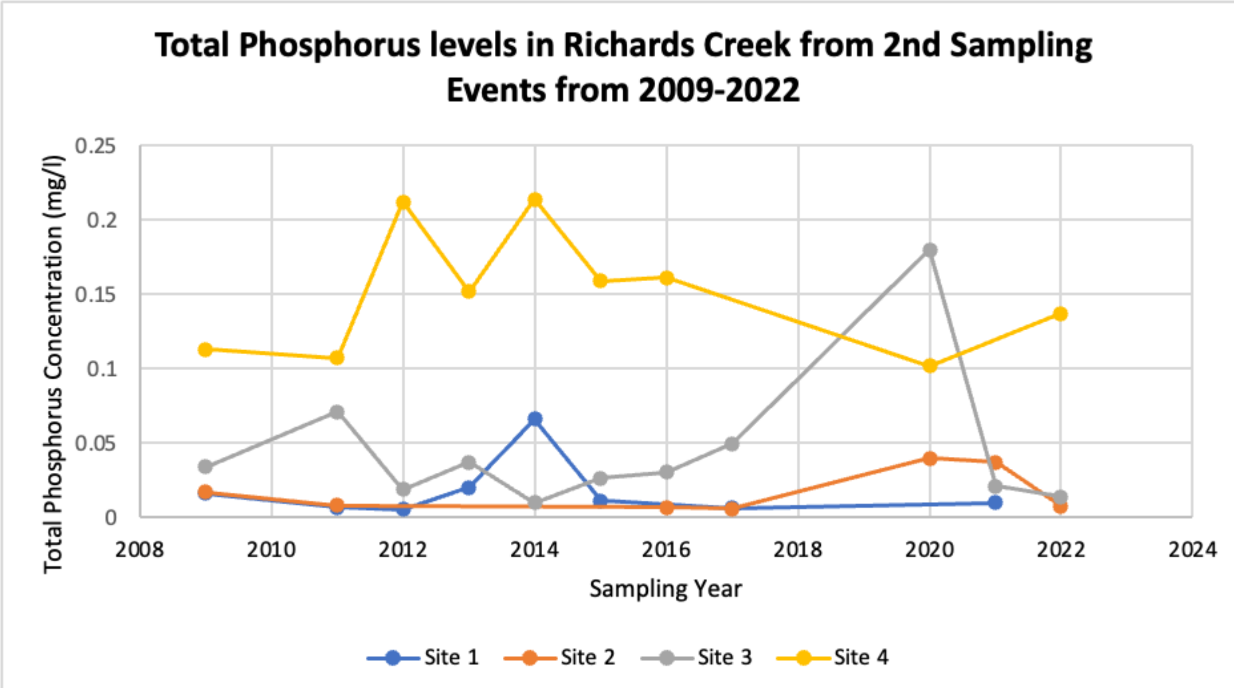

Figure 19. Data compiled from 2009-2022 illustrating the trend of total Phosphorus concentration in Richards Creek from second sampling events.

Figure 19 illustrates the long-term trend of total Phosphorus concentrations of Sites 1 – 4 of Richards Creek, and through analyzing this past data it becomes apparent that Site 4 has had problematic Phosphorus levels for a long period of time. It can be seen in Figure 19 that many portions of Richards Creek have been eutrophic since the beginning of the monitoring program. A particular trend in Sites 3 and 4 become visible as well. There is a clear correlation between the rise in Phosphorus concentration in Site 3 and the decrease in Phosphorus concentration in Site 4. The relationship between Site 3 and 4 is seen most prominently in 2011, 2013 and then progressively from 2015 to 2020, where in each sampling year the Phosphorus levels rise in Site 3 and subsequently fall in Site 4. As Phosphorus is the most limiting nutrient in a natural system, the relationship between Site 3 and 4 seen in the long-term data might be the result of Phosphorus being entered into the system before Site 3 and being absorbed by the aquatic vegetation of the creek before it can be dispersed downstream to Site 4. The Phosphorus levels in Richards Creek are most likely the consequence of anthropogenic sources as there is no natural mechanism for Phosphorus fixation, as there is for Nitrogen. The most probable anthropogenic source is the agricultural land that borders much of Richards Creek. The absence of a true riparian zone to buffer and filter the effluent from agricultural land and urban development is a most likely the main driving force in the further eutrophication of Richards Creek.

4.4 Stream Invertebrates

4.4.1 Site Rating and Diversity

Table 6. Total Invertebrate Count for Richards Creek Sites 1 – 3 (October 26 2022)

Pollution Tolerance	Invertebrate Taxa	Site 1	Site 2	Site 3
Category 1	Caddisfly Larva	11	19	7
Pollution	Mayfly Nymph	250	100	5
Intolerant	Stonefly Nymph	14	11	0
	Dobsonfly	0	1	0
Category 2	Cranefly Larva	44	3	0
Somewhat Pollution	Damselfly Larva	0	5	0
Intolerant	Dragonfly Larva	3	0	0
	Amphipod	3	0	17
Category 3	Aquatic Worm	6	46	0
Pollution Tolerant	Midge Larva	0	0	16
	Water Mite	0	1	0
Total Abundance		331	186	45
Density (Invertebrate/m²)		1225	689	167
Site Assessment Average Rating		2.75	3.25	1.5
Shannon-Wiener Diversity Index		0.855	1.3	1.27

Above are the results we acquired from three invertebrate samples taken from sites 1 – 3 with a Hess sampler from Richards Creek on October 26, 2022. Each site scored a different site assessment average rating from poor to good, ranging between a 1 – 4, with 1 being poor and 4 being good. Site 1 had the largest total abundance of 331 invertebrates compared to the other sites, with the Mayfly Nymph being the dominant taxon (Figure 20). Site 1 also had the greatest invertebrate density of 1225/m^2 and a site assessment rating of 2.75, being in the marginal to acceptable category. Site 2 had a much lower total abundance and density but had the best site assessment rating of 3.25, being in the acceptable to good category. Site 2 also had the Mayfly Nymph being the dominant taxon which is pollution intolerant (Figure 21). Site 3 had the worst site assessment average rating at 1.5 while also having the lowest abundance rating by a large margin. Site 3 had a somewhat pollution intolerant dominant taxon with the Amphipod being the most prevalent (Figure 22). The overall site assessment average received in October 2022 compared to reports done on Richards Creek in the past fare quite well (Evans et al. 2020), having a higher average than most and the exact same score as the report done in 2016 by George et al. (2016).

Table 7. Total Invertebrate Count for Richards Creek Sites 1 – 3 (November 16 2022)

Pollution Tolerance	Invertebrate Taxa	Site 1	Site 2	Site 3
Category 1	Caddisfly Larva	0	15	2
Pollution	Mayfly Nymph	100	41	12
Intolerant	Stonefly Nymph	2	19	3
Category 2	Cranefly Larva	1	2	0
Somewhat Pollution	Amphipod	3	3	5
Intolerant	Watersnipe Larva	1	0	0
Category 3	Aquatic Worm	0	0	1
Pollution Tolerant	Midge Larva	0	6	0
	Blackfly Larva	30	5	0
	True Adult Bug	1	0	1
Total Abundance		138	91	24
Density (Invertebrate/m²)		511	337	89
Site Assessment Average Rating		2.25	3	2.5
Shannon-Wiener Diversity Index		0.817	1.52	1.41

Above is a summary table of the invertebrate data we collected from sites 1-3 where 3 samples were taken with a Hess sampler from Richards Creek on November 16, 2022. Site 1 had the greatest abundance once again with 138 invertebrates and a density of 511/m² but dropped by more than half compared to the sample taken in October. Its site assessment average also dropped to 2.25 compared to 2.75 and again the Mayfly Nymph was the dominant taxon (Figure 23). Site 2 had its abundance and density also dropped by more than half with an invertebrate density of 337/m². Its site assessment average dropped slightly compared to site 1 with a rating of 3, still being acceptable and having the Mayfly Nymph being the dominant taxon (Figure 24). Site 3 also saw a drop in total invertebrate abundance and density but not as bad compared to site 1 and 2. Its site assessment average actually increased by 1, giving it an overall rating of 2.5, being in the marginal to acceptable range. Site 3 also saw its dominant taxon be the Mayfly Nymph (Figure 25) which is a pollution intolerant invertebrate. This is the same trend as Evans et al. (2020), with site 3 having the site assessment average go up from October compared to site 1 and 2 rates drop.

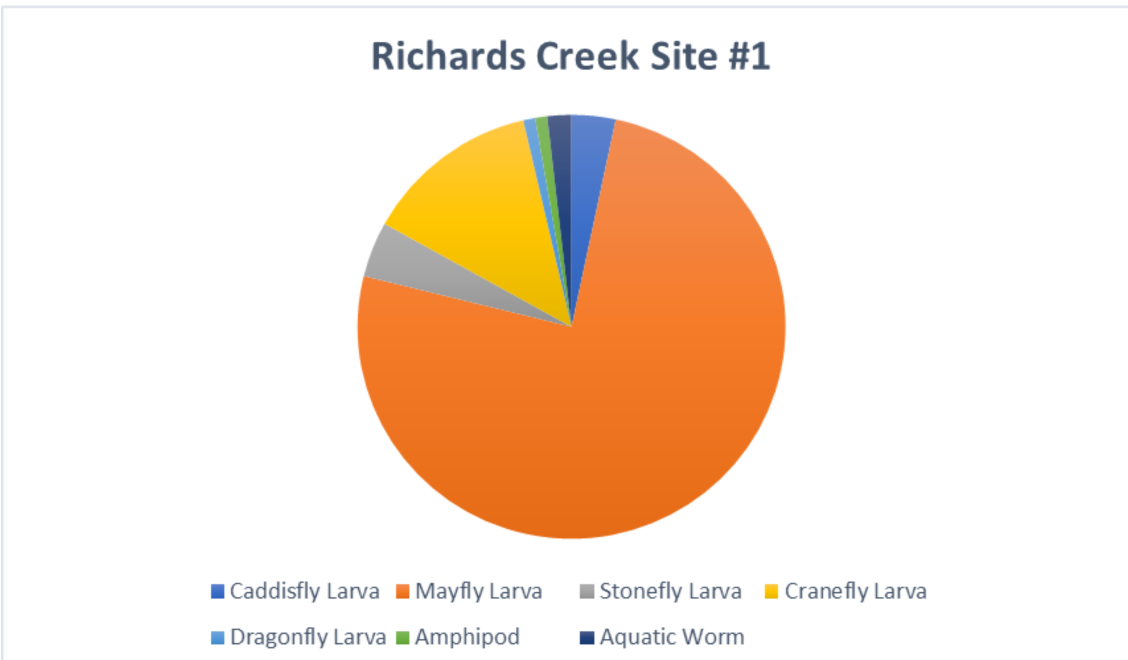

Figure 20. Richards Creek Invertebrate Site 1 (October 26 2022)

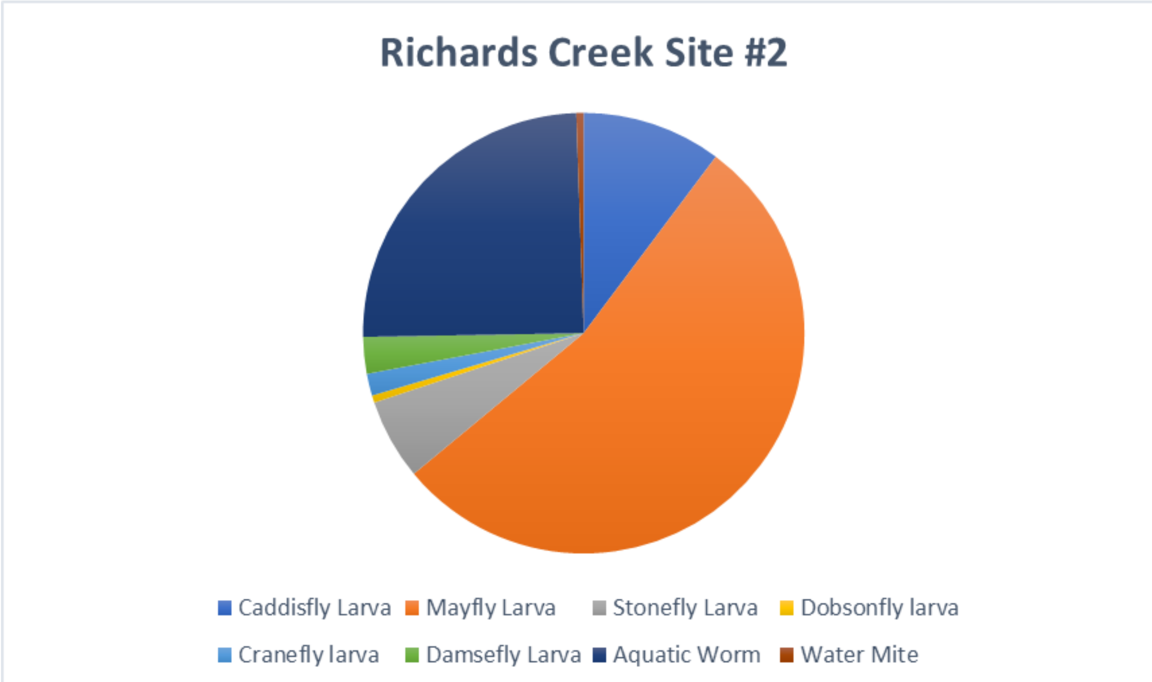

Figure 21. Richards Creek Invertebrate Site 2 (October 26 2022)

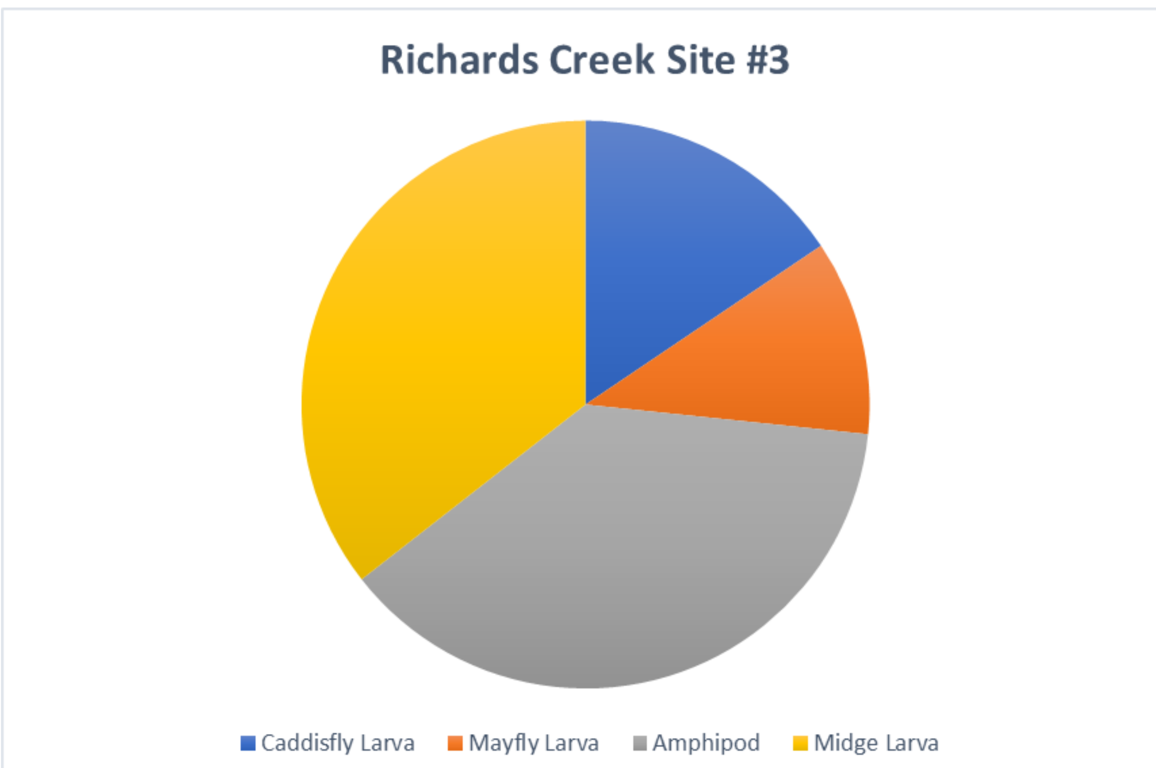

Figure 22. Richards Creek Invertebrate Site 3 (October 26 2022)

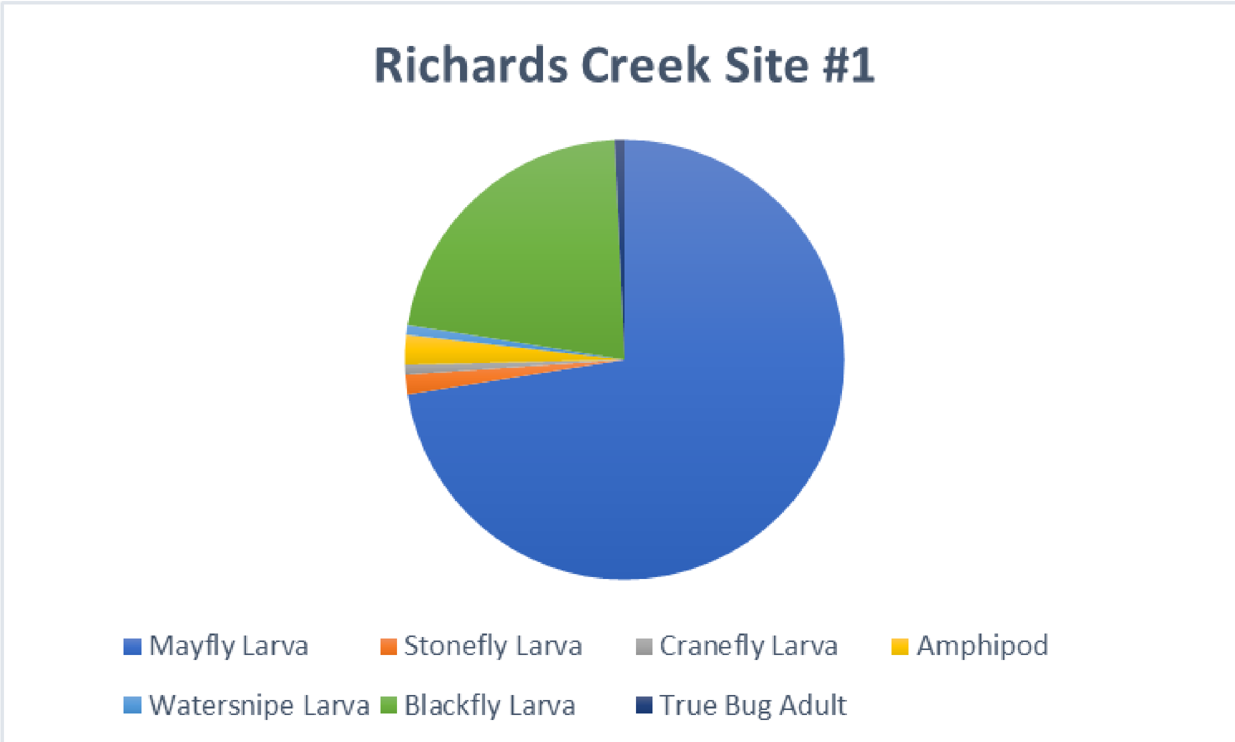

Figure 23. Richards Creek Invertebrate Site 1 (November 16 2022)

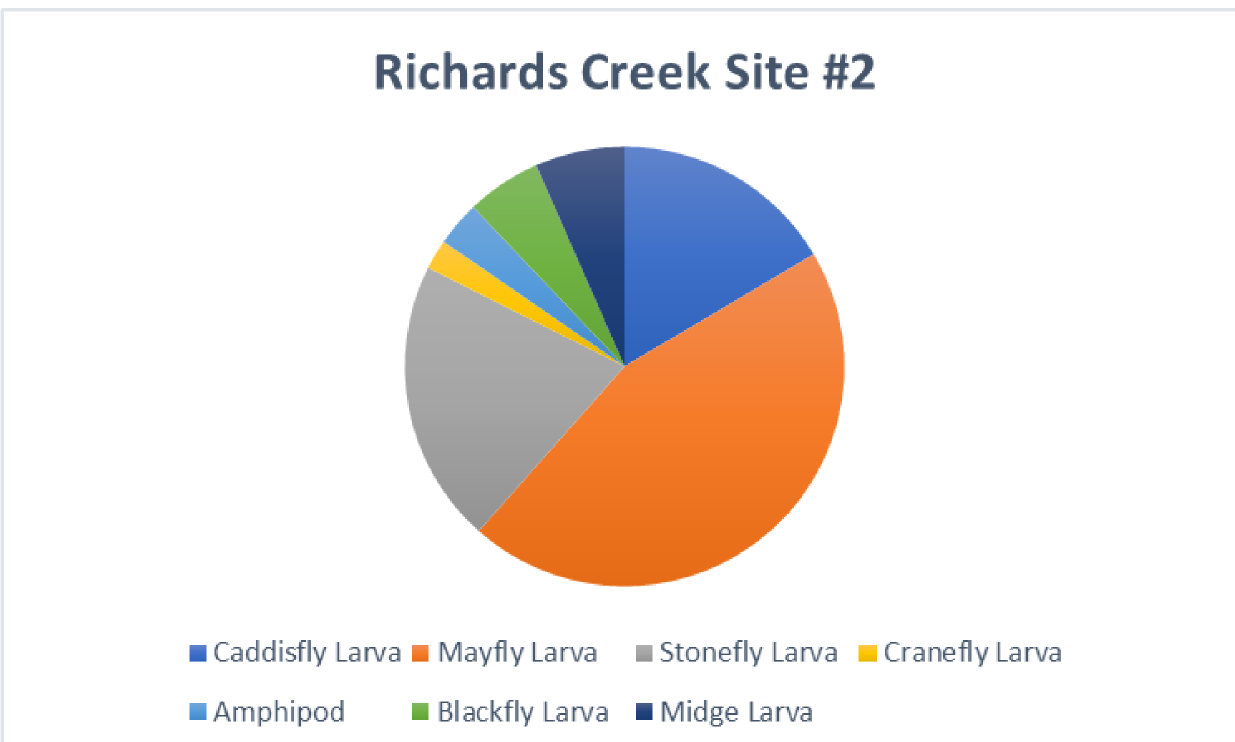

Figure 24. Richards Creek Invertebrate Site 2 (November 16 2022)

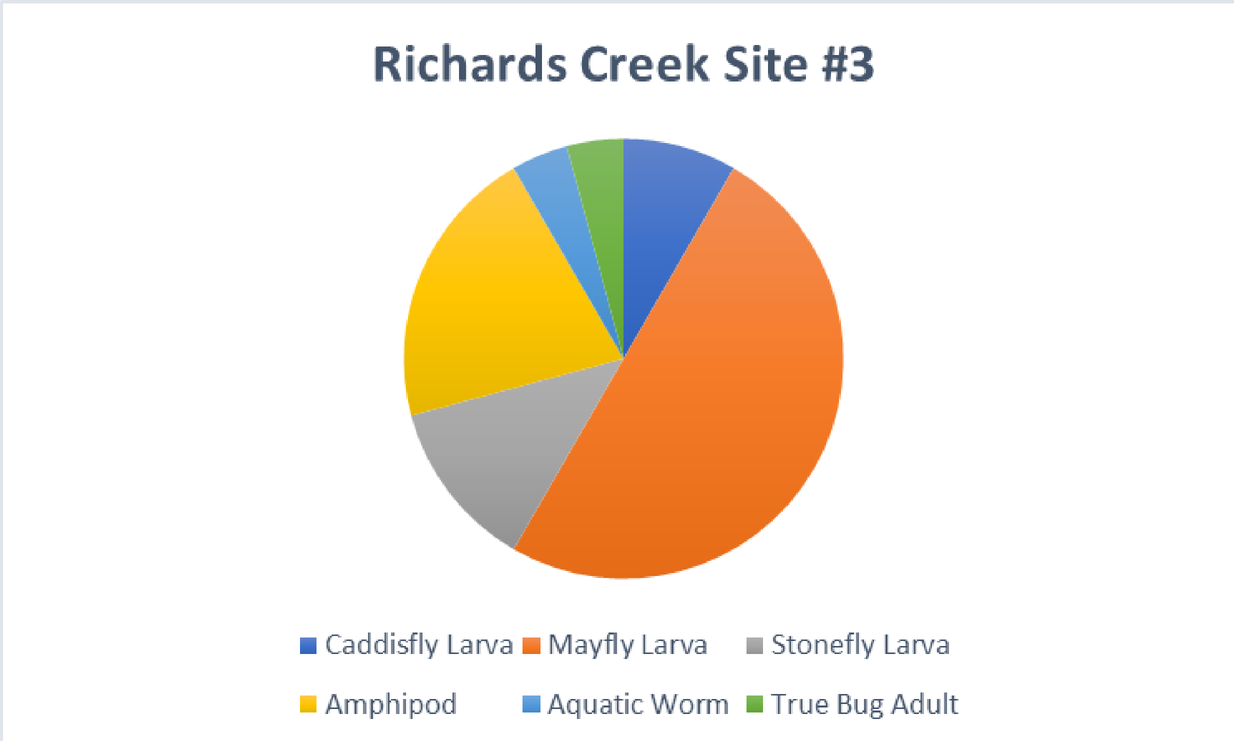

Figure 25. Richards Creek Invertebrate Site 3 (November 16 2022)

4.4.2 Taxon Richness and Diversity

In Table 6 and 7 a Shannon-Weiner diversity index was calculated to determine the invertebrate taxon diversity analyzed at each site. The Shannon-Wiener calculation is done by taking the number of species, the proportion of each species from the total number of organisms and summing the proportion times the logarithm of the proportion of each species. Scoring a 1 is considered high diversity on the Shannon-Wiener diversity index.

Observing table 6 and 7, the Shannon-Wiener diversity index decreased between phase 1 and phase 2, being less diverse. The species collected halved between the two phases, with phase 1 receiving a higher total abundance compared to the overall past years collections. This could be the case because of the unseasonal drought that took place with the stream having a lower flow than normal. In phase 1 site 3 had the lowest site assessment rating but that increased in phase 2, where site 1 and 2 decreased between the two phases. The pollution at site 3 in phase 1 could be from the farms adjacent to Richards Creek as site 3 did not have many pollution intolerant invertebrates.

5.0 Summary/Recommendations

Richards creek is overall a healthy stream, The locations of sampling were well representative of each aspect that the stream had to offer and creates a thorough depiction. Through two events of water quality sampling, hydrology and invertebrate sampling at four sites, a holistic report was generated to not only show the short term assessment but to contribute to the long term collection of stream data. Richards creek was found to be heavily affected by the surrounding agricultural activities as well as the residential infrastructure. The progressive eutrophication in sequence of site number, lead to site four being uninhabitable. The agricultural deficits were accompanied with a lack of riparian area, unnatural trench-like shape and direction as well as a low gradient/ low flow stream. It is recommended that buffer strips or improved riparian areas be installed. Being that Richards creek is nitrate limited, the regulation and control of fertilizing events, frequencies and timing may help to reduce the degrading eutrophic state.

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Appendix:

Tables:

Dissolved Oxygen Trends, 2009-2022

Dissolved Oxygen (mg/L): Field Day 1				
Year	**Site 1**	**Site 2**	**Site 3**	**Site 4**
2009	10.23	11.29	11.12	2.54
2010	9.47	10.8	10.7	2.5
2011	12.88	12.67	16.05	8.09
2013	4.7	4.7	4.7	0.81
2014	9.1	10	9.8	1.9
2015	12.5	12.1	11.8	3.7
2016	10	10.5	10	2
2019	11.7	11.7	11.6	1.7
2020	11.4	11.75	11.76	4.9
2021	10	10.5	10.2	1
2022	11.39	11.69	11.73	1.24

Dissolved Oxygen Trends, 2008-2022

Dissolved Oxygen (mg/L): Field Day 2				
Year	**Site 1**	**Site 2**	**Site 3**	**Site 4**
2008	9.83	10.61	9.16	1.88
2009	11.2	11.4	11.4	8.75
2010	13.12	13.73	13.61	8.81
2011	21.63	21.1	21.44	18
2012	9.41	10.1	9.95	4.9
2013	11.6	12.8	12.4	5.36
2014	12.9	13.1	13.3	5.6
2015	11.2	13.1	13.5	8.1

2016	11	11	11	11
2019	10.6	10.8	10.3	1.3
2020	11.34	11.83	11.48	6.15
2022	9.98	12.27	12.47	2.09

Temperature Trends, 2008-2022

Temperature (Celsius): Field Day 1				
Year	**Site 1**	**Site 2**	**Site 3**	**Site 4**
2008	6	7	7	7
2009	8.16	7.95	7.79	7.3
2010	10.85	10.26	10.41	9.92
2011	7.5	7.88	6.97	6.04
2012	9.6	9.5	9.4	8.5
2013	-	10.1	9.4	9.4
2014	9.4	9.4	9.5	10.3
2015	10.1	9.4	9.4	11.3
2016	10	10	10	11
2019	7.5	7.5	7.2	7
2020	11.5	11.3	11.3	11.6
2021	9.9	9.8	10.2	11
2022	8.5	8.1	7.8	7.9

Temperature Trends, 2008-2022

Temperature (Celsius): Field Day 2				
Year	**Site 1**	**Site 2**	**Site 3**	**Site 4**
2008	8.52	8.46	8.49	8.83
2009	7.13	7.36	7.36	6.67
2010	2.63	2.44	2.17	1.71

2011	2.04	2.45	1.72	3.31
2012	7.72	7.78	7.77	7.17
2013	7.5	7.3	8.3	6.6
2014	4.5	4.2	3.6	3
2015	6.9	5.6	5.6	4.2
2016	9	9	9	9
2019	9.4	9.9	9.9	13.3
2020	8.7	8.6	8.6	6.9
2022	4.4	4.6	3.5	3.5

pH Trends, 2009-2022

pH: Field Day 1				
Year	**Site 1**	**Site 2**	**Site 3**	**Site 4**
2009	8.38	8.26	8	7.65
2010	7.02	6.55	6.76	6.37
2011	5.89	6.74	6.18	6.04
2012	7	7.4	7.5	7.6
2013	6.43	6.47	6.49	6.07
2014	7.4	7.6	7.7	6.9
2015	8.6	8	8.2	7.5
2016	7.5	8	7	6.5
2017	7.7	7.6	7.4	6.4
2019	8.3	8.4	8.1	7.6
2020	8.2	8.1	7.5	7.1
2021	8	8	8.6	7.7
2022	6.9	7.2	7.5	7.9

pH Trends, 2008-2022

pH: Field Day 2				
Year	**Site 1**	**Site 2**	**Site 3**	**Site 4**
2008	7.48	7.41	7.55	6.2
2009	7.5	7.15	6.89	8.75
2010	5.38	7.24	6.64	6.67
2011	6.18	6.6	6.3	6.44
2012	7.63	7.27	7.43	5.1
2013	7.45	7.6	7.7	6.9
2014	8	7.7	7.7	7.2
2015	8.9	8.5	8.1	7.5
2016	6.5	7	7	6.5
2017	8.1	8.1	7.4	7.2
2019	8.3	8.4	8	7.3
2020	7.6	6.7	6.6	6.6
2021	8.3	8.5	8.1	-
2022	6.8	6.8	6.6	8.7

Conductivity Trends, 2009-2022

Conductivity: Field Day 1				
Year	**Site 1**	**Site 2**	**Site 3**	**Site 4**
2009	135	175	184	212
2010	120	141	161	150
2011	90	132	134	175
2012	89	112	141	142
2013	71	92	102	301
2014	148	180	180	220
2015	152	175	163	227

2016	80	100	110	125
2017	161	202	211	333
2019	90	133	141	205
2020	95	120	129	243
2021	108	138	155	197
2022	68	96	106	128

Conductivity Trends, 2008-2022

Conductivity: Field Day 2				
Year	**Site 1**	**Site 2**	**Site 3**	**Site 4**
2008	149	167	181	204
2009	78	86	91	110
2010	135	146	162	182
2011	118	164	176	276
2012	122	142	151	188
2013	112	126	143	175
2014	80	101	104	153
2015	75	94	100	133
2016	60	75	75	125
2017	127	130	142	155
2019	128	148	171	204
2020	86	92	95	122
2021	114	90	153	-
2022	153	185	197	208

ALS Result Summary, October 26, 2022

Project	
Report To	Owen Hargrove, Vancouver Island University
Date Received	27-Oct-2022 12:00
Issue Date	07-Nov-2022 12:36
Amendment	0

Analyte	ALS Sample ID	Client Sample ID	Matrix	Sub-Matrix	Method	Results	Detection Limit	Units	Qual	Date Sampled	Time Sampled	Prep Date	Analysis Date	QC Lot	QC Eval	Hold Time Eval
Physical Tests (Matrix: Water)																
conductivity	VA22C6261-010	Richards Creek -Site 2	Water	Water	E100	100	2.0	µS/cm		26-Oct-2022	09:21	02-Nov-2022	02-Nov-2022	725901	ü	ü
hardness (as $CaCO_3$), from total Ca/Mg	VA22C6261-010	Richards Creek -Site 2	Water	Water	EC100A	38.5	0.50	mg/L		26-Oct-2022	09:21		04-Nov-2022		ü	ü

pH	VA22C6261-010	Richards Creek -Site 2	Water	Water	E108	7.56	0.10	pH units	26-Oct-2022	09:21	02-Nov-2022	02-Nov-2022	725902	ü	û

Anions and Nutrients (Matrix: Water)

ammonia, total (as N)	VA22C6261-010	Richards Creek -Site 2	Water	Water	E298	0.0062	0.0050	mg/L	26-Oct-2022	09:21	02-Nov-2022	03-Nov-2022	726281	ü	ü
nitrate (as N)	VA22C6261-010	Richards Creek -Site 2	Water	Water	E235.NO3-L	0.219	0.0050	mg/L	26-Oct-2022	09:21	02-Nov-2022	02-Nov-2022	725904	ü	û
nitrite (as N)	VA22C6261-010	Richards Creek -Site 2	Water	Water	E235.NO2-L	<0.0010	0.0010	mg/L	26-Oct-2022	09:21	02-Nov-2022	02-Nov-2022	725905	ü	û
nitrogen, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E366	0.420	0.030	mg/L	26-Oct-2022	09:21	02-Nov-2022	03-Nov-2022	726286	ü	ü
phosphate, ortho-, dissolved (as P)	VA22C6261-010	Richards Creek -Site 2	Water	Water	E378-U	<0.0010	0.0010	mg/L	26-Oct-2022	09:21	02-Nov-2022	02-Nov-2022	725910	ü	û
phosphorus, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E372-U	0.0090	0.0020	mg/L	26-Oct-2022	09:21	03-Nov-2022	04-Nov-2022	726282	ü	ü

Total Metals (Matrix: Water)

aluminum, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	0.0324	0.0030	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
antimony, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
arsenic, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	0.00014	0.00010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
barium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	0.00664	0.00010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü

beryllium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.000020	0.000020	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
bismuth, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.000050	0.000050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
boron, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	0.012	0.010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
cadmium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.0000050	0.0000050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
calcium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	11.4	0.050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
cesium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
chromium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.00050	0.00050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
cobalt, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
copper, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	0.00085	0.00050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
iron, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	0.197	0.010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
lead, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.000050	0.000050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
lithium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.0010	0.0010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
magnesium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	2.44	0.0050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü

manganese, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	0.0279	0.00010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
molybdenum, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	0.000072	0.000050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
nickel, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	<0.00050	0.00050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
phosphorus, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	<0.050	0.050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
potassium, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	0.495	0.050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
rubidium, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	0.00061	0.00020	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
selenium, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	<0.000050	0.000050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
silicon, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	4.78	0.10	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
silver, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
sodium, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	4.23	0.050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
strontium, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	0.0415	0.00020	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
sulfur, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	2.30	0.50	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
tellurium, total	VA22C6261-010	Richards Creek-Site 2	Water	Water	E420	<0.00020	0.00020	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü

thallium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
thorium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
tin, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
titanium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	0.00125	0.00030	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
tungsten, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
uranium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
vanadium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.00050	0.00050	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
zinc, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.0030	0.0030	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü
zirconium, total	VA22C6261-010	Richards Creek -Site 2	Water	Water	E420	<0.00020	0.00020	mg/L	26-Oct-2022	09:21	03-Nov-2022	03-Nov-2022	725843	ü	ü

Physical Tests (Matrix: Water)

conductivity	VA22C6261-011	Richards Creek -Site 3	Water	Water	E100	110	2.0	µS/cm	26-Oct-2022	08:56	02-Nov-2022	02-Nov-2022	725901	ü	ü
hardness (as CaCO3), from total Ca/Mg	VA22C6261-011	Richards Creek -Site 3	Water	Water	EC100A	43.3	0.50	mg/L	26-Oct-2022	08:56		04-Nov-2022		ü	ü
pH	VA22C6261-011	Richards Creek -Site 3	Water	Water	E108	7.60	0.10	pH units	26-Oct-2022	08:56	02-Nov-2022	02-Nov-2022	725902	ü	û

Anions and Nutrients (Matrix: Water)

ammonia, total (as N)	VA22C6261-011	Richards Creek -Site 3	Water	Water	E298	0.0076	0.0050	mg/L	26-Oct-2022	08:56	02-Nov-2022	03-Nov-2022	726281	ü	ü
nitrate (as N)	VA22C6261-011	Richards Creek -Site 3	Water	Water	E235.NO3-L	0.297	0.0050	mg/L	26-Oct-2022	08:56	02-Nov-2022	02-Nov-2022	725904	ü	û
nitrite (as N)	VA22C6261-011	Richards Creek -Site 3	Water	Water	E235.NO2-L	<0.0010	0.0010	mg/L	26-Oct-2022	08:56	02-Nov-2022	02-Nov-2022	725905	ü	û
nitrogen, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E366	0.487	0.030	mg/L	26-Oct-2022	08:56	02-Nov-2022	03-Nov-2022	726286	ü	ü
phosphate, ortho-, dissolved (as P)	VA22C6261-011	Richards Creek -Site 3	Water	Water	E378-U	0.0045	0.0010	mg/L	26-Oct-2022	08:56	02-Nov-2022	02-Nov-2022	725910	ü	û
phosphorus, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E372-U	0.0135	0.0020	mg/L	26-Oct-2022	08:56	03-Nov-2022	04-Nov-2022	726282	ü	ü

Total Metals (Matrix: Water)

aluminum, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.0360	0.0030	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
antimony, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
arsenic, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.00018	0.00010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
barium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.00674	0.00010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
beryllium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.000020	0.000020	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü

bismuth, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.000050	0.000050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
boron, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.012	0.010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
cadmium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.0000050	0.0000050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
calcium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	12.5	0.050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
cesium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
chromium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00050	0.00050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
cobalt, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
copper, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.00088	0.00050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
iron, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.190	0.010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
lead, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.000050	0.000050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
lithium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.0010	0.0010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
magnesium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	2.93	0.0050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
manganese, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.0119	0.00010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü

molybdenum, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.000072	0.000050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
nickel, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00050	0.00050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
phosphorus, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.050	0.050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
potassium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.662	0.050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
rubidium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.00062	0.00020	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
selenium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.000060	0.000050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
silicon, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	5.16	0.10	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
silver, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
sodium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	4.47	0.050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
strontium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.0456	0.00020	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
sulfur, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	2.52	0.50	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
tellurium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00020	0.00020	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
thallium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü

thorium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
tin, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
titanium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	0.00150	0.00030	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
tungsten, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
uranium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
vanadium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00050	0.00050	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
zinc, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.0030	0.0030	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü
zirconium, total	VA22C6261-011	Richards Creek -Site 3	Water	Water	E420	<0.00020	0.00020	mg/L	26-Oct-2022	08:56	03-Nov-2022	03-Nov-2022	725843	ü	ü

Physical Tests (Matrix: Water)

conductivity	VA22C6261-012	Richards Creek -Site 4	Water	Water	E100	128	2.0	μS/cm	26-Oct-2022	08:38	02-Nov-2022	02-Nov-2022	725901	ü	ü
hardness (as CaCO3), from total Ca/Mg	VA22C6261-012	Richards Creek -Site 4	Water	Water	EC100A	49.2	0.50	mg/L	26-Oct-2022	08:38		04-Nov-2022		ü	ü
pH	VA22C6261-012	Richards Creek -Site 4	Water	Water	E108	7.21	0.10	pH units	26-Oct-2022	08:38	02-Nov-2022	02-Nov-2022	725902	ü	û

Anions and Nutrients (Matrix: Water)

ammonia, total (as N)	VA22C6261-012	Richards Creek -Site 4	Water	Water	E298	0.0368	0.0050	mg/L	26-Oct-2022	08:38	02-Nov-2022	03-Nov-2022	726281	ü	ü
nitrate (as N)	VA22C6261-012	Richards Creek -Site 4	Water	Water	E235.NO3-L	0.0374	0.0050	mg/L	26-Oct-2022	08:38	02-Nov-2022	02-Nov-2022	725904	ü	û
nitrite (as N)	VA22C6261-012	Richards Creek -Site 4	Water	Water	E235.NO2-L	0.0024	0.0010	mg/L	26-Oct-2022	08:38	02-Nov-2022	02-Nov-2022	725905	ü	û
nitrogen, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E366	0.614	0.030	mg/L	26-Oct-2022	08:38	02-Nov-2022	03-Nov-2022	726286	ü	ü
phosphate, ortho-, dissolved (as P)	VA22C6261-012	Richards Creek -Site 4	Water	Water	E378-U	0.0331	0.0010	mg/L	26-Oct-2022	08:38	02-Nov-2022	02-Nov-2022	725910	ü	û
phosphorus, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E372-U	0.0854	0.0020	mg/L	26-Oct-2022	08:38	03-Nov-2022	04-Nov-2022	726282	ü	ü

Total Metals (Matrix: Water)

aluminum, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.0570	0.0030	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
antimony, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
arsenic, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.00025	0.00010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
barium, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.00891	0.00010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
beryllium, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	<0.000020	0.000020	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
bismuth, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	<0.000050	0.000050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü

boron, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.016	0.010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
cadmium, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.0000072	0.0000050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
calcium, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	14.6	0.050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
cesium, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
chromium, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	<0.00050	0.00050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
cobalt, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.00016	0.00010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
copper, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.00105	0.00050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
iron, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.677	0.010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
lead, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.000110	0.000050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
lithium, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	<0.0010	0.0010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
magnesium, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	3.10	0.0050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
manganese, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.0942	0.00010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
molybdenum, total	VA22C6261-012	Richards Creek -Site 4	Water	Water	E420	0.000108	0.000050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü

nickel, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	<0.00050	0.00050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
phosphorus, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	0.095	0.050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
potassium, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	1.05	0.050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
rubidium, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	0.00110	0.00020	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
selenium, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	0.000068	0.000050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
silicon, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	5.54	0.10	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
silver, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
sodium, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	5.64	0.050	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
strontium, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	0.0545	0.00020	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
sulfur, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	2.52	0.50	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
tellurium, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	<0.00020	0.00020	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
thallium, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	<0.000010	0.000010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü
thorium, total	VA22C6261-012	Richards Creek-Site 4	Water	Water	E420	<0.00010	0.00010	mg/L	26-Oct-2022	08:38	03-Nov-2022	03-Nov-2022	725843	ü	ü

tin, total	VA22C62 61-012	Richar ds Creek -Site 4	Wat er	Wat er	E420	<0.0001 0	0.0001 0	mg/ L	26- Oct -20 22	08: 38	03- No v-2 022	03- No v-2 022	7258 43	ü	ü
titanium, total	VA22C62 61-012	Richar ds Creek -Site 4	Wat er	Wat er	E420	0.00235	0.0003 0	mg/ L	26- Oct -20 22	08: 38	03- No v-2 022	03- No v-2 022	7258 43	ü	ü
tungsten, total	VA22C62 61-012	Richar ds Creek -Site 4	Wat er	Wat er	E420	<0.0001 0	0.0001 0	mg/ L	26- Oct -20 22	08: 38	03- No v-2 022	03- No v-2 022	7258 43	ü	ü
uranium, total	VA22C62 61-012	Richar ds Creek -Site 4	Wat er	Wat er	E420	<0.0000 10	0.0000 10	mg/ L	26- Oct -20 22	08: 38	03- No v-2 022	03- No v-2 022	7258 43	ü	ü
vanadium, total	VA22C62 61-012	Richar ds Creek -Site 4	Wat er	Wat er	E420	0.00053	0.0005 0	mg/ L	26- Oct -20 22	08: 38	03- No v-2 022	03- No v-2 022	7258 43	ü	ü
zinc, total	VA22C62 61-012	Richar ds Creek -Site 4	Wat er	Wat er	E420	<0.0030	0.0030	mg/ L	26- Oct -20 22	08: 38	03- No v-2 022	03- No v-2 022	7258 43	ü	ü
zirconium, total	VA22C62 61-012	Richar ds Creek -Site 4	Wat er	Wat er	E420	<0.0002 0	0.0002 0	mg/ L	26- Oct -20 22	08: 38	03- No v-2 022	03- No v-2 022	7258 43	ü	ü

ALS Result Summary, November 16, 2022

Project	
Report To	Owen Hargrove, Vancouver Island University
Date Received	17-Nov-2022 11:00
Issue Date	28-Nov-2022 12:10
Amendment	0

Analyte	ALS Sample ID	Client Sample ID	Matrix	Sub-Matrix	Method	Results	Detection Limit	Units	Qual	Date Sampled	Time Sampled	Prep Date	Analysis Date	QC Lot	QC Eval	Hold Time Eval
Physical Tests (Matrix: Water)																
conductivity	VA22C8006-001	Richards Creek Site 2	Water	Water	E100	195	2.0	µS/cm		16-Nov-2022	10:05	18-Nov-2022	18-Nov-2022	748870	ü	ü
hardness (as CaCO3), from total Ca/Mg	VA22C8006-001	Richards Creek Site 2	Water	Water	EC100A	74.8	0.50	mg/L		16-Nov-2022	10:05		24-Nov-2022		ü	ü

pH	VA22C8006-001	Richards Creek Site 2	Water	Water	E108	7.53	0.10	pH units	16-Nov-2022	10:05	18-Nov-2022	18-Nov-2022	748868	ü	û

Anions and Nutrients (Matrix: Water)

ammonia, total (as N)	VA22C8006-001	Richards Creek Site 2	Water	Water	E298	0.0064	0.0050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	752627	ü	ü
nitrate (as N)	VA22C8006-001	Richards Creek Site 2	Water	Water	E235.NO3-L	0.878	0.0050	mg/L	16-Nov-2022	10:05	18-Nov-2022	18-Nov-2022	748877	ü	ü
nitrite (as N)	VA22C8006-001	Richards Creek Site 2	Water	Water	E235.NO2-L	0.0015	0.0010	mg/L	16-Nov-2022	10:05	18-Nov-2022	18-Nov-2022	748874	ü	ü
nitrogen, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E366	0.978	0.030	mg/L	16-Nov-2022	10:05	22-Nov-2022	23-Nov-2022	752625	ü	ü
phosphate, ortho-, dissolved (as P)	VA22C8006-001	Richards Creek Site 2	Water	Water	E378-U	0.0014	0.0010	mg/L	16-Nov-2022	10:05	18-Nov-2022	18-Nov-2022	748878	ü	ü
phosphorus, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E372-U	0.0077	0.0020	mg/L	16-Nov-2022	10:05	22-Nov-2022	23-Nov-2022	752628	ü	ü

Total Metals (Matrix: Water)

aluminum, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.0326	0.0030	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
antimony, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
arsenic, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.00016	0.00010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
barium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.0110	0.00010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
beryllium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.000020	0.000020	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
bismuth, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.000050	0.000050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
boron, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.013	0.010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
cadmium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.0000050	0.0000050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
calcium, total	VA22C8006-001	Richards Creek	Water	Water	E420	20.6	0.050	mg/L	16-Nov-2022	10:05	22-Nov-	24-Nov-2022	750766	ü	ü

		Site 2									2022				
cesium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
chromium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.00050	0.00050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
cobalt, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.00010	0.00010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
copper, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.00068	0.00050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
iron, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.144	0.010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
lead, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.000050	0.000050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
lithium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.0010	0.0010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
magnesium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	5.67	0.0050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü

manganese, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.0575	0.00010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
molybdenum, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.000106	0.000050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
nickel, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.00050	0.00050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
phosphorus, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.050	0.050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
potassium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.727	0.050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
rubidium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.00054	0.00020	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
selenium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.000050	0.000050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
silicon, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	9.68	0.10	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
silver, total	VA22C8006-001	Richards Creek	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	10:05	22-Nov-	24-Nov-2022	750766	ü	ü

		Site 2									2022				
sodium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	8.31	0.050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
strontium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.0804	0.00020	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
sulfur, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	4.69	0.50	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
tellurium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.00020	0.00020	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
thallium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
thorium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
tin, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
titanium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.00140	0.00030	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü

tungsten, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
uranium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.000011	0.000010	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
vanadium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	0.00059	0.00050	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
zinc, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.0030	0.0030	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü
zirconium, total	VA22C8006-001	Richards Creek Site 2	Water	Water	E420	<0.00020	0.00020	mg/L	16-Nov-2022	10:05	22-Nov-2022	24-Nov-2022	750766	ü	ü

Physical Tests (Matrix: Water)

conductivity	VA22C8006-002	Richards Creek Site 3	Water	Water	E100	204	2.0	µS/cm	16-Nov-2022	09:42	18-Nov-2022	18-Nov-2022	748870	ü	ü
hardness (as CaCO3), from total Ca/Mg	VA22C8006-002	Richards Creek Site 3	Water	Water	EC100A	79.0	0.50	mg/L	16-Nov-2022	09:42		24-Nov-2022		ü	ü
pH	VA22C8006-002	Richards Creek Site 3	Water	Water	E108	7.56	0.10	pH units	16-Nov-2022	09:42	18-Nov-2022	18-Nov-2022	748868	ü	û

Anions and Nutrients (Matrix: Water)

ammonia, total (as N)	VA22C8006-002	Richards Creek Site 3	Water	Water	E298	0.0072	0.0050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	752627	ü	ü
nitrate (as N)	VA22C8006-002	Richards Creek Site 3	Water	Water	E235.NO3-L	0.965	0.0050	mg/L	16-Nov-2022	09:42	18-Nov-2022	18-Nov-2022	748877	ü	ü
nitrite (as N)	VA22C8006-002	Richards Creek Site 3	Water	Water	E235.NO2-L	0.0016	0.0010	mg/L	16-Nov-2022	09:42	18-Nov-2022	18-Nov-2022	748874	ü	ü
nitrogen, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E366	1.10	0.030	mg/L	16-Nov-2022	09:42	22-Nov-2022	23-Nov-2022	752625	ü	ü
phosphate, ortho-, dissolved (as P)	VA22C8006-002	Richards Creek Site 3	Water	Water	E378-U	0.0043	0.0010	mg/L	16-Nov-2022	09:42	18-Nov-2022	18-Nov-2022	748878	ü	ü
phosphorus, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E372-U	0.0142	0.0020	mg/L	16-Nov-2022	09:42	22-Nov-2022	23-Nov-2022	752628	ü	ü

Total Metals (Matrix: Water)

aluminum, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.0324	0.0030	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü

antimony, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
arsenic, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.00018	0.00010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
barium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.0111	0.00010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
beryllium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.000020	0.000020	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
bismuth, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.000050	0.000050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
boron, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.012	0.010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
cadmium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.0000050	0.0000050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
calcium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	21.2	0.050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
cesium, total	VA22C8006-002	Richards Creek	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	09:42	22-Nov-	24-Nov-2022	750766	ü	ü

		Site 3									2022				
chromium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.00050	0.00050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
cobalt, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
copper, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.00077	0.00050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
iron, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.123	0.010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
lead, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.000050	0.000050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
lithium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.0010	0.0010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
magnesium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	6.32	0.0050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
manganese, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.0146	0.00010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü

molybdenum, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.000105	0.000050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
nickel, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.00050	0.00050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
phosphorus, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.050	0.050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
potassium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.851	0.050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
rubidium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.00061	0.00020	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
selenium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.000050	0.000050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
silicon, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	9.48	0.10	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
silver, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
sodium, total	VA22C8006-002	Richards Creek	Water	Water	E420	8.16	0.050	mg/L	16-Nov-2022	09:42	22-Nov-	24-Nov-2022	750766	ü	ü

		Site 3									2022				
strontium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.0890	0.00020	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
sulfur, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	5.09	0.50	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
tellurium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.00020	0.00020	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
thallium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
thorium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
tin, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
titanium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.00119	0.00030	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
tungsten, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü

uranium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.000016	0.00010	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
vanadium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	0.00050	0.00050	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
zinc, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.0030	0.0030	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü
zirconium, total	VA22C8006-002	Richards Creek Site 3	Water	Water	E420	<0.00020	0.00020	mg/L	16-Nov-2022	09:42	22-Nov-2022	24-Nov-2022	750766	ü	ü

Physical Tests (Matrix: Water)

conductivity	VA22C8006-003	Richards Creek Site 4	Water	Water	E100	211	2.0	µS/cm	16-Nov-2022	09:13	18-Nov-2022	18-Nov-2022	748870	ü	ü
hardness (as CaCO3), from total Ca/Mg	VA22C8006-003	Richards Creek Site 4	Water	Water	EC100A	79.3	0.50	mg/L	16-Nov-2022	09:13		24-Nov-2022		ü	ü
pH	VA22C8006-003	Richards Creek Site 4	Water	Water	E108	6.90	0.10	pH units	16-Nov-2022	09:13	18-Nov-2022	18-Nov-2022	748868	ü	û

Anions and Nutrients (Matrix: Water)

ammonia, total (as N)	VA22C8006-003	Richards Creek Site 4	Water	Water	E298	0.248	0.0050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	752627	ü	ü
nitrate (as N)	VA22C8006-003	Richards Creek Site 4	Water	Water	E235.NO3-L	0.377	0.0050	mg/L	16-Nov-2022	09:13	18-Nov-2022	18-Nov-2022	748877	ü	ü
nitrite (as N)	VA22C8006-003	Richards Creek Site 4	Water	Water	E235.NO2-L	0.0165	0.0010	mg/L	16-Nov-2022	09:13	18-Nov-2022	18-Nov-2022	748874	ü	ü
nitrogen, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E366	1.38	0.030	mg/L	16-Nov-2022	09:13	22-Nov-2022	23-Nov-2022	752625	ü	ü
phosphate, ortho-, dissolved (as P)	VA22C8006-003	Richards Creek Site 4	Water	Water	E378-U	0.0580	0.0100	mg/L	16-Nov-2022	09:13	18-Nov-2022	18-Nov-2022	748878	ü	ü
phosphorus, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E372-U	0.137	0.0200	mg/L	16-Nov-2022	09:13	22-Nov-2022	23-Nov-2022	752628	ü	ü

Total Metals (Matrix: Water)

aluminum, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.0834	0.0030	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
antimony, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü

arsenic, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.00034	0.00010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
barium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.0140	0.00010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
beryllium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.000020	0.000020	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
bismuth, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.000050	0.000050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
boron, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.019	0.010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
cadmium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.0000141	0.0000050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
calcium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	22.8	0.050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
cesium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
chromium, total	VA22C8006-003	Richards Creek	Water	Water	E420	<0.00050	0.00050	mg/L	16-Nov-2022	09:13	22-Nov-	24-Nov-2022	750766	ü	ü

		Site 4									2022				
cobalt, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.00032	0.00010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
copper, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.00141	0.00050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
iron, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.715	0.010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
lead, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.000093	0.000050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
lithium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.0010	0.0010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
magnesium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	5.43	0.0050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
manganese, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.175	0.00010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
molybdenum, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.000124	0.000050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü

nickel, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.00053	0.00050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
phosphorus, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.138	0.050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
potassium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	1.96	0.050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
rubidium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.00160	0.00020	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
selenium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.000059	0.000050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
silicon, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	7.65	0.10	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
silver, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
sodium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	8.75	0.050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
strontium, total	VA22C8006-003	Richards Creek	Water	Water	E420	0.0989	0.00020	mg/L	16-Nov-2022	09:13	22-Nov-	24-Nov-2022	750766	ü	ü

		Site 4									2022				
sulfur, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	8.44	0.50	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
tellurium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.00020	0.00020	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
thallium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
thorium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
tin, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
titanium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.00326	0.00030	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
tungsten, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.00010	0.00010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
uranium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.000010	0.000010	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü

vanadium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	0.00070	0.00050	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
zinc, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.0030	0.0030	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü
zirconium, total	VA22C8006-003	Richards Creek Site 4	Water	Water	E420	<0.00020	0.00020	mg/L	16-Nov-2022	09:13	22-Nov-2022	24-Nov-2022	750766	ü	ü