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Minto Mine
Phase 4 EEM
Study Design Report

Prepared For:
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February 2016

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Prepared for:

Capstone Mining Corp. - Minto Mine

Prepared by:

Minnow Environmental Inc.

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Project Principal

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1.0 INTRODUCTION

1.1 Site Description

The Minto Mine is a high-grade copper mine located within Selkirk First Nation (SFN) Category A Settlement Land Parcel R-6A approximately 240 km northwest of Whitehorse, Yukon Territory (62°37'N latitude and 137°15'W longitude; Figure 1.1). It is owned and operated by Minto Explorations Ltd., a wholly owned subsidiary of Capstone Mining Corporation. Development of the mine was initiated in 1997, commercial operations started in October 2007 and the anticipated operating life is to 2022. The facility is permitted to conduct open pit and underground mining, and includes a mill with a capacity of 4,200 tonnes of ore per day. The Minto Mine produced 18.4 million pounds of copper in 2014. Current mineral reserves are approximately 7.6 million tonnes at an average copper grade of 1.71%.

In addition to open pit mines, underground mines and the mill, the Minto Mine site includes a number of waste rock dumps, a concentrate storage shed, a tailings storage facility, a water retention dam with a water storage pond, a water treatment plant, administrative offices, an airstrip and a camp (Figure 1.2). Mill tailings are stored in a dry stack tailings storage facility and in mined-out open pits. Mine-impacted seepage from the tailings storage facility and under the Mill Valley Fill (MVF) is collected at the Minto Creek Detention Structure at the toe of the MVF and is pumped to the main pit (Figure 1.2). Non-impacted water and treated mine-impacted water are collected in a Water Storage Pond (WSP; Figure 1.2). Effluent from the WSP is periodically discharged to Minto Creek under conditions specified in Water Use Licence (WUL) QZ14-031 (August 2015). Minto Creek, in turn, discharges to the Yukon River approximately 7.7 km south-east of the WSP (Figure 1.2).

1.2 Background

Federal effluent regulations for the metal mining industry (Metal Mining Effluent Regulations; MMER) were most recently updated in February 2015 (Government of Canada 2015). These regulations, administered under the federal *Fisheries Act*, apply to mining and milling operations that discharge effluent at a rate greater than 50 m^3/day and therefore apply to the Minto Mine. The MMER outline requirements for routine effluent monitoring, acute lethality testing, and Environmental Effects Monitoring (EEM). The objective of EEM is to determine whether effluent discharge is causing an effect on fish, benthic invertebrate communities and/or the use of fisheries resources. The Minto Mine triggered the MMER on July 10, 2006.

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Kilometers

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 8N
Data Source: Department of Natural Resources Canada
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Project No. 157202.0087

Map of Canada

Figure 1.1: Location of the Minto Mine

Features

- Waterbody
- Watercourse
- Mine Road
- Water Flow Direction

N
W E
S

0 175 350 700
Meters

MAP INFORMATION
Datum: NAD 83 Map Projection: UTM Zone 8N
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Mine infrastructure data provided by Access Mining Consultants Inc.
Mine site contours derived from 2012 aerial imagery obtained from Challenger Geomatics.

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Figure 1.2: Minto Mine Site Layout and Receiving Environment

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In accordance with the MMER, a Phase 1 EEM study design was developed in 2007 (Minnow/Access 2007) and implemented in 2008 (Minnow/Access 2009), a Phase 2 EEM study design was developed in 2010 (Minnow/Access 2010) and implemented in 2011 (Minnow/Access 2012), and a Phase 3 EEM study design (Investigation of Cause) was developed and implemented in 2014 (Minnow 2014a, 2015a). The Phase 3 EEM indicated that the potential influence of Minto Mine discharge on benthic invertebrate communities of Minto Creek is more effectively evaluated using a Reference Condition Approach (RCA) than a Control Impact (CI) approach (Minnow 2015a). In accordance with technical guidance, the Phase 4 EEM will include a benthic invertebrate community survey, a fish survey and supporting physical, chemical and biological measures, with an Interpretive Report due to Environment Canada by January 10th 2018. In order to achieve this deadline, the Phase 4 EEM will be implemented in 2016.

1.3 Objective

The objective of this Phase 4 EEM Study Design is to provide an overview of the characteristics of the mine and its local environment (site characterization) based on information collected to date, a summary of the results of previous EEM studies and the design of the Phase 4 EEM study. The study section includes detailed descriptions of the benthic invertebrate community survey and the fish survey, along with all supporting physical, chemical and biological measures taking into account relevant site characterization information, previous biological monitoring data, and comments and recommendations from previous EEM studies.

1.4 Report Organization

The content of this report reflects the requirements outlined under the EEM portion of the MMER (Government of Canada 2015) and in the Technical Guidance Document for Metal Mining EEM (Environment Canada 2012). A detailed site characterization is provided in Section 2.0. A summary of the results from the previous EEM studies is presented in Section 3.0. Section 4.0 describes the Minto Mine Phase 4 EEM study design, including a benthic invertebrate community survey, a fish survey, supporting environmental measures, sub-lethal effluent toxicity testing, effluent characterization, and receiving water quality monitoring. Section 5.0 provides a schedule of project activities. References cited throughout the document are provided in Section 6.0.

1.5 Contacts

Please contact Mr. Ryan Herbert if there are any questions or comments regarding this report.

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In the event that Minto personnel should be unavailable to address technical questions or comments, Mr. Pierre Stecko of Minnow Environmental Inc. may also be contacted as follows:

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2.0 SITE CHARACTERIZATION UPDATE

Site characterization information is required with each EEM Study Design. Detailed site characterization information was provided in the Phase 1 to Phase 3 EEM study designs reports (Minnow/Access 2007, 2010; Minnow 2014a), and therefore the following sections only summarize the previous site characterization information and provide updates where applicable.

2.1 Mine History

Copper deposits at the Minto Mine were first discovered in 1970 and claims were staked in 1971. Extensive exploration yielded the first significant drill intersection in July 1973. The Minto Mine claims and leases cover an area of approximately 25.9 km^2. As of December 31, 2014, mineable reserves at the Minto Mine included 2,857,000 tonnes proven and 4,802,000 tonnes probable at average grades of 1.71% copper, 0.74 grams/tonne (g/t) gold and 6.0 g/t silver.

The Minto mine plan is divided into six phases. Currently, the mine is in Phase 5 of operations, and has been since August 2015. There have been four previous phases at the Minto Mine: Phase 1 during construction from April 2006 to October 2007, Phase 2 from October 2007 to July 2008, Phase 3 from July 2008 to February 2011 and Phase 4 from February 2011 to 2015. The first four phases included incremental increases in processing capacity of the Minto Mill (see Section 2.2.1). Phases 5 and 6 extend surface mining at Minto to 2018, underground mining to 2022, and milling of run-of-mine and stockpiled ore to 2022.

2.2 Minto Mine Operations

The Minto operation currently includes one active open pit - the Minto North Pit (Figure 2.1). The Main Pit, the Area 2 Stage 2 Pit, and the Area 118 Pit are now mined out and inactive. The Minto operation currently includes one underground mine – the Minto South Underground (Figure 2.1), which includes one active zone (Area 118). The M-Zone underground is also now mined out and inactive. The Minto site also includes waste dumps associated with the different mining areas, ore storage areas, a mill and mill pond, a concentrate storage shed, a water retention dam with a water storage pond, a water treatment plant, administrative offices, an airstrip, and a camp (Figure 2.1). Ore is processed on site in the mill. Since Phase 2, the mill's main unit operations have remained the same (Minnow/Access 2007, 2010) except for the process of dealing with tailings (Section 2.2.2). Future plans for mining at the Minto operation include three new open pits (Area 2 Stage 3,

Features

- Mine Road
- Water Flow Direction

Phase 4 Features

- Water Treatment Plant
- Minto Creek Detention Structure
- Building
- Mine Feature Footprint

Phase 5/6 Features

- Mine Feature Footprint

*All mined out features are labeled in red, active are in white and future development are in purple.

N
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0 190 380 760
Meters

MAP INFORMATION
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Figure 2.1: Minto Mine Site Layout with Phase 5 and Phase 6 Mines

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Ridgetop North and Ridgetop South) and 2 new underground mines (East Keel and Wildfire; Figure 2.1; Minto 2014).

2.2.1 Mining and Milling

Minto open pits are mined using conventional open pit truck and loader operations, and Minto underground mines are mined by either room-and-pillar, post-pillar cut-and-fill, or longhole stoping methods (Minto 2014). The Minto mill was originally authorized to process 1,800 tonnes per day (tpd) of ore to produce a copper concentrate in its Phase 1 design. In Phase 2, provisions were made to the plant layout and design to accommodate throughput of 2,400 tpd. The main changes included a new building extension to contain the second ball mill circuit, three additional rougher flotation cells, and also the utilization of the new re-cleaner cells in the main mill building. Equipment initially installed in Phase 1 was sized to accommodate tonnages associated with subsequent phases, and only minor modifications to the grinding circuit (i.e., grate sizes inside the SAG [Semi-Autogenous Grinding] mill and trommel screen size) were required to increase the milling rate to 2,400 tpd in Phase 2, 3,600 tpd in Phase 3, and 4,200 tpd in Phase 4.

The primary crusher was originally designed to operate six hours per day, 365 days per year at 75% availability, but due to increased throughput, the crusher now operates 24 hours per day, 365 days per year at an availability of 75%. The mill circuit operates 24 hours per day, 365 days per year at an availability of approximately 93%. Currently, potassium amyl xanthate (PAX), methyl isobutyl carbinol (MIBC), oxide collector alkyl hydroxamates (AM28), mill flocculant, tails flocculant, nitric acid, sodium sulphide, potassium hydroxide, and hydrated lime are the primary process reagents used in Minto's milling process (Table 2.1).

2.2.2 Tailings Management and Waste Management

In 2006, planning and development of the Minto Mine included a review of the proposed tailings de-watering technology. Subsequent to this review, and as part of mine construction, Minto installed a filter press system for dewatering tailings which produces dry tailings (approximately 16.5% to 18% moisture by weight) suitable for dry-stacking and compaction. Tailings were thickened and filtered to form filtered cake. This process ceased in November 2012 and tailings are now thickened and stored as slurry in the Main Pit and the Area 2 Pit. Operation of the tailings facility is in accordance with the amended Quartz Mining Licence (QML)-0001, which expires on December 31st 2030.

Tailings management activities permitted as part of the Phase 5/6 permitting process included expanded use of the Main Pit and Area 2 Pit (Stage 2 and 3) for tailings storage, a

Table 2.1: Reagent use in the Minto Mill and Water Treatment Plant, 2011-2015.

Reagent		Unit	2011	2012	2013	2014	2015
Minto Mill							
	Potassium Amyl Xanthate (PAX)	kg	21,750	26,850	21,150	112,200	318,900
	Methyl Isobutyl Carbinol (MIBC)	L	29,000	26,800	37,400	35,400	37,200
	Oxide Collector Alkyl Hydroxamates (AM28)	kg	1,650	1,050	0	0	0
	Mill Flocculant	kg	3,911	3,921	4,111	4,677	4,677
	Tails Flocculant	kg	18,000	18,000	22,500	27,000	18,000
	Nitric Acid	L	21,222	40,900	39,164	33,376	56,527
	Sodium Sulphide	kg	9,000	53,250	26,250	18,000	198,000
	Potassium Hydroxide	kg	225	75	0	0	0
	Hydrated Lime	kg	0	0	0	37,200	36,400
Minto Water Treatment Plant							
	Hydrex / Aluminex	L	0	19,000	2,000	21,000	24,000
	Flocculant	kg	0	77	25	125	200
	Antiscalant	L	0	832	200	1,664	1,248
	TMT (1,3,5-triazine-2,4,6-trithione trisodium salt)	L	0	0	1,000	0	0
	Sodium Bicarbonate	kg	0	1,763	125	450	1,725
	Hydrated Lime	kg	0	8	0	0	0

dam on the Main Pit, use of Ridgetop North Pit for tailings storage, and tailings placement in the underground facilities. At present, only the Main Pit and Area 2 Pit Tailings Management Facilities are being utilized (Figure 2.1).

As part of mining operations, waste rock is currently generated from the Minto North Pit and the Minto South Underground. Waste rock generated from the active pit and underground working is currently being disposed of in the Main Waste Dump Expansion, Mill Valley Fill Extension Stage 2, or Main Pit (Figure 2.1), depending on the ABA characteristics of the waste rock. Additionally, waste rock that meets the criteria defined in Minto's WUL and QML can be utilized elsewhere on site for construction material. Waste rock from Phase 5/6 operations will be stored in four primary facilities: Main Waste Dump Expansion, Mill Valley Fill Extension Stage 2 (MVFES2), Main Pit Dump and the Ridgetop Waste Dump (Figure 2.1). The Main Pit Dump and the Ridgetop Waste Dump have not been constructed at the time of writing this report. Phase 5/6 activities further include the Ridgetop South Backfill Dump and Area 118 Backfill Dump designed to contain overburden. The Ridgetop South Backfill Dump and Area 118 Backfill Dump have not been constructed.

Overburden material from the Minto North Pit was placed in an overburden pad on top of the Main Waste Dump Expansion to be utilized for reclamation activities at a later date. Overburden material from the Area 2 Pit was placed as a temporary cover for the Dry Stack Tailings Storage Facility (Figure 2.1). A low-grade ore stockpile and an oxide ore stockpile are located in the northeast corner of the Main Waste Dump. Ore from the low-grade ore stockpile will be processed in the last years of mill operation and the oxide ore stockpile may be processed if economics warrant.

Mine-impacted seepage from the Dry Stack Tailings Storage Facility and under the Mill Valley Fill Expansion (MVFE) was originally collected at the Minto Creek Detention Structure (MCDS) at the toe of the MVFE and pumped to the Main Pit (Figure 2.1). In 2016, the MCDS will be decommissioned and replaced by the MVFE Stage 2 (MVFES2) sump as the footprint of the MVFES2 overlaps that of the MCDS. The MVFES2 sump will operate on the same concept as the MCDS, collecting mine-impacted seepage from the Dry Stack Tailings Storage Facility and MVFE and MVFES2 with conveyance to the Main Pit. Precipitation and any surface run-off water meeting end-of-pipe standards are collected in the Water Storage Pond (WSP; Figure 2.1) and additional mine-impacted water may be treated and directed to the WSP. Effluent from the WSP is periodically discharged to Minto Creek.

Minto's Water Treatment Plant (WTP) consists of a filter unit, clarifier unit and two reverse osmosis (RO) trains, constructed in two stages. The first stage consisted of the filter and clarifier units, constructed in 2010. The ballasted lamella clarifier unit (Actiflo®) system was designed for removal of Total Suspended Solids, total metals and dissolved copper. The first stage was designed for a maximum capacity of 3,600 m^3/day but proved to operate reliably at flows of approximately 4,000 m^3/day. In 2012, two RO trains capable of handling 2,500 m^3/day each were added to the treatment process downstream of the existing filtration and clarification units, for the purpose of treating nitrate and selenium. Treatment chemicals used in Minto's WTP include hydrex/aluminex, flocculant, antiscalant, TMT (1,3,5-triazine-2,4,6-trithione trisodium salt), sodium bicarbonate, and hydrated lime (Table 2.1). Treated effluent which meets Minto's WUL standards is typically directed to the Water Storage Pond, but it can also be directed to Minto Creek. The by-product of the process is a brine stream which is pumped to the Main Pit or Area 2 Pit, as is any effluent that does not meet the WUL conditions.

2.3 Effluent Quality and Applicable Regulations

During the 2011-2015 period (EEM Phases 3 and 4), the Minto Mine discharged 1,340,362 m^3 of effluent to Minto Creek. There were no discharge events in 2011. Discharges in the period from 2012 to 2015 were: 164,120 m^3 from April 16th to May 11th 2012; 360,075 m^3 from April 20th to May 31st 2013; 427,154 m^3 February 21st and May 31st 2014; 60,488 m^3 from November 16th and December 21st 2014; and 328,526 m^3 from April 3rd to May 31st 2015 (Figure 2.2).

2.3.1 Applicable Regulations

Effluent from the Minto Mine is regulated under the Federal MMER and a Type A Water Use Licence (WUL; QZ14-031), issued from the Yukon Water Board (YWB) on August 5, 2015. The limits in a Type A WUL are generally more restrictive than those in the MMER, and separate monitoring and reporting for effluent discharge and receiving water quality is required under the WUL's Water Quality Surveillance Program (Table 2.2).

2.3.2 Effluent Quality

Effluent quality monitoring is conducted at Station W3 (Minto Mine final effluent; Figure 2.3) to meet two MMER requirements: routine monitoring (once per week) and effluent characterization (4 times per year). Effluent quality monitoring has been conducted since pre-construction (i.e., prior to April 1, 2006) and has continued through operations. During mine operations, effluent from the mine has been periodically discharged from the WSP into Minto Creek in accordance with the Minto Mine water management plan (see Section 2.3 for discharge dates between 2011 and 2015). Because effluent must be monitored monthly under the MMER, effluent samples collected from months when there is no discharge from

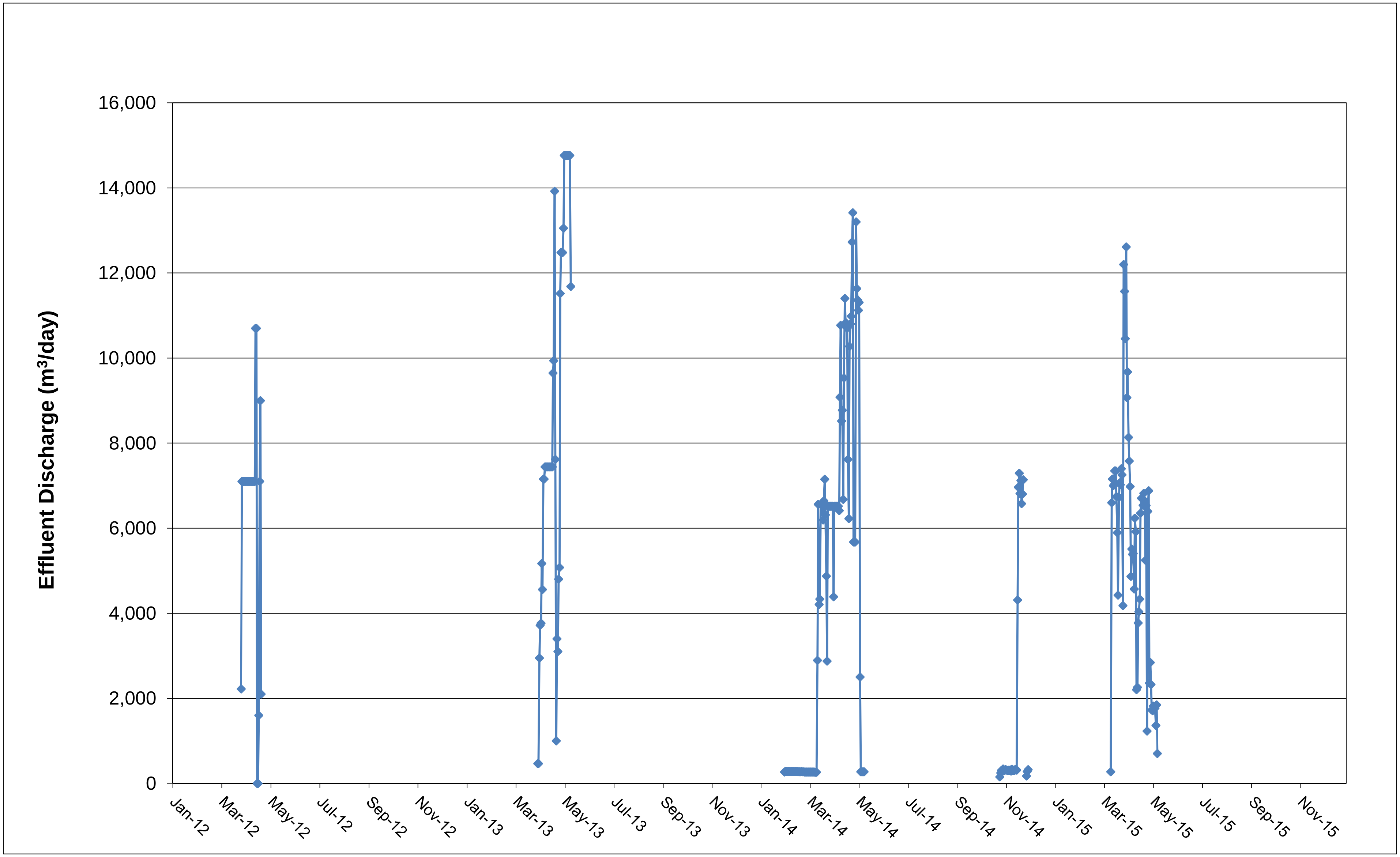
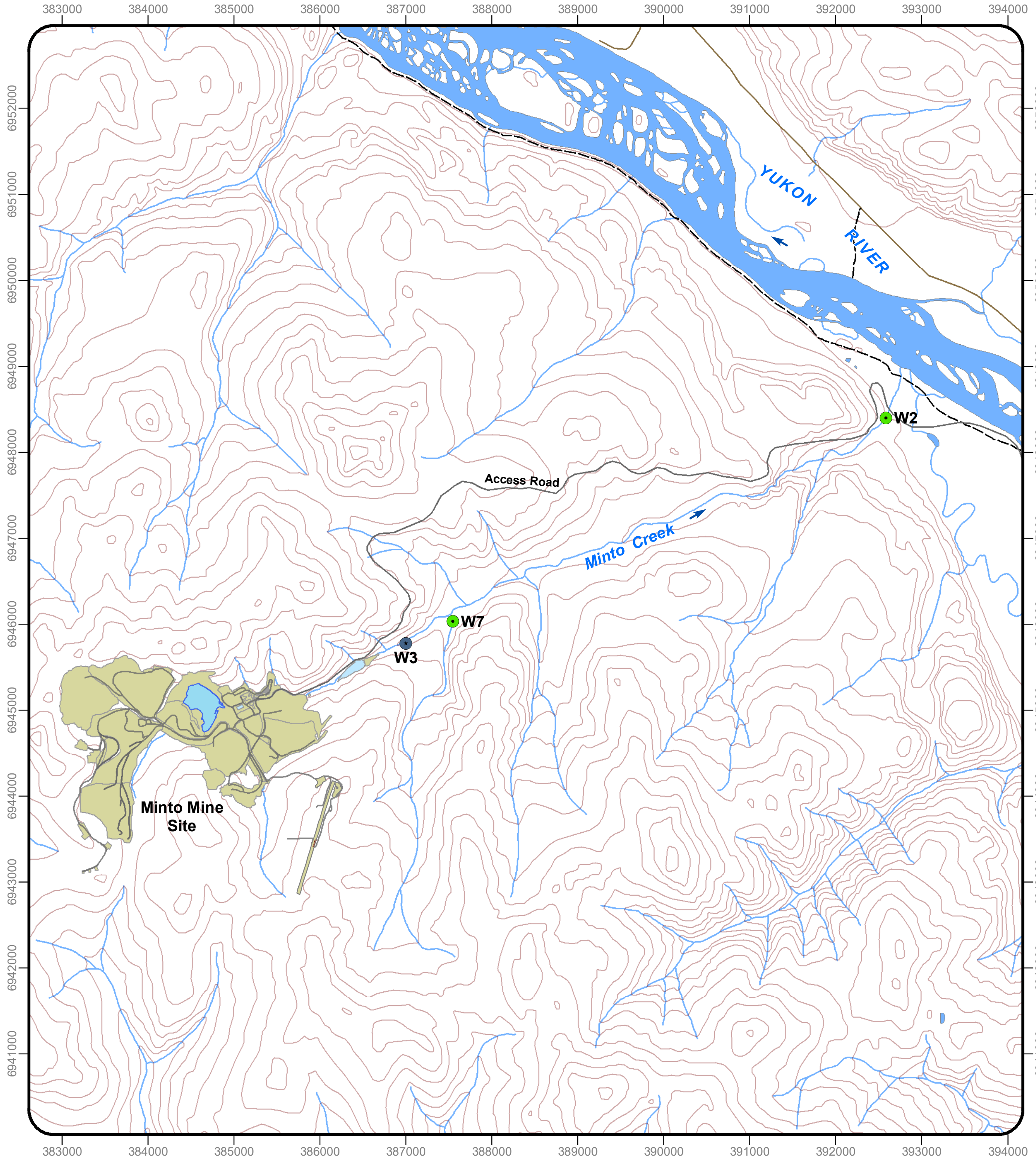


Figure 2.2: Daily effluent discharge volume, 2012 to 2015. Effluent was not discharged in 2011.

Table 2.2: Compliance monitoring frequency and limits applicable to the Minto Mine effluent.

Parameter[1,2]	Units	MMER Effluent Quality Standards[2]			Water Use License QZ14-031 Effluent Quality Standards[2]	
		Frequency	Maximum Monthly Mean	Maximum Authorized Concentration in Grab	Frequency	Daily Limit
pH	pH units	weekly	-	6.0 - 9.5	weekly	6.5 - 9.0
Suspended Solids	mg/L	weekly	15	30	weekly	15
Aluminum	mg/L	-	-	-	weekly	0.30
Arsenic	mg/L	weekly	0.50	1.0	weekly	0.015
Iron	mg/L	-	-	-	weekly	3.3
Copper	mg/L	weekly	0.30	0.60	weekly	0.060
Lead	mg/L	weekly	0.20	0.40	weekly	0.012
Manganese	mg/L	-	-	-	-	-
Nickel	mg/L	weekly	0.50	1.0	weekly	0.33
Radium-226	Bq/L	quarterly	0.37	1.1	-	-
Zinc	mg/L	weekly	0.50	1.0	weekly	0.090
Total Ammonia	mg/L	-	-	-	weekly	1.0
Oil and Grease	visibility	-	-	-	weekly	no visible oil or grease
Rainbow Trout Acute Lethality	LT_{50}	-	-	-	monthly	Pass[3]
Rainbow Trout Acute Lethality	% mortality in 100% effluent	monthly	Pass[3]		-	-
Daphnia magna Acute Lethality	% mortality in 100% effluent	monthly	Pass[3]		-	-

[1] Cyanide analysis not required under MMER as it not a processing agent at the Minto Mine
[2] MMER effluent quality standards apply to total metals; Water Use Licence effluent quality standards apply to dissolved metals
[3] A pass result is < 50% mortality in 100% effluent



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Features
- Water Quality Stations
- Final Effluent Discharge Point
- Mine Feature Footprint
- Main Pit Lake
- Waterbody
- Watercourse
- Contour
- Direction of Flow

Figure 2.3: Minto Mine Effluent and Routine Water Quality Monitoring Stations

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the WSP represent local surface runoff (from the small watershed that reports to Minto Creek between the WSP and Station W3) and groundwater input.

Since 2006, concentrations of all MMER parameters have been well below monthly mean limits during routine effluent monitoring (i.e., for both discharge and non-discharge periods). As in previous EEM phases, occasional exceedence of the maximum authorized concentrations in individual grab samples (MACG) was observed for Total Suspended Solids (TSS) during the period from 2011 to 2015 (i.e., EEM Phases 3 and 4; Table 2.3; Appendix Tables A.1 and A.2). It is notable that many of these samples were taken from Station W3 when the mine was not actively discharging effluent. For example, low frequency elevations above MACG were also observed for copper, lead and zinc in 2011 when Minto Mine did not actively discharge any effluent.

Acute toxicity testing of rainbow trout (*Oncorhynchus mykiss*, 96-h pass/fail) returned non-toxic (pass) results over the period from 2011-2013 (Table 2.4). *Daphnia magna* (48-h pass/fail) returned non-toxic (pass) results for all dates except once in August 2012 (36.7% survival; Table 2.4).

2.4 Effluent Mixing

Mixing of Minto Mine effluent in Minto Creek has been estimated and reported previously (Minnow/Access 2007, 2010). Briefly, the contribution of groundwater discharge/seepage was initially estimated based on relative flows (at discharge versus in lower Minto Creek) to range from 1% in May to 12% in June (Minnow/Access 2007). More recent calculations of mixing confirmed that the percent effluent from groundwater discharge/seepage has been relatively low (<10%) during non-discharge periods. However, during surface water discharge events in 2008 and 2009, effluent concentration at lower Minto Creek ranged from 40% to 100% (Minnow/Access 2010). Flow monitoring in 2014 and 2015, which occasionally included concurrent data for the Water Storage Pond, Final Effluent and lower Minto Creek, suggested an average WSP effluent concentration of 35% and an average Final Effluent (W3) concentration of 56% at lower Minto Creek during discharge (Table 2.5).

2.5 Receiving Water Quality

Receiving water quality has been discussed in detail in the Phase 1 EEM reports (Minnow/Access 2007, 2009), the Phase 2 EEM reports (Minnow/Access 2010, 2012) and the Phase 3 EEM reports (Minnow 2014a, 2015a), as well as in dedicated water quality reports and in annual reports prepared in under the Minto Mine's Water Use Licence (e.g., Minnow 2009a, 2009b, 2010a, 2010b, 2012, 2013, 2014b and 2015b). Under MMER, receiving water quality is monitored at an effluent-exposed station on lower Minto Creek

Table 2.3: Summary of Minto Mine effluent quality, Station W3, 2011 to 2015. Shaded values indicate more than 5% of samples had concentrations greater than MMER Grab limits.

Variables	Units	MMER Limit[1]	MMER Grab[2] (MACG)	WUL Daily Limit	2011			2012			2013			2014			2015		
					Number	Mean	> MMER MACG	Number	Mean	> MMER MACG	Number	Mean	> MMER MACG	Number	Mean	> MMER MACG	Number	Mean	> MMER MACG
Routine Effluent Monitoring																			
pH	pH units	6.0-9.5	6.0-9.5	6.5-9.0	47	8.06	0%	50	8.22	0%	63	8.17	0%	55	8.19	0%	48	8.19	0%
Arsenic	mg/L	0.50	1.0	0.015	47	0.00034	0%	50	0.00031	0%	63	0.00032	0%	55	0.00034	0%	48	0.00029	0%
Copper	mg/L	0.30	0.60	0.060	47	0.0089	2%	50	0.0036	0%	63	0.0081	0%	55	0.010	0%	48	0.0057	0%
Lead	mg/L	0.20	0.40	0.012	47	< 0.00026	2%	50	< 0.00022	0%	63	0.00024	0%	55	0.00021	0%	48	0.00021	0%
Nickel	mg/L	0.50	1.0	0.33	47	0.0023	0%	50	0.0011	0%	63	0.0012	0%	55	0.0012	0%	48	0.0011	0%
Zinc	mg/L	0.50	1.0	0.090	47	0.0083	2%	50	< 0.0049	0%	63	0.0054	0%	55	0.0066	0%	48	0.010	0%
Total Suspended Solids	mg/L	15	30	15	47	4.5	2%	50	2.8	0%	63	4.1	2%	55	9.0	2%	47	2.6	0%
Radium 226	Bq/L	0.37	1.1	-	21	0.0083	0%	5	< 0.010	0%	2	0.015	0%	4	0.011	0%	4	0.010	0%
Effluent Characterization																			
Hardness	mg/L	-	-	-	4	228	-	4	244	-	4	191	-	4	227	-	4	239	-
Alkalinity	mg/L	-	-	-	4	190	-	4	208	-	4	164	-	4	201	-	4	204	-
Aluminum	mg/L	-	-	0.30	4	0.084	-	4	0.045	-	4	0.36	-	4	0.073	-	4	0.036	-
Cadmium	mg/L	-	-	-	4	0.000038	-	4	0.000026	-	4	0.000015	-	4	0.000011	-	4	0.000011	-
Iron	mg/L	-	-	3.3	4	0.12	-	4	0.077	-	4	0.57	-	4	0.11	-	4	0.068	-
Mercury	mg/L	-	-	-	4	< 0.000020	-	4	< 0.000010	-	4	< 0.000010	-	4	< 0.000010	-	4	< 0.000010	-
Molybdenum	mg/L	-	-	-	4	0.0038	-	4	0.0047	-	4	0.0041	-	4	0.0049	-	4	0.0054	-
Ammonia	mg/L	-	-	1.0	4	0.014	-	4	0.036	-	4	0.023	-	4	0.029	-	4	0.037	-
Nitrate	mg/L	-	-	-	4	1.4	-	4	1.5	-	4	1.0	-	4	0.36	-	4	0.92	-
Selenium	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	4	0.00036	-	4	0.00052	-
Conductivity	µS/cm	-	-	-	-	-	-	-	-	-	-	-	-	4	266	-	4	298	-
Temperature	C	-	-	-	-	-	-	-	-	-	-	-	-	4	1.6	-	4	2.9	-

[1] MMER monthly mean limit

[2] MMER authorized concentrations limits in an individual grab samples (MACG)

Table 2.4: Summary of effluent acute toxicity results, Minto Mine 2011-2015.

Year	Sample Date	Discharge[1]	Rainbow Trout		*Daphnia magna*	
			Survival at 100% effluent	Pass/Fail	Survival at 100% effluent	Pass/Fail
2011	17-Jan	ND	100	pass	100	pass
	09-Feb	ND	100	pass	100	pass
	08-Mar	ND	100	pass	100	pass
	27-Apr	ND	100	pass	100	pass
	24-May	ND	100	pass	100	pass
	16-Jun	ND	100	pass	100	pass
	27-Jul	ND	100	pass	100	pass
	16-Aug	ND	100	pass	100	pass
	12-Sep	ND	100	pass	100	pass
	06-Oct	ND	100	pass	100	pass
	13-Dec	ND	100	pass	100	pass
2012	22-Jan	ND	100	pass	100	pass
	14-Feb	ND	100	pass	100	pass
	05-Mar	ND	100	pass	100	pass
	24-Apr	D	100	pass	100	pass
	19-Jun	ND	100	pass	100	pass
	23-Aug	ND	100	pass	37	fail
	05-Sep	ND	100	pass	100	pass
	19-Sep	ND	100	pass	87	pass
	18-Dec	ND	100	pass	100	pass
2013	30-Apr	D	100	pass	100	pass
	21-May	D	100	pass	100	pass
	21-Aug	ND	100	pass	100	pass
	21-Oct	ND	100	pass	100	pass
2014	10-Mar	D	100	pass	100	pass
	30-Jun	ND	100	pass	100	pass
	04-Aug	ND	100	pass	100	pass
	27-Oct	ND	100	pass	100	pass
2015	09-Mar	ND	100	pass	100	pass
	22-Jun	ND	100	pass	100	pass
	31-Aug	ND	100	pass	100	pass
	05-Oct	ND	100	pass	100	pass

[1] D = discharge; ND = non-discharge

Table 2.5: Relative effluent and lower Minto Creek flow rates, 2014 and 2015[a]

Date	Water Flow Rate (m^3/s)			Implied Effluent Concentration (%)	
	Water Storage Pond	Final Effluent (Station W3)	Lower Minto Creek (Station W1)	Water Storage Pond Water at Lower Minto Creek	Final Effluent at Lower Minto Creek
22-Apr-14	0.072	0.088	0.737	10%	12%
1-May-14	0.072	0.079	0.715	10%	11%
6-May-14	0.107	0.012	0.368	29%	3%
17-May-14	0.063	0.141	0.154	41%	92%
19-May-14	0.063	0.080	0.205	31%	39%
20-Apr-15	0.134	0.100	0.365	37%	27%
23-Apr-15	0.105	0.110	0.198	53%	56%
30-Apr-15	0.062	0.080	0.421	15%	19%
9-May-15	0.050	0.030	0.214	23%	14%
14-May-15	0.079	0.100	0.117	68%	85%
21-May-15	0.027	0.090	0.104	26%	87%
22-May-15	0.033	0.090	0.040	83%	225%
Average				35%	56%

[a] Data are only presented when available for the same date at all three monitoring locations

(Station W2) and at a reference station (Station W7) located on a tributary to Minto Creek (Figure 2.3). Generally, water quality in the Minto Creek drainage is characterized as slightly basic, moderately hard, moderately high in total suspended and dissolved solids and moderately to highly conductive (Minnow/Access 2009). Background concentrations of total aluminum, total copper and total iron have been identified as naturally greater than Canadian Water Quality Guidelines (CWQG) in association with elevated total suspended solids (TSS) concentrations (e.g., Minnow 2009a). During the 2011-2015 period (EEM Phases 3 and 4), aluminum, copper and iron were the only analytes that had mean concentrations (in any year) greater than the 95th percentile of background (Table 2.6). These elevations occurred in 2011, 2012 and 2013 in association with elevated concentrations of TSS, but did not occur in 2014 and 2015. Concentrations of TSS and these metals were particularly elevated in 2012. Similar elevations in concentrations of TSS, total aluminum and total iron were observed at the reference area (Station W7) in 2011 and 2012 (Table 2.7). Several additional total metals (cadmium, lead and zinc) had mean concentrations below CWQG, but had concentrations in individual samples that exceeded CWQG at a relatively high frequency (Table 2.6; Appendix Table A.3). As with aluminum, copper and iron, these elevations were particularly prevalent in 2012 when concentrations of TSS were elevated.

Comparison of water quality data of the exposed station (Station W2) to reference (Station W7) indicates that elevations at the former relative to the latter generally occur due to elevated TSS (Appendix Table A.4). One exception was evident with copper in 2015 when total copper was elevated at Station W2 despite TSS concentrations that were lower than at the reference station (Appendix Tables A.3 and A.4). Future water quality data interpretation will be augmented by the analysis of dissolved metals and the application of Site-Specific Water Quality Objectives (SSWQOs) that were recently incorporated into the Minto Mine's WUL. This analysis will be included in the interpretation of Phase 4 EEM data.

2.6 Aquatic Habitats Subject to Biological Monitoring

2.6.1 Receiving Environment

Minto Creek is an ephemeral watercourse with a mainstem length of approximately 17 km and a watershed area of approximately 41 km^2, flowing northeast to its confluence with the Yukon River (Figures 1.2 and 2.3) and has been described in detail previously (Minnow/Access 2007, 2010). Substrate of upper Minto Creek is predominantly sand and gravel, with a smaller proportion of cobble that is generally restricted to locations of higher than average gradient and water velocity. Most of upper Minto Creek is confined within an incised channel with steep banks. During the Cycle 3 EEM, upper Minto Creek and its watershed (i.e., the watershed upstream of the benthic invertebrate sampling area) were

Table 2.6: Summary of receiving water quality at mine-exposed station W2, Minto Mine (2011-2015).

Parameter	Unit	Background 95th Percentile[1]	Canadian Water Quality Guideline (CCME 2015)	2011			2012			2013			2014			2015		
				Number	Mean	% > Applicable Guidelines	Number	Mean	% > Applicable Guidelines	Number	Mean	% > Applicable Guidelines	Number	Mean	% > Applicable Guidelines	Number	Mean	% > Applicable Guidelines
EEM Parameters																		
pH	pH units	-	6.5-9.0	4	7.84	0%	4	7.90	0%	4	8.08	0%	4	8.07	0%	4	7.97	0%
Temperature	Celsius	-	-	4	3.9	-	4	3.2	-	4	1.9	-	4	3.6	-	4	3.9	-
Hardness	mg/L	-	-	4	115	-	4	140	-	4	209	-	4	148	-	4	176	-
Alkalinity	mg/L	-	-	4	103	-	4	117	-	4	140	-	4	137	-	4	157	-
Conductivity	µS/cm	-	-	4	310	-	4	146	-	4	169	-	4	185	-	4	185	-
Dissolved Oxygen	mg/L	-	-	2	12	-	4	14	-	3	13	-	4	13	-	4	12	-
Total Suspended Solids	mg/L	-	-	4	80	-	4	292	-	4	27	-	4	15	-	4	4.2	-
Ammonia	mg/L	-	1.54	4	0.018	0%	4	0.068	0%	4	0.031	0%	4	0.021	0%	4	0.018	0%
Nitrate (as N)	mg/L	-	2.9	4	0.15	0%	4	0.23	0%	4	0.57	0%	4	0.10	0%	4	0.12	0%
Aluminum	mg/L	0.62	0.10	4	2.5	50%	4	5.5	75%	4	0.69	50%	4	0.28	25%	4	0.068	0%
Arsenic	mg/L	-	0.0050	4	0.0018	0%	4	0.0030	25%	4	0.0013	0%	4	0.00063	0%	4	0.00055	0%
Cadmium	mg/L	-	0.00018-0.00029[b]	4	0.00010	25%	4	0.00015	25%	4	0.000016	0%	4	0.000017	0%	4	0.000012	0%
Copper	mg/L	0.013	0.0020-0.0040[b]	4	0.010	25%	4	0.014	25%	4	0.0054	25%	4	0.0036	0%	4	0.0065	25%
Iron	mg/L	1.1	0.30	4	4.2	50%	4	8.7	75%	4	2.7	75%	4	0.60	25%	4	0.23	0%
Lead	mg/L	-	0.0038-0.0065[b]	4	0.0012	0%	4	0.0024	25%	4	0.0004	0%	4	0.00027	0%	4	0.00020	0%
Mercury	mg/L	-	0.00010	4	< 0.000020	0%	4	< 0.000010	0%	4	< 0.000010	0%	4	< 0.000010	0%	4	< 0.000010	0%
Molybdenum	mg/L	-	0.073	4	0.0013	0%	4	0.0013	0%	4	0.0016	0%	4	0.0013	0%	4	0.0018	0%
Nickel	mg/L	-	0.11-0.15[b]	4	0.0058	0%	4	0.010	0%	4	0.0027	0%	4	0.0017	0%	4	0.0012	0%
Selenium	mg/L	-	0.0010	4	0.00020	0%	4	0.0003	0%	4	0.00018	0%	4	0.00012	0%	4	0.00015	0%
Zinc	mg/L	-	0.030	4	0.014	0%	4	0.022	25%	4	0.0060	0%	4	0.0053	0%	4	< 0.0050	0%
Radium-226[c]	Bq/L	-	-	4	< 0.010	-	-	-	-	-	-	-	-	-	-	-	-	-
Additional Parameter with CWQG																		
Thallium	mg/L	-	0.00080	4	0.000058	0%	4	0.000087	0%	4	< 0.000050	0%	4	< 0.000050	0%	4	< 0.000050	0%

(blue) Between 5 and 25% of individual results are > applicable guidelines or, for aluminum, copper and iron, 95th percentiles

(green) Between 25 and 50% of individual results are > applicable guidelines or, for aluminum, copper and iron, 95th percentiles

(yellow) > 50% of individual results are > applicable guidelines or, for aluminum, copper and iron, 95th percentiles

[1] 95th percentile of background identified by Minnow (2009a)

[a] Based on pH 8 and temperature of 5 Celsius

[b] Cadmium, copper, lead and nickel guidelines are dependent on water hardness

[c] Radium-226 discontinued in 2012 in accordance with the MMER

Table 2.7: Summary of receiving water quality at reference station W7, Minto Mine (2011-2015).

Parameter	Unit	Background 95th Percentile[1]	Canadian Water Quality Guideline (CCME 2015)	2011			2012			2013			2014			2015		
				Number	Mean	% > Applicable Guidelines	Number	Mean	% > Applicable Guidelines	Number	Mean	% > Applicable Guidelines	Number	Mean	% > Applicable Guidelines	Number	Mean	% > Applicable Guidelines
EEM Parameters																		
pH	pH units	-	**6.5-9.0**	4	7.86	0%	4	7.68	0%	4	7.94	0%	4	8.09		4	7.73	0%
Temperature	Celsius	-	**-**	4	2.1	-	4	2.3	-	4	1.1	-	4	0.27	-	4	0.78	-
Hardness	mg/L	-	**-**	4	90	-	4	109	-	4	126	-	4	124	-	4	161	-
Alkalinity	mg/L	-	**-**	4	85	-	4	101	-	4	124	-	4	118	-	4	148	-
Conductivity	µS/cm	-	-	4	178	-	4	115	-	4	135	-	4	143	-	4	162	-
Dissolved Oxygen	mg/L	-	-	3	13	-	4	14	-	3	12	-	4	13	-	3	13	-
Total Suspended Solids	mg/L	-	-	4	28	-	4	47	-	4	18	-	4	3.4	-	4	64	-
Ammonia	mg/L	-	**1.5[a]**	4	0.014	0%	4	0.066	0%	4	0.043	0%	4	0.022	0%	4	0.034	0%
Nitrate (as N)	mg/L	-	**2.9**	4	0.073	0%	4	0.11	0%	4	0.12	0%	4	0.15	0%	4	0.10	0%
Aluminum	mg/L	**0.62**	0.10	4	0.76	25%	4	1.6	50%	4	0.40	25%	4	0.065	0%	4	0.42	25%
Arsenic	mg/L	-	**0.0050**	4	0.00080	0%	4	0.0012	0%	4	0.00056	0%	4	0.00046	0%	4	0.00060	0%
Cadmium	mg/L	-	**0.00015-0.00024[b]**	4	0.000045	0%	4	0.000042	0%	4	0.000014	0%	4	0.000015	0%	4	0.000015	0%
Copper	mg/L	**0.013**	0.0020-0.0040[b]	4	0.0087	25%	4	0.0048	0%	4	0.0033	0%	4	0.0026	0%	4	0.0031	0%
Iron	mg/L	**1.1**	0.30	4	1.5	50%	4	2.8	75%	4	0.88	25%	4	0.23	0%	4	0.72	25%
Lead	mg/L	-	**0.0028-0.0058[b]**	4	0.00050	0%	4	0.00062	0%	4	0.00027	0%	4	0.00020	0%	4	0.00031	0%
Mercury	mg/L	-	**0.00010**	4	0.000020	0%	4	0.000010	0%	4	0.000010	0%	4	0.000010	0%	4	0.000010	0%
Molybdenum	mg/L	-	**0.073**	4	0.0010	0%	4	0.0013	0%	4	0.0013	0%	4	0.0014	0%	4	0.0018	0%
Nickel	mg/L	-	**0.088-0.14[b]**	4	0.0033	0%	4	0.0041	0%	4	0.0017	0%	4	0.0012	0%	4	0.0017	0%
Selenium	mg/L	-	**0.0010**	4	0.00013	0%	4	0.00017	0%	4	0.00022	0%	4	0.00019	0%	4	0.00021	0%
Zinc	mg/L	-	**0.030**	4	0.010	0%	4	0.0075	0%	4	0.0052	0%	4	0.0052	0%	4	0.0054	0%
Radium-226[c]	Bq/L	-	**-**	4	0.010	-	-	-	-	-	-	-	-	-	-	-		-
Additional Parameters with CWQG																		
Thallium	mg/L	-	**0.00080**	4	0.000050	0%	4	0.000050	0%	4	0.000050	0%	4	0.000050	0%	4	0.000050	0%

Between 5 and 25% of individual results are > applicable guidelines or, for aluminum, copper and iron, 95th percentiles

Between 25 and 50% of individual results are > applicable guidelines or, for aluminum, copper and iron, 95th percentiles

> 50% of individual results are > applicable guidelines or, for aluminum, copper and iron, 95th percentiles

[1] 95th percentile of background identified by Minnow (2009)

[a] Based on pH 8 and temperature of 5 Celsius

[b] Cadmium, copper, lead and nickel guidelines are dependent on water hardness

[c] Radium-226 discontinued in 2012 in accordance with the MMER

characterized using Geographic Information System (GIS) analysis and in-situ measurement (September 2014; Table 2.8).

2.6.2 Reference Areas

Reference areas for the benthic invertebrate community monitoring include those used in the Phase 1 and Phase 2 EEM studies (upper McGinty Creek and upper Wolverine Creek) and an additional ten benthic invertebrate community reference sites added in Phase 3 to support the evaluation of community conditions using the Reference Condition Approach (RCA; Figure 2.4). Characteristics of the reference sites are comparable to upper Minto Creek. The RCA reference sites were chosen from a list of 60 potential reference sites, all of which required helicopter access. The 60 potential sites were selected from a list of 396 potential reference streams and watersheds chosen based on watershed characteristics listed above for upper Minto Creek. These 60 sites were then ranked using Principal Component Analysis (PCA). The actual reference sites were selected from the 60 ranked potential reference sites on the basis of accessibility (i.e., whether or not a helicopter could land nearby), and the similarity of substrate, water depth, stream gradient and water velocity to upper Minto Creek.

2.7 Fish and Aquatic Resources

Previous fishing in Minto Creek (baseline evaluation in 1994 [HKP 1994] and annual fish surveys from 2006 to present) has indicated that use is restricted to lower Minto Creek and is transient (typically between June and November only). The latter is consistent with other studies indicating that utilization of small creeks that flow into large rivers is typically transient and short-lived (Walker 1976; Scrivener et al. 1994). Fishing conducted by the Minto Mine throughout the ice-free season (2006 to 2014 by R&D Environmental and the Access Consulting Group) has indicated that use is restricted to the area downstream of a natural barrier located approximately 1.5 km upstream of the creek mouth and highest abundance typically occurs between July and September (Table 2.9). Fishing conducted between 1994 and 2015 has documented five fish species in Minto Creek; slimy sculpin (*Cottus cognatus)*, Chinook salmon (juvenile *Oncorhynchus tshawytscha*), Arctic grayling (*Thymallus arcticus*), burbot (*Lota lota*) and longnose sucker (*Catostomus catostomus*). However, by far the most abundant fish species has always been juvenile Chinook salmon (Tables 2.9 and 2.10). The juvenile Chinook salmon are fish migrating to the Pacific Ocean along the Yukon River from natal streams upstream of Minto Creek (Access and Minnow 2013).

Substantially more juvenile Chinook salmon were collected in 2009 and 2010 than in other years (Table 2.9), presumably due to emergency discharge of mine water, which resulted in higher than usual Minto Creek flow and attraction to the stable, elevated flow of warmer

Table 2.8: Summary of habitat characteristics of upper Minto Creek

Watershed or Sampling Site Characteristic	Value
Watershed characteristics measured using GIS:	
Stream order [1]	2
Watershed area [2]	11.3 km^2
Watershed perimeter [2]	16 km
Upstream length [2]	8.3 km
Upstream drainage density [2]	0.73 km/km^2
Elevation [1]	660 m asl
Basin slope	9^0
Watershed aspect	southeast
Coverage by low shrubs	39%
Coverage by herbs	48%
Coverage by sparse conifers	6.8%
Plutonic geology	92.6%
Volcanic geology	7.4%
Not burned since 1950	2.0%
Sampling site characteristics measured in September 2014:	
Mean gradient	2.30%
Mean water velocity	0.14 m/s
Mean depth	9 cm
Maximum depth	17 cm
Mean wetted width	1.4 m
Mean bankfull width	1.7 m
Mean morphology	23% riffle; 77% run
Mean substrate	43% cobble; 23% gravel; 34% sand and finer
Overhead cover	alder, willow, aspen, spruce

[1] At the benthic invertebrate community sampling sites in upper Minto Creek

[2] Prior to mine development

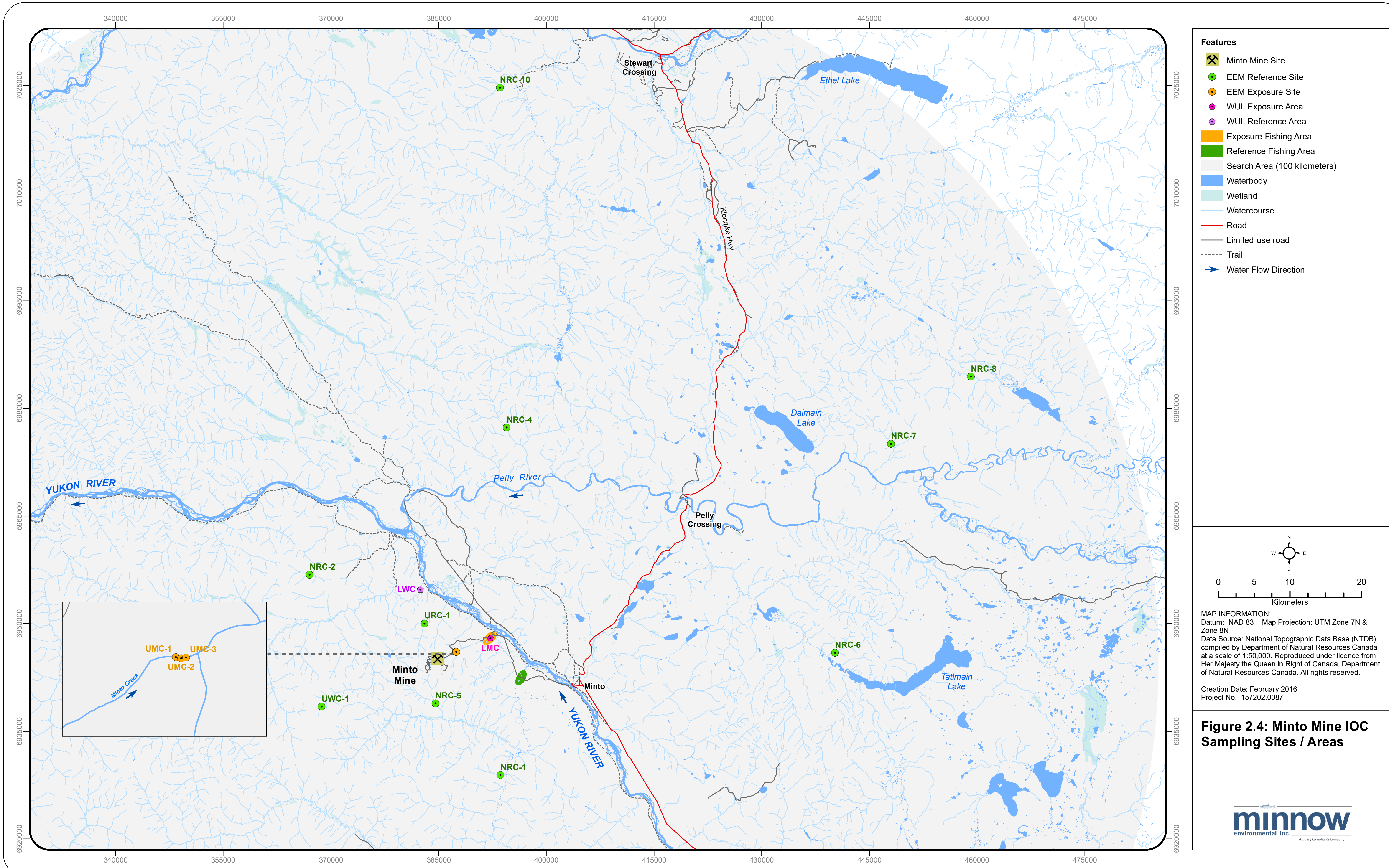


Figure 2.4: Minto Mine IOC Sampling Sites / Areas

Table 2.9: Summary of fish catches in Minto Creek, 1994-2015.

Year	Month	Method[1]	Effort[2]	Round Whitefish	Slimy Sculpin	Arctic Grayling	Chinook Salmon	Burbot	Longnose Sucker
1994 (Hallam Knight Piesold 1994)	June	EF	8.0	1	-	-	-	-	-
		MT	NR	-	2	-	-	-	-
	August	MT	NR	-	4	-	-	-	-
		EF	16	-	2	2	-	-	-
	September	EF	7.0	-	-	2	-	-	-
		MT	NR	-	-	-	-	-	-
2006 (R&D Environmental 2006)	September	MT	1.0	-	-	-	-	-	-
2007 (R&D Environmental 2007)	May	EF	11	-	-	-	8	-	-
		MT	2.1	-	-	-	4	-	-
	June	EF	3.5	-	-	-	-	-	-
		MT	3.4	-	6	-	24	-	-
2008 (Access Consulting Group)	June	EF	6.6	-	-	-	-	-	-
		MT	11	-	-	-	-	-	-
	September	EF	6.7	-	-	-	1	-	-
		MT	19	-	-	-	17	-	-
2009 (Access Consulting Group 2009)	September	MT	32	-	-	1	292	-	-
	October	MT	98	-	-	-	695	1	-
2010 (Access Consulting Group 2010)	June	MT	16	-	3	-	-	-	-
	July	MT	30	-	3	-	493	-	-
	August	MT	35	-	-	3	831	1	-
	September	MT	29	-	1	1	433	1	-
	October	MT	16	-	-	-	95	1	-
	November	MT	35	-	-	-	371	-	-
2011 (Access Consulting Group 2011)	July	MT	19	-	2	-	1	-	-
	August	MT	19	-	-	-	3	-	9
	September	MT	12	-	4	-	6	-	3
	October	MT	15	-	1	-	2	-	-
2012 (Access Consulting Group 2013)	June	EF	9.2	-	3	1	-	-	-
		MT	10	-	4	-	-	-	-
	July	MT	13	-	1	-	-	-	-
	August	MT	8.8	-	-	-	-	-	-
	September	MT	11	-	1	-	3	-	-
2013 (Access Consulting Group 2014a)	May	EF	27	-	-	1	-	-	-
		MT	5.1	-	1	-	-	-	-
	June	EF	30	-	2	-	-	1	-
		MT	10	-	-	-	-	-	-
	July	MT	10	-	-	-	-	-	-
	August	MT	16	-	6	-	19	-	-
	September	MT	14	-	-	-	19	-	-
	October	MT	17	-	-	-	83	-	-
2014 (Access Consulting Group 2014b)	June	MT	12	-	-	-	-	-	-
	July	MT	14	-	-	-	-	-	-
	August	MT	13	-	2	-	58	1	-
	September	MT	18	-	-	-	89	-	-
	October	MT	13	-	-	-	4	-	-
2015 (Access Consulting Group)	June	MT	11	-	-	-	-	-	-
	July	MT	14	-	-	-	4	-	-
	August	MT	13	-	-	-	-	-	-
	September	MT	14	-	-	-	2	-	-
	October	MT	12	-	-	-	-	-	-

[1] EF=electrofishing; MT=Minnow Trapping

[2] MT effort in minnow trap days; EF effort in minutes of electric current application

Table 2.10: Summary of fish catch and catchability results in Minto Creek, 2011-2015

Year	Month	Method[1]	Effort[2]	Units	Round Whitefish	Slimy Sculpin	Arctic Grayling	Chinook Salmon	Burbot	Longnose Sucker
2011 (Access Consulting Group 2011)	July	MT	19	number	-	2	-	1	-	-
				#/MT day	-	0.10	-	0.052	-	-
	August	MT	19	number	-	-	-	3	-	9
				#/MT day	-	-	-	0.16	-	0.49
	September	MT	12	number	-	4	-	6	-	3
				#/MT day	-	0.33	-	0.49	-	0.25
	October	MT	15	number	-	1	-	2	-	-
				#/MT day	-	0.066	-	0.13	-	-
2012 (Access Consulting Group 2013)	June	EF	9.2	number	-	3	1.0[a]	-	-	-
				#/min	-	0.0054	0.002	-	-	-
		MT	10	number	-	4	-	-	-	-
				#/MT day	-	0.38	-	-	-	-
	July	MT	13	number	-	1	-	-	-	-
				#/MT day	-	0.078	-	-	-	-
	August	MT	8.8	number	-	-	-	-	-	-
				#/MT day	-	-	-	-	-	-
	September	MT	11	number	-	1	-	3	-	-
				#/MT day	-	0.092	-	0.28	-	-
2013 (Access Consulting Group 2014a)	May	EF	27	number	-	-	1.0[a]	-	-	-
				#/min	-	-	0.00062	-	-	-
		MT	5.1	number	-	1	-	-	-	-
				#/MT day	-	0.20	-	-	-	-
	June	EF	30	number	-	2	-	-	1	-
				#/min	-	0.067	-	-	0.034	-
		MT	10	number	-	-	-	-	-	-
				#/MT day	-	-	-	-	-	-
	July	MT	10	number	-	-	-	-	-	-
				#/MT day	-	-	-	-	-	-
	August	MT	16	number	-	6	-	19	-	-
				#/MT day	-	0.39	-	1.2	-	-
	September	MT	14	number	-	-	-	19	-	-
				#/MT day	-	-	-	1.3	-	-
	October	MT	17	number	-	-	-	83	-	-
				#/MT day	-	-	-	5.0	-	-
2014 (Access Consulting Group 2014b)	June	MT	12	number	-	-	-	-	-	-
				#/MT day	-	-	-	-	-	-
	July	MT	14	number	-	-	-	-	-	-
				#/MT day	-	-	-	-	-	-
	August	MT	13	number	-	2	-	58	1	-
				#/MT day	-	0.15	-	4.3	0.075	-
	September	MT	18	number	-	-	-	89	-	-
				#/MT day	-	-	-	5.1	-	-
	October	MT	13	number	-	-	-	4	-	-
				#/MT day	-	-	-	0.31	-	-
2015 (Access Consulting Group - reporting in progress)	June	MT	11	number	-	-	-	-	-	-
				#/MT day	-	-	-	-	-	-
	July	MT	14	number	-	-	-	4	-	-
				#/MT day	-	-	-	0.29	-	-
	August	MT	13	number	-	-	-	-	-	-
				#/MT day	-	-	-	-	-	-
	September	MT	14	number	-	-	-	2	-	-
				#/MT day	-	-	-	0.15	-	-
	October	MT	12	number	-	-	-	-	-	-
				#/MT day	-	-	-	-	-	-

[1] EF=electrofishing; MT=Minnow Trapping

[2] MT effort in minnow trap days; EF effort in minutes of electrical current application

[a] Observed but not captured

water with a more consistent temperature regime (Access and Minnow 2013). Studies elsewhere have indicated that juvenile Chinook salmon appear to only enter non-natal tributaries during out-migration when temperatures of those streams reach an equilibrium with the Yukon River, which is usually in June (Walker 1976; Duncan and Bradford 2004). A mark-recapture study completed in 2010 (Access 2010) indicated that up to approximately 1,500 juvenile Chinook salmon were present in lower Minto Creek at any one time (in August, attracted by enhanced water flow). This study also indicated that 90% of the juvenile Chinook salmon spent two weeks or less in Minto Creek and that few individuals (approximately 1%) spent 12 weeks in the creek (Access 2010). This is consistent with previous observations of brief occupancy of juvenile Chinook salmon in non-natal tributaries, which may be as little as nine days on average (Scrivener et al. 1994).

Since 2012, a reference creek, Big Creek (approximately 7 km southeast of Minto Creek; Figure 2.3), has also been fished for comparison to lower Minto Creek (Access 2013, 2014a,b). This fishing has indicated a similar fish community as Minto Creek, as well as similar juvenile Chinook salmon catchability.

Minto Mine has monitored benthic invertebrate community condition in dominant erosional habitat of lower Minto Creek annually since 2010 as required under their Water Use Licence (e.g., Minnow 2011, 2012, 2013, 2014b, 2015b). Samples collected from erosional habitat of lower Minto Creek using a Hess sampler with 500 μm mesh (monitoring from 2012 to present) have documented mean taxon richness of 12 to 20, good representation of sensitive EPT taxa (mayflies, stoneflies and caddisflies; 22% to 63% of all organisms) and good representation by non-biting midge larvae (Chironomidae; 29% to 54% of all organisms). Inter-annual variability has been fairly high, possibly due to glaciation of the creek over the winter and other inter-annual differences in environmental conditions. Comparisons to a reference Creek (lower Wolverine Creek, located approximately 12 km northwest of Minto Creek; Figure 2.3) has generally indicated that lower Minto Creek has a greater number of taxa and a greater dominance of sensitive EPT taxa than the reference creek.

3.0 REVIEW OF PREVIOUS EEM STUDIES

The Minto Mine Phase 1, 2, and 3 EEM studies were implemented in 2008, 2011 and 2014, respectively. The Phase 1 and 2 studies included a benthic invertebrate community survey and a fish population survey (Table 3.1), as well as supporting effluent sublethal toxicity testing and receiving water quality monitoring (Minnow/Access 2009, 2012). The Phase 3 study was an Investigation of Cause (IOC) into differences in benthic invertebrate community structure in upper Minto Creek relative to reference creeks as detected using the Bray-Curtis index of dissimilarity. No fish study was required in Phase 3, but as in Phases 1 and 2, the IOC included supporting effluent sublethal toxicity testing and receiving water quality monitoring (Table 3.1; Minnow 2015a). Results of the Minto Mine Phase 1 to 3 EEM biological studies are briefly summarized in the following subsections.

3.1 Sublethal Toxicity Testing

Sub-lethal toxicity testing of final effluent was conducted twice per year from 2007 to 2009 and has been conducted annually since 2010, all in accordance with MMER. The only recent instance of a response was in 2013 when testing of the water flea *Ceriodaphnia dubia* indicated reproductive impairment at an effluent concentration of 38.6% (Table 3.2). Impairment to this endpoint was also observed in one of two tests conducted in 2008, but was not corroborated in any other tests since then.

3.2 Benthic Invertebrate Community Surveys

Phase 1 and 2 EEM benthic invertebrate community surveys indicated a number of differences between mine-exposed and reference areas (Table 3.3). Bray-Curtis index was the only EEM endpoint that differed in all comparisons to references creeks, indicating a consistent difference in the benthic invertebrate community composition of upper Minto Creek relative to upper McGinty and upper Wolverine creeks. Such differences in Bray-Curtis index are neither unusual, nor necessarily attributable to the Minto Mine. Furthermore, the Bray-Curtis index does not provide information of the nature differences (although supporting analyses can be used to infer reasons for differences in Bray-Curtis index) and has been identified as being pre-disposed towards producing significant differences even in the absence of a real effect (Huebert et al. 2011). The EEM endpoints of number of taxa, density and Simpson's Eveness returned equivocal results in the first two studies, but in general, indicated higher density, higher number of taxa, and lower Simpson's E in upper Minto Creek relative to reference (Table 3.3). Higher number of taxa is often associated with good environmental quality and likely also contributes to lower Simpson's Eveness as is often observed in communities with greater taxon richness. Supporting analyses suggested

Table 3.1: Summary of previous Minto Mine Environmental Effects Monitoring (EEM) study designs.

EEM Phase	Benthic Invertebrate Community Survey	Fish Survey	Fish Usability
1 (2008)	Erosional habitat of upper Minto Creek compared to erosional habitat of upper McGinty Creek. Hess sampling using 250 µm mesh. Results evaluated at > 250 µm.	Non-lethal survey of lower Minto Creek targeting young-of-year chinook salmon.	not required
2 (2011)	Erosional habitat of upper Minto Creek compared to erosional habitat of upper McGinty Creek and erosional habitat of upper Wolverine Creek. Hess sampling using 250 µm mesh. Results evaluated at > 250 µm and at > 500 µm.	Non-lethal survey of lower Minto Creek targeting young-of-year chinook salmon. Laboratory (fish hatchery) exposure of young-of-year chinook salmon to a mixture of Minto effluent and Minto Creek water (approximately 12% effluent) compared to reference fish (reared in hatchery water)	not required
3 (2014)	Erosional habitat of upper Minto Creek compared to erosional habitat of twelve reference creeks using the Reference Condition Approach (RCA). Hess sampling using 500 µm mesh. Results evaluated at > 500 µm.	not required	not required

Table 3.2: Minto Mine effluent sublethal toxicity test results collected at W3 (as % effluent), 2007-2015.

EEM Phase	Date	Rainbow trout embryo	*Ceriodaphnia dubia*		*Pseudokirchneriella subcapitata*	*Lemna minor*	
		EC25 Survival	LC50 Survival	IC25 Reproduction	IC25 Growth[a]	IC25 Dry Weight[1]	IC25 Frond Increase[1]
1	5 & 7-Jun-07	> 100%[2]	> 100%	> 100%	> 90.0%	> 97%	> 97%
	29-Oct-07	> 100%	> 100%	> 100%	> 90.0%	> 97%	> 97%
	3-June-08	88%	> 100%	> 100%	> 90.9%	> 97%	> 97%
	28-Oct-08	> 100%	> 100%	0.33%	> 90.9%	> 97%	> 97%
Geometric Mean		**97%**	**> 100%**	**24%**	**> 90.9%**	**> 97%**	**> 97%**
2	26-May-09	> 100%	> 100%	> 100%	> 90.9%	> 97%	> 97%
	15-Sep-09	-	> 100%	> 100%	-	-	-
	16-Nov-09	> 100%	> 100%	> 100%	> 90.9%	> 97%	> 97%
	11-May-10	> 100%	> 100%	> 100%	> 90.9%	> 97%	> 97%
	22-Nov-11	> 100%	> 100%	> 100%	> 90.9%	> 97%	> 97%
Geometric Mean		**> 100%**	**> 100%**	**> 100%**	**> 90.9%**	**> 97%**	**> 97%**
3	16-Oct-12	> 100%	> 100%	> 100%	> 90.9%	> 97%	> 97%
	5-Nov-13	> 100%	> 100%	38.6%	> 90.9%	> 97%	> 97%
	27-Oct-14	> 100%	> 100%	>100%	> 90.9%	> 97%	> 97%
Geometric Mean		**> 100%**	**> 100%**	**73%**	**> 90.9%**	**> 97%**	**> 97%**
4	13-Oct-15[a]	> 100%[3]	>100%	>100%	>90.9%	>97%	>97%

[1] Highest concentration tested

[2] 2007 June Test invalid due to non-viable eggs - the quality control criteria for viability in controls were not met

[3] Minto also completed a rainbow trout embryo-alevin test which returned the same result

[a] All tests except rainbow trout tests, which were initiated with a sample collected October 5 th 2015

Table 3.3: Summary of comparisons of benthic invertebrate community EEM metrics in upper Minto Creek to reference, Minto Mine Phase 1 (2008), Phase 2 (2011), and Phase 3 (2014).

Metric	**Significantly Different? (effect size expressed as number of reference area standard deviations)**[1]					
	250 µm mesh			500 µm mesh		
	Phase 1 (2008)	Phase 2 (2011)		Phase 2 (2011)		Phase 3 (2014)
	Minto versus McGinty Reference	Minto versus McGinty Reference	Minto versus Wolverine Reference	Minto versus McGinty Reference	Minto versus Wolverine Reference	Minto versus Reference Condition
Density	Yes (+13.9)	Yes (+46.1)	Yes (+22.6)	No	No	No at ⅔ stations[2,3]
Number of Taxa	No	No	Yes (+3.2)	Yes (+3.8)	Yes (+2.3)	No
Simpson's Evenness	No	Yes (-2.4)	Yes (-3.5)	Yes (-2.8)	Yes (-1.5)	No
Bray-Curtis Distance	Yes (+12.7)	Yes (+11.5)	Yes (+6.0)	Yes (+10.5)	Yes (+6.4)	No at ⅔ stations[2,4]

[1] Where a statistically significant difference was found, the value represents the number of standard deviations and direction of change (positive or negative) by which the exposure area differed from the reference areas.

[2] In the Phase 3 EEM, stations UMC-1 and UMC-2 were within reference condition for all EEM primary metrics

[3] One of three stations (station UMC-3) was out of reference condition for density (higher than reference condition)

[4] One of three stations (station UMC-3) was "possibly" out of reference condition for Bray-Curtis index (per Kilgour et al. 1988)

that upper Minto Creek had lower proportions of EPT taxa (mayflies, stoneflies and caddisflies) and higher proportions of chironomids (non-biting midge larvae) compared to reference. These differences may be the cause of differences in the Bray-Curtis Index, and correlation analysis of the Phase 1 and 2 data indicated that they could have been attrubutable to a slight mine-related influence on nutrient concentrations in Minto Creek.

The occurrence of a difference in Bray-Curtis Index in the Phase 1 and the Phase 2 EEM studies triggered an IOC in Phase 3. The Phase 3 (IOC) benthic invertebrate community survey was implemented using the Reference Condition Approach (RCA). The RCA evaluation indicated that two of three upper Minto Creek replicates (UMC-1 and UMC-2) did not differ from the reference condition on the basis of any of the four primary EEM-effect metrics (Table 3.3). One replicate (UMC-3) was within reference condition for taxon richness and Simpson's evenness, had organism abundance significantly greater than the reference condition, and had a Bray-Curtis index that could not be conclusively categorized as within the reference condition nor significantly different from the reference condition (Table 3.1). Overall, the RCA evaluation suggested that effluent exposure had minimal influence on benthic invertebrate communities of upper Minto Creek. The evaluation also suggested that previous control-impact (CI) studies may have been confounded by comparison to too few reference areas that were naturally different from Minto Creek. Nonethless, some supporting benthic invertebrate community metrics continued to suggest subtle differences in community structure of upper Minto Creek relative to reference (including lower percent mayflies and stoneflies, higher percent caddisflies, and higher percent chironomidae) that were similar to those previously observed. Correlation analysis of the Phase 3 data did not identify any clear mine-related influences on the benthic invertebrate community.

3.3 Fish Population Surveys

The Phase 1 EEM fish survey indicated that Minto Creek was not used by fish in June 2008 and was only used by very small numbers of juvenile Chinook salmon in September 2008. The Phase 2 EEM fish survey confirmed the limited use of lower Minto Creek by fish in 2011, with capture of low numbers of juvenile Chinook salmon and extremely low numbers of longnose sucker and slimy sculpin. Hatchery-based exposures in Phase 2 indicated that exposure to mine effluent may result in a very slight increase in fish size and body condition, but that a minimum of five to six weeks of constant exposure would be required to elicit this response. A fish population survey was not required in Phase 3.

4.0 PHASE 4 EEM STUDY DESIGN

The Minto Mine Phase 4 EEM is a “periodic monitoring” study (Environment Canada 2012), and includes a benthic invertebrate community survey, a laboratory-based fish exposure program using juvenile Chinook salmon, and a field-based characterization of the use of Minto Creek by fish (Table 4.1). Other EEM components implemented by the Minto Mine are also presented as part of this study design (sublethal toxicity testing, effluent characterization and water quality monitoring). A fish usability assessment is not required at the Minto Mine because mercury concentrations in final effluent do not exceed 0.10 ug/L (per Environment Canada 2012). The benthic invertebrate community survey will be conducted in erosional habitat of upper Minto Creek (the immediate receiver of Minto Mine effluent), and will be evaluated using a Reference Condition Approach (RCA) consistent with the approach applied in the Minto Mine Phase 3 EEM Investigation of Cause (IOC) study. Requirements for a fish population survey will be addressed in an on-site laboratory study similar to that implemented for the Minto Mine Phase 2 EEM and in a non-lethal fish population survey in lower Minto Creek, which is the area closest to the mine previously shown to support fish. The benthic survey and will be conducted in the late summer (late August or early September) of 2016. The laboratory-based fish exposures will be implemented in the summer (late July to early September) of 2016. The field-based fish occupancy characterization will be implemented at monthly intervals in July, August and September 2016 in order to identify periods of maximum use and to potentially provide sufficient sample size for a non-lethal fish survey. Additional detail on all components of the Minto Mine Phase 4 EEM is provided in the following sections.

4.1 Benthic Invertebrate Community Survey

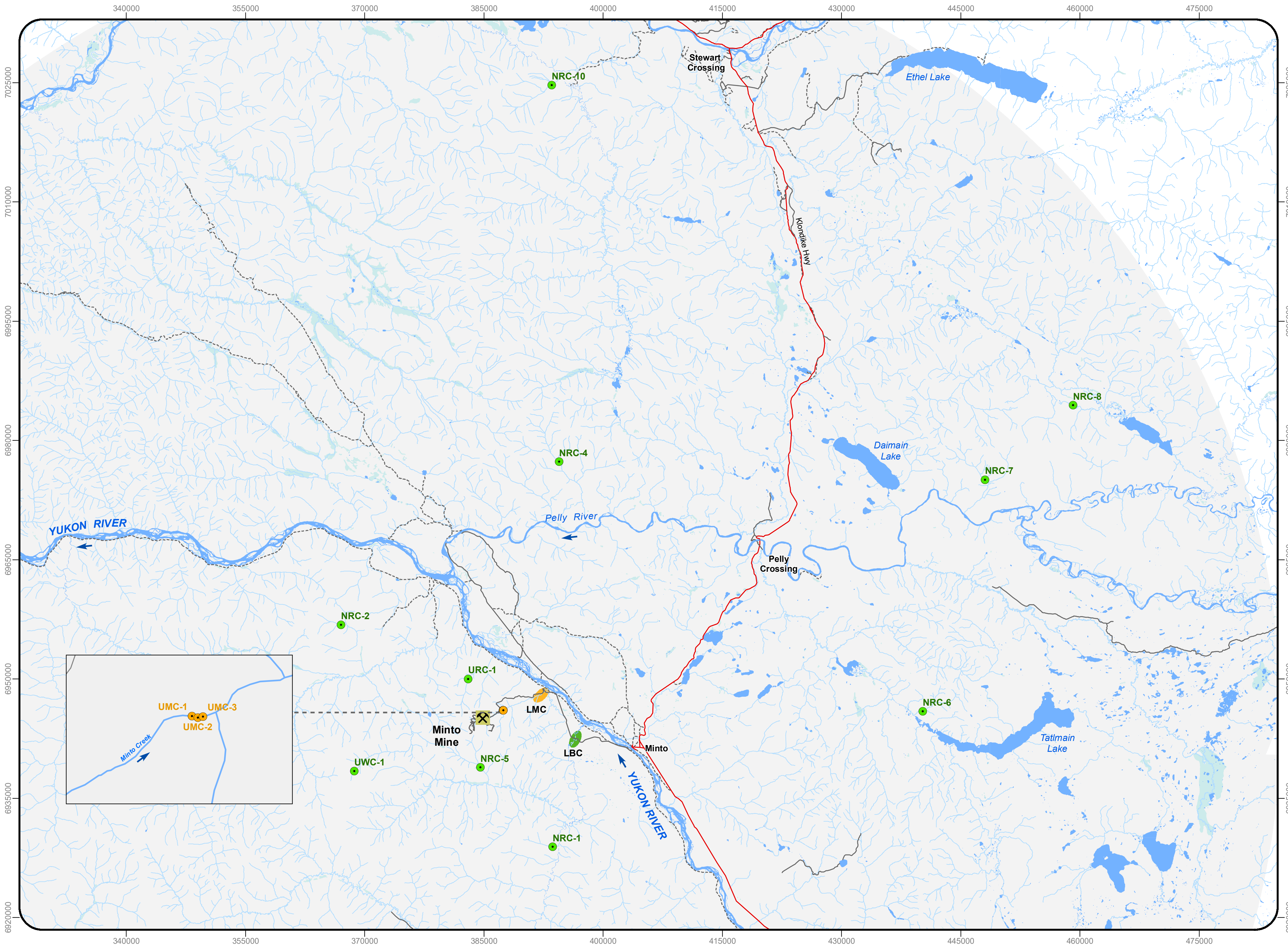
Minto Creek is comprised predominantly of erosional benthic habitat with sand, gravel, and to a lesser extent, cobble substrate. Consequently, the Minto Mine Phase 4 EEM benthic invertebrate community survey will focus on erosional habitat of the upper Minto Creek effluent-exposed area (as in previous EEM studies). The IOC will involve application of a RCA study design (e.g., Bailey et al. 2004; Reynoldson et al. 2005; Bailey et al. 2007) with Hess sampling of erosional habitat (cobble substrate) as applied in the Phase 3 EEM (Minnow 2014a and 2015a). A total of ten reference stations (hereafter referred to as sites to be consistent with RCA terminology) will be used in the benthic survey (Table 4.1; Figure 4.1). These ten reference sites were selected from the twelve reference sites used in the IOC based on similarity to upper Minto Creek in terms of benthic invertebrate community structure and key habitat variables. Specifically, the two IOC reference sites with a combination of biological characteristics and key habitat variables least similar to those of

Table 4.1: Overview of the Minto Mine Phase 4 EEM study design for biological monitoring

Area	Benthic Invertebrate Survey		Fish Survey		Supporting Water Quality	
	Overview	Supporting Data	Overview	Supporting Data	Field-Based Measures[1]	Analytical Samples[2]
Effluent-Exposed Areas						
Minto Creek - Upper	Reference Condition Approach conducted in late August or early September 2016, Erosional habitat, 3 replicate stations. One sample per station with each a 3-grab composite using a Hess Sampler, 500 µm mesh	Substrate characterization, water velocity, sample depth, field-based water quality, habitat notes, and GPS coordinates at each station			Collected at all benthic invertebrate stations	One water sample at each station collected during benthic invertebrate survey. Parameter suite includes all MMER compliance monitoring analytes, chlorophyll a, and additional nutrients
Minto Creek - Lower			Non-lethal survey commencing in July 2016 and repeated monthly through September. Targeting the collection of 100 juvenile Chinook salmon, which will be measured (length and fresh body weight). Any external abnormalities will noted on all fish captured.	Fishing effort, station description, wet and bankfull width, mean depth, field-based water quality, habitat description and GPS coordinates	Collected at all fish survey areas	One water sample collected during each fishing effort. Parameter suite includes all MMER compliance monitoring analytes
Exposure Vessels in Laboratory			Exposure of 150 juvenile Chinook salmon to each of two effluent concentrations (1 part effluent and 3 parts reference water, and 1 part effluent and 6 parts reference water) for six weeks from late July to early September. Length, weight, growth rate, survival and physical condition will be monitored. Results will be compared to the control fish.	Water flow, dissolved oxygen and temperature monitored daily		One sample collected once per week for six weeks during exposure test; Parameter suite includes all MMER compliance monitoring analytes
Reference Areas						
10 RCA Reference Creeks	Reference Condition Approach conducted in late August or early September 2016, Erosional habitat, 3 replicate stations. One sample per station with each a 3-grab composite using a Hess Sampler, 500 µm mesh	Substrate characterization, water velocity, sample depth, field-based water quality, habitat notes, and GPS coordinates at each station			Collected at all benthic invertebrate stations	One water sample at each site collected during benthic invertebrate survey. Parameter suite includes all MMER compliance monitoring analytes, chlorophyll a, and additional nutrients
Lower Big Creek			Non-lethal survey commencing in July 2016 and repeated monthly through September. Targeting the collection of 100 juvenile Chinook salmon, which will be measured (length and fresh body weight). Any external abnormalities will noted on all fish captured.	Fishing effort, station description, wet and bankfull width, mean depth, field-based water quality, habitat description and GPS coordinates	Collected at all fish survey areas	One water sample collected during each fishing effort. Parameter suite includes all MMER compliance monitoring analytes
Control Vessels in Laboratory			Exposure of 150 juvenile Chinook salmon to reference water for six weeks from late July to early September. Length, weight, growth rate, survival and physical condition will be monitored.	Water flow, dissolved oxygen and temperature monitored daily		One sample collected once per week for six weeks during testing. Parameter suite includes all MMER compliance monitoring analytes

[1] Field-based water quality parameter suite includes water temperature, dissolved oxygen, pH and conductivity

[2] Analytical water quality parameter suite includes hardness, alkalinity, pH, total suspended solids, total dissolved solids, ammonia, nitrate, total Kjeldahl nitrogen, total phosphorus, total organic carbon, and ICP total metal scan (including aluminum, arsenic, cadmium, copper, iron, lead, molybdenum, selenium, nickel, and zinc)



Features

- Minto Mine Site
- Benthic Invertebrate Survey Exposure
- Benthic Invertebrate Community Reference Site
- Fish Survey Exposure Area
- Fish Survey Reference Area
- Search Area (100 kilometers)
- Waterbody
- Wetland
- Watercourse
- Road
- Limited-use road
- Trail
- Water Flow Direction

N
W E
S

0 5 10 20
Kilometers

MAP INFORMATION:
Datum: NAD 83 Map Projection: UTM Zone 7N & Zone 8N
Data Source: National Topographic Data Base (NTDB) compiled by Department of Natural Resources Canada at a scale of 1:50,000. Reproduced under licence from Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Creation Date: February 2016
Project No. 157202.0087

Figure 4.1: Minto Mine C4 EEM Benthic Invertebrate Community (RCA Design) and Fish Sampling Locations

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upper Minto Creek (NRC-3 and NRC-9; Figure 4.2) were eliminated from the reference list to reduce the number of reference sites from twelve to ten. Initial reference site selection was completed using a combination of Geographic Information System (GIS)-assisted physical analysis (which identified 60 potential RCA reference sites) and on-site examination of the top candidates as ranked by Principal Components Analysis (as described in detail in the Cycle 3 EEM [IOC] Interpretive Report; Minnow 2015a). In order to ensure that the benthic invertebrate community of the exposed creek has been accurately characterized (i.e., to avoid over-reliance on only one sample), the study design will include three samples from upper Minto Creek and one sample from each of 10 reference sites (Table 4.1; Figure 4.1).

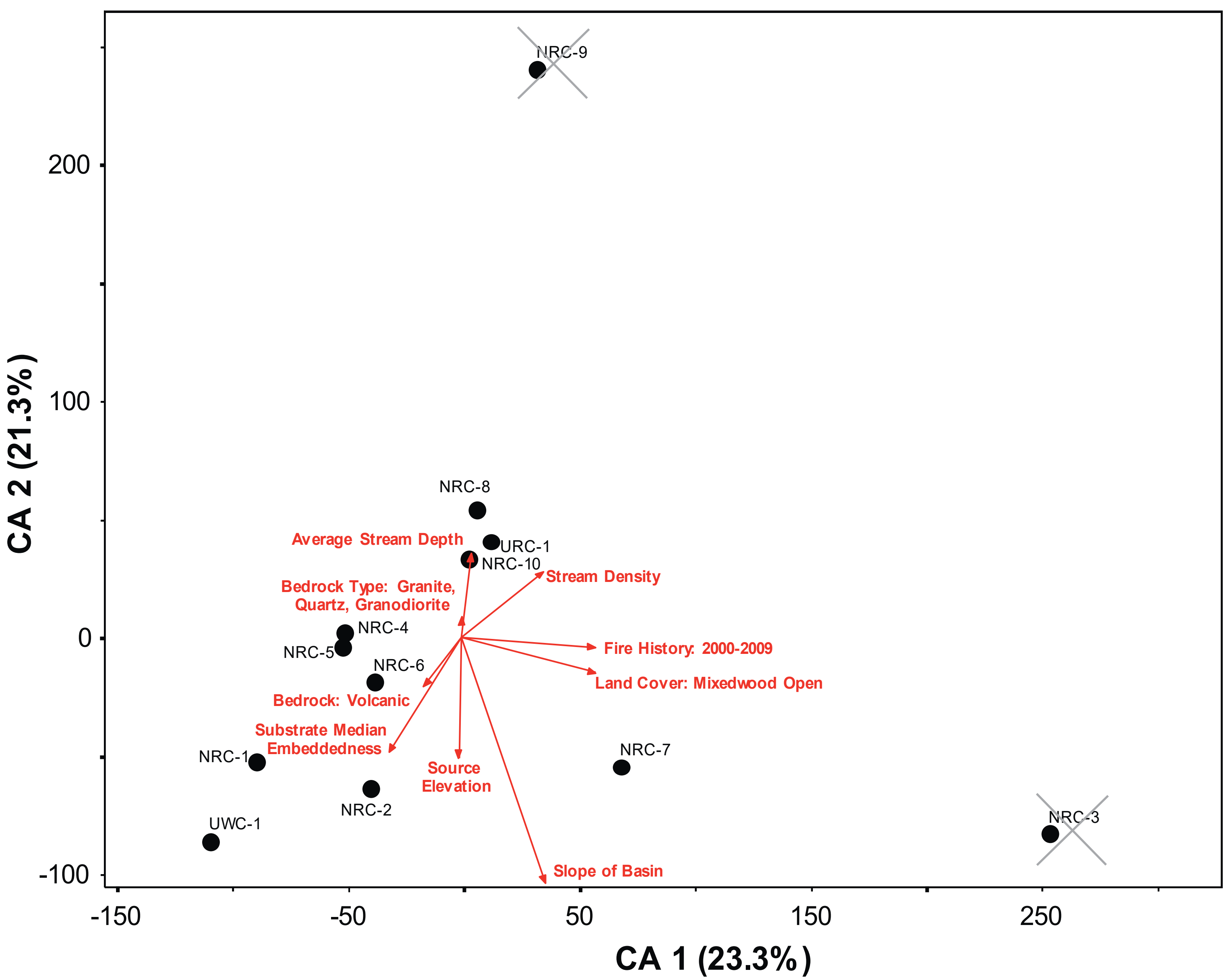
4.1.1 Sample Collection

Benthic invertebrate community samples will be collected at a total of 13 sites (three within the near-field effluent-exposed area of upper Minto Creek and one at each of the reference sites). At each site, actual sampling locations will be carefully selected to standardize habitat features as much as possible in order to to minimize natural influences on data variability. Benthic invertebrate community samples will be collected using a Hess sampler (0.1 m^2) outfitted with 500 µm mesh. Hess samples will be collected using methods consistent with those of the previous EEM (Minnow 2015a). Riffle habitat with cobble and gravel substrate will be targeted for RCA sampling. At each site, three grabs will be collected to a form a composite sample (0.3 m^2 of bottom area in total). Benthic invertebrate samples will be transferred to one-liter wide-mouth jars labelled with the project code, site identification and date of sampling, then preserved to a level of 10% buffered formalin in ambient water. Benthic invertebrate community sample jars will also include internal sample labels to ensure correct sample identification at the lab.

4.1.2 Supporting Data Collection

A number of environmental measures and/or observations will be collected to support the benthic invertebrate community survey. The location of every sampling site will be recorded using a Geographic Positioning System (GPS) with coordinates recorded in latitudes and longitudes (degrees, minutes and seconds to one-tenth of a second using the North American Datum of 1983). At each benthic invertebrate sampling site, substrate characteristics (e.g., size, relative composition, embeddedness etc.), water velocity and sampling depth will be recorded together with a measure of the wetted and bankfull width of each stream sampled. Substrate characterization will be in accordance with the Canadian Aquatic Biomonitoring Network (CABIN) protocols for dominant substrate, embeddedness and substrate dimensions (CABIN 2012). In addition, water quality will be characterized at each site by taking field meter measures and collecting water samples. Field-based water

Correspondence Analysis of benthic invertebrate community structure with superimposed habitat vectors



Principal Components Analysis of habitat variables

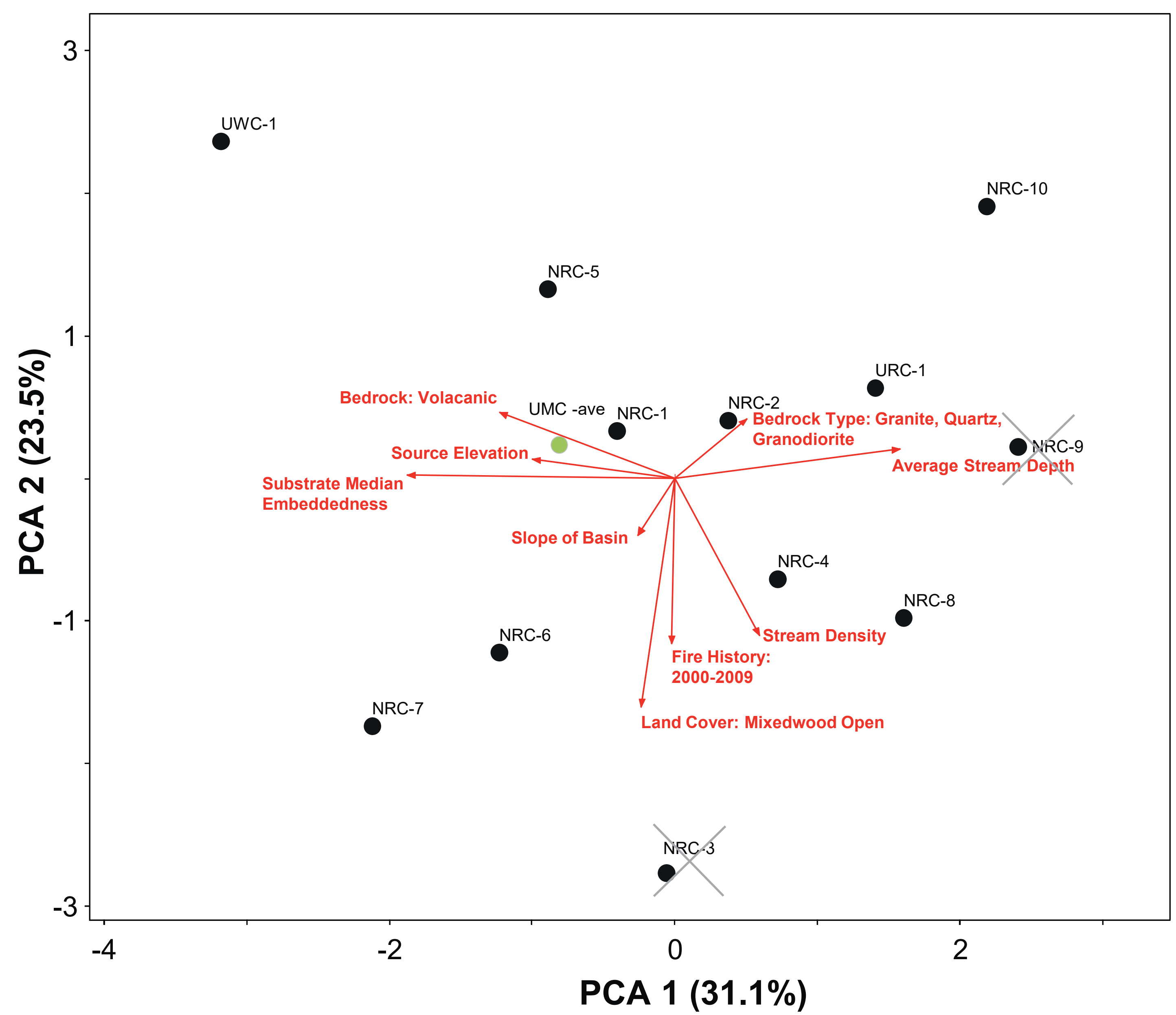


Figure 4.2 minnow

Multivariate Statistical Analyses Supporting Reference Site Selection.

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Date: January 2016

quality, including water temperature, dissolved oxygen, pH and specific conductance, will be measured near the substrate-water interface at each benthic invertebrate sampling site and a water sample will be collected. Water samples will be collected into bottles provided by the analytical laboratory with care taken to ensure that the collection bottle faces upstream to avoid any potential influence of the individual taking the sample. Any required sample preservatives will be added immediately following collection. All samples, including field blanks and field duplicates (collected at a frequency of 10% for quality control/quality assurance), will be placed into a cooler, transported to the mine, and stored in a refrigerator. General habitat notes, including extent of canopy coverage, surrounding land use, general stream morphology etc., will also be recorded at each study area. All supporting environmental variables recommended for sampling under CABIN (CABIN 2012; Table 4.2) will be recorded.

4.1.3 Sample Processing

Benthic invertebrate community samples will be submitted to a qualified laboratory for processing using standard sorting methods. Briefly, sample material greater than 500 µm in diameter will be examined under a stereomicroscope at a magnification of at least ten times. All benthic organisms will be removed from the sample debris and placed into vials containing 70% ethanol. A senior taxonomist will later enumerate and identify the benthic organisms to the family level using up-to-date taxonomic keys. During taxonomic identification, representative specimens of each taxon will be checked against the voucher collection initially created during the Phase 1 EEM, with any new taxa preserved in a 75% ethanol / 3% glycerol solution, placed in separately labelled vials, and added to the existing voucher collection for future reference. Benthic invertebrate community sample processing QA/QC measures will be conducted on a minimum of 10% of samples. These measures will be used to verify that sub-sampling accuracy and precision is within 20% and that greater than 90% of the total organisms were recovered from the benthic invertebrate community samples (Environment Canada 2012).

Water samples will be shipped to an accredited laboratory for analysis of EEM-related parameters including hardness, alkalinity, aluminum, arsenic, cadmium, copper, iron, lead, molybdenum, nickel, selenium, zinc, total suspended solids, ammonia and nitrate (Environment Canada 2012, Government of Canada 2015). Dissolved metals, dissolved organic carbon, total Kjeldahl nitrogen, and total phosphorus concentrations will also be determined.

Table 4.2: CABIN supporting environmental variables, Minto Mine Cycle 4 EEM study.

Category	Sub category	Variable	Units
GIS derived morphology from digital elevation model, digitized flow maps and satellite imagery	GIS derived morphology (catchment and stream)	Basin perimeter	km
		Basin area	km^2
		Total stream length	m
		Total flow segment length	m
		Drainage density of streams	km/km^2
		Drainage density of flow segment	km/km^2
		Station elevation	m
		Source elevation	m
		Distance to source	m
		Average stream gradient	Ratio (m/m)
		Stream order	Strahler
GIS derived from satellite image	GIS derived landcover	Coniferous	Percentage
		Tundra	Percentage
		Barren	Percentage
		Total road length in catchment	km
		Total road density of catchment	km/km^2
GIS derived bedrock classifications from digitized geologic maps	General bedrock type	Sedimentary	Percentage
		Sedimentary/Volcanic	Percentage
		Volcanic	Percentage
		Plutonic	Percentage
	Particular bedrock type	shale/siltstone/sandstone/limestone	Percentage
		mudstone/siltstone/shale/sandstone/conglobe/flows/tuffs/plugs	Percentage
		siltstone/sandstone/conglo	Percentage
		phyllite/shale/sandstone/grit/conglomerate/limestone	Percentage
		shale/quartzite	Percentage
		limestone	Percentage
		diorite/gabbro/sills/greenstone	Percentage
		flows/tuffs/plugs/chert	Percentage
		quartz monzonite/granodiorite/quartz diorite/syenite	Percentage
	Regional unit land	See Yukon Government Website at bottom of table	Percentage
Field sheet measures	Stream Features	Maximum depth of Hess sample locations	cm
		Mean depth of Hess sample locations	cm
		Wetted width of stream at Hess sample location	m
		Estimated bankfull width at Hess sample location	m
		Mean water velocity of Hess sample locations	m/s
		Cobble size using Wolman D method	cm
		Cobble embeddedness class (0,1/4,1/2,3/4,1)	Category
	Substrate Composition	Cobble - Visual estimation of sample area	Percentage
		Gravel - Visual estimation of sample area	Percentage
		Boulder - Visual estimation of sample area	Percentage
		Pebble - Visual estimation of sample area	Percentage
		Sand and finer - Visual estimation of sample area	Percentage
	Canopy and Riparian Features	Bank condition class (1,2,3)	Category
		Periphyton class (0,1/4,1/2,3/4,1)	Category
		Macrophyte class (0,1/4,1/2,3/4,1)	Category
		Canopy class (0,1/4,1/2,3/4,1)	Category
	Stream Morphology	Pool habitat - Visual estimation of sample area	Percentage
		Riffle habitat - Visual estimation of sample area	Percentage
		Run habitat - Visual estimation of sample area	Percentage
		Rapids habitat - Visual estimation of sample area	Percentage

4.1.4 Data Analysis

Data analysis will include an evaluation of the reference sites followed by application of the RCA to determine the condition of the upper Minto Creek benthic invertebrate community relative to reference condition. The appropriateness of the reference sites to define the reference condition will be evaluated using principal components analysis (PCA). PCA will be conducted using non mine-influenced habitat variables to ensure that the range of 'natural' environmental conditions found at the mine-exposed sites is encompassed by the reference sites. Sites identified as outliers will be carefully considered to determine whether they should be used to define the reference condition. Any sites removed will be documented with the supporting rationale provided in the interpretive report. However, previous characterization of the references sites suggests that this would be unlikely.

Benthic invertebrate communities will be evaluated using EEM primary metrics of mean invertebrate density (organisms per m^2), mean taxonomic richness, Simpson's Evenness Index (calculated as in Smith and Wilson 1996; Environment Canada 2012) and the Bray-Curtis Index of Dissimilarity (calculated as in Bray and Curtis 1957). These primary indices will be calculated at the family level in accordance with EEM requirements. The relative proportions of the most abundant taxa will also be computed (calculated as the abundance of each respective dominant/indicator taxon relative to the total number of organisms in the sample). Dominant/indicator taxon groups will be defined as those groups representing greater than 5% of total organism abundance or any groups considered to be important indicators of environmental stress. All required and selected endpoints will be summarized by reporting mean, median, minimum, maximum, standard deviation, standard error and sample size for each sampling site.

Correspondence analysis (CA) will then be used to assess benthic invertebrate community structure associated with mine-exposed and reference sites. CA is a multivariate technique, which is used to create synthetic species prevalence axes extracted in a sequential manner. Each score (number) on a CA axis is the sum of a weighted vector of species proportion. Species with correlated proportions vary together and will have similar weights and scores on a CA axis. When depicted in two-dimensional plots, taxa that tend to co-occur plot together, while those that rarely co-occur plot farther apart. Similarly, sites sharing many taxa plot closest to one another, while those with little in common plot furthest apart. The greatest variation among either taxa or sites is explained by the first axis, with other axes accounting for progressively less variation. This type of multivariate analysis describes not only which sites have distinct benthic communities but also how these benthic communities differ among sites (i.e., which particular taxa differ). Prior to CA, the data will be screened for rare taxa, as these can distort results. Taxa occurring at 5% or fewer of the sites will be removed. After screening and data reduction, a proportional data matrix will be used to conduct a CA using the program PC-ORD© version 6 (McCune and Mefford 2011). Scores for both taxa and sites will be calculated to evaluate the associations of organisms and sites.

Under the RCA design, the benthic invertebrate community data for the regional reference streams will be examined to identify any outlier communities. Outlier communities will be considered to determine if they should be included in the description of reference for the current study. The RCA experimental design evaluates individual mine-exposed sites against a reference condition, which is comprised of multiple reference sites. Therefore, a traditional ANOVA evaluation cannot properly evaluate an RCA design. When testing for statistical differences between multiple reference sites and a single exposed site, two non-central tests will be employed: a one-sample, non-central, equivalence test; and a one-sample, non-central, interval test (Kilgour et al. 1998). Determination that a test site is different from the reference condition (i.e. outside the range of reference values) is assessed using a critical effect size of 1.96 reference standard deviations and tested using two null hypotheses: Ho1 – the absolute value of the reference mean minus the test site value is ≥ 1.96 reference standard deviations (equivalence test), and Ho2 – the absolute value of the reference mean minus the test site value is ≤ 1.96 reference standard deviations (interval test). This testing results in three possible outcomes: a ncP < 0.1 (interval test) that indicates a community endpoint is outside of the reference condition; a ncP > 0.9 (equivalence test) that indicates a community endpoint is within the reference condition; and a ncP-value between 0.1 and 0.9 that is inconclusive with respect to potential difference from the reference condition (Kilgour et al. 1998). Any exposed sites found to be statistically outside the range of reference conditions (ncP < 0.1) will be further evaluated through inspection of the raw data and taxonomic proportions.

The ecological and habitat requirements of the dominant taxa will be assessed using standard references (Clarke 1981, Edmunds et al. 1976, Merritt and Cummins 1984, Weiderholm 1983, Wiggins 1996) in order to consider the statistical results of benthic invertebrate community survey in the context of their ecological and habitat requirements.

Supporting water quality data will be compared to applicable Canadian Water Quality Guidelines for the protection of aquatic life (CCME 2016), and results from the effluent-exposed sites will be compared to reference. All field-based measures and analytical water quality data will also be used in Correlation Analysis with the benthic invertebrate community results to identify relationships between habitat/water quality and benthic invertebrate community condition.

4.2 Fish Survey - Laboratory Exposures

As indicated in Section 2.7, a number of fish studies have been undertaken in Minto Creek (baseline in 1994 and annually since 2006). Over that time, only one species, juvenile Chinook salmon, has occurred at sufficient abundance to potentially support a conventional EEM fish survey and this only occurred in 2009 and 2010 when emergency discharge resulted in significantly enhanced flow in Minto Creek. Furthermore, exposure duration is limited, with 90% of juvenile Chinook salmon spending less than two weeks in Minto Creek during their out-migration along the Yukon River (Access 2010). Thus, fish usage and duration is not sufficiently predictable to ensure that a field-based EEM fish survey will be successful in any given year. Therefore, as in the Phase 2 EEM, the Phase 4 EEM will include a controlled (field laboratory) fish exposure. Juvenile Chinook salmon will be exposed to mixtures of Minto Mine effluent and reference water in a field laboratory setting for six weeks from late July 2016 to early September 2016 (Table 4.1) to mimic the exposure conditions (timing and duration) that would be experienced in Minto Creek. A conventional fish survey will also be attempted (see Section 4.3), but it is anticipated that the conventional survey will primarily serve to characterize fish use of lower Minto Creek in 2016 to support interpretation of the results of the field laboratory exposures described here.

4.2.1 Fish Source and Exposure System

The field laboratory exposure study will be implemented using juvenile Chinook salmon obtained from the Whitehorse Rapids Fish Hatchery (WRFH). However, it is noted that juvenile Chinook salmon from the WRFH are highly valued and there may be some opposition to obtaining these fish for the project. As a result, it is proposed that juvenile kokanee salmon obtained from the WRFH will serve as backup. The kokanee are a Yukon origin salmonid that can act as a good surrogate for the Chinook salmon. Regardless of the fish species ultimately used, they will be of an age (young-of-year fry) and size (approximately 1.0 to 3.0 grams) that effectively represents the juvenile Chinook salmon that utilize lower Minto Creek.

Approximately 450 salmon fry will be obtained for the field-laboratory exposures. These fish will be divided into three groups of 150 fish: 1) a group to be exposed to a mixture of one part Minto Mine effluent (WSP water) to 3 parts reference water (from a Minto Creek reference station or from Big Creek); 2) a group to be exposed to a mixture of one part Minto effluent to 6 parts reference water; and 3) a group to be exposed to reference water. This will result in testing of 25% Minto Mine effluent and 12.5% Minto Mine effluent relative to reference. The former represents the maximum allowable discharge of mine water (from the water storage pond or water treatment plant) to Minto Creek under the Yukon Water Use Licence.

Exposures will be set up at the Minto Mine site using circular fish rearing tanks with a size appropriate for the number of fish being held (200 liters or larger). Flow-through water will be delivered to the aerated tanks from aerated header tanks at a rate sufficient to maintain dissolved oxygen (DO) concentration at 8 mg/L or higher in the tank discharge water. It is anticipated that a flow rate of approximately 1.0 L per kg of fish per minute will be required to sustain DO at the desired level. Based on a maximum starting weight of 3.0 grams and 150 fish per tank, an initial flow rate of 0.5 liters per minute (Lpm) will be required per tank. This flow rate will increase over the course of the study possibly doubling to 1.0 Lpm. In addition to oxygen levels, it is important to maintain consistent temperatures in the exposure and reference tanks. In order to achieve this, feed water will pass in parallel through a tube and pipe type heat exchanger. Either Minto well water or water from the bottom of the WSP will be used as cooling water. It is anticipated that the resulting temperature of water delivered through the heat exchanger to the tanks will be between 8 and 10 ˚C. Flow rate of the cooling water can be adjusted in order to achieve the target temperature and to keep the rearing environments as consistent as possible. If a higher flow-rate through the exchanger is required in order to achieve the appropriate temperature, excess water will be spilled off before entering the tank ensuring that each rearing system receives a similar flow of water.

The salmon fry will be fed a commercial salmon diet at 100% feeding rate recommended by the manufacturer in the salmon feeding tables provided with the diets. Appropriate pellet size will be selected and no feed beyond its expiration date will be used. If mortality occurs in the tanks, feeding rates will be adjusted so as not to differentially influence growth rates between treatments. Quality Control/Quality Assurance (QA/QC) to ensure valid testing will include minimum survival of reference fish (>90%), as well as consistency of temperature, flow rate, pH and DO among treatments and replicates. All groups will be exposed for six weeks (late July to early September). This will allow for an approximate doubling of weight of the reference group. This exposure reflects the brief occupancy of juvenile Chinook salmon in non-natal tributaries (Section 2.7).

4.2.2 Fish Growth and Condition Measures

Physiological measurements recommended for non-lethal fish surveys (Environment Canada 2012) will be collected from each fish upon study initiation (Day 0), at Day 21, and at the end of the exposure period (Day 42). Specifically, body length (both total and fork), fresh body weight and the external condition of each fish will be measured prior to exposure. Fish will be sedated using a dilute solution of clove oil in ethanol or MS222 (a certified fish anaesthetic). Fish processing will be conducted in the following sequence. Fish length (both total and fork length) will be measured to the nearest hundredth of a millimetre using digital calipers. Fresh body weight will be measured using an analytical balance with an accuracy of 0.001 g. While taking these measurements, all fish will be carefully observed for external abnormalities, which will be recorded on data sheets. Following these measurements, all live fish will be placed in recovery buckets containing aerated water for subsequent re-introduction to their exposure or reference tanks. Exposure systems will be monitored daily for mortalities. All mortalities will be removed and measured as described above. At experiment termination, fish will either be released or destroyed (depending upon species used and as required under permit).

4.2.3 Supporting Data Collection

Water in the rearing tanks will be measured continuously for temperature. Water flow and DO will be monitored several times per day. Flows will be adjusted daily if required to adjust temperature and/or DO levels. Water from the Minto WSP and from reference (from a Minto Creek reference station or from Big Creek) will be delivered to the header tanks at a minimum frequency of once per week during the study. As water quality in the system will be subject to change due to environmental influences (e.g., precipitation) water samples from each delivery will be sent to an accredited laboratory for analysis of EEM-related parameters including hardness, alkalinity, aluminum, arsenic, cadmium, copper, iron, lead, molybdenum, nickel, selenium, zinc, total suspended solids, ammonia and nitrate (Environment Canada 2012, Government of Canada 2015). Dissolved metals, dissolved organic carbon, total Kjeldahl nitrogen, and total phosphorus concentrations will also be determined. Samples will be captured post aeration and after passing through the heat-exchanger.

4.2.4 Data Analysis

Raw fish physiological measurement data will be transcribed from field sheets into an electronic spreadsheet and checked by a separate individual for potential entry errors as part of routine QA/QC procedures. Initial data analysis will include plotting size-frequency distributions as described by Bonar (2002) and Gray *et al.* (2002) for each treatment. Consistent with EEM technical guidance (Environment Canada 2012), summary statistics including mean, median, minimum, maximum, standard deviation, standard error and sample size will be calculated by treatment for endpoints related to age, growth, and condition. Length frequency distributions will be compared using a two-sample Kolmogorov-Smirnov (K-S) test. The K-S test is a non-parametric test of potential differences between two distributions (Zar 2010). All length and body weight data will be inspected for normality and homogeneity of variance before applying parametric statistical procedures. Violations of normality and homogeneity of variance will be reduced using $\log_{10}$ transformations, as required. ANOVA with post-hoc testing will be used to evaluate potential differences in treatment means for these metrics. ANCOVA will be used to evaluate potential differences in condition (weight at length) among treatments. All ANOVA and ANCOVA comparisons will be evaluated at an alpha level of 0.10 consistent with the recommendations of Environment Canada (2012) respecting statistical power. Prior to conducting the ANCOVA tests, scatter plots of all variable and covariate combinations will be examined to identify outliers, leverage values or other unusual data. The scatter plots will also be examined to ensure adequate overlap between treatment groups and a linear relationship between the variable and the covariate. In order to verify the existence of a linear relationship, each relationship will be tested using linear regression analysis by treatment and evaluated at an alpha level of 0.05. If no significant linear regression relationship exists between the variable and covariate for the treatments, then ANCOVA will not performed.

If data can be analyzed by ANCOVA, the slopes of the regression lines for the three treatments will be tested to determine if they are equal. A significant interaction in the ANCOVA model for covariate "X" versus treatment (e.g., size*treatment) indicates significantly different slopes. In such cases, the ANCOVA cannot be completed and an effect is determined as a significant difference in slopes between treatments. If the interaction term is not significant (i.e., homogeneous slopes between the treatments), then the ANCOVA model will be run without the interaction term to test for differences in adjusted means between the treatments. The adjusted mean is an estimate of the population mean based on the value of the covariate in the ANCOVA model. If outliers or leverage values are observed in a data set upon examination of scatter plots and residuals, then these values will be removed and ANCOVA tests will be repeated for the reduced data.

Following the ANOVA and ANCOVA testing, the magnitude of the difference between treatments will be calculated for each endpoint where a significant difference is detected. If there is no significant difference detected between treatments, the minimum detectable effect size will be calculated as a percent difference from the reference mean for ANOVA or adjusted reference mean for ANCOVA at alpha and beta equal to 0.10 using the square root of the mean square error (generated during either the ANOVA or ANCOVA procedures) as a measure of variability in the sample population:

$\delta = (t_\alpha + t_\beta)(\sqrt{MSE})(\sqrt{2/n'})$, where

δ = minimum detectable effect size,
MSE = mean square error, and
$n' = (2n_1n_2)/(n_1+n_2)$, where n_1 = reference sample size and n_2 = exposure sample size.

The percent difference will then be calculated using the following equations:

for untransformed data: % difference = ((ref.mean ± δ)/ref.mean – 1) x 100
for $\log_{10}$ transformed data: % difference = $(10^{\pm\delta} - 1) \times 100$

A priori power analyses will also be completed to determine appropriate fish sample sizes for future studies as recommended by Environment Canada (2012). These analyses will be completed based on the mean square error values generated during the ANOVA or ANCOVA procedures at alpha and beta equal to 0.10. Results will be reported as the minimum sample size (number of fish/treatment) required to detect a given magnitude of difference (effect size) between treatment populations for each endpoint. The magnitude of the difference will be presented as a percentage of the reference mean for each endpoint.

In addition to the conventional analysis described above, a Before-After-Control-Impact (BACI) approach will be employed to assess differences in these endpoints among treatment groups. The "Before" denotes measurements taken on Day 0, while the "After" denotes measurements taken on Day 21 and 42. Accordingly, the Control and Impact denote the reference and exposure treatments, respectively. The BACI approach takes into account any possible differences in size of the fish between treatments prior to exposure. BACI analysis will be completed by factorial ANOVA to assess any significant differences (at α=0.10) in fork length, body weight and condition factor. The measurement of endpoints twice during exposure (Day 21 and Day 42) will help determine the duration of exposure necessary to elicit a significant difference (if any), which in turn, will assist in the overall assessment of risks to juvenile Chinook salmon frequenting Minto Creek in their natural setting.

4.3 Fish Survey - Field Studies

The Phase 4 EEM will include fishing of lower Minto Creek and Big Creek (reference) in July, August and September 2016 (Table 4.1; Figure 4.1). Due to limited fish usage of lower Minto Creek as described previously (Sections 2.7 and 4.2), it is anticipated that the fishing will primarily provide information on fish usage of these creeks in 2016, thereby providing additional perspective for interpretation of the field laboratory exposures. However, physiological measurements will be collected on each Chinook salmon captured, and if sufficient numbers are collected to support a non-lethal fish population survey, the analyses, interpretation and reporting recommended for such a survey will be completed, as outlined below.

4.3.1 Fish Collection

Fish collection will be completed in lower Minto Creek between the Minto Mine access road and the fish barrier located approximately 1.2 km upstream. Fish collection in Big Creek will be completed in the vicinity of the Minto Mine access road (both upstream and downstream of the bridge). On each month of sampling, each study area will be sampled semi-quantitatively using minnow traps baited with salmon roe. A minimum of 15 minnow traps will be deployed overnight at each area. All fishing will be conducted under a "Licence to Collect Fish for Scientific, Educational or Public Display Purposes" from Fisheries and Oceans Canada (DFO). The location of each minnow trap will be recorded in degrees latitude and longitude as measured using a handheld GPS unit. Deployment and retrieval times will also be recorded.

All fish captured will be identified and enumerated (by minnow trap). Juvenile Chinook salmon will be retained for measurement (to a maximum of 100 fish) and all other species will be will be released to the waters from which they were captured.

4.3.2 Fish Growth and Condition Measures

Fish length and weight will be measured in the field as described above for the field laboratory exposures (Section 4.2.2). Each fish will be observed during measurement and any abnormality recorded.

4.3.3 Supporting Data Collection

Supporting water quality data will be collected with each fishing effort (monthly) by taking field meter measures and collecting water samples. Field-based water quality, including water temperature, dissolved oxygen, pH and specific conductance, will be measured at each fish sampling area. Water samples will also be collected and sent to an accredited laboratory for analysis of EEM-related parameters including hardness, alkalinity, aluminum, arsenic, cadmium, copper, iron, lead, molybdenum, nickel, selenium, zinc, total suspended solids, ammonia and nitrate (Environment Canada 2012, Government of Canada 2015). Dissolved metals, dissolved organic carbon, total Kjeldahl nitrogen, and total phosphorus concentrations will also be determined.

4.3.4 Data Analysis

Fish capture data will be summarized by reporting total catch and catch-per-unit-effort (CPUE; catch per minnow trap day) for each sampling event and area. Physiological measurement data will treated and analysed as described above for the field laboratory exposures, with the sole exception that no BACI analysis is supported.

4.4 Routine Effluent and Water Quality Monitoring

Effluent and water quality monitoring completed by the Minto Mine consists of effluent characterization, sublethal toxicity testing, and routine MMER receiving environment water quality monitoring. The Minto Mine continues to conduct effluent characterization in accordance with MMER requirements. Effluent characterization samples will continue to be shipped to a Canadian Association for Laboratory Accreditation (CALA) accredited laboratory for analysis.

Sublethal toxicity testing of final effluent will continue to be conducted annually. The suite of sublethal tests conducted (including rainbow trout or fathead minnow [fish], *Ceriodaphnia dubia* [invertebrate], *Lemna minor* [plant] and *Pseudokirchneriella subcapitata* [algae]) will be performed in accordance with Environment Canada Methods (1998; 2007a,b,c; 2011). The results of all sublethal toxicity tests conducted up to the time of the Phase 4 EEM Interpretive Report preparation will be summarized and discussed therein. Any observations of sublethal toxicity will be related to effluent mixing within the creek to comment on whether or not responses observed in the tests would be expected in the receiving environment.

Routine water quality monitoring will continue to be conducted by the Minto Mine four times per year at reference (Station W7) and exposed (Station W2) areas in accordance with MMER requirements. Similar to effluent characterization samples, water quality monitoring samples will continue to be shipped to a CALA accredited laboratory for analysis of EEM-related parameters including pH, hardness, alkalinity, aluminum, arsenic, cadmium, copper, iron, lead, molybdenum, nickel, selenium, zinc, total suspended solids, ammonia and nitrate. All water quality monitoring results collected up to the time of preparation of the Phase 4 EEM Interpretive Report will be summarized and discussed therein.

5.0 SCHEDULE

The Minto Mine's Phase 4 EEM biological survey is scheduled to be conducted between July and September 2016, which is consistent with previous EEM studies and the routine WUL benthic sampling in Minto Creek. At this time, benthic invertebrate communities will be stable and organisms will be well developed.

With submission of benthic samples for analysis shortly after completion of the fieldwork, and water samples submitted upon collection. The Phase 4 Interpretive Report, which provides the results from this program, is due to Environment Canada on or before January 6th, 2018.

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APPENDIX A

SUMMARY OF MMER
EFFLUENT AND WATER QUALITY
2011-2015

Table A.1: Routine effluent quality monitoring 2011-2015 (W3). Shaded values are greater than MMER grab limits.

Sample Date	pH	Arsenic	Copper	Lead	Nickel	Zinc	Total Suspended Solids	Radium-226
	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Bq/L
MACG	6.0-9.5	1.0	0.60	0.40	1.0	1.0	30	1.1
1/1/2011	8.11	0.00040	0.0035	< 0.00020	0.0010	< 0.0050	1.0	
1/10/2011	7.93	< 0.00010	0.0022	< 0.00020	0.0010	< 0.0050	0	< 0.0050
1/17/2011	7.83	0.00030	0.024	< 0.00020	0.0020	0.0050	6.0	0.0060
1/28/2011	8.38	0.00010	0.0029	< 0.00020	0.0010	< 0.0050	< 1.0	< 0.0050
2/3/2011	8.12	0.00010	0.0048	< 0.00020	0.0010	< 0.0050	2.0	
2/9/2011	7.84	0.00020	0.0029	< 0.00020	< 0.0010	< 0.0050	1.0	< 0.0050
2/15/2011	7.85	0.00030	0.0024	< 0.00020	< 0.0010	< 0.0050	2.0	0.020
2/26/2011	7.92	0.00020	0.0021	< 0.00020	< 0.0010	< 0.0050	1.0	< 0.0050
3/3/2011	7.89	0.00020	0.011	< 0.00020	< 0.0010	0.0080	3.0	0.0080
3/8/2011	7.88	0.00030	0.0057	< 0.00020	< 0.0010	< 0.0050	< 2.0	< 0.0050
3/13/2011	7.98	0.00050	0.11	0.00020	0.0020	0.10	18	0.0050
3/27/2011	8.28	0.00030	0.043	< 0.00020	0.0010	0.0050	4.0	< 0.010
4/2/2011	8.13	0.00020	0.0059	< 0.00020	< 0.0010	< 0.0050	2.0	0.010
4/9/2011	7.46	0.00030	0.0098	< 0.00020	< 0.0010	< 0.0050	3.0	< 0.010
4/21/2011	8.22	0.00030	0.0051	< 0.00020	0.0060	< 0.0050	2.0	< 0.010
4/27/2011	7.85	0.00040	0.017	< 0.00020	0.0020	< 0.0050	3.0	0.010
5/5/2011	7.61	0.0040	0.031	0.0028	0.016	0.034	93	
5/14/2011	8.13	0.00040	0.014	< 0.00020	0.0020	< 0.0050	10	
5/24/2011	8.25	0.00030	0.0046	< 0.00020	0.0020	< 0.0050	< 2.0	0
5/29/2011	8.12	0.00030	0.0060	< 0.00020	0.0040	< 0.0050	5.0	
6/2/2011	8.12	0.00030	0.0060	< 0.00020	0.0010	< 0.0050	5.0	
6/4/2011	8.04	0.00030	0.0022	< 0.00020	< 0.0010	< 0.0050	1.0	
6/16/2011	8.21	0.00030	0.0028	< 0.00020	0.0010	0.0060	< 1.0	
6/27/2011	8.20	0.00030	0.0083	0.00020	0.0010	0.0060	3.0	< 0.010
7/1/2011	8.05	0.00040	0.0080	< 0.00020	0.0020	< 0.0050	2.0	
7/12/2011	8.09	0.00020	0.0050	< 0.00020	0.0010	< 0.0050	< 1.0	
7/23/2011	7.98	< 0.00010	0.0042	< 0.00020	0.0010	< 0.0050	< 1.0	< 0.010
7/31/2011	8.24	0.00020	0.0028	< 0.00020	0.0010	< 0.0050	< 1.0	
8/2/2011	8.20	0.00030	0.0096	0.00050	0.027	0.013	3.0	
8/7/2011	7.97	0.00040	0.0096	< 0.00020	0.0040	< 0.0050	< 1.0	
8/16/2011	8.13	0.00040	0.0047	< 0.00020	0.0020	0.013	< 1.0	< 0.010
8/28/2011	8.01	0.00030	0.0029	< 0.00020	0.0010	< 0.0050	< 1.0	
9/1/2011	8.05	0.00030	0.0025	< 0.00020	0.0010	0.0060	< 1.0	
9/7/2011	8.29	0.00020	< 0.0022	< 0.00020	0.0010	< 0.0050	< 1.0	
9/12/2011	8.13	0.00020	0.0024	< 0.00020	0.0010	< 0.0050	< 1.0	< 0.010
9/24/2011	8.17	0.00020	0.0022	< 0.00020	0.0010	< 0.0050	< 4.0	
10/6/2011	8.27	0.00020	0.0026	< 0.00020	0.0010	< 0.0050	< 4.0	< 0.010
10/17/2011	8.00	0.00030	0.0082	< 0.00020	0.0010	< 0.0050	< 4.0	
10/24/2011	8.23	0.00020	0.0028	< 0.00020	< 0.0010	0.010	< 1.0	
10/30/2011	8.21	0.00020	0.0025	< 0.00020	< 0.0010	< 0.0050	< 4.0	
11/13/2011	8.35	0.00030	0.0038	< 0.00020	< 0.0010	0.011	< 1.0	< 0.010
11/22/2011	7.97	0.00020	0.0017	< 0.00020	< 0.0010	< 0.0050	< 1.0	
11/28/2011	8.13	0.00020	0.0024	< 0.00020	0.0010	< 0.0050	< 1.0	
12/5/2011	7.87	0.00020	0.0021	< 0.00020	0.0010	< 0.0050	< 4.0	
12/13/2011	8.12	0.00020	0.0018	< 0.00020	0.0010	< 0.0050	< 1.0	
12/18/2011	8.05	0.00020	0.0024	< 0.00020	0.0020	< 0.0050	< 1.0	
12/27/2011	8.19	0.00020	0.0017	< 0.00020	0.0010	< 0.0050	< 1.0	

Table A.1: Routine effluent quality monitoring 2011-2015 (W3). Shaded values are greater than MMER grab limits.

Sample Date	pH	Arsenic	Copper	Lead	Nickel	Zinc	Total Suspended Solids	Radium-226
	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Bq/L
MACG	6.0-9.5	1.0	0.60	0.40	1.0	1.0	30	1.1
1/2/2012	8.22	0.00020	0.0018	< 0.00020	< 0.0010	< 0.0050	< 4.0	
1/8/2012	8.01	0.00020	0.0018	< 0.00020	0.0010	< 0.0050	< 1.0	
1/22/2012	8.13	0.00030	0.0051	< 0.00020	0.0010	< 0.0050	6.0	
1/31/2012	8.12	0.00020	0.0036	0.00060	0.0010	< 0.0050	< 4.0	
2/7/2012	8.44	0.00020	0.0017	0.00020	< 0.0010	< 0.0050	< 4.0	
2/14/2012	8.34	0.00030	0.0023	< 0.00020	< 0.0010	< 0.0050	< 4.0	
2/20/2012	7.99	0.00020	0.0019	< 0.00020	< 0.0010	< 0.0050	< 4.0	
2/25/2012	8.12	0.00020	0.0065	< 0.00020	< 0.0010	< 0.0050	< 4.0	
3/5/2012	8.32	0.00020	0.0018	< 0.00020	< 0.0010	< 0.0050	3.9	
3/12/2012	8.11	0.0020	0.0019	< 0.00020	< 0.0010	< 0.0050	5.1	
3/19/2012	8.16	0.00030	0.0028	< 0.00020	< 0.0010	< 0.0050	4.2	
3/27/2012	8.26	0.00030	0.0032	< 0.00020	< 0.0010	< 0.0050	2.3	
4/2/2012	8.32	0.00030	0.0027	< 0.00020	< 0.0010	< 0.0050	9.6	
4/9/2012	8.15	0.00060	0.0095	0.00030	0.0010	< 0.0050	13	
4/14/2012	8.24	< 0.00050	0.0066	< 0.00050	0.0015	< 0.0050	17	
4/24/2012	8.23	0.00042	0.026	0.00069	0.0012	< 0.0050	4.7	< 0.010
5/7/2012	8.10	0.00040	0.0080	< 0.00020	0.0012	< 0.0050	6.2	
5/16/2012	8.35	0.00041	0.0086	< 0.00020	0.0016	< 0.0050	4.4	
5/24/2012	8.25	0.00021	0.0053	< 0.00020	0.0012	< 0.0050	< 1.0	
6/2/2012	8.17	0.00024	0.0024	< 0.00020	< 0.0010	< 0.0050	< 1.0	
6/8/2012	8.31	0.00025	0.0031	< 0.00020	0.0011	0.0050	< 1.0	
6/19/2012	8.36	0.00027	0.0037	< 0.00020	0.0012	< 0.0050	< 1.0	< 0.010
6/28/2012	8.19	0.00027	0.0026	< 0.00020	< 0.0010	< 0.0050	< 1.0	
7/5/2012	8.39	0.00029	0.0031	< 0.00020	0.0011	< 0.0050	< 1.0	
7/9/2012	8.47	0.00026	0.0025	< 0.00020	< 0.0010	< 0.0050	< 1.0	
7/18/2012	8.32	0.00026	0.0022	< 0.00020	< 0.0010	< 0.0050	1.8	
7/24/2012	7.96	0.00026	0.0024	0.00020	0.0010	0.0050	1.00	
7/30/2012	8.28	0.00028	0.0021	< 0.00020	< 0.0010	< 0.0050	< 1.0	
8/7/2012	8.33	0.00025	0.0021	< 0.00020	0.0010	< 0.0050	< 1.0	
8/16/2012	8.42	0.00025	0.0019	< 0.00020	< 0.0010	< 0.0050	< 1.0	
8/23/2012	8.25	0.00026	0.0024	< 0.00020	< 0.0010	< 0.0050	< 1.0	< 0.010
8/30/2012	8.33	0.00023	0.0030	< 0.00020	< 0.0010	< 0.0050	< 1.0	
9/3/2012	8.25	0.00027	0.0027	< 0.00020	0.0013	< 0.0050	< 1.0	
9/5/2012	8.30	0.00024	0.0023	< 0.00020	< 0.0010	< 0.0050	< 1.0	
9/9/2012	8.22	0.00032	0.0046	< 0.00020	0.0018	< 0.0050	2.1	
9/19/2012	8.18	0.00024	0.0037	< 0.00020	0.0012	< 0.0050	< 1.0	
9/24/2012	8.33	0.00025	0.0022	< 0.00020	< 0.0010	< 0.0050	< 1.0	
10/3/2012	8.33	0.00023	0.0022	< 0.00020	0.0011	< 0.0050	< 1.0	
10/12/2012	8.03	0.00028	0.0027	< 0.00020	0.0014	< 0.0050	< 1.0	
10/16/2012	8.23	0.00025	0.0023	< 0.00020	0.0012	< 0.0050	< 1.0	< 0.010
10/19/2012	8.09	0.00022	0.0020	< 0.00020	0.0010	< 0.0050	< 1.0	
10/25/2012	8.04	0.00032	0.0031	< 0.00020	0.0014	< 0.0050	3.4	
11/2/2012	7.98	0.00043	0.0020	< 0.00020	0.0013	< 0.0050	< 1.0	
11/9/2012	8.10	0.00024	0.0017	< 0.00001	0.00084	0.00037	< 1.0	
11/18/2012	8.15	0.00028	0.0016	< 0.00020	< 0.0010	< 0.0050	< 1.0	
11/24/2012	8.16	0.00021	0.0023	< 0.00020	0.0012	< 0.0050	< 1.0	
12/4/2012	8.30	0.00025	0.0027	0.00024	0.0012	0.0055	< 1.0	
12/11/2012	8.26	0.00024	0.0021	< 0.00020	0.0011	< 0.0050	< 1.0	
12/18/2012	8.04	0.00028	0.0024	< 0.00020	< 0.0010	< 0.0050	< 1.0	< 0.010
12/27/2012	8.18	0.00023	0.0023	< 0.00020	< 0.0010	< 0.0050	< 1.0	

Table A.1: Routine effluent quality monitoring 2011-2015 (W3). Shaded values are greater than MMER grab limits.

Sample Date	pH	Arsenic	Copper	Lead	Nickel	Zinc	Total Suspended Solids	Radium-226
	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Bq/L
MACG	6.0-9.5	1.0	0.60	0.40	1.0	1.0	30	1.1
1/4/2013	7.92	0.00019	0.0019	< 0.00020	< 0.0010	< 0.0050	< 1.0	
1/9/2013	7.96	0.00012	0.0020	< 0.00020	< 0.0010	< 0.0050	< 4.0	
1/17/2013	7.94	0.00019	0.0022	< 0.00020	< 0.0010	0.0076	< 1.0	
1/22/2013	8.33	0.00026	0.0016	< 0.00020	< 0.0010	< 0.0050	< 1.0	
1/28/2013	8.06	0.00020	0.0019	< 0.00040	< 0.0020	< 0.010	< 1.0	
2/7/2013	8.02	0.00027	0.0023	< 0.00020	< 0.0010	< 0.0050	< 1.0	
2/12/2013	7.92	0.00023	0.0016	< 0.00020	< 0.0010	< 0.0050	< 1.0	
2/19/2013	8.06	0.00022	0.0015	< 0.00020	< 0.0010	< 0.0050	< 1.0	
2/26/2013	8.07	0.00024	0.0019	< 0.00020	< 0.0010	< 0.0050	< 1.0	
3/4/2013	8.28	0.00019	0.0015	0.00020	< 0.0010	< 0.0050	< 1.0	
3/11/2013	8.31	0.00023	0.0018	< 0.00020	< 0.0010	< 0.0050	< 1.0	
3/18/2013	8.20	0.00021	0.0017	< 0.00020	< 0.0010	< 0.0050	< 1.0	
3/31/2013	8.16	0.00029	0.0034	< 0.00020	0.0011	< 0.0050	2.3	
4/6/2013	8.19	0.00029	0.0017	< 0.00020	< 0.0010	< 0.0050	< 1.0	
4/12/2013	8.32	0.00027	0.0031	< 0.00020	< 0.0010	< 0.0050	< 1.0	
4/15/2013	8.24	0.00023	0.0025	< 0.00020	< 0.0010	< 0.0050	< 1.0	
4/30/2013	8.28	0.00035	0.020	< 0.00020	< 0.0010	< 0.0050	5.3	0.020
5/2/2013	8.27	0.00033	0.021	< 0.00020	< 0.0010	< 0.0050	< 4.0	
5/9/2013	8.09	0.00038	0.027	< 0.00020	0.0012	< 0.0050	8.3	
5/14/2013	7.74	0.0011	0.082	0.00087	0.0032	0.010	21	
5/21/2013	7.71	0.00077	0.053	0.00083	0.0022	0.0068	30	
5/28/2013	7.97	0.00050	0.035	0.00022	0.0015	< 0.0050	8.6	
6/6/2013	8.38	0.00034	0.0087	< 0.00020	0.0015	< 0.0050	37	
6/14/2013	8.23	0.00032	0.0062	< 0.00020	0.0017	0.0052	14.5	
6/17/2013	8.30	0.00039	0.0049	< 0.00020	0.0015	< 0.0050	< 1.0	
6/19/2013	8.29	0.00032	0.0043	0.00026	< 0.0010	< 0.0050	1.1	
6/24/2013	8.34	0.00026	0.0028	< 0.00020	< 0.0010	< 0.0050	4.8	
7/1/2013	8.37	0.00032	0.0028	< 0.00020	0.0011	< 0.0050	< 1.0	
7/10/2013	8.21	0.00031	0.0032	< 0.00020	0.0014	< 0.0050	< 1.0	
7/11/2013	8.20	0.00027	0.0030	< 0.00020	0.0010	< 0.0050	< 1.0	
7/19/2013	8.35	0.00037	0.0030	< 0.00020	0.0013	< 0.0050	< 1.0	
7/23/2013	8.28	0.00047	0.0061	< 0.00020	0.0019	< 0.0050	< 1.0	
7/30/2013	8.35	0.00032	0.0031	< 0.00020	0.0012	< 0.0050	< 1.0	
8/8/2013	8.27	0.00032	0.0028	< 0.00020	0.0011	< 0.0050	< 1.0	
8/14/2013	8.31	0.00030	0.0026	< 0.00020	0.0014	< 0.0050	< 1.0	
8/19/2013	8.23	0.00032	0.0024	< 0.00020	0.0011	< 0.0050	< 1.0	
8/21/2013	8.35	0.00031	0.0023	< 0.00020	< 0.0010	< 0.0050	< 1.0	< 0.010
8/26/2013	8.28	0.00025	0.0022	< 0.00020	< 0.0010	< 0.0050	< 1.0	
9/2/2013	8.04	0.00029	0.0025	< 0.00020	0.0011	< 0.0050	< 1.0	
9/12/2013	8.14	0.00028	0.0026	< 0.00020	0.0011	< 0.0050	< 1.0	
9/17/2013	8.13	0.00034	0.0026	< 0.00020	0.0012	< 0.0050	< 1.0	
9/28/2013	8.16	0.00033	0.0036	< 0.00020	0.0016	< 0.0050	< 1.0	
10/3/2013	8.18	0.00028	0.0027	< 0.00020	0.0012	< 0.0050	< 1.0	
10/8/2013	8.25	0.00027	0.0026	< 0.00020	0.0013	< 0.0050	< 1.0	
10/16/2013	8.44	0.00018	0.0027	< 0.00020	0.0012	< 0.0050	< 1.0	
10/16/2013	8.45	0.00026	0.0030	< 0.00020	0.0012	< 0.0050	< 1.0	
10/21/2013	8.25	0.00025	0.0023	< 0.00020	0.0010	< 0.0050	< 1.0	
10/28/2013	8.27	0.00034	0.0023	< 0.00020	0.0011	< 0.0050	1.0	
11/5/2013	8.23	0.00025	0.0022	< 0.00020	0.0010	< 0.0050	< 1.0	
11/14/2013	8.33	0.00023	0.0021	< 0.00020	< 0.0010	< 0.0050	< 1.0	
11/18/2013	8.30	0.00025	0.0023	< 0.00020	0.0011	< 0.0050	< 1.0	
11/18/2013	8.28	0.00023	0.0019	< 0.00020	< 0.0010	< 0.0050	< 1.0	
11/30/2013	8.04	0.00025	0.0022	< 0.00020	0.0010	< 0.0050	< 1.0	
12/5/2013	7.98	0.00025	0.0018	< 0.00020	< 0.0010	< 0.0050	< 1.0	
12/5/2013	8.01	0.00023	0.0020	< 0.00020	< 0.0010	< 0.0050	< 1.0	
12/9/2013	8.24	0.00023	0.0022	< 0.00020	< 0.0010	< 0.0050	< 1.0	
12/16/2013	8.21	0.00023	0.0016	< 0.00020	< 0.0010	< 0.0050	< 1.0	
12/23/2013	8.21	0.00028	0.0023	< 0.00020	0.0011	< 0.0050	< 1.0	

Table A.1: Routine effluent quality monitoring 2011-2015 (W3). Shaded values are greater than MMER grab limits.

Sample Date	pH	Arsenic	Copper	Lead	Nickel	Zinc	Total Suspended Solids	Radium-226
	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Bq/L
MACG	6.0-9.5	1.0	0.60	0.40	1.0	1.0	30	1.1
1/2/2014	8.12	0.00034	0.0018	< 0.00020	< 0.0010	< 0.0050	< 1.0	
1/7/2014	8.24	0.00033	0.0023	< 0.00020	< 0.0010	< 0.0050	< 1.0	
1/16/2014	7.97	0.00023	0.0020	< 0.00020	< 0.0010	< 0.0050	< 1.0	
1/22/2014	8.28	0.00020	0.0019	< 0.00020	< 0.0010	< 0.0050	3.9	
1/27/2014	8.09	0.00042	0.0065	< 0.00020	< 0.0010	< 0.0050	< 1.0	
2/3/2014	8.20	0.00022	0.0016	< 0.00020	< 0.0010	< 0.0050	< 1.0	
2/13/2014	8.16	0.00024	0.0020	< 0.00020	< 0.0010	< 0.0050	< 1.0	
2/18/2014	8.09	0.00027	0.0019	< 0.00020	< 0.0010	< 0.0050	< 1.0	
2/20/2014	8.25	0.00026	0.0016	< 0.00020	< 0.0010	< 0.0050	< 1.0	
2/25/2014	8.18	0.00032	0.0049	< 0.00020	< 0.0010	< 0.0050	< 1.0	
3/8/2014	8.24	0.00038	0.0046	< 0.00020	0.0012	< 0.0050	1.8	
3/10/2014	8.20	0.00035	0.0052	< 0.00020	0.0011	< 0.0050	1.4	0.013
3/17/2014	8.31	0.00046	0.0058	< 0.00020	0.0015	< 0.0050	11	
3/27/2014	8.30	0.00026	0.0045	< 0.00020	0.0013	< 0.0050	4.3	
4/2/2014	8.29	0.00040	0.0051	< 0.00020	0.0012	< 0.0050	5.8	
4/7/2014	7.94	0.00045	0.018	< 0.00020	0.0016	0.0058	14	
4/17/2014	8.21	0.00045	0.045	0.00023	0.0013	0.0059	13	
4/21/2014	8.21	0.00045	0.048	0.00021	0.0014	0.0055	13	
4/28/2014	8.15	0.00062	0.048	0.00027	0.0018	0.0063	13	
5/5/2014	8.13	0.00040	0.018	< 0.00020	0.0016	< 0.0050	6.5	< 0.010
5/11/2014	8.05	0.00046	0.041	< 0.00020	0.0016	0.011	5.9	
5/14/2014	7.96	0.00067	0.040	0.00027	0.0019	0.0069	16	
5/17/2014	7.98	0.00045	0.034	< 0.00020	0.0016	< 0.0050	9.3	
5/22/2014	7.82	0.00086	0.070	0.00051	0.0024	0.012	14	
5/26/2014	7.96	0.00080	0.054	0.00035	0.0018	0.0074	15	
6/4/2014	8.41	0.00032	0.0046	< 0.00020	0.0013	< 0.0050	< 1.0	
6/11/2014	8.28	0.00026	0.0032	< 0.00020	0.0012	< 0.0050	< 1.0	
6/17/2014	8.30	0.00024	0.0029	< 0.00020	< 0.0010	< 0.0050	< 1.0	
6/24/2014	8.37	0.00026	0.0026	< 0.00020	< 0.0010	< 0.0050	< 1.0	
6/30/2014	8.29	0.00024	0.0026	< 0.00020	< 0.0010	< 0.0050	< 1.0	
7/9/2014	8.54	0.00028	0.0027	< 0.00020	< 0.0010	< 0.0050	< 1.0	
7/15/2014	8.19	0.00024	0.0024	< 0.00020	< 0.0010	< 0.0050	< 1.0	
7/21/2014	8.40	0.00028	0.0048	< 0.00020	< 0.0010	< 0.0050	< 1.0	
7/31/2014	8.25	0.00026	0.0027	< 0.00020	< 0.0010	< 0.0050	< 1.0	
8/4/2014	8.20	0.00026	0.0025	< 0.00020	< 0.0010	< 0.0050	< 1.0	< 0.010
8/14/2014	8.31	0.00023	0.0077	< 0.00020	< 0.0010	< 0.0050	1.1	
8/18/2014	8.31	0.00023	0.0025	< 0.00020	< 0.0010	< 0.0050	< 1.0	
8/26/2014	8.22	0.00027	0.0026	< 0.00020	< 0.0010	< 0.0050	< 1.0	
9/4/2014	8.22	0.00023	0.0023	< 0.00020	0.0012	< 0.0050	283	
9/12/2014	8.28	0.00051	0.0029	< 0.00020	< 0.0010	< 0.0050	1.5	
9/15/2014	8.26	0.00020	0.0024	< 0.00020	< 0.0010	< 0.0050	1.0	
9/22/2014	8.36	0.00027	0.0027	< 0.00020	< 0.0010	< 0.0050	4.1	
10/5/2014	8.23	0.00025	0.0053	< 0.00020	0.0013	< 0.0050	13	
10/8/2014	8.27	0.00026	0.0028	< 0.00020	< 0.0010	< 0.0050	< 1.0	
10/13/2014	8.26	0.00029	0.0023	< 0.00020	< 0.0010	< 0.0050	< 1.0	
10/20/2014	8.37	0.00023	0.0022	< 0.00020	< 0.0010	< 0.0050	< 1.0	
10/27/2014	8.11	0.00022	0.0063	< 0.00020	0.0014	< 0.0050	1.0	< 0.010
11/5/2014	8.29	0.00026	0.0022	< 0.00020	< 0.0010	< 0.0050	< 1.0	
11/10/2014	8.24	0.00024	0.0028	< 0.00020	< 0.0010	< 0.0050	< 1.0	
11/17/2014	7.95	0.00027	0.0046	< 0.00020	0.0011	0.065	2.3	
11/24/2014	8.15	0.00028	0.0036	< 0.00020	< 0.0010	0.014	1.2	
12/3/2014	8.07	0.00028	0.0034	< 0.00020	0.0010	< 0.0050	1.5	
12/9/2014	8.03	0.00043	0.010	< 0.00020	0.0010	< 0.0050	6.4	
12/16/2014	7.87	0.00030	0.0080	< 0.00020	< 0.0010	< 0.0050	1.7	
12/22/2014	8.19	0.00028	0.0025	< 0.00020	< 0.0010	< 0.0050	1.1	

Table A.1: Routine effluent quality monitoring 2011-2015 (W3). Shaded values are greater than MMER grab limits.

Sample Date	pH	Arsenic	Copper	Lead	Nickel	Zinc	Total Suspended Solids	Radium-226
	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Bq/L
MACG	6.0-9.5	1.0	0.60	0.40	1.0	1.0	30	1.1
1/2/2015	8.11	0.00025	0.0031	< 0.00020	0.0012	< 0.0050	3.6	
1/6/2015	8.04	0.00027	0.0024	< 0.00020	< 0.0010	< 0.0050		
1/13/2015	8.26	0.00024	0.0023	< 0.00020	< 0.0010	< 0.0050	1.5	
1/21/2015	8.28	0.00023	0.0019	< 0.00020	< 0.0010	< 0.0050	1.7	
1/29/2015	8.29	0.00024	0.0023	< 0.00020	< 0.0010	< 0.0050	1.2	
2/3/2015	8.19	0.00042	0.0034	< 0.00020	0.0016	< 0.0050	2.9	
2/11/2015	7.91	0.00023	0.0033	< 0.00020	0.0011	< 0.0050	< 1.0	
2/18/2015	7.88	0.00022	0.0021	< 0.00020	0.0011	< 0.0050	< 1.0	
2/26/2015	8.08	0.00021	0.0018	< 0.00020	0.0012	< 0.0050	< 1.0	
3/3/2015	7.88	0.00021	0.0038	< 0.00020	0.0012	0.032	< 1.0	
3/9/2015	8.06	0.00023	0.0033	< 0.00020	< 0.0010	< 0.0050	< 1.0	
3/16/2015	8.11	0.00021	0.0034	< 0.00020	0.0011	0.021	< 1.0	< 0.010
3/25/2015	8.09	0.00022	0.0017	< 0.00020	0.0011	< 0.0050	< 1.0	
3/30/2015	8.45	0.00023	0.0046	< 0.00020	0.0012	0.16	< 1.0	
4/6/2015	8.11	0.00048	0.011	< 0.00020	< 0.0010	0.014	2.8	
4/14/2015	8.22	0.00041	0.015	0.00058	< 0.0010	< 0.0050	4.3	< 0.010
4/21/2015	8.13	0.00049	0.019	0.00021	< 0.0010	< 0.0050	9.4	
4/27/2015	8.14	0.00035	0.023	< 0.00020	< 0.0010	< 0.0050	4.2	
5/10/2015	8.16	0.00033	0.0099	< 0.00020	< 0.0010	0.016	< 1.0	
5/14/2015	8.06	0.00043	0.021	< 0.00020	< 0.0010	< 0.0050	11	
5/20/2015	8.07	0.00049	0.024	< 0.00020	0.0012	< 0.0050	5.4	
5/29/2015	8.13	0.00035	0.012	< 0.00020	< 0.0010	< 0.0050	1.4	
5/31/2015	8.24	0.00041	0.013	< 0.00020	< 0.0010	< 0.0050	2.0	
6/4/2015	8.15	0.00025	0.0030	< 0.00020	< 0.0010	0.051	< 1.0	
6/9/2015	8.19	0.00025	0.0029	< 0.00020	< 0.0010	< 0.0050	< 1.0	
6/15/2015	8.21	0.00053	0.020	0.00028	0.0018	< 0.0050	13	
6/22/2015	8.32	0.00026	0.0024	0.00020	< 0.0010	< 0.0050	< 1.0	
6/29/2015	8.32	0.00022	0.0030	< 0.00020	< 0.0010	< 0.0050	< 1.0	
7/7/2015	8.31	0.00027	0.0027	< 0.00020	< 0.0010	< 0.0050	8.3	
7/14/2015	8.16	0.00023	0.0026	< 0.00020	< 0.0010	< 0.0050	< 1.0	
7/20/2015	8.26	0.00028	0.0024	< 0.00020	< 0.0010	< 0.0050	< 1.0	
7/29/2015	8.22	0.00029	0.0025	< 0.00020	< 0.0010	< 0.0050	< 1.0	
8/5/2015	8.34	0.00027	0.0021	< 0.00020	< 0.0010	< 0.0050	< 1.0	
8/14/2015	8.18	0.00028	0.0029	< 0.00020	< 0.0010	< 0.0050	< 1.0	
8/18/2015	8.32	0.00032	0.0033	< 0.00020	< 0.0010	< 0.0050	< 1.0	
8/24/2015	8.04	0.00025	0.0022	< 0.00020	< 0.0010	< 0.0050	< 1.0	
8/31/2015	8.19	0.00033	0.0053	< 0.00020	0.0012	< 0.0050	4.6	< 0.010
9/8/2015	8.27	0.00029	0.0058	< 0.00020	0.0011	< 0.0050	17	
9/15/2015	8.34	0.00029	0.0030	< 0.00020	< 0.0010	< 0.0050	< 1.0	
9/23/2015	8.43	0.00026	0.0026	< 0.00020	< 0.0010	< 0.0050	< 1.0	
9/30/2015	8.42	0.00030	0.0026	< 0.00020	< 0.0010	< 0.0050	< 1.0	
10/5/2015	8.38	0.00025	0.0021	< 0.00020	< 0.0010	< 0.0050	< 1.0	< 0.010
10/13/2015	8.28	0.00021	0.0027	< 0.00020	< 0.0010	< 0.0050	< 1.0	
10/22/2015	8.16	0.00028	0.0025	< 0.00020	< 0.0010	< 0.0050	< 1.0	
10/28/2015	8.20	0.00027	0.0025	< 0.00020	< 0.0010	< 0.0050	< 1.0	
10/28/2015	8.12	0.00026	0.0025	< 0.00020	< 0.0010	< 0.0050	< 1.0	
11/2/2015	8.15	0.00017	0.0021	< 0.00020	< 0.0010	< 0.0050	< 1.0	
11/9/2015	8.20	0.00023	0.0025	< 0.00020	< 0.0010	< 0.0050	< 1.0	

Table A.2: W3 Effluent Characterization 2011-2015 MMER samples only.

Date	Units	2011					2012				
		4/27/2011	6/16/2011	8/16/2011	10/6/2011	Mean	4/24/2012	6/19/2012	8/23/2012	10/16/2012	Mean
Hardness	mg/L	156	271	234	251	228	206	241	241	288	244
Alkalinity	mg/L	110	220	210	220	190	182	213	224	214	208
Aluminum	mg/L	0.13	0.12	0.070	0.014	0.084	0.15	0.016	0.0049	0.0068	0.045
Cadmium	mg/L	0.000060	0.000040	0.000040	0.000010	0.000038	0.000065	0.000017	0.000010	0.000010	0.000026
Iron	mg/L	0.17	0.15	0.14	0.037	0.12	0.22	0.044	0.020	0.027	0.077
Mercury	mg/L	< 0.000020	< 0.000020	< 0.000020	< 0.000020	< 0.000020	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Molybdenum	mg/L	0.0020	0.0050	0.0040	0.0040	0.0038	0.0052	0.0042	0.0048	0.0046	0.0047
Ammonia	mg/L	0.016	0.0070	0.016	0.015	0.014	0.025	0.094	0.012	0.012	0.036
Nitrate-N	mg/L	1.4	2.5	0.36	1.2	1.4	4.2	0.62	0.51	0.53	1.5
Selenium	mg/L	0.00040	0.00060	0.00040	0.00040	0.00045	0.0015	0.00034	0.00040	0.00039	0.00065
Conductivity	µS/cm	398	322	454	564	434	484	488	513	490	494
Temperature	°C		2.6	2.6	0.10	1.8	1.7	3.2	2.8	0.70	2.1

Table A.2: W3 Effluent Characterization 2011-2015 MMER samples only.

Date	Units	2013						2014				
		4/30/2013	5/21/2013	8/21/2013	8/21/2013	10/21/2013	Mean	5/5/2014	6/30/2014	8/4/2014	10/27/2014	Mean
Hardness	mg/L	213	62.3	251	248	236	202.06	153	243	241	269	226.5
Alkalinity	mg/L	182	46	218	221	210	175	136	218	229	220	201
Aluminum	mg/L	0.17	1.2	0.029	0.015	0.015	0.29	0.25	0.0043	0.0076	0.030	0.073
Cadmium	mg/L	< 0.000010	0.000031	< 0.000010	< 0.000010	< 0.000010	0.000014	0.000014	< 0.000010	< 0.000010	< 0.000010	0.000011
Iron	mg/L	0.28	1.9	0.027	0.023	0.035	0.46	0.36	0.014	0.022	0.061	0.11
Mercury	mg/L	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Molybdenum	mg/L	0.0041	0.0015	0.0055	0.0051	0.0052	0.0043	0.0046	0.0052	0.0051	0.0048	0.0049
Ammonia	mg/L	0.020	0.034	0.014	0.019	0.022	0.022	0.041	0.021	0.010	0.043	0.029
Nitrate-N	mg/L	2.6	0.81	0.29	0.29	0.31	0.86	0.74	0.20	0.21	0.28	0.36
Selenium	mg/L	0.00069	0.00015	0.00046	0.00046	0.00039	0.00043	0.00027	0.00038	0.00037	0.00043	0.00036
Conductivity	µS/cm	450	128	497	497	496	414	181	289	321	274	266
Temperature	°C	1.2	2.1			0	1.1	2.4	3.1	2.4	-1.5	1.6

Table A.2: W3 Effluent Characterization 2011-2015 MMER samples only.

Date	Units	2015				
		4/14/2015	6/9/2015	8/24/2015	10/13/2015	Mean
Hardness	mg/L	211	253	240	252	239
Alkalinity	mg/L	154	209	230	222	204
Aluminum	mg/L	0.13	0.0040	0.0032	0.0076	0.036
Cadmium	mg/L	0.00001	< 0.000010	< 0.000010	< 0.000010	0.000011
Iron	mg/L	0.20	0.013	0.025	0.036	0.068
Mercury	mg/L	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Molybdenum	mg/L	0.0074	0.0048	0.0047	0.0046	0.0054
Ammonia	mg/L	0.064	0.024	0.033	0.028	0.037
Nitrate-N	mg/L	2.9	0.36	0.20	0.19	0.92
Selenium	mg/L	0.0011	0.00034	0.00029	0.00037	0.00052
Conductivity	µS/cm	262	336	311	282	298
Temperature	°C	2.8	4.9	3.2	0.50	2.9

Table A.3: MMER EEM Water quality at mine-exposed (W2) and reference (W7) areas (2011-2015). Shaded values are greater than the background 95th percentile or guidelines[1].

Parameter	Units	Background 95th Percentile[1]	Canadian Water Quality Guideline (CCME 2015)	W2									
				2011					2012				
				4/27/2011	6/16/2011	8/16/2011	10/6/2011	mean	4/24/2012	6/19/2012	8/23/2012	10/16/2012	mean
EEM Parameters													
pH	pH units	-	6.5-9.0	7.63	7.32	8.50	7.92	7.84	8.04	7.75	7.91	7.88	7.90
Temperature	Celsius	-	-	0	6.5	9.3	0	3.9	0	5.6	7.0	0.20	3.2
Hardness	mg/L	-	-	62	140	116	142	115	57	193	158	153	140
Alkalinity	mg/L	-	-	51	110	110	140	103	55	110	159	144	117
Conductivity	µS/cm	-	-	78	414	438	311	310	66	169	192	155	146
Dissolved Oxygen	mg/L	-	-	-	-	12	13	12	16	12	11	15	14
Total Suspended Solids	mg/L	-	-	5	190	120	< 4.0	80	32	1,030	76	30	292
Ammonia	mg/L	-	1.5[a]	0.0080	0.033	0.018	0.013	0.018	0.0051	0.20	0.049	0.017	0.068
Nitrate (as N)	mg/L	-	2.9	< 0.020	0.24	0.12	0.22	0.15	0.39	0.15	< 0.20	0.16	0.23
Aluminum	mg/L	0.62	0.10	0.16	7.2	2.3	0.18	2.5	0.68	20	0.75	0.25	5.5
Arsenic	mg/L	-	0.0050	0.00040	0.0036	0.0023	0.00070	0.0018	0.00073	0.0091	0.0013	0.00089	0.0030
Cadmium	mg/L	-	0.00019-0.00023[b]	0.000080	0.00019	0.000070	0.000040	0.000095	0.000040	0.00055	0.000021	< 0.000010	0.00015
Copper	mg/L	0.013	0.0020-0.0040[b]	0.011	0.017	0.0095	0.0032	0.010	0.00654	0.044	0.0042	0.0026	0.014
Iron	mg/L	1.1	0.30	0.30	11	4.7	0.76	4.2	1.2	30.5	2.1	1.1	8.7
Lead	mg/L	-	0.0041-0.0057[b]	< 0.00020	0.0030	0.0012	< 0.00020	0.0012	0.00031	0.0086	0.00062	0.00021	0.0024
Mercury	mg/L	-	0.00010	< 0.000020	< 0.000020	< 0.000020	< 0.000020	< 0.000020	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Molybdenum	mg/L	-	0.073	< 0.0010	0.0020	0.0010	0.0010	0.0013	< 0.0010	0.0020	0.0010	0.0010	0.0013
Nickel	mg/L	-	0.11-0.14[b]	0.0010	0.013	0.0070	0.0020	0.0058	0.0021	0.035	0.0031	0.0022	0.010
Selenium	mg/L	-	0.0010	0.00010	0.00040	0.00020	0.00010	0.00020	0.00017	0.00056	0.00014	0.00013	0.00025
Zinc	mg/L	-	0.030	< 0.0050	0.030	0.014	0.0050	0.014	< 0.0050	0.072	0.0056	< 0.0050	0.022
Radium-226[c]	Bq/L	-	-	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010					-
Additional Parameters with CWQG													
Thallium	mg/L		0.00080	< 0.000050	0.000080	< 0.000050	< 0.000050	0.000058	< 0.000050	0.00020	< 0.000050	< 0.000050	0.000087

[1] 95th percentile of background identified by Minnow (2009)

[a] based on pH 8 and temperature of 5 Celsius

[b] cadmium, copper, lead and nickel guidelines are dependent on water hardness

[c] Radium-226 discontinued in 2012 in accordance with the MMER

Table A.3: MMER EEM Water quality at mine-exposed (W2) and reference (W7) areas (2011-2015). Shaded values are greater than the background 95th percentile or guidelines[1].

Parameter	Units	Background 95th Percentile[1]	Canadian Water Quality Guideline (CCME 2015)	W2									
				2013					2014				
				4/30/2013	5/19/2013	8/21/2013	10/21/2013	mean	5/5/2014	6/30/2014	8/7/2014	10/31/2014	mean
EEM Parameters													
pH	pH units	-	6.5-9.0	8.30	8.17	7.71	8.15	8.08	8.22	8.30	8.08	7.69	8.07
Temperature	Celsius	-	-	-0.10	0.60	7.0	0.010	1.9	0.30	8.7	6.6	-1.4	3.55
Hardness	mg/L	-	-	412	91	168	163	209	69	167	180	176	148
Alkalinity	mg/L	-	-	183	75	154	149	140	61	151	154	181	137
Conductivity	µS/cm	-	-	219	89	205	164	169	77	239	237	188	185
Dissolved Oxygen	mg/L	-	-	-	13	11	14	13	14	11	14	14	13
Total Suspended Solids	mg/L	-	-	< 1.0	79	24	2.3	27	54	< 1.0	4.2	< 1.0	15
Ammonia	mg/L	-	1.5[a]	0.022	0.044	0.025	0.032	0.031	0.021	0.040	0.014	0.0091	0.021
Nitrate (as N)	mg/L	-	2.9	1.6	0.40	0.14	0.19	0.57	0.054	0.049	0.12	0.18	0.099
Aluminum	mg/L	0.62	0.10	0.030	2.0	0.71	0.051	0.69	0.90	0.051	0.16	0.014	0.28
Arsenic	mg/L	-	0.0050	0.0016	0.0015	0.0012	0.00077	0.0013	0.00096	0.00052	0.00072	0.00032	0.00063
Cadmium	mg/L	-	0.00019-0.00023[b]	< 0.000010	0.000033	0.000012	< 0.000010	0.000016	0.000028	0.000020	< 0.000010	< 0.000010	0.000017
Copper	mg/L	0.013	0.0020-0.0040[b]	< 0.00020	0.016	0.0036	0.0019	0.0054	0.0070	0.0034	0.0022	0.0016	0.0036
Iron	mg/L	1.1	0.30	5.0	3.6	1.6	0.64	2.7	1.7	0.12	0.49	0.083	0.60
Lead	mg/L	-	0.0041-0.0057[b]	< 0.00020	0.00096	0.00030	< 0.00020	0.00042	0.00049	< 0.00020	< 0.00020	< 0.00020	0.00027
Mercury	mg/L	-	0.00010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Molybdenum	mg/L	-	0.073	0.0018	0.0013	0.0017	0.0014	0.0016	< 0.001	0.0016	0.0015	0.0012	0.0013
Nickel	mg/L	-	0.11-0.14[b]	0.0014	0.0045	0.0028	0.0021	0.0027	0.0032	0.0011	0.0013	0.0011	0.0017
Selenium	mg/L	-	0.0010	< 0.00010	0.00029	0.00019	0.00014	0.00018	0.00014	0.00013	0.00010	< 0.00010	0.00012
Zinc	mg/L	-	0.030	< 0.0050	0.0091	< 0.0050	< 0.0050	0.0060	0.0060	0.0053	< 0.0050	< 0.0050	0.0053
Radium-226[c]	Bq/L	-	-					-					-
Additional Parameters with CWQG													
Thallium	mg/L		0.00080	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050

[1] 95th percentile of background identified by Minnow (2009)

[a] based on pH 8 and temperature of 5 Celsius

[b] cadmium, copper, lead and nickel guidelines are dependent on water hardness

[c] Radium-226 discontinued in 2012 in accordance with the MMER

Table A.3: MMER EEM Water quality at mine-exposed (W2) and reference (W7) areas (2011-2015). Shaded values are greater than the background 95th percentile or guidelines[1].

Parameter	Units	Background 95th Percentile[1]	Canadian Water Quality Guideline (CCME 2015)	W2				
				2015				
				4/14/2015	6/11/2015	8/25/2015	10/13/2015	mean
EEM Parameters								
pH	pH units	-	6.5-9.0	8.34	7.70	8.12	7.72	7.97
Temperature	Celsius	-	-		5.7	5.6	0.30	3.9
Hardness	mg/L	-	-	194	170	175	163	176
Alkalinity	mg/L	-	-	169	143	163	153	157
Conductivity	µS/cm	-	-	199	209	159	174	185
Dissolved Oxygen	mg/L	-	-	14	11	13	11	12
Total Suspended Solids	mg/L	-	-	< 1.0	< 1.0	14	< 1.0	4.2
Ammonia	mg/L	-	1.5[a]	0.013	0.020	0.018	0.020	0.018
Nitrate (as N)	mg/L	-	2.9	0.21	0.14	0.056	0.077	0.12
Aluminum	mg/L	0.62	0.10	0.068	0.044	0.15	0.013	0.068
Arsenic	mg/L	-	0.0050	0.00054	0.00046	0.00069	0.00049	0.00055
Cadmium	mg/L	-	0.00019-0.00023[b]	0.000016	< 0.000010	< 0.000010	< 0.000010	0.000012
Copper	mg/L	0.013	0.0020-0.0040[b]	0.019	0.0023	0.0029	0.0016	0.0065
Iron	mg/L	1.1	0.30	0.28	0.12	0.36	0.15	0.23
Lead	mg/L	-	0.0041-0.0057[b]	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020
Mercury	mg/L	-	0.00010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Molybdenum	mg/L	-	0.073	0.0024	0.0017	0.0017	0.0012	0.0018
Nickel	mg/L	-	0.11-0.14[b]	< 0.0010	0.0014	0.0013	0.0012	0.0012
Selenium	mg/L	-	0.0010	0.00025	0.00013	0.00013	< 0.00010	0.00015
Zinc	mg/L	-	0.030	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
Radium-226[c]	Bq/L	-	-					-
Additional Parameters with CWQG								
Thallium	mg/L		0.00080	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050

[1] 95th percentile of background identified by Minnow (2009)

[a] based on pH 8 and temperature of 5 Celsius

[b] cadmium, copper, lead and nickel guidelines are dependent on water hardness

[c] Radium-226 discontinued in 2012 in accordance with the MMER

Table A.3: MMER EEM Water quality at mine-exposed (W2) and reference (W7) areas (2011-2015). Shaded values are greater than the background 95th percentile or guidelines[1].

Parameter	Units	Background 95th Percentile[1]	Canadian Water Quality Guideline (CCME 2015)	W7									
				2011					2012				
				4/27/2011	6/16/2011	8/16/2011	10/6/2011	mean	4/24/2012	6/19/2012	8/23/2012	10/16/2012	mean
EEM Parameters													
pH	pH units	-	6.5-9.0	8.33	7.63	7.82	7.65	7.86	7.43	7.59	7.79	7.89	7.68
Temperature	Celsius	-	-	-0.41	3.1	5.6	0	2.1	0	4.1	4.6	0.40	2.3
Hardness	mg/L	-	-	43	108	97	113	90	37	105	151	143	109
Alkalinity	mg/L	-	-	34	92	94	120	85	36	87	147	132	101
Conductivity	µS/cm	-	-	105	189	166	251	178	40	122	161	138	115
Dissolved Oxygen	mg/L	-	-	-	14	12	12	13	16	12	11	17	14
Total Suspended Solids	mg/L	-	-	< 1.0	85	22	< 4.0	28	11	165	1.5	9.9	47
Ammonia	mg/L	-	1.5[a]	0.010	0.013	0.015	0.019	0.014	< 0.0050	0.18	0.049	0.028	0.066
Nitrate (as N)	mg/L	-	2.9	< 0.020	0.10	0.060	0.11	0.073	< 0.020	0.083	0.21	0.13	0.11
Aluminum	mg/L	0.62	0.10	0.10	2.5	0.40	0.065	0.76	0.77	5.4	0.034	0.13	1.6
Arsenic	mg/L	-	0.0050	0.00030	0.0014	0.0010	0.00050	0.00080	0.00074	0.0023	0.00093	0.00065	0.0012
Cadmium	mg/L	-	0.00019-0.00023[b]	0.000050	0.000080	0.000040	0.000010	0.000045	0.000029	0.00012	< 0.000010	< 0.000010	0.000042
Copper	mg/L	0.013	0.0020-0.0040[b]	0.012	0.0075	0.014	0.0012	0.0087	0.0064	0.010	0.0013	0.0014	0.0048
Iron	mg/L	1.1	0.30	0.19	4.0	1.3	0.49	1.5	1.3	7.9	1.1	1.0	2.8
Lead	mg/L	-	0.0041-0.0057[b]	< 0.00020	0.0012	0.00040	< 0.00020	0.00050	0.00029	0.0018	< 0.00020	< 0.00020	0.00062
Mercury	mg/L	-	0.00010	< 0.000020	< 0.000020	< 0.000020	< 0.000020	< 0.000020	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Molybdenum	mg/L	-	0.073	< 0.0010	0.0010	< 0.0010	0.0010	0.0010	< 0.0010	0.0012	0.0016	0.0012	0.0013
Nickel	mg/L	-	0.11-0.14[b]	< 0.0010	0.0080	0.0030	0.0010	0.0033	0.0019	0.011	0.0016	0.0023	0.0041
Selenium	mg/L	-	0.0010	< 0.00010	0.00020	0.00010	0.00010	0.00013	< 0.00010	0.00020	0.00017	0.00020	0.00017
Zinc	mg/L	-	0.030	< 0.0050	0.013	0.017	< 0.0050	0.010	< 0.0050	0.015	< 0.0050	< 0.0050	0.0075
Radium-226[c]	Bq/L	-	-	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010					-
Additional Parameters with CWQG													
Thallium	mg/L		0.00080	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	0.000050	< 0.000050	< 0.000050	0.000050

[1] 95th percentile of background identified by Minnow (2009)
[a] based on pH 8 and temperature of 5 Celsius
[b] cadmium, copper, lead and nickel guidelines are dependent on water hardness
[c] Radium-226 discontinued in 2012 in accordance with the MMER

Table A.3: MMER EEM Water quality at mine-exposed (W2) and reference (W7) areas (2011-2015). Shaded values are greater than the background 95th percentile or guidelines[1].

Parameter	Units	Background 95th Percentile[1]	Canadian Water Quality Guideline (CCME 2015)	W7									
				2013					2014				
				4/30/2013	5/14/2013	8/21/2013	10/21/2013	mean	5/5/2014	6/30/2014	8/10/2014	10/31/2014	mean
EEM Parameters													
pH	pH units	-	6.5-9.0	8.18	8.20	7.81	7.58	7.94	8.19	8.11		7.29	7.86
Temperature	Celsius	-	-	0	0	4.2	0	1.1	-0.1	2.5		-1.6	0.27
Hardness	mg/L	-	-	198	36	144	126	126	52	135	143	164	124
Alkalinity	mg/L	-	-	187	29	143	138	124	48	130	142	150	118
Conductivity	µS/cm	-	-	191	31	168	149	135	59	171		199	143
Dissolved Oxygen	mg/L	-	-	-	13	12	12	12	14	12		13	13
Total Suspended Solids	mg/L	-	-	5.8	55	3.8	7.4	18	3.5	4.5	2.9	2.6	3.4
Ammonia	mg/L	-	1.5[a]	0.0082	0.066	0.051	0.048	0.043	0.014	0.025	0.025	0.022	0.022
Nitrate (as N)	mg/L	-	2.9	0.13	< 0.020	0.16	0.17	0.12	< 0.020	0.20	0.16	0.20	0.15
Aluminum	mg/L	0.62	0.10	0.011	1.3	0.14	0.093	0.40	0.12	0.10	0.032	0.010	0.065
Arsenic	mg/L	-	0.0050	0.00019	0.00072	0.00070	0.00061	0.00056	0.00049	0.00040	0.00049	0.00044	0.00046
Cadmium	mg/L	-	0.00019-0.00023[b]	< 0.000010	0.000025	< 0.000010	< 0.000010	0.000014	0.000026	0.000012	< 0.000010	< 0.000010	0.000015
Copper	mg/L	0.013	0.0020-0.0040[b]	0.0021	0.0084	0.0014	0.0012	0.0033	0.0062	0.0021	0.0012	0.00098	0.0026
Iron	mg/L	1.1	0.30	0.029	2.2	0.62	0.68	0.88	0.40	0.18	0.18	0.15	0.23
Lead	mg/L	-	0.0041-0.0057[b]	< 0.00020	0.00046	< 0.00020	< 0.00020	0.00027	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020
Mercury	mg/L	-	0.00010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Molybdenum	mg/L	-	0.073	0.0013	< 0.0010	0.0016	0.0011	0.0013	< 0.0010	0.0015	0.0016	0.0015	0.0014
Nickel	mg/L	-	0.11-0.14[b]	< 0.0010	0.0029	0.0014	0.0016	0.0017	0.0019	< 0.0010	< 0.0010	< 0.0010	0.0012
Selenium	mg/L	-	0.0010	0.00042	0.00011	0.00014	0.00021	0.00022	0.00011	0.00018	0.00030	0.00016	0.00019
Zinc	mg/L	-	0.030	< 0.0050	0.0059	< 0.0050	< 0.0050	0.0052	0.0059	< 0.0050	< 0.0050	< 0.0050	0.0052
Radium-226[c]	Bq/L	-	-					-					-
Additional Parameters with CWQG													
Thallium	mg/L		0.00080	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050

[1] 95th percentile of background identified by Minnow (2009)
[a] based on pH 8 and temperature of 5 Celsius
[b] cadmium, copper, lead and nickel guidelines are dependent on water hardness
[c] Radium-226 discontinued in 2012 in accordance with the MMER

Table A.3: MMER EEM Water quality at mine-exposed (W2) and reference (W7) areas (2011-2015). Shaded values are greater than the background 95th percentile or guidelines[1].

Parameter	Units	Background 95th Percentile[1]	Canadian Water Quality Guideline (CCME 2015)	W7				
				2015				
				4/14/2015	6/10/2015	8/21/2015	10/15/2015	mean
EEM Parameters								
pH	pH units	-	6.5-9.0	8.04	7.49	7.85	7.53	7.73
Temperature	Celsius	-	-	0	0.10	3.0	0	0.78
Hardness	mg/L	-	-	196	128	164	154	161
Alkalinity	mg/L	-	-	195	117	140	138	148
Conductivity	µS/cm	-	-	203	131	161	152	162
Dissolved Oxygen	mg/L	-	-	13	14	12	12	13
Total Suspended Solids	mg/L	-	-	< 1.0	90	161	4.1	64
Ammonia	mg/L	-	1.5[a]	0.011	0.045	0.043	0.038	0.034
Nitrate (as N)	mg/L	-	2.9	0.047	0.12	0.11	0.11	0.095
Aluminum	mg/L	0.62	0.10	0.015	1.5	0.074	0.097	0.42
Arsenic	mg/L	-	0.0050	0.00030	0.0011	0.00062	0.00041	0.00060
Cadmium	mg/L	-	0.00019-0.00023[b]	0.000022	0.000017	< 0.000010	< 0.000010	0.000015
Copper	mg/L	0.013	0.0020-0.0040[b]	0.0051	0.0038	0.0018	0.0016	0.0031
Iron	mg/L	1.1	0.30	0.034	2.3	0.29	0.27	0.72
Lead	mg/L	-	0.0041-0.0057[b]	< 0.00020	0.00062	< 0.00020	< 0.00020	0.00031
Mercury	mg/L	-	0.00010	< 0.000010	< 0.000010	< 0.000010	< 0.000010	< 0.000010
Molybdenum	mg/L	-	0.073	0.0021	0.0017	0.0019	0.0014	0.0018
Nickel	mg/L	-	0.11-0.14[b]	<0.0010	0.0035	0.0014	0.0010	0.0020
Selenium	mg/L	-	0.0010	0.00033	0.00019	0.00016	0.00014	0.00021
Zinc	mg/L	-	0.030	< 0.0050	0.0064	< 0.0050	< 0.0050	0.0054
Radium-226[c]	Bq/L	-	-					-
Additional Parameters with CWQG								
Thallium	mg/L		0.00080	< 0.000050	< 0.000050	< 0.000050	< 0.000050	< 0.000050

[1] 95th percentile of background identified by Minnow (2009)
[a] based on pH 8 and temperature of 5 Celsius
[b] cadmium, copper, lead and nickel guidelines are dependent on water hardness
[c] Radium-226 discontinued in 2012 in accordance with the MMER

Table A.4: Comparison of mean concentrations of key analytes at mine exposed (W2) and reference (W7) stations, MMER EEM dataset, 2011-2015.

Analyte	Units	2011			2012			2013			2014			2015		
		W7	W2	Ratio	W7	W2	Ratio	W7	W2	Ratio	W7	W2	Ratio	W7	W2	Ratio
Total Suspended Solids	mg/L	28	80	2.8	47	292	6.2	3.4	27	7.9	3.4	15	4.5	64	4.2	0.065
Aluminum	mg/L	0.76	2.46	3.2	1.58	5.47	3.5	0.065	0.69	11	0.065	0.28	4.3	0.42	0.068	0.16
Arsenic	mg/L	0.00080	0.0018	2.2	0.0012	0.0030	2.6	0.00046	0.0013	2.8	0.00046	0.00063	1.4	0.00060	0.00055	0.92
Cadmium	mg/L	0.000045	0.00010	2.1	0.000042	0.00015	3.7	0.000015	0.000016	1.1	0.000015	0.000017	1.2	0.000015	0.000012	0.78
Copper	mg/L	0.0087	0.010	1.2	0.0048	0.0144	3.0	0.0026	0.0054	2.1	0.0026	0.0036	1.4	0.0031	0.0065	2.1
Iron	mg/L	1.5	4.2	2.8	2.8	8.7	3.1	0.23	2.7	12	0.23	0.60	2.7	0.72	0.23	0.32
Lead	mg/L	0.00050	0.0012	2.3	0.00062	0.0024	3.9	0.00020	0.00042	2.1	0.00020	0.00027	1.4	0.00031	0.00020	0.66
Zinc	mg/L	0.010	0.014	1.4	0.0075	0.022	2.9	0.0052	0.0060	1.2	0.0052	0.0053	1.0	0.0054	< 0.0050	0.93