British Columbia and Alaska Transboundary Rivers Sampling Program: 2019 Status Report

March 2020

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Acknowledgements

This report was a collaborative effort between Alaska's Department of Environmental Conservation (DEC) and British Columbia's Ministry of Environment and Climate Change Strategy (ENV). This report is an update on a region-wide assessment of general water quality in transboundary watersheds in Southeast Alaska and Northwest British Columbia. Alaska's survey efforts were supported in part through the United States' Environmental Protection Agency (EPA) Section 1-6 Clean Water Act grants I-01J19101, I-01J37901, and AA-J25201. British Columbia's sampling was funded by the ENV and the B.C. Ministry of Energy, Mines and Petroleum Resources (EMPR).

We would like to acknowledge and thank the many entities that contributed to the development and execution of this project including:

- DEC Environmental Health Laboratory
- DEC Fish Tissue Monitoring Program
- Alaska Department of Natural Resources
- Alaska Department of Fish and Game
- B.C. Environmental Environment and Climate Change Strategy
- B.C. Ministry or Forests, Lands, Natural Resource Operations and Rural Development
- B.C. Ministry of Energy, Mines and Petroleum Resources
- Ketchikan Indian Community
- Tahltan Central Government
- Taku River Tlingit First Nation
- University of Alaska's Alaska Center for Conservation Science (ACCS)
- U.S. Environmental Protection Agency
- U.S. Forest Service
- U.S. National Park Service

Acronyms and Abbreviations

AKMAP - Alaska Monitoring and Assessment Program

DEC – Alaska Department of Environmental Conservation

DFG – Alaska Department of Fish and Game

DNR – Alaska Department of Natural Resources

ENV – British Columbia Ministry of Environment and Climate Change Strategy

EMPR – British Columbia Ministry of Energy, Mines and Petroleum Resources

GLOF – Glacial Lake Outburst Flood

NRSA – National Rivers and Streams Assessment

WQG – British Columbia Water Quality Guidelines

WSQG – British Columbia Working Sediment Quality Guidelines

Glossary

The following terms are used to define the operational status of mining projects referenced in this report. The terms were developed by the Alaska Department of Natural Resources (DNR) and British Columbia Ministry of Energy, Mines, and Petroleum Resources (EMPR) as part of the Master Project List which is a key deliverable under the Bilateral Working Group between B.C. and Alaska (DNR and EMPR, 2019):

Advanced Exploration Project – Exploration with multi-year drill programs, possible permanent camp, access roads, or possible bulk samples from surface or underground. May include underground drilling and possible dewatering associated with underground exploration activities. These projects are often in preparation to becoming a proposed mine. Possible preliminary engineering or economic assessment.

Proposed Mine – This is a mine project that has not yet been certified for construction and operation but is in the process of obtaining necessary certificates or permits.

Operating Mine – This is a mine project that has existing authorizations, including Environmental Assessment Certificates and permits, that allow the production of a mineral, a placer mineral, coal, sand, gravel or rock.

Closed Mine – A mine at which all mining activities have ceased but in respect of which the owner, agent, manager or permittee remains responsible for compliance with the B.C. *Mines Act*, the regulations, the code and that person's obligations under the permit(s) for that mine.

Care and Maintenance - A mine project that is closed but there is potential to recommence operations at a later date. Production is stopped but the site is managed to ensure it remains in safe and stable condition.

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Executive Summary

The transboundary region in Southeast Alaska and Northwest British Columbia provides important social, economic, and cultural resources. The region is rich in mineral resources, attracting prospective mines and supporting operating mines for decades. The transboundary watersheds in this region are home to economically and culturally significant fisheries.

Public concerns about potential impacts to transboundary waters from historical mining activities, mine development projects, or a future unexpected catastrophic event, such as a tailing impoundment failure, led to development of the Joint Water Quality Program for Transboundary Waters by the State of Alaska and the Province of British Columbia. This coordinated two-year environmental quality sampling program was focused on collecting information for the Taku, Stikine, and Unuk watersheds.

This status report summarizes the progress on the B.C. - Alaska Transboundary Rivers Sampling Program activities from August 2017 to June 2019. A final report will be published in 2020 and will include sample results from August 2017 to September 2019. The aquatic sampling program included physical habitat assessments; physical and chemical analyses of water and sediment, and chemical analyses of biological samples, including: benthic invertebrates, periphyton, and fish. The water, sediment, and biological components were analyzed for metals that tend to be of greatest interest due to their potential ecological impacts (i.e., constituents of concern).

The B.C. Water Quality Guidelines (WQG) and B.C. Working Sediment Quality Guidelines (WSQG) for Aquatic Life were selected to assess the preliminary results of the water and sediment sampling study. The B.C. guidelines are designed to be applied province wide. They are developed to prevent adverse effects to the most sensitive aquatic species for which data is available. However, they do not reflect site specific conditions. For example, mining exploration and development typically occur in locations with highly mineralized geology and naturally elevated background concentrations for some constituents of concern. These background concentrations although elevated compared to the B.C. guidelines, do not necessarily pose risks to aquatic organisms that may be adapted to these conditions.

An analysis of metals in water samples from the target watersheds identified sites with elevated concentrations of cadmium, copper, selenium and zinc relative to WQG. The analysis of sediment samples from all target watersheds identified sites with concentrations of total arsenic, copper, iron, manganese, and nickel above the WSQG for Aquatic Life.

In some cases, metal concentrations in water were above provincial guidelines upstream from mine sites (e.g. a subset of Unuk River sites), likely reflecting waters with naturally elevated metal concentrations. Metal concentrations in water were also found to be above provincial guidelines at sites downstream relative to operating or historic mines (e.g. a subset of Tulsequah River sites).

The results presented in this midterm report are preliminary until the final report is published.

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Introduction

The transboundary region between Southeast Alaska and Northwest British Columbia provides important social, economic, and cultural resources. Transboundary watersheds in this region are home to economically and culturally significant fisheries (McDowell, 2016; Fisheries and Oceans Canada, 2019). Exploration of the complex geology of the region has resulted in historic, active, and proposed mining operations.

Public concerns about the potential impact of mine impoundment failures, contamination from historical mining activities, and a desire to establish baseline data in anticipation of future proposed projects, have resulted in discussions among local communities and governments regarding the condition of the aquatic environment in transboundary waters (State of Alaska, 2015). In response to these concerns, the State of Alaska and the Province of British Columbia signed a Memorandum of Understanding and Cooperation (November 25, 2015), and a Statement of Cooperation on the Protection of Transboundary Waters (October 6, 2016). These agreements can be found at the B.C. Alaska Transboundary Waters information link[1] and the State of Alaska website[2]

The Statement of Cooperation outlined a process for development of a Joint Water Quality Sampling Program for Transboundary Waters. The program's objectives were to:

1. Collect seasonal aquatic data in the Taku, Stikine, and Unuk watersheds to characterize aquatic conditions,
2. Collaborate between Alaska and B.C. to share methods and exchange environmental data on transboundary rivers.

To assess the current health of the Taku, Stikine, and Unuk transboundary watersheds, the Transboundary Rivers Sampling Project has been collecting seasonal aquatic environmental quality data between August 2017 to September 2019. Sampling for this coordinated project between the State of Alaska and the Province of British Columbia has been accomplished with the assistance and support of regional Indigenous communities.

Mining History of B.C. - Alaska Transboundary Watersheds

The Taku, Stikine and Unuk River watersheds of Northwest British Columbia draining through Southeast Alaska to the Pacific Ocean, are characterized as remote and primarily in a wilderness or semi-wilderness state. Indigenous peoples have occupied this land for at least ten thousand years and claim most of the area as traditional hunting and fishing grounds and used the major tributaries as trade routes (Province of B.C., 2000). Influxes of people from around the world searching for minerals (primarily gold) started in the 1860s to the goldfields in northwest B.C.

TAKU

The Taku River watershed provides high value fish and wildlife habitats, Indigenous peoples' cultural values, wilderness recreation, and mineral exploration and development. Two underground hard rock mine sites, both currently closed, are located within the watershed along the Tulsequah River with active mining between 1938 and 1957. New Polaris gold mine operated for 14 years from 1937 to 1951. The Tulsequah Chief Mine operated between 1951 and 1957, and currently discharges untreated mine contact water into the Tulsequah River. An

[1] B.C. Alaska Transboundary Waters information link https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/compliance-enforcement/bc-alaska-transboundary-waters

[2] State of Alaska website http://dnr.alaska.gov/commis/opmp/Canadian-Mines/index.htm

ecological risk assessment completed in 2017 (SLR Consulting Ltd, 2017), identified risks associated with acid rock drainage to fish and invertebrates near the mine site.

STIKINE

The Stikine River watershed is the largest watershed in Northwest B.C. The watershed, in addition to ecological resources, has Indigenous Nations' cultural and non-aboriginal heritage resources dating back to the mid-1800s. There are several small settlements in the area, and activities include: mining, commercial fisheries, hydroelectric power generation, transportation, forestry, agriculture, tourism, and recreation.

Mining activity in the Stikine River watershed dates back to the mid-1800s. Currently, the only operating mine is Red Chris which is located in the upper Iskut River drainage. Galore Creek flows northward to the Scud River, a tributary to the Stikine River, and the proposed Galore Creek Mine Project is located between the Stikine and Iskut Rivers. Schaft Creek drains to the north into Mess Creek, a tributary to the Stikine River. The Schaft Creek advanced exploration project is located approximately 60 km (37.5 miles) south of the village of Telegraph Creek in the upper Schaft Creek watershed.

Other industrial development within the Stikine watershed includes the Forrest Kerr hydroelectric project on the Iskut River.

UNUK

The Unuk River watershed is the lowermost watershed along the B.C.-Alaska Boundary. The watershed has substantial fish, wildlife, recreation, mineral exploration and development, and timber harvesting values (Province of B.C., 2000). Three existing/proposed mine sites are present in the watershed: the Brucejack mine started operation in 2017, the Kerr-Sulphurets-Mitchell (KSM) proposed mining project, and the closed Eskay Creek project which operated from 1971 to 2008. All sites are subject to ongoing discharge and/or environmental monitoring.

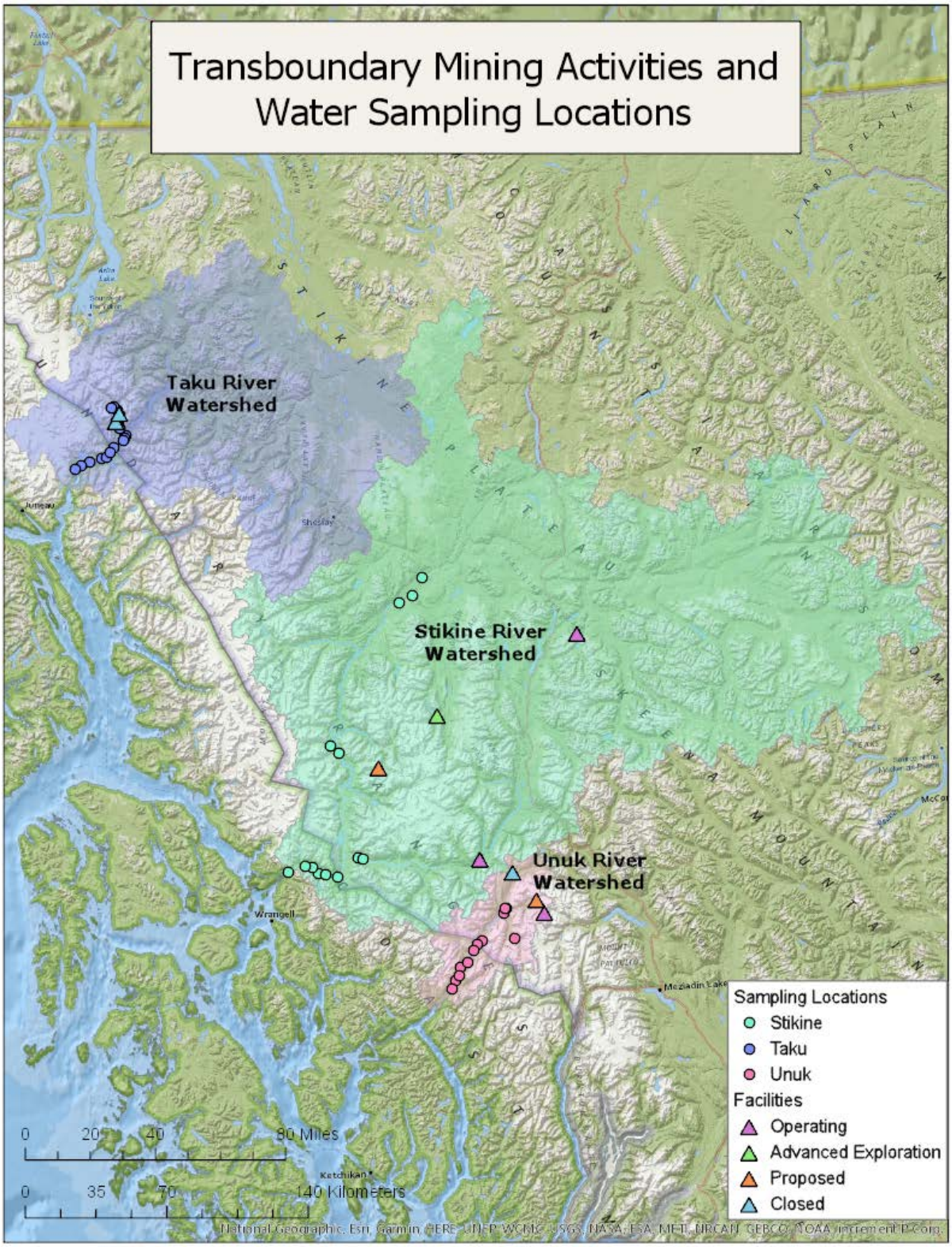

Figure 1. Transboundary Watersheds showing Mining Activities and Forest Kerr Hydroelectric Project.

Study Area

The study area for B.C.-Alaska Transboundary Rivers Sampling Program includes the Taku, Stikine and Unuk River watersheds. Figure 1 shows the selected watersheds and sampling sites, and significant industrial development, including high priority mining activities. Selected mining activities are classified based on the Master Project List, jointly developed by Alaska Department of Natural Resources (DNR) and the B.C. Ministry of Energy, Mines, and Petroleum Resources (EMPR) (2019). Further explanation of each classification may be found in the glossary.

Taku River Watershed

The Taku River is about 87 km (54.059 miles) long and drains an area of approximately 27,500 km^2 (10,600 square miles) into the Pacific Ocean; the Tulsequah River is a tributary. Sample sites extended from 1 km (0.625 miles) upstream of the closed Tulsequah Chief Mine to 20 km (12.427 miles) downstream of the B.C. - Alaska border. The overall length of the sampling area is about 30 km (18.641 miles). Most of the B.C. sample sites were located along the Tulsequah River above and below the Tulsequah Chief and New Polaris mines. All sites in Alaska were in the non-tidally influenced portion of the Taku River.

The Tulsequah River travels within a very broad, flat floodplain. The mainstem gradient is estimated at approximately 1.0 to 2.5% (Rescan, 1997). Typical of rivers in glaciated valleys, the Tulsequah River contains elevated concentrations of suspended sediments and a larger bedload. The abundance of sediment, supplied by the glacier immediately upstream, and wide floodplain has allowed the channel to develop heavily braided morphology. Under typical conditions this morphology exhibits dynamic and active channel migration, usually associated with seasonal high flows. Within the Tulsequah River, the principal channel forming flows are associated with annual Glacial Lake Outburst Flood (GLOF) events, which are the rapid release of water from a lake impounded by a moraine or glacier. During a GLOF, the discharge of the Tulsequah River may increase up to 30 times above estimated annual maximum discharges (Palmer et al., 2013).

Throughout much of the year the local hydrograph is snow and glacial melt driven; however, on at least one occasion per year the river is subject to GLOFs from a glacier impounded lake that drain quickly, and with little warning, beneath the Tulsequah glacier. During a GLOF, river flows range from 1,711 to 2,975 m^3/s (60,423 to 105,061 ft^3/s) (SLR, 2017). The water levels rise over a period of 24 to 48 hours and subside to normal summer flow levels of around 100 m^3/s (3,531 ft^3/s) over a similar time period.

Stikine River Watershed

The Stikine River watershed covers more than 80,290 km^2 (31,000.142 square miles), from the Spatsizi Plateau Wilderness Park in Northwestern British Columbia to the Pacific Ocean in Southeast Alaska. The river flows about 644 km (400.163 miles) and drains 49,800 km^2 (30,944.276 square miles). On its way to the ocean the Stikine River has 15 major tributaries within British Columbia. It also runs through the Grand Canyon of the Stikine, a 305 m (1,000 ft) deep, 72 km (44.739 mile) long canyon; known as one of the hardest whitewater runs in the world. The canyon ends near the community of Telegraph Creek. The average gradient of the river is 0.76 m/km (4.013 feet per mile) and within the United States it has a nearly flat gradient. The basin is highly glaciated, draining the southern half of the Stikine Icefield. Sample sites in this watershed extended from 12 km (7.456 miles) upstream of the town of Telegraph Creek in northwest B.C. to 30 km (18.641 miles) downstream of the B.C. – Alaska border. The overall length of the sampling area is about 150 km (93.206 miles).

All sample sites were in the mainstem of the Stikine River, except for one site each in Christina Creek and the Iskut River, tributaries to the Stikine River, and the Johnson River, a glacially fed tributary to the Iskut River.

Unuk River Watershed

The Unuk River is 129 km (80.157 miles) long and drains an area of 3,885 km^2 (1,500 square miles). Sample sites in the Unuk River extended from 3 km (1.864 miles) upstream of the confluence with Sulphurets Creek, to 27 km (16.777 miles) downstream of the B.C.-Alaska border. The overall length of the sampling area is about 46 km (28.583 miles). Within the Unuk River study area, there is a confined canyon section with small, clear, groundwater fed side-channels and non-glacial tributaries, as well as heavily-glaciated tributaries, including the South Unuk River and Sulphurets Creek. The lower section consists of braided sections with slopes of 0.4-0.7% and channel widths 100-800 m (328.1 – 2,624.7 feet) (Hawthorn et al., 1984).

Hydrological Regime in British Columbia-Alaska Transboundary Region

The large transboundary rivers of the Southeast Alaska and British Columbia/Yukon region (Alsek, Chilkat, Taku, Stikine, Whiting, and Unuk Rivers) straddle the maritime (to the west) and continental (to the east) climatic zones (Kottek et al., 2006). The maritime climate zone is characterized with mild year-round temperatures tempered by proximity to the ocean and prodigious precipitation amounts. The continental climate zone has a greater range of temperatures over the seasons and is drier than the maritime zone. The Coastal Mountain Range that forms the border between Alaska and Canada is the transitional zone between the two climatic regions. At this transition most precipitation falls as snow and is stored in large snow fields or glaciers.

All the transboundary basins are hydrologically driven by the storage and melt of snow and ice (O'Neel et al., 2015). They all exhibit the similar pattern of extended high flows from late spring to fall months due to prolonged snow and ice melt. During the melt period of the summer months, the primary driver of discharge is snow and ice melt due to incoming solar radiation which peaks at in late June through early July. Discharge fluctuates on a diurnal cycle in concert with night and day (Nienow et al., 2005). Temperatures decrease and precipitation increases in the fall months and discharge become more variable and peaks with rainfall events. During the winter and early spring months, precipitation is stored in snowpack and on glaciers. The lowest flows of the year are during late spring when baseflows are depleted and snowmelt has not yet begun. A unique hydrologic phenomenon that is characteristic of many glaciated watersheds are GLOFs. There have been observed GLOF events on the Taku River that occur annually and can double the volume of the river for two to seven days (Neal, 2007).

Methods

Site Selection

In B.C., sample sites were primarily located in the mainstem portion of rivers and were selected based on their locations relative to the most active mining properties and a hydroelectric power generating station. All sites were helicopter access only. In the Taku watershed, sample sites were selected upstream and downstream of mining properties. In the Stikine watershed, sample sites were selected above and below confluences of major tributaries with upstream mining properties or hydroelectric project(s). In the Unuk watershed, sample sites were selected above and below confluences of major tributaries, on tributaries located downstream of mining properties or on the South Unuk River (no mining). In B.C., a total of 23 sites were sampled.

In Alaska, under the Alaska Monitoring and Assessment Program's (AKMAP) 2018 Southeast Rivers Survey design, up to five sites in each watershed were randomly selected for sampling. Another six sites within each of the priority watersheds were targeted for sampling to maximize coverage. Site selection in Alaska was determined based on stream-order[3], accessibility, and distance from water tidal influences. Sites were eliminated if unsafe conditions (e.g., flooding, hazardous weather conditions, and accessibility concerns) were present during verification.

Efforts were made by DEC and ENV to collect water, sediment, and biota samples using similar or comparable protocols and to have samples analyzed using similar or comparable methods. Table 1 contains a list of all the sampling sites within both jurisdictions, aquatic components and sampling frequency. The Appendix includes additional maps and sample site location information.

Physical, Chemical and Biological Sampling Components

To characterize the current state of aquatic conditions in the Taku, Stikine, and Unuk watersheds, the sampling program design included physical habitat assessments; physical and chemical analyses of water and sediment, and collecting benthic invertebrates, periphyton, and fish. The water, sediment, and biological components were also analyzed for a standard suite of metals that tend to be of greatest interest due to their potential ecological impacts (i.e., constituents of concern).

[3] the project sample frame came from the U.S. Forest Service StreamNet and University of Montana Riverscape Analysis Project (RAP) which target Strahler order 5 and larger rivers and third order or larger rivers respectively.

Table 1. Transboundary Sampling Sites, Aquatic Components, and Sampling Dates

Watershed	Site Name	Map Display Name	River/Creek	DEC/ B.C.	Aquatic Components Sampled					Sampling Date						
					Water	Sediment	Benthic Inverts	Periphyton	Fish	Aug '17	Jun '18	Jul'18	Sep '18	Nov '18	Feb '19	Jun '19
Taku	Taku 1	Taku 1	Tulsequah	B.C.	X	X				X				X	X	X
	Taku 2	Taku 2	Tulsequah	B.C.	X	X				X				X	X	X
	Taku 3	Taku 3	Tulsequah	B.C.	X	X	X			X			X	X	X	X
	Taku 4	Taku 4	Taku	B.C.	X	X	X			X			X	X	X	X
	Taku 5	Taku 5	Taku	B.C.	X	X				X				X	X	X
	Taku 6	Taku 6	Whitewater	B.C.	X								X		X	X
	Taku 7	Taku 7	Whitewater	B.C.	X				X				X		X	X
	Taku 8	Taku 8	Tulsequah	B.C.	X		X						X			
	Taku 9	Taku 9	Tulsequah	B.C.					X				X			
	Taku 10	Taku 10	Tulsequah	B.C.	X	X			X				X			
	Taku 11	Taku 11	Taku	B.C.	X	X	X						X			
	NRS18-AK-10159	Taku A	Taku	DEC	X						X					
	NRS18-AK-10160	Taku B	Taku	DEC	X						X					
	NRS18-AK-10162	Taku C	Taku	DEC	X						X					
	NRS18-AK-10165	Taku D	Taku	DEC	X						X					
	NRS18-AK-10167	Taku E	Taku	DEC	X	X					X					
	NRS18-AK-Taku1	Taku F	Taku	DEC	X						X					
	NRS18-AK-Taku2	Taku G	Taku	DEC	X	X					X					
Stikine	Stikine 1	Stikine 1	Stikine	B.C.	X	X				X			X	X	X	X
	Stikine 2	Stikine 2	Stikine	B.C.	X	X				X			X	X	X	X
	Stikine 3	Stikine 3	Stikine	B.C.	X	X				X						X
	Stikine 4	Stikine 4	Iskut	B.C.	X	X	X			X			X	X	X	X
	Stikine 5	Stikine 5	Iskut	B.C.					X				X			
	Stikine 6	Stikine 6	Christina	B.C.			X		X				X			
	Stikine 7	Stikine 7	Stikine	B.C.	X		X		X				X	X	X	X
	NRS18-AK-10064	Stikine A	Stikine	DEC	X	X						X				
	NRS18-AK-10139	Stikine B	Stikine	DEC	X							X				
	NRS18-AK-10147	Stikine C	Stikine	DEC	X							X				
	NRS18-AK-10150	Stikine D	Stikine	DEC	X	X						X				
	NRS18-AK-Stik1	Stikine E	Stikine	DEC	X							X				
	NRS18-AK-Stik2	Stikine F	Stikine	DEC	X							X				
Unuk	Unuk 1	Unuk 1	Unuk	B.C.	X	X	X						X	X	X	X
	Unuk 2	Unuk 2	South Unuk	B.C.	X	X	X		X				X	X	X	X
	Unuk 3	Unuk 3	Unuk	B.C.	X	X	X						X	X	X	X
	Unuk 4	Unuk 4	Sulphurets	B.C.	X	X	X		X				X	X	X	X
	Unuk 5	Unuk 5	Unuk	B.C.	X	X	X		X				X	X	X	X
	NRS18-AK-10177	Unuk A	Unuk	DEC	X							X				
	NRS18-AK-10178	Unuk B	Unuk	DEC	X							X				
	NRS18-AK-10180	Unuk C	Unuk	DEC	X							X				
	NRS18-AK-10181	Unuk D	Unuk	DEC	X							X				
	NRS18-AK-10182	Unuk E	Unuk	DEC	X							X				
	NRS18-AK-Unuk1	Unuk F	Unuk	DEC	X	X						X				
	NRS18-AK-Unuk2	Unuk G	Unuk	DEC	X	X						X				

*Note B.C. sites were also sampled in Aug/Sept of 2019, the results of which will be included in the final report.

Field Staff Training

DEC and ENV staff selected to lead and participate in fieldwork for this project were trained on aquatic sampling methods. Training included an overview of protocols for assessment of physical habitat parameters and collection of water, sediment, fish, periphyton, and benthic macroinvertebrate samples. Internal efforts were made by DEC and ENV staff to ensure similar methods were followed by both organizations using guidance from the U.S. EPA's National Rivers and Streams Assessment Field Operations Manual and the B.C. Field Sampling Manual. DEC staff led field crews comprised of University of Alaska Anchorage staff contracted with the AKMAP and/or volunteers from local communities. ENV biologists provided additional training to individuals from the Taku River Tlingit First Nation and Tahltan Central Government. These trained First Nations individuals sampled with ENV staff on two occasions and led the quarterly water quality sampling events in B.C.

Physical Habitat

Site surveys were conducted at each sample site to describe the physical habitat of the stream or river in relation to the collection and analysis of water, biological, and sediment samples. Assessment of the physical habitat by DEC of Alaskan sites followed the U.S. EPA's National Rivers and Streams (NRSA) protocols throughout the sampling reach of the stream or river (EPA, 2018a & 2018b). At sites within B.C., ENV collected physical habitat descriptions at the reach level during site access, and sampled according to the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Sites Card Field Guide* (Ministry of Environment, 2008). The assessments included investigation and documentation of the riparian habitat, instream fish habitat, vegetation cover, substrate, and anthropogenic alterations and uses at each transect.

Water Chemistry

Water quality sampling followed the standard methods described in either Part E of the B.C. Field Sampling Manual (B.C. Ministry of Environment, 2013) or NRSA methods (EPA, 2018a & 2018b). Table 2 references all water chemistry parameters assessed jointly by DEC and ENV in the lab and the field. The water quality parameters selected for analysis are relevant for the purpose of characterizing the quality of the water above and below mining activities and comparing the results to guidelines for the protection of aquatic life. Dissolved and total metals were of interest in relation to the bioavailability of metals in the watersheds and potential for bioaccumulation and biomagnification in aquatic life. Effort was made to use the same or complimentary lab analysis methods for all parameters assessed by Alaska and B.C. when sampling transboundary watersheds. Additional parameters assessed by the agencies are not included in the table, but the data will be available as an appendix to the final sampling program report.

Table 2. Water Quality Parameters

Parameter		
Field Measurements		
Temperature	Dissolved Oxygen	Specific Conductance[1]
pH[1]	Turbidity	
Lab Measurements		
Sulfate	Dissolved Organic Carbon (DOC)	Nitrate and Nitrite
Total Suspended Solids	Alkalinity	Total Nitrogen
Total Metals	Ammonia	Total Organic Nitrogen
Dissolved Metals	Total Kjeldahl Nitrogen	Phosphorus

[1]Parameter is measured in the field and in the lab

Sediment

Ultrafine sediment (<63 µm) deposits were targeted throughout the reach of the sample stream or river. This size fraction is important to the assessment of sediment quality because these particles accumulate greater concentrations of elements than coarser particles. (B.C. Ministry of Environment, 2016). Sediment <63 µm from all sites were analyzed for total element concentrations. For comparison purposes, sediment samples collected at two B.C. sites in each watershed were analyzed at both the <63 µm and <2 mm size fractions. A steel spoon was used to collect sediment. Lab issue, plastic sediment bags were half filled with sediment for lab analysis. Sediment sampling equipment was decontaminated prior to field work. Sampling was limited to a depth of three centimeters to capture gravimetrically deposited fine sediment for analysis of the parameters listed in Table 3. Additional parameters assessed by the individual agencies are not included in the table, but the data will be available as an appendix to the final sampling program report.

Table 3. Sediment Quality Parameters

Parameters:					
Particle Size Analysis	Percent Moisture	Total Organic Carbon	Sulphur	Percent Solids	Stable Isotopes
***Total Metals:**					
Aluminum (Al)	Cadmium (Cd)	Lead (Pb)	Nickel (Ni)	Tin (Sn)	
Antimony (Sb)	Copper (Cu)	Manganese (Mn)	Selenium (Se)	Vanadium (V)	
Arsenic (As)	Iron (Fe)	Mercury (Hg)	Silver (Ag)	Zinc (Zn)	

*The parameters selected for analysis are those commonly of greatest interest due to their potential ecological impacts (i.e., constituents of concern)

Biological

Benthic Invertebrates / Periphyton

Benthic macroinvertebrates were collected for each stream or river. Alaska field crews used a D-frame 400 µm mesh kick net to sample a square-foot quadrat for 30 seconds and the sample was preserved in the field using ethanol. The samples were submitted to the Alaska Center for Conservation Science (ACCS) for taxonomic identification and to assess benthic diversity.

ENV field crews employed a triangular kick net with 400 µm mesh using kick net methods described in the Canadian Aquatic Biomonitoring Network (CABIN) (B.C. Ministry of Environment, 2009) to collect benthic samples. A minimum of three grams of benthic material were hand-picked from each sample and submitted to ALS Environmental for whole body total metals analysis.

Periphyton samples were collected by Alaska field crews for the sites downstream of the B.C./Alaska border. Samples were collected from a 12 cm^2 area. Collection was carried out using methodology contained in the National Rivers & Streams Assessment 2018-19 Field Operations Manual Non-Wadeable (2018b). The collection and preservation method varied depending on whether the defined sample area contained coarse sediment (cobbles or larger) or fine sediment.

Fish Tissue

Fish tissue samples were collected by Alaska and B.C. in the targeted watersheds using either baited minnow traps or electrofishing throughout the sample reach of the selected stream or rivers. Appropriate permits were obtained prior to collection of fish samples and proper fish harvesting procedures were followed as outlined in Fish

Collection Methods and Standards Version 4 (B.C. Ministry of Environment, 1997). Dolly Varden char (*Salvelinus malma*) with a fork length between 90 and 130 mm and weighing at least 5 g was the target species and size for fish capture from each watershed in September 2018. The 90 mm fish provides an adequate amount of tissue for analysis while the max fish size of 130 mm improves the likelihood of sampling resident fish. The target sample size was eight fish per site, as per the Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operation (B.C. Ministry of Environment, 2016). Fish sampling opportunities were more limited based on permitting availability and locations with desirable fish habitat. DEC coordinated with Alaska Department of Fish and Game (DFG) to collect fish tissue samples prior to planned stream and river surveys. DEC completed additional fish tissue sampling throughout the 2018 field season when practical. This resulted in other fish species including round whitefish (*Prosopium cylindraceum)*, Three-spined stickleback (*Gasterosteus aculeatus*), sockeye (*Oncorhynchus nerka*) salmon, and chinook (*Oncorhynchus tshawytscha*) salmon being retained. ENV targeted three sites per watershed in September of 2018 based on accessibility and physical habitat parameters. Where an insufficient number of Dolly Varden were captured, slimy sculpin (*Cottus cognatus*), and coho salmon (*Oncorhynchus kisutch*) were collected as alternative species of interest.

Table 4 references all fish tissue parameters assessed jointly by DEC and ENV in the field and the lab. The parameters were selected to document fish condition and tissue element concentrations. Additional parameters assessed by the individual agencies are not included in the table, but the data will be available in the Appendix of the final sampling program report.

Table 4. Fish Tissue Sampling Parameters

Parameters:				
Field Measurements – Water				
Dissolved Oxygen	Temperature	Specific Conductance	pH	
Field Measurements – Fish				
Species	Fork Length (mm)	Weight (g)		
Lab Measurements – Fish				
Tissue Percent Moisture	Inorganic Arsenic			
Total Metals:				
Arsenic (As)	Cadmium (Cd)	Copper (Cu)	Mercury (Hg)	Selenium (Se)

Selection and Relevance of Regulatory Guidelines

We acknowledge that all regulatory guidelines and standards developed by the participating agencies are established to safeguard human and environmental health. However, to evaluate the preliminary results in this report, a review of U.S. Federal Standards, DEC Standards, and B.C. Guidelines was completed to determine the most conservative limits for the combined study. The B.C. Water Quality Guidelines (WQG), which are set at levels at or below those of the U.S. EPA and the DEC for the parameters of interest, were used to evaluate the water results of the combined study. The B.C. Working Sediment Quality Guidelines (WSQG) for Aquatic Life, were used to evaluate the results of the combined sediment study.

These guidelines are designed to be applied province wide and do not consider site specific conditions (e.g. highly mineralized areas or glaciated areas). Therefore, exceedances in long term average water quality guidelines for aquatic life do not necessarily pose a risk to aquatic organisms; as these guidelines are developed to prevent adverse effects to the most sensitive aquatic species for which data are available. Mining exploration and development typically occur in locations with highly mineralized geology and naturally elevated background concentrations of metals and TSS, conditions to which local aquatic organisms may be adapted.

Results

All available results for sites sampled between August 2017 and June 2019 are presented in tables in the Appendix.

Overall, the water chemistry results are referenced against the WQG for aquatic life. Field measurement of pH and temperature for all sampling events were within acceptable limits for proliferation of aquatic life. Analysis of metals in water samples from the target watersheds identified sites with elevated concentrations of total and dissolved cadmium, copper, selenium, and zinc as reported in Tables 6-8.

Trace metals analysis, including aluminum, antimony, arsenic, cadmium, copper, iron, lead, manganese, nickel, selenium, silver, tin, vanadium, zinc, and mercury, was conducted for sediment samples collected in the transboundary watershed regions. Analysis of sieved sediment samples from all target watersheds identified sites with elevated concentrations of total arsenic, copper, iron, manganese, and nickel above WSQG. The metal concentrations in depositional sediment <63 µm were consistently higher than for depositional sediment <2 mm. Results, outlined by watershed and reported in Tables 9-11, are referenced against the WSQG for aquatic life for identified parameters to further identify trends. An expanded metals analysis was completed for ENV water and sediment samples and results are included in the B.C.-Alaska Transboundary Rivers Monitoring Program Update (B.C. Ministry of Environment, 2019).

A total of 156 samples, whole body individual fish and composite samples, were collected in 2018 by DEC and ENV for tissue metals analysis. The target fish species, Dolly Varden char, was captured in all three watersheds and submitted for tissue analysis. Whitefish, stickleback, coho, sockeye, and chinook captured in the Taku; sculpin in the Stikine and coho and sculpin in the Unuk were also submitted for tissue analysis. Analysis of tissue metal concentrations included arsenic cadmium, copper, lead, selenium, and mercury. All fish measured concentrations of total mercury below the Health Canada standard maximum limit for total mercury in retail fish (0.5 mg/kg) (Health Canada, 2019). An analysis of tissue concentrations for the other elements of interest/concern was not available prior to the submission of this report.

Taku Watershed

Water Quality

A total of 17 sites were sampled for water quality. Seven sites in Tulsequah River were sampled upstream and downstream of the Tulsequah Chief and New Polaris mine sites. The remaining ten sites were along the Taku River, one of which was located upstream of the confluence with the Tulsequah River. The water quality sampling sites are identified in Table 1. WQG for zinc were regularly exceeded at all sampling sites along the Tulsequah River, including sites upstream (Taku 1 and 8) of the Tulsequah Chief mine. No measurable exceedances of the WQG was observed upstream of New Polaris mine (Taku 6). There were measurable exceedances of WQG for acute short-term exposure for total zinc and, or dissolved cadmium and, or copper, at sample sites downstream of the Tulsequah Chief and New Polaris mines (Taku 2, 3, and 7). The highest concentration of total zinc, 69.2 µg/L, and dissolved copper, 5.88 µg/L, was at Taku 2, located 900 m (2,953 feet) downstream of mine discharge. Taku 2 is located within, as defined by an earlier ecological risk assessment (Palmer et al., 2013), the zone of influence for the Tulsequah Chief mine. Dissolved metal concentrations decreased with increasing distance downstream from the historic mining properties and dissolved concentrations in the Taku River were similar at sites upstream and downstream of its confluence with the Tulsequah River, except for dissolved selenium. Dissolved selenium concentrations were similar throughout the Tulsequah and Taku River sampling sites.

Sediment

Sediment sampling was conducted at nine sites in the watershed. Four sites were located on the Tulsequah River, one upstream and three downstream of the Tulsequah Chief mine. Five sites were located on the Taku River. Sediments collected from sample locations on the Tulsequah River 1 km (0.621 miles) upstream and 4 km (2.485 miles) downstream of the Tulsequah Chief mining property revealed concentrations of arsenic and/or iron above the WSQG. Exceedances were also observed for sediment samples collected on the Taku River upstream and downstream of the Tulsequah River confluence.

Stikine Watershed

Water Quality

A total of eleven sites were sampled for water quality. Four sites were on the Stikine River, one was on the Iskut River, and the remaining six sites were on the Stikine River south of the B.C.-Alaska border.

Samples collected throughout the B.C. portion of the Stikine River watershed frequently exceeded the chronic WQG for total zinc and dissolved copper concentrations. Zinc concentrations were highest and exceeded the acute WQG on the Iskut River in one of five samples. Elevated concentrations were also reported for Stikine River sites below the Mess Creek and Scud River confluences.

Sediment

Sediment sampling was conducted at five sites on the Stikine River throughout the watershed and one site on the Iskut River. Sediment metal concentrations for arsenic and iron were above the upper WSQG on the lower Iskut River, downstream of mining projects. The only other occurrence above the upper WSQG was iron in the upper portion of the Stikine River downstream of the Mess Creek confluence.

Unuk Watershed

Water Quality

A total of twelve sites were sampled for water quality. Three sites were on the Unuk River, two on tributaries in B.C., and seven sites were sampled in Alaska. All twelve sample locations in the watershed reported elevated metal concentrations above chronic threshold limits. Chronic WQG for dissolved copper concentrations was exceeded at all sampling sites in the Unuk watershed. Acute WQG for total zinc was regularly exceeded at Sulphurets Creek and the Unuk River downstream of Sulphurets Creek (Unuk 4 and 3). The highest dissolved metal concentrations, including cadmium, copper, and zinc, and total concentrations for selenium and zinc were reported in Sulphurets Creek. For zinc, exceedances above the acute WQG ranging from 35.5 µg/L (dissolved) to 226.0 µg/L (total) were reported for Unuk River sites upstream and downstream of Sulphurets Creek, including one site in Alaska (35.5ug/L, Unuk C).

Sediment

Sediment sampling in the B.C. portion of the Unuk watershed was conducted at the same five sites water samples were collected. There were two sites on the Alaska portion of the Unuk River at which sediment samples were collected. Most of the sites in the Unuk watershed reported concentrations of total arsenic and iron above the upper WSQG for aquatic life. Copper and manganese concentrations were above the upper WSQG at Sulphurets Creek, the Unuk River 2 km (1.243 miles) downstream of Sulphurets and the Unuk sites in Alaska. Total mercury

and zinc were reported as above the lower WSQG Sulphurets Creek, the Unuk River 2 km (1.243 miles) downstream of Sulphurets and zinc was also above the lower WSQG at the Unuk sites in Alaska.

Biological (Benthic Invertebrates, Periphyton and Fish)

Benthic macroinvertebrate analysis will include a taxonomy study of DEC samples and a metals tissue study of ENV samples, which will provide valuable information about community diversity and bioaccumulation of metals in the selected watersheds. The results from this sampling, the periphyton sampling and fish tissue metal results will be included in the final report.

Tables 12 to 14 in the Appendix provide a summary of the number and species of fish captured for tissue analysis from each sampling location in each watershed. Once all the fish tissue data have been received the sample results will be compared to provincial and/or federal fish tissue guidelines where they exist.

Next Steps

The B.C.-Alaska Transboundary Rivers Monitoring Project has outlined the following action items for continued work in 2020:

- Analysis and reporting of 2018 benthic macroinvertebrate and periphyton sampling data and the 2018/2019 fish sample data when available,
- Data comparisons with the 2017 Southeast Data Mining Project (Bellmore, 2017) gathered for the State of Alaska (Alaska, DEC commitment),
- Analysis and reporting out on data validation and split sampling audits for KSM, Brucejack, and Red Chris mines (B.C., ENV commitment) and
- Develop final report in April 2020.

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Appendix

NOTES:

In Table 5 the “Location in Watershed” column identifies the location of the sample sites in the watershed relative to the mine sites identified in the Site Location Description column.

In Tables 6, 7 and 8, the term Reference Site is used to identify those sample locations furthest upstream in the watershed and does not characterize a specific water quality condition.

Table 5. B.C and Alaska Sampling Sites and Location Descriptions

TAKU RIVER WATERSHED				
Location in Watershed	**Site Name**	**Site Location Description**	**NAD 83 Datum****	
			Latitude	**Longitude**
Tulsequah River upstream of mining	TAKU 1	Tulsequah River mainstem (site synonym SW16-1), 1 km upstream from Tulsequah Chief mining project	58.744029	-133.61494
	TAKU 8	Tulsequah River mainstem upstream of Shazah Creek.	58.763	-133.646
	TAKU 9	Side channel on opposite side of the Tulsequah River from Taku 1 and Taku 8	58.756	-133.665
Tulsequah River downstream of mining	TAKU 2	Tulsequah side-channel, ~1.25 km downstream from Tulsequah Chief mining project	58.724072	-133.594682
	TAKU 3	Tulsequah mainstem. ~3-4km downstream of Tulsequah Mine.	58.698506	-133.601925
	TAKU 10	Tulsequah River ~7.5km downstream of Tulsequah Mine site.	58.666	-133.593
Taku River Mainstem	TAKU 4	Taku mainstem, ~1km upstream of confluence with the Tulsequah River.	58.633846	-133.544719
	TAKU 5	Taku mainstem, 800 m downstream of confluence with the Tulsequah River	58.624369	-133.555016
	TAKU 11	Taku River mainstem ~2km downstream of confluence with Tulsequah River and downstream of Stuhini Creek confluence.	58.611	-133.568
Whitewater Creek	TAKU 6	"Whitewater Creek" tributary to Tulsequah River, upstream of closed New Polaris Mine.	58.700144	-133.628312
	TAKU 7	"Whitewater Creek" tributary to Tulsequah River, downstream of closed New Polaris Mine.	58.682	-133.628
Downstream of B.C. – Alaska Border	Taku A	Taku River mainstem near Wright River confluence (NRS18 AK 10159)	58.5304	-133.7479
	Taku B	Taku River mainstem~ before Johnson Creek confluence (NRS18 AK 10160)	58.5146	-133.8541
	Taku C	Taku River mainstem (NRS18 AK 10162)	58.5388	-133.7055
	Taku D	Taku River mainstem~ 15 miles downstream of Alaska Dept. of Fish & Game smolt camp (NRS18 AK 10165)	58.5021	-133.9221
	Taku E	Taku River mainstem~ near US Canada international border (NRS18 AK 10167)	58.5791	-133.6418
	Taku F	Taku River mainstem downstream of Fish Creek confluence (NRS18 AK Taku1)	58.5579	-133.6785
	Taku G	Taku River mainstem~20 miles downstream of Alaska Dept. of Fish & Game smolt camp (NRS18 AK Taku2)	58.484	-133.9735

STIKINE RIVER WATERSHED				
Location in Watershed	**Site Name**	**Site Location Description**	**NAD 83 Datum**	
			Latitude	**Longitude**
Stikine River downstream of mining	STIKINE 1	Stikine River mainstem - ~7km downstream of Skud River and near confluence with Flood River. (Galore Creek mining project)	57.206660	-131.803923
	STIKINE 2	Stikine River mainstem, ~4km downstream from Mess Creek (Schaft Creek mining project).	57.870242	-131.267409
Christina Creek	STIKINE 6	Christina Creek tributary to Stikine River. ~2km downstream of Stikine /Scud River confluence	57.23947	-131.87495
Stikine River upstream of mining	STIKINE 3	Stikine River mainstem at Telegraph Creek, ~3km upstream of Mess Creek	57.899996	-131.159452
	STIKINE 7	Stikine River mainstem ~12km upstream of Telegraph Creek town site and ~15km upstream of Mess Creek confluence.	57.979	-131.06474
Iskut River downstream of hydroelectric	STIKINE 4	Iskut River mainstem downstream of Johnson River and various hydroelectric and mining projects.	56.738900	-131.673600
	STIKINE 5	Johnson River upstream of confluence with Iskut River mainstem. Mountain runoff.	56.735394	-131.637083
Downstream of B.C. – Alaska Border	Stikine A	Stikine River mainstem downstream of Fifteen Mile Island (NRS18 AK 10064)	56.6853	-132.2414
	Stikine B	Stikine River mainstem ~6 miles downstream of the border (NRS18 AK 10139)	56.6747	-131.9988
	Stikine C	Stikine River mainstem upstream of Shakes Lake (NRS18 AK 10147)	56.7028	-132.0451
	Stikine D	Stikine River mainstem near US Canada International Border (NRS18 AK 10150)	56.6596	-131.8389
	Stikine E	Stikine River mainstem at Shakes Lakes confluence (NRS18 AK Stik1)	56.7096	-132.1051
	Stikine F	Stikine River mainstem (NRS18 AK Stik2)	56.6677	-131.9352

UNUK RIVER WATERSHED				
Location in Watershed	**Site Name**	**Site Location Description**	**NAD 83 Datum**	
			Latitude	**Longitude**
Unuk River downstream of mining	UNUK 1	Unuk River mainstem ~3km upstream of US Border and downstream of KSM mine project (UR2 site). Downstream of Unuk River / Canyon Creek confluence.	56.353745	-130.696852
	UNUK 3	Unuk River mainstem downstream of Sulphurets Creek. (aka KSM UR1 site).	56.471680	-130.514140
Sulphurets Creek	UNUK 4	Sulphurets Creek -downstream of mining projects. (aka KSM SC3)	56.489608	-130.494113
South Unuk River (no mining)	UNUK 2	South Unuk River reference site ~800m upstream of KSM SUNR E273103. No mining activity	56.358390	-130.440340
Unuk River upstream of mining	UNUK 5	Unuk mainstem upstream of KSM and Brucejack projects. Near KSM site UR1A.	56.49259	-130.50249
Downstream of B.C. – Alaska Border	Unuk A	Unuk River, heavily braided section (NRS18 AK 10177)	56.1822	-130.919
	Unuk B	Unuk River mainstem, near USGS Gage Station (NRS18 AK 10178)	56.2398	-130.8804
	Unuk C	Unuk River mainstem at US Canada International Border (NRS18 AK 10180)	56.3393	-130.7339
	Unuk D	Unuk River, heavily braided section (NRS18 AK 10181)	56.1461	-130.9567
	Unuk E	Unuk River, heavily braided section (NRS18 AK 10182)	56.1998	-130.8973
	Unuk F	Unuk River mainstem near US Canada International Border (NRS18 AK Unuk1)	56.313	-130.772
	Unuk G	Unuk River mainstem near Blue River confluence, lava rock canyon (NRS18 AK Unuk2)	56.2582	-130.8194

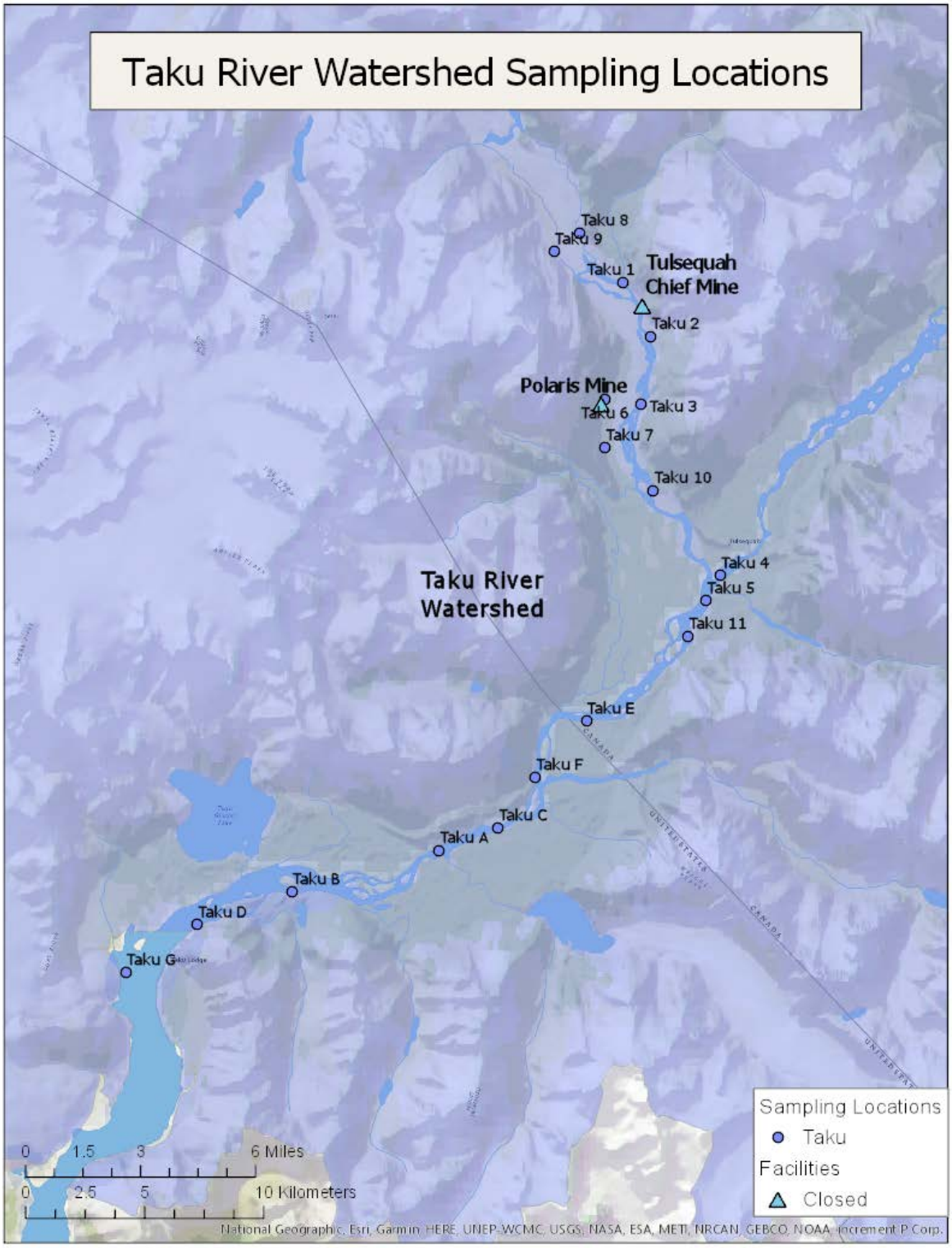

Figure 2. Taku Watershed Study Area and Sampling Sites

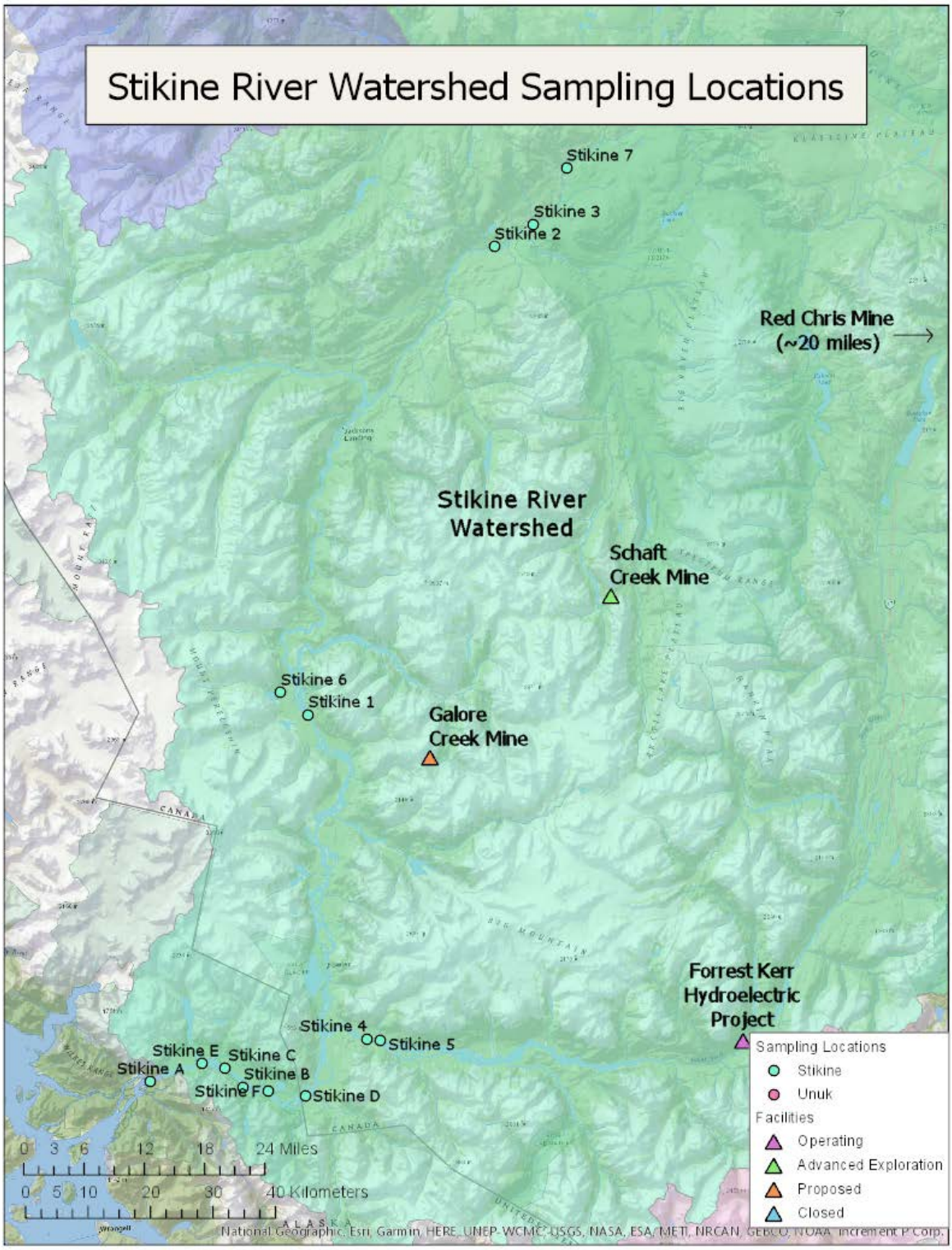

*Figure 3. Stikine Watershed Study Area and Sampling Sites**

*Red Chris Mine is currently listed as operating by the Master Project List (AK DNR & B.C. EMPR, 2019).

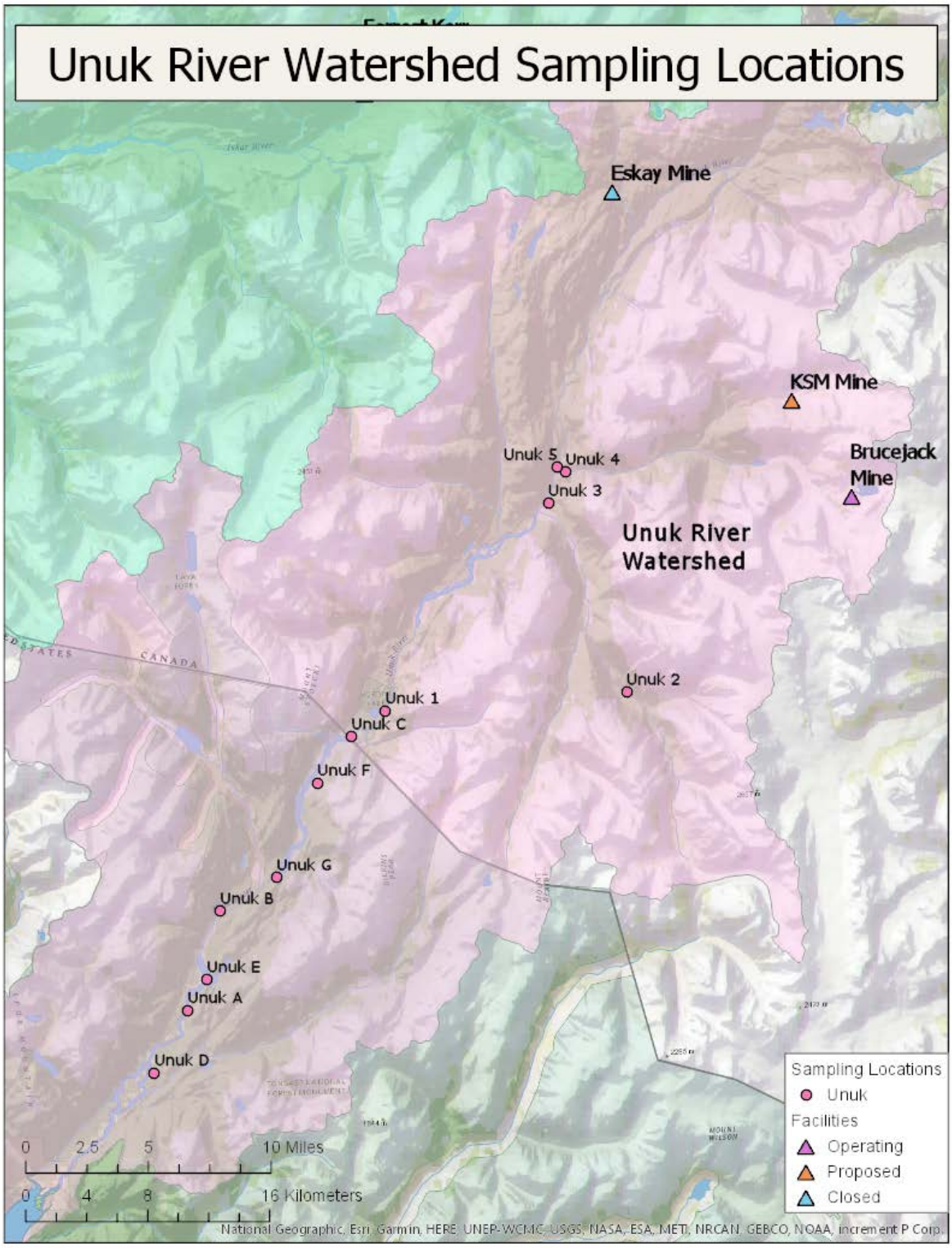

Figure 4. Unuk Watershed Study Area and Sampling Sites

Table 6. Taku Watershed Water Chemistry Analysis

			pH	Temperature	Turbidity	Dissolved Organic Carbon	Total Metals						Dissolved Metals					Alkalinity	Ammonia	Kjeldahl Nitrogen as N	Nitrate Nitrite as N	Nitrogen, Total	Phosphorus	Specific Conductance	Sulfate	Total Suspended Solids
			-	°C	NTU	mg/l	Calcium mg/l	Magnesium mg/l	Potassium mg/l	Sodium mg/l	Selenium µg/l	Zinc[1] µg/l	Cadmium[1] µg/l	Copper[1] µg/l	Lead[1] µg/l	Selenium[2] µg/l	Zinc[1,2] µg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µS/cm	mg/l	mg/l
B.C. Freshwater Water Quality Guidelines for Aquatic Life		Long Term Chronic (30 day) (µg/l)	6.5 - 8.5	<15							1.00	7.50	0.127	0.60												
		Short Term Acute (µg/l)		<19							2.00	33.00	0.288	3.80												
Sampling Location ID		**Sampling Date**	**Watershed**																							
Taku A		06/26/18	Taku	7.93	9.20	149.00	1.20	20.40	5.38	2.04	1.91	NA	NA	ND	0.66	0.07	0.21	ND	59.00	ND	0.47	0.13	0.60	ND	130.00	14.00	91.00
Taku B		06/25/18	Taku	7.98	8.50	218.00	0.91	19.40	5.65	2.61	2.02	NA	NA	ND	0.61	0.10	0.22	ND	52.00	ND	0.23	0.29	0.52	ND	120.00	12.00	150.00
Taku C		06/27/18	Taku	8.00	9.30	121.00	0.99	22.30	5.97	2.32	2.15	NA	NA	0.01	0.75	0.08	0.22	ND	55.00	ND	ND	0.08	0.08	ND	140.00	14.00	80.00
Taku D		06/24/18	Taku	8.16	8.90	259.00	0.80	18.80	6.49	2.96	2.16	NA	NA	0.01	0.66	ND	0.19	ND	49.00	0.02	ND	0.05	0.05	ND	130.00	11.00	160.00
Taku E		06/28/18	Taku	8.04	9.30	104.00	1.10	21.40	5.42	1.77	1.97	NA	NA	0.03	0.83	0.11	0.25	ND	58.00	ND	ND	0.07	0.07	ND	150.00	15.00	85.00
Taku F		06/27/18	Taku	8.04	9.40	132.00	0.95	22.90	6.06	2.35	14.10	NA	NA	0.02	0.68	ND	0.25	ND	57.00	ND	0.34	0.08	0.42	ND	150.00	14.00	73.00
Taku G		06/23/18	Taku	7.99	9.70	266.00	0.80	19.50	6.93	3.52	2.34	NA	NA	ND	0.70	0.02	0.18	ND	48.00	*ND*	ND	0.05	0.05	ND	120.00	11.00	200.00
Reference site	Taku 1	08/24/17	Taku	7.21	0.90	112.00	*0.50*	10.50	3.17	1.90	1.30	0.106	19.2	*0.01*	0.10	0.02	0.122	0.12	21.00	*0.01*	*0.05*	0.02	*0.03*	*0.00*	32.80	9.55	35.70
	Taku 1	11/19/18	Taku	7.75	0.90	115.00	1.01	10.00	1.74	1.49	0.80	0.125	10.1	*0.01*	0.23	0.02	0.145	0.3	21.70	*0.01*	*0.05*	0.07	0.09	0.00	0.06	8.59	21.90
	Taku 1	02/25/19	Taku	-	-	17.80	0.76	11.60	1.55	1.35	0.84	0.256	2.92	*0.01*	0.08	0.01	0.308	0.26	27.10	*0.01*	*0.05*	0.09	0.09	0.00	-	12.40	*3.00*
	Taku 1	06/03/19	Taku	7.78	2.30	80.10	*0.50*	11.20	2.03	1.77	1.27	0.174	9.02	*0.01*	0.17	0.02	0.25	0.21	21.40	*0.01*	*0.05*	0.04	0.06	0.05	0.08	13.20	12.10
Taku 2		08/24/17	Taku	6.78	1.90	96.50	0.50	12.90	2.73	1.84	1.26	0.15	26.2	0.02	0.33	0.02	0.169	5.62	23.60	*0.01*	*0.05*	0.03	*0.03*	*0.00*	37.30	10.60	41.10
Taku 2		11/19/18	Taku	7.85	2.10	83.10	1.43	17.80	2.29	1.12	0.79	0.331	**69.2**	0.20	**5.88**	0.04	0.268	**42.6**	35.70	*0.01*	*0.05*	0.14	0.16	0.00	0.11	17.60	42.70
Taku 2		02/25/19	Taku	-	-	0.41	0.76	25.20	1.96	0.78	0.92	0.322	16.7	0.19	0.35	0.01	0.365	16	55.60	*0.01*	*0.05*	0.18	0.18	*0.00*	-	20.00	*3.00*
Taku 2		06/03/19	Taku	7.62	3.40	68.20	*0.50*	13.40	2.05	1.47	1.11	0.213	30.9	0.07	1.04	0.02	0.27	14.5	28.70	*0.01*	*0.05*	0.05	0.07	0.00	0.09	14.80	8.90
Taku 3		08/24/17	Taku	6.72	2.00	94.70	0.58	11.30	3.05	1.88	1.22	0.181	18.5	*0.01*	0.20	0.02	0.189	1.47	22.70	*0.01*	*0.05*	0.03	*0.03*	*0.00*	36.60	10.30	37.80
Taku 3		09/11/18	Taku	7.87	3.20	164.00	0.68	10.80	2.57	1.68	0.92	0.14	29.3	*0.01*	0.45	0.04	0.125	1.78	24.00	*0.01*	*0.05*	0.02	0.05	0.00	66.90	9.67	98.70
Taku 3		11/19/18	Taku	8.30	2.40	76.20	1.34	18.60	2.16	1.05	0.87	0.244	**49.1**	0.14	3.93	0.04	0.262	24.9	39.00	*0.01*	*0.05*	0.13	0.17	0.00	0.09	15.80	25.10
Taku 3		02/25/19	Taku	-	-	2.69	0.54	25.70	2.35	1.31	3.71	0.323	**58.7**	0.26	3.96	0.02	0.401	**58.9**	57.30	0.01	*0.05*	0.13	0.18	*0.02*	-	20.50	*3.00*
Taku 3		06/03/19	Taku	7.58	4.20	59.60	*0.50*	13.20	2.06	1.46	1.13	0.213	21	0.44	0.73	0.02	0.215	7.02	29.80	0.01	*0.05*	0.05	0.06	*0.02*	0.09	14.10	19.70
Reference site	Taku 4	08/24/17	Taku	7.27	9.80	109.00	1.33	24.60	5.78	1.05	1.89	0.167	14.3	*0.01*	0.48	0.03	0.249	0.63	63.80	0.01	0.07	0.03	0.10	*0.00*	90.90	12.10	134.00
	Taku 4	09/10/18	Taku	8.07	10.00	23.90	0.83	21.50	5.11	0.72	1.61	0.21	3.98	*0.01*	0.36	0.01	0.2	0.13	62.90	*0.01*	*0.05*	0.03	0.07	*0.00*	154.70	14.90	37.40
	Taku 4	11/19/18	Taku	8.36	1.60	8.86	1.15	31.00	7.00	0.67	2.33	0.284	1.52	*0.01*	0.49	0.03	0.322	0.54	87.60	*0.01*	0.06	0.14	0.21	0.00	0.20	19.70	16.70
	Taku 4	02/25/19	Taku	-	-	0.59	0.99	35.40	9.10	0.72	2.83	0.395	1.76	*0.01*	0.31	0.01	0.388	0.41	56.70	*0.01*	*0.05*	0.19	0.19	*0.00*	-	25.90	*3.00*
	Taku 4	06/03/19	Taku	7.92	9.60	43.30	1.30	23.40	5.26	0.74	1.72	0.222	4.57	0.01	0.63	0.03	0.259	0.27	69.80	*0.01*	*0.05*	0.06	0.11	*0.00*	7.44	13.90	45.30
Taku 5		08/24/17	Taku	6.80	3.00	85.60	0.54	12.80	2.79	1.73	1.30	0.146	18.1	*0.01*	0.21	0.02	0.129	0.94	23.80	*0.01*	*0.05*	0.02	*0.03*	*0.00*	38.50	10.40	39.80
Taku 5		11/19/18	Taku	8.20	1.80	7.90	1.28	32.00	6.60	0.68	2.28	0.343	1.68	*0.01*	0.51	0.02	0.335	0.57	87.80	*0.01*	*0.05*	0.15	0.19	0.00	0.11	19.40	13.10
Taku 5		02/25/19	Taku	-	-	0.71	0.87	35.10	8.16	0.75	3.07	0.414	0.98	*0.01*	0.37	0.01	0.337	0.87	114.00	*0.01*	*0.05*	0.19	0.20	0.00	-	25.00	*3.00*
Taku 5		06/03/19	Taku	7.93	9.50	48.40	1.48	25.10	5.41	0.75	1.66	0.21	4.99	*0.01*	0.64	0.03	0.234	0.6	70.10	*0.01*	*0.05*	0.07	0.11	0.00	0.15	13.90	59.40
Reference site	Taku 6	09/11/18	Taku	7.24	10.90	0.86	0.95	15.40	4.42	0.94	2.55	0.201	5.24	0.04	0.28	0.01	0.183	1.59	43.20	0.02	0.07	0.03	0.10	*0.00*	130.00	17.20	*3.00*
	Taku 6	02/26/19	Taku	-	-	1.23	0.92	16.50	4.10	0.96	5.95	0.203	2.51	*0.01*	0.27	0.02	0.242	4.29	47.60	0.01	*0.05*	0.17	0.22	0.00	-	16.10	3.20
	Taku 6	06/03/19	Taku	7.44	8.70	0.21	0.79	10.60	3.21	0.66	1.25	0.113	1.63	0.01	0.28	0.02	0.106	1.49	35.50	*0.01*	*0.05*	0.03	0.07	*0.00*	0.09	7.48	*3.00*
Taku 7		09/11/18	Taku	7.36	12.70	1.37	0.99	19.50	4.11	1.14	4.19	0.166	30.3	0.14	1.47	0.35	0.137	27.9	53.80	0.01	*0.05*	0.06	0.10	*0.00*	140.30	13.60	*3.00*
Taku 7		02/25/19	Taku	-	-	1.54	1.01	20.40	5.19	1.07	5.56	0.146	**50.6**	0.16	1.15	0.14	0.153	**48.1**	58.00	0.02	*0.05*	0.17	0.20	0.00	-	14.80	*3.00*
Taku 7		06/03/19	Taku	7.44	10.00	0.46	0.97	12.60	3.43	0.74	1.70	0.107	15.9	0.07	1.10	0.24	0.102	14.4	41.20	*0.01*	*0.05*	0.05	0.07	*0.00*	0.10	7.59	*3.00*
Reference	Taku 8	09/10/18	Taku	8.20	0.90	169.00	0.55	8.71	3.13	2.13	1.11	0.12	22	*0.01*	0.15	0.04	0.114	0.22	18.70	*0.01*	*0.05*	0.02	0.04	0.00	55.10	7.80	80.20
Taku 10		09/10/18	Taku	7.91	4.50	131.00	0.51	11.70	2.78	1.90	1.09	0.161	25	*0.01*	0.19	0.01	0.2	1.15	26.40	*0.01*	*0.05*	0.03	0.04	*0.00*	73.70	10.30	52.20
Taku 11		09/10/18	Taku	8.12	9.60	19.20	0.81	21.70	4.76	0.70	1.67	0.161	3.79	*0.01*	0.36	0.01	0.202	0.2	67.00	*0.01*	*0.05*	0.03	0.08	*0.00*	154.70	14.90	33.60
Average				**7.74**	**6.14**	**75.59**	**0.88**	**18.81**	**4.26**	**1.44**	**2.28**	**0.211**	**18.38**	**0.05**	**0.83**	**0.05**	**0.22**	**8.97**	**47.72**	**0.01**	**0.08**	**0.08**	**0.13**	**0.01**	**63.23**	**14.03**	**45.46**
Standard Deviation				0.45	3.88	73.92	0.29	7.14	1.96	0.71	2.31	0.085	18.067	0.10	1.19	0.07	0.08	15.99	21.73	0.00	0.09	0.06	0.13	0.01	61.72	4.37	49.82
Min				**6.72**	**0.90**	**0.21**	**0.50**	**8.71**	**1.55**	**0.66**	**0.79**	**0.11**	**0.98**	**0.01**	**0.08**	**0.01**	**0.10**	**0.12**	**18.70**	**0.01**	**0.05**	**0.02**	**0.03**	**0.00**	**0.06**	**7.48**	**3.00**
Max				**8.36**	**12.70**	**266.00**	**1.48**	**35.40**	**9.10**	**3.52**	**14.10**	**0.41**	**69.20**	**0.44**	**5.88**	**0.35**	**0.40**	**58.99**	**114.00**	**0.02**	**0.47**	**0.29**	**0.60**	**0.05**	**154.70**	**25.90**	**200.00**
Median				**7.91**	**8.50**	**72.20**	**0.89**	**19.10**	**4.11**	**1.33**	**1.69**	**0.20**	**15.90**	**0.01**	**0.48**	**0.02**	**0.22**	**1.15**	**48.50**	**0.01**	**0.05**	**0.06**	**0.09**	**0.00**	**38.50**	**13.95**	**34.65**

Italicized results were reported at or below the detection limit for the analysis, NA – Not Available, ND – Not Detected

[1] - Parameter is hardness dependent. Hardness of 50mg/l was used for WQG thresholds.

[2] – Parameter is measured as Dissolved by DEC but compared to WQG thresholds for Total concentration.

Table 7. Stikine Watershed Water Chemistry Analysis

			pH	Temperature	Turbidity	Dissolved Organic Carbon	Total Metals						Dissolved Metals					Alkalinity	Ammonia	Kjeldahl Nitrogen as N	Nitrate Nitrite as N	Nitrogen, Total	Phosphorus	Specific Conductance	Sulfate	Total Suspended Solids
							Calcium	Magnesium	Potassium	Sodium	Selenium	Zinc[1]	Cadmium[1]	Copper[1]	Lead[1]	Selenium[2]	Zinc[1,2]									
			-	°C	NTU	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µS/cm	mg/l	mg/l
B.C. Freshwater Water Quality Guidelines for Aquatic Life	Long Term Chronic (30 day) (µg/l)		6.5 - 8.5	<15							1.00	7.50	0.127	0.60												
	Short Term Acute (µg/l)			<19							2.00	33.00	0.288	3.80												
Sampling Location ID	**Sampling Date**	**Watershed**																								
Stikine A	07/22/18	Stikine	8.37	10.50	300.00	0.67	20.90	5.00	2.46	1.90	NA	NA	ND	0.266	ND	0.162	ND	40.00	ND	ND	0.040	ND	ND	110.00	11.00	-
Stikine B	07/17/18	Stikine	7.50	8.30	252.00	0.76	20.40	5.74	2.26	1.72	NA	NA	ND	0.386	ND	0.233	ND	44.00	0.013	0.170	0.049	0.220	ND	110.00	13.00	170.00
Stikine C	07/19/18	Stikine	7.85	9.50	218.00	2.10	21.30	3.40	1.18	1.39	NA	NA	0.011	0.240	ND	0.264	ND	48.00	ND	ND	0.049	ND	ND	120.00	14.00	140.00
Stikine D	07/18/18	Stikine	8.20	7.60	374.00	0.90	21.30	6.75	2.62	1.90	NA	NA	ND	0.191	ND	0.224	ND	45.00	0.011	ND	0.057	ND	0.250	110.00	13.00	350.00
Stikine E	07/20/18	Stikine	7.70	10.70	200.00	2.20	19.60	5.23	2.38	2.06	NA	NA	ND	0.365	ND	0.200	ND	45.00	ND	ND	ND	ND	ND	110.00	15.00	140.00
Stikine F	07/21/18	Stikine	8.40	10.60	249.00	0.73	16.70	5.99	2.42	1.93	NA	NA	ND	0.272	ND	0.194	ND	45.00	ND	ND	0.061	ND	ND	110.00	14.00	150.00
Stikine 1	08/23/17	Stikine	7.72	9.50	321.00	1.16	23.30	5.08	2.15	1.34	0.269	28.4	0.005	0.585	0.020	0.374	0.33	52.80	*0.005*	0.068	0.023	0.091	0.003	125.00	12.80	306.00
Stikine 1	09/15/18	Stikine	8.11	7.90	11.90	1.35	22.60	4.34	0.80	2.20	0.442	2.26	0.005	0.592	0.015	0.441	0.19	60.90	*0.005*	*0.050*	0.024	0.067	0.002	162.00	23.40	20.20
Stikine 1	11/27/18	Stikine	8.13	1.20	5.13	1.59	25.60	4.49	1.11	2.77	0.426	1.95	0.012	0.933	0.046	0.445	1.12	64.80	*0.005*	0.081	0.141	0.222	0.004	180.00	23.20	6.60
Stikine 1	02/26/19	Stikine	8.02	0.00	-	0.96	33.10	6.73	1.15	4.19	0.618	0.43	0.005	0.351	0.006	0.553	0.14	89.30	-	-	-	0.147	0.007	232.00	28.90	-
Stikine 1	06/03/19	Stikine	7.90	10.90	24.60	2.16	27.40	4.18	1.41	1.67	0.476	3.07	0.022	0.871	0.012	0.503	0.70	67.90	*0.005*	0.147	0.078	0.224	0.004	172.00	16.10	24.90
Stikine 2	08/23/17	Stikine	7.45	10.30	602.00	1.75	25.50	7.39	1.54	2.53	0.27	32.9	0.005	0.686	0.011	0.204	0.34	61.60	*0.005*	*0.120*	0.014	*0.120*	0.004	87.4	16.40	782.00
Stikine 2	09/15/18	Stikine	8.05	7.40	5.23	1.55	22.00	5.60	0.60	3.03	0.374	1.43	0.005	0.433	0.008	0.389	0.34	66.10	*0.005*	0.051	0.010	0.061	0.003	172	25.50	10.00
Stikine 2	11/27/18	Stikine	8.06	0.10	1.80	1.39	24.40	7.17	0.77	4.09	0.456	2.6	0.007	0.504	0.045	0.406	1.06	82.30	*0.005*	0.083	0.049	0.132	0.009	0	28.00	6.40
Stikine 2	02/26/19	Stikine	8.16	0.00	-	1.04	37.60	4.31	1.54	5.02	0.924	2.7	0.027	0.545	0.025	0.932	2.10	92.80	*0.017*	0.158	0.277	0.435	0.004	241.4	32.50	-
Stikine 2	06/03/19	Stikine	7.79	10.10	55.10	2.97	15.60	5.16	0.93	2.34	0.415	8.75	0.059	1.030	0.030	0.300	1.62	44.40	0.006	0.161	0.020	0.181	0.004	89.9	14.90	60.10
Stikine 3	08/23/17	Stikine	7.39	12.40	99.30	2.32	20.10	6.55	0.77	2.61	0.487	15.5	0.005	0.613	0.007	0.403	0.86	58.80	0.005	0.092	0.205	0.112	0.003	99.9	24.60	126.00
Stikine 3	06/03/19	Stikine	7.53	9.10	52.60	2.43	14.60	4.57	0.50	1.78	0.409	4.84	0.012	0.834	0.017	0.291	1.03	39.40	0.005	0.110	0.149	0.125	0.003	111.3	16.00	68.50
Reference site	Stikine 4	08/23/17	Stikine	7.18	6.00	896.00	1.32	30.20	5.52	1.97	2.04	0.32	65.9	0.005	0.420	0.023	0.299	0.34	50.90	0.008	*0.240*	0.046	*0.240*	0.004	13.8	11.70	882.00
	Stikine 4	09/15/18	Stikine	7.89	5.70	31.20	1.07	22.80	3.55	1.02	2.82	0.413	5.08	0.005	0.230	0.008	0.442	0.18	57.90	*0.005*	*0.050*	0.041	0.074	0.003	163.5	26.20	59.00
	Stikine 4	11/27/18	Stikine	7.94	3.60	8.96	0.94	23.40	3.37	1.12	2.97	0.399	2.54	0.005	0.680	0.022	0.394	0.93	59.10	*0.005*	*0.050*	0.165	0.204	0.002	104.6	26.00	10.40
	Stikine 4	02/26/19	Stikine	7.56	0.00	-	1.25	28.40	8.53	0.91	4.89	0.447	2.45	0.005	0.467	0.015	0.522	1.32	94.00	-	-	-	0.193	0.009	275.9	29.90	-
	Stikine 4	06/03/19	Stikine	7.72	8.40	111.00	0.93	24.60	4.29	1.06	2.12	0.477	11.4	0.013	0.408	0.009	0.513	0.35	57.00	0.005	*0.050*	0.136	0.180	0.003	83.9	19.30	113.00
Reference site	Stikine 7	09/15/18	Stikine	8.09	6.90	4.77	1.57	22.1	6.02	0.475	2.78	0.453	1.82	0.005	0.447	0.005	0.428	0.39	64.6	*0.0050*	0.062	0.0051	0.067	0.0021	178.1	29.9	9.4
	Stikine 7	11/27/18	Stikine	8.14	0.90	0.37	2.75	34.4	7.99	1.04	7.04	0.135	1.66	0.005	0.668	0.036	0.112	1.00	119	0.0067	0.106	0.668	0.774	0.0257	142.7	16.2	4.2
	Stikine 7	02/26/19	Stikine	7.82	0.00	-	1.26	28.9	8.25	0.807	4.60	0.488	0.5	0.005	0.386	0.005	0.493	0.26	91.2	-	-	-	0.140	0.0066	194.2	31.4	-
	Stikine 7	06/03/19	Stikine	7.38	9.00	49.00	2.85	14.7	4.62	0.475	1.89	0.352	4.54	0.008	0.784	0.174	0.352	0.81	39.2	0.0104	0.158	0.0166	0.174	0.0037	110.4	16.2	63.5
		Average	**7.85**	**6.54**	**168.39**	**1.55**	**23.76**	**5.55**	**1.31**	**2.80**	**0.431**	**9.558**	**0.01**	**0.53**	**0.03**	**0.37**	**0.73**	**62.26**	**0.01**	**0.11**	**0.10**	**0.19**	**0.02**	**133.70**	**20.34**	**159.19**
		Standard Deviation	0.32	4.17	222.72	0.68	5.74	1.47	0.68	1.35	0.15	15.63	0.01	0.23	0.04	0.17	0.53	20.36	0.00	0.05	0.14	0.15	0.05	61.66	6.98	237.50
		Min	**7.18**	**0.00**	**0.37**	**0.67**	**14.60**	**3.37**	**0.48**	**1.34**	**0.14**	**0.43**	**0.01**	**0.19**	**0.01**	**0.11**	**0.14**	**39.20**	**0.01**	**0.05**	**0.01**	**0.06**	**0.00**	**0.00**	**11.00**	**4.20**
		Max	**8.40**	**12.40**	**896.00**	**2.97**	**37.60**	**8.53**	**2.62**	**7.04**	**0.92**	**65.90**	**0.06**	**1.03**	**0.17**	**0.93**	**2.10**	**119.00**	**0.02**	**0.24**	**0.67**	**0.77**	**0.25**	**275.90**	**32.50**	**882.00**
		Median	**7.89**	**7.90**	**55.10**	**1.35**	**22.80**	**5.23**	**1.11**	**2.34**	**0.43**	**2.70**	**0.01**	**0.47**	**0.01**	**0.39**	**0.70**	**58.80**	**0.01**	**0.09**	**0.05**	**0.16**	**0.00**	**111.30**	**16.40**	**66.00**

Italicized results were reported at or below the detection limit for the analysis

[1] - Parameter is hardness dependent. Hardness of 50mg/l was used for WQG thresholds.

[2] – Parameter is measured as Dissolved by DEC, but compared to WQG thresholds for Total concentration.

Table 8. Unuk Watershed Water Chemistry Analysis

			pH	Temperature	Turbidity	Dissolved Organic Carbon	Total Metals						Dissolved Metals					Alkalinity	Ammonia	Kjeldahl Nitrogen as N	Nitrate Nitrite as N	Nitrogen, Total	Phosphorus	Specific Conductance	Sulfate	Total Suspended Solids
							Calcium	Magnesium	Potassium	Sodium	Selenium	Zinc[1]	Cadmium[1]	Copper[1]	Lead[1]	Selenium[2]	Zinc[1,2]									
			-	°C	NTU	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µS/cm	mg/l	mg/l
B.C. Freshwater Water Quality Guidelines for Aquatic Life		Long Term Chronic (30 day) (µg/l)	6.5 - 8.5	<15							1.00	7.5	0.127	0.60	4.63											
		Short Term Acute (µg/l)		<19							2.00	33.00	0.288	3.80	33.79											
Sampling Location ID		**Sampling Date**	**Watershed**																							
Unuk A		07/25/18	Unuk	7.67	8.10	93.30	0.38	12.90	1.45	0.81	1.00	NA	NA	0.03	0.40	ND	0.22	14.90	28.00	0.029	0.16	0.05	0.21	ND	80.00	11.00	52.00
Unuk B		07/27/18	Unuk	7.42	9.80	118.40	0.58	12.50	2.56	1.65	1.35	NA	NA	0.03	0.80	0.10	0.20	19.30	28.00	ND	0.28	0.05	0.33	ND	78.00	10.00	49.00
Unuk C		08/15/18	Unuk	8.02	6.60	81.00	0.49	14.40	1.48	0.71	0.65	NA	NA	0.05	1.85	ND	0.26	35.50	31.00	0.010	0.22	0.05	0.27	ND	88.00	13.00	94.00
Unuk D		07/25/18	Unuk	7.52	9.50	81.90	0.62	13.70	2.04	1.30	1.24	NA	NA	0.03	0.40	ND	0.22	12.80	27.00	ND	0.43	0.04	0.47	ND	80.00	11.00	40.00
Unuk E		07/28/18	Unuk	7.50	7.80	246.00	0.63	15.10	1.67	1.14	0.95	NA	NA	0.03	1.13	0.07	0.21	30.80	31.00	0.051	0.29	0.05	0.34	0.39	82.00	9.20	140.00
Unuk F		07/26/18	Unuk	7.85	8.80	86.60	0.66	14.20	2.23	1.31	0.90	NA	NA	0.03	0.30	ND	0.29	15.00	28.00	0.025	ND	0.05	ND	ND	92.00	14.00	47.00
Unuk G		07/27/18	Unuk	7.55	7.70	114.70	0.45	15.30	1.49	0.78	0.69	NA	NA	0.04	0.85	ND	0.22	29.70	32.00	ND	0.25	0.04	0.29	ND	93.00	12.00	71.00
Unuk 1		09/13/18	Unuk	7.71	3.90	21.10	*0.50*	19.70	1.71	0.90	0.97	0.49	12.10	0.08	0.57	0.02	0.49	3.59	39.40	*0.005*	*0.05*	0.05	0.06	*0.00*	122.50	22.10	23.30
Unuk 1		11/27/18	Unuk	8.01	3.70	4.61	0.81	27.20	2.49	1.02	1.75	0.74	27.50	0.22	2.68	0.02	0.70	10.30	53.40	*0.005*	*0.05*	0.20	0.22	0.00	111.90	39.50	3.00
Unuk 1		02/26/19	Unuk	7.83	0.10	-	0.70	36.00	2.90	1.20	2.78	0.82	10.50	0.13	1.20	0.02	0.83	7.96	65.00	*0.005*	*0.05*	0.22	0.23	0.00	236.50	46.10	-
Unuk 1		06/03/19	Unuk	7.72	6.80	40.30	*0.50*	22.20	2.32	0.90	1.12	0.64	38.10	0.22	1.67	0.01	0.51	8.86	33.90	*0.005*	*0.05*	0.09	0.11	*0.00*	133.00	28.90	54.70
Reference site	Unuk 2	09/13/18	Unuk	7.51	2.80	5.90	1.03	18.50	1.14	0.78	0.61	0.26	2.18	0.01	0.35	0.06	0.26	0.81	36.30	*0.005*	*0.05*	0.05	0.07	*0.00*	108.00	18.20	11.70
	Unuk 2	11/27/18	Unuk	7.87	2.80	1.46	0.80	28.80	1.74	1.25	1.03	0.46	0.92	0.01	0.66	0.05	0.44	0.37	53.60	*0.005*	*0.05*	0.24	0.24	*0.00*	106.30	34.10	3.20
	Unuk 2	02/26/19	Unuk	7.91	0.80	-	*0.50*	39.40	2.33	1.38	1.25	0.56	0.33	0.01	0.30	0.02	0.66	0.35	65.50	*0.005*	*0.05*	0.34	0.36	*0.00*	238.90	47.90	-
	Unuk 2	06/03/19	Unuk	7.76	5.50	6.60	0.66	18.70	1.23	0.91	0.62	0.31	2.19	0.02	0.41	0.03	0.30	0.60	35.90	*0.005*	*0.05*	0.09	0.11	*0.00*	110.70	17.10	10.30
Unuk 3		09/13/18	Unuk	7.80	4.80	49.30	*0.50*	23.00	2.60	0.92	0.96	0.80	38.90	0.27	1.02	0.02	0.76	12.80	43.80	*0.005*	*0.05*	0.04	0.06	*0.00*	152.90	34.00	46.30
Unuk 3		11/27/18	Unuk	7.89	3.10	15.50	0.67	37.40	4.40	0.98	2.13	1.55	99.90	0.61	2.66	0.01	1.26	25.80	57.20	*0.005*	*0.05*	0.17	0.17	*0.00*	156.00	72.90	11.40
Unuk 3		02/26/19	Unuk	7.89	0.00	-	*0.50*	53.70	5.82	1.33	3.13	1.75	62.00	-	-	-	-	-	79.10	-	-	-	0.20	*0.00*	342.40	87.10	-
Unuk 3		06/03/19	Unuk	7.41	5.90	90.40	*0.50*	24.40	3.49	0.95	1.17	1.03	98.20	0.72	2.71	0.01	0.73	36.00	30.40	*0.005*	*0.05*	0.10	0.09	*0.00*	162.10	44.50	108.00
Unuk 4		09/13/18	Unuk	7.70	2.70	47.60	*0.50*	24.70	2.34	1.12	0.95	0.99	66.40	0.50	1.13	0.01	0.79	27.50	35.00	*0.005*	*0.05*	0.06	0.08	*0.00*	160.30	43.30	71.10
Unuk 4		11/27/18	Unuk	7.76	2.60	39.70	0.54	43.50	4.57	1.32	2.10	2.47	225.00	1.20	1.88	0.02	2.09	53.70	49.00	*0.005*	*0.05*	0.28	0.23	*0.00*	200.40	126.00	23.40
Unuk 4**		02/26/19	Unuk	7.93	0.20	-	2.02	35.10	5.15	1.11	3.57	0.91	8.66	0.10	1.06	0.06	0.83	7.38	74.90	-	-	-	0.51	0.01	440.10	37.40	-
Unuk 4		06/03/19	Unuk	7.30	4.70	90.30	0.61	33.20	3.66	1.40	1.61	1.95	226.00	2.28	13.90	0.01	1.06	153.00	11.90	0.006	0.22	0.20	0.42	*0.00*	220.10	85.70	95.30
Reference site	Unuk 5	09/13/18	Unuk	7.95	6.90	46.20	0.67	22.20	3.23	0.69	1.09	0.64	8.68	0.01	0.17	0.02	0.63	0.35	53.80	*0.005*	*0.05*	0.03	0.06	0.00	142.30	20.90	43.30
	Unuk 5**	11/27/18	Unuk	7.96	3.40	0.51	1.01	24.90	4.22	0.53	1.97	0.58	3.06	0.03	0.40	0.02	0.67	2.64	62.60	*0.005*	*0.05*	0.09	0.12	*0.00*	109.30	30.00	*3.00*
	Unuk 5	02/26/19	Unuk	7.90	0.00	-	*0.50*	67.10	5.96	1.79	3.52	2.27	154.00	1.18	2.56	0.01	2.16	52.20	80.10	*0.005*	*0.05*	0.29	0.26	*0.00*	238.10	135.00	-
	Unuk 5	06/03/19	Unuk	7.84	6.50	35.80	0.99	19.00	3.12	0.56	0.94	0.51	7.84	0.03	0.44	0.02	0.49	0.98	43.20	*0.005*	*0.05*	0.02	0.06	*0.00*	113.50	16.00	28.10
Average				**7.75**	**4.65**	**59.87**	**0.68**	**26.55**	**2.86**	**1.06**	**1.48**	**0.99**	**54.62**	**0.30**	**1.60**	**0.03**	**0.66**	**21.66**	**44.78**	**0.01**	**0.11**	**0.12**	**0.21**	**0.02**	**155.49**	**39.51**	**46.78**
Standard Deviation				0.20	3.02	56.37	0.32	13.25	1.38	0.31	0.87	0.65	71.76	0.53	2.64	0.02	0.51	31.05	17.85	0.01	0.11	0.10	0.13	0.09	85.95	34.09	37.38
Min				**7.30**	**0.00**	**0.51**	**0.38**	**12.50**	**1.14**	**0.53**	**0.61**	**0.26**	**0.33**	**0.01**	**0.17**	**0.01**	**0.20**	**0.35**	**11.90**	**0.01**	**0.05**	**0.02**	**0.06**	**0.00**	**78.00**	**9.20**	**3.00**
Max				**8.02**	**9.80**	**246.00**	**2.02**	**67.10**	**5.96**	**1.79**	**3.57**	**2.47**	**226.00**	**2.28**	**13.90**	**0.10**	**2.16**	**153.00**	**80.10**	**0.05**	**0.43**	**0.34**	**0.51**	**0.39**	**440.10**	**135.00**	**140.00**
Median				**7.80**	**4.70**	**46.90**	**0.61**	**23.00**	**2.49**	**1.02**	**1.12**	**0.77**	**19.80**	**0.05**	**0.94**	**0.02**	**0.57**	**12.80**	**39.40**	**0.01**	**0.05**	**0.06**	**0.22**	**0.00**	**122.50**	**30.00**	**44.80**

Italicized results were reported at or below the detection limit for the analysis

[1] - Parameter is hardness dependent. Hardness of 50mg/l was used for WQG thresholds.

[2] – Parameter is measured as Dissolved by DEC, but compared to WQG thresholds for Total concentration.

**-SUSPECT Unuk 4 and Unuk5 data were transposed for 02/26/19. Data will be reviewed prior to completing the final report

Table 9. Taku Watershed Sieved Sediment Lab Analysis

			Total Organic Carbon mg/kg	Aluminum mg/kg	Antimony mg/kg	Arsenic mg/kg	Cadmium mg/kg	Copper mg/kg	Iron mg/kg	Lead mg/kg	Manganese mg/kg	Nickel mg/kg	Selenium mg/kg	Silver mg/kg	Tin mg/kg	Vanadium mg/kg	Zinc mg/kg	Mercury mg/kg
	B.C. Working Sediment Quality Guidelines (Aquatic Life)	Lower SWQG (mg/kg dry weight)	-	-	-	5.90	0.60	35.70	21,200.00	35.00	460.00	16.00	2.00	0.50	-	-	123.00	0.17
		Upper SWQG (mg/kg dry weight)	-	-	-	17.00	3.50	197.00	43,766.00	91.30	1,100.00	75.00	-	-	-	-	315.00	0.49
Sampling Location ID	**Sampling Date**	**Watershed**																
Taku E-Sieved	6/28/2018	Taku	-	19,000.00	1.13	15.10	0.28	40.80	33,100.00	10.80	628.00	47.90	0.31	0.13	0.89	91.60	75.00	0.04
Taku G-Sieved	6/23/2018	Taku	-	17,300.00	1.05	15.40	0.30	39.70	31,600.00	10.90	610.00	46.40	0.36	0.14	0.71	82.10	83.80	0.06
Taku 1 (reference site)	8/24/2017	Taku	5,400.00	14,400.00	0.79	29.00	0.43	69.80	40,700.00	14.40	735.00	48.30	0.85	0.37	1.34	83.40	81.90	0.01
Taku 2	8/24/2017	Taku	4,100.00	13,900.00	3.74	78.50	1.17	69.00	41,000.00	17.00	790.00	74.40	1.92	0.29	0.58	70.10	155.00	0.15
Taku 3	8/24/2017	Taku	4,100.00	18,200.00	2.83	63.10	1.09	78.10	46,100.00	15.90	905.00	71.70	1.49	0.27	0.73	86.20	167.00	0.11
Taku 4	8/24/2017	Taku	1,900.00	13,400.00	0.93	16.30	0.27	43.90	34,300.00	10.20	666.00	49.90	0.26	0.16	0.57	77.30	71.40	0.03
Taku 4	8/24/2017	Taku	2,100.00	12,900.00	0.85	14.40	0.27	42.30	31,300.00	10.10	640.00	49.20	0.27	0.15	0.60	69.50	67.00	0.03
Taku 4 (reference site)	8/24/2017	Taku	1,500.00	13,900.00	0.92	15.90	0.32	44.00	34,200.00	10.50	678.00	52.00	0.28	0.16	0.65	78.00	72.50	0.04
Taku 4	8/24/2017	Taku	1,900.00	15,200.00	0.98	17.80	0.30	47.60	37,800.00	11.30	723.00	54.00	0.26	0.17	0.66	88.90	77.00	0.03
Taku 4	8/24/2017	Taku	1,700.00	15,300.00	0.95	16.50	0.29	47.30	36,000.00	11.20	735.00	52.20	0.25	0.18	0.65	82.40	76.00	0.03
Taku 5	8/24/2017	Taku	3,500.00	13,700.00	1.39	26.60	0.46	51.70	39,100.00	11.20	674.00	60.50	0.55	0.17	0.56	88.90	91.30	0.19
Taku 10 (*<2mm*)	9/10/2018	Taku	2,670.00	10,100.00	0.57	9.06	0.24	23.10	29,000.00	4.30	393.00	21.20	0.26	0.07	0.24	74.90	60.70	0.02
Taku 11 (*<2mm*)	9/10/2018	Taku	3,100.00	11,000.00	0.47	6.92	0.15	26.80	26,500.00	5.48	482.00	60.20	0.20	0.07	0.26	61.30	49.80	0.02
		Average	**2911.11**	**15200.00**	**1.41**	**28.05**	**0.47**	**52.20**	**36836.36**	**12.14**	**707.64**	**55.14**	**0.62**	**0.20**	**0.72**	**81.67**	**92.54**	**0.07**
		Standard Deviation	1393.24	2065.43	0.96	21.94	0.33	13.52	4585.25	2.43	84.65	9.65	0.57	0.08	0.23	7.36	34.58	0.06
		Min	**1500.00**	**12900.00**	**0.79**	**14.40**	**0.27**	**39.70**	**31300.00**	**10.10**	**610.00**	**46.40**	**0.25**	**0.13**	**0.56**	**69.50**	**67.00**	**0.01**
		Max	**5400.00**	**19000.00**	**3.74**	**78.50**	**1.17**	**78.10**	**46100.00**	**17.00**	**905.00**	**74.40**	**1.92**	**0.37**	**1.34**	**91.60**	**167.00**	**0.19**
		Median	**2100.00**	**14400.00**	**0.98**	**16.50**	**0.30**	**47.30**	**36000.00**	**11.20**	**678.00**	**52.00**	**0.31**	**0.17**	**0.65**	**82.40**	**77.00**	**0.04**

Sediment size fraction was less than 63um unless noted otherwise. Summary Statistics does not include the <2mm results from Taku 10 and Taku11
Italicized results were reported at or below the detection limit for the analysis

Table 10. Stikine Watershed Sieved Sediment Lab Analysis

			Total Organic Carbon mg/kg	Aluminum mg/kg	Antimony mg/kg	Arsenic mg/kg	Cadmium mg/kg	Copper mg/kg	Iron mg/kg	Lead mg/kg	Manganese mg/kg	Nickel mg/kg	Selenium mg/kg	Silver mg/kg	Tin mg/kg	Vanadium mg/kg	Zinc mg/kg	Mercury mg/kg
	B.C. Working Sediment Quality Guidelines (Aquatic Life)	Lower SWQG (mg/kg dry weight)	-	-	-	5.90	0.60	35.70	21,200.00	35.00	460.00	16.00	2.00	0.50	-	-	123.00	0.17
		Upper SWQG (mg/kg dry weight)	-	-	-	17.00	3.50	197.00	43,766.00	91.30	1,100.00	75.00	-	-	-	-	315.00	0.49
Sampling Location ID	**Sampling Date**	**Watershed**																
Stikine A-Sieved	7/22/2018	Stikine	-	23,500.00	0.63	8.64	0.23	50.50	38,200.00	7.88	579.00	36.60	0.36	0.18	0.99	106.00	74.00	0.04
Stikine D-Sieved	7/18/2018	Stikine	-	20,000.00	0.67	10.80	0.38	55.60	40,800.00	7.91	694.00	35.80	0.58	0.21	0.98	109.00	72.80	0.04
Stikine 1	8/23/2017	Stikine	5,000.00	14,700.00	0.48	8.10	0.34	49.70	34,600.00	6.12	720.00	53.10	0.41	0.14	0.54	76.90	78.70	0.03
Stikine 1	8/23/2017	Stikine	5,000.00	15,300.00	0.49	7.98	0.36	50.90	34,400.00	6.06	753.00	52.70	0.42	0.15	0.62	79.50	78.70	0.03
Stikine 1	8/23/2017	Stikine	5,800.00	15,300.00	0.48	8.03	0.37	50.80	33,900.00	6.20	742.00	53.10	0.44	0.15	0.63	78.10	77.80	0.03
Stikine 1	8/23/2017	Stikine	6,000.00	15,400.00	0.49	7.78	0.38	52.50	34,700.00	6.25	760.00	53.90	0.42	0.15	0.62	75.20	81.50	0.03
Stikine 1	8/23/2017	Stikine	5,800.00	15,000.00	0.60	8.07	0.36	50.40	33,700.00	6.16	696.00	53.10	0.46	0.19	0.62	79.80	78.40	0.04
Stikine 1	9/15/2018	Stikine	3,600.00	12,200.00	0.49	9.08	0.30	88.30	33,200.00	7.66	663.00	41.90	0.44	0.21	0.49	93.50	53.90	0.02
Stikine 1 (*<2mm*)	9/15/2018	Stikine	1,700.00	8,730.00	0.29	3.65	0.13	38.90	18,000.00	2.99	432.00	22.30	*0.20*	0.08	0.19	48.40	36.70	0.01
Stikine 2	8/23/2017	Stikine	2,850.00	18,900.00	0.47	8.73	0.24	57.30	46,100.00	6.67	819.00	54.90	0.33	0.15	1.23	106.00	86.60	0.04
Stikine 3	8/23/2017	Stikine	6,250.00	16,500.00	0.48	6.90	0.42	49.60	37,900.00	6.54	663.00	63.20	0.40	0.14	0.84	83.10	89.60	0.06
Stikine 4 (reference site)	8/23/2017	Stikine	3,000.00	20,600.00	0.87	16.80	0.48	68.80	50,900.00	8.68	938.00	46.60	0.74	0.24	0.69	109.00	114.00	0.04
Stikine 4 (reference site)	9/15/2018	Stikine	3,100.00	18,100.00	0.69	19.70	0.34	56.20	48,300.00	7.98	807.00	34.30	0.62	0.23	0.52	113.00	87.30	0.04
Stikine 4 (*<2mm*)	9/15/2018	Stikine	1,530.00	15,600.00	0.45	6.50	0.20	31.90	35,200.00	4.35	654.00	30.20	0.26	0.12	0.46	79.50	68.60	0.03
		Average	**4,640.00**	**17,125.00**	**0.57**	**10.05**	**0.35**	**56.72**	**38,891.67**	**7.01**	**736.17**	**48.27**	**0.47**	**0.18**	**0.73**	**92.43**	**81.11**	**0.04**
		Standard Deviation	1,363.78	3,158.86	0.13	3.99	0.07	11.32	6,253.79	0.94	91.73	9.14	0.12	0.04	0.23	15.07	13.86	0.01
		Min	**2,850.00**	**12,200.00**	**0.47**	**6.90**	**0.23**	**49.60**	**33,200.00**	**6.06**	**579.00**	**34.30**	**0.33**	**0.14**	**0.49**	**75.20**	**53.90**	**0.02**
		Max	**6,250.00**	**23,500.00**	**0.87**	**19.70**	**0.48**	**88.30**	**50,900.00**	**8.68**	**938.00**	**63.20**	**0.74**	**0.24**	**1.23**	**113.00**	**114.00**	**0.06**
		Median	**5,000.00**	**15,950.00**	**0.49**	**8.37**	**0.36**	**51.70**	**36,300.00**	**6.61**	**731.00**	**52.90**	**0.43**	**0.17**	**0.63**	**88.30**	**78.70**	**0.04**

Sediment size fraction was less than 63um unless noted otherwise. Summary Statistics does not include the <2mm results from Stikine 1 Stikine 4
Italicized results were reported at or below the detection limit for the analysis

Table 11. Unuk Watershed Sieved Sediment Lab Analysis

			Total Organic Carbon mg/kg	Aluminum mg/kg	Antimony mg/kg	Arsenic mg/kg	Cadmium mg/kg	Copper mg/kg	Iron mg/kg	Lead mg/kg	Manganese mg/kg	Nickel mg/kg	Selenium mg/kg	Silver mg/kg	Tin mg/kg	Vanadium mg/kg	Zinc mg/kg	Mercury mg/kg
	B.C. Working Sediment Quality Guidelines (Aquatic Life)	Lower SWQG (mg/kg dry weight)	-	-	-	5.90	0.60	35.70	21,200.00	35.00	460.00	16.00	2.00	0.50	-	-	123.00	0.17
		Upper SWQG (mg/kg dry weight)	-	-	-	17.00	3.50	197.00	43,766.00	91.30	1,100.00	75.00	-	-	-	-	315.00	0.49
Sampling Location ID	**Sampling Date**	**Watershed**																
Unuk F-Sieved	7/26/2018	Unuk	-	26,500.00	3.72	48.20	1.25	152.00	73,200.00	26.40	1,150.00	42.50	2.64	8.49	1.14	181.00	174.00	0.07
Unuk G-Sieved	7/27/2018	Unuk	-	46,900.00	4.97	62.00	1.94	236.00	**142,000.00**	42.00	1,800.00	69.80	3.19	15.20	2.29	376.00	292.00	0.12
Unuk 1	9/13/2018	Unuk	3,200.00	16,800.00	2.32	38.50	0.74	96.90	48,700.00	17.40	771.00	26.90	2.00	0.44	0.48	110.00	101.00	0.07
Unuk 1 (<*2mm*)	9/13/2018	Unuk	850.00	14,400.00	0.64	6.82	0.28	37.50	30,100.00	5.21	603.00	21.50	0.50	0.14	0.22	72.30	63.70	0.02
Unuk 2 (reference site)	9/13/2018	Unuk	1,710.00	15,200.00	1.05	18.30	0.57	86.90	48,800.00	40.00	639.00	35.70	0.66	0.40	0.26	121.00	71.00	0.01
Unuk 3	9/13/2018	Unuk	2,800.00	19,000.00	6.26	85.50	2.13	221.00	60,600.00	29.70	1,110.00	32.10	6.26	1.00	0.38	113.00	216.00	0.19
Unuk 4	9/13/2018	Unuk	1,800.00	17,000.00	10.30	67.60	3.28	330.00	62,800.00	44.10	1,110.00	42.80	8.86	1.68	0.44	86.90	268.00	0.25
Unuk 4	9/13/2018	Unuk	1,580.00	15,400.00	10.50	69.40	2.80	310.00	71,300.00	43.60	945.00	21.00	10.20	1.55	0.29	84.10	226.00	0.23
Unuk 4	9/13/2018	Unuk	1,770.00	15,400.00	9.80	60.70	3.17	297.00	63,100.00	36.50	1,010.00	23.00	9.13	1.51	0.30	80.90	233.00	0.22
Unuk 4	9/13/2018	Unuk	1,430.00	13,900.00	9.25	78.90	2.50	286.00	70,200.00	38.40	875.00	20.30	10.30	1.60	0.28	77.60	212.00	0.21
Unuk 4	9/13/2018	Unuk	1,490.00	14,700.00	9.62	74.70	2.71	299.00	67,500.00	42.60	933.00	24.40	10.10	1.54	0.25	75.70	225.00	0.21
Unuk 5 (reference site)	9/13/2018	Unuk	3,600.00	16,400.00	4.05	104.00	0.76	84.00	44,200.00	24.00	929.00	42.50	3.35	0.60	0.29	99.60	115.00	0.17
Unuk 5 (<*2mm*)	9/13/2018	Unuk	3,200.00	16,000.00	2.34	29.80	0.35	53.00	36,200.00	11.90	876.00	31.60	1.28	0.28	0.24	98.40	81.40	0.09
		Average	**2,153.33**	**19,745.45**	**6.53**	**64.35**	**1.99**	**218.07**	**68,400.00**	**34.97**	**1,024.73**	**34.64**	**6.06**	**3.09**	**0.58**	**127.80**	**193.91**	**0.16**
		Standard Deviation	819.05	9638.50	3.49	23.33	1.01	96.40	26326.11	9.14	298.50	14.58	3.76	4.61	0.62	87.65	70.58	0.08
		Min	**1,430.00**	**13,900.00**	**1.05**	**18.30**	**0.57**	**84.00**	**44,200.00**	**17.40**	**639.00**	**20.30**	**0.66**	**0.40**	**0.25**	**75.70**	**71.00**	**0.01**
		Max	**3,600.00**	**46,900.00**	**10.50**	**104.00**	**3.28**	**330.00**	**142,000.00**	**44.10**	**1,800.00**	**69.80**	**10.30**	**15.20**	**2.29**	**376.00**	**292.00**	**0.25**
		Median	**1,770.00**	**16,400.00**	**6.26**	**67.60**	**2.13**	**236.00**	**63,100.00**	**38.40**	**945.00**	**32.10**	**6.26**	**1.54**	**0.30**	**99.60**	**216.00**	**0.19**

Sediment size fraction was less than 63um unless noted otherwise. Summary Statistics does not include the <2mm results from Unuk 1 and Unuk 5
Italicized results were reported at or below the detection limit for the analysis

Table 12. Taku Watershed Fish Collection Summary Data

Sampling Location ID	Sampling Date	Watershed	DEC / B.C.	Species	# Individuals	Tissue
Taku 9	09/11/2018	Taku	B.C.	CHAR - DOLLY VARDEN	10	Ind. Whole Body
Taku 7	09/11/2018	Taku	B.C.	CHAR - DOLLY VARDEN	6	Ind. Whole Body
Taku 7	09/11/2018	Taku	B.C.	SALMON - COHO	2	Ind. Whole Body
Taku 10	09/11/2018	Taku	B.C.	CHAR - DOLLY VARDEN	9	Ind. Whole Body
Taku River (201900351W) (55.5155, -133.8064)	5/22/2018	Taku	DEC	WHITEFISH-ROUND	1	Ind. Whole Body
Taku River (201900361C) (55.5155, -133.8064)	5/22/2018	Taku	DEC	WHITEFISH-ROUND	9	Comp-Juvenile
Taku River (201900370C) (55.5155, -133.8064)	5/22/2018	Taku	DEC	SALMON - SOCKEYE	8	Comp-Juvenile
Taku River (201900386C) (58.5153, -133.7834)	5/22/2018	Taku	DEC	STICKLEBACK-THREESPINE	15	Comp-Whole Body
Taku River (201900397C) (58.5158, -133.7953)	5/22/2018	Taku	DEC	SALMON-CHINOOK	10	Comp-Juvenile
Taku River (201900408C) (58.5158, -133.7953)	5/22/2018	Taku	DEC	SALMON-CHINOOK	10	Comp-Juvenile
Taku River (201900418C) (58.5158, -133.7953)	5/22/2018	Taku	DEC	SALMON-CHINOOK	9	Comp-Juvenile

Table 13. Stikine Watershed Fish Collection Summary Data

Sampling Location ID	Sampling Date	Watershed	DEC / B.C.	Species	# Individuals	Tissue
Stikine 7	9/15/2018	Stikine	B.C.	SCULPIN	8	Ind. Whole Body
Stikine 6	9/15/2018	Stikine	B.C.	SCULPIN	7	Ind. and Comp - Whole Body
Stikine 5	9/15/2018	Stikine	B.C.	CHAR - DOLLY VARDEN	8	Ind. and Comp - Whole Body
Kakwan Slough - Stikine River (201900344C) (56.701, -132.2044)	7/21/2018	Stikine	DEC	CHAR-DOLLY VARDEN	7	Comp-Juvenile
Kakwan Slough - Stikine River (201900346W) (56.701, -132.2044)	7/21/2018	Stikine	DEC	SCULPIN-SLIMY	1	Ind. Whole Body
Rock Island - Stikine River (201900345W) (56.6822, -132.0097)	7/21/2018	Stikine	DEC	SCULPIN-SLIMY	1	Ind. Whole Body
Rock Island - Stikine River (201900347W) (56.6822, -132.0097)	7/22/2018	Stikine	DEC	SCULPIN-SLIMY	1	Ind. Whole Body
Kakwan Slough - Stikine River (201900350C) (56.701, -132.2044)	7/22/2018	Stikine	DEC	CHAR-DOLLY VARDEN	2	Comp-Juvenile

Table 14. Unuk Watershed Fish Collection Summary Data

Sampling Location ID	Sampling Date	Watershed	DEC / B.C.	Species	# Individuals	Tissue
Unuk 5	9/14/2018	Unuk	B.C.	CHAR - DOLLY VARDEN	2	Ind. Whole Body
Unuk 5	9/14/2018	Unuk	B.C.	SALMON - COHO	1	Ind. Whole Body
Unuk4	9/14/2018	Unuk	B.C.	CHAR - DOLLY VARDEN	4	Ind. Whole Body
Unuk 2	9/14/2018	Unuk	B.C.	CHAR - DOLLY VARDEN	8	Ind. Whole Body
Unuk River (201900429C) (56.1611, -130.9563)	7/22/2018	Unuk	DEC	CHAR-DOLLY VARDEN	10	Comp-Juvenile
Unuk River (201900437C) (56.1611, -130.9563)	7/22/2018	Unuk	DEC	CHAR-DOLLY VARDEN	7	Comp-Juvenile