Technical Report No. 22-06

Aquatic Biomonitoring at the Arctic-Bornite Prospect, 2021

by Chelsea M. Clawson

April 2022

Alaska Department of Fish and Game Habitat Section

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in reports by Habitat Section and the Divisions of Sport Fish and Commercial Fisheries. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

TECHNICAL REPORT NO. 22-06

AQUATIC BIOMONITORING AT THE ARCTIC-BORNITE PROSPECT, 2021

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Cover: Subarctic Valley, March 14, 2021. Photograph by Chelsea Clawson.

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ACKNOWLEDGEMENTS

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INTRODUCTION

The Ambler mining district is located in northwest Alaska in the Kobuk River drainage along the southern end of the Brooks Range (Figure 1). There are two primary deposits currently being explored by Ambler Metals (formerly Trilogy Metals). The Bornite deposit is located about 17 km north of Kobuk in the Ruby Creek drainage, and the Arctic deposit is located approximately 37 km northeast of Kobuk in the upper end of the Subarctic Creek drainage. The Bornite deposit contains primarily copper and cobalt while the Arctic deposit contains copper, lead, zinc, silver and gold. Both Ruby and Subarctic creeks are tributaries to the Shungnak River, which flows into the Kobuk River. A large waterfall in the lower Shungnak River prevents upstream passage of fish, so no anadromous fish occur in the drainage above the falls (Figure 2). All fish in the area of the Bornite and Arctic deposits complete their life cycle within the Shungnak River drainage.

All sample sites except Riley Creek are in the Shungnak River drainage. Riley Creek, which flows into the Kogoluktuk River, was selected to sample as it is being considered as a possible location for a tailings storage facility.

Figure 1. Location of the Arctic and Bornite deposits in northwest Alaska.

Figure 2. Waterfall on the Shungnak River blocking fish passage upstream, July 21, 2016.

Aquatic baseline work conducted in the area in 2010 focused on macroinvertebrate and fish species presence (Tetra Tech, 2011). The fish species documented in the 2010 survey were Arctic grayling (*Thymallus arcticus*), round whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*), and Dolly Varden (*Salvelinus malma*). Ambler Metals contracted the ADF&G Habitat Section to continue aquatic sampling beginning in 2016. The ADF&G study plan was based on aquatic biomonitoring the Habitat Section conducts at various large hard rock mines in the state. Three primary types of data were collected: periphyton, aquatic invertebrates, and fish, which included samples for whole body element analyses. Biomonitoring has been performed annually except for 2020 when all camp operations were suspended due to the Covid-19 pandemic.

This report will summarize the periphyton, aquatic invertebrate and fish samples collected by ADF&G, and water quality data collected by Ambler Metals in 2021, with comparisons to prior years when appropriate. Sampling changes in 2021 included the addition of a late winter/early spring sampling event, the addition of a new baseline site, and a change in the aquatic invertebrate sampling gear.

Location and Description of Monitoring Sites

Ten biomonitoring sites were sampled in several of the drainages surrounding the Arctic and Bornite deposits (Table 1, Figure 3). All sites were previously sampled except for Sunshine Creek, which was added in 2021 because it is in the vicinity of a new deposit being explored by Ambler Metals. Sampling efforts were concentrated in Ruby and Subarctic creeks as there may be changes to these aquatic systems based on projected mining development.

- **Upper Ruby Creek** is characterized by beaver pond habitats, deep water, dense vegetative cover, short channels between beaver dams, and minimal gravel/cobble. The sample site is located in a channel between beaver dams and was chosen for its gravel/cobble substrate.

- **Lower Ruby Creek** is characterized by pool/riffle habitat, shallower water, gravel substrate, and grass riparian habitats.

- The **Upper Shungnak River** sample site is characterized by deep water, outside bend cut banks and inside bend gravel bars. The substrate is primarily gravel with some cobble.

- **Upper Subarctic Creek** is located in alpine tundra and is characterized by high gradient with step pools and large boulders. There are some shrubby willows along the banks, but most vegetation is limited to ground cover. This sample site is located a few hundred yards below the origin of the creek, which abruptly forms when water transitions from subsurface to surface flow.

- **Lower Subarctic Creek** has a much lower gradient than the upper site, is wider, and is characterized by riffle/pool habitat with gravel/cobble substrate.

- **Riley Creek** is characterized by riffle/pool habitat with gravel and cobble.

- **Jay Creek** is characterized by riffle/run habitats with very dense vegetation and overhanging canopy cover.

- **Lower Red Rock Creek** has similar habitat to the Lower Subarctic Creek site, with riffle/pool habitat and gravel/cobble substrate. This drainage is the next system up the Shungnak River drainage from Subarctic Creek and could provide alternative fish habitat if Subarctic Creek is impacted by future mining activity.

- **Center of the Universe Creek** is a tributary of Red Rock Creek that enters above the Upper Red Rock Creek sampling location. The creek is characterized by riffles and runs interspersed with pools. Substrate here is smaller gravel than at other downstream sites.

- **Sunshine Creek** is characterized by riffle/run habitats and gravel/cobble substrate. The sample site is just upstream of a large beaver pond. The upper reaches of Sunshine Creek are very high gradient.

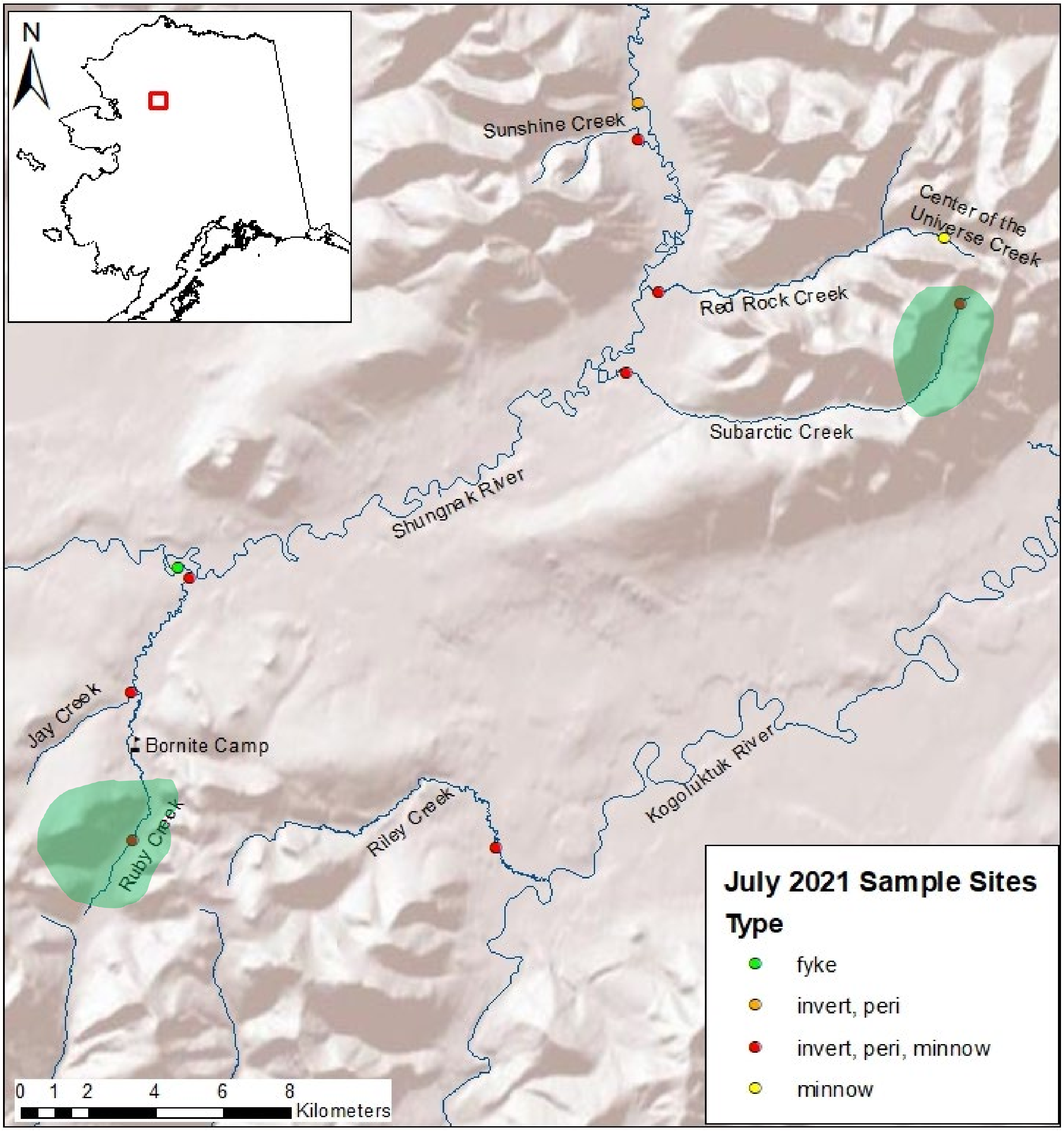

Figure 3. All locations sampled in 2021. The approximate locations of the Bornite and Arctic deposits are denoted by the green polygons.

Table 1. Arctic-Bornite sampling locations (WGS 84), 2021.

Sample Site	Latitude	Longitude	March Minnow	Invertebrates	Periphyton	July Minnow	Fyke Nets
Upper Subarctic	67.1926	-156.3911	X	X	X	X	
Lower Subarctic	67.1720	-156.6208		X	X	X	
Lower Red Rock	67.1932	-156.5991		X	X	X	
Upper Ruby	67.0408	-156.9394		X	X	X	
Lower Ruby	67.1114	-156.9084		X	X	X	
Mouth of Ruby	67.1140	-156.9167					X
Upper Shungnak	67.2440	-156.6160		X	X		
Riley	67.0426	-156.6923		X	X	X	
Jay	67.0804	-156.9445		X	X	X	
Upper Center of the Universe	67.2010	-156.4041				X	
Sunshine	67.2335	-156.6162		X	X	X	

METHODS

Sampling Overview

The objective of the biological monitoring program is to document in-situ productivity of aquatic communities at each sample site, and background levels of elements and metals in the vicinity and downstream of potential project facilities.

Based on results from previous years, sampling events were condensed and streamlined. Baseline data collection continued on Ruby, Subarctic, Red Rock, Jay, Riley, and Center of the Universe creeks, as well as the Upper Shungnak River. A sample site was added on Sunshine Creek near the Sunshine deposit exploration in the Upper Shungnak River drainage.

The first sampling event occurred March 8 – 15, 2021. This sampling event was conducted in addition to the standard sampling regimen in 2021 to assess fish overwintering presence in the spring fed portion of the upper Subarctic Creek drainage.

The main sampling event took place July 14 – 19, 2021. At each baseline location replicate samples of the aquatic community were performed, including aquatic invertebrates, periphyton, and fish (Table 1). A subset of fish were retained for whole body element analysis.

In 2021, Hess samplers were used rather than drift nets to identify and quantify the in-situ macro invertebrate community. This change was made to better identify the in-situ benthic community, rather than the drifting invertebrate community that may be originating from much further upriver. This provides a more accurate baseline for evaluating changes at each particular sampling location, rather than changes that are occurring upstream.

Water Quality

Ambler Metals has collected water quality data from many locations throughout the Arctic-Bornite Prospect project area. The 2016 report summarized all water quality data collected since 2008 (Bradley 2017a). This report summarizes only data collected in 2021. These data were provided to ADF&G and were compiled and graphed showing mean, minimum, and maximum values (Appendix 1). Only water quality data from locations in close proximity to the 2021 sample sites were used. Depending on the sample site, two to four water samples were collected from January to December 2021.

Periphyton

Periphyton, or attached micro-algae, are sensitive to changes in water quality and are often used in monitoring studies to detect changes in aquatic communities (Ott et al. 2010). The presence of periphyton in a stream system is evidence of in-situ productivity (Ott et al. 2010). Periphyton samples were collected at nine locations around the Arctic-Bornite area (Table 1; Figure 3).

Ten flat rocks, each larger than 25 cm^2 were collected from submerged areas at each site. A 5-cm x 5-cm square of high density flexible foam was placed on the rock. All the material around the foam was scrubbed off with a toothbrush and washed back into the stream. The foam square was then removed from the rock, and that section of the rock was brushed and rinsed onto a 0.45 µm glass fiber filter receptacle attached to a hand vacuum pump. Material from the toothbrush was also rinsed onto the filter. The water was extracted from the periphyton covered filter using a hand vacuum pump. Just before all the water was pumped through the filter, one to two drops of magnesium carbonate ($MgCO_3$) were added to the water to prevent acidification and additional conversion of chlorophyll-a to phaeophytin.

Filters from each rock were folded in half, with the sample material on the inside, and placed in individual dry paper coffee filters. All ten coffee filters were placed in a zip-lock bag containing desiccant to absorb remaining moisture. The bags were then wrapped in aluminum foil to prevent light from reaching the samples, placed in a cooler with ice packs, then transferred to a freezer at the Bornite camp. Samples were kept frozen until they were analyzed at the ADF&G laboratory in Fairbanks. Additional details regarding periphyton sampling and analysis methods can be found in ADF&G Technical Report No. 17-09 (Bradley 2017b).

Aquatic invertebrates

At each sample site, five samples were collected using a Hess sampler (Table 1; Figure 4). The Hess stream bottom sampler has a 0.086 m^2 sample area and material is captured in a 200 mL cod end – both constructed with 300 µm mesh net. Rocks within the sample area were scoured by hand, and gravel, sand, and silt were disturbed to about 10 cm depth to dislodge macroinvertebrates into the net. The cod end contents were then removed and placed in individual pre-labeled Nalgene bottles. Denatured ethyl alcohol was added to preserve the samples. Samples were sorted and invertebrates identified to the lowest taxonomic level, typically family or genus, by a private aquatic invertebrate lab in Fairbanks. Because invertebrates belonging to the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) are more sensitive to water quality, the total number of individual specimens of EPT was calculated and compared to groups of other invertebrates, which are less sensitive. Macroinvertebrate density was calculated for each sample by dividing the number of macroinvertebrates by 0.086 m^2, the Hess sampling area. Mean density was estimated for each site by calculating the mean density among the five samples.

Figure 4. Collecting invertebrate samples using a Hess sampler on Lower Subarctic Creek (July 15, 2021).

Fish

A late winter/early spring fish sampling event occurred in the Upper Subarctic Creek drainage from March 8 – 15, 2021. Eight minnow traps were set at the Upper Subarctic Creek site, and five minnow traps were set approximately two kilometers downstream, near the water quality sampling site SCMI. The baited traps were set in sections of open water that were deep enough to submerge the throats of the traps. Due to the extremely cold air temperatures (-28° C) fish were not measured but were immediately released after their presence was noted.

The primary fish sampling event occurred July 14 – 19. At each baseline sample site, after the periphyton and aquatic invertebrates were sampled, ten minnow traps were baited with cured salmon roe in a perforated plastic bag and placed upstream and downstream of the periphyton and aquatic invertebrate sampling locations (Table 1). Traps were placed in a variety of habitats, including cut banks, pools, and near submerged woody debris. Traps were soaked overnight and checked about 24 hours later. All captured fish were measured for fork or total length, depending on species. Some fish were retained for whole body element analyses. Those fish were handled wearing class 100 nitrile gloves and placed in individual pre-labeled plastic zip-lock bags. The bagged fish were placed in a cooler with ice packs and transferred to a freezer in the camp as soon as possible. The samples remained frozen until they were analyzed by ACZ Laboratories, Inc.

In addition to the minnow traps, fyke nets were set at the mouth of Ruby Creek during the July sampling event (Table 1, Figure 5). Fyke nets are used at this location due to the presence of large adult fish, and species that do not typically respond to baited minnow traps (Arctic grayling and whitefish). Two nets were set to capture fish moving both upstream and downstream. Nets were fished for approximately 36 hours and checked twice a day. All captured fish were measured for fork or total length, depending on species. Some fish were retained for whole body element analyses. Captured fish received an upper caudal fin clip to prevent double counting recaptures.

Figure 5. Fyke nets near the mouth of Ruby Creek (July 15, 2021).

RESULTS AND DISCUSSION

Water Quality

A summary of sample dates and water quality results are shown in Appendix 1. Alaska Department of Environmental Conservation (ADEC) water quality standards are presented for some metals for both acute (24 hr) and chronic (one month) aquatic life exposure limits (Appendix 1). Most of the water quality sites are at the same location as the periphyton, aquatic invertebrate, and fish sampling. However, the water quality data from the Shungnak River used in these results were collected just upstream of the mouth of Subarctic Creek, not at the reference site further upstream (Upper Shungnak River).

In general, mean cadmium concentrations in 2021 were low and similar to previous years (Figure 6, Appendix 1). Upper Ruby, Lower Ruby, and Riley were all at or below the detection limit (0.025 µg/L). The highest mean concentration occurred in the Shungnak River, consistent with past years. Water quality acute and chronic exposure standards for aquatic life for cadmium depend on water hardness. Cadmium concentrations were below the acute and chronic water quality standards at all sites for all sampling events except the June, August, and September samples on the Shungnak River, which exceeded chronic exposure standards but were well below acute exposure standards. (Appendix 1). In past years, the dissolved cadmium concentrations at the Shungnak River site have also slightly exceeded the chronic cadmium exposure standard.

Mean selenium concentrations were very low among all sample sites (Figure 6, Appendix 1). All concentrations were well below the current water quality standard for aquatic life which is 20 µg/L for acute exposure and 5 µg/L for chronic exposure.

Mean copper concentrations ranged from 1.09 µg/L at the Shungnak River site to below the detection limit at the Upper Subarctic Creek site (Figure 6, Appendix 1). The highest maximum concentration for copper was 1.23 µg/L and occurred at Shungnak River in August. Acute and chronic water quality standards for aquatic life for copper depend on water hardness. Copper concentrations were below the acute and chronic exposure standards at all sites for all sampling events (Appendix 1).

Mercury concentrations were low at all sample sites (Figure 6). Mean mercury concentrations ranged from below the detection limit at Shungnak River and Lower Subarctic Creek to 0.90 ng/L at Lower Ruby Creek. The highest maximum concentration (1.63 ng/L) occurred at Lower Ruby Creek in June. All mercury concentrations were well below the water quality standards for aquatic life for mercury which are 2,400 ng/L for acute exposure and 12 ng/L for chronic exposure.

No zinc was detected at Upper Ruby, Lower Ruby, and Riley creeks (Figure 6). The highest maximum concentration occurred at Shungnak River in September (30.10 µg/L). Overall, zinc concentrations were very low and well below the acute and chronic water quality standards for aquatic life, which depend on water hardness (Appendix 1).

Total Dissolved Solids (TDS) concentrations in 2021 followed a pattern very similar to past years (Appendix 1). Lowest mean concentrations occurred in Lower Subarctic Creek (60 mg/L) and Upper Subarctic Creek (61.4 mg/L), and the highest mean concentrations occurred in Upper Ruby Creek (171 mg/L) and Lower Ruby Creek (162 mg/L) (Figure 6, Appendix 1).

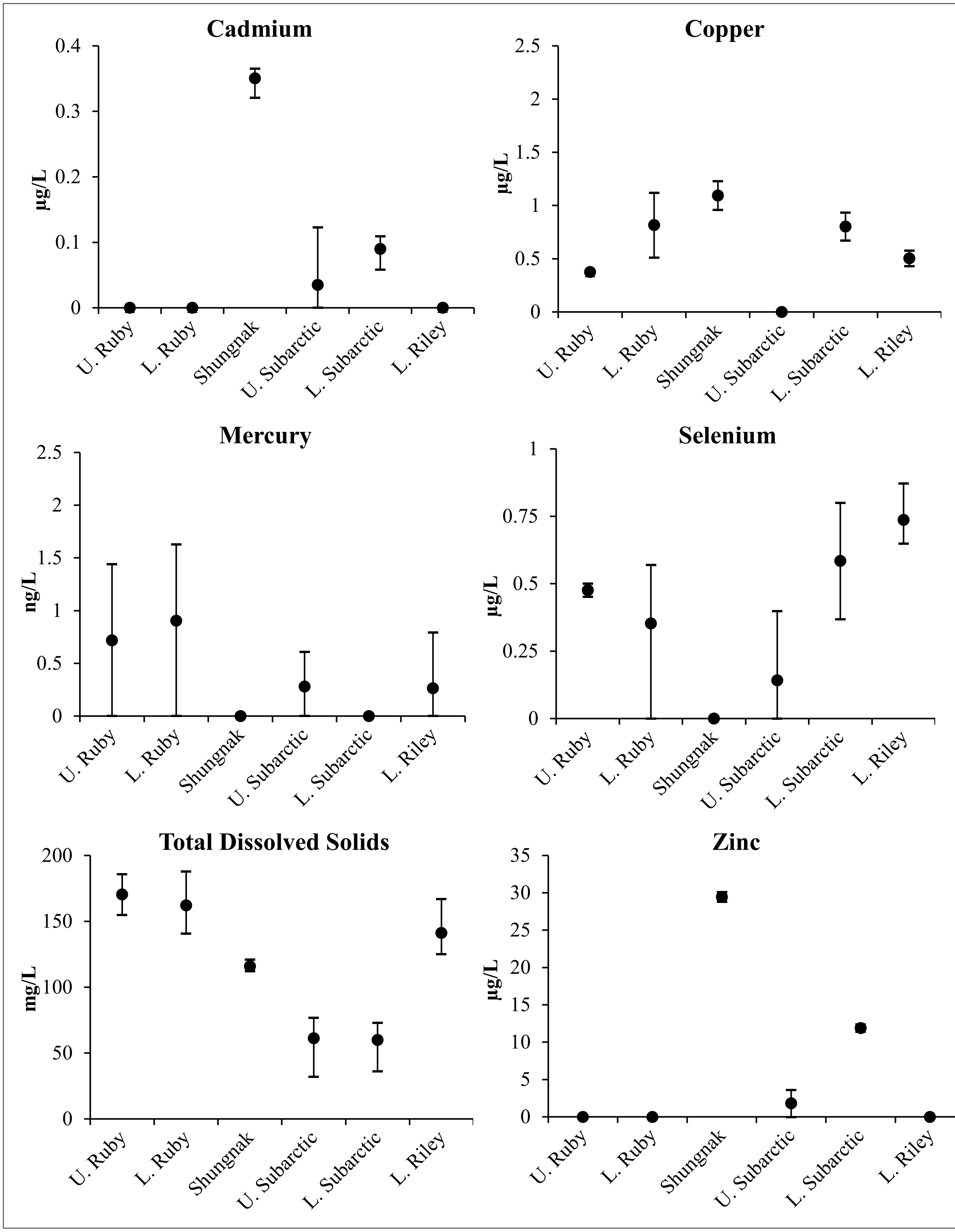

Figure 6. Mean, minimum, and maximum analyte concentrations at water quality sample sites, 2021. All results are total dissolved.

Periphyton

In 2021, mean chlorophyll-a concentrations were highest in Upper Ruby Creek (60.13 mg/m^2) and lowest in Lower Red Rock Creek (0.32 mg/m^2) (Figure 7). The mean chlorophyll-a concentrations at the remaining sites ranged from 0.51 mg/m^2 to 6.16 mg/m^2. Mean chlorophyll-a concentrations in 2021 were similar to previous years' values (Figures 7 and 8). Upper Ruby Creek has consistently had the highest chlorophyll-a concentration of all the sample sites since data collection began.

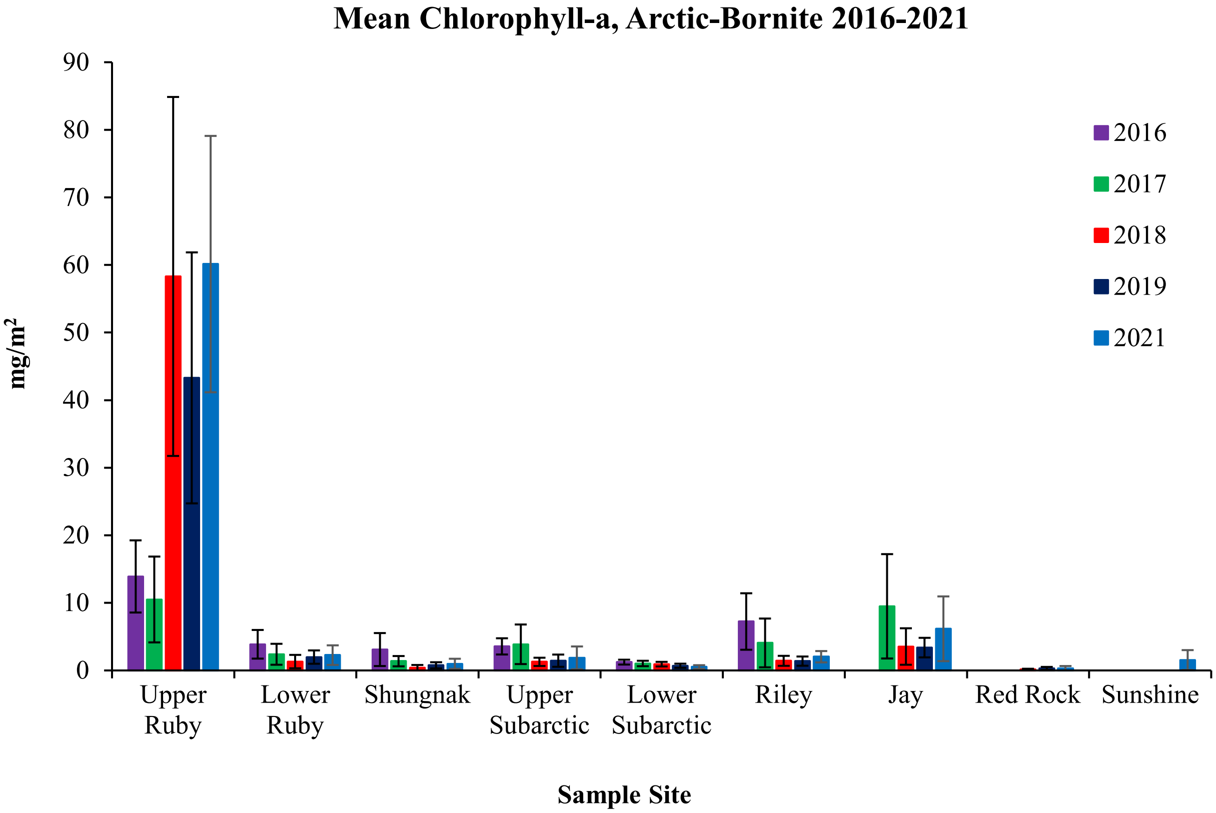

Figure 7. Mean chlorophyll-a concentrations ± 1 SD, 2016 to 2021. The Jay Creek site was added in 2017, the Red Rock Creek site was added in 2018, and the Sunshine Creek site was added in 2021. No sampling was performed in 2020.

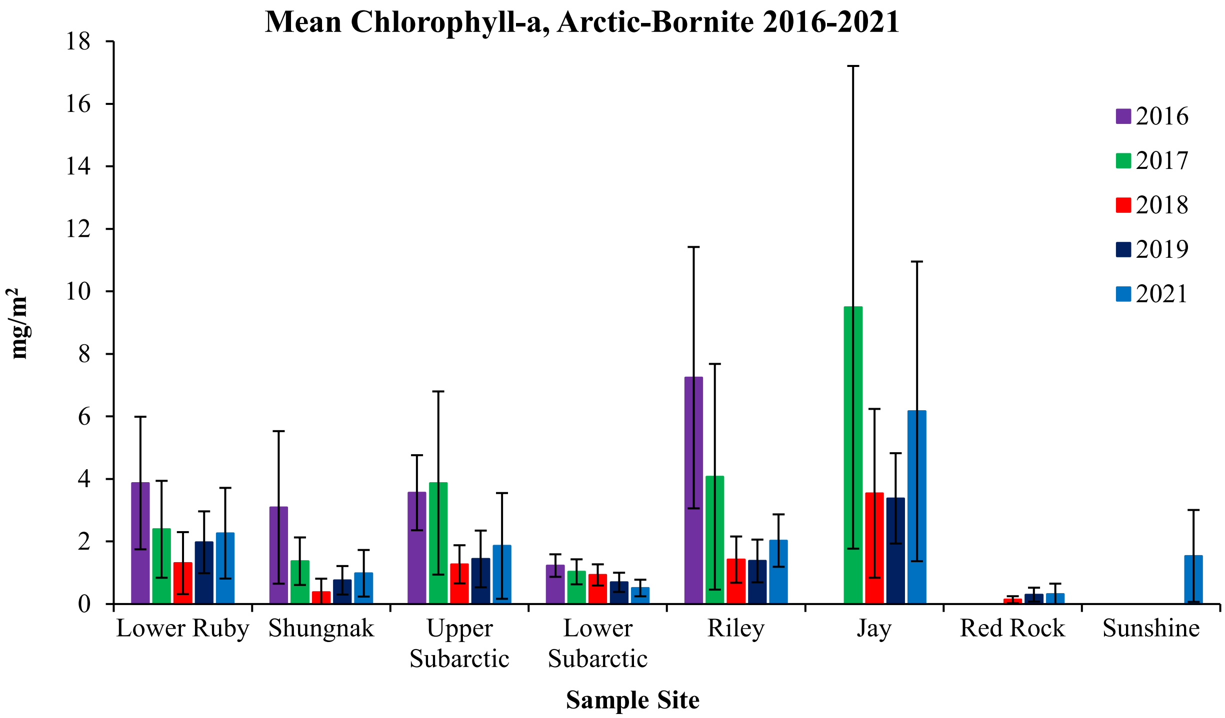

Figure 8. Mean chlorophyll-a concentrations ± 1 SD for all sites except Upper Ruby, 2016 to 2021. The Jay Creek site was added in 2017, the Red Rock Creek site was added in 2018, and the Sunshine Creek site was added in 2021. No sampling occurred in 2020.

Aquatic Invertebrates

Aquatic invertebrate densities in Upper Ruby Creek were the highest among the sample sites and averaged 17,212 aquatic invertebrates/m^2 of substrate (Figure 9). A total of 21 taxa were identified in the Upper Ruby Creek samples. Samples were dominated by aquatic Diptera (93%), which were primarily chironomids, and followed by other species (3%) and Plecoptera (2%) (Figure 10). Ephemeroptera, Plecoptera, and Tricoptera (EPT) only made up 3% of the sample (Figure 11).

Aquatic invertebrate densities in Lower Ruby Creek averaged 1,102 aquatic invertebrates/m^2 of substrate (Figure 9). A total of 19 taxa were identified in Lower Ruby Creek. Samples were dominated by aquatic Diptera (80%), which were primarily chironomids, other species (12%) which were primarily Cladocerans, Ostracods, and Acarians, followed by EPT species (8%) (Figures 10 and 11).

A total of 15 taxa were identified at the Shungnak River site and it had the second lowest density at 730 aquatic invertebrates/m^2 of substrate (Figure 9). Samples were dominated by other species (36%), which were primarily Oligochaetes, followed closely by Ephemeroptera (30%) (Figures 10 and 11). The remaining samples were comprised of aquatic Diptera (23%), primarily chironomids, and Plecoptera (10%).

The average aquatic invertebrate density in Upper Subarctic Creek in 2021 was 11,928 aquatic invertebrates/m^2 of substrate (Figure 9), second only to the Upper Ruby site. Other species, primarily Ostracods, accounted for 49% of the samples, followed by aquatic Diptera at 40% (Figure 10).

The average aquatic invertebrate density at Lower Subarctic Creek was 1,477 aquatic invertebrates/m^2 of substrate (Figure 9). Aquatic invertebrates were comprised of Ephemeroptera (50%), then aquatic Diptera (27%), most of which were chironomids (Figures 10 and 11).

The average aquatic invertebrate density in Riley Creek was 3,095 aquatic invertebrates/m^2 of substrate in 2021 (Figure 9). A total of 17 taxa were captured represented primarily by Ephemeroptera (38%), followed by other species (34%), most of which were Oligochaetes (Figures 10 and 11).

The average aquatic invertebrate density at Jay Creek was 3,391 aquatic invertebrates/m^2 of substrate (Figure 9). Aquatic Diptera dominated the community composition (73%), most of which were chironomids, followed by EPT (21%) (Figures 10 and 11).

The average aquatic invertebrate density at Lower Red Rock Creek was the lowest of all sample sites in 2021 with 311 aquatic invertebrates/m^2 of substrate (Figure 9). Plecoptera species dominated the community composition (59%), followed by aquatic Diptera (23%), and other species (13%) (Figures 10 and 11).

The average aquatic invertebrate density at Sunshine Creek was 1,991 aquatic invertebrates/m^2 of substrate (Figure 9). Aquatic Diptera, primarily chironomids, were most common in the community composition (33%), followed closely by other species (29%), and other species (13%) (Figures 10 and 11).

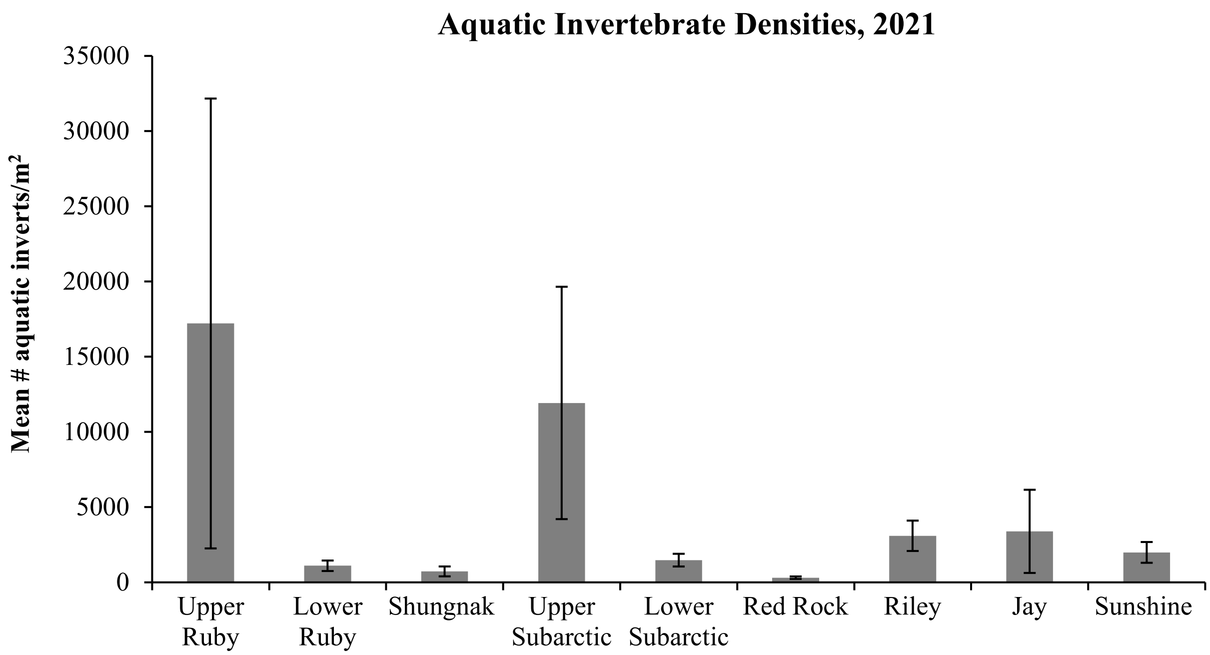

Figure 9. Mean number of aquatic invertebrates/m² substrate (± 1 SD) at each sample site, 2021.

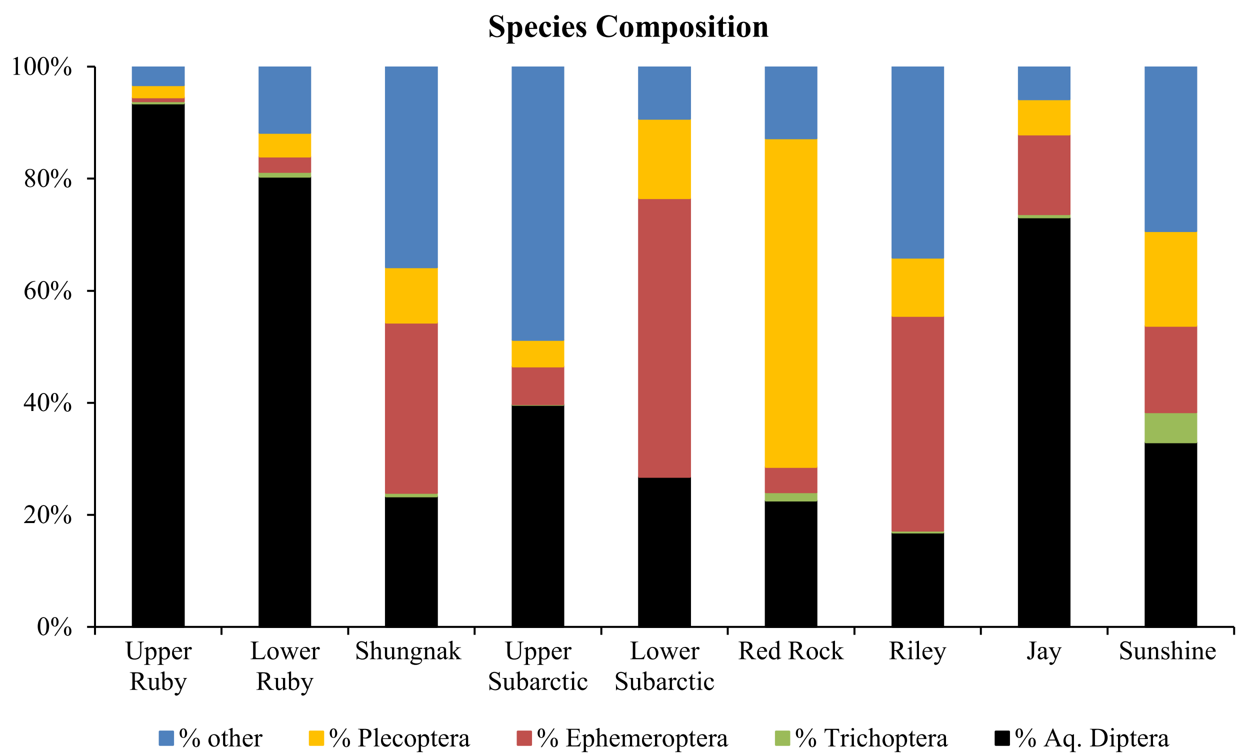

Figure 10. Mean percent EPT, aquatic diptera, and other species in the aquatic invertebrate samples, 2021.

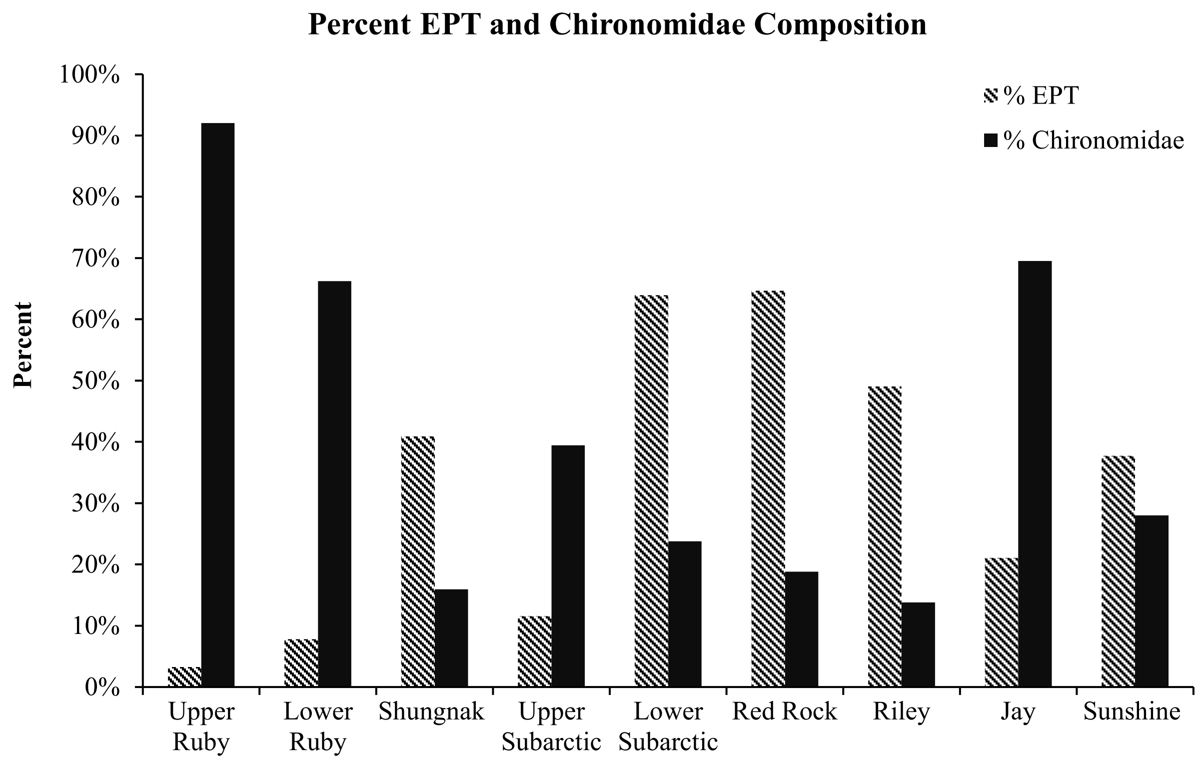

Figure 11. Percent EPT and Chironomidae in the aquatic invertebrate samples at all sample sites, 2021.

Fish Captures

March Minnow Traps

During the March sampling event, one Dolly Varden was caught in the most upstream trap at Upper Subarctic Creek (Figure 12). There were several patches of open water ranging from 10 – 20 centimeters deep, although most of Subarctic Creek was covered by thin (3 – 10 cm) ice or snow bridges. The capture of a Dolly Varden at Upper Subarctic Creek in March confirms that at least some fish overwinter in the upper reaches of Subarctic Creek. Water quality sampling throughout the Subarctic Creek drainage confirms that this creek remains flowing all winter, likely due to the extensive groundwater inputs throughout Subarctic Valley.

Figure 12. Checking minnow traps at Upper Subarctic Creek (left), and the Dolly Varden captured at the most upstream trap (right).

July Minnow Traps

Throughout Ruby Creek, slimy sculpin dominated catches (Table 2). In past years some Dolly Varden have been captured in Ruby Creek, but none were captured in 2021. There are many beaver dams in this drainage which may impede upstream passage of fish. Ponds created by beavers may also provide overwintering habitat for fish in Upper Ruby Creek by creating large, deep pools.

Dolly Varden dominated catches in Subarctic Creek, with only five slimy sculpin captured at the Lower Subarctic Creek sample site (Table 2). Two Dolly Varden from the lower sample site and thirteen from the upper sample site were retained for whole body element analysis.

A total of 10 slimy sculpin and six Dolly Varden were captured on Riley Creek in 2021 (Table 2). Ten slimy sculpin were retained for whole body element analysis.

A total of four Dolly Varden were captured on Jay Creek (Table 2). Since we are unable to consistently catch enough fish for an adequate sample size in this creek, we did not retain any fish for element analysis.

Red Rock Creek was initially sampled in 2018 to ascertain if Red Rock Creek could provide viable fish habitat in case Subarctic Creek is impacted by mine development. Three locations throughout the creek were sampled in 2018, and Dolly Varden were captured at all three sample sites, even above a series of small waterfalls between the middle and upper sample sites. After 2018, sampling was condensed to the lower site only. In 2021 a total of 12 Dolly Varden and two slimy sculpin were captured and eight Dolly Varden were retained for element analysis (Table 2).

Center of the Universe Creek had been previously sampled in September to document spawning Dolly Varden, but had not been minnow trapped in July prior to 2021 (Clawson 2020). In 2021 a total of 12 Dolly Varden were captured during the July sampling event (Table 2).

A total of five Dolly Varden and two slimy sculpin were captured at the Sunshine Creek site (Table 2 and Figure 13).

Figure 13. The sample site on Sunshine Creek, looking downstream toward the beaver pond.

Table 2. Number, mean length, and length range of slimy sculpin and Dolly Varden captured in minnow traps at nine sample sites, July 14 – 19, 2021.

Sample Site	Slimy Sculpin			Dolly Varden		
	Number captured	Mean total length (mm)	Length range (mm)	Number captured	Mean fork length (mm)	Length range (mm)
Subarctic						
Upper	0	---	---	42	110	76-164
Lower	5	61	45-68	2	105	103-106
Ruby						
Upper	40	71	49-85	0	---	---
Lower	24	66	50-76	0	---	---
Red Rock						
Lower	0	---	---	12	115	68-156
Center of the Universe	0	---	---	12	113	63-150
Jay	0	---	---	4	149	118-168
Riley	10	68	60-90	6	83	67-89
Sunshine	2	81	75-86	5	105	73-138

Fyke nets

On July 15, two fyke nets were set near the mouth of Ruby Creek, one to capture fish moving upstream, and the other set to capture fish moving downstream. The nets were checked in the morning on July 16, then checked and pulled in the evening on July 16. All captured fish except slimy sculpin received a fin clip on the upper caudal fin to prevent double counting. A total of 32 round whitefish, nine Arctic grayling, two Dolly Varden, two longnose suckers, and three slimy sculpin were captured (Figure 14). The captured Arctic grayling ranged from 93 – 146 mm FL, with an average size of 132 mm (Figure 15). Captured round whitefish ranged from 35 – 426 mm FL, with an average size of 147 mm (Figures 16 and 17). Fifteen round whitefish between 90 – 140 mm FL were retained for whole body element analysis.

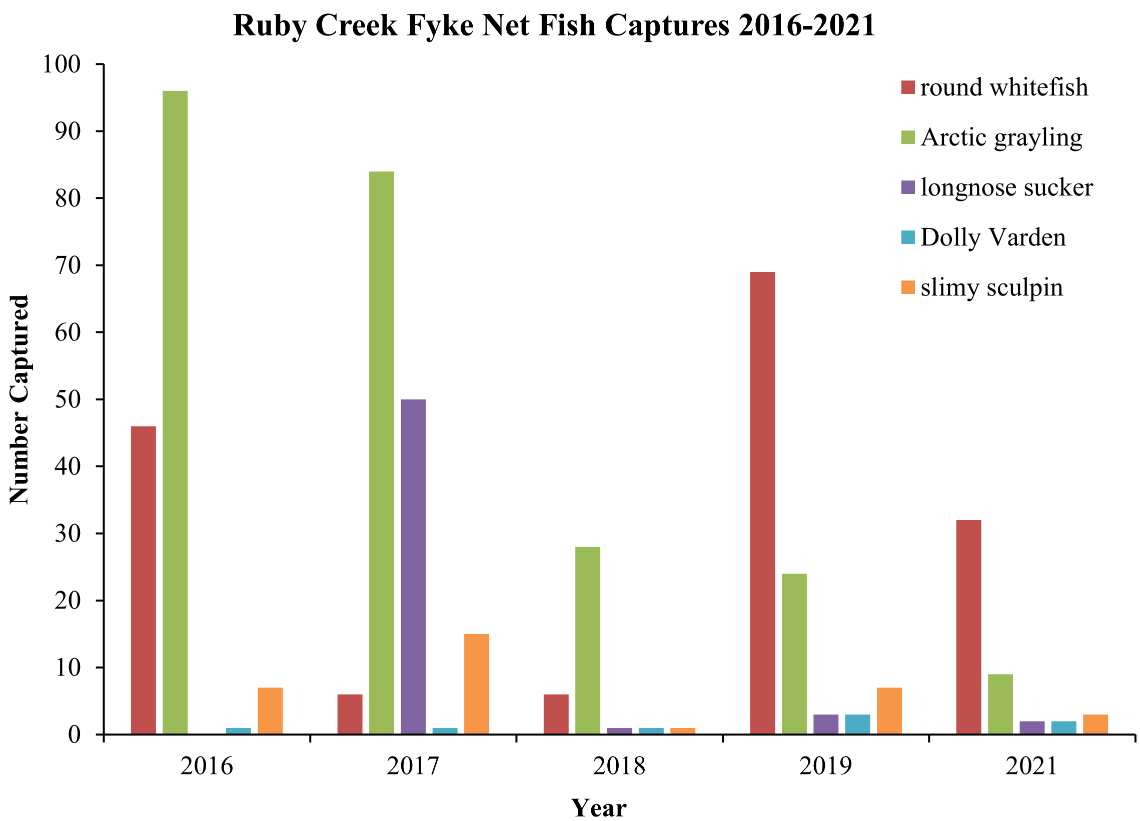

Figure 14. Ruby Creek fyke net fish captures by species for 2016 – 2021. No sampling occurred in 2020.

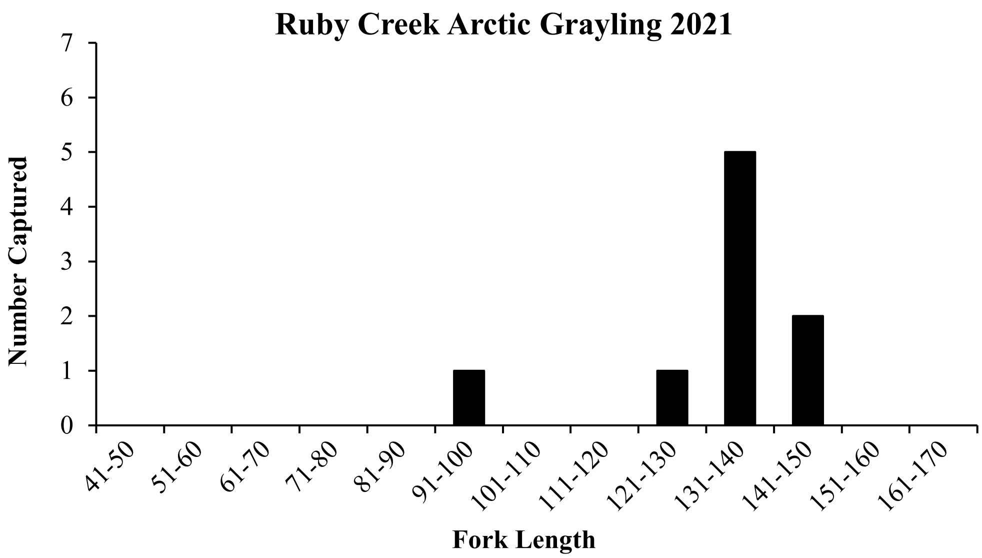

Figure 15. Length frequency distribution of Arctic grayling captured near the mouth of Ruby Creek in 2021.

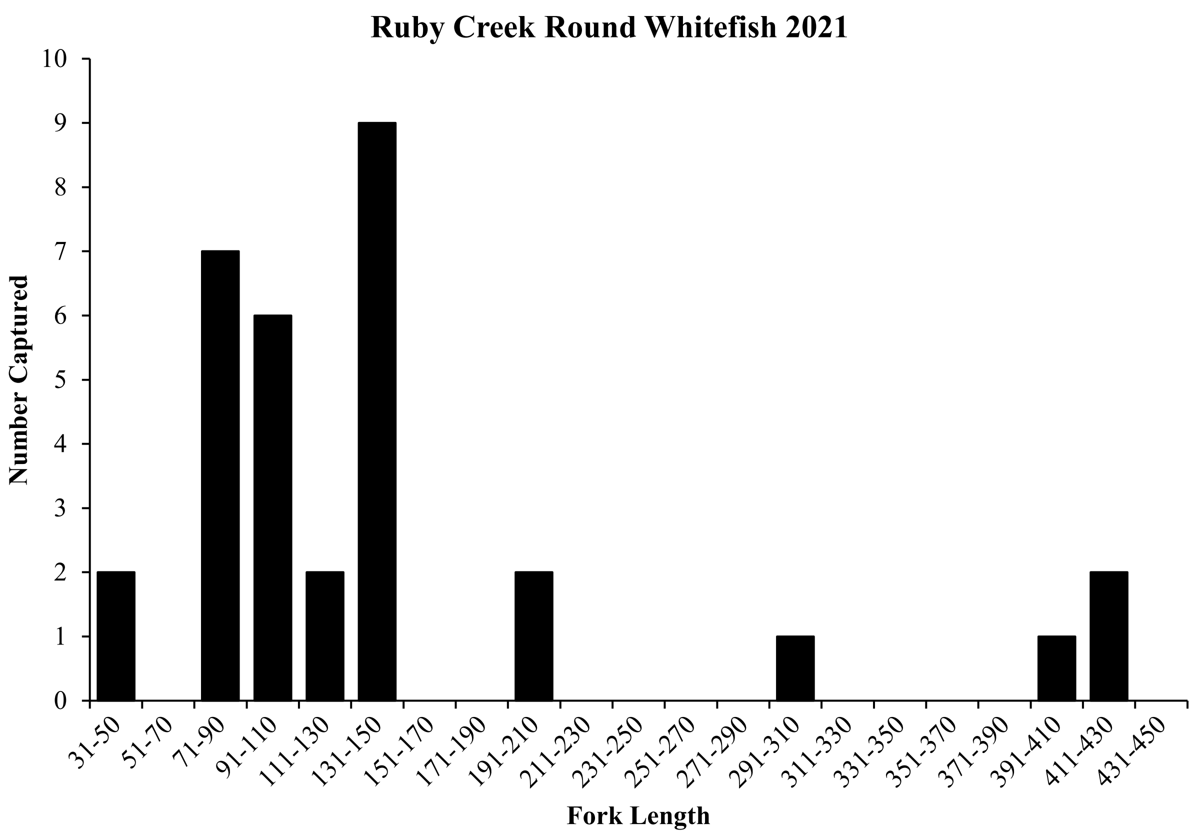

Figure 16. Length frequency distribution of round whitefish captured near the mouth of Ruby Creek in 2021.

Figure 17. Round whitefish captured in the fyke net near the mouth of Ruby Creek.

Fish Metals

Fish retained for element analysis are listed in Appendix 2 and results for each fish are listed in Appendix 3. Similar elements have been examined in whole body juvenile Dolly Varden around the state including Tulsequah Chief Mine, the Pebble prospect, Red Dog Mine, Greens Creek Mine, and Kensington Mine and provide a good data set for comparative purposes (Legere and Timothy, 2016). Arctic grayling, slimy sculpin, Dolly Varden, and round whitefish have been captured in creeks around the Arctic-Bornite Prospect and analyzed for whole body element concentrations from 2016 to 2021. A component of developing the baseline biomonitoring program at Arctic-Bornite has been determining which fish species could reliably be captured in sufficient numbers for element analysis in each system. Dolly Varden are reliably captured in Subarctic Creek and Lower Red Rock Creek, but we discontinued retaining fish from Jay Creek in 2021, since we have been unable to capture an adequate sample size in recent years. Slimy sculpin are retained from Riley Creek, and round whitefish are reliably captured in the fyke net on Ruby Creek.

In 2021, median cadmium concentrations were highest, but variable, in the Dolly Varden from Lower Red Rock Creek, with a median cadmium concentration of 1.24 mg/kg (Figure 21). Round whitefish from Ruby Creek had the lowest median cadmium concentration of 0.35 mg/kg. Ruby Creek fish have consistently had the lowest cadmium concentrations since sampling began in 2016.

The annual median whole body cadmium concentration in Dolly Varden captured in Buddy Creek near the Red Dog Mine has ranged from 0.27 mg/kg to 1.64 mg/kg (Clawson and Ott 2021). The cadmium concentrations in fish from the Arctic-Bornite area are generally within the lower range of concentrations seen in Buddy Creek Dolly Varden.

Median copper concentration in 2021 was highest in Red Rock Creek Dolly Varden at 4.01 mg/kg, similar to the median concentration in 2019 (4.83 mg/kg) (Figure 21). Concentrations were lowest in slimy sculpin from Riley Creek (3.19 mg/kg), although concentrations in Ruby Creek round whitefish and Subarctic Creek Dolly Varden were nearly as low. These copper concentrations in Dolly Varden at Arctic-Bornite are similar to other locations from across the state (Legere and Timothy 2016). Dolly Varden from Buddy Creek (Red Dog Mine) were analyzed for copper in 2014 and 2015, and the median copper concentration was 3.2 mg/kg in 2014 and 3.9 mg/kg in 2015 (Ott et al. 2016).

Median mercury concentration in 2021 was highest in slimy sculpin from Riley Creek (0.20 mg/kg). Median mercury concentration was lowest in Dolly Varden from Red Rock Creek at 0.05 mg/kg (Figure 21). Median mercury concentrations in Dolly Varden from Buddy Creek (Red Dog Mine) have ranged from 0.02 mg/kg to 0.06 mg/kg (Clawson and Ott 2021). Mercury concentrations in fish from the Arctic-Bornite creeks are generally higher those measured in fish from Buddy Creek.

The highest median selenium concentration was 7.49 mg/kg in slimy sculpin from Riley Creek (Figure 21). Riley Creek slimy sculpin typically have the highest median selenium concentration. These values are slightly higher than those found at Tulsequah Chief Mine and the Pebble Prospect, and comparable to those found in juvenile Dolly Varden at Red Dog Mine, Greens Creek Mine, and Kensington Mine (Legere and Timothy, 2016). Median selenium concentrations in Dolly Varden from Buddy Creek have ranged from 3.8 mg/kg to 9.1 mg/kg (Clawson and Ott 2021).

In 2021, median zinc concentration was highest in Dolly Varden from Red Rock Creek (146.37 mg/kg) and lowest in round whitefish from Ruby Creek (96.46 mg/kg) (Figure 21). These zinc concentrations fall within the range of concentrations found in Dolly Varden in other regions of the state (Legere and Timothy, 2016). Dolly Varden from Buddy Creek have had median zinc concentrations ranging from 116 mg/kg to 227 mg/kg (Clawson and Ott 2021). Concentrations in fish from Subarctic, Red Rock, and Riley creeks fall within this range.

Over the four years of baseline data collection at the Arctic-Bornite Prospect, different fish species have been sampled at different locations. Sample sites have been moved, added, and deleted based on changing plans for mine development, accessibility, and likelihood of capturing an adequate sample size. Therefore, comparisons between sample results must be evaluated accordingly. Generally, median whole body cadmium concentrations are highest in fish from Subarctic and Red Rock creeks and lowest in Ruby Creek. Median whole body copper concentrations are similar in Subarctic, Red Rock, Jay, and Riley creeks, and lowest in Ruby Creek. Median whole body mercury concentrations are lowest in fish from the Subarctic and Red Rock Creek drainages, highest in fish from Ruby Creek, and intermediate in fish from Jay and Riley creeks. Median selenium and zinc concentrations are similar among all drainages.

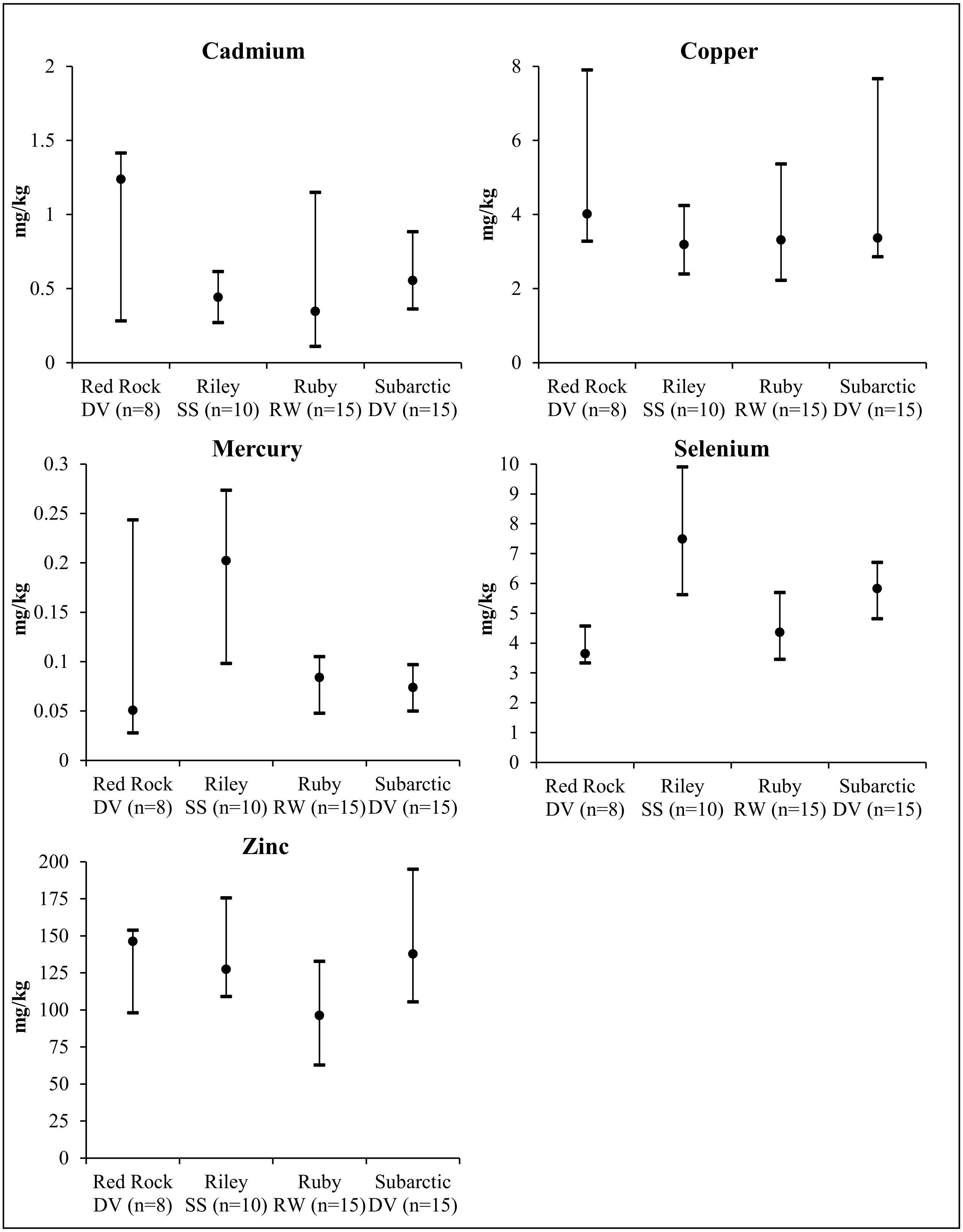

Figure 18. Minimum, median, and maximum whole body dry weight concentrations of various elements in Dolly Varden, slimy sculpin, and round whitefish from various sample sites, 2021.

CONCLUSION

Despite being isolated from the Kobuk River by a large waterfall, the Shungnak River drainage supports self-sustaining populations of Arctic grayling, Dolly Varden, round whitefish, slimy sculpin, longnose sucker, and Alaska blackfish.

Similar to previous years, catches in Subarctic Creek in 2021 were dominated by Dolly Varden. Upper Subarctic Creek typically has low aquatic invertebrate species richness, but high density. It is likely the Dolly Varden move into the upper reaches of Subarctic Creek to feed on the abundant aquatic insects, and with the confirmation of fish in spawning condition in September, they likely remain there to spawn. The capture of a Dolly Varden in upper Subarctic Creek in March 2021 confirms that at least some fish also overwinter in the upper reaches of Subarctic Creek. In other populations of dwarf resident Dolly Varden, males mature as early as age 2 and almost all are mature by age 3, while females mature at ages 3 or 4 (McCart and Craig 1973, McCart and Bain 1974, Armstrong and Morrow 1980). The oldest Dolly Varden that has been aged from the sample sites was an age 7 fish from Subarctic Creek. Dolly Varden in other resident populations have attained age 10, but few fish survive beyond age 5 (Armstrong and Morrow 1980).

Dolly Varden spawning location was confirmed in 2018 through the capture of a very small young of the year fish and capture of ripe females in September (Clawson 2019). So far, spawning has been confirmed in Upper Subarctic Creek and Lower Red Rock Creek, but it is likely that spawning occurs in other places like Center of the Universe Creek. The sampling in September 2019 provided additional evidence of spawning with the capture of ripe males and likely females at Upper Center of the Universe Creek.

The Dolly Varden captured in Riley Creek in July have the potential to be anadromous as no permanent physical barrier exists downstream. A series of rapids on the Kogoluktuk River could impede upstream passage, but are not known to definitively prevent upstream movement. If some of these fish are anadromous, Riley Creek may serve as spawning habitat for resident Dolly Varden and rearing habitat for anadromous juveniles. However, the presence of small, sexually mature males found in previous years does not prove there is a self-sustaining resident population of Dolly Varden in Riley Creek. Many anadromous populations of Dolly Varden contain "residual" males that never migrate to the ocean, but instead spend their entire life cycle in freshwater. These males act as sneaker males and spawn with anadromous females (Armstrong and Morrow 1980). If the Riley Creek area remains in consideration as a tailings storage facility location, future fish sampling in Riley Creek will potentially involve genetic sampling to compare to Subarctic resident Dolly Varden and Kobuk drainage anadromous Dolly Varden. With the baseline genetic information on the resident Dolly Varden in Subarctic Creek showing they are reproductively isolated and contain less genetic variation than anadromous Dolly Varden from the Kobuk River, genetics from Riley Creek could provide insight to whether some are anadromous or not. Additional fall aerial surveys in the Kogoluktuk River to look for anadromous Dolly Varden would help confirm the presence or absence of anadromous fish.

In 2016, fyke net catches in Ruby Creek were dominated by age 0 Arctic grayling and round whitefish. In 2017 and 2018, most Arctic grayling were age 1+ and very few round whitefish were captured. In 2019 and 2021 the fyke nets in Ruby Creek were fished for longer periods of time to better capture the range of fish movement in these tributaries to the Shungnak River. The increased fishing time resulted in higher numbers of fish captures, including a wider range of age classes of Arctic grayling and round whitefish. Based on catches in 2016 to 2021, it is likely that Arctic grayling, round whitefish, and longnose suckers spawn upstream of Ruby Creek in the Shungnak River drainage.

If future aquatic sampling is planned, we recommend continuation of periphyton and aquatic invertebrate sampling. Future fish work should be focused on expanding our understanding of how and when fish utilize target areas around the Arctic and Bornite deposits. Additional recommendations include obtaining greater sample sizes for fish whole body element analysis and conducting fall aerial surveys.

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APPENDIX 1. WATER QUALITY DATA

Only metals data used in fish whole body element analyses are shown. Acute and chronic water quality standards for aquatic life are shown for cadmium, copper, and zinc, which are dependent on water hardness. The cadmium sample highlighted in yellow were the only samples that exceeded the more stringent chronic aquatic life exposure limit.

2021

Site Location	Collection Date	Dissolved Cadmium (ug/L)	Cadmium Acute Limit (ug/L)	Cadmium Chronic Limit (ug/L)	Dissolved Copper (ug/L)	Copper Acute Limit (ug/L)	Copper Chronic Limit (ug/L)	Mercury (ng/L)	Dissolved Selenium (ug/L)	TDS (mg/L)	Dissolved Zinc (ug/L)	Zinc Acute Limit (ug/L)	Zinc Chronic Limit (ug/L)	Hardness CaCO3 (mg/L)
Upper	6/8/2021	0.000	2.287	0.269		15.205	10.017	1.440	0.500	155		130.939	132.011	114
Ruby	8/29/2021	0.000	2.502	0.287	0.38	16.584	10.837	0.000	0.452	186	0.000	141.569	142.727	125
Lower	1/28/2021	0.000	3.160	0.339		20.803	13.311	0.709	0.569	188		173.580	175.000	159
Ruby	6/9/2021	0.000	2.229	0.264		14.828	9.791	1.630	0.421	141		128.014	129.061	111
	8/31/2021	0.000	2.131	0.256	1.120	14.198	9.413	1.280	0.000	144	0.000	123.111	124.118	106
	9/30/2021	0.000	2.676	0.301	0.512	17.706	11.500	0.000	0.420	176	0.000	150.159	151.387	134
Shungnak	6/20/2021	0.321	1.532	0.202		10.313	7.044		0.468	115		92.351	93.106	76
	8/20/2021	0.365	1.647	0.213	1.230	11.058	7.504	0.000	0.335	112	26.700	98.327	99.132	81
	9/29/2021	0.365	1.928	0.238	0.959	12.881	8.618	0.000	0.680	121	28.800	112.797	113.720	96
Upper	1/26/2021	0.018	1.253	0.175		8.488	5.903	0.518	0.310	64		77.512	78.146	61
Subarctic	3/11/2021	0.123	0.972	0.146		6.638	4.724	0.610	0.000	77		62.139	62.647	47
	6/20/2021	0.000	0.789	0.126		5.427	3.935		0.000	32		51.849	52.273	38
	8/22/2021	0.016	0.922	0.141	0.000	6.307	4.509	0.000	0.000	72	0.000	59.345	59.830	45
	9/29/2021	0.017	0.952	0.144	0.000	6.506	4.638	0.000	0.398	62	3.640	61.024	61.523	46
Lower	6/20/2021	0.058	0.846	0.132		5.801	4.180		0.368	36.000		55.051	55.502	41
Subarctic	8/22/2021	0.109	0.807	0.128	0.933	5.548	4.014	0.000	0.588	73.000	11.400	52.882	53.314	39
	9/29/2021	0.103	0.904	0.139	0.672	6.187	4.432	0.000	0.800	71.000	12.400	58.333	58.810	44
Lower	6/9/2021	0.000	2.012	0.246		13.426	8.948	0.793	0.691	125		117.081	118.039	100
Riley	8/21/2021	0.000	2.151	0.258	0.577	14.324	9.489	0.000	0.649	132	0.000	124.094	125.109	107
	9/30/2021	0.000	2.560	0.292	0.432	16.958	11.059	0.000	0.872	167	0.000	144.442	145.624	128

2019

Site Location	Collection Date	Cadmium (ug/L)	Cadmium Acute Limit (ug/L)	Cadmium Chronic Limit (ug/L)	Copper (ug/L)	Copper Acute Limit (ug/L)	Copper Chronic Limit (ug/L)	Mercury (ng/L)	Selenium (ug/L)	TDS (mg/L)	Zinc (ug/L)	Zinc Acute Limit (ug/L)	Zinc Chronic Limit (ug/L)	Hardness CaCO3 (mg/L)
Upper Ruby	3/30/2019	0.025	3.120	0.340	0.273	20.556	13.167	0.831	0.382	198	5.000	171.728	173.133	157
	6/6/2019	0.025	2.346	0.274	0.527	15.582	10.242	0.677	0.596	147	5.000	133.853	134.948	117
	8/29/2019	0.025	2.676	0.301	0.287	17.706	11.500	0.736	0.391	165	5.000	150.159	151.387	134
	12/5/2019	0.025	3.160	0.339	0.370	20.803	13.311	2.190	0.536	198	5.000	173.580	175.000	159
Lower Ruby	3/30/2019	0.025	2.793	0.311	0.536	18.452	11.939	0.500	0.574	180	5.000	155.837	157.111	140
	6/22/2019	0.025	2.735	0.306	1.750	18.080	11.720	1.780	0.500	153	5.000	153.002	154.254	137
	9/2/2019	0.025	2.948	0.323	1.380	19.444	12.520	1.480	0.500	165	5.000	163.350	164.686	148
	12/9/2019	0.025	4.083	0.408	1.120	26.673	16.676	1.130	0.808	294	3.790	217.059	218.834	207
Shungnak	6/27/2019	0.239	1.562	0.205	1.440	10.506	7.163	0.671	0.341	124	19.300	93.903	94.671	77
	8/24/2019	0.369	1.778	0.225	2.160	11.914	8.029	0.544	0.393	75	29.000	105.151	106.012	88
Upper Subarctic	4/1/2019	0.047	1.006	0.150	0.305	6.862	4.868	0.707	0.409	63	5.000	64.026	64.550	49
	6/7/2019	0.018	0.543	0.096	0.250	3.777	2.833	1.940	0.500	23	5.000	37.425	37.731	26
	8/23/2019	0.018	0.946	0.143	0.247	6.466	4.612	0.500	0.500	51	5.000	60.689	61.185	46
	12/8/2019	0.025	1.086	0.158	0.203	7.389	5.206	0.733	0.500	67	5.000	68.428	68.988	53
Lower Subarctic	6/7/2019	0.085	0.563	0.099	2.230	3.914	2.926	1.210	0.420	34	11.300	38.641	38.957	27
	12/11/2019	0.063	1.026	0.152	0.655	6.994	4.953	2.020	0.620	65	7.830	65.132	65.664	50
Lower Riley	6/11/2019	0.025	1.896	0.236	0.618	12.678	8.495	0.500	0.700	151	5.000	111.195	112.105	94
	8/21/2019	0.025	2.307	0.271	0.602	15.331	10.092	1.440	0.593	143	5.000	131.912	132.991	115

2018

Site Location	Collection Date	Cadmium (ug/L)	Cadmium Acute Limit (ug/L)	Cadmium Chronic Limit (ug/L)	Copper (ug/L)	Copper Acute Limit (ug/L)	Copper Chronic Limit (ug/L)	Mercury (ng/L)	Selenium (ug/L)	TDS (mg/L)	Zinc (ug/L)	Zinc Chronic/ Acute Limit (ug/L)	Hardness CaCO3 (mg/L)
Upper Ruby	6/29/2018	0.025	2.980	0.350	0.341	19.090	12.360	0.939	0.500	156	3.10	158.380	139
	8/26/2018	0.025	3.070	0.350	0.392	19.610	12.660	2.030	0.435	179	5.00	162.230	143
	12/10/2018	0.025	3.130	0.360	0.500	20.000	12.890	0.606	0.459	176	5.00	165.110	146
	12/10/2018	0.025	3.290	0.370	0.500	20.900	13.420	*0.500	0.532	158	5.00	171.790	153
Lower Ruby	3/22/2018	0.025	3.110	0.360	0.699	19.870	12.820	0.562	1.000	178	3.10	164.150	145
	6/28/2018	0.025	2.720	0.320	0.896	17.530	11.440	1.140	0.500	148	3.98	146.710	127
	8/24/2018	0.025	2.480	0.300	1.080	16.100	10.590	1.280	0.500	152	5.00	135.870	116
	12/10/2018	0.025	3.090	0.350	0.542	19.740	12.740	0.871	0.592	187	5.00	163.190	144
Upper Shungnak	6/27/2018	0.219	1.530	0.210	1.820	10.270	7.050	1.040	0.521	86	18.00	90.710	72
	8/26/2018	0.227	1.810	0.240	1.420	12.010	8.120	0.513	0.595	104	17.20	104.400	85
Upper Subarctic	3/25/2018	*0.015			0.250	7.700	5.420	*0.500	1.000	72	3.10	69.970	53
	6/24/2018	0.025	0.710	0.120	0.323	5.070	3.710	0.889	0.500	38	3.10	48.030	34
	8/26/2018	0.025	0.950	0.150	0.249	6.600	4.720	0.773	0.450	56	5.00	60.910	45
	12/7/2018	0.017	1.050	0.160	0.250	7.290	5.160	0.601	0.500	56	5.00	66.600	50
Lower Subarctic	3/24/2018	0.042	1.050	0.160	0.303	7.290	5.160	*0.500	1.000	73	4.49	66.600	50
	6/27/2018	0.102	0.630	0.110	1.610	4.500	3.330	0.859	0.337	47	16.40	43.200	30
	6/27/2018	0.103	0.690	0.120	1.580	4.930	3.620	0.965	0.500	44	14.20	46.830	33
	8/26/2018	0.078	0.840	0.140	0.705	5.900	4.260	0.672	0.711	59	9.61	55.120	40
Lower Riley	7/1/2018	0.025	2.110	0.270	0.513	13.870	9.250	0.890	0.825	106	3.10	118.800	99
	7/1/2018	0.034	2.290	0.280	0.863	14.920	9.880	0.976	0.685	111	3.10	126.890	107
	8/28/2018	0.025	2.420	0.300	0.714	15.710	10.360	1.420	0.473	121	5.00	132.890	113

2017

Location	Date Collected	Cadmium µg/L	Cadmium Acute Limit µg/L	Copper Chronic Limit µg/L	Copper µg/L	Copper Acute Limit µg/L	Copper Chronic Limit µg/L	Mercury ng/L	Selenium µg/L	Zinc µg/L	Zinc Acute Limit µg/L	Zinc Chronic Limit µg/L	Hardness $CaCO_3$ mg/L	TDS mg/L
Upper Ruby	4/27/2017	*0.015			0.33	20.38	13.12	*0.5	*0.31	1.56	167.98	167.98	149	169
Upper Ruby	7/18/2017	*0.015			0.47	18.96	12.28	0.605	0.329	1.25	157.41	157.41	138	163
Upper Ruby	8/23/2017	*0.015			0.41	17.14	11.21	*0.5	0.547	1.43	143.77	143.77	124	136
Upper Ruby	9/18/2017	*0.015			0.53	15.18	10.04	0.876	0.385	1.66	128.89	128.89	109	132
Upper Ruby	12/2/2017	0.015	2.98	0.35	0.82	19.09	12.36	*0.5	0.588	4.36	158.38	158.38	139	166
Lower Ruby	4/27/2017	*0.015			0.46	20.25	13.04	*0.5	0.345	0.81	167.02	167.02	148	173
Lower Ruby	7/24/2017	0.0298	1.90	0.25	3.00	12.58	8.47	2.25	*0.31	4.24	108.86	108.86	89.3	119
Lower Ruby	8/26/2017	0.0165	2.52	0.31	1.17	16.36	10.75	0.612	0.409	2.12	137.85	137.85	118	149
Lower Ruby	9/22/2017	*0.015			0.95	16.10	10.59	0.744	*0.31	11.90	135.87	135.87	116	113
Lower Ruby	11/30/2017	*0.015			0.57	19.35	12.51	0.749	0.622	1.32	160.31	160.31	141	160
Upper Shungnak	4/27/2017	0.097	1.77	0.24	0.67	11.80	7.99	*0.5	0.334	8.39	102.74	102.74	83.4	108
Upper Shungnak	7/22/2017	0.130	1.78	0.24	0.88	11.81	8.00	*0.5	0.369	7.45	102.84	102.84	83.5	116
Upper Shungnak	8/24/2017	0.219	1.68	0.23	1.45	11.20	7.62	*0.5	0.563	17.10	98.02	98.02	78.9	97
Upper Shungnak	9/20/2017	0.217	1.57	0.22	1.53	10.54	7.21	0.701	*0.31	16.70	92.84	92.84	74	92
Upper Subarctic	7/21/2017	0.0165	0.89	0.14	0.22	6.21	4.46	*0.5	*0.31	0.96	57.68	57.68	42.2	55
Upper Subarctic	8/21/2017	0.0963	1.05	0.16	0.69	7.29	5.16	*0.5	0.426	3.29	66.60	66.60	50	58
Upper Subarctic	9/20/2017	0.0166	0.86	0.14	0.26	6.06	4.36	0.695	*0.31	1.35	56.41	56.41	41.1	48
Lower Subarctic	4/27/2017	0.0415	1.08	0.16	0.31	7.42	5.25	*0.5	0.704	4.32	67.72	67.72	51	68
Lower Subarctic	7/19/2017	0.1610	0.98	0.15	3.22	6.82	4.86	0.95	0.315	16.10	62.74	62.74	46.6	62
Lower Subarctic	8/24/2017	0.0829	0.81	0.13	1.02	5.71	4.14	*0.5	0.402	11.50	53.48	53.48	38.6	44
Lower Subarctic	9/20/2017	0.1020	0.77	0.13	1.33	5.42	3.94	0.746	0.398	15.30	51.01	51.01	36.5	41
Lower Riley	7/19/2017	*0.015			0.45	14.92	9.88	0.645	0.546	1.15	126.89	126.89	107	129
Lower Riley	8/22/2017	*0.015			0.65	15.58	10.28	*0.5	0.781	1.29	131.89	131.89	112	123
Lower Riley	9/20/2017	0.015	2.10	0.27	0.81	13.77	9.19	0.783	0.464	1.12	118.09	118.09	98.3	115

APPENDIX 2. LIST OF FISH RETAINED FOR WHOLE BODY ELEMENT ANALYSIS

Sample ID	Stream	Site	Date Collected	Fish Spp[1]	Length (mm)	Weight (g)	Metals to be analyzed				
							Cu	Hg	Se	Cd	Zn
071621RUBRWJ01	Ruby	Fyke Mouth	7/16/2021	RW	117	12.0	x	x	x	x	x
071621RUBRWJ02	Ruby	Fyke Mouth	7/16/2021	RW	135	18.6	x	x	x	x	x
071621RUBRWJ03	Ruby	Fyke Mouth	7/16/2021	RW	144	22.4	x	x	x	x	x
071621RUBRWJ04	Ruby	Fyke Mouth	7/16/2021	RW	143	24.1	x	x	x	x	x
071621RUBRWJ05	Ruby	Fyke Mouth	7/16/2021	RW	144	23.1	x	x	x	x	x
071621RUBRWJ06	Ruby	Fyke Mouth	7/16/2021	RW	137	20.1	x	x	x	x	x
071621RUBRWJ07	Ruby	Fyke Mouth	7/16/2021	RW	143	23.5	x	x	x	x	x
071621RUBRWJ08	Ruby	Fyke Mouth	7/16/2021	RW	130	17.6	x	x	x	x	x
071621RUBRWJ09	Ruby	Fyke Mouth	7/16/2021	RW	92	5.8	x	x	x	x	x
071621RUBRWJ10	Ruby	Fyke Mouth	7/16/2021	RW	150	27.4	x	x	x	x	x
071621RUBRWJ11	Ruby	Fyke Mouth	7/16/2021	RW	90	5.3	x	x	x	x	x
071621RUBRWJ12	Ruby	Fyke Mouth	7/16/2021	RW	90	5.0	x	x	x	x	x
071621RUBRWJ13	Ruby	Fyke Mouth	7/16/2021	RW	94	6.3	x	x	x	x	x
071621RUBRWJ14	Ruby	Fyke Mouth	7/16/2021	RW	94	5.9	x	x	x	x	x
071621RUBRWJ15	Ruby	Fyke Mouth	7/16/2021	RW	96	7.3	x	x	x	x	x
071521LRRDV01	Red Rock	Lower	7/15/2021	DV	118	15.8	x	x	x	x	x
071521LRRDV02	Red Rock	Lower	7/15/2021	DV	92	7.8	x	x	x	x	x
071521LRRDV03	Red Rock	Lower	7/15/2021	DV	122	16.5	x	x	x	x	x
071521LRRDV04	Red Rock	Lower	7/15/2021	DV	133	21.1	x	x	x	x	x
071521LRRDV05	Red Rock	Lower	7/15/2021	DV	107	10.7	x	x	x	x	x
071521LRRDV06	Red Rock	Lower	7/15/2021	DV	138	18.6	x	x	x	x	x
071521LRRDV07	Red Rock	Lower	7/15/2021	DV	94	8.3	x	x	x	x	x
071521LRRDV08	Red Rock	Lower	7/15/2021	DV	125	18.5	x	x	x	x	x
071521LSADV01	Subarctic	Lower	7/15/2021	DV	103	10.5	x	x	x	x	x
071521LSADV02	Subarctic	Lower	7/15/2021	DV	106	12.6	x	x	x	x	x
071521USADV03	Subarctic	Upper	7/15/2021	DV	113	14.2	x	x	x	x	x
071521USADV04	Subarctic	Upper	7/15/2021	DV	112	13.4	x	x	x	x	x
071521USADV05	Subarctic	Upper	7/15/2021	DV	110	8.9	x	x	x	x	x
071521USADV06	Subarctic	Upper	7/15/2021	DV	97	7.4	x	x	x	x	x
071521USADV07	Subarctic	Upper	7/15/2021	DV	98	8.0	x	x	x	x	x
071521USADV08	Subarctic	Upper	7/15/2021	DV	130	21.1	x	x	x	x	x
071521USADV09	Subarctic	Upper	7/15/2021	DV	101	9.9	x	x	x	x	x
071521USADV10	Subarctic	Upper	7/15/2021	DV	118	14.9	x	x	x	x	x
071521USADV11	Subarctic	Upper	7/15/2021	DV	115	13.9	x	x	x	x	x
071521USADV12	Subarctic	Upper	7/15/2021	DV	92	6.5	x	x	x	x	x
071521USADV13	Subarctic	Upper	7/15/2021	DV	111	12.7	x	x	x	x	x
071521USADV14	Subarctic	Upper	7/15/2021	DV	110	13.5	x	x	x	x	x
071521USADV15	Subarctic	Upper	7/15/2021	DV	97	7.6	x	x	x	x	x

Sample ID	Stream	Site	Date Collected	Fish Spp[1]	Length (mm)	Weight (g)	Metals to be analyzed				
							Cu	Hg	Se	Cd	Zn
071821RILSS01	Riley		7/18/2021	SS	63	3.0	x	x	x	x	x
071821RILSS02	Riley		7/18/2021	SS	64	3.2	x	x	x	x	x
071821RILSS03	Riley		7/18/2021	SS	65	3.1	x	x	x	x	x
071821RILSS04	Riley		7/18/2021	SS	74	3.1	x	x	x	x	x
071821RILSS05	Riley		7/18/2021	SS	66	2.4	x	x	x	x	x
071821RILSS06	Riley		7/18/2021	SS	90	8.5	x	x	x	x	x
071821RILSS07	Riley		7/18/2021	SS	63	2.5	x	x	x	x	x
071821RILSS08	Riley		7/18/2021	SS	78	4.9	x	x	x	x	x
071821RILSS09	Riley		7/18/2021	SS	60	1.9	x	x	x	x	x
071821RILSS10	Riley		7/18/2021	SS	61	2.0		x	x	x	x

[1] Dolly Varden (DV), slimy sculpin (SS), and round whitefish (RW)

APPENDIX 3. RESULTS FOR WHOLE BODY ELEMENT ANALYSIS

Round Whitefish

Sample ID	Site	Collection Date	Analyte	Dry Wt. Result (mg/Kg)	Dry Wt. MDL (mg/Kg)	% Solid
071621RUBRWJ01	Ruby	7/16/2021	Cadmium	1.15	0.04	20.7
071621RUBRWJ02	Ruby	7/16/2021	Cadmium	0.52	0.04	22.3
071621RUBRWJ03	Ruby	7/16/2021	Cadmium	0.35	0.05	21.7
071621RUBRWJ04	Ruby	7/16/2021	Cadmium	0.42	0.04	23.3
071621RUBRWJ05	Ruby	7/16/2021	Cadmium	0.50	0.03	22.6
071621RUBRWJ06	Ruby	7/16/2021	Cadmium	0.17	0.05	22.4
071621RUBRWJ07	Ruby	7/16/2021	Cadmium	0.21	0.05	21.6
071621RUBRWJ08	Ruby	7/16/2021	Cadmium	0.33	0.05	21.7
071621RUBRWJ09	Ruby	7/16/2021	Cadmium	0.11	0.05	23.3
071621RUBRWJ10	Ruby	7/16/2021	Cadmium	0.60	0.04	22.7
071621RUBRWJ11	Ruby	7/16/2021	Cadmium	0.38	0.04	20.6
071621RUBRWJ12	Ruby	7/16/2021	Cadmium	0.43	0.05	21
071621RUBRWJ13	Ruby	7/16/2021	Cadmium	0.28	0.03	22
071621RUBRWJ14	Ruby	7/16/2021	Cadmium	0.26	0.05	21.8
071621RUBRWJ15	Ruby	7/16/2021	Cadmium	0.15	0.03	23.1
071621RUBRWJ01	Ruby	7/16/2021	Copper	3.65	0.64	20.7
071621RUBRWJ02	Ruby	7/16/2021	Copper	2.61	0.65	22.3
071621RUBRWJ03	Ruby	7/16/2021	Copper	3.99	0.79	21.7
071621RUBRWJ04	Ruby	7/16/2021	Copper	5.36	0.60	23.3
071621RUBRWJ05	Ruby	7/16/2021	Copper	2.23	0.53	22.6
071621RUBRWJ06	Ruby	7/16/2021	Copper	2.23	0.84	22.4
071621RUBRWJ07	Ruby	7/16/2021	Copper	3.31	0.80	21.6
071621RUBRWJ08	Ruby	7/16/2021	Copper	2.65	0.77	21.7
071621RUBRWJ09	Ruby	7/16/2021	Copper	2.41	0.82	23.3
071621RUBRWJ10	Ruby	7/16/2021	Copper	2.94	0.63	22.7
071621RUBRWJ11	Ruby	7/16/2021	Copper	3.49	0.72	20.6
071621RUBRWJ12	Ruby	7/16/2021	Copper	3.63	0.76	21
071621RUBRWJ13	Ruby	7/16/2021	Copper	3.71	0.51	22
071621RUBRWJ14	Ruby	7/16/2021	Copper	2.33	0.73	21.8
071621RUBRWJ15	Ruby	7/16/2021	Copper	3.36	0.54	23.1
071621RUBRWJ01	Ruby	7/16/2021	Mercury	0.09	0.01	20.7
071621RUBRWJ02	Ruby	7/16/2021	Mercury	0.08	0.01	22.3
071621RUBRWJ03	Ruby	7/16/2021	Mercury	0.09	0.01	21.7
071621RUBRWJ04	Ruby	7/16/2021	Mercury	0.08	0.01	23.3
071621RUBRWJ05	Ruby	7/16/2021	Mercury	0.07	0.01	22.6
071621RUBRWJ06	Ruby	7/16/2021	Mercury	0.10	0.01	22.4
071621RUBRWJ07	Ruby	7/16/2021	Mercury	0.08	0.01	21.6
071621RUBRWJ08	Ruby	7/16/2021	Mercury	0.05	0.01	21.7
071621RUBRWJ09	Ruby	7/16/2021	Mercury	0.11	0.01	23.3
071621RUBRWJ10	Ruby	7/16/2021	Mercury	0.09	0.01	22.7
071621RUBRWJ11	Ruby	7/16/2021	Mercury	0.08	0.01	20.6
071621RUBRWJ12	Ruby	7/16/2021	Mercury	0.07	0.01	21
071621RUBRWJ13	Ruby	7/16/2021	Mercury	0.06	0.01	22

Sample ID	Site	Collection Date	Analyte	Dry Wt. Result (mg/Kg)	Dry Wt. MDL (mg/Kg)	% Solid
071621RUBRWJ14	Ruby	7/16/2021	Mercury	0.07	0.01	21.8
071621RUBRWJ15	Ruby	7/16/2021	Mercury	0.10	0.01	23.1
071621RUBRWJ01	Ruby	7/16/2021	Selenium	5.70	0.08	20.7
071621RUBRWJ02	Ruby	7/16/2021	Selenium	5.56	0.08	22.3
071621RUBRWJ03	Ruby	7/16/2021	Selenium	4.05	0.10	21.7
071621RUBRWJ04	Ruby	7/16/2021	Selenium	4.09	0.08	23.3
071621RUBRWJ05	Ruby	7/16/2021	Selenium	4.36	0.07	22.6
071621RUBRWJ06	Ruby	7/16/2021	Selenium	4.18	0.10	22.4
071621RUBRWJ07	Ruby	7/16/2021	Selenium	3.46	0.10	21.6
071621RUBRWJ08	Ruby	7/16/2021	Selenium	5.39	0.10	21.7
071621RUBRWJ09	Ruby	7/16/2021	Selenium	4.38	0.10	23.3
071621RUBRWJ10	Ruby	7/16/2021	Selenium	4.93	0.08	22.7
071621RUBRWJ11	Ruby	7/16/2021	Selenium	4.36	0.09	20.6
071621RUBRWJ12	Ruby	7/16/2021	Selenium	3.78	0.10	21
071621RUBRWJ13	Ruby	7/16/2021	Selenium	4.73	0.06	22
071621RUBRWJ14	Ruby	7/16/2021	Selenium	4.08	0.09	21.8
071621RUBRWJ15	Ruby	7/16/2021	Selenium	4.42	0.07	23.1
071621RUBRWJ01	Ruby	7/16/2021	Zinc	116.43	4.78	20.7
071621RUBRWJ02	Ruby	7/16/2021	Zinc	124.22	4.84	22.3
071621RUBRWJ03	Ruby	7/16/2021	Zinc	79.26	5.94	21.7
071621RUBRWJ04	Ruby	7/16/2021	Zinc	93.99	4.51	23.3
071621RUBRWJ05	Ruby	7/16/2021	Zinc	96.46	3.98	22.6
071621RUBRWJ06	Ruby	7/16/2021	Zinc	107.59	6.29	22.4
071621RUBRWJ07	Ruby	7/16/2021	Zinc	62.96	5.97	21.6
071621RUBRWJ08	Ruby	7/16/2021	Zinc	125.81	11.61	21.7
071621RUBRWJ09	Ruby	7/16/2021	Zinc	78.11	6.18	23.3
071621RUBRWJ10	Ruby	7/16/2021	Zinc	74.01	4.76	22.7
071621RUBRWJ11	Ruby	7/16/2021	Zinc	133.01	5.39	20.6
071621RUBRWJ12	Ruby	7/16/2021	Zinc	116.67	5.71	21
071621RUBRWJ13	Ruby	7/16/2021	Zinc	113.18	3.82	22
071621RUBRWJ14	Ruby	7/16/2021	Zinc	96.33	5.50	21.8
071621RUBRWJ15	Ruby	7/16/2021	Zinc	83.12	4.03	23.1

*MDL = Method Detection Limit

Dolly Varden

Sample ID	Site	Collection Date	Analyte	Dry Wt. Result (mg/Kg)	Dry Wt. MDL (mg/Kg)	% Solid
071521LSADV01	Subarctic	7/15/2021	Cadmium	0.88	0.04	20.6
071521LSADV02	Subarctic	7/15/2021	Cadmium	0.86	0.04	19.9
071521USADV03	Subarctic	7/15/2021	Cadmium	0.48	0.03	23
071521USADV04	Subarctic	7/15/2021	Cadmium	0.41	0.04	21.6
071521USADV05	Subarctic	7/15/2021	Cadmium	0.49	0.04	22.3
071521USADV06	Subarctic	7/15/2021	Cadmium	0.81	0.04	20.2
071521USADV07	Subarctic	7/15/2021	Cadmium	0.88	0.05	21.8
071521USADV08	Subarctic	7/15/2021	Cadmium	0.53	0.05	19.8
071521USADV09	Subarctic	7/15/2021	Cadmium	0.50	0.05	22.8
071521USADV10	Subarctic	7/15/2021	Cadmium	0.56	0.05	22.7
071521USADV11	Subarctic	7/15/2021	Cadmium	0.36	0.05	22.6
071521USADV12	Subarctic	7/15/2021	Cadmium	0.58	0.05	21.9
071521USADV13	Subarctic	7/15/2021	Cadmium	0.50	0.05	23.2
071521USADV14	Subarctic	7/15/2021	Cadmium	0.58	0.05	23.1
071521USADV15	Subarctic	7/15/2021	Cadmium	0.67	0.04	22.5
071521LSADV01	Subarctic	7/15/2021	Copper	7.67	0.60	20.6
071521LSADV02	Subarctic	7/15/2021	Copper	6.98	0.58	19.9
071521USADV03	Subarctic	7/15/2021	Copper	4.03	0.52	23
071521USADV04	Subarctic	7/15/2021	Copper	2.86	0.63	21.6
071521USADV05	Subarctic	7/15/2021	Copper	3.22	0.70	22.3
071521USADV06	Subarctic	7/15/2021	Copper	3.90	0.69	20.2
071521USADV07	Subarctic	7/15/2021	Copper	3.91	0.75	21.8
071521USADV08	Subarctic	7/15/2021	Copper	3.14	0.77	19.8
071521USADV09	Subarctic	7/15/2021	Copper	3.37	0.79	22.8
071521USADV10	Subarctic	7/15/2021	Copper	3.03	0.78	22.7
071521USADV11	Subarctic	7/15/2021	Copper	2.94	0.74	22.6
071521USADV12	Subarctic	7/15/2021	Copper	3.18	0.77	21.9
071521USADV13	Subarctic	7/15/2021	Copper	3.03	0.74	23.2
071521USADV14	Subarctic	7/15/2021	Copper	3.83	0.74	23.1
071521USADV15	Subarctic	7/15/2021	Copper	3.60	0.68	22.5
071521LSADV01	Subarctic	7/15/2021	Mercury	0.07	0.01	20.6
071521LSADV02	Subarctic	7/15/2021	Mercury	0.08	0.01	19.9
071521USADV03	Subarctic	7/15/2021	Mercury	0.09	0.01	23
071521USADV04	Subarctic	7/15/2021	Mercury	0.07	0.01	21.6
071521USADV05	Subarctic	7/15/2021	Mercury	0.06	0.01	22.3
071521USADV06	Subarctic	7/15/2021	Mercury	0.05	0.01	20.2
071521USADV07	Subarctic	7/15/2021	Mercury	0.09	0.01	21.8
071521USADV08	Subarctic	7/15/2021	Mercury	0.10	0.01	19.8
071521USADV09	Subarctic	7/15/2021	Mercury	0.07	0.01	22.8
071521USADV10	Subarctic	7/15/2021	Mercury	0.07	0.01	22.7
071521USADV11	Subarctic	7/15/2021	Mercury	0.05	0.01	22.6
071521USADV12	Subarctic	7/15/2021	Mercury	0.07	0.01	21.9

Sample ID	Site	Collection Date	Analyte	Dry Wt. Result (mg/Kg)	Dry Wt. MDL (mg/Kg)	% Solid
071521USADV13	Subarctic	7/15/2021	Mercury	0.07	0.01	23.2
071521USADV14	Subarctic	7/15/2021	Mercury	0.07	0.01	23.1
071521USADV15	Subarctic	7/15/2021	Mercury	0.08	0.01	22.5
071521LSADV01	Subarctic	7/15/2021	Selenium	6.36	0.08	20.6
071521LSADV02	Subarctic	7/15/2021	Selenium	4.85	0.07	19.9
071521USADV03	Subarctic	7/15/2021	Selenium	5.43	0.07	23
071521USADV04	Subarctic	7/15/2021	Selenium	5.74	0.08	21.6
071521USADV05	Subarctic	7/15/2021	Selenium	5.83	0.09	22.3
071521USADV06	Subarctic	7/15/2021	Selenium	6.58	0.09	20.2
071521USADV07	Subarctic	7/15/2021	Selenium	6.06	0.09	21.8
071521USADV08	Subarctic	7/15/2021	Selenium	6.46	0.10	19.8
071521USADV09	Subarctic	7/15/2021	Selenium	5.09	0.10	22.8
071521USADV10	Subarctic	7/15/2021	Selenium	6.61	0.10	22.7
071521USADV11	Subarctic	7/15/2021	Selenium	4.82	0.09	22.6
071521USADV12	Subarctic	7/15/2021	Selenium	5.39	0.10	21.9
071521USADV13	Subarctic	7/15/2021	Selenium	5.17	0.09	23.2
071521USADV14	Subarctic	7/15/2021	Selenium	6.28	0.09	23.1
071521USADV15	Subarctic	7/15/2021	Selenium	6.71	0.08	22.5
071521LSADV01	Subarctic	7/15/2021	Zinc	195.15	4.51	20.6
071521LSADV02	Subarctic	7/15/2021	Zinc	188.44	8.74	19.9
071521USADV03	Subarctic	7/15/2021	Zinc	137.83	3.91	23
071521USADV04	Subarctic	7/15/2021	Zinc	154.63	9.44	21.6
071521USADV05	Subarctic	7/15/2021	Zinc	134.53	5.25	22.3
071521USADV06	Subarctic	7/15/2021	Zinc	128.22	5.20	20.2
071521USADV07	Subarctic	7/15/2021	Zinc	133.03	5.64	21.8
071521USADV08	Subarctic	7/15/2021	Zinc	105.56	5.76	19.8
071521USADV09	Subarctic	7/15/2021	Zinc	150.88	5.92	22.8
071521USADV10	Subarctic	7/15/2021	Zinc	140.09	5.81	22.7
071521USADV11	Subarctic	7/15/2021	Zinc	106.64	5.58	22.6
071521USADV12	Subarctic	7/15/2021	Zinc	133.33	5.75	21.9
071521USADV13	Subarctic	7/15/2021	Zinc	122.41	5.56	23.2
071521USADV14	Subarctic	7/15/2021	Zinc	148.05	5.58	23.1
071521USADV15	Subarctic	7/15/2021	Zinc	144.89	5.07	22.5
071521LRRDV01	Red Rock	7/15/2021	Cadmium	1.23	0.03	22.4
071521LRRDV02	Red Rock	7/15/2021	Cadmium	0.78	0.04	24.8
071521LRRDV03	Red Rock	7/15/2021	Cadmium	1.20	0.03	22.4
071521LRRDV04	Red Rock	7/15/2021	Cadmium	1.42	0.04	23.1
071521LRRDV05	Red Rock	7/15/2021	Cadmium	1.25	0.04	23.3
071521LRRDV06	Red Rock	7/15/2021	Cadmium	0.28	0.03	22
071521LRRDV07	Red Rock	7/15/2021	Cadmium	1.27	0.03	21.3
071521LRRDV08	Red Rock	7/15/2021	Cadmium	1.30	0.04	22.6
071521LRRDV01	Red Rock	7/15/2021	Copper	7.90	0.54	22.4
071521LRRDV02	Red Rock	7/15/2021	Copper	3.80	0.60	24.8
071521LRRDV03	Red Rock	7/15/2021	Copper	3.63	0.55	22.4
071521LRRDV04	Red Rock	7/15/2021	Copper	3.28	0.62	23.1

Sample ID	Site	Collection Date	Analyte	Dry Wt. Result (mg/Kg)	Dry Wt. MDL (mg/Kg)	% Solid
071521LRRDV05	Red Rock	7/15/2021	Copper	4.23	0.67	23.3
071521LRRDV06	Red Rock	7/15/2021	Copper	4.68	0.53	22
071521LRRDV07	Red Rock	7/15/2021	Copper	6.76	0.54	21.3
071521LRRDV08	Red Rock	7/15/2021	Copper	3.63	0.64	22.6
071521LRRDV01	Red Rock	7/15/2021	Mercury	0.05	0.01	22.4
071521LRRDV02	Red Rock	7/15/2021	Mercury	0.04	0.01	24.8
071521LRRDV03	Red Rock	7/15/2021	Mercury	0.05	0.01	22.4
071521LRRDV04	Red Rock	7/15/2021	Mercury	0.05	0.01	23.1
071521LRRDV05	Red Rock	7/15/2021	Mercury	0.03	0.01	23.3
071521LRRDV06	Red Rock	7/15/2021	Mercury	0.24	0.01	22
071521LRRDV07	Red Rock	7/15/2021	Mercury	0.05	0.01	21.3
071521LRRDV08	Red Rock	7/15/2021	Mercury	0.06	0.01	22.6
071521LRRDV01	Red Rock	7/15/2021	Selenium	3.33	0.07	22.4
071521LRRDV02	Red Rock	7/15/2021	Selenium	3.66	0.07	24.8
071521LRRDV03	Red Rock	7/15/2021	Selenium	3.50	0.07	22.4
071521LRRDV04	Red Rock	7/15/2021	Selenium	3.64	0.08	23.1
071521LRRDV05	Red Rock	7/15/2021	Selenium	3.88	0.08	23.3
071521LRRDV06	Red Rock	7/15/2021	Selenium	3.40	0.07	22
071521LRRDV07	Red Rock	7/15/2021	Selenium	4.57	0.07	21.3
071521LRRDV08	Red Rock	7/15/2021	Selenium	4.04	0.08	22.6
071521LRRDV01	Red Rock	7/15/2021	Zinc	150.00	4.02	22.4
071521LRRDV02	Red Rock	7/15/2021	Zinc	138.31	4.48	24.8
071521LRRDV03	Red Rock	7/15/2021	Zinc	145.98	4.15	22.4
071521LRRDV04	Red Rock	7/15/2021	Zinc	146.75	4.68	23.1
071521LRRDV05	Red Rock	7/15/2021	Zinc	151.93	5.02	23.3
071521LRRDV06	Red Rock	7/15/2021	Zinc	98.18	3.95	22
071521LRRDV07	Red Rock	7/15/2021	Zinc	153.99	4.08	21.3
071521LRRDV08	Red Rock	7/15/2021	Zinc	129.20	4.78	22.6

*MDL = Method Detection Limit

Slimy Sculpin

Sample ID	Site	Collection Date	Analyte	Dry Wt. Result (mg/Kg)	Dry Wt. MDL (mg/Kg)	% Solid
071821RILSS01	Riley	7/18/2021	Cadmium	0.57	0.05	21.3
071821RILSS02	Riley	7/18/2021	Cadmium	0.62	0.05	20.8
071821RILSS03	Riley	7/18/2021	Cadmium	0.27	0.05	22.0
071821RILSS04	Riley	7/18/2021	Cadmium	0.58	0.05	23.1
071821RILSS05	Riley	7/18/2021	Cadmium	0.35	0.04	20.6
071821RILSS06	Riley	7/18/2021	Cadmium	0.33	0.04	22.6
071821RILSS07	Riley	7/18/2021	Cadmium	0.51	0.05	22.6
071821RILSS08	Riley	7/18/2021	Cadmium	0.33	0.04	22.7
071821RILSS09	Riley	7/18/2021	Cadmium	0.52	0.10	23.3
071821RILSS10	Riley	7/18/2021	Cadmium	0.37	0.10	22.6
071821RILSS01	Riley	7/18/2021	Copper	3.27	0.83	21.3
071821RILSS02	Riley	7/18/2021	Copper	2.87	0.79	20.8
071821RILSS03	Riley	7/18/2021	Copper	3.32	0.82	22.0
071821RILSS04	Riley	7/18/2021	Copper	3.51	0.73	23.1
071821RILSS05	Riley	7/18/2021	Copper	3.11	0.72	20.6
071821RILSS06	Riley	7/18/2021	Copper	3.38	0.60	22.6
071821RILSS07	Riley	7/18/2021	Copper	2.98	0.73	22.6
071821RILSS08	Riley	7/18/2021	Copper	2.79	0.67	22.7
071821RILSS09	Riley	7/18/2021	Copper	2.39	1.67	23.3
071821RILSS10	Riley	7/18/2021	Copper	4.25	1.56	22.6
071821RILSS01	Riley	7/18/2021	Mercury	0.24	0.01	21.3
071821RILSS02	Riley	7/18/2021	Mercury	0.13	0.01	20.8
071821RILSS03	Riley	7/18/2021	Mercury	0.16	0.01	22.0
071821RILSS04	Riley	7/18/2021	Mercury	0.27	0.01	23.1
071821RILSS05	Riley	7/18/2021	Mercury	0.16	0.01	20.6
071821RILSS06	Riley	7/18/2021	Mercury	0.21	0.01	22.6
071821RILSS07	Riley	7/18/2021	Mercury	0.20	0.01	22.6
071821RILSS08	Riley	7/18/2021	Mercury	0.26	0.01	22.7
071821RILSS09	Riley	7/18/2021	Mercury	0.10	0.01	23.3
071821RILSS10	Riley	7/18/2021	Mercury	0.23	0.01	22.6
071821RILSS01	Riley	7/18/2021	Selenium	6.29	0.10	21.3
071821RILSS02	Riley	7/18/2021	Selenium	7.69	0.10	20.8
071821RILSS03	Riley	7/18/2021	Selenium	9.64	0.10	22.0
071821RILSS04	Riley	7/18/2021	Selenium	5.63	0.09	23.1
071821RILSS05	Riley	7/18/2021	Selenium	8.30	0.09	20.6
071821RILSS06	Riley	7/18/2021	Selenium	7.17	0.08	22.6
071821RILSS07	Riley	7/18/2021	Selenium	9.91	0.09	22.6
071821RILSS08	Riley	7/18/2021	Selenium	6.83	0.08	22.7
071821RILSS09	Riley	7/18/2021	Selenium	7.68	0.21	23.3
071821RILSS10	Riley	7/18/2021	Selenium	7.30	0.19	22.6

Sample ID	Site	Collection Date	Analyte	Dry Wt. Result (mg/Kg)	Dry Wt. MDL (mg/Kg)	% Solid
071821RILSS01	Riley	7/18/2021	Zinc	153.52	6.20	21.3
071821RILSS02	Riley	7/18/2021	Zinc	129.81	5.91	20.8
071821RILSS03	Riley	7/18/2021	Zinc	109.09	6.14	22
071821RILSS04	Riley	7/18/2021	Zinc	146.32	5.45	23.1
071821RILSS05	Riley	7/18/2021	Zinc	120.87	5.39	20.6
071821RILSS06	Riley	7/18/2021	Zinc	175.66	4.51	22.6
071821RILSS07	Riley	7/18/2021	Zinc	125.22	5.44	22.6
071821RILSS08	Riley	7/18/2021	Zinc	156.83	5.02	22.7
071821RILSS09	Riley	7/18/2021	Zinc	119.31	12.49	23.3
071821RILSS10	Riley	7/18/2021	Zinc	124.34	11.68	22.6

*MDL = Method Detection Limit