

SUMMARY OF ENVIRONMENTAL MONITORING
ACTIVITIES AT THE ABANDONED
CLINTON CREEK ASBESTOS MINE, 2009

FOR



ASSESSMENT AND ABANDONED MINES

ENERGY MINES AND RESOURCES

BY



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1.0 BACKGROUND

The former Clinton Creek Asbestos Mine is located approximately 100 km northwest of Dawson City, Yukon, and nine km upstream of the confluence of Clinton Creek and the Forty Mile River. The mine operated from 1967 to 1978. The site encompasses three open pits (Porcupine, Snowshoe and Creek), two waste rock piles (Clinton Creek Dump and Porcupine Creek Dump), and a tailings pile.

In 1974, 60 million tonnes of the Clinton Creek waste rock pile slumped across the Clinton Creek valley creating the formation of Hudgeon Lake. During the 1980s various weirs were constructed to reinforce the Clinton Creek channel in attempts to stabilize and control the outflow from Hudgeon Lake, with limited success. The structures were washed out during a high flow event in 1997. The Federal Government (DIAND) assumed responsibility for the site in 1999; following Devolution in 2003, the Government of Yukon (YG) assumed responsibility for site management. In a series of stages from 2002 to 2004, gabion drop structures were constructed within the channel downstream of the Hudgeon Lake outlet. YG continues to monitor these structures and conducts repairs as necessary.

In the early summer of 2009, Minnow Environmental Inc (Minnow) was contracted by YG to review all existing environmental data pertaining to the Clinton Creek site and make recommendations for any data gaps.

1.1 Scope of Work

Laberge Environmental Services (Laberge) was contracted by YG to conduct various environmental monitoring surveys on Clinton Creek and several of its tributaries during the late summer of 2009, based on the recommendations by Minnow. Methods and the results of each of the three field trips are summarized in this report.

2.0 METHODS

Three separate field trips were made to the site in an attempt to capture conditions under varying flow regimes. Due to the lateness of the contract, the three field trips were conducted; August 17th to 20th, September 1st to 4th and September 19th to 21st, 2009. Although this only covered a period of five weeks, a low water event was sampled during August and a very high flow event was captured during September 20th.

Michelle Bowman, an employee with Minnow, accompanied a field crew of two from Laberge to establish exposure sites on Clinton Creek and reference sites on appropriate tributaries. Water samples, stream sediment samples and benthic invertebrate samples were collected. Habitat assessments were also conducted at each site.

2.1 Water Quality Sampling

Exova, formerly Bodycote Analytical, supplied Laberge with the necessary sample kits prior to each field trip. Each sample bottle was rinsed three times with the sample waters and then filled and preserved as specified by the laboratory's protocols. Samples were kept cool then shipped as soon as possible to Exova in Surrey, BC.

In situ measurements of pH, conductivity, water temperature and dissolved oxygen were made. Discharge measurements were also conducted where possible on each visit.

2.2 Benthic Invertebrate Sampling

Benthic invertebrates were collected with a D-net equipped with a 400 micron mesh net using the kick and sweep method following CABIN protocols. Triplicates were collected per site for three minutes each and the number of transects was noted. Note that only duplicates were collected on the Forty Mile River due to the lack of appropriate sampling habitat. Samples were treated with 10% formalin and sent to Cordillera Consulting in Summerland, BC for sorting, identification and enumeration. Due to the high number of invertebrates in many of the samples, fractions were sub sampled as necessary.

Various habitat conditions were noted and recorded on CABIN field sheets.

2.3 Stream Sediment Geochemistry

Composite stream sediment samples were collected with a steel trowel from three sites during the final field trip. Fine grained material from recently deposited areas were chosen and placed into ziplock bags, kept cool, and shipped to Exova with the water samples.

3.0 RESULTS

3.1 Established Sites

A total of eleven sites were eventually established, five reference sites and six exposure sites. These are listed below in Table 1 along with the sampling matrices and frequencies.

TABLE 1 SAMPLING FREQUENCY AND MATRIX				
Site #	Site Description	Sampling Event, 2009		
		Aug 18, 19	Sept 2, 3	Sept 20
<i>Reference Sites:</i>				
R1	Clinton Cr u/s Hudgeon Lake	WQ, BI	WQ	
R2	Easter Cr u/s Hudgeon Lake	WQ, BI	WQ	
R3	Wolverine Cr u/s tailings		WQ, BI	
R4	Eagle Creek u/s culverts at road crossing	WQ, BI	WQ	WQ
R6	Forty Mile River u/s Clinton Creek		WQ, BI	
<i>Exposed Sites:</i>				
E1	Clinton Cr d/s gabions, u/s Porcupine Cr	WQ, BI	WQ	WQ
E2	Clinton Cr d/s Porcupine Cr, u/s Wolverine Cr	WQ, BI	WQ	WQ
E3	Wolverine Cr u/s culverts at road crossing	WQ, BI	WQ	WQ, SS
E4	Clinton Cr d/s Wolverine Cr, u/s Eagle Cr	WQ, BI	WQ	WQ, SS
E7	Clinton Cr near mouth	WQ, BI	WQ	WQ
E8	Forty Mile River d/s Clinton Creek		WQ, BI	WQ
	Porcupine Beaver Ponds			SS
WQ = water quality BI = benthic invertebrates SS = stream sediments				

3.2 Water Quality

Water quality samples were not collected at all sites on all sampling events. During the initial trip in August, eight sample locations were established; three reference sites and five exposed sites. Upon review, Minnow recommended that samples should also be collected upstream on Wolverine Creek as well as on the Forty Mile River, upstream and downstream of the confluence of Clinton Creek. These three sites were sampled for the first time during the second field trip in early September. Due to a high rainfall event proceeding and during the third field trip, flood conditions prevented access (fording) across Clinton Creek to sample upstream on the Forty Mile River. Since the boat for collecting samples upstream of Hudgeon Lake was located at the resident's location situated on the other side of Clinton Creek, samples could not be collected from R1 and

R2 in late September. These flood conditions also prevented safe access to R3, Wolverine Creek upstream of the sloughed tailings.

Table 2 summarizes the data collected from all sites for all occasions. Only metals where the CCME guidelines were exceeded have been included in the table. Although the guideline was slightly exceeded for selenium at R4 on September 20th only, selenium has not been included in Table 2.

All waters in the study area were slightly alkaline and ranged in pH from 7.66 to 8.36. All sampled waters had high conductivity especially during the undiluted state during the August sampling when flows were the lowest measured. In August, conductivity values ranged from 548 uS/cm at R4 and E1, to 1180 uS/cm at E4. In September, the Forty Mile River was sampled and conductivity values were lower here, however the same general trend was followed during the other sampling events. Note that E8, Forty Mile River downstream of Clinton Creek, was not sampled sufficiently downstream of the influence of Clinton Creek to ensure that full mixing had taken place, and this is reflected in the conductivity values. The hardness levels followed the same general trend as conductivity. All waters in the study area were hard or very hard.

Discharge varied significantly over the study period. Flows were higher in early September than during mid August, and in late September flows were almost a magnitude greater than those recorded in early September. The increase in flow created greater turbidity with higher total suspended solids readings documented at most sites during the third sampling event. Eagle Creek was very turbid and had a TSS value of 164 mg/L. The waters in the study area were generally clear during the other sampling events.

Some of the metals at some of the sites exceeded the CCME recommended guidelines for the protection of freshwater aquatic life. Since all the waters within the study area were hard or very hard, the appropriate guidelines for hard waters were used for the metals where the guidelines vary with hardness. The guideline for cadmium is very conservative but since the flows in the study area were hard or very hard, the

TABLE 2

Clinton Creek Water Quality Sampling Program - Analytical Summary

Site #	Site Description	Date (2009)	pH (Lab)	Conductivity (uS/cm@25°C) (Lab)	TSS mg/L	Discharge (cms)	Cadmium mg/L	Chromium mg/L	Copper mg/L	Iron mg/L	Hardness mg CaCO ₃ /L
DL CCME	Detection Limit CCME Guidelines			1	1		0.00001	0.0004 0.001	0.001 0.004	0.01 0.3	1
R1	Clinton Creek u/s Hudgeon Lake	Aug. 18, 19 Sept. 2, 3	7.88 7.73	785 457	3 7	0.1737 0.5063	0.00004 0.00004	0.0004 0.0009	0.002 0.004	0.294 0.504	491 273
R2	Easter Creek u/s Hudgeon Lake	Aug. 18, 19 Sept. 2, 3	8.05 7.94	816 635	<2 2	0.0429 0.0842	0.00001 0.00007	<0.0004 0.0009	<0.001 0.002	0.205 0.226	532 396
R3	Wolverine Cr u/s Tailings Upstream of beaver pond u/s of tailings	Sept. 2, 3	7.96	703	9	0.062	0.00024	0.0011	0.002	0.502	444
R4	Eagle Creek u/s culvert	Aug. 18, 19 Sept. 2, 3 Sept. 20	8.09 7.94 7.66	548 438 226	<2 10 164	0.047 0.0576 0.426	0.00004 0.00003 0.00018	0.0006 0.0011 0.0052	0.003 0.003 0.008	0.216 0.393 3.45	323 251 130
R6	Forty Mile River u/s Clinton Ck	Sept. 2, 3	7.66	191	<2	N/A	<0.00001	0.0005	0.003	0.208	94.9
E1	Clinton Creek d/s gabions and u/s Porcupine Creek	Aug. 18, 19 Sept. 2, 3 Sept. 20	7.77 7.91 7.92	548 468 457	<2 <2 12	0.2605 0.5051 4 (e)	0.00005 0.00004 0.00004	0.0007 0.0008 0.0024	0.002 0.003 0.004	0.262 0.226 0.635	311 281 263
E2	Clinton Creek d/s Porcupine and u/s Wolverine Cr	Aug. 18, 19 Sept. 2, 3 Sept. 20	7.84 7.86 7.93	886 561 467	4 2 20	0.0925 0.4085 4 (e)	0.00005 0.00003 0.00006	0.0008 0.0009 0.0029	0.001 0.002 0.003	1.04 0.363 0.643	584 346 265
E3	Wolverine Cr u/s culvert d/s tailings	Aug. 18, 19 Sept. 2, 3 Sept. 20	8.36 8.2 7.87	862 742 421	2 <2 28	0.063 0.0557 0.3972	<0.00001 0.00007 0.00002	0.0014 0.0014 0.0056	<0.001 0.002 0.004	0.064 0.089 1.25	565 497 244
E4	Clinton Creek d/s Wolverine Cr and u/s Eagle Creek	Aug. 18, 19 Sept. 2, 3 Sept. 20	7.97 7.84 7.85	1180 770 516	3 2 21	0.2534 0.6920 7 (e)	0.00005 0.00374 0.00006	0.0009 0.0009 0.0047	0.001 0.003 0.004	0.48 0.376 0.778	819 472 296
E7	Clinton Creek near mouth	Aug. 18, 19 Sept. 2, 3 Sept. 20	7.95 7.84 7.8	1080 771 483	<2 <2 58	0.2758 0.8625	0.00003 0.00002 0.0001	0.0009 0.001 0.0059	0.001 0.002 0.005	0.148 0.255 1.61	713 484 284
E8	Forty Mile River d/s Clinton Ck	Sept. 2, 3 Sept. 20	7.77 7.79	504 441	<2 58	N/A	0.00001 0.00007	0.0008 0.0059	0.002 0.005	0.244 1.87	289 259

Note: (e) = estimated flow

calculation, using the formula $10\{0.86[\log(\text{hardness})]-3.2\}$, was used to determine the site specific guideline for each site. The guideline for cadmium was exceeded at the reference sites R3 (Sept 3) and R4 (Sept 20) and at the exposed sites E4 (Sept 3) and E7 (Sept 20), with the highest concentration documented at E4.

The recommended guideline for chromium was exceeded at the reference sites R3 (Sept 3) and R4 (Sept 3 and 20), and at the exposed sites E1 (Sept 20), E2 (Sept 20), E3 (all three sampling dates), E4 (Sept 20), E7 (Sept 20) and E8 (Sept 20).

The recommended guideline for copper was exceeded at the reference site R4 (Sept 20) and at the exposed sites E7 (Sept 20) and E8 (Sept 20).

The recommended guideline for iron was exceeded on at least one occasion at all of the sites with the exception of R2 (Easter Creek). The guideline was exceeded on all sampling dates at E2 and E4.

The majority of these exceedences occurred during the September 20th sampling event. All sampled waters were turbid at this time due to runoff from the heavy rains. The higher suspended sediment load documented during this field trip created greater concentrations of many of the metals in Table 2 since analysis was performed on 'total metals'. Thus the data represents concentrations contained within the mobilized sediment as well as within the water column. The toxicity of most metals is more toxic to aquatic life in the dissolved phase. Future sampling should also include the analysis of dissolved metals to get an indication of the presence of the more toxic phase, especially during turbid events.

Several significant parameters had greater concentrations at the upstream site on Wolverine Creek (R3) than downstream at E3, consequently R3 may not represent a very effective reference site for impacts at E3. The reference site R4, Eagle Creek, also had higher concentrations of some metals than E3 and it appears that R2, Easter Creek, may be the best reference site for water chemistry for Wolverine Creek.

3.3 Benthic Macro-Invertebrates

Three phyla were found in the study area: Arthropoda, Mollusca and Annelida. A total of 45,914 individual invertebrates, representing 103 different taxonomic groups, were identified within the study area. These data are presented in Appendix A.

The kick and sweep method is not a quantifiable approach and densities cannot be calculated. However, as the time taken to complete sampling was consistent at each site (with the exception of the two sites on the Forty Mile River), some general comparisons and observations on the benthic populations have been suggested below. Minnow will be doing a detailed analysis of the habitat and benthic communities which will be submitted in a separate report (Minnow, 2010, in preparation).

3.3.1 Habitat Descriptions

Using CABIN field sheets, habitat data was collected at each site and is summarized in Appendix B. Similar characteristics were targeted at each site in attempts to allow realistic comparisons between reference and exposed sites.

3.3.2 Abundance and Diversity

Three sweeps of three minutes duration each were made at all of the sites except on the Forty Mile River where only two sweeps were made. The objective was not to compare the Clinton Creek sites with the Forty Mile River sites since the habitat characteristics of large rivers are very different to those of creeks.

To enable a snapshot of the general characteristics of the benthic communities, the total number of invertebrates captured at each site is presented in Table 3. Excluding the Forty Mile River sites, population numbers ranged from 641 individuals collected from E4 (Clinton Creek d/s Wolverine Cr and u/s Eagle Creek) to 13,005 individuals collected at E1 (Clinton Creek d/s gabions and u/s Porcupine Creek). Population numbers on the Forty Mile River were low and similar to each other.

As a measure of community diversity, the number of taxonomic groups identified from species to phylum at each site was tallied (Table 3). The benthic community at Easter Creek (R2) was the most diverse with 40 different taxa identified. The community at R1, Clinton Creek u/s Hudgeon Lake was the least diverse in the study area with 22 different taxa present.

To further characterize the taxonomic wealth of each community, the diversity was related to the population size using the formula: (Diversity – 1) divided by the natural log of the population (Table 3) resulting in a similar trend for the extremes, but E8 and E4 now show greater richness.

TABLE 3 ABUNDANCE, DIVERSITY AND TAXONOMIC RICHNESS IN THE WATERSHEDS AT CLINTON CREEK, 2009				
SITE	LOCATION	ABUNDANCE	DIVERSITY	TAXONOMIC RICHNESS INDEX
<i>REFERENCE SITES:</i>				
R1		6,456	22	2.4
R2		1,807	40	5.2
R3		1,312	35	4.7
R4		5,375	23	2.6
R6		510	23	3.5
<i>EXPOSED SITES:</i>				
E1		13,005	34	3.5
E2		6,437	35	3.9
E3		8,557	24	2.5
E4		641	32	4.8
E7		1,354	33	4.4
E8		461	32	5.1

3.3.3 Distribution

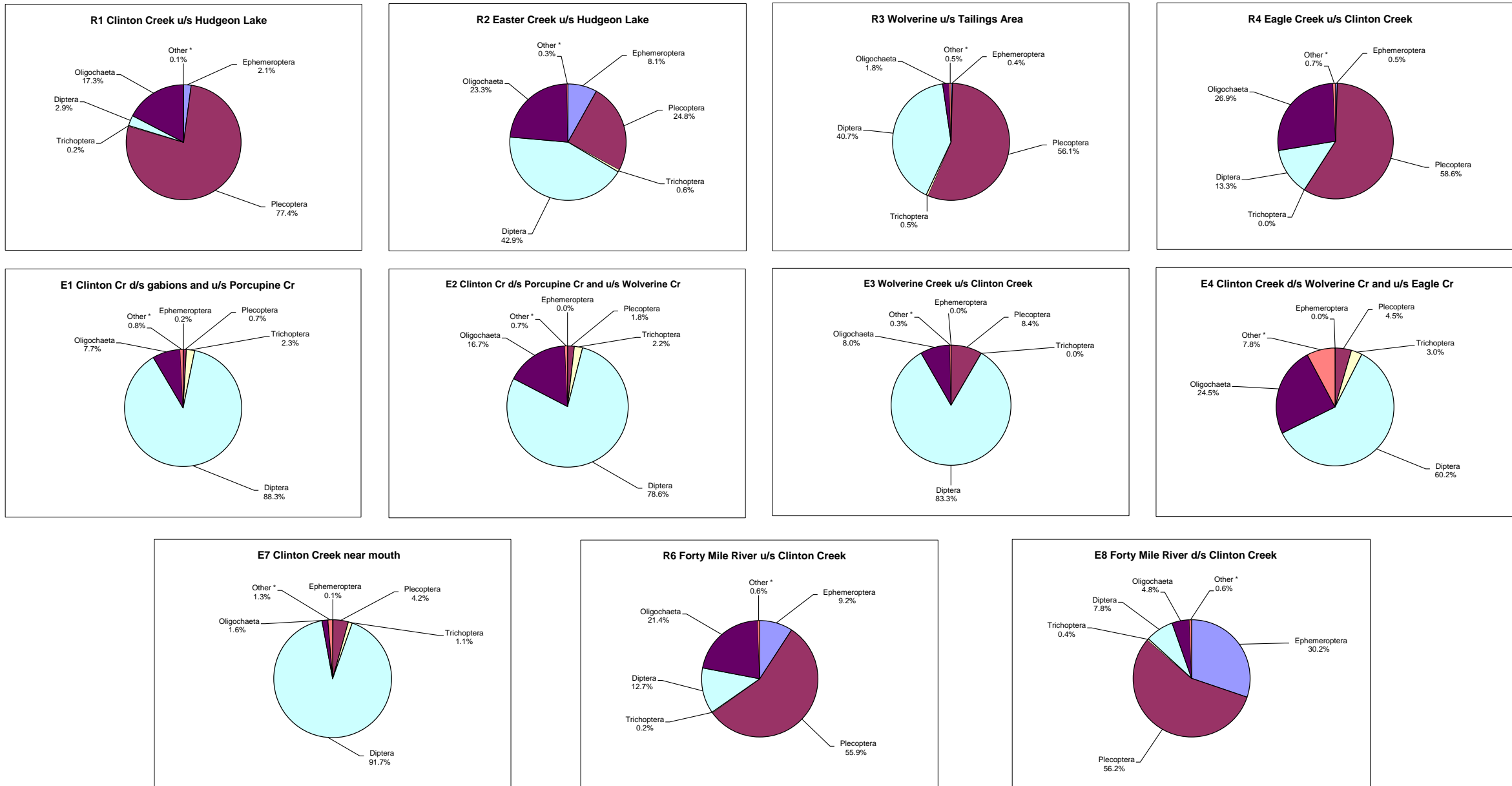
The composition of the benthos communities was displayed as a percentage of the major taxonomic groups for each station (Figure 1). Based on this, taxa were classified with respect to their dominance within the community (Table 4).

TABLE 4 TAXONOMIC DISTRIBUTION OF BENTHIC INVERTEBRATES					
SITE	LOCATION	DOMINANT (* 25%)	SUBDOMINANT (10% to 24.9%)	COMMON (1.0% to 9.9%)	RARE (0.1% to 0.9%)
R1	Clinton Cr u/s Hudgeon Lake	Plecoptera	Oligochaeta	Diptera Ephemeroptera	Trichoptera Other
R2	Easter Cr u/s Hudgeon Lake	Diptera	Plecoptera Oligochaeta	Ephemeroptera	Trichoptera Other
R3	Wolverine Cr u/s Tailings area	Plecoptera Diptera		Oligochaeta	Trichoptera Ephemeroptera Other
R4	Eagle Cr u/s Clinton Cr	Plecoptera Oligochaeta	Diptera		Ephemeroptera Other
R6	Forth Mile River u/s Clinton Cr	Plecoptera	Oligochaeta Diptera	Ephemeroptera	Other Trichoptera
E1	Clinton Cr d/s gabions & u/s Porcupine Cr	Diptera		Oligochaeta Trichoptera	Other Plecoptera Ephemeroptera
E2	Clinton Cr d/s Porcupine & u/s Wolverine Cr	Diptera	Oligochaeta	Trichoptera Plecoptera	Other
E3	Wolverine Cr u/s Clinton Cr	Diptera		Plecoptera Oligochaeta	Other
E4	Clinton Cr d/s Wolverine & u/s Eagle Cr	Diptera	Oligochaeta	Other Plecoptera Trichoptera	
E7	Clinton Cr near mouth	Diptera		Plecoptera Oligochaeta Trichoptera	Ephemeroptera Other
E8	Forth Mile R d/s Clinton Cr	Plecoptera Ephemeroptera		Diptera Oligochaeta	Trichoptera Other

With just a cursory visual review of Figure 1, it is obvious that the composition of the benthic communities at the reference sites is considerably different from that of the exposed sites. Note that the two communities on the Forty Mile River were relatively similar. The communities at the reference sites were comprised of large numbers of Plecoptera (stoneflies) and this order was either dominant or subdominant at these sites. The populations at the exposed sites were dominated by large numbers of Dipterans (true flies).

FIGURE 1

THE COMPOSITION OF THE BENTHIC COMMUNITIES AT EACH OF THE SITES IN THE CLINTON CREEK STUDY AREA, 2009



NOTE: *Other* consists of one or more of the following: Coleoptera, Collembola, Amphipoda, Arachnida, and Gastropoda

Throughout the study area the most abundant organism present was *Diamesa sp.* (from the subfamily Diamesinae of the family Chironomidae belonging to the order of Diptera), forming 17.1 % of the total invertebrates collected (Appendix A). This was closely followed by the grouping “Cricotopus/Orthocladius sp.” also within the order Diptera, with 15.4%. The third most abundant grouping was “Family Nemouridae”, within the order Plecoptera, which formed 11.3% of all the invertebrates captured within the study area.

Oligochaeta, a class within the phylum Annelida (aquatic earthworms), formed a significant portion of the communities, especially at the reference sites where it was frequently subdominant. Studies at the Brewery Creek Mine Site on the lower Dempster Highway, in similar habitat and similar latitudes as the Clinton Creek study area, documented high numbers of Oligochaeta at most of the sites as well (Burns, 2009). They appear to be ubiquitous in these types of mountain streams and do not indicate a stressed environment.

3.4 Stream Sediment Geochemistry

Following the second field trip, Minnow recommended that stream sediment samples be collected from Wolverine Creek upstream of the culverts (E3), Clinton Creek just downstream of Wolverine Creek (labelled E4 but not in the same location as the water quality site that is situated just upstream of Eagle Creek) and from the Porcupine Beaver Pond.

The analytical results for the three stream sediment samples are presented in Table 5 and are compared to the CCME (1999) interim freshwater sediment quality guidelines (ISQG) and to the probable effects levels (PEL). Generally, concentrations greater than the PEL have a 50% incidence of creating adverse biological effects.

With the exception of three of the analyzed metals (chromium, cobalt and nickel), the stream sediments from the Porcupine Beaver Pond had the greatest concentration of the metals tested. The ISQG was exceeded here for mercury, arsenic, cadmium, chromium, copper and zinc, with the PEL also exceeded for arsenic and chromium. The ISQG for arsenic was also exceeded at the other two sites. The PEL for chromium was significantly

exceeded at E-3 and E-4. To put these high chromium concentrations into perspective, the Yukon stream sediment database maintained by Environment Canada was reviewed. Of the 2,614 stream sediment samples where chromium was detected, the concentrations ranged from 0.2 ppm to 363 ppm. The highest concentrations were documented from stream sediments in the South MacMillan River, part of the Pelly River drainage. The concentrations recorded in the stream sediments at Wolverine (1,180 ppm) and Clinton (1,170 ppm) Creeks are the highest yet recorded.

Parameter	Units	E-3, Wolverine Cr u/s culverts	E-4, Clinton Cr just d/s culverts	Porcupine Beaver Pond	ISQG	PEL
Mercury	mg/kg	0.02	0.03	0.24	0.17	0.486
Antimony	ug/g	1.3	1.6	3.5		
Arsenic	ug/g	8.6	11.6	28.4	5.9	17
Barium	ug/g	132	202	370		
Beryllium	ug/g	<0.1	0.1	0.4		
Cadmium	ug/g	0.15	0.19	2.28	0.6	3.5
Chromium	ug/g	1180	1170	331	37.3	90.0
Cobalt	ug/g	69.5	77.2	38.2		
Copper	ug/g	8	8	45	35.7	197
Lead	ug/g	3.6	3	11.1	35	91.3
Molybdenum	ug/g	<1	1	5		
Nickel	ug/g	1660	1600	590		
Selenium	ug/g	0.6	0.6	6.7		
Silver	ug/g	0.1	<0.1	0.6		
Thallium	ug/g	<0.05	<0.05	0.26		
Tin	ug/g	<1	<1	<1		
Uranium	ug/g	2.3	2.2	2.6		
Vanadium	ug/g	4	<0.1	22.7		
Zinc	ug/g	35	39	148	123	315
Asbestos	%	15 - 20	15 - 20	20 - 25		

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

4.0 RECOMMENDATIONS

It is recommended that additional water quality and stream sediment samples be collected from all sites of the study area in the spring, summer and fall of 2010 to create a larger database before drawing any long term conclusions. It is also recommended that dissolved metals be included as an analytical parameter when the creeks are flowing turbid to determine the portion of the metals that are in the bioavailable and hence more toxic phase.

5.0 REFERENCES

Burns, B.E. 2009. *Biological Monitoring Survey at Brewery Creek, Y.T. 2009*. Laberge Environmental Services. Prepared for Alexco Resource Corporation.

APPENDIX A

BENTHIC INVERTEBRATE DATA, 2009

Laberge Env. Services 2009Clinton Creek

Cordillera Consulting

Taxonomist: Sue Salter

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250-494-7553

	Sample Site	Clinton Cr u/s Hudgeon Lake			Easter Cr u/s Hudgeon Lake			Wolverine Cr u/s tailings			Eagle Creek u/s culvert			Forty Mile River u/s Clinton Cr		Clinton Cr d/s gabions, u/s Porcupine Cr		
		R1-A	R1-B	R1-C	R2-A	R2-B	R2-C	R3-A	R3-B	R3-C	R4-A	R4-B	R4-C	R6-A	R6-B	E1-A	E1-B	E1-C
	Sample ID:	090349	090350	090351	090352	090353	090354	090377	090378	090379	090355	090356	090357	090373	090374	090358	090359	090360
	CC#:																	
	Subsample amount:	13/100	25/100	14/100	100/100	37/100	49/100	100/100	46/100	100/100	16/100	20/100	19/100	100/100	100/100	10/100	4/100	29/100
		total	total	total	total	total	total	total	total	total	total	total	total	total	total	total	total	total
PHYLUM ARTHROPODA																		
Class: Insecta																		
Order: Ephemeroptera																		
Family: Ameletidae																		
<i>Ameletus sp.</i>	nymph				2	5	4							4	32			
Family: Baetidae																		
<i>Acentrella sp.</i>	nymph	8		7	1													
<i>Baetis sp.</i>	nymph				3	8	6								1			
<i>Baetis bicaudatus</i>	nymph			7	2													
<i>Baetis tricaudatus</i>	nymph				10	35	12											25
Family: Ephemerellidae																		
<i>Drunella doddsi</i>	nymph							1		1								
<i>Ephemerella sp.</i>	nymph													1				
Family: Heptageniidae																		
<i>Cinygmula sp.</i>	nymph (juv./dam.)			14	12	30	12			3				6	1			
<i>Cinygmula sp.</i>	nymph	39	16	36							6	15	5					
<i>Epeorus sp.</i>	nymph				2													
<i>Rhithrogena sp.</i>	nymph																	
<i>Stenonema femoratum</i>	nymph														2			
Family: Leptophlebiidae																		
<i>Leptophlebia sp.</i>	nymph (juv./dam.)			7														
Order: Plecoptera																		
Family: Capniidae																		
<i>Capnia sp.</i>	nymph (juv./dam.)	293	320	511	50	211	106	48	15	40	10	19	10	69	46	234	10	25
Family: Chloroperlidae																		
<i>Suwallia sp.</i>	nymph											5	5					
Family: Nemouridae																		
<i>Nemoura sp.</i>	nymph (juv./dam.)	1132	492	1108	28	30	14	57	191	23	738	645	488					50
<i>Ostrocerca sp.</i>	nymph		136	170		3	2	127	202	21	275	290	159					
<i>Podmosta sp.</i>	nymph	493	136	213							94	85	37					
Family: Perlodidae																		
<i>Isoperla sp.</i>	nymph (juv./dam.)													1	4			
<i>Isoperla sp.</i>	nymph																	
<i>Skwala sp.</i>	nymph																	
Family: Taeniopterygidae																		
<i>Taeniopteryx sp.</i>	nymph (juv./dam.)									2								
Order: Trichoptera																		
Family: Brachycentridae																		
<i>Brachycentrus sp.</i>	larvae (juv./dam.)							2		1								7
<i>Brachycentrus sp.</i>	larvae															30	50	
<i>Micrasema sp.</i>	larvae																	14
Family: Glossosomatidae																		
<i>Glossosoma sp.</i>	larvae																	
Family: Lepidostomatidae																		
<i>Lepidostoma sp.</i>	larvae	8																
Family: Limnephilidae																		
<i>Limnephila sp.</i>	larvae (juv./dam.)					5	4		2	2					1			
<i>Dicosmoecus sp.</i>	larvae		4															
<i>Ecclisomyia sp.</i>	larvae																	
<i>Psycholophya sp.</i>	larvae																	
Family: Rhyacophiliidae																		
<i>Rhyacophila sp.</i>	larvae				1													

Appendix A

BENTHIC INVERTEBRATE DATA, CLINTON CREEK STUDY AREA 2009

	Sample Site	Clinton Cr u/s Hudgeon Lake			Easter Cr u/s Hudgeon Lake			Wolverine Cr u/s tailings			Eagle Creek u/s culvert			Forty Mile River u/s Clinton Cr		Clinton Cr d/s gabions, u/s Porcupine Cr		
		Sample ID:	R1-A	R1-B	R1-C	R2-A	R2-B	R2-C	R3-A	R3-B	R3-C	R4-A	R4-B	R4-C	R6-A	R6-B	E1-A	E1-B
	CC#:	090349	090350	090351	090352	090353	090354	090377	090378	090379	090355	090356	090357	090373	090374	090358	090359	090360
	Subsample amount:	13/100	25/100	14/100	100/100	37/100	49/100	100/100	46/100	100/100	16/100	20/100	19/100	100/100	100/100	10/100	4/100	29/100
		total	total	total	total	total	total	total	total	total	total	total	total	total	total	total	total	total
<i>Chelifera/Metachela sp.</i>	larvae	15	4													10	25	20
<i>Clinocera sp.</i>	larvae																	
<i>Oreogeton sp.</i>	larvae				1			1								10	25	7
Family: Muscidae																		
<i>Limnophora sp.</i>	larvae							1	2							10		
Family: Psychodidae																		
<i>Pericoma sp.</i>	larvae							1										
Family: Simuliidae	pupae				7	5	6	1	7		38	55	11					
<i>Prosimulium sp.</i>	nymph				1						200	40	11					
<i>Simulium sp.</i>	larvae		4		1			1	4							80	425	27
Family: Tipulidae	larvae (juv./dam.)						2											
<i>Dicranota sp.</i>	larvae		4	7		5	10	19	13		19	10				80		
<i>Erioptera ilisia</i>	larvae																	
<i>Hesperoconopa sp.</i>	larvae														1			
<i>Ormosia sp.</i>	larvae							18	7	6								
<i>Rhabdomastix sp.</i>	larvae																	
<i>Tipula sp.</i>	larvae			21				2	2			5	5			10		
Order: Collembola										1	6	10						
Class: Crustacea																		
Order: Amphipoda																		
<i>Gammarus sp.</i>																		
Class: Arachnida																		
Super-Order: Acariformes	deutonymph						2									10		3
Family: Hydrozetidae	adult					3								2				
Family: Hygrobatidae																		
<i>Hygrobatas sp.</i>	adult										6							
Family: Lebertiidae																		
<i>Lebertia sp.</i>	adult																	
Family: Sperchontidae																		
<i>Sperchon sp.</i>	adult		4		1								16					7
PHYLUM MOLLUSCA																		
Class: Gastropoda								1								20		
Family: Hydrobiidae								1										
Family: Planorbidae																	50	3
PHYLUM ANNELIDA																		
Class: Oligochaeta																		
Family: Lumbriculidae		801		142	10	78	306				375	335	647	5	13	100	75	41
<i>Rhynchelmis sp.</i>		8				8	16			1	25	10	53	1				
Family: Naididae																		
Sub-Family: Tubificinae		8	160				2	6	13	4				8	45	140	500	20
Sub-Family: Naidinae														16	21	100	27	
TOTAL SUBSAMPLE		2841	1328	2286	250	837	720	418	680	214	2006	1620	1749	113	397	3610	8375	1020
TOTAL PER SITE		6456			1807			1312			5375			510		13005		
TAXONOMIC RICHNESS/SAMPLE		11	13	14	26	21	23	22	17	19	17	17	18	16	17	18	21	21
TAXONOMIC RICHNESS/SITE		22			40			35			23			23		34		

Appendix A

BENTHIC INVERTEBRATE DATA, CLINTON CREEK STUDY AREA 2009

	Sample Site	Clinton Cr d/s Porcupine Cr, u/s Wolverine Cr			Wolverine Cr			Clinton Cr d/s Wolverine Cr, u/s Eagle Cr			Clinton Cr near mouth			Forty Mile River d/s Clinton Cr		Total # of Invertebrates	%
		E2-A	E2-B	E2-C	E3-A	E3-B	E3-C	E4-A	E4-B	E4-C	E7-A	E7-B	E7-C	E8-A	E8-B		
CC#:	Sample ID:	090361	090362	090363	090364	090365	090366	090367	090368	090369	090370	090371	090372	090375	090376		
Subsample amount:		15/100	35/100	10/100	19/100	13/100	9/100	100/100	100/100	100/100	100/100	100/100	100/100	100/100	100/100		
		total	total	total	total	total	total	total	total	total	total	total	total	total	total		
Order: Coleoptera	larvae (juv./dam.)							1								1	0.00
Family: Chrysomelidae	larvae															1	0.00
Family: Dytiscidae																	
<i>Oreodytes sp.</i>	adult									1						1	0.00
Family: Hydraenidae																	
<i>Hydraena sp.</i>	larvae													1		1	0.00
Family: Hydrophilidae	larvae (juv./dam.)															2	0.00
Order: Diptera UID	pupae	27	20													203	0.44
Order: Diptera UID	larvae (juv./dam.)					8					1					37	0.08
Family: Ceratopogonidae	larvae (juv./dam.)								1						1	7	0.02
<i>Alluaudomyia sp.</i>	larvae												13			13	0.03
<i>Bezzia/Palpomvia sp.</i>	larvae	7		20												27	0.06
<i>Ceratopogon sp.</i>	larvae															5	0.01
<i>Culicoides sp.</i>	larvae															2	0.00
<i>Mallochohelea sp.</i>	larvae		15	10								1				26	0.06
<i>Probezzia sp.</i>	larvae	7	12					3	1							23	0.05
Family: Chironomidae	pupae						233			7						265	0.58
Family: Chironomidae	larvae																
Subfamily: Chironominae	larvae																
Tribe: Tanytarsini	larvae																
<i>Micropsectra/Tanytarsus</i>	larvae	174	44	320							11			6	8	1261	2.75
<i>Rheacricotopus sp.</i>	larvae															3	0.01
<i>Stempellina sp.</i>	larvae									2						2	0.00
Tribe: Chironominae	larvae																
<i>Tribelos sp.</i>	larvae															123	0.27
Subfamily: Orthoclaadiinae	larvae																
<i>Brillia sp.</i>	larvae																
<i>Corynoneura sp.</i>	larvae		6	20				2	1	1	6	2				187	0.41
<i>Cricotopus/Orthoclaadius sp.</i>	larvae	369	348	1200	90			26	51	28	211	167	212	1	3	7042	15.34
<i>Eukiefferiella sp.</i>	larvae	603	125	700		54	56	85	18	7	37	145	185			3077	6.70
<i>Euryhopsis sp.</i>	larvae		6	50												452	0.98
<i>Diplocladius sp.</i>	larvae															13	0.03
<i>Heterotrissocladius sp.</i>	larvae															2	0.00
<i>Hydrobaenus sp.</i>	larvae		9	60												128	0.28
<i>Krenosmittia sp.</i>	larvae										1	3				4	0.01
<i>Metriocnemus sp.</i>	larvae															2	0.00
<i>Parametricnemus sp.</i>	larvae	40														67	0.15
<i>Parorthoclaadius sp.</i>	larvae															3	0.01
<i>Pseudosmittia sp.</i>	larvae													1		1	0.00
<i>Tvetenia sp.</i>	larvae	168													1	3594	7.83
Subfamily: Diamesinae	larvae																
<i>Diamesa sp.</i>	larvae		20		1378	2495	2498				7		7			7827	17.05
<i>Paqhastia sp.</i>	larvae						11		3	2	9	3	5			40	0.09
<i>Pothastia longimana</i>	larvae	20	12	30												167	0.36
Subfamily: Tanypodinae	larvae	7	41	100				1							2	565	1.23
<i>Procladius sp.</i>	larvae															1	0.00
Family: Empididae	larvae						11									11	0.02

Appendix A

BENTHIC INVERTEBRATE DATA, CLINTON CREEK STUDY AREA 2009

	Sample Site	Clinton Cr d/s Porcupine Cr, u/s Wolverine Cr			Wolverine Cr			Clinton Cr d/s Wolverine Cr, u/s Eagle Cr			Clinton Cr near mouth			Forty Mile River d/s Clinton Cr		Total # of Invertebrates	%
		E2-A	E2-B	E2-C	E3-A	E3-B	E3-C	E4-A	E4-B	E4-C	E7-A	E7-B	E7-C	E8-A	E8-B		
Sample ID:	CC#:	090361	090362	090363	090364	090365	090366	090367	090368	090369	090370	090371	090372	090375	090376		
Subsample amount:		15/100	35/100	10/100	19/100	13/100	9/100	100/100	100/100	100/100	100/100	100/100	100/100	100/100	100/100		
		total	total	total	total	total	total	total	total	total	total	total	total	total	total		
<i>Chelifera/Metachela sp.</i>	larvae	34	15	30	32	23	122	1			40	56	49	2		478	1.04
<i>Clinocera sp.</i>	larvae		6	10		15										31	0.07
<i>Oreogeton sp.</i>	larvae				16		11				5	10	9			95	0.21
Family: Muscidae																	
<i>Limnophora sp.</i>	larvae															13	0.03
Family: Psychodidae																	
<i>Pericoma sp.</i>	larvae							1				1				3	0.01
Family: Simuliidae	pupae	20		20			11		1	1			2			184	0.40
<i>Prosimulium sp.</i>	nymph						11								1	264	0.57
<i>Simulium sp.</i>	larvae	101	6	130	5			7	2	1					1	795	1.73
Family: Tipulidae	larvae (juv./dam.)															2	0.00
<i>Dicranota sp.</i>	larvae	7	38	40	37	8		55	56	22	9	19	15	6		479	1.04
<i>Erioptera ilisia</i>	larvae													1		1	0.00
<i>Hesperoconopa sp.</i>	larvae															1	0.00
<i>Ormosia sp.</i>	larvae										1			1		33	0.07
<i>Rhabdomastix sp.</i>	larvae														1	1	0.00
<i>Tipula sp.</i>	larvae			20	5											71	0.15
Order: Collembola					5			1			1					25	0.05
Class: Crustacea																	
Order: Amphipoda																	
<i>Gammarus sp.</i>						15					1			1		17	0.04
Class: Arachnida																	
Super-Order: Acariformes	deutonymph	7	6									1	2			31	0.07
Family: Hydrozetidae	adult															5	0.01
Family: Hygrobatidae																6	0.01
<i>Hygrobates sp.</i>	adult																
Family: Lebertiidae																	
<i>Lebertia sp.</i>	adult							4	2		1	3	2		1	13	0.03
Family: Sperchontidae																	
<i>Sperchon sp.</i>	adult	7	3	10				11	26	3	3		3			93	0.20
PHYLUM MOLLUSCA																	
Class: Gastropoda		7	3					1								32	0.07
Family: Hydrobiidae																1	0.00
Family: Planorbidae																53	0.12
PHYLUM ANNELIDA																	
Class: Oligochaeta																	
Family: Lumbriculidae		362	75	30		100	566	79	43	25	12	4				4224	9.20
<i>Rhynchelmis sp.</i>								2		1						125	0.27
Family: Naididae																	
Sub-Family: Tubificinae		13	58	400	21				2	4	2	1	3	6	4	1421	3.09
Sub-Family: Naidinae		127	12						1						12	316	0.69
TOTAL SUBSAMPLE		2198	919	3320	1738	2834	3985	317	215	109	383	430	541	65	396		
TOTAL PER SITE		6437			8557			641			1354			461			
TAXONOMIC RICHNESS/SAMPLE		24	26	24	14	11	14	23	17	16	21	21	21	14	22		
TAXONOMIC RICHNESS/SITE		35			24			32			33			32			

APPENDIX B

**HABITAT CHARACTERISTICS OF THE BENTHIC
INVERTEBRATE SITES, CLINTON CREEK, 2009**

APPENDIX B HABITAT CHARACTERISTICS OF THE BENTHIC SITES IN THE CLINTON CREEK STUDY AREA, 2009

Site #	Site Description	Date Sampled	Time Sampled	NAD 83 Easting	Zone 07W Northing	Water Temp oC	pH	Conductivity uS/cm	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Velocity at each kick site (m/s)	Number of transects/kicknet	Average Depth at sites (mcm)	Discharge (cms)
R1	Clinton Creek u/s Hudgeon Lake	19/08/2009	15:00	510600	7147506	6.6	*	762	*	*	0.642, 0.309, 0.771, 0.538	2, 2, 1	10	0.1737
R2	Easter Creek u/s Hudgeon Lake	19/08/2009	12:45	512006	7148015	7.2	*	822	*	*	0.521, 0.919, 0.462	3, 2, 2.5	20	0.0429
R3	Wolverine Cr u/s Tailings Upstream of beaver pond u/s of tailings	03/09/2009	8:00	513953	7148633	1.0	8.84				0.317, 0.319, 0.307 (0.0932)	3	14	0.062
R4	Eagle Creek u/s culvert	18/08/2009	16:45	515990	7145340	5.6	9.11	544	99.9	11.96	0.642, 0.522, 0.317	4	10	0.047
R6	Forty Mile River u/s Clinton Ck	03/09/2009	14:13	519436	7141962	7.5	8.26				0.591, 0.313	<1	30	Flow not Measured
E1	Clinton Creek d/s gabions and u/s Porcupine Creek	18/08/2009	12:10	513695	7147183	13.5	7.67	506	82	8.08	0.717, 0.375, 0.288	1.5	15	0.2605
E2	Clinton Creek d/s Porcupine and u/s Wolverine Cr	18/08/2009	15:15	514181	7147079	12.2	8.13	901	73.5	7.49	0.322, 0.327, 0.274	1	15	0.0925
E3	Wolverine Cr u/s culvert	18/08/2009	14:15	514183	7147163	9.1	8.82	865	94.5	10.31	0.442, 0.196, 0.386	4	15	0.063
E4	Clinton Creek d/s Wolverine Cr and u/s Eagle Creek	18/08/2009	15:30	515933	7145279	10.7	8.49	1191	83.7	8.83	0.576, 0.360, 0.237	1	20	0.2534
E7	Clinton Creek near mouth	18/08/2009	19:00	519421	7142049	10.1	8.44	1084	90.5	9.75	0.483, 1.096, 0.534	1	20	0.2758
E8	Forty Mile River d/s Clinton Ck	03/09/2009	13:15	519428	7142091	6.6	7.77				0.422, 0.805	<1	25	Flow not Measured

* meter malfunctioned

APPENDIX B HABITAT CHARACTERISTICS OF THE BENTHIC SITES IN THE CLINTON CREEK STUDY AREA, 2009

Site #	Site Description	Wetted Width (m)	Bankfull Width (m)	Riparian Vegetation	Canopy Coverage (%)	Particle Size Score			Embeddedness Score	General	Comments
						Dominant	SubDominant	Surrounding			
R1	Clinton Creek u/s Hudgeon Lake	7.5	8.0	grasses, willows, spruce, equestem	0 - 25	5	6	2	5	riffles, runs, pool	moose sign throughout, orange 'puffy' algae
R2	Easter Creek u/s Hudgeon Lake	2.5	2.5	willows, spruce, grasses, shrubby cinqfoil, eqistem, moss, grass of parnasus	0 - 25	4	5	2	5	riffles, runs, pool	large muddy flood plain, moose sign throughout, beaver activity - small dam between b & c, clean gravels
R3	Wolverine Cr u/s Tailings Upstream of beaver pond u/s of tailings	3.0	5.0	Mainly grasses, some shrubs in valley. White and black spruce, willows, shrubs and sparse poplar on slopes.	0	4	3	1	4	riffles, runs, not many pools	There is evidence of another creek bed on north side of valley. Entire valley could be bank full width in times of high water because valley floor is saturated. Approx 50m width.
R4	Eagle Creek u/s culvert	1.3	1.8	willows, alder, grasses, moss, equestem, rose, monks hood, languid lady	80	6	5	2	4	riffles, runs, not many pools	mostly clean washed gravels.
R6	Forty Mile River u/s Clinton Ck	N/A Wide River	N/A Wide River	Grasses, willows and sedges. White spruce, paper birch and trembling aspen up slopes.	0	7	6	5	2	River - Riffles and runs no pools.	R6(A) First visual riffle u/s of Clinton. R6(B) Drove to the residence of Earl and Sandy who allowed us access to riffle in front of thier house.
E1	Clinton Creek d/s gabions and u/s Porcupine Creek	6.03	22.2	mostly willows, aspen, grasses, fireweed	0 - 25	6	8	4 - 5	4 - 5	riffles, runs, pool	An unidentified 6" fish observed under an overhanging willow, water brown coloured, rust coloured deposit on rocks - slippery
E2	Clinton Creek d/s Porcupine and u/s Wolverine Cr	5.0		grasses, willows, spruce. Waste rock and eroded slopes, not much veg	0	6	7	4	2	riffles, pools, runs, side channels	many seeps from beaver pond upstream of site, minnows observed in pool u/s of Woverine culvert
E3	Wolverine Cr u/s culvert	2.02	24.0	grasses, willow,	0 - 25 (first), 70 - 80 (other 2)	6	5	2	4 - 5	riffles, runs, pools	large sandy flood plain u/s culvert, then willow forest complex
E4	Clinton Creek d/s Wolverine Cr and u/s Eagle Creek	5.5	12.7	willow, alder, spruce, grasses	0 - 25	7	6	2	3	riffles, runs, pools	Site E4a had a large boulder and difficult to sample
E7	Clinton Creek near mouth	4.2	14.3	willows, grasses, alder	0 - 25	7	6	2	4	riffles, runs	green moss/algae on rocks
E8	Forty Mile River d/s Clinton Ck	N/A Wide River	N/A Wide River	Grasses, willows and sedges. White spruce, paper birch and trembling aspen up slopes.	0	7	6	3	3	River - Riffles and runs no pools.	E8(A) Riffle at Clinton confluence. E8(B) Access RH bank riffle in center of river across from rock wall.

* meter malfunctioned

APPENDIX C

PHOTOS OF SAMPLE SITES AND

DISCHARGE VARIANCE, CLINTON CREEK, 2009