Department of Environment
Environmental Protection Service
Pacific Region
Yukon Branch

BASELINE STUDY OF THE WATERSHED NEAR PROPOSED MARBACO MINE, B.C. AND MARBACO MILL, YUKON TERRITORY

Regional Program Report 82-06

by

I. Soroka and M.E. Jack

April 1982

ABSTRACT

A baseline study of the watershed near the proposed Marbaco Mine in northwestern British Columbia and proposed Marbaco Mill in south-central Yukon was conducted by the Environmental Protection Service from June 24 to June 26, 1981. The water quality, bottom fauna characteristics and sediment quality of nine sampling stations were documented and evaluated.

Generally, the water chemistry parameters in the Tootsee-Rancheria watersheds showed no unusual levels. The bottom fauna results were representative of generally clear, unpolluted mountain streams. The high silver (Ag), lead (Pb) and zinc (Zn) concentrations in the adit sediments reflected the presence of the mine ore body. The high arsenic (As), cadmium (Cd) and iron (Fe) concentrations in the adit sediments reflect the presence of gangue minerals associated with the mine ore body. When the proposed mine and mill go into operation, concentrations of arsenic and cadmium are of possible concern and treatment of effluents may be required to prevent environmental damage downstream.

RÉSUMÉ

Du 24 au 26 juin 1981, le Service de la protection de l'environnement a fait une étude portant sur les secteurs du bassin hydrographique avoisinant la mine proposée de Marbaco, située dans le nord-ouest de la Colombie-Britannique, et de la scierie proposée de Marbaco, située dans le centre sud du Yukon. On a choisi neuf points d'échantillonnage afin d'établir et d'évaluer les paramètres de l'eau, les caractéristiques de la faune aquatique des profondeurs et la qualité des sédiments.

En général, les paramètres chimiques de l'eau du bassin de Tootsee-Rancheria n'ont révélé aucun niveau inhabituel. Les résultats de la faune aquatique des profondeurs étaient représentatifs de ruisseaux de montagne clairs et non pollués. Les fortes concentrations d'argent (Ag), de plomb (Pb) et de zinc (Zn) dans les sédiments d'adduction reflétaient la présence du corps minéralisé de la mine. Les concentrations élevées d'arsenic (As), de cadmium (Cd) et de fer (Fe) dans les sédiments d'adduction reflétaient la présence des minerais de gangue du corps minéralisé. A la mise en service de la mine et de la scierie, les concentrations d'arsenic et de cadmium pourraient poser un problème et le traitement des effluents pourra être nécessaire pour éviter de la pollution en aval.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

In February 1981, Marbaco Resources Ltd. submitted an application to the Yukon Territory Water Board for the construction of a mill and further development of a camp site in the Rancheria area, Yukon Territory. The ore is to be produced from a mine located in British Columbia, 16 km south of the proposed mill and camp.

The drainage systems that could be potentially affected by the mine and mill activity are part of the Tootsee-Rancheria-Liard River system. The study area is located 100 km upstream of the community of Watson Lake (see Figure 1). The Rancheria and Tootsee Rivers support resident fish such as Dolly Varden, whitefish and Arctic grayling. The Rancheria and Tootsee Rivers are used for recreational fishing only.

The Environmental Protection Service undertook a baseline study of the watershed in the vicinity of the proposed mine and mill. The purpose of this study was to gather baseline information in order to document and assess the existing quality of the streams and rivers. In order to obtain this baseline information, water quality, sediments and bottom fauna samples were collected on June 24-26, 1981.

1.1 Background

The location of the Marbaco project is in the vicinity of the Klondike Silver and Logjam properties. The proposed mill and unoccupied camp site are near the Tootsee River at latitude 60°04'N, longitude 130°18'W, approximately 16 km north of the mine development in British Columbia which is at latitude 59°55'N and longitude 130°25'W. The access road in connection with the mine, proposed mill and camp has been in existence for a number of years. The company has intentions of upgrading the road and constructing proper stream crossing in order to accommodate vehicles and mining equipment.

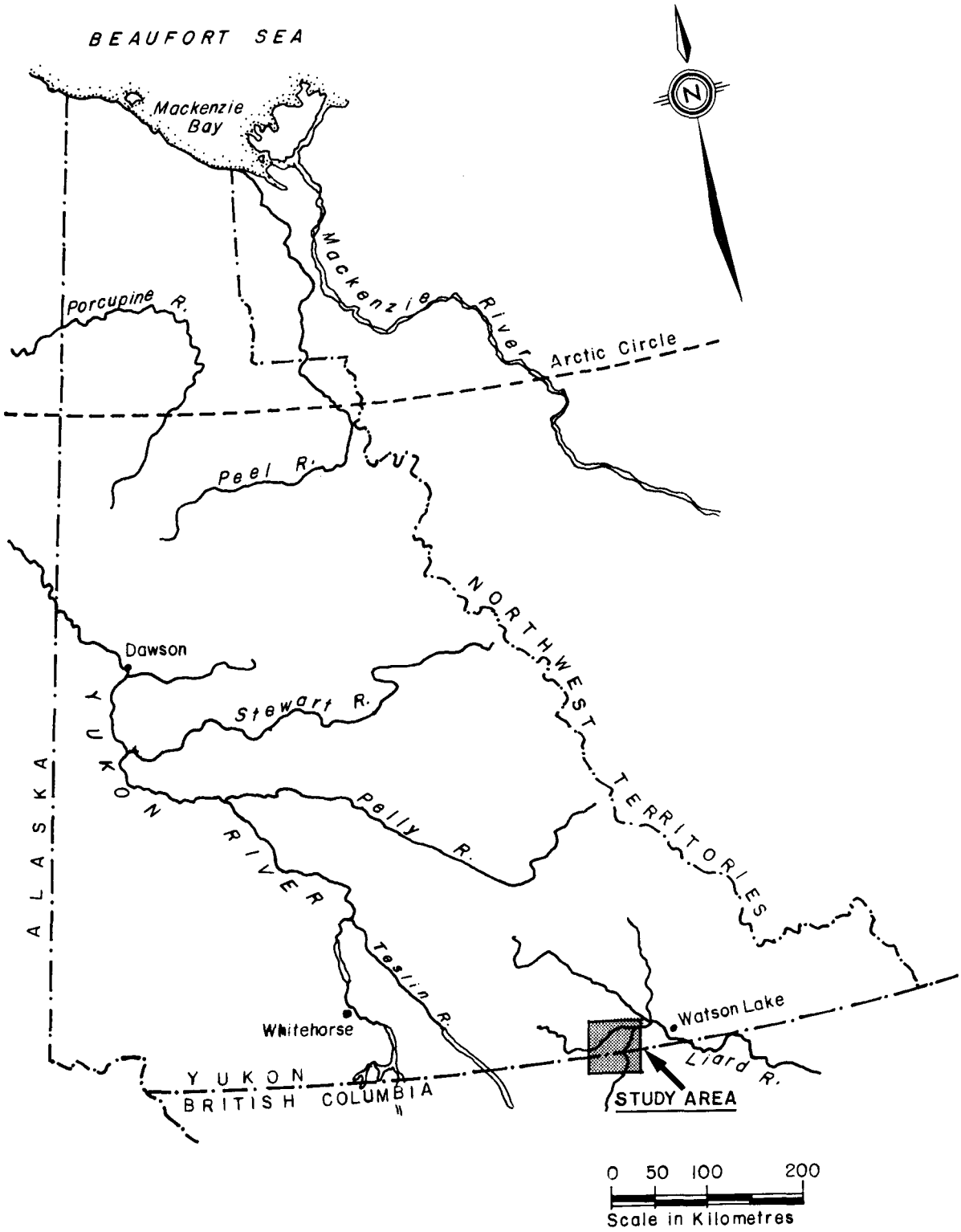

FIGURE 1 MAP OF YUKON TERRITORY SHOWING THE LOCATION OF THE MARBACO STUDY AREA

There are two mine adits; the upper adit is located at an elevation of 1370 m and the lower adit is at an elevation of 1290 m. The upper adit is dry but the lower adit presently discharges approximately 0.1 m^3/s of water. The silver-lead-zinc ore body belonging to Marbaco Resources Ltd. has estimated reserves of 73,000 tonnes, with a grade of 333 gm/t (10.7 oz/ton) silver, 2.8% lead and 6.03% zinc. The country rock consists primarily of limestone intruded by the Cassiar batholite. The gangue minerals associated with the ore body consist mainly of sulphides (Marbaco Resources, 1981).

Once Marbaco Resources begins conventional underground mining operations, the estimated ore production will be 90 tonne per day with a 20 m^3/day water requirement. Water for the mine will be obtained from the mine itself and excess mine water will be discharged through the 1290 m adit. It is not known what progress was made in developing the mine in 1981.

Water for the proposed mill will be obtained by damming off a small creek (unnamed creek 1) at its outflow from a pond and redirecting all flow to the mill. Approximately 200 m^3/day of water will be required for use in the proposed mill. Decant from the proposed tailings pond would enter unnamed creek 2. Unnamed creek 2 flows through the proposed mill and unoccupied camp site to the Tootsee River.

No progress was made in constructing the proposed mill or improvements on the camp site in 1981. When the mine and mill go into operation, production will last five to eight years.

2 STUDY AREA

The study area of the proposed Marbaco mine and mill site is in the Tootsee-Rancheria Rivers watershed. This area is located approximately 100 km by road north of Watson Lake and 370 km by road south of Whitehorse (Figure 1). The claims and proposed mine are situated in British Columbia and the proposed mill site is located 16 km north of the mine but in the Yukon Territory. They are all in the Tootsee and Rancheria River watersheds which subsequently drain into the Liard River system.

Samples were taken at nine sites, the locations of which are shown on Figure 2. A description of the sample sites is provided in Table 1. Photographs of Stations 1 to 9 are shown in Figures 4 to 12.

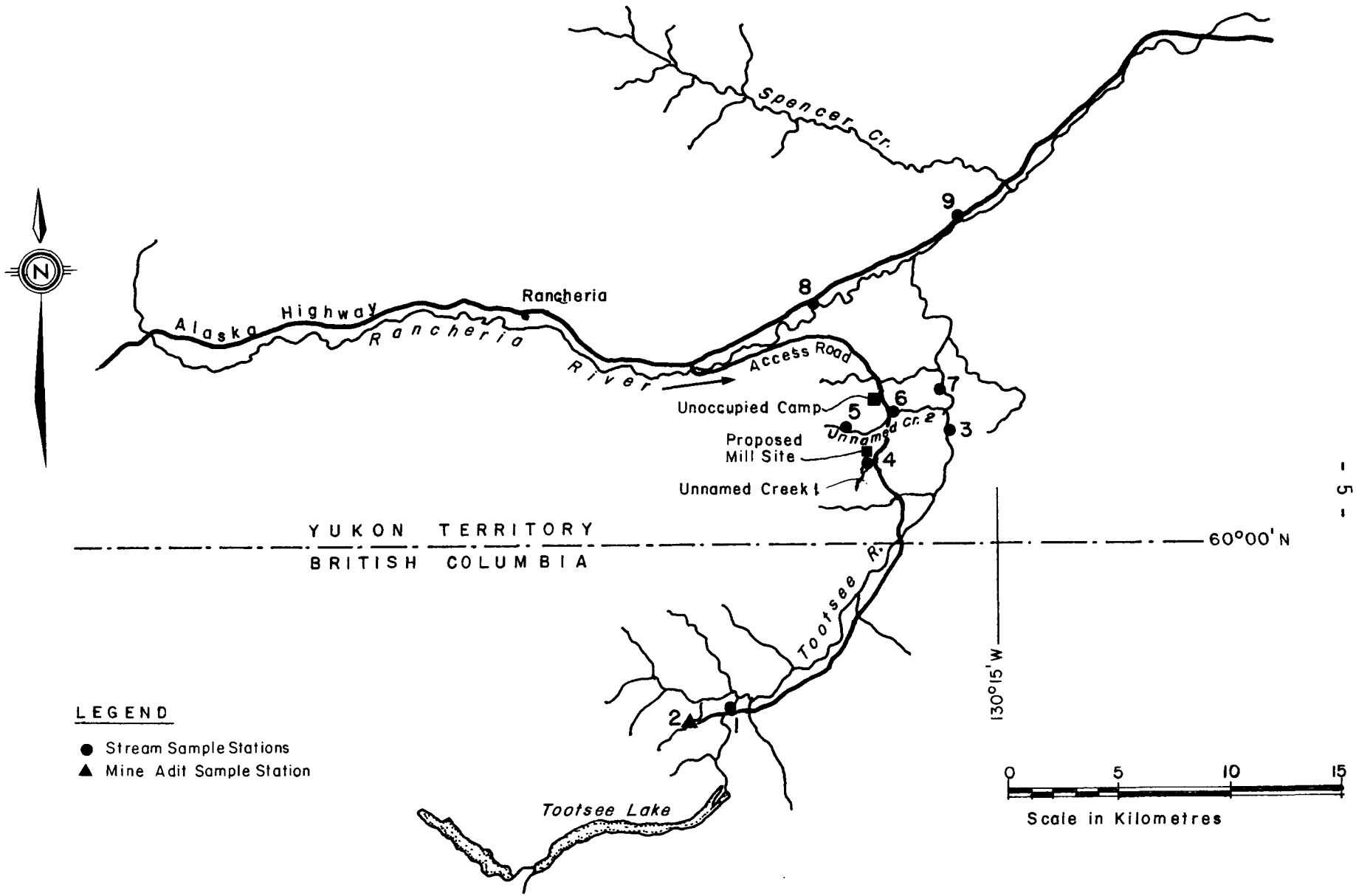

FIGURE 2 SAMPLE STATION LOCATIONS, STREAMS AND RIVERS IN THE MARBACO STUDY AREA

TABLE 1 DESCRIPTION OF SAMPLE SITES IN MARBACO STUDY AREA

STATION	LOCATION	STREAM BOTTOM	REMARKS
1	59°55'N 130°26'W on the Tootsee River. Located upstream of the proposed Marbaco mill and mine at a ford on the Marbaco mine road. Elevation 1110 m.	Coarse gravel to fine silt. (Colour - dark brown).	River bank stable. Buckbrush, grasses and spruce growing in the area. 50% of gravel larger than 1 cm discarded from sediment sample. No shade. Too large to electrofish.
2	59°56'N 130°29'W. Lower Marbaco mine adit. Elevation 1290 m.	Cobbles, coarse gravel and sand. Colour - orange.	Flow (0.1 m^3/second) of water coming out of adit. Stream disturbed by mining. No shade.
3	60°04'N 130°17'W. Located on the Tootsee River, upstream of its confluence with unnamed creek 2 which runs through Marbaco mill and camp site. Elevation 970 m.	Large cobbles, coarse gravel and sand.	Sediment sample taken in areas where sand was more predominate. Vegetation on banks consists of buckbrush, grasses, moss and spruce. No shade. Too deep and swift to electrofish but looks like good fish habitat.
4	60°03'N 130°18'W. Located at a pond just beyond the proposed Marbaco mill and camp site, planned water source for the mill. The pond drains south into unnamed creek 1. Elevation 1115 m.	Small pebbles and fine silt.	Approximately 5% of the small pebbles were removed from the sediment sample. Stable banks. Vegetation consists of willow, grasses and spruce. No shade. Bottom too soft for electrofishing.
5	60°04'N 130°19'W. Located upstream on unnamed creek 2 approximately 300 m from proposed Marbaco mill and camp site. Elevation 1140 m.	Mainly large boulders and some fine sand.	Fine sand and silt collected for sediment sample. Sample was not representative of stream bed. Very fast flowing creek. Stable banks. Vegetation consists of grasses, buckbrush and spruce trees. 40% shaded. Velocity of 1 m/sec. Too difficult to electrofish.

TABLE 1 DESCRIPTION OF SAMPLE SITES AT MARBACO MINE (continued)

STATION	LOCATION	STREAM BOTTOM	REMARKS
6	60°04'N 130°18'W. Located downstream on unnamed creek 2, 50 m downstream of the proposed Marbaco mill and camp site road culvert. Elevation 1110 m.	Large gravel, sand and sediment.	Stream bottom not typical due to the fill used for the installation of the culvert. Sediment, sample taken from sand bar. Vegetation consists of of buckbrush, grasses and moss. No shade.
7	60°04'N 130°17'W. Located on the Tootsee River downstream of the confluence of unnamed creek 2 running through the proposed Marbaco mill and camp site and the Tootsee River. Elevation 970 m.	Large boulders, fine silt.	Sampled in area where silt predominated. Stable riverbank with moss, spruce and buckbrush. 60% shade. Too deep and fast to electrofish but looks like good fish habitat.
8	60°06'N 130°20'W. Located on the Rancheria River approximately 5 km upstream of the Tootsee River and Rancheria River confluence. Elevation 845 m.	Large rocks, gravel with sand bars.	Sediment sample taken in area which may be dry during low water periods. Riverbank stable with grasses, buckbrush and spruce. Water too deep and fast flowing to take bottom fauna or to electrofish. School of grayling observed here. Good fish habitat.
9	60°07'N 130°16'W. Located downstream on the Rancheria River approximately 4.5 km from the Tootsee River and Rancheria River confluence. Elevation 845 m.	Mostly large boulders, some gravel and fine silt.	Sediment sample taken only where fine sediment existed. No representative of stream bed. Water too deep and fast to electrofish. Appeared to be good fish habitat. 90% shaded where bottom fauna sample taken.

FIGURE 3. AERIAL VIEW OF TOOTSEE LAKE.

FIGURE 4. STATION 1 ON THE TOOTSEE RIVER. LOCATED AT A FORD ON THE MARBACO MINE ROAD.

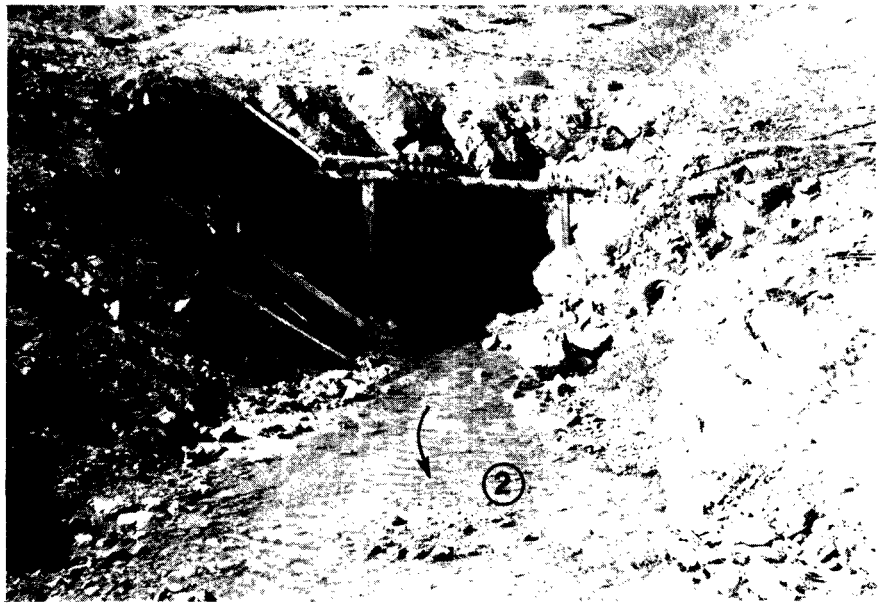

FIGURE 5. STATION 2 LOCATED AT THE MARBACO 1290 m MINE ADIT.

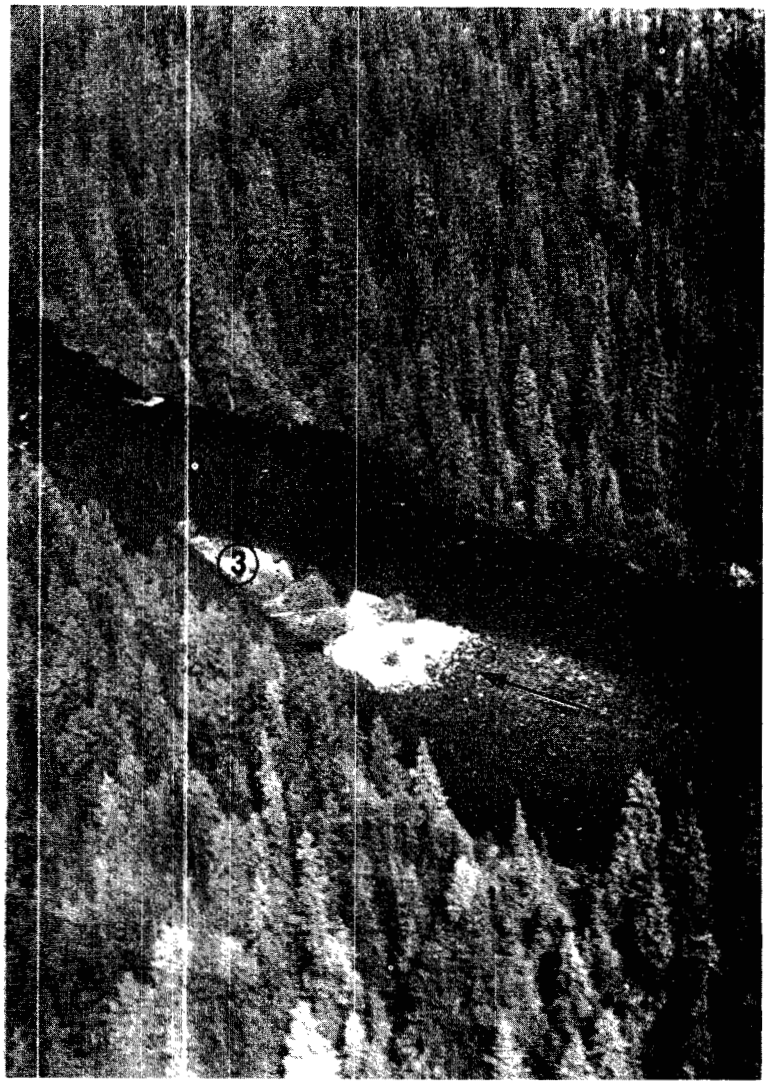

FIGURE 6. AERIAL VIEW OF STATION 3. LOCATED NEAR A GRAVEL BAR ON THE TOOTSEE RIVER.

FIGURE 7. STATION 4. LOCATED AT A LAKE JUST BEYOND THE MARBACO MILL AND CAMP SITE. UNNAMED CREEK 1 DRAINS LAKE.

FIGURE 8. STATION 5. LOCATED ON UNNAMED CREEK 2, 300 m UPSTREAM FROM THE MARBACO MILL AND CAMP SITE.

FIGURE 9. STATION 6. LOCATED ON UNNAMED CREEK 2, 50 m DOWNSTREAM OF MARBACO MILL AND CAMP SITE.

FIGURE 10. AERIAL VIEW OF STATION 7 ON THE TOOTSEE RIVER.
NOTE: 'X' IS THE LOCATION WHERE UNNAMED CREEK 2 ENTERS THE TOOTSEE RIVER.

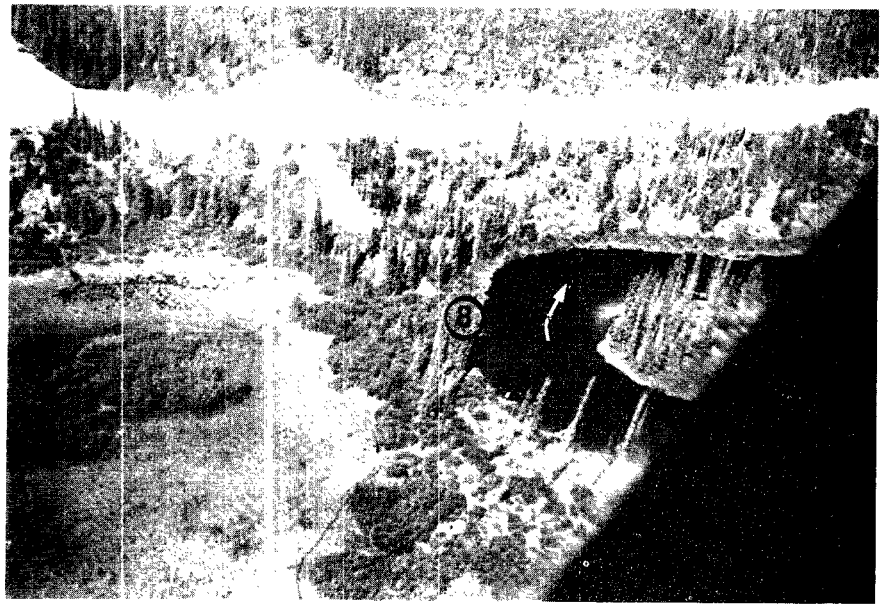

FIGURE 11. AERIAL VIEW OF STATION 8 ON THE RANCHERIA RIVER.

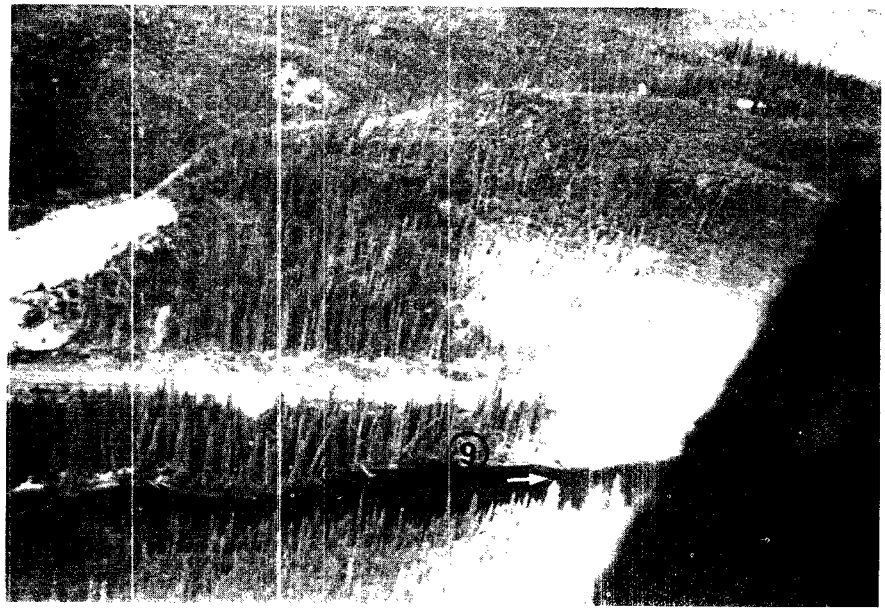

FIGURE 12. AERIAL VIEW OF STATION 9 ON THE RANCHERIA RIVER.

3 METHODS

Access to sample sites 1, 2, 3, and 7 was by helicopter and to sample sites 4, 5, 6, 8 and 9 by truck. Each site was sampled once in the period June 24-25, 1981.

3.1 Water Quality

Water samples were collected and preserved at each site as described in Appendix I Table 1. Water samples were collected from Stations 1, 2, 4, 5, 6, 8 and 9 on June 24, 1981 and from Station 3 and 7 on June 25, 1981.

Temperature, flow, pH and conductivity were measured in the field. Dissolved oxygen was measured in the Environmental Protection Service laboratory in Whitehorse. All other water quality analyses were done by Laboratory Services, Environmental Protection Service, 4195 Marine Drive, West Vancouver, B.C. Analytical methods are described in Appendix I Table 1.

Water samples were collected and preserved for analysis of conductivity, dissolved oxygen, pH, colour, turbidity, filterable residue, non-filterable residue, total alkalinity, total hardness, total phosphate, nitrate, nitrite, ammonia, sulphate, cyanide, chloride and the following extractable metals:

Aluminum (Al)	Copper (Cu)	Selenium (Se)
Antimony (Sb)	Iron (Fe)	Silicon (Si)
Arsenic (As)	Lead (Pb)	Silver (Ag)
Barium (Ba)	Magnesium (Mg)	Sodium (Na)
Beryllium (Be)	Manganese (Mn)	Strontium (Sr)
Cadmium (Cd)	Mercury (Hg)	Tin (Sn)
Calcium (Ca)	Molybdenum (Mo)	Titanium (Ti)
Chromium (Cr)	Nickel (Ni)	Vanadium (V)
Cobalt (Co)	Potassium (K)	Zinc (Zn)

The percent dissolved oxygen saturation was calculated by first determining the dissolved oxygen saturation concentration from the formula:

$$S' = S \frac{P}{760} \text{ (APHA et al 1975)}$$

where S' = Dissolved Oxygen (DO) saturation concentration at the in situ temperature and atmospheric pressure.

S = DO saturation concentration at sea level for in situ temperature.

P = Atmospheric pressure in mm of mercury at site elevation.

The percent dissolved oxygen saturation was obtained by using the ratio of field dissolved oxygen and S' in the following formula:

$$\frac{\text{Field DO}}{S'} \times 100 = \text{\% DO Saturation}$$

3.2 Sediments

Sediment samples were collected at Stations 1, 2, 4, 5, 6, 8 and 9 on June 24, 1981 and at Stations 3 and 7 on June 25, 1981. Four sediment samples were collected at each site, using an aluminum shovel, and then scooped into labelled Whirl Pak bags. A description of sediment collection, preparation and analysis methods is given in Appendix I, Table 2. The sediments were shipped to Vancouver for analysis at Laboratory Services, Environmental Protection Service, 4195 Marine Drive, West Vancouver.

One sediment sample per station was analyzed for cyanide concentration. The other sediment samples were each analyzed for particle size and the following metals:

Aluminum (Al)	Iron (Fe)	Selenium (Se)
Antimony (Sb)	Lead (Pb)	Silicon (Si)
Arsenic (As)	Magnesium (Mg)	Silver (Ag)
Barium (Ba)	Manganese (Mn)	Sodium (Na)
Beryllium (Be)	Mercury (Hg)	Strontium (Sr)
Cadmium (Cd)	Molybdenum (Mo)	Tin (Sn)
Calcium (Ca)	Nickel (Ni)	Titanium (Ti)
Chromium (Cr)	Phosphorus (P)	Vanadium (V)
Copper (Cu)	Potassium (K)	Zinc (Zn)

3.3 Bottom Fauna

Bottom fauna was sampled at Stations 1, 2, 4, 5, 6, and 9 on June 24, 1981 and at Stations 3 and 7 on June 25, 1981. Three samples were taken at each site using a 30 cm x 30 cm Surber sampler (total area 900 cm^2) with a mesh size of 0.76 mm. Bottom fauna samples were not obtained at Station 8 because the river was too deep.

Bottom fauna collection, preservation and identification methods are given in Appendix I, Table 3.

To statistically calculate diversity indices from the invertebrate data collected, the formula described by Pielou (1975) was used:

$$\text{Species diversity } (H') = -\sum_{i-1}^{g} (P_i \log_{10} P_i)$$

where: $P_i = n_i/N$

n_i = total number of individuals in the ith genus in one sample.

N = total number of individuals identified to genus level in one sample.

g = total number of genera in one sample.

The use of individuals identified only to the genus level rather than to species level results in slightly lower H' values. (Hughes 1978).

The diversity indices calculated for the samples are listed in Appendix IV.

3.4 Fish

The study objective was to collect fish by electrofishing in order to obtain tissue samples for metals analysis. However, all stations presented difficulties to electrofishing and this method could not be used. An unsuccessful attempt was made to collect fish at Stations 8 and 9 by angling.

4 RESULTS AND DISCUSSION

4.1 Water Quality

The water chemistry data is summarized in Appendix II. All water data was compared to the "Water Quality Criteria" listed in Appendix I, Table 4.

The water chemistry data for samples from the Rancheria and Tootsee River watersheds did not exceed water quality criteria for public drinking water except for hardness which slightly exceeded the recommended level. Only two parameters, aluminum and zinc, exceeded recommended levels for aquatic life.

At all stations the dissolved oxygen was high with the exception of the adit (Station 2) which had a percent dissolved oxygen saturation of 69%. Colour, pH and turbidity all demonstrated levels that were within "acceptable limits" for public drinking water.

Total alkalinity, filterable and non-filterable residue were within levels recommended for drinking water and within acceptable limits recommended for aquatic life.

According to Taylor et al (1979), total hardness levels that exceed 150 mg/l $CaCO_3$ constitute hard water. Total hardness slightly exceeded acceptable limits of 80-100 mg/l $CaCO_3$ for drinking water at four stations, the highest result being 192 mg/l $CaCO_3$ at Station 4.

All other parameters such as PO_4, NO_2, NO_3, SO_4, CN and Cl were within recommended levels for drinking water and aquatic life. The cyanide detection limit used in this study was greater than the recommended levels for aquatic life, however, all results were "less than" the detection limit of 0.03 mg/l.

Generally, the extractable metal concentrations did not exceed water quality criteria. Silver concentrations were less than the 0.05 mg/l level for drinking water but the detection limit of 0.030 mg/l used in this study was greater than the 0.0001 mg/l upper recommended level for aquatic life. Aluminum met the criteria for drinking

water but slightly exceeded the 0.1 mg/l limit for aquatic life at Station 2 with a level of 0.181 mg/l, and Station 8 with a level of 0.117 mg/l. Cadmium was within the acceptable limits for drinking water; but again the detection limit of 0.0010 mg/l exceeded the recommended level of 0.0002 mg/l for aquatic life. All cadmium results were "less than" the detection limit. Zinc was within the acceptable levels for drinking water, but slightly exceeded the recommended levels for aquatic life of 0.03 mg/l at Station 1 with a level of 0.0582 mg/l and Station 2 with a level of 0.0306 mg/l. All other metal concentrations were within acceptable values for drinking water and recommended levels for aquatic life.

4.2 Sediments

The sediment data is given in Appendix III. Most of the metal concentrations in the sediments appeared similar to sediment metal concentrations found in other Yukon streams (Burns 1980). As would be expected, silver, lead and zinc concentrations were higher at the adit (Station 2) than at other stations. Sediment concentrations were 43 to 80 mg/kg Ag, 3,300 to 7,150 mg/kg Pb and 5,560 to 8,080 mg/kg Zn. These concentrations reflect the presence of the silver-lead-zinc ore body at the Marbaco mine. Arsenic, cadmium and iron sediment concentrations were also higher at the adit. The sediment levels were 273-367 mg/kg As, 18.5 to 26.3 mg/kg Cd and 53,300 to 72,300 mg/kg Fe. These high concentrations probably reflect the presence of these metals in waste minerals closely associated with the ore. Since arsenic and cadmium are very toxic to aquatic life, concentrations of these metals will have to be kept low in mine and mill effluents.

Other metals in sediments that exceeded concentrations found in other Yukon streams (Burns 1980) were copper, mercury, molybdenum and nickel at Station 1, a control creek above the mine adit.

4.3 Bottom Fauna

A taxonomic list of bottom fauna collected in the Marbaco study is given in Table 2. A list of diversity indices and numbers per m^2 is given in Table 3. The numbers of individuals per taxonomic group in each sample and the diversity index for each sample are listed in Appendix IV.

The diversity index is a measure of community structure and relative stability. Communities of high diversity are characterized by large numbers of species with no single species overwhelmingly abundant. Communities of low diversity contain few species, some of which are represented in disproportionately high numbers. High diversity is characteristic of relatively undisturbed, unpolluted waters. Low diversity is often associated with disturbed, stressed or polluted waters.

In general the diversity indices found in this study were similar to those reported by Archibald et al (1981) for other unpolluted streams in the Yukon. However, zero diversities were found in subsamples of Stations 1, 6 and 9. The low diversity at Station 1 was probably due to a road crossing through the stream. Diversity was affected by sediment at Station 6 as a result of a recently installed culvert. It was not known why the diversity was low at Station 9.

Unshaded sample sites (2, 3 and 4) had larger numbers of individuals per sample than the other sites. These sites also had the most taxonomic groups present. Cinygmula genus of order Ephemeroptera and Procladius genus of order Diptera were the two most common genera represented. The genus Cinygmula was represented in seven out of eight stations and the genus Procladius was represented in six out of eight stations.

4.4 Fish

Although no fish were collected, a school of Arctic grayling was observed feeding at Station 8, and good lake trout fishing was reported in Tootsee Lake. The streams in the Tootsee-Rancheria watershed are thus utilized by fish at the present time.

TABLE 2 BOTTOM FAUNA TAXONOMIC GROUPS FOUND IN THE MARBACO STUDY AREA (Numbers are cross referenced to the groups listed in Appendix IV).

	Phylum:	Annelida
	Class:	Oligochaeta
	Order:	Plesioptera
	Family:	Tubificidae
1.		*Tubifex* sp.
2.	Family:	Enchytraeidae
	Phylum:	Arthropoda
	Class:	Crustacea
	Order:	Copepoda
	Family:	Cyclopoida
3.		*Eucyclops speratus*
	Class:	Arachnoidae
4.	Order:	Acari
	Class:	Insecta
	Order:	Plecoptera (stonefly)
	Family:	Chloroperlinae
5.		*Alloperla* sp.
	Family:	Isogeninae
6.		*Arcynopteryx* sp.
	Family:	Nemouridae
7.		*Nemoura (Zapada)* sp.
8.		*Prostoia* sp.
	Family:	Perlodidae
9.		*Cultus* sp.
10.		*Diura* sp.
11.		*Kogotus* sp.
	Order:	Ephemeroptera (mayfly)
	Family:	Baetidae
12.		*Ameletus* sp.
13.		*Baetis* sp.
	Family:	Ephemerellidae
14.		*Ephemerella levis*
15.		*Ephemerella proserpina*

TABLE 2 BOTTOM FAUNA TAXANOMIC GROUPS FOUND IN THE MARBACO STUDY AREA (continued)

	Family:	Heptagenildae
16.		Cinygmula sp.
17.		Epeorus sp.
18.		Rithrogena sp.
	Family:	Siphlonuridae
19.		Siphlonurus sp.
	Order:	Hemiptera
	Family:	Saldidae
20.		Saldolda sp.
	Order:	Homoptera
21.	Family:	Aphididae
	Order:	Trichoptera (caddisfly)
22.		Cases, empty
	Family:	Brachycentridae
23.		Brachycentrus sp.
24.	Family:	Limnephilidae, juvenile, undetermined
25.		Asynarchus sp.
26.		Desmona sp.
27.		Drusinus sp.
28.		Halesochila taylori
	Family:	Rhyacophilidae
29.		Agapetus sp.
30.		Rhyacophila tucula
31.	Order:	Lepidoptera, larva, undetermined
	Order:	Coleoptera
	Family:	Haliplidae
32.		Haliplus sp.
33.	Order:	Diptera, adult (truefly)
34.	Family:	Chironomidae, adults
35.		Chironomidae, pupae
36.		Cardiocladius sp.
37.		Crictopus sp.

TABLE 2 BOTTOM FAUNA TAXANOMIC GROUPS FOUND IN THE MARBACO STUDY AREA (continued)

38.		*Dicrotendipes* sp.
39.		*Euklefferiella* sp.
40.		*Heterotrissocladius* sp.
41.		*Micropsectra* sp.
42.		*Polypedilum* sp.
43.		*Procladius* sp.
	Family:	Ceratopogonidae
44.		*Palpomyia* sp.
	Family:	Culicidae
45.		*Anopheles* sp., pupa
	Family:	Empididae
46.		*Weidemannia* sp.
47.	Family:	Simuliidae, larvae, undetermined
48.		*Prosimulium onychodactylum*, pupa
	Family:	Tipulidae
49.		*Dicranota* sp.
50.		*Hexatoma* sp.
51.		*Paradelphomyia* sp.
52.	Family:	Tanypodinae, undetermined
53.		*Corynoneura* sp.
54.	Phylum:	Mollusca, empty shells
	Class:	Gastropoda
	Order:	Cytenobranchiata
	Family:	Lymnaeidae
55.		*Lymnaea stagnalis*
	Class:	Pelecypoda
	Family:	Sphaeriidae
56.		*Pisidium* sp.
57.	Class:	Turbellaria

TABLE 3 SUMMARY OF MARBACO STUDY BOTTOM FAUNA DIVERSITY INDICES AND NUMBERS

STATION NUMBER	DIVERSITY (H')	NUMBER PER FT^2	CALCULATED NUMBER PER M^2
1-1	0.47	21	226
1-2	0	39	420
1-3	0.40	114	1227
2-1	0.82	33	355
2-2	0.82	36	388
2-3	0.74	12	129
3-1	0.78	32	344
3-2	0.79	18	194
3-3	0.67	35	377
4-1	0.78	42	452
4-2	0.58	27	291
4-3	0.51	30	323
5-1	0.57	9	97
5-2	0.45	4	43
5-3	0.30	3	32
6-1	0.45	5	54
6-2	0	12	129
6-3	0.49	20	215
7-1	0.70	17	183
7-2	0.55	7	75
7-3	0.24	4	43
9-1	0.60	4	43
9-2	0	4	43
9-3	0.69	19	205

REFERENCES

Anonymous, Guidelines for Establishing Water Quality Objectives for the Territorial Waters of the Yukon and Northwest Territories. Report of the Working Group on Water Quality Objectives to the Chairmen, Water Boards, Yukon and Northwest Territories, July (1977).

APHA, AWWA, WPCF, Standard Methods for the Examination of Water and Wastewater, 14 Ed., (1975).

Archibald, P.L., Burns, B.E., A Baseline Survey of the Water Quality and Biological Conditions in the Streams of the Howard's Pass Area, Yukon Territory. Environmental Protection Service, Yukon Branch, Pacific Region. No. 81-13 January (1981).

Baker, S.A., An Environmental Survey of Selected Yukon River Headwaters Lakes Impacted by Communities. Regional Program Report No. 79-26, Environmental Protection Service, Pacific Region, Environment Canada, (1979a).

Burns, B.E., Water Quality Investigations of Placer Gold Mining Streams in Yukon Territory. Contaminants Contract Fund. Contract No. 05SB.KE114-0-2308, unpublished 1980 data, (1980).

California State Water Resources Control Board, Water Quality Criteria Publication, No. 3-A, Second Edition by McKee and Wolf, (1963).

Davidson, John, Personal Communication, Assistant Manager of Laboratory Services, 4195 South Marine Drive, West Vancouver, B.C. (October 1981).

Demayo, A., M.C. Taylor, S.W. Reeder, Guidelines for Surface Water Quality, Vol. 1, Inorganic Chemical Substances, Arsenic. Environment Canada, Inland Waters Directorate, Ottawa, (1979).

REFERENCES (continued)

Demayo, A., M.C. Taylor, and S.W. Reeder, Guidelines for Surface Water Quality, Vol. 1, Inorganic Chemical Substances, Lead. Environment Canada, Inland Waters Directorate, Ottawa, (1980).

Department of Environment, Department of Fisheries and Oceans, Laboratory Manual. Environmental Protection Service, Fisheries and Marine Service, (1979).

Edmunds, G.F., S.L. Jensen, and L. Berner, Mayflies of North and Central America. University of Minnesota Press, Minneapolis, (1976).

Environment Canada, Pollution Sampling Handbook. Fisheries and Marine Service and Environmental Protection Service, Laboratory Services, Vancouver, B.C., (1976).

Health and Welfare Canada, Guidelines for Canadian Drinking Water Quality 1978, Supply and Services Canada, (1979).

Hughes, B.D., "The Influence of Factors Other Than Pollution on the Value of Shannon's Diversity Index for Benthic Macro-Invertebrates in Streams", Water Research Vol. 12, p 359, (1978).

Jack, Mary E., Baseline Study of the Watershed Near Venus Mine, Yukon and Venus Mill, British Columbia, Regional Program Report 81-18. (1981).

Low, C.J., Ph.D., Personal Communication, Invertebrate Biologist Consultant, 33 Milton Street, Nanaimo, B.C.

Marbaco Resources Ltd., Water Use Application to the Yukon Territory Water Board, (February 1981).

Mathers, J.S., N.O. West, and B.Burns, Aquatic and Wildlife Resources of Seven Yukon Streams Subject to Placer Mining. Department of Fisheries and Oceans, Vancouver, B.C. (September, 1981).

REFERENCES (continued)

Ontario Ministry of the Environment, Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment. (1978).

Pennak, R.W., Ph.D., Fresh Water Invertebrates of the United States, The Ronald Press Company, New York, (1953).

Pielou, E.C., Ecological Diversity, John Wiley and Sons Inc., Toronto, Chapter 1, p.8, (1975).

Reeder, S.W., A. Demayo and M.C. Taylor, Guidelines for Surface Water Quality, Vol. 1, Inorganic Chemical Substances, Cadmium. Environment Canada, Inland Waters Directorate, Ottawa, (1979a).

Reeder, S.W., A. Demayo and M.C. Taylor, Guidelines for Surface Water Quality, Vol. 1, Inorganic Chemical Substances, Mercury. Environment Canada, Inland Waters Directorate, Ottawa, (1979b).

Taylor, M.C., A. Demayo and S.W. Reeder, Guidelines for Surface Water Quality, Vol. 1, Inorganic Chemical Substances, Silver. Environment Canada, Inland Waters Directorate, Ottawa, (1979b).

Thurston, R.V., R.C. Russo, C.M. Fetteroff Jr., T.A. Edsall, and Y.M. Barber Jr. (Eds.), A Review of the EPA Red Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda, MD., 313 p., (1979).

Ward, H.B., G.C. Whipple, Fresh-Water Biology, John Wiley and Sons, Inc., New York, Copyright (1918).

ACKNOWLEDGEMENTS

The authors wish to thank T. Strukoff, and S. Withers and D. Simpson from the Department of Indian and Northern Affairs, for their assistance in the collection of field data at Marbaco. The authors would also like to thank all the Environmental Protection Service regular and summer staff for their involvement in lab analyses, drafting, typing and manuscript review.

APPENDICES

APPENDIX I

COLLECTION, PRESERVATION AND ANALYSIS OR IDENTIFICATION METHODS AND WATER QUALITY CRITERIA

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Temperature		In situ temperature reading.	Standard Centigrade Thermometer	
Flow		Flow measurements taken for general evaluation purposes only.	Cross-section of stream was estimated and the velocity of flow was measured by noting the time it took a twig to travel a given length of the stream, i.e., 5 m. Flow measurement given in m^3/s.	
Dissolved Oxygen	1.00 mg/l	Duplicate samples collected in 300 ml glass BOD bottles. The BOD bottles were rinsed 3 times with sample before filling. Preserved with 2 ml manganese sulphate and 2 ml alkali-iodide -azide solution and shaken 15 times. A water seal was maintained and DO analysis was done within 7 days.	Iodometric Azide Modification Winkler Titration Method	048
pH		Small aliquots of sample were taken and read soon after collection. No preservative.	Potentiometric	080
Conductivity	0.2 umhos/cm	In situ measurement.	YSI Conductivity Meter Model 33	044
		Laboratory measurement. No preservative. The measurement was taken from the same sample as NH_3 below.	Radiometer Conductivity Meter (CDMC)	044

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Ammonia NH_3-N	0.0050 mg/l	Single samples collected in 2 litre linear polyethylene containers. The container was rinsed 3 times with sample before it was filled. No preservatives. Stored at 4°C.	Phenol Hypochlorite-Colorimetric-Automated	058
Colour	5 (colour units)	Same sample as NH_3.	Platinum-Cobalt Visual Comparison	040
Turbidity	1.0 (FTU)	Same sample as NH_3.	Nephelometric Turbidity	130
Non-Filterable Residue (NFR)	5.0 mg/l	Same sample as NH_3.	Filtration, drying and weighing of residue on filter	104
Filterable Residue (FR)	10.0 mg/l	Same sample as NH_3.	Filtration, drying and weighing of filtrate	100
Total Alkalinity	1.0 mg/l as $CaCO_3$	Same sample as NH_3.	Potentiometric Titration	006
Total Phosphate T PO_4-P	0.0050 mg/l	Same sample as NH_3.	Acid-persulphate, Autoclave Digestion	086
Nitrite NO_2-N	0.0050 mg/l	Same sample as NH_3.	Diazotization-Colorimetric-Automated	070
Nitrate NO_3-N	0.010 mg/l	Same sample as NH_3.	Cadmium Copper Reduction Colorimetric Automated	072

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Sulphate SO_4	1.00 mg/l	Same sample as NH_3.	Barium Chloranilate -UV Spectrophotometric	122
Chloride Cl	0.50 mg/l	Same sample as NH_3.	Thiocyanate-Combined Reagent-Colorimetric	024
Cyanide CN	0.03 mg/l	Sample was collected in a 1 litre nalgene wide mouth bottle, which was rinsed 3 times with sample before filling. The sample was preserved with NaOH pellets to pH >12 and stored at 4°C.	Tetracyanonickelate (II) - UV - Colorimetric	032
Silicon Total Si	0.50 mg/l	Same sample as NH_3.	Ascorbic Acid Reduction - Colorimetric	118
Mercury Total Hg	0.00020 mg/l	Single samples were collected in a 200 ml linear polyethylene bottle. Preserved with 10 ml 5% nitric dichromate solution.	Open Flameless System for Hg-AAS Determination	211 224 284 411
Extractable Metals	mg/l	Single samples collected in 200 ml linear polyethylene bottles. The bottle was rinsed 3 times with sample before filling. Preserved to a pH <1.5 using 2.0 ml concentrated HNO_3.	Inductively Coupled Argon Plasma (ICAP) combined with Optical Emission Spectrometer (OES)	210 592
Al	0.050			
As	0.075			
Ba	0.0015			
Be	0.0010			
Ca	0.050			
Cd	0.0040			
Co	0.0075			

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
Extractable metals (con't)	mg/l			
Cr	0.0075			
Cu	0.0050			
Fe	0.0050			
Mg	0.10			
Mn	0.0010			
Mo	0.015			
Na	0.050			
Ni	0.040			
Pb	0.040			
Sb	0.040			
Se	0.075			
Sn	0.10			
Sr	0.0020			
Tl	0.0040			
V	0.020			
Zn	0.0050			
As	0.00050	Same sample as metals.	Hydride Generation-ICAP.	J.Davidson EPS Lab
Cd	0.0010	Same sample as metals.	Graphite Atomic Absorption Flameless Technique (AAS)	Atomic Absorption Jerrel-Ash 850 Manual
Cu	0.0010	Same sample as metals.		
Pb	0.0010	Same sample as metals.		
Zn	0.0010	Same sample as metals.		
Ag	0.030	Same sample as metals.	Flame Atomic Absorption Spectrophotometry	210 290

APPENDIX I TABLE 1 WATER SAMPLE COLLECTION, PRESERVATION AND ANALYSIS METHODS (continued)

PARAMETER	DETECTION LIMIT	COLLECTION AND PRESERVATION PROCEDURE[1]	ANALYTICAL PROCEDURE	METHOD SECTION[2]
K	0.010 mg/l	Same sample as metals.	Flame Atomic Emission Spectrophotometry	210 423
Total Hardness	0.030 mg/l as $CaCO_3$	Same sample as metals.	The sum of the ICAP results for Mg x 4.116 and Ca x 2.497 reported as mg/l $CaCO_3$	

1 As described in Environment Canada (1976).

2 As described in Department of Environment (1979).

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS

PARAMETER	COLLECTION/PREPARATION	ANALYSIS	METHOD CODE[1]
All Parameters	Creek and River Stations: Sediment samples were collected using an aluminum shovel to scoop sample into pre-labelled Whirl-Pak bags. Four samples were taken at each station. Samples were kept cool and were frozen (-19°C) as soon as possible.		
Cyanide CN	Some distilled water was added to a known weight of sediment sample before starting the digestion step in the analytical procedure.	Tetracyanonickelate (II) - UV - Colorimetric Method	032
Mercury Hg (Total)	Sample was freeze-dried for 48 hours to remove water. Sample was sieved through a size 100 mesh (.15 mm) stainless steel sieve. The portion passing through was analyzed for mercury. Sample was completely oxidized by digestion with H_2SO_4 and H_2O_2.	Atomic Absorption Spectrophotometer - Open Flameless System	231 236 238 275 284 411
Metals (Leachable) Al Ba Be Ca Cd Cr Cu	Same as Mercury except portion passing through was analyzed for metals. Sample was leached with HCL and HNO_3. The sample was heated for 3 hours.	Inductively Coupled Argon Plasma (ICAP) Combined with Optical Emission Spectrometer (OES)	231 236 238 242

APPENDIX I TABLE 2 SEDIMENT COLLECTION, PREPARATION AND ANALYSIS METHODS (continued)

PARAMETER	PREPARATION	ANALYSIS	METHOD CODE[1]
Metals (Leachable) (continued)			
Fe			
Mg			
Mn			
Mo			
Na			
Ni			
P			
Pb			
Si			
Sn			
Sr			
Ti			
V			
Zn			
As	Same as other metals.	Hydride Generation ICAP	J. Davidson
[2]Sb	Same as other metals.	Hydride Generation ICAP	EPS Lab
[2]Se	Same as other metals.	Hydride Generation ICAP	
Ag	Same as other metals.	Flame Atomic Absorption Spectrophotometry	290
Cd	Same as other metals.	Graphite Flameless Atomic Absorption	Jerrel-Ash 850 Manual
K	Same as other metals.	Flame Atomic Emission Spectrophotometry	423
Particle Size	Sample was freeze-dried.	Standard Sieving Operation	078

1 Department of Environment, Department of Fisheries and Oceans, Laboratory Manual, Environmental Protection Service, Fisheries and Marine Service (1979).

2 The concentrations of Sb and Se are for information only since the analysis method has not yet been fully tested.

APPENDIX I TABLE 3 BOTTOM FAUNA COLLECTION, PRESERVATION AND IDENTIFICATION METHODS

FIELD COLLECTION, SAMPLING PROCEDURES AND PRESERVATION	LABORATORY PROCEDURES	IDENTIFICATION AND ENUMERATION
Surber Sampler: Creek and river samples were taken using a Surber Sampler with a 60 cm long net (mesh size - 0.76 mm). Area sampled was 900 cm^2 (1 ft^2). Surber samples were washed into a cup at the bottom of a plankton net (.75 mm mesh size), put in separate labelled glass jars and preserved with 10% formalin. Three samples were taken at each station.	Bottom fauna was removed from other material in a labelled vial containing 70% methanol.	Bottom fauna was sent to Dr. Charles Low, Consulting Invertebrate Biologist, at Nanaimo, British Columbia, for identification to genus, species if possible, and enumeration.

APPENDIX I TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Physical				
Colour Pt. Counts	15	1		
Odour and taste	0	1		
Turbidity J.T.U.	5	1		
Chemical				
Alkalinity mg/l (Total)	Not considered a public health problem	4	>20	3
Aluminum (Al) mg/l	Not considered a public health problem	7	0.1	5
Ammonia (NH_3-N) mg/l	0.5	4	0.02	3
Antimony (Sb) mg/l				
Arsenic (As) mg/l	0.05	1	0.05	2
Barium (Ba) mg/l	1.0	1	5.0	7
Boron (Bo) mg/l	1.0	1		
Cadmium (Cd) mg/l	0.005	1	0.0002	2
Calcium (Ca) mg/l	75-200	7		
Chloride (Cl)mg/l	250	1		
Chromium (Cr) mg/l	0.05	1	0.04	2
Cobalt (Co) mg/l				
Conductivity @ 25°C (umhos/cm)	Depends on dissolved salts	7	150-500	6
Copper (Cu) mg/l	1.0	1	0.005	5
Cyanide (CN) mg/l	0.2	1	0.005	3
Dissolved oxygen (% saturation)	Near 100%	4	$\geq$5.0 mg/l	3

APPENDIX I TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Fluoride (F) mg/l	1.5	1	1.5	7
Hardness (Total) as mg/l $CaCO_3$	80-100	1		
Iron (Fe) mg/l	0.3	1	1.0	3
Lead (Pb) mg/l	0.05	1	0.005 (soft H_2O*)	2
			0.01 (hard H_2O*)	2
Magnesium (Mg) mg/l	50	4		
Manganese (Mn) mg/l	0.05	1	1.0	7
Mercury (Hg) mg/l	0.002	1	0.0001-0.0002	2
Molybdenum (Mo)				
Nickel (Ni) mg/l	0.25	2	0.025 (soft H_2O*)	2
			0.25 (hard H_2O*)	2
Nitrate (NO_3-N) mg/l	10	1		
Nitrite (NO_2-N) mg/l	0.001	1		
pH units	6.5 - 8.5	1	6.5 - 9.0	3
Phosphorus (P) mg/l (Total)			0.020 to prevent algae	5
Potassium (K) mg/l				
Residue: Filterable mg/l (Total dissolved solids)	1000	4	70 - 400 with a maximum of 2000	6
Residue: Non-Filterable (mg/)				
Selenium (Se) mg/l	0.01	1	0.01	2
Silica (Si) mg/l				
Silver (Ag) mg/l	0.05	1	0.0001	2
Sodium (Na) mg/l	20	1		
Strontium (Sr) mg/l	10	1		
Sulphate (SO_4) mg/l	500	1		
Tin (Sn) mg/l	Not present in natural waters	7		
Titanium (Ti) mg/l				

APPENDIX I TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)
Total Inorganic Carbon (TIC)				
Total Organic Carbon (TOC)	5.0	5		
Vanadium (V)				
Zinc (Zn) mg/l	5.0	1	0.030	5

* Soft water has a total hardness less than 95 mg/l as $CaCO_3$. Hard water has a total hardness of more than 95 mg/l as $CaCO_3$ (Reference 6).

REFERENCES:

1. Health & Welfare Canada, Guidelines for Canadian Drinking Water Quality 1978, Supply and Services, Canada (1979).

2. Inland Waters Directorate, Guidelines for Surface Water Quality, Vol. 1, Inorganic Chemical Substances. Environment Canada, Ottawa (1979, 1980).

3. Thurston, R.V., R.C. Russo, C.M. Fetteroff Jr., T.A. Edsall, and Y.M. Barber Jr. (Eds.), A Review of the EPA Red Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda, MD, 313p. (1979).

4. Anonymous, Guidelines for Establishing Water Quality Objectives for the Territorial Waters of the Yukon and Northwest Territories. Report of the Working Group on Water Quality Objectives to the Chairmen, Water Boards, Yukon and Northwest Territories, July (1977).

5. Ontario Ministry of the Environment, Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment. (1978).

APPENDIX I TABLE 4 WATER QUALITY CRITERIA FOR DRINKING WATER AND AQUATIC LIFE (continued)

SUBSTANCE	RECOMMENDED LEVEL(S) FOR DRINKING WATER	REFERENCE(S)	RECOMMENDED LEVEL(S) FOR AQUATIC LIFE	REFERENCE(S)

6. Environment Canada, Pollution Sampling Handbook. Pacific Region Laboratory Services, Fisheries Operations and Environmental Protection Service, West Vancouver, B.C. (1976).

7. California State Water Resources Control Board, Water Quality Criteria. Publication No. 3-A Second Edition by McKee and Wolf. (1963).

APPENDIX II

WATER QUALITY DATA

APPENDIX II MARBACO WATER QUALITY DATA - JUNE 24-25, 1981

STATION NUMBER	FLOW m^3/s	TEMP (°C)	D.O. (mg/l)	% D.O. SATURATION (%)	IN SITU pH	LAB pH	IN SITU CONDUCTIVITY (umhos/cm)	LAB CONDUCTIVITY (umhos/cm)	COLOUR (colour units)	TURBIDITY (FTU)
1	16 (e)	8.0	10.03	98	-	7.5	50	76.3	<5	<1.0
2	0.1 (e)	3.5	7.93	69	-	7.3	150	286	<5	3.0
3	22 (e)	5.0	10.40	91	8.30	7.9	70	115	<5	<1.0
4	<0.01(e)	12.0	11.13	117	8.15	8.0	260	375	<5	<1.0
5	0.3 (e)	5.0	10.30	92	8.10	8.2	172	292	<5	<1.0
6	0.3 (e)	6.5	10.13	91	8.40	8.2	170	293	5	<1.0
7	22 (e)	5.0	-	-	8.20	8.0	88	147	5	<1.0
8	20 (e)	9.5	-	-	8.20	7.4	41	59.8	8	<1.0
9	27 (e)	9.0	10.60	102	8.45	7.6	45	78.5	6	<1.0

(e) Very rough estimate.

APPENDIX II MARBACO WATER QUALITY DATA - JUNE 24-25, 1981 (continued)

STATION NUMBER	N.F. RESIDUE (mg/l)	F. RESIDUE (mg/l)	TOTAL ALKALINITY (mg/l as $CaCO_3$)	TOTAL HARDNESS (mg/l as $CaCO_3$)	TOTAL PO_4-P (mg/l)	NO_2-N (mg/l)	NO_3-N (mg/l)	NH_3-N (mg/l)	SO_4 (mg/l)	CN (mg/l)	Cl (mg/l)
1	<5	49.5	34.1	32.9	0.0044	<0.0050	0.010	<0.0050	4.50	<0.03	<0.50
2	10.0	163.5	127	135.0	0.0072	<0.0050	0.022	<0.0050	15.8	<0.03	0.69
3	<5	72.0	49.6	52.2	0.0055	<0.0050	<0.010	<0.0050	7.70	<0.03	0.54
4	<5	214.0	193	192.0	0.0055	<0.0050	<0.010	<0.0050	5.80	<0.03	0.69
5	<5	167.5	149	148.0	0.0056	<0.0050	0.011	<0.0050	5.60	<0.03	0.67
6	<5	230.0	149	148.0	0.0072	<0.0050	<0.010	<0.0050	5.20	<0.03	0.64
7	6.0	87.5	66.3	69.5	0.0088	<0.0050	<0.010	<0.0050	7.80	<0.03	<0.50
8	<5	46.0	26.8	25.5	0.0055	<0.0050	0.012	0.0111	3.40	<0.03	0.60
9	<5	53.5	34.1	34.5	0.0051	<0.0050	<0.010	<0.0050	4.80	<0.03	<0.50

APPENDIX II MARBACO WATER QUALITY DATA - JUNE 24-25, 1981 (continued)
(All extractable metal concentrations are given in mg/l)

STATION NUMBER	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
1	<0.030	<0.050	<0.00050	0.0252	<0.0010	9.79	<0.0010	<0.0075	<0.0075	<0.0010	0.0721	<0.00020	0.407
2	<0.030	0.181	0.00173	0.0146	<0.0010	46.4	<0.0010	<0.0075	<0.0075	<0.0010	0.272	<0.00020	0.403
3	<0.030	<0.050	<0.00050	0.0422	<0.0010	15.3	<0.0010	<0.0075	<0.0075	<0.0010	0.0519	<0.00020	0.400
4	<0.030	<0.050	<0.00050	0.121	<0.0010	53.3	<0.0010	<0.0075	<0.0075	<0.0010	0.0101	<0.00020	0.495
5	<0.030	<0.050	0.00088	0.0115	<0.0010	40.5	<0.0010	<0.0075	<0.0075	<0.0010	0.0273	<0.00020	0.306
6	<0.030	0.059	0.00091	0.0154	<0.0010	40.5	<0.0010	<0.0075	<0.0075	<0.0010	0.0911	<0.00020	0.328
7	<0.030	<0.050	<0.00050	0.0409	<0.0010	19.9	<0.0010	<0.0075	<0.0075	<0.0010	0.0735	<0.00020	0.419
8	<0.030	0.117	<0.00050	0.0080	<0.0010	8.39	<0.0010	<0.0075	<0.0075	<0.0010	0.209	<0.00020	0.285
9	<0.030	<0.050	<0.00050	0.0174	<0.0010	10.7	<0.0010	<0.0075	<0.0075	<0.0010	0.0744	<0.00020	0.313

APPENDIX II MARBACO WATER QUALITY DATA - JUNE 24-25, 1981 (continued)
(All extractable metal concentrations are given in mg/l)

STATION NUMBER	Mg	Mn	Mo	Na	Ni	Pb	Sb	Se	Si	Sn	Sr	Ti	V	Zn
1	2.05	0.0084	<0.015	1.07	<0.040	<0.0010	<0.040	<0.075	2.87	<0.10	0.0630	<0.0040	<0.020	0.0582
2	4.71	0.0305	<0.015	1.62	<0.040	0.0029	<0.040	<0.075	3.45	<0.10	0.405	0.0051	<0.020	0.0306
3	3.40	0.0030	<0.015	0.91	<0.040	<0.0010	<0.040	<0.075	2.71	<0.10	0.0632	<0.0040	<0.020	0.0035
4	14.4	0.0018	<0.015	0.97	<0.040	<0.0010	<0.040	<0.075	2.71	<0.10	0.164	<0.0040	<0.020	0.0022
5	11.4	0.0011	<0.015	0.57	<0.040	<0.0010	<0.040	<0.075	2.02	<0.10	0.146	<0.0040	<0.020	0.0012
6	11.3	0.0063	<0.015	0.59	<0.040	0.0041	<0.040	<0.075	2.07	<0.10	0.141	<0.0040	<0.020	0.0086
7	4.81	0.0048	<0.015	0.89	<0.040	<0.0010	<0.040	<0.075	2.64	<0.10	0.0771	<0.0040	<0.020	0.0058
8	1.10	0.0111	<0.015	0.99	<0.040	<0.0010	<0.040	<0.075	2.79	<0.10	0.0519	0.0056	<0.020	0.0014
9	1.88	0.0062	<0.015	0.96	<0.040	<0.0010	<0.040	<0.075	2.76	<0.10	0.0561	<0.0040	<0.020	0.0013

APPENDIX III

SEDIMENT DATA

APPENDIX III TABLE 1 MARBACO SEDIMENT CHEMISTRY DATA - JUNE 24-25, 1981
(all measurements are in mg/kg dry weight unless otherwise noted)

STATION	CN w/w*	Ag	Al	As	Ba	Be	Ca	Cd	Cr	Cu	Fe	Hg	K	Mg	Mn
1-1	<3.0	<4.98	28700	13.7	261.0	2.63	8690	<0.58	42.9	20.0	34400	1.33	1810	9130	544.0
1-2		<5.00	26300	25.1	293.0	2.05	10400	<0.58	121	830	46200	8.16	2370	9340	2000
2-1	<3.0	79.9	27500	367	154.0	2.15	26500	26.3	34.1	79.7	72300	<0.185	6290	9080	1460
2-2		43.5	20100	273	120.0	1.48	30700	18.5	22.8	64.9	53300	<0.170	4230	7950	1870
3-1	<3.0	<4.94	10800	12.6	994.0	0.406	11100	0.58	26.6	30.6	19000	<0.204	1530	7250	626.0
3-2		<4.94	12000	9.48	944.0	0.447	11500	0.64	24.3	28.6	19600	<0.196	1730	7540	621.0
3-3		<4.98	12400	11.6	962.0	0.505	11300	0.90	35.3	37.4	21300	<0.185	1880	7410	803.0
4-1	<3.0	<4.95	21000	9.07	319.0	0.643	34100	<0.58	26.0	14.8	26400	<0.192	1860	18100	465.0
4-2		<4.99	16500	7.54	406.0	0.473	33200	0.82	20.2	13.3	18800	<0.200	1400	8840	377.0
4-3		<4.95	25500	10.7	345.0	0.825	28200	<0.58	31.0	14.5	31200	<0.200	1940	15500	590.0
5-1	<3.0	<4.93	15000	20.0	158.0	0.576	38800	<0.58	27.1	9.65	28600	2.04	1930	20900	2470
5-2		<4.89	11500	42.0	108.0	0.407	27200	<0.57	29.6	7.85	19900	<0.170	1640	14500	1380
5-3		<4.92	12600	19.4	101.0	0.434	26900	<0.58	48.1	12.3	22200	<0.196	1650	14900	1490
6-1	<3.0	<4.86	9810	11.5	238.0	0.340	55100	<0.57	17.4	14.5	24900	<0.196	1770	16300	446.0
6-2		<4.92	11100	9.97	294.0	0.393	54600	<0.58	33.9	20.1	27100	<0.175	1930	15400	504.0
6-3		<4.95	11700	14.1	354.0	0.420	56200	<0.58	37.6	42.1	35400	<0.204	2140	16600	568.0
7-1	<3.0	<4.90	9550	10.1	2550	0.465	12800	<0.57	32.8	71.9	30100	<0.192	1640	8380	471.0
7-2		<4.95	10900	9.95	1410	0.519	14800	<0.58	25.1	21.2	20100	<0.189	1660	8400	454.0
7-3		<4.98	9610	9.13	2880	0.457	14700	<0.58	29.4	20.8	28900	<0.192	1600	9070	464.0
8-1	<3.0	<4.84	14900	4.47	97.9	0.685	4850	<0.56	21.2	10.4	19600	<0.200	1960	4080	335.0
8-2		<4.92	15400	4.77	98.4	0.749	4880	<0.57	21.6	10.8	19600	<0.196	1920	4180	335.0
8-3		<4.96	16400	5.26	104.0	0.746	5070	<0.57	22.9	12.2	21400	<0.196	2010	4490	398.0
9-1	<3.0	<4.93	10900	4.26	451.0	0.436	11300	<0.58	17.4	9.91	16200	<0.192	1520	7260	328.0
9-2		<4.95	10800	4.44	373.0	0.429	10900	<0.58	17.2	35.1	15500	<0.170	1520	6970	318.0
9-3		<4.91	11100	4.34	532.0	0.499	12100	<0.58	17.4	9.10	16900	<0.189	1650	7470	343.0

w/w* means wet weight. All other concentrations in this table are given in mg/kg dry weight for the portion passing a 150 um sieve.

APPENDIX III TABLE 1 MARBACO SEDIMENT CHEMISTRY DATA - JUNE 24-25, 1981 (continued)
(all measurements are in mg/kg dry weight unless otherwise noted)

STATION	Mo	Na	Ni	P	Pb	Sb*	Se*	Si	Sn	Sr	Ti	V	Zn
1-1	<2.48	631.0	29.4	1320	28.2	<8.30	<8.30	2340	<16.6	61.7	1380	90.8	202.0
1-2	15.3	810.0	101	1150	51.0	<8.35	<8.35	3030	60.9	74.8	2010	89.0	229.0
2-1	<2.48	270.0	51.0	742.0	7150	<8.25	<8.25	4130	<16.6	127.0	508.0	34.1	8080
2-2	<2.48	224.0	23.5	1210	3300	<8.20	<8.20	2870	<16.6	150.0	761.0	27.9	5560
3-1	<2.48	330.0	36.6	931.0	43.4	<8.35	<8.35	4640	27.4	40.2	641.0	36.5	220.0
3-2	<2.48	291.0	31.5	866.0	41.5	<8.20	<8.20	4120	20.7	42.4	753.0	40.6	224.0
3-3	<2.49	331.0	39.9	891.0	48.8	<8.25	<8.25	3870	30.7	44.3	684.0	40.9	260.0
4-1	<2.47	528.0	15.9	564.0	66.4	<8.20	<8.20	3710	<16.5	86.3	690.0	29.9	146.0
4-2	<2.49	372.0	11.0	773.0	41.0	<.835	1.46	4650	<16.7	107.0	449.0	19.9	123.0
4-3	<2.48	664.0	16.0	548.0	67.3	<8.25	<8.25	3250	<16.5	92.7	878.0	35.1	147.0
5-1	<2.47	521.0	14.3	1040	61.5	<8.15	<8.15	3900	23.0	80.3	707.0	23.8	202.0
5-2	<2.44	415.0	16.3	803.0	43.5	<8.20	<8.20	3130	24.4	60.6	555.0	18.6	144.0
5-3	<2.46	434.0	31.1	830.0	48.1	<8.30	<8.30	3570	66.3	62.8	603.0	18.9	158.0
6-1	<2.44	375.0	18.6	871.0	22.8	<.810	<.810	4100	<16.2	122.0	695.0	35.8	66.0
6-2	<2.46	395.0	32.0	822.0	24.9	<8.30	<8.30	3570	20.6	134.0	770.0	38.2	69.8
6-3	<2.47	395.0	32.6	936.0	28.0	<8.30	<8.30	3580	28.8	132.0	866.0	52.6	82.3
7-1	<2.45	276.0	29.7	1110	39.3	<.805	<.805	4380	22.9	41.3	1060	67.2	185.0
7-2	<2.47	340.0	26.6	1010	48.7	<.820	<.820	3550	23.9	47.7	1080	46.4	193.0
7-3	<2.49	326.0	27.4	1220	42.5	<.830	<.830	4330	<23.3	45.5	1170	65.6	188.0
8-1	<2.42	265.0	10.4	1200	14.8	<.805	<.805	2770	<16.1	34.5	833.0	28.4	74.9
8-2	<2.47	248.0	12.4	1140	15.2	<.820	<.820	2750	<16.4	35.8	826.0	29.0	74.7
8-3	<2.49	259.0	13.4	1150	18.6	<.825	<.825	2890	<16.6	37.7	848.0	31.1	79.0
9-1	<2.46	256.0	13.5	1120	23.3	<.820	<.820	2990	<16.4	33.9	759.0	28.6	106.0
9-2	<2.47	242.0	14.6	1090	17.6	<.820	<.820	3210	<16.5	32.2	757.0	28.1	98.5
9-3	<2.46	251.0	13.0	1230	17.1	<.815	<.815	2420	<16.4	36.1	887.0	31.4	99.9

* The concentrations of Sb and Se are included for information only since the analysis method has not yet been fully tested.

APPENDIX III TABLE 2 MARBACO SEDIMENT PARTICLE SIZE ANALYSIS - JUNE 24-25, 1981

STATION NUMBER	PERCENT COMPOSITION				
	>500 um	250-500 um	150-250 um	63-150 um	<63 um
2-1	85.9	7.6	2.8	2.6	1.1
2-2	72.1	7.4	5.4	8.0	7.1
3-1	61.3	33.5	4.0	1.0	0.2
3-2	60.9	34.5	3.3	1.1	0.2
3-3	57.3	36.6	4.6	1.3	0.2
4-1	68.3	12.0	5.5	6.9	7.3
4-2	48.4	15.1	9.3	11.5	15.7
4-3	62.7	13.0	6.3	8.1	9.9
5-1	78.8	18.7	1.7	0.6	0.2
5-2	67.9	28.9	2.3	0.8	0.1
5-3	69.5	26.9	2.4	0.8	0.4
6-1	26.7	24.2	17.8	22.5	8.8
6-2	76.0	14.4	4.7	3.2	1.7
6-3	71.8	17.2	4.2	2.8	4.0
7-1	44.3	38.4	11.7	4.6	1.0
7-2	24.9	58.5	12.3	3.6	0.7
7-3	37.4	42.1	14.9	4.8	0.8
8-1	1.2	5.9	22.9	47.3	22.7
8-2	1.5	5.5	25.5	37.7	29.8
8-3	1.5	5.8	22.9	47.5	22.3
9-1	2.9	34.2	35.2	24.1	3.6
9-2	3.1	33.6	37.1	21.5	4.7
9-3	3.8	37.0	35.1	20.7	3.4

APPENDIX IV

BOTTOM FAUNA DATA

APPENDIX IV BOTTOM FAUNA DATA AT MARBACO SAMPLING STATIONS - JUNE 24-25, 1981

TAXONOMIC GROUP	STATION 1			STATION 2			STATION 3			STATION 4		
	1-1	1-2	1-3	2-1	2-2	2-3	3-1	3-2	3-3	4-1	4-2	4-3
1. *Tubifex* sp.	-	-	-	-	-	-	-	-	-	-	-	-
2. Enchytraeidae	2	-	-	-	-	-	-	-	-	-	1	1
3. *Eucyclops speratus*	-	-	-	-	-	-	-	-	-	-	1	-
4. Acari	-	-	-	-	-	-	-	-	-	2	-	-
5. *Alloperla* sp.	-	-	-	-	1	1	-	-	1	-	-	-
6. *Arcynopteryx* sp.	-	-	6	-	-	-	-	-	-	-	-	-
7. *Nemoura (Zapada)* sp.	-	-	41	3	-	-	1	-	-	-	-	-
8. *Prostoia* sp.	4	-	-	-	-	-	-	-	-	-	-	-
9. *Cultus* sp.	-	-	-	1	-	-	-	-	-	-	-	-
10. *Diura* sp.	-	-	-	-	1	-	-	-	-	-	-	-
11. *Kogotus* sp.	-	-	-	1	1	-	2	1	-	3	-	-
12. *Ameletus* sp.	-	-	-	2	2	2	-	-	-	-	-	-
13. *Baetis* sp.	-	-	-	-	-	-	9	2	-	19	-	-
14. *Ephemerella levis*	-	-	-	1	6	3	-	1	-	4	-	-
15. *Ephemerella proserpina*	-	-	-	-	-	-	-	1	1	-	-	-
16. *Cinygmula* sp.	-	-	-	-	-	2	11	6	-	1	-	-
17. *Epeorus* sp.	1	-	-	-	-	-	-	1	-	-	-	-
18. *Rithrogena* sp.	-	-	-	-	-	-	3	-	-	2	-	-
19. *Siphlonurus* sp.	-	-	-	-	3	1	-	-	-	-	-	-
20. *Saldoida* sp.	-	-	-	-	-	-	1	-	-	-	-	-
21. Aphididae	-	-	-	-	-	-	-	-	-	-	-	-
22. Tricoptera, cases empty	-	-	6	-	-	-	-	-	-	-	-	-
23. *Brachycentrus* sp.	-	-	-	-	-	-	1	-	1	-	-	-
24. Limnephilidae, juveniles (undet.)	-	-	1	-	-	-	-	-	-	-	-	-
25. *Asynarchus* sp.	-	-	-	-	-	-	-	-	-	-	-	3
26. *Desmona* sp.	-	-	-	1	-	-	-	-	-	-	-	-
27. *Drusinus* sp.	-	-	-	-	-	-	-	-	-	2	-	-
28. *Halesochila taylori*	-	-	-	-	-	-	-	-	-	-	2	-
29. *Agapetus* sp.	-	-	-	-	-	-	-	3	-	4	-	-
30. *Rhyacophila tucula*	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX IV BOTTOM FAUNA DATA AT MARBACO SAMPLING STATIONS - JUNE 24-25, 1981 (continued)

TAXONOMIC GROUP	STATION 1			STATION 2			STATION 3			STATION 4		
	1-1	1-2	1-3	2-1	2-2	2-3	3-1	3-2	3-3	4-1	4-2	4-3
31. Lepidoptera, larva (undet.)	-	-	-	-	-	-	-	-	-	-	-	-
32. *Haliplus* sp.	-	-	-	-	-	-	-	-	-	-	-	-
33. Diptera, adult	-	-	-	-	-	-	-	-	-	-	-	-
34. Chironomidae, adults	-	1	2	1	-	-	-	2	-	-	-	-
35. Chironomidae, pupae	-	1	2	1	2	-	-	-	-	-	-	-
36. *Cardiocladius* sp.	-	-	-	-	1	-	-	-	2	-	-	-
37. *Cricotopus* sp.	12	34	55	3	-	-	1	-	20	-	-	-
38. *Dicrotendipes* sp.	-	-	-	-	1	-	-	-	-	-	-	-
39. *Euklefferiella* sp.	-	-	-	1	-	-	-	-	-	-	-	-
40. *Heterotrissocladius* sp.	-	-	-	-	-	-	-	-	1	1	11	3
41. *Micropsectra* sp.	-	-	-	14	14	3	-	-	-	-	7	12
42. *Polypedilum* sp.	-	-	-	-	-	-	-	-	-	-	-	-
43. *Procladius* sp.	-	-	-	3	3	-	-	-	1	-	1	1
44. *Palpomyia* sp.	-	-	-	-	-	-	-	-	1	1	-	-
45. *Anopheles* sp., pupa	-	-	-	-	-	-	-	-	-	1	-	-
46. *Weidemannia* sp.	-	-	1	-	-	-	-	-	5	-	-	1
47. Simuliidae, larvae (undet.)	-	-	-	-	-	-	1	-	-	-	-	-
48. *Prosimulium onychodactylum* pupa	-	-	-	-	-	-	1	-	-	-	-	-
49. *Dicranota* sp.	1	-	-	1	1	-	-	-	-	-	-	-
50. *Hexatoma* sp.	1	-	-	-	-	-	1	1	2	-	-	-
51. *Paradelphomyia* sp.	-	-	-	-	-	-	-	-	-	-	-	-
52. Tanypodinae (undet.)	-	-	-	-	-	-	-	-	-	1	-	-
53. *Corynoneura* sp.	-	-	-	-	-	-	-	-	-	-	1	-
54. Mollusca, empty shells	-	-	-	-	-	-	-	-	-	-	3	9
55. *Lymnae stagnalis*	-	-	-	-	-	-	-	-	-	1	-	-
56. *Pisidium* sp.	-	-	-	-	-	-	-	-	-	-	-	-
57. Turbellaria	-	3	-	-	-	-	-	-	-	-	-	-
Column Total	21	39	114	33	36	12	32	18	35	42	27	30
Total Number (N)	19	34	103	31	34	12	31	16	35	39	23	20
Diversity (H')	.47	0	.4	.82	.82	.74	.78	.79	.67	.78	.58	.51

APPENDIX IV BOTTOM FAUNA DATA AT MARBACO SAMPLING STATIONS - JUNE 24-25, 1981 (continued)

TAXONOMIC GROUP	STATION 5			STATION 6			STATION 7			STATION 9		
	5-1	5-2	5-3	6-1	6-2	6-3	7-1	7-2	7-3	9-1	9-2	9-3
1. *Tubifex* sp.	-	-	-	-	-	-	-	-	-	-	-	1
2. Enchytraeidae	1	-	-	-	-	-	-	-	-	-	-	1
3. *Eucyclops speratus*	-	-	-	-	-	-	-	-	-	-	-	-
4. Acari	-	-	-	-	-	-	-	-	-	-	-	-
5. *Alloperla* sp.	-	1	-	-	-	-	-	-	-	-	-	-
6. *Arcynopteryx* sp.	-	-	-	-	-	-	-	-	-	-	-	-
7. *Nemoura (Zapada)* sp.	-	-	-	-	-	-	-	-	-	-	-	-
8. *Prostola* sp.	-	-	-	-	-	-	-	-	-	-	-	-
9. *Cultus* sp.	-	-	-	-	-	-	-	-	-	-	-	-
10. *Diura* sp.	-	-	-	-	-	-	-	-	-	-	-	-
11. *Kogotus* sp.	-	-	-	-	-	-	-	-	-	-	-	-
12. *Ameletus* sp.	3	-	1	-	-	-	4	-	-	1	-	1
13. *Baetis* sp.	2	-	-	2	1	2	4	2	-	-	-	1
14. *Ephemerella levis*	-	-	-	-	-	-	-	-	-	1	-	-
15. *Emphemerella proserpina*	-	-	-	-	-	-	-	-	-	-	-	1
16. *Cinygmula* sp.	2	2	-	1	-	1	3	-	-	-	-	9
17. *Epeorus* sp.	-	-	-	-	-	-	-	-	-	-	-	-
18. *Rithrogena* sp.	-	-	-	-	-	-	-	-	-	-	-	-
19. *Siphlonurus* sp.	-	-	-	-	-	-	-	-	-	-	-	-
20. *Saldoida* sp.	-	-	-	-	-	-	-	-	-	-	-	-
21. Aphididae	-	-	-	-	2	-	-	-	-	-	-	-
22. Tricoptera, cases empty	-	-	-	-	-	-	2	-	-	-	-	-
23. *Brachycentrus* sp.	-	-	-	-	-	-	-	-	-	-	-	-
24. Limnephilidae, juveniles (undet.)	-	-	-	-	-	-	-	-	-	-	-	-
25. *Asynarchus* sp.	-	-	-	-	-	-	-	-	-	-	-	-
26. *Desmona* sp.	-	-	-	-	-	-	1	-	-	-	-	-
27. *Drusinus* sp.	-	-	-	-	-	-	-	-	-	-	-	-
28. *Halesochila taylori*	-	-	-	-	-	-	-	-	-	-	-	-
29. *Agapetus* sp.	-	-	-	-	-	-	-	-	-	-	-	-
30. *Rhyacophila tucula*	1	-	1	-	-	-	-	-	-	-	-	-

APPENDIX IV BOTTOM FAUNA DATA AT MARBACO SAMPLING STATIONS - JUNE 24-25, 1981 (continued)

TAXONOMIC GROUP	STATION 5			STATION 6			STATION 7			STATION 9		
	5-1	5-2	5-3	6-1	6-2	6-3	7-1	7-2	7-3	9-1	9-2	9-3
31. Lepidoptera, larva (undet.)	-	-	-	-	-	1	-	-	-	-	-	-
32. Haliplus sp.	-	-	-	-	-	-	-	-	-	-	-	1
33. Diptera, adult	-	-	-	1	-	-	1	-	-	-	-	-
34. Chironomidae, adults	-	-	-	-	9	-	-	-	-	-	1	-
35. Chironomidae, pupae	-	-	1	-	-	-	-	-	-	-	-	1
36. Cardiocladius sp.	-	-	-	-	-	-	-	-	-	-	-	-
37. Cricotopus sp.	-	-	-	-	-	-	-	-	-	-	-	-
38. Dicrotendipes sp.	-	-	-	-	-	-	-	-	-	-	-	-
39. Euklefferiella sp.	-	-	-	-	-	-	-	-	-	-	-	-
40. Heterotrissocladius sp.	-	1	-	1	-	3	-	-	1	-	-	-
41. Micropsectra sp.	-	-	-	-	-	12	1	1	-	-	-	1
42. Polypedilum sp.	-	-	-	-	-	-	-	-	-	-	-	2
43. Procladius sp.	-	-	-	-	-	1	-	-	-	1	-	-
44. Palpomyia sp.	-	-	-	-	-	-	-	-	-	-	-	-
45. Anopheles sp., pupa	-	-	-	-	-	-	-	-	-	-	-	-
46. Weldemannia sp.	-	-	-	-	-	-	-	3	-	-	-	-
47. Simuliidae, larvae (undet.)	-	-	-	-	-	-	-	-	-	-	-	-
48. Prosimulium onychodactylum pupa	-	-	-	-	-	-	-	-	-	-	-	-
49. Dicranota sp.	-	-	-	-	-	-	-	-	-	-	-	-
50. Hexatoma sp.	-	-	-	-	-	-	-	-	-	-	-	-
51. Paradelphomyia sp.	-	-	-	-	-	-	1	-	3	1	-	-
52. Tanypodinae (undet.)	-	-	-	-	-	-	-	-	-	-	-	-
53. Corynoneura sp.	-	-	-	-	-	-	-	-	-	-	-	-
54. Mollusca, empty shells	-	-	-	-	-	-	-	-	-	-	-	-
55. Lymnae stagnalis	-	-	-	-	-	-	-	-	-	-	-	-
56. Pisidium sp.	-	-	-	-	-	-	-	1	-	-	3	-
57. Turbellaria	-	-	-	-	-	-	-	-	-	-	-	-
Column Total	9	4	3	5	12	20	17	7	4	4	4	19
Total Number (N)	8	4	2	4	1	19	14	7	4	4	3	17
Diversity (H')	.57	.45	.3	.45	0	.49	.7	.55	.24	.60	0	.69