Pacific Region Mine Effluent Chemistry and Acute Toxicity Survey, 1973

PACIFIC REGION MINE EFFLUENT CHEMISTRY AND ACUTE TOXICITY SURVEY, 1973

By

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INTRODUCTION

One of the principal responsibilities of the Environmental Protection Service is to spearhead the development of national water pollution control regulations for industry in Canada. Regulations governing effluent discharges from the Pulp and Paper and Chlor-Alkali industries were the first to be completed and were promulgated in November, 1971, and March, 1972, respectively. More recently (November, 1973), guidelines and regulations for Petroleum Refinery effluents were also completed and gazetted.

Early in 1973, a Task Force was assembled consisting of Federal, Provincial and Industrial representatives who were familiar with the environmental control aspects of the metal mining industry. The basic objective of the Task Force is to develop effluent regulations and/or guidelines that will govern the release of metal mining waste waters into the environment. These requirements will be evaluated with respect to the concept of best practical waste treatment technology.

To achieve this objective, several working groups were established to produce technical documents that could be used as an information base upon which the criteria for effluent quality could be developed. One such unit is the Analytical and Sampling Methods Working Group and one of its objectives is to prepare a document outlining a suitable toxicity test to characterize mining effluents. In order to complete this task it was deemed necessary to consolidate all existing toxicity and effluent chemistry data, supplemented by that which could be obtained over a relatively short time frame during the summer of 1973. In addition, it was requested that all regions, in obtaining new information for the program, apply a standardized static bioassay procedure agreed to by the members of the Working Group.

This manuscript describes the sampling, bioassay, and analytical chemistry procedures used and the results obtained by the joint Environmental Protection-Fisheries Contingent which participated in the program on behalf of the Pacific Region.

SCOPE OF SURVEY

During the summer of 1973 technical personnel of the Environmental Protection Service and the Fisheries and Marine Service visited and collected wastewater samples from a total of 26 of the major producing mines in British Columbia and the Yukon. The locations of all mines included in the survey are illustrated in Figures 1 and 2. Table I summarizes the metals or minerals mined, the 1972-73 production rates (B.C. & Yukon Chamber of Mines, 1973) and the forms of waste treatment and/or effluent minimization practiced at the mines sampled. It should be noted that effluent samples from two additional mines, namely Utah Mines Ltd. and Jordan River Mines Ltd. were not obtained directly as part of this survey, but were nevertheless included in the bioassay testing phase of the program. This brings to 28, the total number of mines for which at least some data was obtained during the survey period.

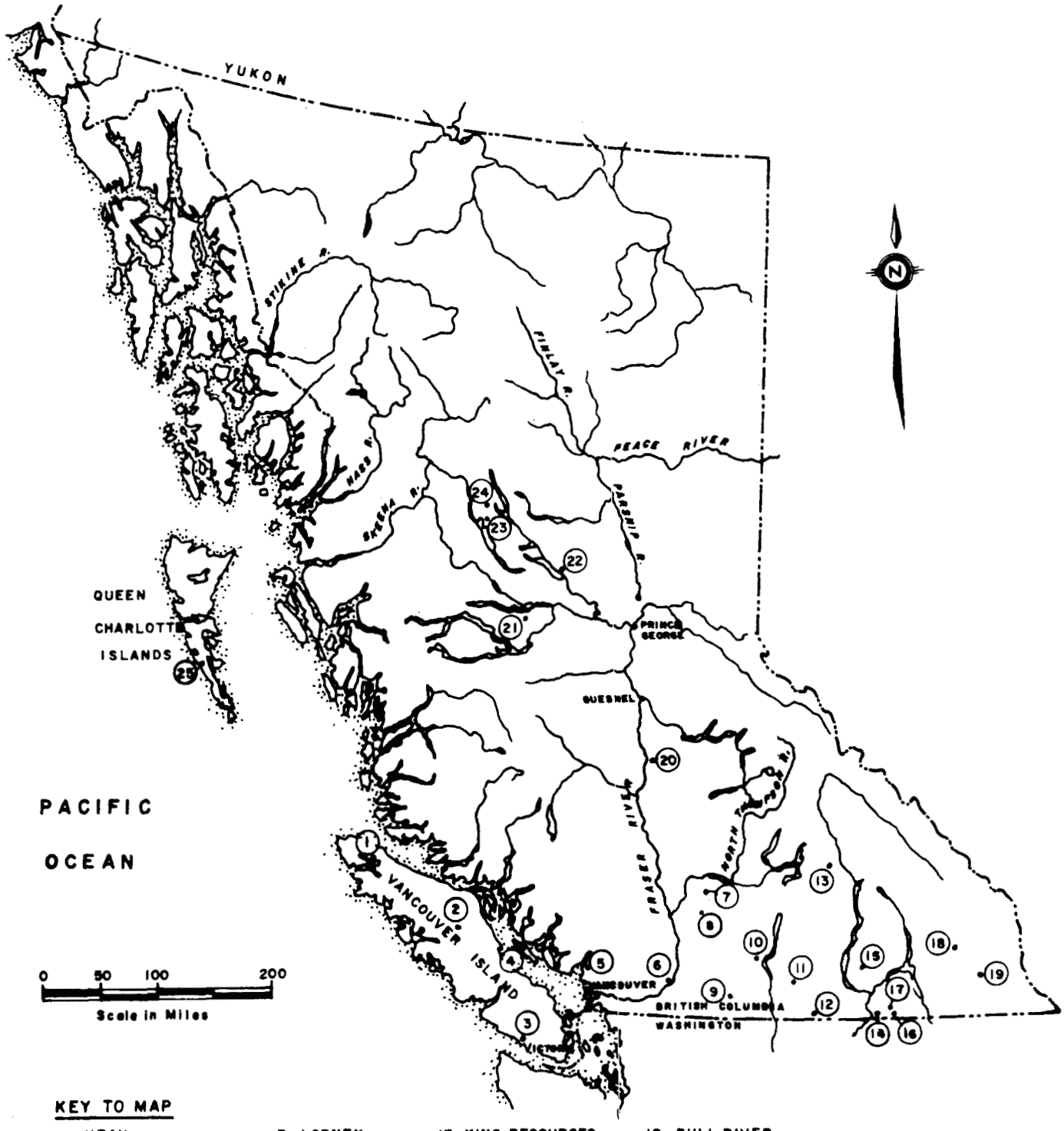

FIGURE 1 ACTIVE MINES SAMPLED IN BRITISH COLUMBIA FOR 1973 MINE SURVEY.

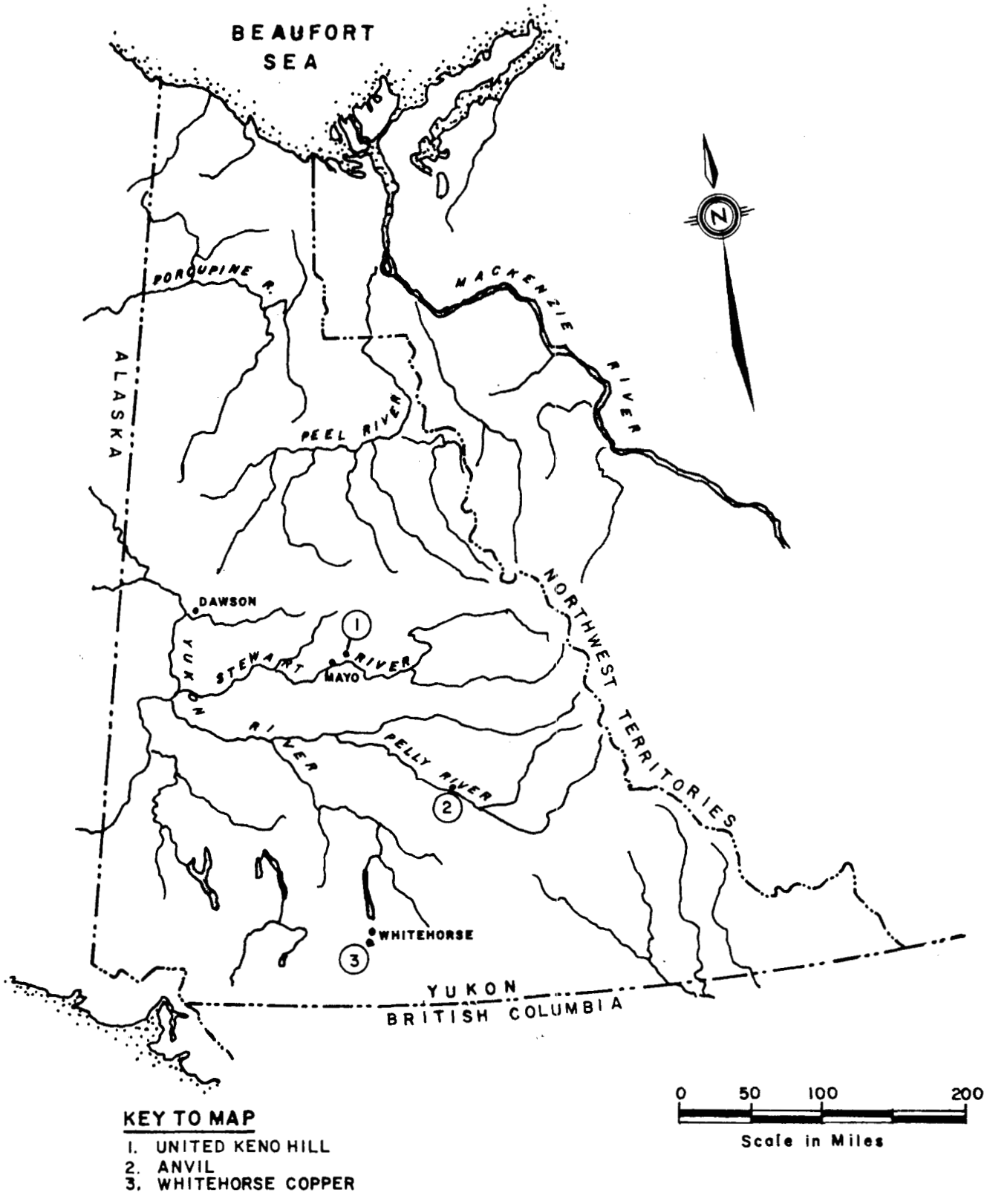

FIGURE 2 ACTIVE MINES SAMPLED IN THE YUKON FOR 1973 MINE SURVEY.

TABLE I

Summary of Producing Base Metal Mines of the Pacific Region included in the 1973 Mine Effluent Survey.

COMPANY	LOCATION	METAL OR MINERAL	TAILINGS HANDLING	PRODUCT T.P.D.
1. Anaconda Britannia Mines Ltd.	Britannia Beach, B.C.	Cu-Zn	Raw tailings to Howe Sound (marine). Mine water to copper precipitation plant to Britannia Creek	3,000
2. Anvil Mining Corporation Ltd.	Faro, Y.T.	Zn-Pb-Ag	Tailings decant to Rose Creek	6,600
3. Brenda Mines Ltd.	Peachland, B.C.	Cu-Mo	Complete recycle	24,000
4. Canex Placer Ltd. (Endako MInes Div.)	Endako, B.C.	Mo	Complete recycle	25,000
5. Canex Placer Ltd. (Tungsten Div.)	Salmo, B.C.	W	Tailings decant to to Lime Creek	600
6. Cominco Ltd. (H.B. Mine)	Salmo, B.C.	Zn-Pb	Tailings decant to Salmon River	1,000
7. Cominco Ltd. (Pinchi Mine)	Ft. St. James, B.C.	Hg	Complete recycle except for spring runoff	800
8. Cominco Ltd. (Sullivan Mine)	Kimberley, B.C.	Pb-Zn-Ag	Tailings decants from "Silicious" and "iron" ponds to James Creek	10,000
9. Craigmont Mines Ltd.	Merritt, B.C.	Cu	Complete recycle	5,000

TABLE I cont'd

Summary of Producing Base Metal Mines of the Pacific Region included in the 1973 Mine Effluent Survey.

	COMPANY	LOCATION	METAL OR MINERAL	TAILINGS HANDLING	PRODUCT T.P.D.
10.	Giant Mascot Mines Ltd.	Hope, B.C.	Ni-Cu	Tailings pond decant in spring. No flow in summer	1,750
11.	Gibraltar Mines Ltd.	McLeese Lake, B.C.	Cu-Mo	Complete recycle except for spring runoff	40,000
12.	Granby Mining Co. Ltd.	Phoenix, B.C.	Cu	Complete recycle	2,500
13.	Granisle Copper Ltd.	Granisle, B.C.	Cu	Complete recycle. Some seepage to Babine Lake	14,000
14.	Jordan River	Jordan River, B.C.	Cu	Raw tailings to sea	1,500
15.	Kam Kotia-Burkam Joint Venture	New Denver, B.C.	Ag-Zn-Pb	Tailings decant to Carpenter Creek. No overflow when sampled	150 (not operating) when sampled
16.	King Resources Company	Revelstoke, B.C.	Mo	Tailings decant to Creek No overflow when sampled	200 (not operating when sampled
17.	Lornex Mining Corporation	Highland Valley, B.C.	Cu-Mo	Complete recycle	38,000
18.	Noranda Mines Ltd.	Newman Peninsula, B.C.	Cu	Complete recycle	10,000
19.	Placid Oil Co.	Bull River, B.C.	Cu-Ag-Pb-Zn	Complete recycle if and when tailings pond fills. Not necessary to date	750

TABLE I cont'd

Summary of Producing Base Metal Mines of the Pacific Region included in the 1973 Mine Effluent Survey.

	COMPANY	LOCATION	METAL OR MINERAL	TAILINGS HANDLING	PRODUCT T.P.D.
20.	Reeves MacDonald	Remac, B.C.	Zn-Pb	Raw tailings to Pend Oreille River.	1,000
21.	Similkameen Mining Co. Ltd.	Princeton, B.C.	Cu	Complete recycle	15,000
22.	Teck Corporation Ltd.	Beaverdell, B.C.	Ag-Pb-Zn	Tailings decant to creek.	110
23.	Texada Mines Ltd.	Vananda, B.C.	Fe-Cu	Raw tailings to Georgia Strait (Marine).	3,600
24.	United Keno Hill	Elsa, Y.T.	Ag-Pb-Zn	Tailings decant to creek.	400
25.	Utah Mines Ltd.	Rupert Inlet, B.C.	Cu-Mo	Raw tailings to Rupert Inlet (Marine).	33,000
26.	Wesfrob Mines Ltd.	Tasu, B.C.	Fe-Cu	Raw tailings to Tasu Inlet (Marine).	8,000
27.	Western Mines Ltd.	Buttle Lake, B.C.	Cu-Zn-Ag-Pb	Raw tailings to Buttle Lake	1,125
28.	Whitehorse Copper Mines Ltd.	Whitehorse, Y.T.	Cu	Complete recycle	2,000

METHODS AND MATERIALS

1. Sampling Point Selection

The selection of a suitable sampling point was governed in all instances by the requirement that the concentrator tailings discharge water be sampled at the terminal point of its run but prior to either its discharge to the receiving environment, or its return to the concentrator, in the case of a recycle system. Three basic methods of tailings waste handling were encountered so that establishment of a sampling point differed for each of the three situations. Site selection was determined in the following manner:

- Where the raw tailings and water were discharged directly, usually via a flume, pipe, or open trough, into a stream, lake, or salt water system, sampling was done at the final point of discharge prior to entering the aforementioned system. These samples contained both tailing solids and mill water.

- Where the raw tailings and water were directed to a tailings pond for solids precipitation and only the "clear" supernatant was allowed to overflow, sampling was effected at the final discharge end of the decant system. In some instances, because of a "no flow" condition due to temporary mill shutdown, production less than mill capacity or high evaporation losses at the pond surface, it was not possible to sample at this point. Where these conditions prevailed supernatant samples were taken at a point close to the decant tower.

- Where the raw tailings and water were fed into a tailings pond, heavy materials settled out, and the resulting supernatant reclaimed by pumping back to the concentrator, sampling was carried out at the point of return, usually off the pump house floating barge.

With one exception, no attempt was made to directly sample mine seepage. The exception was Britannia mine runoff which was collected because it is known to represent one of the major wastewater problems associated with this mine operation, and was therefore of extra interest to us.

2. Sampling Procedure and Treatment

Three separate water samples for chemical analysis were taken at each site and returned to the Environment Canada Chemistry Laboratory, West Vancouver.

Sample One - for total heavy metals, was collected in a 1 liter polyethylene bottle and immediately preserved by the addition of 5 ml of concentrated analytical reagent grade Nitric Acid and mixed thoroughly (Davidson et. al., 1972).

Sample Two - for dissolved heavy metal analysis, was collected in a 250 ml polyethylene bottle and filtered, as close to the collection time as was practical (i.e. usually within 30 minutes), through a 0.45 micron membrane filter using a Sartorius Multi Purpose Plastic Filtration System* into a second 250 ml polyethylene bottle. The filtrate was immediately preserved with 1.5 ml of concentrated analytical reagent grade Nitric Acid (Davidson et. al., 1972). Where field micro-filtration equipment was not available, the sample collected for "dissolved heavy metals" was permitted to stand for approximately 30 minutes, 250 ml of supernatant decanted off, and preserved with 1.5 ml analytical reagent grade Nitric Acid. The chemical results for samples treated in this manner were expressed as extractable heavy metal.

Sample Three - for non metal analysis, was collected in a 1 litre polyethylene bottle but retained in the untreated state.

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* References to product manufacturers are not to be considered as endorsements of these products.

Water samples for bioassay were obtained at the same sites as those for the chemical samples. For the majority of mines visited, where LT_{50}* determinations only were to be run, 2 x 5 gallons of waste water were collected in sealing lid type plastic pails (Y-Lok containers) or jerry cans. At mines for which the more detailed LC_{50}** toxicity assessment was specified, 4 x 5 gallons of water were collected. All samples for toxicity evaluation were returned to the Environment Canada Bioassay Laboratory, West Vancouver.

Field temperature and pH measurements were obtained using a mercury thermometer and a Seibold Model G.K.A. portable pH meter, respectively.

3. Bioassay Procedures

Juvenile Coho Salmon (Oncorhynchus kisutch) acclimated to untreated Capilano Reservoir tap water held at 11°C ± 1°C were used in all bioassays. Five fish with a mean weight and length of 4.34 gm and 5.7 cm, respectively, were placed in 10 gallon glass aquaria held in a 11°C ± 1°C water bath. All bioassays were static with no replacement during the 96 hour test period. Dissolved oxygen levels were maintained at or above 9.5 mg/l by continuous aeration.

For the majority of the mines sampled a 96 hour LT_{50} at 100% concentration was determined. In cases where the pH of the original samples fell outside the range 6-8, two LT_{50}'s were conducted, one on the neutralized sample and one on an unneutralized sample.

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*LT_{50} - This term refers to Median Lethal Time, that is, the time to death of the 50th percentile organism in a specific concentration or level of measurable lethal agent (used interchangeably with MST, Median Survival Time). The exposure time must be specified, and in this case is 96 hours.

**LC_{50} - This notation refers to Median Lethal Concentration or that level of a measurable lethal agent required to kill the 50th percentile in a group of test organisms, over the time period of 96 hours. The 50th percentile is meant to represent the average organism.

In addition, six of the mines were identified by the Working Group for more detailed static 96 hour LC_{50} determinations. For these cases concentration series (usually 100, 56, 32, 10, 0%) using untreated Capilano Reservoir tap water as the dilution water were also conducted. The diluent had a pH of 6.4 ± 0.1 log units and a total $CaCO_3$ hardness of approximately 9.7 ppm.

4. Analytical Chemistry Procedures

Total heavy metals. The method used for total heavy metal analysis of the mine wastes was that described by Bernas (1968). As a matter of interest, Hurley and Pinson (1970) used a modification of this technique to investigate Rubidium-Strontium relationships in lunar soil samples. The Bernas technique was adopted by the chemistry lab for this exercise because it demonstrated a superior ability to digest all of the silicates and other tailings components present, while providing a more rapid technique for the analysis of the wide variety of metals desired. Since this procedure would appear to have considerable potential for the extensive effluent monitoring programs carried out by the Environmental Protection Service, the technique is described in detail.

The decomposition or digestion method is best described in the following abstract from Bernas (1968). "*Rapid decomposition of silicates is achieved in a specially designed vessel made of Teflon (Du Pont) without volatilization losses by hydrofluoric acid at 110°C. A fluoboric-boric acids system was found to provide a favorable decomposition medium and a suitable salt-free single matrix system. Conditions were developed for sufficient inhibition of the hydrolytic decomposition rate of fluoboric acid. This matrix was found to diminish significantly or to eliminate entirely the chemical, ionization, matrix, and instrumental*

interferences for atomic absorption measurements. The system permits contamination-free sample handling in glass equipment, ensures sample solution stability, and to date provides an interference-free environment for the rapid and reliable atomic absorption spectrometric determinations of silicon, aluminum, titanium, and vanadium using a nitrous oxide-acetylene flame and for iron, calcium, magnesium, sodium, and potassium using an air-acetylene flame."

For the mine waste samples, the following procedures were carried out. Between 50 and 200 ml of well mixed sample was pipetted into a weighed, dry, acidwashed 250 ml teflon beaker. The sample was evaporated to dryness at 90°C and then heated for 1 hour at 180°C. The final drying temperature of 180°C was chosen to drive off the mechanically occluded water and much of the water of crystallization. At 180°C much of the organic matter is reduced by volatilization but not completely destroyed. Bicarbonate is converted to carbonate and carbonate may be partially decomposed to oxide or basic salts. In addition, some chloride and nitrate salts may be lost (Apha, 1971).

After cooling in a desiccator, the beaker was weighed and approximately 50 mg of dry sample was placed in a teflon bomb. To the sample were added 0.5 ml of aqua-regia and 3 ml of concentrated Hydrofluoric acid. The bomb was closed and placed in a 110°C oven for 1 hr. When cool the sample was transferred to a 50 ml plastic beaker with 4-6 ml of deionized water. 2.8 gm of Boric acid was then added with stirring. When the Boric acid was partially dissolved, 5-10 ml of deionized water was added and the sample diluted to about 40 ml. The sample was volumized to 100 ml in a volumetric flask and stored in a linear polyethylene bottle. Standards were prepared from commercial AA standards and made up in the HF, aqua-regia Boric acid matrix. The Standard series contained all the elements analyzed. All standards and samples were analyzed with a Jarrell-Ash 800 atomic absorption spectrophotometer.

Dissolved and Extractable heavy metals. The microfiltered acidified samples for dissolved metal analysis, and the unfiltered (but decanted), acidified samples for extractable metal analysis were analyzed directly by atomic absorption and/or flame emission spectrophotometry. (Davidson et. al., 1972).

Miscellaneous parameters. Total hardness ($CaCO_3$), total alkalinity, total residue, non-filterable residue, and sulphates were all determined using techniques described by Davidson et. al., 1972.

RESULTS AND DISCUSSION

Bioassay Testing

Table II summarizes all of the 96 hr LT_{50} toxicity results and associated bioassay parameters obtained in the 1973 mine survey. Of the 28 mine effluents evaluated, 18 were not acutely toxic, 10 were toxic without neutralization, and 5 remained toxic after neutralization.

Eleven of the mines sampled were operating on complete recycle systems and somewhat surprisingly, only Lornex had an acutely toxic recycle water after neutralization (LT_{50} - 1.3 hr). It had been expected that there might be a build-up of reagents and metals to toxic levels in recycle systems. These results indicate that this is not necessarily the case, a fact which is encouraging from the standpoint of water minimization.

A further 10 mines had tailings ponds but decant was only being discharged from 5 of them during the survey period. Kam Kotia-Burkam Joint Venture and King Resources were not operating when visited, Giant Mascot and the H.B. Mine have seasonally limited discharges, and the Placid Oil operation has no discharge at all due to high evaporation losses and the tailings pond capacity. The untreated decant from Sullivan, Anvil, United Keno Hill and Kam Kotia-Burkam Joint Venture were all acutely toxic with LT_{50}'s of 3.8, 3.8, 31, and 34 hours, respectively. The Anvil effluent lost its acute toxicity after neutralization.

The remaining 7 mines surveyed discharge their tailings directly to the receiving environment. Reeves MacDonald mine tailings is discharged to the Pend Oreille River, a tributary of the Columbia River. Slight fish mortalities occurred (40% in neutralized effluent)

but no clear acute toxicity problem, as evaluated by the LT_{50} method, was detected. The tailings from Western Mines which is directed to the bottom of Buttle Lake in Strathcona Provincial Park was found to be very toxic with an LT_{50} of 1.6 hours. The other 5 raw tailings discharges - all to the sea - were found to be relatively non-toxic, with none exhibiting lethal responses after neutralization.

One other mine flow was sampled, namely the acid mine water draining the Anaconda property at Britannia Mine. The water, which is directed through a copper precipitation plant prior to discharge to Britannia Creek, was found to be toxic both before and after neutralization with LT_{50}'s of 7.0 and 9.4 hours, respectively.

Tables III to VIII summarize the 96 hour LC_{50} values determined for untreated effluent from Anvil, Gibraltar, Granisle, Similkameen, Sullivan, and United Keno Hill mines. Sullivan Mine effluent from the iron tailings pond proved to be the most toxic with an LC_{50} of 3.0%, followed by United Keno Hill (40%), Anvil, Gibraltar, and Similkameen (75%) and Granisle, which did not have acutely toxic mine water, as reported earlier. The 75% LC_{50}'s observed were all directly due to the high ph of the untreated wastewaters at 100% concentration.

Effluent Chemistry and its Relationship to Toxicity.

Tables IX and X summarize all of the metal and non-metal analytical results, respectively, obtained in the 1973 mine survey. Since the total volume of chemical data compiled is rather extensive, (≃33 parameters) discussion will generally be limited to highlights pertaining to the key effluent constituents, namely copper, zinc, lead, iron, and non-filterable residue (suspended solids). Before continuing, it should also be noted that in several instances, the concentration of dissolved fraction of an element reported exceeds its total value. This physical

impossibility is primarily due to the different analytical techniques and sensitivities used in determining the dissolved versus total fractions, and interferences exerted by other chemical constituents present in the solutions tested.

Without exception, all raw tailings discharges to the receiving environment contained much higher concentrations of all the major heavy metals and obviously, suspended solids, than did any other mine/mill effluents samples. This would be expected as considerable amounts of bound up heavy metals are lost through tailings particles. Western Mines effluent, in particular, contained exceedingly high levels of total copper (230 mg/l), zinc (1300 mg/l), and lead (88 mg/l) and, although no dissolved measurements were conducted on this sample, it would appear that these metals, in conjunction with other effluent components, acted synergistically to produce the acutely toxic response reported in the bioassay results (LT_{50} - 1.6 hr). The other interesting observation was that it was also clear that none of the other raw tailings discharges created acute toxicity problems when tested at neutral pH, despite the presence of high concentrations of total heavy metals. This supports the well established fact that most, if not all, of the acute toxicity problems caused by heavy metals can be attributed to the ionic or dissolved components of the metals present.

Some of the mines presently discharging untreated tailings to the receiving environment have caused or are expected to cause serious environmental consequences which could have been avoided or minimized if alternate means of disposal had been adopted. In many instances the worst environmental problems associated with a mining operation or its tailings occur years after start-up or after abandonment. If the problems originate from an area that is unconfined or inaccessible (such as in the bottom of an inlet) it will be extremely difficult if not impossible to apply remedial action and the problem could continue in

perpetuity. Therefore it is important that some assurance be given which will permit a decision to discharge raw tailings to the receiving environment to be reversed, if deemed necessary by the responsible regulatory agencies.

Besides those mines with raw tailings discharges, and including the operations which completely recycle their wastewater, only 4 of the other mines tested exhibited effluent toxicities attributable to effluent constituents other than pH. These results, plus the most probable explanation for the observed toxicities, were as follows:

Water from the surface of the first tailings pond at Kam Kotia-Burkam Joint Venture contained 1.2 mg/l of total copper of which 1.0 mg/l was dissolved, thereby contributing to the observed LT_{50} of 34 hours.

The recycled mine water at Lornex contained 8.0 mg/l of copper, all in the dissolved form, and resulted in a highly toxic solution with an LT_{50} of 1.3 hours. Fortunately, this effluent is not discharged to the receiving environment, thus no problems would be encountered.

Effluent from the Sullivan Mine operation contained high concentrations of several key effluent parameters in both of their tailings ponds. The "silicious tailings decant" had 27.0 mg/l of iron, 1.9 mg/l of lead, 1.5 mg/l of zinc, and 55.0 mg/l of suspended solids, while the corresponding results for the "iron tailings pond" were 410 mg/l, 1.3 mg/l, 4.5 - 5 mg/l, and 106 mg/l, respectively. Only the latter effluent was subjected to bioassay and the result was an LT_{50} of 3.8 hours; attributed primarily to the dissolved zinc content of approximately 4.75 mg/l.

The tailings decant at United Keno Hill mine contained 0.40 mg/l of copper and 1.9 mg/l of zinc, the majority of which were dissolved

and which acted synergistically to produce an LT_{50} of 31 hours. In addition, previous unpublished results had indicated the presence of considerable cyanide, which, if present again, would undoubtedly have contributed to the toxicity of this effluent.

One final result which warrants a comment, although it should be considered separately, is the acid mine drainage from Anaconda Britannia mine. This discharge contained 38 mg/l of copper (11.0 mg/l dissolved), 51 mg/l of zinc (50 mg/l of dissolved), and 208 mg/l of suspended solids. These and other constituents combined to produce an LT_{50} of 9.4 hours and demonstrates the toxicity problem associated with acid generating conditions. The same problem is encountered at Sullivan Mine and explains in large part the high metal concentrations found in their effluents at the time sampled.

SUMMARY

Based on preliminary data obtained from 28 of the major producing mines in British Columbia and the Yukon, several general conclusions and/or statements pertinent to this region can be made.

1. The application of a "not acutely toxic in 96 hours clause" to cover off the toxic components which could be present in mine effluents would appear to be attainable, and should therefore be acceptable to most sectors of the metal mining industry in the Pacific Region if embodied in Guidelines or Regulations. Eighteen mine mill effluents were not acutely toxic, 10 were toxic without neutralization, and 5 remained toxic after neutralization, of which one was a recycled effluent. The four toxic effluents which were discharged were produced by Kam Kotia-Burkam Joint Venture, Sullivan, United Keno Hill, and Western mines. In addition, the neutralized acid mine drainage from Britannia mine was also found to be acutely toxic. The toxicity of all these effluents was demonstrated to be attributable in large part, or entirely, to the toxic effects of dissolved copper and/or zinc and/or lead.

2. Of the 11 mines sampled which utilize complete recycle systems only one (Lornex) had an acutely toxic recycle water after neutralization. It had been expected that there might be a build-up of reagents and metals to toxic levels in recycle systems. These preliminary results indicate that this is not necessarily the case, a fact which is encouraging from the standpoint of water minimization.

3. It would seem inevitable, particularly as the demand for base metals increases, that there will remain certain limiting geographical, topographical, and environmental circumstances under which it will be impossible or perhaps preferable to dispose of raw tailings and other wastes from a mining operation in any manner other than directly to the receiving environment. If this is to be the case, criteria and

procedures should be developed to assess the desirability and/or necessity of utilizing this method of waste disposal and to justify its application over all other alternatives.

ACKNOWLEDGEMENTS

Due to the extensive nature of the survey, numerous people from both the Fisheries and Marine Service, and Environmental Protection Service participated in one or more facets of the Program. The authors would sincerely like to acknowledge their assistance. The participants were G. Adam, J. Davidson, J. Gass, R. Hallam, G. Hardaker, M. Jones, W. Knapp, R. Leary, V. MacKinnon, L. Martin, R. McIndoe, C. Nagy, R. Pummell, W. Schouwenburg, T. Swann, R. Watts, G. Webster and D. Yoshioka.

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TABLE II

96 hour LT_{50} Bioassay Results

TABLE II

96 HR LT_{50} BIOASSAY RESULTS

Test Fish: Juvenile Coho Salmon (Oncorhynchus Kisutch) Acclimated to Untreated Capilano Reservoir Tap Water at 11°C ± 1°C
5 fish / test tank
Mean fish weight - 4.34 gm
Mean fish length - 5.7 cm
Test tank volume - 20 liters
Dissolved Oxygen content - 9.5 ± 1 mgm / liter

Dilution Water: Untreated Capilano Reservoir Tap Water
pH - 6.4 ± 0.1
Hardness - 9.7 ppm $CaCO_3$

* Denotes sample neutralised prior to Bioassay

Mine	Sampling Point	Date Sampled	Date Bioassay Started	Initial Sample pH	Final Sample pH	Temp. Range °C	Loading Density gm/litre	% Survival/ 96 hr.	LT_{50}
Anaconda Britannia Mine	Discharge from mill.	Aug. 30/73	Sept 5/73	8.23	7.82	11-11	1.18	100	>96 hr
	Discharge from scavenger flotn.	Aug. 30/73	Sept 5/73	10.80	7.33	11-11	1.18	100	>96 hr
	Discharge from scavenger flotn.	Aug. 30/73	Sept 5/73	7.83*	7.31	11-11	1.18	100	>96 hr
	Discharge from precipitation plant	Aug. 30/73	Sept 5/73	4.20	3.82	10-10.5	0.78	0	7.0 hr
	Discharge from precipitation plant	Aug. 30/73	Sept 5/73	7.21*		11-11	0.78	0	9.4 hr
Anvil Mine	Tailings pond decant	Aug. 9/73	Sept 2/73	9.93	9.70	10.5-11.0	0.78	0	3.8 hr
	Tailings pond decant	Aug. 9/73	Sept 2/73	6.97*	7.58	11.0-11.0	0.78	100	>96 hr
Brenda Mines Ltd.	Tailings pond pump house well	July 25/73	July 30/73	7.57	7.87	10-10.5	0.67	80	>96 hr
Canex Placer (Tungsten) Mine	Tailings pond discharge pipe	Aug. 7/73	Aug. 12/73	6.43	7.55	11-11	0.68	100	>96 hr

96 HR LT_{50} BIOASSAY RESULTS (CONTINUED)

Mine	Sampling Point	Date Sampled	Date Bioassay Started	Initial Sample pH	Final Sample pH	Temp. Range °C	Loading Density gm/litre	% Survival/ 96 hr.	LT_{50}
Craigmont Mine (Placer Development)	Collection ditch at ft of tailings dam	July 12/73	July 15/73	9.60	7.26	10.5-10	0.83	100	>96 hr
	Collection ditch at ft of tailings dam	July 12/73	July 15/73	6.73*	6.98	10.5-10	0.83	100	>96 hr
Endako Mine (Placer Develpment)	Tailings pond reclaim	July 13/73	July 19/73	8.10	8.17	10-10	0.90	100	>96 hr
	Tailings pond reclaim	July 13/73	July 19/73	7.77*	8.08	10-10	0.90	100	>96 hr
Giant Mascot Mine	Tailings pond surface	July 10/73	July 15/73	8.13	7.69	10.5-10	0.83	100	>96 hr
	Tailings pond surface	July 10/73	July 15/73	7.17*	7.49	10.5-10	0.83	100	>96 hr
Granby Mine (Phoenix Division)	Tailings pond surface	July 24/73	July 30/73	7.74	7.69	10.5-10	0.67	100	>96 hr
Gibralter Mine	Tailings pond	July 12/73	July 20/73	9.24	8.88	10-10	0.90	0	1.4 hr
	Tailings pond	July 12/73	July 20/73	7.03*	7.71	10-10	0.84	100	>96 hr
Granisle Copper Mine	Tailings pond recycle	July 17/73	July 20/73	8.77	7.90	9.5-10.0	0.90	100	>96 hr
	Tailings pond recycle	July 17/73	July 20/73	7.06*	7.78	10.0-10.0	0.90	80	>96 hr
HB Mine (Cominco Ltd.)	Tailings pond surface	Aug 7/73	Aug 12/73	7.00	7.6	11.0-11.0	0.68	100	>96 hr
Jordan River Mine	Raw tailings discharge to sea	May /73	June 28/73	11.37	11.28	11-12	0.61	0	0.35 hr
	Raw tailings discharge to sea	May /73	June 28/73	7.00*	7.63	11-12	0.61	100	>96 hr
Kam-Kotia/ Burkam Mine	1st tailings pond surface	Aug 9/73	Aug 12/73	7.46	7.58	10-10.0	0.68	0	34 hr
King Resources Mt Copeland Mine	Tailings pond surface	July 26/73	July 30/73	7.80	7.56	10.5-10.0	0.67	100	>96 hr

96 HR LT_{50} BIOASSAY RESULTS (CONTINUED)

Mine	Sampling Point	Date Sampled	Date Bioassay Started	Initial Sample ph	Final Sample pH	Temp. Range °C	Loading Density gm/litre	% Survival/ 96 hr	LT_{50}
Lornex Mine	Tailings pond surface - pump ho	July 11/73	July 15/73	10.61	10.24	10.5-10.0	0.83	0	1.4 hr
	Tailings pond surface - pump ho	July 11/73	July 15/73	7.25*	7.60	10.5-10.0	0.83	0	1.3 hr
Noranda Mine	Tailings pond surface	July 17/73	July 19/73	9.33	7.79	10.0-10.0	0.90	80	>96 hr
	Tailings pond surface	July 17/73	July 19/73	7.33*	7.55	10.0-10.0	0.90	100	>96 hr
Pinchi Lake Mine (Cominco Ltd)	Tailings pond surface	Sept 12/73	Sept 14/73	7.46	7.73	10.5-10.5	0.87	100	>96 hr
		Sept 12/73	Sept 14/73						
Placid Oil Company Bull River Mine	Tailings pond surface - pump ho	Aug 21/73	Aug 25/73	8.32	8.22	8.5-8.5	0.77	100	>96 hr
	Tailings pond surface - pump ho	Aug 21/73	Aug 25/73	7.07*	7.80	8.5-8.5	0.77	100	>96 hr
Reeves MacDonald Mine	Raw tailings pipe discharge	Aug 8/73	Aug 12/73	8.22	8.02	11.0-11.0	0.68	80	>96 hr
	Raw tailings pipe discharge	Aug 8/73	Aug 12/73	7.73*	7.89	11.0-11.0	0.68	60	>96 hr
Similkameen Mine	Tailings pond surface - pump ho	July 13/73	July 15/73	10.21	9.94	10.5-10.0	0.83	0	4 hr
	Tailings pond surface - pump ho	July 13/73	July 15/73	6.32*	6.85	10.5-10.0	0.83	100	>96 hr
Sullivan Mine (Cominco Ltd)	Iron tailings pond decant pipe	Aug 21/73	Sept 2/73	3.36	3.44	10.5-11.0	0.78	0	3.8 hr
	Iron tailings pond decant pipe	Aug 21/73	Sept 2/73	6.54*	4.84	10.5-11.0	0.78	0	3.8 hr
Teck Corpn Mine	Tailings pond decant pipe	July 24/73	July 30/73	7.17	7.53	10.5-10.0	0.67	100	>96 hr
Texada Mine	Raw tailings pipe discharge	July 18/73	July 20/73	7.78	7.85	10.0-10.0	0.90	100	>96 hr
United Keno Mine	Tailings pond decant	Aug 9/73	Sept 5/73	7.34	7.63	11.0-11.0	0.78	0	31 hr

96 HR LT_{50} BIOASSAY RESULTS (CONTINUED)

Mine	Sampling Point	Date Sampled	Date Bioassay Started	Initial Sample pH	Final Sample pH	Temp. Range °C	Loading Density gm/litre	% Survival/ 96 hr	LT_{50}
Wesfrob Mine	Raw tailings discharge to sea	Aug 22/73	Sept 5/73	10.37	8.13	11.0-11.0	1.18	100	>96 hr
	Raw tailings discharge to sea	Aug 22/73	Sept 5/73	7.88*	7.78	11.0-11.0	1.18	100	>96 hr
Western Mines	Raw tailings discharge to lake	July 26/73	July 29/73	6.68	--	8.5-8.5	0.66	0	1.6 hr
Whitehorse Copper Mine	Tailings reclaim pond	Aug 8/73	Aug 25/73	7.91	7.67	8.5-8.5	0.86	100	>96 hr
	Tailings reclaim pond	Aug 8/73	Aug 25/73	7.08*	7.91	8.5-8.5	0.86	100	>96 hr
Utah mine	raw tailings discharge to Rupert Inlet (Sea)	June 20/72	June 21/72	10.2	--	10.0	--	0	24 hr
	raw tailings discharge	June 20/72	June 21/72	7.47	--	10.0	--	60	96 hr

TABLES III TO VIII INCLUSIVE

96 hour LC_{50} Bioassay Results

- Anvil Mine
- Gibralter Mine
- Granisle Copper Mine
- Similkameen Mine
- Sullivan Mine
- United Keno Mine

TABLE III

96 HR LC_{50} BIOASSAY RESULTS

Mine Sampled: Anvil Mine, Y. T.
Sampling Point: Tailings Pond Decant
Sampling Date: Aug. 9/73

Bioassay Starting Date: Sept. 9/73
Test Fish: Juvenile Coho Salmon (Oncorhynchus kisutch) Acclimated to Untreated Capilano Reservoir Tap Water at 11°C± 1°C
5 fish / test tank
Mean Fish weight: 4.05 gm
Mean Fish Length: 7.1 cm
Test Tank Volume: 20 liter
Test Tank Temp: 11°C ±1°C
Fish Loading Density: 0.78 gm/liter
Dilution Water: Untreated Capilano Reservoir Tap Water
pH 6.4± 0.1
Hardness: 9.7 ppm $CaCO_3$

Test Concentration %	Initial pH	Final pH	Initial Dissolved Oxygen mg/l	Final Dissolved Oxygen mgm/l	% Survival							96HR LC_{50} %
					0.07hr (5 min)	0.75hr (45 min)	19hr	24hr	48hr	72hr	96hr	
100	9.93	9.70	8.6	10.1	100	100	0	--	--	--	--	= 75
56	9.80	7.49	8.6	9.0	100	100	100	100	100	100	100	
32	9.54	7.52	8.6	9.8	100	100	100	100	100	100	100	
10	8.05	7.20	8.6	9.8	100	100	100	100	100	100	100	
Control (untreated tap water)	6.40				100	100	100	100	100	100	100	

* neutralized sample non-toxic at 100% concentration over 96 hours.

TABLE IV

96 HR LC_{50} BIOASSAY RESULTS

Mine Sampled: Gibraltar Mine, B. C.
Sampling Point: Tailings pond
Sampling Date: July 12/73

Bioassay Starting Date: July 20/73
Test Fish: Juvenile Coho Salmon (Oncorhynchus kisutch)
Acclimated to untreated Capilano Reservoir Tap Water
at 11°C±1°C
5 fish/test tank
Mean Fish Weight: 2.7gm
Mean Fish Length: 5.6cm
Test Tank Vol: 20 liter
Test Tank Temp: 9.5°C±1°C
Fish Loading Density: 0.67 gm/liter
Dilution Water: Untreated Capilano Reservoir Tap Water
pH 6.4 ± 0.1
Hardness: 9.7 ppm $CaCO_3$

Test Concentration %	Initial pH	Final pH	Initial Dissolved Oxygen mgm/liter	Final Dissolved Oxygen mgm/liter	% Survival							96HR LC_{50} %
					1hr	2.5hr	20hr	24hr	48hr	72hr	96hr	
100	9.24	9.05	9.4	9.4	100	100	0	--	--	--	--	≈75
56	8,92	8,19	8.8	10.0	100	100	100	100	100	100	100	
32	8.66	8.20	8.9	10.2	100	100	100	100	100	100	100	
Control (Untreated tap water)	6.53				100	100	100	100	100	100	100	

* neutralized sample non-toxic at 100% concentration over 96 hours.

TABLE V

96 HR LC_{50} BIOASSAY RESULTS

Mine Sampled: Granisle Copper Mine, B. C.
Sampling Point: Tailings Pond Recycle
Sampling Date: July 17/73

Bioassay Starting Date: July 20/73
Test Fish: Juvenile Coho Salmon (Oncorhynchus kisutch) Acclimated to Untreated Capilano Reservoir Tap Water at 11°C ± 1°C
5 fish/test tank
Mean Fish Weight: 2.5 gm
Mean Fish Length: 6.0 cm
Test Tank Vol: 20 liter
Test Tank Temp: 9.5°C ± 1°C
Fish Loading Density: 0.67 gm/liter
Dilution Water: Untreated Capilano Reservoir Tap Water
pH: 6.4 ± 0.1
Hardness: 9.7 ppm $CaCO_3$

Test Concentration %	Initial pH	Final pH	Initial Dissolved Oxygen mgm/liter	Final Dissolved Oxygen mgm/liter	% Survival							96 HR LC_{50} %
					1HR	2.5HR	20HR	24HR	48HR	72HR	96HR	
100	8.77	7.90	8.4	9.8	100	100	100	100	100	100	100	Not established
56	8.42	7.68	8.8	10.0	100	100	100	100	100	100	100	
32	7.72	7.21	9.4	9.9	100	100	100	100	100	100	100	
Control (Untreated tap water)	6.53				100	100	100	100	100	100	100	

TABLE VI

96 HR LC_{50} BIOASSAY RESULTS

Mine Sampled: Similkameen Mine, B. C.
Sampling Point: Tailings Pond Supernatent
Sampling Date: July 13/73

Bioassay Starting Date: July 15/73
Test Fish: Juvenile Coho Salmon (Oncorhynchus kisutch)
Acclimated to Untreated Capilano Reservoir Tap Water
at 11°C ± 1°C
5 fish/test tank
Mean Fish Weight: 3.8gm
Mean Fish Length: 6.1cm
Test Tank Vol: 20 liter
Test Tank Temp: 10°C
Fish Loading Density: 0.83 gm/liter
Dilution Water: Untreated Capilano Reservoir Tap Water
pH: 6.4 ± 0.1
Hardness: 9.7 ppm $CaCO_3$

Test Concentration %	Initial pH	Final pH	Initial Dissolved Oxygen mgm/liter	Final Dissolved Oxygen mgm/liter	% Survival						96 HR LC_{50} %
					4HR	16.5HR	24HR	48HR	72HR	96HR	
100	10.21	9.94	3.8	8.0	100	100	0	--	--	--	≈75
56	9.91	9.06	10.2	8.6	100	100	100	100	100	100	
32	9.60	7.31	9.8	9.8	100	100	100	100	100	100	
18	9.46	7.26	10.1	9.4	100	100	100	100	100	100	
10	9.02	7.12	9.9	9.3	100	100	100	100	100	100	
Control (Untreated tap water)	6.41				100	100	100	100	100	100	

* neutralized sample non-toxic at 100% concentration over 96 hours.

TABLE VII

96 HR LC_{50} BIOASSAY RESULTS

Mine Sampled: Sullivan Mine (C. M. & S. Co), B. C.
Sampling Point: Iron Tailings Pond Decant Discharge
Sampling Date: Aug. 21/73

Bioassay Starting DAte: Sept. 2/73
Test Fish: Juvenile Coho Salmon (Oncorhynchus kisutch)
Acclimated to Untreated Capilano Reservoir Tap Water
at 11°C ± 1°C
5 fish/test tank
Mean Fish Weight: 4.34 gm
Mean Fish Length: 6.4 cm
Test Tank Vol: 20 liter
Test Tank Temp: 11.0°C ± 1°C
Fish Loading Density: 0.78 gm/liter
Dilution Water: Untreated Capilano Reservoir Tap Water
pH: 6.4 ± 0.1
Hardness: 9.7 ppm $CaCO_3$

Test Concentration %	Initial pH	Final pH	Initial Dissolved Oxygen mgm/l	Final Dissolved Oxygen mgm/l	% Survival							96HR LC_{50} %
					0.07HR (5min)	0.75HR (45min)	19HR	24HR	48HR	72HR	96HR	
100	3.36	3.44	5.2	10.2	100	100	0	--	--	--	--	
10	4.64	5.35	--	10.1	100	100	100	100	0	--	--	
5.6	5.31	5.16	--	10.2	100	100	100	100	20	20	20	3.0
1.0	6.15	6.69	--	10.0	100	100	100	100	100	100	100	
0.56	6.30	6.60	--	10.0	100	100	100	100	100	100	100	
Control (Untreated tap water)	6.40				100	100	100	100	100	100	100	

TABLE VIII
96HR LC_{50} BIOASSAY RESULTS

Mine Sampled: United Keno Mine, Y. T.
Sampling Point: Tailings Pond Decant
Sampling Date: Aug 9/73

Bioassay Starting Date: Sept 5/73
Test Fish: Juvenile Coho Salmon (Oncorhynchus kisutch)
Acclimated to Untreated Capilano Reservoir Tap Water
at 11°C ± 1°C
5 fish/test tank
Mean Fish Weight: 4.45 gm
Mean Fish Length: 6.6 cm
Test Tank Vol: 20 liter
Test Tank Temp: 11.0°C ± 1°C
Fish Loading Density: 1.18 gm/liter
Dilution Water: Untreated Capilano Reservoir Tap Water
pH: 6.4 ± 0.1
Hardness: 9.7 ppm $CaCO_3$

Test Concentration %	Initial pH	Final pH	Initial Dissolved Oxygen mgm/l	Final Dissolved Oxygen mgm/l	% Survival									96HR LC_{50}%
					.07HR 5min	.17HR 10min	.33HR 20min	1HR	2HR	24HR	48HR	72HR	96HR	
100	7.34	7.63	9.6	10.1	100	100	100	100	100	80	0	--	--	
56	7.21	7.65	9.8	10.2	100	100	100	100	100	100	20	0	--	40
32	7.06	7.38	10.5	10.1	100	100	100	100	100	100	80	80	80	
18	6.94	7.02	9.0	9.6	100	100	100	100	100	100	100	100	100	
Control (Untreated tap water)	6.34				100	100	100	100	100	100	100	100	100	

TABLE IX

Mine Effluent Metal Analysis Results

TABLE IX

MINE EFFLUENT METAL ANALYSIS RESULTS

MINE	SAMPLING POINT	DATE SAMPLED	FRACTION	Al mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Ni mg/l	Cu mg/l	Fe mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Pb mg/l	Zn mg/l
Anaconda	Discharge from Mill	Aug 30/73	Total	4700	400	<1.4	<3.5	2.1	<3.5	26.0	3600	990	140	<21	<7.1	11.0
			Diss	-	20.0	<0.03	-	<0.02	<0.05	<0.01	0.50	10.0	0.07	<0.30	<0.05	<0.01
Britannia Mine	Discharge from Copper Scavenger Flotation	Aug 30/73	Total	1100	170	<1.2	<3.0	<1.8	<3.0	20.0	4700	170	29	<18	<6.0	4.8
			Diss	-	27.0	<0.03	-	<0.02	<0.05	<0.01	0.05	1.7	<0.03	<0.30	<0.05	<0.01
	Discharge from Precipitation Plant	Aug 30/73	Total	54	310	<0.24	0.15	0.06	0.12	38.0	220	150	8.6	< .38	0.18	51.0
			Diss	-	340	0.21	-	0.03	0.12	11.0	210.0	280	7.7	1.20	<0.05	50.0
Anvil Mine	Tailings pond decant	Aug 9/73	Total	0.09	5.2	0.02	<.03	<0.02	<0.03	0.02	0.97	0.80	<0.03	<0.02	0.25	0.15
			Diss	-	4.5	<0.03	-	<0.02	<0.05	0.02	0.35	0.96	<0.03	<0.30	0.21	0.06
Brenda Mines Ltd.	Tailings pond pump house well	July 25/73	Total	0.19	90	<0.01	<0.03	<0.02	<0.03	0.14	0.30	18.0	0.14	0.54	<0.06	<0.006
			Diss	<0.10	13.0	<0.03	-	0.02	<0.05	<0.01	<0.06	1.6	0.13	1.70	<0.05	<0.03
Canex Placer (Tungsten Mine	Tailings pond Discharge pipe	Aug 7/73	Total	0.56	430	<0.03	<0.06	<0.04	<0.06	<0.03	5.9	20.0	8.2	0.50	<0.13	0.05
			Diss	-	430	<0.03	-	<0.02	<0.05	0.02	2.0	36.0	7.6	1.30	<0.05	0.05
Craigmont Mine (Placer Development)	Collection ditch at foot of tailings dam	July 12/73	Total	0.42	21	<0.02	<0.05	<0.03	<0.05	<0.02	1.1	1.8	<0.05	<0.30	<0.10	<0.10
			Ext	0.48	18	<0.03	-	<0.03	<0.1	0.02	0.73	0.63	0.03	<0.3	<0.03	<0.01
Endako Mine (Placer Development)	Tailings pond reclaim	July 13/73	Total	7.0	31	<0.01	<0.04	<0.02	<0.04	0.10	1.5	3.9	0.20	2.3	<0.07	0.04
			Diss	-	18	<0.03	-	<0.01	<0.05	0.11	0.98	7.4	0.16	2.2	<0.05	0.04
Giant Mascot Mine	Tailings pond surface	July 10/73	Total	2.1	25	<0.01	<0.03	0.12	0.24	0.10	4.7	32	0.09	<0.2	<0.06	0.03
			Ext	0.24	16	<0.03	-	<0.03	0.18	0.02	2.0	14	0.03	<0.3	0.11	<0.01
Granby Mine (Phoenix Division)	Tailings pond surface	July 24/73	Total	0.14	270	<0.01	0.05	0.02	<0.04	0.05	0.19	23	0.10	0.21	0.12	<0.007
			Diss	<0.10	13.0	<0.03	<0.01	0.04	<0.05	<0.01	<0.06	2.10	0.10	0.41	<0.05	<0.03

TABLE IX (cont'd)

MINE	SAMPLING POINT	DATE SAMPLED	FRACTION	Al mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Ni mg/l	Cu mg/l	Fe mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Pb mg/l	Zn mg/l
Gibraltar Mine	Tailings pond	July 12/73	Total	4.1	41	<0.01	<0.03	<0.02	0.03	0.23	1.9	1.8	0.03	0.60	<0.07	0.03
			Diss	-	36	<0.03	-	0.01	<0.05	0.17	0.85	3.1	0.04	0.34	<0.05	0.02
Granisle Copper Mine	Tailings pond recycle	July 17/73		-	4.8 5.3	<0.03 <0.03	-	0.03 <0.01	<0.06 <0.06	0.38 0.26	-	4.8 3.5	-	<0.3 <0.3	<0.3 <0.3	0.07 0.03
H.B. Mine (Cominco Ltd)	Tailings pond surface	Aug 7/73	Total	0.31	54	<0.01	<0.04	<0.02	<0.04	0.02	0.07	49	0.04	<0.21	0.11	0.18
			Diss	-	52	<0.03	-	<0.02	<0.05	<0.01	<0.05	76	0.04	<0.30	<0.05	0.10
Kam Kotia/ Burkam Mine	1st tailings pond surface	Aug 9/73	Total	0.34	61	<0.01	0.03	<0.02	0.07	1.2	1.1	3.9	0.37	0.17	0.12	0.15
			Diss	-	1.20	<0.03	-	<0.02	<0.05	1.0	<0.05	7.1	0.25	0.63	<0.05	<0.01
King Resources Mt. Copeland Mine	Tailings pond surface	July 26/73	Total	2.5	18	<0.01	<0.03	<0.02	<0.03	0.006	2.2	1.3	0.35	<0.2	<0.06	0.03
			Diss	<0.10	2.3	-	-	<0.02	<0.05	<0.01	-	1.10	0.29	0.56	<0.05	-
Lornex Mine	Tailings pond surface @ Pump House	July 11/73	Total	0.28	41	<0.01	<0.03	<0.02	<0.03	8.0	0.23	0.23	<0.03	0.73	<0.06	0.006
			Extr	0.54	32	<0.03	-	<0.03	<0.1	8.0	0.15	0.16	<0.03	0.54	0.03	0.02
Noranda Mine	Tailings pond surface	July 17/73	Total	0.39	130	<0.02	<0.05	<0.03	<0.06	0.03	0.22	4.2	<0.06	<0.33	<0.11	0.06
			Diss	-	160	<0.03	-	<0.01	<0.05	0.03	0.10	7.1	0.05	0.68	<0.05	0.07
Pinchi Lake Mine (Cominco Ltd)	Tailings pond surface	Sept 12/73	Total	-	-	-	-	-	-	-	-	-	-	-	-	-
			Diss	-	250	<0.03	-	<0.03	<0.05	<0.03	<0.06	37.0	0.04	0.99	<0.05	<0.03
Placid Oil Company Bull River Mine	Tailings pond surface @ Pump House	Aug 21/73	Total	0.11	34.0	<0.01	<0.03	<0.02	<0.03	0.07	0.24	21.0	0.19	<0.18	<0.06	0.006
			Diss	-	29.0	<0.03	-	<0.02	<0.05	0.03	<0.05	37.0	0.18	0.37	<0.05	0.06

TABLE IX (cont'd)

MINE	SAMPLING POINT	DATE SAMPLED	FRACTION	Al mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Ni mg/l	Cu mg/l	Fe mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Pb mg/l	Zn mg/l
Reeves MacDonald Mine	Raw tailings pipe discharge	Aug. 08/73	Total	130	33,000	<5.4	<14	8.2	19	2.7	7400	22,000	76	<82	410	460
			Diss	--	36	<0.03	--	<0.02	<0.05	<0.01	<0.05	66	<0.03	0.53	0.05	0.02
Similkameen Mine	Tailings pond Surface @pump house	July 13/73	Total	0.50	42	<0.01	<0.03	<0.02	<0.03	0.02	1.1	1.5	<0.03	0.25	<0.06	0.02
			Extr	0.95	38	<0.03	--	<0.03	<0.1	0.02	0.91	0.8	0.03	<0.30	0.18	<0.01
Sullivan Mine (Cominco Ltd.)	Silicious tailings pond decant	Aug. 21/73	Total	56	580	<0.02	<0.06	0.06	<0.06	0.09	27	44	6.6	<0.33	1.9	1.5
			Diss	--	660	<0.03	--	0.02	<0.05	0.01	0.09	67	5.4	0.60	<0.05	0.06
	Iron Tailings pond decant	Aug. 21/73	Total	0.60	130	<0.02	<0.04	<0.02	<0.04	0.06	410	73	6.6	0.41	1.3	4.5
			Diss	--	210	<0.03	--	<0.02	<0.05	0.05	240	114	6.3	1.20	1.0	5.0
Teck Corpn Mine	Tailings pond decant pipe	July 24/73	Total	0.31	50	<0.02	<0.04	<0.02	<0.04	0.02	0.34	0.69	0.09	0.40	<0.08	0.09
			Diss	0.33	8.7	<0.03	--	<0.02	<0.05	<0.01	0.08	0.73	0.04	1.20	<0.05	<0.03
Texada Mine	Raw tailings pipe discharge	July 18/73	Total	1100	7000	0.74	7.4	2.2	5.1	44	6700	2100	180	11	<3.7	7.8
			Diss	<0.10	290	<0.03	--	<0.06	0.19	0.23	<0.06	600	0.40	<0.3	<0.03	0.01
United Keno Mine	Tailings pond decant	Aug. 09/73	Total	0.33	110	0.04	<0.03	<0.02	0.03	0.40	0.52	31	9.9	<0.2	0.12	1.9
			Diss	--	130	0.05	--	<0.02	<0.05	0.36	0.24	34	9.3	0.44	0.70	1.70
Wesfrob Mines	Raw tailings discharge to sea	Aug. 22/73	Total	1600	7300	<2.4	19	<3.6	6.0	41	23,000	870	230	42	<12	12
			Diss	--	42.0	<0.03	--	<0.02	<0.05	0.01	0.20	0.7	<0.03	<0.30	<0.05	<0.01

TABLE IX (cont'd)

MINE	SAMPLING POINT	DATE SAMPLED	FRACTION	Al mg/l	Ca mg/l	Cd mg/l	Co mg/l	Cr mg/l	Ni mg/l	Cu mg/l	Fe mg/l	Mg mg/l	Mn mg/l	Mo mg/l	Pb mg/l	Zn mg/l
Western Mines	Raw tailings discharge to lake	July 26/73	Total	6000	1400	<2.7	<6.8	5.4	<6.8	280	6400	280	4 5	<41	88	1300
			Diss	--	--	--	--	--	--	--	--	--	--	--	--	--
Whitehorse Copper mine	Tailings reclaim pond	Aug. 08/73	Total	0.21	57	<0.01	<0.03	<0.02	<0.03	0.01	0.42	20	1.2	<20	<0.07	.007
			Diss	--	63	<0.03	--	<0.02	--	0.01	0.21	13	1.1	--	--<0.01	

TABLE X

Mine Effluent Non Metal Analysis Results

TABLE X

MINE EFFLUENT NON-METAL ANALYSIS RESULTS

MINE	SAMPLING POINT	DATE SAMPLED	SAMPLE Ph	TEMP. °C	TOTAL HARDNESS (mg/ℓ $CaCo_3$)	TOTAL ALKALINITY (mg/ℓ $CaCo_3$)	TOTAL RESIDUE (mg/ℓ)	NON-FILTERABLE RESIDUE (mg/ℓ)	SULPHATES (mg/ℓ So_4)
Anaconda	Discharge from mill. #1	Aug. 30/73	8.23	--	400.0	66.2*	76,000 (103°C) 78,900 (180°C)	89,300.0	87
Britannia Mine	Discharge from scavenger flotn. #2	Aug. 30/73	10.80	--	200.0	31.9*	16,000 (103°C) 29,000 (180°C)	28,900.0	106
	Discharge from precipitation plant #3	Aug. 30/73	4.20	--	2,400.0	--	35,000 (103°C) 3,680 (180°C)	208.0	2,150
Anvil Mine	Tailings pond decant	Aug. 09/73	9.93	--	17.0	90.9	637 (103°C) 699 (180°C)	<2.5	172
Brenda Mines Ltd.	Tailings pond pump house well	July 25/73	7.57	18	317.0	83.8	904 (103°C) 1,080 (180°C)	6.1	210
Canex Placer (Tungsten) Mine	Tailings pond discharge pipe	Aug. 07/73	6.43	19	2,790.0	42.4	2,590 (103°C) 2,490 (180°C)	3.2	5
Craigmont Mine (Placer Development)	Collection ditch at ft of tailings dam	July 12/73	9.60	--	79.3	37.3	482 (103°C) 485 (180°C)	10.7	176
Endako Mine (Placer Development)	Tailings pond Pond #1 Seepage #2 Reclaim #3	July 13/73	8.10	--	--	--	251 (180°C) 548 (180°C) 484 (180°C)	--	--
Giant Mascot Mine	Tailings pond surface	July 10/73	8.13	18	133.6	55.5	406 (103°C) 409 (180°C)	60.9	146

* Sample Filtered Prior To Determination.

TABLE X (cont'd)

MINE	SAMPLING POINT	DATE SAMPLED	SAMPLE Ph	TEMP. °C	TOTAL HARDNESS (mg/ℓ $CaCo_3$)	TOTAL ALKALINITY (mg/ℓ $CaCo_3$)	TOTAL RESIDUE (mg/ℓ)	NON-FILTERABLE RESIDUE (mg/ℓ)	SULPHATES (mg/ℓ So_4)
Granby Mine (Phoenix Division)	Tailings pond surface	July 24/73	7.74	17	1,020.0	45.8	1,530 (103°C) 1,460 (180°C)	2.5	680
Gibralter Mine	Tailings Pond #1 Tailings Pond #2	July 12/73	9.24	--	--	--	510 (180°C) 414 (180°C)	--	--
Granisle Copper Mine	Tailings Pond recycle	July 17/73	8.77	--	--	--	-- --	--	--
HB Mine (Cominco Ltd.)	Tailings pond surface	Aug. 07/73	7.00	18	2,608.0	47.3	486 (103°C) 506 (180°C)	5.0	1,600
Jordan River Mine	Raw tailings discharge to sea	May /73	11.37	--	--	--	-- --	--	--
Kam-Kotia/ Burkam Mine	1st tailings pond surface	Aug. 09/73	7.46	25	2,010.0	30.7	508 (103°C) 499 (180°C)	14.0	240
King Resources Mt. Copeland Mine	Tailings pond surface	July 26/73	7.80	20	55.4	37.0	107 (103°C) 148 (180°C)	25.0	39
Lornex Mine	Tailings pond surface - pump ho	July 11/73	10.61	19	79.3	96.1	455 (103°C) 464 (180°C)	18.2	7.4
Noranda Mine	Tailings pond surface	July 17/73	9.33	--	--	--	924 (180°C)	--	--

TABLE X (cont'd)

MINE	SAMPLING POINT	DATE SAMPLED	SAMPLE Ph	TEMP. °C	TOTAL HARDNESS (mg/ℓ $CaCo_3$)	TOTAL ALKALINITY (mg/ℓ $CaCo_3$)	TOTAL RESIDUE (mg/ℓ)	NON-FILTERABLE RESIDUE (mg/ℓ)	SULPHATES (mg/ℓ So_4)
Pinchi Lake Mine (Cominco Ltd.)	Tailings pond surface	Sept 12/73	7.46	--	800.0	47.0	1,300 (103°C)	4.1	770
Placid Oil Company Bull River Mine	Tailings pond surface - pump ho	Aug. 21/73	8.32	--	170.0	128.0	369 (103°C) 499 (180°C)	14.8	97
Reeves MacDonald Mine	Raw tailings pipe discharge	Aug. 08/73	8.22	24	2,627.0	99.0	152,000 (103°C) 184,000 (180°C)	153,000.0	200
Similkameen Mine	Tailings pond surface - pump house	July 13/73	10.21	18.5	126	71.2	555 (103°C) 631 (180°C)	19.1	200
Sullivan Mine (Cominco Ltd.)	Iron tailings pond decant	Aug. 21/73	3.36	--	1,400.0	Acidity 539.0	1,890 (103°C) 2,960 (180°C)	55.0	1,190
	Silicious tailings pond decant	Aug. 21/73	--	--	1,780.0	178.0	2,990 (103°C) 1,940 (180°C)	106.0	1,500
Teck Corpn Mine	Tailings pond decant pipe	July 24/73	7.17	19	165.0	33.1	387 (103°C) 390 (180°C)	5.9	150
Texada Mine	Raw tailings pipe discharge	July 18/73	7.78	19	2,700.0	13,000.0	61,473 (103°C) 71,000 (180°C)	31,900.0	1,750
United Keno Mine	Tailings pond decant	Aug. 09/73	7.34	--	300.0	80.1	762 (103°C) 768 (180°C)	9.0	400

TABLE X (cont'd)

MINE	SAMPLING POINT	DATE SAMPLED	SAMPLE Ph	TEMP. °C	TOTAL HARDNESS (mg/ℓ $CaCo_3$)	TOTAL ALKALINITY (mg/ℓ $CaCo_3$)	TOTAL RESIDUE (mg/ℓ)	NON-FILTERABLE RESIDUE (mg/ℓ)	SULPHATES (mg/ℓ So_4)
Wesfrob Mine	Raw tailings discharge to sea	Aug. 22/73	10.37	--	11.0	11.0	41,391 (103°C) 77,900 (180°C)	132,000.0	35
Western Mines	Raw tailings discharge to lake	July 26/73	6.68	16.3	--	--	86,900 (180°C)	--	--
Whitehorse Copper Mine	Tailings reclaim pond	Aug. 08/73	7.91	--	260.0	83.7	403 (103°C) 450 (180°C)	2.5	134