97-e10

DEPARTMENT OF ECOLOGY

December 31, 1997

(December 4, 1996 - draft)

TO: Jim Milton
Central Regional Office (CRO)

FROM: Art Johnson
Environmental Investigations and Laboratory Services (EILS)

SUBJECT: **Survey of Metal Concentrations in the Similkameen River**
Waterbody No. WA-49-1030

Summary

Copper, zinc, nickel, lead, cadmium, silver, arsenic, chromium, mercury, and selenium were analyzed in water and sediment samples collected from four sites in the Similkameen River during low flow in August 1995 and spring runoff in April 1996. Data on general water quality, as well as iron, aluminum, manganese, and grain size in the sediments, were also obtained.

All metals concentrations in the water column were within EPA criteria for protection of aquatic life criteria and within state drinking water standards. Copper (0.51 - 2.6 ug/L; parts per billion), arsenic (2.0 - 7.0 ug/L), and mercury (<0.001 - 0.006 ug/L) were the predominant metals of interest in the water column, with peak concentrations occurring in the spring. From a statewide perspective, mercury concentrations were high in spring runoff samples and, in a few cases, approached the EPA chronic water quality criterion of 0.012 ug/L. Review of Environment Canada routine monitoring data for total recoverable metals shows potential for occasional violations of the EPA chronic criterion for dissolved copper when peak concentrations of copper coincide with low hardness conditions during spring runoff events. A similar peak also occurs for arsenic and may be related to mine tailings in Canada. The sources of metals may also be natural, due to highly mineralized soils.

Arsenic concentrations in the Similkameen River exceed the EPA human health criteria of 0.14 ug/L (consumption of fish) and 0.018 ug/L (consumption of fish and water). Although other rivers in Washington commonly exceed these very low criteria, the arsenic levels in the Similkameen River are higher than typically encountered.

Copper (22 - 60 mg/Kg, dry; parts per million) and arsenic (12 - 46 mg/Kg) were also elevated in Similkameen River sediments. Arsenic concentrations exceeded a level shown to have a severe effect on benthic invertebrate communities.

Recommendations

1) Conduct a biological assessment of Similkameen River sediments to determine if the copper and arsenic concentrations are toxic to aquatic life.

2) In light of the mining activity in British Columbia, Ecology should keep abreast of results from the routine water quality monitoring done on the Similkameen by the Ministry of Environment and Environment Canada, paying particular attention to copper, arsenic, mercury, and cyanide. [Environment Canada now makes these data available on the internet (http://yvrwww1.pwc.bc.doe.ca/pubservices/hydro_serv.html) [Neil McLennan, 604-664-9071.]

3) Include the Similkameen River among EILS routine monitoring stations for metals. (This monitoring was begun 12/11/95.)

Background

The Similkameen River originates in the Cascade Range along the international border and flows about 72 miles through British Columbia and Washington before joining the Okanogan River at Oroville. Mining, agriculture, and forestry are the major activities in the drainage. Active gold, silver, and copper mines and old tailings left along the river are potential sources of metals to the Similkameen. Historical water quality data show elevations in several metals in the British Columbia main stem, including copper, zinc, and lead, but this has been attributed to sample contamination or natural sources.

The lack of information on possible mining impacts to the lower Similkameen River was a concern identified in the 1994 Needs Assessment for the Okanogan Basin (Milton, 1995). At the request of the Central Regional Office, Environmental Investigations & Laboratory Services conducted a limited survey of metal concentrations in water and sediment samples from the international border to the Okanogan River confluence. Results are reported here along with a review of other recent metals data.

Survey Description

Sampling locations are shown in Figure 1. Water samples were collected in British Columbia approximately three miles above the border at Chopaka bridge (r.m. 34.6); at the town of Nighthawk (r.m. 17.5); and at Oroville (r.m. 5.0). Sediment samples were taken at Chopaka bridge, below Palmer Lake outlet, at Nighthawk, and just above

Enloe Dam (r.m. 8.8). No sediment sampling was done in the last eight miles of river because the bottom is rocky.

Field work was done during low flow and spring runoff to cover a range of suspended solids and associated metals concentrations. Low flow samples were collected August 29-30, 1995 and spring runoff samples on April 24, 1996. Sediment sampling was done during low flow when scouring of the river bed is at a minimum. USGS flow data for the Similkameen River at Nighthawk during 1995-96 are shown in Figure 2. The gage was not operating during March and parts of April 1996

Water samples were simple grabs, collected in duplicate, and analyzed for the ten metals covered by state water quality standards. Metals were analyzed as dissolved (copper, zinc, nickel, lead, cadmium, and silver) or total recoverable (arsenic, chromium, mercury, and selenium) depending on the form stipulated in the standards. Sediment samples were composites of the top 2cm layer from five grabs each. The same metals were analyzed as in water, with the addition of aluminum, iron, and manganese. Ancillary measurements included temperature, pH, conductivity, turbidity, total suspended solids (TSS), and hardness in water; and grain size and percent solids in sediment.

Methods of Sampling and Analysis

Water samples for metals were collected in 0.5 liter teflon bottles, specially pre-cleaned for low-level metals analysis by the Ecology Manchester Environmental Laboratory (Kammin et al., 1995). Samples for determination of dissolved metals were filtered in the field through a 0.45 micron Nalgene filter unit, also pre-cleaned by Manchester. The samples were preserved to pH < 2 in the field with sub-boiled 1:1 nitric acid, carried in small teflon vials, cleaned as above.

Sediment samples were taken with a 0.05m^2 stainless steel Ponar sampler and homogenized in stainless steel beakers. Sampling equipment was cleaned by washing with Liquinox detergent and sequential rinses with tap water, dilute nitric acid, and de-ionized water. The homogenate was split into glass jars with teflon lid-liners, cleaned to EPA QA/QC specifications (EPA, 1990), or into twist-lock bags for grain size. All water and sediment samples were held on ice for transport to Manchester.

Samples were analyzed by Manchester, except for grain size which was done by Soil Technology, Inc. Water samples were analyzed for mercury by cold vapor atomic fluorescence, EPA method 245.7. The remaining metals were analyzed by inductively coupled plasma/mass spectrometry following EPA method 200.8. Mercury analysis in sediment samples was by cold vapor atomic fluorescence, EPA method 245.5. Other sediment metals were analyzed by inductively coupled plasma following EPA method 200.7. Grain size distribution was determined by the Puget Sound Estuary Program method. Ancillary water quality analyses followed methods routinely used by Manchester (MEL, 1994).

Quality of the Data

No significant problems were encountered in analyzing these samples and the accuracy and precision of the data are good. Bottle and filter blanks for water samples were prepared in the field and showed no evidence of metals contamination arising from sampling methods.

Manchester prepared written quality assurance reviews of the metals data (Appendix A). These assess adherence to sample holding times, instrument calibration, results on procedural blanks, spike recoveries, and laboratory control samples. Two minor problems were identified:

1) Matrix spike recoveries for chromium (73% and 74%) and one of the mercury spikes (72% and 81%) in the April water samples were slightly below the EPA Contract Laboratory Program (CLP) limit of 75%. These data have been qualified as estimates, indicated by a "J" flag.

2) Duplicate matrix spike recoveries of lead in the sediment samples (89% and 73%) differed by more than the 25% allowed by CLP. The lead results for sediment are therefore qualified with an "N"

The analytical precision of the metals data reported for the Similkameen can be estimated from results on duplicate (split) samples (Appendix B). Results on water samples agreed within 16% or better, except for mercury. Mercury was only detected in one of the three duplicate pairs analyzed, with concentrations differing by 82% (0.0010 and 0.0024 ug/L; part per billion). The precision on sediment samples ranged from 9% for silver to 38% for copper.

Results and Discussion

Water Samples

General water quality conditions encountered in the Similkameen River are summarized in Table 1. At the time of the August survey, river flow at the USGS Nighthawk gage was 566 cfs, compared to the long-term monthly mean of 946 cfs. The flow was 6,720 cfs when samples were collected in April.

TSS and turbidity were an order of magnitude higher, and hardness and conductivity approximately 70% lower in April than in August. These differences reflect the effects of scouring and reduced influence of ground water. Water quality remained relatively unchanged within the study reach during low flow, but TSS and turbidity dropped by about half between the border and river mouth in the spring.

Of the ten metals analyzed, only copper and arsenic were at detectable levels during low flow (Table 2). Copper concentrations ranged from 0.51 - 0.71 ug/L and arsenic concentrations were estimated at 2.0 - 4.0 ug/L. Both metals showed evidence of a consistent increase with distance downstream.

Significantly higher concentrations of copper (1.4 - 2.6 ug/L), arsenic (2.9 - 7.0 ug/L), and mercury (0.001 - 0.006 ug/L) were observed in the spring (Wilcoxon-Mann-Whitney, $p<0.05$). Copper and arsenic approximately doubled in concentration, and mercury was higher by factors of up to 6 or more. Improved detection limits for zinc, nickel, lead, and chromium allowed these metals to be quantified at sub-ppb levels in the spring. Metal concentrations either decreased slightly (arsenic) or showed little change moving downstream, in contrast to the low flow findings for copper and arsenic.

Table 3 shows Ecology data on metal concentrations typical of other eastern Washington rivers, including samples collected at the mouth of the Okanogan River during the present survey. Metal concentrations in the lower Okanogan were essentially no different from those measured 60 miles upstream in the Similkameen during the same period (low flow).

Median levels of copper, zinc, nickel, lead, and cadmium in these rivers are comparable to or greater than those found in the Similkameen. The mercury concentrations measured in the Similkameen in the spring appear higher than normal, and are at the upper end of the range for Ecology statewide results (Appendix C). The detection limits routinely employed by Ecology are not low enough to provide data on ambient concentrations of arsenic. [Addendum 1 at the back of this report has newer Ecology data on arsenic, collected since the present report was initially prepared. A low level analysis for arsenic was instituted in 1996. Results show that arsenic concentrations in the Similkameen are an order of magnitude higher than other rivers currently being monitored.]

Sediment Samples

Results on Similkameen River sediment samples are shown in Table 4. Metal concentrations tended to be highest in mid-reach in the vicinity of Palmer Lake/ Nighthawk. However, the overall range in concentrations of most metals was generally small and within the analytical precision of the data (Appendix B). The largest differences occurred for copper and arsenic, which were 2 - 3 times higher in the samples below Palmer Lake outlet and at Nighthawk than in the British Columbia or Enloe Dam samples. Metals that were at or below detection limits at all locations were silver, mercury, selenium, and cadmium.

Table 5 summarizes statewide metals data on freshwater sediments and terrestrial soils. This information comes from a variety of studies on sites ranging from background to substantially contaminated. Examination of the statewide data indicates metals concentrations in the Similkameen sediments are at background levels except for copper and arsenic. Arsenic appears particularly elevated, equaling or exceeding the state

90th percentile at three of the four sites sampled.

Comparison to Criteria

Water Quality Criteria - EPA (1995) recently proposed new metals criteria for protection of aquatic life criteria. Ecology intends to adopt these in place of the current state water quality standards during the triennial review (Mark Hicks, personal communication). [The new EPA criteria were adopted in November 1997.]

Table 6 compares metal concentrations in the Similkameen River to EPA water quality criteria and state drinking water standards. The lowest hardness observed in the river (58 mg/L) was used to calculate criteria for metals where toxicity is hardness dependent (all but arsenic, mercury, and selenium). Because this survey was conducted prior to the criteria revision, chromium was analyzed as total recoverable rather than dissolved, as now specified by EPA.

All of the metal concentrations measured in the Similkameen met criteria for protection of aquatic life and were well within state drinking water standards. Most metals were an order of magnitude or more lower than the criteria and standards. Mercury approached the 0.012 ug/L aquatic life criteria for continuous exposure, reaching 0.006 ug/L in several of of the samples collected during the spring. The only other metal coming close to criteria levels was copper, also in the spring collected samples (1.3 - 2.6 ug/L vs. 7.0 ug/L).

Arsenic concentrations in the Similkameen River exceed the EPA human health National Toxics Rule (NTR) criteria of 0.14 ug/L (consumption of fish) and 0.018 ug/L (consumption of fish and water). Although other rivers in Washington commonly exceed these very low criteria, the arsenic levels in the Similkameen River are higher than typically encountered. No other NTR criteria are exceeded in the Similkameen.

Sediment Quality Criteria - No state or EPA criteria have been established for metals in freshwater sediments. In lieu of this, Table 7 lists sediment quality guidelines for protection of freshwater benthic invertebrates proposed by Ontario, Canada. The lowest effect levels are tolerated by the majority of invertebrate species. Pronounced disturbances in the benthic community would be expected when metal concentrations are at severe effect levels.

As in the comparison with statewide sediment data, copper and arsenic stand out as being elevated in Similkameen River sediments. Both metals exceed lowest effect levels, with arsenic concentrations being at or above the severe effect level at two of four sites sampled (below Palmer Lake and at Nighthawk).

Other Similkameen Data

EPA - The abandoned Kabba-Texas mine above Nighthawk (Figure 1) was the subject of an inspection by EPA in 1991 (Ecology & Environment, 1991). Mining began here in 1915 and continued until 1951. Minerals recovered included lead, silver, copper, gold, zinc, tungsten, and molybdenum.

This operation left 23 acres of tailings along the northwest bank of the river. Data collected by EPA and results of a tailings sample collected along the river bank during the present survey show the tailings are high in copper, zinc, lead, and cadmium (Table 8). Portions of the tailing piles are vulnerable to erosion by the river during high flows. An earlier study by Harper-Owes (1984) concluded it was uncertain if leaching of the tailings would contaminate the river under natural conditions.

Ecology & Environment collected five water and six sediment samples from the Similkameen River in the vicinity of the tailings pile in April 1991. River water samples showed no increase in concentrations of total recoverable copper, arsenic, zinc, or other metals below the mine. In most cases, concentrations were at or below the method detection limit. Sediment samples had some elevations in copper, zinc, and lead at sites adjacent to the tailings piles but not immediately downstream.

USGS - During September 1993, the U.S. Geological Survey conducted a more extensive water quality investigation for the Bureau of Land Management along a 13-mile reach of the Similkameen River from the Kabba-Texas mine to downstream of Enloe Dam (Ford, 1993; USGS, unpublished). Metals were analyzed in water and sediment samples collected from 23 sites. Water samples were also analyzed for chlorinated pesticides and PCBs but nothing of significance was detected.

Water samples were analyzed for dissolved metals. Detection limits (shown in parentheses) were not low enough to quantify copper, lead, and nickel (<10 ug/L); chromium (<5.0 ug/L); or cadmium and silver (<1.0 ug/L). The majority of samples (20 of 23) also had no zinc detectable (<3 ug/L). Five locations scattered through the study area showed zinc concentrations of 4 - 12 ug/L. Although these concentrations are much higher than found in the present survey (<1 - 1.8 ug/L) they are well within EPA water quality criteria.

Results on USGS sediment samples showed some moderate elevations in copper (to 38 mg/Kg). The detection limit (30 mg/Kg; parts per million) was not low enough to give useful data on arsenic; all samples were below detection limits.

Environment Canada/B.C. Ministry of Environment - Shaw and Taylor (1994) reviewed Canadian water quality data on the Similkameen River collected between 1984 and 1990. Their review includes a description of mining activities in the drainage – which are much

more extensive than in Washington – and raises concerns about contamination from metals, cyanide, suspended solids, and nutrients.

The data, however, show water quality in the Similkameen River was generally good during 1984 - 90. Exceedances of criteria were noted for copper, lead, zinc, and several other metals, as previously mentioned. Violations were also seen for cyanide. These problems were, or are now, variously attributed to sample contamination, analytical artifacts, or association with elevated levels of particulates during high flow (Shaw and Taylor, 1994; personal communication Bruce Holms, Larry Pommen).

Table 9 summarizes more recent metals data reported by Environment Canada since January 1994 for the Similkameen River near the U.S. border. This is the same site sampled for Ecology's 1995-96 survey (Chopaka bridge). The complete metals data are in Appendix D.

Because metals analysis at this site is restricted to total recoverable, only the data on arsenic, mercury, chromium, and selenium are directly comparable to the results reported here. The concentration ranges reported for these metals by Environment Canada are consistent with present survey findings, except for mercury. Higher mercury levels were recorded in the Canadian samples, but this analysis was dropped in early 1994 due to data quality problems (Andrea Ryan, personal communication).

Environment Canada data show little or no evidence of the earlier water quality concerns due to metals. A pronounced seasonal cycle can be seen for several metals that peak in spring, notably arsenic and copper (Figure 3). According to the B.C. Ministry of Environment, the source of arsenic during freshets may be mine tailings in British Columbia (Larry Pommen, personal communication). Occasional violations of EPA chronic water quality criteria for dissolved copper could occur when high concentrations of total recoverable copper coincide with reduced hardness levels in the spring. Within this data record, such conditions were encountered on 22/3/94, 16/5/95, 30/5/95, and 28/5/96 when the older EPA Goldbook criteria for total recoverable copper were exceeded (Appendix D).

The recent data on cyanide (not included in the appendix) show generally low concentrations, typically ranging from <0.5 - 1 ug/L (weak acid dissociable cyanide). Two isolated instances of elevated cyanide (4 and 6.7 ug/L) were recorded in April 1993. These concentrations are at the state water quality standard of 5.2 ug/L for chronic exposure.

Conclusions

Results of this survey show metal concentrations in the Similkameen River are generally low. The primary finding of concern is the elevated level of copper and arsenic in the sediments and potential for adverse effects on benthic invertebrate communities, especially due to arsenic. Whether these elevations are naturally occurring or due to pollution sources is unknown.

Water samples did not violate EPA aquatic life criteria or state drinking water standards, although occasional violations of the EPA chronic criteria for dissolved copper could occur during spring runoff. Mine tailings in British Columbia may contribute to arsenic peaks observed during this same period. Mercury concentrations were elevated in spring compared to rivers in other parts of the state, although not above water quality criteria.

Acknowledgments

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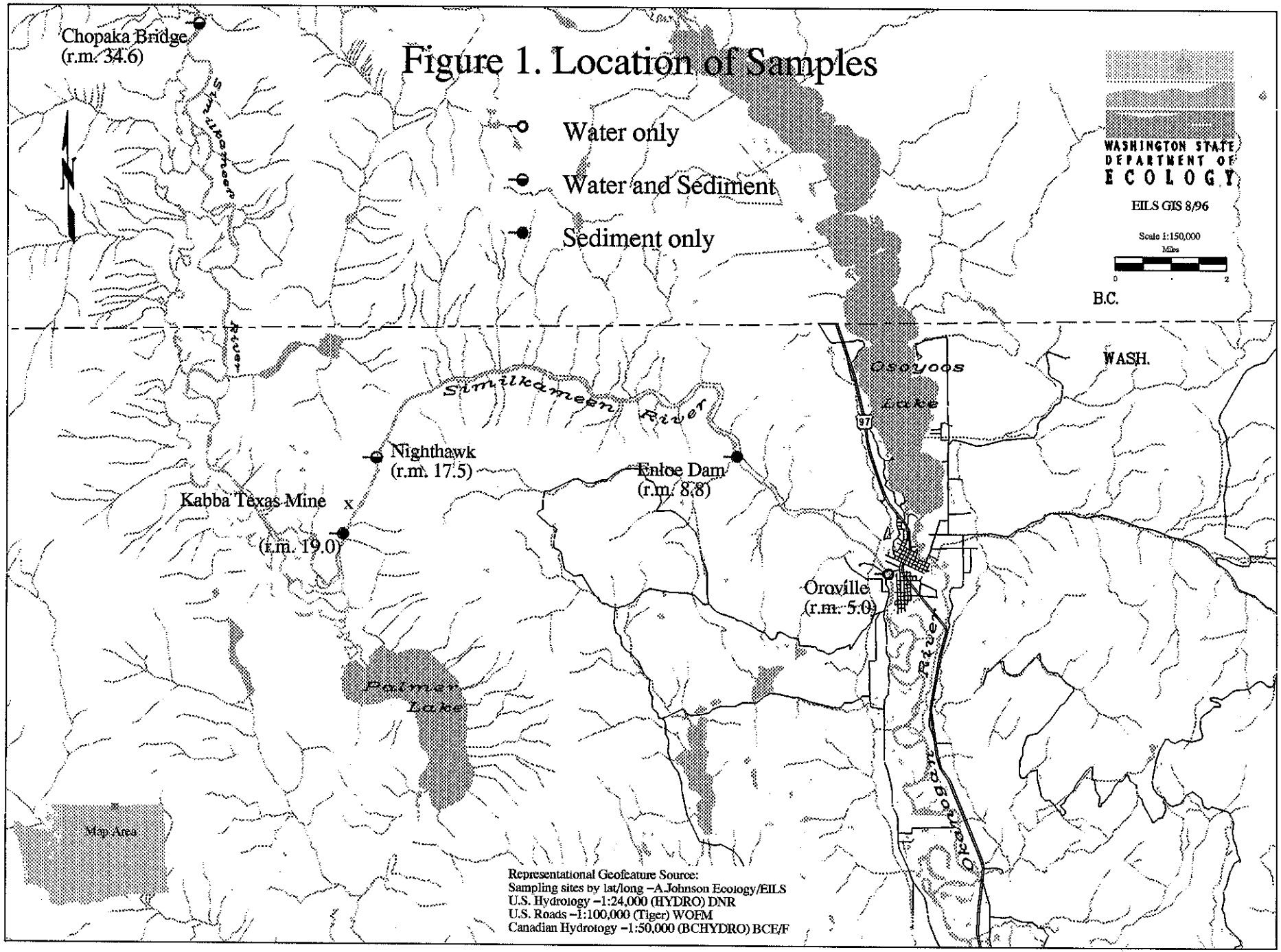
Figure 1. Location of Samples
Water only
Water and Sediment
Sediment only
Chopaka Bridge
(r.m. 34.6)
Similkameen River
Similkameen River
Nighthawk
(r.m. 17.5)
Kabba Texas Mine
x
(r.m. 19.0)
Enloe Dam
(r.m. 8.8)
Oroville
(r.m. 5.0)
Palmer Lake
Osoyoos Lake
97
B.C.
WASH.
Okanogan River
Map Area
WASHINGTON STATE DEPARTMENT OF ECOLOGY
EILS GIS 8/96
Scale 1:150,000
Miles
0
2
Representational Geofeature Source:
Sampling sites by lat/long –A.Johnson Ecology/EILS
U.S. Hydrology –1:24,000 (HYDRO) DNR
U.S. Roads –1:100,000 (Tiger) WOFM
Canadian Hydrology –1:50,000 (BCHYDRO) BCE/F

Figure 2. Similkameen River Flow @ Nighthawk

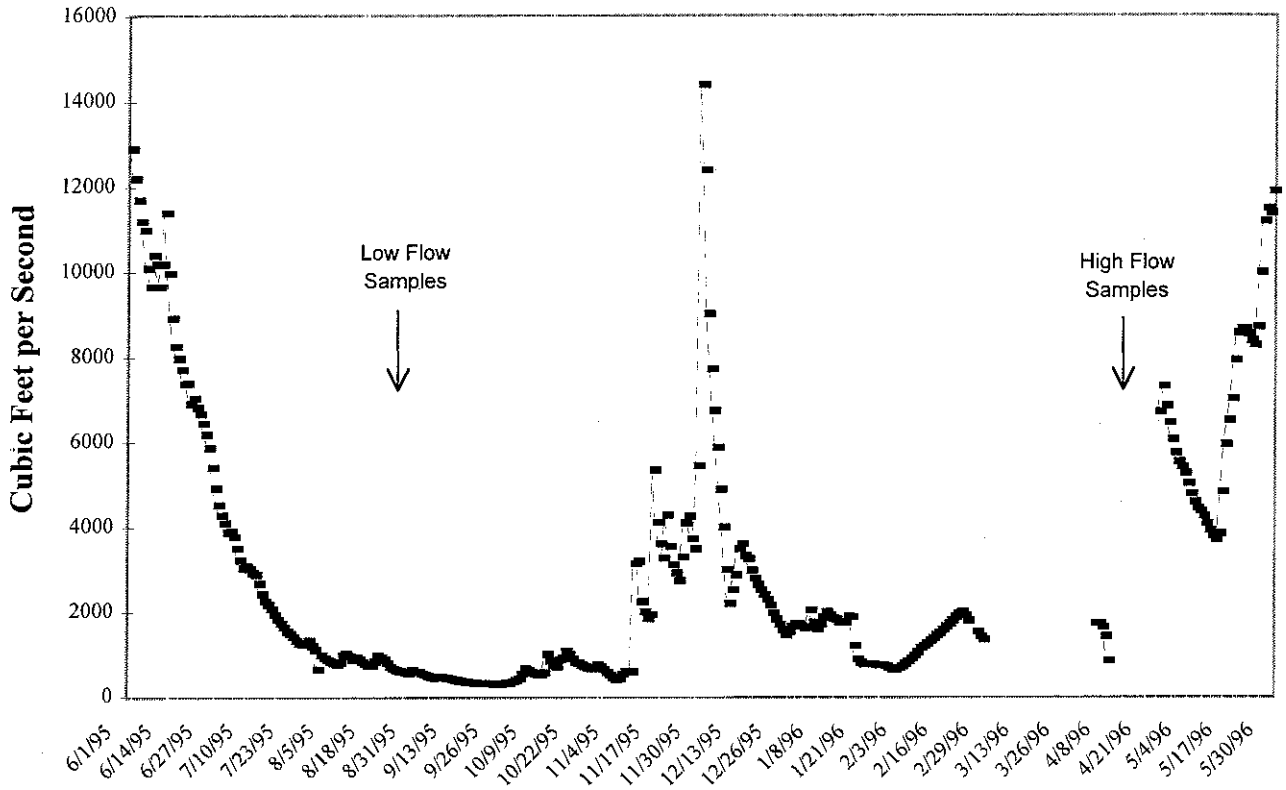

Figure 3. Total Arsenic and Copper in the Similkameen River, BC

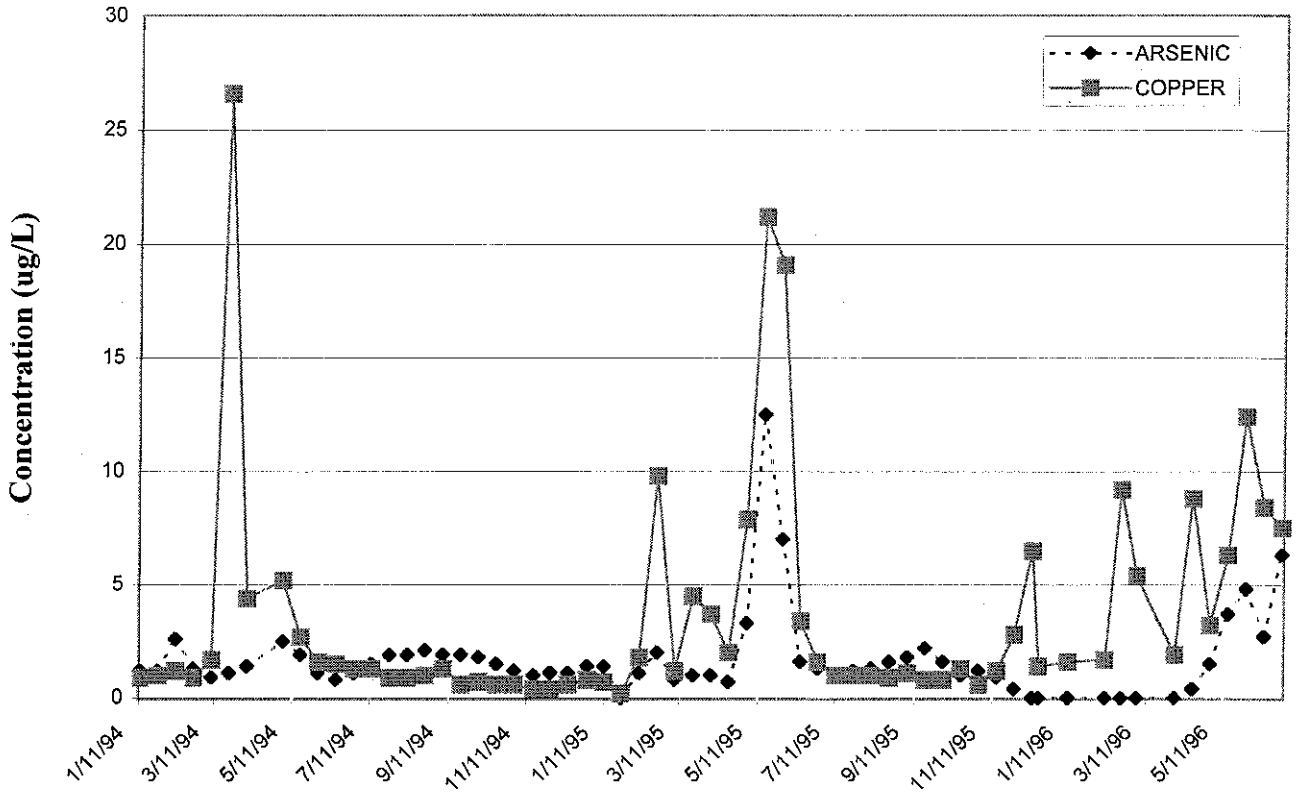

Table 1 General Water Quality Conditions in the Similkameen River

	SUMMER LOW FLOW (08/29/95)		
Location:	Chopake Bridge, B.C.	@ Nighthawk	@ Oroville
Sample No.:	35-8234[1]	35-8232	35-8230[1]
Temperature (C)	18.3	na	17 5
pH	7.6	8.2	8.2
Conductivity (umho/cm)	184	192	195
Hardness (mg/L)	82	88	88
Turbidity (NTU)	0.6	1.2	1.0
TSS (mg/L)	2	2	1

	SPRING RUNOFF (04/24/96)		
Location:	Chopaka Bridge, B.C.	@ Nighthawk	@ Oroville
Sample No.:	17-8184[1]	17-8182	17-8180
Temperature (C)	5.9	6.6	7 3
pH	7.5	7 3	7 7
Conductivity (umho/cm)	133	140	144
Hardness (mg/L)	58	62	63
Turbidity (NTU)	38	21	20
TSS (mg/L)	111	41	73

[1]mean of duplicate analyses
na = not analyzed

Table 2. Metal Concentrations in Similkameen River Water Samples (ug/L)

	SUMMER LOW FLOW (08/29/95)					
Location:	Chopaka Bridge, B.C.		@ Nighthawk		@ Oroville	
Sample No.:	35-8234[1]	35-8235	35-8232	35-8233	35-8230[1]	35-8231
Dissolved						
Copper	**0.55**	**0.51**	**0.62**	**0.65**	**0.71**	**0.63**
Zinc	1 U	1 U	1 U	1 U	1 U	1 U
Nickel	1 U	1 U	1 U	1 U	1 U	1 U
Lead	0.03 U	0.03 U	0.03 U	0.03 U	0.03 U	0.03 U
Cadmium	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U	0.04 U
Silver	0.03 U	0.03 U	0.03 U	0.03 U	0.03 U	0.03 U
Total Recoverable						
Arsenic	**2.1 P**	**2.0 P**	**3.7 P**	**3.6 P**	**3.9 P**	**4.0 P**
Chromium	1 U	1 U	1 U	1 U	1 U	1 U
Mercury	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Selenium	1 U	1 U	1 U	1 U	1 U	1 U

	SPRING RUNOFF (04/24/96)					
Location:	Chopaka Bridge, B.C.		@ Nighthawk		@ Oroville	
Sample No.:	17-8184	17-8185	17-8182[1]	17-8183	17-8180	17-8181
Dissolved						
Copper	**2.6**	**1.3**	**1.3**	**1.4**	**1.4**	**1.4**
Zinc	**1.8**	**0.59**	**0.64**	**0.95**	**0.77**	**0.56**
Nickel	**0.58**	**0.54**	**0.62**	**0.65**	**0.58**	**0.63**
Lead	**0.10**	0.02 U	**0.02**	**0.03**	**0.03**	**0.02**
Cadmium	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	**0.02**
Silver	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Total Recoverable						
Arsenic	**7.0**	**5.9**	**2.9**	**3.2**	**4.8**	**4.3**
Chromium	**0.66 J**	**1.3 J**	**0.88 J**	**0.99 J**	**1.2 J**	**0.93 J**
Mercury	**0.001 J**	**0.006 J**	**0.002 J**	**0.004 J**	**0.006 J**	**0.003 J**
Selenium	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U

Note: detected concentrations in **bold**

[1]mean of duplicate analyses

U = not detected at or above reported value (i.e., less than)

P = below minimum quantitation limit

J = estimated concentration

Table 3. Metal Concentrations Typical of Other Rivers in Eastern Washington (ug/L)
[1994-95 medians; n = 6, except n = 2 for Okanogan River]

	Okanogan[1] @ Mallot	Sanpoil[2] bw Republic	Spokane[2] @ Stateline	Columbia[2] @ Northport	Columbia[2] @ Umatilla
Dissolved					
Copper	**0.88**	**0.62**	**0.50**	**1.7**	**0.99**
Zinc	1 U	1 U	**70**	**3.2**	**1.4**
Nickel	1 U	1 U	1 U	1 U	0.04 U
Lead	0.03 U	**0.03**	**0.16**	**0.10**	**0.08**
Cadmium	0.04 U	0.04 U	**0.16**	**0.048**	0.04 U
Silver	0.03 U	na	na	na	na
Total Recoverable					
Arsenic	**4.0**	30 U	30 U	30 U	30 U
Chromium	1 U	5 U	5 U	5 U	5 U
Mercury	0.001 U	0.001 U	0.001 U	**0.001**	0.001 U
Selenium	0.001 U	na	na	na	na

Note 1: detected concentrations in **bold**
Note 2: median calculated using 1/2 the detection limit
[1]present study, collected August 31, 1995
[2]Brad Hopkins, unpublished data, Ecology Ambient Monitoring Program
U = not detected at or above reported value (i.e., less than)
na = not analyzed

Table 4. Metal Concentrations in Similkameen River Sediment Samples (mg/Kg, dry weight)

Location:	Chopaka Bridge B.C.	Below Palmer Lake Outlet	@ Nighthawk	Above Enloe Dam
Sampe No.:	35-8246	35-8244	35-8243[1]	35-8242
Iron	**12900**	**19500**	**17000**	**16200**
Aluminum	**7030**	**10700**	**8490**	**8940**
Manganese	**236**	**389**	**300**	**305**
Zinc	**35**	**56**	**46**	**50**
Copper	**22**	**60**	**43**	**45**
Arsenic	**12**	**30**	**46**	**21**
Chromium	**12**	**21**	**18**	**18**
Nickel	**12**	**19**	**17**	**16**
Lead	**2.4 N**	**5.4 N**	**4.5 N**	**4.1 N**
Silver	0.3 U	**0.3 J**	**0.3 J**	0.3 U
Mercury	0.01 U	**0.012 P**	0.01 U	**0.012 P**
Selenium	0.4 U	0.4 U	0.4 U	0.4 U
Cadmium	0.3 U	0.3 U	0.3 U	0.3 U
% Gravel	0	0	1	0
% Sand	99	56	77	99
% Silt	1	36	17	25
% Clay	0	8	5	6
% Solids	74	54	77	63

Note: detected concentrations in **bold**

[1]mean of duplicate analyses

U = not detected at or above reported value (i.e., less than)

P = below minimum quantitation limit

J = estimated concentration

N = spike recovery outside control limits

Table 5. Metal Concentrations in Washington State Sediments and Soil (mg/Kg, dry)

Metal	Freshwater Sediments Background[1] median	Terrestrial Soils Background[2] median	Freshwater Sediments Various Sites[3] median	90th percentile
Iron	- -	22,030	26,700	40,000
Aluminum	- -	21,960	- -	- -
Manganese	- -	510	500	815
Zinc	84	51	160	1,000
Copper	24	17	40	230
Arsenic	3.4	2.9	5.6	23
Chromium	58	18	34	81
Nickel	- -	16	23	63
Lead	41	7.9	34	398
Silver	- -	- -	nd	1.9
Mercury	- -	0.03	0.05	0.7
Selenium	- -	- -	- -	- -
Cadmium	0.5	0.5	0.8	7.4

[1]PTI. (1989 draft). Background Concentrations of Selected Chemicals in Water, Soil, Sediments, and Air of Washington State. Prep. for Wash. St. Dept. Ecology. (n=25-52)

[2] San Juan, C. 1994. Natural Background Soil Metals Concentrations in Washington State. Wash. St. Dept. Ecology. Pub. No. 94-115. (n=490)

[3]FSEDQUAL data base (Jim Cubbage) Wash. St. Dept. Ecology. (n=64-227)

Table 6. Similkameen River Metal Concentrations vs. Water Quality Criteria (ug/L)

Metal	Range of Concentrations in Similkameen	Aquatic Life Criteria[1,2]		Drinking Water Standards[3]	
		Continuous	Maximum	Primary	Secondary
Copper	0.51 - 2.6	7.0	10	--	1,000
Zinc	0.56 - 1.8	66	72	--	5,000
Nickel	<1 - 0.54	99	891	--	--
Lead	<0.2 - 0.10	1.3	35	50	--
Cadmium	<0.02 - 0.02	0.7	2.0	10	--
Silver	<0.01 - <0.03	--	1.4	--	100
Arsenic	2.0 - 7.0	190	360	50	--
Chromium	0.66 - 1.3	114	351	50	--
Mercury	<0.001 - 0.006	0.012	2.1	2	--
Selenium	<1 - <0.4	5	20	10	--

[1]EPA. 1995. Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States' Compliance - Revision of Metals Criteria. CRF 60:86

[2]@ 58 mg/L hardness

[3]DOH. 1992. Drinking Water Regulations. Wash. St. Dept. Health, Olympia, WA.

Table 7. Similkameen River Metal Concentrations vs. Sediment Quality Criteria
(mg/Kg, dry)

Metal	Range of Concentrations in Similkameen	Canadian Freshwater Guidelines[1]	
		Lowest Effect	Severe Effect
Iron	16,200 - 19,500	20,000	40,000
Aluminum	7,030 - 10,700	- -	- -
Manganese	236 - 389	460	1,100
Zinc	35 - 56	120	820
Copper	22 - 60	16	110
Arsenic	12 - 46	6	33
Chromium	12 - 21	26	110
Nickel	12 - 19	16	75
Lead	2.4 - 5.4	31	250
Silver	<0.3 - 0.3	0.5	- -
Mercury	<0.01 - 0.012	0.2	2
Selenium	< 0.4 (all)	- -	- -
Cadmium	<0.3 (all)	0.6	10

[1]Persaud, D., et al., 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of Environment. ISBN 0-7729-9248-7.

Table 8. Metal Concentrations in Kabba-Texas Mine Tailings (mg/Kg, dry weight)

Investigator:	Ecology & Environment (1991)			Ecology (present study)
Location:	Background Soil	Tailings Pile Near Mine Shaft	Center of Tailings Pile	Tailings Pile at River Bank
Sampe No.:	SB1	SB6	SB7	95-358245
Iron	nr	nr	nr	**18300**
Aluminum	nr	nr	nr	**2330**
Manganese	**536**	**846**	**271**	**175**
Zinc	**56**	**7820**	**56**	**1340**
Copper	**30**	**1300**	**28**	**531**
Arsenic	**4.9**	**7**	**14**	**12**
Chromium	**28**	**21**	**11**	**8.1**
Nickel	**26**	**18**	**12**	**7.8 P**
Lead	**9.6**	**13000**	**5.6**	**355**
Silver	0.9 U	**97**	0.8 U	**3.9 J**
Mercury	0.1 U	**0.8**	0.1 U	**0.06 P**
Selenium	na	na	na	0.4 U
Cadmium	0.6 U	**68**	0.6 U	**10**

Note 1: detected concentrations in **bold**
Note 2: E&E also analyzed barium, beryllium, cobalt, sodium, vanadium, and cyanide
U = not detected at or above reported value (i.e., less than)
P = below minimum quantitation limit
J = estimated concentration
nr = not reported
na = not analyzed

Table 9. Summary of Environment Canada Data on the Similkameen River near U.S. Border, January 1994 - June 1996
(total recoverable metal in ug/L; hardness in mg/L)

	Copper	Zinc	Nickel	Lead	Cadmium
N =	62	62	62	62	62
median =	1.4	0.8	0.2	0.2	< 0.1
mean =	3.6	2.1	0.7	0.5	< 0.1
90th percentile	8.8	5.6	1.6	0.9	0.2
maximum =	27	17	5.6	3.6	0.6

	Arsenic	Chromium	Mercury	Selenium	Hardness
N =	55	62	9	42	62
median =	1.4	0.3	0.005*	0.2	79
mean =	1.9	0.8	0.011*	0.2	74
90th percentile	3.1	1.6	0.029*	0.3	100
maximum =	12	6.8	0.031*	0.4	110

Note: Detection limit used to calculate statistics (see Appendix C)
*Sample contamination suspected

Appendices

Appendix A

June 4, 1996

To: Art Johnson

From: Randy Knox, RDK Metals Chemist

Subject: Similkameen Metals Project Water

QUALITY ASSURANCE SUMMARY

Data quality for this project is generally good, except recovery of added chromium spike and of one of the mercury spikes is slightly below the allowed limit. No other significant quality assurance issues are noted with the data.

SAMPLE INFORMATION

The samples from the Similkameen Metals Project were received by the Manchester Laboratory on 4/25/96 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. Hardness determination standards were run at a frequency of 20%. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples show no analytically significant levels of analytes.

SPIKED SAMPLES ANALYSIS

Spiked and duplicate spiked sample analysis were performed on this data set. All spike recoveries except those for chromium and that of the duplicate mercury spike are within the CLP acceptance limits of +/- 25%. Chromium recoveries of 73% and 74% and mercury duplicate spike recovery of 72 % are less than the allowed 75 %. Chromium and mercury values are qualified J as estimated if detected and UJ as undetected at estimated detection level if not detected.

PRECISION DATA

The results of the spiked and duplicate spiked samples are used to evaluate precision on this sample set. The relative percent difference (RPD) for all analytes is within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSIS

LCS analyses are within the windows established for each parameter.

Please call Bill Kammin at SCAN 360-871-8801 to further discuss this project.

RLK:rlk

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (360) 871-8860 • FAX (360) 871-8850

September 26, 1995

To: Art Johnson, Project Officer

From: Myrna McIntosh, Metals Chemist

Subject: Similkameen Metals Project, Waters

QUALITY ASSURANCE SUMMARY

Data quality for this project is generally good. No significant quality assurance issues are noted with the data.

SAMPLE INFORMATION

The samples from the Similkameen Metals, water project were received by the Manchester Laboratory on 9/5/95 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples show no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSIS

Spiked and duplicate spiked sample analysis were performed on this data set. All spike recoveries are within the CLP acceptance limits of +/- 25%.

PRECISION DATA

The results of the spiked and duplicate spiked samples are used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes is within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSIS

LCS analysis are within the windows established for each parameter, with the exception of selenium. The selenium recovery of NIST 1643c is somewhat low at 65% recovery but the rest of the laboratory control samples are OK. Data was not qualified.

Please call Bill Kammin at SCAN 360-871-8801 to further discuss this project.

MMM:mmm

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (360) 871-8860 • FAX (360) 871-8850

September 26, 1995

To: Art Johnson, Project Officer

From: Myrna McIntosh, Metals Chemist

Subject: Similkameen Metals Project, Sediments

QUALITY ASSURANCE SUMMARY

Data quality for this project is generally good. One lead spike recovery was slightly low and the lead results are qualified "N". There was also a low recovery of silver from the LCS so the silver results are qualified as estimates, "J". The silver spikes recovered well from the samples so there may not be any loss of silver from the samples.

SAMPLE INFORMATION

The samples from the Similkameen Metals, sediment project were received by the Manchester Laboratory on 9/1/95 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples show no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSIS

Spiked and duplicate spiked sample analysis were performed on this data set. All spike recoveries, with the exception of lead, are within the CLP acceptance limits of +/- 25%. The lead results are qualified with "N".

PRECISION DATA

The results of the spiked and duplicate spiked samples are used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes is within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSIS

LCS analysis are within the windows established for each parameter.

Please call Bill Kammin at SCAN 360-871-8801 to further discuss this project.

MMM:mmm

Appendix B.Precision of Duplicate Sample Analyses

A. Water Samples (ug/L)

Sample No.:	358230	358230D	RPD[1]	358234	358234D	RPD	178182	178182D	RPD
Chromium	nd	nd	--	nd	nd	--	1.0	0.76	16%
Arsenic	3.9	3.9	0%	2.0	2.2	10%	2.96	2.83	4%
Selenium	nd	nd	--	nd	nd	--	nd	nd	--
Nickel	nd	nd	--	nd	nd	--	0.602	0.641	6%
Copper	0.698	0.716	3%	0.553	0.546	1%	1.32	1.35	2%
Zinc	nd	nd	--	nd	nd	--	0.66	0.62	6%
Silver	nd	nd	--	nd	nd	--	nd	nd	--
Cadmium	nd	nd	--	nd	nd	--	nd	nd	--
Lead	nd	nd	--	nd	nd	--	0.024	0.021	13%
Mercury	nd	nd	--	nd	nd	--	0.0010	0.0024	82%

B. Sediment Samples (mg/Kg)

Sample No.:	358243	358243D	RPD
Aluminum	7810	10700	31%
Cadmium	nd	nd	--
Chromium	16.2	20.9	25%
Copper	40.4	59.6	38%
Iron	15700	19500	22%
Manganese	282	389	32%
Nickel	15.8	19	18%
Silver	0.34	0.31	9%
Zinc	43.9	56.4	25%
Arsenic	32.3	27.8	15%
Lead	4.72	4.23	11%
Selenium	nd	nd	--

[1]Relative Percent Difference (duplicate range/mean)
nd = not detected

Appendix C. Metals Concentrations in Other Washington Rivers
(dissolved metal in ug/L, except total recoverable Hg)
Source: Brad Hopkins, Ecology Ambient Monitoring Program

Skagit River near Mount Vernon (03A060)

	Ni	Cu	Zn	Cd	Pb	Hg
5/17/94	1 U	0.348 P	1 U	0.04 U	0.023 P	0.001 U
7/19/94	1 U	0.29 P	9.34 P	0.04 U	0.02 U	0.001 U
9/20/94	1 U	0.28 P	1 U	0.04 U	0.02 U	0.001 U
11/16/94	1 U	0.546	1.9 P	0.04 U	0.02 U	0.001 U
1/19/95	0.62	0.36 P	0.55 P	0.02 U	0.02 U	0.001 U
3/22/95	0.689	0.46 P	0.4 U	0.03 U	0.02 U	0.001 P

Skagit River at Marblemount (04A100)

	Ni	Cu	Zn	Cd	Pb	Hg
5/17/94	1 U	0.36 P	1.95 P	0.04 U	0.067 P	0.001 U
7/19/94	1 U	0.23 P	1 U	0.04 U	0.02 U	0.001 U
9/20/94	1 U	0.22 P	1 U	0.04 U	0.02 U	0.001 U
11/15/94	1 U	0.25 P	1 U	0.04 U	0.02 U	0.0013 P
1/18/95	0.16 P	0.21 P	0.4 U	0.02 U	0.02 U	0.0029 J
3/21/95	0.26 P	0.24 P	0.4 U	0.03 U	0.02 U	0.001 U

Stillaguamish River near Silvana (05A070)

	Ni	Cu	Zn	Cd	Pb	Hg
5/17/94	1.32	0.671	1.34 P	0.04 U	0.057 P	0.001 U
7/19/94	1.2 P	0.884	2.4 P	0.04 U	0.058 P	0.001 U
9/20/94	1 U	0.5 P	1 U	0.04 U	0.02 U	0.0014 P
11/16/94	1.7 P	0.879	1 U	0.04 U	0.039 P	0.0032 P
1/19/95	1.48	0.832	0.4 U	0.02 U	0.034 P	0.0129 N
3/20/95	1.62	0.79	0.4 U	0.03 U	0.02 U	0.0021 P

Puyallup River at Meridian Street (10A070)

	Ni	Cu	Zn	Cd	Pb	Hg
5/25/94	1 U	0.446	2.1	0.04 U	0.02 U	0.0014 P
7/27/94	1 U	0.531	1 U	0.04 U	0.02 U	0.0093 P
9/28/94	1 U	0.535	1 U	0.04 U	0.02 U	0.0171
11/14/94	1 U	0.865	2.4 P	0.04 U	0.208	0.0016 P
1/17/95	0.28 P	0.855	0.44 P	0.02 U	0.022 P	0.001 U
3/20/95	0.524	1.55	1.6 P	0.034 P	0.052 P	0.001 P

Columbia River at The Dalles (30A070)

	Ni	Cu	Zn	Cd	Pb	Hg
5/9/94	1 U	0.916	1 U	0.04 U	0.04 P	0.0012 P
7/18/94	1 U	0.989	1.5 P	0.04 U	0.043 P	0.001 U
9/11/94	1 U	0.851	1 U	0.04 U	0.02 U	0.0012 P
11/20/94	1 U	0.873	1	0.04 U	0.02 U	0.001 U
1/3/95	0.33 P	0.837	2.1 P	0.022 P	0.027 P	0.001 U
3/12/95	0.583	0.92	1.1 P	0.03 U	0.028 P	0.001 U

Columbia River at Umatilla (31A070)

	Ni	Cu	Zn	Cd	Pb	Hg
5/9/94	1 U	1	1.21 P	0.04 U	0.046 P	0.0015 P
7/18/94	1 U	1.14	1.6 P	0.042 P	0.16 P	0.001 U
9/12/94	1 U	0.951	1 U	0.04 U	0.02 U	0.0017 P
11/20/94	1 U	0.978	4.2 P	0.04 U	0.02 U	0.0011 P
1/3/95	0.37 P	1.02	1.4 P	0.078 P	0.12 P	0.001 U
3/12/95	0.535	0.954	3.4 P	0.03 U	0.034 P	0.001 U

Sanpoil River below Republic (52A110)

	Ni	Cu	Zn	Cd	Pb	Hg
5/11/94	1 U	0.916	1.09 P	0.04 U	0.06 P	0.0098 P
7/13/94	1 U	0.603	1 U	0.04 U	0.02 U	0.0024 P
9/14/94	1 U	0.503	1 U	0.04 U	0.02 U	0.001 U
11/9/94	1 U	0.436 P	1 U	0.04 U	0.02 U	0.001 U
1/12/95	0.49 P	0.641	0.56 P	0.02 U	0.094 P	0.001 U
3/7/95	0.82	0.923	0.4 U	0.046 P	0.044 P	0.0048 P

Spokane River at Stateline Bridge (57A150)

	Ni	Cu	Zn	Cd	Pb	Hg
5/3/94	1 U	1.42	96.9	0.298 P	0.209	0.001 K
7/6/94	1 U	0.496 P	58	0.15 P	0.18 P	0.0013 P
9/6/94	1 U	0.4 P	22.3	0.04 U	0.12 P	0.001 U
11/7/94	1 U	0.495 P	59.7	0.13 P	0.143 P	0.001 U
1/10/95	0.41 P	0.44 P	79.7	0.18	0.064	0.001 U
3/6/95	0.575	0.706	104	0.406	0.818	0.0012 P

Columbia River at Northport (61A070)

	Ni	Cu	Zn	Cd	Pb	Hg
5/4/94	1 U	1.7	3.55	0.047 P	0.097 P	0.001 K
7/7/94	1 U	1.46	2.2 P	0.04 U	0.046 P	0.0021 P
9/7/94	1 U	1.71	2.5 P	0.065 P	0.11 P	0.0015 P
11/8/94	1 U	1.34	2.8 P	0.049 P	0.091 P	0.001 U
1/11/95	0.39 P	1.68	3.7 P	0.088 P	0.244	0.001 U
3/7/95		2.01	6.7 J	0.1 U	0.66 P	0.001 U

Note: Arsenic not detected in any of above samples at a detection limit of 30 ug/L
U = not detected at or above reported value
P = detected but below minimum quantitation limit
N = spike recovery outside control limits
J = value is an estimate

Appendix D. Environment Canada Data on Metals Concentrations in the Similkameen River (total metals in mg/L, except ug/L for mercury)

Station No. (ENVIRODAT): BC08NL0005
Station Description: Similkameen River near U.S. Border
Road bridge exit off Hwy 3A. British Columbia. Water Survey 08NL022
Latitude: 49:0 Longitude: 119:42:28

DATE/TIME	HARDNESS	ALUMINUM	ARSENIC	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	SELENIUM	ZINC
11-JAN-94 13:40 PST	95.3	0.013	0.0012	0.0001 L	0.0002	0.0009	0.0002 L	0.005 L	0.0002 L	0.0003	0.0007
25-JAN-94 13:40 PST	86.3	0.021	0.0012	0.0001 L	0.0002	0.001	0.0002 L	0.005	0.0002 L	0.0002	0.0002
08-FEB-94 11:15 PST	106	0.081	0.0026	0.0001 L	0.0003	0.0012	0.0002 L	0.005	0.0002 L	0.0003	0.0006
22-FEB-94 13:00 PST	92.3	0.016	0.0013	0.0001 L	0.0002 L	0.0009	0.0002 L	0.005 L	0.0002 L	0.0003	0.0002
08-MAR-94 11:45 PST	75.6	0.072	0.0009	0.0001 L	0.0003	0.0017	0.0002 L	0.005 L	0.0002 L	0.0002	0.0011
22-MAR-94 13:00 PST	85.2	0.043	0.0011	0.0001 L	0.0002	0.0266	0.0003	0.005 L	0.0003		0.0033
05-APR-94 13:40 PST	63.2	0.401	0.0014	0.0001	0.0008	0.0044	0.0006	0.029	0.0009		0.0024
03-MAY-94 13:40 PDT	46.2	0.408	0.0025	0.0001 L	0.0006	0.0052	0.0004	0.031	0.0005		0.0029
17-MAY-94 13:40 PDT	44.1	0.362	0.0019	0.0001 L	0.0005	0.0027	0.0002 L	0.01	0.0002 L		0.0014
31-MAY-94 13:40 PDT	43.9	0.17	0.0011	0.0001 L	0.0003	0.0016	0.0002		0.0003		0.0008
14-JUN-94 13:40 PDT	44.1	0.196	0.0008	0.0001 L	0.0003	0.0015	0.0002 L		0.0003		0.0009
28-JUN-94 13:40 PDT	47.4	0.144	0.0011	0.0001 L	0.0002	0.0013	0.0002 L		0.0004		0.002
12-JUL-94 13:40 PDT	65.1	0.143	0.0015	0.0001 L	0.0003	0.0013	0.0002		0.0002		0.0005
26-JUL-94 13:40 PDT	78.9	0.031	0.0019	0.0001 L	0.0002	0.0009	0.0002 L		0.0002 L		0.0002
09-AUG-94 13:40 PDT	85	0.03	0.0019	0.0001 L	0.0002 L	0.0009	0.0002 L		0.0002 L		0.0002
23-AUG-94 13:40 PDT	91.1	0.028	0.0021	0.0001 L	0.0002 L	0.001	0.0002 L		0.0002 L		0.0002
06-SEP-94 13:40 PDT	89.3	0.028	0.0019	0.0001 L	0.0002 L	0.0013	0.0002 L		0.0002 L		0.0004
20-SEP-94 13:40 PDT	96.9	0.017	0.0019	0.0001 L	0.0003	0.0006	0.0002 L		0.0002 L		0.0002
04-OCT-94 13:40 PDT	104	0.013	0.0018	0.0001 L	0.0002 L	0.0007	0.0002 L		0.0002 L	0.0002	0.0002
18-OCT-94 13:40 PDT	101	0.013	0.0015	0.0001 L	0.0002 L	0.0006	0.0002 L		0.0002 L	0.0002	0.0002
01-NOV-94 13:40 PST	91.7	0.035	0.0012	0.0001 L	0.0002 L	0.0006	0.0002 L		0.0002 L	0.0003	0.0002
16-NOV-94 11:20 PST	99	0.015	0.001	0.0001 L	0.0002 L	0.0004	0.0002 L		0.0002 L	0.0001	0.0003
29-NOV-94 09:50 PST	107	0.01	0.0011	0.0001 L	0.0002 L	0.0004	0.0002 L		0.0002	0.0001	0.0002
13-DEC-94 13:40 PST	99.2	0.025	0.0011	0.0001 L	0.0002	0.0006	0.0002 L		0.0003	0.0003	0.0009
28-DEC-94 15:40 PST	92.2	0.032	0.0014	0.0001 L	0.0002 L	0.0008	0.0002 L		0.0002 L	0.0002	0.0003
10-JAN-95 10:30 PST	109	0.024	0.0014	0.0001 L	0.0002 L	0.0007	0.0002 L		0.0002 L	0.0002	0.0007
24-JAN-95 13:40 PST	110	0.009		0.0001 L	0.0002 L	0.0002 L	0.0002 L		0.0002 L		0.0004
07-FEB-95 13:40 PST	76.1	0.2	0.0011	0.0001 L	0.0004	0.0018	0.0002 L		0.0003	0.0001	0.001
21-FEB-95 13:40 PST	73.8	0.846	0.002	0.0001 L	0.0013	0.0098	0.0007		0.0011	0.0002	0.0041

Appendix . (continued)

DATE/TIME	HARDNESS	ALUMINUM	ARSENIC	CADMIUM	CHROMIUM	COPPER	LEAD	MERCURY	NICKEL	SELENIUM	ZINC
07-MAR-95 13:40 PST	87.2	0.073	0.0008	0.0001 L	0.0002 L	0.0012	0.0002		0.0002 L	0.0002	0.0008
21-MAR-95 13:40 PST	87	0.177	0.001	0.0001 L	0.0003	0.0045	0.0003		0.0002	0.0002	0.001
04-APR-95 13:40 PDT	82.6	0.263	0.001	0.0001	0.0004	0.0037	0.0002 L		0.0005	0.0002	0.0012
18-APR-95 13:40 PDT	86.3	0.19	0.0007	0.0001 L	0.0003	0.002	0.0002 L		0.0002	0.0002	0.0008
02-MAY-95 10:15 PDT	58.9	1.25	0.0033	0.0002	0.0016	0.0079	0.0014		0.0016	0.0001	0.0051
16-MAY-95 01:40 PDT	35.1	4.71	0.0125	0.0006	0.0068	0.0212	0.0036		0.0056	0.0002	0.0167
30-MAY-95 01:40 PST	26.6	3.84	0.007	0.0005	0.0047	0.0191	0.0031		0.0041	0.0001	0.0135
13-JUN-95 01:40 PDT	32	0.661	0.0016	0.0001	0.0009	0.0034	0.0007		0.0007	0.0001	0.0022
27-JUN-95 01:40 PDT	40.3	0.213	0.0013	0.0001	0.0003	0.0016	0.0004		0.0002	0.0001	0.0012
11-JUL-95 01:40 PDT	50.2	0.096	0.001	0.0001	0.0002	0.001	0.0002		0.0002	0.0001	0.0008
25-JUL-95 01:40 PDT	69.8	0.04	0.0012	0.0001	0.0003	0.001	0.0002		0.0002	0.0001	0.0007
08-AUG-95 01:40 PDT	76.5	0.092	0.0013	0.0001	0.0002	0.001	0.0002		0.0002	0.0004	0.0006
22-AUG-95 01:40 PDT	76.3	0.026	0.0016	0.0001	0.0002	0.0009	0.0002		0.0002	0.0001	0.0003
05-SEP-95 02:40 PDT	91.7	0.019	0.0018	0.0001	0.0002	0.0011	0.0002		0.0002	0.0001	0.0004
19-SEP-95 01:40 PDT	99.8	0.012	0.0022	0.0001	0.0002	0.0008	0.0002		0.0002	0.0003	0.0002
03-OCT-95 01:40 PDT	95	0.015	0.0016	0.0001	0.0002	0.0008	0.0002		0.0002	0.0002	0.0002
17-OCT-95 01:40 PDT	70	0.082	0.001	0.0001	0.0002	0.0013	0.0002		0.0002	0.0002	0.0007
17-OCT-95 01:40 PDT	70.2	0.079	0.0011	0.0001	0.0003	0.0018	0.0002		0.0002	0.0001	0.0007
31-OCT-95 13:40 PST	86	0.01	0.0012	0.0001	0.0002	0.0006	0.0002		0.0002	0.0003	0.0002
14-NOV-95 01:40 PST	58.4	0.127	0.0009	0.0001	0.0002	0.0012	0.0002		0.0003	0.0002	0.0008
28-NOV-95 01:40 PST	51	0.252	0.0004	0.0001	0.0005	0.0028	0.0004		0.0004	0.0001	0.001
12-DEC-95 14:30 PST	57.1	0.929		0.0001	0.0014	0.0065	0.0008		0.0016		0.0041
27-DEC-95 13:40 PST	79.2	0.214		0.0001	0.0003	0.0014	0.0002		0.0003		0.0009
09-JAN-96 13:40 PST	63.3	0.418		0.0001	0.0006	0.0016	0.0002		0.0006		0.0015
07-FEB-96 13:00 PST	91.9	0.129		0.0001	0.0003	0.0017	0.0002		0.0003		0.0006
20-FEB-96 13:40 PST	81.5	1.22		0.0001	0.0026	0.0092	0.0004		0.0024		0.0057
03-MAR-96 01:00 PST	83.9	0.183		0.0001	0.0007	0.0054	0.0002		0.0004		0.0017
02-APR-96 13:15 PST	88.8	0.075		0.0001	0.0004	0.0019	0.0002		0.0004		0.0007
16-APR-96 13:30 PST	63.6	1.48	0.0004	0.0002	0.0025	0.0088	0.0009		0.0022	0.0001	0.0067
30-APR-96 13:40 PST	67	0.491	0.0015	0.0001	0.0008	0.0032	0.0006		0.0008	0.0001	0.0111
14-MAY-96 13:40 PST	57.3	1.05	0.0037	0.0001	0.0015	0.0063	0.001		0.0014	0.0003	0.0046
28-MAY-96 13:40 PST	39.5	2.57	0.0048	0.0004	0.0044	0.0124	0.0022		0.004	0.0002	0.0102
11-JUN-96 13:40 PST	36.1	1.69	0.0027	0.0002	0.0024	0.0084	0.0015		0.003	0.0002	0.0059
25-JUN-96 09:30 PST	35.8	1.16	0.0063	0.0002	0.0015	0.0075	0.0004		0.0016	0.0001	0.002
25-JUN-96 09:30 PST	35.8	1.08	0.0034	0.0001	0.0014	0.0058	0.0004		0.0014	0.0001	0.0017

Addendum 1. Recent Ecology Ambient Monitoring Data on Arsenic (ug/L, tot. recoverable)

stano	b->staname	date_c	result	remark
07A090	Snohomish R @ Snohomish	95/12/17	1.100	
07A090	Snohomish R @ Snohomish	96/02/19	1.900	
07A090	Snohomish R @ Snohomish	96/04/22	0.730	
07A090	Snohomish R @ Snohomish	96/06/17	0.750	
07A090	Snohomish R @ Snohomish	96/08/19	0.910	
07A090	Snohomish R @ Snohomish	96/10/21	0.800	
07A090	Snohomish R @ Snohomish	96/12/15	0.690	
07A090	Snohomish R @ Snohomish	97/02/17	0.750	
07A090	Snohomish R @ Snohomish	97/04/21	1.030	
07A090	Snohomish R @ Snohomish	97/06/16	0.620	
07A090	Snohomish R @ Snohomish	97/08/18	0.850	
23A160	Chehalis R @ Dryad	96/10/30	0.200	U
23A160	Chehalis R @ Dryad	96/12/17	0.200	U
23A160	Chehalis R @ Dryad	97/02/24	0.200	U
23A160	Chehalis R @ Dryad	97/04/28	0.100	
23A160	Chehalis R @ Dryad	97/06/25	0.160	
23A160	Chehalis R @ Dryad	97/08/25	0.200	U
26B070	Cowlitz R @ Kelso	95/12/20	1.000	U
26B070	Cowlitz R @ Kelso	95/12/20	1.000	U
26B070	Cowlitz R @ Kelso	96/02/28	1.510	
Press any key to continue...				
26B070	Cowlitz R @ Kelso	96/04/30	0.840	
26B070	Cowlitz R @ Kelso	96/06/25	0.400	
26B070	Cowlitz R @ Kelso	96/08/28	0.370	
30A070	Columbia R @ The Dalles	94/11/20	1.360	
31A070	Columbia R @ Umatilla	94/11/20	1.440	
49B070	Similkameen R @ Oroville	95/12/11	21.600	
49B070	Similkameen R @ Oroville	96/02/12	1.940	
49B070	Similkameen R @ Oroville	96/04/15	3.600	
49B070	Similkameen R @ Oroville	96/06/11	6.270	
49B070	Similkameen R @ Oroville	96/08/13	3.780	
49B070	Similkameen R @ Oroville	96/10/15	2.770	
49B070	Similkameen R @ Oroville	96/12/10	1.900	
49B070	Similkameen R @ Oroville	97/04/15	2.040	
49B070	Similkameen R @ Oroville	97/06/10	8.280	
49B070	Similkameen R @ Oroville	97/08/12	4.180	
57A150	Spokane R @ Stateline Br	95/12/04	1.000	U
57A150	Spokane R @ Stateline Br	96/02/05	1.000	U
57A150	Spokane R @ Stateline Br	96/04/09	1.000	U
57A150	Spokane R @ Stateline Br	96/06/03	0.470	
57A150	Spokane R @ Stateline Br	96/08/05	0.430	
57A150	Spokane R @ Stateline Br	96/10/08	0.330	
Press any key to continue...				
57A150	Spokane R @ Stateline Br	96/12/03	0.460	
57A150	Spokane R @ Stateline Br	97/02/04	0.470	
57A150	Spokane R @ Stateline Br	97/06/03	0.580	
57A150	Spokane R @ Stateline Br	97/07/08	0.370	
57A150	Spokane R @ Stateline Br	97/08/05	0.410	
61A070	Columbia R @ Northport	95/04/04	0.590	P
61A070	Columbia R @ Northport	95/05/03	0.700	P
61A070	Columbia R @ Northport	95/06/06	0.579	P
61A070	Columbia R @ Northport	95/09/06	1.000	U
61A070	Columbia R @ Northport	95/11/07	1.000	U
61A070	Columbia R @ Northport	95/12/05	1.000	U
61A070	Columbia R @ Northport	96/01/09	1.000	U
61A070	Columbia R @ Northport	96/03/05	0.410	
61A070	Columbia R @ Northport	96/07/09	0.480	
61A070	Columbia R @ Northport	96/09/04	0.260	
61A070	Columbia R @ Northport	96/10/09	0.290	
61A070	Columbia R @ Northport	96/11/06	0.290	
61A070	Columbia R @ Northport	96/12/04	0.280	
61A070	Columbia R @ Northport	97/02/05	0.410	
61A070	Columbia R @ Northport	97/03/05	0.470	
61A070	Columbia R @ Northport	97/04/09	0.560	

Press any key to continue.

61A070	Columbia R @ Northport	97/05/07	0.610
61A070	Columbia R @ Northport	97/06/04	1.010
61A070	Columbia R @ Northport	97/07/09	0.600
61A070	Columbia R @ Northport	97/08/06	0.350