Minto Explorations Ltd.

A SUBSIDIARY OF CAPSTONE MINING LTD.

APPENDIX N
Baseline Aquatic Ecosystems and Fisheries Resources Report

Minto Explorations Ltd.

ISSUED FOR USE

MINTO MINE
PHASE IV DEVELOPMENT
FISHERIES AND AQUATIC BASELINE STUDY SUMMARY

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1.0 INTRODUCTION

Minto Exploration Inc. (MintoEx) is planning an expansion of their Minto Mine, located in central Yukon, named the Phase IV expansion. This new project phase will involve the expansion of mining areas and an associated expansion in accessory activities.

EBA Engineering Consultants Ltd. (EBA) was retained by Minto Exploraton Ltd. to help prepare baseline environmental data to support the assessment and regulatory processes for the mine expansion. This report has been produced to help provide a comprehensive summary of baseline environmental studies that have been conducted in the Minto Mine area in the fields of fisheries and aquatic habitat. The report is based on material modified from a number of existing baseline study reports and regulatory/assessment documents produced since 1994 by Hallam Knight Piesold, R&D Environmental, Access Consulting Group, and Minnow Environmental.

2.0 ENVIRONMENTAL SETTING

2.1 LOCATION

The Minto Mine is located adjacent and southwest of the Yukon River in the Central Yukon, roughly 45 km southwest of the Village of Pelly Crossing (Figure 1). The mine is situated within the Minto Creek drainage, which empties directly into the Yukon River.

2.2 DESCRIPTION OF STUDY AREAS

For the purpose of this report, information on fisheries and aquatic resources has been assembled from both the local and regional areas surrounding the Minto Mine site.

Regional Study Area

The regional area with respect to the Minto Mine includes the Yukon River in the vicinity of the project area, as well as smaller tributaries to the Yukon River, including 7 km upstream to Big Creek and 13 km downstream to Wolverine Creek.

Local Study Area

The local study area related to the Minto Mine centers on two small drainages in the mine area that drain directly to the Yukon River. The primary drainage is that of Minto Creek, which flows northeast from the existing mine site roughly 17 km to the Yukon River, and covers an area of roughly 41 km^2. The second drainage is that of an unnamed creek (referred to as Creek A herein) that flows to the north near the lower end of Minto Creek, and is crossed by the Minto Project access road.

3.0 FISH AND FISH HABITAT

3.1 CHRONOLOGY OF KEY STUDIES

Numerous studies on fisheries and fish habitat have been conducted over the recent history of the Minto Mine. These studies are summarized chronologically in Table 1, below.

TABLE 1. SUMMARY OF KEY FISH AND FISH HABITAT STUDIES, MINTO MINE

Year	Firm and Study Name	Scope of Studies
1994	Hallam Knight Piesold (HKP) – IEE for Minto Project Area	• Fisheries investigations on Minto Creek and Creek A. • Backpack electrofishing, minnow trapping. • Reach definition and description, identification of barriers to fish passage.
2006 – 2007	Access Consulting Group, R&D Environmental – Various Fisheries Investigations for Minto Explorations Ltd.	• Fisheries investigations in Minto Creek to support the permitting of the Minto Mine. • Backpack electrofishing, minnow trapping.
2008	Access Consulting Group, Minnow Environmental – EEM Program, Cycle 1	• Fisheries investigation of Minto Creek. • Backpack electrofishing and minnow trapping.
2009	Access Consulting Group – Fish Salvage Program	• Minnow trapping and transfer of fish to the Yukon River

3.1 REGIONAL OVERVIEW

3.1.1 Yukon River Fish and Fisheries

3.1.1.1 Fish Species

A variety of resident and migratory fish species inhabit the Yukon River in the vicinity of the Minto Mine. These include chinook, coho and chum salmon, lake trout, least cisco, Bering cisco, round whitefish, lake whitefish, inconnu, Arctic grayling, northern pike, burbot, longnose sucker and slimy sculpin. The scientific names and general life history descriptions for these species are attached in Appendix 1.

3.1.1.2 Local Habitat Use by Salmon

The Yukon River in the vicinity of the Minto Mine provides important salmon spawning and rearing areas. Spawning shoals are present in the Ingersoll Islands (downstream of the project area) and the islands upstream of the Minto Mine, near Big Creek. These offer an extensive network of side channels and sloughs which provide good spawning gravel. In support of this, spaghetti tags applied by DFO to fall Chum salmon were recovered in the area along the Yukon River between Minto and Fort Selkirk in 2008 (de Graff 2008).

The Yukon River in the project vicinity also provides rearing habitat for Chinook salmon, as evidenced by numerous studies in the project area tributaries. Juvenile Chinook salmon generally spend up to 1.5 years feeding and growing within fresh water tributaries prior to outmigrating to the ocean, and feed or stage in the Yukon river and its various tributaries during this protracted outmigration.

3.1.1.3 Trends in Yukon River Salmon Catch Records

Total catch data, including breakdowns of commercial and First Nations Harvest for both Chinook and Chum salmon in the Canadian portion of the Yukon River drainage (1970 to 2009) has been compiled using data from JTC (2010) (Figure 2a). Total harvest for these two species relative to spawning escapement (i.e. fish not harvested) is also presented in Figure 2b from 1982 (Chinook) and 1980 (Fall Chum) to 2009).

Chinook salmon catch was low through the 1970s, ranging from 5,000 to 10,000, and increased in the 1980s and early 1990s to levels ranging from 16,000 to 22,000. These catches remained relatively stable at these levels until 1998, when numbers dropped significantly and subsequently fluctuated between 4,000 and 12,500 until 2005. More recently, catches have remained below 5,000 with the discontinuation of most commercial fisheries since 2007.

Catches of Chum salmon have traditionally been more variable, but displayed a similar overall trend with increased effort in the early 1980s resulting in a larger recorded catch, and a drastic decrease in numbers beginning in 1997 and remaining low through 2009 (JTC 2010).

The cause of the 1997 to 1998 decrease in productivity is largely unknown, although it has been suggested that the Yukon River salmon run failures were in part caused by anomalous ocean conditions (Kruse 1998). In 2000, the Alaska Board of Fisheries (BOF) classified the Yukon River Chinook salmon stock as a stock of yield concern and a management action plan was developed (Howard et al. 2009). As a result, both Canadian and Alaskan Yukon River drainage Chinook salmon escapement goals have generally been met over the 2005 to 2009 period, particularly in 2005 and 2006 when runs were quite high (Bue & Hayes 2009; Howard et al. 2009). However, despite ongoing conservation measures, poor runs were observed from 2007 to 2009, especially for Canadian-origin stocks (Bue & Hayes, 2009; Howard et al. 2009). Summer and fall Chum salmon have been exhibiting steady improvements since 2001 and 2003, respectively (Bue & Hayes, 2009).

3.2 LOCAL FISH HABITAT INVESTIGATIONS

3.2.1 Methods

The primary fish habitat data collected for the Minto Mine area was acquired by HKP for the Initial Environmental Evaluation of the Minto Mine in 1994. During these studies, Minto Creek, McQuinty Creek, Creek A, and Dark Creek were all assessed (Figure 3), however only information for Minto Creek and Creek A are summarized in this report.

Each of the above watercourses was first traversed via helicopter to observe and record obstructions such as beaver dams, log jams or waterfalls, and to determine the biophysical homogeneity of the system so that reaches could be defined. General physical attributes of the individual reaches were later determined during fish assessments, and gradients for individual reaches are assumed to have been calculated from topographic maps. Stream-based habitat assessments and surveys were later also conducted in conjunction with fish presence assessments, in order to identify spawning, rearing and overwintering areas and barriers to fish migration.

3.2.2 Results

3.2.2.1 Minto Creek

Minto Creek originates at the Minto Mine site and flows northeast roughly 17 km before entering the Yukon River (Figure 3). The creek has five major tributaries which were designated as T1 through T5 by HKP (1994). The Minto Creek mainstem was described as having seven primary reaches. HKP's original reach descriptions have been transcribed, and are included in Appendix B with original photographs from the 1994 report. Reach breaks are also shown in Figure 3.

In Minto creek, Reach 1 leads upstream from the Yukon River confluence and is approximately 2 km in length with an average gradient of 1.7% and a wetted width of 3.3 m. Three habitat and fisheries sample sites were located in Reach 1: site 1 located 30 m upstream from the Yukon River confluence (Appendix B; Plate 1), site 2 located approximately 300 m upstream from the Yukon River confluence (Appendix B; Plate 2) and site 3 located at the upper reach break.

Reach 2 was approximately 2 km in length and had an average wetted width of 3 m. Within this reach, a steep canyon with a gradient 21% was noted.

Reach 3 was 4 km long, has an average gradient of 1.2% and an average wetted width of 3 m. This reach drains an area which had been severely burnt at the time, and had an abundance of debris that had accumulated in the creek mainstem.

Reach 4 was 2 km long and had an average gradient of 2%. The average wetted width was 3.0 m.

Reach 5 was 4 km in length, had a gradient of 3.5%, and a wetted width of 3.0 m. Two sample sites were established in Reach 5: site 1, located 1.8 km upstream of the reach break, and site 2 located 800 m downstream of site 1.

Reach 6 was 2 km long and had a gradient of 3.5% and average wetted width of 1.5 m.

Reach 7 contained the headwaters of Minto Creek, and had a length of approximately 1 km, and average gradient of 6.9%, and a wetted width of 1 m.

The surface water in Minto Creek has been noted to have a high sediment and organic load due to the fact that a large proportion of the watershed has been burned by forest fires in the recent past. The entire creek is ephemeral with no flows during the coldest winter period and therefore provides no overwintering fish habitat.

Based on an assessment of Minto Creek completed under the former Yukon Fisheries Protection Authorization (1988) the creek was been classified as Type II habitat, salmonid rearing stream. From an assessment of topographic maps and site habitat assessment, this Type II habitat is restricted to the lower 1.5 km of creek immediately upstream of the Yukon River. Steep gradients above this point prevent fish from further upstream migration. The possibility of overwintering habitat is questionable, as the creek freezes completely during the winter and no flows are present within the watershed. A survey of Minto Creek conducted by Environment Canada (1977) concluded that the absence of fish in the watershed was likely due to the intermittent nature of the creek. During that 1977 study, Minto Creek was classified as a salmonid rearing stream, and all previous fisheries investigations had confirmed that this habitat was found in the lower sections of that watercourse. It was also previously noted that a steep canyon 1.5 km upstream of the confluence with the Yukon River represented a barrier to fish migration. The effects of forest fire (reduced cover and substrate siltation) in the upper reaches of Minto Creek have also reduced the quality of the habitat upstream of the canyon. The ephemeral nature of the creek also prohibits overwintering of fish populations in the lower reaches of the creek (HKP 1994).

3.2.2.2 Creek A

Creek A is a small watercourse that drains an area adjacent to the Minto Mine access road and the Yukon River (Figure 3). The headwaters of Creek A originate approximately 4 km southeast of Minto Creek and flow for 7 km along a riparian floodplain into the Yukon River. This watercourse was defined as having two reaches when surveyed by HKP (1994). Reach 1 leads from the Yukon River confluence to roughly 3 km upstream, where another tributary joins from the northeast.

Reach 2 is roughly 4 km long, and flows through riparian floodplain. Two fish habitat sampling sites were established in Reach 1: site 1 located approximately 2 km upstream of the Yukon River confluence and site 2 located approximately 1.5 km downstream of site 1 (at the road crossing).

3.3 LOCAL FISH ASSESSMENTS

A number of fish assessment efforts have been undertaken on watercourses of the Minto Mine area between 1994 and 2009, and are tied to sampling efforts as outlined in Table 1.

3.3.1 1994 Baseline Studies

3.3.1.1 Methods

HKP performed basic fisheries investigations in 1994 at a selection of fish habitat sites described in section 3.3.2, above. These investigations took place from June 4 to 7, August 10 to 14, and September 13 to 15, 1994. At these times, a combination of multiple pass electrofishing and minnow trapping was conducted. Electrofishing was accomplished using a Smith Root Model 12 electrofisher, and electrofishing effort was recorded in seconds of current applied and area surveyed. Detailed methodologies are available in HKP (1994).

3.3.1.2 Results and Discussion

Minto Creek

A total of five sites in Minto Creek were assessed for the presence and abundance of fish in 1994, and detailed results outlining the timing, individual efforts, and numbers of fish captured are provided in Table 2 (attached). During the June 1994 surveys, only two slimy sculpin and one round whitefish were captured, at the most downstream site (Reach 1, Site 1). In August of 1994, slimy sculpin were again captured at the two most downstream sites (Reach 1, Sites 1 and 2), and two Arctic grayling were captured at Site 3 of Reach 1. Two Arctic grayling were again captured at Site 3 of Reach 1 in September. Of the Arctic grayling captured in Minto Creek during these studies, three were classified as being young of year (0+), while one was an adult. No speculation was made as to whether Minto creek was their natal stream.

The only other sampling locations for Minto Creek in 1994 were in Reach 5 (Sites 1 and 2), where no fish were captured.

At the time of the 1994 investigation, the Minto Creek valley below the canyon had not been burned by forest fire, so the creek cover (and consequent water temperatures/food source) and clean substrate in the area below the canyon provided good habitat for Arctic grayling. This area was part of a 1995 burn that impacted the majority of the watershed, resulting in a degradation of creek habitat primarily in the lower section, including reduced vegetative cover, a significant increase in LOD loading and increased siltation of downstream reaches.

Creek A

Two sites in Creek A were sampled during the 1994 studies; Site 1 of reach 1 in June, and Site 2 of Reach 1 in August and September. No fish were captured. Details regarding the efforts employed are summarized in Table 3, attached.

3.3.2 2006 / 2007 Fisheries Investigations

3.3.2.1 Methods

During late 2006 and the summer of 2007, R&D Environmental performed fisheries investigations in Minto Creek as part of the permitting process for the Minto Mine. These studies entailed electrofishing and minnow trapping, and efforts were all focused in Reach 1 of the creek through June and August of 2007, and September of both years.

3.3.2.2 Results and Discussion

During the 2006/2007 studies of Minto Creek, juvenile Chinook salmon, Arctic grayling, and slimy sculpin were captured. Details are provided below, and overall details regarding specific effort levels are provided in Table 2, attached.

During spring assessments in May and June of 2007, 36 juvenile Chinook salmon and six slimy sculpin were captured through minnow trapping. The majority of Chinook captured were at a site roughly 1 km upstream of the Yukon River confluence.

In August of 2007, the only fish species captured were young of year Chinook salmon at the mouth of Minto Creek in the upper reach of the flood zone (backwater) of the Yukon River, a single Arctic grayling, and slimy sculpin in the same location and further upstream in the vicinity of the road crossing and culvert. Sculpin were only captured in the June and August 2007 sampling events.

29 Chinook salmon were captured through minnow trapping efforts in September of 2007.

Changes in stream features and the expected changes in fish usage were confirmed by fisheries investigations in 2006 and 2007. Catches and catch per unit effort (CPUE) have been low in all fish studies conducted on Minto Creek between 1994 and 2007 (Table 2, attached). Significant effort in both trapping and electrofishing has returned very few individuals, most notably in the surveys of 2006 and 2007.

In addition, there is little consistency in presence of species in the lower reaches of Minto Creek, suggesting the lack of a significant resident fish population. The morphological changes related to forest fire activity in the Minto Creek basin have likely contributed to fish population changes since the initial surveys of 1994. Low or no flow conditions in the lower reaches of Minto Creek likely also prevents the establishment of resident fish populations in this section of the stream.

3.3.3 2008 Fish Sample Collection

3.3.3.1 Methods

In accordance with the approved study design of the Cycle 1 EEM Program, a fish population survey was undertaken in lower Minto Creek in June and September of 2008. During that study, fish communities of Minto Creek were sampled by backpack electrofishing and minnow trapping from June 26 to 27 2008, and from September 9 to 11 2008. All fishing was conducted under a "Licence to Collect Fish for Scientific, Educational or Public Display Purposes" (Permit #CL-08-22). Electrofishing was conducted as a combination of both closed station (quantitative) and open station electrofishing, and minnow trapping was conducted using standard Gee traps baited with salmon roe. Detailed information regarding sampling details is available in the EEM Interpretive Report (Minnow/Access 2009).

3.3.3.2 Results and Discussion

No fish were captured during the June sampling event, despite electrofishing effort of 393 seconds of applied current and coverage of approximately 289 m^2 of lower Minto Creek. Ten trap-days of minnow trapping effort were also applied (Table 4). Juvenile Chinook salmon were the only fish captured in September 2008 and were found in low abundance. Backpack electrofishing yielded one fish (observed and shocked but not captured) in 403 seconds of applied current and coverage of approximately 340 m^2. Minnow trapping in September yielded a total of 17 juvenile Chinook salmon in a total effort of 18.6 minnow trap-days. It should be noted that the spatial coverage of fishing in June and September represents approximately 40% of the area of lower Minto Creek downstream of an observed fish barrier that is believed to prohibit fish passage to upper Minto Creek.

As a result of the low catches in Minto Creek, the decision to not sample the allocated reference stream was made.

TABLE 4. SUMMARY OF FISH ASSESSMENT EFFORT AND DATA FROM THE 2008 EEM CYCLE 1 PROGRAM

Period	Method	Effort[1]	Summary Statistic	Units	Juvenile Chinook Salmon
June	Backpack Electrofishing	393 s 289 m^2	Catch	#	0
			CPUE[2]	fish/min	0.00
			CPUA[3]	fish/100 m^2	0.00
	Baited Gee Minnow Trapping	10 days	Catch	#	0
			CPUE[2]	fish/day	0.00
September	Backpack Electrofishing	403 s 340 m^2	Catch[4]	#	1
			CPUE[2]	fish/min	0.15
			CPUA[3]	fish/100 m^2	0.74
	Baited Gee Minnow Trapping	18.6 days	Catch	#	17
			CPUE[2]	fish/day	0.91

[1] Effort refers to number of minutes electrofishing current was applied to the water.
[2] Catch-per-unit-effort represented in specified units.
[3] Catch-per-unit-area represented in specified units.
[4] In the September electrofishing, one fish was observed and electroshocked but not captured.

Both the absence of Chinook salmon in June and their presence in low abundance later in the summer are supported by both the scientific knowledge of Chinook salmon life history and the documented physical characteristics of Minto Creek. Briefly, Chinook salmon spawn in the fall, preferentially in larger streams, but also in river mainstems and small streams (Eiler et al. 2004, 2006; McPhail 2007). They typically prefer faster water and coarser spawning substrate than other salmon, and require well oxygenated sub-gravel water flow (McPhail 2007). Minto Creek does not provide preferred spawning habitat and becomes completely glaciated (covered with aufeis (layered ice)) in the winter and therefore provides no suitable over-wintering habitat for eggs, fry, or juveniles. Accordingly, there is no evidence of spawning into Minto Creek (HKP 1994, R&D 2006 and 2007), nor is there traditional knowledge of spawning in Minto Creek (HKP 1994). Thus, use of Minto Creek by Chinook salmon appears to be limited to transient use by out-migrating young of year whose natal streams are tributaries of the Yukon River upstream of Minto Creek. Juvenile Chinook of the Yukon River drainage typically emerge in spring and early summer (e.g., mid-May) and enter non-natal tributaries (such as Minto Creek) in late June following temperature equilibration of the river and tributaries (Bradford et al. 2001). This is supported by the findings of this study. Use of non-natal streams may be saltatory, with fish stopping in suitable feeding areas as they move downstream (Bradford et al. 2001). There is little information in the scientific literature on the duration of saltatory use of creeks although it appears that this use can range from days (e.g., Scrivener et al. 1994) to complete over-wintering (Bradford et al. 2001). Because over-wintering appears not to occur in Minto Creek, use of the creek by out-migrating juvenile Chinook salmon is likely of short duration and is often restricted by the drying of lower Minto Creek in summer months.

Based on this information, the EEM program interpretation concluded that out-migrating juvenile Chinook salmon are not exposed to mine effluent for significant periods of time, nor are they distinct from out-migrating Chinook salmon temporarily populating other regional creeks draining into the Yukon River.

Juvenile Chinook salmon captured in lower Minto Creek in September 2008 were of similar size (mean fork length of 76 ± mm). This is consistent with the expectation that all of the juvenile Chinook were of the same out-migrating cohort (of 2008 hatches, spawned in 2007). Due to the timing of the catches and the size of the fish, the captured juvenile Chinook were all likely young-of-the-year (YOY; i.e., 0+ fish). Specifically, although YOY can over-winter in the Yukon River and some tributaries, all 1+ fish are out of the upper areas by June (e.g., Duncan & Bradford 2004). As previously indicated, the water of Minto Creek is much colder in June than that of the Yukon River, so use of Minto Creek by 1+ fish would not be expected at that time of year. This was generally confirmed by the fact that no fish were captured in June 2008.

In summary, the fish survey implemented in 2008 under the EEM indicated and confirmed that Minto Creek is not used by fish in June and was used by very small numbers of juvenile Chinook salmon in September. The juvenile Chinook salmon captured in Minto Creek in August were out-migrating 0+ fish, which use Minto Creek and other creeks flowing into the Yukon River transiently, so exposure to Minto Creek likely occurs only for very short periods.

3.3.4 2009 Fish Sample Collection

3.3.4.1 Methods

During work by ACG at the Minto Mine site during the summer of 2009, efforts to again determine the use of Minto Creek by fish were undertaken. On June 25 and 26 of that year, a total of 6 minnow traps were fished in Minto Creek for 24 hours (3 upstream and 3 downstream of the culvert at the road crossing). In July of 2009, an additional trapping session of 10 trap days was undertaken during an emergency release of water from the Minto Mine.

3.3.4.2 Results and Discussion

During June sampling in 2009, no fish were captured in Minto Creek (Table 5). In contrast, 142 fish were captured during the sampling event in late July, with only a 60% increase in sampling effort (Table 5). No other sampling event to date had yielded such a high catch per unit effort (CPUE). In fact, the CPUE for this event was at least an order of magnitude higher than any previous sampling event.

As noted, this July sampling occurred while MintoEx was conducting an emergency release of water from the mine site, which resulted in stable, high flow conditions in lower Minto Creek. It is believed that this stable elevated flow and warmer, more consistent temperature regime (i.e., less diurnal temperature fluctuation) may have attracted juvenile Chinook salmon into the system from the Yukon River.

TABLE 5. SUMMARY OF FISH ASSESSMENT EFFORT AND DATA FROM JUNE AND JULY 2009 EFFORTS

Period	Method	Effort	Summary Statistic	Units	Juvenile Chinook Salmon	Slimy Sculpin
June	Baited Gee Minnow Trapping	6 Days	CPUE	#	0	0
				Fish/day	0	0
July	Baited Gee Minnow Trapping	10 Days	CPUE	#	136	6
				Fish/day	13.6	0.6

3.3.5 Fish Relocation Program

3.3.5.1 Methods

Under the assumption that increased flows from Minto Creek resulting from the emergency water discharge during the summer/fall of 2009 was attracting juvenile Chinook salmon into that watercourse and the fact that the discharge was to occur until late October, Fisheries and Oceans Canada (DFO) identified the potential that many of the fish could get stranded once the discharge ended and the creek freezes. Therefore DFO recommended that MintoEx conduct a program to capture and relocate fish from lower Minto Creek to another open system. MintoEx, working with their consultants, executed this program from September 29 to October 14, 2009. The program also involved establishing a temporary fish barrier on Minto Creek near the Yukon River in order to prevent additional recruitment of fish into the system.

3.3.6 Results

During the relocation program a total of 986 juvenile Chinook salmon were captured and released into the Yukon River and/or Big Creek. This included 822 Chinook salmon in 114 traps set from September 30 to October 2, 2009, and 165 Chinook salmon in 66 traps set from October 12 to 14, 2009. In addition to the salmon only one sculpin and one juvenile burbot were caught. A natural upstream fish barrier was identified during the program and confirmed by zero fish captured in traps set upstream. Fish capture and relocation continued until CPUE dropped well below 10% of the CPUE established during the first day of capture. A detailed summary of the fish relocation program is attached to this report as Appendix C.

3.4 FISH USAGE AND TRADITIONAL KNOWLEDGE SURVEYS

3.4.1 1994 Fish Tissue Analysis

There is no known documentation or instance of any human use of fish from Minto Creek as a food source. Accordingly, there is only one documented instance of fish tissue analysis from populations in Minto Creek (HKP, 1994). The highest copper, mercury and zinc concentrations from this study were detected in Arctic grayling muscle tissue from the mouth of McQuinty Creek (which was used as a reference during HKP's 1994 study), and the highest arsenic concentrations were observed in slimy sculpins from the mouth of Minto Creek. Arsenic and zinc concentrations in Minto Creek grayling muscle tissue may not be representative of site-specific values due to the transient nature of the grayling in the lower reaches of Minto Creek (HKP, 1994).

3.4.2 1999 First Nations Interview (Pelly Crossing)

An interview was conducted with 12 members of the Selkirk First Nation residing in Pelly Crossing from November 25 to 30, 1999. Each person was provided with a brief background of the project and then asked to answer a series of questions. The purpose of this questionnaire was to integrate local knowledge into MintoEx's understanding of the local environment and to help document environmental conditions in the project area. The key fisheries-related information acquired during these interviews is summarized below, and the interview details have been included in Appendix D:

- All interviewees have fished within their traditional territory in the Minto Mine area;
- The fishing area considered most important is the stretch from Minto to Fort Selkirk on the Yukon River, including the creek mouths in this region;
- Minto Landing is fished for grayling, spring salmon and dog salmon (chum salmon) from May to November with rod and reel, stickline hook and net; Ft. Selkirk is fished for whitefish and salmon from May to November using the net and stick method; Carpenter Slough is fished for whitefish and salmon from July to November with nets;

and the Yukon River area is fished for grayling, whitefish and pike from July to November with nets;

- Known spawning locations are Big Creek for Chinook salmon (King, Spring), Chum salmon (Dog), and Arctic grayling; the Yukon River for burbot, inconnu, lake whitefish, longnose sucker, mountain whitefish, and northern pike; and Slough Creek for lake whitefish, longnose sucker and northern pike;
- Most of the interviewees noticed that over the years, fish populations have grown smaller and runs are taking place later, and one participant also noted that fish body size was getting smaller;
- Table 6 outlines the answers of interviewees when questioned about the quality of fish caught in the river or tributaries and if they had noticed any changes.

TABLE 6: SELKIRK FIRST NATION SUMMARY OF YUKON RIVER SYSTEM FISH QUALITY (1999)

Species	Fish Quality (Number of Answers)
Whitefish	Less fat (2)
King Salmon	100% good (6) 25% soft and deformed (7) 75%-85% good (4)
Dog Salmon	100% good (4) 70-80% good (8) 25% soft and deformed (4) 35% less fat (1)
Inconnu	Small (4) Soft (1)
Grayling	Small (7) Not so fat (9) Some not so fat (2)

4.0 AQUATIC ENVIRONMENT

4.1 STREAM SEDIMENT ANALYSES

4.1.1 Chronology of Key Studies

Stream sediments have been monitored for relevant metals, physical properties, and particle size distribution in several key studies from 1994 to present, as summarized in Table 7, below.

TABLE 7. SUMMARY OF KEY SEDIMENT MONITORING STUDIES, MINTO MINE		
Year	Firm and Study Name	Scope of Studies
1994	Hallam Knight Piesold (HKP) – IEE for Minto Creek	• Sediment collection and analysis from four sites.
2006-2009	Access Consulting Group and Minnow Environmental	• Stream sediment sampling and analysis under terms of Water Use License.

4.1.2 1994 Baseline Study Program

4.1.2.1 Methods

Baseline sediment quality data was first collected during the original Minto Mine baseline studies, prior to the initiation of mine operations (HKP 1994). During this study, triplicate samples of fine sediments were collected at four locations within the Minto Creek mainstem. Three of the sampling locations corresponded to water sampling stations W9 (S1), W3 (S2), and W2 (S4) and the other was situated at the junction of Minto Creek and the tributary where sampling site W6 is located (S3; approx. 100 m downstream of W6) (Figure 5).

These 1994 samples were sent to Analytical Services Laboratories (ASL) Ltd. for analysis of moisture, total metals and grain size. Metals analysed included antimony, arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, silver and zinc. Metal determination was conducted through hydride vapour atomic absorption spectrophotometry (HVAAS) for antimony and either atomic absorption spectrophotometry (AAS) or atomic emission spectrophotometry (ICP) for the other metals. As chromium and molybdenum are often associated with the silicate matrix of the sediment, the recovery of these elements may have been low using the specified digestion. However, since available metals are considered most important, from an environmental standpoint this is not typically an area of concern (ASL 1994).

4.1.2.2 Results

A summary of results from the 1994 baseline stream sediment analysis are presented in Table 8 (all results detailed in Appendix E). At this time, prior to the commencement of mine operations, sediments in Minto creek were composed mostly of sand, with some gravel and minimal fractions of silt and clay. Levels of antimony, cadmium, mercury, molybdenum and silver were low at all sites. Levels of arsenic were extremely high, with a maximum level detected at site S4 (W2), at the bottom of the Minto Creek watershed. Levels of chromium and zinc were highest at site S3 (approx. 100 m downstream of W6), with average values of 23.3 mg/kg and 48.53 mg/kg, respectively. Copper levels were extremely elevated at site S1 (W9) in the vicinity of the deposit.

TABLE 8: BASELINE STREAM SEDIMENT RESULTS (HKP, 1994)

Analysis	Sampling Station			
	S1 (W9)	S2 (W3)	S3 (~100m d/s W6)	S4 (W2)
	Average	Average	Average	Average
Physical Tests:				
Moisture %	25.23	21.70	24.10	18.47
Total Metals*				
Antimony	0.36	0.42	0.44	0.29
Arsenic	4.07	4.37	4.22	4.44
Cadmium	0.07	0.13	0.00	0.00
Chromium	17.20	22.13	23.30	14.03
Copper	102.80	48.27	40.47	13.80
Lead	3.37	3.93	3.83	1.60
Mercury	0.02	0.01	0.01	0.01
Molybdenum	0.00	0.00	0.00	0.00
Silver	0.00	0.00	0.00	0.00
Zinc	35.73	47.80	48.53	29.43
Particle Size				
Gravel - % (>2.00 mm)	9.24	4.90	1.75	28.83
Sand - % (2.00 – 0.063 mm)	72.17	75.20	77.87	62.63
Silt - % (0.063 mm - 4 µm)	14.07	13.93	14.10	6.63
Clay - % (< 4 µm)	4.55	5.98	6.31	1.89

* Results are expressed as milligram per dry kilogram

Adapted from Table 5.9 in MintoEx's IEE (1994)

4.1.3 2006 – 2009 Sediment Monitoring Program

4.1.3.1 Methods

Under the terms of MintoEx's current Water Licence (QZ96-006), sediment monitoring has been required on an annual basis, during July/August. To date, the Minto Mine has collected sediment samples in Minto Creek and tributaries on four occasions since the commencement of mine operations (2006-2009). On all occasions, sediment samples were collected from two locations exposed to mine effluent in the Minto Creek (Stations W2 and W3; Figure 5) and two reference stations located on tributaries to Minto Creek (Stations W6 and W7; Figure 5).

For each sampling effort, sediment samples were collected according to a standard methodology, as described below:

- Samples were collected using an aluminum scoop and deposited into laboratory supplied, clear plastic bags;
- Samples were kept under refrigeration and forwarded to an analytical laboratory for analysis;
- In the laboratory, samples were dried and screened using stainless steel sieves at ASTM mesh number 10, 20, 40, 60, 100, 140 and 270, after which fraction weights were recorded;
- A minus 230-mesh sieve sub-sample was analyzed for 33-element ultra trace ICP and loss-on-ignition (LOI) was determined by heating the sample to 600°C; and,
- Routine water quality samples were collected concurrently with sediment samples (not included in this report).

4.1.3.2 Results and Discussion

Across all four years of sampling, sands were dominant at nearly all stations (Table 9; Figure 6; Appendix E). Fine particles (silts and clays) were present at low proportions (0.1% to 26%) and were notably less abundant in 2008 and 2009 than in previous years (Table 9; Figure 6), possibly due to increased flows associated with both high precipitation and mine water discharge. Generally, metal concentrations tend to be greater in fine sediments due to the high surface area and chemical complexity of small particles (e.g., Horowitz and Elrick, 1987), however the potential result of this on Minto samples was not investigated.

Comparison of sediment quality data collected in 2006-2009 to earlier baseline data (1994) indicated that concentrations of copper and zinc at Station W3 (upper Minto Creek) were significantly greater in 2006 to 2009 compared to earlier data (Appendix E). Also levels of lead and mercury were higher in most samples relative to baseline, despite lower proportions of silt and clay in recent samples. (Appendix E). At Station W2 (lower Minto Creek), concentrations of chromium, copper and zinc were significantly greater in every year from 2006 to 2009 than in 1994 (Appendix E). Concentrations of lead were higher in most, but not all, operational years relative to baseline (Appendix E). Lastly, it is notable that the proportion of silt/clay was significantly greater in 2007 than baseline, whereas it was significantly lower in all other years than in baseline (Appendix E). This indicates that sediments collected in 2007 were physically different than in other years, which should be considered in data interpretation.

Comparison of mean sediment quality against Canadian Environmental Quality Guidelines (CEQG; CCME 1999) indicated that arsenic, chromium and copper were the only parameters with concentrations greater than national Interim Sediment Quality Guidelines (ISQG; Table 9; Appendix E). The ISQG are "threshold effect levels" below which adverse effects are expected to rarely occur (CCME 1999). In the case of both chromium and copper, rare exceedences of Probable Effect Levels (PEL; CCME 1999) were also observed (Table 9; Appendix E). The PEL defines the level above which adverse effects are expected to occur frequently (CCME 1999). Subsequent interpretation of the sediment quality of Minto Creek is largely focused on the parameters that have exceeded ISQG (i.e., arsenic, chromium and copper).

Arsenic

Mean sediment arsenic concentrations ranged from 2.5 to 6.9 mg/kg, with three instances of mean concentration greater than the ISQG of 5.9 mg/kg (Table 9). Two of the three instances of concentrations greater than the ISQG occurred at Station W6, a reference site that is not exposed to mine effluent. Furthermore, concentrations of arsenic at exposed areas (Stations W2 and W3) were not significantly greater than at Station W6 in any year (Figure 7a). Lastly, there was no consistent difference from baseline (Appendix E), nor any evidence of temporal increase in arsenic concentrations at any of the monitored stations (Figure 7b). Accordingly, available data indicate that the Minto Mine has not influenced arsenic concentrations in Minto Creek sediments.

Chromium

Mean sediment chromium concentrations ranged from 14 to 157 mg/kg, with three instances of mean concentration marginally greater than the ISQG of 37 mg/kg and one of mean concentration greater than the PEL of 90 mg/kg (Table 9). All elevations above ISQG occurred in 2008 and 2009 (Table 9 and Figure 8), despite the lowest percentages of silt and clay (Figure 6). The most substantial elevation in chromium was observed at Station W2 (lower Minto Creek) in 2008, when average chromium concentration was 157 mg/kg. This concentration was significantly greater than at all other monitored stations (Figure 8a) and was significantly greater than previously observed at the same station (Figure 8b), both of which suggest that the elevated concentration may be mine-related. It is also notable that the concentrations of a number of other parameters were highest at Station W2 in 2008 (i.e., antimony, arsenic, cobalt, magnesium, manganese, molybdenum, nickel, phosphorus, selenium, and sodium). Because many of these metals are moderately elevated in Minto Mine effluent (e.g., Minnow/Access 2009), this further supports a mine-related influence. In 2009, concentrations of chromium at Stations W3, W2 and W6 were elevated relative to the ISQG (but not PEL; Table 9; Figure 8). Concentrations at both exposed stations (Stations W3 and W2) were significantly greater than at the reference stations (Figure 8a) and were significantly greater in 2009 than in 1994 through 2007 (Figure 8b). Overall, the available data suggest that the Minto Mine has influenced chromium concentrations in Minto Creek sediments, occasionally to levels that could be associated with adverse biological effects.

Copper

Mean sediment copper concentrations ranged from 14 to 248 mg/kg, with numerous instances of mean concentration greater than the ISQG of 36 mg/kg in both exposed and reference areas and during baseline (Table 9). In addition, the average sediment copper concentration at Station W6 (reference) exceeded the PEL of 197 mg/kg in 2009 (Table 9). In general, exceedence of ISQG was more common in the exposed areas than in the reference areas (8 of 9 instances; Table 9) and copper concentrations were significantly greater in exposed areas than in reference areas in 2006, 2007, and 2008 (Figure 9a). Despite the fact that sediment copper concentrations were significantly greater in 2006 to 2009 than baseline (1994), there is no evidence of a consistent trend of increasing concentrations over time (Figure 9b). Furthermore, exceedance of ISQG during baseline and the fact that the highest observed concentration was observed at a reference station suggest that sediment copper concentrations are naturally high and that natural variability, not a mine-related influence, may account for observed concentrations. Overall, the Minto Mine appears to have had some influence on the sediment copper concentrations in Minto Creek, but the influence appears to be within the range of natural concentrations.

4.1.3.3 General Discussion of Sediment Quality Data

In summary, there is some evidence that the Minto Mine has had an influence on the sediment concentrations of a number of parameters in both upper and lower Minto Creek (particularly chromium, copper, lead, and zinc). However, only three parameters (arsenic, chromium, and copper) have been observed above sediment quality guidelines for the protection of aquatic life. In the case of arsenic, there is no evidence that mine activities have influenced sediment concentrations. In the case of chromium, there is evidence of greater concentration at exposed areas than at reference areas and of an increase over time. In the case of copper, the evidence was less definitive, with some indication of greater concentration at exposed areas than at reference areas tempered by the fact that the highest concentration observed was at a reference area (in 2009) and that there is no evidence of a consistent trend of increasing concentrations of sediment copper over time. The observed mine-related exceedances of sediment quality guidelines for the protection of aquatic life (chromium and copper) suggest a potential for adverse effect, but are not indicative of adverse effect, particularly in a highly mineralized area with naturally high concentrations of these metals (Prairie & McKee 1994; see Minnow 2009 for evidence of similar exceedences in water). Assessment of the actual implications of mine-influenced sediment chemistry should rely on biological monitoring of benthic invertebrate community condition (currently conducted as a requirement of the Minto Mine Water Use License [WUL] and federal Environment Effects Monitoring [EEM]).

In reviewing the available sediment quality data from 2006 to 2009, several opportunities to improve the study design became apparent. Firstly, the current design is focused on small sampling stations (e.g., single pools within the creek), with "replicates" being repeated grabs from the same station. To infer potential influences on sediment quality of an area (e.g., lower Minto Creek); it would be preferable for the replicates be taken from separate stations (e.g., pools) within the area. Secondly, total organic carbon should be included as an analyte in all sediment collections due its importance in influencing trace element chemistry by binding and concentrating trace elements (e.g., Horowitz & Elrick 1987; Sposito 1987).

Thirdly, the requirement for collecting sediments concurrently with benthic invertebrates during EEM sampling will in the future provide concurrent data that could be used to link observed sediment chemistry and the condition of benthic invertebrate communities. Without concurrent biological data, the biological implications of elevated sediment metal concentrations cannot be determined.

4.2 BENTHIC MACROINVERTEBRATE MONITORING PROGRAM

Benthic macroinvertebrates are non-backboned animals inhabiting the bottom substrates of aquatic habitats. Along with being the most important primary consumers in stream ecosystems, they are a key source of food for fish and a key energy link between trophic levels. The abundance and diversity of benthos can be used as indicators of changing environmental conditions as their distribution and abundance can be influenced by a wide variety of physical parameters such as hydrology, substrate composition, metal concentrations, water temperatures, dissolved oxygen, pH, salinity, and sediment C/N ratios. The benthic communities that develop are an indication of the ability of the various species to adapt to particular environments.

4.2.1 Chronology of Key Efforts

Benthic invertebrate sampling has been undertaken in the Minto Mine area in the following projects (Table 10):

TABLE 10. SUMMARY OF KEY BENTHIC MACROINVERTEBRATE MONITORING STUDIES, MINTO MINE

Year	Firm and Study Name	Scope of Studies
1994	Hallam Knight Piesold (HKP) – IEE for Minto Creek	• Collection of benthic samples at 6 sites in Minto Creek in conjunction with baseline studies.
2006	Access Consulting Group	• Collection of benthic invertebrate samples under the terms of the water use license.
2008	Minnow Environmental	• Collection of benthic invertebrate samples under the terms of the water use license.
2008	Minnow Environmental	• Collection of benthic samples as part of the EEM, Cycle 1 program

4.2.2 1994 Baseline Study Program

4.2.2.1 Methods – 1994 Baseline Study Program

As part of the original baseline studies at the Minto Mine Site in 1994, triplicate benthic macroinvertebrate samples were collected at six sites in the Minto Creek watershed in late August. Samples were collected using a modified Hess sampler (42 cm high x 35 cm diameter, 250 µm mesh). Samples were preserved in 10% formalin with Rose Bengal stain and shipped to Dr. Charles Low for taxonomic analysis and identification. Three of the six sites sampled in this program overlap with sites sampled during the 2006 water license sampling program (described below).

4.2.2.2 Methods – 2006 Water Use License Sampling Program

Under the terms of MintoEx's Water Use License #QZ06-006, benthic macroinvertebrate communities were required to be routinely monitored in Minto Creek. This sampling included Upper Minto Creek (Station W2) and two tributaries uninfluenced by mine effluent discharge (Stations W6 and W7; Figure 5). Under the terms of that water license, samples were to be collected bi-annually, and under the Metal Mining Effluent Regulations (MMER), further sampling was required in conjunction with EEM studies (outlined below).

During the 2006 macroinvertebrate sampling program, samples were collected at each of the three sites noted above using a 200 μm mesh Surber Sampler.

4.2.2.3 Results – 1994 Baseline Study and 2006 Water Use Licence Program

Data from both the 1994 and 2006 sampling efforts in Minto Creek were tabulated into similar formats and are presented below in Table 11. It is recognized that sampling devices used in each study were different, and this data is not intended to be compared directly. A representative list of all benthic invertebrates captured during the 1994 sampling event can be found in Appendix F.

TABLE 11. SUMMARY OF BENTHIC INVERTEBRATE DATA COLLECTED IN 1994 AND 2006

	W2		W3		W7	
	2006	1994	2006	1994	2006	1994
Density (m^2)	10,018	9,327	2,070	2,637	2,379	20,140
Diversity	32	43	33	38	19	34
EPT Index	4	7	6	6	5	6
Richness Index	3.9	5.3	5.0	5.6	3.3	3.8
% sensitive	3.7	37.4	44.4	49.4	44.8	71.8
% facultative	88.7	62.2	53.6	44.5	22.6	23.2
% tolerant	7.5	0.4	2.1	6.1	32.6	5.0

Only relative comparisons are possible between 1994 and 2006 data sets. Also, 1994 figures are based on triplicate samples whereas the 2006 data are based on a single sample only.

4.2.2.4 Methods – 2008 Water Use License Sampling Program

In 2008, Minnow Environmental assisted ACG in implementing the benthic invertebrate community component of the Water Use License monitoring program with the objective of characterizing current biological conditions at previously established monitoring stations

W2, W7 and W6. A two-grab composite sample was collected at each sample site with a Hess sampler (0.1 m^2) outfitted with 250 μm mesh.

4.2.2.5 Results – 2008 Water Use License Sampling Program

Based on the 2008 Water Use License sampling data, benthic invertebrate taxon richness and density ranged from 12 to 17 taxa and from 350 to 5,445 organisms per m^2, respectively, at the monitoring stations sampled (Figure 10). Both taxon richness and density were highest at main stem Minto Creek Station W2, and lowest at the south-flowing tributary Station W6. The Simpson's Evenness Index calculated for the three sites were similar between the three sites, although several taxonomically related trends in data were observed.

Dominant/indicator taxon groups were defined as those groups representing greater than roughly 5% of total organism abundance. In the 2006 WUL data, dominant taxon groups identified included chironomids, ephemeropterans/plecopterans (mayflies/stone flies), oligochaetes (segmented aquatic worms) and nematans (non-segmented aquatic roundworms). Chironomids include a highly diverse, ubiquitous group that exhibit a wide range of sensitivities to various chemical stressors, but in general are considered tolerant of contaminant inputs (e.g., Taylor & Bailey 1999). Chironomids were observed to be higher in relative abundance at site W2 (treatement) as compared to the two reference sites in 2006. Mayfly and stonefly taxa exhibit a broad range of habitat requirements and sensitivities to various metal and/or organic enrichment sources, but in general are considered sensitive to contaminant inputs (Rosenberg and Resh 1993; Taylor and Bailey 1999). In 2008, both W2 (treatment) and the W7 reference site were found to have lower mayfly and stonefly compositions compared with the W6 reference site. Finally, aquatic oligochaetes and nematans are typically considered highly tolerant of low oxygen environments characteristic of organic- and/or nutrient-enriched (i.e., eutrophic) environments (Pennak 1978). Although oligochaetes can show variable sensitivity to metals (e.g., Malueg et al. 1984; Wiederholm et al. 1987), they are generally considered relatively tolerant to high metal concentrations (Chapman et al. 1982a,b). Therefore, a proportionately higher abundance of this taxon group may be indicative of poor environmental conditions. Oligochaetes were found to occur more abundantly in two reference sites compared to W2 (treatment), while nematans were less abundant in reference site W6 in comparison with W2 and W7.

As a similar sampling technique was used in 2008 compared with earlier 1994 baseline data, some direct comparisons of metrics were possible between these two sampling periods (Figure 11). Generally, benthic invertebrate communities sampled in 2008 were found to have lower taxon richness, lower total organism densities and a lower relative abundance of sensitive mayfly/stonefly groups in 2008 compared to 1994 (pre-operational) data at main-stem Station W2 and north-flowing tributary Station W7. In addition, the relative abundance of more tolerant taxon groups, including chironomids and oligochaetes, was higher at these stations over this same time period. Results of this investigation are presented below (Figure 11) and a representative list of all species collected at the three stations can be found in Appendix F.

Based on the results of the 2008 WUL invertebrate sampling program, is was difficult to draw conclusions regarding the extent of potential effects on the aquatic environment as a result of the Minto Mine operations. Several fundamental differences in the physical characteristics of effluent-exposed and reference stations were noted, and are believed to result in differences between reference sites W6 and W7 as noted above. In the treatment site, a high taxon richness and Simpson's Evenness Index suggested a somewhat stable aquatic habitat, however the observation of a low taxon richness compared to other second order streams, a relatively high abundance of taxa considered tolerant of environmental disturbance and a relatively low proportion of metal sensitive (mayfly/stonefly) taxa in Minto Creek compared to reference did suggest subtle mine-related effects. It could not be determined whether these effect could be caused secondarily through habitat changes, or whether the noted differences in benthic invertebrate community composition were due to physical habitat variability among sites.

TABLE 12: SUMMARY OF SUPPORTING MEASURES COLLECTED DURING 2008 BENTHIC INVERTEBRATE SAMPLING

Observation	Station		
	W2 Effluent-Exposed	W6 Reference	W7 Reference
GPS Coordinates	62° 39' 04" N 137° 05' 45.5" W	62° 37' 55.7" N 137° 11' 34.7" W	62° 37' 40.4" N 137° 11' 34.0" W
Location Description	Lower Minto Creek, approximately 100 m upstream of confluence with Yukon River	South-flowing tributary to Minto Creek	North-flowing tributary to Minto Creek
Habitat Description	Substrate predominantly sandy with cobble observed at fast flowing areas; moderate flow at time of sampling	Tributary dominated by sand substrate. Found only one sampling location containing cobbler at cascade area; low flow at time of sampling	Tributary dominated by sand substrate. Few areas with cobble of marginal quality for sampling; low flow at time of sampling.
Temperature (°C)	5.82	3.03	4.17
Dissolved Oxygen (mg/L)	10.79	11.73	11.06
Dissolved Oxygen (% Saturation)	86	87	85
pH (units)	8.09	7.51	7.51
Specific Conductance (μS/cm)	263	143	133
Redox (mV)	122	97	90
Sampling Water Velocity (m/s)	0.50	0.20	0.24
Sampling Depth (cm)	21	15	18

4.2.3 Benthic Invertebrate Sampling under MMER

Concurrent with the 2008 WUL macroinvertebrate sampling program was sampling for MintoEx's Environmental Effects Monitoring (EEM) program under MMER. This rigorously designed sampling program was conducted to determine potential effects of the mine operations, and the *First Interpretive Report for Cycle 1*, as required under MMER for the mine, was completed and submitted to Environment Canada in January 2009. This report details an additional benthic invertebrate study conducted during 2008 following the MMER – EEM protocols. These collections did, however, occur approximately two weeks into an emergency water release that was being conducted by the mine following an exceptionally wet summer and rainfall event that occurred late August 2008.

4.2.3.1 Methods

The 2008 EEM sampling program used a comparative approach between Minto Creek and McQuinty Creek which is located to the North (as a reference site, shown in Figure 3). Samples were collected on September 9 and 10, 2008 using a 0.1 m^2 Hess Sampler with 250 µm mesh. At each (treatment and reference) site, five individual samples were collected, and targeted cobble substrates with a target of 3 bankfull widths of distance between samples. Each sample consisted of three composite sub-samples (0.3 m^2 total area). Substrate penetration with the Hess sampler was targeted at 10-15 cm, and samples were preserved within six hours in 10% buffered formalin solution. Invertebrate taxonomic analysis was conducted by Zarenko Environmental Assessment Services, and quality control re-identification for QA/QC purposes was conducted by Bill Mortoon of Invertebrate Taxonomic Services.

4.2.3.2 Results

Basic results of the 2008 EEM benthic analyses indicated that Minto Creek (treatment) had a significantly higher invertebrate density and slightly lower number of taxa (not significant) compared to McQuinty Creek. The mean abundance of oligochaetes was higher in Minto Creek, while the mean abundance of Ephemeroptera, Plecoptera, and Trichoptera (EPT) and chironomids were higher in McQuinty Creek. Basic metrics are provided in Table 13, while raw invertebrate data is provide in Appendix F.

Overall, the analysis of benthic metrics and supporting measures (by ANOVA and correlation) showed that there were clear differences between the Minto Creek exposure area and the McQuinty Creek reference area. These differences appeared to be related to a combination of subtle habitat differences (water depth at sampling stations) and effluent exposure (as evident in higher temperature, conductivity and PC-1 water quality parameters). Detailed information regarding the sampling program or other results are available in the *First Interpretive Report for Cycle 1*(Minnow/Access 2009).

TABLE 13. BASIC METRICS AND SUPPORTING DATA SUMMARIES FROM 2008 EEM PROGRAM BENTHIC DATA		
Parameter	Reference Area (McQuinty Creek)	Exposure Area (Minto Creek)
Density (Ind./m²)	1010.7 ± 184.8	6750.0 ± 824.7
Number of Taxa	20.6 ± 1.4	18.6 ± 1.3
Oligochaetes (%)	6.9 ± 0.9	34.6 ± 10.9
EPT (%)	32.1 ± 3.6	9.0 ± 1.5
Chironomids (%)	44.8 ± 2.7	38.1 ± 9.5
Simpson's D	0.852 ± 0.011	0.821± 0.042
Simpson's E (Smith & Wilson 1996)	0.341 ± 0.031	0.343 ± 0.042
Field DO (% Sat)	88.000 ± 1.924	77.200 ± 0.970
Field Conductivity (µS/cm)	75.000 ± 1.789	243.800 ± 0.374
Field pH	6.266 ± 0.166	7.746 ± 0.214
Avg. Velocity at Sample (m/s)	0.592 ± 0.014	0.586 ± 0.026
Avg. Depth at Sample (cm)	19.200 ± 0.583	27.800 ± 1.158
Bedrock (%)	0.000 ± 0.000	0.000 ± 0.000
Boulder (%)	0.000 ± 0.000	0.000 ± 0.000
Cobble (%)	78.000 ± 2.000	82.000 ± 2.000
Gravel (%)	12.000 ± 2.000	9.000 ± 1.000
Sand (%)	10.000 ± 0.000	9.000 ± 1.000
Data summarized from Minnow/Access 2009.		

4.3 PERIPHYTON SAMPLING

Periphytic algae are simple aquatic plants which inhabit the substrate of water bodies. As photosynthesizers, algae form the base of the aquatic food web. Algal concentrations and population composition vary seasonally with changing photoperiod, temperature, nutrient levels and flow regimes. Periphyton can provide a valuable biological monitoring tool to assess potential impacts of nutrient enrichment and metal toxicity.

Indirect effects mining and runoff originating from disturbance of igneous and metamorphic rocks in the mine site area can potentially have effects on water quality. Excessive increases in nitrogen have the potential to impair water quality for drinking, aquatic life and recreation due to toxicity of nitrates, nitrites and ammonia, and their role as a limiting nutrient in promoting algal growth. Biologically available phosphorous or ortho-phosphate is more readily accumulated by living organisms and can contribute to accelerated algae growth. Excessive algal growth can in turn result in lake eutrophication and the choking of streams.

Chlorophyll "a" is the primary photosynthetic pigment and is common to all algae. Determining chlorophyll "a" concentrations provides a measure of algae biomass and thus, the primary productivity of a given location. Measuring this environmental parameter provides baseline data for monitoring possible future impacts to downstream water quality.

Taxonomic identification and relative abundance ranking of the algae samples provides information on community complexity and composition. Species presence information allows comparison to known community associations from the literature and regional studies, and permits increased prediction capabilities. This qualitative sampling should be able to detect gross changes in the dominant species.

4.3.1 Periphyton Sampling during 1994 Baseline Studies

4.3.1.1 Methods

Periphyton sampling was conducted as part of the original baseline study program by HKP in August 1994, concurrent with benthic invertebrate collection. These collections were intended to provide a temporal and spatial baseline database of relative productivity and typical algal community composition. Five samples sites (P1 through P5) were sampled, with locations upstream and downstream of expected potential impact areas at that time. These sites correspond to current water quality sampling locations as outlined in Figure 5, according to reference Table 14.

TABLE 14: REFERENCE BETWEEN PERIPHYTON / WATER QUALITY SAMPLING SITES.

1994 Sample Site	Water Quality Station
P1	W1
P2	W2
P3	W3
P4	W7
P5	W8
P6	W9

At each site, six replicate samples each were taken for taxonomic analysis and chlorophyll "a" analysis at each site. Samples at each location were normalized to areas of similar depth and velocity. Representative samples of algae were taken from 5.3 cm^2 areas of cobble-sized substrate at each site using a 50 mL Stockner sampler and transferred to plastic 50 mL sample containers.

Samples for chlorophyll "a" concentration determination were individually filtered through 0.45 µm cellulose acetate filters, buffered with $MgCO3$, stored on silicate crystals and submitted to ASL Laboratories Ltd. for analysis.

Samples for community composition studies were preserved with Lugol's iodine solution and sent to Munroe Environmental Consulting for taxonomic analysis. Subsamples were settled in 2.5 mL settling chambers, and then examined to identify species and estimate percent abundance of green, blue-green and other common species. Diatoms were identified and assigned the relative abundance rankings of predominant, common and present.

4.3.1.2 Chlorophyll "a" Results

Mean chlorophyll "a" values were ranged from 0.079 µg/cm^2 at station P3 to 0.392 µg/cm^2 at station P5 (Table 15). The highest mean concentration of chlorophyll "a" was detected at P5 in the upper reaches of the Minto Creek watershed in an area of disturbance. Very little cover vegetation exists in this region due to mining exploration activities and forest fire. Therefore, an abundance of sunlight is allowed into the water column. A thick algal mat was observed on the creek substrate. The lowest value was detected in an area with thick overgrowth consisting of willows and alder. Extreme variability was observed between replicates at sites P3 and P5.

TABLE 15. CHLOROPHYLL "A" CONTENT OF PERIPHYTON (µg/cm^2)

Replicate	Site P1	Site P2	Site P3	Site P4	Site P5
1	0.187	0.059	0.094	0.352	0.375
2	0.208	0.112	0.141	<0.01	0.181
3	0.132	0.637	0.098	0.153	1.104
4	0.059	0.077	0.073	0.092	0.189
5	0.941	0.473	0.022	0.081	0.167
6	0.061	0.312	0.047	0.077	0.334
Mean	**0.265**	**0.278**	**0.079**	**0.126**	**0.392**
S.D.	**0.045**	**0.053**	**0.206**	**0.109**	**0.142**
Adapted from Table 8.1 in MintoEx's IEE (1994)					

4.3.1.3 Species Composition Results

A comparison of species presence between sampling areas is included as Table 16. A summary of dominant and common species is also presented in Appendix G.

In general, samples from most sites contained very little periphyton material, which likely indicates a relatively unproductive stream or a stream subject to scouring from high flows during freshet. Species composition was similar to other creeks observed in the southwest Yukon. High proportions of the diatoms *Nitzschia* spp. were found at sites P2 and P3. *Nitzschia* species, in abundance, are often associated with organic or nutrient enrichment. Although periphyton abundance was low, *Nitzschia* predominance at sites P2 and P3 may indicate locations with a potential sensitivity to enrichment.

TABLE 16. STREAM PERIPHYTON RESULTS FROM MINTO CREEK AS DESCRIBED BY HKP (1994)	
Site P1 (W1)	Three samples from site B1 contained very little visible sediment and three contained a moderate amount, which consisted mostly of detritus, silt and small amounts of algae. Diatoms comprised 50 to 95% of the periphyton. *Navicula* spp. were predominant. The red alga *Audouinella violacea* was predominant in some samples, comprising 5 to 50% of the alga.
Site P2 (W2)	Four samples contained very little visible sediment and two contained a moderate amount (silt, detritus and algae). Diatoms comprised 59 to 99% of the periphyton; *Nitzschian* spp. were predominant. The bluegreen algae *Chamaesiphon incrustans*, *Lyngbya diguetii*, and *Plectonema notatum* were common in two samples and comprised up to 25% of the sample.
Site P3 (W3)	All samples contained very little visible sediment or algae. Only two samples contained enough algae to estimate percent abundance. Diatoms comprised 30 and 90% of the periphyton in these two samples. Common diatoms in all six samples included *Nitzschia* spp., *Navicula* spp., *Synedra* cf. *incisa* and *Synedra rumpens*. *Audouinella violacea* and *Phormidium* sp. were common (5 to 35%) in the two samples where abundance was estimated.
Site P4 (W7)	Samples from P4 were not collected quantitatively due to limited substrate, but were analyzed in the usual manner for periphyton composition. Three samples contained coarse sand and were comprised almost completely of diatoms. *Nitzschia* spp. were predominant and *Navicula* spp. were common. Two samples contained large amounts of moss (*Fontinalis* sp.) and were covered by the epiphytic bluegreen alga *Lyngbya nordgaardii*. One sample was composed of filamentous algae and contained the chrysophyte *Hydrurus foetidus* (50%), *Nitzschia* spp. and *Navicula* spp.
Site P5 (W8)	Samples from P5 contained very small amounts of fine sediment and very little algae. Two samples contained too little periphyton to estimate percent abundance. Diatoms comprised 90 to 99% of the periphyton in the other four samples. The most common diatom species were *Navicula* spp., *Synedra rumpens*, and *Nitzschia* spp. The bluegreen alga *Nostoc* sp. was common in one sample. *Audouinella violacea* was common in another.
Site P6 (W9)	Samples from P6 contained very small amounts of sediment. Diatoms comprised 45 to 93% of the periphyton. *Gomphonema* spp. were predominant. *Meridion circulaire*, *Navicula* spp. and *Synedra rumpens* were common. The chrysophyte *Hydrurus foetidus* was predominant in two samples (25 to 40%) and common (5%) in three others. The crustose bluegreen alga *Chamaesiphon incrustans* was predominant in two samples and common in two others. Other common species included *Lyngbya diguetii* and an unidentified filamentous bluegreen algae.

4.3.2 Periphyton Monitoring Under MMER

In accordance with the Metal Mining Effluent Regulations (MMER), Minto Mine is required to conduct an Environmental Effects Monitoring (EEM) program which includes an optional periphyton analysis classified under "Focused Monitoring". The objective of Focused Monitoring is to determine the magnitude and geographical extent of the effects of mine effluent on benthic invertebrate communities. In order to assess the magnitude of the effects, a consideration of other biotic indicators is suggested. These include the biomass and taxonomic composition of periphyton, phytoplankton, macrophyte or zooplankton communities, as well as toxicity tests of sediment and water.

Rather than pursuing this objective through further periphyton analyses, MintoEx has been conducting regular EEM Aquatic Toxicity Tests since June 2007.

5.0 LIMITATIONS OF REPORT

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6.0 CLOSURE

EBA Engineering Consultants Ltd. is pleased to provide Minto Exploraton Ltd. with this Minto Mine Fisheries and Aquatic Resources baseline data summary. We trust this report meets your present requirements. Should you have any questions or comments, please contact the undersigned at your convenience.

Respectfully Submitted,
EBA Engineering Consultants Ltd.

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GEO-ENVIRONMENTAL REPORT – GENERAL CONDITIONS

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TABLES

TABLE 2. SUMMARY OF FISH EFFORT AND CAPTURE DATA FOR MINTO CREEK, 1994 TO 2009									
Year, Study	Month	Stream/ Site	Method	Effort (s or h)	Species	Round Whitefish	Slimy Sculpin	Arctic Grayling	Chinook Salmon
1994 (Hallam Knight Piesold)	June	Minto Creek, Site 1	Electrofishing	210 s	number	1	-	-	-
					#/min	0.29	-	-	-
			Minnow Trap	NR	number	-	2	-	-
		Minto Creek, Site 2	Electrofishing	270 s	number	-	-	-	-
					#/min	-	-	-	-
			Minnow Trap	NR	number	-	-	-	-
	August	Minto Creek, Site 1	Angling	3600 s	number	-	-	-	-
					#/min	-	1	-	-
			Minnow Trap	NR	number	-	2	-	-
		Minto Creek, Site 2	Electrofishing	390 s	number	-	2	-	-
					#/min	-	0.31	-	-
			Minnow Trap	NR	number	-	2	-	-
		Minto Creek, Site 3	Electrofishing	564 s	number	-	-	2	-
					#/min	-	-	0.21	-
	September	Minto Creek, Site 2	Electrofishing	270 s	number	-	-	-	-
					#/min	-	-	-	-
			Minnow Trap	NR	number	-	-	-	-
		Minto Creek, Site 3	Electrofishing	150 s	number	-	-	2	-
					#/min	-	-	0.8	-
2006 (R&D Environmental)	September	Minto Creek	Gee Trap	24 h	number	-	-	-	-
					#/min	-	-	-	-
2007 (R&D Environmental)	May	Yukon River backwater at mouth of Minto Creek	Electro-fishing	191	#/min	-	-	-	8
					#/min	-	-	-	2.51
			Gee Trap (x6)	5.5 h	number	-	-	-	4
					#/trap/h	-	-	-	0.12
		Minto Creek, d/s Haul Road	Electrofishing	460 s	number	-	-	-	-
					#/trap/h	-	-	-	-
			Gee Trap (x8)	15 h	number	-	-	-	-
					#/trap/h	-	-	-	-
		Minto Creek, ~100m u/s Haul Road	Gee Trap (x3)	15 h	number	-	-	-	-
					#/trap/h	-	-	-	-
		Minto Creek, @ base of canyon	Gee Trap (x5)	15 h	number	-	-	-	-
					#/trap/h	-	-	-	-
	June	Minto Creek, ~100m u/s Yukon River	Gee Trap (x5)	18 h	number	-	1	-	24
					#/trap/h	-	0.01	-	0.27
		Minto Creek, d/s Haul Road	Electrofishing	212 s	number	-	-	-	-
					#/min	-	-	-	-
			Gee Trap (x8)	22 h	number	-	4	-	-
					#/trap/h	-	0.02	-	-
		Minto Creek, ~100 m u/s Haul Road	Gee Trap (x2)	22 h	number	-	1	-	-
					#/trap/h	-	0.02	-	-
		Minto Creek, @ base of canyon	Gee Trap (x5)	20 h	number	-	-	-	-
					#/trap/h	-	-	-	-

TABLE 2. SUMMARY OF FISH EFFORT AND CAPTURE DATA FOR MINTO CREEK, 1994 TO 2009									
Year, Study	Month	Stream/ Site	Method	Effort (s or h)	Species	Round Whitefish	Slimy Sculpin	Arctic Grayling	Chinook Salmon
	August	Minto Creek, ~100m u/s Yukon River	Gee Trap (x5)	22 h	number	-	-	1	3
					#/trap/h	-	-	0.01	0.01
		Minto Creek, d/s Haul Road	Gee Trap (x5)	27 h	number	-	-	-	3
					#/trap/h	-	-	-	0.02
		Minto Creek, ~100m u/s Haul Road	Gee Trap (x5)	27 h	number	-	2	-	32
					#/trap/h	-	0.01	-	0.24
		Minto Creek, @ base of canyon	Gee Trap (x0)	0	number	-	-	-	-
					#/trap/h	-	-	-	-
	September	Minto Creek, ~100m u/s Yukon River	Gee Trap (x1)	23 h	number	-	-	-	5
					#/trap/h	-	-	-	0.22
		Minto Creek, d/s Haul Road	Gee Trap (x4)	23 h	number	-	-	-	-
					#/trap/h	-	-	-	-
		Minto Creek, ~100m u/s Haul Road	Gee Trap (x5)	23 h	number	-	-	-	24
					#/trap/h	-	-	-	0.21
		Minto Creek, @ base of canyon	Gee Trap (x0)	0	number	-	-	-	-
					#/trap/h	-	-	-	-

TABLE 3. SUMMARY OF FISH ASSESSMENT EFFORTS AND DATA FOR CREEK A.

Year, Study	Month	Stream/ Site	Method	Effort (s or h)	Species	Round Whitefish	Slimy Sculpin	Arctic Grayling	Chinook Salmon
1994 (Hallam Knight Piesold)	June	Creek A, Site 2	Electrofishing	71 s	number	-	-	-	-
					#/min	-	-	-	-
	August	Creek A, Site 2	Electrofishing	80 s	number	-	-	-	-
					#/min	-	-	-	-
	September	Creek A, Site 2	Electofishing	342 s	number	-	-	-	-
					#/min	-	-	-	-

				1994				2006				2007				2008				2009			
				baseline				reference		exposed		reference		exposed		reference		exposed		reference		exposed	
Parameter	**Unit**	**ISQG[a]**	**PEL[b]**	**W6 [c]**	**W7 [d]**	**W3 [e]**	**W2 [f]**	**W6 [c]**	**W7 [d]**	**W3 [e]**	**W2 [f]**	**W6 [c]**	**W7 [d]**	**W3 [e]**	**W2 [f]**	**W6 [c]**	**W7 [d]**	**W3 [e]**	**W2 [f]**	**W6 [c]**	**W7 [d]**	**W3 [e]**	**W2 [f,g]**
Particle Size																							
gravel - % (>2.00mm)	% by weight	-	-	-	-	4.9	28.8	3.1	7.1	5.7	17.0	7.6	1.2	12.2	12.5	13.8	9.0	18.7	44.4	45.5	52.6	87.7	80.3
sand - % (2.00-0.053mm)	% by weight	-	-	-	-	75.2	62.6	96.6	88.5	96.4	84.9	81.6	96.2	74.4	61.7	82.5	84.3	76.9	55.4	54	45.4	12.5	20.0
silt/clay - % (<0.053mm)	% by weight	-	-	-	-	19.8	8.52	6.1	9.1	2.5	2.3	10.8	2.6	13.5	25.8	3.3	6.5	3.9	0.2	0.2	1.7	0.1	0.1
Metals																							
Aluminum	mg/kg	-	-	-	-	-	-	12,820	10,334	12,400	11,820	12,680	10,640	17,360	10,660	12,233	10,600	14,100	13,833	12,100	9,650	9,833	8,780
Antimony	mg/kg	-	-	-	-	0.42	0.29	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.97	0.93	0.70	1.47	<0.5	<0.5	<0.5	<0.5
Arsenic	mg/kg	5.9	17	-	-	4.4	4.4	6.4	4.0	5.6	5.1	5.0	3.4	3.8	5.2	5.6	3.0	3.8	6.9	6.4	2.5	4.8	5.5
Barium	mg/kg	-	-	-	-	-	-	199	159	228	188	210	182	429	196	226	187	284	311	291	152	330	226
Beryllium	mg/kg	-	-	-	-	-	-	0.39	0.33	0.44	0.39	0.41	0.35	0.67	0.39	0.38	0.33	0.52	0.52	0.55	0.33	0.47	0.39
Bismuth	mg/kg	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.58	<0.64	1.48	<0.64	<0.5	<0.5	<0.5	<0.5	0.77	<0.6	1.37	1.13
Cadmium	mg/kg	0.6	3.5	-	-	0.13	*<0.1*	0.10	0.10	0.12	0.20	0.24	0.22	0.3	0.3	<0.05	<0.05	<0.05	<0.05	0.30	0.13	0.23	0.23
Calcium	mg/kg	-	-	-	-	-	-	7,916	7,546	8,382	9,120	7,860	8,120	12,120	20,160	8,177	7,983	15,767	13,167	9,137	6,760	7,713	7,517
Chromium	mg/kg	37.3	90	-	-	22.1	14.0	28.9	27.8	28.2	27.9	28.3	27.8	26.8	23.9	31.2	31.4	33.8	157	50.1	29.7	76.7	70.8
Cobalt	mg/kg	-	-	-	-	-	-	7.3	6.6	8.4	8.1	8.3	8.1	11.0	8.7	7.8	7.5	9.0	13.8	14.0	8.0	13.0	11.7
Copper	mg/kg	35.7	197	-	-	48.3	13.8	28.2	20.1	96.8	81.5	25.8	28.7	133	34.0	22.6	17.5	126	92.8	248	16.3	123	79.1
Iron	mg/kg	-	-	-	-	-	-	23,020	19,480	24,700	22,640	24,220	21,400	32,520	23,660	27,467	23,933	31,133	35,767	37,267	22,033	49,300	38,333
Lead	mg/kg	35	91.3	-	-	3.9	<2.27	6.9	5.7	6.9	8.6	4.1	4.0	4.7	4.2	9.4	7.9	15.0	8.9	9.6	4.8	16.7	13.5
Lithium	mg/kg	-	-	-	-	-	-	10.6	8.4	10.1	10.3	11.1	9.7	16.0	11.9	9.9	8.8	11.8	13.6	10.7	9.2	9.3	9.9
Magnesium	mg/kg	-	-	-	-	-	-	5,174	5,006	6,158	5,912	5,480	5,698	8,848	6,866	5,070	5,500	7,030	8,170	6,670	5,357	5,377	4,897
Manganese	mg/kg	-	-	-	-	-	-	435	363	785	746	518	556	1,148	566	638	479	934	1,400	1,890	382	2,033	1,097
Mercury	mg/kg	0.17	0.486	-	-	0.01	0.01	0.068	0.140	0.034	0.038	0.046	0.052	0.047	0.050	0.033	0.025	0.031	0.056	0.027	0.018	0.025	0.033
Molybdenum	mg/kg	-	-	-	-	*<4*	*<4*	0.44	0.54	0.86	0.54	0.26	0.38	0.86	0.42	0.43	0.51	1.00	14.9	4.20	0.76	7.55	6.35
Nickel	mg/kg	-	-	-	-	-	-	23.9	23.4	27.0	27.6	22.8	23.8	25.6	20.4	23.2	24.7	27.5	107	42.5	26.4	52.1	50.4
Phosphorus	mg/kg	-	-	-	-	-	-	846	1,079	1,035	970	959	1,214	1,050	912	999	1,180	1,177	1,253	1,137	1,077	1,120	877
Potassium	mg/kg	-	-	-	-	-	-	748	742	1,324	990	751	773	2,326	1,234	682	720	1,417	1,313	1,330	705	1,297	1,015
Selenium	mg/kg	-	-	-	-	-	-	<0.3	<0.3	<0.3	<0.3	0.54	0.5	0.7	0.48	<0.33	<0.4	0.50	1.20	1.20	<0.3	0.73	0.40
Silicon	mg/kg	-	-	-	-	-	-	116	101	169	146	171	251	208	217	289	245	558	487	528	374	602	616
Silver	mg/kg	-	-	-	-	*<3*	*<2*	<0.2	<0.18	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3	<0.2	0.3	0.2
Sodium	mg/kg	-	-	-	-	-	-	204	214	241	275	181	200	221	258	198	218	312	444	385	254	369	329
Strontium	mg/kg	-	-	-	-	-	-	43.4	59.0	61.5	78.3	43.0	71.3	84.5	81.6	46.4	70.3	90.9	101	104	57.7	68.1	69.4
Thallium	mg/kg	-	-	-	-	-	-	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.8	1.5	0.3	1.3	0.8
Tin	mg/kg	-	-	-	-	-	-	0.74	0.88	0.84	2.6	0.48	0.6	0.6	0.4	0.2	<0.2	0.5	0.6	3.3	1.3	9.5	8.4
Titanium	mg/kg	-	-	-	-	-	-	342	288	298	333	345	303	360	350	519	502	521	603	722	579	720	569
Vanadium	mg/kg	-	-	-	-	-	-	45.4	41.4	49.9	44.4	46.5	42.2	61.9	48.3	48.6	45.6	56.8	69.1	70.1	41.5	102.0	76.5
Zinc	mg/kg	123	315	-	-	48	29	50	47	61	117	48	50	83	59	48	48	68	100	73	45	67	53
Zirconium	mg/kg	-	-	-	-	-	-	5.0	4.0	4.8	4.5	5.1	4.4	5.7	5.1	3.3	3.1	3.8	3.8	3.4	2.6	2.8	2.0

Italicized "<" values are averages calculated from replicates that were all non-detects; non-italicized "<" values are averages calculated from replicates with one or more (but not all) non-detects

[a] Interim Sediment Quality Guideline, Canadian Environmental Quality Guidelines, CCME (1999)

[b] Probable Effects Level, Canadian Environmental Quality Guidelines, CCME (1999)

[c] Station W6 - south-flowing tributary to Minto Creek (see Figure 1)

[d] Station W7 - north-flowing tributary to Minto Creek (see Figure 1)

[e] Station W3 - upper Minto Creek (see Figure 1)

[f] Station W2 - lower Minto Creek (see Figure 1)

[g] Station W2 was sampled three times in 2009, however only July 28, 2009 data was used as it corresponds with sampling at other stations

(green) Average concentration exceeds the Interim Sediment Quality Guidelines (ISQG)

(red) Average concentration exceeds the Probable Effect Level (PEL)

Table adapted from Minnow (2009) internal report on Minto Creek Sediment Quality prepared for Minto Explorations Ltd.

NOTES

CLIENT

CAPSTONE MINING CORP.

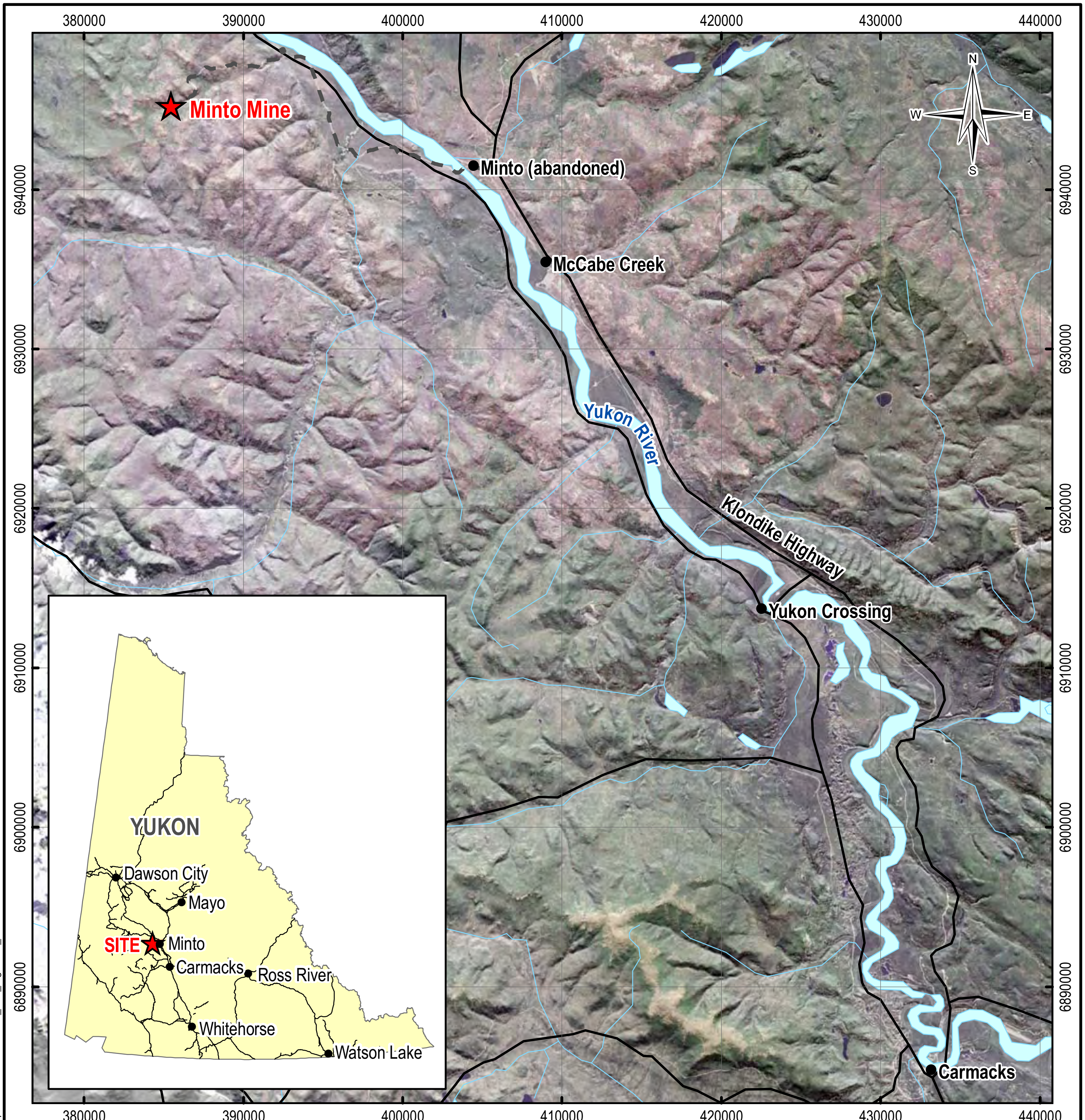
EBA Engineering Consultants Ltd.

MINTO MINE
2010 FISHERIES & AQUATICS BASELINE REPORT

2006 – 2009 Sediment Quality Data with Comparison to 1994 Sediment Quality Data

PROJECT NO.	DWN	CKD	REV	
W14101068.021	NJB	CJJ	1	Table 9
OFFICE	DATE			
EBA-WHSE	March 31, 2010			

FIGURES



Q:\Vancouver\GIS\ENGINEERING\W141\W14101068_CapstoneMaps\021_AquaticFish\W14101068_021_Figure01_Site.mxd

LEGEND

- Minto Mine
- Populated Place
- Minto Mine Access Road
- Road
- River
- Waterbody

NOTES

Base data source:
Geomatics Yukon

ISSUED FOR USE

MINTO MINE
2010 FISHERIES AND AQUATICS BASELINE REPORT

Site Location

PROJECTION	DATUM
UTM Zone 8	NAD83

Scale: 1:350,000

5 2.5 0 5
Kilometres

FILE NO.
W14101068_021_Figure01_Site.mxd

PROJECT NO.	DWN	CKD	REV
W14101068.021	MEZ	CJJ	0

OFFICE	DATE
EBA-VANC	August 11, 2010

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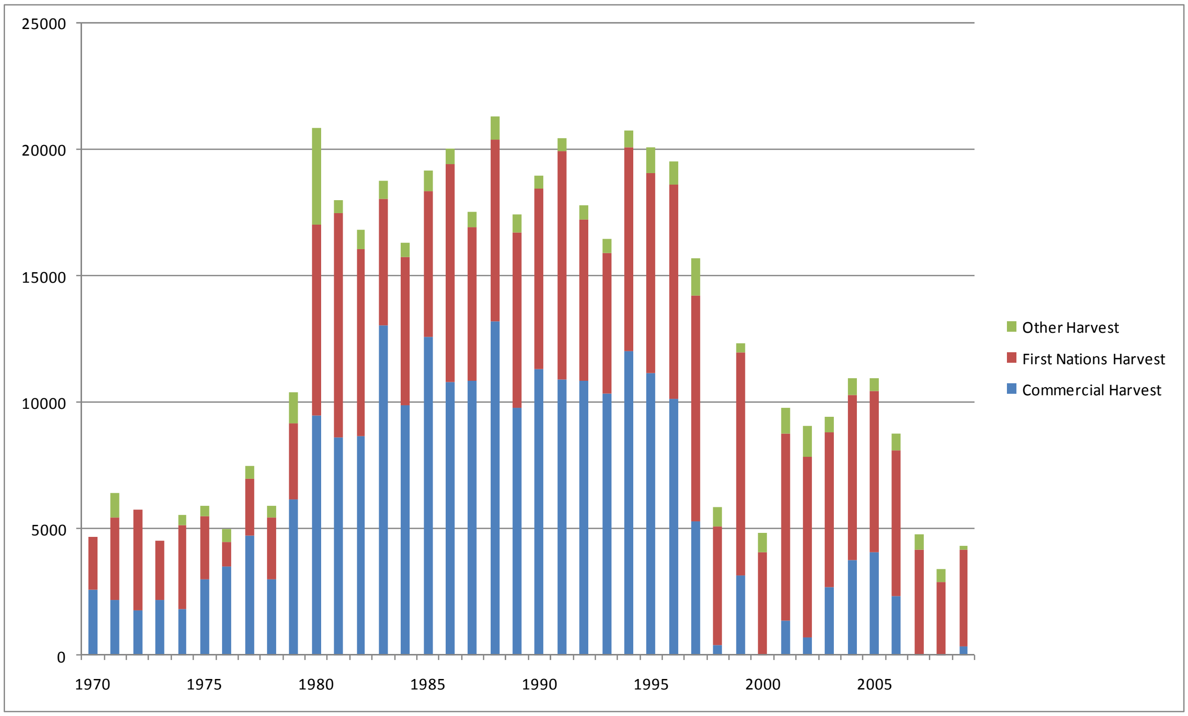
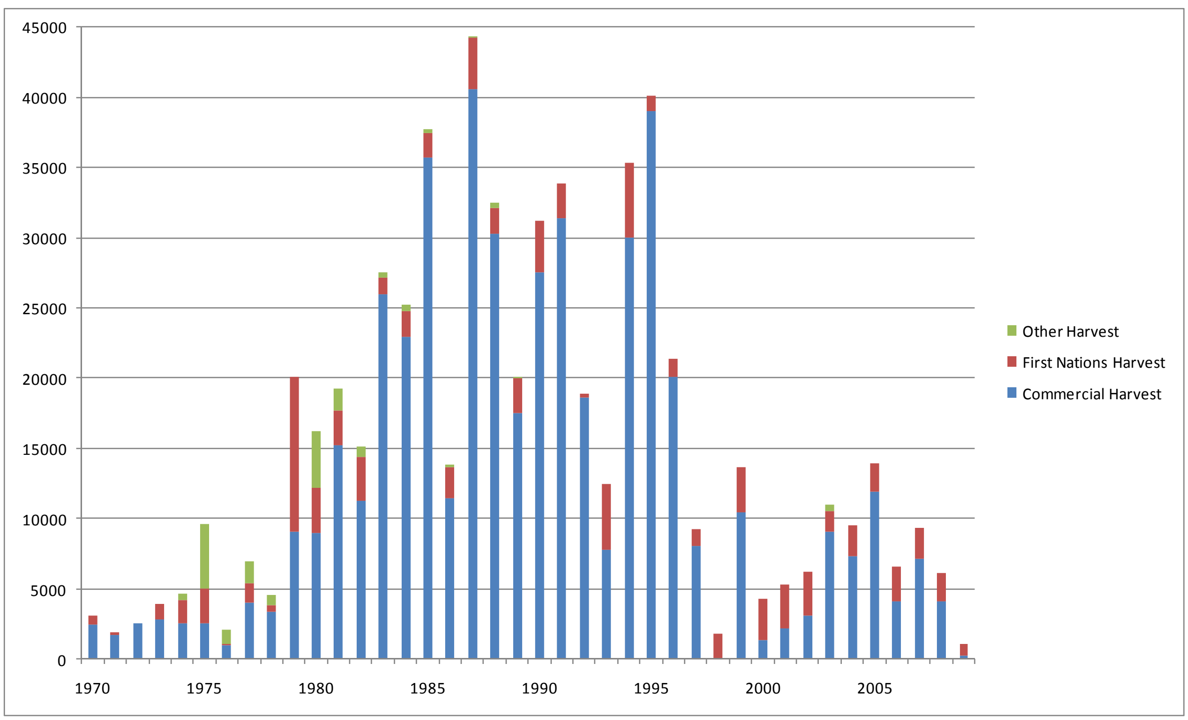
Figure 1

A) Chinook Salmon



B) Chum Salmon



NOTES

Figure based on Data from JTC (2010). Salmon Catch data presented is for Canadian portions of the Yukon River only. Other Harvest includes domestic harvest, sport harvest, and test fisheries.

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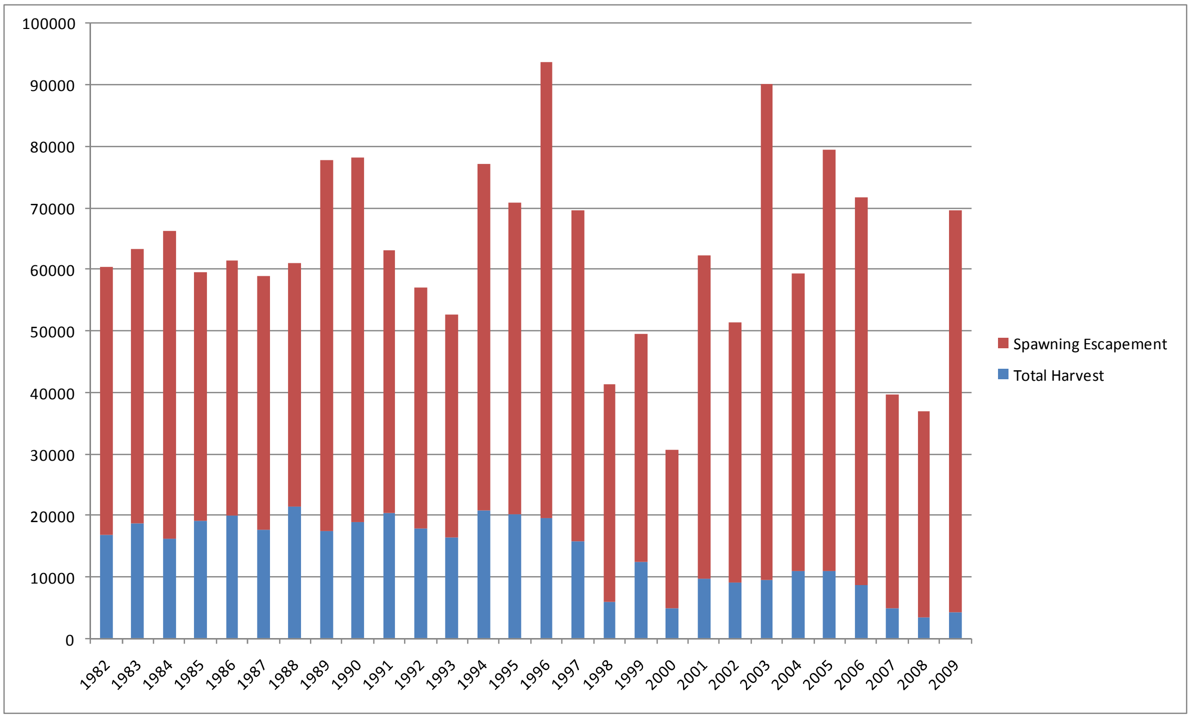
FISHERIES AND AQUATICS BASELINE REPORT

Yukon River
Historical Chinook and Chum
Salmon Catches

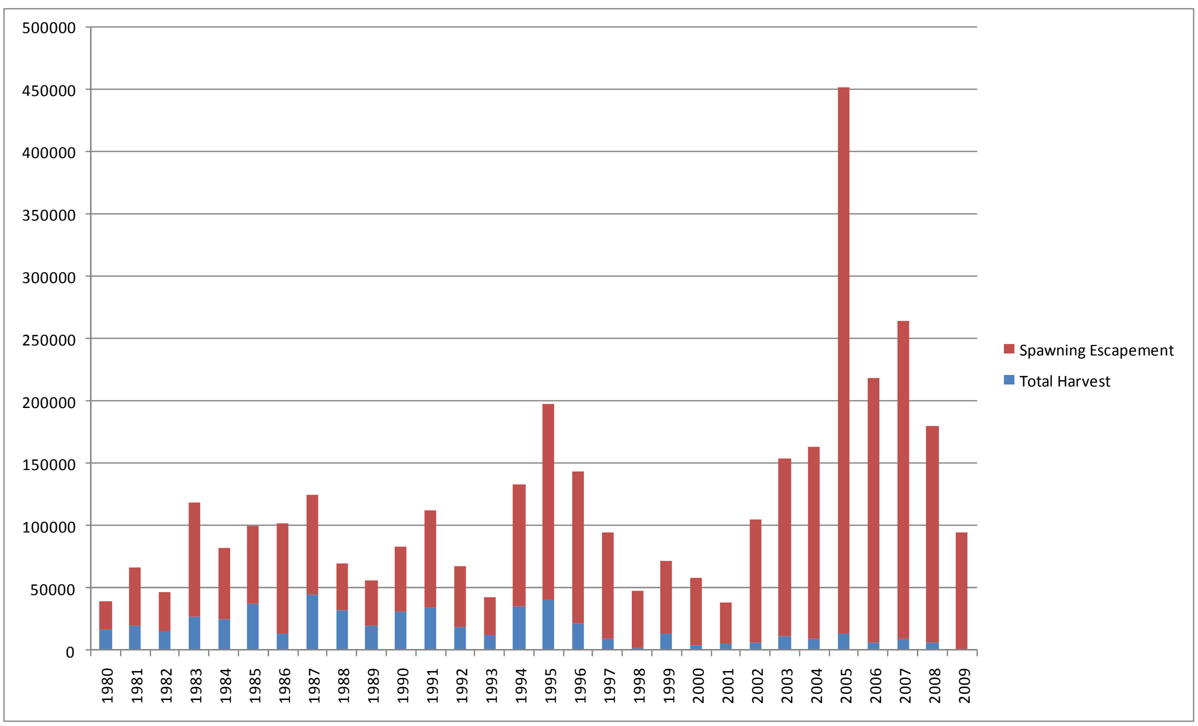
PROJECT NO.	DWN	CKD	REV
W14101068.021	NJB	CJJ	1
OFFICE	DATE		
EBA-WHSE	July 22, 2010		

Figure 2a

A) Chinook Salmon



B) Chum Salmon



NOTES

Figure based on Data from JTC (2010). Data presented is for Canadian portions of the Yukon River only. Total column heights represent the total border passage estimate, which have been subdivided into harvested and non- harvested (escapement) portions.

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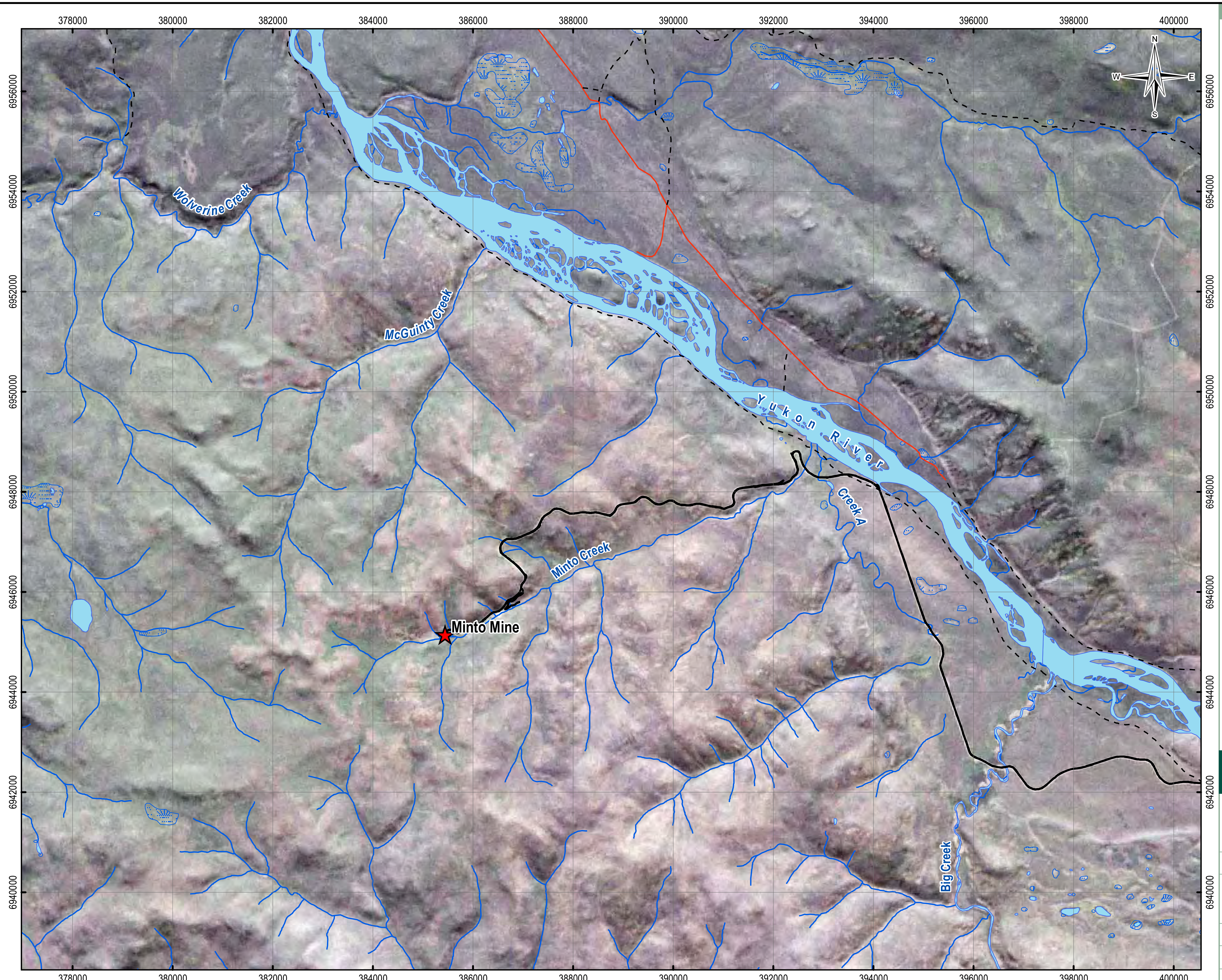
MINTO MINE
FISHERIES AND AQUATICS BASELINE REPORT

Yukon River
Historical Chinook and Chum Salmon
Harvest Relative to Spawning Escapement

PROJECT NO.	DWN	CKD	REV
W14101068.021	NJB	CJJ	1

OFFICE	DATE
EBA-WHSE	July 22, 2010

Figure 2b



LEGEND

- Minto Access Road
- Limited Use Road
- Trail
- Watercourse
- Waterbody
- Wetland

ISSUED FOR USE

NOTES

Base data source:
NTS 1:50,000 (Sheet 115I10 & 115I11)
Imagery from Geomatics Yukon

MINTO MINE
2010 FISHERIES AND AQUATICS BASELINE REPORT

Fisheries and Aquatics Regional Study Area

PROJECTION	DATUM
UTM Zone 8	NAD83

Scale: 1:75,000

1 0.5 0 1
Kilometers

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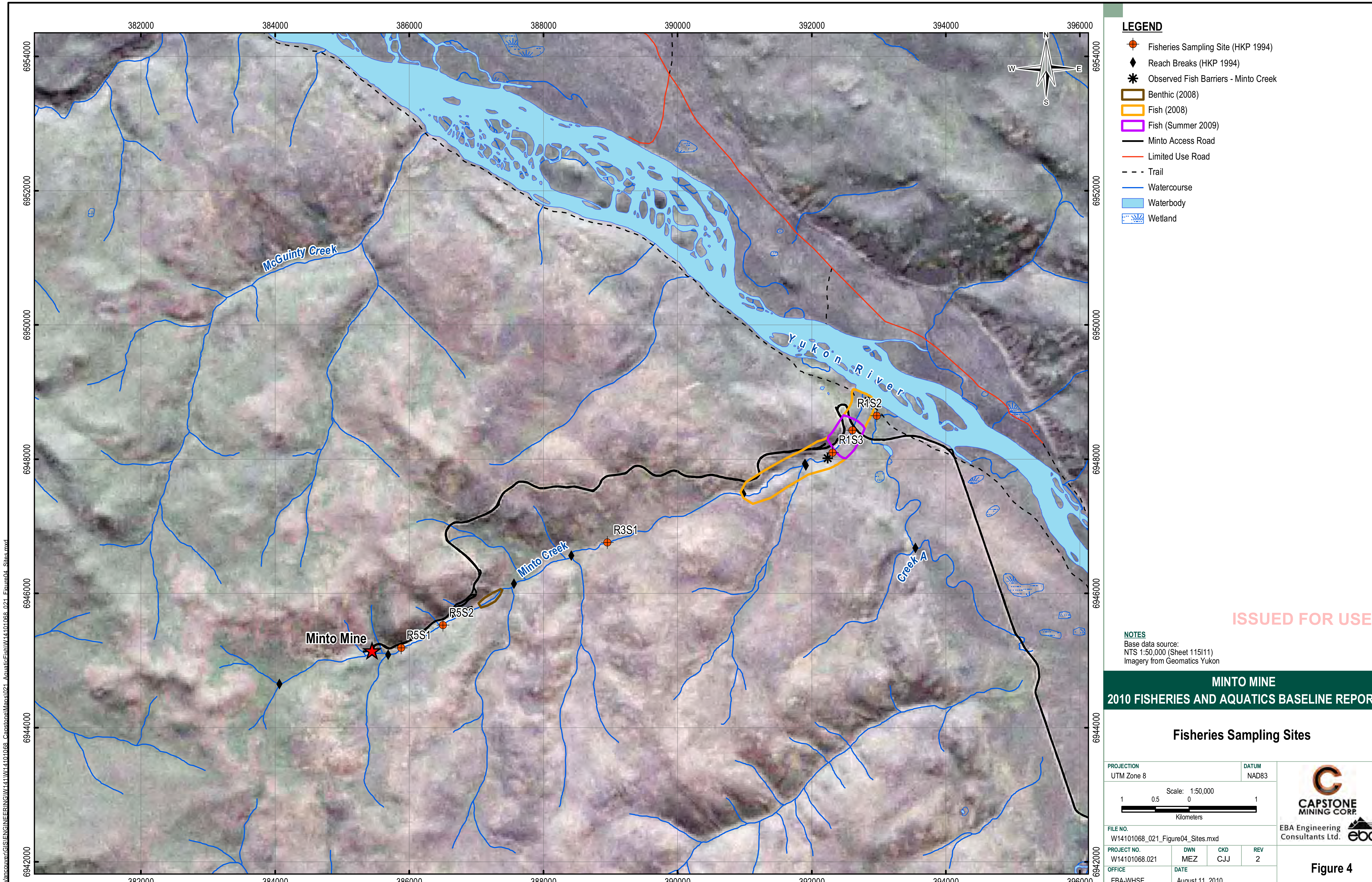
FILE NO.			
W14101068_021_Figure03_AREA.mxd			
PROJECT NO.	DWN	CKD	REV
W14101068.021	MEZ	CJJ	2
OFFICE	DATE		
EBA-VANC	August 11, 2010		

Figure 3

Q:\Vancouver\GIS\ENGINEERING\W141\W14101068_Capstone\Maps\021_AquaticFish\W14101068_021_Figure03_AREA.mxd



382000
384000
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388000
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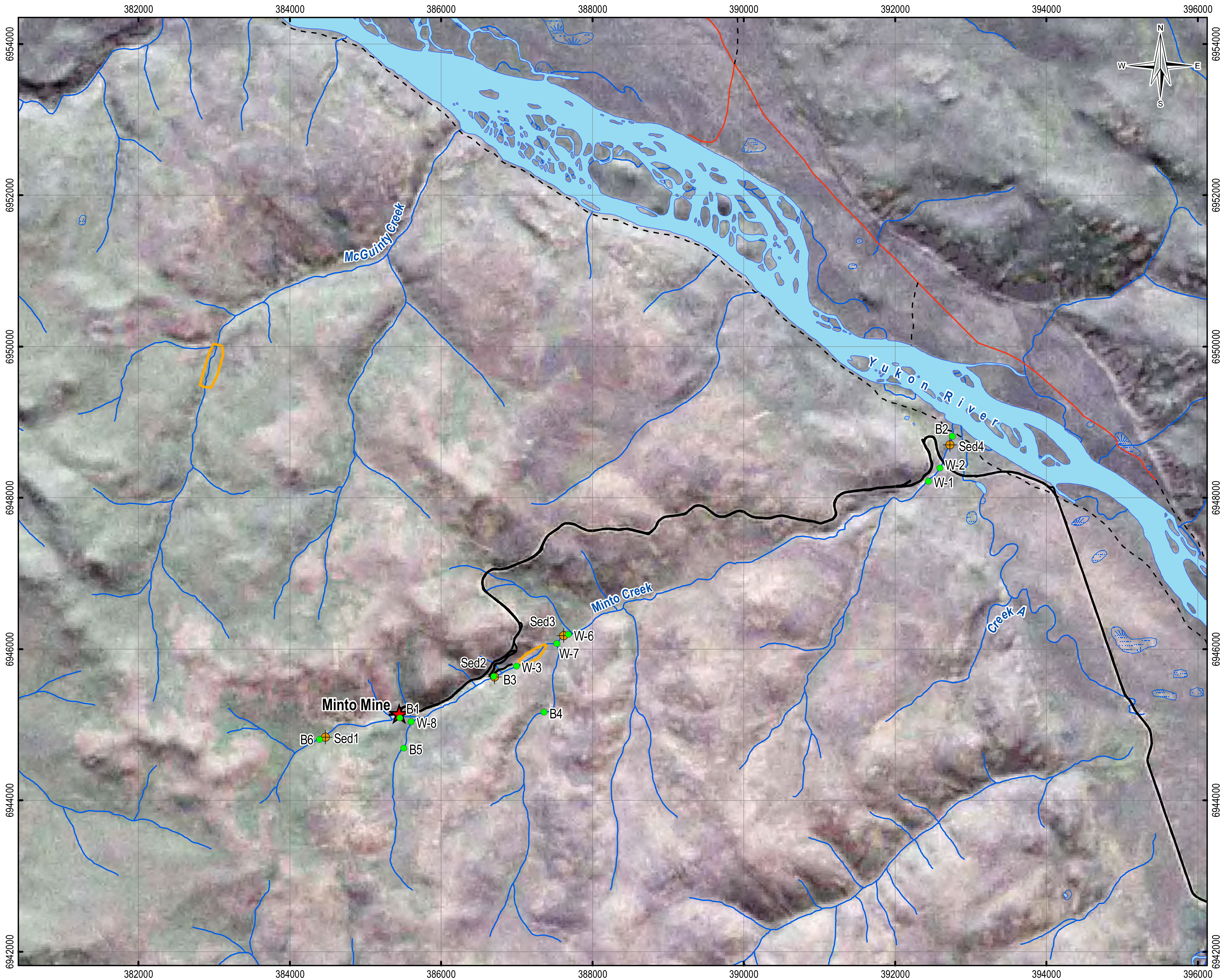
392000
394000
396000
6954000
6952000
6950000
6948000
6946000
6944000
6942000
N
S
E
W
McGuinty Creek
Yukon River
R1S2
R1S3
R3S1
Minto Creek
Creek A
R5S2
R5S1
Minto Mine
LEGEND
Fisheries Sampling Site (HKP 1994)
Reach Breaks (HKP 1994)
Observed Fish Barriers - Minto Creek
Benthic (2008)
Fish (2008)
Fish (Summer 2009)
Minto Access Road
Limited Use Road
Trail
Watercourse
Waterbody
Wetland
ISSUED FOR USE
NOTES
Base data source:
NTS 1:50,000 (Sheet 115I11)
Imagery from Geomatics Yukon
MINTO MINE
2010 FISHERIES AND AQUATICS BASELINE REPORT
Fisheries Sampling Sites
PROJECTION
UTM Zone 8
DATUM
NAD83
Scale: 1:50,000
1 0.5 0 1
Kilometers
FILE NO.
W14101068_021_Figure04_Sites.mxd
PROJECT NO.
W14101068.021
DWN
MEZ
CKD
CJJ
REV
2
OFFICE
EBA-WHSE
DATE
August 11, 2010
CAPSTONE MINING CORP.
EBA Engineering Consultants Ltd.
eba
Figure 4



LEGEND

- Sediment Sample Sites (HKP 1994)
- Benthic, Water Quality, and Periphyton Sample Sites (2005-2009)
- Benthic Sampling Area (2008 EEM)
- Minto Access Road
- Limited Use Road
- Trail
- Watercourse
- Waterbody
- Wetland

ISSUED FOR USE

NOTES

Base data source:
NTS 1:50,000 (Sheet 115I11)

MINTO MINE
2010 FISHERIES AND AQUATICS BASELINE REPORT

Aquatics Sampling Sites

PROJECTION	DATUM
UTM Zone 8	NAD83

Scale: 1:50,000

1 0.5 0 1

Kilometers

FILE NO.			
W14101068_021_Figure05_Sites.mxd			
PROJECT NO.	DWN	CKD	REV
W14101068.021	MEZ	CJJ	0
OFFICE	DATE		
EBA-VANC	August 11, 2010		

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Figure 5

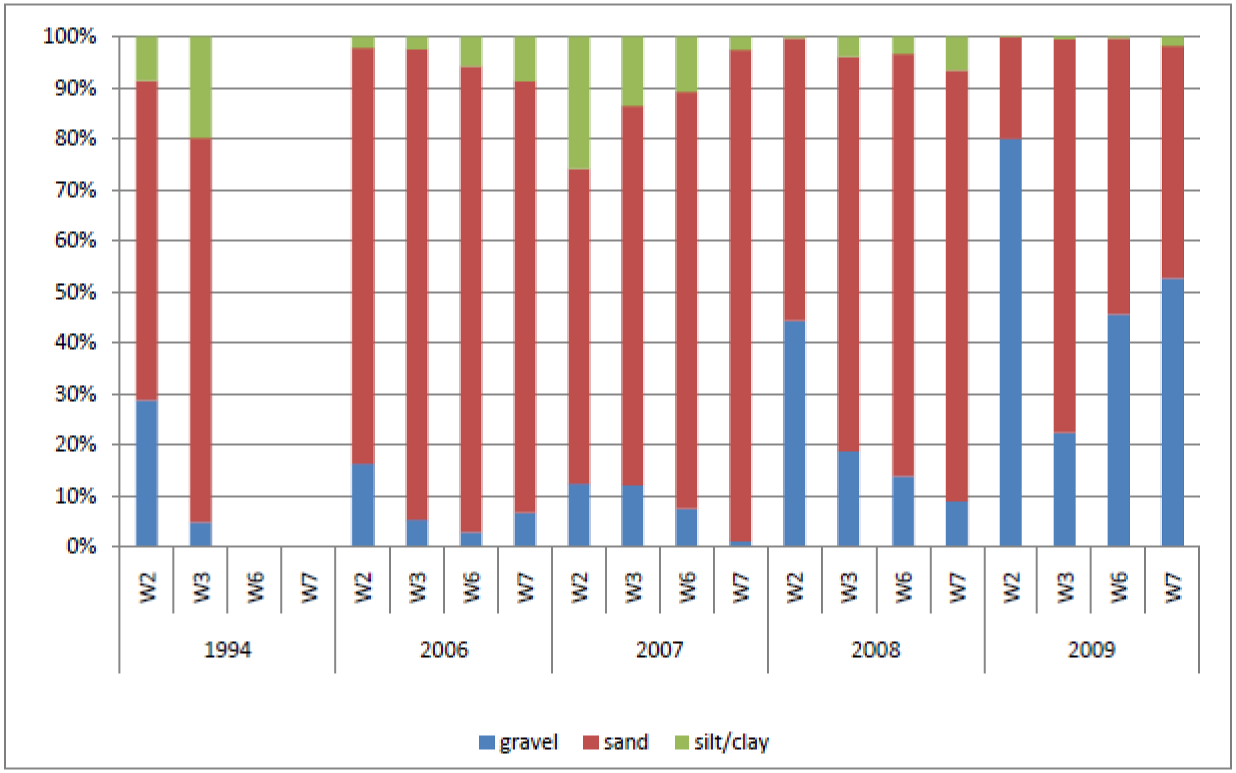

Figure 2: Particle size distribution of sediment collected in Minto Creek, 1994-2009 [a]

[a] Station W2 - lower Minto Creek; Station W3 - upper Minto Creek; Station W6 - south-flowing tributary to Minto Creek

Station W7 - north-flowing tributary to Minto Creek (see Figure 1)

Figure adapted from Minnow (2009)

NOTES

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MINTO MINE
FISHERIES AND AQUATICS BASELINE REPORT

Sediment Quality Data
1994 and 2006-2009
Particle Size Distribution

PROJECT NO.	DWN	CKD	REV
W14101068.021	NJB	CJJ	1

OFFICE EBA-WHSE

DATE March 31, 2010

Figure 6

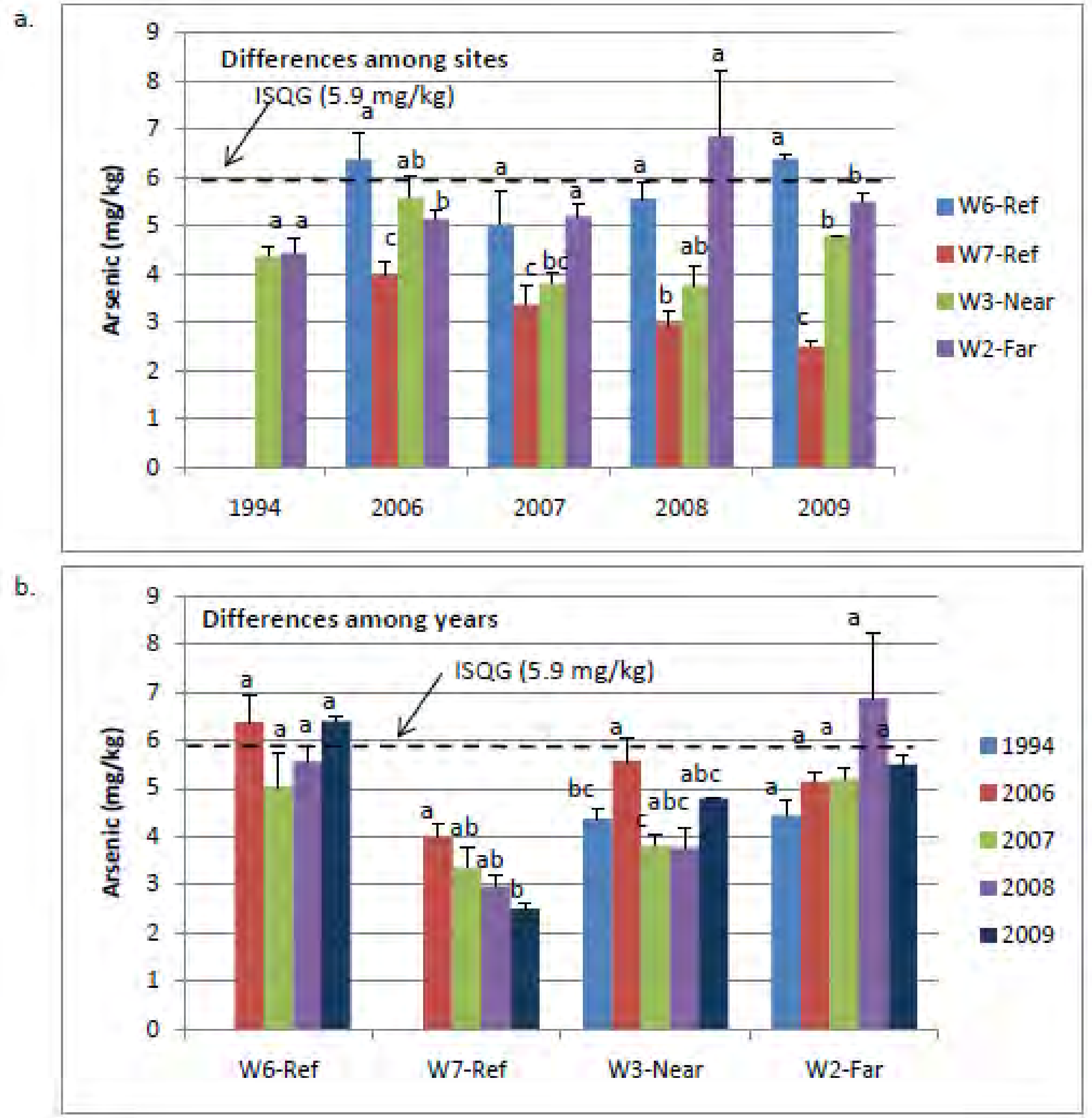

Figure adapted from Minnow (2009)

NOTES

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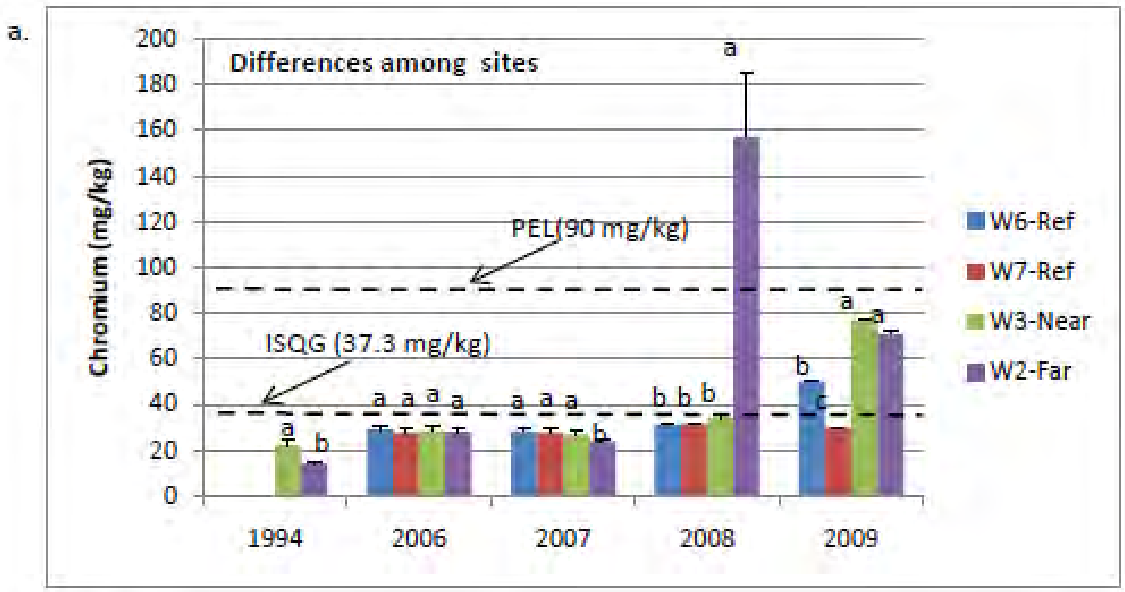
MINTO MINE
FISHERIES ADN AQUATICS BASELINE REORT

Minto Creek
Sediment Quality
Arsenic Concentrations

PROJECT NO.	DWN	CKD	REV
W14101068.021	NJB	CJJ	1
OFFICE	DATE		
EBA-WHSE	March 31, 2010		

Figure 7



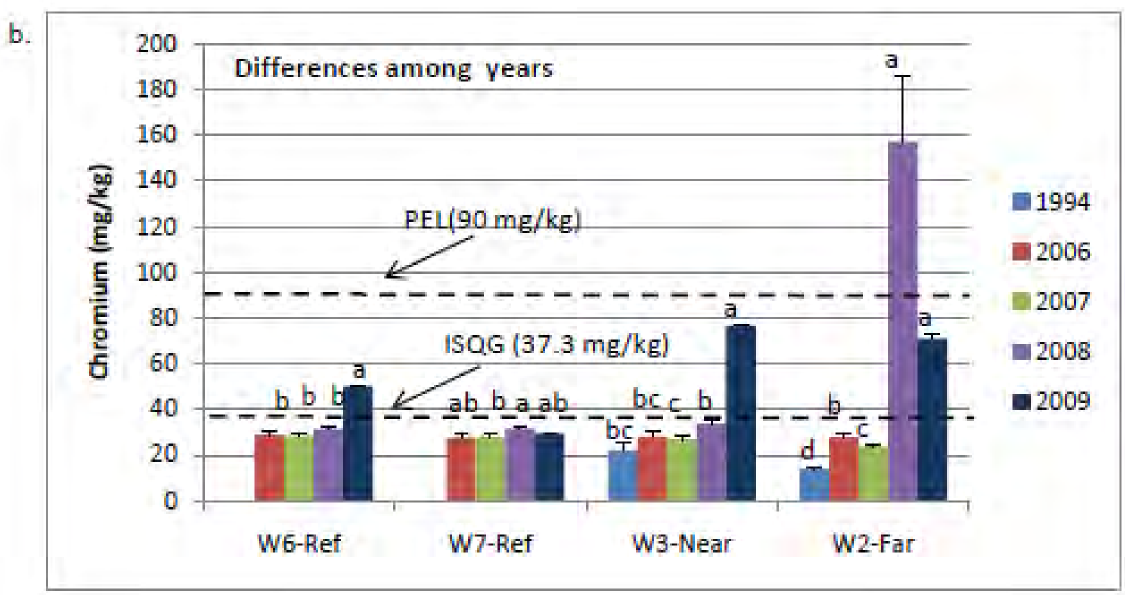


Figure adapted from Minnow (2009)

NOTES

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MINTO MINE
FISHERIES AND AQUATICS BASELINE REPORT

Minto Creek
Sediment Quality
Chromium Concentrations

PROJECT NO.	DWN	CKD	REV
W14101068.021	NJB	CJJ	1
OFFICE	DATE		
EBA-WHSE	March 31, 2010		

Figure 8

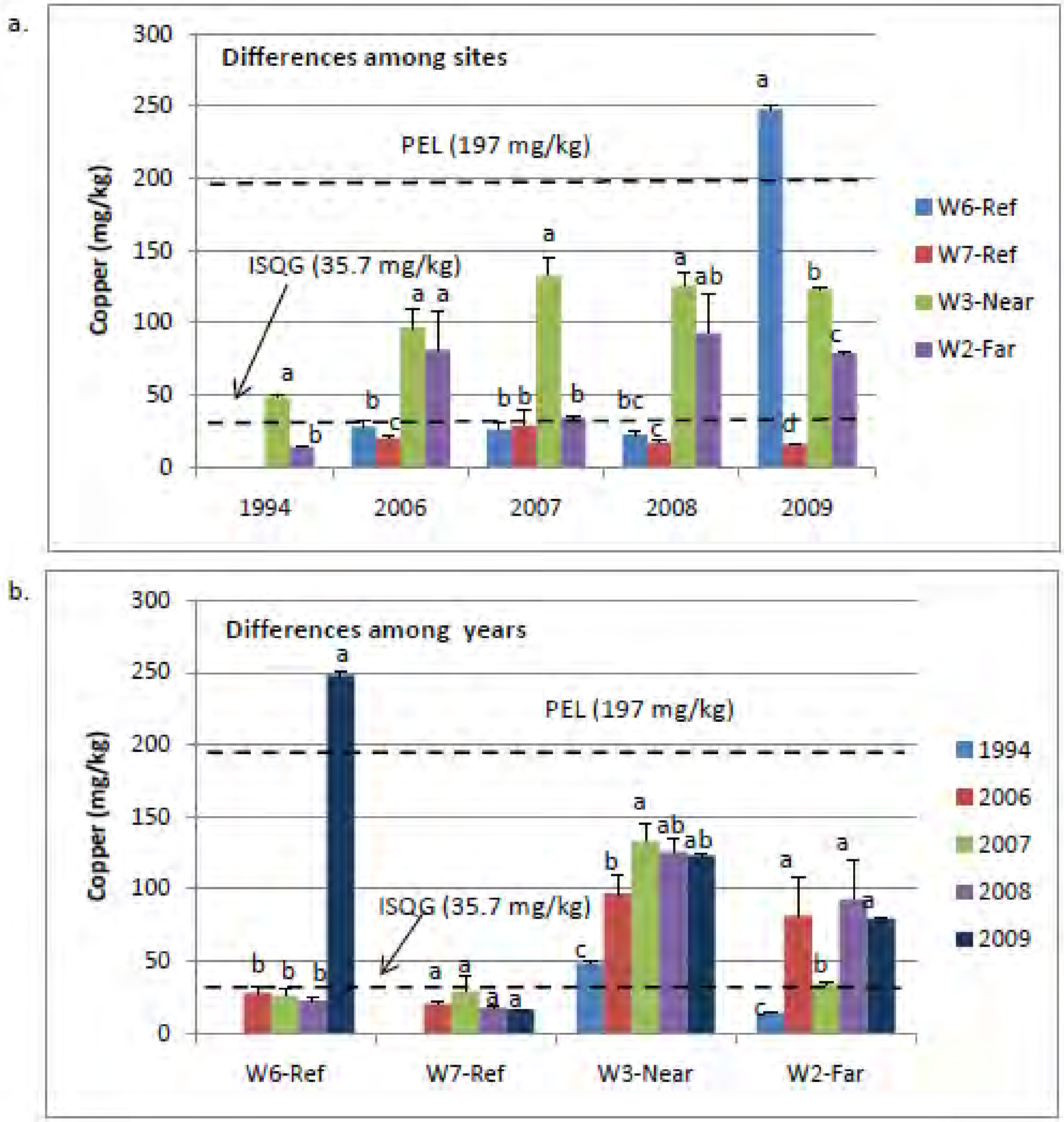

Figure adapted from Minnow (2009)

NOTES

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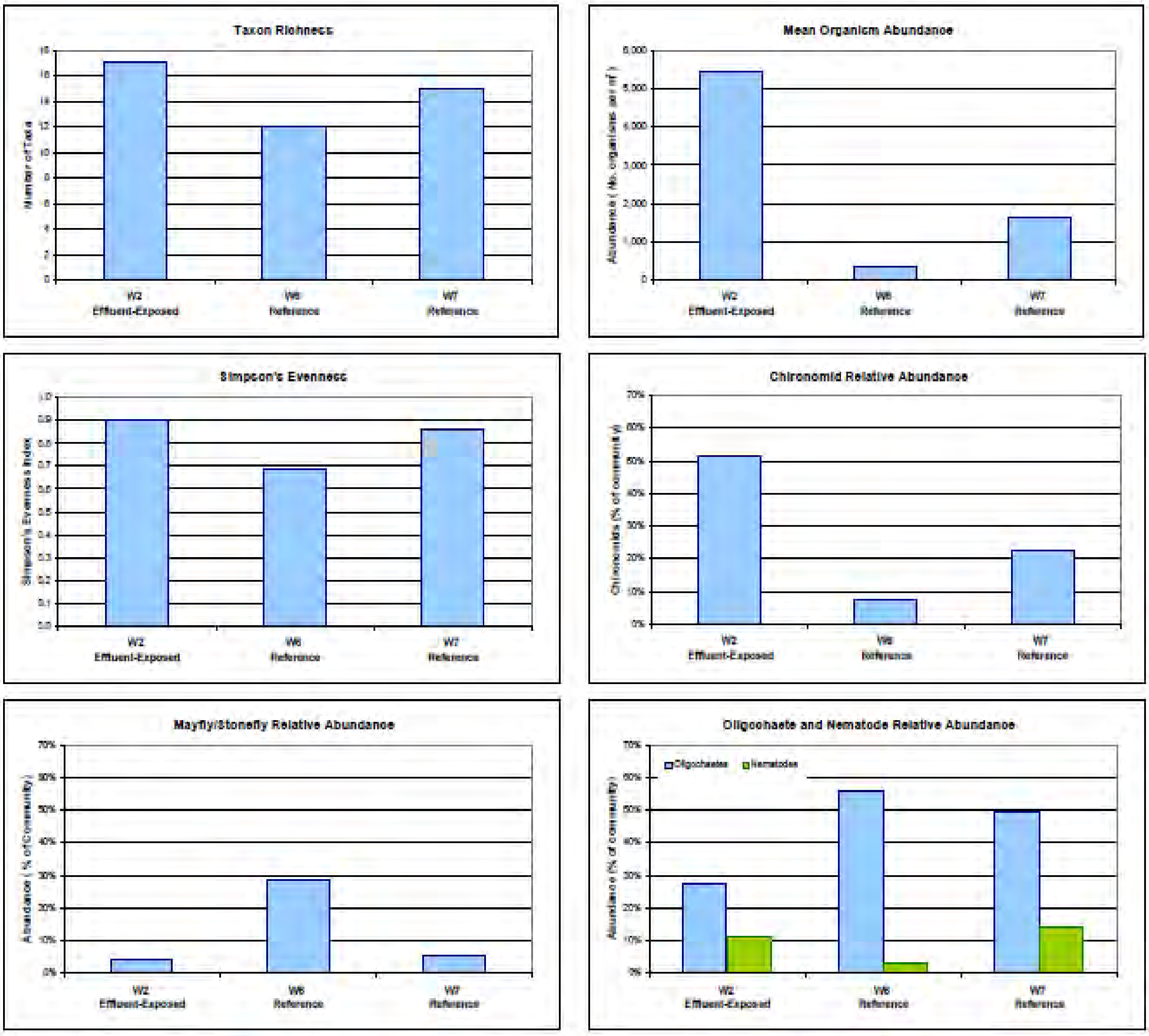
MINTO MINE
FISHERIES AND AQUATICS BASELINE REPORT

Minto Creek
Sediment Quality
Copper Concentrations

PROJECT NO.	DWN	CKD	REV
W14101068.021	NJB	CJJ	1

OFFICE	DATE
EBA-WHSE	March 31, 2010

Figure 9



LEGEND

Figure adapted from Minnow (2009)

NOTES

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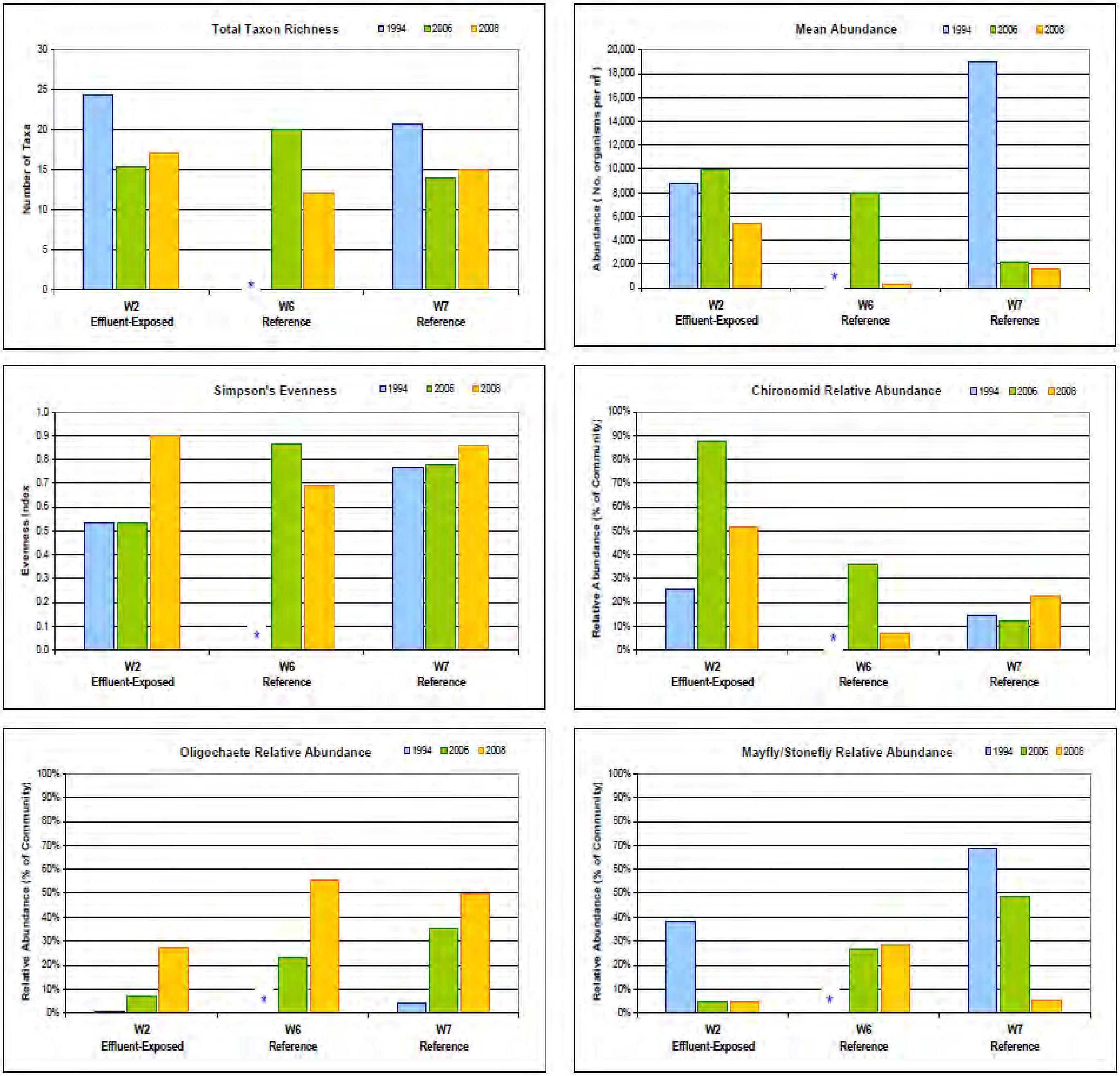
MINTO MINE
FISHERIES AND AQUATICS BASELINE REPORT

Benthic Community Index Results
Minto Project Water Use Licence
September 2008

PROJECT NO.	DWN	CKD	REV	
W14101068.021	NJB	CJJ	1	Figure 10
OFFICE	DATE			
EBA-WHSE	March 31, 2010			



LEGEND

Figure adapted from Minnow (2009)

NOTES

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MINTO MINE
FISHERIES AND AQUATICS BASELINE REPORT

Benthic Community Index Comparison
Minto Project Water Use Licence
1994, 2006, and 2008 Data

PROJECT NO.	DWN	CKD	REV
W14101068.021	NJB	CJJ	1
OFFICE	DATE		
EBA-WHSE	March 31, 2010		

Figure 11

APPENDIX A

APPENDIX A GENERAL LIFE HISTORY CHARACTERISTICS OF YUKON RIVER FISH SPECIES

GENERAL LIFE HISTORY CHARACTERISTICS OF YUKON RIVER FISH SPECIES

The following life history summaries have been modified from HKP (1994) using information from sources including the Yukon Territorial Government's website (2009).

Coho salmon *Onocorhynchus kisutch*

Starting in October, Coho salmon spawn in swift flowing tributaries with gravel substrate as far inland as Dawson. They are brood hiders and, although they do not guard the deposited eggs, females often guard the redd throughout the spawning period. Exogenous feeding starts at the alevin phase and prey includes insects and other invertebrates. As the smolt phase is reached, fish become an important food source. While in the Yukon River system, the juveniles inhabit shallow gravel areas and in late summer or fall, move to deeper pools. The majority of juvenile Coho salmon reach the ocean as smolts by the end of their first year and return to spawn after a further year and some months in the ocean. The presence of Coho salmon in the Minto region has not yet been documented.

Chum salmon *Oncorhynchus keta*

Two chum salmon spawning runs take place in the Yukon River; one in late summer and one in late fall. The range extends into the major tributaries of the Yukon River (White, Stewart, Pelly and Teslin Rivers) and into the Minto region. Chum salmon are brood hiders and the female partially covers the redd after spawning. Hatching occurs in winter and free embryos remain in the gravel until they are able to migrate to the sea. The freshwater rearing period for Chum salmon alevins and juveniles has been reduced and migration to the sea may take only a few days to a few weeks. Alevins and juveniles may or may not feed during their migration. Chum salmon return to spawn their third or fourth year.

Chinook salmon *Oncorhynchus tshawytacha*

Chinook salmon migrate up the Yukon River at a rate greater than 30 km per day and reach their spawning areas by July or August. They are brood hiders and the redds are covered with gravel after spawning. Females may dig several redds and spawn with more than one male and will guard the nest as long as possible before dying. Hatching occurs in the following spring and free embryos remain in the gravel until the yolk is absorbed. Alevins and juveniles prey on various invertebrate organisms during their first year in freshwater and then migrate downstream as smolts, becoming primarily piscivorous at sea. While in freshwater, alevins will school but juveniles soon become defensive of territories. Adults return to spawn in the Yukon river usually after 4 to 7 years in the ocean. The presence of juvenile Chinook salmon was detected in the lower section of the Minto Creek (near its confluence with the Yukon River) during the 2007 and 2009 surveys conducted for MintoEx.

Burbot *Lota lota*

Burbot spawn in mid-winter, usually between January and March. They are bottom-dwellers and open substrate spawners and produce pelagic larvae. At night during spawning activity several individuals roll together in a constantly moving ball over sand or gravel substrate. Larger females may produce over a million small eggs (approximately 1 mm in diameter) which are not guarded. Eggs are semi-pelagic and are easily transported by water movement. Free embryos lack embryonic respiratory organs, similar to those belonging to the pelagic spawning guild. Feeding actively at night, small burbots prey aquatic insects, crustaceans, plankton and fish eggs, whereas larger individuals prey predominantly on fish. The adult stage is reached at 3 or 4 years of age.

Arctic grayling *Thymallus arcticus*

Arctic grayling spawn in small streams as soon as ice break up has commenced. Males defend territories while on the spawning ground. Arctic grayling spawn over unprepared cobble or gravel and produce benthic embryos and larvae. Hatching occurs fairly quickly and exogenous feeding starts while the yolk is still present. At this phase, prey consists largely of zooplankton, while bottom nymphs, snails, small fish and eggs, and a high percentage of terrestrial insects make up the diet of older juveniles and adults. Spawning populations consist of individuals four years of age and older. A small number of juvenile arctic grayling were detected in the lower section of the Minto Creek (near its confluence with the Yukon River) during the 1994 and 2007 surveys conducted for MintoEx.

Inconnu *Stenodus leucichthys*

Inconnu are relatively abundant in the Yukon, Pelly, Stewart and Porcupine River systems. They are rock and gravel spawners and brood hiders, and no protection is given to the embryos once spawning is completed. Spawning takes place between late summer and early winter in tributary streams, producing free embryos that remain in the spawning substrate until they emerge as fully formed alevins. Young inconnu prey on various invertebrates such as insect larvae and planktonic crustaceans, whereas fish, including the Chinook salmon, comprise much of the diet of larger individuals.

Bering cisco *Coregonus laurettae*

In Canada, Bering cisco are only found in the Yukon River. They spawn in fast-flowing water on open rock and gravel substrates and do not attempt to hide their brood. Hatching occurs in the spring and the free embryos are photophobic and retreat into the substrate. Being an anadramous species, juvenile Bering cisco do not appear to spend much time rearing in freshwater and migrate out of the river as fry. Their diet likely consists of a variety of benthic and planktonic foods and adults return to spawn probably in early fall. Bering cisco reach sexual maturity between 4 and 9 years of age.

Least cisco *Coregonus sardinella*

Least cisco are rock and gravel, open substrate spawners. Spawning usually occurs in September and adults abandon the eggs after spawning has been completed. Hatching occurs the following spring and free embryos move into the substrate. Least cisco diet consists of aquatic insects, mollusks, crustaceans, aquatic worms and small fish. There are both anadramous and freshwater populations.

Lake whitefish *Coregonus clupeaformis*

Lake whitefish spawn on rock and gravel substrates in the shallow water of lakes and rivers. Embryos are benthic and not guarded by the spawning adults. The diet of adult lake whitefish includes aquatic insects, mollusks, crustaceans, fish eggs and small fish. Spawning occurs in fall or early winter.

Round whitefish *Prosopium cylindraceum*

Round whitefish, like many other coregonids, are rock and gravel, open substrate spawners. Round whitefish do not guard their broods and embryos are benthic. Their diet consists of benthic invertebrates including mayfly larvae and pupae, chironomid and caddisfly larvae, amphipods, mollusks, crustaceans, fish eggs and small fish. Spawning occurs during the fall in both lakes and rivers.

Northern pike *Esox lucius*

Northern pike are spring, obligatory plant spawners and non-guarders. Spawning occurs in shallow weedy areas close to shore or calm rivers over a two to five day period. During this time, females release a small number of eggs in each of many spawning acts. After each episode, the highly adhesive eggs are scattered by a tail thrust and attach to macrophytes. Eggs hatch in approximately two weeks and non-photophobic free embryos are shaped so that they swim upwards. Cement glands are present on the heads of free embryos. These strategies have evolved so that embryos are not subject to the often hypoxic conditions of the spawning ground bottom. Small juveniles feed on zooplankton and sub-adult aquatic insects while larger juveniles and adults prey on various larger organisms such as fish and amphibians as well as small mammals and aquatic birds. In northern areas, males and females usually mature at five and six years of age, respectively. Northern pike typically winter in deeper rivers and lakes.

Slimy sculpin *Cottus cognatus*

Slimy sculpin are spring, nest spawners and guarders of their young. Eggs are deposited in natural rock cavities or clean, constructed burrows where the male guards the embryos. These areas are generally well oxygenated and therefore, respiratory organs of the embryos are only partially developed. The adult diet consists of aquatic insects, crustaceans, fish eggs and small fish. Throughout the year, the slimy sculpin lives in rock- or cobble-bottomed streams and lakes and sometimes in brackish waters.

Longnose sucker *Catostomus catostomus*

Longnose suckers are rock and gravel spawners and produce benthic larvae. Their spring spawning runs commence when stream water temperatures reach 5°C. Spawning usually occurs in streams at an approximate mean depth of 20 cm with a 30 to 45 cms^{-1} flow rate and a gravel and cobble substrate size range from 5 to 10 cm. Longnose sucker will spawn in shoal areas of lakes if streams are not present. Hatching occurs in approximately two weeks and photophobic free embryos remain in the substrate for one to two weeks. Prey of the longnose sucker is almost exclusively benthic invertebrates including amphipods, caddisfly, midge, mayfly, ostracods, gastropods, beetles, pelecypods, as well as copepods and cladocerans. They will also occasionally feed on fish eggs and vegetation. Longnose sucker reach sexual maturity at varying ages, the youngest possibly at five years.

APPENDIX B

APPENDIX B REACH DESCRIPTIONS FROM HKP 1994 BASELINE STUDIES

Minto Creek	
Reach 1, site 1 (Plate 1):	The stream gradient is 1.5%. Bed material consists of clays, silts and small gravel. This section of the creek is in an area of backwater from the Yukon River, and therefore, the water is relatively static. The stream cover was approximated at 45% and was comprised of large organic debris (LOD), undercut banks and deep pools. In addition, the water was extremely turbid. The average depth of the creek was 1.3 m. The average wetted width was 4.5 m. The creek banks are very unstable.
Reach 1, site 2 (Plate 2):	The stream gradient is 2.5%. Bed material consists of mostly fines (40%), gravel (35%) and small cobble (30%). The stream is composed mostly of run (45%), with areas of riffle (35%) and several pools (20%). Cover was provided by cutbanks, deep pools and LOD. The average wetted width was 2.5 m. Flows were estimated at 0.612 m^3/s. The water was clearer than site #1, but was dark brown in colour.
Reach 1, site 3 (Plate 3):	Due to limited access a new site was established approximately 1.5 km downstream of site 1. Unlike site 1, site 2 did not appear to be in the burn zone which covers the majority of the Minto Creek watershed. The stream gradient at site 2 is 6% and the average wetted width is 3 m. Bed material consists of mostly large cobble with some boulders. The creek is primarily composed of pools and chutes. Stream cover was approximated at 20% and was comprised of overvegetation and large boulders.
Reach 3, site 1 (Plate 4):	The stream gradient is 3.0% and the average wetted width is 3.0 m. Bed material consists of mostly fines (85%) with some small gravel (15%). The creek is primarily composed of run with some pools. Stream cover was approximated at 65% and was comprised of LOD, deep pools, overstream vegetation and cutbanks.
Reach 5, site 1 (Plate 5):	The stream gradient is 4% and the average wetted width is 3.0 m. Bed material consists mostly of fines (60%) with some gravel and small cobble. The stream is composed of mostly riffle (45%), with some areas of pool and run. Substantial cover (50%) is provided by LOD, overstream vegetation, cutbanks and deep pools.
Reach 5, site 2 (Plate 6):	An alternate site was also designated for reach 5 so that it could be accessed by vehicle. The stream gradient is 4% and the average wetted width is 3.0 m. Bed material consists mostly of fines (60%) with some gravel and small cobble. The stream is composed of mostly riffle (45%), with some areas of pool and run. Substantial cover (50%) is provided by LOD, overstream vegetation, cutbanks and deep pools.

Creek A	
Reach 1, site 1 (Plate 7):	The creek has an approximate gradient of 0.5% and an average wetted width of 0.5 m. The stream is composed mainly of run (88%) and the stream bed consists exclusively of fines. The stream cover is provided mostly by cutbanks, with some areas of deep pools, and occasional in-stream and over-stream vegetation.
Reach 1, site 2 (Plate 8):	An alternate site adjacent to the road was chosen so the site could be accessed by truck. The creek has an average wetted width of 0.50 m. The stream is composed mainly of run (88%) and the stream bed consists exclusively of fines. The stream cover is provided mostly by cutbanks, with some areas of deep pools, and occasional in-stream and over-stream vegetation. The creek meanders throughout an area which consists mostly of sedge. Many small ponds exist in the area.

Plates 1-12: Fisheries Sample Sites in Minto Creek and Tributaries (HKP, 1994)

Plate 1: Minto Creek, Reach 1, Site 1 (at Yukon River)

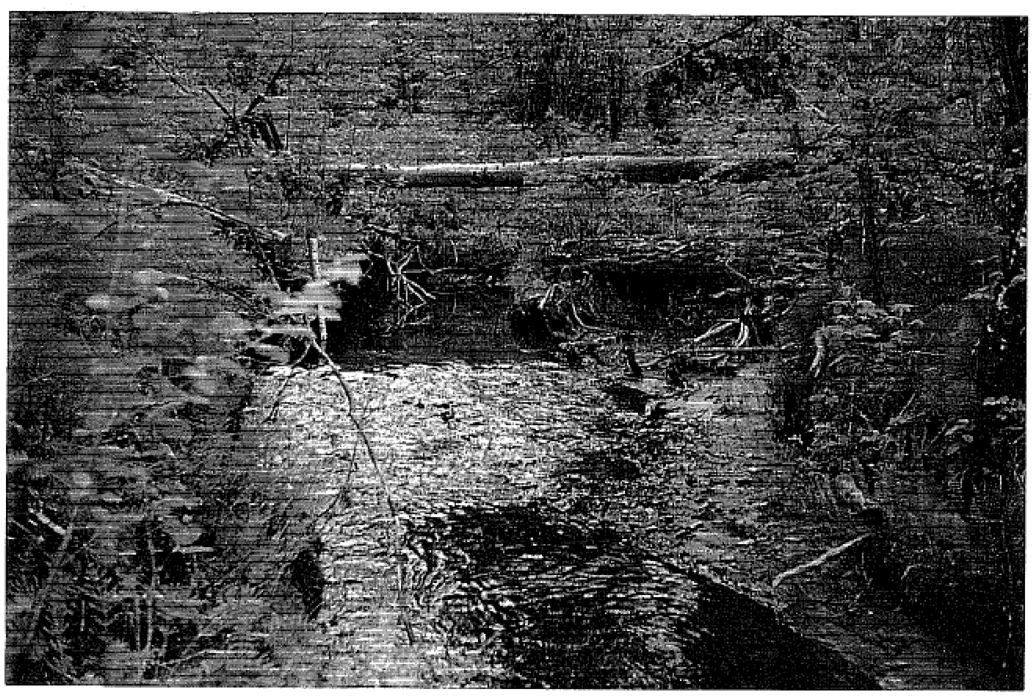

Plate 2: Minto Creek, Reach 1, Site 2.

Plate 3: Minto Creek, Reach 1, Site 3.

Plate 4: Minto Creek, Reach 3, Site 1.

Plate 5: Minto Creek, Reach 5, Site 1.

Plate 6: Minto Creek, Reach 5, Site 2 (at H3/W3).

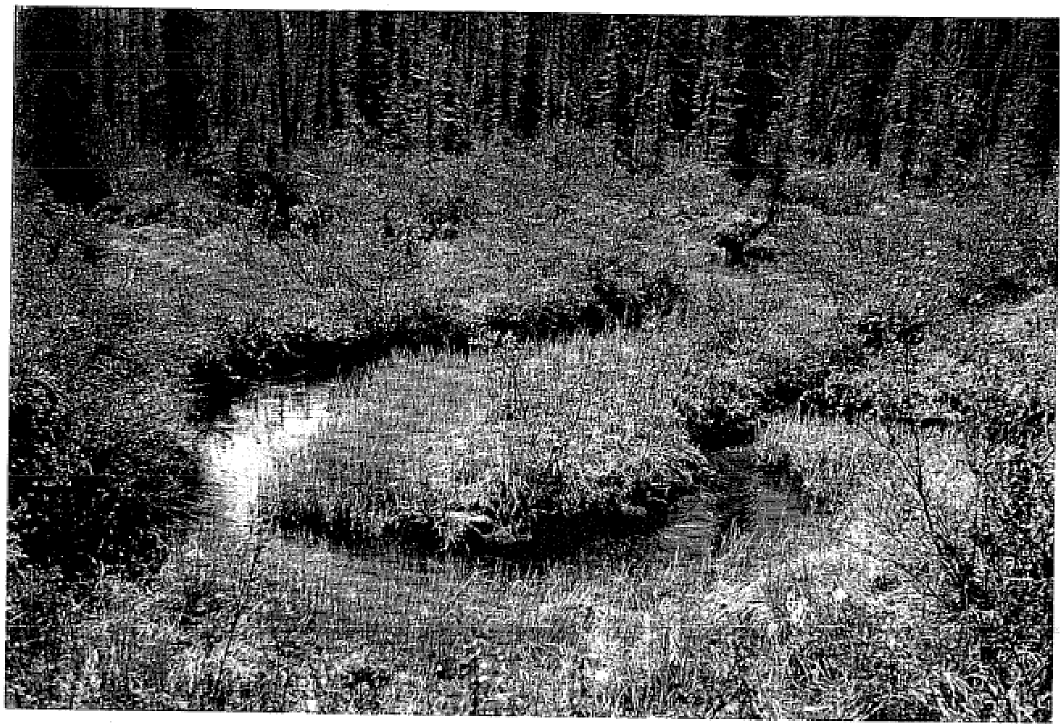

Plate 7: Creek A, Reach 1, Site 1.

Plate 8: Creek A, Reach 1, Site 2.

Plate 9: Creek B, Reach 1, Site 1.

Plate 10: Creek B, Reach 2, Site 1.

Plate 11: Dark Creek Tributary, Site 1

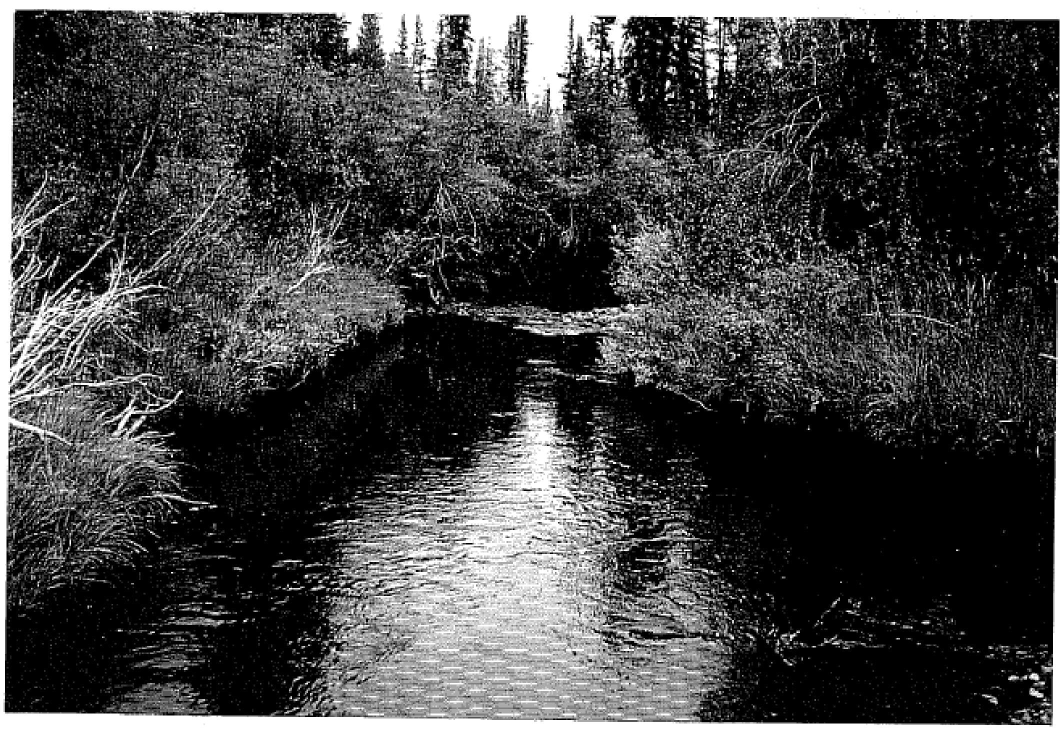

Plate 12: Dark Creek, Site 1.

Plate 13: Fish Barrier in Minto Creek, Reach 2

APPENDIX C

APPENDIX C 2009 FISH RELOCATION SUMMARY REPORT BY ACCESS CONSULTING GROUP

A MEMBER OF ALEXCO RESOURCE GROUP
3 Calcite Business Centre, 151 Industrial Road, Whitehorse, Yukon Y1A 2V3
PHONE (867) 668-6463 **FAX** (867) 667-6680
WWW.ACCESSCONSULTING.CA
mail@accessconsulting.ca

Letter Report

MINTO CREEK FISH RELOCATION PROJECT
September 29 – October 2, 2009
October 12 – 14, 2009

Background

There was some expectation that, due to increased flows occurring in the lower Minto Creek system (from the emergency discharge program), Chinook salmon young of the year (YOY), as well as other naturally occurring species (Slimy Sculpins), might have been attracted into lower Minto Creek from the Yukon River. The Department of Fisheries and Oceans Canada (DFO) submitted a letter to the Yukon Water Board dated June 23, 2009 in response to an application Minto Explorations Ltd. made requesting permission to discharge water. DFO's letter recommended installation of a temporary fish barrier to prevent fish from entering Minto Creek during elevated discharge periods. In addition a fish relocation program was conducted to prevent fish from being trapped in the system at freeze-up and/or following a substantial reduction in flow.

Accordingly, the Minto Creek Fish Relocation Project was conceived, organized and executed as described below.

Authority

DFO Permit #CL-09-45

Relocation Project

Physical Layout

The Lower Minto Creek System (project area) was arbitrarily divided into two parts for the purpose of this project. The division was set at the culvert crossing of Minto Creek at km 11 of the Minto Mine Road. The area upstream of that point, Minto Creek upstream (upstream aspect), constituted a potential linear Creek distance of approximately 1.5 km. The area downstream from the road crossing (downstream aspect) incorporated a linear Creek distance of approximately 500 m, terminating at its confluence with the Yukon River.

The section of lower Minto Creek where fish have been captured in the past is a small, low gradient stream, averaging approximately 2 m in width. Access to the Creek is substantially compromised due to the very dense bush and abundant deadfall bordering the lower Creek on both sides, for much of its length. There is an existing, minimally maintained walking trail along about 600 m of the eastern upstream aspect of the project area. No such access existed along the downstream aspect, which is even more heavily inundated with vegetation and deadfall than the upstream aspect.

Approval had been given (Selkirk First Nation Access and Land Use Permit #09-03/Sept. 24, 2009) to construct a basic ATV accessible trail into the downstream portion, in order to accommodate some access to the Creek, and also to allow for the transport of sandbags and related equipment and materials for the purpose of constructing a temporary fish barrier near the Minto Creek confluence with the Yukon River. This barrier was conceived, designed and installed to prevent the migration of additional fish into Minto Creek during the emergency discharge and fish re-location program

Methodology

Minnow trapping with Gee's minnow traps had been determined to be the primary method for fish capture, with the possibility for electrofishing as applicable, although actual access to, and subsequent use within, the Creek with an electrofishing unit was generally considered to entail a substantial safety risk.

All minnow traps were baited with Yukon River origin Chinook salmon roe. All captured fish during Phase I were released into Big Creek, approximately 150 m upstream of the confluence of Big Creek with the Yukon River. Big Creek is a substantial tributary to the Yukon River, located eight road kilometres upstream on the Yukon River from Minto Creek. All captured fish during Phase II were released directly into the Yukon River at a point approximately 1.5 road kilometers upstream from its confluence with Minto Creek.

PHASE I

<u>September 29</u>

The actual hands-on project was initiated on September 29, 2009. The route of the proposed ATV access trail, having been evaluated a substantial time previously, was identified and flagged that morning. Cutting of the trail was intended to have begun at the same time, but circumstances delayed the trail clearing crew until the following day.

Trapping began on the upstream aspect of the project area on September 29. An extensive reconnaissance had already been conducted on this portion of the Creek, and a rough walking trail had been identified and flagged. The Creek was followed on foot to a point approximately 600 m upstream from the culvert crossing at km 11. At this point, due to the enclosing canyon wall on the east, it was necessary to cross the Creek. The Creek was followed for another approximate 400 m until another crossing would have been required due to the impending canyon wall to the west.

In between the first and second Creek crossings, three natural in-stream barriers were encountered. The first two were considered substantial but likely only partial fish barriers; the third was considered to be a complete fish barrier.

Plate 1. Natural existing fish barrier approximately 900 m upstream of km 11.

The barrier was approximately 0.6 m high and spanned the entire width of the Creek.

Three traps were set upstream of the natural barrier, and the installation of an additional 29 traps was undertaken, spaced somewhat evenly (allowing for stream configuration and access) over the entire distance all the way back downstream to the Minto Mine Road.

All traps were flagged in a specific and highly visible manner so that none would be missed during re-setting and/or recovery.

After the setting of the upstream traps was completed, a temporary fish barrier was constructed at the outlet of each of the two culverts (Minto Creek) at the road crossing at km 11. A total of 20 sandbags were used for the two barriers.

Plate 2. Temporary fish barriers placed at the outlets of Road crossing culverts – Km. 11, Minto Mine Road.

A layer of plastic Vexar® screening (1/4 “) was added and extended downstream from the barrier, aiding in the prevention of upstream fish migration. This allowed for isolation of the upstream section of the project area in terms of trapping and monitoring Catch per Unit Effort (CPUE)

<u>September 30</u>

Checking of the upstream traps began at approximately 11:30, starting with the upstream extent of the sets. The results from the first set of upstream traps are presented in Table 1. Traps were not set in the downstream aspect on September 29 as the access trail had not been completed at that time.

TABLE 1: Overnight Minnow Trapping Results – September 30.

Location	Date of Catch	Set Duration	Fish Captured	# Traps	Average Catch per Trap (ch)
Upstream of Culvert	September 30	Overnight	292 Ch; 1 SS	32	9.13
Downstream of Culvert	N/A	N/A	N/A	N/A	N/A

Ch = Chinook salmon fry; SS = Slimy Sculpin

No fish were captured in the traps set upstream of the suspected natural barrier, confirming it as a barrier to fish migration. Each of the 29 remaining traps, with the exception of three, contained at least one salmon fry. One trap contained 80 salmon fry.

One trap contained a single dead salmon fry. That trap was pulled and placed at another location. All traps, with the exception of the three upstream of the complete fish barrier, were re-set. No other mortalities were encountered.

During the afternoon, a fish barrier was constructed in Minto Creek in the downstream aspect of the project, near its confluence with the Yukon River. A total of 29 sandbags were used for this barrier.

Plate 3. Temporary fish barrier placed in Minto Creek near its confluence with the Yukon River.

Plate 4. Different view of the same temporary fish barrier as in Plate 3.

Location of terminal downstream Minto Creek fish barrier: 0392846 6948664

A layer of plastic Vexar® screening extended downstream from the barrier, aiding in the prevention of upstream fish migration.

This downstream barrier measured 251 cm in width and spanned the entirety of Minto Creek while providing a minimum drop of 50 cm from the surface of the water to the bottom of the sandbags.

The site for the barrier was chosen due to its relative closeness to the Yukon River, and a manageable width and depth for the purpose of installing an artificial barrier. From this point downstream to the Yukon River, Minto Creek was extremely heavily inundated with deadfall and large woody debris, to the extent that any reasonable access to and within the Creek was not available.

Immediately after the construction of the downstream barrier, a total of 16 minnow traps were set in the downstream aspect (from km 11 downstream to the barrier) of the project area. The first nine set sites were accessible by walking within the Creek, downstream from the Minto Mine Road. The remaining seven were set upstream from the barrier with the assistance of ATV access on the newly cut trail.

<u>October 1</u>

On the morning of October 1, all minnow traps throughout the entire project area were checked, and most were re-set with fresh bait.

At approximately 6:00 am that morning, the flow into Minto Creek had been reduced by approximately 60%, according to the pre-determined procedure for this project. A significant reduction in flow was not noticeable at this time.

The results of the overnight trapping on October 1 are presented in Table 2.

TABLE 2: Overnight Minnow Trapping Results – October 1.

Location	Date of Catch	Set Duration	Fish Captured	# Traps	Average Catch per Trap (ch)
Upstream of Culvert	October 1	Overnight	69 Ch	25	2.76
Downstream of Culvert			142 Ch	16	8.875

Ch = Chinook salmon fry

All artificial fish barriers were inspected for soundness and function.

All minnow traps were supplied with fresh bait and re-set.

<u>October 2</u>

All minnow traps were checked and then removed from Minto Creek, and the relocation project was suspended, pending additional supplies and personnel.

The results of the overnight trapping on October 2 are presented in Table 3.

TABLE 3: Overnight Minnow Trapping Results – October 2.

Location	Date of Catch	Set Duration	Fish Captured	# Traps	Average Catch per Trap (ch)
Upstream of Culvert	October 2	Overnight	175 Ch; 1 BB	25	7.0
Downstream of Culvert			144 Ch	16	9.0

Ch = Chinook salmon fry; BB = Burbot

A summary of effort and results from Phase I is presented in Table 4.

TABLE 4: Summary of Minnow Trapping Effort and Results – Phase I

Minto Creek Total	Trapping Period	Set Duration	Fish Captured	# Traps Set	Average Catch per Trap (ch)

Upstream @ natural fish barrier ► downstream to artificial fish barrier near Yukon River	Sept. 29 – Oct. 2	Three nights upstream; two nights downstream	822 Ch (1 found dead)	114	7.21

Ch = Chinook salmon fry

During this phase of the relocation project, a total of 822 Chinook salmon fry were captured. Eight hundred and twenty-one (821) Chinook salmon fry were released unharmed into Big Creek, a tributary of the Yukon River in the same general area as Minto Creek. One slimy sculpin and one juvenile burbot were also captured and released unharmed. Two sub-samples of Chinook fry were measured for fork length (mm). The sample sizes were 36 and 25. The respective averages of the two sub-samples (fork length) were 73.1 mm and 70.8 mm.

Nineteen Chinook salmon fry were retained for metals analyses (DFO permit #CL-09-54), but were included in the total count of 822.

Plate 5. Salmon fry about to be sampled for fork length prior to release.

Plate 6. Salmon fry captured in Minto Creek being relocated into Big Creek.

PHASE II

For a variety of reasons, including availability of necessary resources, both personnel and material, the fish relocation project was suspended for one week. Water flow in Minto Creek from the discharge continued during this interval ensuring survival of any remaining fish. The barriers only prevented fish from migrating upstream and did not prevent them from migrating downstream past the barriers and out of Minto Creek.

<u>October 12</u>

Phase II was initiated on the morning of October 12, employing the same basic methodology that was used during Phase I.

A total of 24 minnow traps were set in the area upstream of the culvert at km 11 on the Minto Mine Road.

A total of 17 minnow traps were set in the area downstream of the culvert at km 11. These traps were somewhat evenly distributed from the culvert to the previously installed downstream barrier.

All traps were baited with Yukon River Chinook salmon roe. All captured fish were released unharmed into the Yukon River. During Phase I, fish were released into Big Creek. This was done at the time in order to prevent the possibility of fish moving a short distance downstream from the release site on the Yukon River and being attracted back up into Minto Creek. During Phase II, the downstream barrier on Minto Creek had proven to hold fast, and all indications were that it provided a complete and formidable barrier to upstream migration. The Yukon River release site was a much closer and more conveniently accessible release site than Big Creek.

October 13

The morning of October 13 was clear and cold. The ambient temperature was approximately – 12 °C. Ice had formed overnight along the edges of Minto Creek, and the water level had risen noticeably due to downstream ice blockages. Ice had to be chipped away at almost every minnow trap site in order to retrieve them. As the water was super-chilled (below freezing), a substantial amount of crystallized, or frazzle, ice immediately formed on each minnow trap as it was removed from the water. While this caused no apparent damage to any fish trapped inside, it made the entire process of checking and re-setting traps more difficult and time consuming.

The cold ambient temperature also presented another problem. When the plastic containers used to transport captured fish out to the Mine Road were filled with Creek water, the super-chilled water immediately began to freeze when exposed to the sub-freezing air temperature. Captured fish would not be able to survive for long, as the container water immediately began to form ice crystals as it progressed to a solid block of ice. In order to circumvent this problem, several containers were filled with water taken from the Yukon River, which was still well above 0 °C. Then the containers were driven back to the culvert at km 11, and left in the vehicle with the heater on for approximately 20 minutes. This process warmed the water sufficiently to allow for the walk to the upstream terminus and back to the road without the water forming any substantial amount of ice. Also, as the day progressed, the air temperature began to rise, and eventually the sun broke into the canyon and provided moderate warmth to the opaque fish containers. The project crew made it a point to place the containers in the sun whenever they stopped to check traps. This method proved to be successful and was employed both mornings that the traps were checked (Oct. 13 and 14).

The results of the overnight trapping as collected on October 13 are listed in Table 5.

TABLE 5: Overnight Minnow Trapping Results – October 13.

Location	Date of Catch	Set Duration	Fish Captured	# Traps	Average Catch per Trap (ch)
Upstream of Culvert	October 13	Overnight	102 Ch	24	4.25
Downstream of Culvert			52 Ch	17	3.06

Ch = Chinook salmon fry

All artificial fish barriers were inspected for soundness and function. Minto Creek was just at about the same level as the top of the barrier on the morning of October 13, in the higher flow culvert. As previously mentioned, the Creek had risen overnight due to ice dam blockages downstream. The extreme downstream barrier was evaluated and determined to still be functioning as a complete fish barrier.

All minnow traps were supplied with fresh bait. Due to a very low catch rate in the upstream aspect of the upstream area of the project, eleven traps were removed from that area. The upper 2/3 of the upstream area yielded a very small number of fish, therefore emphasis was placed on the first 200 metres or so upstream of the culvert at km 11. A total of 13 traps were set overnight in the overall upstream aspect.

Due to the substantial rise in the level of Minto Creek, four traps were removed from the downstream aspect of the project area, out of concern for having safe access to them should the Creek continue to rise. As it turned out, this concern was justified. An additional trap was removed from the vicinity of the terminal downstream barrier, as it was damaged while attempting to remove it through the surface ice. A total of 12 traps were set overnight in the downstream aspect.

October 14

All minnow traps were removed from Minto Creek, and due to the significant reduction in the number of fish captured as compared to the previous day, the relocation project was considered successful, and therefore terminated at that point.

The ambient air temperature was -15 °C that morning, and the same precautions regarding water freezing in the fish containers were taken as were the previous morning.

Minto Creek had risen again overnight. The water level in the high flow culvert was measured, and found to be 28 cm above the uppermost aspect of the barrier.

The results of the overnight trapping as collected on October 14 are listed in Table 6.

TABLE 6: Overnight Minnow Trapping Results – October 14.

Location	Date of Catch	Set Duration	Fish Captured	# Traps	Average Catch per Trap (ch)	Catch Compared to previous day
Upstream of Culvert	October 14	Overnight	10 Ch	13	0.77	9.8%
Downstream of Culvert			1 Ch	12	0.08	1.9%

Ch = Chinook salmon fry

A summary of effort and results from Phase II is presented in Table 7.

Table 7: Summary of Minnow Trapping Effort and Results – Phase II

Minto Creek Total	Trapping Period	Set Duration	Fish Captured	# Traps Set	Average Catch per Trap (ch)
Upstream @ natural fish barrier ► downstream to artificial fish barrier near	Oct. 12 – Oct. 14	Two nights upstream; two nights downstream	165 Ch	66	2.5

Yukon River					

Ch = Chinook salmon fry

During this phase of the relocation project, a total of 165 Chinook salmon fry were captured. All captured fish were released unharmed into the Yukon River just upstream of the Minto Creek confluence.

Summary

During both phases of the relocation project, a collective total of 987 Chinook salmon fry were captured from Minto Creek. Accounting for one salmon mortality in the trap, and 19 retained for “metals in tissue” analysis, 967 Chinook salmon fry were removed from Minto Creek and relocated unharmed into either Big Creek or the Yukon River. In addition, one slimy sculpin and one juvenile burbot were captured and released unharmed.

During the entire relocation project, a total of 180 overnight minnow trap sets was accomplished. The last collection day yielded a total of 11 fish constituting about 1% of the number captured overall, providing confidence that well over 90% of the fish occurring in lower Minto Creek, between the natural and man-made barrier, at the time of this project had been captured and re-located

The man-made fish barriers located at the culverts at km 11, installed on September 29, were removed at approximately 2:00 pm on October 14. The barrier near the Yukon River was left in place and was to be removed following cessation of discharge of water from the mine site.

APPENDIX D

APPENDIX D SELKIRK FIRST NATION INTERVIEW QUESTIONNNAIRE – COMPILED REPORT 1999

Minto Mine

Interview Questionnaire Compiled Report

Interviewer: Nancy Alfred

List of Interview Participants:

Kitty Johnathan	Elder
Tommy Joe	Elder
George McGinty	SFN Member
Maria VanBibber	Elder
Alex Joe	Elder
Franklin Roberts	Elder
Danny Roberts	Elder
Daniel Luke	SFN Member
Darryl Johnny	SFN Member
Annie McGinty	Elder
Mary Blanchard	Elder
Johnny Simon	SFN Member

Location: All 12 interviewee's reside in Pelly Crossing

Date of Interview: Nov. 25-30, 1999

General

1. Provide each person with a brief background of the project.

- DIAND is trying to compile existing information on the Minto Mine as part of the devolution of Federal responsibilities to YTG and First Nations.
- Minto Explorations Ltd. is developing the Minto Mine on Minto Creek that flows into the Yukon River near the Ingersoll Islands.
- The Minto Mine is located within Selkirk First Nation's traditional territory and on settlements lands.
- Due to First Nation's longstanding history with the area and local fish and wildlife resources, their local knowledge is essential in assisting with understanding the local environment.
- Interviews are being conducted to help document environmental conditions in the project area.

Note: Numbers in parentheses indicate number of similar interviewee responses.

2. How long have your lived in this area and have you been in the Minto Mine area?

(9) Lifetime; (1) 37 Years; (2) only hunt and fish in area.

Fishing

3. Do you or have you ever fished within your traditional territory in the Minto Mine area?
Yes 12
No 0

4. If yes, where do you consider important fishing areas? (Show these locations on the map and write them down in the space below).

- (11) Good fishing from Minto to Fort Selkirk on Yukon River
- (2 of 11) also fish in Creek Mouths in area
- (1) all areas

Location

5. What species of fish do you catch at each site and when do you fish at each site (i.e, which months)? What methods do you use (i.e., gillnets, hook and line, etc.)?

	Species of Fish	**Month Fished**	**Method**
Site 1	grayling; Spring Salmon Dog Salmon (Minto Landing)	May – November	Rod & Reel Stickline; Hook and Net
Site 2	Whitefish; Salmon (Ft. Selkirk)	May- November	Net & stick
Site 3	Whitefish; Salmon; (Carpenter Slough)	July – November	Net
Site 4	Salmon, Grayling, Whitefish, Pike (Yukon River area)	July – November	Net

6. Do you know where any of these fish spawn? (Show the locations on the map).

Fish Species	Code (for map) (F = fish)	General Location
Chinook Salmon (King, Spring)	F-CS	Big Creek
Chum Salmon (Dog salmon)	F-CS	Big Creek
Arctic Grayling (Grayling)	F-AG	Big Creek
Burbot (Loch; Ling; Lingcod; Myria)	F-BU	Yukon River

Fish Species	Code (for map)	General Location
Inconnu (Coney)	F-IC	Yukon River
Lake whitefish (Whitefish; Crooked back)	F-LW	Yukon River –Slough Creek
Longnose sucker (Sucker)	F-LS	Yukon River –Slough Creek
Mountain whitefish (whitefish)	F-MW	Yukon River
Northern pike (Pike; Jackfish)	F-NP	Yukon River,-Slough Creek mouths
Others? - Species Name:		Tizra, Broad Whitefish
	F-SP1	________________
	F-SP2	________________
	F-SP3	________________
	F-SP4	________________
	F-SP5	________________

7. Have you noticed any changes in the abundance of fish or timing of their migrations over the years? If so, what are the changes?

- Fish are getting less (12)
- The runs are later (11)
- The fish are smaller (1)

8. Have you noticed changes in the quality of fish caught in the river or tributaries (i.e., flavour, watery flesh, parasites, etc.)? If yes, what changes have you noticed?

Whitefish	Less fat (2)
King Salmon	100% good (6) –25% Soft and deformed (7),75% Thru 85% good (4) 45% soft are deformed.
Dog Salmon	100% good (4) 70-80% good (8) 50% Soft and deformed 25% soft and deformed (4) 35% less fat (1)
Inconnu	Coney (5) small (4) soft (1)
Grayling	Small (7) Not so fat (9) Some not so fat (2)

Waterfowl

9. What species of waterfowl do you know of in the Minto Mine area?

- All kinds of waterfowl during migration time. (12)
- Summer time for small duck (12) --- and Goose (6)

10. Do you know of waterfowl species resting in the project area? (Show the locations on the map).

Waterfowl	Code (for map) (W = waterfowl)	General Location
Widgeon	W-WG	From Minto to Selkirk, (12)
Goldeye	W-GE	"
Teal	W-TE	"
Canada goose	W-CG	"
Mallard	W-MA	"
Shoveller	W-SH	"
Others? - Waterfowl Name:		
	W-WF1	
	W-WF2	
	W-WF3	
	W-WF4	
	W-WF5	

11. Do you know where, or if, eagles and hawks nest in the project are?

- Up and down the Yukon River (11)
- Less eagles in 1940; No eagles in 1999 (1)

12. Have you noticed any changes in the abundance of waterfowl or timing of their migrations over the years? If so, what are they?

- Less ducks noted in area (12)

Trapping

13. Do you or have you ever trapped within your traditional territory in the project area?
Yes (12)
No none

14. If so, what species have you trapped and where have you trapped them?

Trapped Species	Code (for map) (T = trapping)	General Location
Beaver	T-BE	4
Muskrat	T-MU	4
Lynx	T-LY	4
Fisher	T-FI	4

Otter	T-OT	4
Rabbit/Hare	T-RA	4
Marten	T-MA	
Mink	T-MI	4
Fox	T-FO	4
Wolverine	T-WO	4
		All (12)

Others? - Species Names:

	T-SP1	Squirrels
	T-SP2	Wolf
	T-SP3	
	T-SP4	
	T-SP5	

15. Of the above, what are the most important species?.

- All (12)

16. Have you noticed any changes in the abundance of furbearing species over the years? If so, what were these changes?

- When there are less rabbits, there are less animals (1)
- When there are no rabbits, there are no animals (4)
- When there are less rabbits, there are less animals; when there are no rabbits, there are no animals (7)

Wildlife

17. What species do you consider important in the Minto Mine area? (show the locations on the maps).

Species	Code (for map) (H = hunting)	General Location
Black Bear	H-BB	4
Caribou	H-CA	4
Grizzly Bear	H-GB	4
Moose	H-MO	4
Mule Deer	H-MD	4
Elk	H-EL	none
Wolf	H-WO	4
		(12)

Others? - Species Name:

____	H-SP1	

____ H-SP2 ______________________
____ H-SP3 ______________________
____ H-SP4 ______________________

18. Have you noticed any changes in the number of any of these species? If so, how have the numbers of each species changed?

- Less number of animals since the 1995 fire, but they are coming back. (12)

19. Have you noticed any changes in the location of any of these species? If so, which species are more or less common then they were previously?

- Less number of all species, but they are coming back (12)

20. Have you noticed any changes in the quality of the waterfowl or game that you eat?

- No noticeable changes-(4)
- Note: The rest of interviewees misunderstood the question

Other Resource Areas

21. Are you aware of any archaeological and traditional land use areas within the Minto Mine area? (show on the Map)

- There is a sacred traditional area within the Project area, but will not disclose (12)

22. Are you aware of any other activities in the Minto Mine area that you think are important (berry picking, plants or others)? (Show on map)

- berry picking, grouse, rabbits, Indian medicine plants (12)

23. Have you noticed any changes in the amount of wet areas along the river (i.e., are more or less areas flooded in the spring or dried out in the summer)?

- Wet area along the river is slowly drying up (12)

24. Have you noticed any changes in the river that have affected the habitat or populations of fish, birds, or game over the years?

- If there is less water, than less animals, and then the ecosystem is in trouble

Notes

All people are concerned about the area being mined . It is their traditional land and they are relying on the land for food and wish the land to be available to their offspring.

APPENDIX E

APPENDIX E MINTO MINE, DETAILED SEDIMENT QUALITY RESULTS, 1994 – 2009

Results of Stream Sediment Survey[+] Conducted for Minto Exploration Ltd.'s IEE (HKP, 1994), Adapted from Table 5.9 of MintoEx's IEE (HKP 1994)

Analysis	Sampling Station															
	S1 (W9)				S2 (W3)				S3 (~100 m d/s W6)				S4 (W2)			
	Replicate				Replicate				Replicate				Replicate			
	a	b	c	AVG	a	b	c	AVG	a	b	c	AVG	a	b	c	AVG
Physical Tests:																
Moisture %	24.50	27.50	23.70	**25.23**	25.30	20.40	19.40	**21.70**	23.00	24.30	25.00	**24.10**	21.00	18.10	16.30	**18.47**
Total Metals:*																
Antimony	0.45	0.31	0.33	0.36	0.46	0.36	0.44	0.42	0.38	0.49	0.45	0.44	0.32	0.29	0.25	0.29
Arsenic	4.59	4.62	3.01	4.07	4.16	4.59	4.17	4.37	4.25	3.85	4.56	4.22	4.57	4.66	4.09	4.44
Cadmium	0.11	0.11	<0.1	0.07	0.12	0.15	0.12	0.13	<0.1	<0.1	<0.1	0.00	<0.1	<0.1	<0.1	0.00
Chromium	17.40	19.30	14.90	17.20	25.30	19.70	21.40	22.13	24.00	21.50	24.40	23.30	13.40	15.00	13.70	14.03
Copper	113.0	104.0	91.40	102.8	46.70	49.00	49.10	48.27	41.50	39.00	40.90	40.47	14.20	14.20	13.00	13.80
Lead	3.10	4.00	3.00	3.37	3.90	4.10	3.80	3.93	3.90	3.70	3.90	3.83	2.60	2.20	<2.0	1.60
Mercury	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01
Molybdenum	<4.0	<4.0	<4.0	0.00	<4.0	<4.0	<4.0	0.00	<4.0	<4.0	<4.0	0.00	<4.0	<4.0	<4.0	0.00
Silver	<2.0	<2.0	<2.0	0.00	<2.0	<6.0	<2.0	0.00	<2.0	<2.0	<2.0	0.00	<2.0	<2.0	<2.0	0.00
Zinc	34.30	38.00	34.90	35.73	47.20	49.10	47.10	47.80	47.20	46.50	51.90	48.53	30.40	28.90	29.00	29.43
Particle Size:																
Gravel - % (>2.00 mm)	8.39	10.50	8.84	9.24	5.36	4.39	4.95	4.90	2.58	1.24	1.43	1.75	25.00	27.50	34.00	28.83
Sand - % (2.00–0.063 mm)	74.00	72.60	69.90	72.17	75.30	75.20	75.10	75.20	78.80	77.70	77.10	77.87	65.40	64.00	58.50	62.63
Silt - % (0.063 mm-4 µm)	13.10	12.80	16.30	14.07	13.60	14.20	14.00	13.93	12.30	14.80	15.20	14.10	7.59	6.56	5.74	6.63
Clay - % (<4 µm)	4.47	4.16	5.02	4.55	5.79	6.24	5.91	5.98	6.39	6.24	6.31	6.31	1.99	1.93	1.75	1.89

[+]Values expressed are means

+ Results are expressed as milligram per dry kilogram

Adapted from Table 5.9 in

Appendix Table 1b: Summary of individual and average metal concentrations at reference (W6 and W7) and exposed (W2 and W3) sites in 2006, Minto Mine

Parameter	Unit	ISQG[a]	PEL[b]	W2-1	W2-2	W2-3	W2-4	W2-5	Mean	SD	W3-1	W3-2	W3-3	W3-4	W3-5	Mean	SD	W6-1	W6-2	W6-3	W6-4	W6-5	Mean	SD	W7-1	W7-2	W7-3	W7-4	W7-5	Mean	SD
Metals																															
Aluminum	mg/kg	-	-	11300	12000	12300	11300	12200	11820	487	12600	12700	12800	13300	10600	12400	1042	12100	12300	13600	13100	13000	12820	614	10200	9470	10800	10600	10600	10334	530
Antimony	mg/kg	-	-	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0
Arsenic	mg/kg	5.9	17	5	5.4	5.1	4.9	5.3	5.1	0.2	5.3	5.7	5.7	6.2	5	5.6	0.5	5.6	6	7	6.7	6.6	6.4	0.6	4.1	3.5	4.2	4.1	4	4.0	0.3
Barium	mg/kg	-	-	182	195	190	180	191	188	6	224	228	244	248	196	228	21	185	189	211	202	206	199	11.1	156	147	168	163	161	159	8
Beryllium	mg/kg	-	-	0.38	0.4	0.4	0.38	0.4	0.39	0.01	0.45	0.45	0.46	0.48	0.38	0.44	0.04	0.36	0.37	0.42	0.41	0.4	0.39	0.0	0.32	0.3	0.35	0.34	0.33	0.33	0.02
Bismuth	mg/kg	-	-	0.5	*<0.5*	*<0.5*	*<0.5*	*<0.5*	<0.5	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0
Cadmium	mg/kg	0.6	3.5	0.2	0.2	0.2	0.2	0.2	0.2	0	0.2	0.1	0.1	0.1	0.1	0.1	0.04	0.1	0.1	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1	0.1	0.1	0.1	0
Calcium	mg/kg	-	-	8670	9270	9540	8800	9320	9120	369	8520	8700	8780	9080	6830	8382	891	7260	7480	8460	8120	8260	7916	519	7390	6860	8020	7850	7610	7546	452
Chromium	mg/kg	37.3	90	26.1	28.7	29.3	26.8	28.7	27.9	1.4	29.4	29.2	28.8	30.1	23.6	28.2	2.6	27	27.1	31.8	29.3	29.1	28.9	2.0	27.2	24.7	29	29.6	28.3	27.8	1.9
Cobalt	mg/kg	-	-	7.66	8.09	8.49	7.76	8.46	8.09	0.38	8.43	8.42	8.56	9.12	7.28	8.36	0.67	6.84	6.94	7.76	7.53	7.59	7.33	0.4	6.52	6.17	6.96	6.68	6.5	6.57	0.29
Copper	mg/kg	35.7	197	121	97.6	63.6	64.9	60.6	81.5	26.7	110	98.6	92.8	105	77.6	97	13	26.4	24.6	34.1	28.4	27.5	28.2	3.6	22.2	21.6	20	19.8	17.1	20.1	1.98
Iron	mg/kg	-	-	21600	23200	23400	21600	23400	22640	953	25000	25000	25600	26700	21200	24700	2076	21500	21700	24800	23500	23600	23020	1395	19100	17600	20400	20600	19700	19480	1207
Lead	mg/kg	35	91.3	7.8	8.8	7.2	10.4	8.6	8.6	1.2	7.8	7.1	7.1	7.1	5.6	6.9	0.8	6.4	6.3	7.8	7.2	7	6.9	0.6	5.6	5.3	6.6	6	5.2	5.7	0.6
Lithium	mg/kg	-	-	9.8	10.5	10.7	9.9	10.8	10.3	0.5	10.3	10.4	10.4	10.9	8.4	10.1	1.0	10	10.2	11.3	10.8	10.8	10.6	0.5	8.4	7.7	8.9	8.6	8.5	8.4	0.4
Magnesium	mg/kg	-	-	5680	6030	6090	5650	6110	5912	228	6190	6260	6330	6710	5300	6158	520	4880	4920	5470	5290	5310	5174	260	4960	4670	5270	5100	5030	5006	220
Manganese	mg/kg	-	-	689	747	760	733	802	746	41	773	784	814	864	688	785	64	396	405	465	446	462	435	32	361	358	381	361	352	363	11
Mercury	mg/kg	0.17	0.486	0.04	0.037	0.038	0.035	0.039	0.038	0.002	0.033	0.037	0.031	0.037	0.032	0.034	0.003	0.033	0.213	0.035	0.032	0.029	0.068	0.081	0.026	0.031	0.029	0.03	0.582	0.140	0.247
Molybdenum	mg/kg	-	-	0.51	0.55	0.55	0.52	0.55	0.54	0.02	0.86	0.85	0.87	0.95	0.76	0.86	0.07	0.4	0.4	0.51	0.5	0.4	0.4	0.06	0.52	0.5	0.56	0.62	0.5	0.54	0.05
Nickel	mg/kg	-	-	26.8	28.1	28.1	26.4	28.5	27.6	0.9	27.2	27.6	27.5	29.3	23.3	27.0	2.2	22.4	22.6	25.7	24.3	24.7	23.9	1.4	23.4	21.9	24.7	23.7	23.2	23.4	1
Phosphorus	mg/kg	-	-	938	984	1040	913	977	970	49	1090	1030	1070	1100	884	1035	88	795	803	901	871	862	846	46	1060	937	1120	1160	1120	1079	87
Potassium	mg/kg	-	-	940	1010	1020	952	1030	990	41	1330	1340	1390	1440	1120	1324	122	709	716	795	764	756	748	36	741	685	781	755	750	742	35
Selenium	mg/kg	-	-	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0
Silicon	mg/kg	-	-	136	153	150	149	140	146	7	169	164	176	165	169	169	5	132	119	108	119	102	116	12	99	86	93	110	116	101	12
Silver	mg/kg	-	-	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*	0	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0	*<0.2*	0.1	*<0.2*	*<0.2*	*<0.2*	<0.2	0.04
Sodium	mg/kg	-	-	275	279	277	257	285	275	11	245	246	248	258	210	241	18	196	198	221	206	200	204	10	210	202	220	217	221	214	8
Strontium	mg/kg	-	-	74.5	79.2	79.7	76.6	81.6	78.3	2.8	61.3	64.3	63.7	66.1	52	61.5	6	40.5	41.4	46.2	44.2	44.6	43.4	2	57.9	56.3	62.5	60.1	58.2	59	2
Thallium	mg/kg	-	-	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0
Tin	mg/kg	-	-	1.9	2.5	1.2	5	2.6	2.6	1.4	1.2	0.9	0.9	0.8	0.4	0.8	0.3	0.8	0.5	1	0.9	0.5	0.7	0.2	0.6	0.6	1.7	0.9	0.6	0.9	0.5
Titanium	mg/kg	-	-	315	332	353	321	344	333	16	296	317	312	313	251	298	27	324	328	380	343	336	342	22	278	265	290	297	308	288	17
Vanadium	mg/kg	-	-	42.1	45.2	46.3	42.3	46	44.4	2	50.9	50.7	52.2	53.4	42.5	49.9	4.3	42.3	43.1	49.2	46.4	46.2	45.4	2.8	40.3	36.6	43	44.4	42.7	41.4	3.1
Zinc	mg/kg	123	315	120	118	115	107	123	117	6	62.6	62.5	62.1	65.5	51.4	60.8	5.4	47.3	47	53.2	51.5	51	50	2.7	47	43.7	49.8	48.7	47.5	47.3	2.3
Zirconium	mg/kg	-	-	4.3	4.6	4.7	4.4	4.7	4.5	0.2	4.8	4.9	5.07	5.13	4.2	4.8	0.4	4.7	4.8	5.26	5	5	4.95	0.2	4	3.8	4.2	4.2	4	4.0	0.2
Particle size																															
gravel - % (>2.00mm)	% by weight	-	-	21.1	17.9	15.2	16.6	14.4	17.0	2.6	6.1	6.6	3.5	5.2	7	5.7	1.4	2.6	4.4	2.9	2.8	2.6	3.1	0.8	8.2	6.9	5.6	6.4	8.2	7.1	1.1
sand - % (2.00-0.053mm)	% by weight	-	-	79.6	83.3	86.7	86.1	88.8	84.9	3.6	96.6	96.2	97.7	95.9	95.4	96.4	0.9	95.4	94.3	96.8	96	100.4	96.6	2.3	88.2	87.4	86.6	90.7	89.7	88.5	1.7
silt/clay - % (<0.053mm)	% by weight	-	-	2.2	2.5	2.6	2.1	1.9	2.3	0.3	2.2	2	3	3.3	2.2	2.5	0.6	6.2	5.8	5.9	6.2	6.5	6.1	0.3	7.8	9.4	12	7.9	8.3	9.1	1.8
Other																															
pH	pH units	-	-	7.8	7.7	8	8	8.1	7.9	0.2	7.9	7.9	7.9	7.8	7.9	7.9	0.04	7.3	7.2	7.3	7.2	7.2	7.2	0.1	7	7.1	7	7	7	7.02	0.04

Values in italics are below detection limit

[a] Interim Sediment Quality Guideline, Canadian Environmental Quality Guidelines, CCME (1999)

[b] Probable Effects Level, Canadian Environmental Quality Guidelines, CCME (1999)

(light grey box) Individual sample concentration exceeds ISQG

(dark grey box) Average concentration exceeds ISQG

Appendix Table 1c: Summary of individual and average metal concentrations at reference (W6 and W7) and exposed (W2 and W3) sites in 2007, Minto Mine

Parameter	Unit	ISQG[a]	PEL[b]	W2-1	W2-2	W2-3	W2-4	W2-5	Mean	SD	W3-1	W3-2	W3-3	W3-4	W3-5	Mean	SD	W6-1	W6-2	W6-3	W6-4	W6-5	Mean	SD	W7-1	W7-2	W7-3	W7-4	W7-5	Mean	SD
Metals																															
Aluminum	mg/kg	-	-	10300	10700	10900	10600	10800	10660	230	17900	17200	17300	17100	17300	17360	313	13000	13300	12800	12100	12200	12680	517	10200	10900	10500	10900	10700	10640	297
Antimony	mg/kg	-	-	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0
Arsenic	mg/kg	5.9	17	5	5.3	5.3	5.5	4.9	5.2	0.2	4	3.8	3.4	3.9	3.9	3.8	0.2	5.6	5.5	5.5	4.1	4.5	5.0	0.7	2.9	3.2	3.1	3.7	3.9	3.4	0.4
Barium	mg/kg	-	-	194	198	195	196	198	196	2	446	443	404	411	440	429	20	215	222	221	194	198	210	13	164	178	177	196	194	182	13
Beryllium	mg/kg	-	-	0.39	0.39	0.4	0.39	0.4	0.39	0.01	0.69	0.67	0.67	0.66	0.68	0.67	0.01	0.42	0.43	0.42	0.37	0.39	0.41	0.03	0.32	0.36	0.34	0.38	0.37	0.35	0.02
Bismuth	mg/kg	-	-	0.5	0.8	0.7	0.7	*<0.5*	<0.6	0.1	1.4	1.5	1.3	1.8	1.4	1.5	0.2	*<0.5*	*<0.5*	*<0.5*	0.8	0.6	<0.6	0.1	*<0.5*	*<0.5*	0.8	0.6	0.8	<0.6	0.2
Cadmium	mg/kg	0.6	3.5	0.3	0.3	0.3	0.3	0.3	0.3	0	0.3	0.3	0.3	0.3	0.3	0.3	0	0.3	0.3	0.2	0.2	0.2	0.24	0.05	0.2	0.2	0.2	0.3	0.2	0.22	0.04
Calcium	mg/kg	-	-	18400	21500	20000	21700	19200	20160	1433	12900	12400	11200	11800	12300	12120	646	8270	8260	8440	6910	7420	7860	663	7370	8080	7810	8780	8560	8120	568
Chromium	mg/kg	37.3	90	22.7	23.6	25.1	23.8	24.1	23.9	0.9	27.4	26.7	24.9	28.8	26	26.8	1.5	29.8	29.7	28.8	26.5	26.5	28.3	1.7	25.9	27	27.4	29.1	29.7	27.8	1.56
Cobalt	mg/kg	-	-	8.34	8.77	8.95	8.73	8.48	8.65	0.24	11.4	10.9	11	10.9	10.9	11.0	0.2	8.63	8.76	8.74	7.72	7.87	8.34	0.51	7.55	8.01	7.98	8.42	8.64	8.12	0.42
Copper	mg/kg	35.7	197	32	33.5	36	33.9	34.5	34.0	1.5	135	123	151	123	133	133	11	31.7	30.6	25.2	21.1	20.2	25.8	5.3	15.8	21.3	46.2	31.5	28.6	28.7	11.6
Iron	mg/kg	-	-	22700	24000	24200	23800	23600	23660	581	33300	32200	32700	32400	32000	32520	507	25500	25700	25300	22000	22600	24220	1771	20000	21200	21100	22100	22600	21400	1002
Lead	mg/kg	35	91.3	4.1	4.2	4.2	4.2	4.2	4.2	0.04	4.6	4.7	3.9	5.5	4.6	4.7	0.6	4.6	4.5	4.2	3.8	3.5	4.1	0.5	3.1	3.6	4.2	4.2	4.8	4.0	0.6
Lithium	mg/kg	-	-	11.4	12.1	12.2	12.1	11.7	11.9	0.3	16.6	15.9	15.9	15.6	15.9	16.0	0.4	11.5	11.6	11.3	10.4	10.7	11.1	0.5	9.2	9.8	9.5	9.9	9.9	9.7	0.3
Magnesium	mg/kg	-	-	6470	7010	7080	7010	6760	6866	253	9160	8660	8990	8640	8790	8848	223	5600	5700	5560	5250	5290	5480	199	5410	5770	5600	5820	5890	5698	193
Manganese	mg/kg	-	-	537	577	590	563	565	566	20	1200	1140	1170	1110	1120	1148	37	565	563	622	372	466	518	99	453	504	570	616	638	556	77
Mercury	mg/kg	0.17	0.486	0.053	0.054	0.045	0.042	0.055	0.050	0.006	0.045	0.035	0.05	0.051	0.055	0.047	0.008	0.046	0.04	0.063	0.029	0.052	0.046	0.013	0.041	0.046	0.102	0.039	0.034	0.052	0.028
Molybdenum	mg/kg	-	-	0.4	0.4	0.5	0.4	0.4	0.4	0.04	0.86	0.85	0.88	0.95	0.76	0.86	0.07	0.3	0.3	0.3	0.2	0.2	0.26	0.05	0.3	0.4	0.4	0.4	0.4	0.4	0.04
Nickel	mg/kg	-	-	19.5	20.6	21.5	20.4	20.2	20.4	0.72	26.8	25.8	23.6	26.8	25	25.6	1.3	23.2	23.8	23.5	21.7	21.8	22.8	1.0	22.2	23.6	23.2	24.8	25.4	23.8	1.3
Phosphorus	mg/kg	-	-	900	891	917	880	970	912	35	1040	1020	1060	1080	1050	1050	22	1020	982	979	892	924	959	51	1200	1210	1200	1220	1240	1214	17
Potassium	mg/kg	-	-	1150	1300	1300	1250	1170	1234	71	2410	2270	2440	2190	2320	2326	102	769	798	781	683	724	751	47	739	782	760	797	787	773	23
Selenium	mg/kg	-	-	0.6	0.3	0.4	0.3	0.8	0.5	0.2	0.9	0.7	0.6	0.7	0.6	0.7	0.1	0.7	0.4	0.6	0.5	0.5	0.5	0.1	0.3	0.5	0.5	0.6	0.6	0.5	0.1
Silicon	mg/kg	-	-	304	318	130	169	163	217	87	168	85	129	306	353	208	116	142	166	241	155	153	171	40	345	189	116	378	229	251	109
Silver	mg/kg	-	-	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0
Sodium	mg/kg	-	-	247	267	261	260	255	258	7	229	222	212	222	222	221	6.1	183	191	176	176	178	181	6	195	200	199	207	201	200	4
Strontium	mg/kg	-	-	78.1	83.3	81.4	83	82.3	81.6	2.1	92.8	87.5	75.2	80.6	86.2	84.5	6.8	44.4	45.2	45.5	38.7	41	43.0	3.0	62.9	70.5	68.9	78.7	75.7	71.3	6.1
Thallium	mg/kg	-	-	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0
Tin	mg/kg	-	-	0.4	0.3	0.4	0.3	0.6	0.4	0.1	0.6	0.6	0.6	0.8	0.4	0.6	0.1	0.7	0.4	0.4	0.4	0.5	0.5	0.13	0.4	0.4	0.7	0.7	0.8	0.6	0.2
Titanium	mg/kg	-	-	327	373	354	352	346	350	17	365	342	362	368	362	360	10	348	372	336	341	326	345	17.3	316	294	275	329	302	303	21
Vanadium	mg/kg	-	-	46.2	49.1	49	48.9	48.5	48.3	1.2	63.3	61.2	62	61.9	61.1	61.9	0.9	49.2	49	47.4	43.2	43.7	46.5	2.9	39.9	41.7	41.2	43.9	44.1	42.2	1.8
Zinc	mg/kg	123	315	57.5	60.3	61.3	55.5	58.6	58.6	2.3	86.7	80.8	85	81.8	82.6	83.4	2.4	51.2	50.5	49.6	45.1	46	48.5	2.8	45.1	48.9	51.7	50.8	51.2	49.5	2.7
Zirconium	mg/kg	-	-	5.07	5.22	5.08	5.16	4.9	5.1	0.1	5.85	5.57	5.33	5.8	5.83	5.68	0.22	5.14	5.49	5.25	5	4.8	5.1	0.3	4.3	4.2	4	4.9	4.6	4.4	0.4
Particle Size																															
gravel - % (>2.00mm)	% by weight	-	-	5.3	27.6	11.6	9.2	8.6	12.5	8.8	17.2	4.8	11.5	17.8	9.5	12.2	5.5	17.9	2.8	2	4.9	10.3	7.6	6.6	2.4	1.9	1.1	0.4	0.2	1.2	0.9
sand - % (2.00-0.053mm)	% by weight	-	-	59.3	52.9	68.4	58.2	69.6	61.7	7.1	69.3	81.7	75.7	74.4	71.1	74.4	4.8	75.7	88.7	86.5	80.5	76.8	81.6	5.8	94.6	93.4	97.7	97.6	97.5	96.2	2.0
silt/clay - % (<0.053mm)	% by weight	-	-	35.4	19.2	19.9	32.5	21.9	25.8	7.6	13.7	13.5	12.3	7.5	20.4	13.5	4.6	6.8	8.7	11.4	14.3	12.6	10.8	3.0	2.6	4.4	1.3	2.2	2.3	2.6	1.1
Other																															
pH	-	-	-	8	8.2	8.3	8.2	8.3	8.2	0.1	7.8	7.8	7.8	8	7.8	7.84	0.09	7	6.8	6.9	7	6.8	6.9	0.1	7.2	7.2	7.3	7.2	7.1	7.2	0.1

Values in italics are below detection limit

[a] Interim Sediment Quality Guideline, Canadian Environmental Quality Guidelines, CCME (1999)

[b] Probable Effects Level, Canadian Environmental Quality Guidelines, CCME (1999)

(light grey shading) Individual sample concentration exceeds ISQG

(dark grey shading) Average concentration exceeds ISQG

Appendix Table 1d: Summary of individual and average metal concentrations at reference (W6 and W7) and exposed (W2 and W3) sites in 2008, Minto Mine

Parameter	Unit	ISQG[a]	PEL[b]	W2-1	W2-2	W2-3	Mean	SD	W3-1	W3-2	W3-3	Mean	SD	W6-1	W6-2	W6-3	Mean	SD	W7-1	W7-2	W7-3	Mean	SD
Metals																							
Aluminum	mg/kg	-	-	16500	12700	12300	13833	2318	14600	13400	14300	14100	624	12000	12000	12700	12233	404	11300	10400	10100	10600	624
Antimony	mg/kg	-	-	1.8	1.4	1.2	1.5	0.3	0.7	0.5	0.9	0.7	0.2	0.7	1	1.2	1.0	0.3	0.6	1.4	0.8	0.9	0.4
Arsenic	mg/kg	5.9	17	8.4	6.4	5.8	6.9	1.4	4	3.3	4	3.8	0.4	5.7	5.2	5.8	5.6	0.3	3.2	3	2.7	3.0	0.3
Barium	mg/kg	-	-	398	276	259	311	76	290	262	300	284	20	229	217	233	226	8	201	189	170	187	16
Beryllium	mg/kg	-	-	0.64	0.48	0.44	0.52	0.11	0.53	0.49	0.53	0.52	0.02	0.38	0.36	0.4	0.38	0.02	0.35	0.34	0.3	0.33	0.03
Bismuth	mg/kg	-	-	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0
Cadmium	mg/kg	0.6	3.5	*<0.1*	*<0.1*	*<0.1*	*<0.1*	0	*<0.1*	*<0.1*	*<0.1*	*<0.1*	0	*<0.1*	*<0.1*	*<0.1*	*<0.1*	0	*<0.1*	*<0.1*	*<0.1*	*<0.1*	0
Calcium	mg/kg	-	-	16100	12000	11400	13167	2558	18200	15400	13700	15767	2272	8150	7930	8450	8177	261	8380	7960	7610	7983	386
Chromium	mg/kg	37.3	90	188	151	132	157	28	36	33	32.5	33.8	1.9	30.7	30.6	32.2	31.2	0.9	32	30.9	31.3	31.4	0.6
Cobalt	mg/kg	-	-	16.8	12.8	11.8	13.8	2.6	9.15	8.49	9.5	9.05	0.51	7.9	7.48	7.92	7.77	0.25	7.97	7.59	6.98	7.51	0.50
Copper	mg/kg	35.7	197	119	95.1	64.4	92.8	27.4	126	134	117	126	9	23.9	20.6	23.2	22.6	1.7	19.6	17.6	15.4	17.5	2.1
Iron	mg/kg	-	-	38800	35500	33000	35767	2909	32300	29600	31500	31133	1387	27700	26700	28000	27467	681	24800	24000	23000	23933	902
Lead	mg/kg	35	91.3	6.3	10.4	10.1	8.9	2.3	16.4	14.3	14.2	15.0	1.2	9.5	9.2	9.5	9.4	0.2	8.5	7.8	7.5	7.9	0.5
Lithium	mg/kg	-	-	17.1	12.1	11.6	13.6	3.0	12.1	11.2	12	11.8	0.5	9.8	9.6	10.2	9.9	0.3	9.4	8.7	8.3	8.8	0.6
Magnesium	mg/kg	-	-	10000	7490	7020	8170	1602	7300	6650	7140	7030	339	5070	4900	5240	5070	170	5800	5480	5220	5500	291
Manganese	mg/kg	-	-	1750	1290	1160	1400	310	970	835	998	934	87	670	592	651	638	41	537	483	416	479	61
Mercury	mg/kg	0.17	0.486	0.084	0.053	0.03	0.06	0.03	0.041	0.027	0.026	0.031	0.008	0.04	0.035	0.023	0.033	0.009	0.02	0.03	0.026	0.025	0.005
Molybdenum	mg/kg	-	-	17.5	14.6	12.5	14.9	2.5	1.2	0.86	0.94	1.0	0.2	0.5	0.4	0.4	0.4	0.06	0.5	0.5	0.53	0.51	0.02
Nickel	mg/kg	-	-	128	104	89.7	107	19	28.4	26.2	28	27.5	1.2	23.3	22.2	24	23.2	0.9	26.2	24.6	23.4	24.7	1.4
Phosphorus	mg/kg	-	-	1540	1100	1120	1253	248	1190	1200	1140	1177	32	975	1030	992	999	28	1140	1160	1240	1180	53
Potassium	mg/kg	-	-	1580	1200	1160	1313	232	1460	1320	1470	1417	84	677	664	706	682	22	769	706	684	720	44
Selenium	mg/kg	-	-	1.6	1.2	0.8	1.2	0.4	0.3	0.4	0.8	0.5	0.3	0.4	*<0.3*	*<0.3*	<0.3	0.06	0.6	*<0.3*	*<0.3*	<0.4	0.2
Silicon	mg/kg	-	-	598	424	440	487	96	622	549	502	558	60	280	276	310	289	19	264	240	231	245	17
Silver	mg/kg	-	-	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0
Sodium	mg/kg	-	-	578	383	370	444	117	327	304	306	312	13	194	196	204	198	5	224	214	216	218	5
Strontium	mg/kg	-	-	128	90	83.6	100.5	24	98	87.7	87.1	90.9	6.1	46.1	45.6	47.6	46.4	1.0	76.9	71.7	62.2	70.3	7.5
Thallium	mg/kg	-	-	1.1	0.7	0.5	0.8	0.3	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0
Tin	mg/kg	-	-	1	0.5	0.3	0.6	0.4	0.6	0.4	0.6	0.5	0.1	0.2	0.2	0.3	0.2	0.06	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0
Titanium	mg/kg	-	-	638	579	593	603	31	528	549	485	521	33	504	515	539	519	18	515	496	496	502	11
Vanadium	mg/kg	-	-	82.8	64	60.6	69.1	12.0	58.9	55	56.4	56.8	2.0	48.2	48	49.5	48.6	0.8	46.5	45.5	44.9	46	0.8
Zinc	mg/kg	123	315	123	97.2	79.5	99.9	21.9	70.8	64.5	69.7	68.3	3.4	48.1	46.6	50.4	48.4	1.9	50.3	47.4	45.7	47.8	2.3
Zirconium	mg/kg	-	-	4.4	3.5	3.5	3.8	0.5	3.8	3.9	3.6	3.8	0.2	3.4	3.2	3.4	3.3	0.1	3.3	3.2	2.8	3.1	0.3
Particle size																							
gravel - % (>2.00mm)	% by weight	-	-	49	36.6	47.6	44.4	6.8	19.7	19.8	16.7	18.7	1.8	14.1	13.2	14.2	13.8	0.6	11.6	6.8	8.5	9.0	2.4
sand - % (2.00-0.053mm)	% by weight	-	-	51	63	52.3	55.4	6.6	75.8	77.1	77.8	76.9	1.0	81.5	83.3	82.6	82.5	0.9	82.1	86.1	84.6	84.3	2.0
silt/clay - % (<0.053mm)	% by weight	-	-	0.1	0.4	0.2	0.23	0.15	4	2.7	4.9	3.9	1.1	3.6	3.1	3.1	3.3	0.3	5.9	6.9	6.7	6.5	0.5
Other																							
pH	pH units	-	-	8.4	8.3	8.4	8.4	0.1	8.3	8.4	8.4	8.4	0.1	7.6	7.6	7.4	7.5	0.1	7.6	7.6	7.7	7.6	0.1

Values in italics are below detection limit

[a] Interim Sediment Quality Guideline, Canadian Environmental Quality Guidelines, CCME (1999)

[b] Probable Effects Level, Canadian Environmental Quality Guidelines, CCME (1999)

Individual sample concentration exceeds ISQG

Average concentration exceeds ISQG

Appendix Table 1e: Summary of individual and average metal concentrations at reference (W6 and W7) and exposed (W2 and W3) sites in 2009, Minto Mine

				28-Jul-09					8-Aug-09					24-Aug-09					28-Jul-09					28-Jul-09					28-Jul-09				
Parameter	**Unit**	**ISQG[a]**	**PEL[b]**	**W2-1**	**W2-2**	**W2-3**	**Mean**	**SD**	**W2-1**	**W2-2**	**W2-3**	**Mean**	**SD**	**W2-1**	**W2-2**	**W2-3**	**Mean**	**SD**	**W3-1**	**W3-2**	**W3-3**	**Mean**	**SD**	**W6-1**	**W6-2**	**W6-3**	**Mean**	**SD**	**W7-1**	**W7-2**	**W7-3**	**Mean**	**SD**
Metals																																	
Aluminum	mg/kg	-	-	8920	8520	8900	8780	225	4610	4510	3870	4330	401	15300	11600	12900	13267	1877	9640	9940	9920	9833	168	12000	12300	12000	12100	173	9560	9690	9700	9650	78
Antimony	mg/kg	-	-	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0
Arsenic	mg/kg	5.9	17	5.7	5.4	5.5	5.5	0.2	2.8	2.7	3.2	2.9	0.3	6.5	5.6	5.7	5.9	0.5	4.8	4.8	4.8	4.8	0	6.5	6.4	6.3	6.4	0.1	2.5	2.4	2.6	2.5	0.1
Barium	mg/kg	-	-	230	221	227	226	5	78.4	82.2	70.1	76.9	6.2	312	213	250	258	50	326	332	332	330	3	289	294	291	291	3	151	152	153	152	1
Beryllium	mg/kg	-	-	0.4	0.38	0.4	0.39	0.01	0.17	0.17	0.17	0.17	0	0.56	0.41	0.47	0.48	0.08	0.47	0.47	0.47	0.47	0	0.54	0.55	0.55	0.55	0.01	0.34	0.33	0.33	0.33	0.01
Bismuth	mg/kg	-	-	1	1.1	1.3	1.1	0.2	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	*<0.5*	*<0.5*	*<0.5*	*<0.5*	0	1.3	1.3	1.5	1.4	0.1	1	0.7	0.6	0.8	0.2	*<0.5*	0.8	*<0.5*	<0.6	0.2
Cadmium	mg/kg	0.6	3.5	0.2	0.2	0.3	0.2	0.06	*<0.1*	*<0.1*	*<0.1*	*<0.1*	0	0.1	0.2	0.1	0.13	0.06	0.2	0.3	0.2	0.2	0.06	0.3	0.3	0.3	0.3	0	0.1	0.1	0.2	0.1	0.06
Calcium	mg/kg	-	-	7610	7400	7540	7517	107	3660	3960	3560	3727	208	16800	17100	18100	17333	681	7660	7750	7730	7713	47	9120	9200	9090	9137	57	6710	6770	6800	6760	46
Chromium	mg/kg	37.3	90	72.7	68.9	70.8	70.8	1.9	10.2	14.8	8.68	11.23	3.19	57.2	31.9	45.7	44.9	12.7	75.8	77.2	77.1	76.7	0.8	49.7	50.6	50.1	50.1	0.5	29.6	29.6	29.9	29.7	0.2
Cobalt	mg/kg	-	-	11.8	11.5	11.8	11.7	0.2	6.36	5.7	5.94	6.0	0.3	13.4	9.6	11.2	11.4	1.9	13	13	13	13	0	14	14	14	14	0	7.97	7.97	8.04	7.99	0.04
Copper	mg/kg	35.7	197	79.3	78.1	80	79.1	1.0	18.7	19.6	15.7	18.0	2.0	165	120	132	139	23	123	122	124	123	1	250	249	245	248	3	16.2	16.3	16.4	16.3	0.1
Iron	mg/kg	-	-	39000	37300	38700	38333	907	16000	14600	15100	15233	709	35000	27000	30600	30867	4007	48300	49700	49900	49300	872	37200	37600	37000	37267	306	21900	22100	22100	22033	115
Lead	mg/kg	35	91.3	13.1	13.4	13.9	13.5	0.4	2.5	2.6	2.5	2.5	0.06	8	4.8	6.5	6.4	1.6	16.6	16.2	17.4	16.7	0.6	9.6	9.6	9.5	9.6	0.06	4.9	4.6	4.9	4.8	0.2
Lithium	mg/kg	-	-	10.1	9.8	9.9	9.9	0.2	5	4.9	4.7	4.9	0.2	16.5	13.7	14.6	14.9	1.4	9.4	9.4	9.2	9.3	0.1	10.7	10.8	10.6	10.7	0.1	9.2	9.2	9.2	9.2	0
Magnesium	mg/kg	-	-	4950	4800	4940	4897	84	3200	3020	2610	2943	302	8570	6870	7580	7673	854	5380	5400	5350	5377	25	6660	6730	6620	6670	56	5330	5370	5370	5357	23
Manganese	mg/kg	-	-	1100	1070	1120	1097	25	624	544	666	611	62	824	721	923	823	101	2050	2030	2020	2033	15	1880	1900	1890	1890	10	379	383	384	382	3
Mercury	mg/kg	0.17	0.486	0.043	0.03	0.027	0.033	0.009	0.013	0.019	0.01	0.014	0.005	0.088	0.055	0.059	0.067	0.018	0.025	0.026	0.023	0.025	0.002	0.029	0.025	0.028	0.027	0.002	0.018	0.018	0.018	0.018	0
Molybdenum	mg/kg	-	-	6.34	6.3	6.4	6.3	0.05	0.4	0.3	0.4	0.4	0.06	3.4	1	2.3	2.2	1.2	7.56	7.56	7.54	7.55	0.01	4.2	4.2	4.2	4.2	0	0.76	0.75	0.78	0.76	0.02
Nickel	mg/kg	-	-	51.4	49.2	50.6	50.4	1	11.1	11.4	11.6	11.4	0.3	47.1	26.7	36.5	36.8	10.2	52.1	52.3	51.9	52.1	0.2	42.5	42.7	42.4	42.5	0.2	26.3	26.5	26.4	26.4	0.1
Phosphorus	mg/kg	-	-	885	865	882	877	11	423	625	418	489	118	1060	979	1030	1023	41	1120	1120	1120	1120	0	1140	1140	1130	1137	6	1060	1080	1090	1077	15
Potassium	mg/kg	-	-	1040	994	1010	1015	23	499	490	527	505	19	1720	1430	1570	1573	145	1290	1310	1290	1297	12	1330	1340	1320	1330	10	704	704	707	705	2
Selenium	mg/kg	-	-	0.4	0.4	0.4	0.4	0	0.3	*<0.3*	*<0.3*	<0.3	0	1	0.4	0.4	0.6	0.3	0.8	0.7	0.7	0.7	0.1	1.1	1.1	1.4	1.2	0.2	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0
Silicon	mg/kg	-	-	615	576	658	616	41	117	146	127	130	15	740	670	715	708	35	546	647	612	602	51	566	534	484	528	41	373	365	383	374	9.0
Silver	mg/kg	-	-	0.2	0.2	0.2	0.2	0	0.3	0.2	*<0.2*	<0.2	0.06	0.6	0.4	0.7	0.6	0.2	0.3	0.2	0.3	0.3	0.1	0.3	0.2	0.3	0.3	0.06	*<0.2*	*<0.2*	*<0.2*	*<0.2*	0
Sodium	mg/kg	-	-	340	315	332	329	13	158	109	92	120	34	405	407	400	404	4	362	377	368	369	8	384	390	380	385	5	250	255	256	254	3
Strontium	mg/kg	-	-	70.1	68	70	69	1	29.4	32	30.4	30.6	1.3	131	95	112	113	18	67.4	68.6	68.4	68.1	0.6	104	106	102	104	2	57.4	57.7	58	57.7	0.3
Thallium	mg/kg	-	-	0.6	1.1	0.7	0.8	0.3	*<0.3*	*<0.3*	*<0.3*	*<0.3*	0	1.5	*<0.3*	*<0.3*	<0.7	0.7	1	1.6	1.4	1.3	0.3	1.6	1.5	1.5	1.5	0.06	0.3	0.2	0.3	0.3	0.06
Tin	mg/kg	-	-	7.9	8.4	8.9	8.4	0.5	0.3	*<0.2*	*<0.2*	<0.2	0.06	3.1	1.1	2.2	2.1	1.0	9.5	8.5	10.4	9.5	0.95	3.2	3.3	3.4	3.3	0.1	1.2	0.8	1.8	1.3	0.5
Titanium	mg/kg	-	-	589	545	572	569	22	322	302	237	287	44	751	721	799	757	39	696	732	731	720	21	710	733	722	722	12	574	582	582	579	5
Vanadium	mg/kg	-	-	78.4	73.8	77.3	76.5	2.4	31.2	28.8	26.7	28.9	2.3	66.6	55.3	62.6	61.5	5.7	100	103	103	102	2	69.8	71.1	69.5	70.1	0.9	41.3	41.4	41.8	41.5	0.3
Zinc	mg/kg	123	315	53	52	53.3	52.8	0.7	29.9	27.9	32.3	30.0	2.2	81.6	57.6	63.4	67.5	12.5	66.4	66.7	66.7	66.6	0.2	73.1	73.4	72.4	73.0	0.5	45	45.3	45.4	45.2	0.2
Zirconium	mg/kg	-	-	2.1	1.9	2.1	2.0	0.1	2	2.2	2.3	2.2	0.2	3.6	3.2	3.4	3.4	0.2	2.7	2.8	2.8	2.8	0.06	3.3	3.5	3.4	3.4	0.1	2.6	2.6	2.6	2.6	0
Particle Size																																	
gravel - % (>2.00mm)	% by weight	-	-	81.5	82.7	76.6	80.3	3.2	20.4	17.8	29.3	22.5	6.0	34.4	31.6	26.6	30.9	4.0	76	91.8	95.4	87.7	10.3	48.2	42.7	45.7	45.5	2.8	55.7	52.2	50	52.6	2.9
sand - % (2.00-0.053mm)	% by weight	-	-	18.8	17.5	23.6	20.0	3.2	79.2	81.6	70.3	77.0	6.0	57.6	59.9	72.1	63.2	7.8	23.9	8.9	4.8	12.5	10.1	51.3	56.8	53.9	54.0	2.8	42.8	46	47.3	45.4	2.3
silt/clay - % (<0.053mm)	% by weight	-	-	*0.1*	*0.1*	*0.1*	0.1	0	0.4	0.6	0.5	0.5	0.1	1.1	1.4	1.1	1.2	0.2	*<0.1*	*<0.1*	*<0.1*	<0.1	0	0.2	0.3	0.2	0.2	0.06	1.2	1.7	2.3	1.7	0.6

Values in italics are below detection limit

[a] Interim Sediment Quality Guideline, Canadian Environmental Quality Guidelines, CCME (1999)

[b] Probable Effects Level, Canadian Environmental Quality Guidelines, CCME (1999)

(light grey box) Individual sample concentration exceeds ISQG

(dark grey box) Average concentration exceeds ISQG

Summary of Significant Differences in Sediment Particle Size and Metal Concentrations at Station W3 (upper Minto Creek) from baseline. From Minnow Environmental (2009)					
Parameter	ANOVA p-value	Baseline	Operational	Difference (O-B)	p-value
Gravel	Yes (0.000)	1994	2006	0.8	0.972
			2007	7.3	0.339
			2008	**13.8**	**0.033**
			2009	82.8	0.123
Sand	Yes (0.000)	1994	2006	**21.2**	**0.000**
			2007	-0.8	1.000
			2008	1.7	0.657
			2009	**-62.7**	**0.063**
Silt/Clay	Yes (0.000)	1994	2006	**-17.3**	**0.000**
			2007	-6.3	0.296
			2008	**-15.9**	**0.002**
			2009	**-19.7**	**0.002**
Antimony	Yes (0.004)	1994	2006	-	-
			2007	-	-
			2008	**0.28**	**0.059**
			2009	-	-
Arsenic	Yes (0.000)	1994	2006	**1.2**	**0.020**
			2007	-0.6	0.143
			2008	-0.6	0.739
			2009	**0.4**	0.568
Cadmium	Yes (0.000)	1994	2006	-0.01	0.999
			2007	**0.17**	**0.075**
			2008	**-0.13 to -0.08**	**0.059**
			2009	**0.1**	0.279
Chromium	Yes (0.000)	1994	2006	6.1	0.430
			2007	4.7	0.675
			2008	11.7	0.151
			2009	**54.6**	**0.032**
Copper	Yes (0.000)	1994	2006	**48.5**	**0.002**
			2007	**84.7**	**0.000**
			2008	**77.4**	**0.004**
			2009	**74.7**	**0.001**
Lead	Yes (0.000)	1994	2006	**3**	**0.002**
			2007	0.8	0.316
			2008	**11.1**	**0.002**
			2009	**12.8**	**0.000**
Mercury	Yes (0.000)	1994	2006	**0.024**	**0.000**
			2007	**0.0372**	**0.000**
			2008	0.0213	0.154
			2009	**0.0147**	**0.016**
Molybdenum	Yes (0.000)	1994	2006	-	-
			2007	-	-
			2008	-	-
			2009	**3.55 to 7.55**	**0.000**
Silver	Yes (0.000)	1994	2006	-	-
			2007	-	-
			2008	-	-
			2009	-	-
Zinc	Yes (0.000)	1994	2006	**13**	**0.035**
			2007	**35.6**	**0.000**
			2008	**20.5**	**0.019**
			2009	**18.8**	**0.015**

Particle size data was arc-sin transformed prior to statistical analysis
Metal concentrations were log10 transformed prior to statistical analysis
Grey boxes: operational year is significantly different than baseline

Summary of Significant Differences in Sediment Particle Size and Metal Concentrations at Station W2 (lower Minto Creek) from baseline. From Minnow Environmental (2009)

Parameter	ANOVA p-value	Baseline	Operational	Difference (O-B)	p-value
Gravel	Yes (0.000)	1994	2006	-11.8	0.288
			2007	-16.3	0.131
			2008	15.6	0.329
			2009	51.5	0.001
Sand	Yes (0.000)	1994	2006	22.3	0.002
			2007	-0.9	1.000
			2008	-7.2	0.882
			2009	-42.6	0.003
Silt/Clay	Yes (0.000)	1994	2006	-6.3	0.069
			2007	17.3	0.067
			2008	-8.3	0.045
			2009	-8.4	0.050
Antimony	Yes (0.000)	1994	2006	-	-
			2007	-	-
			2008	1.18	0.000
			2009	-	-
Arsenic	Yes (0.000)	1994	2006	0.7	0.400
			2007	0.8	0.322
			2008	2.4	0.390
			2009	1.1	0.189
Cadmium	-	1994	2006	-	-
			2007	-	-
			2008	-	-
			2009	0.2 to 0.23	0.144
Chromium	Yes (0.000)	1994	2006	13.9	0.001
			2007	9.9	0.009
			2008	143	0.007
			2009	56.8	0.001
Copper	Yes (0.000)	1994	2006	67.7	0.002
			2007	20.2	0.000
			2008	79	0.075
			2009	65.3	0.001
Lead	Yes (0.000)	1994	2006	6.3 to 8.6	0.001
			2007	1.9 to 4.2	0.138
			2008	1.7 to 8.9	0.056
			2009	2.4 to 13.5	0.012
Mercury	Yes (0.000)	1994	2006	0.0278	0.338
			2007	0.0398	0.203
			2008	0.0457	0.206
			2009	0.0233	0.287
Molybdenum	-	1994	2006	-	-
			2007	-	-
			2008	-	-
			2009	-	-
Silver	-	1994	2006	-	-
			2007	-	-
			2008	-	-
			2009	-	-
Zinc	Yes (0.000)	1994	2006	87.2	0.000
			2007	29.2	0.000
			2008	70.5	0.094
			2009	23.4	0.001

particle size data was arc-sin transformed prior to statistical analysis
metal concentrations were log10 transformed prior to statistical analysis
[shaded] that operational year is significantly different than baseline

Summary of ANOVA and Post-Hoc Statistics for Each Sampling Area. From Minnow Environmental (2009)

Area	Metal	ANOVA	Year	1994	2006	2007	2008
W2	Arsenic	Yes (0.000)	1994	-	-	-	-
			2006	0.400	-	-	-
			2007	0.322	1.000	-	-
			2008	0.390	0.738	0.761	-
			2009	0.189	0.206	0.434	0.900
	Chromium	Yes (0.000)	1994	-	-	-	-
			2006	0.001	-	-	-
			2007	0.009	0.007	-	-
			2008	0.007	0.025	0.024	-
			2009	0.001	0.000	0.000	0.141
	Copper	Yes (0.000)	1994	-	-	-	-
			2006	0.002	-	-	-
			2007	0.000	0.034	-	-
			2008	0.075	1.000	0.270	-
			2009	0.001	1.000	0.000	1.000
W3	Arsenic	Yes (0.000)	1994	-	-	-	-
			2006	0.020	-	-	-
			2007	0.143	0.000	-	-
			2008	0.739	0.093	1.000	-
			2009	0.568	0.144	0.012	0.470
	Chromium	Yes (0.000)	1994	-	-	-	-
			2006	0.430	-	-	-
			2007	0.675	0.988	-	-
			2008	0.151	0.140	0.033	-
			2009	0.032	0.000	0.000	0.011
	Copper	Yes (0.000)	1994	-	-	-	-
			2006	0.002	-	-	-
			2007	0.000	0.031	-	-
			2008	0.004	0.099	0.987	-
			2009	0.001	0.141	0.711	1.000
W6	Arsenic	Yes (0.009)	1994	-	-	-	-
			2006	-	-	-	-
			2007	-	0.093	-	-
			2008	-	0.242	0.728	-
			2009	-	1.000	0.100	0.244
	Chromium	Yes (0.000)	1994	-	-	-	-
			2006	-	-	-	-
			2007	-	0.997	-	-
			2008	-	0.328	0.110	-
			2009	-	0.000	0.000	0.003
	Copper	Yes (0.000)	1994	-	-	-	-
			2006	-	-	-	-
			2007	-	0.942	-	-
			2008	-	0.127	0.884	-
			2009	-	0.000	0.000	0.002
W7	Arsenic	Yes (0.000)	1994	-	-	-	-
			2006	-	-	-	-
			2007	-	0.185	-	-
			2008	-	0.053	0.646	-
			2009	-	0.000	0.026	0.300
	Chromium	Yes (0.022)	1994	-	-	-	-
			2006	-	-	-	-
			2007	-	1.000	-	-
			2008	-	0.086	0.034	-
			2009	-	0.451	0.291	0.131
	Copper	Yes (0.057)	1994	-	-	-	-
			2006	-	-	-	-
			2007	-	0.708	-	-
			2008	-	0.684	0.380	-
			2009	-	0.059	0.270	0.966

[shaded box] Denotes significant difference at $p < 0.10$ using Tamhane's post-hoc

Summary of ANOVA and Post-Hoc Statistics for Each Year. From Minnow Environmental (2009)

Year	Metal	ANOVA	Station	W2	W3	W6
1994	Arsenic	No (0.787)	W2	-	-	-
			W3	-	-	-
	Chromium	Yes (0.005)	W2	-	-	-
			W3	0.005	-	-
	Copper	Yes (0.000)	W2	-	-	-
			W3	0.000	-	-
2006	Arsenic	Yes (0.000)	W2	-	-	-
			W3	0.461	-	-
			W6	0.022	0.220	-
			W7	0.002	0.001	0.000
	Chromium	No (0.850)	W2	-	-	-
			W3	-	-	-
			W6	-	-	-
			W7	-	-	-
	Copper	Yes (0.000)	W2	-	-	-
			W3	0.790	-	-
			W6	0.005	0.000	-
			W7	0.002	0.000	0.010
2007	Arsenic	Yes (0.000)	W2	-	-	-
			W3	0.000	-	-
			W6	0.996	0.052	-
			W7	0.004	0.422	0.009
	Chromium	Yes (0.000)	W2	-	-	-
			W3	0.036	-	-
			W6	0.007	0.672	-
			W7	0.009	0.882	0.999
	Copper	Yes (0.000)	W2	-	-	-
			W3	0.000	-	-
			W6	0.178	0.000	-
			W7	0.846	0.004	1.000
2008	Arsenic	Yes (0.000)	W2	-	-	-
			W3	0.095	-	-
			W6	0.755	0.069	-
			W7	0.048	0.248	0.005
	Chromium	Yes (0.000)	W2	-	-	-
			W3	0.014	-	-
			W6	0.020	0.497	-
			W7	0.023	0.586	0.999
	Copper	Yes (0.000)	W2	-	-	-
			W3	0.740	-	-
			W6	0.072	0.000	-
			W7	0.034	0.001	0.245
2009	Arsenic	Yes (0.009)	W2	-	-	-
			W3	0.071	-	-
			W6	0.020	0.006	-
			W7	0.000	0.007	0.001
	Chromium	Yes (0.000)	W2	-	-	-
			W3	0.135	-	-
			W6	0.005	0.000	-
			W7	0.001	0.000	0.000
	Copper	Yes (0.000)	W2	-	-	-
			W3	0.000	-	-
			W6	0.000	0.000	-
			W7	0.000	0.000	0.000

[shaded box] Denotes significant difference at $p < 0.10$ using Tamhane's post-hoc

APPENDIX F

APPENDIX F MINTO MINE, BENTHIC MACROINVERTEBRATE DATA SUMMARY

TABLE F1: BENTHIC INVERTEBRATES CAPTURED AT THE MINTO MINE, 1994 (HALLAM KNIGHT PIESOLD LTD.)

Station	B1			B2			B3			B4			B5			B6		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Ephemeroptera																		
Ameletus sp.	1	2	12			1				1	1	2						
Baetis sp.	7	5	4	3	1	1	38	16	7	71	40	159	51	16	8	8	1	5
Cinygmula sp.	2						3	1	1	15		9	1	4				
Ephemerella doddsi																		
Ephemerella grandis																		
Ephemerella infrequens																		
Ephemerella sp.																		
Heptagenia sp.																		
Rhithrogena sp.																		
Plecoptera, unid Juv	10	30	143	266	66	196	26	27	21	1	12	144	144	88	142	24	8	37
Arcynopteryx sp.																		
Capnia sp.	33	30	87	52	83	36	103	32	29	142 9	404	155 5	46	63	50	5	8	
Isoperla sp.																		
Podmosta sp.	2	1	2	147	60	49	5	1	1	41	7	127	10	16	12			
Setvena (bradleyi)																		
Sweltsa sp. group		1																
Taenionema sp.																		
Utaperla sp.																		
Zapada sp.																		
Trichoptera, unid Juv/dam						1												
Adult trichoptera																		
Dicosmoecus sp.	11		1	1	2	5		1										
Ecclisomyia sp.																		
Glossosoma sp.																		
Grensia sp.																		
Facultative organisms																		
Diptera unid Adult																		
Chironomidae, unid Juv/dam	3	86	72	56	41	49	58	11	15	66	1	34	121	409	231	881	670	417
Chironomidae pupae		2	4	3	2					33	56		4	5	35	8	10	2
Chironomidae adult									1									
S.F. Chironominae																		
Chironomus sp.																		1
Micropsectra sp.		1															8	
Phaenopsectra sp.	2					2										8	31	36
Rheotanytarsus sp.		1		2		2											1	
S.F. Diamesinae																		
Diamesa sp.										8		8	4			4		1
Odontomesa sp.																	1	1
Prodiamesa sp.																		
S.F. Orthocladiinae																		
Cardiocladius sp.			2		2	7									2			
Corynoneura sp.																		
Crocotopus sp.	1	4	18	68	17	89	3	3	1	17	33	59	2		1	32	73	6
Diplocladius sp.		2	4	4		5	2			4	1	4	24	15	12	8	16	5
Eukiefferiella sp.		44	64	95	23	138	9	11	10	44	50	68	158	155	76	67	117	36
Euryhapsis sp.	14	32		4	5	27	9	3	2	29	51	63	60	27	17	17	29	3
Heleniella sp.		10		2	2	1				4	8	16		4	10			
Metriocnemus cf. fuscipes															1			
Orthocladius sp.																		
Rheocricotopus sp.																		

TABLE F1: BENTHIC INVERTEBRATES CAPTURED AT THE MINTO MINE, 1994 (HALLAM KNIGHT PIESOLD LTD.)

Station	B1			B2			B3			B4			B5			B6		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Symposiocladius sp.				6	1				1						4			
Synorthocladius sp.		2		2	2	17	6	3	4		1							
Thienemanniella sp.																		
Ceratopogonidae																		
Palpomyia sp.																1		
Culicidae A																		
Empididae																		
Chelifera sp.																		
Clinocera sp.				1														
Weidemannia sp.																		
Muscidae, unid J/D				1	1	1		1				2			1			8
Lispe sp.						1				1					2			
Psychodidae																		
Pericoma sp.								1										
Simulidae unid J/D										1								
Gymnopais sp.																		
Prosimulium sp.	1	7	12					1				2						
Prosimulium sp. P			1															
Simulium sp.		8	18				5	8	12	3	1	8						
Simulium sp. P			7						1									
Syrphidae																		
Syrphus sp.																	1	
Tipulidae unid J/D												1						
Antocha sp.																		
Dicranota sp.	8	8	3	22	24	12	10	10	3	12	13	18	6	19	26	60	6	2
Hesperoconopa sp.																		
Hexatoma sp.																		
Tipula sp.				1	2							1	1					
Homoptera unid A	1		1															
Aphididae	1	1	2	2	2	1	3	1	1	4				4	10	14	14	55
Hymenoptera unid A			2				1											
Coleoptera unid L/A					1													
Thysanoptera																		
Colembola																		
Bourletiella spinata					1													
Hypogastrura sp.				4	9	82		1	1									
Isotoma sp.		24	10	28	68	176	13	4	5		4	8		4				
Podura aquatica							5	2	8					4	30			
Lepidoptera unid L Terr.		1																
Aranea																		
Hydracarina unid J		2	2	2	3	6	4	1		4	8		18		4	4		
Lebertia sp.																		
Sperchon sp.		2		1		3									1		1	
Torrentico la sp.			2		1	2	1	1			4							
Wandesia sp.																		
Oribatei		6	2		1	4	1	1						20	6		8	
Copepoda																		
Cyclopoida	20	26	28	26	18	8		2	2	4	12	8	16	48	30	124	112	8
Harpacticoida		8	2	8	9	14	10	1		32	72	120	4	24	16	12	24	

TABLE F1: BENTHIC INVERTEBRATES CAPTURED AT THE MINTO MINE, 1994 (HALLAM KNIGHT PIESOLD LTD.)

Station	B1			B2			B3			B4			B5			B6		
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
Ostracoda																		
Candona sp.	1	11	6		1	16		1	1	16	24	16	476	323	141	64	21	20
Cypria sp.	1	1			1				1									
Tardigrada			1															
Gastropoda unid Terr.					1													
Oligochaeta, Naididae																		
Nais (communis)																12		
Pristina so	4	2	10	2						4	8		8		8	13		
Nematoda	7	254	90	193	94	80	39	5	5	33	44	153	20	81	162	139	333	249
Turbellaria									1						1			
Tolerant organisms																		
Oligochaeta																		
Enchytraeidae	8	15	23	2	1			4	4	37	4	29	5	24	25	9	17	4
Lumbriculidae	1		2				1	1									1	
Kincaidiana hexatheca								1										
Tubificidae	2	9	57	3	2	2	9	11	6	105	21	16	42	145	60	157	24	22

Station	B1	B2	B3	B4	B5	B6
Density (#/m²)						
Sensitive	1381	3489	1302	14453	2342	345
Facultative	3496	5802	1173	4673	10395	13608
Tolerant	421	36	162	1014	1277	950
Total	5298	9327	2637	20140	14014	14903
%						
Sensitive	26.07	37.41	49.39	71.76	16.71	2.32
Facultative	65.99	62.21	44.47	23.20	74.18	91.31
Tolerant	7.94	0.39	6.14	5.04	9.11	6.37
# of Species	44	43	38	34	33	31
Shannon Weiner Diversity	3.88	3.69	3.76	2.59	3.56	2.82
Dominance	0.11	0.11	0.13	0.38	0.13	0.27
Equitability	0.71	0.68	0.72	0.51	0.71	0.57
Richness	5.89	5.34	5.61	3.82	3.87	3.60
TU Diversity	0.892	0.894	0.873	0.623	0.871	0.732
Variance	0.027	0.015	0.049	0.319	0.030	0.165

Adapted from Tables 7.2 & 7.3 in MintoEx's IEE (1994)

TABLE 2: BENTHIC INVERTEBRATES COLLECTED AT MINTO MINE, SEPTEMBER 2008	Station W2	Station W6	Station W7
ROUNDWORMS			
P. Nemata	600	10	225
ANNELIDS			
P. Annelida			
WORMS			
Cl. Oligochaeta			
F. Enchytraeidae	1,405	0	200
F. Tubificidae			
Psammoryctides californianus	0	195	600
F. Lumbriculidae			
Stylodrilus	75	0	0
ARTHROPODS			
P. Arthropoda			
MITES			
Cl. Arachnida			
O. Acarina	40	0	20
HARPACTICOIDS			
O. Harpacticoida	0	10	0
SEED SHRIMPS			
Cl. Ostracoda	80	5	0
SPRINGTAILS			
Cl. Entognatha			
O. Collembola	80	5	0
INSECTS			
Cl. Insecta			
MAYFLIES			
O. Ephemeroptera			
F. Baetidae			
?Callibaetis	0	5	0
STONEFLIES			
O. Plecoptera			
F. Capniidae			
immature	0	5	80
F. Nemouridae			
Nemoura/Podomosta	45	10	5
immature	200	80	0
TRUE FLIES			
O. Diptera			
indeterminate	40	0	60
BITING-MIDGE			
PHANTOM MIDGE			
F. Chaoboridae			
Chaoborus americanus	0	0	20
Chaoborus flavicans	40	0	20
MIDGES			
F. Chironomidae			
chironomid pupae	80	0	0
S.F. Diamesinae			
Pseudokiefferiella	0	5	0
S.F. Orthocladiinae			
Chaetocladius	120	0	0

TABLE 2: BENTHIC INVERTEBRATES COLLECTED AT MINTO MINE, SEPTEMBER 2008			
	Station W2	Station W6	Station W7
Diplocladius	0	5	20
Eukiefferiella	40	0	0
?Gymnometriocnemus	40	0	0
Hydrobaenus	40	5	200
Krenosmittia	0	5	20
Orthocladius	600	0	20
Paraphaenocladius	720	0	0
Tokunagaia	1,120	0	100
indeterminate	40	5	0
OTHER TRUE FLIES			
F. Culicidae			
Mansonia/Coquillettidia	0	0	20
F. Tipulidae			
Dicranota	40	0	0
Total Number of Organisms	5,445	350	1,610
Total Number of Taxa*	17	12	15
Simpson's Diversity	0.846	0.633	0.802
Simpson's Evenness	0.899	0.691	0.859
Key Taxa Groups (% Composition)			
Nemata	11.0%	2.9%	14.0%
Oligochaeta	27.2%	55.7%	49.7%
Mayflies/Stoneflies	4.5%	28.6%	5.3%
Chironomids	51.4%	7.1%	22.4%

* Bold entries excluded from taxa count

Benthic macroinvertebrate data from Minnow (2009) EEM Cycle 1 Program.

TABLE C2: Benthic Macroinvertebrates Collected for the Minto Mine EEM, September 2008

Station	MREF					MEXP				
	1	2	3	4	5	1	2	3	4	5
ROUNDWORMS										
P. Nemata	6	4	-	8	20	224	200	82	81	113
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
O. Tricladida	-	-	-	-	-	-	-	8	-	-
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	8	20	15	26	16	96	-	54	94	162
F. Tubificidae										
Psammoryctides californianus	-	-	-	4	-	96	64	490	1416	126
F. Lumbriculidae										
Kincaidiana hexatheca	-	-	-	-	-	-	16	-	-	-
Stylodrilus	3	8	-	2	-	48	240	544	378	72
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina	11	5	4	4	12	-	36	56	32	8
HARPACTICOIDS										
O. Harpacticoida	-	-	1	-	-	-	40	160	80	24
SEED SHRIMPS										
Cl. Ostracoda	5	-	3	18	4	64	36	328	48	24
SPRINGTAILS										
Cl. Entognatha										
O. Collembola	6	4	1	6	4	-	4	-	-	-
INSECTS										
Cl. Insecta										
MAYFLIES										
O. Ephemeroptera										
F. Ameletidae										
Ameletus	11	4	5	4	4	32	-	32	-	-
F. Baetidae										
Baetis sp.	3	-	-	-	4	-	-	-	-	-
Baetis bicaudatus	1	-	3	4	-	-	-	-	-	-
?Callibaetis	-	-	-	-	-	-	-	-	-	-
F. Heptageniidae										
Cinygmula	-	-	-	2	-	-	-	-	-	-
STONEFLIES										
O. Plecoptera										
F. Capniidae										
immature	67	99	44	80	36	128	100	250	96	152
F. Nemouridae										
Nemoura/Podomosta	11	14	4	16	-	17	16	25	-	-
immature	3	12	3	14	-	-	12	18	-	-
F. Limnephilidae										
immature	4	-	-	4	4	-	-	-	-	8
TRUE FLIES										
O. Diptera										
indeterminate	9	-	-	4	4	-	8	24	-	-
BITING-MIDGE										
F. Ceratopogonidae										
indeterminate	-	-	-	-	4	-	-	-	-	-
PHANTOM MIDGE										
F. Chaoboridae										

TABLE C2: Benthic Macroinvertebrates Collected for the Minto Mine EEM, September 2008

Station	MREF					MEXP				
	1	2	3	4	5	1	2	3	4	5
Chaoborus americanus	-	-	-	-	-	1	1	-	-	16
Chaoborus flavicans	-	-	-	-	-	32	4	8	-	-
MIDGES										
F. Chironomidae										
chironomid pupae	**4**	**4**	**1**	**4**	**-**	**32**	**24**	**8**	**32**	**24**
S.F. Chironominae										
Micropsectra	1	-	1	4	4	16	-	8	-	-
Paratanytarsus	-	-	3	-	-	-	-	-	-	-
Stictochironomus	1	-	-	-	-	-	-	-	-	-
S.F. Diamesinae										
Diamesa	-	20	2	6	-	96	24	-	-	-
Pseudodiamesa	-	-	-	-	-	32	-	-	16	-
Pseudokiefferiella	-	-	-	-	-	-	-	-	-	-
S.F. Orthocladiinae										
Chaetocladius	-	-	-	-	-	-	4	8	-	16
Corynoneura	-	-	3	-	-	-	-	-	-	-
Diplocladius	27	72	6	64	48	176	44	32	32	48
Eukiefferiella	1	-	-	-	-	-	12	-	-	-
?Gymnometriocnemus	1	-	-	-	-	-	-	-	-	-
Hydrobaenus	-	-	-	-	-	368	324	328	80	496
Krenosmittia	-	-	-	-	-	-	-	-	16	-
Limnophyes	6	-	-	-	-	-	-	-	-	-
Metriocnemus	-	-	-	-	4	-	-	-	-	-
Orthocladius	14	-	1	2	4	496	100	80	16	40
Orthocladius (S.) lignicola	1	-	-	-	4	-	-	-	-	-
Paracricotopus	-	4	-	-	-	-	-	-	-	-
Parakiefferiella	-	-	-	-	-	-	8	8	-	16
Paraphaenocladius	4	-	-	-	-	-	-	-	-	-
Rheocricotopus	1	4	1	-	-	-	-	-	-	-
Rheosmittia	-	-	1	2	-	-	-	-	-	-
Smittia	-	4	-	-	-	-	-	-	-	-
Tokunagaia	24	56	34	112	4	-	104	56	64	152
Tvetenia	-	-	-	4	4	-	-	-	-	-
Indeterminate	2	40	9	30	28	-	-	8	48	-
S.F. Podonominae										
Trichotanypus	7	-	2	4	8	-	-	-	-	-
OTHER TRUE FLIES										
F. Culicidae										
Mansonia/Coquillettidia	-	-	-	-	-	-	-	-	-	-
F. Empididae										
Clinocera	-	-	-	-	-	-	4	-	-	-
F. Psychodidae										
Pericoma	-	-	-	-	-	-	4	-	-	-
F. Simuliidae	7	29	2	8	8	-	-	11	16	-
F. Tipulidae										
Dicranota	7	10	2	12	20	2	16	-	-	8
Tipula	-	-	-	-	-	2	21	-	-	2
Indeterminate	-	-	-	-	-	-	-	-	16	8
TOTAL NUMBER OF ORGANISMS	256	413	151	448	248	1958	1466	2625	2561	1515
TOTAL NUMBER OF TAXA[a]	28	17	22	25	22	18	25	22	17	19

[a] Bold entries excluded from taxa count

APPENDIX G

APPENDIX G MINTO MINE, PERIPHYTON DATA FROM HKP (1994)

MINTO CREEK PERIPHYTON STUDY RESULTS (HKP, 1994)

Species	Site P3 Replicate						Site P2 Replicate						Site P3 Replicate					
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2***	**3***	**4***	**5***	**6**
Cyanophyceae																		
Chamaesiphon incrustans										10%	10%							
Lyngbya digueti										25%	5%	1%						
Lyngbya nordgaardii																		
Nostoc sp.										+							+	+
Phormidium sp.										+		+	35%	+	+			5%
Plectonema notatum			10%			+				5%	5%							
(unidentified filament)																		
Chlorophyceae																		
Closterium sp.	+						+		+		+							
Microspora amoena																		
Stigeoclonium sp.																		
(unidentified – 15 µm)																		
Chrysophyceae																		
Hydrurus foetidus						+							+					
Rhodophyceae																		
Audouinella violacea	25%	50%	10%	59%	5%	25%		+	1%	1%	2%		35%	+		+	+	5%
Bacillariophyceae																		
Achnanthes spp.	++	++	+	+	+	+		+		+		+	+	+			+	+
Amphora sp.					+							+						
Caloneis ventricosa								+										
Cymbella spp.	+		+				+	+	+	+	+	+				+		
Eunotia sp.			+															
Fragilaria cf. *capucina*																		
Gomphonema spp.				+			+	+	+	+	+	+	+		+	+	+	+
Hannaea arcus																	+	
Meridion circulaire	+	+	+	+	+		+	+	+	+	+	+						+
Navicula spp.	+++	+++	+++	+	+++	+++	+	++	+	+	+	+++	+	+	+		+	+++
Nitzschia spp. (30-50 µm)	+	+	+	+	+	+	++	+++	+++	++	++	++				+	+	++
Nitzschia sp. (100x6 µm)			+			+	+++	+++	++	++	+++	+++						
Nitzschia sp. (100x10 µm)								++	++	++	++	+++			++	+	+	+++
Nitzschia acicularis									+	+		++						
Pinnularia sp.	+				+	+		+										
Stauroneis sp.			+							+		+						+
Surirella angustata					+		+	+	+	+	+	+						+
Synedra cf. *incisa*	+	+++	++	+++	+	++				+		+	++		++	+	+	++
Synedra rumpens	+				+		+		+		+	+	+	+	+	+	++	++
Synedra ulna					+							+						+
% Bacillariophyceae	75	50	80	50	95	75	>99	>99	99	59	78	99	30					90

Key to abundance: +++ Dominant, ++ Common, + Present
* too little in sample to estimate % abundance
i sample not collected quantitatively

MINTO CREEK PERIPHYTON STUDY RESULTS (HKP, 1994)

Species	Site P4[i] Replicate						Site P5 Replicate						Site P6 Replicate					
	1	**2**	**3**	**4**	**5**	**6**	**1***	**2***	**3**	**4**	**5**	**6**	**1***	**2***	**3***	**4***	**5***	**6***
Cyanophyceae																		
Chamaesiphon incrustans															30%	10%	10%	25%
Lyngbya digueti	20%				5%								5%	5%	5%	5%	5%	5%
Lyngbya nordgaardii																		
Nostoc sp.										+	10%	+						
Phormidium sp.							+			1%								
Plectonema notatum																		
(unidentified filament)														1%	1%	1%	10%	+
Chlorophyceae																		
Closterium sp.	5%	1%	+	+	1%	+		+					+	+	+	5%	5%	+
Microspora amoena	+												+					
Stigeoclonium sp.														1%				
(unidentified - 15 µm)																	+	
Chrysophyceae																		
Hydrurus foetidus				50%							+		40%		5%	5%	25%	5%
Rhodophyceae																		
Audouinella violacea										+	+	5%						
Bacillariophyceae																		
Achnanthes spp.	+	+	+	+	+	+	+	+	++	+	+	+	+	+	++	+	+	+
Amphora sp.																		
Caloneis ventricosa			+															
Cymbella spp.	+	+	+	+	+	+			+			+	+		+	+	+	+
Eunotia sp.	+				+	+												
Fragilaria cf. *capucina*		+																
Gomphonema spp.	++	+		+	+	+				++	+		+++	+++	+++	+++	++	++
Hannaea arcus																		
Meridion circulaire	++ +	+	+	+	+	++		+	+	+		+	++	+	++	+	+	++
Navicula spp.	++	++	++	++	++	++	+	++	+	+++	++	++	++	++	++	++	+	+
Nitzschia spp. (30-50 µm)	+	++	+++	+++	+++	+++	+	+		+	+	+	+		+	+	+	+
Nitzschia sp. (100x6 µm)	++	+	++	++	++	++					+				+	+	+	+
Nitzschia sp. (100x10 µm)	++	+++	+++	++	+++	++		+				+						+
Nitzschia acicularis							+	+	+	++	+	+						
Pinnularia sp.																		
Stauroneis sp.	+	+							+									
Surirella angustata	+	+	+	+		+	+				+	+			+			
Synedra cf. *incisa*	+	+				+	+	+			+	+	+					+
Synedra rumpens							++	++	++	+	+	+	+				++	++
Synedra ulna	+	+		+	+	+											+	
% Bacillariophyceae	75	99	>99	50	95	>99			100	99	90	95						

Key to abundance: +++ Dominant, ++ Common, + Present
* too little in sample to estimate % abundance
i sample not collected quantitatively