Province of British Columbia
Ministry of Environment

ALDRICH LAKE:
A DATA REPORT ON WATER QUALITY AND BIOLOGICAL DATA FROM THE RECEIVING WATERS OF THE AREA AROUND THE ABANDONED DUTHIE MINE

Compiled By

D. B. Maclean

WASTE MANAGEMENT BRANCH
ENVIRONMENTAL SECTION

Report No. 83.05

Remington Environmental
RR 2, Site 59, C. 9
Smithers, B.C. V0J 2N0

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View of Aldrich Lake looking S.W.
showing Old Duthie Tailings and
West End (outlet) of lake

TABLE OF CONTENTS

1. Introduction

Within the last two years increasing attention has been directed by the Waste Management Branch (WMB) toward the effects of previous and proposed mining operations on the headwaters of the Zymoetz Rivers,specifically Aldrich Lake and its tributaries. This attention was triggered by an application by Paul Kindrat for a permit to cover the discharge from a 50 ton per day lead-silver flotation mill and the hope that the existing problems due to failure of the old tailings dams could be mitigated by the new working of the property. This report is an attempt to bring under one cover the environmental monitoring of receiving waters done by the WMB and the Environmental Protection Service (EPS) of Environment Canada.

1.1 Description of Area

Aldrich Lake, 54^{0}45'39" N., 127^{0}22'22" W., is located approximately 12 km West of Smithers, B.C., at an elevation of 850 metres. Figure 1 shows Aldrich Lake, its feeder creeks of interest to this report, and the old tailings dump which is presumed to be the source of heavy metal contamination. It is a shallow (mean depth 4.4 meters) roughly circular lake with a surface area of 47.6 hectares and a volume of 2.1 million cubic meters. Aldrich Lake drains into Dennis Lake 3 km to the West via the Zymoetz River. Dennis Lake drains into McDonnel Lake which in turn is drained by the Zymoetz River which empties into the Skeena River 12 km upstream from Terrace (Figure 2).

1.2 Fishery Resource

The Zymoetz River's upper reaches support natural populations of sockeye, coho, chinook, steelhead trout and cutthroat trout. It has been speculated but unconfirmed that sockeye and coho salmon runs to Aldrich Lake have been eliminated by habitat degradation of previous mining operations. The upper Zymoetz at Serb and Fossil Creeks (Figure 2) is a site for chinook salmon and steelhead trout enhancement. In 1981 90,000 chinook fry were released by federal personnel throughout the Zymoetz below Serb Creek. Provincial Fish and Wildlife personnel have been incubating and releasing steelhead trout fry throughout the system since 1981 when the Zymoetz between Aldrich Lake and Dennis Lake was stocked.

1.3 Recreational Uses

Aldrich Lake is not heavily used recreationally for fishing or camping. There is one small campsite accessible by road adjacent to WMB site 0700157 (figure 1) which appears to be used as a hunting camp. Arsenic levels in the lake have exceeded the recommended objective for recreational water in one sample and approaches the level on two other occasions. A sign was posted by the Regional Health Officer at the tailings outwash on April 20, 1982 stating that the water was not potable.

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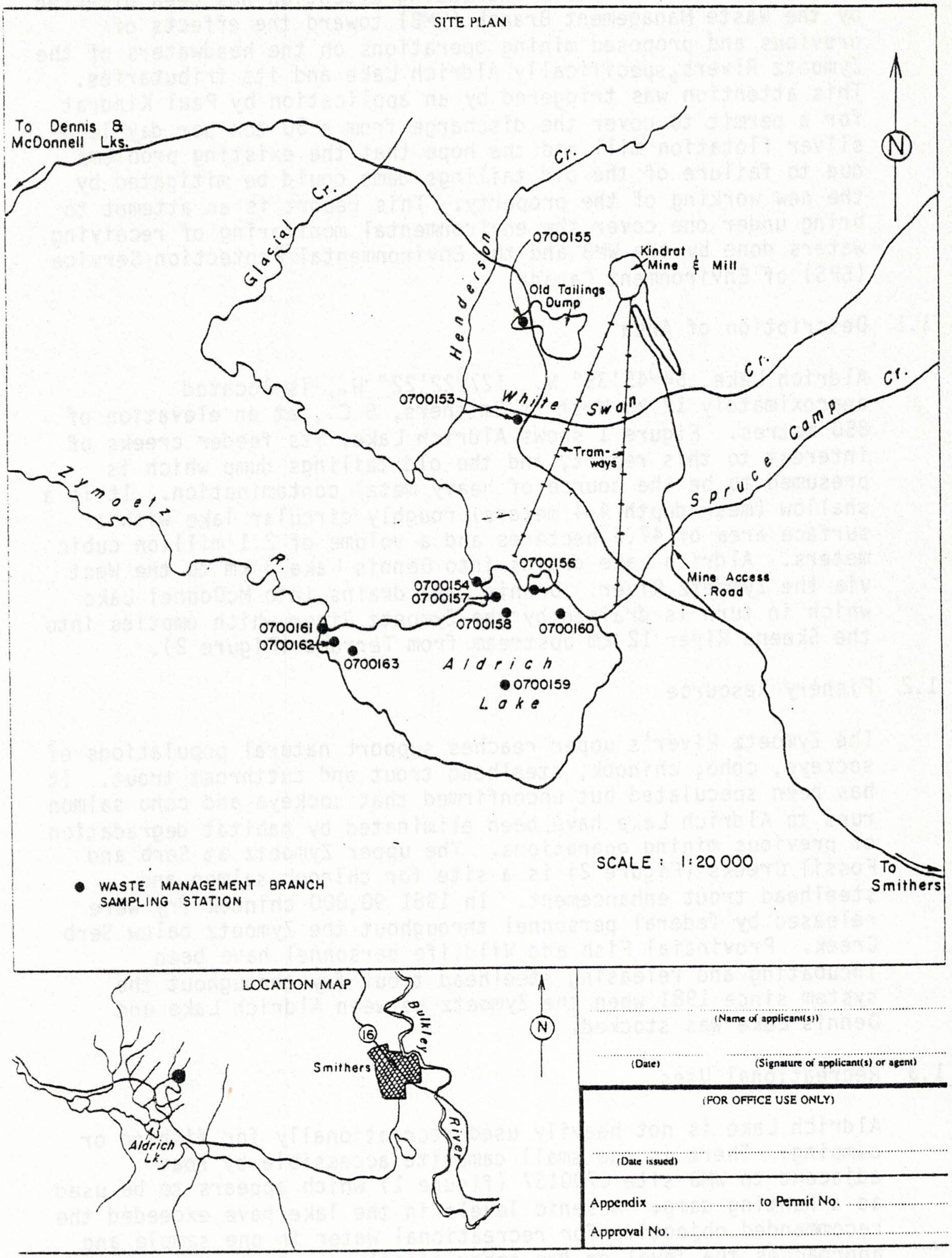
Fig. 1 Aldrich Lake and Tributaries



(Name of applicant(s))

(Date) (Signature of applicant(s) or agent)

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Appendix .... to Permit No. ....

Approval No. ....

ENV 1987

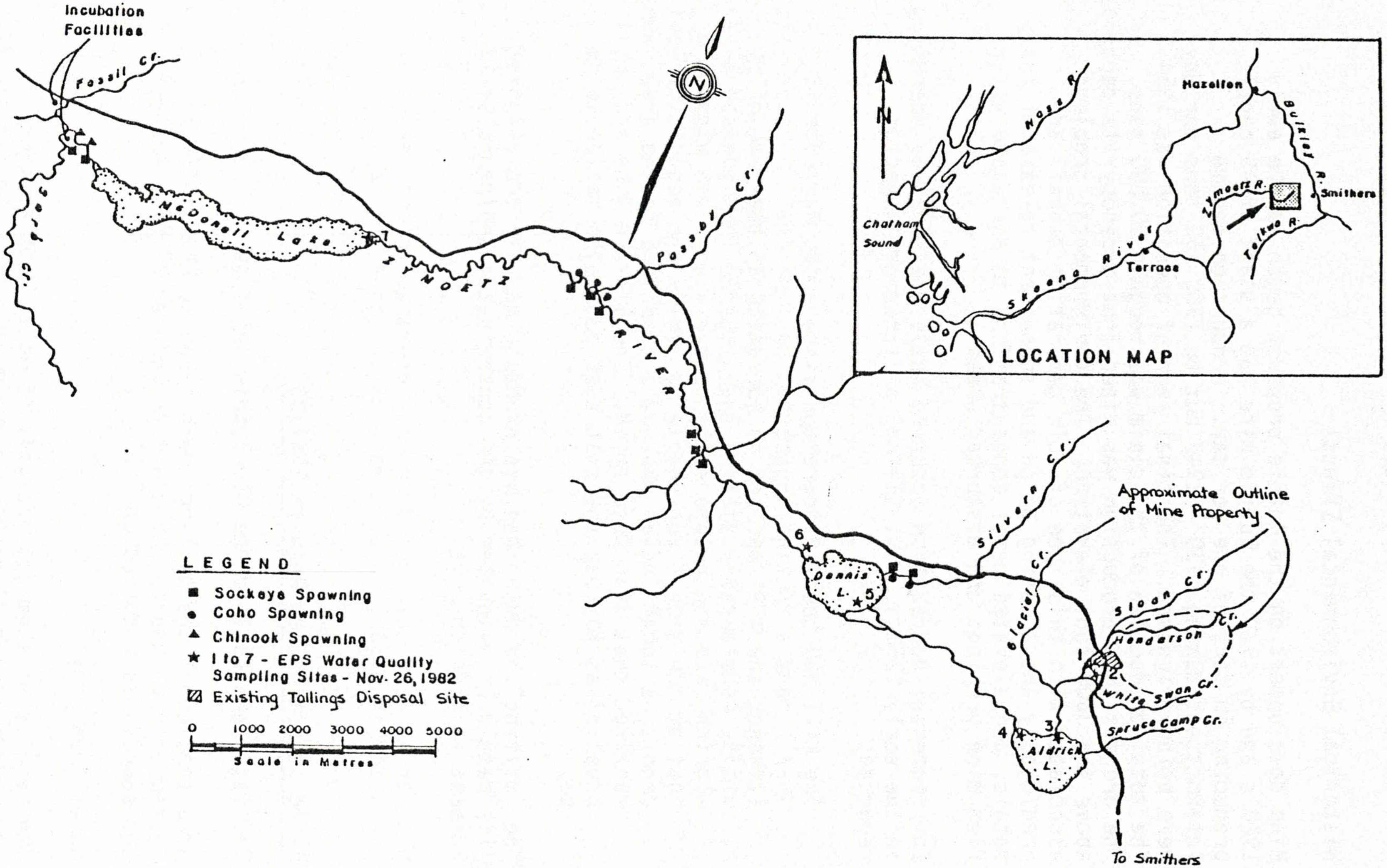

FIGURE 2 UPPER ZYMOETZ RIVER

1.4 Historical Environmental Effects

Mine development on the Duthie property began in the early 1920's and by 1928 the Duthie mine had a staff of 45 people producing 50 tons of ore per day. Production became intermittent during 1930 - 1940 but by 1950 150 tons per day were being processed. The final year of operation was 1954. The total production of the claim was roughly 80,000 tons. The ore for this production was mined from arsenopyrite deposits above the 3600 foot elevation. The environmental problems associated with this type of acid generating deposit are predictably the lowering of pH and subsequent release of heavy metals, and elevated metal concentrations in any waste water from mine workings and disturbed areas.

Environmental degradation occurred while the mine was operating in the early 1950's, W.K. Elliot, a fisheries inspector reported:

> The mill has been in operation since about May 20th/53. When I made a routine inspection on June 24th, I found that, although the mill was not in operation at the time of my visit, considerable silting had occurred in Henderson Creek. Aldrich Lake had become quite opaque. As I was without a boat at the time I was unable to verify the account of David Dennis, a local Indian who has a trap line in the area, who reported that fish were dying. The Sil-Van Mine had small brush piles to keep the silt back but these failed to do so.

The "silting" he describes was probably heavily contaminated with metals as evidenced by the contaminated sediments still present in Aldrich Lake.

Most of the old tailings dump was generated in one season of operation in 1953/1954 at a rate of 150 tons per day.

2. Field Investigation Results 1982/83

2.1 Tailings Samples from the Old Duthie Tailings

Grab samples of the tailings were taken by EPS staff on September 9/82 and by WMB staff on October 27/82. Analysis of the samples is recorded in Table 1.

2.2 Water Chemistry

The results of chemical analysis of water samples taken concurrently with Aldrich Lake sediment samples on January 27/83 are recorded in Table 2. Multi date and multi site results are shown in Table 3. Table 3 includes the source of metal contamination the Duthie mine tailings outwash (site #0700155) which flows into Glacial Creek (site #0700154). White Swan Creek (site #0700153) can be considered a relatively pristine control for comparison to Glacial Creek. Table 4 summarizes EPS data from their November 26, 1982 field trip and includes the downstream sites for Dennis Lake and McDonnel Lake.

2.3 Lake Sediment Chemistry

The results of chemical analysis of sediment samples taken on January 27/83 are recorded in Table 5. Where a good core sample was obtained it was sectioned into 6 cm sections which were analyzed separately.

2.4 Hepatic Metallothionein and Metal Analysis

Cutthroat trout were netted at two sites on July 13, 1983. Livers were dissected from three and four year old fish and sent to the University of Victoria's department of biochemistry and microbiology for analysis. The results are recorded in Table 6.

2.5 Muscle Tissue Analysis for Metals

Muscle tissue from the same fish (2.4) was sent to the Environmental Laboratory for analysis. Results are recorded in Table 7.

3. Discussion of Results

3.1 Tailings Analysis

As the majority of the 80,000 tons of ore processed since 1950 came from an arsenopyrite ore deposit the tailings have a very large quantity of arsenic (.69 to 1.7 percent) and iron (4.9 to 7.5 percent). Aluminum (.43 to .99 percent) and lead (.22 to .28 percent) are also present in substantial amounts. Table 1 shows elevated levels for other metals as well. It is the failure of the dyking around these old tailings that is causing elevated levels of metals to still be present in Glacial Ck and Aldrich Lk, as the leachate from the tailings flows freely into Henderson and subsequently Glacial Ck.

3.2 Water Quality

a) Tailings Outwash (#0700155)

Analysis of the leachate which outwashes from the old Duthie tailings reported in Table 3 shows excessive metal concentrations. The Federal Metal Mining Liquid Effluent Regulations maximum authorized concentrations (Appendix 1) are exceeded for As, Zn (up to 29 times the regulation) and pH. The elevated metal concentrations and low pH indicate that the tailings are still acid generating. Because of the failed berms large volumes of local runoff has been flowing through the tailings and washing the tailings several hundred meters downstream. Paul Kindrat in a first attempt at mitigating the problem dug diversion ditching around the old tailings in the fall of 1982. This should greatly reduce the quantity of water being contaminated.

b) Glacial Creek Mouth (#0700154)

Elevated levels of metals exist in Glacial Creek when the analysis is compared to the unadulterated White Swan Creek (#0700153). The Canadian recommended surface fresh water quality objectives (Reeder et al 1979) are exceeded for Cd, Cu, Pb, Zn. Appendix 2 has the master table from Reeder for the readers reference.

c) Aldrich Lake (#0700156 - #0700163)

Table 2 shows significant elevated levels of total and dissolved metals in Aldrich Lake. The Canadian recommended surface fresh water quality objectives (Appendix 2) are exceeded for As, Cd, Cu, Pb, Zn. The site at Glacial Ck inlet (0700157) has the highest total metals levels of any point in the lake and is higher than Glacial Ck itself. This suggests that the sediments are contributing metal contaminated particulates to the water column, possibly as a result of sampling disturbance. Concentrations are generally higher near Glacial Creek inlet and decrease towards the lake centre and outlet.

d) Downstream EPS Sites (#1-7, figure 2)

Data recorded in Table 4 shows that metal concentrations become progressively lower from sampling points downstream. Zn and As concentrations found in McDonnel Lake are similar to those found in White Swan Ck. Fe concentrations at McDonnel are still elevated compared to White Swan Ck and do not show the same downward progression of concentration.

3.3 Sediment Metals

Table 5, shows highly elevated levels of As, Cu, Pb, Cd, Zn in the most recent sediments taken from Aldrich Lake.

Although all sediments in the lake appears to have elevated metals, it is evident that the degree of metals contamination decreases with increasing distance from Glacial Ck. It is also evident from the sites where enough length of core was sampled that metals concentration is highest in the most recent sediments (ie. the top layer of core, 0-6 cm) and levels decline progressively down the sampled core. No attempt to date the core sections was made and it is assumed that the top layer (0-6 cm) would show anthropogenic influences while the bottom layer (24-30 cm) should be approaching "background" levels.

Metal concentrations in sediments of other lakes in the watershed are not available, indications from Babine Lake near Granisle Mine are that As should range from about 20-80 ug/g, Cu from 40-400 ug/g and Zn from 100-300 ug/g.

3.4 Hepatic Metallothionein and Metal Analysis

Metallothionein concentration in fish livers is expected to increase with metal contamination and allows an assessment of biological hazard in rainbow trout (M. Roch 1982).

Analysis of cutthroat trout livers shown in Table 6 shows concentration similar to those found in rainbow trout at an unpolluted site. This was entirely unexpected, Figure 3 shows that with elevated Zn concentrations, metallothionein should increase. One possible explanation is that cutthroat trout tend to be more piscivorous than rainbow trout and small fish tend to have a lower heavy metal content than zooplankton the primary food source of rainbow trout.

3.5 Muscle Tissue Metal Levels

Table 7 reports heavy metals content in fish muscle tissue collected by netting. Metals are reported in micrograms per gram (ppm) dry weight, to convert to wet weight the dry weight reading is divided by the proportion of moisture (approximately 4:1). Concern was raised that fish angled from Aldrich Lake may have significant metals storage resulting in unacceptable dietary levels for human consumption. The standards mentioned below are all supplied by Health and Welfare Canada in unpublished documents.

Zn: Cutthroat trout had much lower levels of Zn (5-9 ppm wet) than the Canadian guideline for human consumption of 100 ppm wet weight.

As: Cutthroat trout were all below detection limits of 5 ppm wet weight which is the Canadian maximum acceptable concentration for fish.

Pb: Cutthroat trout were all below detection limits of 25 ppm wet weight. The Canadian standard is 10 ppm wet weight.

Cu: Two trout had detectable levels of Cu (.25-1 ppm wet weight) which is well below the standard maximum acceptable concentration of 100 ppm wet weight.

The levels of metals in resident Aldrich Lake cutthroat trout tissue appear unremarkable and levels are similar to those of fish from relatively unpolluted waters (Reeder 1979).

3.6 Discussion Summary

This is a data compilation, not an interpretive report, so extensive comments are unwarranted. Some comment is necessary regarding the continuous drainage of poor quality leachate from the old tailings.

a) Table 3 (site 0700155) shows that heavy metal laden leachate continues to drain into Aldrich Lake.

b) There is a clear recent build up of heavy metals in lake bottom sediments, particularly adjacent to the mouth of glacial creek (Table 5).

c) Arsenic levels measured in the lake have exceeded maximum allowable drinking water standards of .05 ppm on one occasion, and come very close to this limit on at least two other sampling occasions (Tables 2 & 3).

d) There is no corresponding evidence of metal contamination in fishes collected from Aldrich Lake 14 July/83. This finding is contrary to expectations.

e) Despite the findings for fish, it is recognized that this mine drainage is undesireable; also it is likely that ecosystem effects are present but have not been discovered yet. The absence of rainbow trout in this lake may suggest a selective removal of this species. It is probable that chronic sublethal effects such as reduced growth and reproduction will occur given existing concentrations of Zn and Cu (Alderdice & McLean, 1982).

4. Recommendations and Further Work

a) Drainage from the tailings must be stopped. Ditching by Mr. Kindrat is an excellent start. The main solution is to cap the tailings and revegetate the area.

b) Capping and revegetation trials should be jointly carried out by the Permittee with expertise from MEMPR. Future de-watered coarse tailings and waste rock from Mr. Kindrat's operation may or may not be appropriate capping materials.

c) The burden of continuing monitoring lake water quality should fall on the Waste Management Branch. Mr. Kindrat's new operation is not responsible for the present problems with tailings drainage.

d) Further biological investigation is warranted to determine the reason for the unexpected result with fish contamination. This lake system represents a good experimental opportunity because it has been stressed with metals for 30 years. University researchers will be approached to pursue this further.

5. Acknowledgements

Numerous WMB and EPS personnel participated in the collection of data presented in this report. Special thanks to Sig Hatlevik, Fish and Wildlife Branch for assisting in collecting fish and to M. Roch of the University of Victoria for performing metallothionein analysis, and to B.D. Wilkes of WMB for writing sections 3.6 and 4.

FIGURE 3 (from Roch, 1982)

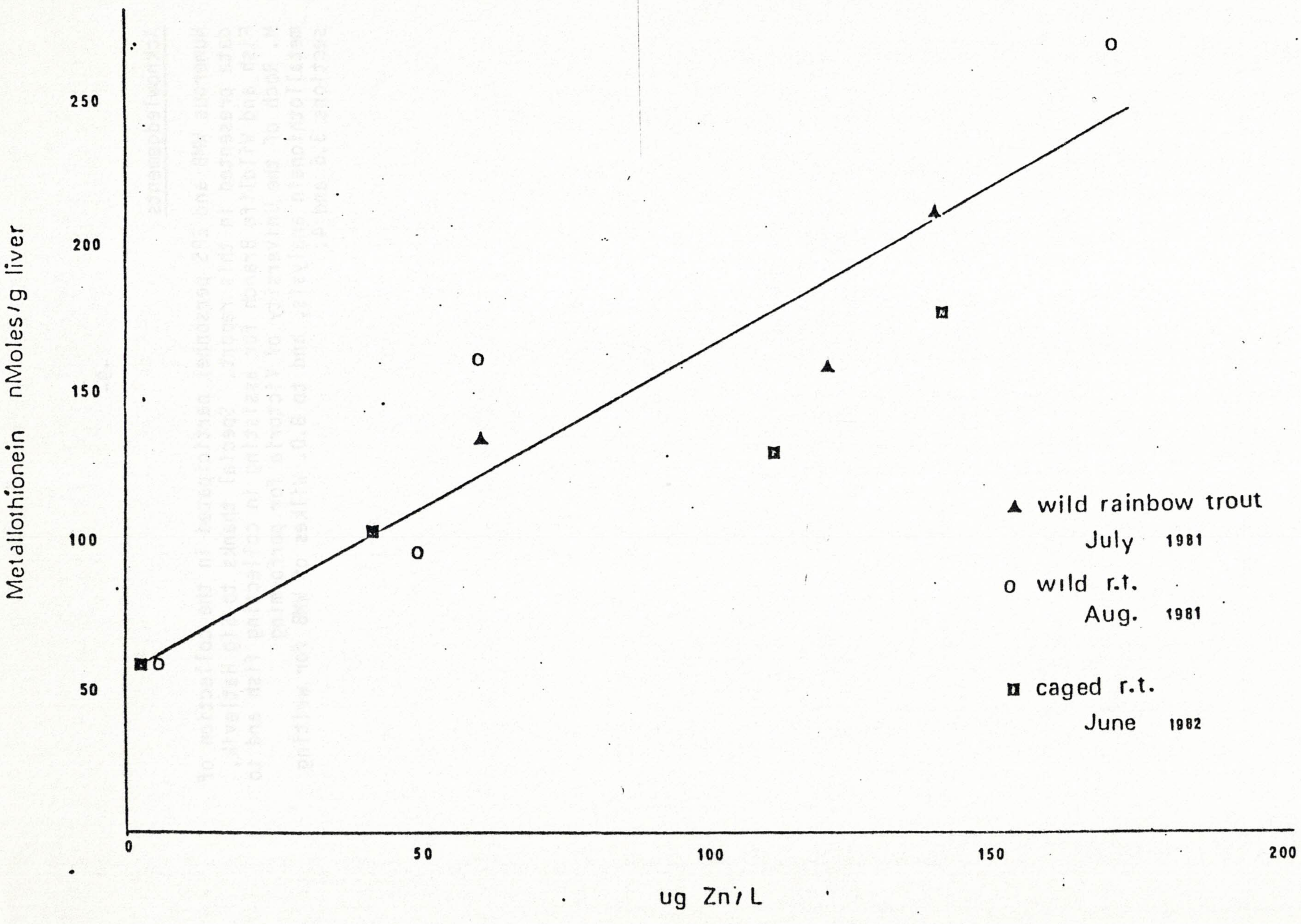

TABLE 1

Sediment Analysis of Existing Tailings - Duthie Mine
ug/g Dry Weight

Parameter	EPS Sample September 9/82	WMB Samples October 27/82	
		lower tails	upper tails
As	17 500	13 200	6 930
B	22.1	21	1
Ba	67.6	27	16
Be	.2	1	1
Cd	.3	1	12
Co	.8	13	11
Cr	18.5	53	33
Cu	177	115	172
Mn	907	1 770	6 555
Mo	23.9	19	21
Ni	3	6	6
P	724	333	290
Pb	2 840	2 840	2 190
Sn	2	5	5
Sr	9.8	6	6
Tl	51.5	36	20
V	27	17	16
Zn	311	298	2 750
Al	9 970	4 900	4 300
Fe	74 800	62 700	49 000
SL	6 450	--	--
Ca	1 190	6 360	7 090
Mg	2 410	2 120	2 490
Na	210	--	--
Se	--	23	17
Ti	--	3	3

TABLE 2 Water Chemistry - Aldrich Lake - January 27
Total & Dissolved Metals - mg/L

	Glacial Creek at Mouth #0700154	S*	Aldrich Lake at Glacial Inlet #0700157	S*	Aldrich Lake 30 m S Glacial Ck. Inlet #0700158	S*	Aldrich Lake East #0700160	S	Aldrich Lk. Outlet at Beaver Dam #0700161	Aldrich Lk. Outlet 60 m SE Beaver Dam #0700162	Aldrich Lk. Outlet 90 m SE Beaver Dam #0700163	Aldrich Lake Middle #0700159
T.As	0.041	.006	1.18	.144	.023	.004	.015	.001	.012	.048	.03	.016
D.As	0.012	-	.077	-	.01		.009		.011	.012	.011	.016
T.Cd	0.0006	.00005	.0067	.0012	.0005	0	L.0005		L.0005	.0015	.0016	L.0005
D.Cd	0.0006		.0006		.0005		L.0005		L.0005	L.0005	L.0005	L.0005
T.Cu	0.002	.001	.047	.0115	.0013	.0006	.002	0	.002	.006	.004	.004
D.Cu	0.002		.002		.001		.001		.002	.003	.001	.001
T.Pb	0.0058	.003	.014	.0115	.0033	.0015	.01		.013	.04	.02	.003
D.Pb	0.001		.006		.001		.002		.006	.001	.001	.002
T.Mn	0.49	.001	1.513	1.1365	.502	.031	.143	.006	.026	.11	.07	.006
D.Mn	0.44		0.67		.52		.14		.003	.09	.04	.003
T.Zn	0.21	.005	0.95	.121	.19	0	.093	.006	.05	.23	.17	.05
D.Zn	0.18		.18		.18		.08		.04	.025	.025	.04
T.Ca	8.07	.138	9.61	.662	9.58	1.035	7.28	.249	4.59	5.19	4.99	6.96
D.Ca	7.91		8.86		10.5		7.42		4.4	5.01	4.54	6.86
T.Cr	0.01	0	0.017	.0057	L.01	0	.01		L.01	.01	L.01	L.01
D.Cr	L0.01		L0.01		L.01		L0.01		L.01	L.01	L.01	L.01
T.Fe	2.22	.07	15.76	2.108	1.79	.045	.58	.015	.32	2.23	1.55	.24
D.Fe	.97		1.67		.86		.42		.2	.3	.19	0.16
T.Mg	.93	.02	1.64	0.240	1.007	.159	.86	.09	.71	.98	.91	.98
D.Mg	.91		0.95		1.19		.77		.71	.7	.65	.98
T.Mo	.015	.007	.01	0	L.01	0	L.01		L.01	.01	L.01	L.01
D.Mo	.01		L0.01		L.01		L.01		L.01	L.01	L.01	L.01
T.Ni	L.05		L.05	0	L.05	0	L.05		L.05	L.05	L.05	L.05
D.Ni	L.05		L.05		L.05		L.05		L.05	L.05	L.05	L.05
T.Al	.13	.01	2.97	0.499	.027	.0115	L.02		.06	1.75	1.25	.03
D.Al	.05		.07		.04		L.02		.04	.03	.02	.02
T.V	L.01		.01	0	L.01	0	L.01		L.01	L.01	L.01	L.01
D.V	L.01		L.01		.01		L.01		L.01	L.01	L.01	L.01
T.Co	L0.1		L0.1	0	L0.1	0	L.1		L.1	L.1	L.1	L0.1
D.Co	L0.1		L0.1		L0.1		L.1		L.1	L.1	L.1	L0.1
D.Bg	.01		.01		.01		0.01		L.01	L.01	L.01	L0.01
Conductance			66		-		55		-	-	36	59

* Where standard deviation valve present - sample was taken in triplicate and valve given is mean

TABLE 3

SAMPLING & MONITORING RESULTS

FILE : AE 6681

PROGRAM : Aldrich Lake Background

MONITORING : ☒ Source ☒ Environment

SITE No. OR DATE : multi site/date

SAMPLER : Rhebergen / Maclean / EPS personnel

SAMPLE TYPE : Water

SITE No. or DATE	LOCATION	Permittee Data	pH (units)	SP. COND. µmhos/cm	Temp. (°c)	TOTAL / As diss	TOTAL / Cd diss	TOTAL / Cu diss	TOTAL / Pb diss	TOTAL / Ni diss	TOTAL / Zn diss	TOTAL / Al diss	TOTAL / Fe diss	TOTAL / Mn diss	TOTAL / Mg diss	TOTAL / Mg diss	TOTAL / Ca diss	TOTAL / Co diss	TOTAL / Cr diss	Ba	SO
						SAMPLING RESULTS (mg/l)															
Aug 13/82	Duthie Mine Tailings Outwash			932	-	.73 / <.25	.02 / .02	.09 / .07	.03 / .02	<.05 / <.05	16.4 / 16.4	1.49 / 1.18	52.9 / 43.3	42.2 / 42.2	.04 / .04	20.0 / 18.5	80.6 / 78.6	<0.1 / <0.1	<.01 / <.01	.02	427
Sept 9/82*	#0700155		3.4		-	2.86 / .75	.066 / .061	.435 / .402	.2 e / .57	.03 / .03	29.1 / 25.9	5.48 / 4.71	958 / 67.3	8.71 / 4.85	.014 / -	29.4 / 24.9	95.9 / 83.	.156 e / .217	.01 / .007	.018	663
Oct 12/82	#0700155				-	1.75 / .64	.06 / .05	.25 / .23	.1 / .095	.02 / .02	28.2 / 28.2	4.51 / 4.03	79.1 / 63.1	59.7 / 59.7	<.01 / <.01	25.2 / 25.2	84.7 / 82.7	<.1 / <.1	.03 / <.01	.02	
Nov 26/82*	#0700155		6.3		-	.11 / .06	.006 / .005	.018 / .008	.015 / .0025	.03 / .02	2.05 e / 2.13	.45 / .07	13.53 / 11.93	13.13 / 12.5	- / -	10.3 / 10.87	56.03 / 59.9	- / -	.007 / -	.034	210
May 11/83	#0700155		4.2	490	-	.45 / .058	.03 / .03	.12 / .12	.2 / <0.1	<.05 / <.05	7.67 / 7.1	3.57 / 2.27	15.9 / 5.63	12.0 / 11.5	.03 / .02	9.46 / 9.13	46.7 / 41.5	<.1 / <.1	.03 / <.01	.03	215
Oct 12/82	Glacial Ck. Mouth		-	-	-	.008 / <.005	<.0005 / <.0005	.001 / .001	<.001 / <.001	<.01 / <.01	.015 / .015	.04 / <.02	.52 / .31	.05 / .05	<.01 / <.01	147.e / .39	5.04 / 4.97	<.1 / <.1	<.01 / <.01	<.01	-
Jan 27/83	#0700154		6.4	79	-	.044 / .012	.0006 / .0006	.002 / .002	.0058 / .001	<.05 / <.05	.21 / .18	.13 / .05	2.22 / .97	.49 / .44	.015 / .01	.93 / .91	8.07 / 7.91	<.1 / <.1	.01 / <.01	.01	-
May 11/83	#0700154		6.2	40	-	.005 / .005	<.01 / <.01	.006 / .004	.005 / .002	<.05 / <.05	.39 / .39	.15 / .05	.62 / .29	.61 / .51	<.01 / <.01	.78 / .71	5.87 / 5.54	<.1 / <.1	<.01 / <.01	<.01	12.8
Aug 13/82	Aldrich Lk. at Tramway Rd.		-	36	-	<.25 / <.25	<.01 / <.01	<.01 / <.01	.003 / .003	<.05 / <.05	.04 / .03	.02 / .02	.27 / .27	.04 / .04	<.01 / <.01	.52 / .52	4.64 / 4.61	<.1 / <.1	<.01 / <.01	<.01	5.3
Oct 12/82	#0700158		-	-	-	.038 / .02	<.0005 / <.0005	.002 / .001	.002 / .002	<.01 / <.01	.021 / -	.02 / <.02	.27 / .24	.03 / .03	<.01 / <.01	.47 / .47	4.46 / 4.46	<.1 / <.1	<.01 / <.01	<.01	-
Jan 27/83	#0700158		6.2	83	-	.014 / -	<.0005 / -	.002 / -	.011 / -	<.05 / -	.09 / -	.02 / -	.58 / -	.15 / -	<.01 / -	.94 / -	7.09 / -	<.1 / -	.01 / -	-	-
May 11/83	#0700158		7.2	42		.048 / .025	<.01 / <.01	.003 / .002	.004 / .002	<.05 / <.05	.13 / .13	.1 / .03	1.01 / .61	.4 / .38	<.01 / <.01	.8 / .77	4.99 / 4.68	<.1 / <.1	<.01 / <.01	<.01	7.0
Oct 12/82	White Swan Ck. at Rd.					<.005 / <.005	<.0005 / <.0005	<.001 / <.001	<.001 / <.001	<.01 / <.01	<.005 / <.005	.05 / .02	.06 / .05	<.01 / <.01	<.01 / <.01	.96 / .96	5.7 / 5.47	<.1 / <.1	<.01 / <.01	.01	-
	#0700153																				
*	EPS sampling																				

POLLUTION CONTROL OBJECTIVES :

TABLE 4

WATER QUALITY ANALYSES OF TAILINGS RUNOFF AND THE FRESHWATER SITES NOVEMBER 26, 1983

	Acid Mine Drainage	White Swan Creek	Aldrich Lk at Glacial Ck	Aldrich Lk Outlet	Dennis Lk Inlet	Zymoetz R below Dennis Lk	McDonnel Lk
	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$
pH	6.3	.93	6.5	6.9	6.6	6.87	7.0
total residue (mg/l)	455.00	52.00	57.33	51.33	52.00	72.67	82.00
non-filterable residue (mg/l)	30.0	L5	L5	L5	L5	L5	L5
sulfate (SP)(mg/l)	210.00	3.53	8.77	5.93	4.83	4.50	4.17
conductivity (umhos/cm)	496.00	41.93	55.8	42.97	62.2	75.1	89.0
turbidity (FTU)	78.0	0.1	0.8	1.1	1.6	0.7	1.3
total alkalinity (mg/l)	22.33	15.67	15.17	12.17	22.67	29.67	36.67
total acidity (mg/l)	40.00	5.33	13.33	2.0	9.33	4.0	6.33
hardness, Ca, Mg (ug/ml)	194.33	16.80	21.07	16.87	26.53	33.13	38.8
hardness, total (ug/ml)	242.00	17.0	22.50	17.33	27.5	33.57	39.53
Metals mg/l							
total As	.111	.00076	.0079	.017	.006	.002	.00077
diss As	.06	.00063	.0055	.010	.004	.001	.00063
total Cd	.006	L.0006	L.0006	L.0006	L.0006	L.0006	L.0006
diss Cd	.005	L.0005	L.0005	L.0005	L.0005	L.0005	L.0005
total Cu	.018	L.001	L.0055	L.001	L.001	L.001	L.001
diss Cu	.008	L.001	L.0015	.0013	.0007	L.001	L.001
total Pb	.015	L.001	L.001	.0008	L.001	L.001	L.001
diss Pb	.0025	L.001	.0001	.0007	L.001	L.001	L.001
total Zn	2.05	.013	.131	.035	.020	.003	.002
diss Zn	2.13	.01	.14	.036	.022	.009	.0027
total Al	.45	L.06	.047	L.06	L.06	.073	L.06
diss Al	.07	L.05	L.05	L.05	L.05	L.05	L.05
total Fe	13.53	.06	.418	.26	.513	.248	.415
diss Fe	11.93	.04	.29	.195	.329	.159	.266

TABLE 5 SEDIMENT CORE PROFILES, ALDRICH LAKE

METALS ug/g dry wt.

STATION	CORE SECTION	As	Cu	Pb	Mn	Fe	Al	Cd	Cr	Zn	Ni	Mg
Aldrich Lk. at Glacial Creek inlet: #0700157	0-10 cm	3030	247	657	4930	33900	7770	29	14	4920	10	3370
Aldrich Lk. 30 m S of Glacial Inlet: #0700158	0-10 cm	3830	389	984	8780	55300	5560	63	43	10300	11	3670
Aldrich Lk. - middle: #0700159	0-6 cm	718	103	841	1810	31800	17100	7	27	1030	15	3610
	6-12 cm	157	42	61	649	22900	18900	3	19	533	12	3280
	12-18 cm	102	46	87	706	26600	20600	3	26	587	15	3900
	18-24 cm	100	45	65	725	32800	21600	3	25	646	14	4230
	24-30 cm	73	38	187	740	45600	23200	L1	32	504	19	4800
Aldrich Lk. - 400 m east of Glacial Inlet: #0700160 (control?)	0-6 cm	332	50	586	641	17000	11800	6	17	1010	12	2560
	6-12 cm	116	51	298	551	14800	11000	4	14	560	11	2860
	12-18 cm	69	38	148	433	14100	13000	2	17	374	12	2790
	18-24 cm	53	33	266	391	14200	13500	2	17	312	13	2860
	24-30 cm	38	30	48	350	13600	11600	2	15	265	11	2540
Aldrich Lk. - 60 m S E from outlet: #0700162	0-10 cm	62	32	79	379	13600	11100	4	19	370	12	2870
Aldrich Lk. - 90 m S E from outlet: #0700163	0-5 cm	337	52	286	573	15000	10300	8	14	966	10	2470
	5-10 cm	126	29	40	430	12400	8300	4	11	352	8	2180
	10-16 cm	67	32	71	415	14000	11500	4	15	383	10	2790

TABLE 6

Metallothionein and Metals in Aldrich Lake Cutthroat Trout

	Length (cm)	Metals - ug/g wet weight			Metallothionein
		Zn	Cu	Cd	nanomoles/g
Site 1-0700158					
1	23	32	12.6	1.6	43
2	22	33	3.4	1.2	25
3	22.5	23	6.3	0.5	18
4	19.5	29	6.2	1.1	36
		$\bar{x}$ = 29	$\bar{x}$ = 7.1	$\bar{x}$ = 1.1	$\bar{x}$ = 30
		s = 5	s = 3.9	s = 0.4	s = 11
Site 2-0700163					
1	23.5	19	1.9	0.5	19
2	23	60	5.7	1.3	55
3	23.5	35	4.1	1.9	37
4	20.5	48	4.2	0.4	45
		$\bar{x}$ = 40	$\bar{x}$ = 4.0	$\bar{x}$ = 1.0	$\bar{x}$ = 39
		s = 17	s = 1.6	s = 0.7	x = 15

TABLE 7

- FISH TISSUE METALS ANALYSIS -
Aldrich Lake Cutthroat Trout Netted July 14, 1983

				metals ug/g dry						
	Length (cm)	age yrs	% moisture	As	Cd	Cu	Pb	Zn	Fe	Al
Site 0700158 Aldrich Lk 30 m S of Glacial	23.7	3	81.7	L26	L1	4	L11	38	24	L2
	22.0	3	78.8	L25	L1	L1	L10	37	21	L2
	22.5	3	80.0	L25	L1	L1	L10	34	21	L2
Site 0700163 Aldrich Lk Outlet	23.5	3	79.6	L23	L1	1	L10	25	19	L2
	23	3	79.6	L23	L1	L1	L10	31	16	L2
	23.5	4	77.8	L23	L1	L1	L10	27	18	L2
	24.5	3	78.9	L24	L1	L1	L10	20	18	L2
	25.5	3	78.9	L24	L1	L1	L10	22	20	L2
	23.8	4	79.3	L24	L1	L1	L10	32	24	L2
	31.5	4	77.2	L21	L1	L1	L10	35	29	L2

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Appendix 1

Metal Mining Liquid Effluent Regulations and Guidelines*

PART 1
AUTHORIZED LEVELS OF SUBSTANCES

Item	Substance	Column I Maximum Authorized Monthly Arithmetic Mean Concentration	Column II Maximum Authorized Concentration in a Composite Sample	Column III Maximum Authorized Concentration in a Grab Sample
1.	Arsenic	0.5 mg/l	0.75 mg/l	1.0 mg/l
2.	Copper	0.3 mg/l	0.45 mg/l	0.6 mg/l
3.	Lead	0.2 mg/l	0.3 mg/l	0.4 mg/l
4.	Nickel	0.5 mg/l	0.75 mg/l	1.0 mg/l
5.	Zinc	0.5 mg/l	0.75 mg/l	1.0 mg/l
6.	Total Suspended Matter	25.0 mg/l	37.5 mg/l	50.0.mg/l
7.	Radium 226	10.0 pCi/l	20.0 pCi/l	30.0 pCi/l

PART 2
AUTHORIZED LEVELS OF pH

Parameter	Column I Minimum Authorized Monthly Arithmetic mean pH	Column II Minimum Authorized pH in a Composite Sample	Column III Minimum Authorized pH in a grab sample
pH	6.0	5.5	5.0

* From Regulations Codes and Protocols - EPS-1-WP-77-1
Water Pollution Control Directorate, Fisheries and Environment Canada, April, 1977.

Appendix 2

MASTER TABLE
CANADIAN RECOMMENDED SURFACE FRESH WATER QUALITY OBJECTIVES[(a)]
(mg/L as total metal)

Constituent	Raw Public Water Supply	Aquatic Life and Wildlife		Agricultural Water Supply		Recreation	Food Processing
		Aquatic Life	Wildlife	Livestock	Irrigation		
Volume 1 – Inorganic Chemical Substances							
Arsenic	0.05	0.05	•[(b)]	0.5	0.1 (sensitive crop, sandy loam) 1.0 (sensitive crop, clay) 1.0 (tolerant crop, sandy loam) 2.0 (tolerant crop, clay)	0.05	0.05
Cadmium	0.01	0.0002	•	0.02	0.01	0.01	0.01
Chromium	0.1	0.04	0.04	1.0	0.1	0.1	0.1
Copper	0.5	0.002	0.002	1.0 (sheep and cattle present) 5.0 (all other cases)	0.2 (continuous use, sensitive plants) 1.0 (less sensitive plants) 5.0 (short-term use)	0.5	0.5
Lead	0.25 (conventional treatment) 0.05 (disinfection only)	0.005 (hardness <95 mg/L as $CaCO_3$) 0.01 (hardness >95 mg/L as $CaCO_3$; waters with sensitive species of fish) 0.03 (hardness >95 mg/L as $CaCO_3$; sensitive species of fish absent)	0.005 (hardness <95 mg/L as $CaCO_3$) 0.03 (hardness >95 mg/L as $CaCO_3$)	0.5 (horses present) 1.0 (horses absent)	5.0 (continuous use) 10.0 (intermittent use)	0.05	0.25 (conventional treatment) 0.05 (disinfection only)
Mercury	0.001	0.0001 (to protect consumers of fish) 0.0002 (where fish not eaten)	0.003 (see mercury content of fish for fish eaters)	0.003	no recommendation	0.001	0.001
Nickel	0.25 (conventional treatment)	0.025 (soft water) 0.25 (hardness >150 mg/L as $CaCO_3$)	0.025 (soft water) 0.25 (hardness >150 mg/L as $CaCO_3$)	5.0	0.2 (continuous use) 2.0 (intermittent use)	0.25	0.25
Selenium	0.05 (simple treatment) 0.25 (conventional treatment)	0.01	0.01	0.02 minimum 0.05 maximum	0.02 (continuous use) 0.05 (intermittent use)	0.05	0.05 (simple treatment) 0.25 (conventional treatment)
Silver	0.05 (no treatment or simple treatment) 0.2 (conventional treatment)	0.0001	•	•	•	0.05	0.05 (simple treatment) 0.2 (conventional treatment)
Zinc	5.0 (simple treatment) 10.0 (conventional treatment)	0.05 (hardness 0–120 mg/L as $CaCO_3$) 0.10 (hardness 120–180 mg/L as $CaCO_3$) 0.20 (hardness 180–300 mg/L as $CaCO_3$) 0.30 (hardness >300 mg/L as $CaCO_3$)	0.05 (hardness 0–120 mg/L as $CaCO_3$) 0.10 (hardness 120–180 mg/L as $CaCO_3$) 0.20 (hardness 180–300 mg/L as $CaCO_3$) 0.30 (hardness >300 mg/L as $CaCO_3$)	50.0	1.0 (soils pH <6.5) 5.0 (soils pH >6.5)	5.0	5.0 (simple treatment) 10.0 (conventional treatment)

(a) Table will be expanded as new limits are developed and issued.
(b) Insufficient information to set a defensible limit.