Technical Report No. 24-05

Aquatic Biomonitoring at the Arctic-Bornite Prospect, 2023

by

Chelsea M. Clawson

June 2024

Alaska Department of Fish and Game | Habitat Section

Symbols and Abbreviations

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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)

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. 24-05

AQUATIC BIOMONITORING AT THE ARCTIC-BORNITE PROSPECT, 2023

By

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June 2024

Cover: Dolly Varden from Center of the Universe Creek, July 12, 2023. Photograph by Audra Brase.

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ACKNOWLEDGEMENTS

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ADF&G Habitat staff Audra Brase and Maria Wessel performed the July aquatic biomonitoring, and Olivia Edwards and Lauren Yancy processed all periphyton samples in the ADF&G laboratory in Fairbanks. Nora Foster of NRF Taxonomic Services was responsible for sorting and identification of benthic macroinvertebrates. Kelsey Stockert (Kuna Engineering) and Cal Craig (Ambler Metals) collected water quality samples. ACZ Laboratories was responsible for the fish whole body element analysis.

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INTRODUCTION

The Ambler Mining District is located in the Kobuk River drainage in the southwest region of the Brooks Range (Figure 1). There are two primary deposits currently being explored by Ambler Metals (formerly Trilogy Metals). The Bornite deposit, located 17 km north of Kobuk in the Ruby Creek drainage, contains primarily copper and cobalt. The Arctic deposit, located 37 km northeast of Kobuk in the upper end of the Subarctic Creek drainage, 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 waterfall in the lower Shungnak River prevents upstream passage of fish, therefore no anadromous fish occur in the drainage upstream of the falls and any resident species of fish upstream complete their life cycle within this isolated extent of the Shungnak River drainage (Figure 2).

All sample sites except Riley Creek are in the Shungnak River drainage. Riley Creek, a tributary to the Kogoluktuk River, is monitored as it may be impacted by future mine development.

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). 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 Alaska Department of Fish and Game (ADF&G) Habitat Section to continue aquatic sampling beginning in 2016. The ADF&G study plan is based on aquatic biomonitoring the Habitat Section conducts at various large hard rock mines throughout the state (Bradley 2017b). Three primary types of data are collected: periphyton, benthic macroinvertebrates, and fish, which includes 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 summarizes the periphyton, benthic macroinvertebrate, and fish samples collected by ADF&G, and water quality data collected by Ambler Metals in 2023, with comparisons to prior years when appropriate. Ambler Metals did not operate a full exploration season in 2023, therefore the 2023 aquatic biomonitoring program was an abbreviated version of the standard mid-summer sampling event.

Location and Description of Monitoring Sites

Biomonitoring activities were performed at nine sites during July 2023 (Table 1; Figure 3). Sampling effort continues to be concentrated in Ruby and Subarctic creeks as there may be changes to these aquatic systems based on projected mining development. In 2023 Upper Ruby Creek was not sampled due to high water and changing site conditions, and a fyke net was not set on Ruby Creek due to limited helicopter availability.

- **Lower Ruby Creek** is characterized by pool/riffle habitat, relatively shallow water, and gravel substrate. Riparian vegetation is a mix of grasses and willows, with some mature spruce trees (Figure 4).
- **Upper Shungnak River** is characterized by outside bend cut banks and inside bend gravel bars, deep water, gravel substrate with some cobble, and forested riparian habitat (Figure 4).
- **Upper Subarctic Creek** is characterized by high gradient with step pools and large boulders with riparian habitat of alpine tundra with some shrubby willows along the banks. This sample site is located a few hundred meters below the origin of the creek, which abruptly forms when water transitions from subsurface to surface flow (Figure 5).
- **Lower Subarctic Creek** is wider with a much lower gradient than the upper site, characterized by riffle/pool habitat with gravel/cobble substrate, with riparian vegetation of willows and mature spruce trees (Figure 5).
- **Riley Creek** is characterized by riffle/pool habitat with gravel and cobble substrate. Riparian habitat is primarily willows and grasses with some mature trees (Figure 6).
- **Jay Creek** is characterized by riffle/run habitats, gravel with some cobble substrate, and very dense mostly willow vegetation and overhanging canopy (Figure 6).
- **Lower Red Rock Creek** has similar habitat to the Lower Subarctic Creek site, characterized by riffle/pool habitat with gravel/cobble substrate, with riparian vegetation of willows and mature spruce trees (Figure 7). This drainage is directly north of Subarctic

Creek drainage on the Shungnak River and may provide alternative fish habitat if Subarctic Creek is altered by future mining activity.

- **Center of the Universe Creek** is a tributary of Red Rock Creek in the upper extent of the drainage. The creek is characterized by riffles and runs interspersed with pools. Substrate here is smaller gravel than at other downstream sites. Riparian habitat is mostly alpine tundra with some willows along the banks (Figure 7).
- **Sunshine Creek** is characterized by riffle/run habitats and gravel/cobble substrate. Riparian vegetation is primarily willows and grasses with mature spruce trees. The sample site is just upstream of a large beaver pond. The upper reaches of Sunshine Creek are very high gradient (Figure 8).

Table 1.–Arctic-Bornite sampling locations (WGS 84), 2023.

Sample Site	Latitude	Longitude	Invertebrates	Periphyton	Minnow
Upper Subarctic	67.1926	-156.3911	X	X	X
Lower Subarctic	67.1720	-156.6208	X	X	X
Lower Red Rock	67.1932	-156.5991	X	X	X
Lower Ruby	67.1114	-156.9084	X	X	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	X	X
Sunshine	67.2335	-156.6162	X	X	X

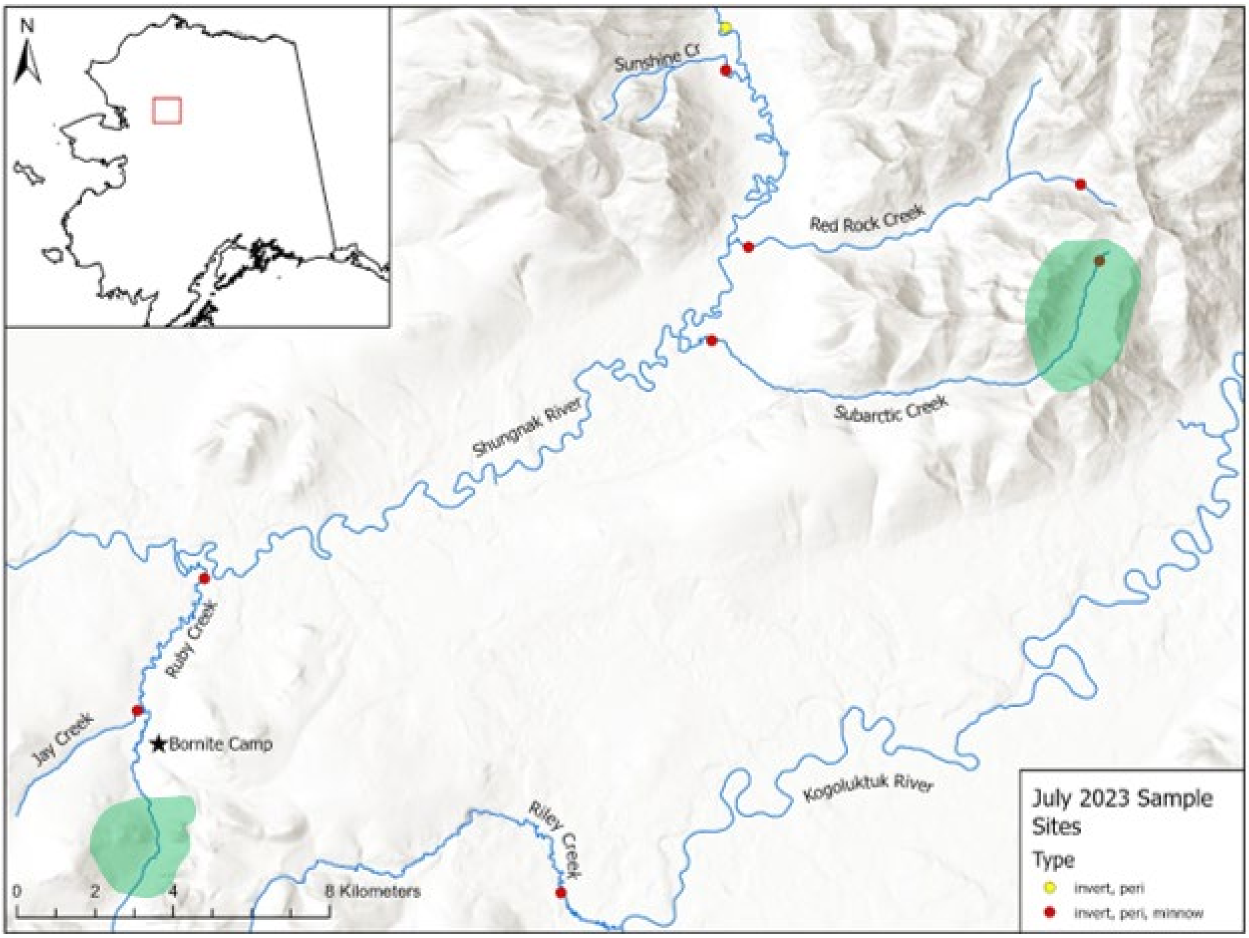

Figure 3.–All locations sampled in July 2023. The approximate location of the Bornite and Arctic deposits are denoted by the green polygons.

Figure 4.–Sample sites on Lower Ruby Creek (left) and Upper Shungnak River (right).

Figure 5.–Sample sites on Upper Subarctic Creek (left) and Lower Subarctic Creek (left).

Figure 6.–Sample sites on Riley Creek (left) and Jay Creek (right).

Figure 7.–Sample sites on Lower Red Rock Creek (left) and Center of the Universe Creek (right).

Figure 8.–Sample site on Sunshine Creek above the beaver dam (left) and below the beaver dam (right).

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 in the vicinity and downstream of potential project facilities.

In 2023 there was one sampling event in the Arctic Bornite area which took place from July 10–14. Ambler Metals did not run an exploration program in 2023, so their camp was operated for a short period to accomplish environmental monitoring. At each location replicate samples of the aquatic community were collected, including benthic macroinvertebrates (BMI), periphyton, and fish (Table 1). A subset of fish were retained for whole body element analysis.

Beginning in 2021, BMI were collected with Hess samplers rather than drift nets to identify and quantify the in-situ community. This change was made because the benthic community is a more accurate characterization of the conditions at each sample site, rather than the conditions upstream. This provides a more accurate baseline for evaluating changes at each sampling location.

Hobo TidbiT v2 water temperature data loggers were deployed on July 12, 2023 at four locations to record over winter temperatures. Loggers were attached to rebar and placed in pools on Center of the Universe Creek, Upper Center of the Universe Creek, Upper Subarctic Creek, and Lower Red Rock Creek. Loggers will be retrieved in summer 2024.

Water Quality

Ambler Metals has collected water quality data from many locations throughout the Arctic-Bornite Prospect project area. The 2016 ADF&G technical report summarized all water quality data collected from 2008 to 2016 (Bradley 2017a). This report summarizes only the water data collected in 2023. Water quality sampling in 2023 was limited to a single collection event at a smaller number of sites than in past years. Only two water quality sample locations in 2023 were near aquatic biomonitoring sites, so only those results are reported here.

Periphyton

Field Methods

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. The presence of periphyton in a stream system is evidence of in-situ productivity (Ott and Morris 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 rinsed 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.

Laboratory Methods

In the lab, periphyton samples were removed from the freezer, the glass fiber filters were cut into small pieces and placed in individual 15 ml centrifuge tubes with 10 ml of 90% spectrophotometric grade acetone. The centrifuge tubes were secured in a vial rack covered with aluminum foil to reduce light exposure and stored in a dark refrigerator overnight. On the following day (18-24 hours after preparation), sample tubes were placed in a centrifuge and spun at 1,600 rpm for 20 minutes. Samples were then decanted individually into cuvettes and absorption values at 750 nm, 664 nm, 647 nm, and 630 nm were recorded on a split beam spectrophotometer. Each sample was treated with 80 µL of 0.1N hydrochloric acid for 90 seconds to convert the chlorophyll to phaeophytin and then absorbance was measured at 750 nm and 665 nm.

Trichromatic equations were used to estimate chlorophyll a, -b, and -c concentrations. Phaeophytin was calculated to determine if a chlorophyll-a conversion had occurred, and to correct chlorophyll-a concentrations for the presence of phaeophytin. Additional details regarding periphyton sampling and analysis methods can be found in ADF&G Technical Report No. 17-09 (Bradley 2017b).

BENTHIC MACROINVERTEBRATES

Field Methods

At each BMI sample site, five replicates were collected using a Hess sampler (Table 1; Figure 5). 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 with denatured ethyl alcohol to preserve the benthic macroinvertebrates.

Laboratory Methods

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. Taxa richness is reported as the number of taxonomic groups identified to the lowest practical level. Insects of the orders Ephemeroptera, Plecoptera, Trichoptera, and Diptera were identified to genus, except nonbiting midges in the Chironomidae family. All other invertebrates were identified to class or order. Terrestrial organisms were excluded from all calculations.

Figure 9.–Collecting invertebrate samples using a Hess sampler on Lower Subarctic Creek.

FISH

Five baited minnow traps were placed upstream and five downstream of baseline sampling sites after collecting the periphyton and aquatic invertebrate samples. (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. A subset of 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 in the field and then transferred to a freezer in the camp. The samples remained frozen until they were analyzed by ACZ Laboratories, Inc.

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). A smaller number of sites were sampled for water quality in 2023 due to the abbreviated field program. Results from the single sample event at Lower Ruby Creek (RCDN) and Upper Subarctic Creek (SCUP) are presented. All results are presented as total recoverable µg/L.

Total cadmium was low at both sites in 2023. Cadmium was not detected at Lower Ruby and the concentration at Upper Subarctic Creek was 0.017 µg/L (Table 2). 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 for these two samples (Appendix 1).

No selenium was detected in the water samples from Lower Ruby Creek and Upper Subarctic Creek. Both samples were therefore below the current water quality standard for aquatic life which is 20 µg/L for acute exposure and 5 µg/L for chronic exposure.

The total copper concentration was 1.40 µg/L at the Lower Ruby Creek site, and no copper was detected at the Upper Subarctic Creek site (Table 2; Appendix 1). 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 (Appendix 1).

The mercury concentration was below the detection limit for the sample from Upper Subarctic Creek and was 4.03 ng/L for the Lower Ruby Creek sample (Appendix 1). 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.

Total zinc concentrations were nearly identical at both sample sites, with 11.7 µg/L at Lower Ruby Creek and 11.4 µg/L at Upper Subarctic Creek (Table 2). These 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).

Consistent with past years, Total Dissolved Solids (TDS) concentrations were lower at the Upper Subarctic Creek sample site (46 mg/L) and higher at the Lower Ruby Creek sample site (141 mg/L) (Table 2; Appendix 1).

Table 2.–Water quality sampling results from a single collection event in July 2023.

Site	Cadmium (µg/L)	Copper (µg/L)	Mercury (ng/L)	Selenium (µg/L)	Zinc (µg/L)	TDS (mg/L)
Lower Ruby	0	1.40	4.03	0	11.70	141
Upper Subarctic	0.017	0	0	0	11.40	46

PERIPHYTON

In 2023, mean chlorophyll-a concentrations were highest in Jay Creek (2.61 mg/m^2) and lowest in Lower Red Rock Creek (0.10 mg/m^2) (Figure 5). The mean chlorophyll-a concentrations at the remaining sites ranged from 0.12 mg/m^2 to 1.74 mg/m^2. Mean chlorophyll-a concentrations in 2023 were similar or slightly lower than previous years' values (Figure 5). Typically, Upper Ruby Creek has the highest chlorophyll-a concentration of all the sample sites by a wide margin but was not sampled in 2023 due to high water and changing site conditions. These chlorophyll-a values fall in the middle of the range seen near Red Dog Mine, where there are several highly productive sites with average chlorophyll-a concentrations above 5.0 mg/m^2 and several low production sites with concentrations below 0.10 mg/m^2 (Clawson 2023). Full periphyton results can be found in Appendix 2.

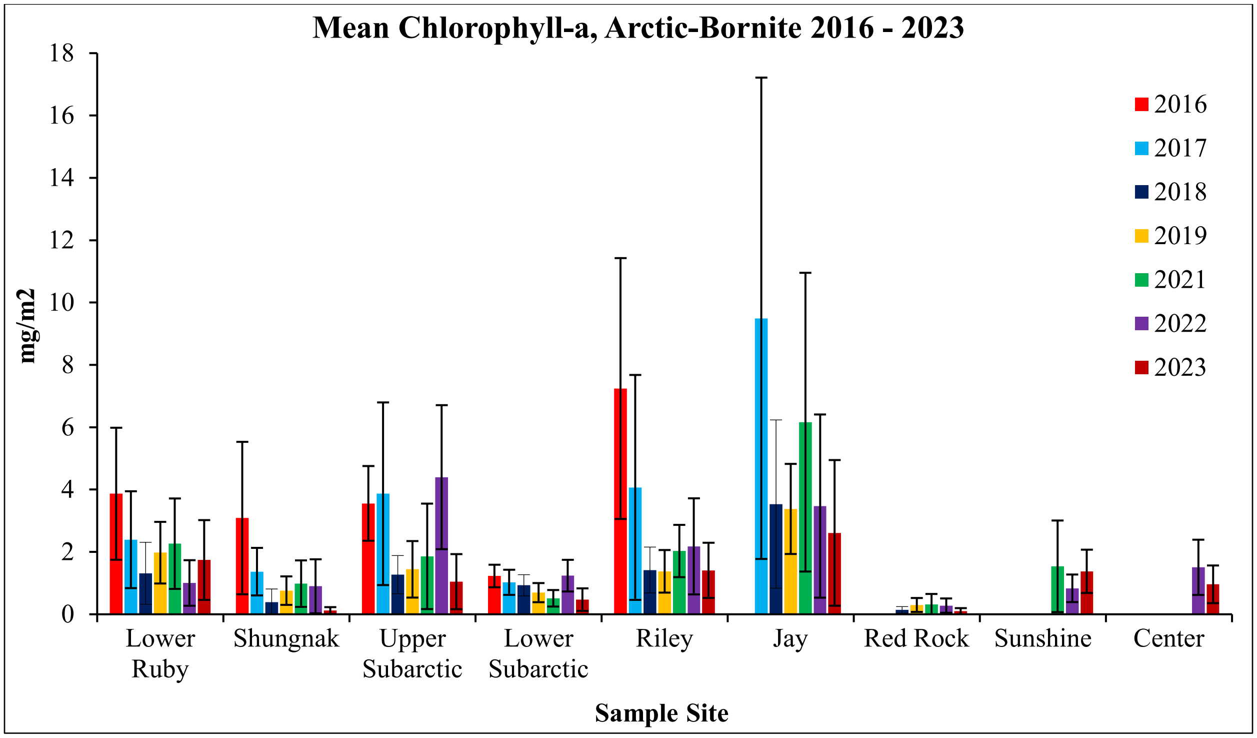

Figure 10.–Mean chlorophyll-a concentrations ± 1 SD, 2016–2023. The Jay Creek site was added in 2017, the Red Rock Creek site was added in 2018, the Sunshine Creek site was added in 2021, and the Center of the Universe Creek site was added in 2022. No sampling was performed in 2020. Upper Ruby was not sampled in 2023, so is not included in this figure.

Benthic Macroinvertebrates

Trends in BMI abundance in 2023 were similar to past years. In past years Upper Ruby Creek has had substantially higher BMI densities than the other sites but was not sampled in 2023. In 2023 Riley Creek had the highest density with 4,790 BMI/m^2 (Figure 6). Red Rock Creek had the lowest density with 95 BMI/m^2, consistent with past years (Figure 6). Ruby Creek samples are dominated by aquatic Diptera, primarily chironomids (Figure 7). The Subarctic Creek sample sites generally have a higher proportion of EPT species than the Ruby Creek sample sites, which was also the case in 2023 (Figure 8). Center of the Universe Creek also had a high proportion of EPT species in 2023 at 44% (Figure 8). In 2023, 33% of the aquatic invertebrate sample at Center of the Universe Creek was comprised of other species, primarily Oligochaetes. At Upper Subarctic Creek, 33% of the sample was also composed of species other than EPT and Diptera, but at this site those were primarily Ostrocods. Taxa richness varied from a minimum of 9 species at

Shungnak River to a maximum of 21 species at Riley and Jay creeks. The remaining sites ranged from 12–17 species. Full invertebrate results can be found in Appendix 3.

Similar to the chlorophyll-a concentrations, these BMI results fall in the middle of the ranges seen near Red Dog Mine, where there are several highly productive sites with average BMI densities above 5,000 BMI/m^2 and several lower production sites with densities below 1,000 BMI/m^2 (Clawson 2023). At the ten sites sampled near Red Dog Mine in 2023, taxa richness varied from a minimum of 2 species to a maximum of 24 species (Clawson 2024).

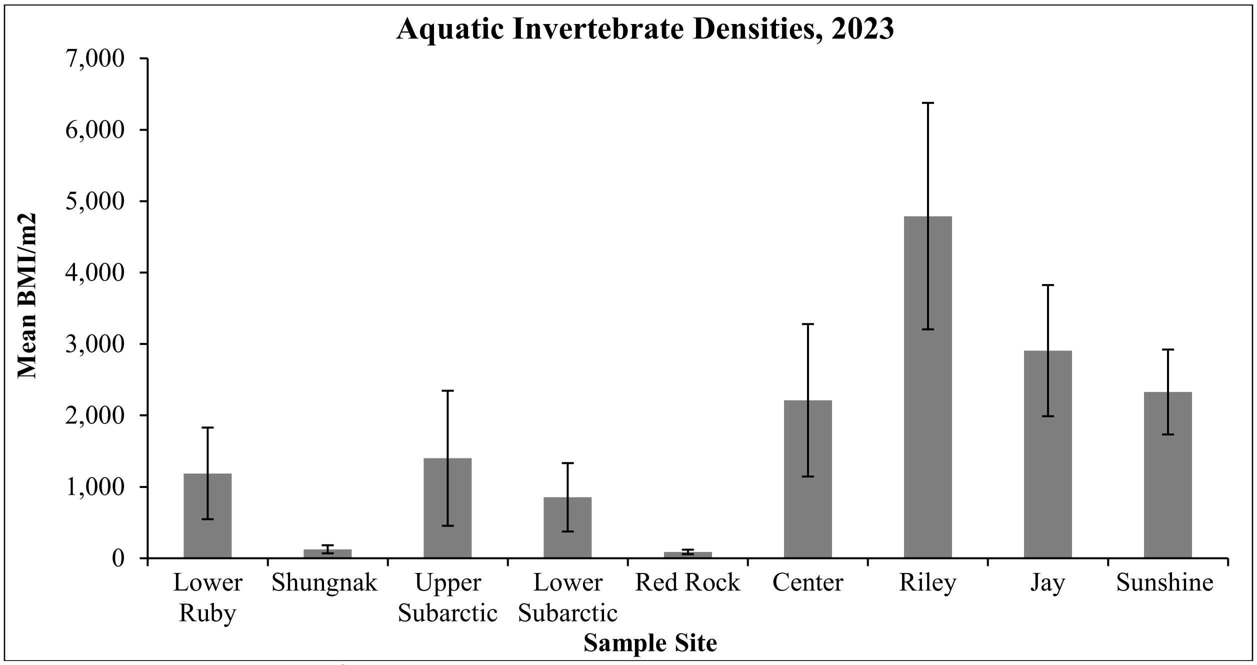

Figure 11.–Mean BMI/m^2 (± 1 SD) at each sample site, 2023.

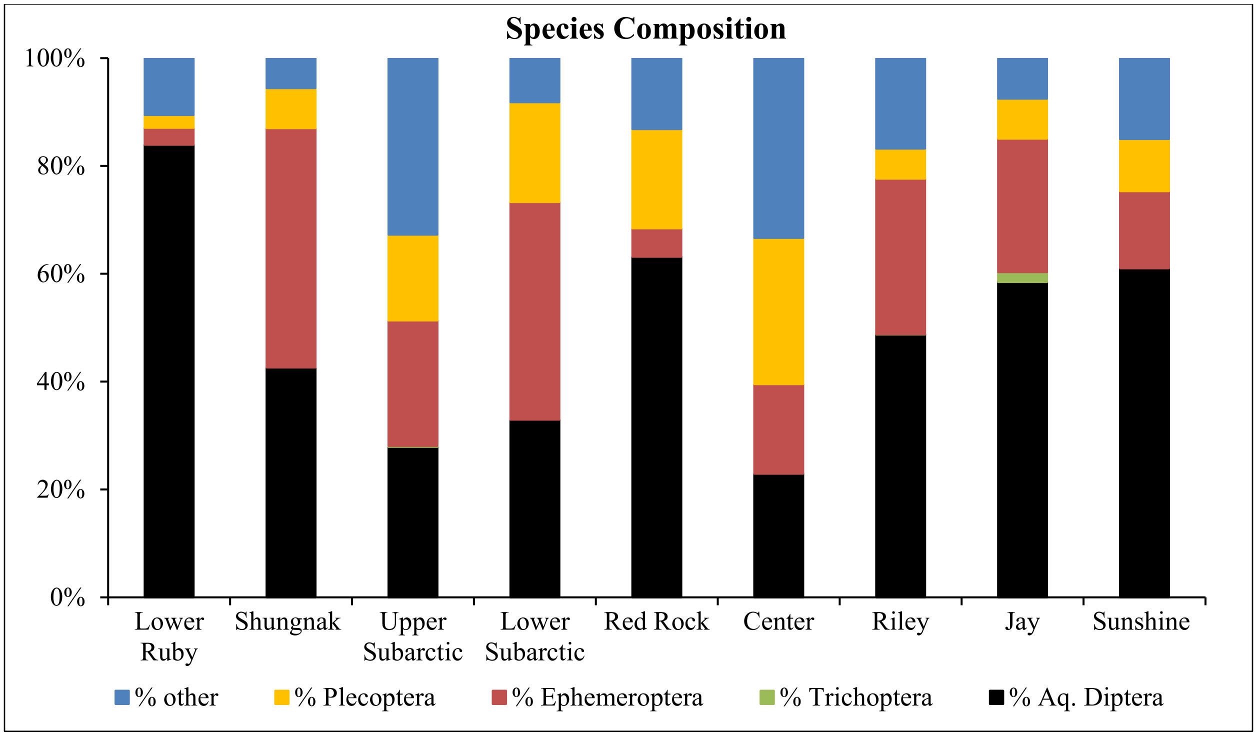

Figure 12.–Mean percent EPT, aquatic Diptera, and other species in the aquatic invertebrate samples, 2023.

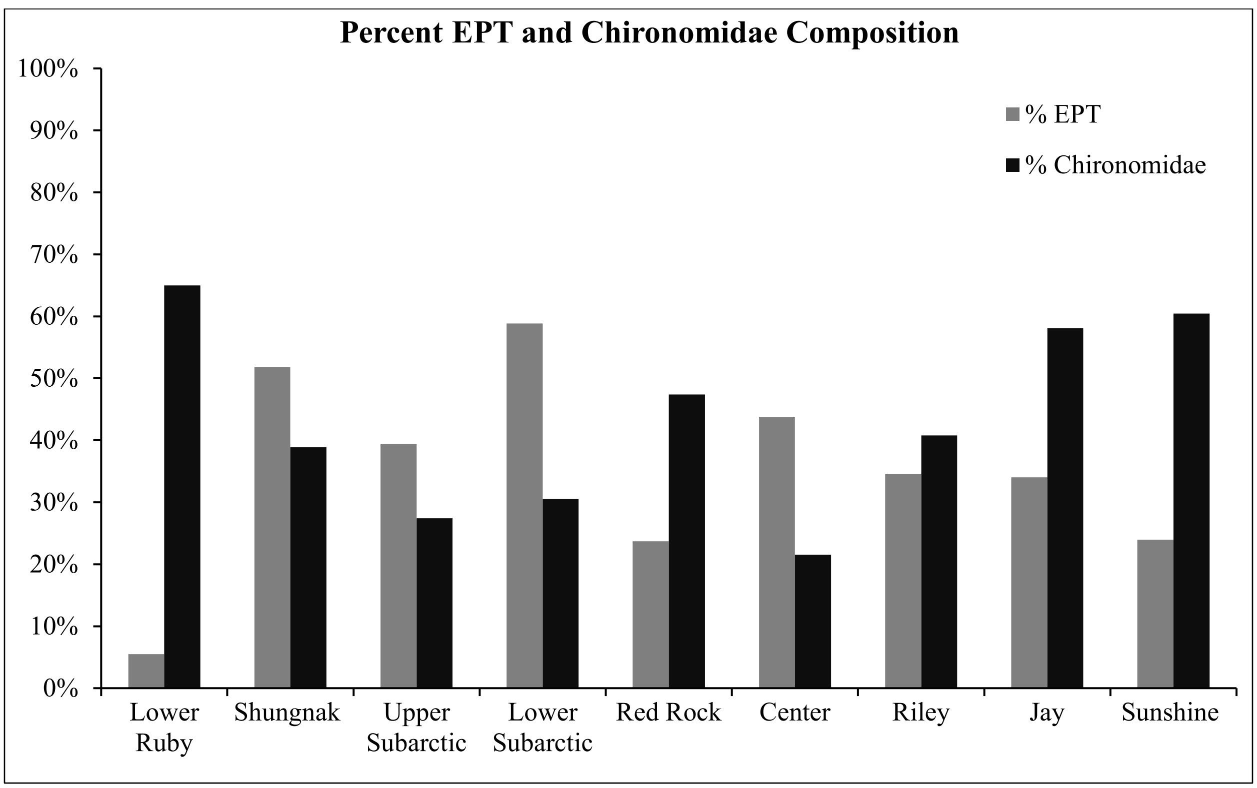

Figure 13.–Percent EPT and Chironomidae in the aquatic invertebrate samples, 2023.

FISH CAPTURES

Slimy sculpin dominated catches in Ruby Creek in 2023 (Table 3). In past years there have been two sample sites in Ruby Creek, but in 2023 site conditions changed by high water limited sampling to the Lower Ruby Creek site. Lower Ruby Creek is the only location where Alaska blackfish and longnose suckers have been captured, but they are not consistently captured every year. There are many beaver dams in this drainage which may impede passage of fish, but ponds created by beavers, if large and deep enough, may provide overwintering habitat for fish in Upper Ruby Creek.

Dolly Varden have been the only species caught at the Upper Subarctic Creek site and are typically the majority of catch at the lower site. In 2023, 20 Dolly Varden were captured in Upper Subarctic Creek, but only one was captured at the Lower Subarctic Creek site. Twenty slimy sculpin were captured at the lower site, more than have been seen in past years (Table 3). Twelve Dolly Varden from the upper site were retained for element analysis. High flow conditions may have affected catch numbers and composition as the increased water depth and velocity decreased the number of suitable locations for minnow trap placement.

A total of four slimy sculpin and two Dolly Varden were captured on Riley Creek in 2023 (Table 3). Trapping conditions were challenging due to high water. Fish catches in Riley Creek are generally a mix of slimy sculpin and Dolly Varden, although typically more slimy sculpin are caught than Dolly Varden.

Two Dolly Varden were captured on Jay Creek (Table 3). Catches in Jay Creek are generally low.

Red Rock Creek was initially sampled in 2018 to ascertain if Red Rock Creek could provide viable fish habitat in case Subarctic Creek is altered 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 2023, five slimy sculpin were captured (Table 3). Dolly Varden have been caught in all past sampling years, but high-water conditions may have affected catches in 2023.

Center of the Universe Creek was added to the July minnow trapping roster in 2021 (Clawson 2020). In 2023, one Dolly Varden was captured during the July sampling event (Table 3). Again, high water conditions likely limited minnow trapping effectiveness.

Three Dolly Varden and two slimy sculpin were captured at the Sunshine Creek site (Table 3). All fish were captured below the beaver dam.

Table 3.–Number, mean length, and length range of slimy sculpin and Dolly Varden captured in minnow traps, July 2023.

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	---	---	20	103	79-147
	Lower	20	65	54-76	1	81	81
Ruby							
	Lower*	21	61	44-79	1	72	72
Red Rock							
	Lower	5	69	60-75	0	---	---
Center of the Universe		0	---	---	1	123	123
Jay		0	---	---	2	123	93-153
Riley		4	69	59-75	2	62	60-64
Sunshine		2	67	61-72	3	105	80-132

* Three Alaska blackfish were also captured at Lower Ruby Creek, ranging 46-79 mm total length.

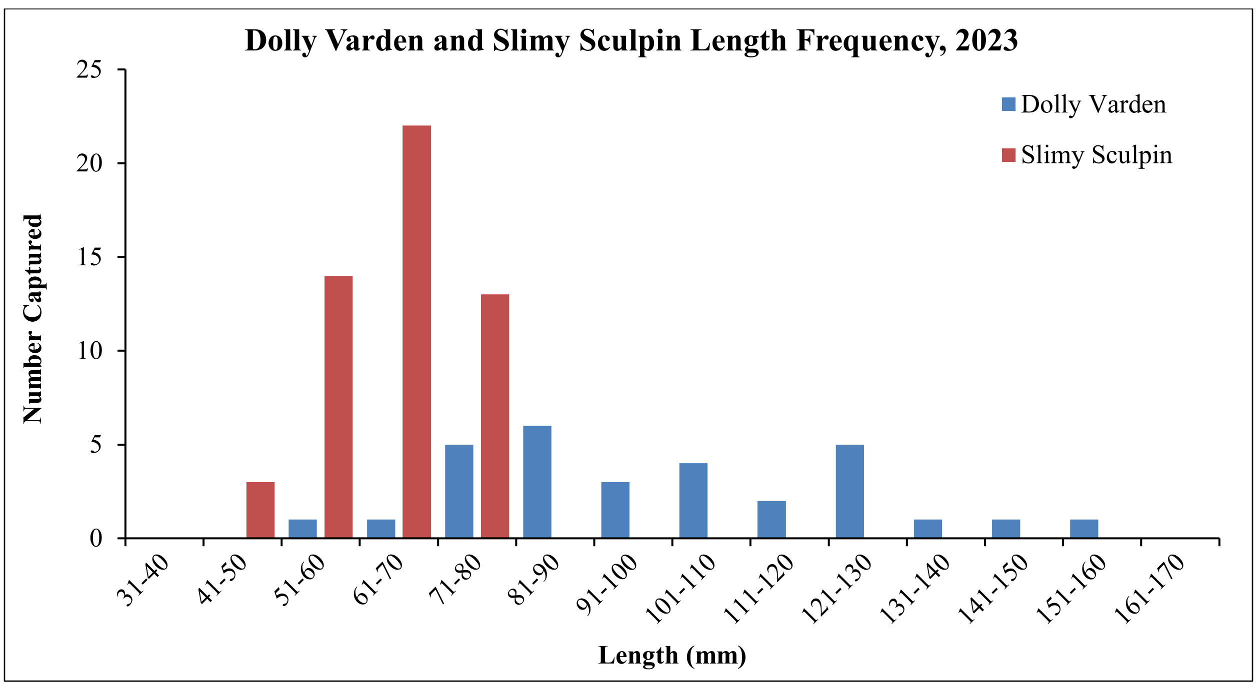

Figure 14.–Length frequency for all Dolly Varden and slimy sculpin captured in minnow traps from various drainages in the vicinity of the Arctic Bornite prospects in 2023.

FISH METALS

Fish retained for element analysis are listed in Appendix 4 and results for each fish are listed in Appendix 5. 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 2023. 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 and a subset are retained for element analysis in Subarctic Creek and Lower Red Rock Creek, but we discontinued retaining fish from Jay Creek in 2021 since we were unable to capture an adequate sample size for several consecutive years. Slimy sculpin are retained from Riley Creek, and round whitefish are reliably captured and a subset are retained in the fyke net on Ruby Creek. The fyke net on Ruby Creek was not set in 2023 due to time constraints, so slimy sculpin were retained from minnow traps in Ruby Creek for element analysis instead of round whitefish. Since high-water conditions reduced catches, fish were not retained from Riley Creek or Red Rock Creek in 2023.

In 2023, the mean cadmium concentration in Dolly Varden from Subarctic Creek was 0.89 mg/kg, and the mean cadmium concentration in slimy sculpin from Ruby Creek was 0.23 mg/kg (Figure 11). Typically, Ruby Creek fish have had the lowest cadmium concentrations since sampling began in 2016 (Figure 12). The annual median whole body cadmium concentration in Dolly Varden captured in Buddy Creek near the Red Dog Mine has ranged from 0.27 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.

Mean copper concentration in 2023 was higher in Subarctic Creek Dolly Varden at 6.47 mg/kg (Figure 11). Concentrations were lower in Ruby Creek slimy sculpin, with a mean concentration of 4.71 mg/kg. These mean copper concentrations are slightly higher than the previous two years, but with overlapping standard deviations (Figure 13). These copper concentrations in Dolly Varden at Arctic-Bornite are similar or slightly higher than other locations from across the state (Legere and Timothy 2016). For example, the annual median whole body copper concentration in

Dolly Varden captured in Buddy Creek near Red Dog Mine was 3.2 mg/kg in 2014 and 3.9 mg/kg in 2015 (Ott et al. 2016).

Mean mercury concentration in 2023 was 0.10 mg/kg in Subarctic Creek Dolly Varden, and 0.15 mg/kg in Ruby Creek slimy sculpin (Figure 11). In past sample years, mean mercury concentration was typically highest in fish from Riley Creek (Figure 14). When compared to mercury concentrations from fish in the vicinity of Red Dog mine, mercury concentrations in fish from the Arctic-Bornite creeks are generally higher. For example, median mercury concentrations in Dolly Varden from Buddy Creek (Red Dog Mine) have ranged from 0.02 to 0.06 mg/kg (Clawson and Ott 2021).

The mean selenium concentrations in slimy sculpin from Ruby Creek and Dolly Varden from Subarctic Creek were very similar in 2023, 5.93 mg/kg and 5.34 mg/kg, respectively (Figure 11). Mercury values were consistent with past years (Figure 15). 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 (Red Dog Mine) have ranged from 3.8 to 9.1 mg/kg (Clawson and Ott 2021).

In 2023, mean zinc concentration was higher in Dolly Varden from Subarctic Creek (212.61 mg/kg) and lower in slimy sculpin from Ruby Creek (153.25 mg/kg) (Figure 11). Zinc concentrations have consistently been lowest in fish from Ruby Creek since collection began (Figure 16). These zinc concentrations are slightly higher than those found in juvenile Dolly Varden from Buddy Creek near Red Dog Mine (116–227 mg/kg) but are within the range of concentrations found in Dolly Varden in other regions of the state (Legere and Timothy 2016).

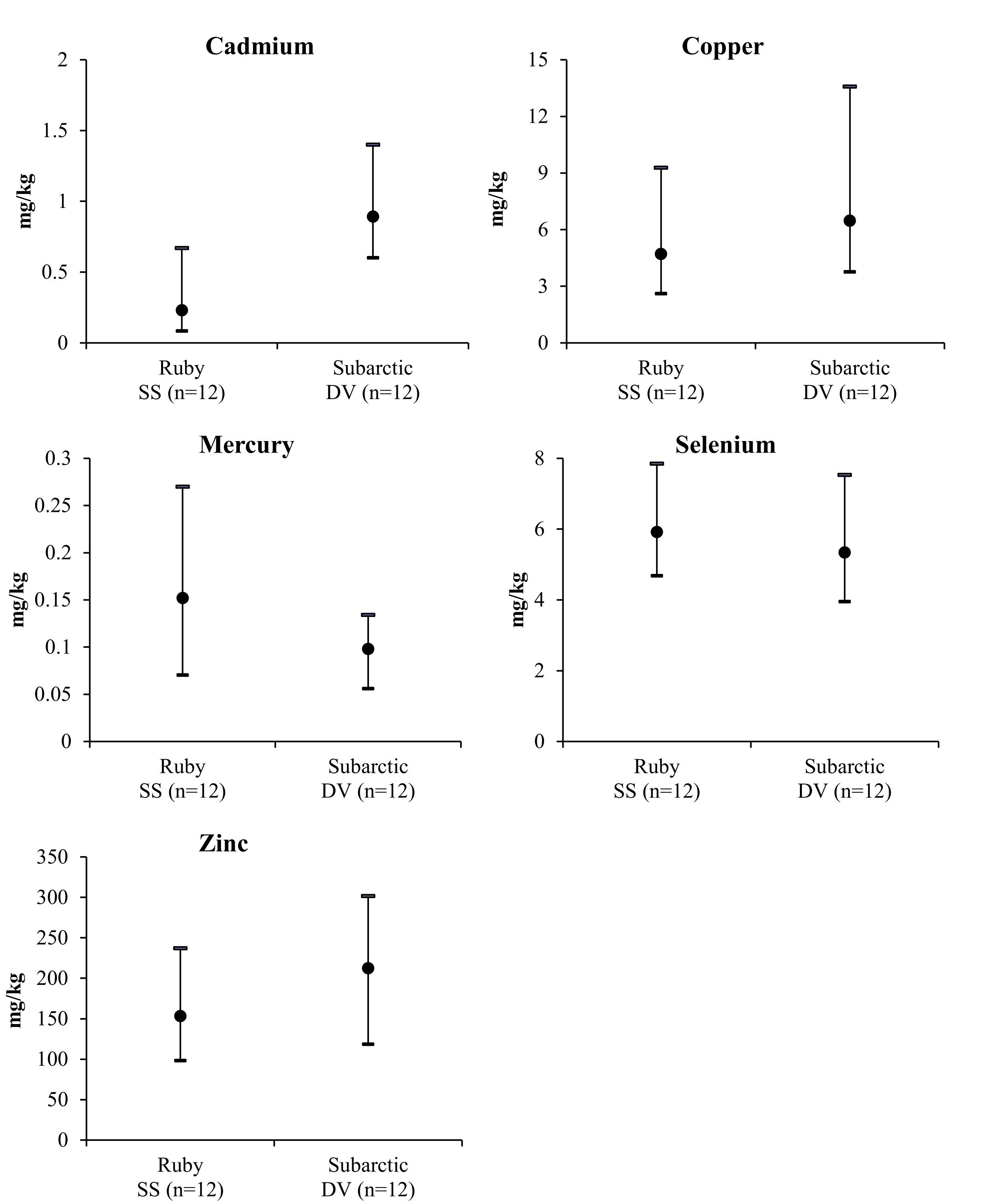

Figure 15.–Minimum, mean, and maximum whole body dry weight concentrations of various elements in Dolly Varden from various drainages in the vicinity of the Arctic Bornite prospects, 2023.

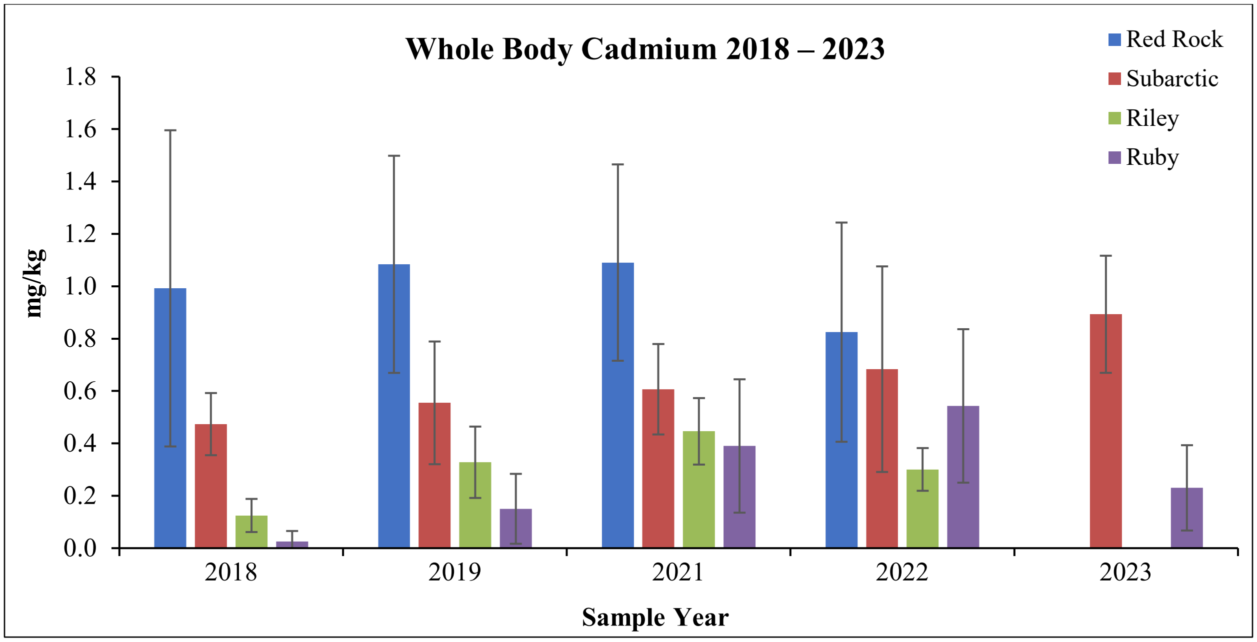

Figure 16.–Mean (± 1 SD) whole body cadmium concentrations in Dolly Varden from Subarctic and Red Rock creeks, slimy sculpin from Riley Creek, slimy sculpin from Ruby Creek (2018 and 2023), and round whitefish from Ruby Creek (2019–2022).

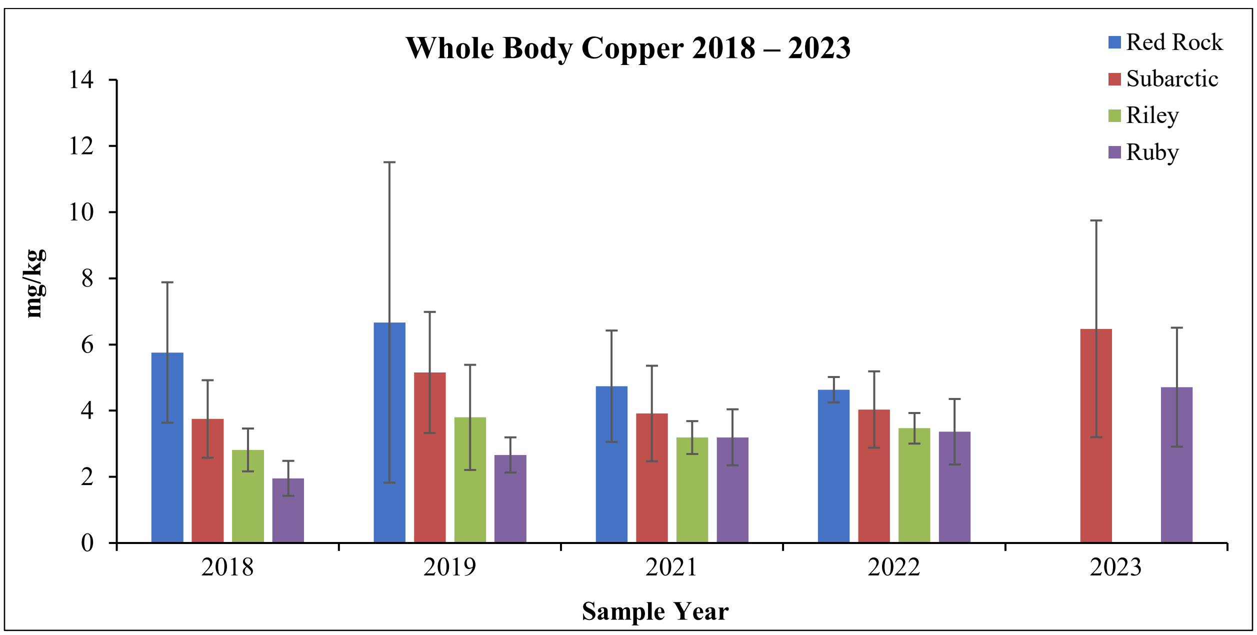

Figure 17.–Mean (± 1 SD) whole body copper concentrations in Dolly Varden from Subarctic and Red Rock Creek, slimy sculpin from Riley Creek, slimy sculpin from Ruby Creek (2018 and 2023), and round whitefish from Ruby Creek (2019–2022).

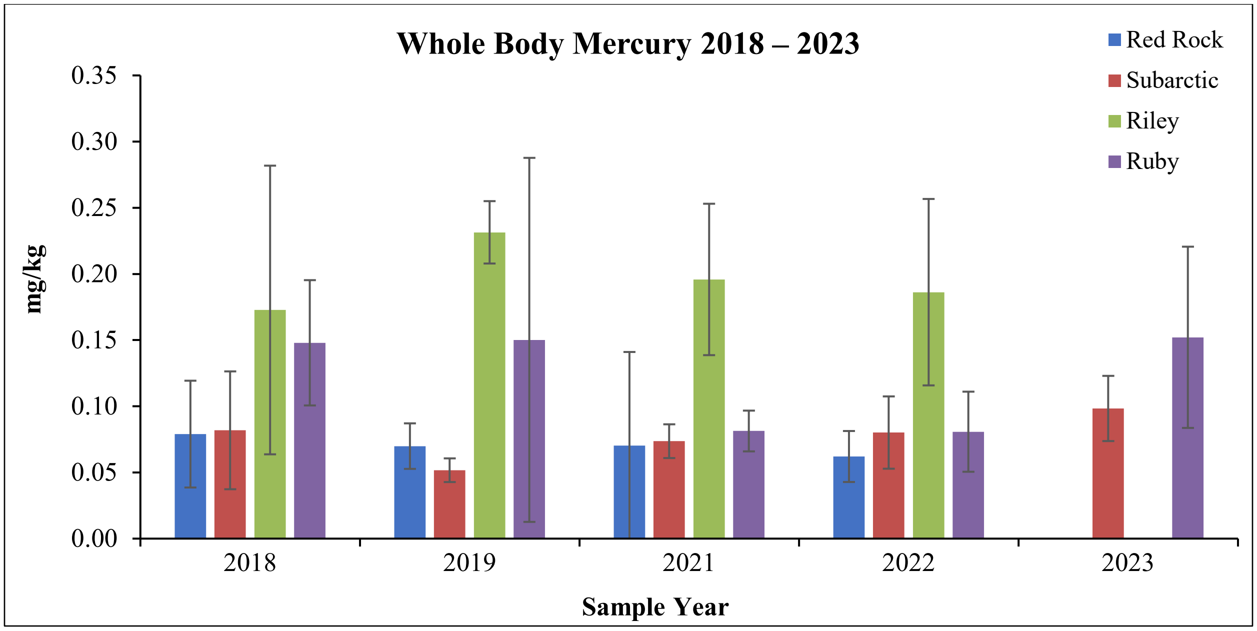

Figure 18.–Mean (± 1 SD) whole body mercury concentrations in Dolly Varden from Subarctic and Red Rock Creek, slimy sculpin from Riley Creek, slimy sculpin from Ruby Creek (2018 and 2023), and round whitefish from Ruby Creek (2019–2022).

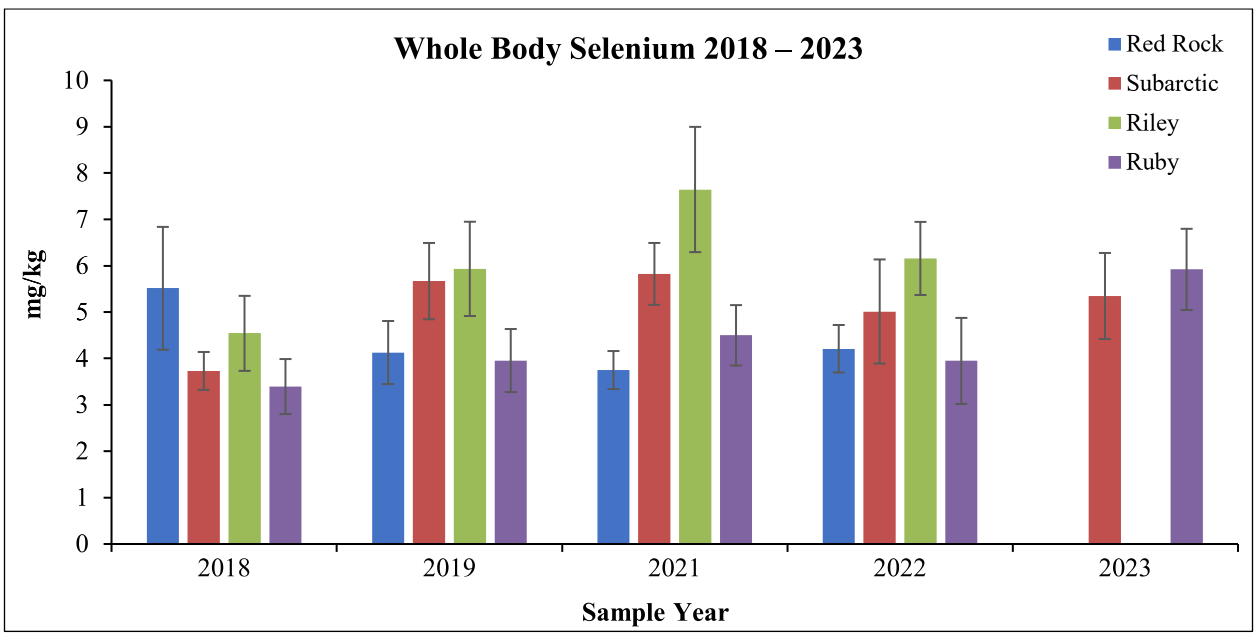

Figure 19.–Mean (± 1 SD) whole body selenium concentrations in Dolly Varden from Subarctic and Red Rock Creek, slimy sculpin from Riley Creek, slimy sculpin from Ruby Creek (2018 and 2023), and round whitefish from Ruby Creek (2019–2022).

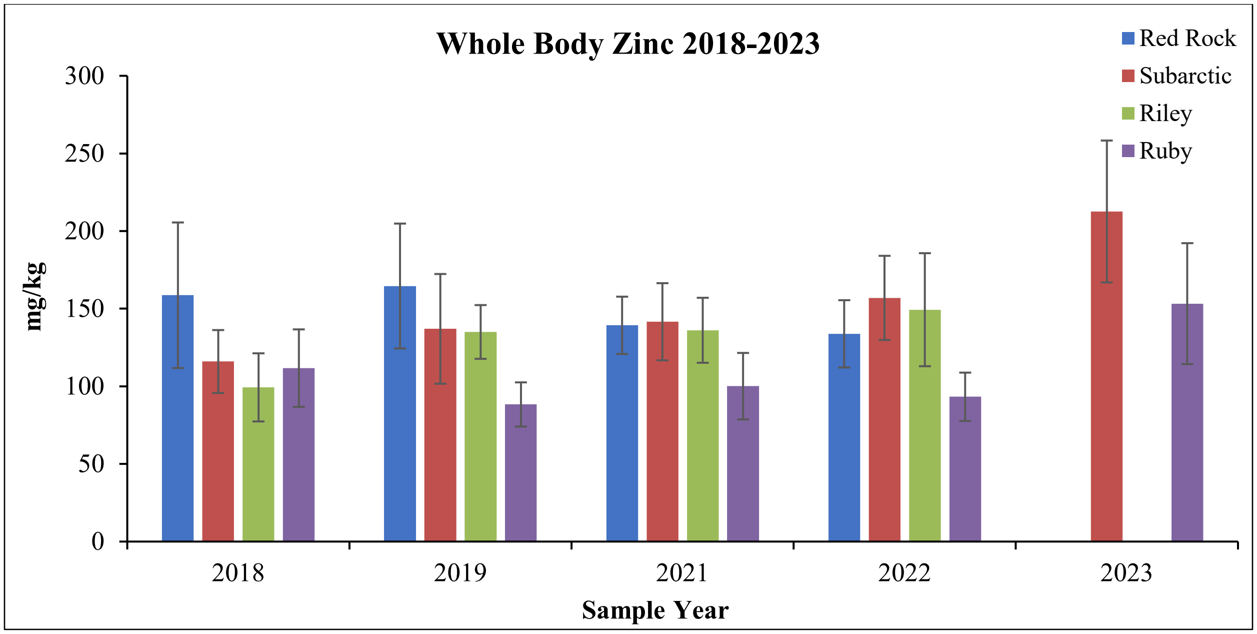

Figure 20.–Mean (± 1 SD) whole body zinc concentrations in Dolly Varden from Subarctic and Red Rock Creek, slimy sculpin from Riley Creek, slimy sculpin from Ruby Creek (2018 and 2023), and round whitefish from Ruby Creek (2019–2022).

CONCLUSION

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

Dolly Varden are the only fish species observed in the upper section of Subarctic Creek, while slimy sculpin and Dolly Varden inhabit the lower section of the creek. Arctic grayling have also been caught near the mouth of Subarctic Creek. While Dolly Varden typically dominate catches at both sample sites, in 2023 almost all the fish that were caught at the lower site were slimy sculpin. This could be due to the high-water conditions that made it difficult to access and trap all areas of the creek. Dolly Varden spawning is known to occur in the upper section of the creek since both male and female ripe fish have been captured there in late fall. Overwintering was confirmed at the Upper and Middle Subarctic Creek sample sites after fish were captured in March 2021 and April 2022 and it is likely that overwintering occurs throughout the drainage (Clawson 2022 and Clawson 2023b).

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). Based on the sizes of ripe fish captured in Subarctic Creek, it appears that males mature earlier than females, consistent with these studies. The oldest Dolly Varden aged was seven from Subarctic Creek. Dolly Varden in other resident populations have attained age 10, but few fish survive beyond age 5 (Armstrong and Morrow 1980).

Similar to Subarctic Creek, Dolly Varden typically dominate catches at all sample sites in the Red Rock Creek drainage, but in 2023 all the fish that were caught at the lower site were slimy sculpin. This could be due to the high-water conditions that made it difficult to access and trap all areas of the creek. Generally, catches are higher in Center of the Universe Creek (an upper tributary of Red Rock Creek) than at Lower Red Rock Creek, although this was not the case in 2023. Again, these differences were likely due to high-water conditions. Spawning is known to occur in Red Rock Creek and Center of the Universe Creek as a very small young of the year fish was captured in Red Rock Creek in July 2018 and ripe males and females have been captured in both creeks during fall sampling (Clawson 2019). Red Rock and Center of the Universe creeks provide similar habitat to the upper extent of Subarctic Creek that may be affected by future mining activities. Genetic work conducted in 2018 showed that the spawning populations in Red Rock and Subarctic creeks are genetically distinct, indicating that the greater Shungnak River drainage supports more than one spawning population of Dolly Varden. It is likely that each tributary of the Shungnak River has its own spawning population, as this type of population structure in resident salmonids is not uncommon, even at small spatial scales with no physical barriers to gene flow (Koizumi et al. 2006).

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. Fall aerial surveys conducted in 2019 and 2022 did not document any anadromous fish upstream on the rapids (Clawson 2020 and Clawson 2023b). 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 may act as sneaker males and spawn with anadromous females (Armstrong and Morrow 1980). If the Riley Creek area remains in consideration for mine facility development, 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 and Red Rock creeks showing reproductive isolation and less genetic variation than anadromous Dolly Varden from the Kobuk River, genetics from Riley Creek could provide insight into potential anadromy.

If future aquatic sampling is planned, we recommend continuation of periphyton and benthic macroinvertebrate 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 continuing fall aerial surveys in the Kogoluktuk River drainage.

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APPENDIX 1. WATER QUALITY DATA FROM LOCATIONS NEAR THE ARCTIC-BORNITE PROSPECT, 2017–2023.

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 samples highlighted in yellow were the only samples that exceeded the more stringent chronic aquatic life exposure limit.

2023

Site Location	Collection Date	Total Cadmium (ug/L)	Cadmium Acute Limit (ug/L)	Cadmium Chronic Limit (ug/L)	Total Copper (ug/L)	Copper Acute Limit (ug/L)	Copper Chronic Limit (ug/L)	Mercury (ng/L)	Total Selenium (ug/L)	TDS (mg/L)	Total Zinc (ug/L)	Zinc Acute Limit (ug/L)	Zinc Chronic Limit (ug/L)	Hardness CaCO3 (mg/L)
Lower Ruby	7/11/2023	0.000	2.482	0.286	1.400	16.459	10.763	4.030	0.000	141	11.700	140.608	141.759	124
Upper Subarctic	7/11/2023	0.017	0.920	0.140	0.000	6.293	4.501	0.000	0.000	46	11.400	59.233	59.717	45

2022

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	4/18/2022	0.000	3.834	0.390	0.34	25.092	15.777	0.000	0.000	228	0.000	205.452	207.132	194
Ruby	8/14/2022	0.000	2.773	0.309	0.00	18.328	11.866	0.000	0.000	182	10.700	154.893	156.160	139
Lower	8/19/2022	0.000	2.443	0.282	1.410	16.208	10.614	0.000	0.000	147	4.350	138.684	139.819	122
Ruby	10/18/2022	0.000	3.025	0.329	1.360	19.939	12.808	2.350	0.332	152	4.180	167.083	168.449	152
Shungnak	4/18/2022	0.221	1.967	0.242	1.650	13.135	8.772	0.000	0.544	129	35.300	114.793	115.732	98
	8/13/2022	0.413	1.943	0.240	2.170	12.983	8.680	0.000	0.447	128	32.700	113.596	114.525	96
Upper	4/22/2022	0.063	1.074	0.157	0.766	7.310	5.155	0.000	0.000	93	4.750	67.771	68.325	52
Subarctic	8/12/2022	0.015	1.016	0.151	0.000	6.928	4.911	0.000	0.000	56	10.500	64.579	65.108	50
Lower	4/19/2022	0.052	1.136	0.163	0.286	7.717	5.415	0.000	0.713	60.000	5.750	71.153	71.735	56
Subarctic	8/12/2022	0.104	0.978	0.147	0.699	6.677	4.749	0.000	0.380	66.000	21.000	62.473	62.984	48
Riley	4/18/2022	0.000	3.237	0.345	0.345	21.296	13.596	0.000	0.000	190	0.000	177.273	178.723	163

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	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
Ruby	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	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
Ruby	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	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
Subarctic	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	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
Subarctic	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	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
Riley	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	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
Ruby	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	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
Ruby	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	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
Shungnak	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	3/25/2018	*0.015			0.250	7.700	5.420	*0.500	1.000	72	3.10	69.970	53
Subarctic	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	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
Subarctic	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	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
Riley	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. CHLOROPHYLL DATA FROM LOCATIONS NEAR THE ARCTIC-BORNITE PROSPECT, 2023

IDL = 0.09 mg/m^2					Linear Check Maximum = 65.03 mg/m^2				
EDL = 0.39 mg/m^2						**Phaeo Corrected**			
Daily Vial #	Site/Volume (liters)	Site	Date Analyzed	Vial chl a	Chl a mg/m2	**Chl a mg/m2**	**664/665 ratio**	Chl b mg/m	Chl c mg/m
2	Arctic Bornite	Lower Ruby	12/15/2023	0.00	0.00	0.64	1.60	0.00	0.07
4	Arctic Bornite	Lower Ruby	12/15/2023	0.02	0.09	1.17	1.61	0.00	0.08
6	Arctic Bornite	Lower Ruby	12/15/2023	0.08	0.31	0.32	1.60	0.06	0.05
8	Arctic Bornite	Lower Ruby	12/15/2023	0.02	0.09	3.10	1.67	0.14	0.22
10	Arctic Bornite	Lower Ruby	12/15/2023	0.01	0.04	1.07	1.67	0.06	0.28
12	Arctic Bornite	Lower Ruby	12/15/2023	0.02	0.09	1.50	1.61	0.00	0.14
14	Arctic Bornite	Lower Ruby	12/15/2023	0.01	0.04	0.64	1.75	0.07	0.15
16	Arctic Bornite	Lower Ruby	12/15/2023	0.03	0.14	4.17	1.66	0.00	0.55
18	Arctic Bornite	Lower Ruby	12/15/2023	0.01	0.05	3.52	1.66	0.00	0.32
20	Arctic Bornite	Lower Ruby	12/15/2023	0.08	0.31	1.28	1.80	0.10	0.23
89	Arctic Bornite	Riley	12/15/2023	0.05	0.22	0.96	1.75	0.08	0.14
91	Arctic Bornite	Riley	12/15/2023	0.24	0.96	1.17	1.61	0.05	0.22
93	Arctic Bornite	Riley	12/15/2023	0.71	2.82	1.07	1.71	0.01	0.12
95	Arctic Bornite	Riley	12/15/2023	0.24	0.95	1.60	1.71	0.00	0.14
97	Arctic Bornite	Riley	12/15/2023	0.17	0.69	1.17	1.69	0.00	0.10
99	Arctic Bornite	Riley	12/15/2023	0.17	0.69	1.17	1.73	0.04	0.17
101	Arctic Bornite	Riley	12/15/2023	0.09	0.36	1.28	1.60	0.00	0.13
103	Arctic Bornite	Riley	12/15/2023	0.79	3.18	1.17	1.65	0.01	0.06
105	Arctic Bornite	Riley	12/15/2023	0.07	0.27	3.95	1.71	0.00	0.34
107	Arctic Bornite	Riley	12/15/2023	0.31	1.23	0.53	1.71	0.00	0.12
2	Arctic Bornite	Upper Shungnak	12/15/2023	0.00	0.00	0.00		0.00	0.00
3	Arctic Bornite	Upper Shungnak	12/15/2023	0.02	0.09	0.11	2.00	0.03	0.05
5	Arctic Bornite	Upper Shungnak	12/15/2023	0.08	0.31	0.32	1.75	0.08	0.06
7	Arctic Bornite	Upper Shungnak	12/15/2023	0.02	0.09	0.11	2.00	0.03	0.05
9	Arctic Bornite	Upper Shungnak	12/15/2023	0.01	0.04	0.00	1.00	0.05	0.06
11	Arctic Bornite	Upper Shungnak	12/15/2023	0.02	0.09	0.11	2.00	0.00	0.00
13	Arctic Bornite	Upper Shungnak	12/15/2023	0.01	0.04	0.00	1.00	0.04	0.16
15	Arctic Bornite	Upper Shungnak	12/15/2023	0.03	0.14	0.11	1.50	0.02	0.00
17	Arctic Bornite	Upper Shungnak	12/15/2023	0.01	0.05	0.11		0.00	0.00
18	Arctic Bornite	Upper Shungnak	12/15/2023	0.08	0.31	0.32	1.75	0.07	0.16
20	Arctic Bornite	Upper Subarctic	12/15/2023	0.05	0.22	0.32	2.50	0.10	0.27
22	Arctic Bornite	Upper Subarctic	12/15/2023	0.24	0.96	0.85	1.62	0.01	0.07
24	Arctic Bornite	Upper Subarctic	12/15/2023	0.71	2.82	2.67	1.68	0.02	0.41
26	Arctic Bornite	Upper Subarctic	12/15/2023	0.24	0.95	0.85	1.62	0.08	0.14
28	Arctic Bornite	Upper Subarctic	12/15/2023	0.17	0.69	0.64	1.67	0.00	0.07
30	Arctic Bornite	Upper Subarctic	12/15/2023	0.17	0.69	0.64	1.67	0.00	0.07
32	Arctic Bornite	Upper Subarctic	12/15/2023	0.09	0.36	0.32	1.60	0.06	0.05
34	Arctic Bornite	Upper Subarctic	12/15/2023	0.79	3.18	2.78	1.59	0.12	0.83
36	Arctic Bornite	Upper Subarctic	12/15/2023	0.07	0.27	0.21	1.50	0.10	0.06
38	Arctic Bornite	Upper Subarctic	12/15/2023	0.31	1.23	1.17	1.69	0.03	0.07

IDL = 0.09 mg/m^2					Linear Check Maximum = 65.03 mg/m^2				
EDL = 0.39 mg/m^2						**Phaeo Corrected**			
Daily Vial #	Site/Volume (liters)	Site	Date Analyzed	Vial chl a	Chl a mg/m2	**Chl a mg/m2**	**664/665 ratio**	Chl b mg/m	Chl c mg/m
40	Arctic Bornite	Jay	12/15/2023	0.92	3.67	2.78	1.47	0.22	0.63
42	Arctic Bornite	Jay	12/15/2023	0.43	1.74	1.60	1.65	0.00	0.13
44	Arctic Bornite	Jay	12/15/2023	0.40	1.60	1.50	1.67	0.01	0.15
46	Arctic Bornite	Jay	12/15/2023	0.29	1.15	1.07	1.67	0.00	0.04
48	Arctic Bornite	Jay	12/15/2023	0.42	1.68	1.50	1.61	0.05	0.11
50	Arctic Bornite	Jay	12/15/2023	0.83	3.33	3.10	1.66	0.00	0.38
52	Arctic Bornite	Jay	12/15/2023	2.48	9.94	8.97	1.63	0.00	0.31
54	Arctic Bornite	Jay	12/19/2023	0.46	1.83	1.60	1.60	0.00	0.18
57	Arctic Bornite	Jay	12/19/2023	0.37	1.47	1.39	1.68	0.00	0.13
59	Arctic Bornite	Center of the Univers	12/19/2023	0.28	1.13	0.85	1.47	0.06	0.28
61	Arctic Bornite	Center of the Univers	12/19/2023	0.07	0.27	0.32	2.00	0.02	0.10
63	Arctic Bornite	Center of the Univers	12/19/2023	0.15	0.59	0.43	1.44	0.02	0.09
65	Arctic Bornite	Center of the Univers	12/19/2023	0.24	0.96	1.07	1.91	0.00	0.17
67	Arctic Bornite	Center of the Univers	12/19/2023	0.15	0.59	0.53	1.63	0.02	0.09
69	Arctic Bornite	Center of the Univers	12/19/2023	0.27	1.09	0.96	1.60	0.00	0.22
71	Arctic Bornite	Center of the Univers	12/19/2023	0.60	2.40	2.14	1.61	0.15	0.31
73	Arctic Bornite	Center of the Univers	12/19/2023	0.15	0.59	0.53	1.63	0.02	0.09
75	Arctic Bornite	Center of the Univers	12/19/2023	0.55	2.19	2.03	1.66	0.00	0.26
77	Arctic Bornite	Center of the Univers	12/19/2023	0.19	0.77	0.75	1.70	0.02	0.03
79	Arctic Bornite	Sunshine	12/19/2023	0.42	1.68	1.50	1.61	0.04	0.20
81	Arctic Bornite	Sunshine	12/19/2023	0.78	3.11	2.78	1.60	0.46	0.15
83	Arctic Bornite	Sunshine	12/19/2023	0.60	2.41	2.24	1.66	0.08	0.24
85	Arctic Bornite	Sunshine	12/19/2023	0.21	0.82	0.85	1.80	0.00	0.12
87	Arctic Bornite	Sunshine	12/19/2023	0.39	1.58	1.39	1.59	0.25	0.16
89	Arctic Bornite	Sunshine	12/19/2023	0.34	1.36	1.28	1.67	0.03	0.21
91	Arctic Bornite	Sunshine	12/19/2023	0.33	1.31	1.07	1.53	0.15	0.09
93	Arctic Bornite	Sunshine	12/19/2023	0.50	1.98	1.71	1.57	0.29	0.10
95	Arctic Bornite	Sunshine	12/19/2023	0.11	0.45	0.43	1.67	0.00	0.14
97	Arctic Bornite	Sunshine	12/19/2023	0.15	0.59	0.53	1.63	0.02	0.09
2	Arctic-Bornite	Lower Red Rock	12/19/2023	0.01	0.05	0.11		0.00	0.09
3	Arctic-Bornite	Lower Red Rock	12/19/2023	0.01	0.04	0.11		0.05	0.06
4	Arctic-Bornite	Lower Red Rock	12/19/2023	0.01	0.04	0.11		0.05	0.06
5	Arctic-Bornite	Lower Red Rock	12/19/2023	0.00	0.00	0.00		0.00	0.00
6	Arctic-Bornite	Lower Red Rock	12/19/2023	0.02	0.09	0.00	0.67	0.03	0.05
8	Arctic-Bornite	Lower Red Rock	12/19/2023	0.08	0.31	0.32	1.75	0.08	0.06
10	Arctic-Bornite	Lower Red Rock	12/19/2023	0.00	0.00	0.00		0.00	0.00
11	Arctic-Bornite	Lower Red Rock	12/19/2023	0.00	0.00	0.00		0.00	0.00
12	Arctic-Bornite	Lower Red Rock	12/19/2023	0.01	0.05	0.11		0.00	0.00
13	Arctic-Bornite	Lower Red Rock	12/19/2023	0.03	0.14	0.21	3.00	0.01	0.05
15	Arctic-Bornite	Lower Subarctic	12/19/2023	0.27	1.09	0.96	1.60	0.00	0.22
17	Arctic-Bornite	Lower Subarctic	12/19/2023	0.23	0.91	0.85	1.67	0.03	0.08
19	Arctic-Bornite	Lower Subarctic	12/19/2023	0.13	0.54	0.53	1.71	0.12	0.16
21	Arctic-Bornite	Lower Subarctic	12/19/2023	0.15	0.59	0.53	1.63	0.02	0.09
23	Arctic-Bornite	Lower Subarctic	12/19/2023	0.03	0.14	0.11	1.50	0.01	0.05
25	Arctic-Bornite	Lower Subarctic	12/19/2023	0.01	0.04	0.11		0.05	0.06
26	Arctic-Bornite	Lower Subarctic	12/19/2023	0.02	0.09	0.11	2.00	0.03	0.05
28	Arctic-Bornite	Lower Subarctic	12/19/2023	0.02	0.09	0.11	2.00	0.03	0.05
30	Arctic-Bornite	Lower Subarctic	12/19/2023	0.09	0.36	0.32	1.60	0.06	0.05
32	Arctic-Bornite	Lower Subarctic	12/19/2023	0.29	1.17	1.07	1.63	0.21	0.11

APPENDIX 3. BENTHIC MACROINVERTEBRATE DATA FROM LOCATIONS NEAR THE ARCTIC-BORNITE PROSPECT 2023

	Lower Ruby	Shungnak	Upper Subarctic	Lower Subarctic	Red Rock	Center	Riley	Jay	Sunshine
Total aquatic invert taxa/site	13	9	14	16	12	12	21	21	17
Total Ephemeroptera (corrected for subsampling)	16	24	140	148	2	158	593	309	143
Total Plecoptera (corrected for subsampling)	12	4	96	68	7	258	116	93	97
Total Trichoptera (corrected for subsampling)	0	0	1	0	0	0	2	23	0
Total Aquatic Diptera (corrected for subsampling)	429	23	168	121	24	218	1003	731	611
Misc. Aquatic species (corrected for subsampling)	54	3	197	30	5	317	345	94	150
% other	11%	6%	33%	8%	13%	33%	17%	8%	15%
% Ephemeroptera	3%	44%	23%	40%	5%	17%	29%	25%	14%
% Plecoptera	2%	7%	16%	19%	18%	27%	6%	7%	10%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	2%	0%
% Aq. Diptera	84%	43%	28%	33%	63%	23%	49%	58%	61%
Total Chironomidae (corrected for subsampling)	332	21	165	112	18	205	840	726	605
% EPT	5%	52%	39%	59%	24%	44%	35%	34%	24%
% Chironomidae	65%	39%	27%	31%	47%	22%	41%	58%	60%
Dominant taxon (corrected for subsampling)	310	21	265	109	18	389	765	704	585
% Dominant Taxon	61%	39%	44%	30%	47%	41%	37%	56%	58%
Total Area Sampled (m2)	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.43
Estimated total inverts/m2 substrate	1198	128	1402	865	95	2219	4856	2926	2344
Estimated aquatic inverts/m2 substrate	1188	126	1400	853	88	2212	4791	2907	2328
Average inverts/m2 substrate	1198	128	1402	865	95	2219	4856	2926	2344
Average aq. inverts/m2 substrate	1188	126	1400	853	88	2212	4791	2907	2328
StDev of Aq. Invert Density	641	57	945	479	31	1067	1585	918	594
Total aquatic invertebrates (corrected for subsampling)	511	54	602	367	38	951	2060	1250	1001
Total terrestrial invertebrates (corrected for subsampling)	4	1	1	5	3	3	28	8	7
Total invertebrates (corrected for subsampling)	515	55	603	372	41	954	2088	1258	1008
% Sample aquatic	99%	98%	100%	99%	93%	100%	99%	99%	99%
% Sample terrestrial	1%	2%	0%	1%	7%	0%	1%	1%	1%
Average # aquatic inverts/replicate	102	11	120	73	8	190	412	250	200
StDev of aquatic inverts/replicate	55	5	81	41	3	92	136	79	51
Average # terr inverts/replicate	1	0	0	1	1	1	6	2	1
Average # inverts/replicate	103	11	121	74	8	191	418	252	202
StDev of inverts/replicate	54	5	81	43	3	92	135	77	52
Total larval fish/site	0	0	0	0	0	0	0	0	0

APPENDIX 4. FISH RETAINED FOR ELEMENT ANALYSIS FROM RUBY AND SUBARCTIC CREEKS, 2023.

Sample ID	Stream	Site	Date Collected	Fish Spp[1]	Length (mm)	Weight (g)	Metals to be analyzed				
							Cu	Hg	Se	Cd	Zn
071323LRUBSS01	Ruby	Lower	7/13/2023	SS	79	6.3	x	x	x	x	x
071323LRUBSS02	Ruby	Lower	7/13/2023	SS	60	2.6	x	x	x	x	x
071323LRUBSS03	Ruby	Lower	7/13/2023	SS	70	4.4	x	x	x	x	x
071323LRUBSS04	Ruby	Lower	7/13/2023	SS	64	3.4	x	x	x	x	x
071323LRUBSS05	Ruby	Lower	7/13/2023	SS	70	4.2	x	x	x	x	x
071323LRUBSS06	Ruby	Lower	7/13/2023	SS	65	3.4	x	x	x	x	x
071323LRUBSS07	Ruby	Lower	7/13/2023	SS	61	2.7	x	x	x	x	x
071323LRUBSS08	Ruby	Lower	7/13/2023	SS	60	3.2	x	x	x	x	x
071323LRUBSS09	Ruby	Lower	7/13/2023	SS	67	3.8	x	x	x	x	x
071323LRUBSS10	Ruby	Lower	7/13/2023	SS	70	3.9	x	x	x	x	x
071323LRUBSS11	Ruby	Lower	7/13/2023	SS	75	5.2	x	x	x	x	x
071323LRUBSS12	Ruby	Lower	7/13/2023	SS	76	6.2	x	x	x	x	x
071223USADV01	Subarctic	Upper	7/12/2023	DV	125	18.2	x	x	x	x	x
071223USADV02	Subarctic	Upper	7/12/2023	DV	127	19.0	x	x	x	x	x
071223USADV03	Subarctic	Upper	7/12/2023	DV	98	8.8	x	x	x	x	x
071223USADV04	Subarctic	Upper	7/12/2023	DV	117	15.5	x	x	x	x	x
071223USADV05	Subarctic	Upper	7/12/2023	DV	107	10.1	x	x	x	x	x
071223USADV06	Subarctic	Upper	7/12/2023	DV	90	6.3	x	x	x	x	x
071223USADV07	Subarctic	Upper	7/12/2023	DV	105	7.9	x	x	x	x	x
071223USADV08	Subarctic	Upper	7/12/2023	DV	96	8.5	x	x	x	x	x
071223USADV09	Subarctic	Upper	7/12/2023	DV	130	22.7	x	x	x	x	x
071223USADV10	Subarctic	Upper	7/12/2023	DV	115	14.1	x	x	x	x	x
071223USADV11	Subarctic	Upper	7/12/2023	DV	123	18.1	x	x	x	x	x
071223USADV12	Subarctic	Upper	7/12/2023	DV	106	11.3	x	x	x	x	x

[1] Dolly Varden (DV) slimy sculpin (SS)

APPENDIX 5. RESULTS FOR WHOLE BODY ELEMENT ANALYSIS FOR FISH FROM RUBY AND SUBARCTIC CREEKS, 2023.

Dolly Varden

Sample ID	Creek	Collection Date	Analyte	Dry Wt Result (mg/kg)	Dry Wt MDL (mg/kg)	% Solid
071223USADV01	Subarctic	7/12/2023	Cadmium	0.88	0.04	20.3
071223USADV02	Subarctic	7/12/2023	Cadmium	1.14	0.04	18.7
071223USADV03	Subarctic	7/12/2023	Cadmium	0.65	0.05	23.5
071223USADV04	Subarctic	7/12/2023	Cadmium	0.61	0.05	20.5
071223USADV05	Subarctic	7/12/2023	Cadmium	0.92	0.05	19.3
071223USADV06	Subarctic	7/12/2023	Cadmium	0.60	0.05	21.6
071223USADV07	Subarctic	7/12/2023	Cadmium	0.87	0.04	22.3
071223USADV08	Subarctic	7/12/2023	Cadmium	0.80	0.04	20
071223USADV09	Subarctic	7/12/2023	Cadmium	1.40	0.05	19.5
071223USADV10	Subarctic	7/12/2023	Cadmium	0.96	0.05	19
071223USADV11	Subarctic	7/12/2023	Cadmium	0.80	0.03	20.9
071223USADV12	Subarctic	7/12/2023	Cadmium	1.07	0.04	20.8
071223USADV01	Subarctic	7/12/2023	Copper	8.28	0.57	20.3
071223USADV02	Subarctic	7/12/2023	Copper	13.58	0.60	18.7
071223USADV03	Subarctic	7/12/2023	Copper	3.85	0.73	23.5
071223USADV04	Subarctic	7/12/2023	Copper	4.60	0.78	20.5
071223USADV05	Subarctic	7/12/2023	Copper	4.82	0.75	19.3
071223USADV06	Subarctic	7/12/2023	Copper	3.76	0.74	21.6
071223USADV07	Subarctic	7/12/2023	Copper	3.96	0.72	22.3
071223USADV08	Subarctic	7/12/2023	Copper	4.06	0.58	20
071223USADV09	Subarctic	7/12/2023	Copper	7.03	0.78	19.5
071223USADV10	Subarctic	7/12/2023	Copper	5.89	0.84	19
071223USADV11	Subarctic	7/12/2023	Copper	12.78	0.54	20.9
071223USADV12	Subarctic	7/12/2023	Copper	5.10	0.62	20.8
071223USADV01	Subarctic	7/12/2023	Mercury	0.10	0.01	20.3
071223USADV02	Subarctic	7/12/2023	Mercury	0.13	0.01	18.7
071223USADV03	Subarctic	7/12/2023	Mercury	0.09	0.01	23.5
071223USADV04	Subarctic	7/12/2023	Mercury	0.07	0.01	20.5
071223USADV05	Subarctic	7/12/2023	Mercury	0.10	0.01	19.3
071223USADV06	Subarctic	7/12/2023	Mercury	0.07	0.01	21.6
071223USADV07	Subarctic	7/12/2023	Mercury	0.06	0.01	22.3
071223USADV08	Subarctic	7/12/2023	Mercury	0.11	0.01	20
071223USADV09	Subarctic	7/12/2023	Mercury	0.13	0.01	19.5
071223USADV10	Subarctic	7/12/2023	Mercury	0.13	0.01	19
071223USADV11	Subarctic	7/12/2023	Mercury	0.10	0.01	20.9
071223USADV12	Subarctic	7/12/2023	Mercury	0.09	0.01	20.8

*MDL = Method Detection Limit

Dolly Varden, continued

Sample ID	Creek	Collection Date	Analyte	Dry Wt Result (mg/kg)	Dry Wt MDL (mg/kg)	% Solid
071223USADV01	Subarctic	7/12/2023	Selenium	4.48	0.07	20.3
071223USADV02	Subarctic	7/12/2023	Selenium	5.33	0.07	18.7
071223USADV03	Subarctic	7/12/2023	Selenium	5.11	0.09	23.5
071223USADV04	Subarctic	7/12/2023	Selenium	5.17	0.10	20.5
071223USADV05	Subarctic	7/12/2023	Selenium	5.34	0.09	19.3
071223USADV06	Subarctic	7/12/2023	Selenium	3.96	0.09	21.6
071223USADV07	Subarctic	7/12/2023	Selenium	4.17	0.09	22.3
071223USADV08	Subarctic	7/12/2023	Selenium	5.20	0.07	20
071223USADV09	Subarctic	7/12/2023	Selenium	7.54	0.10	19.5
071223USADV10	Subarctic	7/12/2023	Selenium	5.53	0.11	19
071223USADV11	Subarctic	7/12/2023	Selenium	6.12	0.07	20.9
071223USADV12	Subarctic	7/12/2023	Selenium	6.20	0.08	20.8
071223USADV01	Subarctic	7/12/2023	Zinc	224.14	4.29	20.3
071223USADV02	Subarctic	7/12/2023	Zinc	234.22	4.49	18.7
071223USADV03	Subarctic	7/12/2023	Zinc	162.98	5.49	23.5
071223USADV04	Subarctic	7/12/2023	Zinc	179.02	5.85	20.5
071223USADV05	Subarctic	7/12/2023	Zinc	253.37	5.60	19.3
071223USADV06	Subarctic	7/12/2023	Zinc	173.61	5.56	21.6
071223USADV07	Subarctic	7/12/2023	Zinc	118.39	5.38	22.3
071223USADV08	Subarctic	7/12/2023	Zinc	226.00	4.35	20
071223USADV09	Subarctic	7/12/2023	Zinc	301.54	5.85	19.5
071223USADV10	Subarctic	7/12/2023	Zinc	236.32	6.32	19
071223USADV11	Subarctic	7/12/2023	Zinc	224.88	4.02	20.9
071223USADV12	Subarctic	7/12/2023	Zinc	216.83	4.62	20.8

*MDL = Method Detection Limit

Slimy Sculpin

Sample ID	Creek	Collection Date	Analyte	Dry Wt Result (mg/kg)	Dry Wt MDL (mg/kg)	% Solid
071323LRUBSS01	Ruby	7/13/2023	Cadmium	0.13	0.04	23.5
071323LRUBSS02	Ruby	7/13/2023	Cadmium	0.38	0.06	19.5
071323LRUBSS03	Ruby	7/13/2023	Cadmium	0.15	0.04	23.3
071323LRUBSS04	Ruby	7/13/2023	Cadmium	0.13	0.04	24.3
071323LRUBSS05	Ruby	7/13/2023	Cadmium	0.15	0.05	23.2
071323LRUBSS06	Ruby	7/13/2023	Cadmium	0.33	0.05	23.5
071323LRUBSS07	Ruby	7/13/2023	Cadmium	0.67	0.06	20.9
071323LRUBSS08	Ruby	7/13/2023	Cadmium	0.31	0.04	25.4
071323LRUBSS09	Ruby	7/13/2023	Cadmium	0.12	0.05	23.3
071323LRUBSS10	Ruby	7/13/2023	Cadmium	0.20	0.05	23.7
071323LRUBSS11	Ruby	7/13/2023	Cadmium	0.08	0.04	23.1
071323LRUBSS12	Ruby	7/13/2023	Cadmium	0.10	0.04	20.8
071323LRUBSS01	Ruby	7/13/2023	Copper	5.70	0.70	23.5
071323LRUBSS02	Ruby	7/13/2023	Copper	4.96	0.96	19.5
071323LRUBSS03	Ruby	7/13/2023	Copper	4.04	0.60	23.3
071323LRUBSS04	Ruby	7/13/2023	Copper	2.61	0.69	24.3
071323LRUBSS05	Ruby	7/13/2023	Copper	3.24	0.74	23.2
071323LRUBSS06	Ruby	7/13/2023	Copper	3.81	0.78	23.5
071323LRUBSS07	Ruby	7/13/2023	Copper	9.28	0.90	20.9
071323LRUBSS08	Ruby	7/13/2023	Copper	6.14	0.71	25.4
071323LRUBSS09	Ruby	7/13/2023	Copper	3.55	0.81	23.3
071323LRUBSS10	Ruby	7/13/2023	Copper	6.24	0.76	23.7
071323LRUBSS11	Ruby	7/13/2023	Copper	3.31	0.66	23.1
071323LRUBSS12	Ruby	7/13/2023	Copper	3.60	0.67	20.8
071323LRUBSS01	Ruby	7/13/2023	Mercury	0.18	0.01	23.5
071323LRUBSS02	Ruby	7/13/2023	Mercury	0.08	0.01	19.5
071323LRUBSS03	Ruby	7/13/2023	Mercury	0.19	0.01	23.3
071323LRUBSS04	Ruby	7/13/2023	Mercury	0.08	0.01	24.3
071323LRUBSS05	Ruby	7/13/2023	Mercury	0.11	0.01	23.2
071323LRUBSS06	Ruby	7/13/2023	Mercury	0.07	0.01	23.5
071323LRUBSS07	Ruby	7/13/2023	Mercury	0.08	0.01	20.9
071323LRUBSS08	Ruby	7/13/2023	Mercury	0.13	0.01	25.4
071323LRUBSS09	Ruby	7/13/2023	Mercury	0.18	0.01	23.3
071323LRUBSS10	Ruby	7/13/2023	Mercury	0.27	0.01	23.7
071323LRUBSS11	Ruby	7/13/2023	Mercury	0.25	0.01	23.1
071323LRUBSS12	Ruby	7/13/2023	Mercury	0.22	0.01	20.8

*MDL = Method Detection Limit

Slimy Sculpin, continued

Sample ID	Creek	Collection Date	Analyte	Dry Wt Result (mg/kg)	Dry Wt MDL (mg/kg)	% Solid
071323LRUBSS01	Ruby	7/13/2023	Selenium	5.19	0.09	23.5
071323LRUBSS02	Ruby	7/13/2023	Selenium	4.69	0.12	19.5
071323LRUBSS03	Ruby	7/13/2023	Selenium	5.19	0.08	23.3
071323LRUBSS04	Ruby	7/13/2023	Selenium	6.58	0.09	24.3
071323LRUBSS05	Ruby	7/13/2023	Selenium	6.03	0.09	23.2
071323LRUBSS06	Ruby	7/13/2023	Selenium	6.34	0.10	23.5
071323LRUBSS07	Ruby	7/13/2023	Selenium	7.08	0.11	20.9
071323LRUBSS08	Ruby	7/13/2023	Selenium	5.28	0.09	25.4
071323LRUBSS09	Ruby	7/13/2023	Selenium	7.85	0.10	23.3
071323LRUBSS10	Ruby	7/13/2023	Selenium	5.65	0.09	23.7
071323LRUBSS11	Ruby	7/13/2023	Selenium	5.93	0.08	23.1
071323LRUBSS12	Ruby	7/13/2023	Selenium	5.29	0.08	20.8
071323LRUBSS01	Ruby	7/13/2023	Zinc	198.30	5.23	23.5
071323LRUBSS02	Ruby	7/13/2023	Zinc	148.72	7.23	19.5
071323LRUBSS03	Ruby	7/13/2023	Zinc	150.64	4.51	23.3
071323LRUBSS04	Ruby	7/13/2023	Zinc	98.35	5.19	24.3
071323LRUBSS05	Ruby	7/13/2023	Zinc	110.34	5.56	23.2
071323LRUBSS06	Ruby	7/13/2023	Zinc	163.83	5.87	23.5
071323LRUBSS07	Ruby	7/13/2023	Zinc	167.94	6.75	20.9
071323LRUBSS08	Ruby	7/13/2023	Zinc	119.69	5.31	25.4
071323LRUBSS09	Ruby	7/13/2023	Zinc	113.73	6.05	23.3
071323LRUBSS10	Ruby	7/13/2023	Zinc	186.92	5.70	23.7
071323LRUBSS11	Ruby	7/13/2023	Zinc	237.23	4.94	23.1
071323LRUBSS12	Ruby	7/13/2023	Zinc	143.27	5.05	20.8

*MDL = Method Detection Limit