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CONSERVATION AND PROTECTION
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NORTH VANCOUVER, B.C.

COMINCO SEDIMENT BIOASSAYS, SEDIMENT AND WATER CHEMISTRY
- October and November 1991 -

REGIONAL DATA REPORT DR 92-13

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ABSTRACT

Slag was collected from the Cominco Lead Smelter in Trail, B.C. and tested for toxicity using standard Daphnia magna sediment bioassays. Following the results of the test, sediments were collected from Columbia River sites upstream and downstream of the Cominco discharge. The supernatant waters in the bioassays for both the Cominco slag and the downstream sediment were toxic. The acute toxicity is attributed at least partly to elevated levels of copper and zinc. The physical abrasive effect of sharp fine particles may have been a factor. No attempt was made in these tests to distinguish between physical and chemical effects.

RESUME

De la scorie fut recueillie de la fonderie de plomb Cominco à Trail, C.-B., et fut testée pour la toxicité selon les bio-essais standards de sédiment Daphnia magna. A la suite des résultats du test, des sédiments de la rivière Columbia furent recueillis à l'amont et à l'aval du déversement de Cominco. Les eaux surnageantes pour les bio-essais utilisant la scorie de Cominco et les sédiments en aval furent toxiques. La toxicité aigue est attribué au moins partiellement aux niveaux élevés de cuivre et de zinc. L'effet abrasif des fines particules peut être aussi un facteur. Aucune tentative a été entreprise pour distinguer entre les effets physiques et chimiques.

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1.0 INTRODUCTION

Cominco Ltd. operates a lead/zinc smelter at Trail which discharges effluent containing metals, nutrients, and slag into the Columbia River. In November 1991, slag from Cominco effluent was tested for toxicity. Following the results of this test, sediments were collected upstream and downstream of the Cominco smelter (Table 1, Figure 1). Sediment bioassays were done using these Columbia River samples, and the chemistry of water and sediment from the tests was analyzed.

TABLE 1: SAMPLE COLLECTION

Site	Location	Remarks
Genelle-Island	Columbia River, 600 m downstream of Genelle Trailer Park	Near gravel-sand island in mid-river, 1 m from shore, in water 1 m deep. 13.7 km upstream of Cominco. Collected November 1991
Genelle-Back Eddy Pool	Columbia River, 150 m downstream of Genelle Trailer Park on right bank	About 0.2 m from shore, sand with small amount of organic material. 14.1 km upstream of Cominco. Collected November 1991
Mid Tap Furnace Slag	Cominco-Trail effluent discharge pipe, Sewer No 1.	Sampled during middle of furnace slag discharge period, 28 Oct '91
Beaver Creek	Columbia River, 500 m downstream of Beaver Creek mouth on right bank	About 3 - 4 m from shore in sand/slag sediment. Water depth 0.5 - 3 m, composite sample taken. 8.7 km downstream of Cominco and 7.7 km upstream of Canada/US border. Collected November 1991

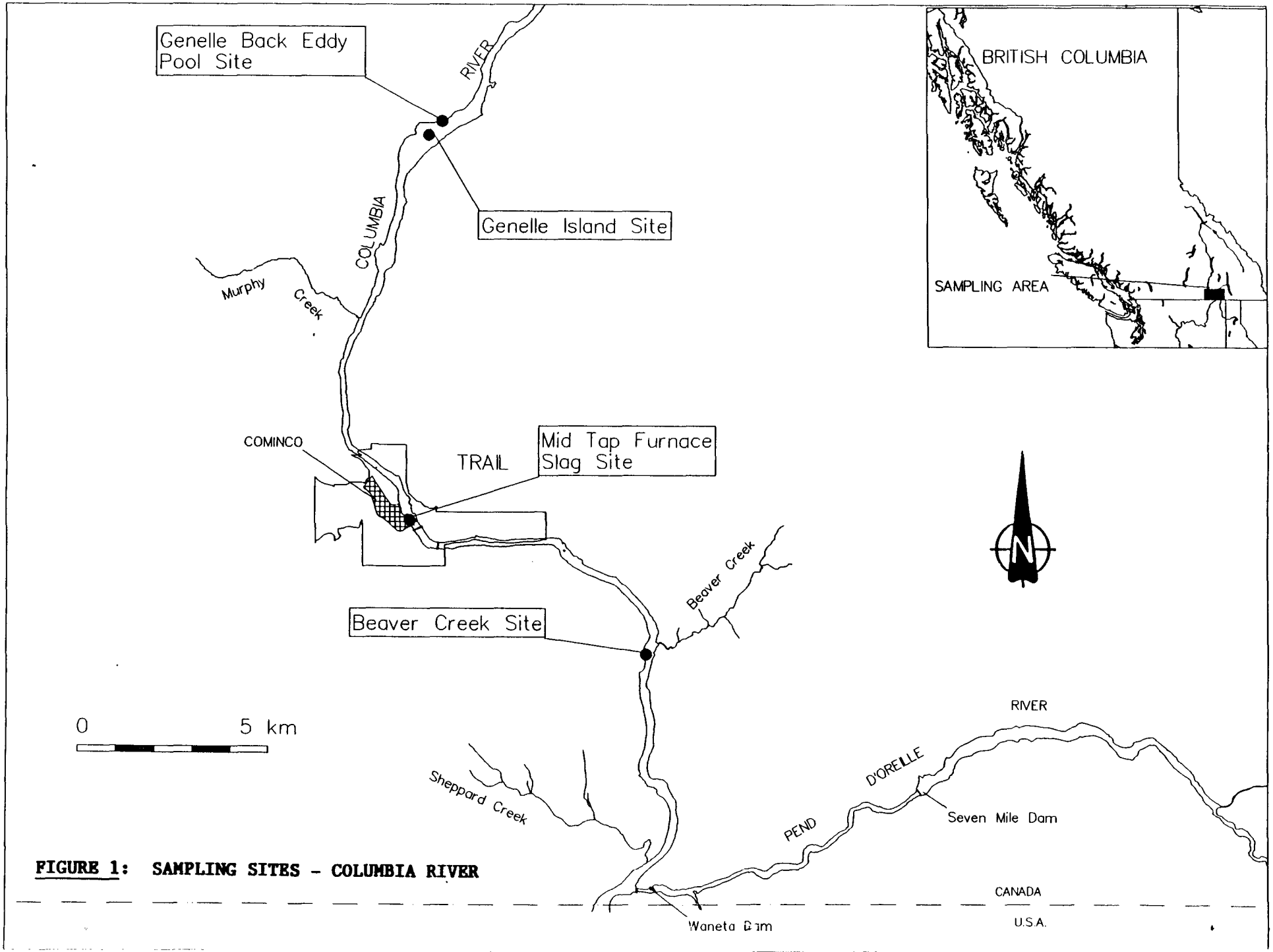

FIGURE 1: SAMPLING SITES - COLUMBIA RIVER

2.0 MATERIALS AND METHODS

A sample of mid tap furnace slag, taken during the middle of a pulse of quenched slag discharge, was collected by Cominco on 28 October 1991. The sample was collected in a two-litre polyethylene container, shipped by commercial truck, and stored in the dark at 4° C until testing was initiated. Under contract to Environment Canada, EVS Consultants performed sediment bioassays on the samples beginning 13 November 1991. ASL Laboratories analysed the test water for metal content. EVS Consultants also performed sediment bioassays using Daphnia magna on samples collected by Inland Waters (Environment Canada) on 28 November 1991. Samples were collected from two sites near Genelle and one near Beaver Creek (Figure 1).

Sediment bioassays were performed using a test procedure adapted from Nebeker, et al. (1984). Juvenile daphnia were obtained from an EVS laboratory culture. Cultures of daphnia were maintained in two-litre glass beakers. Culture water was Milli-Q reagent grade water reconstituted to a hardness of approximately 160 mg/l as $CaCO_3$, the standard hardness for this test. Culture medium was replaced every Monday, Wednesday, and Friday; offspring were removed at that time. The daphnia were fed a diet consisting of YCTF (yeast, cereal leaves, trout food) and algae, at a rate of 15 ml/l of culture water. Neonates (<24 hours old) were collected from 2 - 5 week old adults and aged 7 days. Seven-day-old animals were used because they had not yet begun to produce off-spring but were expected to fully mature during the ten day exposure period.

A two-centimetre layer of test sediment was placed in one-litre glass jars and covered with 800 ml of the culture water. The negative control consisted of culture water only. Five replicates were prepared for each treatment and the control. The jars were covered with plastic lids, fitted with aeration lines, and allowed to equilibrate overnight. The following day (Day 0), each jar was randomly seeded with 10 daphnia. Temperature was measured daily in one replicate for each treatment. Dissolved oxygen and pH were measured in one replicate for each treatment on Day 0 and every Monday,

Wednesday, and Friday. These parameters, as well as conductivity, were measured in every replicate on Day 10.

The containers were checked every Monday, Wednesday, and Friday to establish trends in mortality and to count and remove any offspring produced. Each replicate received 8 ml of the YCTF-algae diet at that time. The bioassay was allowed to proceed for ten days, at which time final counts of surviving adults and offspring were made.

In order for the test to be considered valid, mean mortality in the negative control could not exceed 20%. Statistical analyses were performed on the reproduction data using the TOXSTAT software program (Gulley, et al., 1990). Differences at $P \leq 0.05$ were considered statistically significant. Methods were the same for the December 10th tests.

Following the Columbia River bioassay, overlying water was decanted from the test containers, stored in one litre polyethylene bottles, and kept cool until analysis by the Environmental Protection laboratory in West Vancouver. Analysis included alkalinity, pH, conductivity, chloride, fluoride, nitrites, nitrates, sulphates, total phosphorous, and dissolved and total metals. The organic and inorganic carbon samples were stored in acid washed glass jars and preserved with a few drops of concentrated hydrochloric acid. The dissolved fraction of these two parameters were filtered within 24 hours of collection using a 0.45 um cellulose nitrate filter.

Total metal samples were stored in acid washed polyethylene sample bottles and preserved with 0.5 ml of nitric acid per 100 ml. Dissolved metal samples were filtered the same day through a 0.45 um cellulose nitrate filter into a 100 ml polyethylene bottle and preserved with 0.5 ml of nitric acid. Total and dissolved metals were analysed by Inductively Coupled Argon Plasma (ICP) emission spectroscopy which gave a reading of twenty-eight metals. Cadmium, copper, and lead samples were re-analysed with the graphite furnace when the values were below twice the detection limit of the ICP procedure. Hardness was determined from the dissolved metal sample.

Sediment samples were collected in duplicate from the sediment bioassay tests using a plastic spoon. All sediment samples were transferred into Kraft soil sample envelopes, contained in a Whirl pack bag, and kept cool until analysed. Samples were air dried, sieved to <150 um, digested with aqua regia, and analysed for heavy metals using ICP. A portion of the sediments were ignited at 500° C in a muffle furnace. The loss of weight was reported as volatile residue and the remainder as fixed residue. All analytic procedures were in accordance with the Environment Canada, Pacific Region, Laboratory Manual (Anon., 1979). Particle size analysis were performed on the samples by the Water Survey of Canada New Westminster laboratory in accordance with their usual procedures.

3.0 RESULTS AND DISCUSSION

The 10-day Daphnia magna sediment bioassay test on the mid tap furnace slag sample was initiated 13 November 1991. No adults remained alive two days into the test, and the 11 offspring produced were also dead. In the control, all adults were alive and had produced an average of 37 offspring per replicate (Table 2).

The acute toxicity could be attributed at least partly to elevated levels of copper (total: 0.478 mg/l; LC_{50} 0.0065 mg/l in hard water (US EPA, 1985a)) and zinc (total: 0.208 mg/l; 48-hr LC_{50} 0.04 mg/l for D. hyalina (Baudouin and Scappa, 1972)) in the overlying water (Table 3). Anderson and Weber (1975) showed that toxicity of zinc and copper mixtures are more than additive.

TABLE 2: SUMMARY OF 10-DAY DAPHNIA MAGNA SEDIMENT BIOASSAY INITIATED 13 NOVEMBER 1991 ON MID TAP FURNACE SLAG*

SAMPLE ID	% SURVIVAL	TOTAL REPRODUCTION	LIVE YOUNG/REPLICATE
Mid Tap Furnace Slag	0	11	0
Control	100	185	37 ± 6

* Test concluded after two days

WATER QUALITY PARAMETERS AT DAY 2

SAMPLE	TEMP (° C)	D.O. (mg/l)	pH	COND (µmho/cm)
Mid Tap Furnace Slag	25	7.2 - 7.4	8.3	600
Control	25	7.5 - 8.0	8.3	490 - 500

TABLE 3: WATER QUALITY ANALYSIS OF WATER FROM MID TAP FURNACE SLAG SEDIMENT BIOASSAY

PARAMETER (mg/l)	TOTAL METALS	DISSOLVED METALS
Aluminium	<0.20	<0.20
Antimony	<0.20	<0.20
Arsenic	<0.20	<0.20
Barium	0.054	0.049
Beryllium	<0.005	<0.005
Bismuth	<0.10	<0.10
Cadmium	<0.010	<0.010
Calcium	22.7	22.9
Chromium	<0.015	<0.015
Cobalt	<0.015	<0.015
Copper	0.478	0.165
Iron	0.309	<0.030
Lead	<0.050	<0.050
Lithium	<0.015	<0.015
Magnesium	25.1	25.1
Manganese	0.031	0.020
Molybdenum	0.031	<0.030
Nickel	<0.20	<0.20
Phosphorus	<0.30	<0.30
Potassium	6.8	6.8
Selenium	<0.20	<0.20
Silver	<0.015	<0.015
Sodium	54.4	54.4
Strontium	0.018	0.017
Thallium	<0.10	<0.10
Tin	<0.30	<0.30
Titanium	<0.010	<0.010
Tungsten	<0.10	<0.10
Vanadium	<0.030	<0.030
Zinc	0.208	0.071

The 10-day Daphnia magna Columbia River sediment bioassay tests initiated 10 December 1991 indicated that the Genelle Island and Back Eddy Pool sediments were non-toxic (Table 4). However, survival of adults exposed to Beaver Creek sediments was zero by day 10. Reproduction was significantly lower compared to daphnia exposed to sediments from the other sites.

In the water samples decanted from the Columbia River sediment bioassay, silver, dissolved aluminium, arsenic, beryllium, cobalt, chromium, dissolved manganese, molybdenum, nickel, selenium, tin, and vanadium were all less than the detection limit. Nitrate, antimony, barium, copper, total iron,

TABLE 4: SUMMARY OF 10-DAY *DAPHNIA MAGNA* SEDIMENT BIOASSAY INITIATED 10 DECEMBER 1991 ON COLUMBIA RIVER SEDIMENTS

SAMPLE ID	% SURVIVAL	TOTAL REPRODUCTION	LIVE YOUNG/REPLICATE
Beaver Creek	0	75	15 ± 13
Back Eddy Pool	100	1322	264 ± 28
Genelle Island	100	785	157 ± 28
Control	100	1242	248 ± 17

RANGES FOR WATER QUALITY PARAMETERS DURING TEST

SAMPLE	TEMP (° C)	D.O. (mg/l)	pH	COND (µmho/cm)
Beaver Creek	24 - 25	8.0 - 8.3	8.1 - 8.3	550
Back Eddy Pool	23.5 - 25	7.9 - 8.3	8.2 - 8.4	550
Genelle Island	23.5 - 25	7.9 - 8.3	8.2 - 8.4	550
Control	23.5 - 25	8.0 - 8.3	8.2 - 8.3	480 - 490

total lead, silicon, strontium, and zinc were higher in the Beaver Creek sample than for the other two sites. Cadmium levels were lower in the Beaver Creek sample.

The acute toxicity of Columbia River bioassay water could be attributed at least partly to elevated levels of copper (total: 0.042 mg/l; LC_{50} 0.0065 mg/l in hard water (US EPA, 1985a)) and zinc (total: 0.040 mg/l; 48-hr LC_{50} 0.04 mg/l for *D. hyalina* (Baudouin and Scappa, 1972)). Lead (total: 0.0115 mg/l) did not exceed the species mean acute toxicity concentration of 0.4478 mg/l for *D. magna* found by the US EPA (1985b), but it did exceed the CCREM (1987) guideline (0.004 mg/l in hard water).

Arsenic (50 µg/g), barium (1025 µg/g), cadmium (5.5 µg/g), chromium (91.2 µg/g), copper (1860 µg/g), iron (10300 µg/g), mercury (37 µg/g), manganese (1170 µg/g), molybdenum (9 µg/g), lead (776 µg/g), antimony (257 µg/g), silicon (2010 µg/g), tin (81 µg/g), strontium (105 µg/g), titanium (1205 µg/g), vanadium (115 µg/g), and zinc (5230 µg/g) were all considerably higher in sediments from the Beaver Creek site than the Genelle sites (Table 6). Of these, the toxic components copper, lead, and zinc ranged from 32 to 155 times greater in Beaver Creek sediments than in Genelle sediments.

TABLE 5

ANALYSIS OF WATER FROM COLUMBIA RIVER SEDIMENT BIOASSAY

Station	ALK MG/L	PH REL.U.	COND UMHOS	DISICP HC MG/L	DISICP HT MG/L	DIC MG/L	DOC MG/L	CL MG/L	F MG/L	NH3 MG/L	NO2 MG/L	NO2,3 MG/L	SO4 MG/L	TP MG/L
Genelle Is	105	8.3	.563	160	160	25	1	4.1	.06	<.002	<.002	.167	158	.430
Back Pool	115	8.3	580	171	171	29	1	4.1	.06	<.002	.004	.281	145	.736
Beaver Cr	104	8.3	577	164	164	24	<1	4.2	.24	<.002	<.002	.514	152	.230
Control	111	8.3	581	166	166	27	1	4.1	.03	.048	.011	.234	170	.683

Station	TOTICP AG MG/L	DISICP AG MG/L	TOTICP AL MG/L	DISICP AL MG/L	TOTICP AS MG/L	DISICP AS MG/L	TOTICP B MG/L	DISICP B MG/L	TOTICP BA MG/L	DISICP BA MG/L	TOTICP BE MG/L	DISICP BE MG/L	TOTICP CA MG/L	DISICP CA MG/L
Genelle Is	<.01	<.01	.07	<.05	<.06	<.05	.07	.03	.065	.041	<.001	<.001	33.0	28.6
Back Pool	<.01	<.01	.18	<.05	<.06	<.05	.06	.01	.068	.060	<.001	<.001	35.2	32.5
Beaver Cr	<.01	<.01	.13	<.05	<.06	<.05	.04	.01	.090	.083	<.001	<.001	34.7	34.0
Control	<.01	<.01	<.06	<.05	<.06	<.05	.05	.03	<.001	<.001	<.001	<.001	27.9	27.1

Station	TOTICP CD MG/L	TOTGF CD MG/L	DISICP CD MG/L	DISGF CD MG/L	TOTICP CO MG/L	DISICP CO MG/L	TOTICP CR MG/L	DISICP CR MG/L	TOTICP CU MG/L	TOTGF CU MG/L	DISICP CU MG/L	DISGF CU MG/L	TOTICP FE MG/L	DISICP FE MG/L	TOTICP K MG/L	DISICP K MG/L
Genelle Is	<.006	.0010	<.005	.0006	<.006	<.005	<.006	<.005	<.006	.0021	<.005	.0019	.054	.014	5	5
Back Pool	<.006	.0007	<.005	.0007	<.006	<.005	<.006	<.005	<.006	.0025	<.005	.0022	.149	.014	6	5
Beaver Cr	<.006	.0002	.005	.0002	<.006	<.005	<.006	<.005	.042	---	.021	---	.337	<.005	4	4
Control	<.006	<.0001	<.005	.0003	<.006	<.005	<.006	<.005	<.006	.0009	<.005	<.0005	.023	.023	5	5

Station	TOTICP MG MG/L	DISICP MG MG/L	TOTICP MN MG/L	DISICP MN MG/L	TOTICP MO MG/L	DISICP MO MG/L	TOTICP NA MG/L	DISICP NA MG/L	TOTICP NI MG/L	DISICP NI MG/L	TOTICP P MG/L	DISICP P MG/L	TOTICP PB MG/L	TOTGF PB MG/L	DISICP PB MG/L	DISGF PB MG/L
Genelle Is	22.1	21.4	<.001	<.001	<.01	<.01	51.1	51.2	<.02	<.02	.5	1.0	<.06	.0023	<.05	.0011
Back Pool	22.5	21.9	.005	<.001	<.01	<.01	52.6	50.6	<.02	<.02	.8	.4	<.06	.0023	<.05	.0020
Beaver Cr	20.5	19.2	.006	<.001	<.01	<.01	50.9	48.1	<.02	<.02	.2	.3	<.06	.0115	<.05	.0010
Control	25.2	24.0	.001	<.001	<.01	<.01	55.2	53.6	<.02	<.02	.8	.9	<.06	.0007	<.05	.0023

Station	TOTICP SB MG/L	DISICP SB MG/L	TOTICP SE MG/L	DISICP SE MG/L	TOTICP SI MG/L	DISICP SI MG/L	TOTICP SN MG/L	DISICP SN MG/L	TOTICP SR MG/L	DISICP SR MG/L	TOTICP TI MG/L	DISICP TI MG/L	TOTICP V MG/L	DISICP V MG/L	TOTICP ZN MG/L	DISICP ZN MG/L
Genelle Is	<.06	<.05	<.06	<.05	1.41	1.48	<.06	<.05	.059	.040	.003	<.002	<.01	<.01	.013	.008
Back Pool	<.06	<.05	<.06	<.05	1.33	1.28	<.06	<.05	.046	.051	.009	<.002	<.01	<.01	.010	.013
Beaver Cr	.10	.11	<.06	<.05	2.55	2.32	<.06	<.05	.117	.112	.008	<.002	<.01	<.01	.040	.017
Control	<.06	<.05	<.06	<.05	.33	.25	<.06	<.05	<.001	<.001	<.002	<.002	<.01	<.01	.027	.009

TABLE 6

ANALYSIS OF SEDIMENT FROM COLUMBIA RIVER SEDIMENT BIOASSAY

Station		SEDICP AG UG/G	SEDICP AL UG/G	SEDICP AS UG/G	SEDICP BA UG/G	SEDICP BE UG/G	SEDICP CA UG/G	SEDICP CD UG/G	SEDICP CO UG/G	SEDICP CR UG/G	SEDICP CU UG/G	SEDICP FE UG/G	SEDHG HG UG/G	SEDICP K UG/G	SEDICP MG UG/G	SEDICP MN UG/G
Genelle Island	Repl. 1	<2	5170	<8	55.7	.2	5860	<.8	<20	66.8	17.2	46400	---	1000	3290	233
	Repl. 2	<2	4330	<8	41.2	.2	4900	<.8	<20	52.2	7.9	36100	.010	800	2680	191
Back Pool	Repl. 1	<2	5740	<8	57.7	.2	5890	<.8	<20	33.7	9.2	26200	---	1000	3230	202
	Repl. 2	<2	5250	<8	53.6	.2	5370	<.8	<20	33.2	8.2	25300	.023	1000	3070	191
Beaver Creek	Repl. 1	5	10300	49	1030	.4	22900	6.3	<20	89.1	1820	99800	---	1900	4360	1140
	Repl. 2	<2	9180	51	1020	.4	25300	4.6	<20	93.2	1900	105000	37	1700	3710	1210
Ref.		<2	25900	<8	65.0	.9	4460	<.8	<20	52.0	19.7	33800	---	5900	9150	232
NBS		<2	25100	<8	60.6	.9	4430	<.8	<20	51.3	17.9	31800	---	5800	9180	234
1646		<2	22800	<8	54.7	.8	4170	<.8	<20	48.3	17.6	30400	---	5300	8580	221

Station		SEDICP MO UG/G	SEDICP NA UG/G	SEDICP NI UG/G	SEDICP P UG/G	SEDICP PB UG/G	SEDICP SB UG/G	SEDICP SI UG/G	SEDICP SN UG/G	SEDICP SR UG/G	SEDICP TI UG/G	SEDICP V UG/G	SEDICP ZN UG/G	SFR MG/KG	SVR MG/KG
Genelle Island	Repl. 1	<2	170	20	1400	18	<8	793	<8	46.7	824	100	92.5	---	---
	Repl. 2	<2	100	10	1100	10	<8	686	20	40.9	720	82	68.6	996000	4100
Back Pool	Repl. 1	<2	190	10	1400	24	<8	593	<8	45.3	856	49	122	---	---
	Repl. 2	<2	170	10	1300	24	<8	633	<8	42.9	780	49	121	990000	10300
Beaver Creek	Repl. 1	7	670	25	1950	852	252	2060	85	104	1260	110	5040	---	---
	Repl. 2	10	720	24	2090	700	261	1960	77	106	1150	120	5420	991000	9240
Ref.		<2	11200	22	450	20	<8	1510	<8	40.2	811	55	144	---	---
NBS		<2	11500	23	450	20	<8	1660	<8	40.1	794	55	136	---	---
1646		2	10800	22	430	20	<8	1730	<8	37.3	761	52	119	---	---

Mercury was not analysed in the water fraction of the test. Mercury levels in the Beaver Creek sediment sample were as high as 37 µg/g, 1600 times greater than levels at Genelle. It is not possible at this time to evaluate how much mercury would have been transferred to the water column. No attempt was made to calculate the metal flux rate of the sediment to the bioassay supernatant.

Columbia River hardness is typically 60 - 80 mg/l as $CaCO_3$. The toxicity of cadmium, copper, or lead concentrations is generally reduced in harder water.

The sediment particle size distribution is given in Table 7. The Beaver Creek sample is much darker, and is assumed to indicate the presence of slag in the sediment. Visual examination of the particle size following sieving did not reveal that slag was concentrated in a particular fraction size. The finer particle fraction of slag is known to have an "eggshell and needles" apparance (Cominco 1991), with sharp edges that may physically affect the organisms exposed to it in a confined environment. The potential influence of this effect on Daphnia was not assessed during these tests.

TABLE 7: PARTICLE SIZE DISTRIBUTION IN COLUMBIA RIVER SEDIMENTS COLLECTED 28 NOVEMBER 1991

Site	Percentage Finer Than (Opening in Millimeters)							
	8	4	2	1	0.5	0.25	0.125	0.0625
Beaver Creek	100.0	100.0	100.0	99.7	90.0	24.3	2.0	0.4
Island	100.0	97.9	95.4	88.8	63.6	6.9	0.4	0.0
Back Eddy Pool	100.0	97.7	97.2	96.4	87.8	31.7	8.8	1.4

4.0 SUMMARY

The slag from Cominco and the sediments collected from downstream of the Cominco discharge at Beaver Creek are toxic according to the results of standard Daphnia magna sediment bioassay tests.

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APPENDIX

BIOASSAY DATA

Sample Control

Initiation Date Nov 13/91

E.V.S. CONSULTANTS

Daphnia magna 10 D SEDIMENT BIOASSAY TEST DATA

E.V.S. Project No. 91047-32

E.V.S. Work Order No. 910607

Replicate	Date/Day of Test										Totals at Day 10 2		Water Chemistry at Day 10 2			
	Nov 14	Nov 15									Adults Alive at Day 10 2	Total Offspring Produced	Temp. (°C)	D.O. (mg/L)	pH	Cond. (µmho/cm)
	1	2	3	4	5	6	7	8	9	10						
A	10/10	10/10									10	46	25	8.0	8.3	490
		46														
B	10/10	10/6									10	35	25	7.8	8.3	490
		35														
C	10/10	10/10									10	37	25	7.7	8.3	500
		37														
D	10/10	10/10									10	29	25	7.5	8.3	500
		29														
E	10/10	10/10									10	38	25	7.6	8.3	500
		38														
Tech'n Init.	LS	LS									LS	LS	LS	LS	LS	LS

D = dead female *Daphnia* S = stressed female *Daphnia* M = molt No. = number of young born

Comments: _____

Sample Mud Tap Furnace

Initiation Date Nov 13/91

E.V.S. CONSULTANTS

***Daphnia magna* 10 D SEDIMENT BIOASSAY TEST DATA**

E.V.S. Project No. 91-47-32

E.V.S. Work Order No. 91-0607

Replicate	Date/Day of Test										Totals at Day 10 [2]		Water Chemistry at Day 10 [2]			
	Nov 14	Nov 15									Adults Alive at Day 10 [2]	Total Offspring Produced	Temp. (°C)	D.O. (mg/L)	pH	Cond. (µmho/cm)
	1	2	3	4	5	6	7	8	9	10						
A	0/10	0/10									0	0	25	7.4	8.3	600
		0														
B	2/10	0/10									0	1	25	7.4	8.3	600
		1 dead														
C	2/10	0/10									0	0	25	7.3	8.3	600
		0														
D	0/10	0/10									0	6	25	7.3	8.3	600
		6 dead														
E	0/10	0/10									0	4	25	7.2	8.3	600
		4 dead														
Tech'n Init.	LS	LS									LS	LS	LS	LS	LS	LS

D = dead female *Daphnia* S = stressed female *Daphnia* M = molt No. = number of young born

Comments: _____

Sample Control

Initiation Date Dec 10 91

E.V.S. CONSULTANTS

Daphnia magna 10 D SEDIMENT BIOASSAY TEST DATA

E.V.S. Project No. 9104-32

E.V.S. Work Order No. 9104-8

Replicate	Date/Day of Test										Totals at Day 10		Water Chemistry at Day 10			
	Dec 11		Dec 13			Dec 16		Dec 18		Dec 20.	Adults Alive at Day 10	Total Offspring Produced	Temp. (°C)	D.O. (mg/L)	pH	Cond. (µmho/cm)
	1	2	3	4	5	6	7	8	9	10						
A	10/10		10/10			10/10		10/10		10/10	10	220	24	8.3	8.2	480
	27		53			86		18 LS		36						
B	10/10		10/10			10/10		10/10		10/10	10	265	24	8.3	8.3	485
	20		48			105		81		11						
C	10/10		10/10			10/10		10/10		10/10	10	255	24	8.3	8.3	485
	26		66			10 2 78 LS		39		22						
D	10/10		10/10			10/10		9/10		9/10	9	252	24.5	8.2	8.3	490
	37		55			79		34		27						
E	10/10		10/10			10/10		10/10		10/10	10	250	24	8.3	8.3	490
	30		18			94		81		27						
Tech'n Init.	LS		LS			LS		LS		LS	LS	LS	LS	LS	LS	LS

D = dead female *Daphnia* S = stressed female *Daphnia* M = molt No. = number of young born

Comments: Feeding regime 1 mL food 100 mL test sol'n

Sample Granville - Back Eddy Pool 1

Initiation Date Dec 10 / 91

E.V.S. CONSULTANTS

Daphnia magna 10 D SEDIMENT BIOASSAY TEST DATA

E.V.S. Project No. 91047.12

E.V.S. Work Order No. 9104-8

Replicate	Date/Day of Test										Totals at Day 10		Water Chemistry at Day 10			
	Dec 11		Dec 13			Dec 16		Dec 18		Dec 20	Adults Alive at Day 10	Total Offspring Produced	Temp. (°C)	D.O. (mg/L)	pH	Cond. (µmho/cm)
	1	2	3	4	5	6	7	8	9	10						
A	10/10		10/10			10/10		10/10		10/10	10	220	24.5	8.3	8.3	550
	11		2			85		77		45						
B	10/10		10/10			10/10		10/10		10/10	10	273	24.5	8.2	8.3	550
	8		1			93		94		77						
C	10/10		10/10			10/10		10/10		10/10	10	263	24.5	8.3	8.4	550
	1		1			92		89		80						
D	10/10		10/10			10/10		10/10		10/10	10	270	24.5	8.1	8.3	550
	14		6			83		94		73						
E	10/10		10/10			10/10		10/10		10/10	10	296	24.5	8.3	8.3	550
	15		16			125		62		78						
Tech'n Init.	LS		LS			LS		LS.		LS	LS	LS	LS	LS	LS	L.S

D = dead female *Daphnia* S = stressed female *Daphnia* M = molt No. = number of young born

Comments: _____

Sample Gonella - Island

Initiation Date Dec 10 '91

E.V.S. CONSULTANTS

***Daphnia magna* 10 D SEDIMENT BIOASSAY TEST DATA**

E.V.S. Project No. 91-07-32

E.V.S. Work Order No. 91-07-8

Replicate	Date/Day of Test										Totals at Day 10		Water Chemistry at Day 10			
	Dec 11		Dec 13			Dec 16		Dec 18		Dec 20	Adults Alive at Day 10	Total Offspring Produced	Temp. (°C)	D.O. (mg/L)	pH	Cond. (µmho/cm)
	1	2	3	4	5	6	7	8	9	10						
A	10/10		10/10			10/10		10/10		10/10	10	142	24.5	8.3	8.3	550
	17		13			84		14		12						
B	10/10		10/10			10/10		10/10		10/10	10	155	24.5	8.3	8.3	550
	35		7			70		33		10						
C	10/10		10/10			10/10		10/10		10/10	10	151	24.5	8.2	8.3	550
	18		8			84		29		12						
D	10/10		10/10			10/10		10/10		10/10	10	133	24.5	8.3	8.3	550
	9		8			64		34		18						
E	10/10		10/10			10/10		10/10		10/10	10	204	24.5	8.3	8.4	550
	43		1			96		48		16						
Tech'n Init.	LS		LS			LS		LS		LS	LS	LS	LS	LS	LS	LS

D = dead female *Daphnia* S = stressed female *Daphnia* M = molt No. = number of young born

Comments: _____

Sample Beaver Creek

Initiation Date Dec 10 / 91

E.V.S. CONSULTANTS

***Daphnia magna* 10 D SEDIMENT BIOASSAY TEST DATA**

E.V.S. Project No. 91-43.32

E.V.S. Work Order No. 91064-8

Replicate	Date/Day of Test										Totals at Day 10		Water Chemistry at Day 10			
	Dec 11		Dec 13			Dec 16		Dec 18			Adults Alive at Day 10	Total Offspring Produced	Temp. (°C)	D.O. (mg/L)	pH	Cond. (µmho/cm)
	1	2	3	4	5	6	7	8	9	10						
A	9/10		4/10			0/10					0	16	24.5	8.2	8.2	550
	14		2			0										
B	9/10		8/10			0/10					0	6	24.5	8.1	8.3	550
	0		6			0										
C	10/10		3/10			1/10		0			0	35	24.5	8.1	8.3	550
	6		6			22		1								
D	10/10		8/10			0/10					0	1	24.5	8.1	8.3	550
	0		1			0										
E	9/10		6/10			0/10					0	17 (1 dead)	24.5	8.1	8.3	550
	14		2			1 dead										
Tech'n Init.	LS.		LS			LS.		LS			LS	LS	LS	LS	LS	LS

D = dead female *Daphnia* S = stressed female *Daphnia* M = molt No. = number of young born

Comments: _____