AQUATICS EXISTING CONDITIONS INVESTIGATIONS

AT

CLINTON CREEK MINE SITE, 2016

FOR

Yukon

ASSESSMENT AND ABANDONED MINES

ENERGY MINES AND RESOURCES

BY

Laberge
ENVIRONMENTAL SERVICES

March 2017

EXECUTIVE SUMMARY

The Clinton Creek asbestos mine operated from 1967 to 1978, and Cassiar Asbestos Corporation Ltd. retained ownership until 1991. A closure plan was never accepted and the Northern Affairs Program of Indian and Northern Affairs Canada (INAC) and Yukon Government have monitored the site since.

Physical mitigation measures have been undertaken over the years; removal of all structures, risk management of the outlet structures at Hudgeon Lake, construction of a rock lined channel to prevent the undercutting of the tailings by Wolverine Creek (AECOM, 2011) and continued road maintenance. These efforts have not been sufficient to control the release of metals and tailings from reaching the receiving environment.

Conditions at the time of the investigations reflect a typical fall season in the north central Yukon. All stream levels appeared to be normal for the time of the year. Many of the sampled creeks were running relatively clear while the remainder did exhibit moderate turbidity.

The existing aquatic conditions at the Clinton Creek mine site indicate that the waste rock dump and the tailings have some impact on Wolverine and Clinton creeks. Both the right and left canyon walls of the channel below the gabion structures respectively contribute waste rock and shattered or exfoliated bedrock to the stream channel (von Finster, 2012). The detailed water chemistry reveals that Canadian Council Ministers of the Environment Guidelines for the protection of freshwater aquatic life (CCME-FAL) for total aluminium, total copper, total iron, total selenium and total chromium were exceeded at many of the monitoring sites (both exposed and reference). Eagle Creek (E4) exhibited the greatest degree of exceedance for most of these total metals. Eagle Creek had a high suspended sediment load at the time of sampling. Dissolved metals concentrations were much lower. Porcupine Creek and the exposed sites on Clinton Creek near the waste rock dump (E1 and E2) had high concentrations of some metals and several CCME-FAL guidelines were exceeded.

Most of the stream sediment samples from the reference sites were found to be devoid of asbestos fibres. The amount of asbestos reported in the stream sediments downstream of the tailings at exposed sites appears to vary and is likely dependent on events flushing exposed tailings through the system. Although asbestos fibres do not seem to be a significant issue to the aquatic receiving environment in water (Laberge, 2010) or in fish (Marty et al, 2012), the associate trace metals may create detrimental effects to aquatic biota (Schreier et al, 1987).

Several CCME recommended guidelines for the protection of freshwater aquatic life were exceeded in the stream sediments at the exposed sites close to the waste rock dump and the tailings. Chromium was one of the most common metals found in high concentrations in the stream sediments and the PEL was exceeded at E1, Porcupine Creek, E2 and E4. The high concentrations of chromium documented here are likely due to the fact that the mineral chromite (iron chromium oxide) is associated with the serpentine minerals in this area (Htoon, 1979). Nickel concentrations were much higher at the stream sediments at the exposed sites. No guidelines for nickel in sediments have been developed. (The CCME-FAL guideline for nickel in water was met at all sites, however the exposed sites did have higher concentrations). Arsenic concentrations in stream sediments were high

throughout the study area and the ISQG was exceeded at all sites except upstream on Wolverine Creek, R3.

Periphyton communities were the largest in terms of density and biomass at the Clinton Creek sites downstream of Hudgeon Lake; E1 and E2. The lake acts as a heat sink and temperatures were still warm in Clinton Creek at these sites. It is likely that the lake is a source of nutrients. Clinton Creek at E2 is located downstream of Porcupine Creek, and the area adjacent and upstream of E2 was overlain by a large beaver pond until recently. The decomposing organic material probably adds to nutrient availability. The periphyton community at Eagle Creek, E4, had the lowest abundance.

The most abundant periphyton species based on cell density was *Heteroleibeinia profundal* of Cyanophyta (27%), and was identified at all of the sites, with higher densities usually documented at the exposed sites. Based on cell biomass, the species *Synedra ulna* (Nitzsch), a diatom, represented 51% of the periphyton in the study area. However, this species was not identified at any of the reference sites.

The benthic communities at the exposed sites E1, E2 and Porcupine Creek were heavily dominated by Chironomids of the order Diptera. These invertebrates can tolerate stresses to the environment more than many other groups of insects. The proportion of the insect orders (Ephemeroptera, Plecoptera and Trichoptera) that have a very low tolerance to pollution was much lower at these sites than the others in the study area. As benthic invertebrates populate on and in the substrate, the high concentrations of metals in the stream sediments at these exposed sites are likely inhibiting colonization of the more sensitive species.

Beaver dams still play a role in the distribution of fish in Clinton Creek and the gabion structure downstream of Hudgeon Lake continues to be the upper limit of fish utilization. The perched culverts on Eagle and Wolverine Creeks prevent movement into these watersheds. A large beaver dam (3m x ~100m) located approximately two kilometres upstream of sample station R6 likely poses a barrier to both upstream and downstream passage of fish. There will likely be small or complete breaches during the 2017 spring freshet and salmon trapped upstream for the overwinter period should have no difficulty exiting the creek at that time.

The instability of the canyon walls downstream of the gabion structures continues to introduce material to Clinton Creek, especially following precipitation events.

All age classes of slimy sculpin were documented throughout Clinton Creek. The spill pond immediately below the gabion structures had the greatest densities of fish. Numerous juvenile chinook salmon, sub adult and juvenile Arctic grayling, and very rarely, adult Arctic grayling were captured at this location.

The tissue analysis of the resident species Slimy Sculpin show much higher concentrations of several metals in the tissues at E1 than from sculpin at the downstream sites on Clinton Creek. The mercury CCME tissue residue guideline for protecting wildlife consumers of aquatic biota was exceeded in all sculpin tissues, all grayling livers and in most of the grayling muscle tissues. The mercury levels in the Clinton Creek sculpin tissues were far greater than the Yukon wide mean. The source of mercury is likely methylmercury production in Hudgeon Lake.

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1.0 BACKGROUND

The former Clinton Creek Asbestos Mine Site is located northwest of Dawson City, Yukon, approximately 100 km by road, and is eight km upstream of the confluence of Clinton Creek and the Forty Mile River. The mine operated from 1967 to 1978. The site encompasses three open pits (Porcupine, Snowshoe and Creek), two waste rock piles (Clinton Creek Dump and Porcupine Creek Dump), and a tailings pile. The abandoned mine property falls within the Traditional Territory of the Tr'ondëk Hwëch'in First Nation.

During the operational life of the mine, approximately 14 million tonnes of tailings were deposited over a slope adjacent to the Wolverine Creek valley. In 1974, the original tailings deposit (the south lobe) slid down the valley blocking the flow of Wolverine Creek and forming a small lake. The blockage was almost immediately breached dispersing tailings as far as two kilometres downstream. Following the failure of the south lobe, tailings were placed further to the north. By 1986 the north lobe had reached the valley floor forming a second pond.

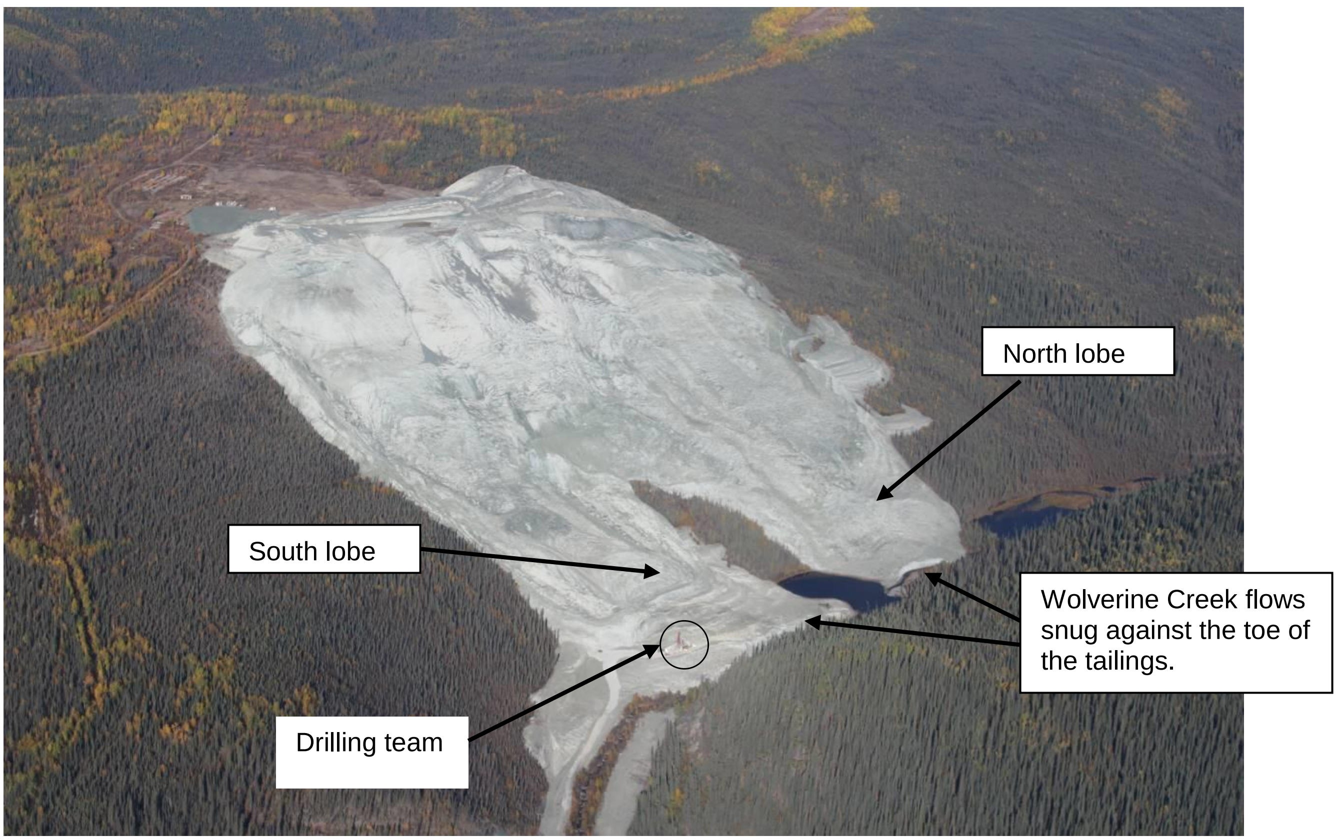
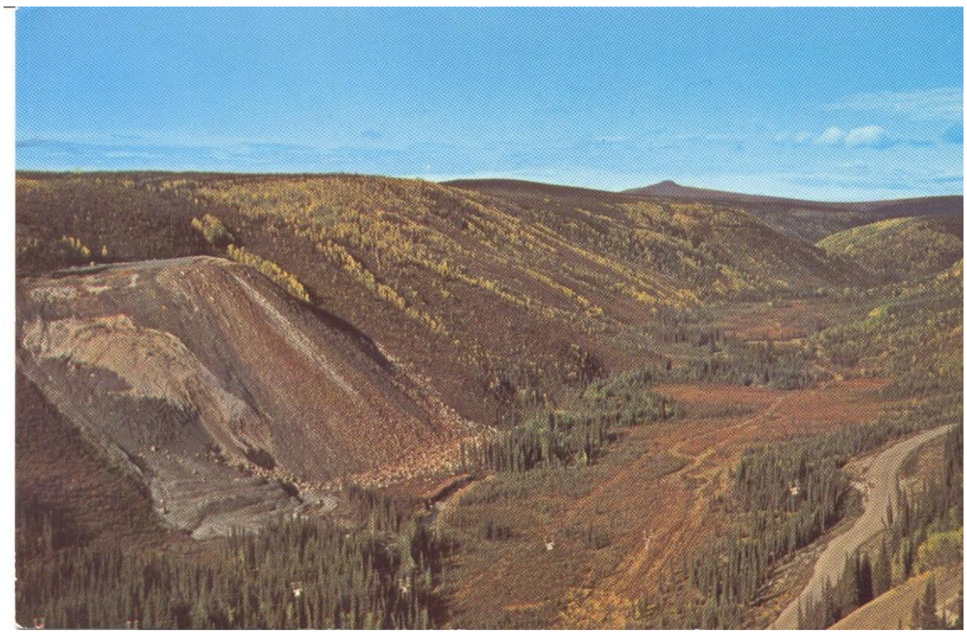


Photo credit: B. Burns, September 2016

Also in 1974, 60 million tonnes of the Clinton Creek waste rock pile slumped across the Clinton Creek valley creating Hudgeon Lake. The waste rock dam displaced Clinton Creek at the outflow of the lake approximately 25 m above the valley floor and cut a new channel into the waste material and the northern valley wall (Liebau, 2010). During the 1980s various weirs were constructed to reinforce the Clinton Creek channel in attempts to stabilize and control the outflow from Hudgeon Lake, with limited success. The structures were washed out during a high flow event in 1997. The Federal Government (Department of Indian Affairs and Northern Development) assumed responsibility for the site in 1999; following Devolution in 2003, the Government of Yukon (YG) assumed responsibility for site management. In a series of stages from 2002 to 2015, gabion drop structures were constructed within the channel downstream of the Hudgeon Lake outlet. YG continues to monitor these structures and conducts repairs as necessary. Further reinforcement to the structures occurred in 2015.

The undated photo below is a postcard of Clinton Creek (B. Burns, personal collection) taken sometime prior to 1974 before the slumping of the waste rock and the formation of Hudgeon Lake. The valley with the original location of Clinton Creek can be observed and the tramline transporting crushed asbestos ore from Porcupine Pit to the mill can be seen in foreground.



The above photo can be compared to the cover photo to observe the significant changes that have occurred in the landscape since the late 1960s. The status, as of September 2016, of the outlet of Hudgeon Lake following the upgrades to the structures and reinforcement to the lower portion by the canyon entrance in 2015, can be viewed in the photo below.

1.1 Scope of Work

To aid in the completion of a decommissioning plan for the Clinton Creek abandoned asbestos mine site, it was necessary to investigate and characterize the existing aquatic conditions of the watersheds affected as well as document the current conditions at the reference sites. The resulting information will form a component towards the preparation of a Yukon Environmental and Socio-economic Assessment Act (YESAA) Project Proposal.

The objective of the project as stated in the Scope of Work is as follows:

> The objective is to investigate and characterize aquatic existing conditions in anticipation of preparing a Yukon Environmental and Socio-economic Assessment Act (YESAA) Project Proposal.

Assessment and Abandoned Mines (AAM) retained Laberge Environmental Services (Laberge) to conduct a detailed survey of the existing aquatic conditions at several sites. The survey included the following disciplines:

- Fisheries: presence, abundance, health, habitat use, tissue analysis
- Habitat: descriptions using CABIN and RICs, determine and map barriers to fish movements
- Benthic invertebrates: community abundance and structure using CABIN methods
- Water Temperature Profiling: installation of temperature loggers
- Water Quality: snap shot of conditions at time of sampling
- Stream Sediments: asbestos, metals and organic contents, particle sizing
- Periphyton: determine primary productivity

Table 1 below details the activities by site.

TABLE 1 DISCIPLINES TO BE UNDERTAKEN PER SITE

Relevant Water Sampling Station Code	Station Description	Fish Condition and Growth	Fish Sampling – Tissue Metals	Aquatic Habitat Mapping	Temperature Profiling	Benthic Macroinvertebrates	Periphyton	Stream Sediments
Exposed Sites								
n/a	Clinton Creek (General)	•	•					
E1	Clinton Creek downstream of gabions and canyon, but upstream of Porcupine Creek			•	•	•	•	•
E2	Clinton Creek, downstream of Porcupine Creek but upstream of Wolverine Creek					•	•	•
E3	Wolverine Creek, upstream of culvert			•	•	•	•	•
E4	Clinton Creek downstream of Wolverine Creek but upstream of Eagle Creek			•		•	•	•
E6	Clinton Creek upstream of ford crossing to town site			•	•	•	•	•
E8	Forty Mile River downstream of Clinton Creek			•		•	•	•

TABLE 1 DISCIPLINES TO BE UNDERTAKEN PER SITE								
Relevant Water Sampling Station Code	Station Description	Fish Condition and Growth	Fish Sampling – Tissue Metals	Aquatic Habitat Mapping	Temperature Profiling	Benthic Macroinvertebrates	Periphyton	Stream Sediments
n/a	Porcupine Creek at its discharge into Clinton Creek (below beaver ponds)				•	•	•	•
Reference Sites								
R1	Clinton Creek upstream of Hudgeon Lake			•	•	•	•	•
R2	Easter Creek upstream of Hudgeon Lake					•	•	•
R3	Wolverine Creek, upstream of tailings			•		•	•	•
R4	Eagle Creek, upstream of culvert			•		•	•	•
R6	Forty Mile River, upstream of Clinton Creek			•		•	•	•
n/a	Maiden Creek or other off-site reference	•						

2.0 STUDY AREA

The study area lies in the north-west section of the Klondike Plateau Ecoregion. This ecoregion is part of Beringia and due to the lack of glaciation, V-shaped valleys and extensive upland boulder fields are characteristic (Smith et al, 2006). Permafrost is discontinuous but widespread. In the Clinton Creek valley, the south facing slopes are generally well drained and are vegetated with aspen, birch and white spruce. The north facing slopes tend to be underlain with permafrost and contain stands of black spruce.

The study area encompasses tributaries to Hudgeon Lake, Clinton Creek and some of its tributaries, Maiden Creek, and two sites on the Forty Mile River. Site descriptions and locations are presented in Figure 1 and below in Table 2. The sample sites within the study area are categorized as either reference sites or exposed sites. During an evaluation of existing information and data at Clinton Creek, Minnow Environmental Inc recommended a sampling design to identify exposure to any influences from the abandoned asbestos mine (Minnow, 2009). This resulted in the identification of several reference and exposed sample sites. The reference sites R1, R2, R3, R4 and R6 are all located upstream of any mining related influences or upstream of the potentially affected portion of Clinton Creek. The reference site Maiden Creek was provided to Laberge by AAM as an off-site location. All of the exposed sites are potentially influenced by effects from the waste rock dumps, the tailings or Hudgeon Lake.

Conditions during the sampling period (September 4th to 9th) in 2016 appeared typical for the season. Water levels were low to moderate. The large gravel bar on the Forty Mile River just downstream of the bridge was fully exposed, the ford across Clinton Creek to the Clinton Creek Townsite was very navigable, and flows were well within their channels at the assessed streams. Judging by the water levels it did not appear that any significant rain events had occurred recently. Weather conditions were generally sunny, calm, warm during the day and cool at night, frequently associated with frost. No weather related factors affected the sampling programs.

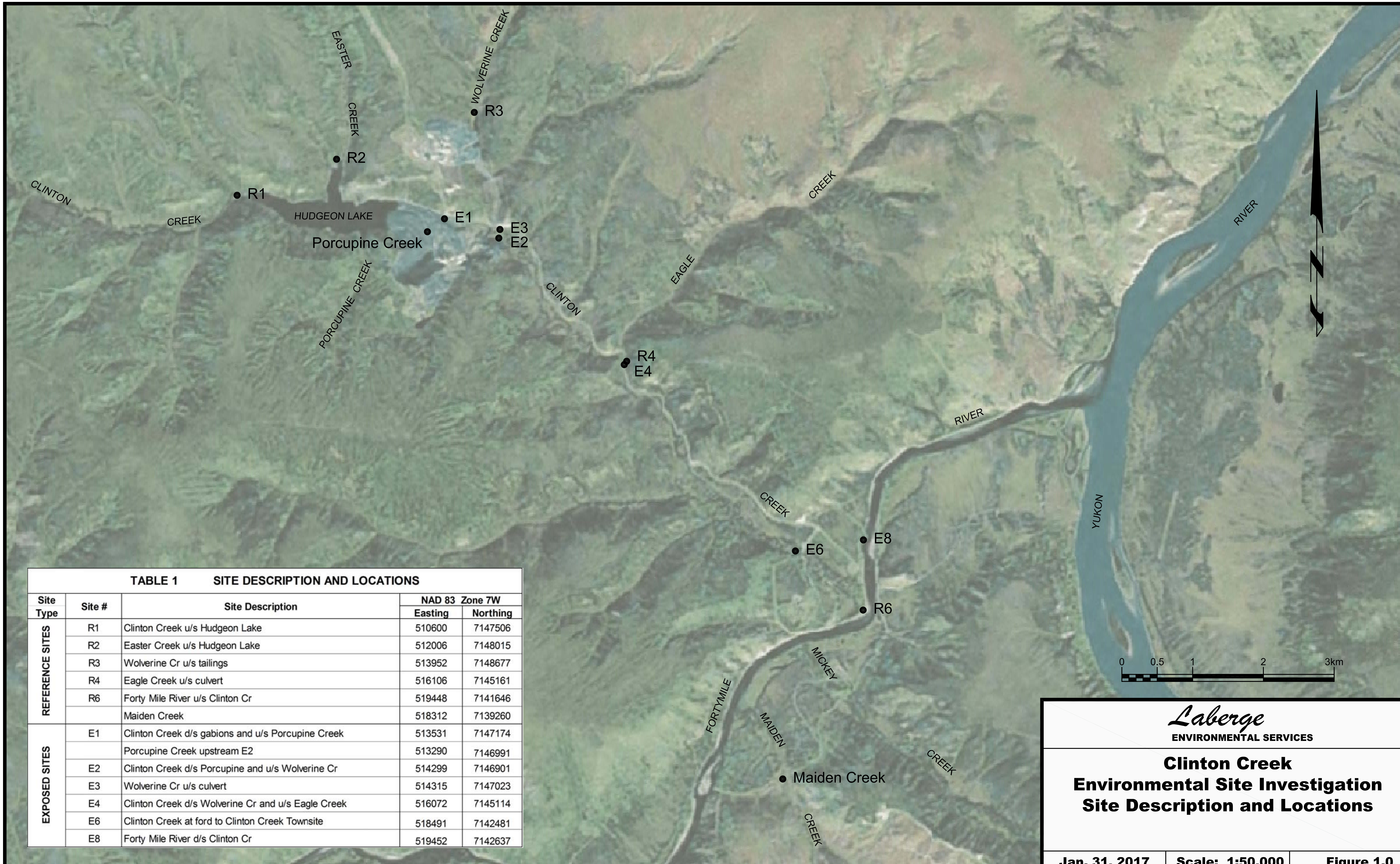


TABLE 1 SITE DESCRIPTION AND LOCATIONS

Site Type	Site #	Site Description	NAD 83 Zone 7W Easting	NAD 83 Zone 7W Northing
REFERENCE SITES	R1	Clinton Creek u/s Hudgeon Lake	510600	7147506
	R2	Easter Creek u/s Hudgeon Lake	512006	7148015
	R3	Wolverine Cr u/s tailings	513952	7148677
	R4	Eagle Creek u/s culvert	516106	7145161
	R6	Forty Mile River u/s Clinton Cr	519448	7141646
		Maiden Creek	518312	7139260
EXPOSED SITES	E1	Clinton Creek d/s gabions and u/s Porcupine Creek	513531	7147174
		Porcupine Creek upstream E2	513290	7146991
	E2	Clinton Creek d/s Porcupine and u/s Wolverine Cr	514299	7146901
	E3	Wolverine Cr u/s culvert	514315	7147023
	E4	Clinton Creek d/s Wolverine Cr and u/s Eagle Creek	516072	7145114
	E6	Clinton Creek at ford to Clinton Creek Townsite	518491	7142481
	E8	Forty Mile River d/s Clinton Cr	519452	7142637

Laberge
ENVIRONMENTAL SERVICES

Clinton Creek
Environmental Site Investigation
Site Description and Locations

Jan. 31, 2017	Scale: 1:50,000	Figure 1.0

TABLE 2 SITE DESCRIPTION AND LOCATIONS

Site Type	Site #	Site Description	NAD 83 Zone 7W	
			Easting	Northing
REFERENCE SITES	R1	Clinton Creek u/s Hudgeon Lake	510600	7147506
	R2	Easter Creek u/s Hudgeon Lake	512006	7148015
	R3	Wolverine Cr u/s tailings	513952	7148677
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3.0 SURFACE WATER QUALITY

The monitoring programs were conducted from September 4th to 9th, 2016. The upstream sites R1 and R2 were accessed by boat from Hudgeon Lake. All other sites were accessed by foot.

The objective of the water sampling program undertaken during the aquatic investigations was to obtain a snap shot of the conditions at the time of sampling the various media at each site during September 2016. The characterization of this medium provides important information on the conditions of this segment of the habitat since aquatic biota are in constant contact with water. Water quality can change rapidly in response to rainfall events and other disturbances, natural or anthropogenic. Regular water quality monitoring and hydrology studies have been completed at the Clinton Creek mine site for the past two years by Hemmera/ELR.

3.1 Methods

Water samples were collected midstream prior to any other sampling activity at each site. *In-situ* readings were collected using a YSI 600XML sonde and YSI 650 display. The sonde was deployed at each site for approximately 10 min. The YSI 650 was configured to log readings at one second intervals for temperature, pH, specific conductance, dissolved oxygen and oxygen reduction potential (ORP). All data files were later downloaded from the YSI 650 Display unit, reviewed and averaged for reporting purposes. Conductivity, pH and ORP were calibrated daily with certified calibration solutions. Dissolved oxygen was calibrated daily using the instrument's % saturation method.

The ALS Whitehorse depot supplied Laberge with the necessary sample kits prior to the field trip. Samples to be analysed for total suspended solids (TSS), pH, conductivity, alkalinity, and hardness were collected in 500 mL plastic bottles. Sulphate samples were collected in 125 mL plastic bottles. Samples to be analysed for total metals were collected in 125 mL plastic bottles and preserved with nitric acid. As total metals analysis includes any suspended sediment within the sample, dissolved samples were also collected to determine the metal concentration in the water column. These samples were filtered in the field using disposable syringes equipped with 45 micron filters and then preserved with nitric acid. Total mercury samples were collected in 50 mL vials and preserved with hydrochloric acid (HCl). Dissolved mercury samples were also collected and were filtered as described above and preserved with HCl. Except for samples to be analysed for dissolved parameters, each bottle was rinsed three times with the sample waters and then filled. The bottles for dissolved parameters were rinsed with the filtrate.

Samples were immediately placed into coolers after collection and kept cool with frozen ice packs. As the ice packs thawed they were replaced with frozen ones stored in the freezer at the Clinton Creek Townsite. At the termination of the sampling program the coolers of water samples were air shipped from Dawson to Whitehorse to ensure arrival before the laboratory closed for the weekend in order to meet the appropriate holding times. The coolers were then delivered to the ALS depot, logged in, and the appropriate samples were forwarded to their laboratory in Burnaby, BC. For these analyses, ALS used methods as described in Standard Methods for the Examination of Water and Wastewater and from the US Environment Protection Agency test methods. Further details per parameter are provided in the analytical report in Appendix B.

The data was compared to the most recent Canadian Council of Ministers on the Environment (CCME) Water Quality Guidelines for Protection of Aquatic Life (CCME-FAL), where applicable. Hardness plays an important role regarding the toxicity of several constituents. Generally, an increase in hardness decreases the toxicity of some metals to freshwater aquatic life, and thus CCME-FAL guidelines vary accordingly for these parameters. Soft waters are defined as having a hardness value of 0 to 60 mg/L as $CaCO_3$, medium hard waters have a hardness value of 60 to 120 mg/L, hard waters have a hardness value of 120 to 180 mg/L, and very hard waters are any over 180 mg/L. The guidelines for cadmium, copper, lead and nickel range depending on hardness, and parameter specific equations are used for specified ranges of hardness. To determine the site-specific guideline for cadmium when hardness was less than 280 mg/L as $CaCO_3$, the following equation was used:

$$10^{\{0.83(log[hardness])-2.46\}}$$

The following equation was used to derive the guideline for copper for samples with moderately hard waters:

$$0.2 * e^{\{0.8545[ln(hardness)]-1.465\}}$$

The guideline for lead was determined for all samples using the following equation:

$$e^{\{1.273[ln(hardness)]-4.705\}}$$

The guideline for nickel was determine for all samples using the following equation:

$$e^{\{1.273[ln(hardness)]-4.705\}}$$

3.2 Quality Assurance / Quality Control (QA/QC)

QA/QC was maintained in the field through the use of dedicated disposable gloves for sampling and handling at each site. Sample procedures and protocols were strictly adhered to for all sample types and parameters, as described in Section 3.1. An undisturbed, fast flowing section of the stream channel at each site was chosen for sampling prior to any other activity. In addition, one duplicate sample was collected, alongside one field blank and one travel blank.

A duplicate sample was collected at E2, Clinton Creek upstream of Wolverine, and data for both sets were very similar (Appendix B). Relative percent difference (RPD) was performed on each parameter, with a difference of 20% or more indicating a sampling or analytical bias. The RPD was calculated according to the following formula:

RPF = (value in sample – value in duplicate)/((value in sample + value in duplicate)/2) *100

Of the 70 constituents tested, cadmium had the greatest RPD of 9.4% (Table 5, Appendix B). The very low RPDs for all parameters indicates no concerns with sampling or analytical techniques.

No constituents were detected in the field blank, which was prepared at R6, indicating that no contamination was introduced during preparation and filtering. Although a travel blank was requested from the lab, only prepared samples for general analysis and sulphate were provided. All analyses were below the method detection limit, and pH was reported at 5.53. Based on this, no contamination occurred during the field trip or via shipping.

The ALS laboratory performs their own QA/QC for each of the parameters tested and these are included in the analytical report in Appendix B.

3.3 Results and Discussion

In-situ data were collected at each site and are presented below in Table 3. Water temperatures were generally cool and reflected late summer/early autumn conditions. The warmest temperatures were documented in Clinton Creek downstream of Hudgeon Lake which acts as a modifying effect until it has cooled as well. Conductivity was very high in Porcupine Creek (1,980 uS/cm) which drains the waste rock and would contain greater concentrations of dissolved mineral ions. The conductivity in the waters of the Forty Mile River (243 µS/cm at R6 and 250 uS/cm at E8) and in Maiden Creek (196 µS/cm) were considerably lower.

Generally, all sites were well aerated. The concentration of dissolved oxygen was the lowest at Porcupine Creek (7.2 mg/L) which does not meet the CCME-FAL minimum allowable concentration of 9.5 mg/L for the early life stages of cold water fish. The primary source of Porcupine Creek at this site location are groundwater seeps from the waste rock dump, which would have very low levels of dissolved oxygen. The dissolved oxygen at the other sites ranged from 10.0 mg/L at E4 to 12.9 mg/L at R1.

All sites were slightly alkaline with pH ranging from 7.88 at E6 to 8.67 at E3. ORP is a measure of the sampled water's ability to reduce or oxidize other substances. The higher the ORP the greater the number of oxidizing agents present. ORP ranged from 10.3 mV at E2 to 70.1 mV at E6.

TABLE 3	*IN-SITU* DATA, CLINTON CREEK SEPTEMBER 2016						
	Site	**Date & Time**	**Temp C**	**Cond uS/cm**	**DO mg/L**	**pH**	**ORP mV**
REFERENCE SITES	R1	9/7/2016 12:41	3.07	670	12.9	8.46	29.8
	R2	9/7/2016 15:03	4.02	594	12.8	8.42	40.1
	R3	9/6/2016 11:13	3.15	659	12.8	8.28	42.3
	R4	9/5/2016 14:30	3.02	600	11.4	8.37	53.8
	R6	9/8/2016 16:23	9.05	257	11.4	8.26	46.4
	Maiden Creek	9/8/2016 12:00	0.50	220	----	8.16	---
EXPOSED SITES	E1	9/6/2016 14:20	9.92	511	11.1	8.55	42.0
	Porcupine Creek	9/7/2016 9:23	4.83	1968	7.2	8.11	29.7
	E2	9/6/2016 16:03	9.34	632	10.5	8.33	10.3
	E3	9/6/2016 8:54	3.32	616	12.2	8.67	36.9
	E4	9/5/2016 13:23	8.40	684	10.0	7.92	48.0
	E6	9/5/2016 9:30	5.69	699	11.1	7.88	70.1
	E8	9/8/2016 14:49	8.28	264	12.1	8.65	31.8

The analytical data has been summarized in Table 4. Total suspended solids (TSS) ranged considerably throughout the study area. The streams were visibly turbid at R4 (Eagle Creek), and Maiden Creek with TSS concentrations of 130 mg/L and 98 mg/L respectively. It is unknown why the water was so turbid at R4 as water levels throughout the study area did not indicate the possibility of recent rainfall events. A possible explanation may be effects from the documented landslide located upstream (see Section 8.2.3). Placer mining activity occurring upstream on a tributary to Maiden Creek produced the suspended sediment load visible at the sample site here. The clearest waters were documented in Clinton Creek at E1, E2, E4 and E6, as well as in Porcupine Creek.

Currently there are no national (CCME) guidelines for Sulphate for the protection of freshwater aquatic life. The BC Ministry of the Environment (BC MoE) has set guidelines that vary with hardness; 309 mg/L for moderately hard to hard waters and 429 mg/L for very hard waters (Meays and Nordin, 2013). The concentration of sulphate was below the BC MoE guideline at all sites except for Porcupine Creek where a concentration of 1090 mg/L was reported.

The sampled waters were hard (120 to 180 mg/L as $CaCO_3$) to very hard (greater than 180 mg/L as $CaCO_3$) except at the Forty Mile River sites and in Maiden Creek where the water was moderately hard (60 to 120 mg/L as $CaCO_3$).

Of 33 metals analysed, five were below the method detection limits in all samples; beryllium, bismuth, phosphorus, thallium and tin (Appendix B). Table 4 summarizes the total and dissolved metals data for select parameters and includes comparisons to the most recent CCME-FAL. Although the guidelines apply to total metals only, both phases have been included in the table and compared to the guidelines due to a high suspended sediment load at some of the sites.

The concentrations of arsenic, lead, molybdenum, nickel, silver, uranium and zinc were below the respective CCME-FAL guidelines in both the dissolved and total phases at all sites. Due to changes of toxicity with hardness, site-specific guidelines for lead and nickel were generated using the equations described in Section 3.1.

Concentrations of aluminium exceeded the CCME-FAL guideline (0.100 mg/L) in the total metals samples from all of the sites except for E1, E2 and Porcupine Creek, and ranged from 0.0051 mg/L in Porcupine Creek to 2.22 mg/L in Eagle Creek (R4). The guideline was also exceeded in the dissolved sample from Maiden Creek (0.172 mg/L).

Boron was only detected at Porcupine Creek but the concentration did not exceed the CCME-FAL guideline.

The CCME-FAL guideline for cadmium varies with hardness and the equation was used to determine each site-specific guideline for the samples where hardness was less than 280 mg/L as $CaCO_3$. The CCME-FAL guideline of 0.00037 mg/L is used where the hardness is greater than 280 mg/L as $CaCO_3$. Detected cadmium ranged from 0.000127 to 0.00139 mg/L. Only total cadmium at Maiden Creek exceeded its site-specific guideline.

There is no CCME guideline for total chromium but there are guidelines for two species of chromium, trivalent chromium and hexavalent chromium. Trivalent chromium is commonly found in reducing environments such as sediments and wetlands whereas hexavalent is the dominant species found in surface waters (CCME, 1997). For the purposes of this report the guideline for hexavalent chromium (0.001 mg/L) was used to assess the sites where chromium may pose an issue for freshwater aquatic life. Testing completed by Hemmera/ELR (2016) showed that hexavalent chromium concentrations were frequently similar to total chromium concentrations. This guideline was exceeded in the total metals samples from all of the sites except at R6, E1, E2, and E8. Dissolved chromium was only detected at Porcupine Creek and E3, where it also exceeded the guideline.

Copper is another metal whose toxicity varies with hardness. The CCME-FAL guideline for very hard waters (greater than 180 mg/L as CaCO3) is 0.004 mg/L. For moderately hard water the copper equation as described in Section 3.1 was used. Total copper exceeded the applicable guideline at R1, R4, R6, Maiden Creek, E3, E6 and E8. The softer water sites, R6, Maiden Creek and E8 also exceeded the guideline in the dissolved samples.

The CCME-FAL guideline for iron (0.30 mg/L) was exceeded in all of the total samples except at Porcupine Creek, and in the dissolved samples at R2, R3, R6, Maiden Creek and E6.

Detectable concentrations of total mercury ranged from 0.0000051 to 0.0000640 mg/L and the CCME-FAL guideline of 0.000026 mg/L was exceeded at Eagle Creek, R4 (0.0000640 mg/L). Dissolved mercury was detected in the samples from Maiden Creek and E6 but concentrations were below the recommended CCME-FAL guideline.

The CCME-FAL guideline for the protection of freshwater aquatic life for selenium (0.001 mg/L) was exceeded in both the dissolved and total phases at R1, R4, E1, Porcupine Creek, E2, E3, E4 and E6.

TABLE 4 **SUMMARY OF ANALYTICAL RESULTS, SEPTEMBER 2016**

	Method Detection Limit	REFERENCE SITES						EXPOSED SITES							
		R-1	**R-2**	**R-3**	**R-4**	**R-6**	**MAIDEN CR**	**E-1**	**PORCUPINE CR**	**E-2**	**E-3**	**E-4**	**E-6**	**E-8**	**CCME-FAL mg/L**
Date Sampled		7-Sep-2016	7-Sep-2016	6-Sep-2016	5-Sep-2016	8-Sep-2016	8-Sep-2016	6-Sep-2016	7-Sep-2016	6-Sep-2016	6-Sep-2016	5-Sep-2016	5-Sep-2016	8-Sep-2016	
Time Sampled		12:45	15:00	11:30	11:40	16:40	12:00	14:30	9:40	16:30	9:00	13:10	9:30	14:50	
Hardness (as CaCO3)	0.50	375	328	367	324	111	84	281	1370	370	337	386	385	116	
TSS (mg/L)	2.0	37.0	9.8	12.0	130.0	4.9	98.0	2.4	2.4	2.2	63.0	4.9	32.0	7.7	
Sulfate (SO4) (mg/L)	0.30	224	169	218	159	45.9	53.5	151	**1090**	219	191	236	235	47.9	BC MoE*
Aluminum (Al)-Dissolved (mg/L)	0.0050	0.0289	0.0406	0.0298	0.0199	0.0846	**0.172**	0.0432	<0.0050	0.0348	0.0303	0.0294	0.0286	0.0922	0.100
Aluminum (Al)-Total (mg/L)	0.0050	**0.819**	**0.316**	**0.345**	**2.22**	**0.334**	**2.21**	0.0656	0.0051	0.0516	**1.23**	**0.185**	**0.549**	**0.281**	0.100
Arsenic (As)-Dissolved (mg/L)	0.00050	0.00057	0.00108	0.00067	0.00207	0.00059	0.00076	0.00078	0.00255	0.00105	0.00085	0.00108	0.00123	0.00060	0.00500
Arsenic (As)-Total (mg/L)	0.00050	0.00148	0.00132	0.00101	0.00493	0.00078	0.00210	0.00090	0.00239	0.00109	0.00198	0.00135	0.00195	0.00079	0.00500
Boron (B)-Dissolved (mg/L)	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.22	<0.10	<0.10	<0.10	<0.10	<0.10	1.5
Boron (B)-Total (mg/L)	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.23	<0.10	<0.10	<0.10	<0.10	<0.10	1.5
Cadmium (Cd)-Dissolved (mg/L)	0.0000050	0.0000749	0.0000271	0.0000190	0.0000464	0.0000227	0.0000397	0.0000391	0.000181	0.0000500	0.0000248	0.0000419	0.0000492	0.0000256	0.00037 or
Cadmium (Cd)-Total (mg/L)	0.0000050	0.000174	0.0000351	0.0000320	0.000365	0.0000315	**0.000186**	0.0000453	0.000162	0.0000474	0.000186	0.0000621	0.000104	0.0000339	equation
CCME Cadmium calculated:		*0.000370*	*0.000370*	*0.000370*	*0.000370*	*0.0001728*	*0.000137*	*0.000370*	*0.000370*	*0.000370*	*0.000370*	*0.000370*	*0.000370*	*0.0001793*	
Chromium (Cr)-Dissolved (mg/L)	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	**0.0024**	<0.0010	**0.0051**	<0.0010	<0.0010	<0.0010	0.001**
Chromium (Cr)-Total (mg/L)	0.0010	**0.0018**	**0.0013**	**0.0013**	**0.0052**	<0.0010	**0.0039**	<0.0010	**0.0024**	<0.0010	**0.0032**	**0.0011**	**0.0023**	<0.0010	0.001**
Copper (Cu)-Dissolved (mg/L)	0.0010	0.0019	0.0016	0.0018	0.0019	**0.0026**	**0.0039**	0.0027	0.0011	0.0024	0.0018	0.0021	0.0022	**0.0027**	0.002 or
Copper (Cu)-Total (mg/L)	0.0010	**0.0041**	0.0021	0.0027	**0.0123**	**0.0033**	**0.0081**	0.0030	0.0020	0.0026	**0.0062**	0.0028	**0.0042**	**0.0031**	0.0040
CCME Copper Guideline		*0.0040*	*0.0040*	*0.0040*	*0.0040*	*0.0020*	*0.0020*	*0.0040*	*0.0040*	*0.0040*	*0.0040*	*0.0040*	*0.0040*	*0.0020*	
Iron (Fe)-Dissolved (mg/L)	0.030	0.269	**0.519**	**0.365**	0.159	**0.306**	**0.516**	0.246	<0.030	0.268	0.280	0.284	**0.323**	0.300	0.300
Iron (Fe)-Total (mg/L)	0.030	**1.73**	**1.01**	**1.01**	**4.98**	**0.762**	**3.38**	**0.323**	<0.030	**0.349**	**2.67**	**0.645**	**1.40**	**0.634**	0.30
Lead (Pb)-Dissolved (mg/L)	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.025 to
Lead (Pb)-Total (mg/L)	0.00050	0.00132	<0.00050	<0.00050	0.00330	<0.00050	0.00189	<0.00050	<0.00050	<0.00050	0.00141	<0.00050	0.00077	<0.00050	0.007
CCME Lead Guideline		*0.007*	*0.007*	*0.007*	*0.007*	*0.004*	*0.003*	*0.007*	*0.007*	*0.007*	*0.007*	*0.007*	*0.007*	*0.004*	
Mercury (Hg)-Dissolved (mg/L)	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000059	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000051	<0.0000050	0.000026
Mercury (Hg)-Total (mg/L)	0.0000050	0.0000128	0.0000052	0.0000056	**0.000064**	<0.0000050	0.0000108	0.0000057	0.0000051	0.0000062	0.0000189	0.0000068	0.0000114	<0.0000050	0.000026
Molybdenum (Mo)-Dissolved (mg/L)	0.0010	0.0012	<0.0010	0.0011	0.0013	<0.0010	<0.0010	0.0012	0.0024	0.0014	0.0012	0.0014	0.0014	<0.0010	0.0730
Molybdenum (Mo)-Total (mg/L)	0.0010	0.0015	<0.0010	0.0013	0.0024	<0.0010	<0.0010	0.0013	0.0026	0.0015	0.0017	0.0016	0.0016	<0.0010	0.0730
Nickel (Ni)-Dissolved (mg/L)	0.0010	0.0042	0.0041	0.0037	0.0117	0.0032	0.0050	0.0044	0.0594	0.0107	0.0080	0.0117	0.0131	0.0034	0.150 or
Nickel (Ni)-Total (mg/L)	0.0010	0.0065	0.0047	0.0044	0.0242	0.0040	0.0087	0.0046	0.0573	0.0110	0.0093	0.0134	0.0164	0.0038	equation
CCME Nickel Guideline		*0.150*	*0.150*	*0.150*	*0.150*	*0.103*	*0.084*	*0.150*	*0.150*	*0.150*	*0.150*	*0.150*	*0.150*	*0.107*	
Selenium (Se)-Dissolved (mg/L)	0.000050	**0.00291**	0.000725	0.000994	**0.00324**	0.000257	0.000574	**0.00192**	**0.00514**	**0.00198**	**0.00146**	**0.00196**	**0.00186**	0.000295	0.0010
Selenium (Se)-Total (mg/L)	0.000050	**0.00298**	0.000780	0.000985	**0.00363**	0.000280	0.000582	**0.00188**	**0.00501**	**0.00194**	**0.00167**	**0.00179**	**0.00190**	0.000317	0.0010
Silver (Ag)-Dissolved (mg/L)	0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	0.00025
Silver (Ag)-Total (mg/L)	0.000020	0.000031	<0.000020	<0.000020	0.000169	<0.000020	0.000036	<0.000020	<0.000020	<0.000020	0.000053	<0.000020	0.000033	<0.000020	0.00025
Uranium (U)-Dissolved (mg/L)	0.00020	0.00226	0.00341	0.00302	0.00314	0.00087	0.00042	0.00178	0.00526	0.00196	0.00236	0.00207	0.00231	0.00098	0.0150
Uranium (U)-Total (mg/L)	0.00020	0.00253	0.00350	0.00319	0.00353	0.00099	0.00067	0.00185	0.00530	0.00207	0.00248	0.00223	0.00242	0.00100	0.0150
Zinc (Zn)-Dissolved (mg/L)	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0063	<0.0050	<0.0050	<0.0050	0.0062	<0.0050	0.0300
Zinc (Zn)-Total (mg/L)	0.0050	0.0138	<0.0050	<0.0050	0.0245	0.0057	0.0214	<0.0050	0.0067	<0.0050	0.0147	<0.0050	0.0147	0.0054	0.0300

* BC MoE: British Columbia Ministry of the Environment Guideline: 309 mg/L for medium hard to hard water; 429 mg/L for very hard water

** This guideline is actually applicable to hexavalent chromium, as described in the text.

Values are in bold and highlighted where the recommended guideline has been exceeded.

When examining the reference data exclusively, the concentrations for most parameters were the greatest at Eagle Creek (R4), where the recommended CCME-FAL guidelines for total aluminium, chromium, copper, iron, mercury and selenium were exceeded. As discussed previously, the concentration of TSS was high here, 130 mg/L. The dissolved concentrations of these parameters, except for selenium, were much lower indicating that the majority of the metals were contained in the suspended matter.

For the exposed sites dataset, greatest concentrations of several parameters were recorded at Porcupine Creek, with selenium exceeding the recommended CCME-FAL guideline and sulphate exceeding the BC MoE guideline. Total and dissolved chromium also exceeded the CCME-FAL guideline here but higher concentrations were documented at E3, Wolverine Creek. In addition, maximum levels of aluminium, copper and iron were recorded at E3.

4.0 WATER TEMPERATURE LOGGERS

Temperature data loggers were installed in five locations in the Clinton Creek study area to assess the thermal regime over the course of a one-year period. This will assist in the determination of over wintering potential for fish at these areas.

Temperature data loggers have been installed at several locations in Clinton Creek and at groundwater seep areas during the summer months only in 2010 (Laberge, 2011) and 2012, 2013, 201 and 2015 (von Finster, 2016).

4.1 METHODS

Hobo “Tidbit V2” temperature loggers were installed at R1, E1, Porcupine Creek, E3 and E6. Each data logger was installed inside a short piece of open ended two-inch diameter black PVC pipe tethered to a steel weight. The tether used was 3/16 inch plastic coated steel clothes line cable. All cable ends were secured with two aluminum cable clamps. The tethered data logger was then deployed where water was deepest and where there was some protection such as a back eddy or in a slow moving section of the creek (See Photos 1 and 2 in Appendix A). By choosing deeper sections of the creek, there is less likelihood of freezing to the substrate. GPS coordinates were collected at each of the data logger sites. The tether was secured to either a nearby tree or stand of willow. The tethered tree and PVC pipe were marked with orange flagging. In some cases, local cobble material was placed on top of the submerged cable and/or PVC pipe to provide additional protection during high flow periods.

The Hobo data loggers were initiated on August 31, 2016 prior to deployment. Table 6 lists the site, the logger ID, submerged start time and coordinates for each of the dataloggers. The data loggers were initiated on a 15 minute interval starting on the hour and will be deployed for a one year period. Battery life should last approximately 2.5 years. It is recommended that the temperature loggers be downloaded in September 2017.

Table 6 INSTALLATION DESCRIPTIONS FOR THE TEMPERATURE LOGGERS								
Site	Hobo Tidbit V2 serial number	NAD 83 Zone 7W		Elevation (m)	Bank	Date Installed	Time Installed	First Reading
		Easting	Northing					
R 1	10956744	510575	7147490	416.1	Right	9/7/2016	13:10	13:30
E 1	10956743	513652	7147096	371.6	Right	9/6/2016	15:20	15:30
Porcupine Cr	10956741	513920	7146991	353.3	Right	9/7/2016	10:15	10:30
E 3	10956739	514184	7147196	368.3	Left	9/6/2016	9:40	10:00
E 6	10956742	518491	7142481	305.4	Left	9/5/2016	10:10	10:30

5.0 STREAM SEDIMENTS

5.1 Methods

Triplicate stream sediments were collected from depositional areas at each of the 12 benthic invertebrate sites. A stainless steel scoop was used to place the stream sediments into two glass jars per sample (a total of six jars per site). One jar was for the analysis of asbestos and the other jar provided material for the analyses of metals, particle size analysis and loss of ignition (LOI). Samples were kept cool prior to shipment to the ALS laboratory in Whitehorse, Yukon, where they were logged in and sent on to the ALS lab in Edmonton, AB.

The ALS lab analyzed each sample for asbestos content prior to the initiation of the other parameters (metals, LOI and particle sizing). All of the stream sediment samples collected from the exposed sites (all those with the prefix E) contained asbestos, and these samples were sent to the Golder Laboratory in Burnaby, BC, for the analyses of particle sizing and LOI due to Workers' Compensation Safety regulations related to asbestos fibres.

For the samples where asbestos was not detected, the ALS lab in Edmonton completed LOI, particle size analysis, and the 33 metals scan. For the asbestos positive samples, a wet analysis for metals was performed and converted to dry weight, due to the presence of asbestos fibres and health and safety concerns. The complete analytical report is provided in Appendix C. Details on the laboratory methods used for all parameters are provided in Appendix C as well.

5.2 Results and Discussion

5.2.1 Asbestos Content

Most of the samples from the reference sites (R1-A, R1-B, R1-C, R2C, R3-B, R4-B, R6-B and R6-C) were found to be devoid of asbestos fibres, although other forms of fibre were occasionally present (cellulose, mica, etc.). The fibre content of all samples is displayed in Table 7, Appendix C. None of the samples where asbestos was detected was greater than 5%.

Stream sediments from the Clinton Creek site have been analysed for asbestos on two other occasions; in 1998 by Royal Roads University (1999) and in 2009 by Laberge, (2010). In 1998, asbestos was not detected in the sediments from Wolverine Creek upstream of the tailings (R3) and asbestos fibre content was determined to be 10% in the sediments in Wolverine Creek upstream of Clinton Creek at E3. In 2009, stream sediments were collected from E3 and E4 (Clinton Creek downstream of Wolverine Creek), and analysed for asbestos. The reported fibre content at both sites was 15 to 20% (Laberge, 2010). The amount of asbestos occurring in the stream sediments downstream of the tailings appears to vary and is likely dependant on events flushing tailings through the system.

5.2.2 Geochemistry

The stream sediment samples were analysed for 33 metals and the complete analytical report can be found in Appendix C. Metals that are known to have toxic effects to aquatic biota and/or are present in the waste rock or tailings were examined. Data for the triplicate samples were averaged for arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc with the results tabulated below in Table 8. The CCME guidelines for the protection of freshwater aquatic life are also included; Interim Freshwater Sediment Quality (ISQG) and Probable Effects Levels (PEL). Values in bold indicate that the ISQG has been exceeded and the cells that are highlighted represent where the PEL is also exceeded.

TABLE 8 CONCENTRATIONS OF METALS (mg/kg) IN THE STREAM SEDIMENTS, SEPTEMBER 2016

Site	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
E-1	**18.3**	**1.13**	**266**	31.4	12.1	**0.262**	436	95.9
Porcupine Cr	**14.3**	**0.83**	**226**	18.6	5.8	0.112	356	65.5
E-2	**15.8**	**0.87**	**257**	27.2	10.6	0.150	402	84.6
E-3	**7.8**	0.49	**45**	22.7	9.7	0.077	58	84.5
E-4	**9.1**	0.54	**106**	19.5	7.3	0.078	155	71.3
E-6	**12.2**	0.34	**51**	17.6	8.3	0.050	73	65.9
E-8	**12.2**	0.16	13	11.8	4.1	0.071	13	46.8
R-1	**11.9**	**0.86**	36	34.4	13.9	**0.187**	42	105.1
R-2	**12.2**	0.32	32	17.6	8.0	0.035	54	61.1
R-3	5.3	0.33	**38**	18.4	6.6	0.067	44	57.7
R-4	**16.8**	**0.70**	**42**	23.9	9.4	0.060	68	86.3
R-6	**9.0**	0.34	35	25.1	8.8	0.060	30	84.4
ISQG	5.9	0.6	37.3	35.7	35	0.170		123
PEL	17	3.5	90	197	91.3	0.486		315

Note: ISQG = Interim freshwater Sediment Quality Guidelines, in **bold** where exceeded.
PEL = Probable Effects Level (>50% of adverse effects occur above this level), shaded and in bold where exceeded.

Arsenic concentrations were high throughout the study area and the ISQG was exceeded at all sites except upstream on Wolverine Creek (R3). The PEL was exceeded as well at E1, Clinton Creek at the base of the waste rock dump.

The ISQG was exceeded for cadmium at E1, Porcupine Creek, E2, R1 and R4.

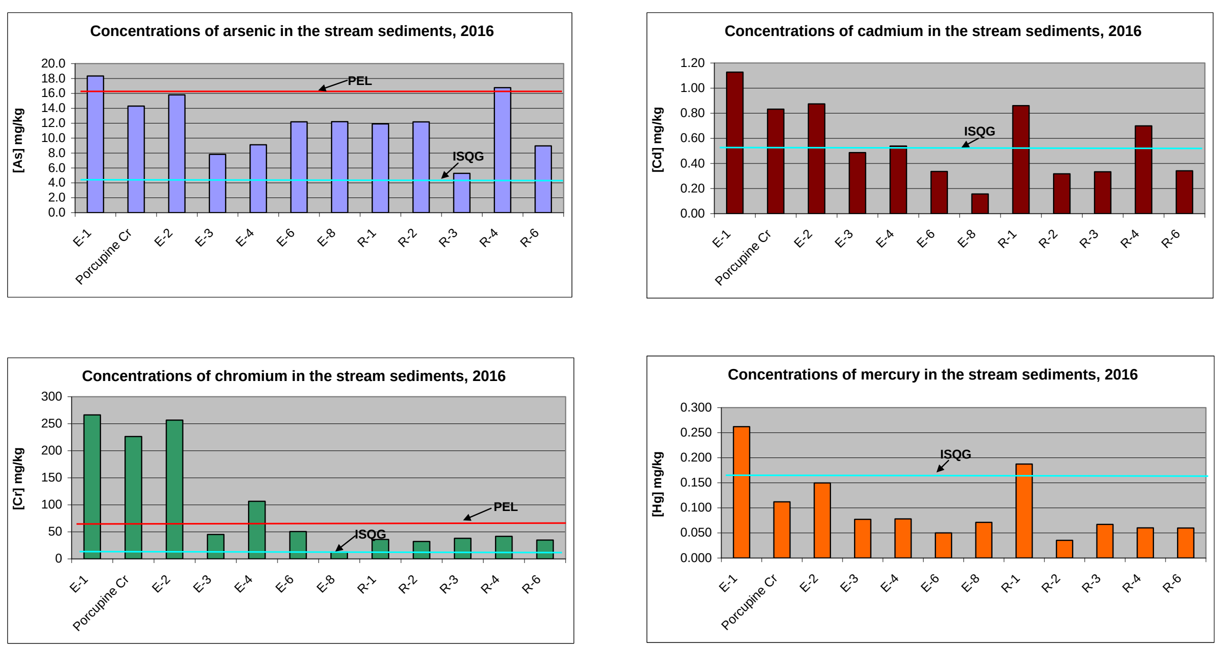
Chromium has been identified as a potential contaminant of concern at the Clinton Creek site (Laberge, 2012). In general, concentrations of chromium in the stream sediments were considerably higher at the exposed sites than at the reference sites. Concentrations of chromium exceeded the ISQG and the PEL in the stream sediments at E1, Porcupine Creek, E2 and E4. The ISQG was also exceeded at E3, E6, R3 and R4. The type of chrysotile asbestos fibres that were mined at Clinton Creek, contain high levels of nickel, chromium, cobalt and manganese (Schreier et al, 1987). Chromium appears to be mobilizing out of the asbestos mineralogy from the waste rock and the tailings.

Concentrations of copper, lead and zinc were low in the stream sediments at all sites and no guidelines were exceeded. There are no CCME guidelines for nickel. Concentrations of nickel were far greater at the exposed sites near and downstream of the waste rock and Wolverine Creek than at the other sites. As nickel is a component of the asbestos mineralogy, the high levels documented at the sites near the waste rock indicate that it could have possible influences to the receiving environment.

The ISQG was exceeded for mercury in the stream sediments at E1 and R1 only.

The metals where guidelines have been exceeded are graphically displayed in Figure 2.

FIGURE 2 CONCENTRATIONS OF METALS (mg/kg) IN THE STREAM SEDIMENTS AT CLINTON CREEK, 2016



Stream sediment samples have been collected on a few previous occasions; in 1998 (Royal Roads University), 2009 (Laberge), 2010 (Laberge) and 2011 (Laberge), however not all sites were sampled during each sampling event. Table 9 in Appendix C summarizes the data for arsenic, cadmium, chromium and nickel from these monitoring programs.

Arsenic concentrations appear to be background levels of the study area since there is little fluctuation over time or between sites, although slightly higher values are found at the upper exposed sites. Likewise, there is little change over time in the cadmium concentrations. Chromium decreased at Wolverine Creek (E3) after 2010. It was speculated that the scouring action of the extreme flows that occurred during flooding events in August 2010 flushed the fines through the system (Laberge, 2012). There has been little change at the reference sites indicating ambient chromium levels at these sites. Concentrations of nickel in the stream sediments at Wolverine Creek (E3) have also decreased considerably after 2010. The tailings were tested in 2011 (Laberge, 2012) and the average concentration (N=3) of chromium and nickel was 1650 mg/kg and 2797 mg/kg respectively. Based on the low upstream concentrations in Wolverine Creek at R3, and the increased concentrations at E3, the tailings have contributed chromium and nickel to the creek. It appears that nickel and chromium have mobilized down the creek over the past five years as concentrations have increased downstream at E4 (Clinton Creek upstream of Eagle Creek).

5.2.3 Particle Size

Due to the presence of asbestos in many of the sediment samples, two different labs completed the particle size analysis, as described in Section 5.1. Each laboratory (ALS and Golder) reported the results for different sieve sizes. Although both labs received the same instruction, Golder reported more fractions. Table 10, Appendix C, displays the lowest common denominator of particle sizes so that all samples can be viewed equally. Figure 3 in Appendix C, is a graphical representation of the fractional components of each sample. Gravels formed the largest component of the stream sediments collected at E8, Forty Mile River d/s of Clinton Creek. The dominant class form at the other exposed sites was medium to fine sand. Samples from the reference sites R1, R2, R3 and R6 were comprised primarily of silt.

5.2.4 Organic Content

Loss on ignition analysis was performed by both labs on the sediment samples to determine the percentage of organic content. There were very low levels of organic content throughout the study area ranging from 0.4% in the sediments at the Forty Mile River downstream of Clinton Creek (E8-B) to 16.4% in sample R3B, Wolverine Creek upstream of the tailings (Table 11, Appendix C). The lotic conditions at each of the sites provided little opportunity for the deposition of organic material that may be carried downstream. Macrophytes were not present at any of the sample sites which also would have provided organic material.

6.0 PERIPHYTON

The objective of the periphyton sampling program is to describe the current periphyton communities in relation to the Clinton Creek site. Periphyton studies have not been undertaken at the site previously.

Periphyton are a complex assemblage of algae and microbes that grow on submerged substrates (e.g., rocks, woody debris, macrophyte plants) in aquatic ecosystems. It serves as an important food source for invertebrates and certain fish species, and can be an important sorber of contaminants (Wu, 2016). The abundance and taxonomic diversity of periphyton communities can be used to assess the health of a stream and identify the presence of stressors (e.g., sedimentation, metals contamination, nutrient enrichment).

6.1 Methods

Replicate periphyton samples were collected at each site. Larger flat-surfaced rocks were selected from the wetted stream channel at each of the sites visited. Due to the lack of suitable sized rocks at R1, no periphyton samples could be collected. All stream bed material at R1 was comprised of sand and small gravels.

A stainless steel cup with a 30mm diameter rubber ring was securely clamped to the upper rock surface for sampling (see Appendix A, Photo #3). A small rigid brush was used to rigorously scour the enclosed surface area of the rock. Each sample area was rinsed into the sample container and then brushed and rinsed a second time. The brush was also rinsed into the sample container to ensure as much of the material removed from the rock surface was collected. Triplicate samples were collected in this manner to produce a composite periphyton sample, representing a total sample area of 21.2 cm^2 per site. The labelled sample was preserved with Lugol's Solution and shipped to "Plankton R Us" in Winnipeg, Manitoba, for identification and enumeration.

At "Plankton R Us", all samples were taken to a constant volume using water filtered through 2µm mesh Nitex netting. Depending on the density of algal and silt/detritus material, 1 to 2 mL subsamples of epilithic suspension were sonicated for 10-20 s using a Sonifer Cell Disruptor (model w140) (Findlay et al.1999) and gravity settled for 24 h in an Ütermohl chamber. Cells were identified, counted and measured from random fields until 100 cells of the dominant species were found. Only cells that were intact and contained viable chloroplasts, identifiable by staining from the Lugol's, were enumerated. Cell counts were converted to biomass (wet weight µg cm^{-2}) by estimating cell volumes and assuming a specific gravity of 1. Estimates of cell volume for each species were obtained by measurements of up to 50 cells of an individual species and applying the geometric formula best fitted to the shape of the cell (Rott, 1981).

Replicate counts were performed on 10% of the samples as a QA/QC protocol. Replicate samples were chosen at random and processed at different times from the original analysis to reduce bias. For this study replicate counts were completed on the periphyton sample collected from E3, Wolverine Creek, to fulfil the QA/QC requirement of reanalysis of 10% of the samples. The sample was reanalyzed and was 13% higher than the original analysis which is within the variance of ±15% suggested in the literature. The largest variance between samples was due to *Audouinella sp.*

A duplicate set of three rock scrapings, following the above field protocols, was also collected at each site for chlorophyll analysis. These samples were filtered a short time later using a field hand vacuum filtration apparatus and 0.45 µm filters. Filters were then carefully removed, folded and stored in small 20mL black plastic vials, labelled and kept cool on ice until delivered to the ALS laboratory in Whitehorse, Yukon. Once the samples were logged in they were forwarded to the ALS lab in Burnaby, BC. Chlorophyll in biota was analyzed by Fluorimeter. This analysis is done using procedures adapted from EPA Method 445.0. Chlorophyll-a is determined by a routine acetone extraction followed with analysis by fluorometry using the non-acidification procedure. Although the analysis of Chlorophyll-b was requested in the scope of work, Chlorophyll-b is a degradation product of chlorophyll and is not reported separately. However, its concentration is captured in the analysis of pheophytin. Pheophytin is determined by a routine acetone extraction followed with analysis by fluorometry using the acidification procedure.

6.2 Results and Discussion

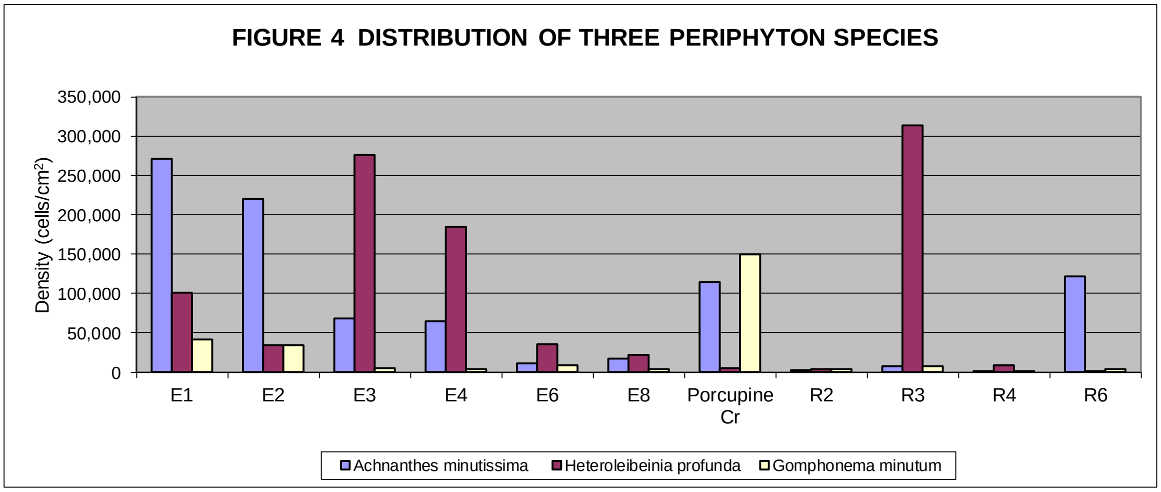
6.2.1 Periphyton Community Structure

Four phyla were identified in the study area; Cyanophyta (cyanobacteria), Chlorophyta (green algae), Bacillariophyta (Diatoms) and Rhodophyta (red algae). Data are presented in Appendix D as density (cells/cm^2) and as biomass (µg/cm^2). Bacillariophyta formed the greatest density throughout the study area (47%) followed closely by Cyanophyta (40%). Ryodophyta was not represented at E6, R4 and R6. Chlorophyta was only detected at the Porcupine Creek site. Based on biomass, Bacillariophyta was dominant in the study area (70%) followed by Rhodophyta (23%).

Small alpine and montane streams without blooms of filamentous green algae are generally dominated by diatoms and cyanobacteria (Brown et al, 2008) which appears typical of the Clinton Creek watershed. However, filamentous green algae have frequently been observed on the gabion structures (White Mountain Environmental Consulting, 2008, von Finster, 2016) and in areas of groundwater upwellings throughout the mine site (Laberge, 2011, Laberge, 2012, von Finster, 2016). Filamentous green algae were not observed in September 2016 at any of the sample sites. Cyanobacterial cells are generally small compared to diatoms, so high numerical abundance does not necessarily translate to dominance of biomass (Brown et al, 2008) thus both cell density and cell biomass are included in the tables and discussion.

Within these phyla, several species were identified and this data is also included in Appendix D.

The most abundant species based on cell density was *Heteroleibeinia profunda* of Cyanophyta (27%), and was identified at all of the sites, with higher densities usually documented at the exposed sites. Two other species were found at all of the sites; *Achnanthes minutissima* and *Gomphonema minutum*, both belonging to Bacillariophyta (Diatoms). The densities of these three species are presented in Figure 4 to show the distribution throughout the study area.



Based on cell biomass, the species *Synedra ulna* (Nitzsch), also a diatom, represented 51% the periphyton in the study area. However, this species was not identified at any of the reference sites, but was present at all of the exposed sites.

Each site has been examined individually and metrics are presented in Table 12. The greatest cell density and cell biomass occurred at E2 (Clinton Creek downstream of Porcupine Creek and upstream of Wolverine Creek). The substrate here had visible organic growth on the rocks (Appendix A, Photo #4). The lowest cell density and biomass was recorded at R4 (Eagle Creek) and the rocks at this site were quite devoid of any growth or biofilm (Appendix A, Photo #5).

Taxonomic richness (diversity) is a metric used to determine the health of a stream and involves enumerating the different taxa present per site. Diversity ranged slightly over the study area from 8 different species identified at R4 to 15 at E8.

TABLE 12 SUMMARIZED PERIPHYTON DATA, SEPTEMBER 2016							
Site	Density (cells/cm^2)	Biomass (ug/cm^2)	Species Richness	Dominant Species as Density	% Dominant Species as Density	Dominant Species as Biomass	% Dominant Species as Biomass
E1	697,674	478.1	13	Achnanthes minutissima Kutzing	38.9	Synedra ulna (Nitzsch) Ehrenberg	63.7
E2	813,954	735.5	14	Audouinella / Chantransia stage	30.7	Synedra ulna (Nitzsch) Ehrenberg	51.5
E3	503,876	62.9	10	Heteroleibeinia profunda Komarek	54.7	Heteroleibeinia profunda Komarek	38.9
E4	428,510	240.4	12	Heteroleibeinia profunda Komarek	43.2	Synedra ulna (Nitzsch) Ehrenberg	75.0
E6	85,271	12.5	9	Heteroleibeinia profunda Komarek	41.4	Synedra ulna (Nitzsch) Ehrenberg	28.2
E8	96,402	30.1	15	Chamaesiphon incrustans Smith	35.4	Didymosphenia geminata Schmidt	44.0
Porcupine Cr	340,224	212.2	13	Gomphonema minutum	43.9	Gomphonema minutum	34.7
R2	25,409	14.7	11	Audouinella / Chantransia stage	43.6	Phormidium autumnale Agardh	41.4
R3	446,454	49.5	9	Heteroleibeinia profunda Komarek	70.1	Heteroleibeinia profunda Komarek	67.9
R4	22,136	1.6	8	Heteroleibeinia profunda Komarek	39.3	Heteroleibeinia profunda Komarek	37.1
R6	175,711	30.5	11	Achnanthes minutissima Kutzing	69.1	Fragilaria capucina Grunow	33.9
Study Area	3,635,621	1867.9	29	Heteroleibeinia profunda Komarek	27.1	Synedra ulna (Nitzsch) Ehrenberg	51.0

The dominant species in terms of cell density and cell biomass for each site, including the proportion within the community, is also depicted in Table 12. *Heteroleibeinia profunda*, of the phylum Cyanophyta, was the dominant species at E3, E4, E6, R3 and R4 in both cell density and cell biomass, except at E4 where *Synedra ulna*, a diatom species, was dominant for cell biomass. The density of the periphyton communities at E1 and R6 was dominated by the diatom species, *Achnanthes minutissima*. The community at Porcupine Creek was dominated by another diatom species, *Gomphonema minutum*, both as cell density and cell biomass. The periphyton community at R2, Easter Creek, was the only site where a red algal species was dominant, *Audouinella/Chantransia*. *Synedra ulna* dominated the Clinton Creek sites (E1, E2, E4 and E6) in terms of cell biomass.

Small numbers of *Didymosphenia geminata*, commonly known as Didymo, were documented only at E8 (Forty Mile River downstream of Clinton Creek) where it was also the dominant species in terms of cell biomass. Didymo is considered an invasive species and was first documented in western Canada (on Vancouver Island) in 1989 (Leland et al, 2015). Although present in Yukon waters, it hasn't been determined if it is spreading, and it may be native to the Yukon (Environment Yukon, 2014[1]). In the summer of 2014, Environment Yukon conducted a study to understand the distribution of Didymo in the Yukon Territory. Didymo was more widespread than anticipated and occurred in all Yukon watersheds except the Southwest Alaska drainage (Copper River area). The survey gave a baseline for presence and not detected. It does not indicate whether Didymo is a native species to Yukon, if it is spreading, or if it affects aquatic environments (Environment Yukon, 2014[2]). Further studies will be required before conclusive statements can be made. Didymo is characterized as a cold water species and appears to thrive in streams where phosphorus levels are low or undetected. (Leland et al, 2015). Phosphorus was not detected at any of the sites in the study area (Appendix B).

The available literature regarding the biomonitoring purpose of analysing periphyton relate to the tolerance and sensitivity to nutrient enrichment via organic pollution. Little information could be found related to chemical influences. As mentioned above, *Heteroleibeinia profundal* was common throughout the study area. The taxonomist for the Clinton Creek set of samples has identified this species in the Arctic, the Canadian Shield and in British Columbia (D. Findlay, personal communication, Feb 20, 2016).

The diatom *Achnanthes minutissima* was also found at all of the sites and in fairly high numbers throughout the study area. This species is typically found in unpolluted clean waters (Wu, 201; Agarwal, 2005).

The diatom *Synedra ulna* had high representation as biomass but was only found at the exposed sites. Different studies have shown *Synedra ulna* to be both highly tolerant and highly sensitive to metal pollution (Kelly et al, 1991). Its abundant presence at only the exposed sites is difficult to explain within the current dataset and the documented existing conditions.

6.2.2 Chlorophyll Analysis

Chlorophyll *a* and Pheophytin *a* content of the periphyton were determined and are presented in Table 13. The quantity of Chlorophyll *a* is a measure of live biomass. Chlorophyll degrades naturally as communities age and cells die. This results in the formation of phaeopigments and the analysis of Pheophytin *a* presents the quantity of degradation products in the periphyton sample, including Chlorophyll b. The total biomass per site is also included in Table 13 as well as total density.

Chlorophyll *a* and Pheophytin *a* generally followed the same trend within the study area. Periphyton Chlorophyll *a* and Pheophytin *a* concentrations reflected the density of organisms at each site with the highest concentrations at E2 (Clinton Creek downstream of Porcupine Creek) and the lowest at R4 (Eagle Creek). This corresponded to the visual observations of growth on the rocks that were sampled at the sites.

TABLE 13 CHLOROPHYLL CONCENTRATIONS IN PERIPHYTON SAMPLES					
	Site	Total Density (cells/cm^2)	Total Biomass (ug/cm^2)	Chlorophyll *a* (ug/21.2cm^2)	Pheophytin *a* (ug/21.2cm^2)
Exposed Sites	E1	697,674	478.1	70.6	56.0
	Porcupine Cr	340,224	735.5	37.4	31.7
	E2	813,954	62.9	87.0	75.1
	E3	503,876	240.4	26.4	19.6
	E4	428,510	12.5	31.9	27.5
	E6	85,271	30.1	24.1	20.7
	E8	96,402	212.2	11.3	10.3
Reference Sites	R2	25,409	14.7	16.5	14.6
	R3	446,454	49.5	22.0	17.3
	R4	22,136	1.6	0.1	0.11
	R6	175,711	30.5	18.3	14.4

The amount of Chlorophyll *a* varies among taxonomic groups and this can result in apparent biomass differences among communities when quantities of organic matter vary only a little (Biggs and Kilroy, 2000). In terms of biomass, the periphyton communities at E1, E2, E3, E4, E6, E8, Porcupine Creek and R6 were all dominated by diatoms. Cyanophytes dominated the sites at R2, R3 and R4.

7.0 BENTHIC INVERTEBRATES

The objective of the benthic invertebrate program was to collect data to describe current benthic macroinvertebrate communities in relation to the Clinton Creek Site, including community composition, species present, abundance, and community indicator indices.

Benthic invertebrates are bottom dwelling organisms that reside in lotic (running water) or lentic (standing water) environments. They are common inhabitants and are important in moving energy through food webs. Unlike chemical measures, invertebrate assemblages reflect long-term exposure to varying water quality conditions and thus integrate effects of contaminants over time (Rosenberg and Resh, 1993). Benthic invertebrates have been used to monitor ecological effects of contaminants, including metals, on stream communities since the early 1900s. These organisms are useful in this respect as their abundance and taxonomic diversity respond to a wide range of impacts including sedimentation, organic loading and changes in water chemistry. Using benthic invertebrates as biomonitoring tools offers many advantages for the following reasons; they are ubiquitous, they are abundant and easy to collect, there are a large number of species offering a spectrum of responses to environmental stress, they are generally sedentary and therefore are representative of local conditions, and they have long life cycles compared to other groups (i.e. periphyton). As such, benthic macroinvertebrates act as continuous monitors of the water they inhabit and therefore can serve as sentinels of change in local conditions.

7.1 Methods

Canadian Aquatic Biomonitoring Network (CABIN) procedures as outlined in the 2012 manual were followed for the collection of benthic invertebrates. Samples were collected from twelve sites in the study area in late summer (September 5th and 8th, 2016) using the kick and sweep method. A D-net equipped with a 400 µm mesh size was used to capture disturbed invertebrates while kicking the substrate in each stream for a duration of three minutes while moving upstream in a zigzag pattern for approximately 10 m. The captured detritus and benthic invertebrates were placed in a one litre nalgene bottle and preserved with 10% buffered formalin. Samples were stored and shipped in coolers.

Quality assurance and quality control (QA/QC) procedures for the field component consisted of; ensuring all personnel were adequately trained, sampling methods per site and between sites were consistent, samples were correctly collected, labeled and preserved, equipment was properly maintained, detailed field notes were kept, chain-of-custody forms were used and safe shipping and storage methods were followed. The samples were shipped by ground transport to Cordillera Consulting in Summerland, B.C. for sorting, enumeration and identification following CABIN protocols.

At the Cordillera Consulting lab, the following procedures were followed:

• Using a gridded Petri dish, fine forceps and a low power stereo-microscope (Olympus, Nikon, Leica) the sorting technicians removed the invertebrates and sorted them into family/orders.

• The sorting technician kept a running tally of total numbers excluding organisms from Porifera, Nemata, Platyhelminthes, Ostracoda, Copepoda, Cladocera and terrestrial drop-ins such as aphids. These organisms were marked for their presence (given a value of 1) only and left in the sample. They were not included towards the 300-organism subsample count.

• Where specimens are broken or damaged, only heads were counted.

• Subsampling was conducted with the use of a Marchant Box.

• When using the Marchant box, cells were extracted at the same time in the order indicated by a random number table. If the 300th organism was found part way into sorting a cell then the balance of that cell was sorted. If the organism count had not reached 300 by the 50th cell then the entire sample was sorted.

• The total number of cells sorted and the number of organisms removed were recorded manually on a bench sheet and then recorded into the database INSTAR1.

• Organisms were stored in vials containing 80% ethanol and an interior label indicating the site names, date of sampling, site code numbers and portion subsampled. This information was also recorded on the laboratory bench sheet and on INSTAR1.

• The sorted portion of the debris was preserved and labeled separately from the unsorted portion and was tested for sorting efficiency (Sorting Quality Control – Sorting Efficiency). The unsorted portion was also labeled and preserved in separate jars.

• Identifications were made at the genus/species level for all insect organisms found including Chironomidae (Based on CABIN protocol).

• Non-insect organisms (except those not included in CABIN count) were identified to genus/species where possible and to a minimum of family level with intact and mature specimens.

• The Standard Taxonomic Effort lists compiled by the CABIN manual1, Southwest Association of freshwater Invertebrate Taxonomists (SAFIT2), and Pacific Northwest Aquatic Monitoring Partnership (PMAMP3) were used as a guideline for what level of identification to achieve where the condition and maturity of the organism enabled.

• Organisms from the same families/order were kept in separate vials with 80% ethanol and an interior label of printed laser paper.

• Chironomidae was identified to genus/species level where possible and was aided by slide mounts. CMC-10 was used to clear and mount the slide.

• Oligochaetes were identified to family/genus level with the aid of slide mounts. CMC-10 was used to clear and mount the slide.

• Other Annelida (leeches, polychaetes) were identified to the family/genus/species level with undamaged, mature specimens.

• Decapoda, Amphipoda and Isopoda were identified at family/genus/species level where possible.

• Bryozoans and Nemata remained at the phylum level.

Taxonomic QC was performed in house by a technician other than the original taxonomist:
• Quality control protocol involved complete, blind re-identification and re-enumeration of at least 10% of samples by a second SFS-certified taxonomist.
• Samples for taxonomic quality control were randomly selected and quality control procedures were conducted as the project progressed through the laboratories.

The data was subjected to several metrics and indices to describe the benthic populations. Abundance was determined by summing all of the individuals present in the sample. Taxonomic richness is a simple measure of diversity where each type of invertebrate is counted per sample. Diversity can be refined using many different indices and the Shannon Weiner Diversity Index (Pielou,1966) was used on this dataset using the equation:

$$H' = \sum \left(P_i(\log 10P_i)\right)$$

where P_i equals n_i divided by N. n_i is the total number of individuals in the ith taxa in one sample and N represents the total number of individuals in one sample.

To determine how evenly distributed the different types of individuals are within the community the Shannon Wiener Evenness Index was performed using the following equation:

$$\frac{H'}{\log_{10} S}$$

where the Shannon Weiner Diversity index is divided by the log of the total number of individuals in the sample.

A percent similarity index (Brock, 1977) was used to describe the similarity within the benthic communities at the different sites. The following formula was used where ‘a’ and ‘b’ are for a given taxa percentage of the total samples A and B which that taxa represents. The absolute value of their difference is summed over all taxa, K.

$$Psc = 100 - 0.5 \sum^{k} |a - b|$$

Biotic indices are often used to ascertain the general water quality at a particular site. The Hilsenhoff Biotic Index is based on a formula using pre-assigned pollution tolerance scores for families. The following equation was used where n equals the number of individuals in taxa i, a is the preassigned pollution tolerance value assigned to taxa i, and N is the total number of individuals in the sample.

$$HBI = \frac{\sum n_i \times a_i}{N}$$

7.2 Results and Discussion

Benthic invertebrate samples were collected from twelve sites in the Clinton Creek drainage and the dataset is provided in Appendix E. Site descriptions are detailed in Section 8.1.2 and in Appendix F. Four phyla were found in the study area: Arthropoda, Nemata, Annelida, and Platyhelminthes. Of these, Cordillera Consulting does not consider Nemata or Platyhelminthes to be benthic organisms. In addition, crustaceans within the phylum Arthropoda were not considered as benthos. The numbers for these taxa indicated in Appendix E reflect presence, not total numbers, of individuals in the sample. The portion of the sample that was sorted and identified is indicated in Appendix E, in the row under the date each sample was collected.

Of the organisms that were enumerated, a total of 12,670 invertebrates, representing 90 different taxonomic groups were identified in the study area. The following sections pertain to these taxa.

7.2.1 Abundance and Taxonomic Richness

The total number of organisms per site represents the abundance, which ranged from 80 individuals at the reference site R1, Clinton Creek upstream of Hudgeon Lake, to 3,687 individuals at E8, Forty Mile River downstream of Clinton Creek (Table 14).

The simplest method for determining diversity for each site is by enumerating all the taxonomic groups identified from species to phylum. High taxa richness is assumed to indicate high biotic integrity because many species are adapted to the conditions present in the habitat. The most diverse community occurred at E1 (Clinton Creek downstream of the gabions) with 33 different taxa identified. The community at E8 was the least diverse with only 11 different taxa present (Table 14). Another form of representing diversity is to use the Shannon Wiener Diversity Index which takes into account taxa richness as well as the proportion of each taxa in the community. The higher the index the greater the biodiversity in that community. The Shannon Wiener Diversity Index ranged from 0.20 at E8 to 1.2 at E2, Clinton Creek downstream of Porcupine Creek.

To determine how evenly the taxa were distributed within the community, the Evenness Index was used, which incorporates the index generated by the Shannon Wiener Diversity Index. This index ranges from zero, where there is only one taxa in the community to 10 where each taxa is represented equally. Evenness ranged from 0.20 at E8 to 0.83 at E2.

TABLE 14 GENERAL STATISTICS ON THE BENTHIC COMMUNITIES, 2016

Site	Site Description	Abundance (# of individuals)	Taxonomic Richness (# of taxa)	Shannon Wiener Diversity Index	Evenness Index
E-1	Clinton Cr d/s gabions and u/s Porcupine Cr	459	33	1.17	0.75
Porcupine Creek	Porcupine Cr u/s Wolverine Cr	2809	24	0.94	0.67
E-2	Clinton Cr u/s Wolverine Cr	1120	28	1.21	0.83
E-3	Wolverine Cr u/s Clinton Cr	451	30	1.10	0.75
E-4	Clinton Cr d/s Wolverine Cr	255	26	0.84	0.58
E-6	Clinton Cr u/s road crossing to Townsite	299	27	0.78	0.53
E-8	Forty Mile R d/s Clinton Cr	3687	11	0.20	0.20
R-1	Clinton Cr u/s Hudgeon L	80	13	0.70	0.63
R-2	Easter Cr	1149	27	0.99	0.68
R-3	Wolverine Cr u/s tailings	902	30	1.01	0.67
R-4	Eagle Cr	257	16	0.72	0.59
R-6	Forty Mile R u/s Clinton Cr	1202	20	0.48	0.37

7.2.2 Community Composition

The composition of the benthos communities was calculated as a percentage of the major taxonomic orders present, with pie charts generated for each site (Appendix E, Figure 5). The grouping "Other" consists of invertebrates from Collembola, Arachnida, Amphipoda and Hirudinea. Based on the percentages, taxa were then classified with respect to their dominance within the community (Table 15).

Plecoptera (stoneflies) and/or Diptera (true flies) were the dominant orders at all of the sites. Many of these populations had a very high percentage of the dominant order, and thus did not have any subdominant groups. The communities at the exposed sites closest to Hudgeon Lake and the waste rock dump were dominated by Diptera of over 70%. The majority of the Dipterans belonged to the family Chironomidae. The community upstream on Wolverine Creek (R3) also was largely dominated by Diptera.

Plecoptera formed the majority of the remaining populations, with the communities at E8, R1, R4 and R6 comprised of 78% or more.

TABLE 15 TAXONOMIC DISTRIBUTION OF THE BENTHIC COMMUNITIES, 2016

SITE	DOMINANT (>25%)	SUBDOMINANT (10% to 24.9%)	COMMON (1.0% to 9.9%)	RARE (0.1% to 0.9%)
E-1	Diptera		Trichoptera Oligochaeta Ephemeroptera Other	Plecoptera
Porcupine Cr	Diptera	Other Plecoptera	Oligochaeta	Trichoptera
E-2	Diptera	Oligochaeta	Trichoptera Plecoptera Other	Ephemeroptera
E-3	Plecoptera Diptera	Other Trichoptera Oligochaeta		
E-4	Plecoptera Oligochaeta	Diptera	Other Trichoptera	Ephemeroptera
E-6	Oligochaeta Plecoptera	Diptera	Other	Trichoptera
E-8	Plecoptera		Oligochaeta Diptera	Other
R-1	Plecoptera	Diptera	Other	
R-2	Plecoptera Diptera	Ephemeroptera	Oligochaeta	Trichoptera
R-3	Diptera	Plecoptera	Ephemeroptera Oligochaeta	Other
R-4	Plecoptera	Diptera	Oligochaeta	Other
R-6	Plecoptera	Diptera	Oligochaeta Ephemeroptera	

To determine how similar the composition of the benthic communities were to each other throughout the study area, a percent similarity index (PSI) (Brock, 1977) was applied to the dataset. Higher values indicate a greater similarity between the two sites (Table 16).

There were a few notable observations. The two sites on the Forty Mile River, (R6 upstream Clinton Creek, and E8, downstream Clinton Creek) were very similar to each at 83.68% suggesting that influence from Clinton Creek to the benthic community downstream is minimal . E1 and E2 were quite similar to each other with a PSI of 53.12 %, but had very low similarities to any of the other sites in the study area. The benthic community at Porcupine Creek was unlike any of the other communities with low similarities to the majority of the sites.

TABLE 16 PERCENT SIMILARITY FOR ALL SITES, 2016

Site	E2	E3	E4	E6	E8	Porcupine Creek	R1	R2	R3	R4	R6
E1	53.12	26.90	11.33	10.20	3.42	19.01	4.62	23.94	37.14	9.22	7.25
E2		25.44	20.03	20.84	9.53	17.36	7.58	17.24	18.23	7.82	12.38
E3			23.31	30.39	16.61	27.74	34.94	37.10	44.69	49.25	19.28
E4				59.02	49.14	9.61	48.58	46.13	13.79	33.34	51.66
E6					36.53	11.78	39.44	46.23	16.09	34.82	38.84
E8						6.39	46.79	36.45	10.83	33.07	83.68
Porcupine Creek							16.20	23.92	35.80	14.39	10.50
R1								47.01	24.64	47.76	47.50
R2									34.87	46.09	40.84
R3										33.58	16.55
R4											32.64

The community at E4 had close to 50% similarity with several sites, E6, E8, R1, R2 and R6.

Many aquatic insects require good water quality to thrive. Larvae of mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) require clear, clean, well oxygenated water and have very low tolerance to pollution (Rosenberg and Resh, 1993). Analyzing the combined EPT (Ephemeroptera, Plecoptera, Trichoptera) at a site, gives an indication of the overall health of the stream. Table 17 summarizes the number of EPT found per site, the number of EPT taxa (richness) and the proportion of EPT in each community.

TABLE 17 EPT ABUNDANCE, PROPORTION AND RICHNESS

Site	Site Description	EPT Abundance	EPT Proportion	EPT Richness
E-1	Clinton Cr d/s gabions and u/s Porcupine Cr	48	10.5%	11
Porcupine Creek	Porcupine Cr u/s Wolverine Cr	325	11.6%	4
E-2	Clinton Cr u/s Wolverine Cr	153	13.7%	8
E-3	Wolverine Cr u/s Clinton Cr	235	52.1%	10
E-4	Clinton Cr d/s Wolverine Cr	130	51.0%	6
E-6	Clinton Cr at road crossing to Townsite	107	35.8%	4
E-8	Forty Mile R d/s Clinton Cr	3356	91.0%	1
R-1	Clinton Cr u/s Hudgeon L	67	83.8%	3
R-2	Easter Cr	655	57.0%	9
R-3	Wolverine Cr u/s tailings	294	32.6%	9
R-4	Eagle Cr	219	85.2%	4
R-6	Forty Mile R u/s Clinton Cr	993	82.6%	5

The community at E8 (Forty Mile River d/s Clinton Creek) had the greatest abundance of EPT, which formed 91% of the population, however only one taxon was represented, Capniidae, a family of Plecoptera. These are cold water stoneflies and the nymphs inhabit the zone of flow beneath the rocks and gravel on the bottom of streams and rivers, known as the hyporheic zone. They move near the substrate surface prior to emergence (Nelson, 1996). Due to the capture of numerous Capniidae at E8 as well as at many other sites, the sampling period probably coincided with a period of imminent emergence.

The lowest abundance occurred at E1 with 48 individuals, however this community had the greatest EPT richness with 11 different taxa identified and each of the EPT orders was represented (Figure 5).

EPT representation at E2 was low, however this site had the greatest proportion of Trichoptera (caddisflies) in the study area (Figure 5, Appendix E). Caddisflies were readily observed attached to the subsurface of the rocks in the creek (Photo #6).

The Pacific Stream Keepers Federation has indicated that streams with an EPT richness greater than 8 are of good quality (DFO). Based on this water quality assessment protocol, sites R2, R3, E3 and E1 are of good quality. Richness values below 5 could indicate that the habitat is compromised in some way. This situation applies to sites E8, R1, Porcupine Creek, E6 and R4.

Another method to determine the health of a stream is to calculate the Hilsenholf Biotic Index (Hauer and Lamberti, 2006). Due to differences in their tolerance to pollution, the presence or absence of certain invertebrates can provide valuable information on stream water quality. The HBI ranges from 0 to 10, where lower numbers indicate the presence of pollution sensitive organisms and the higher numbers represent a greater presence of pollution tolerant families. Therefore, sites with excellent water quality would contain benthic communities with a high number of pollution sensitive families. Table 18 gives the listing of the categories for the condition of the water and Table 19 summarizes the data for Clinton Creek.

TABLE 18 WATER QUALITY BASED ON HBI

Hilsenhoff Biotic Index	Water Quality Category
0.00 - 3.75	Excellent
3.76 - 4.25	Very Good
4.26 - 5.00	Good
5.01 - 5.75	Fair
5.76 - 6.50	Fairly Poor
6.51 - 7.25	Poor
7.26 - 10.00	Very Poor

TABLE 19 WATER QUALITY BASED ON HBI FOR CLINTON CREEK

Site Type	Site	Hilsenhoff Biotic Index	Water Quality Category
Exposed Sites	E-1	5.84	Fairly Poor
	Porcupine Creek	5.02	Fair
	E-2	5.23	Fair
	E-3	3.64	Excellent
	E-4	2.59	Excellent
	E-6	4.88	Good
	E-8	1.58	Excellent
Reference Sites	R-1	2.01	Excellent
	R-2	3.81	Very Good
	R-3	5.66	Fair
	R-4	2.35	Excellent
	R-6	1.94	Excellent

The HBI metric lists the water quality at E1, Porcupine Creek, E2 and R3 as Fair or Fairly Poor. These sites were heavily dominated by Chironomids (Figure 5, Appendix E), invertebrates that have a wide range of tolerance to a wide variety of habitat conditions (Merrit and Cummins, 1984). As such, the family Chironomidae would have a high pollution tolerance score. Additionally, the stream sediments at the first three sites have high concentrations of metals (Table 8, Figure 2), compromising stream health. The PEL for arsenic and chromium was exceeded at E1, and for chromium at Porcupine Creek and E2. Aquatic organisms may be adversely affected by exposure to elevated levels and the more tolerant organisms would tend to dwell there.

There was excellent water quality at E3, E4, E8, R1, R4 and R6, however a review of Table 4 shows that that aluminium, chromium, copper, iron and selenium exceeded the CCME-FAL guidelines at most of these sites. This would suggest that the metals are likely not in a bioavailable form allowing for the presence of sensitive species at these sites.

Some of these metrics contradict each other, thus other aspects must also be taken into consideration. The Pacific Stream Keepers Federation rates E8 as a site of poor quality yet the HBI rates it as excellent. The laboratory analysis of the water and sediment quality, and the in-situ conditions at E8 all indicate a healthy environment at the time of sampling (i.e. low metal concentrations in the water and the sediments, high dissolved oxygen, clear water, etc). In Appendix E, only 9% of the total benthic sample for E8 was sorted and identified. As stated in the Methods section, 7.1, the whole sample is subsampled until a minimum of 300 organisms are counted and the totals are then calculated accordingly. This would lead one to believe that many individuals were present in the whole sample collected from E8, resulting with the apparent capture of emerging stoneflies. Conversely, the complete benthic sample collected from E1, E3, E4, E6, R1 and R4 was sorted and counted.

Benthic invertebrates have been collected at the Clinton Creek site on only one other occasion at most of the sampling sites and using the same sampling methodology. In late summer of 2009, Laberge conducted environmental monitoring studies at the Clinton Creek site following a program designed by Minnow Environmental Inc (Laberge, 2010). Benthic invertebrate samples were not collected from Porcupine Creek or E6 in 2009. Triplicate samples were collected in 2009 and averages have been presented in Table 20.

A review of the two years of benthic data shows that abundance fluctuated between sites and between sampling periods (Table 20). Some sites had greater populations during 2009 while others had greater populations during 2016. Diversity was generally similar or higher during the 2016 sampling period. Composition of the benthic communities was quite similar between the two years. Diptera formed large portions of the communities at the exposed sites, where it was the dominant order except at E8 (Forty Mile River). Plecoptera was abundant at most of the other sites. However, two years of data is insufficient to perform statistical analysis and determine any trends.

TABLE 20 2009 AND 2016 BENTHIC INVERTEBRATE DATA				
Site	**Year**	**Abundance**	**Taxa Richness**	**Dominant Group**
E1	2009	4335	20	Diptera
	2016	459	33	Diptera
E2	2009	2146	25	Diptera
	2016	1120	28	Diptera
E3	2009	2852	13	Diptera
	2016	451	30	Plecoptera and Diptera
E4	2009	214	19	Diptera
	2016	255	26	Plecoptera
E8	2009	304	19	Plecoptera and Ephemeroptera
	2016	3687	11	Plecoptera
R1	2009	2152	13	Plecoptera
	2016	80	13	Plecoptera
R2	2009	602	23	Diptera
	2016	1149	27	Plecoptera and Diptera
R3	2009	437	19	Plecoptera and Diptera
	2016	902	30	Diptera
R4	2009	1792	17	Plecoptera and Oligochaeta
	2016	257	16	Plecoptera
R6	2009	767	17	Plecoptera
	2016	1202	20	Plecoptera

8.0 FISHERIES

8.1 Methods

Fish habitat and fish utilization assessments were conducted at sample stations within the Clinton Creek study area between September 5 and 9, 2016. The fish utilization assessments were conducted under the Authority of License to collect fish # XR 286 2016 issued by the Federal Department of Fisheries and Oceans (DFO), Whitehorse. A total of 9 sites were evaluated for habitat and 7 of these were evaluated for the presence and condition of fish.

Fish habitat assessments consisted of a suite of criteria designed to encompass both CABIN standards and British Columbia's Resource Inventory Committee's (RICs) reconnaissance fish and fish habitat inventory modelling (Appendix F). A representative reach of creek that varied in length between 60 and 300 meters was chosen for each of the pre-identified sample sites. Each selected sample reach consisted of a variety of available habitats (riffle, rapid, run, pool) for that site and each of the selected sample reaches was assessed for wetted width, dry width (normal high water mark), average depth calculated from 10 to 12 depth measurements, flood depth (difference between high water mark and existing flow level), % slope was determined with a clinometer, velocity using either a Marsh McBirney meter or floating object method, morphology and channel stability (lateral movement), bank characteristics, and for substrates an assessment of substrate composition and compaction, a measure of the B axis of the largest substrate (D 90) and a measure of the largest particles moved during recent flows (D). The sites were also assessed for available cover, surrounding vegetation and potential barriers to fish passage. A set of photos looking upstream, downstream, across the creek and of any unusual features representative of the site, was taken for each site. And finally an assessment of available cover as described in the RICs manual was conducted.

Fish utilization assessments to describe species utilization and collect specimens for metal analysis and general condition, were conducted with minnow trapping as the primary tool; angling, electro-fishing and seining were also used to augment the data set, provide a greater account of species utilization and to collect fish samples for analysis of metals in tissues.

Minnow trapping was conducted with ¼" G-type minnow traps baited with chinook salmon roe (Yukon River origin) and were set in a variety of habitats within the study area. Traps were set for an overnight period and an approximate 24 hour soak time. Care was taken to keep traps out of flows greater than 0.5m/second in an effort to reduce mortalities. G-traps are known as an excellent measure of juvenile chinook salmon (jcs) and slimy sculpin utilization. Electro-fishing was conducted with a Smith-Root POW back pack electro-fisher at an R5, 200 volt setting with a small anode ring in all available habitats within the sample reach. Seining was conducted with a 5 meter long pole seine with 1/8" rochel weave netting where conditions allowed at the plunge pool below the gabion structure. Angling was conducted using light spinning gear with small spinners or small dry flies. Fork or total lengths were measured and recorded on all fish captured in the minnow traps. To decrease stress to the captured fish, handling was kept to a minimum. Captured fish were identified by species and either released, live sampled for fork or total length depending on the species, and released back to the water of capture or sacrificed for metal analysis and detailed sampling. Fish maturity was based on the size of the fish. Chinook salmon were assumed to be juveniles and 0+ years of age although it was possible that some may be 1+. Sculpin were assessed as juvenile if less than 30 mm, sub adults >30 mm and <55 mm, and adults >55 mm. Arctic grayling were assessed as juveniles when <140 mm, sub adults between 140 and 180 mm and as adults when larger than 180 mm. External development such as fin size was also used in assessing maturity of live grayling.

Fishing effort in addition to the standard sampling was exerted to meet the required sample size of 15 Arctic grayling and 30 slimy sculpin for metals analysis. Fish taken for metal samples were processed at the end of each day. The defined sample size was collected and each sacrificed fish was assessed for external lesions and parasites, measured for fork or total length depending on species (mm), weighed for round weight (g), and the gonads were internally examined to determine sex and sexual maturity.

Age determination was not in the scope of work, however DFO had requested otoliths from any of the sacrificed fish. DFO covered the analytical costs and the data would be provided when available. Otolith bones were removed from each fish, dried and stored in individual sample envelopes with the data for that fish clearly labelled. The otoliths were delivered to Whitehorse DFO for the purposes of age determination for both the Arctic grayling and slimy sculpin samples.

Upon completion of the above, each sacrificed fish was processed for laboratory analysis of metals in the flesh. Slimy sculpin samples were maintained as whole body samples and each sample represented a single adult fish. Arctic grayling samples were dissected and the liver was removed and processed as a separate sample. A portion of the whole mid body spanning the dorsal fin of each grayling was also taken as an individual sample, meaning that each grayling had both a liver and flesh sample taken. Samples were frozen the day they were taken and were sent to ALS laboratories in Burnaby, BC for analysis immediately after the conclusion of the field session.

Condition factor (K) is a measure of fish health based on a correlation between length and weight using the following equation:

$$K = \frac{10^N W}{L^3}$$

where N=5, W is the weight and L is the length of the fish.

All field data was recorded on field sheets and later transferred to an electronic format.

8.2 Results and Discussion

8.2.1 Fish Habitat and Utilization Assessment

Previous work at the Clinton Creek site identified three reaches for the main channel of Clinton Creek below Hudgeon Lake (von Finster, 2012). Reach 1 is 3,170 m long, commencing at the mouth and meanders through a large valley. Reach 2 is 3,500 m long and flows in a confined valley. Reach 3 is also approximately 3,500 m long and includes the section of Clinton Creek that receives any direct effects from the abandoned mine and includes the existing physical mitigation measures. Ground truthing during the September 2016 investigation confirms the delineation of these reaches. The main observation during the 2016 reach assessment was that the substrate in Reach 1 gradually became coarser moving up the reach. The terminus of Reach 1 coincides with the first partial obstruction on the creek, old abandoned beaver dams (see Section 8.2.2).

Individual reaches were established at each of the sample sites, and tables per site incorporating all of the information recorded on the CABIN and RICs forms are provided in Appendix F. Lengths were taken on all fish captured in the minnow traps (Table 21 in Appendix F). To decrease stress to the captured fish handling was kept to a minimum and weights were not always measured. Fish were live released at the site of capture as soon as the lengths were recorded. Summaries of the habitat and utilization assessment for the sites are presented below.

EXPOSED SITES:

Site E1, Clinton Creek Ford at Waste Rock
A sample reach 120 meters in length was assessed at site E1. At the time of investigation E1 had an average channel width of 6.5m an average wetted width of 5.1m, an average depth of 0.35m and an average velocity of >1m/sec. The substrate consisted of angular materials from the waste rock pile that consisted of 60% boulder, 30% cobble and 10% sand and fines. The substrates were not consolidated at all and the channel was partially

confined by eroding waste rock piles. Water temperature at the time of investigation was 9.8°C.

A set of 15 minnow traps set at this site recorded an abundance of robust juvenile chinook salmon (jcs) with a total of 20 captured. The sampled jcs had an average length of 92.3mm and ranged in length from 72 to 103mm. Also captured were 11 juvenile Arctic grayling with an average length of 101 mm (range 87-140mm) and 9 adult slimy sculpin with average length of 93.1mm (range 88-109mm). (Table 21, Appendix F).

Electro-fishing for 312 seconds at this site recorded 8 slimy sculpin that ranged in length from 45 to 102 mm, 6 juvenile Arctic grayling that ranged in length from 77 to 109mm and 2 jcs. Angling for 30 minutes at this site captured no fish.

The access road to Hudgeon Lake fords Clinton Creek at this sample site. The ford requires semi constant maintenance and is utilized regularly by vehicle traffic resulting in the lower section of the sample reach having a more or less constant destabilization of the banks. The site cuts through old waste rock and the stream channel has not stabilized.

Site E2, Clinton Creek Upstream of Wolverine Creek

A sample reach 160 meters in length was assessed and at the time of investigation this site had an average channel width of 13m, an average wetted width of 7.5m, an average depth of 0.19m and an average velocity of 0.6 m/sec. The substrates were loosely consolidated and consisted of 50% gravel, 20% cobble, 5% boulder and 25% sand and fines. The channel was partially confined on the left bank by the access road berm and was open on the right bank. The sample site is located at the downstream edge of what was a large beaver dam that has breached in recent years and the channel upstream of the sample site is a new channel that courses through the old beaver pond. Water temperature at the time of investigation was 9.3°C.

A set of 10 minnow traps set at E2 captured 65 robust jcs. A subsample of 33 were measured and had an average length of 84.7mm that ranged in length from 66 to 107 mm, four adult slimy sculpin were also captured in the minnow traps, with an average length of 80.5mm. Electrofishing at this sample site for 300 seconds captured 3 adult slimy sculpin (55 to 83mm) and 5 juvenile slimy sculpin (31 to 40mm). A single adult Arctic grayling was observed. Angling for 75 minutes captured 2 adults and 1 sub-adult Arctic grayling.

Site E3, Wolverine Creek Upstream of Confluence with Clinton Creek

A sample reach 200 meters in length was assessed. The site had an average channel width of 6.7m, an average wetted width of 4.2m, an average depth of 0.12m and an average velocity of 0.54 m/sec. The substrates consisted of partially embedded substrates consisting of 30% cobble, 50% gravel and 20% fines that were the result of washed tailings. The channel was partially confined by deposition banks in an entirely open flood plain with no vegetation opposite banks with newly established willow and young spruce. Water temperature at the time of investigation was 3.3°C. This site contains no cover for fish and virtually no fish habitat at the water level observed during sampling. Possible fish habitat is limited upstream of the first tributary flowing into Wolverine Creek from the east, due to the high gradient (von Finster, 2016). The perched culvert at the Clinton Creek access road prevents fish movement into Wolverine Creek.

Site E4, Clinton Creek Upstream of Eagle Creek

A sample reach 100 meters in length was assessed. At the time of investigation this sample site had an average channel width of 7.0m an average wetted width of 6.5m, an average depth of 0.4m and an average velocity of 1.2 m/sec. The substrates consisted of mostly flat rocks that varied from loosely to tightly embedded with 35% gravel, 25% boulder, 25% cobble and 15% silty sand and the channel was partially entrenched. The channel flows 90% as fast riffle through a very straight channel. Water temperature at the time of investigation was 8.4°C.

A set of eight minnow traps captured 3 jcs and 9 adult slimy sculpins. The jcs had an average length of 79.7mm with a range of 75-82 mm and the sculpin had an average length of 73.6 mm and ranged in length from 54 to 99mm. Electro-fishing for 280 seconds recorded 8 slimy sculpin and angling for 45 minutes captured 2 sub adult and 1 adult Arctic grayling.

Site E6, Clinton Creek at the Old Town Site Access Road

A sample reach 120 meters in length, upstream of the ford, was assessed. At the time of investigation this sample site had an average channel width of 13.5m an average wetted width of 11m, an average depth of 0.25m and an average velocity of 0.7m/sec. The substrates consisted of 50% gravel, 30% cobble and 20% fines and were loosely compacted. The channel was partially confined in the upper areas of the reach by a bedrock wall and was open to the valley bottom flood plain on the opposite bank. Flows consisted of 60% glide and 30% riffle with occasional pools. Water temperature at the time of investigation was 6.4°C.

The downstream end of the sample site is used as a ford for the road that accesses the residence nearby and the old town site. The old bridge used to access the historic town site still remains (abandoned) immediately downstream of the active ford.

A set of 14 minnow traps captured 35 jcs and 1 adult sculpin. The jcs had an average length of 70.3mm and ranged in length from 55-88mm. Electro-fishing for 220 seconds captured 1 sub adult Arctic grayling (165mm), 1 juvenile Arctic grayling (82 mm), 5 sub adult slimy sculpin (52-63 mm) and 1 adult slimy sculpin (88 mm). Angling for 40 minutes captured 2 sub-adult Arctic grayling (147 and 153 mm).

The jcs and slimy sculpin captured at E1 were the largest of any of the sites sampled and it was noted that length decreased moving downstream through the creek. The jcs captured at E6 were significantly smaller than those captured higher up in the creek. Table 22 summarizes the average lengths of the fish captured in the minnow traps, and decreasing length of fish coincides with greater distance from the upstream site (E1).

TABLE 22 AVERAGE LENGTHS (mm) OF LIVE SAMPLED FISH FROM MINNOW TRAPPING, CLINTON CREEK, SEPTEMBER 2016

Site	Juvenile Chinook Salmon		Arctic Grayling		Slimy Sculpin	
	Length (mm)	N	Length (mm)	N	Length (mm)	N
E1	92.3	20	100.5	11	93.1	9
E2	84.7	33		0	80.5	4
E4	79.7	3		0	73.6	9
E6	70.3	35		0	72.0	1

REFERENCE SITES:

No fish assessments were to be completed on the reference sites with the exception of Maiden Creek (Table 1), however habitat assessments were completed. Fish have not been documented at the reference sites in the past (WMEC, 2008), and the perched culverts on Wolverine and Eagle Creeks, and the gabion structure at Hudgeon Lake prevent movement of fish to these sites. Nonetheless, general observations were made while on site.

Site R1, Clinton Creek Upstream of Hudgeon Lake
A sample reach 100 meters in length was assessed and at the time of investigation this sample site had an average channel width of 7.0m, an average wetted width of 6.0m, an average depth of 0.2m and an average velocity of 0.5 m/sec. The substrates consisted of unconsolidated shifting small gravels over silt with silt deposition in off-channel areas. The creek flows predominantly as a glide with occasional riffling and side pools. The channel was partially entrenched on the right bank giving way to an open flood plain on the left bank, confined with shallow banks that rose 0.25m. Habitats at this immediate site have limited potential for fish utilization with little cover available and shifting substrates. However, most of Upper Clinton Creek beyond the first tributary would provide fish habitat if this area was accessible (see Section 8.2.2). Water temperature at the time of investigation was 3.1°C. No fish were observed during the habitat assessment.

Site R2, Easter Creek Upstream of Hudgeon Lake
A sample reach 55 meters in length was assessed and at the time of investigation this sample site had an average channel width of 4.2m, an average wetted width of 2.2m, an average depth of 0.25m and an average velocity of 0.7 m/sec. The substrates consisted of loosely consolidated shifting gravel (70%) and silty sand (30%) and the channel was partially confined with banks that rose 0.65m opposite of an open flood plain. Water temperature at the time of investigation was 4.1°C. No fish were observed in Easter Creek during the 2016 visit.

R4, Eagle Creek Immediately Upstream of the Confluence with Clinton Creek
A sample reach 80 meters in length was assessed. At the time of investigation this site had an average channel width of 1.6m, an average wetted width of 1.5m, an average depth of 0.2m and an average velocity of 0.75 m/sec. The creek flows entirely as a fast

riffle. The substrates consisted of tightly embedded 40%cobble, 30% gravel and 30% sand and the channel was entirely entrenched. Water temperature at the time of investigation was 3.3°C.

No fish were observed in Eagle Creek. Eagle Creek has a straight and uniformly featureless channel that outflows to Clinton Creek through a perched culvert that does not allow for fish passage. An old log bridge structure still spans Eagle Creek on the upstream side of the present culvert.

Maiden Creek

Active placer mining occurred on Maiden Creek during the 2016 season and although the 2016 activity was likely conducted off channel the creek has a long history of placer mining and the habitat and creek structure has been modified by historic mining activity. The reach sampled appeared to have been mined decades ago on the east bank side and the west bank side was old growth forest.

A sample reach 300 meters in length was assessed and at the time of investigation this sample site had an average channel width of 8.0m, an average wetted width of 3.2m, an average depth of 0.6m and an average velocity of >1.5m/sec. The substrates consisted of unconsolidated gravels and sand with occasional cobbles. The channel was partially confined by banks rising up to 1.5 meters and became partially entrenched at the downstream end of the reach investigated. The creek was very cold at the time of sampling with water temperatures near 0°C and frazil ice forming in the water.

No fish were observed or captured in Maiden Creek during the 2016 sampling investigation. A set of 8 minnow traps were set in Maiden Creek and no fish were captured. Electro-fishing for 180 seconds produced the sample result. The electro-fishing effort was reduced at this site due to cold water temperatures (0.5ºC).

8.2.2 Barriers and Obstructions to Fish Passage Investigations

There are three previously known barriers to fish passage within the Clinton Creek study area. The perched culverts at Eagle and Wolverine Creeks prevent fish movement from Clinton Creek into these watersheds. The gabion structures at the outlet of Hudgeon Lake prevent fish passage to Hudgeon Lake and to upper Clinton Creek and Easter Creek.

Active slumping of the shale cliffs immediately downstream of the gabion structure continues to pose a threat to flows in Clinton Creek. Increased turbidity resulting from the slumping and introduction of sediment into Clinton Creek has the potential to impact fish. Observations of this area go back to 1991 and Roach et al (2002) noted active slumping on the north side of the channel due to undercutting of the native rock during a site visit in May, 2002. Several more areas were in the process of sliding downslope and into the creek downstream. AECOM (2010) performed a site inspection following the major flood event in the summer of 2010. Downstream of the last drop structure, the channel was 4 to 5 meters lower than it was before the flood. A number of large boulders were observed downstream indicative of the force of the flood waters required to displace them (AECOM, 2010). Water Resources conducted a site inspection on October 10th, 2010. The flood and heavy rains over the summer created severe erosion in the channel and downstream, and resulted in Clinton Creek changing its course and caused road washouts. The north valley wall is unstable through the length of the canyon section downstream of the existing gabion structure (von Finster, 2016). No recent failures were observed during the September 2016 investigations, however the nature of the rock failure make it difficult to assess the time frames that failures had occurred.

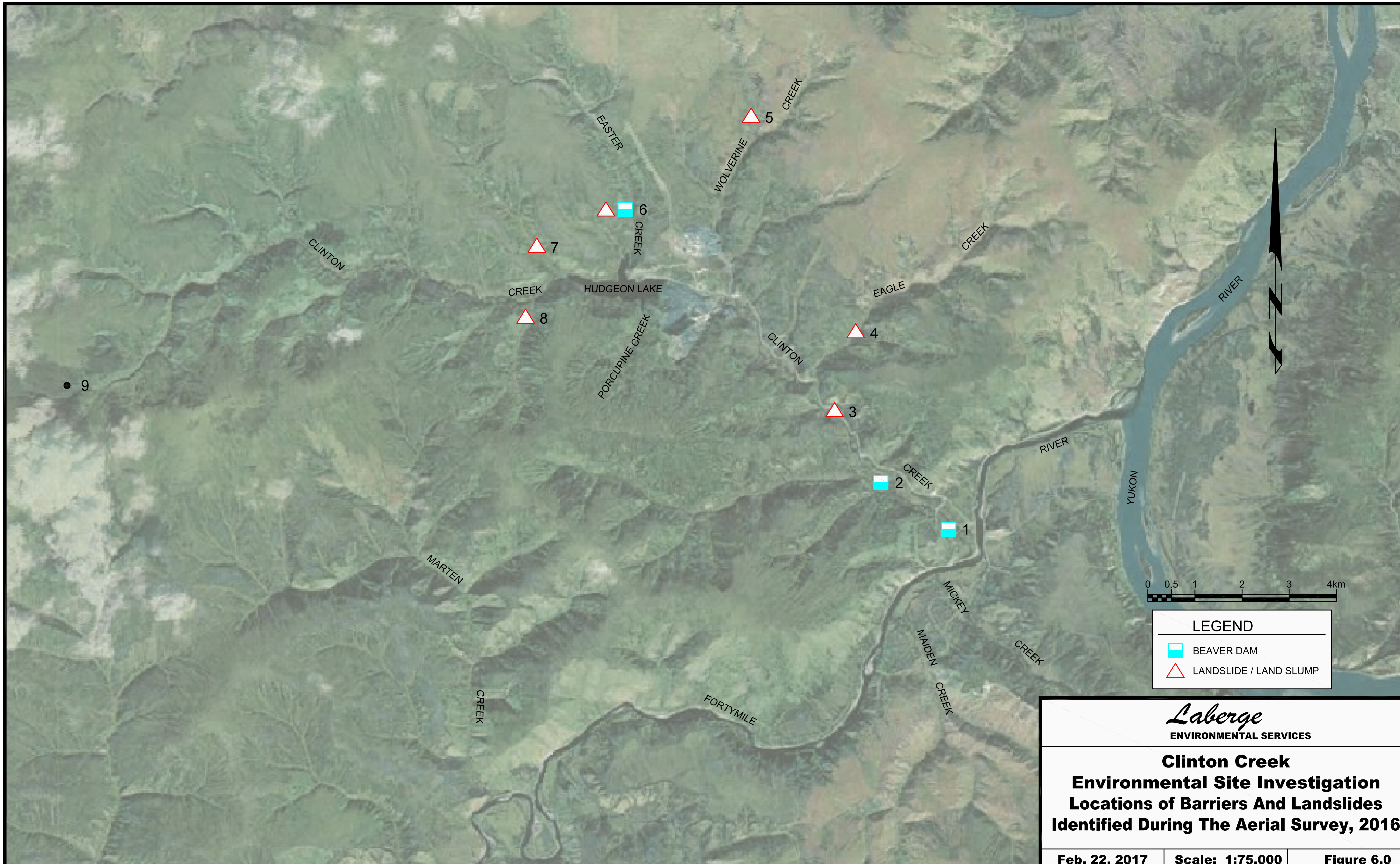
To determine if any barriers or obstructions to fish passage existed on Clinton Creek itself from the mouth at the Forty Mile River to Hudgeon Lake, an aerial survey was conducted on September 8th, 2016. The flight also included assessments on Eagle, Wolverine, Easter and Upper Clinton creeks to their respective headwaters. The objective of the survey was to document any active bank slumps, landslides and/or beaver dams that affected fish passage, fish habitat or water quality. Two experienced observers rode in the helicopter equipped with hand held GPS units and digital cameras.

Table 23 describes the observations, which are plotted on Figure 6. Photographs are in Appendix A.

TABLE 23 LOCATIONS OF BARRIERS AND LANDSLIDES IDENTIFIED DURING THE AERIAL SURVEY, 2016

Waypoint #	NAD 83		Description
	Easting	Northing	
1	518879	7142145	First beaver dam up from mouth of Clinton Cr
2	517437	7143135	Second beaver dam, plus large landslide near by
3	516455	7144639	Landslide on road
4	516903	7146314	Landslide on Eagle Creek
5	514682	7150894	Land slump on Wolverine, left fork
6	512006	7148935	Old landslide on Easter cr and old beaver dam a bit d/s
7	510130	7148132	Land slump on trib to Upper Clinton
8	509893	7146626	Slump along upper Clinton on left side looking up/s, very active
9	500156	7145200	Significant flow in upper Clinton Cr to this point

Waypoint #1 represents two partial barriers to fish passage that were observed at a point mid-way between the Forty Mile River and sample station E6. A crew hiked into these barriers after the flight to investigate. Both of the partial barriers consisted of old and abandoned beaver dams that had become stick and log jams that did not pose a barrier to fish passage or would they become a barrier at greater or lower flow levels (Appendix A, Photos #7 and #8). These two old beaver dams which have become log jams, were within 250 meters of each other and occur at a point in the Clinton Creek valley where the slope decreases and the creek enters the flood plain of the Forty Mile River.



Clinton Creek
Environmental Site Investigation
Locations of Barriers And Landslides Identified During The Aerial Survey, 2016

Feb. 22, 2017	Scale: 1:75,000	Figure 6.0

A large beaver dam located approximately two kilometres upstream of sample station E6 at Waypoint #2 (Appendix A, Photo #9) was also accessed on foot after the flight. This spectacular beaver dam appears to be a barrier to upstream passage of fish and likely is also a deterrent to downstream movement. Passive integrated transponders (Pit) radio tags were applied to six grayling in Clinton Creek during the summer of 2016 by DFO. The tagged fish were released near the gabions and of the six tags placed, only three moved past a receiver point downstream of E6, one in mid July and the last two were recorded in mid September (Jody Mackenzie-Grieve, personal communication, March 2017). The beaver dam has a face height of more than three meters and spanned more than 100 meters across the valley (Appendix A, Photo 10). Spillage from the beaver pond occurred on the east side in several small rivulets that cascaded through the forest before re-joining the main creek as far as 200 meters downstream of the dam, a difficult course for out migrating fish to attempt.

Waypoint #3 is the location of the active landslide on the Clinton Creek access road (Appendix A, Photo #11). Removal of the displaced earth and debris was undertaken just prior to the September field trip.

A small land slump was observed at Waypoint #4 on Eagle Creek (Photo #12). This slump appears to be degrading permafrost or ice lenses and threatens to deposit large quantities of materials into Eagle Creek. Eagle Creek upstream of the confluence with Clinton Creek is located in a steep valley and does not provide suitable flows for fish habitat.

Active slumping was observed on the upper reaches of the left fork of Wolverine Creek at Waypoint #5 (Photo #13), but no beaver activity was evident in this drainage.

An old landslide was noted on Easter Creek at Waypoint #6 (Photo #14). Evidence of old beaver dams was observed on the lower reaches of Easter Creek (Photo #15) but no active dams were observed.

Minor land movements were noted at Waypoint #7 on the southwest facing slope of the tributary entering upper Clinton Creek near the outlet to Hudgeon Lake.

Active slumping was observed at Waypoint #8 on the west facing slope in the upper reaches of a tributary draining from the south to upper Clinton Creek, just upstream of Hudgeon Lake. The slumping has been active and continuous over a period of years. The valley around this tributary appeared to have significant ice lens failures, as indicated by large up-slope unconsolidated and moving silty bed materials. Moving and slumping of the valley walls was extensive at this location (Photos #17 to #19). Turbidity derived from this slump affected sample station R1 but was settled out in the lake. There is a large muddy delta where Upper Clinton Creek enters Hudgeon Lake, indicative of many years of sediment deposition from areas upstream (Appendix A, Photo #20).

Waypoint #9 represents the uppermost limit on upper Clinton Creek that appears to have suitable habitat for fish (clear water with sufficient flow). This represents an approximate 10 km length of stream from the confluence of the south tributary (where Waypoint #8 is located) that is currently unutilized.

Several small active slumps were recorded on the lower reaches of Clinton Creek but were not new nor were they considered to be affecting fish habitat or fish passage.

8.2.3 Fish Distribution

Fish studies have been undertaken in the Clinton Creek area since 1976 (von Finster, 2012) and the same common three species documented in the past, utilized the site during the September 2016 survey; slimy sculpin, Arctic grayling and juvenile Chinook salmon. Beaver dams still play a role in the distribution of fish and the gabion structure downstream of Hudgeon Lake continues to be the upper limit of fish utilization in Clinton Creek. A large amount of small creek fish habitat exists upstream of Hudgeon Lake with no fish presence. The gabion structure is a barrier to fish passage to Hudgeon Lake and the spill pool immediately below the gabions had the greatest abundance of fish found in Clinton Creek. Seining at this site was the source of most of the Arctic grayling metal samples.

The spill pool held significant numbers of large juvenile chinook salmon (jcs from here and E1 were 15 to 20% longer than those from E6 (Table 21, Appendix F, and Table 22)), many sub adult and juvenile Arctic grayling and also an occasional adult grayling. The abundance of fish likely results from a combination of three factors. First, Hudgeon Lake acts as a thermal heat sink and during September the spill water from the lake was as much as 5°C warmer than downstream at site E6. The second reason being Hudgeon Lake has an abundance of nutrients spilling over the gabions that is not being cropped by fish within the lake. Lastly, the gabions are a barrier to fish passage resulting in the congregation of fish as this is the farthest point they can traverse upstream.

Large numbers of fish have been documented in the spill pool on several other occasions (Roach and Ricks, 2003; Copland, 2004 and 2008; ELR, 2015). The high densities of fish here may reflect their inability to move higher into the watershed rather than be a response to the availability of food organisms present (von Finster, 2016).

The large beaver dam two kilometers upstream of the ford to the old town site has created a barrier to fish passage for the fall/ winter of 2016/17. The dam will likely restrict out migrations of fish during the fall and all fish above the dam may be forced to remain in the creek for the winter period. Dams such as this typically have small or complete breaches during the spring freshet and salmon trapped upstream for the overwinter period should have no difficulty exiting the creek at that time.

Unlike the earlier investigation in 2007 (White Mountain Environmental Consulting, 2008), when a missing length class of sculpin was observed in the 3 or 4 year class, all length classes of slimy sculpin were recorded in 2016. Juvenile Arctic grayling were well distributed throughout the creek.

Adult Arctic grayling were not common in Clinton Creek during either the 2007 or the 2016 investigations. This may simply be a factor of the lateness of the season that sampling was conducted. Arctic grayling are known to travel up small tributaries during early spring, feed for the summer and move back into larger water for the fall and winter.

Although considerable effort was expended, no fish were observed or captured at Maiden Creek during the investigation. This is likely due to the near zero water temperatures and/or the disturbance to the watershed through active placer mining.

Greater distributions of fish in Clinton Creek occurred in the upper reaches near the gabion structure. Condition factor (K) was calculated for each fish (Table 24, Appendix G) and the average per site is presented below in Table 25. Higher numbers indicate that the fish is in better condition and thus healthier than those with lower K values. Almost all of the Arctic grayling samples were captured in the same area, in the upper reaches of the creek immediately downstream of Hudgeon Lake. These grayling all had a consistent K value of near 1 (average 1.0) and were visually healthy fish, both internally and externally.

TABLE 25 CONDITION FACTOR (K) FOR FISH AT CLINTON CREEK

	Site	Average K	Standard Deviation	Range	N
Slimy Sculpin	E1	1.2	0.09	1.0-1.3	12
	E2	1.0	0.05	1.0-1.1	9
	E4	1.0	0.21	0.8-1.4	7
	E6	0.85	0.01	0.8-0.9	2
Arctic Grayling	Gabion Pool	1.0	0.1	0.9-1.1	14
	E2	1.1	na	na	1

Slimy sculpin were more evenly distributed throughout Clinton Creek, however at the downstream site of E6, only two sculpin were captured. The K values for the sculpin taken from various stations throughout the drainage clearly show an increase in the K value for samples taken progressively closer to the outlet of Hudgeon Lake. Sculpin samples from E1 had the highest average condition factor with a K value of 1.2. The K values at stations downstream decreased to the lowest K from a sculpin captured at E6, 0.8 (Table 24, Appendix G).

When this information is coupled with the consistent increase of fork length from jcs in the upper reach (Table 21, Appendix F) it can be inferred that the upper reaches of Clinton Creek have a greater productivity than the lower reaches. This increase in productivity can be directly related to the warmer water temperatures observed in the flows coming over the gabion structure from Hudgeon Lake. Hudgeon Lake undoubtedly acts as a heat sink that attenuates temperature variations. It is also very likely that an important nutrient supply comes with this warmer flow because with no fish in the lake, exploitation of those nutrients will be very limited.

8.2.4 Tissue Analysis

The objective of the tissue analysis was to document the current levels of metals in fish tissue in the surface waters in relation to the Clinton Creek Site. This data will both provide current data describing the levels of metals in fish tissue, and will serve as a baseline with which to compare monitoring data during and after the reclamation. Fish tissue analysis has not been performed at the Clinton Creek site for metals. Slimy sculpin tissues were analyzed in 2010 for asbestos presence and to determine health implications of short and long term exposure to asbestos fibers through histological examination (Marty et al, 2014).

There are two main vectors of metal uptake by aquatic organisms, from the water with which they inhabit and from the food that they consume. Sediments represent the most concentrated pool of metals in aquatic environments (Luoma, 1983). Benthic (bottom dwelling) organisms live in close contact with the sediments and ingest and / or adsorb particles. Depending on the bioavailability of the metals they may be incorporated into the tissues or exoskeleton, or eliminated from the body.

Slimy sculpin are a bottom dwelling, resident fish common in Clinton Creek. They are thought to be relatively sedentary and analysis of their tissues would tend to reflect the local environment. Thirty whole body sculpins, captured throughout Clinton Creek were analyzed for the presence of metals. Arctic grayling migrate into and out of Clinton Creek seasonally and the liver and muscle tissue of 15 Arctic grayling were analyzed.

The analytical report containing all of the tissue results are presented in Appendix G. Lengths and weights were measured on each of the sacrificed fish and this data is presented in Table 24 (Appendix G), along with the mass (g) of tissue that was analysed and the moisture content (%). Since the tissue data is reported as dry weight, concentrations of selected parameters were converted to wet weight to allow comparisons to guidelines and databases (Tables 26 and 27, Appendix G). Metals that are known to create adverse effects to fish, and metals that are known to be components of the Clinton Creek asbestos mineralogy were those that were selected for closer examination.

The data was averaged per site of capture for each species and compared to the CCME (1999) tissue residue guidelines (TRG) for the protection of wildlife consumers of aquatic biota, and to the Canadian Food Inspection Agency guidelines for chemical contaminants and toxins in freshwater fish and fish products.

The Northern Contaminants Program in the Yukon maintained a database for metals in whole body slimy sculpin collected throughout the Yukon, and the maximum concentration and mean for each metal is also compared to the Clinton Creek sculpin data in Table 28.

The US Geological Survey maintains a database on metals in muscle tissue for northern pike, longnose sucker and burbot. The maximum concentration and mean for these three species was compared to the Arctic grayling data (Table 29) and also to the sculpin data to provide more information.

The main observations and points of interest in this first set of tissue data are summarized below:

- Concentrations of chromium, manganese and nickel were higher in the sculpin tissues captured from E1 than at the downstream sites.

- Slimy sculpin mercury concentrations were consistently higher than the reported means for sculpin in the Northern Contaminants Program database, at all of the sites.

- Average mercury concentrations of Arctic grayling liver and muscle, as well as whole body slimy sculpin, were above the mercury CCME-TRG (0.033 µg/g wet weight) for the protection of wildlife consumers of aquatic biota. This guideline was exceeded in all of the sculpin samples and ranged from 0.04 to 0.14 µg/g wet weight. Concentrations in all the grayling livers exceeded the guideline and ranged from 0.08 to 0.24 µg/g wet weight. The guideline was exceeded in most of the grayling muscle tissue samples and ranged from 0.03 to 0.20 µg/g wet weight.

- Cadmium, copper, iron, selenium and zinc concentrations were higher in the Arctic grayling liver samples compared to grayling muscle tissue samples.

- Arctic grayling tissue samples were below the food inspection guideline for arsenic, lead and mercury for chemical contaminants and toxins for fish and fish products.

- Arctic grayling tissue samples were generally below reported means for northern pike, longnose sucker and burbot tissues for the Yukon River in the USGS Large Rivers Monitoring Network in Alaska. Adult northern pike, longnose sucker and burbot have longer life expectancies than Arctic grayling and are therefore prone to bioaccumulate more contaminants with age.

The relatively high mercury concentrations found in all of the fish tissues (almost all of the 60 tissue samples exceeded the CCME-TRG) may be the result of methylmercury production in Hudgeon Lake. Methylmercury is formed during microbial action on decomposing vegetation under water. The valley was flooded in 1974 with the creation of Hudgeon Lake. Due to its northern location, the submerged vegetation has likely been rotting at a slow rate, and likely will continue to do so for a long time. It is reasonable to assume that mercury has gradually been released to Clinton Creek in the form of methylmercury. Methylation of mercury is highest during the warm months and under anoxic conditions (Hall et al, 1998). Hudgeon Lake is known to be anoxic several meters below the surface, however it is also a meromictic lake and very little mixing occurs (Liebau, 2010). Low levels of mercury were detected in the water samples in Clinton Creek and the highest concentration of mercury in the stream sediments was documented at E1, where it exceeded the ISQG. Studies on Hudgeon Lake would be required before the degree of methylmercury production could be determined.

Methylmercury is very toxic and accumulates readily in aquatic biota. It can be absorbed directly from water across the gills of fish or absorbed from the food it eats (Hecky el al, 1991) although most of mercury in fish comes from the diet (Hall et al, 1998). The concentrations of methylmercury increase as it passes through the food chain from periphyton to aquatic insects and on to fish. Tissue analysis was not performed on these lower trophic forms.

TABLE 28
COMPARISON OF SLIMY SCULPIN WHOLE BODY METAL CONCENTRATIONS (WET WEIGHT) CLINTON CREEK, YUKON 2016

DESCRIPTION			ARSENIC (ug/g)	CADMIUM (ug/g)	CHROMIUM (ug/g)	COPPER (ug/g)	IRON (ug/g)	LEAD (ug/g)	MAGANESE (ug/g)	MERCURY (ug/g)	NICKEL (ug/g)	SELENIUM (ug/g)	ZINC (ug/g)
WHOLE BODY	SITE NUMBER (N)	E1 (12)	0.10	0.04	0.41	0.78	76.79	0.08	22.93	0.08	1.08	1.56	26.00
		E2 (9)	0.08	0.03	0.10	0.60	38.90	0.04	12.82	0.08	0.32	1.48	23.77
		E4 (7)	0.09	0.03	0.11	0.62	28.17	0.05	13.86	0.09	0.42	1.45	26.56
		E6 (2)	0.14	0.04	0.12	0.63	58.14	0.07	14.81	0.13	0.66	1.32	30.54
CCME guideline			-	-	-	-	-	-	-	0.033[a]	-	-	-
CFIA guideline			3.50[b]	-	-	-	-	0.50[b]	-	0.50[b]	-	-	-
NCP Yukon Database (SS)	Maximum		10.2	1.03	5.71	27.6	476	29.4	188	0.17	4.5	9.0	187.1
	Mean (N)		1.85 (72)	0.16 (72)	0.60 (72)	1.6 (72)	83.1 (72)	2.44 (72)	24.8 (72)	0.02 (62)	0.69 (72)	1.71 (56)	42.2 (72)
USGS Yukon River Database (NP, LNS, BB)	Maximum		1.08	0.12	1.64	1.49	341.9	-	15.6	0.65	0.71	0.85	56.4
	Mean (N)		0.15 (30)	0.07 (9)	0.49 (25)	0.69 (30)	39.1 (27)	<0.3 (30)	5.10 (30)	0.24 (30)	0.41 (3)	0.51 (30)	35.6 (30)

CCME = Canadian Council of Ministers of the Environment, Canadian Guidelines for the Protection of Wildlife Consumers of Aquatic Biota – [a] MeHg Tissue Residue Guideline; CFIA = Canadian Food Inspection Agency, Canadian Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products – [b] for all freshwater fish products; NCP = DIAND, Northern Contaminants Program Yukon Database for slimy sculpin (SS); USGS = US Geological Survey – Biomonitoring of Environmental Status and Trends (BEST) Large Rivers Monitoring Network – Database for freshwater fish (NP=northern pike, LNS=longnose sucker, BB=burbot). Reported concentration means only used data from individual samples that were above the limits of detection for each element.

TABLE 29
COMPARISON OF ARCTIC GRAYLING TISSUE METAL CONCENTRATIONS (WET WEIGHT) CLINTON CREEK, YUKON 2016

DESCRIPTION			ARSENIC (ug/g)	CADMIUM (ug/g)	CHROMIUM (ug/g)	COPPER (ug/g)	IRON (ug/g)	LEAD (ug/g)	MAGANESE (ug/g)	MERCURY (ug/g)	NICKEL (ug/g)	SELENIUM (ug/g)	ZINC (ug/g)
LIVER	SITE NUMBER (N)	Gabion Pool (14)	0.02	0.24	0.19	1.54	41.45	<0.02	1.43	0.16	0.10	2.93	18.67
		E2 (1)	0.01	0.25	<0.08	1.39	54.00	<0.02	1.31	0.11	<0.08	4.75	16.93
MUSCLE	SITE NUMBER (N)	Gabion Pool (14)	0.03	0.01	0.07	0.50	11.18	0.01	1.98	0.11	0.08	1.27	13.82
		E2 (1)	0.02	0.01	0.05	0.49	6.63	<0.01	2.08	0.11	<0.06	2.16	12.52
CCME guideline			-	-		-		-		0.033[a]		-	-
CFIA guideline			3.50[b]	-		-		0.50[b]		0.50[b]		-	-
USGS Yukon River Database (Muscle-NP, LNS, BB)	Maximum		1.08	0.12	1.64	1.49	341.9	-	15.6	0.65	0.71	0.85	56.4
	Mean (N)		0.15 (30)	0.07 (9)	0.49 (25)	0.69 (30)	39.1 (27)	<0.3 (30)	5.10 (30)	0.24 (30)	0.41 (3)	0.51 (30)	35.6 (30)

CCME = Canadian Council of Ministers of the Environment, Canadian Guidelines for the Protection of Wildlife Consumers of Aquatic Biota – [a] MeHg Tissue Residue Guideline; CFIA = Canadian Food Inspection Agency, Canadian Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products – [b] for all freshwater fish products; NCP = DIAND, Northern Contaminants Program Yukon Database for slimy sculpin (SS); USGS = US Geological Survey – Biomonitoring of Environmental Status and Trends (BEST) Large Rivers Monitoring Network – Database for freshwater fish (NP=northern pike, LNS=longnose sucker, BB=burbot). Reported concentration means only used data from individual samples that were above the limits of detection for each element.

9.0 RECOMMENDATIONS

This investigation of the existing aquatic conditions of Clinton Creek provides new and updated information and data for the area, however a few recommendations are suggested to create a more complete assessment.

It is recommended that the temperature data loggers be downloaded in September 2017 which will give a full year of thermal activity at these five sites. This will provide useful information on winter conditions in Clinton Creek related to temperature. It may be beneficial to redeploy them at these locations for another year, and possibly to additional sites.

It is highly recommended that a suitable reference fisheries site be established. It is well documented that the reference sites for surface water quality within the study area do not contain fish (due to the various barriers) and thus a nearby reference site is required. The creek specified for this study (Maiden Creek) was actively placer mined preceding and during the 2016 assessment and no fish were observed or captured. Research will need to be undertaken prior to field work to ensure a proposed reference creek is currently not undergoing any activity. This can be accomplished by checking with the Dawson Mining Recorder's office and consulting the land use maps. By having a reliable reference site, it can be determined if the health and metal burden of the fish in Clinton Creek are typical of the area or if there is impact from the abandoned asbestos mine. It is suggested that upstream of Clinton Creek on the Forty Mile River could be one of the locations for a reference site as it would be off-site yet is very local. They are very different sized water bodies, however the collected data could serve as a background check. Another reference site on a similar sized creek as Clinton Creek should definitely be included. In addition, it is recommended that all media be sampled at the fisheries reference site(s); water quality, stream sediments, periphyton and benthic invertebrates.

It is also recommended that periphyton and benthic invertebrate tissues be analyzed for metals. Because of their importance in nutrient cycling and as a food source for fish, periphyton and benthic invertebrates can provide a means of metals transfer to higher trophic levels (Poulton et al, 1995). As well, some metals bioaccumulate providing an increased dose to consumers higher up the food chain. The fish species in the study area (jcs, slimy sculpin and Arctic grayling) consume periphyton and/or benthic invertebrates at some stage in the life cycles. The analysis of periphyton and benthic invertebrate tissues will provide an indication of the dose of metals fish may be consuming in their diet.

Since it is well documented that fish congregate in the pool and area immediately below the gabion structures, it is recommended that another exposed site be established here, if safety factors allow. Samples for the food sources for fish, periphyton and benthic invertebrates, should be collected, identified and analysed for metals. Sediment and surface water should also be sampled. Data collected from this area will provide information on possible influences from Hudgeon Lake.

It is also recommended that a water quality program be undertaken on Hudgeon Lake. Very limited data exists on the water quality of the lake and no analytical data on metals could be located. Liebau (2010) conducted a study on Hudgeon Lake and determined it was a meromictic lake and anoxic a few meters below the surface. Profiling should be repeated with the addition of water quality samples collected at various depths, with a focus on mercury. Additionally, it is recommended that horizontal plankton hauls are carried out to identify any pelagic life in the upper layer of the lake. Surface water samples for the analysis of chlorophyll are suggested to determine the productivity of the active layer of the lake during the summer.

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APPENDIX A

PHOTOGRAPHS OF THE SITES IN THE

CLINTON CREEK STUDY AREA

SEPTEMBER 2016

Photo #1: Temperature logger installation at Porcupine Creek.

Photo #2: Temperature logger installation at E6, secured to spruce tree.

Photo #3: Periphyton sampling apparatus clamped to a rock at E-6, September 2016.

Photo #4: Visible periphyton growth on sampled rocks at E-2, Clinton Creek upstream Wolverine Cr.

Photo #5: The rocks at Eagle Creek R-4 contain very little periphyton growth as evidenced on this sampled rock.

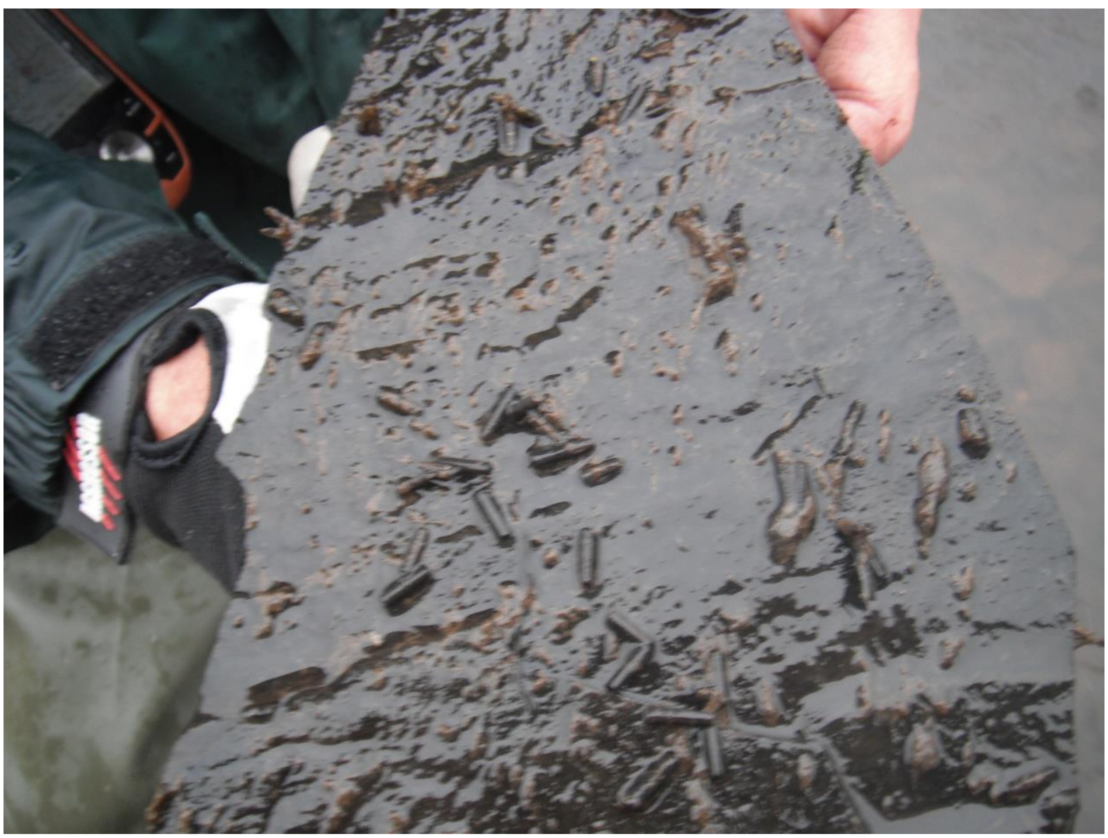

Photo #6: Trichopterans (*Brachycentrus spp*.) on the underside of a rock at E-2. Trichoptera formed 9.5% of the benthic community here.

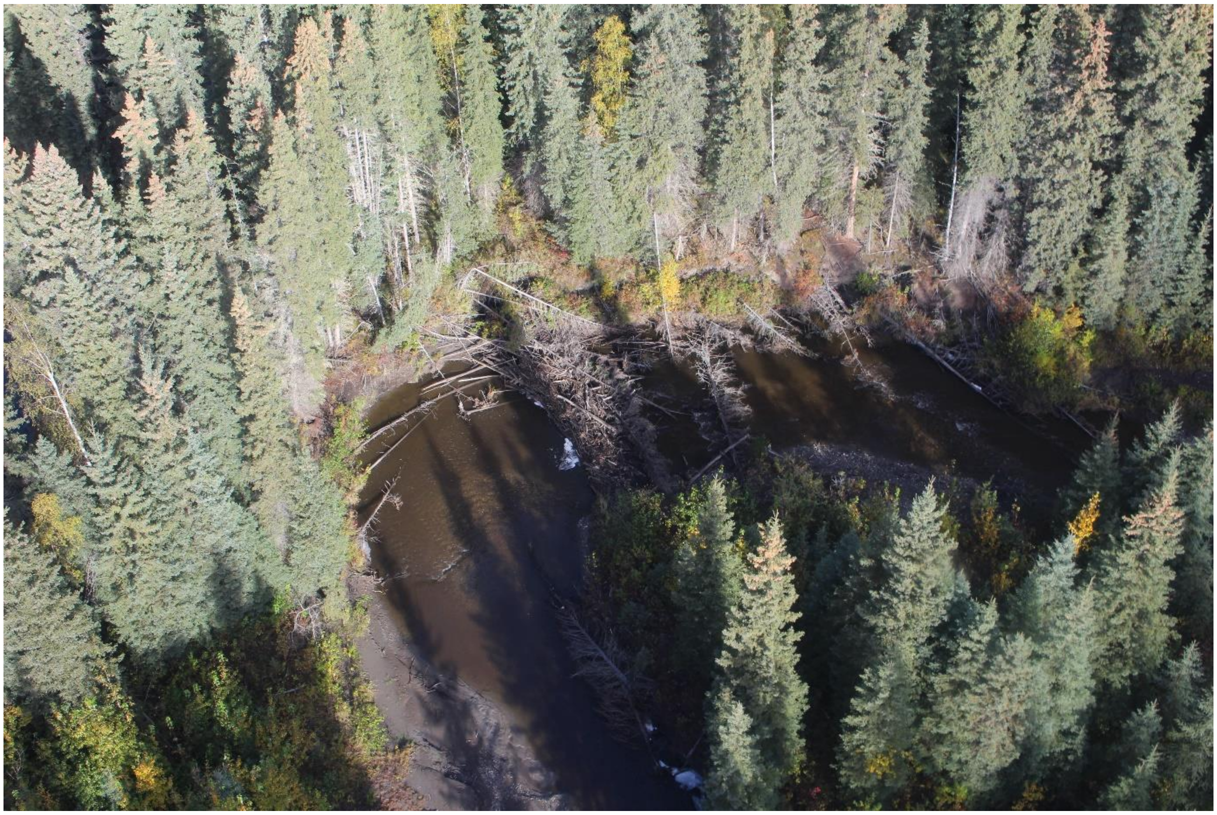

Photo #7: Aerial view of stick and debris jam resulting from an old abandoned beaver dam at Waypoint #1, September 2016.

Photo #8: Ground view of the above, Waypoint #1, that did not pose a barrier to fish passage.

Photo #9: Aerial view of active beaver dam at Waypoint #2 that likely prevents fish passage.

Photo #10: Downstream view of the massive beaver dam at Waypoint #2, September 2016.

Photo #11: Waypoint #3, landslide on Clinton Creek road.

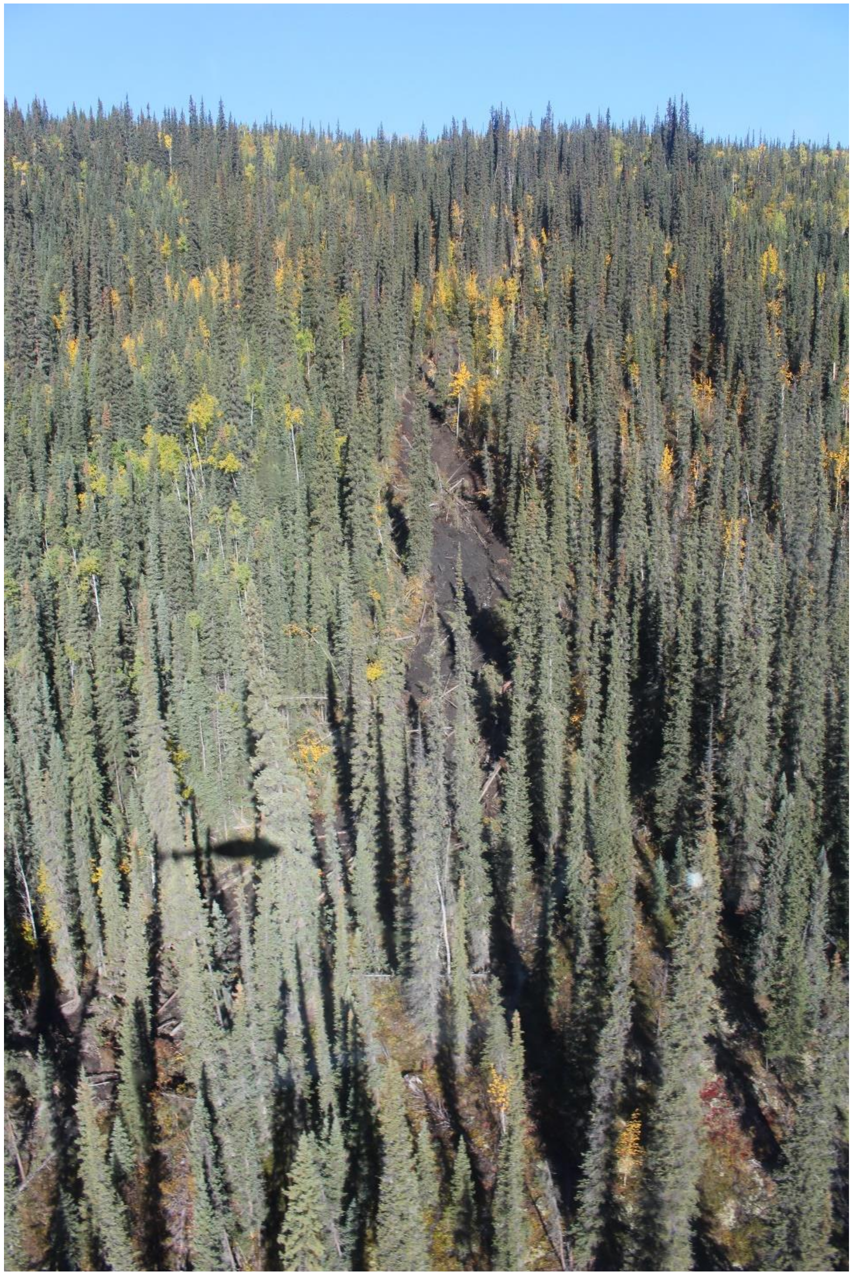

Photo #12: Waypoint #4, small landslide on Eagle Creek.

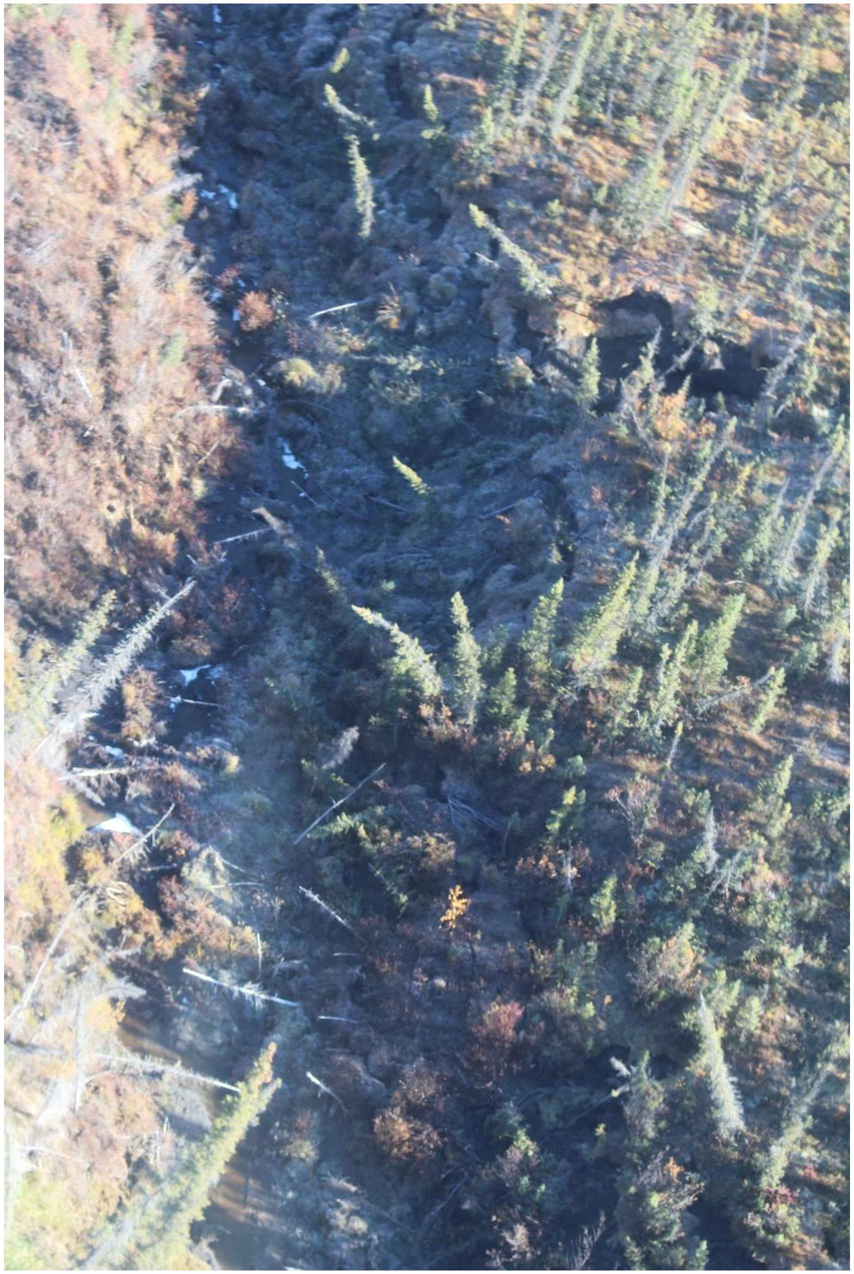

Photo #13: Waypoint #5, Landslide on left fork of Wolverine Creek.

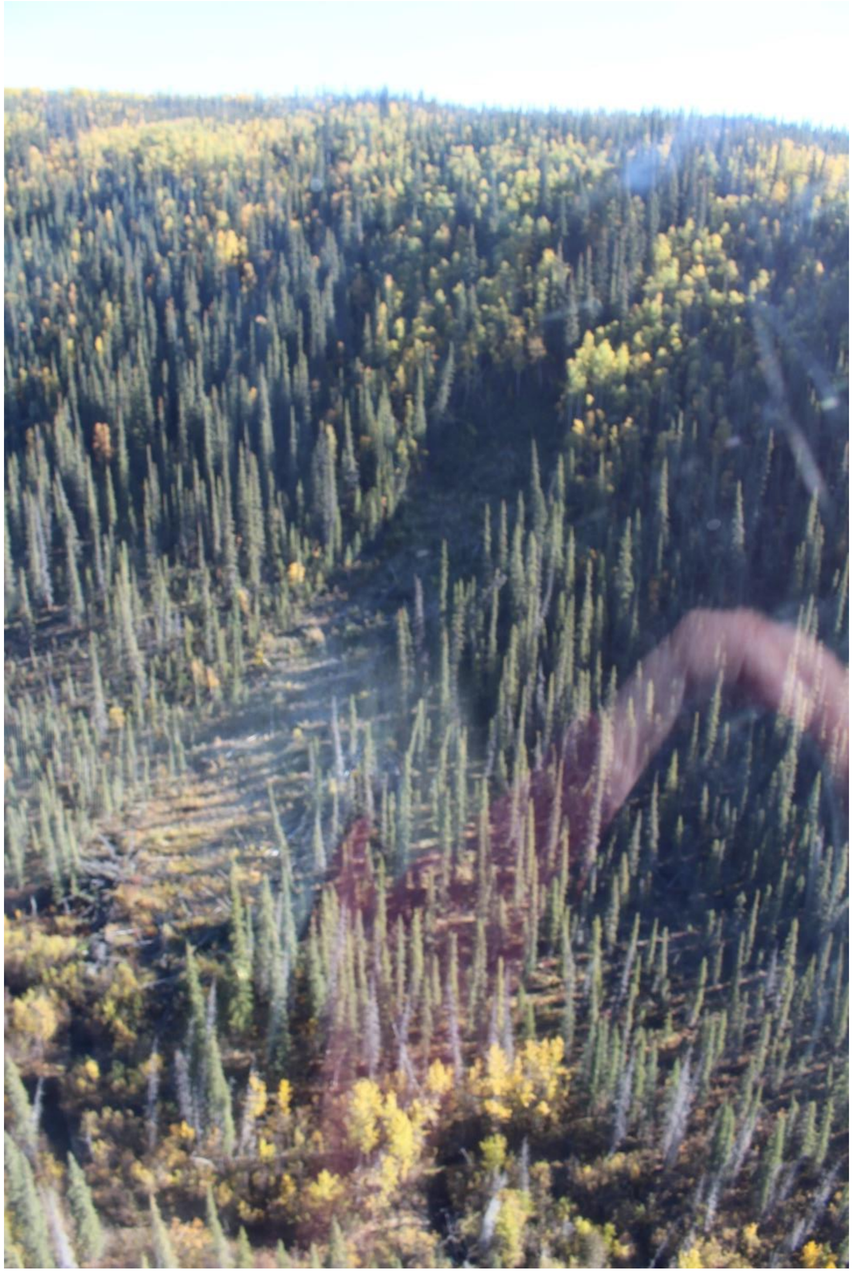

Photo #14: Waypoint #6, landslide on Easter Creek, Sept 2016.

Photo #15: Near Waypoint #6, old breached beaver dam on Easter Creek, Sept 2016.

Photo 16: Headwaters of Easter Creek, September 8th, 2016.

Photo 17: Active landslide area at Waypoint #8, on south tributary to upper Clinton Creek.

Photo 18: The stream has cut through the deposited slumped material.

Photo 19: Looking upstream to the active slope degradation at Waypoint #8. Note numerous areas of deposition of mobilized sediments.

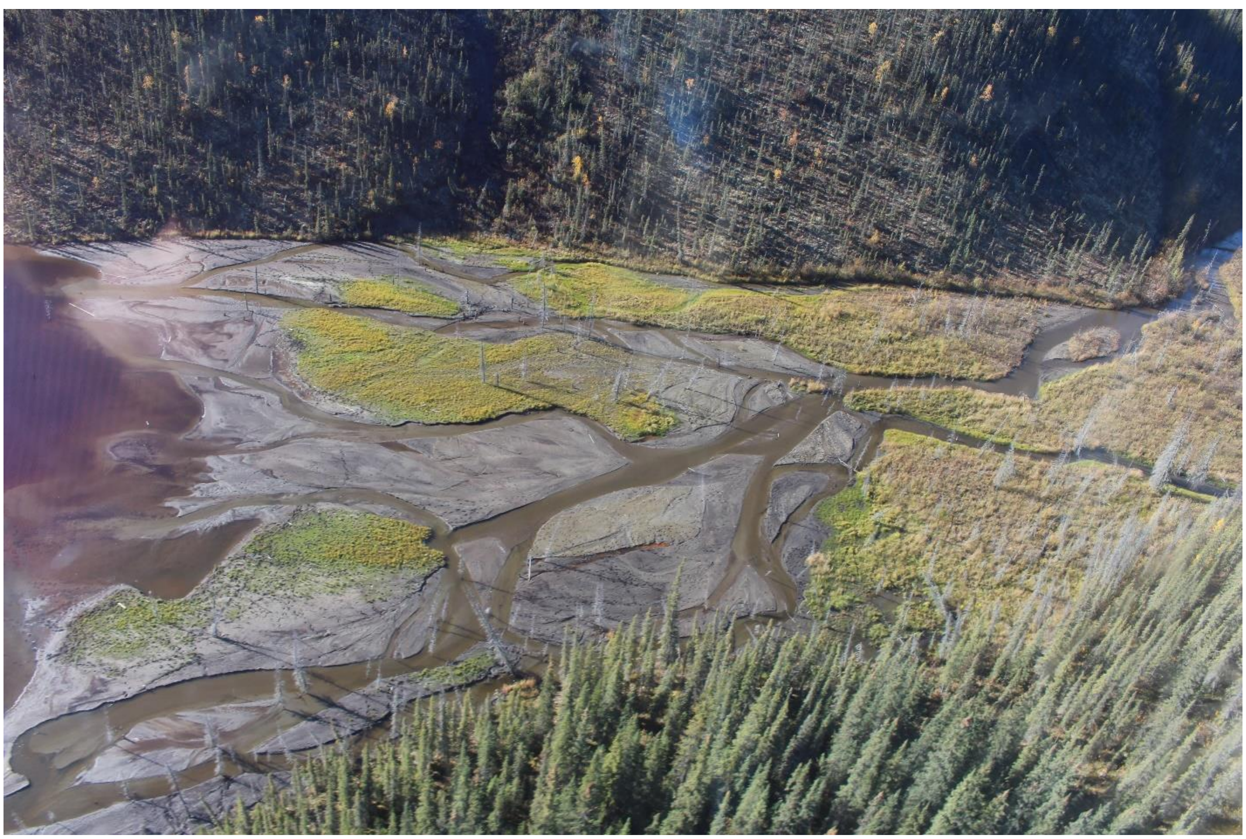

Photo 20: The delta region of upper Clinton Creek as it enters Hudgeon Lake.

APPENDIX B

WATER QUALITY ANALYTICAL DATA, 2016

TABLE 5 RPD VALUES FOR DUPLICATE SAMPLE			
	E-2	DUPLICATE	RPD %
Date Sampled	6-Sep-2016	6-Sep-2016	
Physical Tests (Water)			
Conductivity	664	684	3.0
Hardness (as CaCO3)	370	366	1.1
pH	8.11	8.09	0.2
Anions and Nutrients (Water)			
Sulfate (SO4)	219	219	0.0
Total Metals (Water)			
Aluminum (Al)-Total	0.0516	0.0525	1.7
Antimony (Sb)-Total	<0.00050	<0.00050	N/A
Arsenic (As)-Total	0.00109	0.00115	5.4
Barium (Ba)-Total	0.066	0.066	0.0
Beryllium (Be)-Total	<0.0010	<0.0010	N/A
Bismuth (Bi)-Total	<0.20	<0.20	N/A
Boron (B)-Total	<0.10	<0.10	N/A
Cadmium (Cd)-Total	0.0000474	0.0000521	9.4
Calcium (Ca)-Total	78.3	80.1	2.3
Chromium (Cr)-Total	<0.0010	<0.0010	N/A
Cobalt (Co)-Total	0.00064	0.00067	4.6
Copper (Cu)-Total	0.0026	0.0026	0.0
Iron (Fe)-Total	0.349	0.355	1.7
Lead (Pb)-Total	<0.00050	<0.00050	N/A
Lithium (Li)-Total	0.0074	0.0073	1.4
Magnesium (Mg)-Total	42.9	43.9	2.3
Manganese (Mn)-Total	0.166	0.179	7.5
Mercury (Hg)-Total	0.0000062	0.0000058	6.7
Molybdenum (Mo)-Total	0.0015	0.0014	6.9
Nickel (Ni)-Total	0.0110	0.0115	4.4
Phosphorus (P)-Total	<0.30	<0.30	N/A
Potassium (K)-Total	<2.0	<2.0	N/A
Selenium (Se)-Total	0.00194	0.00184	5.3
Silicon (Si)-Total	5.05	5.13	1.6
Silver (Ag)-Total	<0.000020	<0.000020	N/A
Sodium (Na)-Total	3.7	3.5	5.6
Strontium (Sr)-Total	0.418	0.412	1.4
Thallium (Tl)-Total	<0.00020	<0.00020	N/A
Tin (Sn)-Total	<0.00050	<0.00050	N/A
Titanium (Ti)-Total	<0.010	<0.010	N/A
Uranium (U)-Total	0.00207	0.00198	4.4
Vanadium (V)-Total	0.00067	0.00071	5.8
Zinc (Zn)-Total	<0.0050	<0.0050	N/A
Average RPD for total metals: 3.9%			
Dissolved Metals (Water)			
Aluminum (Al)-Dissolved	0.0348	0.0370	6.1
Antimony (Sb)-Dissolved	<0.00050	<0.00050	N/A
Arsenic (As)-Dissolved	0.00105	0.00106	0.9
Barium (Ba)-Dissolved	0.059	0.058	1.7
Beryllium (Be)-Dissolved	<0.0010	<0.0010	N/A
Bismuth (Bi)-Dissolved	<0.20	<0.20	N/A
Boron (B)-Dissolved	<0.10	<0.10	N/A
Cadmium (Cd)-Dissolved	0.0000500	0.0000497	0.6
Calcium (Ca)-Dissolved	74.9	73.2	2.3
Chromium (Cr)-Dissolved	<0.0010	<0.0010	N/A
Cobalt (Co)-Dissolved	0.00061	0.00063	3.2
Copper (Cu)-Dissolved	0.0024	0.0024	0.0
Iron (Fe)-Dissolved	0.268	0.256	4.6
Lead (Pb)-Dissolved	<0.00050	<0.00050	N/A
Lithium (Li)-Dissolved	0.0073	0.0072	1.4
Magnesium (Mg)-Dissolved	44.5	44.5	0.0
Manganese (Mn)-Dissolved	0.160	0.166	3.7
Mercury (Hg)-Dissolved	<0.0000050	0.0000051	N/A
Molybdenum (Mo)-Dissolved	0.0014	0.0014	0.0
Nickel (Ni)-Dissolved	0.0107	0.0110	2.8
Phosphorus (P)-Dissolved	<0.30	<0.30	N/A
Potassium (K)-Dissolved	<2.0	<2.0	N/A
Selenium (Se)-Dissolved	0.00198	0.00195	1.5
Silicon (Si)-Dissolved	4.86	4.75	2.3
Silver (Ag)-Dissolved	<0.000020	<0.000020	N/A
Sodium (Na)-Dissolved	2.9	2.8	3.5
Strontium (Sr)-Dissolved	0.373	0.368	1.3
Thallium (Tl)-Dissolved	<0.00020	<0.00020	N/A
Tin (Sn)-Dissolved	<0.00050	<0.00050	N/A
Titanium (Ti)-Dissolved	<0.010	<0.010	N/A
Uranium (U)-Dissolved	0.00196	0.00199	1.5
Vanadium (V)-Dissolved	<0.00050	<0.00050	N/A
Zinc (Zn)-Dissolved	<0.0050	<0.0050	N/A
Average RPD for dissolved metals: 2.1%			

LABERGE ENVIRONMENTAL
ATTN: Bonnie Burns
PO Box 21072
Whitehorse YT Y1A 6P7

Date Received: 12-SEP-16
Report Date: 29-SEP-16 11:58 (MT)
Version: FINAL

Client Phone: 867-668-6838

Certificate of Analysis

Lab Work Order #: L1829615

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers: 14-470932, 14-470930
Legal Site Desc:

Brent Mack, B.Sc.
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1829615-1	L1829615-2	L1829615-3	L1829615-4	L1829615-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	06-SEP-16	07-SEP-16	06-SEP-16	06-SEP-16	05-SEP-16
	Sampled Time	14:30	09:40	16:30	09:00	13:10
	Client ID	E-1	PORCUPINE CR	E-2	E-3	E-4
WATER						
Physical Tests	Conductivity (uS/cm)	531	1980	664	622	708
	Hardness (as CaCO3) (mg/L)	281	1370	370	337	386
	pH (pH)	8.20	8.38	8.11	8.15	8.14
Anions and Nutrients	Sulfate (SO4) (mg/L)	151	1090	219	191	236
Total Metals	Aluminum (Al)-Total (mg/L)	0.0656	0.0051	0.0516	1.23	0.185
	Antimony (Sb)-Total (mg/L)	<0.00050	0.00148	<0.00050	0.00066	<0.00050
	Arsenic (As)-Total (mg/L)	0.00090	0.00239	0.00109	0.00198	0.00135
	Barium (Ba)-Total (mg/L)	0.071	0.026	0.066	0.107	0.067
	Beryllium (Be)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bismuth (Bi)-Total (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Total (mg/L)	<0.10	0.23	<0.10	<0.10	<0.10
	Cadmium (Cd)-Total (mg/L)	0.0000453	0.000162	0.0000474	0.000186	0.0000621
	Calcium (Ca)-Total (mg/L)	68.1	187	78.3	65.0	76.0
	Chromium (Cr)-Total (mg/L)	<0.0010	0.0024	<0.0010	0.0032	0.0011
	Cobalt (Co)-Total (mg/L)	0.00049	<0.00030	0.00064	0.00164	0.00085
	Copper (Cu)-Total (mg/L)	0.0030	0.0020	0.0026	0.0062	0.0028
	Iron (Fe)-Total (mg/L)	0.323	<0.030	0.349	2.67	0.645
	Lead (Pb)-Total (mg/L)	<0.00050	<0.00050	<0.00050	0.00141	<0.00050
	Lithium (Li)-Total (mg/L)	0.0028	0.0645	0.0074	0.0045	0.0095
	Magnesium (Mg)-Total (mg/L)	28.0	209	42.9	42.0	46.2
	Manganese (Mn)-Total (mg/L)	0.182	0.00134	0.166	0.226	0.193
	Mercury (Hg)-Total (mg/L)	0.0000057	0.0000051	0.0000062	0.0000189	0.0000068
	Molybdenum (Mo)-Total (mg/L)	0.0013	0.0026	0.0015	0.0017	0.0016
	Nickel (Ni)-Total (mg/L)	0.0046	0.0573	0.0110	0.0093	0.0134
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	<2.0	2.6	<2.0	<2.0	<2.0
	Selenium (Se)-Total (mg/L)	0.00188	0.00501	0.00194	0.00167	0.00179
	Silicon (Si)-Total (mg/L)	5.13	6.10	5.05	7.74	5.26
	Silver (Ag)-Total (mg/L)	<0.000020	<0.000020	<0.000020	0.000053	<0.000020
	Sodium (Na)-Total (mg/L)	2.9	13.7	3.7	4.9	4.2
	Strontium (Sr)-Total (mg/L)	0.304	1.62	0.418	0.327	0.426
	Thallium (Tl)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Tin (Sn)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	0.030	<0.010
	Uranium (U)-Total (mg/L)	0.00185	0.00530	0.00207	0.00248	0.00223
	Vanadium (V)-Total (mg/L)	0.00069	<0.00050	0.00067	0.00430	0.00105
	Zinc (Zn)-Total (mg/L)	<0.0050	0.0067	<0.0050	0.0147	<0.0050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1829615-6	L1829615-7	L1829615-8	L1829615-9	L1829615-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	05-SEP-16	08-SEP-16	07-SEP-16	07-SEP-16	06-SEP-16
	Sampled Time	09:30	14:50	12:45	15:00	11:30
	Client ID	E-6	E-8	R-1	R-2	R-3
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	716	250	700	618	682
	Hardness (as CaCO3) (mg/L)	385	116	375	328	367
	pH (pH)	8.20	8.06	8.21	8.25	8.17
Anions and Nutrients	Sulfate (SO4) (mg/L)	235	47.9	224	169	218
Total Metals	Aluminum (Al)-Total (mg/L)	0.549	0.281	0.819	0.316	0.345
	Antimony (Sb)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Arsenic (As)-Total (mg/L)	0.00195	0.00079	0.00148	0.00132	0.00101
	Barium (Ba)-Total (mg/L)	0.089	0.048	0.081	0.062	0.080
	Beryllium (Be)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bismuth (Bi)-Total (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Total (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Cadmium (Cd)-Total (mg/L)	0.000104	0.0000339	0.000174	0.0000351	0.0000320
	Calcium (Ca)-Total (mg/L)	78.0	31.2	93.6	61.9	71.2
	Chromium (Cr)-Total (mg/L)	0.0023	<0.0010	0.0018	0.0013	0.0013
	Cobalt (Co)-Total (mg/L)	0.00166	0.00073	0.00142	0.00054	0.00076
	Copper (Cu)-Total (mg/L)	0.0042	0.0031	0.0041	0.0021	0.0027
	Iron (Fe)-Total (mg/L)	1.40	0.634	1.73	1.01	1.01
	Lead (Pb)-Total (mg/L)	0.00077	<0.00050	0.00132	<0.00050	<0.00050
	Lithium (Li)-Total (mg/L)	0.0088	0.0035	0.0039	0.0058	0.0033
	Magnesium (Mg)-Total (mg/L)	45.0	9.51	34.5	42.2	45.5
	Manganese (Mn)-Total (mg/L)	0.378	0.0625	0.400	0.143	0.280
	Mercury (Hg)-Total (mg/L)	0.0000114	<0.0000050	0.0000128	0.0000052	0.0000056
	Molybdenum (Mo)-Total (mg/L)	0.0016	<0.0010	0.0015	<0.0010	0.0013
	Nickel (Ni)-Total (mg/L)	0.0164	0.0038	0.0065	0.0047	0.0044
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Selenium (Se)-Total (mg/L)	0.00190	0.000317	0.00298	0.000780	0.000985
	Silicon (Si)-Total (mg/L)	6.02	5.82	6.02	6.36	6.61
	Silver (Ag)-Total (mg/L)	0.000033	<0.000020	0.000031	<0.000020	<0.000020
	Sodium (Na)-Total (mg/L)	4.2	3.7	3.5	3.2	4.4
	Strontium (Sr)-Total (mg/L)	0.433	0.158	0.425	0.328	0.347
	Thallium (Tl)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Tin (Sn)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Titanium (Ti)-Total (mg/L)	0.021	<0.010	0.032	0.012	0.011
	Uranium (U)-Total (mg/L)	0.00242	0.00100	0.00253	0.00350	0.00319
	Vanadium (V)-Total (mg/L)	0.00227	0.00151	0.00255	0.00164	0.00172
	Zinc (Zn)-Total (mg/L)	0.0147	0.0054	0.0138	<0.0050	<0.0050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1829615-11	L1829615-12	L1829615-13	L1829615-14	L1829615-15
	Description	Water	Water	Water	Water	Water
	Sampled Date	05-SEP-16	08-SEP-16	08-SEP-16		
	Sampled Time	11:40	16:40	12:00		
	Client ID	R-4	R-6	MAIDEN CR	FIELD BLANK	TRAVEL BLANK
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	610	243	196	<2.0	<2.0
	Hardness (as CaCO3) (mg/L)	324	111	84.0	<0.50	
	pH (pH)	8.26	8.06	7.15	5.57	5.53
Anions and Nutrients	Sulfate (SO4) (mg/L)	159	45.9	53.5	<0.30	<0.30
Total Metals	Aluminum (Al)-Total (mg/L)	2.22	0.334	2.21	<0.0050	
	Antimony (Sb)-Total (mg/L)	0.00067	<0.00050	<0.00050	<0.00050	
	Arsenic (As)-Total (mg/L)	0.00493	0.00078	0.00210	<0.00050	
	Barium (Ba)-Total (mg/L)	0.183	0.052	0.104	<0.020	
	Beryllium (Be)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Bismuth (Bi)-Total (mg/L)	<0.20	<0.20	<0.20	<0.20	
	Boron (B)-Total (mg/L)	<0.10	<0.10	<0.10	<0.10	
	Cadmium (Cd)-Total (mg/L)	0.000365	0.0000315	0.000186	<0.0000050	
	Calcium (Ca)-Total (mg/L)	84.1	32.3	17.2	<0.10	
	Chromium (Cr)-Total (mg/L)	0.0052	<0.0010	0.0039	<0.0010	
	Cobalt (Co)-Total (mg/L)	0.00376	0.00078	0.00272	<0.00030	
	Copper (Cu)-Total (mg/L)	0.0123	0.0033	0.0081	<0.0010	
	Iron (Fe)-Total (mg/L)	4.98	0.762	3.38	<0.030	
	Lead (Pb)-Total (mg/L)	0.00330	<0.00050	0.00189	<0.00050	
	Lithium (Li)-Total (mg/L)	0.0040	0.0031	0.0021	<0.0010	
	Magnesium (Mg)-Total (mg/L)	33.4	10.0	12.1	<0.10	
	Manganese (Mn)-Total (mg/L)	0.433	0.0676	0.252	<0.00010	
	Mercury (Hg)-Total (mg/L)	0.000064 DLM	<0.0000050	0.0000108	<0.0000050	
	Molybdenum (Mo)-Total (mg/L)	0.0024	<0.0010	<0.0010	<0.0010	
	Nickel (Ni)-Total (mg/L)	0.0242	0.0040	0.0087	<0.0010	
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	
	Potassium (K)-Total (mg/L)	<2.0	<2.0	<2.0	<2.0	
	Selenium (Se)-Total (mg/L)	0.00363	0.000280	0.000582	<0.000050	
	Silicon (Si)-Total (mg/L)	8.86	6.35	8.56	<0.050	
	Silver (Ag)-Total (mg/L)	0.000169	<0.000020	0.000036	<0.000020	
	Sodium (Na)-Total (mg/L)	4.5	3.9	2.4	<2.0	
	Strontium (Sr)-Total (mg/L)	0.439	0.166	0.0852	<0.0050	
	Thallium (Tl)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	
	Tin (Sn)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Titanium (Ti)-Total (mg/L)	0.058	0.011	0.066	<0.010	
	Uranium (U)-Total (mg/L)	0.00353	0.00099	0.00067	<0.00020	
	Vanadium (V)-Total (mg/L)	0.00774	0.00169	0.00631	<0.00050	
	Zinc (Zn)-Total (mg/L)	0.0245	0.0057	0.0214	<0.0050	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte					
	Sample ID	L1829615-16				
	Description	Water				
	Sampled Date	06-SEP-16				
	Sampled Time					
	Client ID	DUPLICATE				
WATER						
Physical Tests	Conductivity (uS/cm)	684				
	Hardness (as CaCO3) (mg/L)	366				
	pH (pH)	8.09				
Anions and Nutrients	Sulfate (SO4) (mg/L)	219				
Total Metals	Aluminum (Al)-Total (mg/L)	0.0525				
	Antimony (Sb)-Total (mg/L)	<0.00050				
	Arsenic (As)-Total (mg/L)	0.00115				
	Barium (Ba)-Total (mg/L)	0.066				
	Beryllium (Be)-Total (mg/L)	<0.0010				
	Bismuth (Bi)-Total (mg/L)	<0.20				
	Boron (B)-Total (mg/L)	<0.10				
	Cadmium (Cd)-Total (mg/L)	0.0000521				
	Calcium (Ca)-Total (mg/L)	80.1				
	Chromium (Cr)-Total (mg/L)	<0.0010				
	Cobalt (Co)-Total (mg/L)	0.00067				
	Copper (Cu)-Total (mg/L)	0.0026				
	Iron (Fe)-Total (mg/L)	0.355				
	Lead (Pb)-Total (mg/L)	<0.00050				
	Lithium (Li)-Total (mg/L)	0.0073				
	Magnesium (Mg)-Total (mg/L)	43.9				
	Manganese (Mn)-Total (mg/L)	0.179				
	Mercury (Hg)-Total (mg/L)	0.0000058				
	Molybdenum (Mo)-Total (mg/L)	0.0014				
	Nickel (Ni)-Total (mg/L)	0.0115				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	<2.0				
	Selenium (Se)-Total (mg/L)	0.00184				
	Silicon (Si)-Total (mg/L)	5.13				
	Silver (Ag)-Total (mg/L)	<0.000020				
	Sodium (Na)-Total (mg/L)	3.5				
	Strontium (Sr)-Total (mg/L)	0.412				
	Thallium (Tl)-Total (mg/L)	<0.00020				
	Tin (Sn)-Total (mg/L)	<0.00050				
	Titanium (Ti)-Total (mg/L)	<0.010				
	Uranium (U)-Total (mg/L)	0.00198				
	Vanadium (V)-Total (mg/L)	0.00071				
	Zinc (Zn)-Total (mg/L)	<0.0050				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1829615-1	L1829615-2	L1829615-3	L1829615-4	L1829615-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	06-SEP-16	07-SEP-16	06-SEP-16	06-SEP-16	05-SEP-16
	Sampled Time	14:30	09:40	16:30	09:00	13:10
	Client ID	E-1	PORCUPINE CR	E-2	E-3	E-4
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0432	<0.0050	0.0348	0.0303	0.0294
	Antimony (Sb)-Dissolved (mg/L)	<0.00050	0.00148	<0.00050	0.00054	<0.00050
	Arsenic (As)-Dissolved (mg/L)	0.00078	0.00255	0.00105	0.00085	0.00108
	Barium (Ba)-Dissolved (mg/L)	0.065	0.025	0.059	0.063	0.058
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Dissolved (mg/L)	<0.10	0.22	<0.10	<0.10	<0.10
	Cadmium (Cd)-Dissolved (mg/L)	0.0000391	0.000181	0.0000500	0.0000248	0.0000419
	Calcium (Ca)-Dissolved (mg/L)	64.4	185	74.9	60.8	73.9
	Chromium (Cr)-Dissolved (mg/L)	<0.0010	0.0024	<0.0010	0.0051	<0.0010
	Cobalt (Co)-Dissolved (mg/L)	0.00043	<0.00030	0.00061	0.00051	0.00066
	Copper (Cu)-Dissolved (mg/L)	0.0027	0.0011	0.0024	0.0018	0.0021
	Iron (Fe)-Dissolved (mg/L)	0.246	<0.030	0.268	0.280	0.284
	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Lithium (Li)-Dissolved (mg/L)	0.0028	0.0629	0.0073	0.0035	0.0091
	Magnesium (Mg)-Dissolved (mg/L)	29.3	221	44.5	44.9	49.0
	Manganese (Mn)-Dissolved (mg/L)	0.164	0.00116	0.160	0.170	0.174
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.0012	0.0024	0.0014	0.0012	0.0014
	Nickel (Ni)-Dissolved (mg/L)	0.0044	0.0594	0.0107	0.0080	0.0117
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	<2.0	2.8	<2.0	<2.0	<2.0
	Selenium (Se)-Dissolved (mg/L)	0.00192	0.00514	0.00198	0.00146	0.00196
	Silicon (Si)-Dissolved (mg/L)	4.88	6.08	4.86	5.77	4.93
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Sodium (Na)-Dissolved (mg/L)	2.3	14.0	2.9	4.0	3.5
	Strontium (Sr)-Dissolved (mg/L)	0.278	1.65	0.373	0.284	0.389
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Tin (Sn)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.00178	0.00526	0.00196	0.00236	0.00207
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	0.00055	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	<0.0050	0.0063	<0.0050	<0.0050	<0.0050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1829615-6	L1829615-7	L1829615-8	L1829615-9	L1829615-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	05-SEP-16	08-SEP-16	07-SEP-16	07-SEP-16	06-SEP-16
	Sampled Time	09:30	14:50	12:45	15:00	11:30
	Client ID	E-6	E-8	R-1	R-2	R-3
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0286	0.0922	0.0289	0.0406	0.0298
	Antimony (Sb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Arsenic (As)-Dissolved (mg/L)	0.00123	0.00060	0.00057	0.00108	0.00067
	Barium (Ba)-Dissolved (mg/L)	0.068	0.043	0.057	0.052	0.064
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Dissolved (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Cadmium (Cd)-Dissolved (mg/L)	0.0000492	0.0000256	0.0000749	0.0000271	0.0000190
	Calcium (Ca)-Dissolved (mg/L)	74.7	30.8	90.2	59.4	69.5
	Chromium (Cr)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cobalt (Co)-Dissolved (mg/L)	0.00111	0.00056	0.00071	0.00034	0.00052
	Copper (Cu)-Dissolved (mg/L)	0.0022	0.0027	0.0019	0.0016	0.0018
	Iron (Fe)-Dissolved (mg/L)	0.323	0.300	0.269	0.519	0.365
	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Lithium (Li)-Dissolved (mg/L)	0.0087	0.0036	0.0028	0.0057	0.0027
	Magnesium (Mg)-Dissolved (mg/L)	48.3	9.40	36.4	43.6	46.9
	Manganese (Mn)-Dissolved (mg/L)	0.351	0.0544	0.331	0.130	0.261
	Mercury (Hg)-Dissolved (mg/L)	0.0000051	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Molybdenum (Mo)-Dissolved (mg/L)	0.0014	<0.0010	0.0012	<0.0010	0.0011
	Nickel (Ni)-Dissolved (mg/L)	0.0131	0.0034	0.0042	0.0041	0.0037
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Selenium (Se)-Dissolved (mg/L)	0.00186	0.000295	0.00291	0.000725	0.000994
	Silicon (Si)-Dissolved (mg/L)	4.98	5.54	4.71	5.82	6.00
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Sodium (Na)-Dissolved (mg/L)	3.4	3.0	2.6	2.4	3.6
	Strontium (Sr)-Dissolved (mg/L)	0.383	0.143	0.374	0.293	0.311
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Tin (Sn)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.00231	0.00098	0.00226	0.00341	0.00302
	Vanadium (V)-Dissolved (mg/L)	<0.00050	0.00079	<0.00050	0.00066	0.00060
	Zinc (Zn)-Dissolved (mg/L)	0.0062	<0.0050	<0.0050	<0.0050	<0.0050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1829615-11	L1829615-12	L1829615-13	L1829615-14	L1829615-15
	Description	Water	Water	Water	Water	Water
	Sampled Date	05-SEP-16	08-SEP-16	08-SEP-16		
	Sampled Time	11:40	16:40	12:00		
	Client ID	R-4	R-6	MAIDEN CR	FIELD BLANK	TRAVEL BLANK
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Aluminum (Al)-Dissolved (mg/L)	0.0199	0.0846	0.172	<0.0050	
	Antimony (Sb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Arsenic (As)-Dissolved (mg/L)	0.00207	0.00059	0.00076	<0.00050	
	Barium (Ba)-Dissolved (mg/L)	0.090	0.041	0.049	<0.020	
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	
	Boron (B)-Dissolved (mg/L)	<0.10	<0.10	<0.10	<0.10	
	Cadmium (Cd)-Dissolved (mg/L)	0.0000464	0.0000227	0.0000397	<0.0000050	
	Calcium (Ca)-Dissolved (mg/L)	76.7	29.3	15.6	<0.10	
	Chromium (Cr)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Cobalt (Co)-Dissolved (mg/L)	0.00123	0.00055	0.00126	<0.00030	
	Copper (Cu)-Dissolved (mg/L)	0.0019	0.0026	0.0039	<0.0010	
	Iron (Fe)-Dissolved (mg/L)	0.159	0.306	0.516	<0.030	
	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Lithium (Li)-Dissolved (mg/L)	0.0020	0.0032	<0.0010	<0.0010	
	Magnesium (Mg)-Dissolved (mg/L)	32.1	9.09	10.9	<0.10	
	Manganese (Mn)-Dissolved (mg/L)	0.299	0.0508	0.188	<0.00010	
	Mercury (Hg)-Dissolved (mg/L)	<0.0000050	<0.0000050	0.0000059	<0.0000050	
	Molybdenum (Mo)-Dissolved (mg/L)	0.0013	<0.0010	<0.0010	<0.0010	
	Nickel (Ni)-Dissolved (mg/L)	0.0117	0.0032	0.0050	<0.0010	
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	
	Potassium (K)-Dissolved (mg/L)	<2.0	<2.0	<2.0	<2.0	
	Selenium (Se)-Dissolved (mg/L)	0.00324	0.000257	0.000574	<0.000050	
	Silicon (Si)-Dissolved (mg/L)	5.44	5.56	5.74	<0.050	
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	
	Sodium (Na)-Dissolved (mg/L)	3.6	3.0	<2.0	<2.0	
	Strontium (Sr)-Dissolved (mg/L)	0.371	0.140	0.0714	<0.0050	
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	
	Tin (Sn)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	
	Uranium (U)-Dissolved (mg/L)	0.00314	0.00087	0.00042	<0.00020	
	Vanadium (V)-Dissolved (mg/L)	<0.00050	0.00080	0.00078	<0.00050	
	Zinc (Zn)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1829615-16				
	Description	Water				
	Sampled Date	06-SEP-16				
	Sampled Time					
	Client ID	DUPLICATE				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Mercury Filtration Location	FIELD				
	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	0.0370				
	Antimony (Sb)-Dissolved (mg/L)	<0.00050				
	Arsenic (As)-Dissolved (mg/L)	0.00106				
	Barium (Ba)-Dissolved (mg/L)	0.058				
	Beryllium (Be)-Dissolved (mg/L)	<0.0010				
	Bismuth (Bi)-Dissolved (mg/L)	<0.20				
	Boron (B)-Dissolved (mg/L)	<0.10				
	Cadmium (Cd)-Dissolved (mg/L)	0.0000497				
	Calcium (Ca)-Dissolved (mg/L)	73.2				
	Chromium (Cr)-Dissolved (mg/L)	<0.0010				
	Cobalt (Co)-Dissolved (mg/L)	0.00063				
	Copper (Cu)-Dissolved (mg/L)	0.0024				
	Iron (Fe)-Dissolved (mg/L)	0.256				
	Lead (Pb)-Dissolved (mg/L)	<0.00050				
	Lithium (Li)-Dissolved (mg/L)	0.0072				
	Magnesium (Mg)-Dissolved (mg/L)	44.5				
	Manganese (Mn)-Dissolved (mg/L)	0.166				
	Mercury (Hg)-Dissolved (mg/L)	0.0000051				
	Molybdenum (Mo)-Dissolved (mg/L)	0.0014				
	Nickel (Ni)-Dissolved (mg/L)	0.0110				
	Phosphorus (P)-Dissolved (mg/L)	<0.30				
	Potassium (K)-Dissolved (mg/L)	<2.0				
	Selenium (Se)-Dissolved (mg/L)	0.00195				
	Silicon (Si)-Dissolved (mg/L)	4.75				
	Silver (Ag)-Dissolved (mg/L)	<0.000020				
	Sodium (Na)-Dissolved (mg/L)	2.8				
	Strontium (Sr)-Dissolved (mg/L)	0.368				
	Thallium (Tl)-Dissolved (mg/L)	<0.00020				
	Tin (Sn)-Dissolved (mg/L)	<0.00050				
	Titanium (Ti)-Dissolved (mg/L)	<0.010				
	Uranium (U)-Dissolved (mg/L)	0.00199				
	Vanadium (V)-Dissolved (mg/L)	<0.00050				
	Zinc (Zn)-Dissolved (mg/L)	<0.0050				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Aluminum (Al)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Antimony (Sb)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1829615-1, -10, -11, -12, -13, -14, -16, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Aluminum (Al)-Total	MS-B	L1829615-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Aluminum (Al)-Total	MS-B	L1829615-10, -11, -12, -13, -14, -16, -9
Matrix Spike	Manganese (Mn)-Total	MS-B	L1829615-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Manganese (Mn)-Total	MS-B	L1829615-10, -11, -12, -13, -14, -16, -9
Matrix Spike	Calcium (Ca)-Total	MS-B	L1829615-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Iron (Fe)-Total	MS-B	L1829615-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Iron (Fe)-Total	MS-B	L1829615-10, -11, -12, -13, -14, -16, -9
Matrix Spike	Silicon (Si)-Total	MS-B	L1829615-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Silicon (Si)-Total	MS-B	L1829615-10, -11, -12, -13, -14, -16, -9
Matrix Spike	Strontium (Sr)-Total	MS-B	L1829615-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Sulfate (SO4)	MS-B	L1829615-2
Matrix Spike	Sulfate (SO4)	MS-B	L1829615-2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
AREA SAMPLED-VA	Biota	Area Sampled (cm2)	Not Applicable

Reference Information

CHLOROA-F-VA | Biota | Chlorophyll a in Biota by Fluorometer | EPA 445.0

This analysis is done using procedures adapted from EPA Method 445.0. Chlorophyll-a is determined by a routine acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b. Note: Biota samples are typically submitted as scrapings on a filter.

EC-PCT-VA | Water | Conductivity (Automated) | APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA | Water | Hardness | APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-D-CVAA-VA | Water | Diss. Mercury in Water by CVAAS or CVAFS | APHA 3030B/EPA 1631E (mod)

Water samples are filtered (0.45 um), preserved with hydrochloric acid, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

HG-T-CVAA-VA | Water | Total Mercury in Water by CVAAS or CVAFS | EPA 1631E (mod)

Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS or CVAFS.

MET-D-CCMS-VA | Water | Dissolved Metals in Water by CRC ICPMS | APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-ICP-VA | Water | Dissolved Metals in Water by ICPOES | EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA | Water | Total Metals in Water by CRC ICPMS | EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-TOT-ICP-VA | Water | Total Metals in Water by ICPOES | EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

PH-PCT-VA | Water | pH by Meter (Automated) | APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA | Water | pH by Meter (Automated) | APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PHEOPHYTIN-F-VA | Biota | Pheophytin a in Biota by Fluorometer | EPA 445.0

This analysis is done using procedures modified from EPA 445.0 . Pheopigments present in a biota sample are determined collectively as pheophytin a. Pheophytin a is determined by a routine acetone extraction followed with analysis by flourometry using the acidification procedure.
Note: Biota samples are typically submitted as scrapings on a filter.

Reference Information

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

14-470932, 14-470930

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

23-Sep-2016

Brent Mack
ALS Environmental
8081 Lougheed HWY
Suite 100
Burnaby, BC V5A1W9

Tel: (604) 253-4188
Fax:

Re: L1829615 Work Order: **1609561**

Dear Brent,

ALS Environmental received 16 samples on 20-Sep-2016 10:35 AM for the analyses presented in the following report.

The analytical data provided relates directly to the samples received by ALS Environmental and for only the analyses requested.

QC sample results for this data met laboratory specifications. Any exceptions are noted in the Case Narrative, or noted with qualifiers in the report or QC batch information. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Laboratory Group. Samples will be disposed in 30 days unless storage arrangements are made.

The total number of pages in this report is 22.

If you have any questions regarding this report, please feel free to contact me.

Sincerely,

Shawn Smythe

Electronically approved by: Chris Gibson

Shawn Smythe
Project Manager

Client: ALS Environmental
Project: L1829615
Work Order: **1609561**

Work Order Sample Summary

Lab Samp ID	Client Sample ID	Matrix	Tag Number	Collection Date	Date Received	Hold
1609561-01	L1829615-1	Water		9/6/2016	9/20/2016 10:35	☐
1609561-02	L1829615-2	Water		9/7/2016	9/20/2016 10:35	☐
1609561-03	L1829615-3	Water		9/6/2016	9/20/2016 10:35	☐
1609561-04	L1829615-4	Water		9/6/2016	9/20/2016 10:35	☐
1609561-05	L1829615-5	Water		9/5/2016	9/20/2016 10:35	☐
1609561-06	L1829615-6	Water		9/5/2016	9/20/2016 10:35	☐
1609561-07	L1829615-7	Water		9/8/2016	9/20/2016 10:35	☐
1609561-08	L1829615-8	Water		9/7/2016	9/20/2016 10:35	☐
1609561-09	L1829615-9	Water		9/7/2016	9/20/2016 10:35	☐
1609561-10	L1829615-10	Water		9/6/2016	9/20/2016 10:35	☐
1609561-11	L1829615-11	Water		9/5/2016	9/20/2016 10:35	☐
1609561-12	L1829615-12	Water		9/8/2016	9/20/2016 10:35	☐
1609561-13	L1829615-13	Water		9/8/2016	9/20/2016 10:35	☐
1609561-14	L1829615-14	Water			9/20/2016 10:35	☐
1609561-15	L1829615-15	Water			9/20/2016 10:35	☐
1609561-16	L1829615-16	Water			9/20/2016 10:35	☐

Client: ALS Environmental
Project: L1829615
Work Order: 1609561

Case Narrative

The sample condition upon receipt was acceptable except where noted.

Results relate only to the items tested and are not blank corrected unless indicated.

Compound identification is based upon retention time matching only. Any compound with a similar retention time will interfere.

Samples were prepared and analyzed by the analytical method and the laboratory's applicable standard operating procedure listed below:
- IH-001- "Determination of Analytes Using NIOSH and OSHA Methods Using Gas Chromatography."
- IH-002- "Determination of Suspended Particulates in the Atmosphere Using Various Media"
- IH-003- "Determination of Suspended Particulates Not Otherwise Regulated (Total and Respirable)."
- IH-004- "Determination of Analytes by NIOSH and OSHA Methods Using Liquid Chromatography."
- IH-005- "Benzene-Soluble Fraction and Total Particulate (Asphalt Fume)."
- IH-006- "Methods IO-3.1 and IO-3.4 Modified for Metals Preparation and Analysis for Suspended Particulates."
- IH-196- "Carbon Black by OSHA 196."
- IH-6009- "Determination of Mercury in Industrial Hygiene Samples by Manual Cold Vapor Atomic Absorption Spectroscopy."
- ENV-6010B- "Determination of Trace Metals in Solution by Inductively Coupled Plasma-Atomic Emission Spectroscopy by EPA Method 6010B Non-VAP."
- IH-7300 modified- "Elements by ICP."

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615
Work Order: 1609561
Sample ID: L1829615-1
Lab ID: 1609561-01
Collection Date: 9/6/2016
Matrix: WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**2.4**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-2 **Lab ID:** 1609561-02
Collection Date: 9/7/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**2.4**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental

Project: L1829615 **Work Order:** 1609561

Sample ID: L1829615-3 **Lab ID:** 1609561-03

Collection Date: 9/6/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**2.2**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-4 **Lab ID:** 1609561-04
Collection Date: 9/6/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**63**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-5 **Lab ID:** 1609561-05
Collection Date: 9/5/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**4.9**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-6 **Lab ID:** 1609561-06
Collection Date: 9/5/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**32**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-7 **Lab ID:** 1609561-07
Collection Date: 9/8/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**7.7**		**2.0**	**mg/L**	1	9/20/2016

Note:

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-8 **Lab ID:** 1609561-08
Collection Date: 9/7/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**37**		**2.0**	**mg/L**	1	9/20/2016

Note:

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615
Work Order: 1609561
Sample ID: L1829615-9
Lab ID: 1609561-09
Collection Date: 9/7/2016
Matrix: WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**9.8**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-10 **Lab ID:** 1609561-10
Collection Date: 9/6/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**12**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-11 **Lab ID:** 1609561-11
Collection Date: 9/5/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**130**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-12 **Lab ID:** 1609561-12
Collection Date: 9/8/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**4.9**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-13 **Lab ID:** 1609561-13
Collection Date: 9/8/2016 **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**98**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-14 **Lab ID:** 1609561-14
Collection Date: **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**2.6**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-15 **Lab ID:** 1609561-15
Collection Date: **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	**2.0**		**2.0**	**mg/L**	1	9/20/2016

Note:

ALS Environmental

Date: *23-Sep-16*

Client: ALS Environmental
Project: L1829615 **Work Order:** 1609561
Sample ID: L1829615-16 **Lab ID:** 1609561-16
Collection Date: **Matrix:** WATER

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
TOTAL SUSPENDED SOLIDS			**E160.2**			Analyst: **rmb**
Total suspended solids	ND		2.0	mg/L	1	9/20/2016

Note:

ALS Environmental

Date: 23-Sep-16

Client: ALS Environmental
Work Order: 1609561
Project: L1829615

QC BATCH REPORT

Batch ID: **R133102** Instrument ID **WETCHEM** Method: **E160.2**

MBLK Sample ID: **MB-R133102-R133102** Units: **mg/L** Analysis Date: **9/20/2016**
Client ID: Run ID: **WETCHEM_160920C** SeqNo: **1360373** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total suspended solids	ND	2.0								

LCS Sample ID: **LCS-R133102-R133102** Units: **mg/L** Analysis Date: **9/20/2016**
Client ID: Run ID: **WETCHEM_160920C** SeqNo: **1360374** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total suspended solids	942.1	2.0	1000	0	94.2	70-130	0			

DUP Sample ID: **1609561-02A Dup** Units: **mg/L** Analysis Date: **9/20/2016**
Client ID: **L1829615-2** Run ID: **WETCHEM_160920C** SeqNo: **1360378** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total suspended solids	2.91	2.0	0	0	0		2.39	19.6		

DUP Sample ID: **1609561-16A Dup** Units: **mg/L** Analysis Date: **9/20/2016**
Client ID: **L1829615-16** Run ID: **WETCHEM_160920C** SeqNo: **1360393** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Total suspended solids	ND	2.0	0	0	0		1.6	0		

The following samples were analyzed in this batch:

1609561-01A	1609561-02A	1609561-03A
1609561-04A	1609561-05A	1609561-06A
1609561-07A	1609561-08A	1609561-09A
1609561-10A	1609561-11A	1609561-12A
1609561-13A	1609561-14A	1609561-15A
1609561-16A		

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client:	ALS Environmental	
Project:	L1829615	
WorkOrder:	**1609561**	

QUALIFIERS, ACRONYMS, UNITS

Qualifier	Description
*	Value exceeds Regulatory Limit
a	Not accredited
B	Analyte detected in the associated Method Blank above the Reporting Limit
E	Value above quantitation range
H	Analyzed outside of Holding Time
J	Analyte detected below quantitation limit
n	Not offered for accreditation
ND	Not Detected at the Reporting Limit
O	Sample amount is > 4 times amount spiked
P	Dual Column results percent difference > 40%
R	RPD above laboratory control limit
S	Spike Recovery outside laboratory control limits
U	Analyzed but not detected above the MDL

Acronym	Description
DUP	Method Duplicate
E	EPA Method
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MBLK	Method Blank
MDL	Method Detection Limit
MQL	Method Quantitation Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PDS	Post Digestion Spike
PQL	Practical Quantitaion Limit
SDL	Sample Detection Limit
SW	SW-846 Method

Units Reported	Description
mg/L	

ALS Environmental

Sample Receipt Checklist

Client Name: **ALS-VANCOUVER**

Date/Time Received: **20-Sep-16 10:35**

Work Order: **1609561**

Received by: **RDN**

Checklist completed by: Stephanie Harrington (eSignature) — Date: 20-Sep-16

Reviewed by: Shawn Smythe (eSignature) — Date: 21-Sep-16

Matrices:

Carrier name: FedEx

	Yes	No	
Shipping container/cooler in good condition?	☑	☐	Not Present ☐
Custody seals intact on shipping container/cooler?	☐	☐	Not Present ☑
Custody seals intact on sample bottles?	☐	☐	Not Present ☑
Chain of custody present?	☑	☐	
Chain of custody signed when relinquished and received?	☑	☐	
Chain of custody agrees with sample labels?	☑	☐	
Samples in proper container/bottle?	☑	☐	
Sample containers intact?	☑	☐	
Sufficient sample volume for indicated test?	☑	☐	
All samples received within holding time?	☑	☐	
Container/Temp Blank temperature in compliance?	☑	☐	

Temperature(s)/Thermometer(s): 5.2

Cooler(s)/Kit(s):

	Yes	No	
Water - VOA vials have zero headspace?	☐	☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	☐	☐	N/A ☑
pH adjusted?	☐	☐	N/A ☑

pH adjusted by: -

Login Notes:

Client Contacted:

Date Contacted:

Person Contacted:

Contacted By:

Regarding:

Comments:

CorrectiveAction:

Short Holding Time

Rush Processing

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1829615-COFC

COC Number: 14 - 470932

Report To
Company: Laberge Environmental Services
Contact: Bonnie Burns
Address: P.O. Box 21072, Whitehorse YT Y1A6P7
Phone: 867-668-6838

Report Format / Distribution
Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)
Quality Control (QC) Report with Report ☑ Yes ☐ No
☑ Criteria on Report - provide details below if box checked
Select Distribution: ☐ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: bonnieburns@
Email 2: northwestel.net

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
R ☑ Regular (Standard TAT if received by 3pm)
P ☐ Priority (2-4 business days if received by 3pm)
E ☐ Emergency (1-2 business days if received by 3pm)
E2 ☐ Same day or weekend emergency if received by 10am – contact ALS for surcharge.
Specify Date Required for E2,E or P:

Invoice To
Same as Report To ☑ Yes ☐ No
Copy of Invoice with Report ☐ Yes ☐ No
Company: Same as above
Contact:

Invoice Distribution
Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX
Email 1 or Fax: bonnieburns@
Email 2: northwestel.net

Project Information
ALS Quote #: 141612DN
Job #: Clinton Creek
PO / AFE:
LSD:

Oil and Gas Required Fields (client use)
Approver ID: | Cost Center:
GL Account: | Routing Code:
Activity Code:
Location:

ALS Lab Work Order # (lab use only): L1829615
ALS Contact:
Sampler: B. Burns

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total metals lowlevel	Dissolved metals lowlevel	Total Mercury	Dissolved Mercury	General, TSS etc	Sox etc	Chlorophyll a +	Phaeophytin	Number of Containers
1	E-1	8/9/16	14:30	H2O	✓	✓	✓	✓	✓	✓	✓	✓	7
2	Porcupine Cr	7/9/16	9:40	"	✓	✓	✓	✓	✓	✓	✓	✓	7
3	E-2	6/9/16	16:30	"	✓	✓	✓	✓	✓	✓	✓	✓	7
4	E-3	6/9/16	09:00	"	✓	✓	✓	✓	✓	✓	✓	✓	7
5	E-4	5/9/16	13:10	"	✓	✓	✓	✓	✓	✓	✓	✓	7
6	E-6	5/9/16	9:30	"	✓	✓	✓	✓	✓	✓	✓	✓	7
7	E-8	8/9/16	14:50	"	✓	✓	✓	✓	✓	✓	✓	✓	7
8	R-1	7/9/16	12:45	"	✓	✓	✓	✓	✓	✓			5
9	R-2	7/9/16	15:00	"	✓	✓	✓	✓	✓	✓	✓	✓	7
10	R-3	6/9/16	11:30	"	✓	✓	✓	✓	✓	✓	✓	✓	7
11	R-4	5/9/16	14:40	"	✓	✓	✓	✓	✓	✓	✓	✓	7
12	R-6	8/9/16	16:40	"	✓	✓	✓	✓	✓	✓	✓	✓	7

Drinking Water (DW) Samples[1] (client use)
Are samples taken from a Regulated DW System? ☐ Yes ☐ No
Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)
to meet CCME freshwater aquatic life criteria. All samples preserved & filtered as necessary

SAMPLE CONDITION AS RECEIVED (lab use only)
Frozen ☐ | SIF Observations Yes ☐ No ☐
Ice packs Yes ☑ No ☐ | Custody seal intact Yes ☑ No ☐
Cooling Initiated ☑
INITIAL COOLER TEMPERATURES °C: 4.4 | 2.2
FINAL COOLER TEMPERATURES °C: 6

SHIPMENT RELEASE (client use)
Released by: Bonnie Burns | Date: Sept 9/16 | Time:

INITIAL SHIPMENT RECEPTION (lab use only)
Received by: [illegible] | Date: 12-SEP-16 | Time: 9:15

FINAL SHIPMENT RECEPTION (lab use only)
Received by: HMC | Date: | Time: 10:55

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

NA FM 0326a v09 Front/04 January 2014

SEP 13 2016

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Short Holding Time

O Rush Processing

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

L1829615-COFC

COC Number: 14 - 470930

Report To	
Company:	Laberge Env. Serv.
Contact:	
Address:	
Phone:	867-668-6838

Report Format / Distribution

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)

Quality Control (QC) Report with Report ☐ Yes ☐ No

☑ Criteria on Report - provide details below if box checked

Select Distribution: ☐ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: bonnieburns@northwestel.net

Email 2

Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)

- R ☐ Regular (Standard TAT if received by 3pm)
- P ☐ Priority (2-4 business days if received by 3pm)
- E ☐ Emergency (1-2 business days if received by 3pm)
- E2 ☐ Same day or weekend emergency if received by 10am – contact ALS for surcharge.

Specify Date Required for E2,E or P:

Invoice To

Same as Report To ☐ Yes ☐ No

Copy of Invoice with Report ☐ Yes ☐ No

Company:

Contact:

Invoice Distribution

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: bonnieburns@northwestel.net

Email 2

Project Information

ALS Quote #:	141612DN
Job #:	Clinton Cr
PO / AFE:	
LSD:	

[redacted] Oil and Gas Required Fields (client use)

Approver ID:	Cost Center:
GL Account:	Routing Code:
Activity Code:	
Location:	

ALS Lab Work Order # (lab use only): L1829615

ALS Contact:

Sampler:

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total metals - low level	Dissolved metals low level	Total Mercury	Dissolved Mercury	General, TSS etc	SO4 etc.	Number of Containers
13	Maiden Cr	8/9/16		H_2O	L	L	L	L	L	L	5
14	Field Blank			"	L	L	L	L	L	L	5
15	Travel blank			"	[illegible]	[illegible]	[illegible]	[illegible]	L	L	5
16	Duplicate	8/9/16		"	L	L	L	L	L	L	5

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System? ☐ Yes ☐ No

Are samples for human drinking water use? ☐ Yes ☐ No

Special Instructions / Specify Criteria to add on report (client Use)

note there wasn't travel blanks for metals or Hg.

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☑ No ☐ Custody seal intact Yes ☑ No ☐

Cooling Initiated ☑

INITIAL COOLER TEMPERATURES °C		FINAL COOLER TEMPERATURES °C
4.4	2.2	6

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Bonnie Burns	Date: Sept 9/16	Time:	Received by: [signature]	Date: 12-SEP-16	Time: 9:15	Received by: HMC	Date: SEP 13 2016	Time: 10:55

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

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1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.