



**Water Characteristics of
The Upper Blackfoot River
with
Inactive Mine Workings**

MIKE HORSE, ANACONDA AND CARBONATE

R E P O R T

prepared by

Margarete Kalin

for

ASARCO (NORTHWESTERN EXPLORATION DIVISION)

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TABLE OF CONTENTS

Summary.....	i
List of Tables.....	iv
List of Figures.....	iv
List of Maps.....	v
List of Plates.....	vi
1.0 Introduction.....	1
2.0 Methods and Materials.....	3
2.1 Water sampling/analysis and sample locations siting.....	3
2.2 Site Description.....	4
2.2.1 The Drainage Basin of the Upper Blackfoot River.....	4
2.2.2 Geology and Mineralogy.....	7
2.2.3 Mining History.....	10
2.2.4 Waste Rock Tailings.....	13
3.0 Results and Discussions.....	15
3.1 Water Characteristics of the Upper Blackfoot River.....	15
3.2 Long term changes in water characteristics.....	37
4.0 Conclusions.....	46
5.0 Recommendations.....	48
6.0 References	52
7.0 Appendix	

SUMMARY

Several old mine workings exist in the Upper Blackfoot river where operations started in the late eighteenth century and ceased in 1964. There has been concern about the possibility of effluents from these abandoned workings and mining wastes adversely affecting the surface water quality of the Blackfoot river. Accordingly, an investigation of the characteristics of the effluents from the Carbonate tailings pond and the portals of the Mike Horse and Anaconda mines was carried out. The composition of the waters leaving these potential sources of contamination was compared to the water characteristics in the Blackfoot river below the discharge point of the abandoned workings.

It was discovered that although the ore of these mines and part of the wastes are pyritic, the effluent contains very little acidity (40 mg/l equivalent CaCO_3 in the Carbonate tailings pond; 60 mg/l equivalent CaCO_3 in the Anaconda portal). As a result of contact with country rock and highly alkaline waters in the drainage basin, all other waters sampled have alkalinity concentrations ranging from 32 to 98 mg/l CaCO_3 . The sulphate concentrations in the portal effluents correspond closely to those expected for calcium and magnesium sulphate solubilities. The very low concentrations of iron found suggest that active acid mine drainage is no longer affecting the effluents. Furthermore, there are indications that

no relationship exists between the characteristics of the mine effluents and the water in the Upper Blackfoot river below the abandoned mine workings. Elevated concentrations of zinc and manganese are evident in the water in the immediate vicinity of the portals of the Mike Horse, the Anaconda and the associated waste dump. Environmental degradation of the water is limited to about 0.8 miles of Mike Horse creek and Beartrap creek between the Mike Horse and the Anaconda.

Natural cleansing processes take place in this affected portion of the creeks through the growth of attached algae which absorb and fix precipitate emerging from the portals. The Carbonate tailings area is partially colonized by indigenous vegetation cover which provides protection from oxygen, thereby curtailing extensive acid generation.

If the aim is to improve the water quality of the Upper Blackfoot river, there is no justification for extensive reclamation measures, as any such activity could disturb the waste material. This may result in a new onset of acid generation which could adversely affect surface water quality. As well, earth moving activities may increase the suspended solids loading to the

Blackfoot river. Any consideration of reclamation measures for aesthetic purposes must carefully incorporate the promotion and maintenance of the natural biological cleansing mechanisms which are presently in place.

LIST OF TABLES

Table 1: Elements which are present generally in concentrations which are below the detection limit.....16

Table 2: pH, Conductivity, Temperature and Flow for 1984 and 1989.....38

Table 3: Cu, Zn, and Pb concentrations in water at point sources.....39

LIST OF FIGURES

Figure 1a: Upper Blackfoot Alkalinity.....21

Figure 1b: Upper Blackfoot Sulphate.....21

Figure 2a: Upper Blackfoot Dissolved Calcium.....24

Figure 2b: Upper Blackfoot Dissolved Magnesium.....24

Figure 2c: Upper Blackfoot Dissolved Ca/Mg.....25

Figure 3a: Upper Blackfoot Dissolved Potassium.....27

Figure 3b: Upper Blackfoot Dissolved Sodium.....27

Figure 3c: Upper Blackfoot Dissolved K/Na.....28

Figure 4a: Upper Blackfoot Dissolved Aluminum.....30

Figure 4b: Upper Blackfoot Dissolved Iron.....30

Figure 4c: Upper Blackfoot Dissolved Al/Fe.....31

Figure 5a: Upper Blackfoot Dissolved Manganese.....33

Figure 5b: Upper Blackfoot Dissolved Zinc.....33

Figure 5c: Upper Blackfoot Dissolved Mn/Zn.....34

LIST OF MAPS

Map 1: Schematic of the sampling
locations around Mike Horse creek.....17

Map 2: Schematic of the Anaconda
Tailings area and the Headwaters
of the Blackfoot river.....22

Map 3: Schematic of the Carbonate Mine
Tailings Pond29

LIST OF PLATES

Plate 1:	Mike Horse portal showing AMD seepage and Precipitation, Oct. 23, 1989.....	5
Plate 2:	Seepage from reclaimed tailings ponds, Oct. 23, 1989.....	5
Plate 3:	The junction of the Anaconda creek and Beartrap creek with precipitation Oct. 23, 1989.....	6
Plate 4:	Mike Horse creek at road to reclaimed tailings pond, Oct. 23, 1989.....	20
Plate 5:	Carbonate Mine tailing pond, view from Highway 200, Oct. 23, 1989.....	26
Plate 6:	View from the Anaconda portal in seepage direction, Oct. 23, 1989.....	35
Plate 7:	View of the Anaconda seepage and old portal from natural seepage retention area.....	36
Plate 8:	Precipitation formation in Anaconda portal with attached filamentous algae.....	40
Plate 9:	Precipitation from Mike Horse creek bed before Station B9 without attached algae.....	40
Plate 10:	Filamentous green algae attached to Mike Horse creek below Station B9.....	41
Plate 11:	Blue-green algal mats, Beartrap creek prior to being joined by the Anaconda.....	42
Plate 12:	Green filamentous algae virtually free of precipitate in the headwaters of Bearfoot river.....	43
Plate 13:	Wetland vegetation colonizing the moist carbonate tailings.....	44
Plate 14:	Natural polishing area below the Anaconda portal.....	45

1.0 INTRODUCTION

In 1987, the Upper Blackfoot River Stream Bank Reclamation Project, Lewis and Clark County, Montana, was declared a project with the highest ranking (total 57) by the Resource Indemnity Trust Grants Program (RIT) issued by the Montana Department of Natural Resources and Conservation. The rankings were based on combined sources of public benefit (23); technical merit (14), urgency (5) and financial assessment (5). It is believed that the basis for the ranking in a report associated with the State of Montana, being Invitation for Bid Section IV Page 1 - 25 Rev. 3/89. Section 4.1 of the same document, which provides a synopsis of the scope of the work of the reclamation project, reads as follows:

"The Blackfoot River Mine Reclamation Project consists of abandoned mill and mine sites approximately 3 miles southwest of Rogers Pass and 16 miles east of Lincoln, Montana. This project is assembled to eliminate hazards to health, safety and welfare, and human life; eliminate hazards to livestock and wildlife; eliminate the source of surface water pollution and sedimentation; and improve the aesthetics of the area. Access to the site is readily available via an adjacent state highway and country road."

The outline of hazards discussed in the reclamation project warrants attention, and one could logically conclude that the abandoned mine workings in the Upper Blackfoot River could pose major hazards. It is because of this possibility that ASARCO retained the services of Boojum Research Limited. This company specializes in Ecological Engineering and Biological Polishing, methods specifically designed to address environmental deterioration resulting from abandoned and inactive mining

disturbances. Boojum's mandate was to determine the extent, if any, of the environmental damage to the Blackfoot River from the effluent of inactive mine workings in its headwaters.

This report is confined to a strict assessment of the characteristics of the mine effluent and does not speak of any of the hazards to the safety and welfare of humans, livestock and wildlife. The various hazards defined in the reclamation program could be addressed once the nature or type of contaminant arising from the abandoned mine effluent has been ascertained.

During the site visit, water samples were collected, on-site measurements of pH and electrical conductivity were carried out, and flow estimates were derived from specific locations. As well, observations were made of the natural processes which may assist in amelioration of the water quality.

Section 2 of this report provides background information and explains in some detail, the methods used in the assessment. Section 3 presents the findings respecting water characteristics. Conclusions are drawn in Section 4, and the measures by which the natural rehabilitation of the disturbed areas could be enhanced are outlined in Section 5.

2.0 METHODS AND MATERIALS

2.1 Water sampling/analysis and sample locations siting

Water samples were collected in new PVC bottles supplied by ASARCO. The samples were stored and shipped in a cooler to the analytical laboratory of ASARCO in Salt Lake City, Utah. Fifteen (15) water samples were analyzed for dissolved metals, acidity or alkalinity, and sulphate concentrations. Precipitate with algae and precipitate formed as the water emerges in the adit of the Mike Horse were analyzed for metal content after wet oxidation. The analytical results submitted to Boojum Research Limited are presented in Appendix 1.

The sampling locations were identified from blueprint maps prepared by Delta Engineering, Great Falls, Montana. The maps found in this report have been reproduced from the same drawings, reduced by photocopy for ease of reference.

2.2 Site Description

2.2.1 The drainage basin of the Upper Blackfoot River

The watercourse addressed in this report is referred to as Mike Horse creek, Beartrap creek and Anaconda creek, which joins the headwaters of the Upper Blackfoot river. It is 2.5 miles long, spanning the distance from the Mike Horse portal at the head of the Mike Horse creek to Highway 200. Along this path are several very small mine workings (Edith and Mary P) which have not been considered in this investigation. These workings are insignificant in relation to those investigated, namely, Mike Horse, Anaconda and the Carbonate.

This investigation focused on the effluent emerging from the three latter workings flowing into the Upper Blackfoot river. Starting at the Mike Horse portal (Plate 1), the effluent joins Mike Horse creek which originates above the portal and runs along the valley where it is joined by a spring about 600 feet below the Mike Horse portal. As the creek runs further along past the base of the reclaimed tailings pond, a seepage stream from the tailings pond (Plate 2) enters Mike Horse creek. After this point, the creek is referred to as Beartrap creek.

Plate 1: Mike Horse portal showing AMD seepage and precipitate October 23, 1989 (Station 6, Map 1)

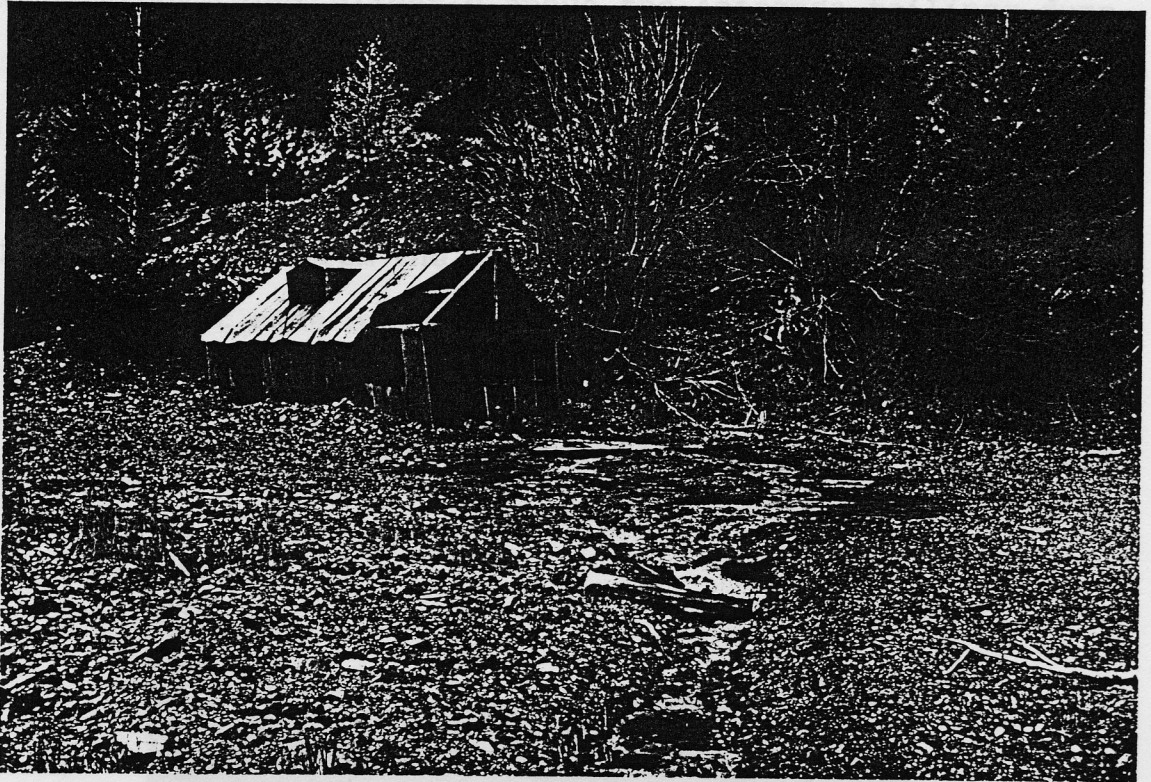


Plate 2: Seepage from reclaimed tailings ponds (Station 3, Map 1) October 23, 1989



About a mile below the Mike Horse portal, Beartrap creek is joined by Anaconda creek, just slightly above the Anaconda tailings dump (Plate 3). At this point in the drainage basin, Beartrap creek becomes the headwaters of the Blackfoot river which, prior to reaching Highway 200, is joined by the drainage of one unnamed gulch, Paymaster gulch from the east side, and Shave gulch and Pass creek from the west side of the valley.

Plate 3: The junction of Anaconda creek (clear) and Beartrap creek with precipitate, October 23, 1989 (Stations 10 and 12, Map 2)



At the Carbonate mine, located some short distance south on Highway 200, the east side of the Blackfoot river receives drainage from the Meadow creek and Porcupine gulch. On the west side, drainage from Swamp gulch enters the Blackfoot river drainage basin, draining through part of the Carbonate dump.

2.2.2 Geology and Mineralogy

The geology of the Heddleston District is described based on reference No. 2 pp. 89 - 108, and reference No. 3, pp. 31 - 36.

The oldest rocks in the district are the argillite (usually referred to as slate) and quartzite or sandstone. These rocks probably overlay the Helena Limestone formation and dip gently northward. They have been intruded by a sheet or sill of diorite about 500 feet thick. The diorite consists mainly of ferromagnesium minerals and feldspars. The ore bodies in the district occur in the diorite or argillite, and are associated with later intrusions of granodiorite or trachyte.

Ore deposits in the district are mostly breccia, (fractured rock), in which replacement has occurred. The deposits are in fairly regular vein-like or tabular forms. The valuable ores occur as definite shoots within the veins and are usually steep dipping, less than six feet wide and 100 feet or more in length. Zinc, lead

and silver occur in all the deposits. Small amounts of copper are found in most of the mines. Sulphide minerals in the deposits include pyrite, galena, spalerite, tetrahedrite, bornite, and chalcopyrite. In localized areas, pyrite may constitute 50% of the vein.

Specific reference is made to the Mike Horse Mine, where the main vein is a fracture filling within the walls of diorite and argillite. Next to the vein, the wall rocks are more or less impregnated with pyrite. In addition, the diorite is partly changed to an aggregate of quartz and sericite, and in the porphyry, the feldspars are largely replaced by sericite. Locally at least, the argillite or slate has been silicified. The Little Nell vein occurs in a grey porphyry. On the footwall of the vein, sulphides appear to have replaced the porphyry. The remainder of the vein consists of mixed carbonate of a later generation.

Less detail is given for the Anaconda, where the country rocks are argillite, diorite, and granodiorite porphyry. The vein has the structure of a filled breccia in which the component minerals have partly replaced the fragments of altered country rock. The ore zone contains galena, spalerite, pyrite, bornite, minor arsenopyrite, and a mixed carbonate that ranges from pure calcite

to rhodochrosite. The carbonate is reported to comprise a rather large party of the lode.

Little information is available respecting the geology of the workings of the Carbonate and what there is refers only to the fact that the workings are located in diorite.

2.2.3 Mining History

There are numerous pits and underground workings in the area. Former operations of possible environmental concern include the Mike Horse, the Carbonate and the Anaconda mines. The most active operations in the district were at the Mike Horse mine.

Mike Horse: Mining activity in the area dates from the late 1880's but was restricted for some time by the lack of transportation facilities.

In the early operations, ore was shipped directly to the smelter at East Helena. Payment was received for the lead and precious metals. Zinc occurred with the lead but was considered a nuisance at the time. Production was reported at the Mike Horse mine in 1915 and 1917. In 1919 a small mill employing concentration was built and it operated intermittently until 1926. In the most productive years, 1923 and 1924, smelter returns show that about 1200 tons of concentrate and direct shipping ore were received (Reference 1).

Miller ² reported the following sequence of events between 1930 and 1964:

- 1930 Early in the year the mine was purchased by the Sterling Mining Company and was operated successfully by that company until 1938.
- 1938 Property was leased to the Mike Horse Mining and Milling Company. Development continued.
- 1939 A 150 ton flotation mill was constructed. Operations were sustained on ore from three veins.
- 1945 At mid-year, American Smelting and Refining (AS & R) purchased the operation.
- 1955 Mine was shut down due to declining metal prices.
- 1958 The Rogers Mining Company leased the mine from AS & R and operated the property intermittently until early 1964.
- 1964 Productive operations ceased.

Three separate veins were mined. The Mike Horse, the main vein, was worked on six levels and laterally for approximately 2000 feet to a depth of 1000 feet below the surface. The two smaller veins mined were the Little Nell and Intermediate veins.

According to Pardee, J.T. and Schrader, F.C. (1933)¹ the underground workings included 3 adits spaced through a vertical range of about 300 feet, and three crosscuts to the ore zones. At the lowest level, No. 3, the Little Nell was intersected at 700 feet from the portal, the Intermediate, at 950 feet and the Mike Horse at 1,140 feet.

Production data are somewhat incomplete. In the period 1941 - 1952, the USBM reported that silver, copper, lead and zinc were produced from milling 592,000 tons of ore containing 2.4 oz./t of silver, 0.36% copper, 4.1% lead and 2.9% zinc. Tailings from this mining period would amount to approximately 530,000 tons.

If the mill operated at the design rate of 150 tons per day during this period, the mill feed tonnage indicates that the plant operated, on average, 90% of the time.

The flotation mill operated for a total of approximately 22 years. Production data are not available for the 10 years not included in the period referred to above. However, if it is assumed that the plant operated at the same average rate for these 10 years as for the other period, total production of tailings would have amounted to approximately 970,000 tons. In fact, the total tailings is probably less than this because production in the period 1958 - 1964 was reported to be limited.

The tailings deposit was reduce by an estimated 100,00 tons due to a breach which occurred in the dam in 1975.⁴ Therefore, the present tailings, impounded now, in all probability amount to something less than 870,000 tons.

The Anaconda: The Anaconda mine was rather extensively developed beginning about 1901. Total production between 1919 and 1948 was reported to amount to 1,1661 tons of ore.² The development workings included a shaft at the foot of a slope, tunnel 1 at the shaft level, tunnel 2 at a level about 200 feet higher and an older caved shaft and adit. The newer shaft was said to be 325 feet deep with the drifts at different levels that aggregate 1,700 feet in length. Tunnel 1 was said to be 900 feet long and tunnel 2 at least 500 feet long. In 1926, the workings below the shaft collar were under water.

The workings at Carbonate mine consisted of an adit and a shaft. The shaft, approximately 300 feet deep was intersected by the adit 110 feet below the collar. Levels were driven from the 200 - 300 foot levels.¹ Stopes in the mine, as well as a nearby tailings pond, indicate that there was some production. Production statistics are not available.

2.2.4 Waste Rock tailings

In the original Mike Horse mill, the ore was concentrated by gravity methods which means that essentially, all the sulphides, including pyrite, reported to the concentrate. The tailings

therefore would have contained minor concentrations of sulphides and limited, if any, acid producing potential. The mill which operated from 1939 employed flotation, in which case, all the pyrite was effectively rejected to the tailings. As a result, these tailings may generate acid. Geological reports indicate significant amounts of carbonate in the ore which would also report in the tailings. To what extent the carbonate will neutralize acid generated from the pyrite cannot be estimated from the records.

Mine rock waste piles may generate acid because pyrite mineralization extends beyond the boundaries of the ore zones. Since many of the rock piles are small and have been in place for many years, acid generation, even if it occurred initially, may well have ceased.

That acid mine drainage activity has decreased substantially can be inferred from comparing conditions in 1926 with the present. In 1926, when Pardee and Schrader visited the Anaconda mine they reported that acid mine water in Tunnel 1 had almost completely dissolved the rails of the car tracks. The effluent from the same workings in 1989 contained a very low level of acid, amounting only to 60 mg/l as CaCO_3 equivalent. After six decades, acid generation can be considered to have ceased.

3.0 RESULTS AND DISCUSSION

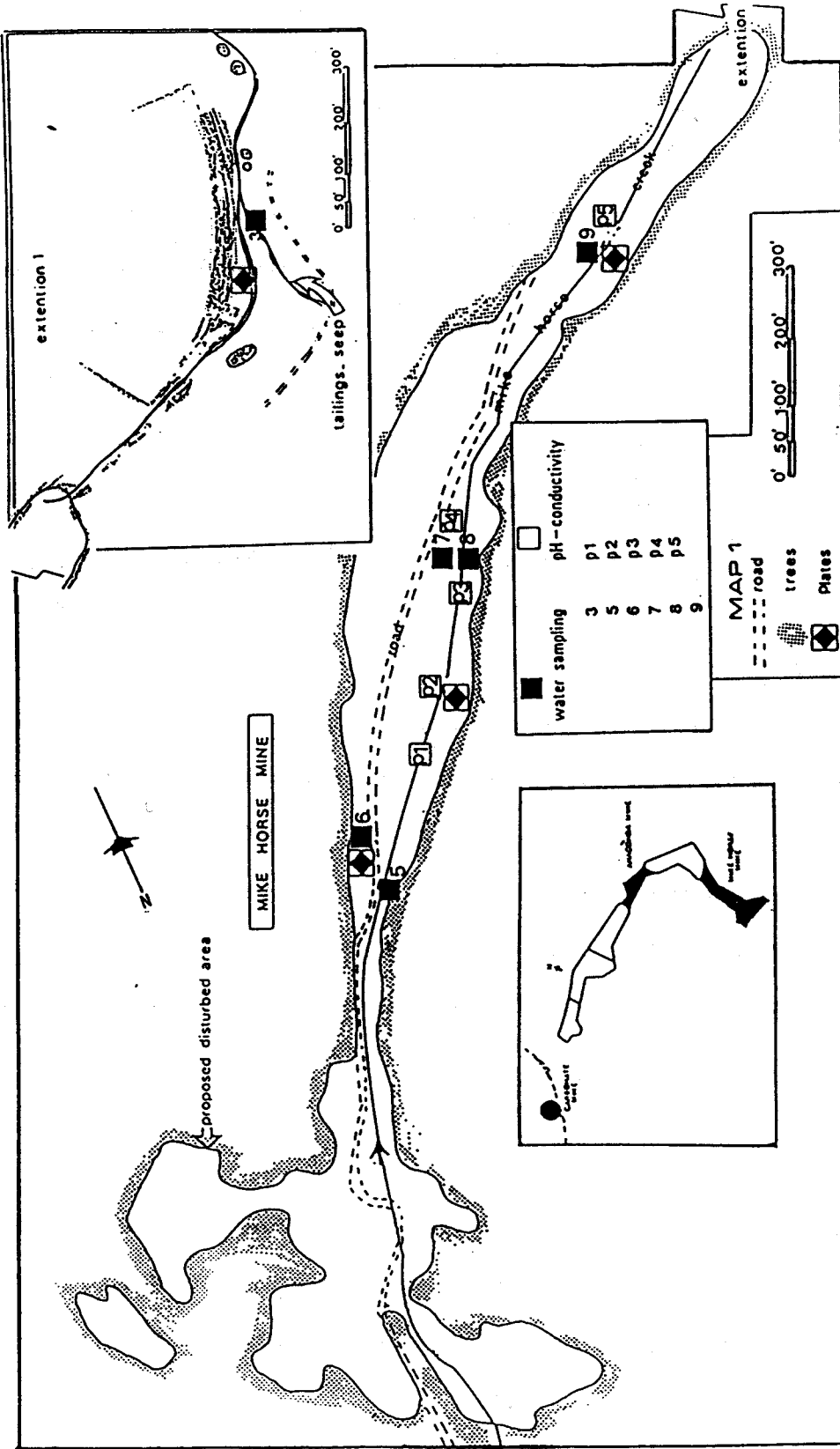
3.1 Water Characteristics in the Upper Blackfoot River

In Table 1, the concentrations of those elements which were present at low concentration (at or below the analytical detection limit) are presented. They are arranged in order of sampling station, i.e. starting above the Mike Horse portal (B5) and following downstream, sampling each time at a location where new contamination could enter or dilution of the existing concentration could occur. The sampling stations are given in Map 1 for the Mike Horse area, Map 2 for the Anaconda area and Map 3 for the Carbonate are respectively.

From an examination of Table 1, it is evident that the concentrations of silver, arsenic, beryllium, chromium, antimony, selenium, titanium, and vanadium are all below the detection limit of <0.017 mg/l in all locations at which water was collected. The same holds true for the metal lead which has a concentration of <0.017 mg/l in all waters, with the exception of the water from the Anaconda portal, which is slightly higher than the detection limit, with a concentration of 0.02 mg/l. The concentrations of these elements are lower than can be determined with the analytical method used.

ELEMENTS AT DETECTION OR BACKGROUND LEVEL mg/l		Ag	As	Ba	Be	Cd	Co	Cr	Cu	Ni	Pb	Sb	Se	Tl	V
185	Clean Headwater Mike Horse Mine	< 0.017	< 0.017	0.081	< 0.017	0.015	< 0.017	< 0.017	0.056	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
186	Mike Horse Portal	< 0.017	< 0.017	< 0.017	< 0.017	0.03	0.075	< 0.017	< 0.017	< 0.12	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
187	Clean Stream entering Mike Horse Min	< 0.017	< 0.017	0.03	< 0.017	0.047	< 0.017	< 0.017	0.069	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
188	Mike Horse Stream at Spring	< 0.017	< 0.017	< 0.017	< 0.017	0.031	0.068	< 0.017	0.017	0.1	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
189	Mike Horse Stream combined at road	< 0.017	< 0.017	0.024	< 0.017	0.031	0.042	< 0.017	< 0.017	< 0.065	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
190	Tailings Reservoir Seep	< 0.017	< 0.017	0.12	< 0.017	< 0.003	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
191	Blackfoot at Anaconda (Bearttrap)	< 0.017	< 0.017	0.2	< 0.017	< 0.003	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
192	Bearttrap. Old Mike Horse	< 0.017	< 0.017	0.055	< 0.017	0.008	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
193	Base of Anaconda Creek	< 0.017	< 0.017	0.27	< 0.017	< 0.003	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
194	Anaconda Portal	< 0.017	< 0.017	0.025	< 0.017	0.013	0.059	< 0.017	1.1	0.022	0.02	< 0.017	< 0.017	< 0.017	< 0.017
195	Blackfoot River at Audit # 3	< 0.017	< 0.01	0.17	< 0.017	0.003	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.01	< 0.017	< 0.017	< 0.017
196	Carbonate Tailings Pond	< 0.017	< 0.017	0.056	< 0.017	0.005	< 0.017	< 0.017	0.23	< 0.017	0.022	< 0.017	< 0.017	< 0.017	< 0.017
197	Carbonate Inflow	< 0.017	< 0.017	0.097	< 0.017	< 0.003	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
198	At Mike Horse Road Turnoff	< 0.017	< 0.017	0.19	< 0.017	< 0.003	< 0.017	< 0.017	< 0.017	0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017
199	Blackfoot River Final	< 0.017	< 0.017	0.099	< 0.017	< 0.003	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017	< 0.017

Table 1: The elements which are present generally below the detection limit of <0.017 mg/l



Map 1: Schematics of the sampling locations around Mike Horse creek

In the drainage basin, the concentration of barium ranges from <0.017 mg/l to 0.09 mg/l, which is a low concentration for surface water. Such low concentrations can be expected, as barium is precipitated naturally in the presence of carbonate and sulphate ions, both of which are present in the Blackfoot drainage basin. The concentrations of cadmium are also very low, ranging from <0.003 mg/l to 0.03 mg/l at all stations. These concentrations are below those concentration levels at which possible environmental effects could be considered. At all sampling stations, with the exception of the water leaving the Mike Horse workings and the Anaconda portal, the water has concentrations of <0.017 mg/l. Although the slightly elevated concentrations in the water emerging from the underground workings are to be expected, the concentrations in the Blackfoot river are lower than <0.017 mg/l, which is probably due to the fact that cobalt is co-precipitated or absorbed immediately as the water oxidizes and the precipitate is formed. Cobalt is an essential trace nutrient required for optimal growth and reproduction in both plants and animals, and may therefore be utilized by the existing aquatic flora and fauna in the river.

The concentrations of copper and nickel in the water samples from Upper Blackfoot river show the same distribution as for cobalt, in that concentrations slightly higher than the detection limit of

<0.017 mg/l are determined in the water leaving the mine workings at Mike Horse and Anaconda and in the water of the Carbonate tailings pond. Again, this would be expected due to the mineralization in the mine workings. In the water below Mike Horse portal, both these metals are slightly elevated above the detection limit of <0.017 mg/l, ranging from 0.069 mg/l to 1.1 mg/l for copper, and 0.1 mg/l for nickel. However, the concentrations in the river (which is the water course to be protected from the metals which are known to affect aquatic life), are below the analytical detection limit used. It should be noted that, compared to effluents from other base metal wastes, the concentrations in water emerging from these portals are extremely low, reflecting the low solubility of the mineral from the workings, the extremely mild acid generating conditions in the area, and possibly the passage of time since these workings were active.

In Figure 1a, the alkalinity for all water samples (determined as mg/l equivalent to CaCO_3) is presented in decreasing order of concentration. It can be noted that the alkalinity is present in all water samples, with the exception of water from station B13 and B1. B13 is the water emerging from the Anaconda portal (Map 2), and B1 is the water located in the Carbonate tailings pond. These waters contained a mild acidity (B1 40mg/l CaCO_3 , and B13, 60 mg/l CaCO_3). No acidity is emerging from the Mike Horse portal,

Station B6, Map 1. Alkalinity is the lowest at Station B9 (Map 1, Plate 4). At this point, the water has not reached Blackfoot river. The seepage from the tailings area (Station B3, Plate 2), carries the highest concentrations of alkalinity, followed by Stations B11, B10 and B12 (Map 2, Plate 3, sampling stations located around the Anaconda.

Plate 4: Mike Horse creek road to reclaimed tailings pond
October 23, 1989 (Station 9, Map 1)



Figure 1b: US

Figure 1a: Upper Blackfoot Alkalinity

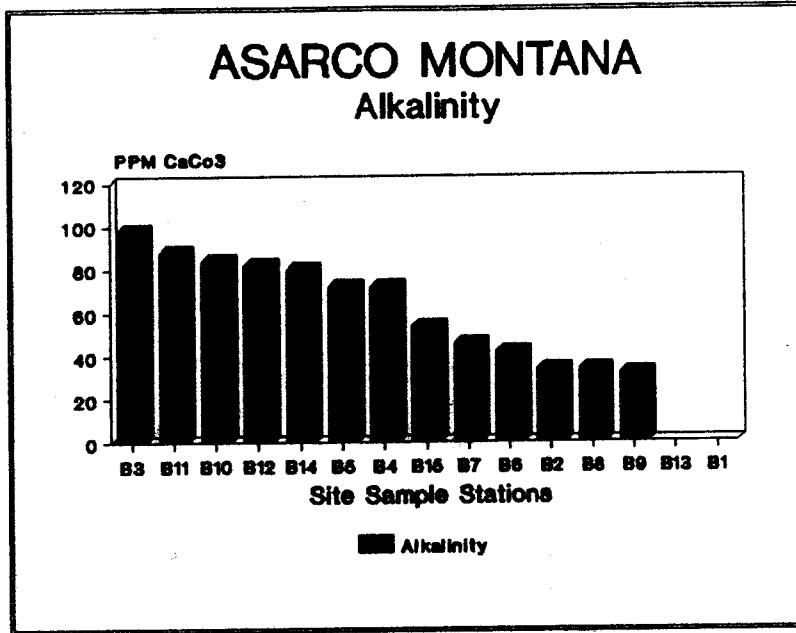
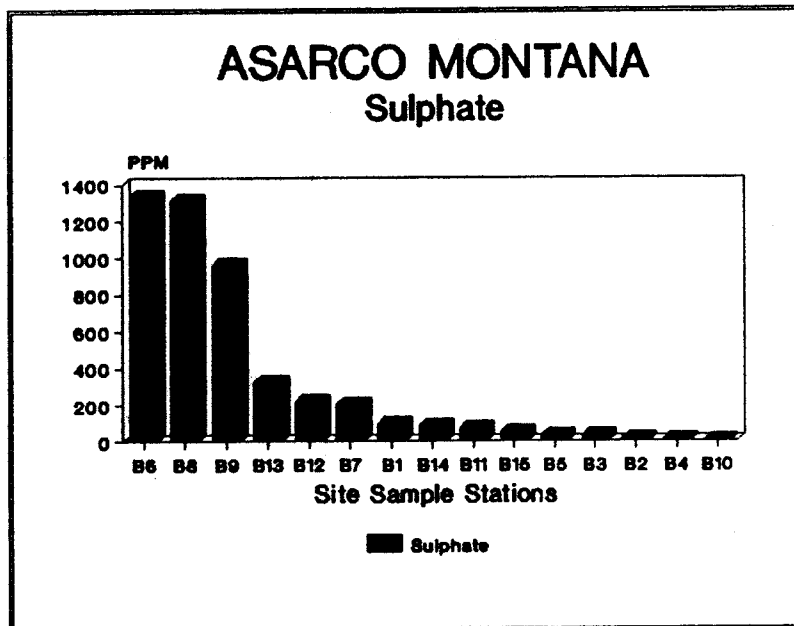
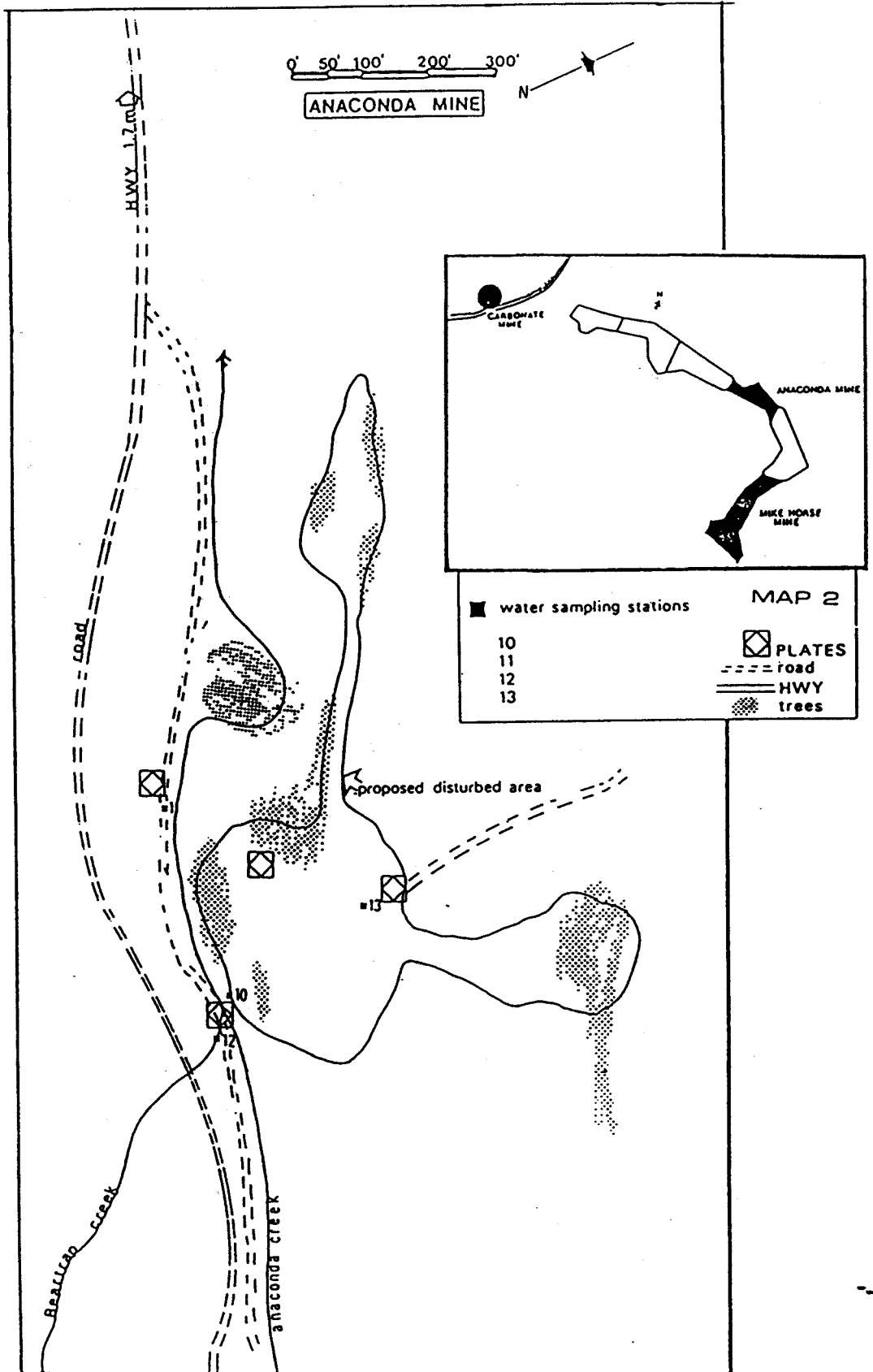


Figure 1b: Upper Blackfoot Sulphates



Map 2: Schematic of Anaconda tailings area and the headwaters of the Blackfoot river



Given the presence of these high concentrations of alkalinity in the headwaters to the Blackfoot river, it is clear that the acid mine drainage from the portals effluent is not a factor which could be detrimental to Blackfoot river.

In Figure 1b, the concentrations of sulphate in the water are presented in decreasing order of presence. The sulphate concentrations at Stations B6, B8 and B9 (Map 1, Plates 1 and 4) do not relate stoichiometrically to the extremely low iron concentrations (all < 0.017 mg/l) in the same samples (Figure 4b). Therefore, the sulphates, given the alkalinity in the waters, are likely occurring predominantly in the form of calcium sulphate or magnesium sulphate. (Calcium sulphate is slightly soluble. It precipitates as gypsum [$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$] above a gypsum concentration of 2,000 mg/l. This corresponds to a sulphate level of 1,120 ppm which is the same order as the total sulphate levels measured in the samples.)

In Figures 2a and 2b, the concentrations of calcium and magnesium are presented in the same manner as in Figures 1a and b. It is evident that the same Stations (B6, B8 and B9) which exhibited high concentrations of sulphate also have high concentrations of bivalent elements. Calcium and magnesium are non-toxic components of surface water, but they determine the hardness of the water.

Figure 2a: Upper Blackfoot Calcium

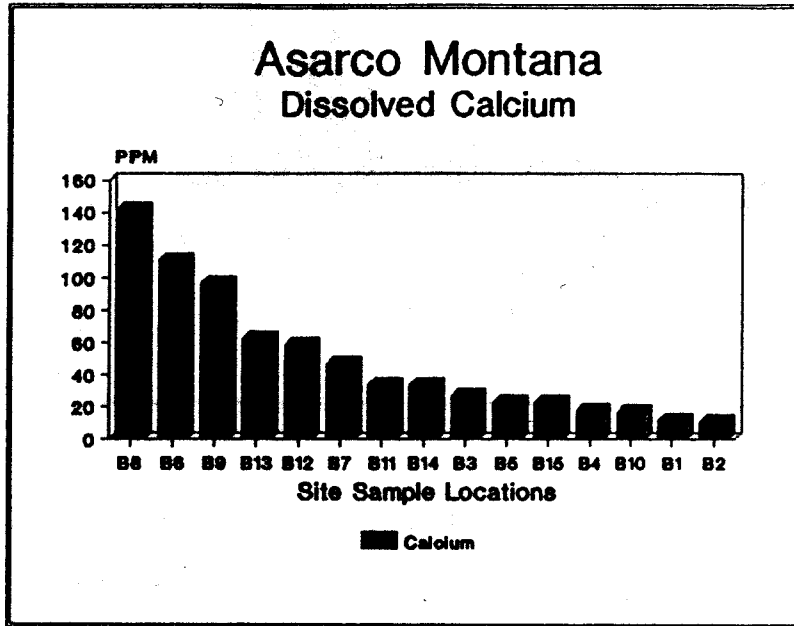


Figure 2b: Upper Blackfoot Magnesium

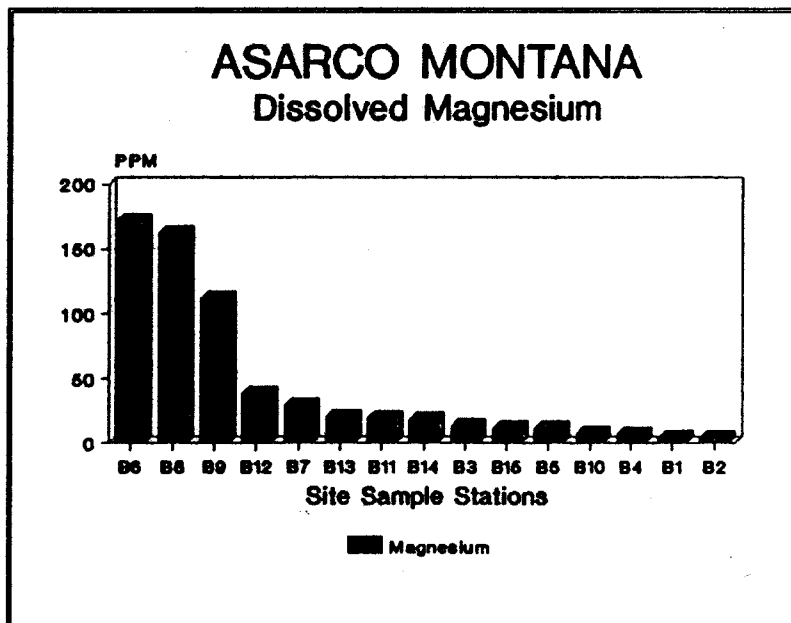
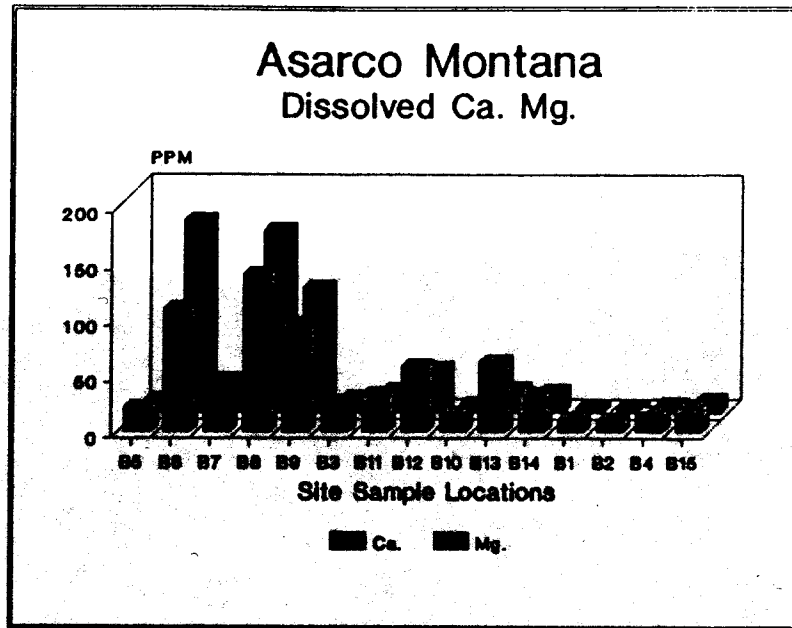
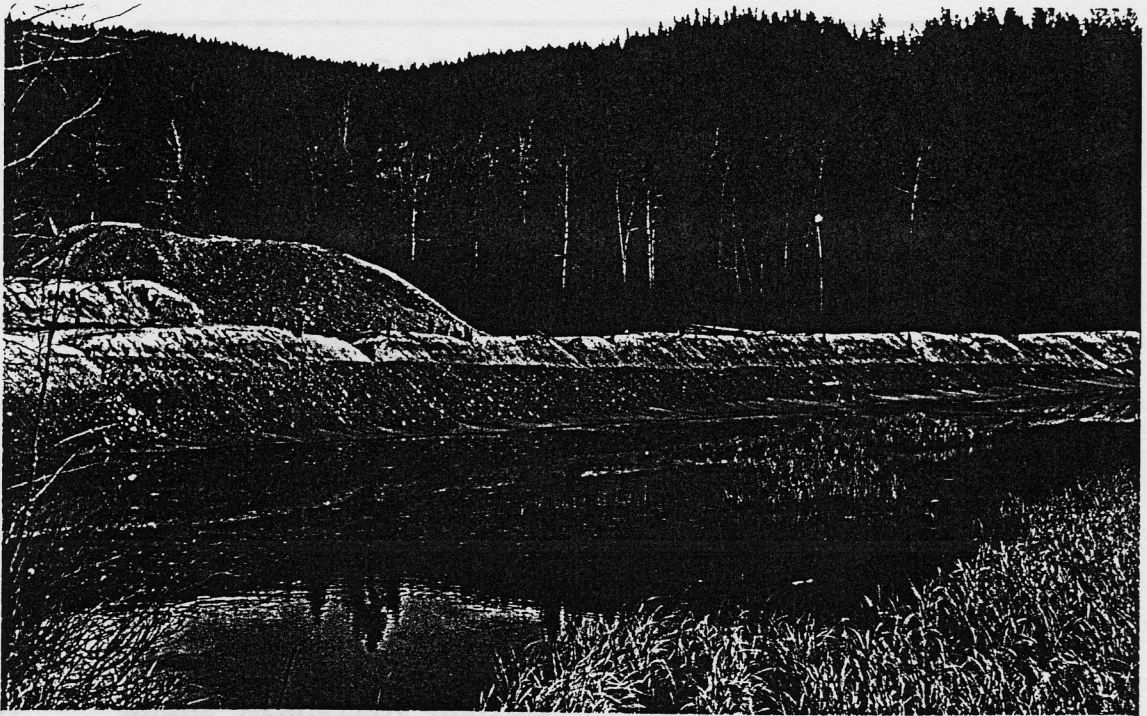


Figure 2c: Upper Blackfoot Calcium/ Magnesium



If the calcium and magnesium concentrations are arranged in order of the watercourse (Figure 2c), it is apparent that the background concentrations in the drainage basin are generally at or below 50mg/l for both elements. Somewhat harder water emerges from the Mike Horse, with concentrations ranging from 111 to 172 mg/l. In general, these concentrations are well within the range of water with relatively low hardness. Other normal constituents of the water, such as potassium and sodium are present in the water samples, and their concentrations are presented in Figures 3a and 3b. Potassium displays slightly higher concentrations in water emerging from the Mike Horse tunnel and sodium concentrations are somewhat higher in the Carbonate area (Samples B1, B2 and B4, Map 3, Plate 5). Both these elements reflect concentration ranges of normal background water, which for potassium range from 0.5 to 10 mg/l, and for sodium 2 to 100 mg/l (Allen et al., 1974).

Plate 5: Carbonate mine tailings pond, view from highway 200, October 23, 1989 (Station 1, Map 1)



Aluminum and iron can be detrimental to water quality. Their concentrations are presented in Figures 4a and 4b in decreasing order. Two locations can be identified as having somewhat elevated concentrations, i.e. the Carbonate tailings pond, and the Anaconda portal.

Most water samples have very low concentrations, well within natural freshwater ranges. For iron, those are 0.05 mg/l to 1 mg/l, and for aluminum 0.1 to 2 mg/l (Allen et al., 1975).

Figure 3a: Upper Blackfoot Potassium

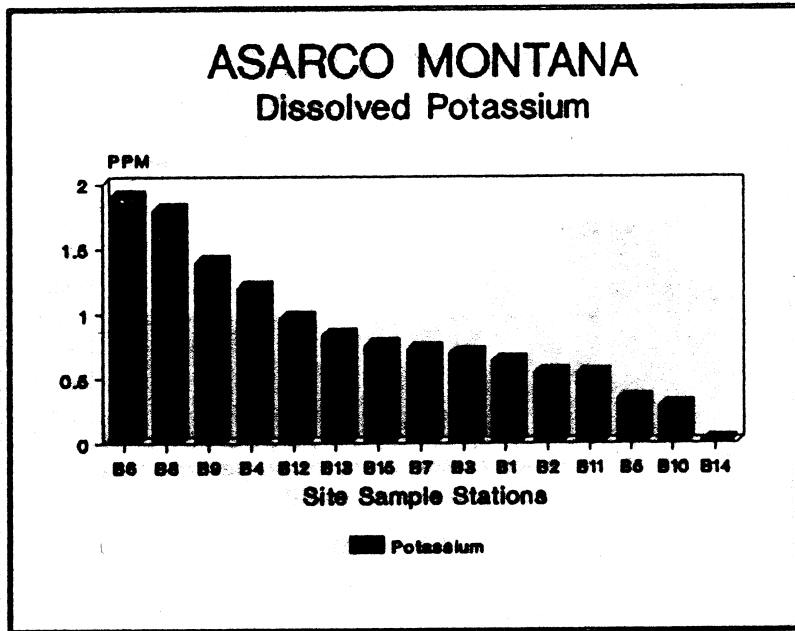


Figure 3b: Upper Blackfoot Sodium

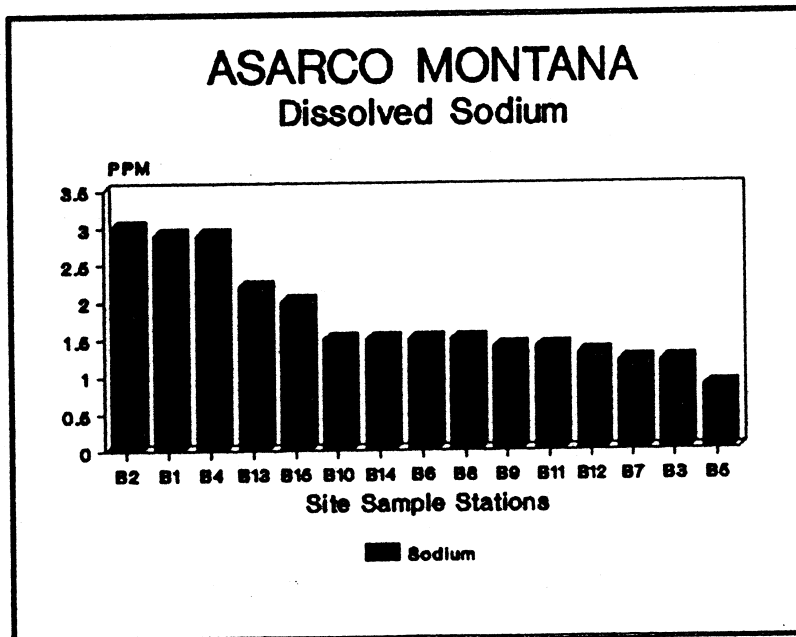
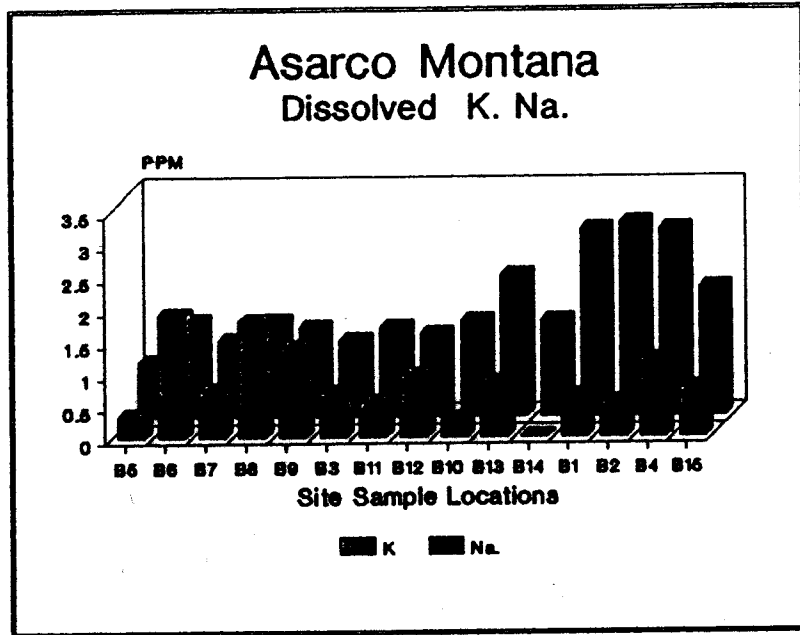
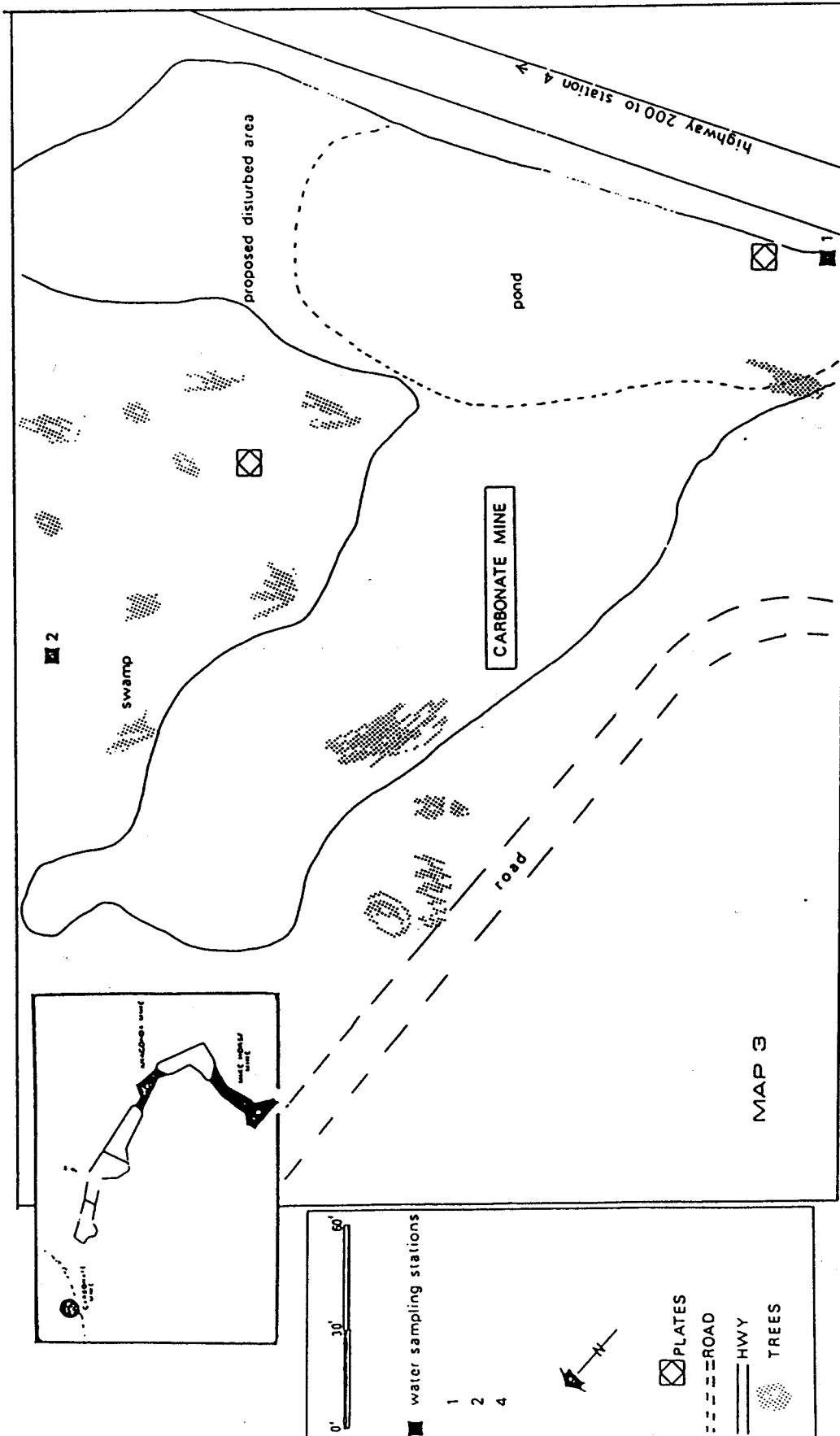


Figure 3c: Upper Blackfoot Potassium/Sodium





Map 3: Carbonate Mine

Figure 4a: Upper Blackfoot Aluminum

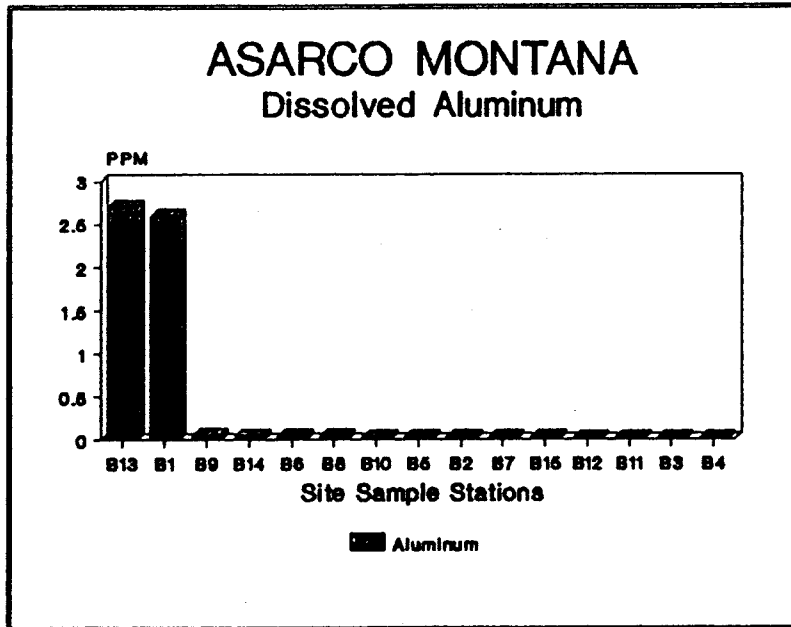


Figure 4b: Upper Blackfoot Iron

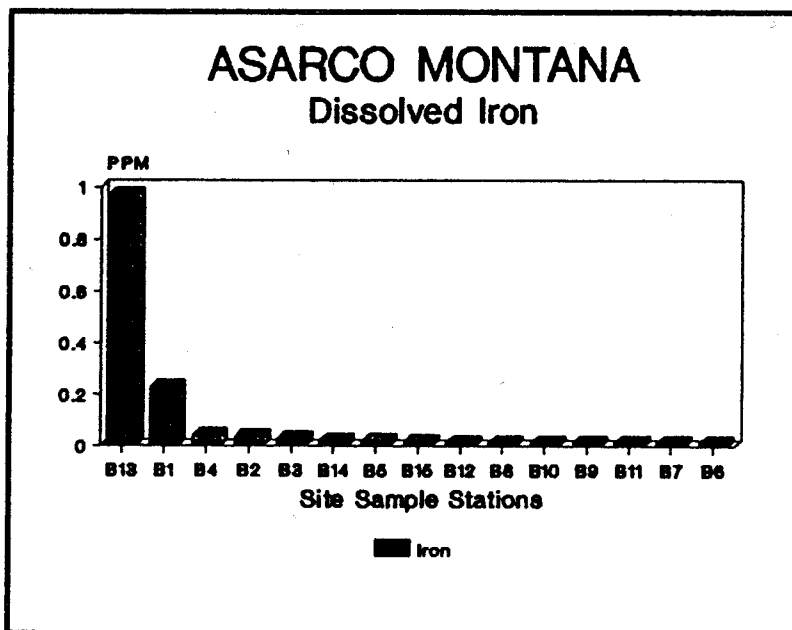
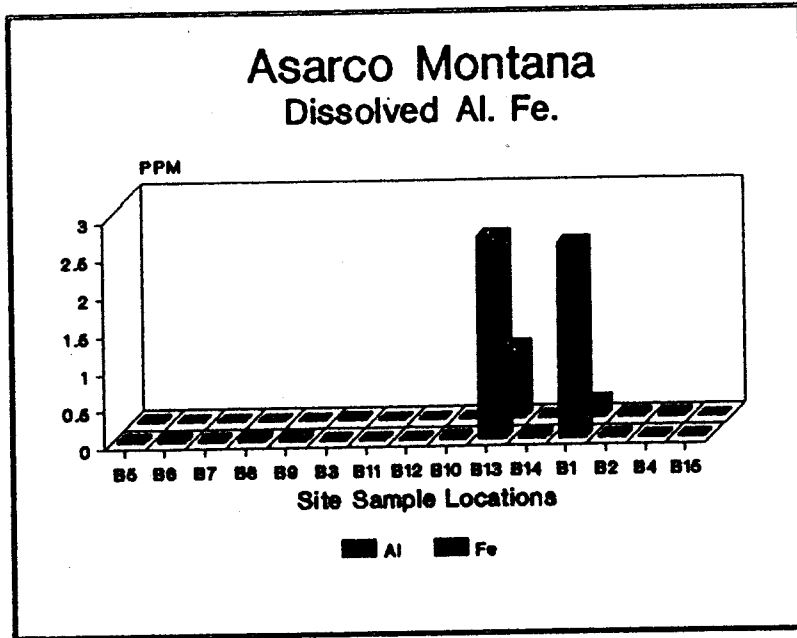


Figure 4c: Upper Blackfoot Aluminum/Iron



In figure 4c, where concentrations are arranged according to sampling stations, namely the Carbonate tailings pond and the Anaconda portal, effluents have somewhat elevated concentrations, as can be expected. However, these elements precipitate within close proximity to the sampling locations.

In Figures 5a and 5b, the concentrations of zinc and manganese are presented in the same fashion as all the other elements. In the upper part of Mike Horse creek (Stations B6, B8 and B9) and in Beartrap creek (Station B12), the concentrations of both these metals are above the natural ranges for freshwater. The concentrations of manganese are elevated, however, for water quality evaluations the zinc concentrations are of concern. In Figure 5c, the concentrations are arranged with respect to locations along the water course, and it is clear that the point source for both metals is the Mike Horse effluent (B6 42 mg/l) and to a significantly lesser degree, the Anaconda portal effluent (B13 2.5 mg/l). Comparatively insignificant concentrations emerge from the Carbonate tailings pond with 0.77 mg/l (B1). The lowest zinc concentrations are determined in the waters from stations B10, B3, B4 and B2. They range from 0.049 to 0.019 mg/l and represent seep from the tailings dam, the Anaconda creek, water at the turn off from Highway 200 to Mike Horse road, and the water entering the

Carbonate tailings pond. All other waters display elevated concentrations of zinc, as can be expected from a mineralized area such as the Upper Blackfoot.

Figure 5a: Upper Blackfoot Manganese

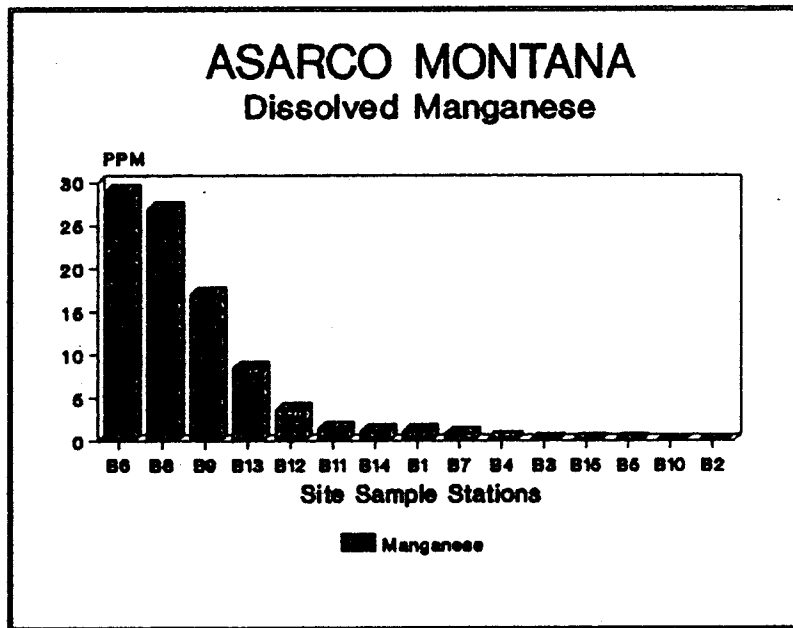


Figure 5b: Upper Blackfoot Zinc

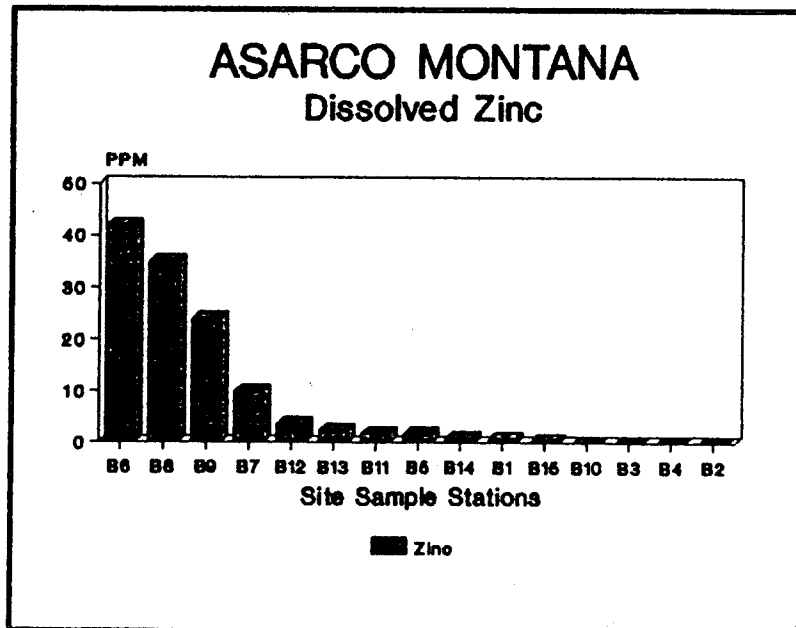
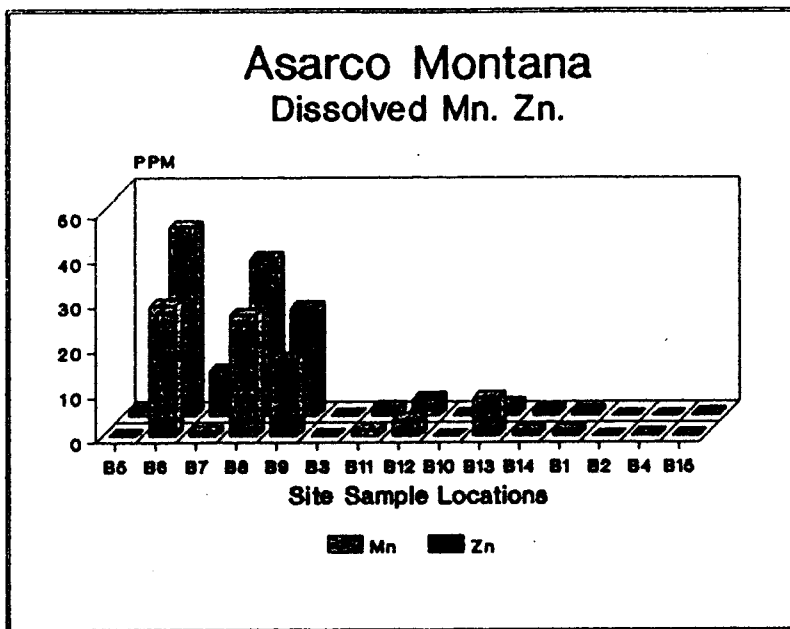


Figure 5c: Upper Blackfoot Manganese/Zinc



Although the concentrations emerging from the Mike Horse portal represent a significant portion of the zinc loading to the surface water, the water above the portal (B5) and below the portal emerging from a spring (B7) are also elevated. It could be argued that, by plugging the portal of the Mike Horse, a considerable improvement of the water quality with respect to zinc could be achieved. However, given that the portal represents the lower of three adits, and that water emerges below the portal with considerable concentrations of zinc (B7 10 mg/l), plugging the portal flow will not remove the natural elevated levels of zinc, due to the mineralization of the area. The water is likely to emerge at other points in the area with unpredictable concentrations of zinc.

From this evaluation of the water quality in the Upper Blackfoot river, it is evident that the uppermost portion of the Mike Horse creek and Beartrap creek, as well as a small area into which the Anaconda effluent drains (Plate 6 and 7, Station 13, Map 2), can be considered to be affected mainly by zinc due to the mineralization of the area. The abandoned Mike Horse portal provides a point discharge. However, without the abandoned mine working, elevated zinc concentrations can be expected in this area, as the mining activities of the past have enhanced the natural elevated background.

Plate 6: View from the Anaconda portal in seepage direction October 23, 1989 (Station 13, Map 2)

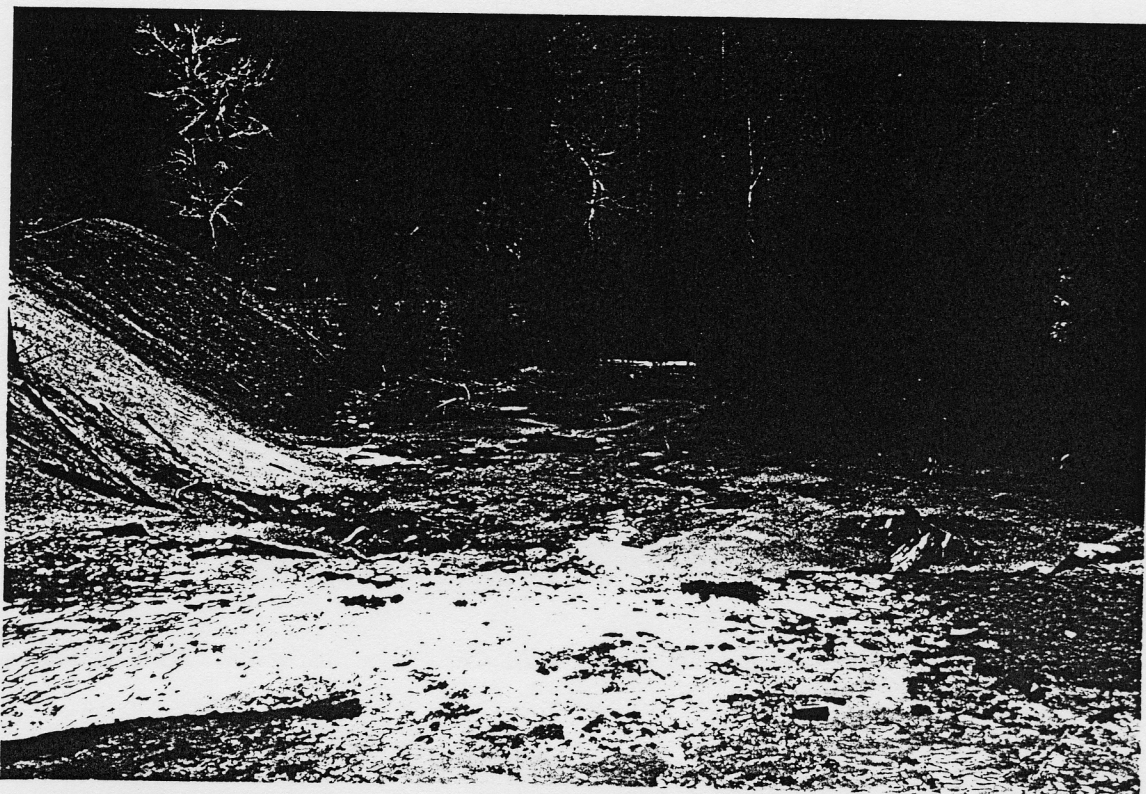
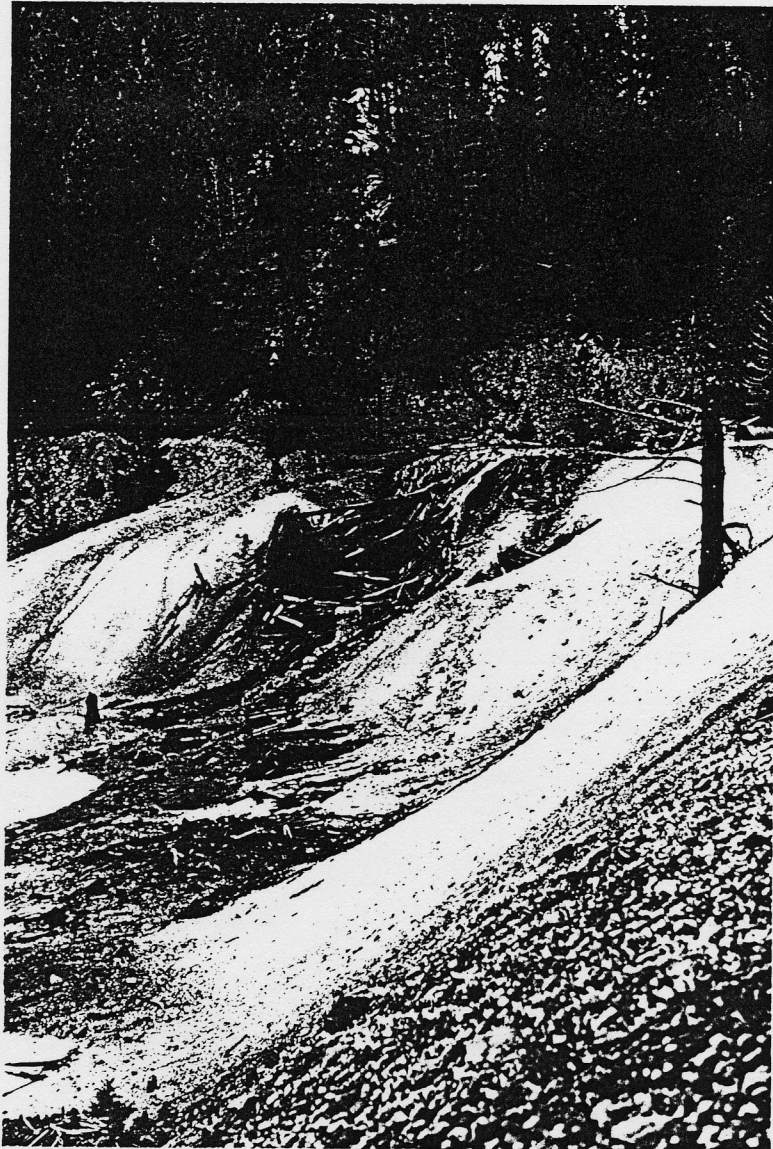


Plate 7: View of the Anaconda seepage and old portal from natural seepage retention area, October 23, 1989



3.2 Long term changes in water characteristics

In Table 2, the values of pH, electrical conductivity, temperature and flow estimates determined in 1984 and 1989 are presented. A comparison of these parameters in the drainage basin indicates that no significant changes with respect to these parameters has taken place over the last 5 years.

The only location with a depressed pH is the Carbonate tailings pond (Station B1, Map 3). As would be expected, the waters with acidifiers from the Mike Horse and Anaconda portals, are somewhat reactive, as indicated by decreases in pH, when the field measurements are compared to those values determined on arrival in the laboratory, as acidification does occur as water leaves both portals. This results in precipitation of iron hydroxide indicated by the brown coating in the creek bed (Plates 8 and 9). However, most of this process (oxidation and thus precipitate formation) likely occurs at some point in the workings.

Considering the flow estimates for the Mike Horse creek between Stations B6 (Mike Horse portal) and B9 (Mike Horse creek at the road to the reclaimed tailings pond), the volume of surface water measured in the stream channel has decreased by about 40 gal/min.

	pH		Lab pH		Cond		Temp		Flow	
	1984	1989	1989	1989	1984	1989	1984	1989	1984	1989
1	Upgradient of Mike Horse Mine along spring	7.79			115		6.5		25	
B5	Clean Headwater Mike Horse Mine		6.95	7.4		130		8		
2	Mike Horse Mine Tunnel	6.37			1050		7		70	
B6	Mike Horse Portal		6.5	5.8		1500		7		65
3	Down Gradient of Mike Horse Mine along spr	7.27			700		6.5		95	
B7	Clean Stream entering Mike Horse Mine		5.71	6.2		320		12		29
B8	Mike Horse Stream at Spring		5.8	6.4		1400		9		42
B9	Mike Horse Stream combined at road		6.3	6.6		1000		8		30
4	Tailings Reservoir Seep	7.61			270		10		80	
B3	Tailings Reservoir Seep		7.23	7.7		180		12		
5	Base of Beartrap Creek	7.29			260		6.8		200	
B11	Blackfoot at Anaconda (Beartrap)		8.18	7.9		200		7		
B12	Beartrap, Old Mike Horse		8.72	7.9		380		9		
6	Base of Anaconda Creek	7.86			103		6.9		70	
B10	Base of Anaconda Creek			7.9						
7	Anaconda Mine Tunnel	3.14			750		6.1		1.5	
B13	Anaconda Portal		5.87	3.2		420		8		
8	Blackfoot River at Road Crossing	7.57			220		4.5		300	
B14	Blackfoot River at Audit # 3		7.15	7.1		212		8		
9	Edith Mine Tunnel									
10	Blackfoot River at Edith Mine Location	7.51			175		4.8		300	
11	Upgradient of Paymaster Mine	3.66			128		7		50	
12	Paymaster Mine Tunnel									
13	Downgradient of Paymaster Mine Tunnel	3.46			145		7.5		55	
14	Carbonate Mine Tailings Pond	4.06			220		3		<1	
B1	Carbonate Tailings Pond		3.57	3.4		130		3		176
B2	Carbonate inflow		4.53	6.3		40		20		
15	Blackfoot River at Porcupine Gulch	6.97			165		8		500	
B4	At Mike Horse Road Turnoff		6.87	7.1		100		8		
B15	Blackfoot River Final		7.45	7.8		140		6.5		

Table 2: pH, Conductivity, Temperature and Flow for 1984 and 1989.

Although the quantity of surface water which will seep into the ground will vary over the season it is generally reasonable to expect, in general, that a decrease of the volume of surface water occurs as the country rock is very porous. This suggests that an unknown quantity of water emerging from the Mike Horse portal leaves the surface and does not enter the Upper Blackfoot river directly. The metals in the ground water will likely be attenuated in the bedrock or overburden. The concentrations of Cu, Zn, Fe, and Mg are reported in Table 3 for 1984 and 1989 for the portals of the Mike Horse, the Anaconda, and the Carbonate tailings pond. It is assumed that the 1984 values do represent dissolved metal concentrations. The concentrations of all elements have decreased in the past 5 years with the exception of Zn in the Mike Horse effluent.

Table 3: Cu, Zn, Fe and Pb concentrations in water at the point source

TABLE 3	Mike Horse Portal		Anaconda Portal		Carbonate	
	1984	1989	1984	1989	1984	1989
Copper mg/l	0.019	< 0.017	6.3	1.1	0.47	0.23
Zinc mg/l	43	42	6.7	2.5	1.4	0.77
Iron mg/l	27	< 0.017	37	0.97	17	0.23
Lead mg/l	0.03	< 0.017	0.13	0.02	0.3	0.022

Plate 8: Precipitate formation in the Anaconda portal with attached filamentous algae, October 23, 1989 (Station 13, Map 2)

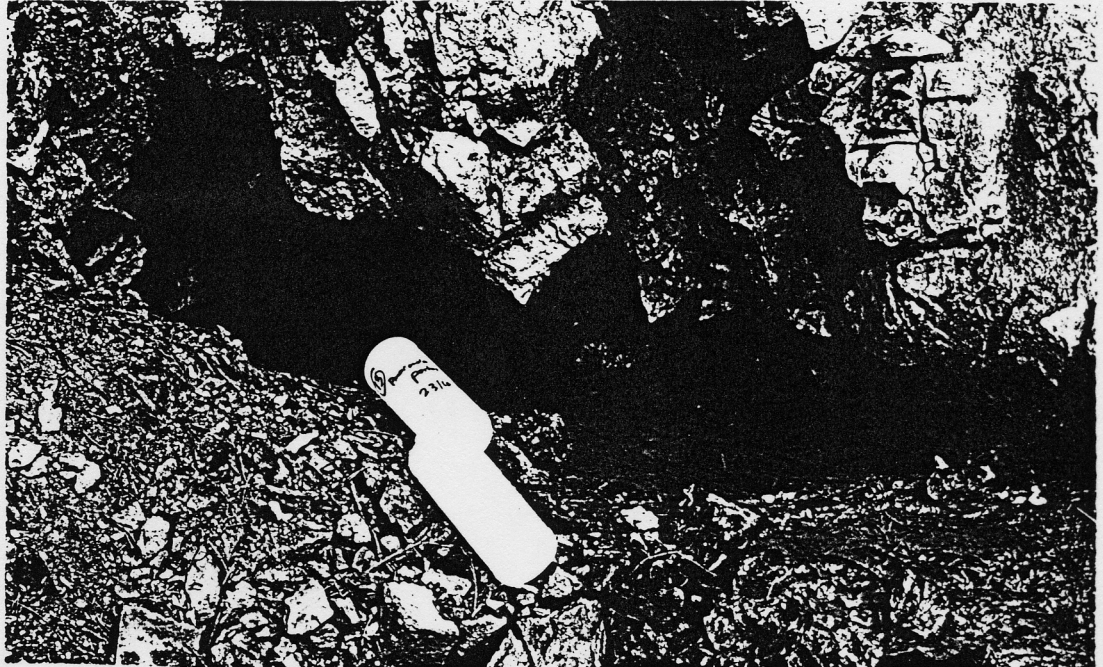
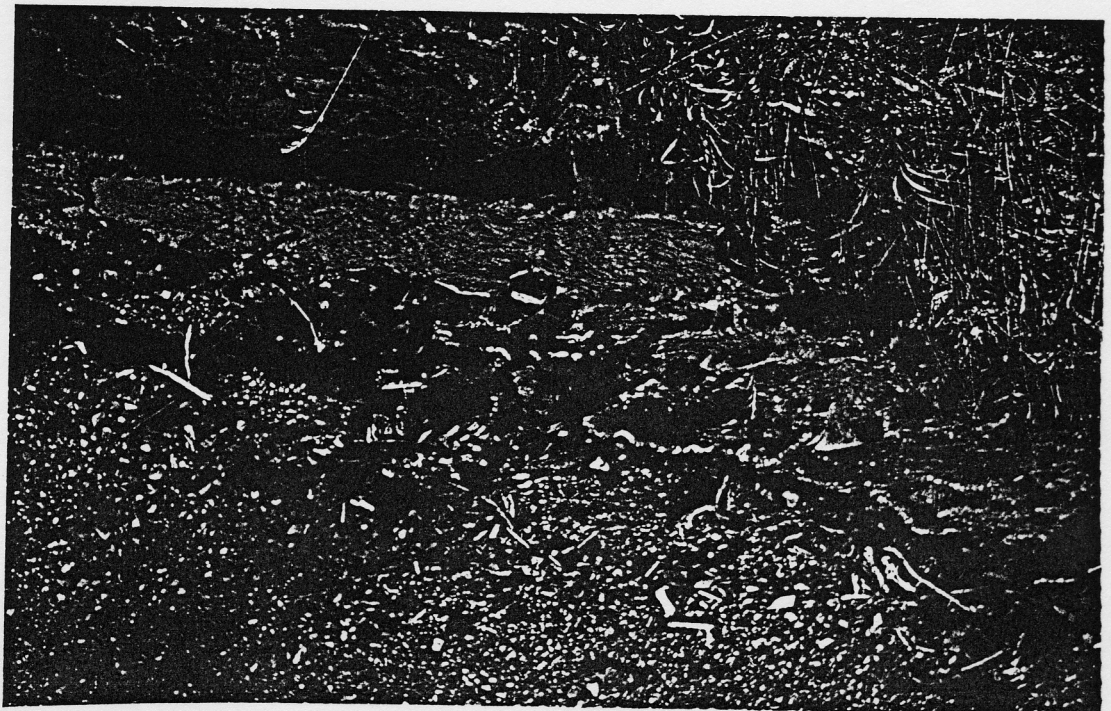


Plate 9: Precipitate formation in the Mike Horse creek bed before Station B9 without attached algae, October 23, 1989. (Around Monitoring Station P4. Map 1)

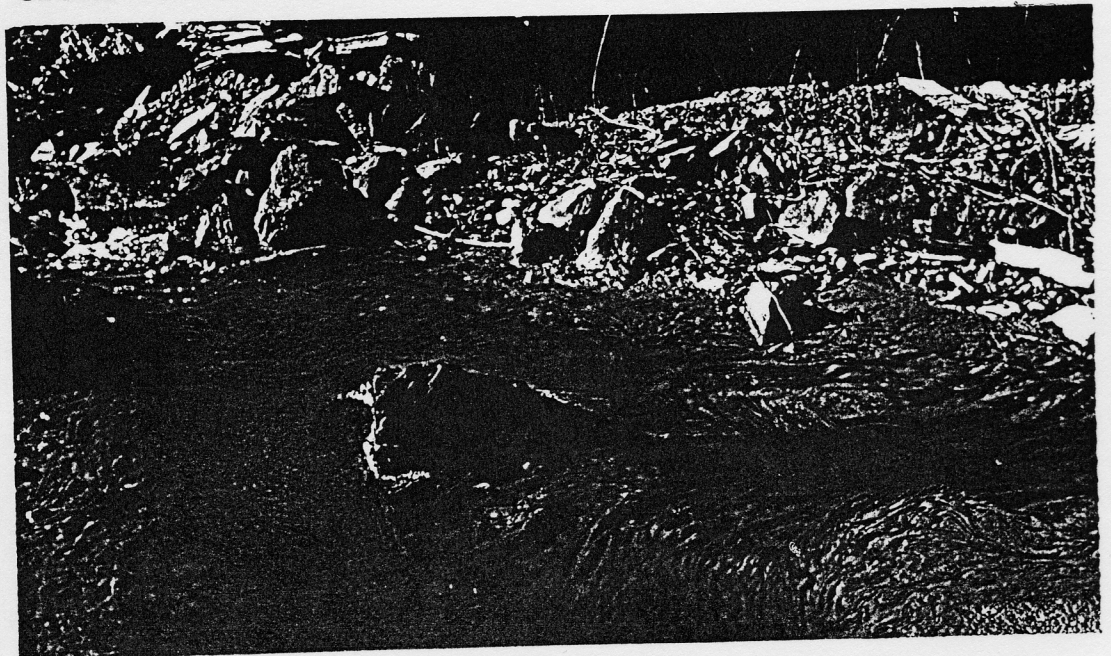


Such decreases in the metal concentrations with time from the inactive portals and the Carbonate tailings can be expected. The weathering process will ultimately remove all the metals from the tailings and the unmined ore. This suggests that in the long term, even lower concentrations will be released.

3.3 Natural amelioration processes

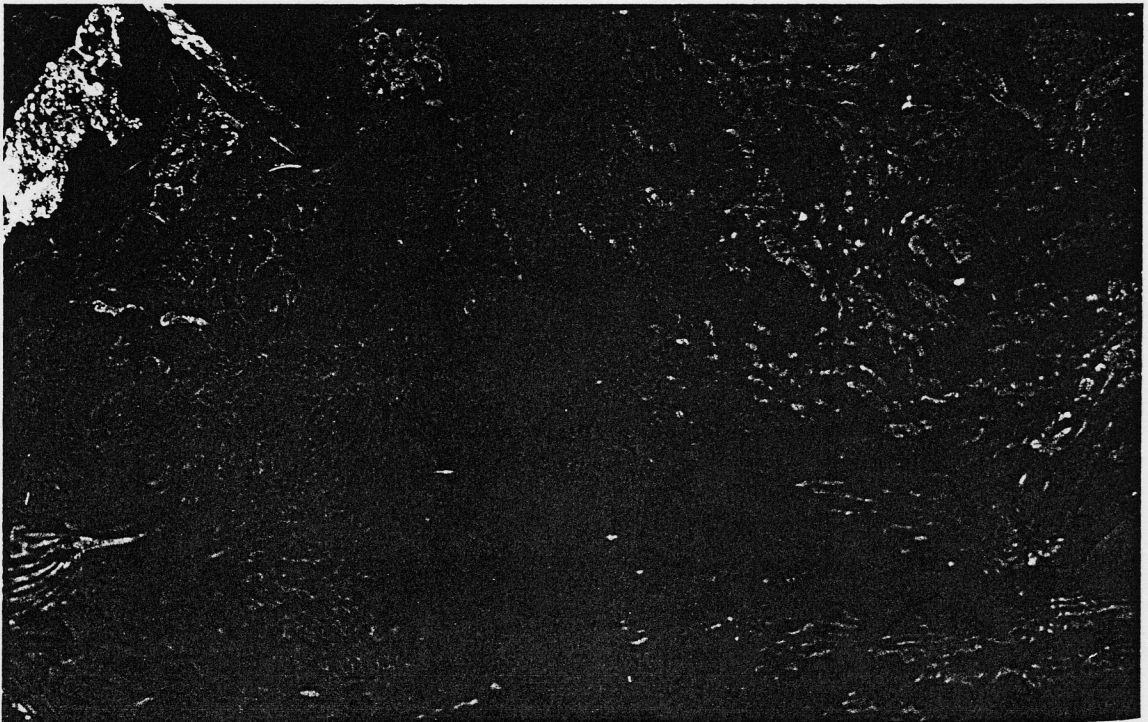
Although the Mike Horse and Anaconda portals, with their emerging seepage, are point sources of Zn and Mn, a natural filtration and fixation process occurs in the contaminated seepage streams, immediately as the effluent emerges from the portals. In Plate 10, the algal mats growing in the Mike Horse creek, just below Station B9, are depicted. This material was collected for the determination of elemental composition as well as precipitate from the Mike Horse portal without algae.

Plate 10: Filamentous algae attached to rock in Mike Horse creek below Station B9



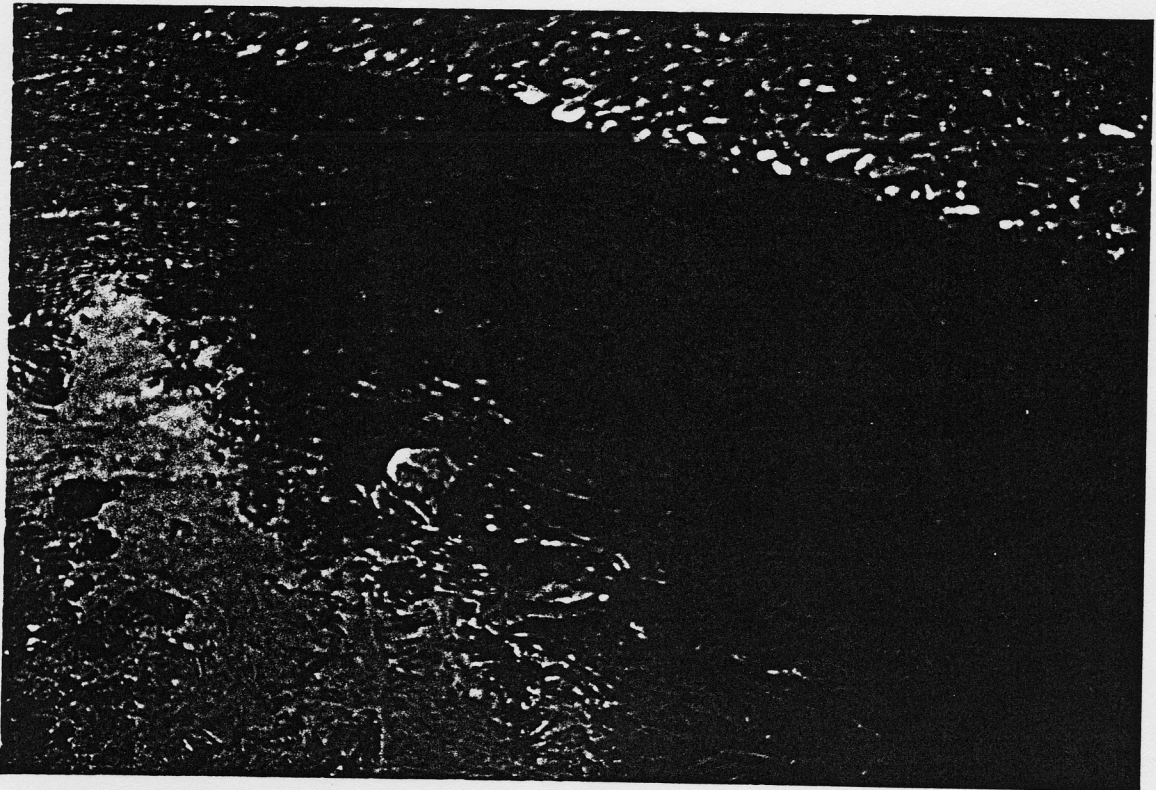
The concentrations of zinc and iron in the precipitate with the algae were 6.5% and 27% respectively. These concentrations compare to the precipitate without the algal growth at 1.4% Zinc and 42% Iron. Manganese concentrations in the precipitate with algae are also higher (0.37%) than in the precipitate settling in the tunnel of the Mike Horse portal (0.17%). These figures indicate that indeed natural polishing or cleansing of the water occurs through the growth of the attached algae. As the concentrations of zinc decrease below station B9 and precipitate is washed along the creek bed, the creek bed is colonized by a different type of algae. A blue-green algal mat fixes the precipitate forming a mat over the creek bed, thereby preventing downstream movement of precipitate. Such blue-green algal mats were observed in Beartrap creek and are depicted in Plate 11.

Plate 11: Blue-green algal mats in Beartrap creek prior to being joined by Anaconda creek



Further down stream these types of algal mats are no longer prevalent in the creek bed, green algae reappear and grow virtually free of precipitate, as depicted in Plate 12.

Plate 12: Green filamentous algae, virtually free of precipitate in the headwaters of the Bearfoot river, October 23, 1989 (Station 11, Map 2)

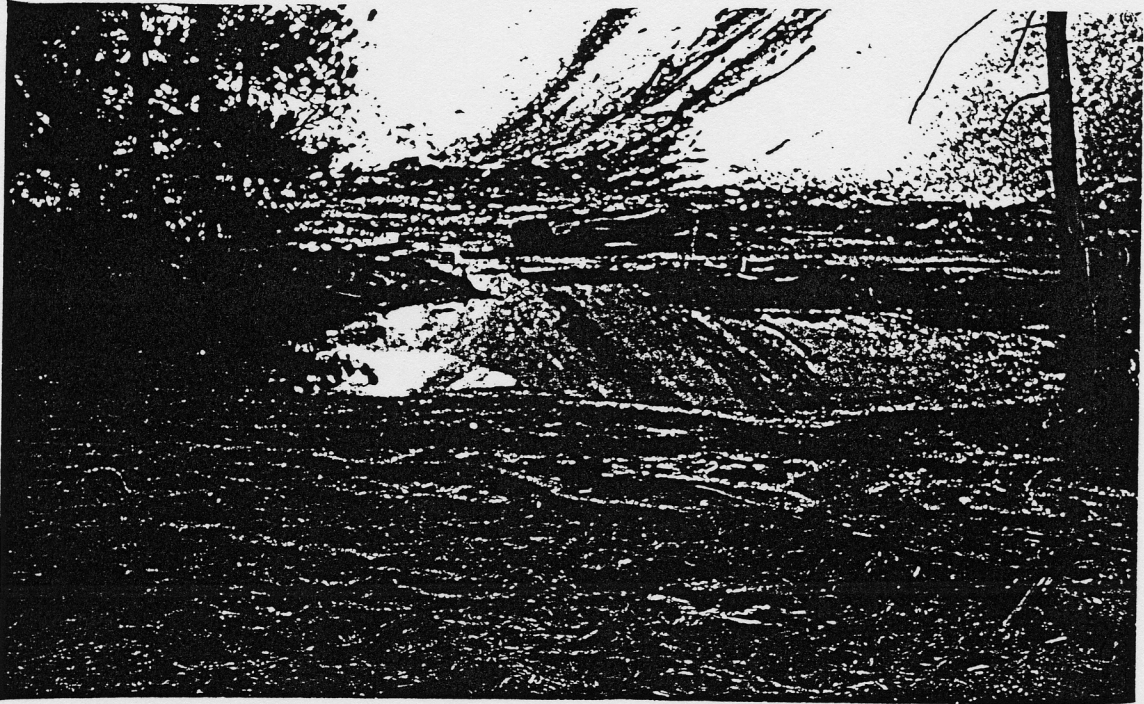


The seepage from the Anaconda workings disappears in a natural depression below the workings and the tailings waste rock dump (Plate 14). The area is covered with an extensive growth of moss serving as a filtration/absorption cover for precipitate and metals.

Plate 13: Wetland vegetation colonizing the moist carbonate tailings



Plate 14: Natural Polishing area below the Anaconda portal



As different algal types colonize Mike Horse and Beartrap creek beds and thereby remove some elements from the water, a similar natural biological process occurs through semi-terrestrial vegetation on the Carbonate tailings (Map 3). Here the tailings which receive water from the Swamp gulch are extensively colonized with shrubs, sedges and rushes (Plate 13). The tailings, excavated below the vegetation cover, showed no sign of oxidation. The vegetation cover provides a seal over the tailings, curtailing oxidation and erosion. It is generally believed that a wetland vegetation cover over tailings will curtail acid generation. This occurs due to reduction of oxygen penetrating into the tailings material, increased evaporation of water and absorption of metals (Kalin and van Everdingen, 1988).

4.0 CONCLUSIONS

It can be concluded that the effluent from the Mike Horse portal affects the water quality in the short section of Mike Horse creek, between Mike Horse portal and the entrance of the seep from the reclaimed tailings pond. Below this section of the creek, natural polishing processes with indigenous algal species provide sinks for the main element of concern, namely zinc.

The contribution from the Carbonate tailings pond can be considered insignificant since the loading is comparatively low. Furthermore natural cleansing of this water will occur in the swamp into which the tailings pond effluent drains. This will result immediately in precipitation of metals, and the acidity is neutralized before it reaches the Blackfoot river. The only element elevated at Station B15, taken 1.3 miles below the Carbonate tailings, is zinc. This information is derived from the data in Figures 1c to 5c, where the concentrations of all elements are arranged in sequence of the sampling stations from the sources above Mike Horse portal to below the Carbonate tailings pond in Upper Blackfoot river (B15).

Although the concentration of this metal is significantly lower in the Upper Blackfoot river than closeby in the vicinity of the Mike

Horse creek, this metal is still present at concentrations which could be detrimental to aquatic life. In mineralized areas, such elevations frequently occur, and the responses of indigenous populations of fauna and flora cannot be addressed with the available data base. Specific toxicity evaluations would have to be carried out.

From the data assessed in this report, it could not be concluded that the only source of zinc to the Upper Blackfoot river is the abandoned mine workings. Other sources may well be present in the mineralized areas of the Upper Blackfoot river but to date they have not been identified.

5.0 RECOMMENDATIONS

Maps 1, 2 and 3 used in this report are part of the reclamation measures proposed by Delta Engineering and they provide outlines of "disturbed areas". The outlines of these areas have been reproduced to provide a perspective for on site inspection. When on site in this magnificent valley, the outlined disturbed areas are not immediately apparent. Although an effort was made to determine technical/scientific criteria for the definition of the boundaries of "disturbed areas" as presented in the maps of the reclamation project, no such criteria could be identified.

If abandoned mine workings are considered part of the history or heritage of the area, they may add to the appeal of the valley. On the other hand, if they are viewed as eyesores and thus declared disturbed areas, it would be reasonable to consider disturbance from construction of highways in the same light. An evaluation of the aesthetic standards of a countryside is not the subject of this investigation.

As the water characteristics emerging from the old mine workings are only partially related to those in the Upper Blackfoot river below the workings, reclamation of the mine workings is not justified until zinc toxicity has been demonstrated and all natural

sources of zinc in the headwaters are identified. At present there is insufficient evidence that the mine workings are the sole sources of the hazards outlined in the Reclamation project report. It should be recognized however, that any activity with respect to the old mine workings could indeed produce conditions which would further add to the zinc loading at the Upper Blackfoot river in the short term. Reclamation would involve major earth moving activities, which could expose tailings and waste rock to further oxidation and hence acid generation.

It is recommended that if any reclamation activity respecting the mine workings is undertaken, that the detrimental impacts to the river due to potential increased or renewed acid generation from the waste materials to be reclaimed, and increased suspended solids loadings from landscaping activities are recognized possibilities. The inactive mine workings with their waste dumps show virtually no signs of erosion on the present surfaces. Acid generation appears to have significantly subsided since mining operation ceased, and this is clear from the operating records where severe acid generation was reported (for example, in the Anaconda workings, details, Section 2.2.3).

Erosion could be enhanced due to disturbance of the surfaces and this in turn would disturb the naturally established recovery

system which has been described, being algal growth and moss and vegetation covers for precipitate and metals. In fact, these processes are utilized in Ecological Engineering and Biological Polishing methods. These water treatment measures can be employed at the time of shut down of mining operations where the remaining mining wastes produce degradation of surface waters. Furthermore any earth moving activities are likely to increase the suspended solids loads, which could have a detrimental effect on the performance of the swamp below the Carbonate tailings. This wetland area is relatively large and has likely served as a significant sink for zinc. It is therefore essential to maintain this bog in a healthy condition.

If the present conditions of the mine workings are unacceptable, reclamation means should focus on enhancing the existing natural cleansing processes, i.e. absorption and fixation of the precipitate with algae, moss covers and indigenous vegetation tolerant to the tailings and waste rock. An evaluation of the growth behaviour of the indigenous species in close vicinity of the Mike Horse and Anaconda, over at least one growing season, along with the determination of flows in relation to precipitation in the

area, may make it possible to devise a means to effectively promote the natural recovery processes taking place. This would provide the least disturbance to their environment and serve as a self-sustaining natural "treatment process".

For the effluent and the iron precipitate (yellowboy) from the Mike Horse and the Anaconda portal, it could be envisaged that by increasing the surface areas for growth of algal populations, enhancement of precipitate fixation in the creek bed could be achieved. The tailings pond at the Carbonate could be contoured in such a way as to provide similar conditions to those in the area of the tailings deposit, where indigenous vegetation is growing on the tailings. It is likely that this would reduce metals leaving the tailings pond to the swamp and stabilize the presently exposed and slightly eroding tailings surfaces. Such measures would likely produce no significant disturbance to the Upper Blackfoot river water quality in either the short or long term.

6.0 REFERENCES

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APPENDIX

ASARCO

Technical Services Center

M.O. Varner
Director

D.E. Holt
Engineering Manager

D.A. Robbins
Environmental Sciences Manager

M.G. King
Research Manager

November 13, 1989

Ms. Margaret Kalin
Boojum Research Ltd.
21 Dundas Square
Suite 405
Toronto, Ontario Canada
M5B 1B7

Dear Ms. Kalin:

Please find attached the results of analyses performed on fifteen (15) water samples and two (2) sludges submitted 10/23/89.

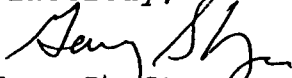
As per your request, an ICP scan was performed for dissolved metals in the water samples. The two sludge samples were analyzed for total metals content. The residue in sample #8 (Mike Horse Creek at p4) was analyzed for total metals, however, sample #4 and #7 had insufficient residue on which to perform reasonable analyses. Results for all solid samples are reported on a dry weight basis.

All waters were analyzed for pH, those with pH values of less than 4.8 were analyzed for total acidity with the results reported as parts per million CaCO_3 . Those waters with pH above 4.8 were analyzed for total alkalinity with the results reported as parts per million CaCO_3 .

The two sludge samples were analyzed for percent moisture (at 110°C) and volatile residue (at 550°C). The volatile residue is reported as percent loss on ignition (at 550°C) and includes the loss due to moisture.

If you have any questions regarding these analyses, please feel free to call.

Sincerely,


Gary R. Standa
Analytical Services Mgr.

GRS/lm
Attach.

cc: DSuhr, RLBrown, DARobbins, MJFabbi (w/attach.)

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Water Sample Results

ASARCO LAB #	SAMPLE DESCRIPTION	1989 SAMPLE DATE	ALK. ppmCaCO3	Acidity ppmCaCO3	Ag(D) ppm	Al(D) ppm	As(D) ppm	Ba(D) ppm
6231	Surface Water	10/23		40.	<.017	2.6	<.017	.056
	#1 Carbonate							
6232	Surface Water	10/23	34.		<.017	.037	<.017	.097
	#2 Carbonate							
6233	Surface Water	10/23	98.		<.017	.021	<.017	.12
	#3 Mike Horse Dam Seep							
6234	Surface Water	10/23	72.		<.017	.020	<.017	.19
	#4 Mike Horse Rd. Turnoff							
6235	Surface Water	10/23	72.		<.017	.038	<.017	.081
	#5 Mike Horse Head Fresh							
6236	Surface Water	10/23	42.		<.017	.048	<.017	<.017
	#6 Mike Horse Portal							
6237	Surface Water	10/23	46.		<.017	.034	<.017	.030
	#7 Clear Stream at p4							
6238	Surface Water	10/23	34.		<.017	.047	<.017	<.017
	#8 Mike Horse Creek at p4							
6239	Surface Water	10/23	32.		<.017	.060	<.017	.024
	#9 At Rd. Mike Horse Creek							
6240	Surface Water	10/23	84.		<.017	.040	<.017	.27
	#10 Clean Creek at Anaconda							
6241	Surface Water	10/23	88.		<.017	.023	<.017	.20
	#11 Blackfoot at Anaconda							
6242	Surface Water	10/23	82.		<.017	.025	<.017	.055
	#12 Beartrap Old Mike Horse							
6243	Surface Water	10/23		60.	<.017	2.7	<.017	.025
	#13 Anaconda Portal							
6244	Surface Water	10/23	80.		<.017	.052	<.017	.17
	#14 Blackfoot River #3 Adit							

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Water Sample Results

1989

ASARCO
 LAB # SAMPLE DESCRIPTION

SAMPLE ALK. Acidity
 DATE ppmCaCO3 ppmCaCO3

6245 Surface Water

10/23

54.

#15 Blackfoot River Final

Al(D) ppm .029

As(D) ppm <.017

Ba(D) ppm .099

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Water Sample Results

ASARCO LAB #	SAMPLE DESCRIPTION	1989 SAMPLE DATE	Be(D) ppm	Ca(D) ppm	Cd(D) ppm	Co(D) ppm	Cr(D) ppm	Cu(D) ppm
6231	Surface Water	10/23	<.017	12.	.005	<.017	<.017	.23
	#1 Carbonate							
6232	Surface Water	10/23	<.017	11.	<.003	<.017	<.017	<.017
	#2 Carbonate							
6233	Surface Water	10/23	<.017	27.	<.003	<.017	<.017	<.017
	#3 Mike Horse Dam Seep							
6234	Surface Water	10/23	<.017	18.	<.003	<.017	<.017	<.017
	#4 Mike Horse Rd. Turnoff							
6235	Surface Water	10/23	<.017	23.	.015	<.017	<.017	.056
	#5 Mike Horse Head Fresh							
6236	Surface Water	10/23	<.017	111.	.030	.075	<.017	<.017
	#6 Mike Horse Portal							
6237	Surface Water	10/23	<.017	47.	.047	<.017	<.017	.069
	#7 Clear Stream at p4							
6238	Surface Water	10/23	<.017	142.	.031	.068	<.017	<.017
	#8 Mike Horse Creek at p4							
6239	Surface Water	10/23	<.017	97.	.031	.042	<.017	<.017
	#9 At Rd. Mike Horse Creek							
6240	Surface Water	10/23	<.017	17.	<.003	<.017	<.017	<.017
	#10 Clean Creek at Anaconda							
6241	Surface Water	10/23	<.017	34.	<.003	<.017	<.017	<.017
	#11 Blackfoot at Anaconda							
6242	Surface Water	10/23	<.017	59.	.008	<.017	<.017	<.017
	#12 Beartrap Old Mike Horse							
6243	Surface Water	10/23	<.017	63.	.013	.059	<.017	1.1
	#13 Anaconda Portal							
6244	Surface Water	10/23	<.017	34.	.003	<.017	<.017	<.017
	#14 Blackfoot River #3 Adit							

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Water Sample Results

1989
 SAMPLE DATE 10/23

ASARCO
 LAB # SAMPLE DESCRIPTION

6245 Surface Water
 #15 Blackfoot River Final

ASARCO LAB #	SAMPLE DESCRIPTION	1989 SAMPLE DATE	Be(D) ppm	Ca(D) ppm	Cd(D) ppm	Co(D) ppm	Cr(D) ppm	Cu(D) ppm
6245	Surface Water #15 Blackfoot River Final	10/23	<.017	23.	<.003	<.017	<.017	<.017

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Water Sample Results

ASARCO LAB #	SAMPLE DESCRIPTION	1989 SAMPLE DATE	Fe(D) ppm	K(D) ppm	Mg(D) ppm	Mn(D) ppm	Na(D) ppm	Ni(D) ppm
6231	Surface Water	10/23	.23	.64	4.9	1.2	2.9	<.017
	#1 Carbonate							
6232	Surface Water	10/23	.039	.55	4.5	<.017	3.0	<.017
	#2 Carbonate							
6233	Surface Water	10/23	.032	.70	14.	.12	1.2	<.017
	#3 Mike Horse Dam Seep							
6234	Surface Water	10/23	.044	1.2	7.5	.31	2.9	<.017
	#4 Mike Horse Rd. Turnoff							
6235	Surface Water	10/23	.024	.34	12.	.057	.86	<.017
	#5 Mike Horse Head Fresh							
6236	Surface Water	10/23	<.017	1.9	172.	29.	1.5	.12
	#6 Mike Horse Portal							
6237	Surface Water	10/23	<.017	.73	30.	.90	1.2	<.017
	#7 Clear Stream at p4							
6238	Surface Water	10/23	<.017	1.8	163.	27.	1.5	.10
	#8 Mike Horse Creek at p4							
6239	Surface Water	10/23	<.017	1.4	112.	17.	1.4	.065
	#9 At Rd. Mike Horse Creek							
6240	Surface Water	10/23	<.017	.29	8.1	<.017	1.5	<.017
	#10 Clean Creek at Anaconda							
6241	Surface Water	10/23	<.017	.54	20.	1.5	1.4	<.017
	#11 Blackfoot at Anaconda							
6242	Surface Water	10/23	<.017	.97	39.	3.7	1.3	<.017
	#12 Beartrap Old Mike Horse							
6243	Surface Water	10/23	.97	.84	21.	8.5	2.2	.022
	#13 Anaconda Portal							
6244	Surface Water	10/23	.026	.57	19.	1.2	1.5	<.017
	#14 Blackfoot River #3 Adit							

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Water Sample Results

ASARCO LAB #	SAMPLE DESCRIPTION	1989 SAMPLE DATE	Fe(D) ppm	K(D) ppm	Mg(D) ppm	Mn(D) ppm	Na(D) ppm	Ni(D) ppm
6245	Surface Water #15 Blackfoot River Final	10/23	.019	.76	12.	.098	2.0	<.017

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Water Sample Results

1989

ASARCO LAB #	SAMPLE DESCRIPTION	SAMPLE DATE	Pb(D) ppm	SO4 ppm	Sb(D) ppm	Se(D) ppm	TSS ppm	Tl(D) ppm
6231	Surface Water	10/23	.022	96.	<.017	<.017		<.017
	#1 Carbonate							
6232	Surface Water	10/23	<.017	18.	<.017	<.017		<.017
	#2 Carbonate							
6233	Surface Water	10/23	<.017	32.	<.017	<.017		<.017
	#3 Mike Horse Dam Seep							
6234	Surface Water	10/23	<.017	12.	<.017	<.017	16.	<.017
	#4 Mike Horse Rd. Turnoff							
6235	Surface Water	10/23	<.017	37.	<.017	<.017		<.017
	#5 Mike Horse Head Fresh							
6236	Surface Water	10/23	<.017	1338.	<.017	<.017		<.017
	#6 Mike Horse Portal							
6237	Surface Water	10/23	<.017	205.	<.017	<.017	3.3	<.017
	#7 Clear Stream at p4							
6238	Surface Water	10/23	<.017	1313.	<.017	<.017	238.	<.017
	#8 Mike Horse Creek at p4							
6239	Surface Water	10/23	<.017	963.	<.017	<.017		<.017
	#9 At Rd. Mike Horse Creek							
6240	Surface Water	10/23	<.017	5.0	<.017	<.017		<.017
	#10 Clean Creek at Anaconda							
6241	Surface Water	10/23	<.017	73.	<.017	<.017		<.017
	#11 Blackfoot at Anaconda							
6242	Surface Water	10/23	<.017	218.	<.017	<.017		<.017
	#12 Beartrap Old Mike Horse							
6243	Surface Water	10/23	.020	325.	<.017	<.017		<.017
	#13 Anaconda Portal							
6244	Surface Water	10/23	<.017	88.	<.010	<.017		<.017
	#14 Blackfoot River #3 Adit							

ASARCO Incorporated
Department of Environmental Sciences
EXPLOR SPOKANE
Water Sample Results

1989

ASARCO
LAB # SAMPLE DESCRIPTION

6245 Surface Water
#15 Blackfoot River Final

SAMPLE Pb(D) SO4 Sb(D) Se(D) TSS Tl(D)
DATE ppm ppm ppm ppm ppm ppm
10/23 <.017 53. <.017 <.017 <.017

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Water Sample Results

ASARCO LAB #	SAMPLE DESCRIPTION	1989 SAMPLE DATE	V(D) ppm	Zn(D) ppm	PH
6231	Surface Water	10/23	<.017	.77	3.4
6232	#1 Carbonate	10/23	<.017	.019	6.3
6233	#2 Carbonate	10/23	<.017	.047	7.7
6234	#3 Mike Horse Dam Seep	10/23	<.017	.030	7.1
6235	#4 Mike Horse Rd. Turnoff	10/23	<.017	1.8	7.4
6236	#5 Mike Horse Head Fresh	10/23	<.017	42.	5.8
6237	#6 Mike Horse Portal	10/23	<.017	10.	6.2
6238	#7 Clear Stream at p4	10/23	<.017	35.	6.4
6239	#8 Mike Horse Creek at p4	10/23	<.017	24.	6.6
6240	#9 At Rd. Mike Horse Creek	10/23	<.017	.049	7.9
6241	#10 Clean Creek at Anaconda	10/23	<.017	1.9	7.9
6242	#11 Blackfoot at Anaconda	10/23	<.017	3.7	7.9
6243	#12 Beartrap Old Mike Horse	10/23	<.017	2.5	3.2
6244	#13 Anaconda Portal	10/23	<.017	1.0	7.1
	#14 Blackfoot River #3 Adit				

Analyst

Reviewer

ASARCO Incorporated
Department of Environmental Sciences
EXPLOR SPOKANE
Water Sample Results

ASARCO
LAB # 6245
SAMPLE DESCRIPTION Surface Water
#15 Blackfoot River Final

1989
SAMPLE DATE 10/23
V(D) ppm <.017
Zn(D) ppm .30
PH 7.8

Analyst

Reviewer

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Miscellaneous Sample Results

1989		Al	As	Ba	Be	Ca
ASARCO	SAMPLE DATE	ppm	ppm	ppm	ppm	ppm
6246 Solid	10/25	3041.	203.	98.	<10.	6192.
Mike Algea						
6247 Solid	10/25	6117.	506.	29.	<10.	3908.
Mike Horse Portal						
6400 Solid	10/25	4255.	398.	15.	<10.	4675.
Residue from #8						

1989		Co	Cr	Cu	Fe	K
ASARCO	SAMPLE DATE	ppm	ppm	ppm	ppm	ppm
6246 Solid	10/25	40.	<10.	1766.	275000.	1522.
Mike Algea						
6247 Solid	10/25	47.	<10.	3065.	428900.	73.
Mike Horse Portal						
6400 Solid	10/25	42.	57.	2116.	361410.	185.
Residue from #8						

1989		Mn	Moistr %	Na	Ni	Pb
ASARCO	SAMPLE DATE	ppm	%	ppm	ppm	ppm
6246 Solid	10/25	3743.	91.	64.	<10.	1093.
Mike Algea						
6247 Solid	10/25	1722.	90.	49.	<10.	1699.
Mike Horse Portal						
6400 Solid	10/25	1352.		339.	<10.	1564.
Residue from #8						

ASARCO Incorporated
 Department of Environmental Sciences
 EXPLOR SPOKANE
 Miscellaneous Sample Results

ASARCO LAB #	SAMPLE DESCRIPTION	1989 SAMPLE DATE	Sb ppm	Se ppm	Tl ppm	V ppm	Vol. R ppm	Zn ppm
6246	Solid Mike Algea	10/25	<10.	<10.	211.	<10.	93.	65560.
6247	Solid Mike Horse Portal	10/25	<10.	<10.	370.	<10.	91.	14270.
6400	Solid Residue from #8	10/25	<10.	<10.	341.	<10.		36763.

 Analyst

 Reviewer