ENVIRONMENTAL PROTECTION BRANCH
ENVIRONMENTAL PROTECTION SERVICE
YUKON BRANCH

WATER CHEMISTRY AND BIOLOGICAL CONDITIONS IN THE WATER SHED NEAR MOUNT NANSEN MINES LTD., YUKON TERRITORY

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ABSTRACT

The water chemistry and biological conditions in the Victoria Creek water shed near Mount Nansen Mines was examined in 1976 and 1977. There was a marked improvement in the quality of tailings decant from 1976 to 1977 as well as in the toxicity of the decant. The creek receiving the decant had a much reduced bottom fauna population but the bottom fauna and fish population in Victoria Creek showed little impact from the decant.

RESUME

La chimie de l'eau et les caractéristiques biologiques du bassin du ruisseau Victoria, près de Mount Nansen Mines, ont fait l'object d'un examen en 1976 et en 1977. La qualité de l'effluent des résidus miniers s'est sensiblement amélioréc de 1976 à 1977 et sa toxicité a aussi diminué de facon notable. La faune benthique du ruisseau òu se déverse l'effluent avait fortement diminué, mais celle du ruisseau Victoria ainsi que le poisson qui y vit n'ont guère été touchés.

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SUMMARY

1. There was a marked improvement in the quality of the tailings pond discharge from 1976 to 1977.

2. The bioassay results showed a decrease in toxicity of the tailings pond discharge from 1976 to 1977, which was most likely related to the reduction of the cyanide, copper and lead levels.

3. The bottom fauna at stations 4 and 5 in 1977 showed close similarities and indicated that the decant was having little impact on the bottom fauna of Victoria Creek.

4. The grayling populations at stations 4 and 5 and the heavy metal concentrations in the grayling muscle indicated the tailings pond discharge had little impact on the grayling in Victoria Creek.

1 INTRODUCTION

The ore body and original development of Mount Nansen Mines Ltd. were described as follows by Craig and Laporte (1972):

"Claims:

Mount Nansen Mines Limited and affiliated Brown-McDade Mines Limited hold 299 and 70 claims respectively in the Mount Nansen area.

Location and Access:

The claim groups are located in the Dawson Range about 30 miles west of Carmacks and approximately 150 miles northwest of Whitehorse. Access is by a 40-mile gravel road which leaves the Carmacks-Laforma road about 1 mile west of Nordenskiold River bridge at Carmacks.

History:

An outcrop of the Webber vein system was discovered in 1962 by G.F. Dickson on the ridge between Nansen and Victoria creeks. The area was being explored at that time by the Mount Nansen Exploration Syndicate, a consortium of several mining and exploration companies (Findlay, 1969a, p. 36). In 1963, the members of the syndicate formed Mount Nansen Mines Limited which carried out a detailed surface exploration program leading to the discovery of additional showings.

In 1964, underground exploration of the Webber and Heustis showings was begun. In the same year, control of the Webber, Heustis, Cabin Creek and Brown-McDade was acquired by Peso Silver Mines Limited. From early 1965 to the Spring of 1966, underground exploration was continued on the Webber Heustis and Brown-McDade (which had been explored by underground workings in 1946) properties consisting

of 6192 feet of drifting, crosscutting, and raising and 7300 feet of drilling. Estimated ore reserves at the end of this period were 173 315 tons averaging 0.484 ounces of gold per ton and 19.49 ounces silver per ton for the Webber, Heustis and Cabin Creek properties and 110 000 tons averaging 0.61 ounces gold per ton and 5.4 ounces silver per ton for the Brown-McDade property. Operations were suspended between April 1966 and June 1967, while financial arrangements were made to bring a 200 tpd mill into production. Control of the Mount Nansen and Brown-McDade properties was acquired in 1967 by Canadawide Investment Limited (Findlay, 1969a).

Description:

Vein structures, consisting os sulphide-bearing quartz lenses, veins and stockworks, cut highly altered quartz-feldspar porphyry (Unit 13, Bostock, 1936a) and Yukon Group quartz-biotite schists and gneisses. Ore-bearing structures occur in two forms. Sulphides are associated with discontinuous quartz lenses and stringers in fractured, altered zones up to several feet wide. Arsenopyrite, pyrite, galena and sphalerite are the principal metallic minerals. Various silver-bearing minerals such as freieslebenite, acanthite, native silver, andorite, and argentiferous tetrahedrite have been identified in the ores (Green, 1966, p. 36).

The three principal vein systems are the Heustis, Webber and Brown-McDade in the deposits. The Heustis and Webber vein systems have been extensively developed by underground workings.

Current Work and Results:

Production commenced from the Heustis property in September 1968. The mill produced at the rate of

> 70 tons per day from September to December 1968 and at 100 tons per day until the mine closed in April of 1969. Mill heads ran approximately 0.2 ounces gold per ton, 5 ounces silver per ton and eight percent lead. The mill was unable to obtain recoveries without the introduction of a cyanide circuit. The mine has been inactive since April 1969."

In April 19, 1976, the Yukon Territory Water Board received an application for water use on behalf of Mount Nansen Mines Ltd. for the purpose of reopening the operation. After a review of the application by the Yukon Water Board and the Department of Fisheries and the Environment, a water use authorization was granted to operate from April 30, 1976 to November 30, 1976. The most important condition of the authorization, relating to protection of the surrounding watercourses, read:

> "Recirculation of water from the tailings pond must be provided for and maintained. The holder shall ensure that no discharge is allowed from the tailings pond."

During the 1976 operating season, routine inspections indicated that the company was not complying with the conditions of the authorization. Samples of the overflow from the tailings pond, taken by the Department of Indian and Northern Affairs on August 11, 1976 and again on August 24, 1976, indicated high arsenic and copper levels. The Environmental Protection Service consequently, undertook to delineate possible adverse impacts. This report details the findings of the E.P.S. investigations of 1976 and 1977.

2 METHODS

2.1 Study Area

The area surrounding the Mount Nansen Mine is drained by the headwater of the Nisling River and is at an elevation of 1300 meters a.s.l. The main creek draining the area is Victoria Creek with a flow of approximately 15 cfs. An unnamed tributary to Victoria Creek drains the mine site and flows for approximately 5 kilometers before entering Victoria Creek. The unnamed Creek receives the effluent from the tailings pond (Figure 1).

The vegetation in the area (part of the Dawson Range Ecoregion) is described by Oswald and Lenyk (1977) as follows:

> "Vegetation: Lower elevations are included in the B26a forest region of Rowe (1972); however, most of the terrain is above treeline at about 1200 m. Open black and white spruce stands occur in valleys and on lower slopes where black spruce prevails on water sites and white spruce on better drained sites. Best tree growth occurs along the White and Yukon river valleys, where white spruce, aspen, balsam poplar and paper birch are constituents of mixed stands.
>
> Willow, shrub birch, Labrador tea, moss and lichens are principal understory species. Shrub birch and willow from extensive stands from valley bottoms to well above treeline. Sedge tussock fields, usually hummocky and supporting ericaceous shrubs, willows, lichens and sphagnum, are prevalent where drainage is impeded, a common situation on lower slopes and valley bottoms."

Sample station locations are shown in Figure 1 and are described as follows:

Station 1: 100 meters above the confluence of the unnamed Creek draining the mine and mill site and the tailings pond decant.

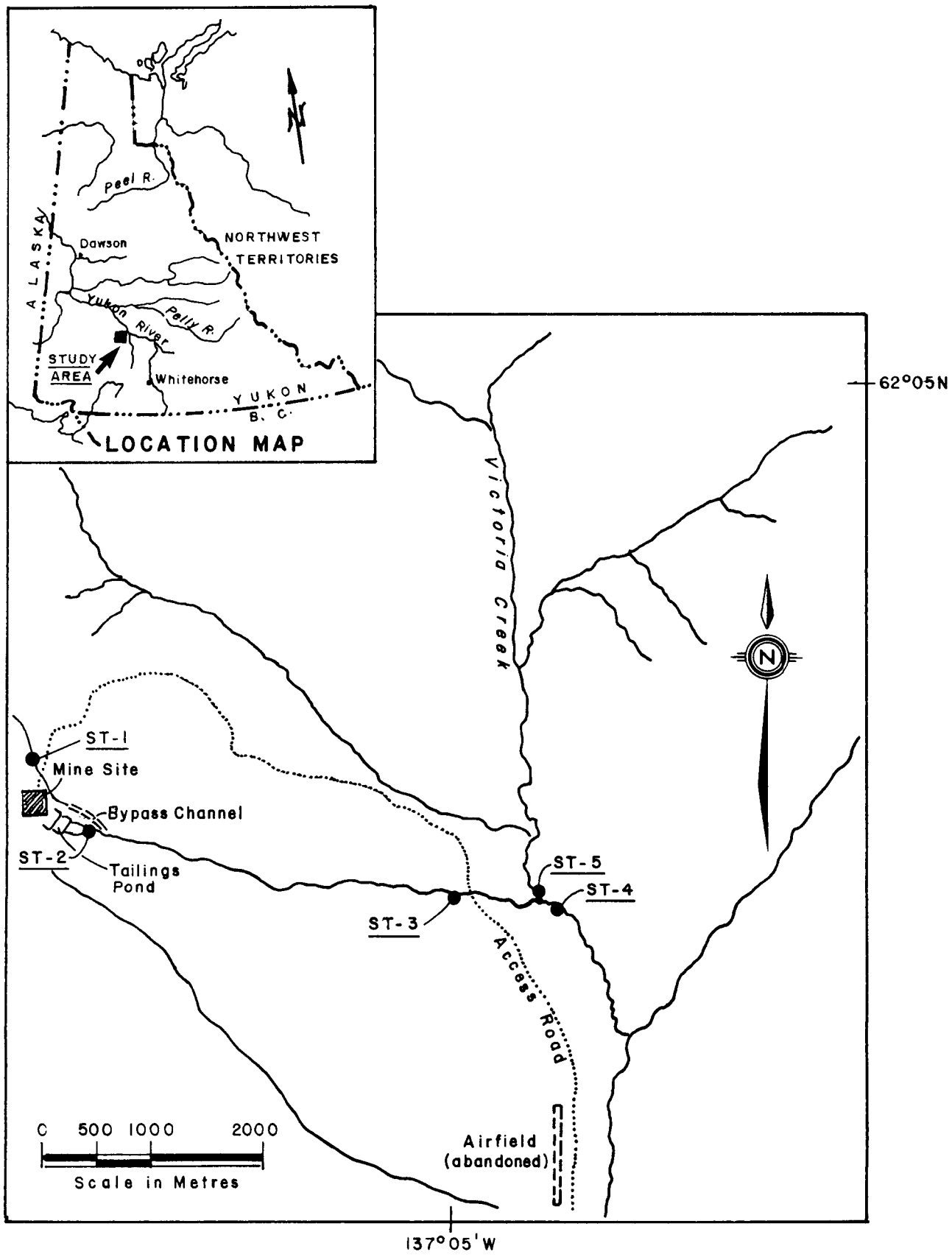

FIGURE 1 STATION LOCATIONS FOR THE MOUNT NANSEN MINE SURVEY

Station 2: the tailings pond decant.

Station 3: 25 meters upstream of the road crossing on the unnamed stream draining the mine and mill site.

Station 4: on Victoria Creek approximately 25 meters downstream of its confluence with the unnamed Creek.

Station 5: on Victoria Creek approximately 25 meters upstream of its confluence with the unnamed Creek.

2.2 Water Chemistry

Samples for water analysis were collected on two dates. On September 21, 1976, samples were collected at stations 2, 3, and 4, and on August 31, 1977, samples were collected at all stations. In the field the samples were analyzed for temperature and conductivity using a Yellow Springs Instruments direct reading, Salinity-Conductivity-Temperature Meter (C9089-1), pH using a Model 296 Radiometer pH meter, and dissolved oxygen using the azide modification of the Winkler method (APHA, 1971). Samples were also collected to be analyzed for Total Alkalinity, Color, Turbidity, Non Filterable Residue, Cyanide, Total Hardness and the following extractable metals; arsenic, copper, iron, lead, zinc, calcium, magnesium, cadmium, nickel, silver, molybdenum, antimony and mercury. The samples were preserved according to the methods outlined in E.P.S. (1974) and sent to the Pacific Environmental Institute, West Vancouver, B.C. for analysis.

2.3 Bottom Fauna

Bottom fauna samples were collected on September 21, 1976 and August 31, 1977, using a 30 cm by 30 cm Surber Sampler (total area 900 cm^2). In 1976, two samples were collected at station 4 and in 1977, three samples were collected at stations 3, 4 and 5. Upon collected, the samples were preserved in 70% methanol and rough sorted to family in Whitehorse. Final identification and counting was done by Dr. Charles Low of Envirocon Ltd., Vancouver, B.C.

Species diversity indices and evenness indices were calculated for each station and sample using the following formulae:

$$\text{Species Diversity } (H') = -\Sigma p_i \log p_i$$

where: $p_i = n_i/N$

n_i = the total number of individuals in the ith species.

N = the total number of individuals sampled.

$$\text{Evenness } (J) = \frac{-\Sigma p_i \log p_i}{\log s}$$

where: s = the toal number of species sampled and $J_{max} = 1$.

These formulae are described by Pielou (1966, 1967).

To compare the similarities between the stations in 1977 a similarity index was used, the formula is as follows:

$$P_{SC} = 100 - 0.5\Sigma|a - b|$$

Where a and b are, for given species, percentages of the total samples A and B which that species represent. This is a comparion of stations A and B (Brock, 1977). These calculations were performed on the combined totals of the three replicates at each station.

2.4 Fish

Fish were collected at stations 4 and 5 in 1977, using a Type VIII Smith-Root electrofisher. The collections were made for two purposes, a) to see what species were present and b) to analyze fish tissue for heavy metals. At both stations flesh samples were taken from adult grayling. These samples were approximately 50 grams in weight and were taken from the right side of the fish just posterior to the dorsal fin. The samples were stored in whirl-pack bags, frozen and sent to the Pacific Environmental Institute for analysis for copper, lead, zinc and mercury.

2.5 Bioassay

On September 21, 1976 and August 31, 1977, bioassay samples were taken from the decant (station 2) at Mount Nansen Mines Ltd. These samples were stored in a 5-gallon plastic jerry cans and shipped to the Pacific Environmental Institue for bioanalysis. In 1976, a 96 hour LT_{50} was determined and in 1977, a 96 hour LC_{50} was determined.

3 RESULTS AND DISCUSSION

3.1 Water Chemistry

The water chemistry data collected in 1976 and 1977, are summarized in Tables 1 and 2. During the period of mill operation (1976) it is evident that there were high levels of cyanide, arsenic, copper and zinc in the tailings pond discharge and that the cyanide levels persisted at least as far downstream at station 3. In 1977, the discharge contained lower levels of all the above parameters except zinc and one would assume that the quality of the tailings pond discharge had improved.

No other parameters measured gave cause for concern.

3.2 Bottom Fauna

The lists of bottom fauna collected by station and sample in 1976 and 1977, are presented in Tables 3 and 4 along with diversity (H') and evennes (J). The diversity found at station 4 in 1976 compared well with that found in 1977. In 1977, a comparison of the diversities at stations 4 and 5 indicates that the stream carrying the decant appears to have had little impact on Victoria Creek. Using the comparison index P_{SC} it was found that the percent similarity between the two stations was 64%. Considering that a Surber Sampler was used to collect the samples and that only three replicates were collected, this represented a relatively high similarity.

The size and nature of the creek at station 3 would suggest that the bottom fauna community in a natural state would be of a lower diversity than stations 4 and 5, however, the community found at station 3 would indicate that the decant was having a substantial impact on the creek in this area. The percent similarity as calculated by the P_{SC} index showed 0% between station 3 and 4 and 0% between station 3 and 5 which would not be expected in a natural state.

The relatively healthy state of station 5 was related to the large dilution factor contributed by Victoria Creek which may be as high as 10:1.

TABLE 1 WATER CHEMISTRY DATA COLLECTED DURING THE 1976 SEASON

Parameters	Stations		
	2	3	4
Temperature (°C)	10.5	7.0	6.5
pH	7.8	7.7	8.0
Total Alkalinity (mg of $CaCO_3$)	160	85	*
Color (Color Units)	*	*	*
Turbidity (FTU)	*	*	*
Conductivity (mhos/cm)	710	300	100
D.O. (mg/l)	7.9	10.4	10.4
NFR (mg/l)	3.2	27	*
Cyanide (mg/l)	0.53	0.38	0.7
As (mg/l, E)	0.19	0.08	*
Cu (mg/l, E)	3.4	0.45	0.03
Fe (mg/l, E)	1.4	4.9	0.41
Pb (mg/l, E)	0.17	0.02	LT 0.02
Zn (mg/l, E)	0.25	0.06	LT 0.01
Ca (mg/l, E)	81	42	20
Mg (mg/l, E)	35	13	6.1
Total Hardness (mg of $CaCO_3$)	350	160	75
Cd (mg/l, E)	LT 0.01	LT 0.01	LT 0.01
Ni (mg/l, E)	0.05	LT 0.05	LT 0.05
Ag (mg/l, E)	LT 0.03	LT 0.03	LT 0.03
Mo (mg/l, E)	LT 0.1	LT 0.1	LT 0.1
Gb (mg/l, E)	0.8	LT 0.3	LT 0.3
Hg (p mg/l, E)	LT 0.0002	LT 0.0002	LT 0.0002

LT = less than

* = not measured

TABLE 2 WATER CHEMISTRY DATA COLLECTED DURING THE 1977 FIELD SEASON

Parameters	Stations				
	1	2	3	4	5
Temperature (°C)	6.0	12.0	7.0	8.5	9.0
pH	7.2	7.9	7.5	7.7	7.7
Total Alkalinity (mg of CaCO)	28	220	54	64	64
Color (Color Units)	0	178	100	29	27
Turbidity (FTU)	1.5	44	6.9	1.2	1.2
Conductivity (mhos/cm)	40	940	158	90	94
D.O. (mg/l)	11.2	10.2	9.9	10.1	10.2
NFR (mg/l)	7	14	LT 5	LT 5	LT 5
Cyanide (mg/l)	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03
As (mg/l, E)	-	-	-	-	-
Cu (mg/l, E)	LT 0.01	LT 0.01	LT 0.01	LT 0.01	LT 0.01
Fe (mg/l, E)	0.22	4.9	2.0	0.25	0.23
Pb (mg/l, E)	LT 0.02	0.05	LT 0.02	LT 0.02	LT 0.02
Zn (mg/l, E)	LT 0.01	1.1	0.38	LT 0.01	LT 0.01
Ca (mg/l, E)	9.9	220	34	20	20
Mg (mg/l, E)	1.8	100	11	6.9	6.9
Total Hardness (mg of CaCO)	32	960	130	78	78
Cd (mg/l, E)	LT 0.01	LT 0.01	LT 0.01	LT 0.01	LT 0.01
Ni (mg/l, E)	LT 0.05	LT 0.05	LT 0.05	LT 0.05	LT 0.05
Ag (mg/l, E)	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03
Mo (mg/l, E)	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03
Gb (mg/l, E)	LT 0.03	LT 0.03	LT 0.03	LT 0.03	LT 0.03
Hg (p mg/l, E)	LT 0.0002	LT 0.0002	LT 0.0002	LT 0.0002	LT 0.0002

LT = less than

TABLE 3 THE DISTRIBUTION OF INDIVIDUALS BY TOXONOMIC GROUP AND STATION, THE TOTAL NUMBER OF INDIVIDUALS PER STATION (N), THE DIVERSITY (H) AND THE EVENNESS (J) FOR THE 1976 BOTTOM FAUNA DATA

Toxonomic Group	Station 4	
	Sample A	Sample B
Heptagenia		4
Cinygmula	1	1
Epeorus	4	
Baetis	2	1
Nemoura	11	8
Chelifera	1	
Diamesinae	1	10
Pseudodiamesinae	3	
Eukiefferiella	1	
Manadiamesa	1	
Tipulidae		1
Empididae		2
Similidae		1
The Total Number of Individuals per Station (N)	25	28
The Diversity (H)	0.7621	0.7245
The Evenness (J)	0.7966	0.8022

TABLE 4 THE DISTRIBUTION OF INDIVIDUALS BY TOXONOMIC GROUP AND STATION, THE TOTAL NUMBER OF INDIVIDUALS PER STATION (N), THE DIVERSITY (H) AND THE EVENNESS (J) FOR THE 1977 BOTTOM FAUNA DATA

Toxonomic Group	Station 3			Station 4			Station 5		
	A	B	C	A	B	C	A	B	C
Cinygmula				6	5	16	9	5	4
Pseudocleon				1					
Baetis					1		1		
Epeorus					2				
Nemoura				1	4	3	10	1	
Isogenus				1					
Arcynopteryx compacta					1	1			2
Alloperla					1		1		
Diura						1			
Drusinus							1		
Ochterus	1								
Aphididae			1						
Conomyia	1								
Emididae			1						
Chironomidae				1				1	1
Procladius				1					
Heterotrissocladius				1					
Limnophora					1				1
Tipula					1		4		7
Hemerodromia						1			
Psectrocladius						3	2		
Cricotopus						1	1		
Eukiefferiella						2			
Pedicia							1		
Chironomus							2		
Enchytraeidae					8	4	4		2
Rhyacophila						1			
Rhyacodrilus							1		
Turbellaria								1	
N	2		2	12	22	33	32	8	17
H	0.3010		0.3010	0.6901	0.7457	0.74675	1.0466	0.4662	0.6700
J	1.0000		1.0000	0.8166	0.8257	0.7567	0.9395	0.7744	0.8610

3.3 Fish

Data collected on the fish in the area of station 4 and 5 is presented in Table 5. Grayling were common in similar numbers at both stations and one grayling was sampled from each station for heavy metals. The results of the heavy metal analysis did not reveal any metal levels of concern.

3.4 Bioassay Results

In 1976, the bioassay sample collected from the decant had a 96 hour LT_{50} of 5.8 hours. The levels of cyanide, copper, lead and zinc would be the most likely contributors to this toxicity.

In 1977, the 96 hour LC_{50} for the samples was 79%. Although LC_{50} and LT_{50} of the two samples is not readily comparable by comparing the data on the 100% concentration for the LC_{50} test it would appear that this sample was considerably less toxic than the 1976 sample. In 1977, the concentrations for cyanide, copper and lead were all reduced from 1976, but the zinc concentration was inreased. The zinc in 1977 was probably a major contributing factor to toxicity.

TABLE 5 THE NUMBER OF FISH COLLECTED BY SPECIES AND STATION AND THE HEAVY METAL CONTENT OF MUSCLE FROM GRAYLING CAUGHT DURING 1977

Station	Seconds Fished	Catches		Species (No. in Sample)	Cu (ppm)		Pb (ppm)		Zn (ppb)		Hg (ppm)	
		Sculpins	Grayling		Wet Wt.	Dry Wt.	Wet Wt.	Dry Wt.	Wet Wt.	Dry Wt.	Wet Wt.	Dry Wt.
4	666		24	Grayling (1)	2.5	8.5	LT 0.2	LT 1.0	8.5	28	0.06	0.19
5	821	6	35	Grayling (1)	1.5	6.7	LT 0.2	LT 1.0	5.7	25	0.04	0.17

LT = less than

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