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ENVIRONMENT CANADA
ENVIRONMENTAL PROTECTION
PACIFIC AND YUKON REGION
NORTH VANCOUVER, B.C.

ENVIRONMENT CANADA 1988 SAMATOSUM PROJECT
BASELINE STUDY

Regional Program Report No. 90 - 02

BY

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December 1990

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ABSTRACT

A monitoring program was conducted in May 1988 to establish the baseline conditions of sediment quality in Johnson Creek which is adjacent to a proposed lead/zinc/silver mine. Sediments in Homestake Creek, an adjacent drainage, were found to be high in metal content. The high metal levels are likely a result of previous mine activity in the drainage. The sediment results are discussed in the context of trend monitoring considerations.

RESUME

Un programme de surveillance a été mené en mai 1988, pour établir les conditions de base de la qualité des sédiments dans le ruisseau Johnson, adjacent à un projet minier de plomb, zinc et argent. Les sédiments du ruisseau Homestake, un drainage adjacent, ont démontré contenir de haut taux en métaux. Les hauts taux en métaux furent probablement le résultat des activités minières antérieures dans le réseau de drainage. Les résultats des analyses de sédiments sont discutés dans le contexte d'une surveillance des tendances des données.

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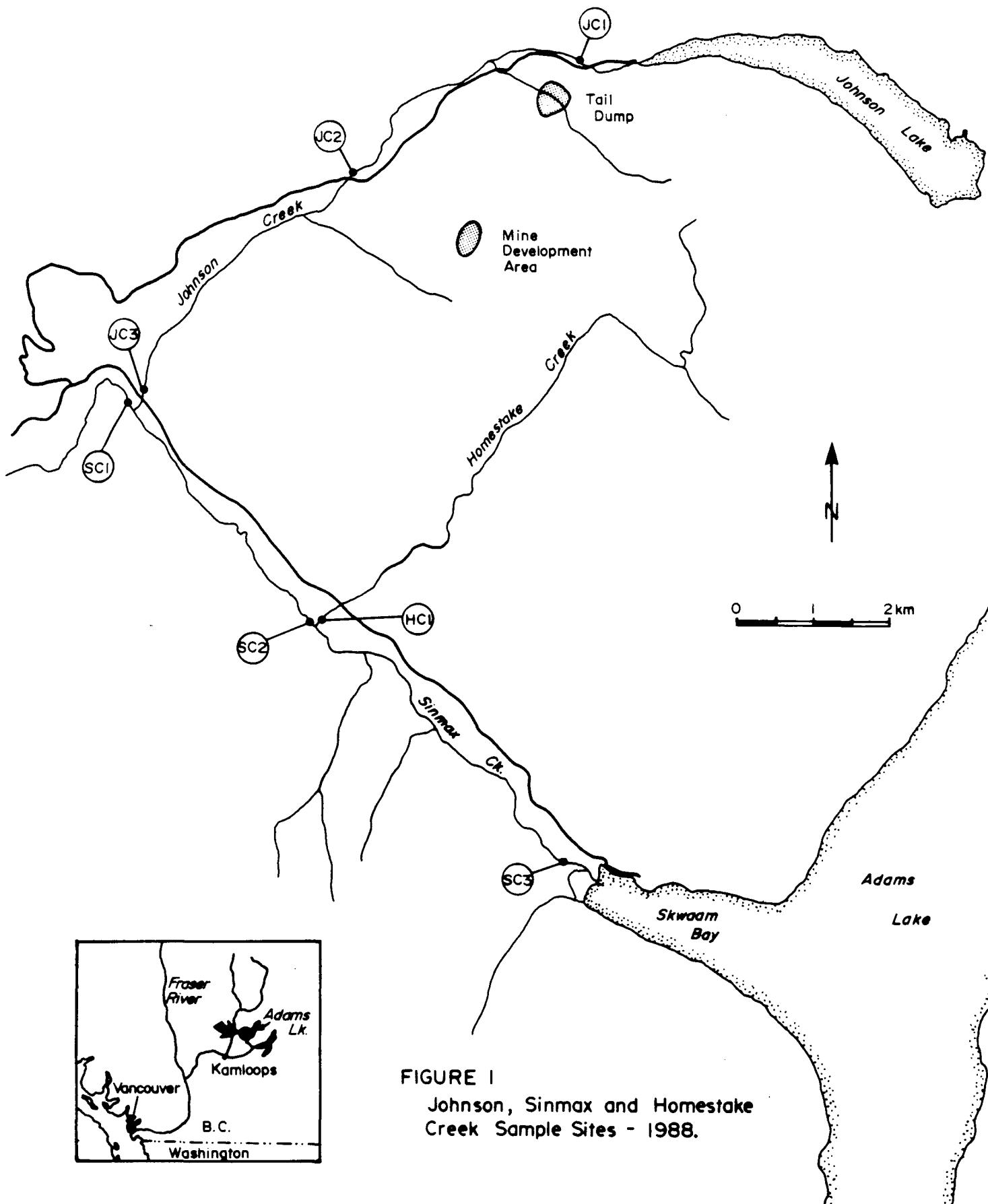
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1.0 INTRODUCTION

In May 1988, Minnova Inc. submitted a Stage I Report to the Provincial Mine Development Steering Committee (Hatfield, 1988). The report outlined the proposed development of an open pit lead/zinc/silver mine in central interior, British Columbia (Figure 1). A supplementary submission to the Stage I Report was made in August 1988 (Hatfield, 1988a). The mine would be located adjacent to Johnson Creek which drains into Sinmax Creek. Sinmax Creek supports both sockeye and coho salmon and is an important kokanee salmon spawning stream (Brown et al., 1979). Johnson Creek has an impassable falls approximately 400 meters upstream of its confluence with Sinmax Creek.

As part of a Samatosum Project pre-development data collection program, Environment Canada (Environmental Protection), undertook a monitoring program in May 1988. The program focused on establishing baseline conditions of sediment quality from which to assess any potential changes in sediment quality resulting from mining activity. As well, sediments were collected from Homestake Creek which was reported to have been impacted by heavy silting from a silver mine in 1971 (Brown et al., 1979). Surface water samples were also collected to characterize the study streams.



2.0 STUDY AREA

Sinmax Creek drains an area of approximately 130 square kilometers. Sinmax Creek discharges into Skwaam Bay of Adams Lake (Figure 1). Homestake Creek drains into Sinmax Creek downstream of Johnson Creek.

2.1 Sample Sites

2.1.1 Surface Water. Water samples were collected on May 17, 1988 from all sediment sites. Sample sites are shown on Figure 1.

2.1.2 Sediment. Sediment samples were collected from three sites on Johnson Creek (JC1-JC3), three sites on Sinmax Creek (SC1-SC3) and one site on lower Homestake Creek (HC1). Sample sites are described in Table 1 and shown on Figure 1.

TABLE 1 : SAMPLE SITE DESCRIPTION

SITE	DESCRIPTION
JC1	- Approximately 15-45 meters downstream of the road crossing at Johnson Lake. Gravel sediment. Trout spawning in this area at time of study
JC2	- Approximately 70 meters upstream of the road crossing. Pockets of fine gravel sampled
JC3	- Sampled at 35 meters and 260 meters upstream of the road. Downstream of Silverspray Falls
SC1	- Approximately 150 meters upstream of Johnson Creek confluence. Pockets of fine gravel sampled
SC2	- Just upstream of Homestake Creek confluence. Coarse sediments mixed with fines, sandy patches
SC3	- Lower Sinmax Creek, approximately 100 meters upstream of bridge crossing. Coarse, well mixed gravel
HC1	- Just upstream of confluence with Sinmax Creek. Channelized stream with coarse sediment.

3.0 MATERIALS AND METHODS

3.1 Surface Water Quality

Grab samples were collected in clean sample bottles and treated as described in Table 2. Triplicate samples were collected for metal analyses and single samples for non metal parameters.

Dissolved total phosphorus samples were filtered through 0.45um distilled water soaked and rinsed cellulose acetate membrane filters. Dissolved metal samples were filtered through 0.45um cellulose nitrate membrane filters. Phosphorus samples were filtered immediately in the field. Metal samples were filtered into clean sample bottles within six hours of collection.

Samples were shipped in coolers with ice to the Environment Canada, West Vancouver Chemistry Laboratory.

Analytical methods are summarized in Table 3 (Environment Canada, 1989).

TABLE 2 : SURFACE WATER SAMPLE CONTAINERS AND TREATMENT

ANALYSIS	SAMPLE BOTTLE & PRESERVATION
<u>Immediates:</u>	
alkalinity	200ml poly, cold
acidity	
pH	
chloride	1000ml poly, cold
sulfate	
residue(non-filterable)	
(total volatile)	
(total residue)	
conductivity	
total carbon	100ml glass, cold
(organic/inorganic)	
nitrogen (ammonia)	200ml poly, cold
(nitrite/nitrate)	
(total)	
phosphorus (total)	60ml glass, cold
(dissolved)	60ml glass, cold
<u>Metals:</u>	
(total and dissolved)	100ml acid washed poly, 0.5ml nitric acid
mercury (total)	100ml acid washed poly, 5ml potassium dichromate - nitric acid

TABLE 3 : SURFACE WATER SAMPLE ANALYTICAL METHODS

PARAMETER (Detection Limit)	METHOD
<u>Immediates:</u>	
alkalinity(1mg/L)	- Potentiometric titration with sulfric acid to pH 4.5.
acidity(1mg/L)	- Potentiometric titration with standard alkali to pH 8.3.
pH(0.1)	- Potentiometric, pH meter.
chloride(0.05mg/L)	- Colourimetric, mercuric thiocyanate-ferric nitrate combined reagent.
conductivity(0.1umho/cm)	- Conductivity cell.
sulfate(1mg/L)	- Colourimetric, methylthymol blue.
residues(5mg/L) (non-filterable)	- Gravimetric, Whatman GFC filtered and dried at 105C for one hour.
(total volatile)	- Gravimetric, evaporated at 75C overnight and then dried at 105C for one hour, loss on ignition at 550C.
(total)	- Gravimetric, evaporated at 75C overnight and then dried at 105C for one hour.
total organic/inorganic carbon(1mg/L)	- Combustion, infra-red
phosphorus(2ug/L)	- total and dissolved. Colourimetric persulphate-autoclave digest, molybdate-ascorbic acid reduction.
nitrogen	
-ammonia(5ug/L)	. Colourimetric, phenolhypochlorite.
-nitrite/nitrate(5ug/L)	. Colourimetric, cadmium/copper reduction.
-total(0.02mg/L)	. Colourimetric, persulphate/autoclave digest, cadmium/copper reduction.

cont'd

TABLE 3 cont'd : SURFACE WATER SAMPLE ANALYTICAL METHODS

PARAMETER (Detection Limit)	METHOD
metals(total and dissolved). Total metal samples (except mercury) are autoclave digested with 3:1 nitric: hydrochloric acid for two hours. Mercury samples are oxidized by the addition of 2:1 sulfuric:nitric acid, 3% potassium persulfate and heated for one hour at 105 C.	
- Ag(0.1ug/L)	,graphite furnace atomic absorption.
- Cd(0.1ug/L)	,graphite furnace atomic absorption.
- Cu(0.5ug/L)	,graphite furnace atomic absorption.
- Pb(0.5ug/L)	,graphite furnace atomic absorption.
- As(0.5ug/L)	,ICP emission spectrometry-hydride.
- Se(0.5ug/L)	,ICP emission spectrometry-hydride.
- Al(0.05mg/L)	,ICP emission spectrometry.
- Ca(0.1mg/L)	,ICP emission spectrometry.
- Fe(5ug/L)	,ICP emission spectrometry.
- Mg(0.1mg/L)	,ICP emission spectrometry.
- Mn(1ug/L)	,ICP emission spectrometry.
- Si(0.05mg/L)	,ICP emission spectrometry.
- Zn(2ug/L)	,ICP emission spectrometry.
- Hg(0.05ug/L)	,cold vapour atomic absorption.
- hardness(mg/L)	- calculated from dissolved metal sample.

3.2 Sediment

Sediment samples were collected with a stainless steel syringe sampler (Derksen 1985).

Five composite sediment samples were collected at each site for metal, total nitrogen, and volatile residue analyses (<0.15mm fraction). The syringe samples were left to settle overnight in the 2L polyethylene sample bottles. Samples were placed in Kraft sediment bags and were kept cold during transit and then frozen until preparation for analysis.

Sediment sample analyses and analytical methods are summarized in Table 4. The samples were analyzed at the Environment Canada, West Vancouver Laboratory. The sediment samples in this study were digested using a microwave oven procedure (Millward and Kluckner, 1989). Sediment reference samples NBS 1645 and MESS 1 were used to determine metal recovery.

TABLE 4 : SEDIMENT ANALYSES AND ANALYTICAL METHODS

PARAMETER (Detection Limit)	METHOD
Volatile Residue	- Sample is oven dried at 90 C overnight, oven dried at 103 C for one hour and then muffled at 550 C for one hour. - Gravimetric analysis.
Total Nitrogen(50 ug/g).	Colourimetric,persulphate/autoclave digest, cadmium/copper reduction.
Metals	- Samples are oven dried at 40 C, sieved to <0.15mm. and then rolled to homogenize. The sample is then weighted (0.3g) into a Teflon digestion vessel and digested with 4.5ml HNO ₃ and 1.5ml HCl and 1ml deionized water in a microwave oven (720 joules/sec) for 15 minutes. The sample is cooled, volumized, and settled overnight. The decant is analyzed.
- Ag(2ug/g)*,	ICP emission spectrometry
- Ag(0.02ug/g)	graphite furnace atomic absorption**
- Al ug/g),	ICP emission spectrometry
- As(8ug/g),	ICP emission spectrometry
- Ba(0.2ug/g),	ICP emission spectrometry
- Ca(20ug/g),	ICP emission spectrometry
- Cd(0.8ug/g),	ICP emission spectrometry
- Cd(0.02ug/g)	graphite furnace atomic absorption**
- Cr(0.8ug/g),	ICP emission spectrometry
- Cu(0.8ug/g),	ICP emission spectrometry
- Fe(8ug/g),	ICP emission spectrometry
- Hg(0.008ug/g),	cold vapour atomic absorption
- Mg(20ug/g),	ICP emission spectrometry
- Mn(0.2ug/g),	ICP emission spectrometry
- Ni(3ug/g),	ICP emission spectrometry
- Pb(8ug/g),	ICP emission spectrometry
- Pb(0.08ug/g)	graphite furnace atomic absorption**
- Si(8ug/g),	ICP emission spectrometry
- V(2ug/g),	ICP emission spectrometry
- Zn(0.3ug/g),	ICP emission spectrometry

* detection limit for 0.3g dried sample

** GFAA analysis if concentration < 2x ICP detection

4.0 RESULTS

4.1 Surface Water Quality

Water quality results for non metal and metal fractions are reported in Appendix A(i) and Appendix A(ii) respectively.

4.2 Sediment Quality

The sediment quality results are reported in Appendix B(i) (non metals) and Appendix B(ii) (metals). The reference sediment results are reported in Appendix B(iii).

5.0 DISCUSSION

5.1 Water Quality

Johnson, Sinmax and Homestake Creeks were characterized by moderate to high water hardness and alkalinity and high pH (Table 5). Stations SC2 and SC3 on Sinmax Creek had higher NFR concentrations (10-11 mg/L) compared to the upstream station (5 mg/L). Johnson and Homestake Creeks did not appear to be the source of the increase in NFR, both had NFR levels less than 5 mg/L. The higher NFR levels appeared to be reflective of some higher total metal levels as well (e.g. Al, Fe, Cu, Mn and Zn). Homestake Creek had the highest mean total zinc (34 ug/L) and mean dissolved zinc (18 ug/L) concentrations (Table 5). Homestake Creek had mean total and dissolved copper concentrations of 3.5 ug/L and 1.6 ug/L respectively.

TABLE 5 : WATER QUALITY SUMMARY

Site	Mean Hardness (mg/L CaCO ₃)		Alkalinity (mg/L CaCO ₃)		pH		NFR (mg/L)	
JC1	126		120		8.4		<5	
JC2	136		127		8.5		<5	
JC3	145		136		8.5		<5	
SC1	264		226		8.6		5	
SC2	179		159		8.6		10	
SC3	194		161		8.6		11	
HC1	121		103		8.4		<5	

Site	Mean Concentration									
	Al(mg/L)		Cu(ug/L)		Fe(ug/L)		Mn(ug/L)		Zn(ug/L)	
	T	D	T	D	T	D	T	D	T	D
JC1	<.05	<.05	1.0	0.6	17	30	<1	2	7	3
JC2	.09	<.05	0.6	<.5	119	17	4	2	8	<2
JC3	.09	<.05	<.5	<.5	109	19	5	<1	7	<2
SC1	.06	<.05	1.4	<.5	145	5	7	4	7	<2
SC2	.28	<.05	3.5	0.5	578	8	18	4	15	2
SC3	.28	<.05	4.2	0.8	670	9	31	7	19	4
HC1	<.05	<.05	3.5	1.6	143	26	11	6	34	18

5.2 Sediment Quality

The sediment data collected in this study represents a baseline for Johnson Creek and from which to make future comparisons (Table 6). To test for significant differences in metal content between stations, analysis of variance were followed by multiple comparisons using Tukey's multiple comparison test (Zar, 1984). All tests for significance were made at the 95% level. The results are shown in Figures 2 to 5.

TABLE 6: SEDIMENT QUALITY SUMMARY

Site	Mean Concentration (ug/g)					
	Ag	Cd	Cu	Hg	Pb	Zn
JC1	.08	.23	39.8	.034	10.4	128
JC2	.07	.08	24.3	.024	5.2	109
JC3	.09	.24	52.5	.154	28.0	155
SC1	.07	.10	40.0	.031	13.4	110
SC2	5.4	1.7	22.2	.633	41	574
SC3	1.6	1.3	37.4	.257	46	475
HC1	29	8.1	288	2.46	1142	2296

For Johnson Creek, the most notable result is the higher mean lead concentration at site JC3 and which might reflect the Samatosum mineral deposit (Figure 3).

Overall, the most notable observation is the high level of metal contamination in lower Homestake Creek (Table 6). Brown et al., 1979 reported that in 1971, a silver mine on Homestake Creek caused heavy silting of the creek. The high metal levels may reflect contamination from earlier mining operations. Further sampling is required to assess the level of contamination throughout the creek and whether there is an ongoing source of contamination. The lower section of Homestake Creek is channelized and there are impassable falls approximately 900 meters upstream from Sinmax Creek.

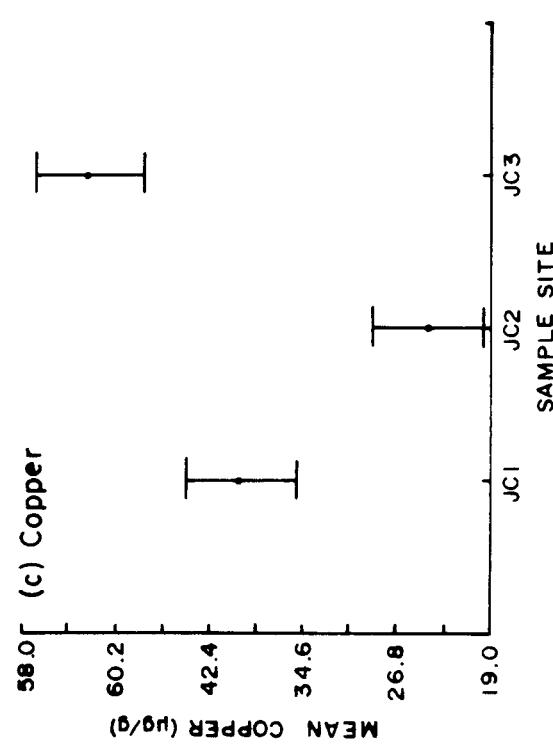
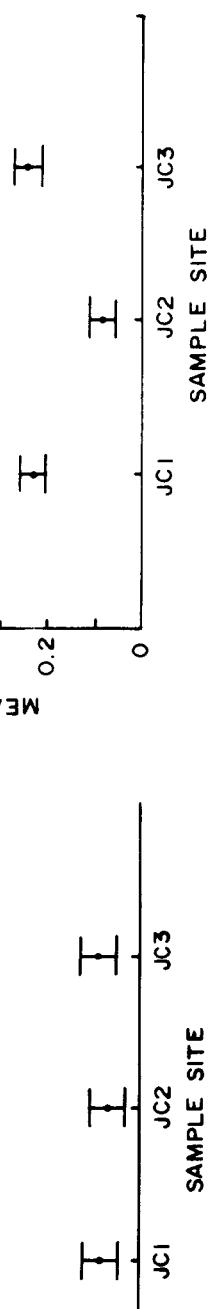


FIGURE 2: Tukey's Multiple Comparison for (a) Mean Silver, (b) Mean Cadmium and (c) Mean Copper Concentrations for Johnson Creek Sediment Samples.

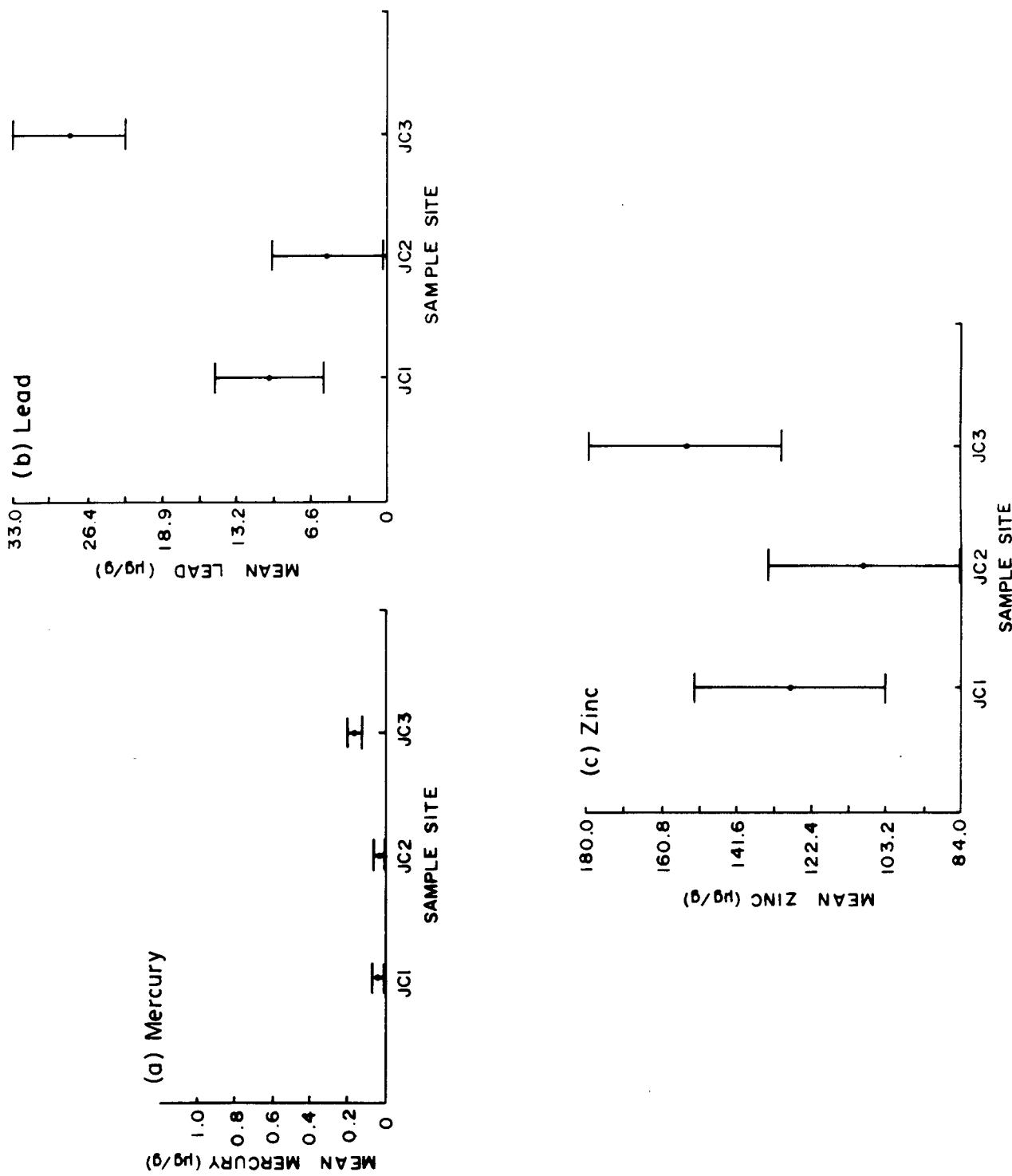


FIGURE 3: Tukey's Multiple Comparison for (a) Mean Mercury, (b) Mean Lead and (c) Mean Zinc Concentrations for Johnson Creek Sediment Samples.

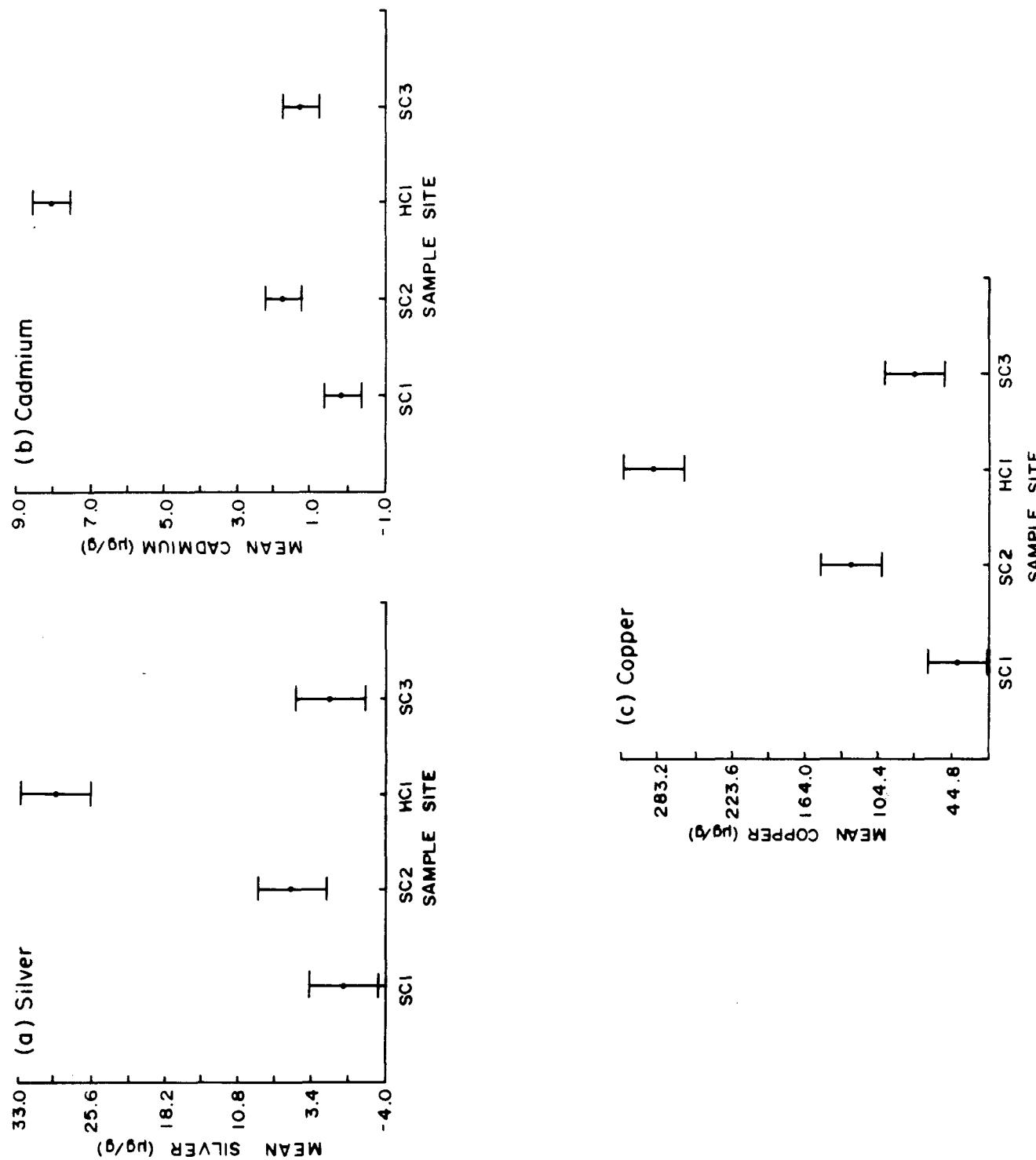


FIGURE 4: Tukey's Multiple Comparison for (a) Mean Silver, (b) Mean Cadmium and (c) Mean Copper Concentrations for Simmax Creek Sediment Samples.

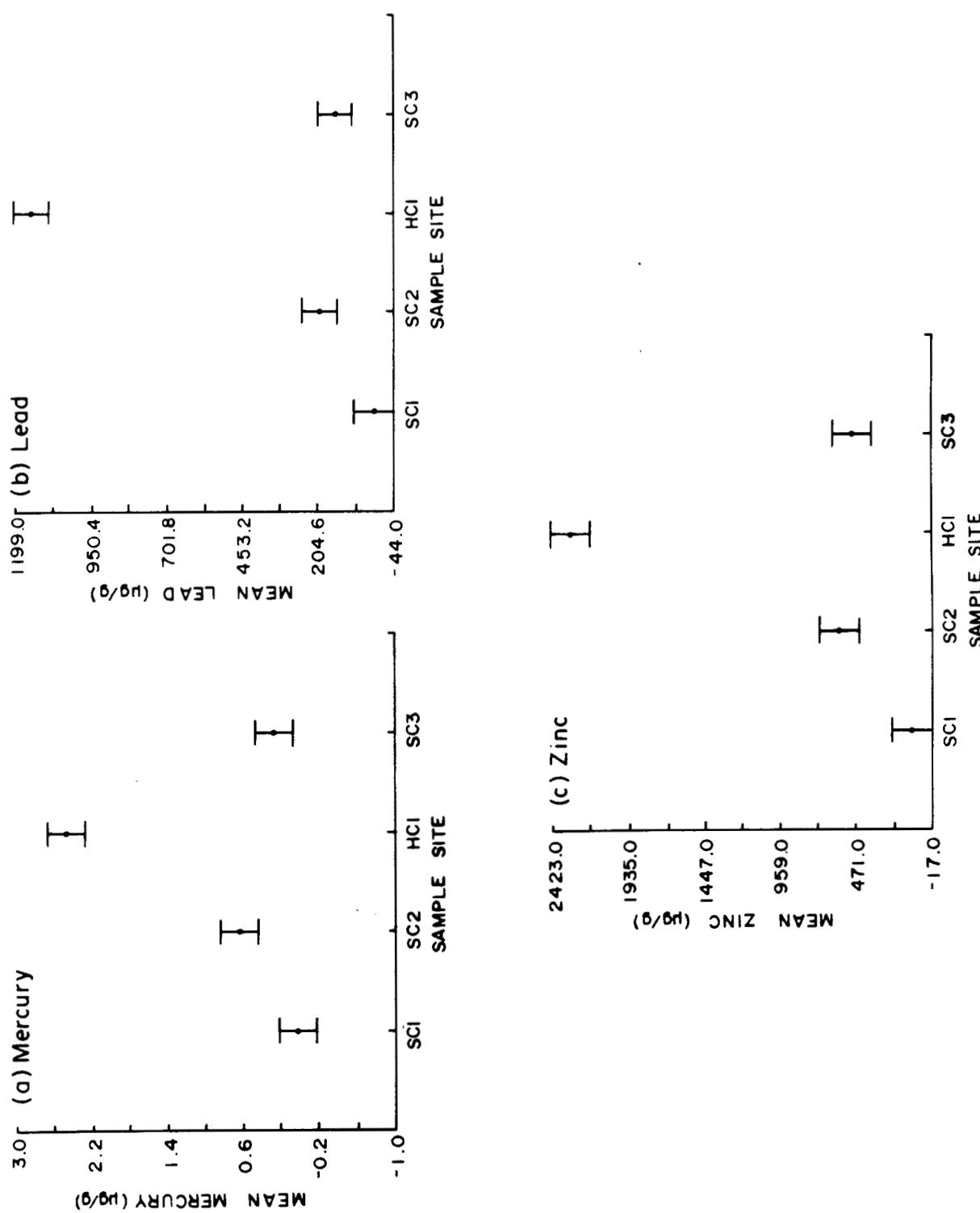


FIGURE 5: Tukey's Multiple Comparison for (a) Mean Mercury, (c) Mean Lead and (c) Mean Zinc Concentrations for Simmax Creek Sediment Samples.

Site SC2 on Sinmax Creek was located just upstream of Homestake Creek. Possibly, the higher metal levels (Figures 3 and 4) reflect some previous influence from Homestake Creek (i.e. if the confluence of the two creeks has changed at all). The higher metal levels in lower Sinmax Creek reflect the influence of Homestake Creek.

5.2.1 Sample Size Considerations. For future impact assessment studies on Johnson Creek, 'contamination' might be defined as increases in sediment levels that are statistically significantly greater than baseline levels (assuming the baseline estimate adequately reflects the population variance). The number of samples required to measure a specified increase in mean metal content (e.g. lead or zinc) can be estimated (Table 7). In order to measure a two standard deviation increase in mean sediment lead or zinc levels, in the order of 4 to 5 samples are required. However, in order to detect a one standard deviation increase, then an estimated 13 samples would be required.

TABLE 7 : ESTIMATED SAMPLE SIZE TO MEASURE A SPECIFIED
LEVEL OF CHANGE IN JOHNSON CREEK SEDIMENT
LEAD AND ZINC CONCENTRATIONS

Background Information			Percent Chance	Specified Change	Estimated n*
Lead	JC2	JC3		(2 x SD)	
mean =	5.2	28	JC2 (i) 90%	2.16ugPb/g	4-5
SD =	1.08	9.9	JC3 (ii) 90%	19.8ugPb/g	4-5
var.=	1.18	98.1		(1 x SD)	
n =	5	5	JC2 (iii) 90%	1.08ugPb/g	13
Zinc	JC2	JC3		(2 x SD)	
mean =	109	155	JC2 (i) 90%	72ugZn/g	4-5
SD =	36	34	JC3 (ii) 90%	68ugZn/g	4-5
var.=	1290	1158		(1 x SD)	
n =	5	5	JC2 (iii) 90%	36ugZn/g	13

* Estimation of required n to test $H_0: U = U_0$, $p=0.05$
(Zar, 1984 pg. 110)

5.3 Future Monitoring

The quality of Johnson Creek sediments should be monitored at various stages of the mine development in order to determine possible impacts from mine discharges. A sample size of five is adequate to measure, with a 90% chance, a two standard deviation increase in background levels of lead or zinc.

Although total mercury in sediment is not generally considered by itself to be a reliable variable for predicting mercury contamination in fish (Elwood et al., 1987), or mercury methylation potential (Jackson, 1988), the mercury levels of resident fish in Sinmax Creek should be checked. Homestake Creek appears to be a source of higher sediment mercury levels. Further sampling and inspection of Homestake Creek is required in order to determine whether there is an ongoing source of contamination occurring at the old mine site.

REFERENCES

- Brown, R.F., M.M. Musgrave and D.E. Marshall. 1979. Catalogue of Salmon Streams and Spawning Escapements for Kamloops Sub-District. Fisheries and Marine Service Data Report No. 151. Fisheries and Oceans.
- Derkson, G. 1985. Heavy Metals in Clastic Stream Sediments of the Yakoun River Drainage and Other B.C. Streams. Regional Program Report No. 83-05. Department of the Environment, Pacific Region.
- Elwood, J.W., R.R. Turner, R.B. Cook, and M.A. Bogle. 1987. Behavior and Fish Uptake of Mercury in a Contaminated Stream. Environmental Sciences Division, Oak Ridge National Library, CONF - 870937-2.
- Environment Canada. 1989. Laboratory Manual. West Vancouver Laboratory. (in prep.).
- Hatfield Consultants Ltd. 1988. Minnova Inc. Samatosum Project. Stage I Environmental and Socio-Economic Impact Assessment. May 1988.
- Hatfield Consultants Ltd. 1988a. Minnova Inc. Samatosum Project. A Supplementary Submissionto the Stage I Report. August 1988.
- Jackson, T.A. 1988. The Mercury Problem in Recently Formed Reservoirs of Northern Manitoba (Canada): Effects of Impoundment and Other Factors on the Production of Methyl Mercury by Microorganisms in Sediments. Can. J. Fish.Aquat Sci. 45: 97-121.
- Millward, C., and P.D. Kluckner. 1989. Microwave Digestion Technique for the Extraction of Minerals from Environmental Marine Sediments for the Analysis by Inductively Coupled Plasma Atomic Emission - Spectrometry and Atomic Absorption Spectrometry. Journal of Analytical Atomic Spectrometry. 4: in press.
- Zar, J.H., 1984. Biostatistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, N.J. 07632.

ACKNOWLEDGEMENTS

The analytical services provided by the staff of the Environment Canada, West Vancouver Laboratory are gratefully acknowledged. Thanks are extended to G. Lynton for his help in the collection of the field samples.

APPENDIX A - WATER QUALITY (i) NON METALS

- acidity, alkalinity, and hardness (Ca+Mg)
- hardness (total), pH and sulphate
- chloride,TOC and TIC
- conductivity,TR and NFR
- TVR,nitrite+nitrate and ammonia
- TN,TP and TDP

APPENDIX A - WATER QUALITY (i) NON METALS

Date : May 17 1988

Station	Parameter		
	Acidity (mg/l CaCO ₃)	Alkalinity (mg/l CaCO ₃)	Hardness(Ca&Mg) (mg/l CaCO ₃)
Johnson Cr			
JC1	<1	120	126,126,126
JC2	<1	127	136,137,136
JC3	<1	136	143,146,146
Sinmax Cr			
SC1	<1	226	261,269,260
SC2	<1	159	181,181,177
SC3	<1	161	194,193,195
Homestake Cr			
HC1	<1	103	121,122,121

Station	Parameter		
	Hardness(Total) (mg/l CaCO ₃)	pH	Sulphate(mg/L)
Johnson Cr			
JC1	127,126,126	8.4	3
JC2	136,137,135	8.5	5
JC3	143,146,146	8.5	8
Sinmax Cr			
SC1	261,269,260	8.6	30
SC2	181,182,177	8.6	15
SC3	194,193,196	8.6	27
Homestake Cr			
HC1	121,122,121	8.4	15

Station	Parameter		
	Chloride(mg/L)	TOC(mg/l)	TIC(mg/l)
Johnson Cr			
JC1	0.5	2	29
JC2	0.6	3	31
JC3	0.6	4	32
Sinmax Cr			
SC1	1.0	4	53
SC2	0.8	2	38
SC3	0.8	2	40
Homestake Cr			
HC1	0.6	7	23

cont'd

APPENDIX A cont'd - WATER QUALITY (i) NON METALS
 Date : May 17 1988

Parameter			
Station	Conductivity (umho/cm)	TR(mg/L)	NFR(mg/L)
Johnson Cr			
JC1	230	143	<5
JC2	240	156	<5
JC3	260	174	<5
Sinmax Cr			
SC1	455	302	5
SC2	310	217	10
SC3	340	237	11
Homestake Cr			
HC1	215	145	<5
Parameter			
Station	TVR(mg/L)	Nitrite+Nitrate-N (ug/L)	Ammonia-N (ug/L)
Johnson Cr			
JC1	28	<5	<5
JC2	27	8	5
JC3	31	20	<5
Sinmax Cr			
SC1	54	291	5
SC2	34	85	<5
SC3	41	146	<5
Homestake Cr			
HC1	22	<5	<5
Parameter			
Station	T Nitrogen-N (ug/L)	TPhos. -P (ug/L)	TDPhos. -P (ug/L)
Johnson Cr			
JC1	110	6	6
JC2	160	9	9
JC3	150	10	8
Sinmax Cr			
SC1	420	22	9
SC2	270	21	9
SC3	320	18	9
Homestake Cr			
HC1	170	8	11

APPENDIX A – WATER QUALITY (ii) METALS

- Ag, Al, and As
- Ca, Cd, and Cr
- Cu, Fe, and Hg
- Mg, Mn, and Se
- Zn

APPENDIX A - WATER QUALITY (ii) METALS - Ag, Al, and As

Site	Silver (ug/l)					SD
	(1)	(ii)	(iii)	Mean		
JC1	Total < 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
	Diss < 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
JC2	Total < 0.1	< 0.1	0.1	0.1	0.1	0.1
	Diss < 0.1	< 0.1	0.1	0.1	0.1	0.1
JC3	Total 0.1	0.1	0.1	0.1	0.1	0.1
	Diss 0.2	0.2	0.1	0.1	0.2	0.2
SC1	Total < 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
	Diss < 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
SC2	Total 0.1	0.1	0.1	0.1	0.1	0.1
	Diss 0.2	0.2	0.2	0.2	0.2	0.2
SC3	Total < 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
	Diss 0.2	0.2	0.2	0.2	0.2	0.2
HC1	Total 0.1	0.1	0.1	0.1	0.1	0.1
	Diss 0.1	0.1	0.1	0.1	0.1	0.1
Site	Aluminium (mg/L)					SD
	(1)	(ii)	(iii)	Mean		
JC1	Total < 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
	Diss < 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
JC2	Total 0.09	0.09	0.08	0.09	0.09	0.00
	Diss < 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
JC3	Total 0.10	0.07	0.09	0.09	0.09	0.01
	Diss < 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
SC1	Total 0.06	0.07	0.06	0.06	0.06	0.00
	Diss < 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
SC2	Total 0.29	0.25	0.29	0.28	0.28	0.02
	Diss < 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
SC3	Total 0.31	0.27	0.25	0.28	0.28	0.02
	Diss < 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
HC1	Total < 0.05	< 0.05	0.05	0.05	0.05	0.05
	Diss < 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Site	Arsenic (ug/l)					SD
	(1)	(ii)	(iii)	Mean		
JC1	Total < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
	Diss < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
JC2	Total < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
	Diss < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
JC3	Total 0.8	< 0.5	0.5	0.5	0.6	0.1
	Diss 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
SC1	Total < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
	Diss 0.5	0.5	0.6	0.5	0.5	0.0
SC2	Total < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
	Diss < 0.5	< 0.5	0.7	0.6	0.6	0.1
SC3	Total < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
	Diss < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
HC1	Total < 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.0
	Diss < 0.5	< 0.5	0.9	0.6	0.6	0.2

APPENDIX A - WATER QUALITY (ii) METALS - Ca, Cd, and Cr

Site		Calcium (mg/L)				
		(i)	(ii)	(iii)	Mean	SD
JC1	Total	34.7	34.6	34.3	34.5	0.2
	Diss	36.6	36.7	36.6	36.6	0.0
JC2	Total	38.6	38.8	37.6	38.3	0.5
	Diss	40.3	39.6	40.0	40.0	0.3
JC3	Total	39.1	39.9	40.1	39.7	0.4
	Diss	41.4	42.3	42.2	42.0	0.4
SC1	Total	61.5	61.7	62.0	61.7	0.2
	Diss	63.1	63.6	63.0	63.2	0.3
SC2	Total	47.5	47.7	47.2	47.5	0.2
	Diss	49.4	49.6	47.9	49.0	0.8
SC3	Total	51.4	49.9	50.4	50.6	0.6
	Diss	51.5	51.2	51.4	51.4	0.1
HC1	Total	35.8	35.7	36.3	35.9	0.3
	Diss	37.8	38.0	37.8	37.9	0.1

Site		Cadmium (ug/L)				
		(i)	(ii)	(iii)	Mean	SD
JC1	Total	< 0.1	< 0.1	< 0.1	< 0.1	0.1
	Diss	< 0.1	< 0.1	< 0.1	< 0.1	0.1
JC2	Total	< 0.1	< 0.1	< 0.1	< 0.1	0.1
	Diss	< 0.1	< 0.1	< 0.1	< 0.1	0.1
JC3	Total	< 0.1	< 0.1	< 0.1	< 0.1	0.1
	Diss	< 0.1	< 0.1	< 0.1	< 0.1	0.1
SC1	Total	< 0.1	< 0.1	< 0.1	< 0.1	0.1
	Diss	< 0.1	< 0.1	< 0.1	< 0.1	0.1
SC2	Total	< 0.1	< 0.1	< 0.1	< 0.1	0.1
	Diss	< 0.1	< 0.1	< 0.1	< 0.1	0.1
SC3	Total	< 0.1	< 0.1	-*	< 0.1	0.1
	Diss	< 0.1	< 0.1	< 0.1	< 0.1	0.1
HC1	Total	< 0.1	< 0.1	< 0.1	< 0.1	0.1
	Diss	< 0.1	< 0.1	< 0.1	< 0.1	0.1

-* outlier value of 2.5ug/L

Site		Chromium (ug/L)				
		(i)	(ii)	(iii)	Mean	SD
JC1	Total	< 5	< 5	< 5	< 5	0
	Diss	< 5	< 5	< 5	< 5	0
JC2	Total	< 5	< 5	< 5	< 5	0
	Diss	< 5	< 5	< 5	< 5	0
JC3	Total	< 5	< 5	< 5	< 5	0
	Diss	< 5	< 5	< 5	< 5	0
SC1	Total	< 5	< 5	< 5	< 5	0
	Diss	< 5	< 5	< 5	< 5	0
SC2	Total	-?	-?	-?	-?	0
	Diss	< 5	< 5	< 5	< 5	0
SC3	Total	-??	-??	-??	-??	0
	Diss	< 5	< 5	< 5	< 5	0
HC1	Total	< 5	< 5	< 5	< 5	0
	Diss	< 5	< 6	< 5	< 5	0

-? highly variable values(82,<5,222)

_??highly variable values(163,32,27)

APPENDIX A - WATER QUALITY (ii) METALS - Cu, Fe, and Hg

Site		Copper (ug/L)			Mean	SD
		(i)	(ii)	(iii)		
JC1	Total	1.3 <	0.5	1.3	1.0	0.4
	Diss	0.9 <	0.5 <	0.5	0.6	0.2
JC2	Total	< 0.5	0.8 <	0.5	0.6	0.1
	Diss	0.6 <	0.5 <	0.5	0.5	0.0
JC3	Total	< 0.5 <	0.5 <	0.5 <	0.5	0.0
	Diss	< 0.5 <	0.5 <	0.5 <	0.5	0.0
SC1	Total	1.0 <	0.5	2.8	1.4	1.0
	Diss	< 0.5 <	0.5 <	0.5 <	0.5	0.0
SC2	Total	1.8	3.8	4.8	3.5	1.2
	Diss	< 0.5 <	0.5	0.5	0.5	0.0
SC3	Total	5.1	3.6	3.9	4.2	0.6
	Diss	0.8	0.8	0.8	0.8	0.0
HC1	Total	1.4	5.7	3.4	3.5	1.8
	Diss	1.5	1.7	1.7	1.6	0.1

Site		Iron(ug/L)			Mean	SD
		(i)	(ii)	(iii)		
JC1	Total	15	26	11	17	6
	Diss	68	16	7	30	27
JC2	Total	131	127	99	119	14
	Diss	33	7	10	17	12
JC3	Total	130	89	107	109	17
	Diss	< 5 <	5	46	19	19
SC1	Total	139	150	145	145	4
	Diss	< 5	6 <	5	5	0
SC2	Total	514	458	763	578	133
	Diss	11	8 <	5	8	2
SC3	Total	819	629	562	670	109
	Diss	9	10	8	9	1
HC1	Total	142	152	135	143	7
	Diss	27	28	23	26	2

Site		Mercury (ug/L)			Mean	SD
		(i)	(ii)	(iii)		
JC1	Total	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05
	Diss					
JC2	Total	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05
	Diss					
JC3	Total	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05
	Diss					
SC1	Total	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05
	Diss					
SC2	Total	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05
	Diss					
SC3	Total	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05
	Diss					
HC1	Total	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05
	Diss					

APPENDIX A - WATER QUALITY (ii) METALS - Mg, Mn, and Se

Site		Magnesium (mg/L)				
		(i)	(ii)	(iii)	Mean	SD
JC1	Total	7.6	7.6	7.6	7.6	0.0
	Diss	8.5	8.4	8.5	8.5	0.0
JC2	Total	7.8	7.9	7.9	7.9	0.0
	Diss	8.7	9.2	8.7	8.9	0.2
JC3	Total	9.5	9.6	8.8	9.3	0.4
	Diss	9.6	9.9	9.9	0.5	0.1
SC1	Total	23.4	23.2	23.2	23.3	0.1
	Diss	25.1	26.7	25.0	25.6	0.8
SC2	Total	13.0	13.4	13.0	13.1	0.2
	Diss	14.1	14.0	13.8	14.0	0.1
SC3	Total	15.2	14.8	14.9	15.0	0.2
	Diss	15.8	15.8	16.3	16.0	0.0
HC1	Total	6.0	6.0	5.9	6.0	0.0
	Diss	6.5	6.6	6.5	6.5	0.0
Site		Manganese (ug/L)				
		(i)	(ii)	(iii)	Mean	SD
JC1	Total	1	<	1	1	0
	Diss	2		2	2	0
JC2	Total	4		4	4	0
	Diss	2		3	2	0
JC3	Total	5		4	5	0
	Diss	<	1	<	1	0
SC1	Total	8		6	7	1
	Diss	4		4	4	0
SC2	Total	22		17	14	3
	Diss	4		3	4	0
SC3	Total	15		33	45	12
	Diss	7		8	6	1
HC1	Total	12		11	10	1
	Diss	5		7	6	1
Site		Selenium (ug/L)				
		(i)	(ii)	(iii)	Mean	SD
JC1	Total	<	0.5	<	0.5	0.0
	Diss	1.0	<	0.5	0.5	0.2
JC2	Total	<	0.5	<	0.5	0.0
	Diss	0.6	<	0.5	0.5	0.0
JC3	Total	<	0.5	<	0.5	0.0
	Diss	0.5	<	0.5	0.5	0.0
SC1	Total	<	0.5	<	0.5	0.0
	Diss	0.5		0.5	0.5	0.0
SC2	Total	<	0.5	<	0.5	0.0
	Diss	<	0.5	<	0.7	0.1
SC3	Total	0.5	<	0.5	0.5	0.0
	Diss	<	0.5	<	0.9	0.2
HC1	Total	<	0.5	<	0.5	0.0
	Diss	<	0.5	<	0.5	0.0

APPENDIX A - WATER QUALITY (ii) METALS - Zn

Site		Zinc (ug/L)			Mean	SD
		(i)	(ii)	(iii)		
JC1	Total	8	6	7	7	1
	Diss	5	<	2	3	1
JC2	Total	8	9	7	8	1
	Diss	<	2	<	2	0
JC3	Total	8	6	6	7	1
	Diss	<	2	<	2	0
SC1	Total	4	10	7	7	2
	Diss	<	2	<	2	0
SC2	Total	28	7	10	15	9
	Diss	<	2	<	2	0
SC3	Total	20	16	20	19	2
	Diss	5	4	4	4	0
HC1	Total	34	32	35	34	1
	Diss	17	20	18	18	1

APPENDIX B - SEDIMENT QUALITY (i) NON METAL

- SVR and TN

APPENDIX (1)

- SVR and TN

SEDIMENT VOLATILE RESIDUE (mg/g) (<0.15mm)							
	Johnson Cr			Sinmax Cr		Homestake Cr	
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	59.8	31.2	58.5	38.5	60.7	39.8	34.6
	56.0	39.9	81.0	33.7	61.7	42.4	29.2
	73.4	77.5	72.1	52.8	51.8	50.8	29.7
	85.5	78.1	58.9	36.9	59.7	43.4	27.7
	60.9	72.0	77.7	43.3	43.0	49.0	24.9
MEAN	67.1	59.7	69.6	41.0	55.4	45.1	29.2
SD	10.9	20.1	9.4	6.6	7.1	4.1	3.2
n	5	5	5	5	5	5	5
rsd(%)	16	34	13	16	13	9	11

TOTAL NITROGEN (mg/g) (<0.15mm)							
	Johnson Cr			Sinmax Cr		Homestake Cr	
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	1.90	1.30	2.10	0.95	2.10	1.20	0.71
	2.20	1.70	2.70	0.68	2.40	1.30	0.50
	3.30	2.70	2.80	1.60	1.90	1.80	0.54
	3.50	3.20	2.10	0.99	2.20	1.30	0.46
	2.50	2.80	2.30	1.30	1.40	1.90	0.38
MEAN	2.68	2.34	2.40	1.10	2.00	1.50	0.52
SD	0.62	0.72	0.30	0.32	0.34	0.29	0.11
n	5	5	5	5	5	5	5
rsd(%)	23	31	12	29	17	19	21

APPENDIX B – SEDIMENT QUALITY (ii) METALS

- Ag, As, and Cd
- Cr, Cu, and Hg
- Ni, Pb, and Zn
- Al, Ca, and Fe
- Mg and Mn

APPENDIX B(ii) - Ag, As, and Cd

			Silver (ug/g) (<0.15mm)				
Johnson Cr			Sinmax Cr		Homestake Cr		
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	0.08	0.02	0.08	0.06	2.6	1.8	27*
	0.08	0.20	0.08	0.06	1.7	1.9	36*
	0.10	0.04	0.10	0.09	2.3	1.9	29*
	0.08	0.04	0.09	0.07	3.4	1.2	25*
	0.06	0.03	0.09	0.09	17.0*	1.2	29*
MEAN	0.08	0.07	0.09	0.07	5.4	1.6	29
SD	0.01	0.07	0.01	0.01	5.8	0.3	4
n	5	5	5	5	5	5	5
rsd(%)	16	102	9	18	108	21	13

* ICP otherwise GF

			Arsenic (ug/g) (<0.15mm)				
Johnson Cr			Sinmax Cr		Homestake Cr		
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	40	17	25	27	32	48	110
	35	21	26	26	30	50	100
	37	25	38	32	34	42	100
	35	25	34	26	52	45	96
	30	20	30	29	55	43	93
MEAN	35	22	31	28	41	46	100
SD	3	3	5	2	11	3	6
n	5	5	5	5	5	5	5
rsd(%)	9	14	16	8	26	7	6

			Cadmium (ug/g) (<0.15mm)				
Johnson Cr			Sinmax Cr		Homestake Cr		
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	0.21	0.06	0.27	0.10	1.5	1.4	8.2*
	0.18	0.08	0.27	0.10	1.4	1.4	9.3*
	0.31	0.10	0.25	0.10	1.1	1.3	8.5*
	0.24	0.10	0.21	0.10	2.4	1.3	7.5*
	0.23	0.08	0.22	0.10	2.3	1.0	6.9*
MEAN	0.23	0.08	0.24	0.10	1.7	1.3	8.1
SD	0.04	0.01	0.02	0.00	0.5	0.1	0.8
n	5	5	5	5	5	5	5
rsd(%)	18	18	10	0	30	11	10

* ICP otherwise GF

APPENDIX B(ii)

-Cr,Cu, and Hg

			Chromium (ug/g) (<0.15mm)				
Johnson Cr			Sinmax Cr		Homestake Cr		
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	114.0	77.9	109.0	97.3	75.5	68.6	41.3
	99.8	108.0	107.0	76.3	89.7	69.4	34.8
	110.0	140.0	181.0	90.6	80.6	68.5	31.8
	115.0	103.0	121.0	89.5	68.1	71.3	33.0
	137.0	106.0	109.0	95.0	65.2	79.5	32.3
MEAN	115.2	107.0	125.4	89.7	75.8	71.5	34.6
SD	12.2	19.8	28.2	7.3	8.8	4.1	3.5
n	5	5	5	5	5	5	5
rsd(%)	11	18	23	8	12	6	10

			COPPER (ug/g) (<0.15mm)				
Johnson Cr			Sinmax Cr		Homestake Cr		
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	41.6	15.0	48.2	37.6	20.3	38.1	296
	34.7	20.6	50.5	37.4	20.6	38.0	310
	39.9	37.1	52.5	44.1	20.2	38.3	283
	43.4	25.6	56.7	38.0	19.1	36.5	279
	39.5	23.0	54.5	42.8	30.8	35.9	271
MEAN	39.8	24.3	52.5	40.0	22.2	37.4	288
SD	2.9	7.3	3.0	2.9	4.3	1.0	14
n	5	5	5	5	5	5	5
rsd(%)	7	30	6	7	20	3	5

			MERCURY (ug/g) (<0.15mm)				
Johnson Cr			Sinmax Cr		Homestake Cr		
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	0.031	0.017	0.074	0.030	0.440	0.251	2.440
	0.026	0.020	0.093	0.025	0.385	0.287	2.620
	0.033	0.032	0.213	0.034	0.357	0.265	2.770
	0.041	0.026	0.209	0.027	0.822	0.254	2.370
	0.039	0.023	0.182	0.041	1.160	0.228	2.090
MEAN	0.034	0.024	0.154	0.031	0.633	0.257	2.458
SD	0.005	0.005	0.059	0.006	0.313	0.019	0.231
n	5	5	5	5	5	5	5
rsd(%)	16	22	38	18	49	7	9

APPENDIX B(11)

- Ni, Pb, and Zn

Nickel (ug/g) (<0.15mm)							
	Johnson Cr			Sinmax Cr			Homestake Cr
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	84	46	79	81	57	61	37
	70	68	74	68	67	60	32
	75	91	120	76	60	61	30
	82	65	83	72	55	62	31
	92	70	77	76	56	66	28
MEAN	81	68	87	75	59	62	32
SD	8	14	17	4	4	2	3
n	5	5	5	5	5	5	5
rsd(%)	9	21	20	6	7	3	10

Lead (ug/g) (<0.15mm)							
	Johnson Cr			Sinmax Cr			Homestake Cr
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	9.08	3.99	44.0*	13.6	32	48	1190*
	9.87	4.32	31.1	13.5	30	50	1250*
	10.40	6.70	21.2	13.0	34	42	1130*
	12.20	5.64	23.4	12.4	52	45	1090*
	10.20	5.36	20.3	14.5	55	43	1050*
MEAN	10.35	5.20	28.0	13.4	41	46	1142
SD	1.03	0.97	8.9	0.7	11	3	71
n	5	5	5	5	5	5	5
rsd(%)	10	19	32	5	26	7	6

* ICP otherwise GF

Zinc (ug/g) (<0.15mm)							
	Johnson Cr			Sinmax Cr			Homestake Cr
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1
MAY17	132	60	161	123	526	465	2420
	112	93	158	98	473	500	2510
	135	155	203	95	359	473	2400
	134	130	142	111	674	470	2120
	126	106	109	123	836	468	2030
MEAN	128	109	155	110	574	475	2296
SD	8	32	30	12	166	13	186
n	5	5	5	5	5	5	5
rsd(%)	7	30	20	11	29	3	8

APPENDIX B(iii)

- Al, Ca, and Fe

ALUMINIUM (mg/g) (<0.15mm)

	Johnson Cr			Sinmax Cr			Homestake Cr	
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1	
MAY17	24.7	11.4	17.8	11.9	15.3	12.0		8.4
	20.8	14.3	17.3	12.0	15.8	12.5		8.1
	19.0	18.0	16.7	12.5	13.9	11.5		8.0
	21.1	14.5	16.0	11.0	15.2	11.6		8.7
	21.9	15.4	14.8	13.3	13.5	13.3		8.9
MEAN	21.5	14.7	16.5	12.1	14.7	12.2		8.4
SD	1.9	2.1	1.0	0.8	0.9	0.7		0.3
n	5	5	5	5	5	5		5
rsd(%)	9	14	6	6	6	5		4

CALCIUM (mg/g) (<0.15mm)

	Johnson Cr			Sinmax Cr			Homestake Cr	
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1	
MAY17	34.4	7.1	29.9	10.0	17.2	13.5		10.0
	46.7	8.6	30.6	9.4	19.2	13.9		7.8
	79.3	10.1	31.3	11.3	18.2	14.8		7.7
	41.6	10.1	27.8	11.6	15.8	13.9		7.4
	31.4	9.4	30.3	11.3	14.6	13.9		7.2
MEAN	46.7	9.1	30.0	10.7	17.0	14.0		8.0
SD	17.2	1.1	1.2	0.9	1.6	0.4		1.0
n	5	5	5	5	5	5		5
rsd(%)	37	12	4	8	10	3		13

IRON (mg/g) (<0.15mm)

	Johnson Cr			Sinmax Cr			Homestake Cr	
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1	
MAY17	47.1	20.7	44.6	44.0	38.6	43.4		73.3
	40.1	24.7	41.1	43.0	37.9	44.5		74.4
	35.7	29.7	47.3	38.3	35.9	42.0		70.5
	39.5	30.4	47.2	39.0	41.3	42.2		64.9
	42.0	30.4	43.1	41.1	45.3	43.9		62.1
MEAN	40.9	27.2	44.7	41.1	39.8	43.2		69.0
SD	3.7	3.9	2.4	2.2	3.2	1.0		4.8
n	5	5	5	5	5	5		5
rsd(%)	9	14	5	5	8	2		7

APPENDIX B(ii)

- Mg and Mn

MAGNESIUM (mg/g) (<0.15mm)

	Johnson Cr			Sinmax Cr			Homestake Cr	
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1	
MAY17	19.7	6.9	16.8	7.4	10.3	8.7		6.0
	17.3	9.2	15.1	7.6	10.6	8.6		5.6
	15.5	11.6	15.5	7.7	9.9	8.3		5.6
	16.1	8.8	15.5	7.5	10.1	8.3		6.0
	17.4	10.0	13.8	7.8	9.7	8.8		6.0
MEAN	17.2	9.3	15.3	7.6	10.1	8.6		5.9
SD	1.4	1.5	1.0	0.1	0.3	0.2		0.2
n	5	5	5	5	5	5		5
rsd(%)	8	16	6	2	3	3		3

MANGANESE (mg/g) (<0.15mm)

	Johnson Cr			Sinmax Cr			Homestake Cr	
(1988)	JC1	JC2	JC3	SC1	SC2	SC3	HC1	
MAY17	0.97	0.24	0.96	1.05	0.65	0.96		1.30
	0.99	0.35	0.94	0.99	0.62	0.98		1.06
	1.72	0.43	0.92	0.97	0.60	0.86		1.27
	1.24	1.97	0.83	0.85	0.60	0.88		1.08
	0.48	1.35	0.95	0.93	0.95	0.98		0.88
MEAN	1.08	0.87	0.92	0.96	0.68	0.93		1.12
SD	0.40	0.68	0.05	0.07	0.13	0.05		0.15
n	5	5	5	5	5	5		5
rsd(%)	37	78	5	7	20	5		14

APPENDIX B – SEDIMENT QUALITY (iii) REFERENCE SEDIMENT

- NBS 1645
- MESS 1

APPENDIX B(iii) - REFERENCE SEDIMENT NBS 1645

METAL (ug/g)	WEST VANCOUVER LABORATORY			mean	sd	rsd (%)
	(i)	(ii)	(iii)			
MERCURY	0.816	0.749	0.778	0.781	0.027	4
ARSENIC	120	120	120	120	0	0
CADMIUM	9.3	8.9	8.7	9.0	0.2	3
CHROMIUM (mg/g)	29.0	28.2	28.3	28.5	0.4	1
COPPER	118.0	114.0	115.0	115.7	1.7	1
LEAD	711	692	685	696	11	2
MANGANESE	738	736	730	735	3	0
NICKEL	41	39	39	40	1	2
VANADIUM	31	31	29	30	1	3
ZINC	1710	1680	1660	1683	21	1
IRON (mg/g)	107	104	105	105	1	1

METAL (ug/g)	NBS 1645		WEST VANCOUVER LABORATORY (MEAN % RECOVERY)*
	CERTIFIED VALUE (+95% limits)		
MERCURY	1.1	(0.6-1.6)	71
ARSENIC			
CADMIUM	10.2	(8.7-11.7)	
COPPER	109	(90-128)	106
LEAD	714	(686-742)	
MANGANESE	785	(688-882)	
NICKEL	45.8	(42.9-48.7)	
VANADIUM	23.5	(16.6-30.4)	
ZINC	1720	(1551-1889)	98
(mg/g)			
CHROMIUM	29.6	(26.8-32.4)	96
IRON	113	(101-125)	93

* based on mean certified value

APPENDIX B(iii) - REFERENCE SEDIMENT

METAL (ug/g)	WEST VANCOUVER LABORATORY			mean	sd	rsd (%)
	(i)	(ii)	(iii)			
MERCURY	0.182	0.188	0.202	0.191	0.008	0.092
ARSENIC	10	19	23	17	5	
CADMIUM(GF)	0.67	0.66	0.67	0.67	0.00	0.71
CHROMIUM	30.1	31.0	31.1	30.7	0.4	1.5
COPPER	26.7	26.7	27.3	26.9	0.3	1.1
LEAD(GF)	29.3	29.2	27.3	28.6	0.9	3.2
MANGANESE	354	370	365	363	7	1.8
NICKEL	25	26	26	26	0	
VANADIUM	43	46	46	45	1	
ZINC	184	183	180	182	2	0.9

METAL	MESS-1 CERTIFIED VALUE (+95%limits)	WEST VANCOUVER LABORATORY (MEAN % RECOVERY)*
MERCURY	.171 (.157-.185)	112
ARSENIC	10.6 (9.4-11.8)	
CADMIUM	.59 (.49-.69)	
CHROMIUM	71 (60-82)	
COPPER	25.1 (21.3-28.9)	107
LEAD	34.0 (27.9-40.1)	
MANGANESE	513 (488-538)	
NICKEL	29.5 (26.8-32.2)	
VANADIUM	72.4 (67.1-77.7)	
ZINC	191 (174-208)	95

* based on mean certified value