Fisheries and Environment Canada

Pêches et Environnement Canada

Environmental Protection Service

Service de la protection de l'environnement

An Assessment of the Pre-Development Water Quality and Biological Conditions in the Water Shed Around the Minto Ore Body.

Manuscript Report
77-9

Pacific Region
September 1977

Environmental Protection Service Report Series

Manuscript reports contain interim results and are primarily designed to serve as regional data records.

Other categories in the EPS series include such groups as Regulation, Codes and Protocols, Policy and Planning, Technical Appraisal, Technology Development, Surveillance, and Reprints of Published Papers.

Inquiries pertaining to Environmental Protection Service Reports should be directed to the Environmental Protection Service, Department of Fisheries and the Environment, Kapilano 100, Park Royal, West Vancouver, B.C., V5T 1A2 or to the Environmental Protection Service, Ottawa, Ontario, K1A 0H3.

AN ASSESSMENT OF THE PRE-DEVELOPMENT WATER QUALITY AND BIOLOGICAL CONDITIONS IN THE WATER SHED AROUND THE MINTO ORE BODY

by

B.W. Kelso, W. Robson and K. Weagle

Environmental Protection Service
Whitehorse, Yukon
Pacific Region

Manuscript Report 77-9
September, 1977

ABSTRACT

The water quality of the Minto drainage area in the Yukon Territory was found to be typical of other similar sized water sheds in the Yukon. Heavy metals in most cases were below the detection limit. A value of 0.01 mg/ℓ of copper was found at the station nearest the ore body. Macroinvertebrate populations were slightly below expected levels on the June 1975 survey, but the samples taken in September 1976 were more typical of similar Yukon creeks. Of particular interest with regards to fish populations was the finding of young chinook salmon in both the Wolverine and Big Creeks.

Further studies are recommended to document the annual fluctuations in invertebrate populations and to delineate the salmon spawning and rearing potential (capability) of the areas.

TABLE OF CONTENTS

		PAGE
ABSTRACT		i
TABLE OF CONTENTS		ii
LIST OF FIGURES		iv
LIST OF TABLES		iv
SUMMARY AND CONCLUSIONS		v
1	INTRODUCTION	1
2	DESCRIPTION OF STUDY AREA	2
3	MATERIALS AND METHODS	6
3.1	Water Chemistry	6
3.2	Macroinvertebrates	6
3.3	Fish	8
4	RESULTS AND DISCUSSION	9
4.1	Water Chemistry	9
4.2	Macroinvertebrates	12
4.3	Fish	16
REFERENCES		20
APPENDIX I	MONTHLY MEAN AND RANGE OF WATER FLOW IN BIG CREEK, YUKON TERRITORY (C.F.S.) FOR PART OF 1974 AND ALL OF 1975 (WATER SURVEY OF CANADA, 1975 AND 1976)	21

		PAGE
APPENDIX II	THE SPECIES LIST FOR THE CLASSES OF MACROINVERTEBRATES FOUND IN THE MINTO AREA STREAMS IN THE JUNE, 1975 SURVEY	23
APPENDIX III	THE SPECIES LIST FOR THE CLASSES OF MACROINVERTEBRATES FOUND IN THE MINTO AREA STREAMS IN THE SEPTEMBER, 1976 SURVEY	26

LIST OF FIGURES

FIGURE		PAGE
1	MAP OF YUKON TERRITORY SHOWING THE LOCATION OF THE STUDY AREA AT THE MINTO ORE DEPOSIT	3
2	SAMPLING STATIONS IN THE MINTO DRAINAGE AREA	4

LIST OF TABLES

TABLE		PAGE
1	CHEMICAL AND PHYSICAL MEASUREMENTS OF WATER QUALITY.	10
2	TOTAL EXTRACTABLE HEAVY METAL CONTENT OF WATER SAMPLES.	11
3	A SPECIES LIST OF MACROINVERTEBRATES COLLECTED BY ARTIFICIAL SUBSTRATE SAMPLER, SURBER SAMPLERS AND HAND PICKED SAMPLES DURING THE JUNE, 1975 SURVEY	13
4	MACROINVERTEBRATES COLLECTED BY SURBER SAMPLER IN JUNE, 1975.	14
5	MACROINVERTEBRATES COLLECTED WITH THE AID OF A SURBER SAMPLER IN SEPTEMBER, 1976	15
6	DIVERSITY INDICES FOR MACROINVERTEBRATES FOR 1975 AND 1976.	17
7	SUMMARY OF ELECTRO-FISHING RESULTS, 1975 AND 1976.	18

SUMMARY AND CONCLUSIONS

In June of 1975 and September 1976 a baseline water quality study was conducted on several creeks draining the proposed copper mining area known as the Minto deposit which is situated approximately 150 miles north of Whitehorse, Yukon Territory.

1. Water chemistry in the study area was typical of other similar-size water sheds in the Yukon.

2. Macroinvertebrates found in June 1975 were low but in September 1976 the populations found were typical of other similar streams in the Yukon. More work is required to determine the annual fluctuations in these aquatic bottom dwelling organisms.

3. In the survey of fish populations in 1976, Chinook salmon were found in Big Creek and Wolverine Creek. Prior to development of the ore body, a more detailed study should be made on fish populations, including work on salmon spawning and rearing areas in the Yukon River.

4. Future studies of the area should include documentation of water chemistry, macroinvertebrate communities and fish populations. The macroinvertebrates and fish tissue should also be analyzed for heavy metal content. These should be conducted in June to coincide with the 1975 study and in September to compare to the 1976 data. Another sampling station should be located on Dark Creek as close to the ore body as possible.

1 INTRODUCTION

In July of 1971 several claims were staked on a copper anomaly located approximately 150 air miles north of Whitehorse, Yukon Territory. This area, located approximately thirteen miles downstream and across the Yukon River from the abandoned village of Minto, is now known as the Minto deposit. The ore body was wholly staked by United Keno Hill Mines (DEF Claims) and Silver Standard (MINTO Claims) with many smaller companies and individuals staking claims around the periphery. At a later date Silver Standard sold 50% of their claims to ASARCO (American Smelting and Refining Company). ASARCO began exploration in the fall of 1971 and between 1972 and 1974 diamond drilling and associated trenching was undertaken on both claims (DEF and MINTO). A winter road from Carmacks to the deposit was built along the west side of the river following, where possible, the old Dawson Trail.

In light of this heavy exploration in the Minto area, the Environmental Protection Service, in consultation with the Department of Indian and North Affairs (DINA), and Fisheries and Marine Service (FMS) of the Department of Fisheries and the Environment, determined that a baseline water quality study was necessary prior to any further development of the area. Thus, in May and June of 1975 and August of 1976, physical, chemical and biological data was collected from streams in the area. This included water samples for heavy metal content and biological surveys of the benthic invertebrate and fish communities.

2 DESCRIPTION OF STUDY AREA

The study area was located to the west of the Yukon River near the Ingersol Islands which are located approximately 20 kilometers (13M) downstream from the abandoned community of Minto (Figure 1). The sampling was concentrated on creeks draining the area of the ore deposit, on Big Creek to the south of the deposit and Wolverine Creek to the north of the deposit. Seven stations were established for the survey (Figure 2) which can be described as follows:

Station 1: On Big Creek, 30 meters upstream from its confluence with Dark Creek (substrate of sand, pebbles, gravel and cobble);

Station 2: On Big Creek, 10 meters upstream of its confluence with Yukon River (substrate of sand, pebbles, gravel and cobble);

Station 3: 10 meters above the point where the access road crosses and unnamed creek which drains the area of the ore body (substrate of sand, pebbles, gravel and cobble with some silt and detrius accumulation);

Station 4: 200 meters upstream on Wolverine Creek from its junction with the Yukon River (substrate of pebbles, gravel and cobble);

Station 5: approximately 10 kilometers upstream from station 4 on Wolverine Creek (substrate of pebbles, gravel and cobble);

Station 6: adjacent to the heliport on the only large creek between Wolverine Creek and the ore body approximately 5 kilometers from the creek's junction with the Yukon River;

Station 7: approximately 6 kilometers upstream from station 3 on the same unnamed creek and just below the ore body.

Although there are no detailed historical records of the hydrology of the area, the stream at stations 1, 2, 4, and 5 appear to have flows throughout the year. The monthly mean and range of water flow for Big Creek are shown in Appendix I. Stations 3, 6, and 7 showed

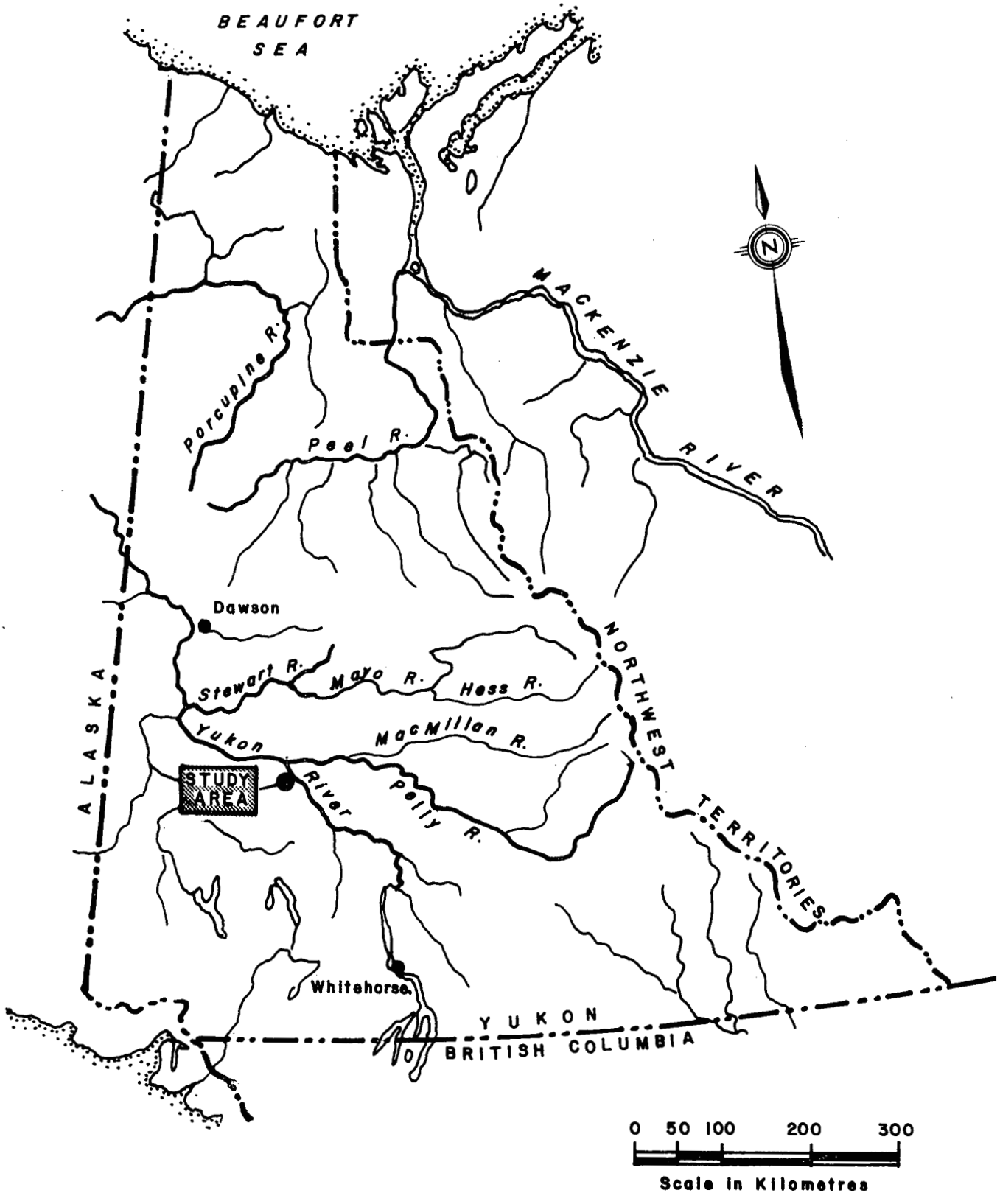

FIGURE I MAP OF YUKON TERRITORY SHOWING THE LOCATIONS OF THE STUDY AREA AT THE MINTO ORE DEPOSIT

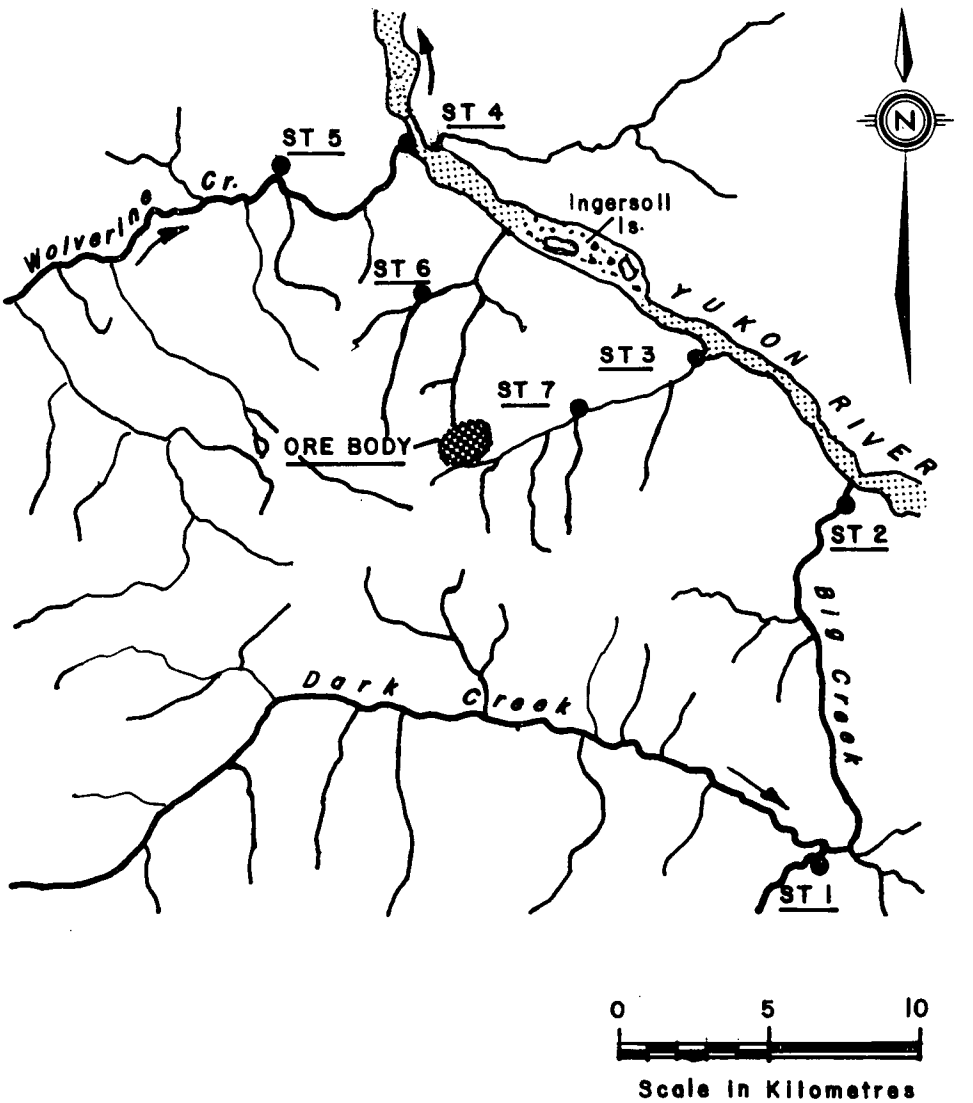

FIGURE 2 SAMPLING STATIONS IN THE MINTO DRAINAGE AREA

signs of extensive glaciation during the May 15, 1975 survey and may freeze to the bottom during the winter months. During the same period, stations 6 and 7 were still frozen and water quality samples were taken from the waters flowing over the ice.

3 MATERIALS AND METHODS

3.1 Water Chemistry

Water quality samples were collected at all seven stations on May 15 and June 30, 1975 and at all stations except Station 6 on September 21, 1976. Temperature, conductivity, and pH were measured in the field with a Y.S.I. (Yellow Springs Instrument), S.C.T. (Salinity, Conductivity and Temperature) meter and a Radiometer model 29B pH meter, respectively. Dissolved oxygen concentrations were measured in the field using the azide modification of the Winkler method.

One liter grab samples were taken and analyzed for non-filterable residue (N.F.R.), total hardness ($CaCO_3$), total alkalinity, turbidity and colour. Five hundred mℓ water samples were collected and acidified in the field to pH 1.0 - 1.5 with nitric acid and analyzed for extractable calcium, magnesium, antimony, barium, cadmium, copper, lead, molybdenum, nickel, silver, zinc, and mercury. An attempt was made on July 15, 1976 to conduct a survey but high flows (7860 cfs at Big Creek) caused by summer rains delayed the survey until September 21, 1976. In 1976 total alkalinity, turbidity, iron and arsenic were added to the list of analysis. All samples were collected in linear polyethylene bottles and later analyzed at the Environmental Protection Service/Fisheries and Marine Service laboratory in West Vancouver, B.C.

3.2 Macroinvertebrates

The invertebrate bottom fauna was sampled by artificial substrate samplers placed at stations 1, 2, 3, 4, and 5 on May 15, 1975 and retrieved on June 30, 1975. The artificial substrate samplers (ASS) were chrome plated, barbecue chicken baskets with exterior dimensions of diameter 17 cm, length 25 cm. The baskets were filled with clean gravel of a uniform size from the creek flood plain or creek bottom. The approximate surface area contained in each basket was 6000±1000 sq cm. Three samplers were completely sumberged in the creek at each station and

secured to the bank by a rope. When the ASS were retrieved, a Surber sampler was first placed immediately downstream and the ASS was slipped into the Surber to ensure a minimum loss of organisms. The rocks were removed from the sampler in the field and the vegetation and organisms were then preserved in 70% methanol.

However, on the return trip to the study area on June 30, 1975 a large percentage of the ASS were either partially or completely out of the water or tampered with. Therefore, a minimum of three Surber samples were taken at each station where ASS were previously located. The Surber sampler had a surface area of 900 sq centimeters (30 cm by 30 cm). Samples collected by means of the Surber sampler were preserved in the same manner as ASS samples. During the 1976 survey, Surber samples were collected at stations 1 to 5 and handled in the same manner as the 1975 Surber samples.

In the Whitehorse laboratory the organisms were separated from the vegetation and debris and roughly sorted into families. Final identification and counting of the organisms were conducted by Dr. Charles Low, of Envirocon Ltd., Vancouver, B.C.

A species diversity index and evenness index was calculated for the organisms collected using the following formuli:

$$\text{Species Diversity } (H') = -\sum_{i=1}^{s} p_i \log_2 p_i$$

Where $P_i = n_i/N$

n_i = the number of individuals in the ith species

N = the total number of individuals sampled

$$\text{Evenness } (J) = \frac{-\sum_{i=1}^{s} p_i \log_2 p_i}{\log_2 s}$$

where s = the total number of species sampled

and $J_{max} = 1$

These formuli are described by Pielow (1966, 1967).

3.3 Fish

During 1975 at stations 1, 2, 3, 4, and 5 attempts were made to collect fish using a Smith-Root Type VIII electro fisher. A barrier net was placed in the creek, and an area reaching approximately 100 feet upstream of the net was fished, with periodic checks of the net. The exact fishing times were recorded automatically on the electro-fishing equipment. The same procedure was followed in 1976, however due to low waters, station three was not fished.

4 RESULTS AND DISCUSSIONS

4.1 Water Chemistry

Generally, the water quality parameters analysed showed no anomalies (Tables 1 and 2). Unfortunately the May 15, 1975 water samples that were sent to West Vancouver for analysis were lost in transit. Further, the total alkalinity and turbidity analyses for the June 30, 1975 survey were not completed due to a delay in transit.

The conductivity readings on the May survey in 1975 at stations 3 to 7 were much lower than observed during the two following surveys. This is probably due to the effect of the spring runoff. The earlier samples were collected during the peak of the spring run-off and the resultant high percentage of relatively pure snow melt water at these stations lowered the conductivity. Stations 1 and 2 on Big Creek had similar conductivity values for all three sample dates which suggests the snow melt had less effect on the water quality of Big Creek. The more consistent flow of Big Creek in comparison to the other creeks would also support this conclusion.

The total hardness (mg/ℓ $CaCO_3$) ranged from 70 to 120 which falls within the classification of being moderately hard (EPA, 1973). Stream pH values were very close to neutral, ranging from 6.65 to 8.0.

The moderately low dissolved oxygen found at Station 3 on June 30, 1975 (6.2 mg/ℓ - 55.4% saturation) was probably related to the nature of the sample locations. The creek, on which station 3 was located, flowed underground in many areas and surfaced in small pools. On June 30, 1975 the flow in the creek was very low which may have resulted in low oxygen concentrations. The rest of the stations showed a relatively high concentration of dissolved oxygen, ranging from 8 to 11.7 mg/ℓ (68-89% saturation).

At all the stations, the heavy metal concentrations were below the detection levels, with three exceptions. The zinc concentration was above the detection limit at station 7 in June 1975

TABLE 1 CHEMICAL AND PHYSICAL MEASUREMENTS OF WATER QUALITY

Analysis		Field				Lab				
Station	Date	Temp °C	Specific Conductance uhmos/cm	Dissolved Oxygen mg/ℓ	pH	NFR mg/ℓ	Total Alkalinity mg/ℓ	Colour Pt-Co Units	Turbidity F.T.U.'s	Total Hardness ($CaCO_3$)
1	15/5/75	1.8	150	11.2	6.90					
	30/6/75	14.0	130	9.0	7.80	<3		43		70
	21/9/76	7.0	95	10.3	7.40	<5	70	25	0.8	74
2	15/5/75	1.8	120	10.6	6.80					
	30/6/75	15.2	115	8.5	7.80	<3		43		71
	21/9/76	9.0	100	10.2	7.80	<5	74			78
3	15/5/75	3.0	30	11.2	6.65					
	30/6/75	10.5	160	6.2	7.25	<3		144		89
	21/9/76	5.0	115	10.1	7.80	11	89	64	1.3	100
4	15/5/75	2.5	28	11.4	6.80					
	30/6/75	12.0	150	8.0	7.50	<3		65		84
	21/9/76	4.0	90	11.7	8.00	<5	72			80
5	15/5/75	2.0	20	11.3	7.15					
	30/6/75	11.5	160	8.5	7.50	<3		69		88
	21/9/76	5.0	95	10.5	7.70	10	99	56	0.7	79
6	15/5/75	0.5	28	11.0	6.75					
	30/6/75	7.0	152	8.3	7.50	<3		87		91
	21/9/76		No Data					No Data		
7	15/5/75	1.0	30	10.8	6.65					
	30/6/75	9.0	200	9.1	7.80	3		91		110
	21/9/76	3.5	120	10.1	7.70	<5	70	61	1.3	120

TABLE 2 TOTAL EXTRACTABLE HEAVY METAL CONTENT OF WATER SAMPLES

Station	Analysis Date	Calcium	Magnesium	Antimony	Barium	Cadmium	Copper	Iron	Lead	Molybdenum	Nickel	Silver	Zinc	Arsenic	Mercury
1	30/5/75	16	7.2	<0.3	CALCIUM INTERFERENCE	<0.01	<0.01		<0.02	<0.3	<0.1	<0.03	0.01		<0.4
	21/9/76	19.	6.5	<0.3		<0.01	<0.01	0.05	<0.02	<0.1	<0.05	<0.03	<0.01	<0.02	<0.2
2	30/5/75	16.	7.6	<0.3		<0.01	<0.01		<0.02	<0.3	<0.1	<0.03	0.01		<0.4
	21/9/76	20.	6.8	<0.3		<0.01	<0.01	<0.03	<0.02	<0.1	<0.05	<0.03	<0.01	<0.02	<0.2
3	30/5/75	22.	8.2	<0.3		<0.01	<0.01		<0.02	<0.3	<0.1	<0.03	<0.01		<0.4
	21/9/76	27.	8.3	<0.3		<0.01	<0.01	0.22	<0.02	<0.1	<0.05	<0.03	<0.01	<0.02	<0.2
4	30/5/75	17.	10.0	<0.3		<0.01	<0.01		<0.02	<0.3	<0.1	<0.03	0.01		<0.4
	21/9/76	18.	8.6	<0.3		<0.01	<0.01	0.10	<0.02	<0.1	<0.05	<0.03	<0.01	0.04	<0.2
5	30/5/75	18.	10.5	<0.3		<0.01	<0.01		<0.02	<0.3	<0.1	<0.03	0.01		<0.4
	21/9/76	18.	8.3	<0.3		<0.01	<0.01	0.07	<0.02	<0.1	<0.05	<0.03	<0.01	<0.02	<0.2
6	30/5/75	24.	7.6	<0.3		<0.01	<0.01		<0.02	<0.3	<0.1	<0.03	0.01		<0.4
	21/9/76	No Data									No data				
7	30/5/75	28.	10.5	<0.3		<0.01	<0.01		<0.02	<0.3	<0.1	<0.03	0.02		<0.4
	21/9/76	30.	9.7	<0.3		<0.01	0.01	0.17	<0.02	<0.1	<0.05	<0.03	<0.01	<0.02	<0.2

where it was measured as .02 mg/ℓ. In 1976 a copper concentration of .01 mg/ℓ (the detection limit) was found at station 7. This station is the closest to the ore body and proposed working area. An arsenic level of 0.04 mg/ℓ was found at station 4 on Wolverine Creek. More sampling would be necessary to determine if these readings are significant.

4.2 Macroinvertebrates

As previously mentioned in the Methods, the artificial substrate samplers (ASS) were found, on the second trip in 1975, to be partially or wholly out of the water due either to decreased levels after spring run-off or physical removal. Out of the fifteen ASS placed in the streams during the first visit, only one sampler, station 3c, was wholly submerged and four were partially submerged. Therefore, Surber samples were collected at all stations to give a quantitative result that could be used for statistical analysis. Several hand picked samples were also collected to determine if the other methods were sampling the entire invertebrate population. Rocks were picked up from the stream bottom at random and the organisms picked off them.

A complete list of the organism taxa found in 1975 in the ASS, Surber sampler and the hand picked samples is shown in Table 3. Station 1 on Big Creek had the highest number of species (19) and station 5 on Wolverine Creek had the lowest number (13). However, half of the total number of species represented for the total area were only found at one station or another. Only 4 species were located at all of the five stations. The breakdown of the species list under Classes, Orders and Families is shown in Appendix II and III. Twice as many species were found in 1976 as in 1975 (Tables 4 and 5). There were three times as many different species of Diptera found in 1976 than 1975. This is probably because samples in 1976 were taken at a later time in the year than in 1975.

Biologists in the past have derived various means of determining a diversity index for stream populations of aquatic organisms.

TABLE 3 A SPECIES LIST OF MACROINVERTEBRATES COLLECTED BY ARTIFICIAL SUBSTRATE SAMPLER, SURBER SAMPLER AND HAND PICKED SAMPLES DURING THE JUNE, 1975 SURVEY

Station Number	1	2	3	4	5
Aranieda					X
Staphylinidae	X				
Limnophora sp	X	X	X	X	
Hemerodroma sp		X	X		
Empididae pupa				X	
Rhagionidae	X				
Chrysops sp					X
Brillia sp	X				
Corynoneura sp	X	X	X	X	
Spaniotoma sp	X	X	X	X	
Pentaneura sp	X	X	X	X	X
Longurio sp	X		X	X	X
Simulidae	X	X	X	X	X
Simulidae pupa		X			
Dipteran Larva	X				
Baetis sp	X				X
Centroptilum sp		X		X	X
Ephemerella doddi		X			
Pseudocleon sp		X	X	X	X
Siphlonurus sp	X	X			
Siphlonuridae			X		
Cinygmula sp	X	X	X	X	X
Epeorus sp		X			
Rithrogena sp		X			
Nemoura sp	X		X		X
Alloperla sp			X	X	
Hastaperla sp		X	X	X	X
Isogenus sp			X		
Adult Perlodidae			X		
Brachycentrus sp a	X	X		X	X
Brachycentrus sp b	X				
Brachycentrus sp b pupa	X				
Lepidostoma sp				X	
Platycentropus sp	X		X		
Oligochaeta	X	X	X	X	X
Number Species	19	17	17	15	13

TABLE 4 MACROINVERTEBRATES COLLECTED BY SURBER SAMPLER IN JUNE, 1975.

	1			2			3			4			5		
Station Number	A	B	C	A	B	C	A	B	C*	A	B	C	A	B	C
Staphylinidae	1														
Limnophora sp				1			1				2				
Hemerodrama sp					1		1								
Empididae pupa											1				
Chrysops sp													1		
Corynoneura sp				1		1	2				1				
Spaniotoma sp			2	1	1	1	67		1	9					
Pentoneura sp	1					1	1		2	9	5				3
Longurio sp									11			1		1	6
Simulidae		1		1			2	86	7		400		1	2	41
Baetis sp													2		
Centroptelum sp				1							2			1	
Pseudocleon sp							4			11			21	8	6
Siphlonurus sp						1									
Siphlonuridae							1								
Cinygmula sp	1		7	6	1	7	5	6	1	4				1	1
Nemoura sp			1					33	32						
Alloperla sp							1			1					
Hastaperla sp						1	1			1		4	6	7	16
Isogenus sp								1							
Adult Perlodidae							1								
Brachycentrus sp		1									16				3
Brachycentrus sp			1												
Lepidostoma sp											2				
Platycentropus sp									1						
Oligochaeta sp			1	1	1		59	24	40	9	1		8	12	18

*Artificial Substrate Sampler

Table 5 Macroinvertebrate Data Collected with the Aid of a Surber Sampler in September 1976

Sample Station	1			2			3			4			5		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Teutonia sp												1			
Celina sp									1						
Limnophora sp										1					
Hemerodromia sp						1									
Empididae					1										
Deuterophlebia sp	1														
Atherix sp									4						
Simulidae	2					1									
Diamesa sp			2		6					1	2				
Monodiamesa sp	5	2													
Pseudodiamesa sp	1		1		4	3									
Diamesinae	5	4				4						1			
Crictopus sp	1	1	9		3	1				21	9	16			
Cardiocladius sp								1							
Brillia sp	2		4							2					
Psectrocladius sp				1		1		2	1		11	17			
Orthocladius sp		2		2								1			
Orthocladinae				3		8		2			1	8	1	2	
Orthocladinae pupae		3		12	5	3									
Eukiefferiella sp	1					1		1							
Chironomini sp			1												
Tanytarsini sp				7											
Constempellina sp				9											
Micropsectra sp					1										
Rheotanytarsus sp						1									
Polypedilum ophioicles														3	
Smittia sp										1					
Chironominae pupae	1								1			16			
Chironomini sp adult	1														
Brachycera pupae		2													
Diptera larva			1												
Sciaridae adult								1							
Pedicia sp	1														
Tipula sp							1	1		3	1	4			
Antiocha sp								2							
Tipulidae sp				1			1		4			1			
Baetis sp	2	1	3			2						1			
Ephemerella sp	12	6	8		1	4									
Centroptilum sp						1									
Heptagenia sp				2	1							1		2	
Cinygmula sp										4	1				
Rithrogena sp						1									
Nemoura sp				1	1		54	71	52	6	1	3			
Isogenus sp	9	4	9		1	1									
Arcynopteryx sp					1										
Diura sp										1					
Hastaperla sp		3	2	14	5	5						7	1		
Paraperla sp										4	3				
Brachycentrus sp						1					1				
Lepidostoma sp												3			
Drusinus sp		1													
Phyrganeidae					1										
Lumbriculus sp					2		2					4			
Lumbriculidae								1							
Kincaidiana hexatheca				4	11	2	8	18			4				
Kincaidiana sp								1		27	2				
Stylodrilus sp	18	3	7	3		1	9		19			21			2
Tubifex sp														10	

In this instance the Shannon-Wiener index has been used (Pielou, 1966, 1967 and Wilhm and Dorris, 1968). The diversity index relates the number of individuals in each taxon to the total number of taxa and the evenness is related to the distribution of the taxa in the population. It is generally believed that diversity values between 3 and 4 are found in unpolluted waters while heavily polluted waters have values of less than 1.5 (Wilhm, 1970). The evenness is a value ranging from 0 (where only one taxa is present) to 1 (where the number of species per tax are exactly even). Thus, in a natural healthy population, the evenness of diversity should range from 0.5 to 0.8.

The species diversity (H') for 1975 all show values of less than 2.5 (Table 6). However, in most cases the evenness (J) is either very high or very low which indicates poor sample size. It has already been stated that the Surber sampler did not pick up all the species present at a station. The diversities for 1976 were much higher; as one would expect for clear, unpolluted mountain streams except for stations 3 and 5. The low diversity at Station 3 is probably due to the nature of the stream, as it is only an intermittant stream, disappearing underground for short distances then reappearing as a very slow moving creek. Station 5 is on Wolverine Creek and has a substantial flow but is at a much higher elevation than station 4. However, in 1975 the two stations had similar diversities.

The invertebrates collected by the ASS at station 3c produced similar data to that obtained from the Surber sampler collections at stations 3a and 3b. The diversite of the ASS was slightly higher, but more Dipterans were taken in the Surber sampler.

Very little else can be said about the macroinvertebrates without conducting more surveys.

4.3 Fish

The ratio of number of fish caught per unit effort in time is much higher in 1976 than in 1975 (Table 7). During the fishing in

TABLE 6 DIVERSITY INDICES FOR MACROINVERTEBRATES FOR 1975 AND 1976

Station/ Year		1975		1976	
		Diversity (H')	Evenness (J)	Diversity (H')	Evenness (J)
	A	1.585	1.000	3.186	0.797
1	B	1.000	1.000	3.382	0.943
	C	1.781	0.767	3.055	0.883
	A	2.292	0.817	3.069	0.856
2	B	2.000	1.000	3.379	0.865
	C	1.947	0.753	3.842	0.904
	A	1.867	0.505	1.358	0.525
3	B	1.598	0.688	1.533	0.443
	C*	2.016	0.672	1.563	0.557
	A	2.365	0.915	2.503	0.724
4	B	0.518	0.163	2.855	0.825
	C	0.722	0.722	3.296	0.824
	A	1.856	0.718	1.000	1.000
5	B	2.229	0.794	1.618	0.809
	C	2.307	0.765	-	-

*Artificial Substrate Sampler

TABLE 7 SUMMARY OF ELECTRO-FISHING RESULTS, 1975 AND 1976

Station	Date	Time Fished Sec.	No. Fish	No. Fish/ Time	No. Species	*Cottis cognatus*	*Thymallus arcticus*	*Oncorhynchus tshawytscha*	*Catostomus catostomus*
1	30/6/75	1174	2	.0017	1	2			
	21/9/76	445	5	.0112	3	3	1	1	
2	30/6/75	818	7	.0086	2	2	5		
	21/9/76	452	6	.0133	1	6			
3	30/6/75	410	-	-	-				
4	30/6/75	574	10	.0174	2	6	4		
	21/9/76	642	7	.0109	2	3		4	
5	30/6/75	836	2	.0024	1	2			
	21/9/76	463	24	.0518	3	17	5		2

June 1975 it was noted that the output amperage recorded on the equipment was very low (less than 0.5 amps). A check of the equipment showed no apparent reason for this and the conductivity of the water during the fishing was well within the operating range of the Type VIII electrofisher unit. This low output amperage may have influenced the number of fish collected. The absence of fish at station 3 is again probably due to the intermittent nature of the stream. The most abundant species found in Big Creek and Wolverine Creek were the slimy sculpin (*Cottis cognatus*) and the arctic grayling (*Thymallus arcticus*). However, of particular interest is one specimen of chinook salmon (*Oncorhynchus tshawytscha*) that was collected at station in Big Creek and 4 specimens that were found at station 4 in Wolverine Creek in 1976.

REFERENCES

1. Environmental Protection Agency, 1973. Water Quality Criteria 1972, U.S. Government Printing Office, Washington, D.C. EPA-R3-73-033.

2. Pielou, E.C. 1966. Shannon's Formula as a measure of specific diversity: its use and misuse. Amer. Nature. 100 (914): 463-465.

3. - 1967. The use of information theory in the study of the diversity of biological populations. Proc. Fifth Berkeley Symposium on Mathematical Statistics and Probability 4:163-177.

4. Water Survey of Canada, 1975. Surface Water Data, Yukon and Northwest Territories, 1974, Inl. Wat. Directorate, Ottawa.

5. , 1976. Surface Water Data, Yukon and Northwest Territories, 1975. Inl. Wat. Directorate, Ottawa.

6. Wilhm, J.L., 1970. Range of diversity index in benthic macroinvertebrate populations. J. Wat. Pollut. Control Fed., 42, 221-224

7. Wilhm, J.L. and T.C. Dorris, 1968. Biological Parameters for Water Quality Criteria, Bioscience 18, 477-481.

APPENDIX I

MONTHLY MEAN AND RANGE OF WATER FLOW
IN BIG CREEK, YUKON TERRITORY (C.F.S.)
FOR PART OF 1974 AND ALL OF 1975
(WATER SURVEY OF CANADA 1975 AND 1976)

APPENDIX I MONTHLY MEAN AND RANGE OF WATER FLOW IN BIG CREEK, YUKON TERRITORY (C.F.S.) FOR PART OF 1974 AND ALL OF 1975 (WATER SURVEY OF CANADA 1975 AND 1976)

Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	Min	-	-	-	-	-	-	-	329	100	50.2	6.1	2.5
	Mean	-	-	-	-	-	-	-	692	160	76.2	21.4	4.2
	Max	-	-	-	-	-	-	-	1600	302	103.0	60.0	6.4
1975	Min	1.5	1.3	3.9	5.6	30	155	167	408	292	21.0	9.0	5.2
	Mean	2.0	2.9	5.3	15.6	1320	509	737	794	487	143.0	14.9	7.0
	Max	3.4	6.3	10.0	29.0	5200	1420	2810	1830	869	336.0	23.0	8.9

APPENDIX II

THE SPECIES LIST FOR THE CLASSES OF MACROINVERTEBRATES FOUND IN THE MINTO AREA STREAMS IN THE JUNE, 1975 SURVEY

APPENDIX II THE SPECIES LIST FOR THE CLASSES OF MACROINVERTEBRATES FOUND IN THE MINTO AREA STREAMS IN THE JUNE 1975 SURVEY

Phylum Arthropoda
- Class Arachnida
  - Order Araneidae
    - Araneidae
- Class Insecta
  - Order Coleoptera
    - Family Staphylinidae
      - Staphylinidae
  - Order Diptera
    - Family Anthomyiidae
      - *Limnophora* sp
    - Family Empididae
      - *Hemerodromia* sp
      - Empididae pupa
    - Family Rhagionidae
      - Rhagionidae
    - Family Tabadinae
      - *Chrysops* sp
    - Family Tendipedidae
      - Sub Family Hydrobaeninae
        - *Brillia* sp
        - *Corynoneura* sp
        - *Spaniotoma* sp
      - Sub Family Pelopiinae
        - *Pentaneura* sp
    - Family Tipulidae
      - *Longurio* sp
    - Family Simulidae
      - Simulidae
      - Simulidae pupa
    - Unknown Dipteran larva

APPENDIX II THE SPECIES LIST FOR THE CLASSES OF MACROINVERTEBRATES FOUND IN THE MINTO AREA STREAMS IN THE JUNE 1975 SURVEY (Continued)

Order Emphemeroptera
- Family Baetidae
  - *Baetis* sp
  - *Centroptilum* sp
  - *Ephemerella doddi*
  - *Pseudocleon* sp
- Family Siphlonuridae
  - *Siphlonurus* sp
  - Siphlonuridae
- Family Heptageniidae
  - *Cinygmula* sp
  - *Epeorus* sp
  - *Rithrogena* sp

Order Plecoptera
- Family Nemouridae
  - Sub Family Nemourinae
    - *Nemoura* sp
- Family Perlodidae
  - Sub Family Isogeninae
    - *Isogenus* sp
  - Sub Family Isoperlinae
    - *Alloperla* sp
    - *Hastaperla* sp
  - Adult Perlodidae sp

Order Tricoptera
- Family Brachycentridae
  - *Brachycentrus* sp a
  - *Brachycentrus* sp b
  - *Brachycentrus* sp b pupa
- Family Lepidostomatidae
  - *Lepidostoma* sp
- Family Limnephilidae
  - *Platycentropus* sp

Phylum Annelida
- Class Oligochaeta
  - Oligochaeta

APPENDIX III

THE SPECIES LIST FOR THE CLASSES OF MACROINVERTEBRATES FOUND IN THE MINTO AREA STREAMS IN THE SEPTEMBER, 1976 SURVEY

APPENDIX III THE SPECIES LIST FOR THE CLASSES OF MACROINVERTEBRATES FOUND IN THE MINTO AREA STREAMS IN THE SEPTEMBER 1976 SURVEY

Phylum Arthropoda
- Class Arachnida
  - Order Acarina
    - *Teutonia* sp

- Class Insecta
  - Order Coleoptera
    - Family Dytiscidae
      - *Celina* sp

  - Order Diptera
    - Sub Order Cyclorrhapha
      - Family Anthomyiidae
        - *Limnophora* sp

      - Family Empididae
        - *Memerodromia* sp
        - Empididae

    - Sub order Orthorrhapha
      - Family Deuterophlebiidae
        - *Deuterophlebia* sp

      - Family Rhagionidae
        - *Atherix* sp

      - Family Simulidae
        - Simulidae sp

      - Family Tendipedidae
        - Sub Family Diamesinae
          - *Diamesa* sp
          - *Monadiamesa* sp
          - *Pseudodiamesa* sp
          - Diamesinae

        - Sub Family Hydrobaeninae
          - *Cricotopus* sp
          - *Cardiocladius* sp
          - *Brillia* sp
          - *Psectrocladius* sp
          - *Orthorcladius* sp
          - *Orthocladinae* pupae

APPENDIX III THE SPECIES LIST FOR THE CLASSES OF MACROINVERTEBRATES FOUND IN THE MINTO AREA STREAMS IN THE SEPTEMBER 1976 SURVEY (Continued)

Sub Family Tendipidinae
- *Eukiefferiella* sp
- *Tendipedini* sp
- *Tanytarsini* sp
- *Constempellina* sp
- *Micropsectra* sp
- *Rheotanytarsus* sp
- *Polypedilum ophcoides*
- *Smittia* sp
- Tendipedinae (pupae)
- Tendipedinae (adult)

- Brachyceran (pupa)
- Diptera larva
- Sciaridae (adult)

Family Tipulidae
- *Pedicia* sp
- *Tipula* sp
- *Antiocha* sp
- Tipulidae

Other Emphemeroptera
Family Baetidae
- *Baetis* sp
- *Ephemerella* sp
- *Centroptilum* sp

Family Heptageniidae
- *Heptagenia* sp
- *Cinygmula* sp
- *Rithrogena* sp

Order Plecoptera
Family Nemouridae
Sub Family Nemourinae
- *Nemoura* sp

Family Perlodidae
Sub Family Isogeninae
- *Isogenus* sp
- *Arcynopteryx* sp
- *Diura* sp

APPENDIX III THE SPECIES LIST FOR THE CLASSES OF MACROINVERTEBRATES FOUND IN THE MINTO AREA STREAMS IN THE SEPTEMBER 1976 SURVEY (Continued)

Family Chloropulidae
Sub Family Choropulinae
Hastaperla sp

Sub Family Paraperlinae
Paraperla sp

Order Tricoptera
Family Brachycentridae
Brachycentrus sp

Family Lepidostomatidae
Lepidostoma sp

Family Limnephilidae
Drusinus sp

Family Phryganeidae
Phyryganeidae

Phylum Annelida
Class Oligochaeta
Order Prosopora
Lumbriculidae
Lumbriculus sp
Kincaideana hexatheca
Kincaidiana sp
Stytodrilus sp

Order Plesiopora
Tubificidae
Tubifix sp