A 1992 BIOLOGICAL RECONNAISSANCE AND SEDIMENT SAMPLING IN THE COLUMBIA RIVER BETWEEN THE HUGH KEENLEYSIDE DAM AND THE INTERNATIONAL BOUNDARY

Prepared for:

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EXECUTIVE SUMMARY

Since the mid-1970's the Canadian and British Columbia governments have undertaken a series of studies to evaluate the environmental quality in the Columbia River between the Hugh Keenleyside Dam and the International Boundary. This section of the river receives discharges from two major industries, the Celgar Pulp Company's bleached kraft mill at Castlegar and the Cominco lead-zinc smelter and fertilizer plant at Trail. Both industries are involved in an ongoing process of modernizing their processes and ugrading the quality of their effluents. As the industries implement their planned improvements, the water quality of the river should improve.

Changes in the river's environment are expected to occur gradually. They should be reflected in reduced contaminant levels in sediments and biota and possibly in changes in species richness of benthic plant and animal communities. An integrated monitoring program, which includes these environmental components, should be able to document the expected changes as they occur.

A joint government and industry committee has been formed to oversee all environmental monitoring in the Columbia River and to coordinate the Columbia River Integrated Environmental Monitoring Program (CRIEMP). Individual participants in CRIEMP share the responsibility for monitoring the condition of all components of the Columbia River ecosystem in the reaches from the Hugh Keenleyside Dam to the International Boundary. The CRIEMP mandate includes sharing data, assuring the quality of information collected, and reducing redundancy.

Norecol Environmental Consultants Ltd. was contracted by the CRIEMP committee to undertake a bioreconnaissance study of the river to establish current conditions and provide background information for developing the monitoring program. The specific objectives of the bioreconnaissance study were to:

- provide an understanding of current spatial differences in community structure and contaminant levels relative to waste discharges; and
- plan a repeatable program which will produce an understanding of temporal changes in community structure and contaminant levels.

The study consisted of the following elements:

- community structure/distribution of benthic invertebrates;
- community structure/distribution of periphyton and aquatic macrophytes;

- sediment contaminant concentrations and toxicity; and
- contaminant bioaccumulation by invertebrates and macrophytes.

The benthic community structure study included sampling benthic invertebrates at six near shore sites in April and October, 1992. The dominant species collected varied both among sites and among times. The major taxonomic groups present included chironomids, oligochaetes, and nematodes. Harpacticoid copepods and the freshwater cnidarian *Hydra* also were abundant at some sites and times. Ephemeroptera (mayflies), Plecoptera (stone flies), and Tricoptera (caddisflies) were generally not abundant in the benthic samples.

There were significant among-site differences in the composition of benthic invertebrate communities, but not all differences were consistent for the April and October samples. The benthic invertebrate community downstream of Celgar (at Robson) was dominated largely by oligochaetes and nematodes. These species were also dominant upstream of Celgar, and their presence may be related more to substrate and water velocity than to any effect of the pulp mill. The entire reach from downstream of the mill (Robson) to the Hugh Keenleyside Dam is lake-like and environmentally distinct from the other sites sampled. Species richness and total abundance of organisms was depressed downstream of Cominco in April by comparison with upstream sites (Birchbank, Robson and the Kootenay River). However, in October the sites downstream of Cominco showed greater species richness than sites farther upstream, and the distribution of communities appeared to be related to distance downstream from the dams.

The primary physical factor affecting species distribution was water level. At most sites species richness in general and abundance of Ephemeroptera, Plecoptera, and Tricoptera species in particular was lower in October than in April. Due to the higher water level in October than in April, the samples had to be collected at an elevation which had been alternately dewatered and flooded throughout the summer. As a result of the fluctuating physical environment, the communities at these sites did not contain a full complement of species.

Periphyton standing crop was lower at the sites immediately downstream from Celgar and Cominco as compared with the other sites sampled, but the samples were not replicated making it difficult to evaluate the difference. Furthermore, results of the limited area (five rocks) sampled may have been misleading. Divers noted extensive algal growth in the vicinity of the Celgar outfall.

Distribution of macrophytes, except moss, appeared to depend upon the presence of suitable substrate and current conditions, and showed no influence of the industries. The distribution of moss apparently was related to Cominco's discharge. Extensive growths of moss occurred in some areas downstream of Cominco, but only one small patch of moss was found upstream of the discharge.

The two industries, Celgar and Cominco, did impact the levels of metals and organic compounds in both sediments and biota. Metal levels (in particular zinc, lead, copper, cadmium, arsenic and mercury) in sediments were significantly elevated at three sites downstream of Cominco by comparison with control and upstream sites. The elevated sediment metal levels were reflected by elevated concentrations in the tissues of freshwater mussels (*Anodonta oregonensis*), emergent caddisflies (various species), and macrophytes (*Potamogeton perfoliatus*). Levels of various chlorinated phenolic compounds, dioxins, and furans including 2,3,7,8-tetchlorodibenzofuran, which is characteristic of pulp mill effluents, were elevated in sediments collected immediately downstream of Celgar. Detectable levels of these compounds were present at Waneta, the sampling station farthest downstream. Dioxins, furans, and some chlorinated phenolic compounds were also present in mussels and caddisflies, but their relation to the Celgar discharge is questionable. These compounds were also found in mussels and caddisflies from the control sites on the Kootenay River above the Brilliant Dam.

Sediment bioassays suggested some toxicity in sediments from the downstream sites nearest Celgar and Cominco. However, sediments from other downstream sites with measurably elevated levels of organic compounds or metals did not show similar toxicity. Thus, any toxic effects of the industrial discharges appeared to be confined to limited areas and were not directly related to measured sediment contaminant levels.

Recommendations for an ongoing monitoring program are based on the results of the bioreconnaissance study. The continuing study should include sediment and tissue monitoring, sediment toxicity tests, and possibly benthic invertebrate community structure. Macrophyte monitoring is unlikely to provide data that will allow hypothesis testing and therefore should not be included. The benthic community survey design employed in the bioreconnaissance study was inadequate to detect effects of the industries, and therefore a revised design is recommended.

Key recommendations for design of the continuing biological impact assessment program include the following:

- The number of benthic invertebrate sampling sites should be increased to include at least three sites per reach with a minimum three sites downstream of each discharge.

- Sampling should take place only at low water to ensure that the sampling sites are rarely, if ever, dewatered.

- If possible, sampling should occur at least two weeks (preferably longer) after any significant flow change. Sampling should not take place immediately after flow reduction, when abundances will be artificially elevated due to organisms moving down from recently dewatered areas.

- Close liaison with B.C. Hydro will be critical to ensure that sampling occurs under the proper flow conditions.

- Periphyton monitoring should only be included if floating artificial substrates are used to control for variations in habitat conditions and prevent dewatering.

- Sediment analyses should include organics, metals, and bioassays. At least some bioassays should be done using whole (not sieved) sediments. If bioassays are done on sieved sediments, then chemical analyses should be done on the particle size fraction used for the toxicity tests.

- Given the absence of amphipods and abundance of chironomids in the benthic samples, the CRIEMP Committee should consider substituting a *Chironomus tentans* test for the *Hyalella* test or adding the *Chironomus* test to the bioassay program.

- For tissue contaminant monitoring the freshwater mussel *Anodonta oregonensis* is the preferred non-fish sentinel species. If a second non-fish species is desired, we recommend the macrophyte *Potamogeton perfoliatus* to monitor metals only.

- To facilitate data interpretation, whenever possible biota should be collected at the same times and locations as the sediments are collected.

- To control for seasonal differences due to growth rate and/or reproductive condition of the monitor organisms, sampling should occur at a consistent time of year whenever the cycle is repeated. Low water, preferred for sediment sampling, will also facilitate biota collection. Since low water consistently occurs in April, we recommend sampling at this time, if only mussels are to be collected. If macrophytes are included in the monitoring program, late summer/early fall sampling is preferred.

- New control sites for sediments and biota should be established. The same sites, which are acceptable controls for both sediments and biota should be selected to facilitate data interpretation. The current sites are inadequate because lake sediments do not appear to be appropriate controls for river sediments. Also, the control sites on the Kootenay River at Glade and Grohman Narrows showed evidence of contamination with chlorophenols and dioxins/furans.

- The possibilities for establishing new control sites include reconsidering two sites on the Columbia and Kootenay rivers which had been rejected for the current study and seeking new control sites on the Slocan River.

- As an alternative to monitoring resident biota, the CRIEMP Committee should consider *in situ* uptake experiments using transplanted mussels or another organism such as leeches. Such experiments would avoid the problems associated with a lack of suitable control areas.

ACKNOWLEDGEMENTS

The study team thanks the following CRIEMP committee members for their help with the study design and logistics: Terry Baturin, Les McDonald, Taina Tuominen, Gary Birch, Walter Kuit, Jim McLaren, Fiona Mackay, and Julia Beatty Spence. We also thank Gail Moyle and Tom Tremblay of Environment Canada who helped with laboratory liaison and arranged construction of the caddisfly traps, and Kelvin Ketchum and Kath Bowie of B.C. Hydro who provided information on Columbia River flows. Scottie Tait piloted the jet boat and provided invaluable knowledge of the river.

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INTRODUCTION

1.1 Background

Since the mid-1970's the Canadian and British Columbia governments have been concerned with environmental quality in the Columbia River between the Hugh Keenleyside Dam and the International Boundary. This section of the river receives discharges from two major industries, the Celgar pulp mill at Castlegar and the Cominco lead-zinc smelter and fertilizer plant at Trail, as well as municipal effluents from the cities of Castlegar and Trail. In addition, the river's environment is affected by dams on the Columbia River mainstem and on its tributaries, the Kootenay and Pend d'Oreille rivers.

The environmental quality of the Columbia River has been extensively studied. In the 1970's the provincial government undertook study of water quality and biota (*Kootenay Air and Water Quality Study, Phases I and II*). In the 1980's the federal and provincial governments began to coordinate efforts to monitor water quality and fish tissue metal levels. At the beginning of the 1990's, federal and provincial monitoring efforts were directed toward dioxins and furans. The federal/provincial data for water quality and fish tissue contaminant levels are currently being used to develop receiving environment objectives for these compartments. In August 1992, the British Columbia Ministry of Environment, Lands, and Parks published provisional water quality objectives for the river reach between the Hugh Keenleyside Dam and Birchbank (Butcher 1992).

Since the late 1970's, the major industries Celgar and Cominco have directed efforts toward modernizing their processes and improving the quality of their effluents. In addition, B.C. Hydro is planning to upgrade its dams, which should lower levels of dissolved gasses below the dams. These improvements are ongoing, and as the quality of the discharges changes, the quality of the river is expected to improve.

Recently a joint government and industry committee was formed to coordinate and integrate environmental monitoring activities in the river and prevent redundancies. This committee coordinates the Columbia River Integrated Environmental Monitoring Program (CRIEMP), whose mandate is to monitor the condition of all components of the Columbia River ecosystem in the reaches from the Hugh Keenleyside Dam to the International Boundary. Norecol Environmental Consultants Ltd. was contracted under the CRIEMP program to undertake a bioreconnaissance study of the river which will establish current conditions and provide background information for developing the ongoing monitoring program.

1.2 Environmental Setting

1.2.1 Hydrology

The study area consists of the Columbia River between the Hugh Keenleyside Dam and the International Boundary, a distance of approximately 60 km. It also includes control sites upstream of the dam in Lower Arrow Lake and on the Kootenay River system (Figure 1-1).

Approximately 97% of the flow of the Columbia River at the International Boundary is regulated by dams (Butcher 1992). Outflow from the Arrow Reservoir controlled by the Hugh Keenleyside Dam contributes 39% of the total flow at the border (based on mean annual flow). The Kootenay River, which enters the Columbia approximately 10 km downstream of the Keenleyside Dam supplies a further 30% of the flow. This flow is regulated at the Brilliant Dam. The Pend D'Oreille River, which enters the Columbia just upstream of the International Boundary and is regulated by the Waneta Dam, contributes 27% of the flow.

The remaining approximately 3% of the flow is contributed by small, unregulated streams. Norns (Pass) Creek upstream of the Columbia-Kootenay confluence and Blueberry, China, and Champion creeks between the confluence and Birchbank collectively supply approximately 2% of the flow. Numerous smaller streams between Birchbank and the Pend D'Oreille confluence collectively account for the remaining 1% of flow.

Flow regulation in the study area began in 1932 with construction of the Corra Linn Dam on the Kootenay River near Nelson, British Columbia. This dam controls the outflow from Kootenay Lake. The Columbia River mainstem has been regulated since the late 1960's by a series of dams including Arrow [Keenleyside] (completed in 1968), Mica (1973), and Revelstoke (1984).

The Arrow and Mica dams were constructed under the Columbia River Treaty (CRT) and are operated by B.C. Hydro to provide flood control and storage for power generation in the USA. The CRT requires Assured Operating Plans for the dams which are based on snowpack, expected U.S. power demand, and maintenance requirements. The CRT also specifies that the average weekly outflow from the Keenleyside Dam is to be greater than 142 m^3/s, unless lower flows are agreed to by the CRT signatories. However, higher flows typically occur over 96% of the year (Butcher 1992).

Stream regulation has altered the natural flow regime of the Columbia River. In general, winter (December through March) low flows at Birchbank have increased from an average in the 600 to 700 m^3/s range to the 1300 to 2000 m^3/s range. The June to July freshet flows which formerly were in the range of 5500 to 6500 m^3/s are

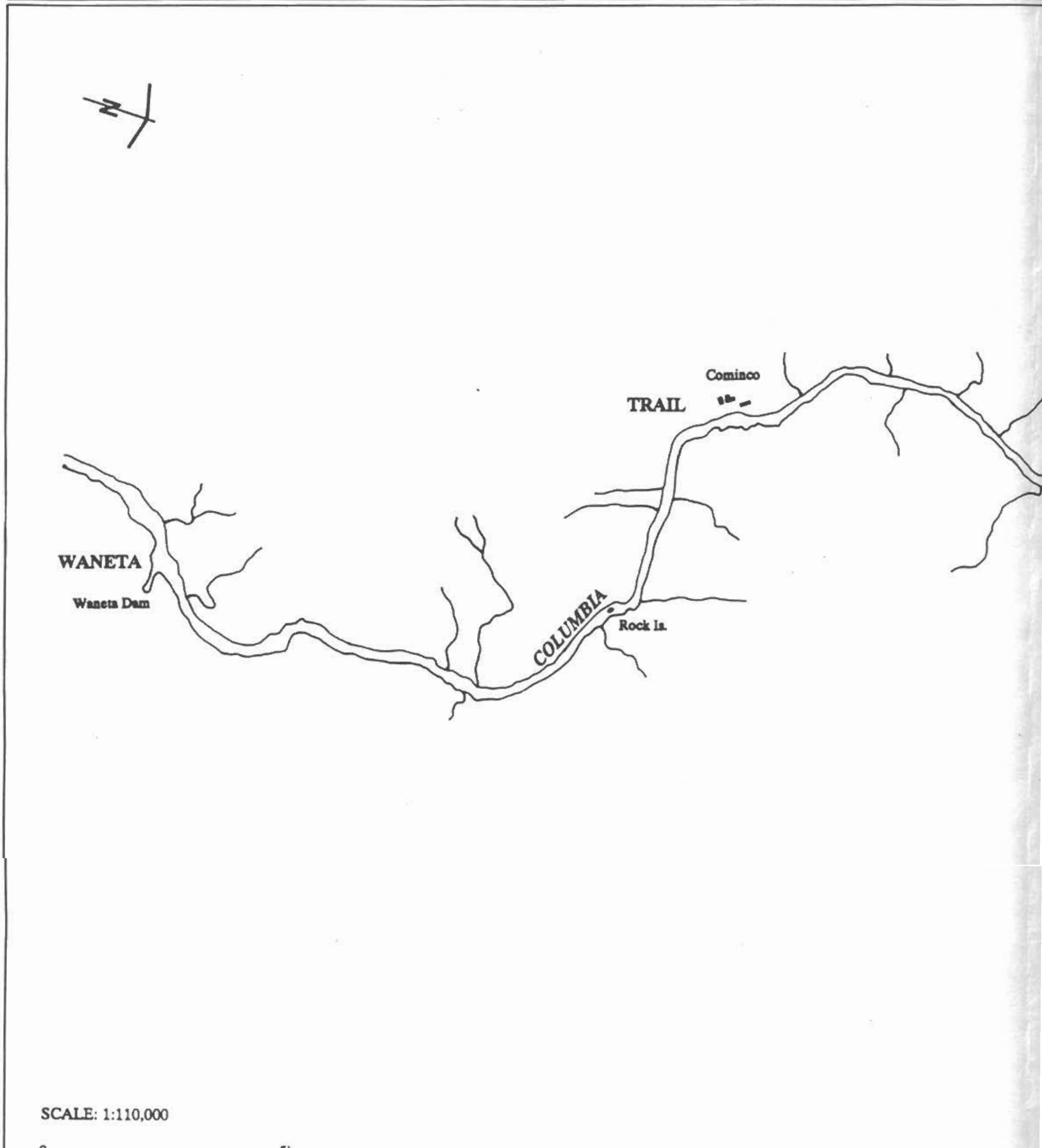
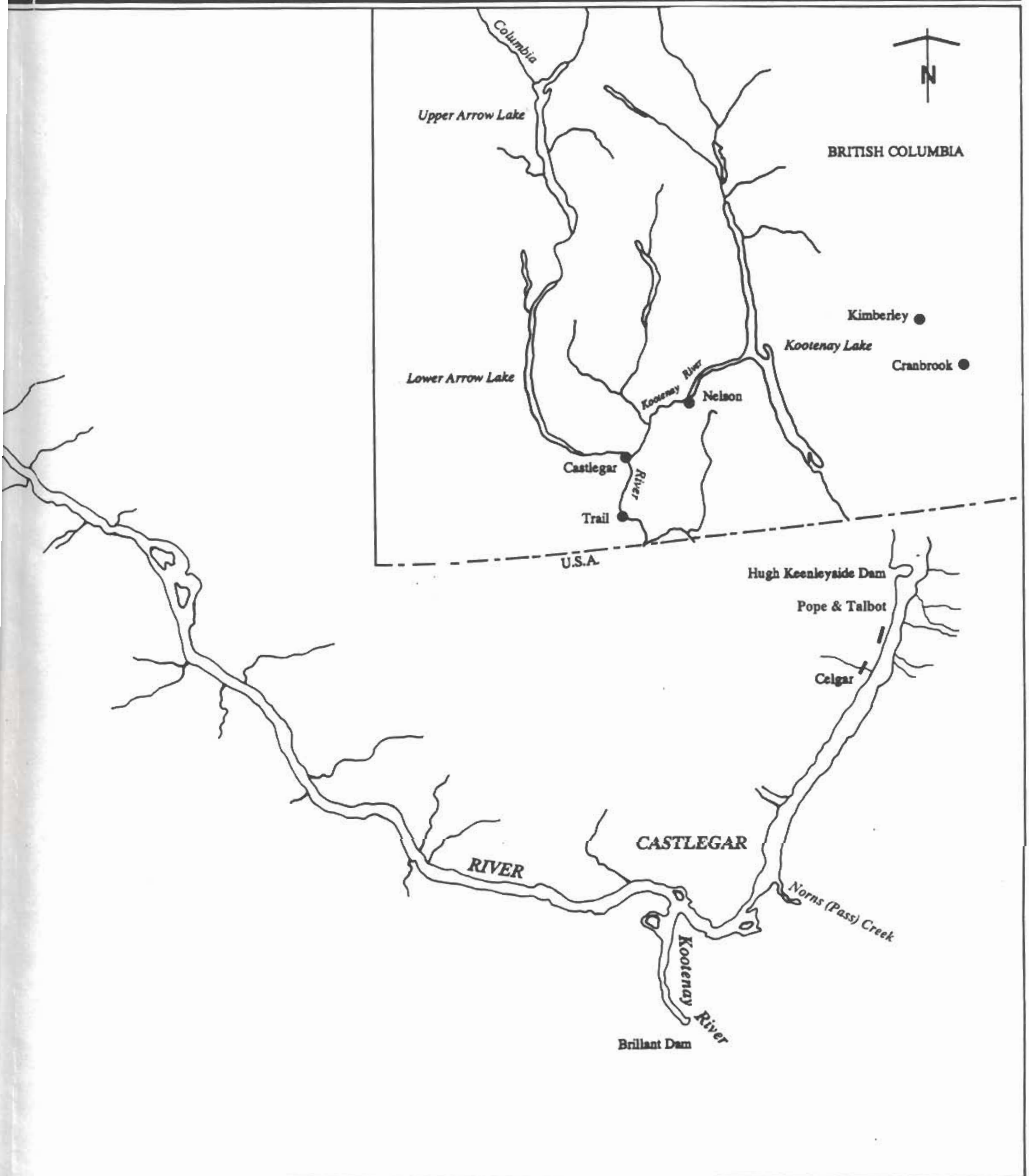

N
Cominco
TRAIL
WANETA
Waneta Dam
COLUMBIA
Rock Is.
SCALE: 1:110,000
0
5km

FIGURE 1-1

STUDY AREA
Columbia River Biological Monitoring



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retained behind the dams. Flows during the early summer period average around 3000 m^3/s (Butcher 1992 based on Water Survey of Canada data).

Although post-regulation average flows show reduced variation compared with pre-regulation average flows, day to day variations in river flow can be considerable. Under the CRT, flow requirements for US power generation are determined weekly and communicated by a conference phone call each Friday afternoon (K. Ketchum, B.C. Hydro, pers. comm.). Water release from the Keenleyside Dam is adjusted in response to these requirements.

1.2.2 Waste Discharges

Waste discharges to the Columbia River within the study area include nonpoint sources, domestic sewage, and effluent from two major industries. The major nonpoint source is runoff from the Pope and Talbot (formerly Westar Timber Ltd.) sawmill and associated landfill sites located immediately below the Hugh Keenleyside Dam (Figure 1-1). Agricultural runoff from irrigated hay crops and small-scale livestock operations located between Castlegar and Birchbank is a relatively unimportant waste source (Butcher 1992). Domestic effluent from poorly-functioning ground disposal systems in the Castlegar/Robson area has been identified as a concern by the provincial Waste Management Branch (Butcher 1992).

The major permitted sources of domestic sewage are the City of Castlegar's two sewage treatment plants and the Regional District of Central Kootenay's sewage treatment plant near Trail. The City of Castlegar's north system discharges treated sewage to the east side of the Columbia River approximately 1.5 km upstream of the Kootenay River confluence. The south system discharges treated sewage to the west side of the river approximately 5 km downstream from the Kootenay River confluence. The Regional District of Central Kootenay's sewage treatment plant discharges to the east side of the river downstream from Trail. There are also several permits issued for smaller sewage discharges such as Selkirk College at Castlegar, a neighbourhood pub at Robson, and a long-term care facility at Raspberry.

The major industrial discharges to the Columbia River are those from the Celgar Pulp Company's bleached kraft mill at Robson/Castlegar and the Cominco Metals Ltd. lead-zinc smelter and fertilizer operation at Trail (Figure 1-1). Both industries have been identified by provincial and federal environment agencies as significant contributors of contaminants to the river. However, over the past decade both industries have undertaken measures to improve their effluent quality and reduce contaminant loadings. Both industries have embarked on major process improvements with planned installation of "best available control technology" to improve effluent quality further, although to date neither industry has completed the planned improvements.

Celgar Pulp Mill

The Celgar mill is a single line bleached kraft pulp mill with a current capacity of 550 ADt/d. It began operating in 1961 and was issued a Waste Management Branch Permit (PE 1272) in 1973 to discharge effluent following primary treatment. The discharge enters the Columbia River via a submerged diffuser 3.3 km downstream from the Hugh Keenleyside Dam. The effluent constituents of concern include BOD, suspended solids, colour, nutrients (nitrogen and phosphorus), resin and fatty acids, mercaptans, adsorbable organic halogens (AOX), chlorinated phenolic compounds, and chlorinated dioxins/furans (Butcher 1992).

As of 1992 the Celgar mill had not completed an effluent treatment system and its chlorine consumption was high (Butcher 1992). The 1992 chlorine use included both chlorine (53 kg/ADt) and chlorine dioxide (13.5-14 kg/ADt). The recent substitution of 20% to 40% chlorine dioxide in the bleaching process has brought about a reduction in overall chlorine usage. Other improvements in effluent quality instituted since the late 1980's include pH neutralization, use of dioxin/furan precursor-free defoamers, use of high shear mixers in the chlorination process, elimination of debarker effluent, and installation of spill recovery systems and other measures to reduce suspended solids loads.

In December 1990 Celgar received government approval to rebuild and expand its present pulp mill. The mill expansion is currently under construction. When the improvements are completed the production capacity will expand to 1200 ADt/day and contaminant loadings will decrease substantially. Substitution of 70% to 100% chlorine dioxide in the first bleaching stage coupled with extended continuous pulp cooking and oxygen delignification will reduce the production of organochlorines. It is anticipated that by 1994 Celgar will meet the Ministry of Environment, Lands, and Parks 1.5 kg/t objective for AOX (which will become effective in 1995). Chlorinated dioxins and furans are expected to be below detection limits, and resin acid concentrations will be significantly reduced (Butcher 1992, Celgar Pulp Company 1990).

Cominco Metals Smelter and Fertilizer Plant

The Cominco lead-zinc smelter at Trail (Figure 1-1) has been operating since the late 1890's. In 1973 Cominco applied for a Waste Management Branch permit to discharge effluent from the metallurgical operation to the Columbia River. That same year the company also applied for a permit to discharge effluent from its fertilizer plant. Permits for both operations were granted in 1978.

Cominco discharges liquid effluents from the fertilizer plant and smelter through a series of separate outfalls referred to as sewers. The plant also discharges fumed slag from the lead smelter. The effluent constituents of greatest concern are phosphorus and metals, particularly zinc, lead, copper, cadmium, arsenic, and mercury.

In the late 1970's Cominco began a modernization program to expand zinc production and reduce metal discharges. The zinc expansion incorporated a pressure leach plant (1981), a new electrolyte and melting plant (1981), a mercury removal plant (1981), and a new gas handling and sulphur scrubbing to the zinc plant gas stream (1985). An effluent treatment plant to remove heavy metals from various plant discharges was completed in 1981. A new lead smelter was completed in 1989, but the startup was unsuccessful and the process has now been abandoned. Alternate technology is under review. A copper products plant to fix arsenic was completed in 1990.

Currently the original lead smelter continues to operate at approximately 110,000 tpy. The 1990 target for annual average discharge of metals from the metallurgical sewers (in kg/day based on average flows and permit limits) was zinc 633, lead 75.6, cadmium 15.7, arsenic 11.42, and mercury 1.12. Actual 1990 metal discharges were lower: zinc 134 kg/d, lead 34 kg/d, cadmium 9.3 kg/d, arsenic 6.3 kg/d, and mercury 1.0 kg/d. Although these loadings represent substantial reductions from the late 1970's to mid-1980's, the current permit limits allow metals concentrations that exceed the B.C. Pollution Control Objectives for the metal smelting industry.

Cominco expects to have a new lead smelter functioning by 1995. With the improved smelter technology in place the operation will be able to meet the Pollution Control Objectives for metals. The company is also working toward reducing metal loadings from other sources, such as the contribution of site runoff to the metallurgical sewers. In addition, Cominco has committed to eliminating the discharge of slag to the river by the end of 1995. These changes will significantly reduce metal loadings to the Columbia River.

1.2.3 Environmental Monitoring Programs

Since the 1970's the federal and provincial environment agencies and the industries have undertaken a series of studies to monitor environmental quality in the Columbia River between the High Keenleyside Dam and the International Boundary. The initial study was the Kootenay Air and Water Quality Study conducted by the B.C. Ministry of Environment (1977, 1979). The program included review of existing effluent quality and permit monitoring data, water quality monitoring, and limited monitoring of fish tissue contaminants, sediment quality, and benthic invertebrate community composition. Subsequent studies (not including regular permit monitoring undertaken by the industries) have included:

- ongoing water quality monitoring at Birchbank and Waneta by Environment Canada and under a joint federal-provincial monitoring program, summarized in reports by Sheehan et al. (1987), Smith (1987a), and Sigma Engineering (1988);

- an Environment Canada algal assay to determine the effects and interactions of nutrients and metals on algal (*Selanastrum capricornutum*) growth (data report by Tuominen et al. 1987);
- sampling of periphyton and phytoplankton communities (reported with the algal assay study);
- Environment Canada and federal-provincial monitoring of metal levels in fish tissues (Smith 1987b, Norecol Environmental Consultants Ltd. 1989);
- an Environment Canada study of dioxins and furans in sediments and fish tissues (Mah et al. 1989);
- BC Environment studies of dioxins and furans in fish and freshwater mussel (clam) tissues (summarized and interpreted in EVS Consultants 1990, Celgar Pulp Company 1990, and Butcher 1992);
- a study of dioxins, furans, and other chlorinated organics in water, sediments and fish tissues conducted for Celgar Pulp Company (EVS Consultants 1990);
- a study of dioxins, furans, and other chlorinated organics in sediments conducted for B.C. Hydro (reported in Celgar Pulp Company 1990); and
- studies of benthic invertebrate community structure undertaken for Celgar Pulp Company (Dwernychuk 1980, 1983, 1984, 1988; summarized in Celgar Pulp Company 1990 and Butcher 1992).

In addition, the Washington State Department of Ecology has undertaken studies of metals and dioxins/furans in sediments and fish tissues in the reach of the Columbia immediately downstream of the International Boundary including the Franklin Roosevelt Reservoir (Johnson et al. 1988, Johnson 1991). All of the studies related to water quality in the river between the Hugh Keenleyside Dam and Birchbank have been reviewed by Butcher (1992) as part of the B.C. Ministry's assessment to establish water quality objectives for this reach of the Columbia River.

Significant findings of the studies include the following:

- Levels of phosphorus and metals (zinc, lead, cadmium) in water at Waneta (downstream of Cominco) are significantly elevated compared with water at Birchbank (upstream of Cominco).

- Levels of most metals in fish tissues are not elevated when compared with metal levels in fish from other areas (Smith 1987b). However, mercury concentrations in 11% of the walleye (*Stizostedion vitreum)* collected from 1980 to 1988 exceed the Health and Welfare Canada guideline for mercury (0.5 μg/g wet weight). In addition, lead levels in some largescale suckers (*Catostomus macrocheilus*) exceed the alert level (0.8 μg/g wet weight), which BC Environment implemented after the Smith (1987b) and Norecol (1989) reports were released.

- Metal levels in fish tissues monitored from 1980 to 1988 do not show either increasing or decreasing trends.

- The primary dioxin/furan congener detected in sediments is 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8 T4CDF), which is characteristic of pulp mill effluents. Sediments collected near the U.S. border (Waneta) have furan concentrations as high as those collected near the Celgar mill.

- Both tetrachloro-para-dibenzodioxin (2,3,7,8 T4CDD) and tetrachlorodibenzofuran (2,3,7,8 T4CDF) are present in fish tissues. Depending upon the study and the detection limits employed higher dioxin/furan congeners (penta- to octachloro) have also been detected. The highest levels occur in lake whitefish and mountain whitefish. Health and Welfare Canada and the provincial Ministry of Health have issued consumption advisories for these species based on 2,3,7,8 TCDD toxic equivalencies (the weighted sum of dioxin/furan congeners) exceeding 15 parts per trillion [ppt] (Butcher 1992).

- Both TCDD and TCDF are present in freshwater mussel tissues. Within the limited data set available, dioxin/furan concentrations are highly variable, and their implications for the health of the aquatic biota are unclear (Butcher 1992).

- Benthic invertebrate population densities and species richness generally increase from sites near the Celgar outfall to sites near the Columbia/Kootenay confluence. Organisms tolerant of degraded conditions (particularly nematodes) are most abundant near the outfall. Downstream there is a progressive shift to "facultative" organisms which can tolerate a moderate degree of pollution. Sensitive organisms are not a significant component of the benthic community upstream of the Columbia/Kootenay confluence.

1.3 Study Objectives

The planned improvements in both process and waste handling at Celgar and Cominco will improve the quality of the effluents these industries discharge. As a result the environmental quality of the Columbia River should also improve. Changes in the river's environment are expected to occur gradually and to be reflected in reduced contaminant levels in sediments and biota and possibly in more diverse benthic plant and animal communities. An integrated environmental monitoring program should be able to document the expected changes as they occur.

CRIEMP has been implemented to integrate all monitoring efforts between the Arrow Reservoir and the U.S. border. The program emphasizes documenting the state of ecosystem health. It includes water and sediment monitoring, a benthic community structure study, contaminant monitoring in selected fish and non-fish sentinel species, sediment toxicity assessment, and a fish health study.

The bioreconnaissance and sediment study is a subset of the larger CRIEMP. The basic study design (McDonald 1992) was approved by the CRIEMP Coordinating Committee and included in the CRIEMP Design Document. It includes:

- community structure/distribution of benthic invertebrates;
- community structure/distribution of periphyton and aquatic macrophytes;
- sediment contaminant concentrations and toxicity; and
- contaminant bioaccumulation by invertebrates and macrophytes.

The specific objectives of the bioreconnaissance study are to:

- provide an understanding of current spatial differences in community structure and contaminant levels relative to waste discharges; and
- plan a repeatable program which will produce an understanding of temporal changes in community structure and contaminant levels.

The planning of a repeatable monitoring program involves using the results of the bioreconnaissance study to identify the study components (including non-fish sentinel species) that will provide the most useful information for evaluating ecosystem health. The planning also includes providing recommendations for the design of the monitoring program.

This report describes the methods and results of the bioreconnaissance program. Based on the monitoring experience and initial results it suggests components to include in the ongoing monitoring program and recommends methods for carrying out that program.

METHODS

The overall study design and sampling methodology were provided by the CRIEMP Coordinating Committee (McDonald 1992). Some modifications to the study design were made due to field conditions such as river flows or availability of benthic species.

The sampling program consisted of the following field trips:

- two benthic invertebrate surveys conducted April 22-23 and October 17-18, 1992;

- a summer trip (July 13-20, 1992), which included periphyton sampling, a macrophyte survey, and collection of biota for tissue contaminant analyses; and

- a sediment collection trip conducted on September 1-2, 1992.

The following sections describe the field methodologies and analytical techniques used for each study component.

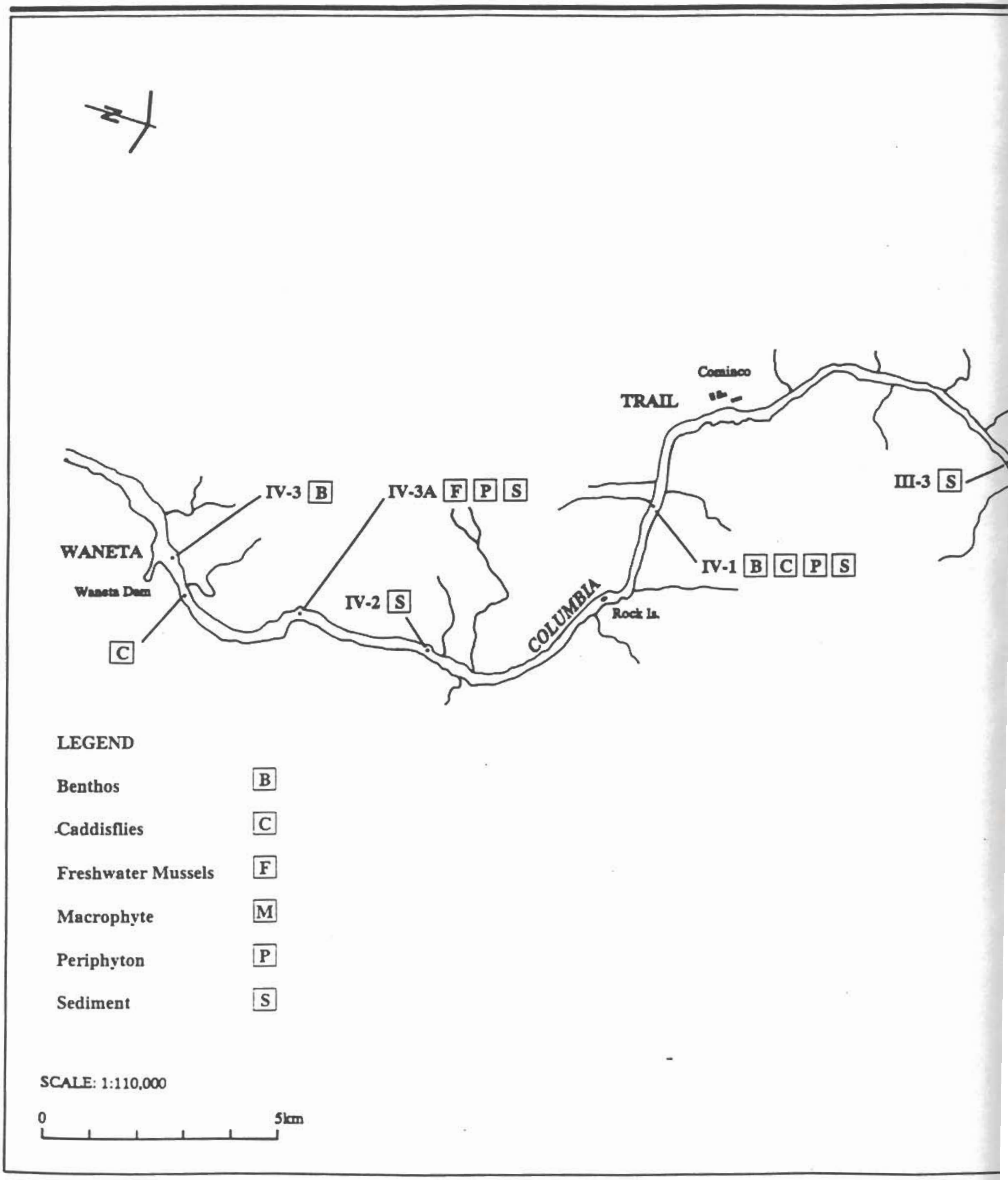
2.1 Benthic Invertebrate Community Structure

2.1.1 Introduction

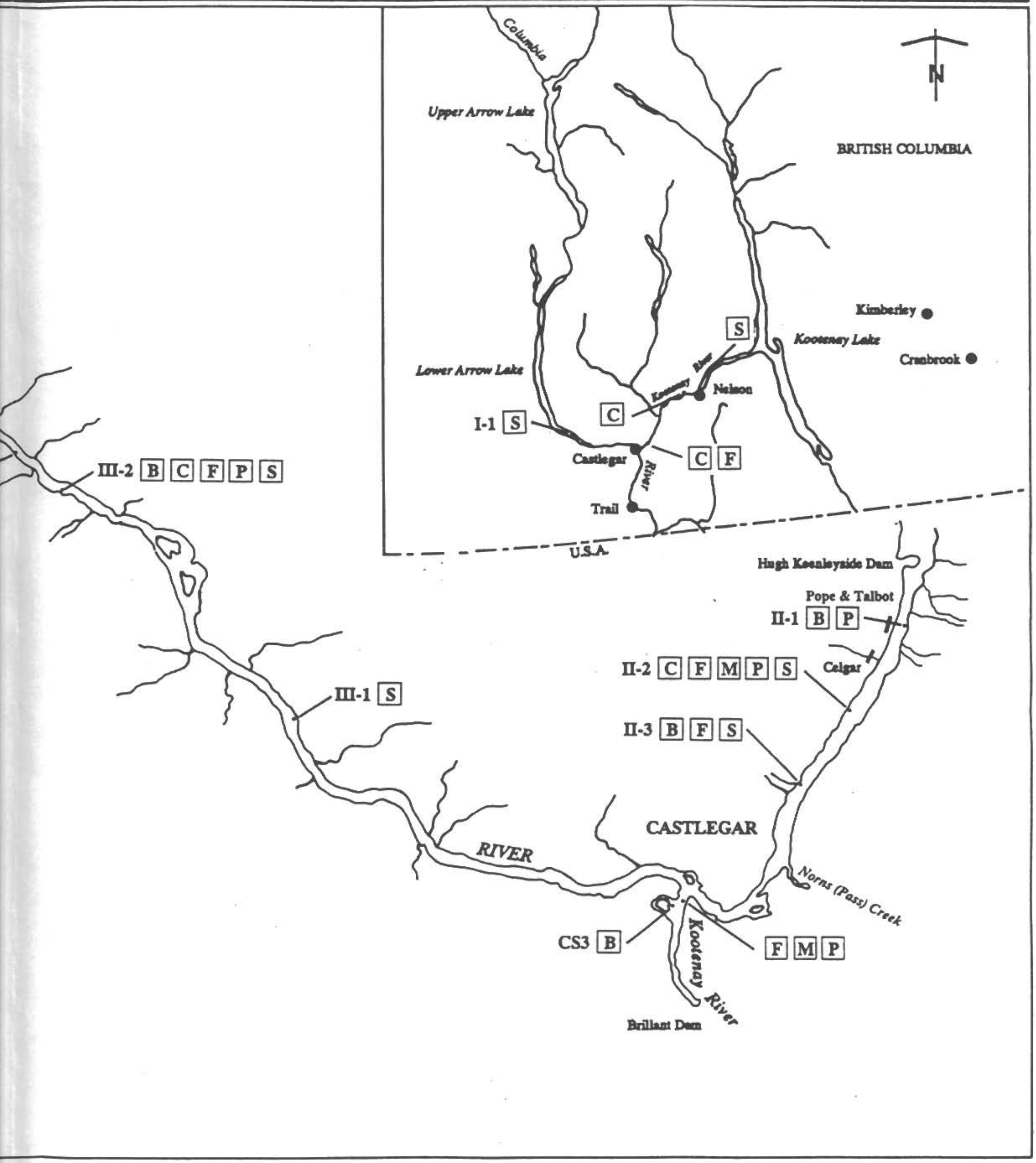
During a site reconnaissance on April 21, 1992, Norecol with input from CRIEMP Committee members identified six benthic invertebrate monitoring sites adjacent to potential sediment sampling sites (Figure 2-1). The sites included two control or reference sites, "Upstream (U/S) Celgar (site II-1) downstream of the Hugh Keenleyside Dam and CS3 on the Kootenay River and four test sites at varying distances downstream from Celgar and Cominco.

The final site selection occurred over the following two days, with the primary criterion being the presence of adequate, accessible invertebrate habitat. The preferred habitat was a gravel or cobble riffle (substrate diameter <15 cm) having a depth < 30 cm. There needed to be enough habitat present that replicated and repeated sampling would not create such a serious disturbance as to bias later samples. In addition, the site was to be deep enough that it would not be exposed at lower water.

Insofar as possible, sites with similar habitat characteristics (substrate size and composition, water velocity, amount of overhanging vegetation/shading) were selected.


TRAIL
Cominco
WANETA
Waneta Dam
COLUMBIA
Rock Is.
IV-3 B
IV-3A F P S
IV-2 S
IV-1 B C P S
III-3 S
C
LEGEND
Benthos B
Caddisflies C
Freshwater Mussels F
Macrophyte M
Periphyton P
Sediment S
SCALE: 1:110,000
0
5km

MONITORING SITES
Columbia River Biological Monitoring



However, the amount of ideal habitat was limited. In some reaches, it was necessary to sample areas with larger rocks or boulders. The Celgar reach differed from the others, having primarily lake-like habitat characteristics.

Norecol collected invertebrate samples on April 22-23 and October 17-18, 1992. To aid in interpretation of the benthic community data, we obtained B.C. Hydro data on reservoir discharge over the study period (Figure 2-2).

2.1.2 April 22-23 Field Sampling

The first benthic invertebrate sampling occurred on April 22-23 at the following sites: site II-1 above Celgar, CS2 Robson West below Celgar (II-3), CS3 (Kootenay River mouth), Birchbank above Cominco (III-2), Ryan Creek below Cominco (IV-2), and Waneta (IV-3) just upstream of the confluence with the Pend d'Oreille River. On April 22, all road access points were investigated and the samples taken at site IV-2 (Ryan Creek) below Cominco. The rest of the samples were taken on April 23 using a jet-boat for access to the sites.

If comparable substrate and current conditions were present, the sample sites were located near the potential sediment sampling sites. Sites CS3, III-2 and IV-2 were immediately adjacent to and upstream of the sediment sites identified during the April 21 reconnaissance. Site II-1 was somewhat upstream of the most upstream depositional area identified in the Celgar reach. Site II-3 was approximately 75 m downstream of and on the opposite shore from the Robson boat ramp. Site CS6 was approximately 20 m downstream of and on the opposite shore from Cominco's Waneta water sampling station. All sites contained some fine-grained material that the invertebrates would be in contact with at all times. Site conditions are described further in Table 2-1.

The sample sites chosen were relatively similar in depth, current velocity, and surficial substrate material. The depths were just less than the height of the sampler (25 to 28 cm). The types of substrate materials at each sample site were estimated visually in percentages of sand, pebble, cobble, boulder and organic material. The substrate types were mainly gravel-cobble-sand (predominantly <10 cm diameter) that could be contained within the sampler to give quantitative results. The sites all were located off shore of bars which likely are submerged at higher flows and contained no vegetation (cover).

Each benthic sampling site was marked with international orange flagging tape for future reference. The locations were also noted on the field map and in notebooks. At each site the depth, flow, temperature, dissolved oxygen and conductivity were measured. This information is summarized in Table 2-1.

The benthic samples were taken with a 30 cm diameter by 30 cm high Waters and Knapp sampler with 220 micron mesh size. A removable bucket with 200 micron

Figure 2-2. Discharge from Arrow Lake During the 1992 CRIEMP Study Period

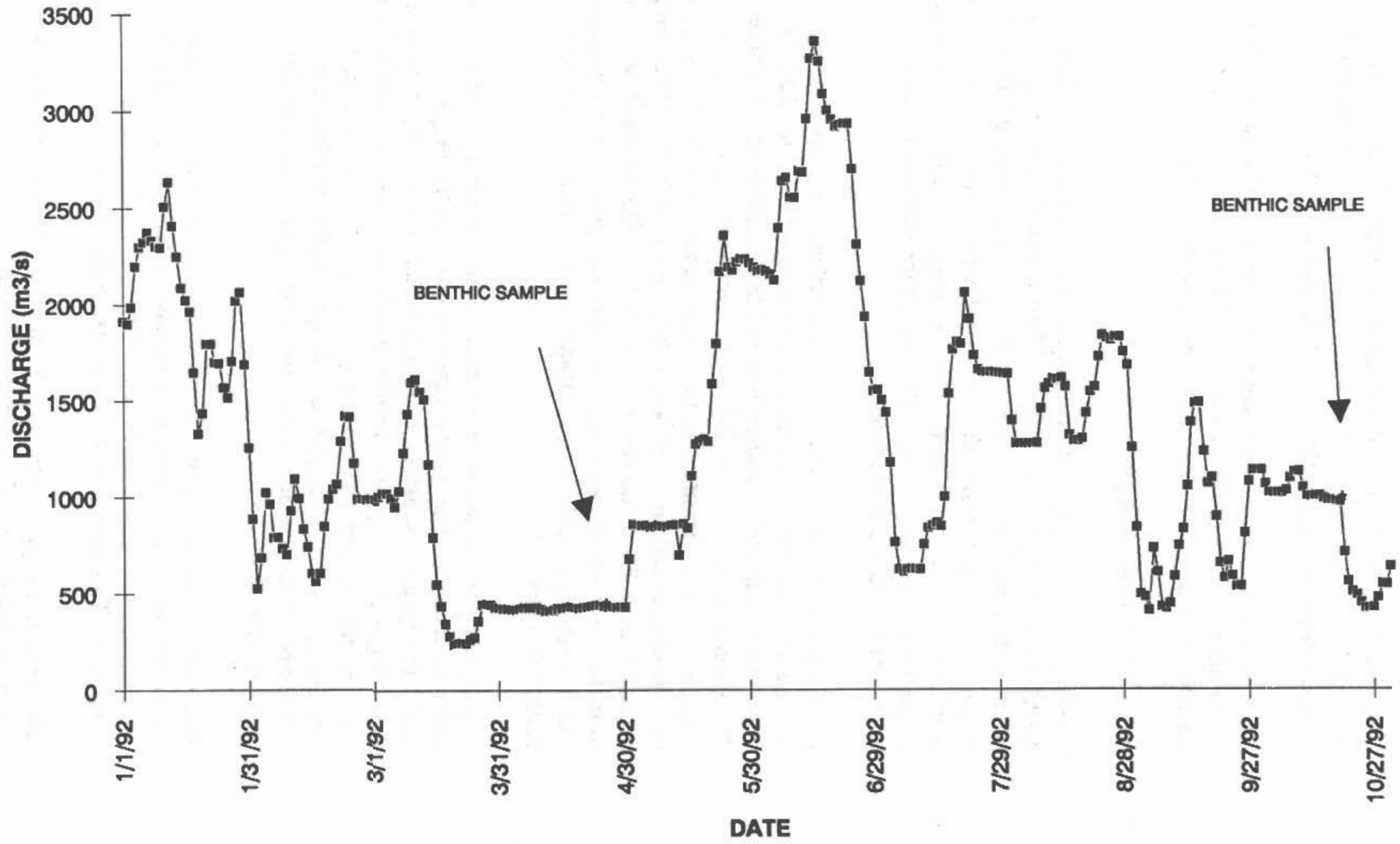


TABLE 2-1

PHYSICAL DATA FOR BENTHIC INVERTEBRATE SAMPLING SITES, COLUMBIA RIVER BIORECONNAISSANCE PROJECT
SAMPLING DATE: APRIL 22-23, 1992

Site	Location	Description	Substrate[a] (%)				D.O. (mg/L)	Temp. (°C)	Velocity (m/s)		
									Replicate		
			F	G	C	B			#1	#2	#3
CS1	Reach II-1	Upstream of Celgar, on east bank across from Pope and Talbot crane and new clarification ponds; backeddy; algae present, particularly in deeper water	60	30	10	0	13.6	8.0	0.033	*--	*--
CS2	Reach II-3	Downstream of Celgar on the west bank approximately 75 m downstream of Robson boat ramp; recognizable by old fence in water immediately upstream of site	30	50	20	0	13.0	8.0	0.014	*--	*--
CS3	Kootenay River	Near mouth, upstream of large sand bar, offshore of Selkirk College property; backeddy; a considerable amount of dead algae present on substrate	30	50	20	0	--	7.8	0.21	0.14	0.17
CS4	Reach III-2	Approximately 200 m downstream of Birchbank Water Survey Station, east bank, just upstream of sand bar	50	40	10	0	13.8	7.0	0.27	0.28	0.36
CS5	Reach IV-1	Downstream of Ryan Creek, west bank, off bar of sand mixed with slag; there was a substantial growth of moss immediately upstream of larger rocks (100 to >256 mm)	50	40	10	0	14.2	7.8	0.56	0.54	0.58
CS6	Reach IV-3	Approximately 20 m downstream and on opposite (west) bank from Waneta Water Sampling Station; backeddy; sampled off bar composed of gravel over sand mixed with slag (20%)	40	50	10	0	13.4	7.0	0.27	0.35	--

* Velocity too low to measure accurately

[a] F = fines (<2 mm)
G = gravel (2 to 64 mm)
C = cobble (64 to 256 mm)
B = boulder (>256 mm)

mesh size was attached to the downstream end of the sampler to catch the organisms.

Five samples were taken at each site. For each sample, the sampler was firmly set into the substrate and the bottom material was stirred by hand for one minute. The dislodged invertebrates were swept into the net and bucket by the current and by hand until the water within the sampler was clear. The sampler was then removed from the substrate and the sample transferred to jars and fixed with formalin.

2.1.3 October 17-18 Field Sampling

Samples were collected with the Waters and Knapp sampler at approximately the same six sites sampled in April. Sampling depth was 20 to 25 cm. The water levels were much higher (flow approximately 980 m^3/s compared with 435 m^3/s; see Figure 2-2) making it impossible to access the identical sites previously sampled. In general, the site characteristics were similar with elevation being the primary difference. However, at sites CS3 (Kootenay River), III-2, and IV-1, the bars off which we had sampled previously were submerged and the accessible substrate was somewhat larger than that sampled in April.

At each site two extra samples were collected in large substrate (>20 cm diameter). The sampling depth was 30 to 40 cm. Norecol used an oversized sampler constructed specifically for this substrate. The sampler was a modified Surber/Hess sampler: a fully-enclosed square aluminum frame, 2 ft (61 cm) on a side by 2 ft (61 cm) high, with a 200 μm mesh collecting bag. The sampler appeared quite effective on low gradient slopes. At sites where the bottom dropped off steeply it was rather unstable and difficult to keep in the substrate.

At each site dissolved oxygen, conductivity, pH, and water temperature were measured with field meters. Dissolved oxygen was measured with a YSI Model 57 meter that was air calibrated in the field prior to taking the first measurement. Conductivity was measured with a YSI Model 33 Salinity-Conductivity-Temperature meter. The pH was measured with a Fisher Model 119 pH/temperature meter that was calibrated with a pH 7 buffer solution prior to taking the first measurement. Water temperatures were taken with a centigrade pocket thermometer and with temperature probes on the dissolved oxygen and conductivity meters.

Some additional measurements of habitat characteristics were made. Water depths were measured against the benthic sampler and/or with a meter stick to the nearest 1 cm. Velocity near the substrate was measured with a flow meter. Substrate composition was estimated visually. In addition, in October, one sample of the substrate underlying the larger rocks was collected for particle size analyses. The field data are summarized in Table 2-2.

TABLE 2-2

PHYSICAL DATA FOR BENTHIC INVERTEBRATE SAMPLING SITES, COLUMBIA RIVER BIORECONNAISSANCE PROJECT
SAMPLING DATE: OCTOBER 17-18, 1992

Site	Location	Description	Substrate[a] (%)				D.O. (mg/L)	Conductivity (µohm/cm)	pH	Temp. (°C)	Velocity (m/s)				
											Replicate				
			F	G	C	B					#1	#2	#3	#4	#5
CS1	Reach II-1	Upstream of Celgar, on east bank across from Pope and Talbot crane and new clarification ponds; wind rising, creating waves; splash zone is to approximately 0.3 m depth; fine silt deposition on substrate below splash zone	30	60	10	0	8.9	88	7.9	11.2	0.074	0.085	0.074	–	–
		Large substrate sampled between 10 and 20 m downstream of original site; light periphyton growth on large rocks	0	20	50	30					0.063[b]	0.074[b]	0.15[c]	0.19[c]	–
CS2	Reach II-3	Downstream of Celgar on the west bank approximately 75 m downstream of Robson boat ramp; recognizable by old fence in water immediately upstream of site	35	55	10	0	10.2	95	8.1	11.8	0.024	0.049	0.027	0.044	0.069
		Large substrate sampled just upstream of original site (but downstream of fence); there are only small patches of large substrate at this location	10	10	40	40									
CS3	Kootenay River	Near mouth, offshore of Selkirk College property; sand bar noted in April was submerged; site somewhat protected by outer bar upstream; considerable silt on rocks below about 0.3 m depth	30	30	30	0	7.3	108	8.2	11.2	0.024	0.007	0.007	0.013	–
		Large substrate sampled at downstream end of outer bar approximately 20 m upstream of original site; bar drops off steeply to main channel considerable algal growth	0	10	30	60	10.8	–	–	12.0	0.17	0.11	0.15	0.36	–
CS4	Reach III-2	Approximately 200 m downstream of Birchbank Water Survey Station, east bank; sand bar observed in April was submerged	0	70	20	10	10.2	–	8.1	12.0	0.34	0.35	0.34	0.26	–
		Large substrate at same site but in slightly (0.3 m) deeper water; algal growth present but appears dead and/or laden with sediment	0	10	60	30					0.49	0.49	0.44	–	–

TABLE 2-2

PHYSICAL DATA FOR BENTHIC INVERTEBRATE SAMPLING SITES, COLUMBIA RIVER BIORECONNAISSANCE PROJECT
SAMPLING DATE: OCTOBER 17-18, 1992

Site	Location	Description	Substrate[a] (%)				D.O. (mg/L)	Conductivity (µohm/cm)	pH	Temp. (°C)	Velocity (m/s)				
											Replicate				
			F	G	C	B					#1	#2	#3	#4	#5
CS5	Reach IV-1	Downstream of Ryan Creek, west bank, off bar of sand mixed with slag; most of the bar sampled in April was submerged; considerable brownish growth on rocks (diatoms or dead algae)	50	20	30	0	11.0	–	8.2	11.5	0.052	0.055	0.063	0.049	0.035
		Large substrate sampled approximately 50 m upstream of original site on outer bar; approximately 30% moss cover on rock, also some algae	0	0	20	80					0.24	0.34	0.48	0.49	0.45
CS6	Reach IV-3	Approximately 20 m downstream and on opposite (west) bank from Waneta Water Sampling Station; sampled off bar composed of gravel over sand mixed with slag (20%); backeddy; considerable periphyton growth	40	50	10	0	9.2	100	7.8	11.5	0.25	0.34	0.21	0.20	0.36
		Large substrate site located approximately 15 m downstream of initial site, same bank; considerable slag accumulation beneath larger rocks	0	25	25	40					0.22	0.29	0.37	0.44	0.46

a F = fines (<2 mm)
G = gravel (2 to 64 mm)
C = cobble (64 to 256 mm)
B = boulder (>256 mm)

b Measured at replicate #1 site
c Measured at replicate #2 site

2.1.4 Sample Sorting and Identification

Norecol arranged for sorting and enumeration of the benthic invertebrate samples. Robert Saunders of Calgary, Alberta, was responsible for the sorting and taxonomy. Taxonomic identifications were taken to the lowest level possible, genus for most insects including chironomids. Representative portions of the samples were archived to form a reference collection.

The enumeration procedure employed QA/QC protocols which included resorting (repicking the debris) in 20% of the replicates. The CRIEMP committee, coordinating with the US Geological Survey, arranged for a second taxonomist (Chadwick and Associates of Littleton, Colorado) to confirm the identifications of the reference collection.

2.1.5 Statistical Analyses

Two statistical tests were used to compare benthic community composition among the different sites. One-way analysis of variance tested differences among community metrics (measurements of community composition such as species richness and average numbers of organisms). These tests were done with the TOXSTAT computer program. Entire species assemblages were compared with cluster analysis using the SIGTREE computer program (Nemec and Brinkhurst 1988).

2.2 Periphyton Community Structure and Standing Crop

2.2.1 Field Procedures

Periphyton monitoring sites were selected and marked during the site reconnaissance as described for the benthic invertebrate monitoring sites. Periphyton sites were located as close as possible to the invertebrate sites. However, where possible, the sites contained larger boulders, as these areas support the largest growths of periphyton. Selected sites were shallow enough to be accessible for sampling and photography but deep enough to reduce the possibility that the sites had recently been dewatered. Because the water level rose rapidly during the course of the survey, the samples taken on July 19 and 20 were collected by divers. Sites, characteristics and sampling dates are listed in Table 2-3.

Habitat characteristics were measured and/or visually assessed and recorded as described for the benthic invertebrate program. In addition, the sites were photographed. Photographs included a quadrat or ruler to provide scale as well as a reference point, where possible, to allow repeat photography.

At each site, samples were collected from five replicate boulders. All periphyton were removed from a 25 cm^2 area on each boulder by means of scraping with a stainless steel razor blade. The five replicates were composited in a single sample jar.

TABLE 2-3

CRIEMP STUDY PERIPHYTON SITE DESCRIPTIONS

LOCATION	DATE	SUBSTRATE	BANK HEIGHT (m)	BANK SLOPE (deg)	STABILITY	DEPTH (m)	ASPECT	WATER TEMPERATURE (C)	AIR TEMPERATURE (C)	FLOW (m/s)	pH	CONDUCT (umhos)	DO (mg/L)
Columbia R., N. Bank below Keenleyside Dam (II-1)	17-Jul-92	cobble, sand	0	15	stable	3	south	17.0	30.0	0.13	7.7	100	11.4
Columbia R., d/s Celgar (II-2)	18-Jul-92	cobble, sand	0	5	stable	2	north	16.5	30.0	0	7.8	97	8.5
Columbia R, across from Cominco gravel Pit (IV-3A)	19-Jul-92	cobble	0	5	stable	1.2	south	20.0	25.0	0.516	8.4	100	10
Columbia R., at Ryan Ck (IV-1)	19-Jul-92	cobble, sand	0	1	stable	1.8	south	20.0	25.0	0	8.0	110	9.4
Columbia R., at Birchbank (III-2) (opposite bank)	19-Jul-92	cobble, sand	1	1	stable	2	south	17.0	22.0	0.05	7.9	100	9.4
Kootenay R. near mouth (CS-3) (opposite bank)	20-Jul-92	cobble, sand	3	1	stable	2	west	20.0	20.0	0	8.2	108	9.5

The samples were processed as follows. The sample bottle was shaken to distribute the algae as evenly as possible and the composite sample was wet filtered through a glass fibre filter. Each filter was cut into thirds with a razor blade. One-third was preserved with magnesium carbonate for chlorophyll *a* analyses, dry filtered, placed in a petri dish with a tight-fitting lid, labelled, wrapped in aluminum foil to keep it dark, and frozen. One-third for biomass determination was treated similarly except that magnesium carbonate was not used. The final third of the sample was washed off the filter into a jar with distilled water, preserved with acid Lugol's solution, and labelled.

The periphyton samples were collected during the July sampling trip. Records of river flows and dam operation during and prior to the sampling trip were obtained as described for the invertebrate monitoring.

2.2.2 Laboratory Procedures

Norecol arranged for periphyton species in a one-third portion of each periphyton sample to be identified and enumerated. The periphyton taxonomist was Linde Looy of Surrey, British Columbia. Following enumeration, representative portions of the samples were archived for the reference collection.

Sample enumeration and identifications were done using an inverted microscope at 1000 power, under an oil immersion objective. The sample preparation and enumeration procedures followed Standard Methods (APHA 1989). Counting continued until at least 100 cells of the dominant species had been enumerated. However, a minimum of ten fields were counted for each sample. Quality assurance/quality control protocols specified in the enumeration methodology were followed. A second taxonomist (Zenon Environmental Laboratories, Burnaby British Columbia) confirmed the species identifications.

The remaining periphyton subsamples were sent to Zenon Environmental Laboratories for analyses of chlorophyll *a* and biomass (ash-free dry weight). Due to difficulty with the filtration and preservation, the sample from Waneta was not analyzed for chlorophyll *a*.

2.2.3 Data Analysis

A Q-mode cluster analysis was performed using periphyton species data. The test employed the CLUSTER computer program (Institute of Ocean Sciences), which is appropriate for non-replicated data.

2.3 Macrophyte Survey

Aquatic macrophytes were surveyed during the summer collecting trip (July 13 to 20). The survey consisted of travelling by boat along each shore between the Hugh Keenleyside Dam and the International Boundary. The reference reach on the Kootenay River was also surveyed. The locations of major aquatic weed beds or accumulations of moss and their approximate extent of coverage were mapped at a 1:20 000 scale. In addition, major emergent beds were photographed for comparison of changes over time. Field notes included approximations of current velocity, depth, substrate and bank characteristics in the vicinity of major weed beds.

Representative macrophytes were collected for taxonomic identifications. The samples were placed in Ziploc bags, labelled, and stored in a cooler (4°C) for transportation to Vancouver. An alternate set were dried in a plant press with two or three changes of papers. The identifications were made using Warrington's (1980) key, as suggested in the terms of reference. The dried samples were then mounted on herbarium sheets to form part of the permanent reference collection. The reference collection was forwarded to Dr. Warrington (BC Environment) for confirmation of identifications.

2.4 Sediment Contaminant Monitoring

2.4.1 Field Sampling Methods

Sediment samples were collected for chemical analyses and toxicity testing. Sediment sampling took place September 1 and 2, 1992. This sampling time was selected because of low flows in the Columbia River during safety inspection and maintenance of the Hugh Keenleyside Dam. Discharge from the dam varied from 140 to 560 m^3/s over the sampling period.

Representatives of Environment Canada met the Norecol personnel and conducted a field audit. The Norecol and Environment Canada groups sampled together at two sites designated for audit and at three additional sites where sample splits for the U.S. Geological Survey (USGS) were collected.

Table 2-4 summarizes sampling site locations and descriptions. Samples were collected from 10 of the 11 sites specified in the study terms of reference (or alternate sites). The CS3 control sites initially selected was deemed unsuitable due to occasional backflow of the Columbia River into the mouth of the Kootenay and dewatering during low discharge periods in the Kootenay and Columbia Rivers. As no suitable alternative site was quickly found, Environment Canada selected and sampled a second control site upstream of Nelson in the west arm of Kootenay Lake. No sample was collected in Reach II-4 because no submerged, fine sediments were encountered in this river section between Norns (Pass) Creek and the Kootenay River.

TABLE 2-4

SUMMARY OF CRIEMP SEDIMENT SAMPLES COLLECTED FOR CONTAMINANT ANALYSES SEPTEMBER 1-2, 1992

SITE	LOCATION	SAMPLING METHOD	SAMPLING DEPTH (m)	SAMPLE TYPE
I-1	Arrow Lake above Syringa Creek, east and west banks	Dredge	25-30	M, O, P, B, QA (duplicate), USGS
II-2	Downstream Celgar IDZ (off north parking lot)	Dredge	4-6	M, O, P, B
II-3	Robson West approximately 75 m downstream of boat launch	Dredge	6	M, O, P, B, USGS
III-1	Approximately 500 m upstream of China Creek, west bank, off beaver lodge	Scoop, dredge	0.6-3	M. O, P, B
III-2	Approximately 200 m downstream of Birchbank Water Survey Station, east bank, inside and outside sand bar	Scoop	0.6 -1.0	M, O, P, B
III-3	Second muddy cove below site III-2, east bank across from Birchbank golf course	Scoop	0.6-1.0	M, O, P, B (alternate)
IV-1	Downstream of Ryan Creek, west bank, in back eddy behind sand/slag bar	Scoop	0.6-1.2	M, O, P, B, USGS
IV-2	Downstream of Beaver Creek on west bank opposite boat launch off sand/slag bar	Scoop, dredge	1-2	M, O, P, B, USGS
IV-3A	Small bay on west bank across from Cominco gravel pit	Scoop, dredge	0.6-1.5 m	M, O, P, B, QA (triplicate), USGS

M - Metals, O - Organics, P - Particle size, B - Bioassay, QA - Splits for Environment Canada QA/QC program, USGS - Splits for U.S. Geological Survey

Prior to sampling at each site all equipment to be used for sampling or preparing composite samples was cleaned in the following manner. The equipment was washed with phosphate-free detergent and river water. It then was rinsed three times with HPLC grade acetone followed by three rinses with hexane (grade suitable for spectrophotometry or chromatography).

Depending upon water depth and distribution of the fine sediments, samples were collected either with a stainless steel Ekman dredge, a stainless steel scoop or a combination of both scoop and dredge (Table 2-4). The scooped samples collected only the surficial sediment ($\leq$5 cm). Sampling continued until it appeared that sufficient sediment had been collected for all of the required tests.

Composite samples were prepared by personnel wearing polypropylene gloves and using only stainless steel equipment. The number of individual samples per composite varied at each site depending upon the amount of material required (which depended upon whether toxicity tests were to be done and whether QA/QC sample splits were required) and the nature of the site (which affected the amount of material collected in any one sample).

The composites were prepared in the following manner. For dredged samples, the material was first placed in a tray or mixing bowl. Wherever possible, the top 5 cm of sediment (excluding the portion which had been in contact with the dredge) was removed with a spoon and transferred to a bucket. The remaining sediment was discarded. In some cases, most notably site IV-2, the dredged sediment did not retain its shape and it was not possible to determine what portion had contacted the dredge. Therefore, the entire sample was placed in the bucket. For scooped samples, the entire sample was used. When sufficient material had been collected in the bucket, the sediment was thoroughly stirred to produce a homogeneous composite.

The composited sediment was transferred to appropriate containers for the required analyses: glass jars for metals and organic analyses, Whirl-Pak bags for particle size, and acid-washed polyethylene bags for toxicity tests. All jars were precleaned by the analytical laboratories. The caps on jars for organic analyses were lined with cleaned and baked aluminum foil.

In most cases, all samples for chemical and particle size analyses, toxicity tests, and splits with Environment Canada and/or the USGS were subsampled from the same composite sample. However, at site IV-3 the sample proved insufficient for the large number of tests (triplicate samples for the CRIEMP and Environment Canada laboratories plus samples for the USGS and a single sample for toxicity tests). Therefore, it was necessary to collect additional sediment for the toxicity tests. The additional material, collected by scooping sediment from 0.6 m depth, comprised approximately half the toxicity sample.

Following subsampling of the composite sample, the CRIEMP samples were immediately transferred to coolers. The samples for metals and organic analyses were placed on dry ice, while the samples for particle size analyses and bioassay tests were placed on regular ice. At the end of each day the samples were transferred to a freezer (chemical samples) or refrigerator (particle size samples). For shipment to the analytical laboratories the samples were again placed in coolers with dry or regular ice.

2.4.2 Laboratory Analytical Methods

Zenon Environmental Laboratories Analyses

Zenon Environmental Laboratories analyzed sediment samples for metals (by Inductively Coupled Argon Plasma [ICAP]), Extractable organic halides (using a Dohrmann Model MC3 analyzer), total Kjeldahl nitrogen (using an automated colourimetric method), acid volatile sulphides (according to EPA SW846 Method 9030A), and total organic carbon (by the LECO method). Appendix 2-1 includes complete protocols employed for these tests.

Axys Laboratory Analyses

Axys Laboratory analyzed a limited subset of the samples for dioxins/furans, chlorinated phenolic compounds, and resin and fatty acids. The remaining samples were archived for possible analysis sometime in the future.

BC Environment Aquatic Toxicity Laboratory

Sediment samples for toxicity analyses were sent to Zenon Laboratories for required sieving and extraction (McDOnald 1992) and then forwarded to the BC Aquatic Toxicity Laboratory where various bioassays were conducted. Sieving was done by washing the sediment through the sieve using a spatula and the small amount of water that came with the sediment samples.

There were some delays between the time the samples were taken (September 1 and 2) and the completion of the bioassays. The samples arrived at Zenon on September 8. Sieving and extraction took another month, and the prepared samples arrived at the Aquatic Toxicity Laboratory on October 8. The various tests were completed on the following dates:

- solid phase Microtox® (125μm sieved whole sediment): October 26;
- USGS solid phase Microtox® (QA sample): October 29;
- 10-day *Hyallela azteca* (250μm sieved whole sediment): November 10;
- *Daphnia magna* (sediment extract using Columbia River water): December 9;

All samples were kept in the dark at 4°C until tested.

The solid phase Microtox® bioassay, which measures toxicity as reduction in light output by the bacterium *Photobacterium phosphoreum*, was conducted according to the protocol in the *Microtox Reference Manual* (Microbionics Corporation 1990). A model M500 Microtox was used for the measurements.

The *Hyalella azteca* bioassay was done according to the method described in Environment Canada (1990a). This test measures survival of the burrowing amphipods over a 10-day period. The test included a control treatment in which cheesecloth replaced the sediment. Results were corrected for mortality in the control treatment.

A *Daphnia magna* 48-h static bioassay was used to test acute lethality of the sediment extract. The test procedure used is described in Environment Canada (1990b).

2.4.3 Data Analysis

Where enough samples had been analyzed to allow statistical analysis (ie. the metals data), levels of selected contaminants were compared among reaches using the TOXSTAT computer program. Sites within reaches were used as replicates for this analysis.

Dioxin/furan levels were converted to 2,3,7,8 toxic equivalence units (TEQ) using the conversion factors shown in Table 2-5. This calculation provides weighted sums of the concentrations dioxin/furan congeners. Weightings (Table 2-6) are based on the relative toxicity of each congener. The calculation used BC Environment's approach of considering the concentration of a non-detectable test to equal half the detection limit.

2.5 Bioaccumulation Monitoring

2.5.1 Field Sampling Methods

The bioaccumulation sampling took place in mid July (13 to 20, 1992). Sample sites and collected organisms are enumerated in Table 2-6.

Collections generally included single (non-replicated) samples of each organism for chlorinated organics and metals analyses. Replicate caddisfly samples were collected at the Kootenay River at Glade and Waneta (IV-3) in conjunction with Environment Canada's QA/QC program.

Handling of organisms was kept to a minimum. Whenever field personal had to touch the tissues, they wore disposable polypropylene gloves. The gloves were changed for handling each new species and/or working at each new site.

TABLE 2-5

TOXICITY EQUIVALENCE FACTORS (TEF) USED TO CALCULATE 2,3,7,8 T4CDD TOXICITY EQUIVALENCES FOR SEDIMENT AND TISSUE SAMPLES

PARAMETER	TEF
Total T4CDD	--
2,3,7,8 T4CDD	1.0
Total P5CDD	--
1,2,3,7,8 P5CDD	0.5
Total H6CDD	--
1,2,3,4,7,8 H6CDD	0.1
1,2,3,6,7,8 H6CDD	0.1
1,2,3,7,8,9 H6CDD	0.1
Total H7CDD	--
1,2,3,4,6,7,8 H7CDD	0.01
O8CDD	0.001
Total T4CDF	--
2,3,7,8 T4CDF	0.1
Total P5CDF	--
1,2,3,7,8 P5CDF	0.05
2,3,4,7,8 P5CDF	0.5
Total H6CDF	--
1,2,3,4,7,8 H6CDF	0.1
1,2,3,6,7,8 H6CDF	0.1
2,3,4,6,7,8 H6CDF	0.1
1,2,3,7,8,9 H6CDF	0.1
Total H7CDF	--
1,2,3,4,6,7,8 H7CDF	0.01
1,2,3,4,7,8,9 H7CDF	0.01
O8CDF	0.001

Source: BC Environment

TABLE 2-6

SAMPLING SITES FOR TISSUE CONTAMINANTS, COLUMBIA RIVER INTEGRATED ENVIRONMENTAL MONITORING PROGRAM, JULY 13-20, 1992

SITE	CADDISFLIES	FRESHWATER MUSSELS	MACROPHYTES
Kootenay River at Grohman Narrows east of highway bridge	X		
Kootenay River at Glade	X, QA	X	
Kootenay River near mouth, north bank		X	X
Columbia River below Hugh Keenleyside Dam (II-1)		X	X
Columbia River d/s Celgar (II-2)	X	X	X
Columbia River at Robson, west bank (II-3)	X	X	X
Columbia River at Birchbank (III-2)	X	X	
Columbia River d/s Cominco	X		
Columbia River at Waneta (IV-3)[1]	X, QA	X	X

X - Sample collected
QA - Environment Canada QA/QC site
[1] - Mussels and macrophytes collected at site IV-3A

In all cases, field notes recorded details of sampling site locations and applicable conditions (sampling depth, indications of effluent plume, slag deposits, or other contamination). Sites were documented with photographs.

Emergent Caddisflies

Equipment

The caddisflies were collected with battery-operated ultraviolet light traps. Traps were designed by Environment Canada based on an original design by Kovats and Ciborowski (1989) and built by Progressive Sheet Metal of North Vancouver. Traps identical to those used by Norecol were pre-tested by Environment Canada for this study.

All equipment used to trap and handle caddisflies was stainless steel with the exception of the baskets to hold caddisflies and wash bottles which were teflon. Ultraviolet lamps were glass. Non-glass exposed parts of the lights were wrapped in teflon tape except the electrical cords which were not in contact with internal surfaces of traps.

Cleaning Procedure

Traps and buckets, as received from the manufacturer, were thoroughly scrubbed with soap and tap water to remove oil residues. Traps and other required equipment were washed in soap and tap water prior to each use. Equipment was dried with cloth towels and then rinsed with de-ionized water. Clean, dry cloth towels were used to dry equipment once again. Equipment was then rinsed with acetone from a teflon wash bottle and the acetone allowed to evaporate. Traps, buckets and ultraviolet lights were then packed into cardboard cartons and transported to the site via a van.

At the site, traps, buckets (to hold traps and dry ice) and baskets (to hold caddisflies) were removed from cardboard boxes and rinsed with hexane by means of a teflon wash bottle. Hexane drippings were collected in a pre-washed and rinsed stainless steel bowl and placed in a spent solvent container for later disposal. Polypropylene gloves were used in the field to handle trap surfaces and all handling of traps, buckets and baskets was kept to a minimum.

Field Trapping Procedures

Traps were set up at dusk at suitable locations near water as listed in Table 2-5. Between three and six traps were used at each site as follows:

NUMBER OF CADDISFLY TRAPS USED AT EACH SAMPLE LOCATION		
SITE	**DATE**	**NO. OF TRAPS**
Kootenay River at Grohman Narrows	07/19	3
Kootenay River at Glade	07/16	4
Columbia River d/s Celgar (II-2)	07/17	3
Columbia River at Robson, west bank (II-3)	07/17	3
Columbia River at Birchbank (III-2)	07/18	3
Columbia River d/s Cominco at Ryan Creek (IV-1)	07/18	3
Columbia River at Waneta (IV-3)	07/15	4

The times ultraviolet lights were switched on and switched off were recorded, together with air and water temperatures. Sampling occurred on evenings with little or no wind to ensure both that the traps function properly and that the insects collected emerged in the sampling area and were not transported from elsewhere by the wind.

Collection baskets were placed on solvent-washed aluminum foil pads within the stainless steel buckets so as to eliminate gaps between the trap cone and the teflon basket. This procedure was suggested by Environment Canada and served to prevent caddisflies from flying out of the teflon basket into the stainless steel bucket and back into the teflon basket, which might have been a source of contamination.

Dry ice was placed around the baskets to within about 5 to 10 cm of the top by means of stainless steel tongs. Lights were then switched on and left on for two to three hours, depending on the number of caddisflies trapped.

Once lights were switched off, the teflon baskets containing caddisflies were covered with baked aluminum foil. New polypropylene gloves were used to handle the baked aluminum foil. Covered baskets were then placed in a cooler on dry ice for transportation.

Sorting and Subsampling

Later the same evening in the motel room the baskets were removed one at a time from the dry ice cooler. The contents were emptied into a washed (water and de-ionized water) and rinsed (acetone and hexane) stainless steel tray. Insects other than caddisflies were removed by means of stainless steel forceps. The sorter wore clean polypropylene gloves. Each basket of caddisflies was sorted twice, by the initial sorter and checked by another person. Caddisflies were weighed into laboratory-cleaned amber glass bottles with baked aluminum cap liners (organics), acid-rinsed polyethylene jars (metals), or polyethylene jars (identification). Containers were labelled with the date, collector, location, assays (metals/organics/ID) and net weight.

Samples for organic and metal analyses were placed in a cooler on dry ice pending transfer the next morning to an electric chest freezer. Jars with samples for identification were filled with 70% ethanol and left at room temperature.

This procedure was used for the following sites: Waneta (Columbia River), Glade (Kootenay River), Robson West (Columbia River) and Celgar (Columbia River). The procedure was slightly modified by samples collected from Grohman Narrows (Kootenay River), Birchbank (Columbia River) and Cominco (Columbia River). These latter samples were frozen unpicked (sorted) and returned to Norecol's office for subsequent sorting and subsampling using otherwise identical procedures.

Shipment

Samples for analyses of organic compounds and metals were placed in two separate coolers, each containing 23 kg dry ice broken up and placed around sample containers. Coolers were rush couriered (overnight) to laboratories (Zenon for metals; Axys for organics). Laboratories were phoned and informed of the shipments with instructions to immediately place samples in a freezer. Samples for identification were returned to Norecol for furtherance to the caddisfly taxonomist for identification.

Freshwater Mussels (Unionidae)

Some preliminary sampling of freshwater mussels had been undertaken by Ministry of Environment, Lands, and Parks, and these organisms were found to accumulate chlorinated compounds. They were relatively abundant downstream of the Hugh Keenleyside Dam and in the Celgar reach and had also been observed downstream of Cominco.

Norecol collected freshwater mussels (predominantly *Anodonta oregonensis*) at seven sites listed in Table 2.5-1. Sites represented both control and effluent receiving sites. Mussels were collected by diving or snorkelling in 0.5 to 5 m during the July, 1992 trip. Mussels were selected for a representative size range and a minimum of five included as a composite for analyses. Separate samples were collected at each site for metals and chlorinated organic analyses. Mussels were collected in a net bag, washed clean of sediment, placed in clean (not solvent rinsed or baked) aluminum foil, placed inside a new zip lock bag and then on dry ice in the field to freeze quickly. Upon return from the field, samples were placed in a dedicated deep freeze until shipment. Shipment was by rush (overnight) courier to the Zenon (metals) or Axys (organics).

A separate subsample was frozen and kept for identification. Laboratories were also instructed to retain shells of mussels submitted for analyses.

Macrophytes

To provide contaminant data from another trophic level, the aquatic macrophyte *Potamogeton perfoliatus* was collected. This genus is widely distributed in Columbia River. Vegetation samples consisted of 2 to 5 g of tissue (wet weight) comprised of several "leaves". Samples generally were limited to one sample per site.

Macrophytes sampled received minimal handling. Samples were appropriately packaged (treated aluminum foil for organics, polypropylene for metals), labelled and frozen. Sample sites for macrophytes are listed in Table 2-5.

Identifications

Analyzed for contaminants were identified to species. Dr. Andrew Nimmo of the University of Alberta sorted and identified the adult caddisflies. Norecol's biologists identified the mussels and macrophytes. Their identifications were checked by Phil Lambert of the Royal British Columbia Museum (mussels) and Dr. Patrick Warrington, BC Environment (macrophytes).

2.5.2 Laboratory Analytical Methods

Zenon Environmental Laboratories

Zenon analyzed the tissue samples for metals by ICAP. Complete analytical and QA/QC protocols are listed in Appendix 2-1.

Axys Laboratories

Axys Laboratories analyzed samples for dioxins/furans and chlorinated phenolic compounds. Complete analytical and QA/QC protocols are listed in Appendix 2-1. A brief summary is included here for reference.

All dioxin/furan samples were spiked with an aliquot of ^{13}C-labelled internal standards prior to analysis. Tissue samples were ground with sodium sulphate, packed in a glass column and eluted with solvent. The extracts were subjected to a series of cleanup steps and then analyzed by gas chromatography with mass spectrometric detection (GC/MS).

BENTHIC INVERTEBRATE COMMUNITY STRUCTURE

3.1 Results

3.1.1 Spring Survey

The April 1992 survey collected a total of 98 benthic invertebrate taxa among the six sampling sites. The organisms collected included six mayfly (Ephemeroptera) taxa, nine caddisfly (Tricoptera) taxa, and four stonefly (Plecoptera) taxa. The abundances of these species varied among the six sites as indicated in Table 3-1 and Appendix 3-1.

The dominant species and taxonomic groups differed from site to site but generally included chironomids, oligochaetes, and nematodes. Chironomids comprised the majority of the organisms collected at the control site on the Kootenay River (CS3) and at the two sites downstream of Cominco, Ryan Creek (IV-1) and Waneta (IV-3) (Figure 3-1). They were also abundant at Birchbank (III-2), where they comprised about 25% of the fauna. Oligochaetes were the dominant organisms at the Robson site (II-3) downstream of the Celgar mill and were also prominent upstream of Celgar (II-1) , at Birchbank, and in the Kootenay River. Nematodes were abundant both upstream and downstream of Celgar (sites II-1 and II-3), while harpacticoid copepods comprised >8% of the organisms at all sites except Ryan Creek and Waneta. Ephemeroptera, Tricoptera, and Plecoptera species represented >10% of the organisms at Ryan Creek and Waneta but comprised <3% of the fauna at the remaining sites.

The six sites were compared with respect to several simple community metrices (measurements), including mean number of organisms per sample, species [taxa] richness (mean number of taxa per sample), and EPT index (Table 3-2). The EPT index is a comparison of Ephemeroptera plus Plecoptera plus Tricoptera to chironomids expressed as the ratio of either number of taxa or number of organisms (Klemm et al. 1990). The EPT index provides a measure of community based on the assumption that Ephemeroptera, Plecoptera, and Tricoptera are generally sensitive to pollution, while chironomids are more tolerant. Healthy communities have relatively balanced representation among these four groups, while disproportionate representation by chironomids may indicate stressed communities. In particular, certain chironomids such as *Cricotopus bicinctus*, are tolerant of metal pollution and may predominate where metal levels are high.

The average numbers of taxa per sample varied significantly ($P<0.05$) among sites (Figure 3-2). Tukey's method of multiple comparisons indicated that there were more taxa per sample at the Kootenay River (CS3), Birchbank (III-2) and Robson (II-3)

TABLE 3-1

RELATIVE ABUNDANCE OF BENTHIC INVERTEBRATES
COLLECTED FROM THE COLUMBIA RIVER, APRIL 23, 1992

TAXA	KOOTENAY RIVER	U/S CELGAR	ROBSON	BIRCHBANK	RYAN CREEK	WANETA
Nematoda	**	**	***	**	*	*
Cnidaria						
Hydra	**	*	*	**	*	*
Bryozoa						
*Cristatella mucedo**	*	*	*	*		*
Turbellaria	*	*	*	*	*	
Tardigrada	*		*	*		*
Hirudinea						
Glossiphonia complanata			*			
Helobdella stagnalis		*	*			
Piscicola					*	
Oligochatea						
Enchytraeidae	**	**	**	**		*
Naididae	***	*	***	***	*	*
Lumbriculidae	**	**	***	**		
Tubficidae	*		*			
Ostracoda						
Candona sp.		*	*			
Copepoda						
Harpacticoida	***	*	***	***		
Hydracarina						
Atractides	*		*			
Lebertia	*				*	
Sperchon					*	*
Torrenticola	*		*	*	*	
Unidentified	*	*	*	*		
Oribatei		*	*			
Pelecypoda						
Pisidium	*		*	*		
Gastropoda						
Gyraulus	*		*	*		
Hydrobiidae				*		
Lymnaeidae			*			
Valvata sincera	*		*	*		
Unidentified			*			*
Collembola		*	*		*	
Ephemeroptera						
Ameletus	*			*		*
Baetis spp.	*		*	*	**	*
Drunella				*	*	
Ephemeralla spp.	**	*	*	*	*	*
Leptophlebia	*					
Rithrogena					*	*
Tricoptera						
Anagapetus				*		

RELATIVE ABUNDANCE OF BENTHIC INVERTEBRATES COLLECTED FROM THE COLUMBIA RIVER, APRIL 23, 1992

TAXA	KOOTENAY RIVER	U/S CELGAR	ROBSON	BIRCHBANK	RYAN CREEK	WANETA
Apatania		*				
Cheumatopsyche				*		
Glossosma					*	
Hydropsyche	*			*	*	*
Hydroptila				*		
Mystacides spp.	**		*	*		
Neureclipsis			*			
Oxyethira	*					
Plecoptera						
Cultus	*					*
Chloroperlidae	*					
Haploperla						*
Podmosta				*	*	*
Heteroptera						
Sigara washingtonensis	*		*		*	
Coleoptera						
Deronectes	*		*			
Heterlimnius	*					
Optioservus	*					
Diptera						
Simuliidae						
Simulium	*	*			*	
Ceratopogonidae						*
Chelifera						*
Unidentified	*		*			*
Dolichopodidae			*			
Tipulidae						
Hemerodromia	*					
Unidentified	*					
Chironomidae						
Chironominae						
Cladotanytarsus	*			*		
Cryptochironomus			*	*	*	
Microtendipes				*	*	
Parachironomus			*			
Paracladopelma		*		*		
Paratanytarsus				*		
Paratendipes				*		*
Phaenopsectra	*		*	*		
Polypedilum		*	*	*	*	
Stempellinella	*	*				
Sublettea	*			*		*
Tanytarsus	*	*	*	*		
Tribelos			*			

RELATIVE ABUNDANCE OF BENTHIC INVERTEBRATES
COLLECTED FROM THE COLUMBIA RIVER, APRIL 23, 1992

TAXA	KOOTENAY RIVER	U/S CELGAR	ROBSON	BIRCHBANK	RYAN CREEK	WANETA
Diamesinae						
Diamesa	*	*	*	*	**	*
Pagastia				*	*	*
Potthastia gaedii group	*			*		*
Potthastia longimana group	*		*			
Othocladiinae						
Ablabesmyia	*					
Cardiocladius					*	
Corynoneura	*			*		
Cricotopus bicinctus group	*	*	*	*	*	*
Cricotopus sylvestris group			*			
Cricotopus tremulus group	*	*	*	*	*	**
Cricotopus or Orthocladius spp.	***	*	**	**	**	**
Eukiefferiella spp.	*	*	*	*	*	**
Heterotrissocladius				*		
Nanocladius	*				*	*
Orthocladiinae - unidentified	*	*	*	*	*	*
Orthocladius (Euorthocladius)	*		*	*	**	*
Paracladius (triquetra type)			*	*		
Parakiefferiella				*		
Parametriocnemus			*	*	*	
Psectrocladius	*		*			
Rheocricotopus				*		*
Smittia						*
Synorthocladius	*	*		*	*	*
Tvetenia bavarica group						*
Tvetenia discoloripes group	*			*	*	*
Tanypodinae						
Procladius			*			
Thienemannimyia group			*	*	*	*

Astericks are related to total abundance in five samples as follows:
* - present (fewer than 100 individuals)
** - 100 - 999 individuals
*** - 1000 or more individuals

FIGURE 3-1
DOMINANT BENTHIC INVERTEBRATE TAXA, APRIL 1992
Columbia River Biological Monitoring

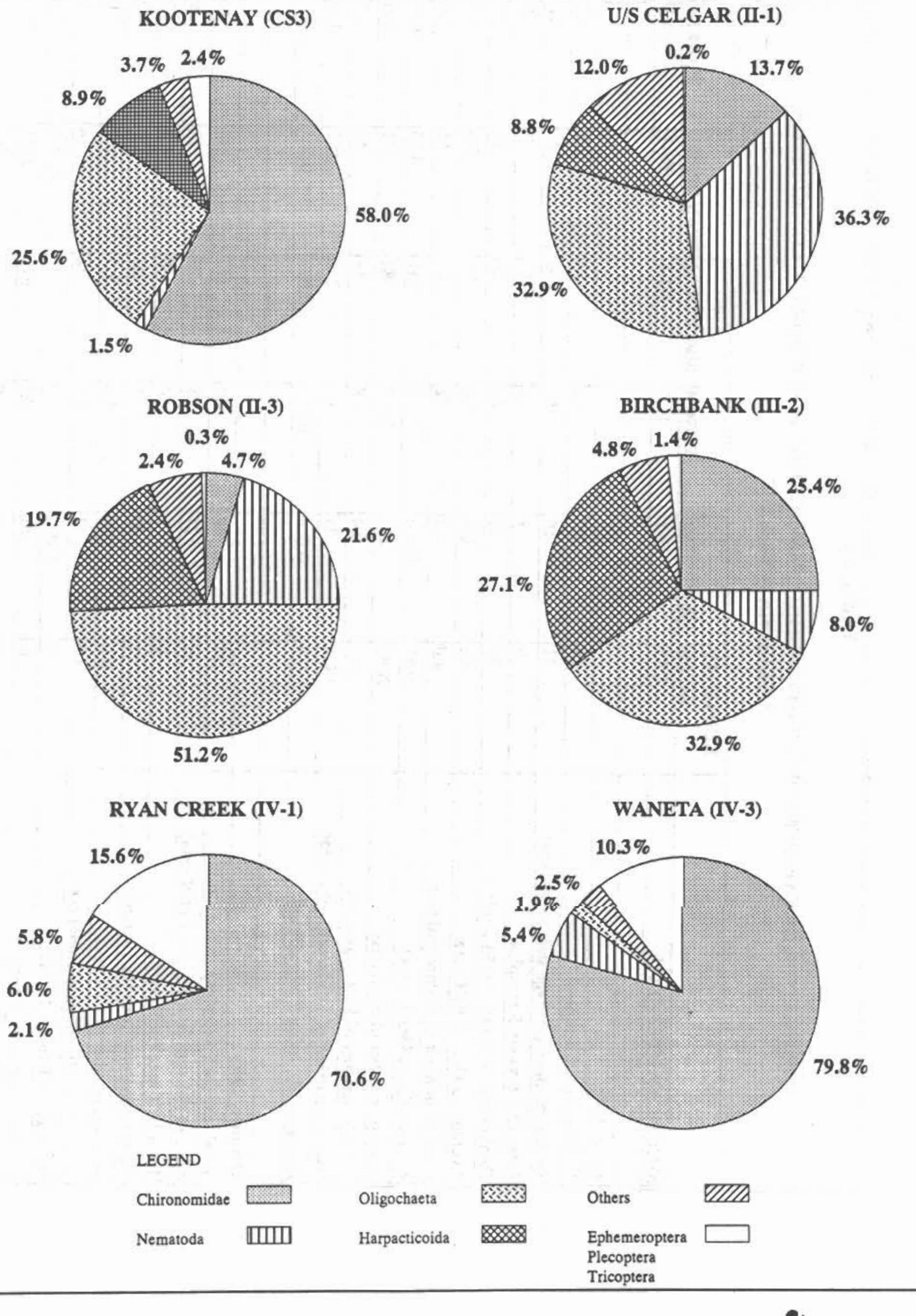


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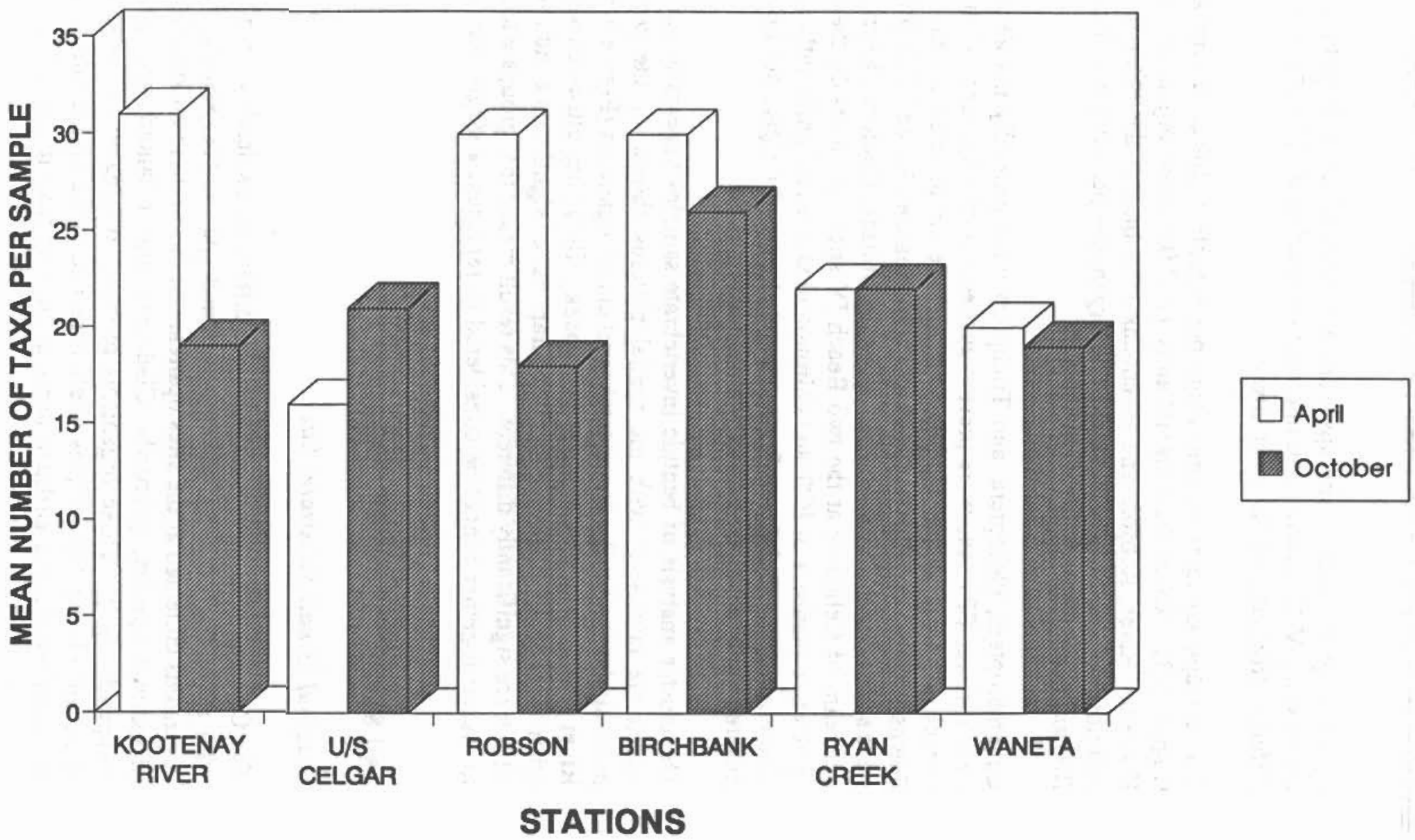
TABLE 3-2

COMPARISON OF VARIOUS COMMUNITY METRICS FOR BENTHIC INVERTEBRATE COMMUNITIES, COLUMBIA RIVER, 1992

METRIC/SAMPLE DATE	KOOTENAY RIVER CS3	U/S CELGAR II-1	ROBSON II-3	BIRCHBANK III-2	RYAN CREEK IV-1	WANETA IV-3
April, 1992						
Total taxa (in 5 samples)	55	27	51	53	35	37
Species richness (average number of taxa)	31	16	30	30	22	20
Total EPT taxa (in 5 samples)	9	2	4	10	7	8
Total chironomid taxa (in 5 samples)	21	11	20	28	17	18
Average number of EPT taxa	3.6	0.4	2.4	4.6	3.8	3.2
Average number of chironomid taxa	9.0	6.2	12	14	11	11
Average EPT Index 1 (taxa)	0.45	0.050	0.21	0.31	0.33	0.28
Average number of organisms	2683	211	2097	984	271	213
Average number of EPT organisms	64	0.4	6.8	14	42	22
Average number of chironomid organisms	1554	29	98	250	191	170
Average EPT Index 2 (organisms)	0.045	0.014	0.067	0.057	0.21	0.14
October, 1993						
Total taxa (in 5 samples)	36	42	33	42	38	30
Species richness (average number of taxa)	19	21	18	26	22	19
Total EPT taxa (in 5 samples)	0	1	0	6	1	2
Total chironomid taxa (in 5 samples)	11	22	11	22	25	17
Average number of EPT taxa	0.0	0.2	0.0	3.2	0.2	1.0
Average number of chironomid taxa	3.0	11	3.6	12	14	10
Average EPT Index 1 (taxa)	0	0.015	0	0.31	0.011	0.096
Average number of organisms	107	184	427	672	1835	780
Average number of EPT organisms	0	0.2	0	13	0.2	2.8
Average number of chironomid organisms	3.6	46	58	110	447	436
Average EPT Index 2 (organisms)	0	0.004	0	0.21	0.0004	0.007
Total EPT taxa (in two large substrate samples)	4	1	1	4	3	2

Figure 3-2. Species Richness of Benthic Invertebrates Sampled at Different Sites and Times



sites than at the control site upstream of Celgar (II-2) or Waneta (IV-3). The Ryan Creek site (IV-1) sustained an intermediate number of taxa and was not significantly different from any of the other sites.

The average numbers of organisms per sample followed a similar spatial pattern (Figure 3-3). There were significantly ($P<0.05$) more organisms per sample at the Kootenay River, Robson, and Birchbank sites than at the other three locations. In addition, there were significantly more organisms per sample at Kootenay River and Robson than at Birchbank.

Ephemeroptera, Plecoptera, and Tricoptera were generally not abundant. However, overall fewer EPT taxa were present upstream of the Kootenay-Columbia confluence (Reach II) than at the Kootenay River site or at sites on the Columbia River downstream of the Kootenay confluence (Reaches III and IV) (Figure 3-4). There were somewhat more chironomid taxa at Birchbank, Kootenay River, and Robson than upstream of Celgar or at the two Reach IV sites. As a result, the EPT index based on relative numbers of EPT and chironomid taxa was significantly ($P<0.05$) higher at Kootenay River and Ryan Creek than upstream of Celgar, but no other among-site differences were significant for this index.

The cluster analysis of benthic invertebrate samples appears to show two groupings which are consistent with the spatial patterns shown by the community metrics, particularly the distribution of total numbers of organisms (Figure 3-5). The Kootenay River (CS3), Robson (II-3) and Birchbank (III-2) sites clustered separately from the other three sites. However, the bootstrap test of significance indicated that all of the sites were significantly different. This result means that groups which visually appear to cluster together cannot be considered to represent a single community.

3.1.2 Fall Survey

Original (Small Substrate) Sites

The October 1992 invertebrate samples differed considerably from the spring samples with respect to numbers of organisms and species composition. Over 50% of the organisms collected at the sites upstream of the Kootenay-Columbia confluence were planktonic species, primarily Cladocera and calanoid and cyclopoid copepods (Appendix 3-2). These organisms probably originated in the reservoirs, and their abundance in the fall samples likely is related to the higher rate of water release from the Keenleyside and Brilliant dams in October than in April (Figure 2-2).

Since cladocerans and copepods (except Harpacticoida) are not benthic organisms, they were not included in the data analysis. When only benthic organisms were considered, a total of 86 taxa were collected in the October samples from the smaller

Figure 3-3. Mean Numbers of Benthic Invertebrates Per Sample Collected at Different Sites and Times

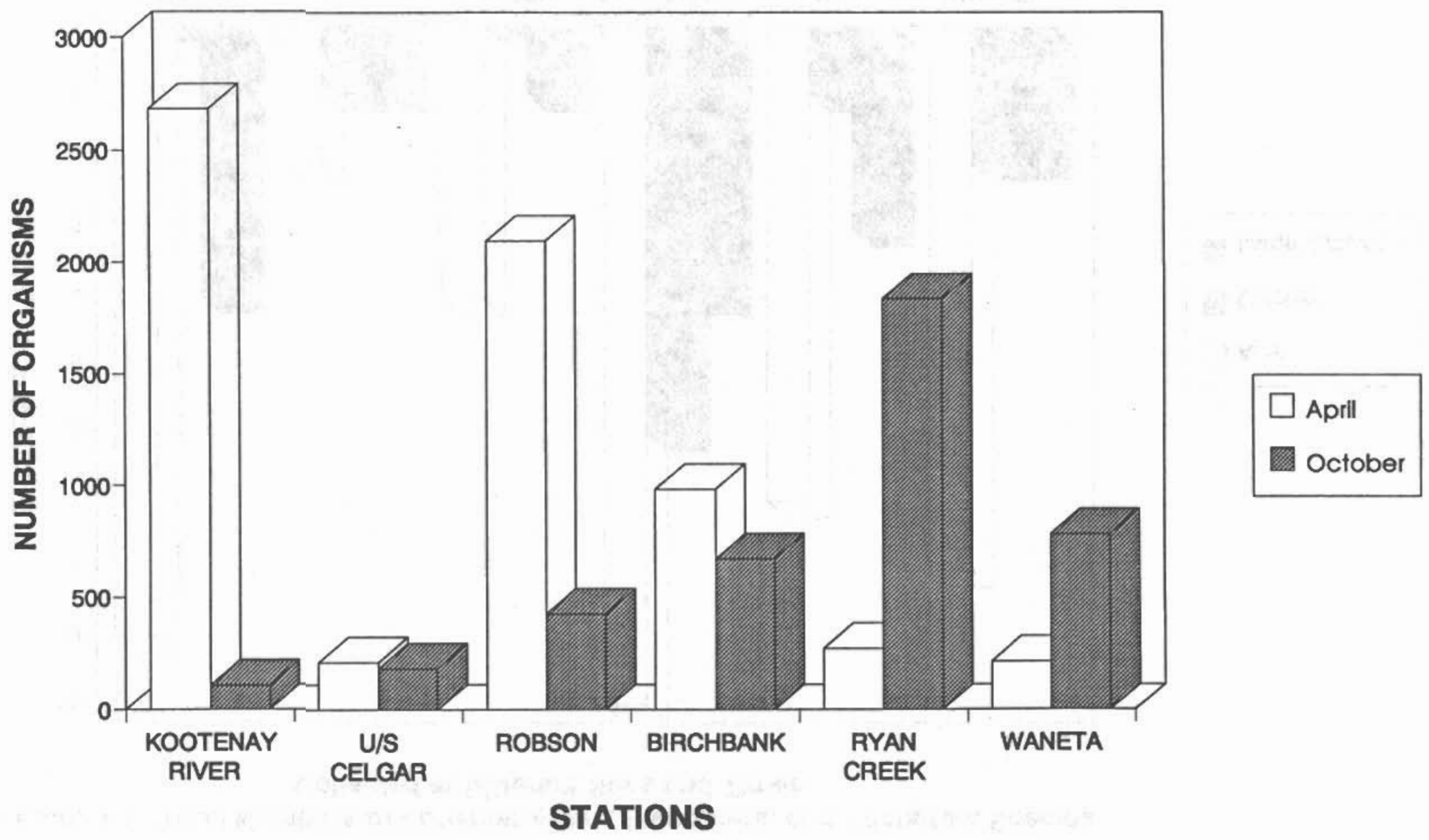
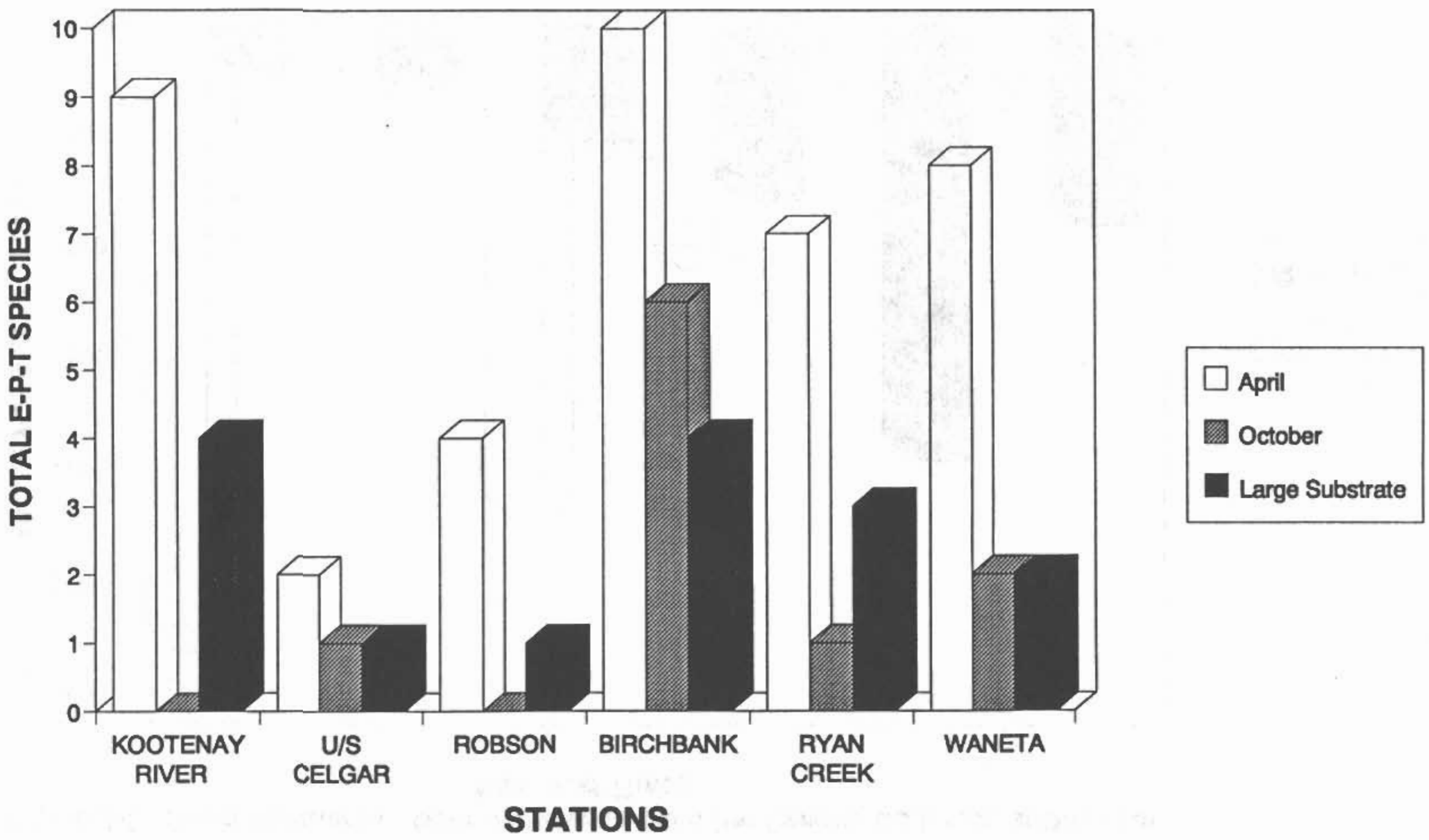
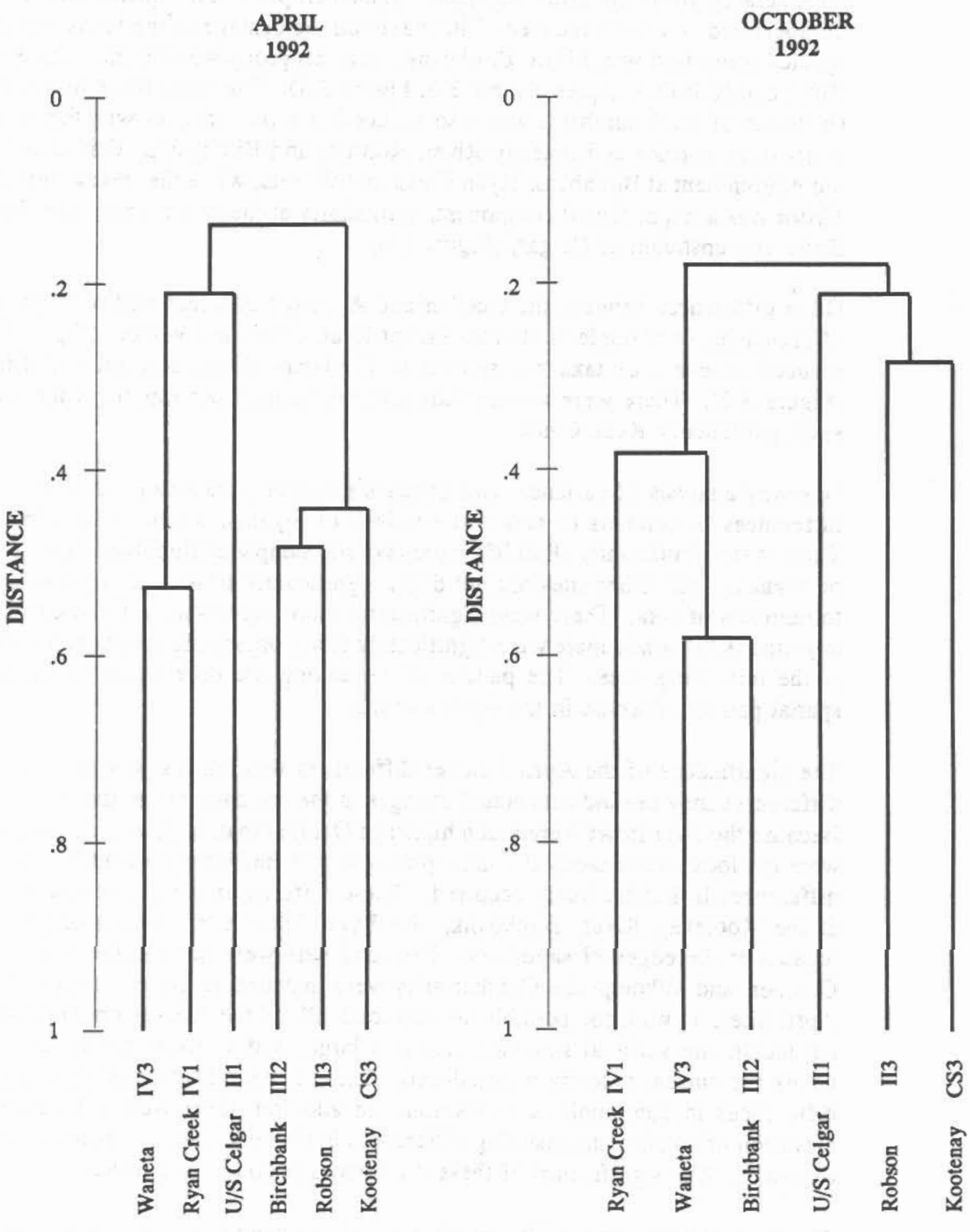


Figure 3-4. Total Numbers of Ephemeroptera, Plecoptera, and Tricoptera Species Collected at Different Sites and Times



CLUSTER ANALYSIS OF BENTHIC INVERTEBRATE SPECIES



substrate similar to that sampled in April. The faunal composition differed considerably from the April samples. Ephemeroptera, Plecoptera, and Tricoptera numbers and taxa were reduced. The maximum percentage of the fauna that the EPT species comprised was 3% (at Birchbank), and this group was absent in the Kootenay River and Robson samples (Table 3-3, Figure 3-4). The importance of chironomids (in terms of total numbers) was also reduced at most sites, as was the number of chironomid species at Kootenay River, Robson, and Birchbank. Oligochaetes were more prominent at Birchbank, Ryan Creek and Waneta, while the freshwater cnidarian *Hydra* was a major faunal component, particularly at the two control sites (Kootenay River and upstream of Celgar) (Figure 3-6).

Other differences between the October and April samples included reduced numbers of organisms per sample at all sites except Ryan Creek and Waneta (Figure 3-3) and reduced numbers of taxa per sample at Kootenay River, Robson and Birchbank (Figure 3-2). There were substantially more organisms per sample at the Reach IV sites, particularly Ryan Creek.

One-way analysis of variance with Tukey's multiple comparison showed significant differences in numbers of taxa and numbers of organisms among sites in October. There were significantly ($P<0.05$) more taxa per sample at Birchbank than at Robson or Waneta. The other sites did not differ significantly from each other with respect to numbers of taxa. There were significantly more organisms at Ryan Creek than at any other sites, while there were significantly fewer organisms at the control sites than at the remaining sites. The pattern of the among-site differences varied from the spatial pattern observed in the April samples.

The significance of the April-October differences was not tested statistically, as the differences may not indicate actual changes in the communities at the sampling sites. Because the river flows were much higher in October than in April, the sampling sites were not located in exactly the same places as they had been previously. As a result, differences in habitat likely occurred. These differences were particularly apparent at the Kootenay River, Birchbank, and Ryan Creek sites, which originally were located at the edges of sand bars. The sand bars were not visible or accessible in October, and although the October sites were matched as closely as possible to the April sites, it was not possible to duplicate all of the habitat characteristics. In particular, the surficial substrate size was larger and at Kootenay River and Ryan Creek the current velocity was reduced. These habitat differences may account for differences in community composition. In addition, there were differences in the elevation of all sites and resulting differences in the sites' history of submergence and exposure. The significance of these differences is considered in Section 3.2.

The associations suggested by the cluster analysis were also different in October than they had been in April (Figure 3-5). The three sites upstream of the Kootenay-Columbia confluence clustered in one group, and the three sites downstream of the

TABLE 3-3

RELATIVE ABUNDANCE OF BENTHIC INVERTEBRATES
COLLECTED FROM THE COLUMBIA RIVER , OCTOBER 17-18, 1993

TAXA	KOOTENAY RIVER	U/S CELGAR	ROBSON	BIRCHBANK	RYAN CREEK	WANETA
Nematoda	*	*	**	**	*	*
Cnidaria						
Hydra	*	**	**	**	*	**
Bryozoa						
*Cristatella mucedo**	*	*	*	*	*	*
Turbellaria						
Polycelis coronata	*					
Unidentified spp.	*	*	**	*	*	*
Tardigrada	*					
Oligochatea						
Aeolosomatidae						
Aeolosoma	*		*	*		
Enchytraeidae	*	*	**	**	*	*
Naididae						
Chaetogaster	*	*	**	***	***	***
Nais	*	*	*	*	**	**
Ophidonais serpentina			*			
Pristina					*	
Stylaria lacustris		*	**			
Vejdovskyella comata			*			
Unidentified		*				
Lumbriculidae	*		*			
Tubficidae	*	*				
Ostracoda						
Candona sp.	*			*		
Harpacticoida	*	*	**	*	*	*
Hydracarina						
Hygrobates	*	*				
Lebertia	*	*		*		
Sperchon					*	*
Torrenticola	**	*		*	*	
Unidentified	*	*	*	*	*	*
Oribatei	*	*	*			
Pelecypoda						
Pisidium				*		
Gastropoda						
Gyraulus	*					
Hydrobiidae						
Lymnaeidae	*	*	*			
Valvata sincera	*					
Collembola	*		*			*

TABLE 3-3

RELATIVE ABUNDANCE OF BENTHIC INVERTEBRATES
COLLECTED FROM THE COLUMBIA RIVER, OCTOBER 17-18, 1993

TAXA	KOOTENAY RIVER	U/S CELGAR	ROBSON	BIRCHBANK	RYAN CREEK	WANETA
Ephemeroptera						
Baetis spp.				*		*
Ephemeralla spp.				*		*
Tricoptera						
Anagapetus				*		
Hydropsyche				*		
Limnephilidae		*		*		
Plecoptera						
Capniidae				*		
Nemouridae					*	
Heteroptera						
Sigara washingtonensis	*	*	*		*	
Coleoptera						
Deronectes			*			
Oreodytes			*			
Diptera						
Tabanidae						
Chrysops			*			
Simuliidae						
Simulium				*		*
Ceratopogonidae			*			
Empididae						
Hemerodromia	*					
Tipulidae						
Hesperoconopa		*				
Unidentified	*					
Chironomidae						
Chironominae						
Chironomus					*	
Cladotanytarsus	*	*				
Cryptochironomus	*	*				
Micropsectra	*	*		**	**	*
Microtendipes				*	**	
Parachironomus		*				
Paracladopelma	*	*			*	
Paratanytarsus	*	*		*	*	*
Phaenopsectra					*	*
Polypedilum		*		*	*	**
Sublettea		*		*		*
Tanytarsus	*	*	*	*	*	
Unidentified		*	*	*	*	

TABLE 3-3

RELATIVE ABUNDANCE OF BENTHIC INVERTEBRATES COLLECTED FROM THE COLUMBIA RIVER , OCTOBER 17-18, 1993

TAXA	KOOTENAY RIVER	U/S CELGAR	ROBSON	BIRCHBANK	RYAN CREEK	WANETA
Diamesinae						
Diamesa				*	*	
Monodiamesa					*	
Pagastia		*		*	**	**
Potthastia	*	*	*			
Othocladiinae						
Ablabesmyia						
Cardiocladius						
Chaetocladius					*	
Corynoneura		*		*	*	*
Cricotopus bicinctus group	*	*	*	*	*	**
Cricotopus sylvestris group		*	**			
Cricotopus tremulus group				*	*	
Cricotopus or Orthocladius spp.	*	*	*	**	**	**
Cricotopus sp.					*	*
Eukiefferiella spp.	*	*	*	*	**	**
Orthocladiinae - unidentified larvae		*		*		
Orthocladiinae - unidentified pupae			*	*	*	
Orthocladius				*	*	*
Orthocladius (Euorthocladius)				*	**	**
Paracladius (triquetra type)		*				
Parametriocnemus				*		
Psectrocladius			*		*	*
Pseudosmittia			*			
Smittia			*			
Synorthocladius		*		*	*	**
Thienemaniella					*	
Tvetenia	*			*		*
Tanypodinae						
Ablabesmyia		*		*		
Thienemannimyia group		*				*

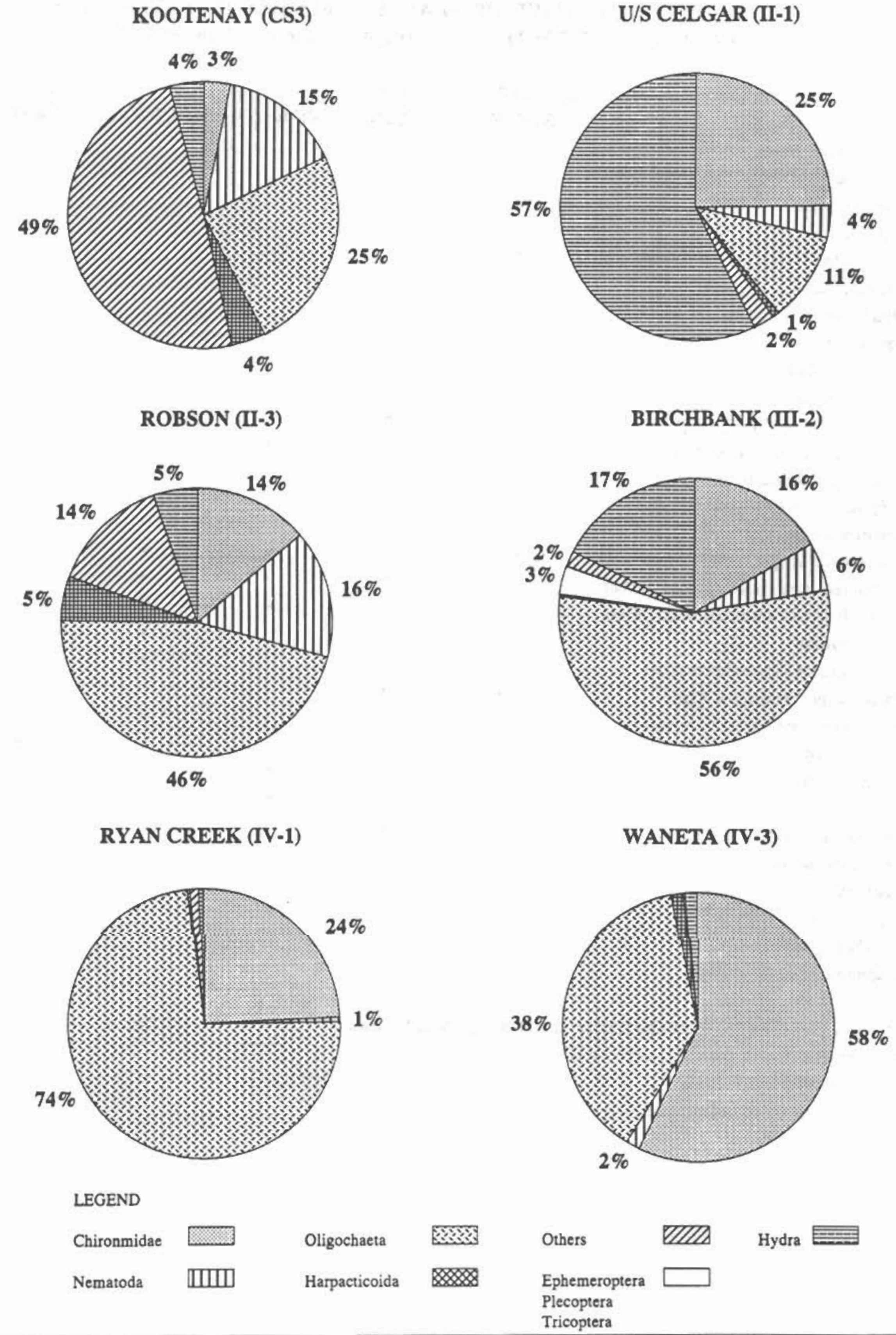
Astericks are related to total abundance in five samples as follows:

* - present (fewer than 100 individuals)

** - 100 - 999 individuals

*** - 1000 or more individuals

FIGURE 3-6
DOMINANT BENTHIC INVERTEBRATE TAXA, OCTOBER 1992
Columbia River Biological Monitoring



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confluence clustered in a separate group. As with the April samples, the bootstrap test showed all sites to be significantly different. Therefore, these groupings cannot be considered to represent "upstream" and "downstream" communities.

Large Substrate Samples

Observations of emergent caddisflies (Tricoptera), including the large numbers and diversity collected for the tissue contaminant study (Section 6) suggests that these organisms are a major component of the Columbia River ecosystem. The numbers of caddisflies collected in the April benthic samples did not confirm the perceived abundance. However, field observations suggested that the caddisflies could be more abundant in the larger rock substrate which was not sampled in April. Therefore, in October additional samples were collected from the large rock substrate.

The large substrate samples collected a total of 71 taxa including 8 Ephemeroptera, Plecoptera and Tricoptera taxa (Appendix 3-2). The large substrate sampler collected EPT species at the Kootenay River and Robson sites, whereas none of these organisms occurred in the small substrate samples (Figure 3-4). There were in total more EPT species in the large substrate samples than in the small substrate samples from Ryan Creek, while at the remaining sites there were similar numbers or fewer EPT species in the large substrate samples.

It is not clear whether the abundances of EPT species in general or caddisflies in particular are similar in the large and small substrates. Other habitat differences could have affected the distribution of these organisms. For example, Ryan Creek was the only site where there were more EPT species in the small surficial substrate than in the large surficial substrate. However, the underlying substrate composition was quite different at the Ryan Creek small substrate site (Table 3-4). In addition, there was moss growing at the large substrate site which no doubt altered the habitat characteristics.

Temporal differences most likely related to water levels appear to have a more significant effect on species composition than the size of substrate sampled. In all cases, neither the small substrate sampler nor the large substrate sampler collected as many EPT species in October as the small substrate sampler collected in April.

3.1.3 Quality Assurance/Quality Control (QA/QC)

Quality control checks on the invertebrate sorting and identification indicated overall acceptable quality. Repicking the benthic samples resulted in finding some additional organisms. The errors (expressed as a percentage of the total organisms enumerated) ranged from 1.3% to 12.7%, but the errors in only one sample of the April set (12.7%) and one sample of the October set (10.8%) exceeded the data quality objective of 10% (Table 3-5). Therefore, overall the sample sorting quality is acceptable.

TABLE 3-4

COMPOSITION OF UNDERLYING SEDIMENT COLLECTED AT BENTHIC INVERTEBRATE SAMPLING STATIONS, OCTOBER 1992

SAMPLE	GRAVEL/COBBLE >2.0 mm	SAND 0.075 - 2.0 mm	SILT/CLAY <0.075 mm
CS3L	95.7%	4.1%	0.1%
CS3S	95.4%	4.5%	0.1%
II-1L	87.2%	12.5%	0.4%
II-1S	89.2%	10.6%	0.2%
II-3L	92.9%	7.0%	0.1%
II-3S	95.6%	4.4%	0.1%
III-1L	98.6%	1.4%	<0.1%
III-1S	96.8%	3.1%	<0.1%
IV-1L	94.8%	5.0%	0.1%
IV-1S	60.3%	39.4%	0.3%
IV-3L	98.4%	1.5%	<0.1%
IV-3S	95.9%	4.1%	<0.1%

TABLE 3-5

PERCENT ERRORS ENCOUNTERED IN INVERTEBRATE SAMPLE ENUMERATION (BASED ON SAMPLE RESORTING)

DATA SET	SAMPLE NUMBER	PERCENT ERROR
April 1992	IV-1 #1	2.8%
April 1992	IV-3 #1	1.3%
April 1992	II-1 #5	5.2%
April 1992	II-2 #1	6.4%
April 1992	CS3 #1	5.7%
April 1992	III-2 #2	12.7%
October 1992	CS3 #4	10.8%
October 1992	IV-3 #1	2.3%
October 1992	II-1 #1	6.1%
October 1992	III-1 #1	3.8%
October 1992	II-3 #1	8.5%
October 1992	IV-1 #1	7.3%
October 1992 (Large Substrate)	II-1 #1	3.9%
October 1992 (Large Substrate)	III-1 #1	9.7%
April Average Error		5.7%
October Average Error		6.6%

The identification checks by the second taxonomist also indicate acceptable quality. Chadwick and Associates, who confirmed the taxonomy, offered the following comment:

> "We feel the vast majority of specimens are correctly identified and represent good identification techniques by the laboratory responsible."

3.2 Discussion

3.2.1 Significant Effects

The among-site differences in benthic invertebrate communities did not show any consistent relationship to the two major industries, Celgar and Cominco. This may have been due to the sample design and the confounding effect of physical factors rather than to an actual absence of effect from the industries. The problems associated with physical factors are considered further in Section 3.2.2.

At the Robson site downstream of Celgar (II-3), the fauna included few species and low numbers of usually "pollution sensitive" Ephemeroptera, Plecoptera, and Tricoptera. The dominant groups were the more "pollution tolerant" oligochaetes and nematodes. Dwernychuk (1988) noted similar benthic community characteristics in the reach downstream of Celgar. However, this pattern cannot be definitively attributed to the impact of the Celgar discharge, as the community at the upstream site (II-1) was similar.

The Celgar effluent may actually influence this "control" site. In the spring when flows are higher in the Kootenay River than in the Columbia River, a degree of hydraulic damming occurs which could carry effluent upstream. However, consultants to Celgar have developed a computer model which refutes the occurrence of flow reversal in the Columbia (Butcher 1992).

A more likely explanation of the similarities between upstream and downstream sites is that community composition in the Celgar reach is determined largely by physical factors. The near-shore current velocities in this reach are low, giving the area lake-like characteristics. In addition, effects of water level fluctuations caused by changes in the rate of release from the Hugh Keenleyside Dam would be most pronounced upstream of the Kootenay confluence (see Section 3.2.2).

In April the two sites downstream of Cominco had lower numbers of species and total population densities than most other sites. This pattern was not repeated in October. Although the April and October samples were not entirely comparable due to differences in the site elevations, the available evidence suggests that the Cominco discharge has not affected overall species richness or population densities at the sampling sites.

Comparison of EPT and chironomid abundances showed no apparent effect of the Cominco discharge. In April the relative abundance of EPT and chironomid taxa was more balanced downstream of Cominco. Although potentially metal tolerant *Cricotopus* species including *C. bicinctus* were abundant in Reach IV, they were also abundant elsewhere.

At all sampling sites EPT abundances were relatively low, while chironomids and also oligochaetes were abundant. These two groups are also dominant downstream in Lake Roosevelt (Beckman et al. 1985), suggesting that similar factors, likely physical, have a dominant effect on community structure throughout the river.

Comparing the benthic communities at all sites similarly failed to show any pattern related to effects of the industries. Based on the cluster analyses, the communities at all six sites were significantly different from each other. Thus, it was not possible to distinguish between differences (if any) due to industrial impacts and differences due to other factors.

3.2.2 Effect of Dams

Changes in water levels due to operation of the dams probably affected the results of the benthic community survey. The April sampling occurred during a period of low water. The sampling sites at this level would rarely be dewatered, although lower flows which may have caused brief dewatering occurred five to six weeks prior to the sampling date (Figure 2-2). Apart from these few days, the sites would have been submerged throughout the winter and spring. Thus, the communities sampled in April should have included nearly the full range of species likely to be encountered in the particular reach and substrate at that time of year.

The October sampling occurred after a summer of higher than normal flows (Figure 2-2). The water levels were much higher in October, and the original (April) sites were not available for sampling. The areas sampled would have been alternately submerged and exposed throughout the summer. The sites likely had been submerged for a maximum of four weeks at the time of the October sampling.

Lower species richness and lower total abundance of organisms is probably related to this history of dewatering. In Lake Roosevelt Beckman et al. (1985) observed that at all times of year the abundance of benthic invertebrates was lowest in zones that were periodically dewatered.

Reduced species richness and abundance likely result from loss of invertebrates during dewatering followed by slow or incomplete recolonization. Decreasing flows cause invertebrate drift which results in loss of species at some sites and possibly in their resettlement downstream (Perry and Perry 1986, Poff and Ward 1991, Voelz and Ward 1991). Stranding during dewatering results in deaths of other invertebrates (Perry and Perry 1986). Thus, the sites at elevation sampled in October likely are in an ongoing state of disturbance and recolonization.

It is possible for recolonization following dewatering to be rapid due to resettlement of organisms which entered the drift with the rising flow. However, the rate of recolonization depends in part on the availability of an algal food source. If the area has undergone frequent or prolonged dewatering which has reduced the abundance of periphyton, recolonization may be delayed (Perry and Perry 1986). In addition, the new assemblage established after disturbance may not return to its previous composition. Rather, individuals from a new recruitment may be added at a different point in the annual species succession, resulting in a new community (Rae 1987). Thus, it is not surprising that the communities sampled in October would differ from the communities sampled in April.

The effects of water level fluctuations should vary with distance downstream from the dams. The fluctuations are expected to be most extreme upstream of the Columbia-Kootenay confluence, where the water level is controlled directly by the operation of a single dam (the Hugh Keenleyside Dam for the Columbia River and the Brilliant Dam for the Kootenay River). Downstream of the confluence, fluctuations would tend to be reduced as high and low outflows from the two dams generally are not synchronized. Thus, changes in community composition downstream of the confluence could be expected.

The operation of the dams could have another potentially significant impact on the distribution of invertebrate communities among sites. Gore (1977) noted that after drawdown of the Tongue River Reservoir, Montana, many invertebrate species that inhabited the river below the dam were displaced 40 to 120 km downstream. Apparently this displacement was due to increased numbers of organisms entering the drift as flows increased. Thus, the relationship between Columbia River communities at upstream and downstream sites may change throughout the year.

3.2.3 Implications for Monitoring Program

Effects of the industries on the benthic invertebrate communities may be masked by the temporal and spatial changes in species composition related to the water level fluctuations and distance from the dams. The sampling design of the bioreconnaissance study was not adequate to distinguish clearly among these effects. It may be possible to alter the sampling design to improve the probability of detecting the effects of the industries, but some complications caused by the physical factors may be difficult to resolve.

The most serious potential problem which cannot easily be resolved by sampling strategy is the effect of displacement of organisms downstream. For example, the eggs of some species could be unable to hatch in the environment created by the Celgar or Cominco discharge, but the larvae might survive for some period if they drifted from upstream and settled in that environment. The effect would only be perceived if enough samples were taken at the right time to detect the absence of the earliest instars at the impacted sites. Such an effect is more likely at Cominco than at Celgar as the limited area upstream of Celgar is less likely to provide enough invertebrate drift to mask impacts of the industry.

If there are significant impacts from either industry on the benthic community, species redistribution through invertebrate drift is unlikely to mask all of them. The following two changes in the sampling design may help to detect industrial impacts:

1) Sample only at low flow

One variable which requires control is the elevation of the sampling sites. Samples should be collected from areas which rarely, if ever, undergo dewatering. Sampling at a constant and permanently submerged elevation will not eliminate variability related to changing water depth, which may affect periphyton productivity and consequently food availability or microhabitat for some species. Neither will site location eliminate variability due to resettlement of invertebrates which have drifted from upstream or to the loss of species which enter the drift in response to changing flows. However, these sources of variability in community structure may be reduced, while gross differences due to frequent, extensive recolonization and/or physical habitat dissimilarities at different elevations will be eliminated.

Different approaches to sampling a constant elevation are possible. One such approach is to plan the sampling time to correspond with low river flows (periods of water retention in the Hugh Keenleyside Dam and possibly in the Brilliant Dam). The probability of low flows occurring in March and April each year is high. At the request of the Department of Fisheries and Oceans and B.C. Environment, B.C. Hydro has been minimizing outflow from the Keenleyside Dam at this time to prevent kokanee from spawning on the gravel/cobble bar at the mouth of Norns Creek, which becomes exposed at low flows (Ketchum, pers. comm.). Rainbow trout also spawn in the Norns Creek fan, and attempts are being made to hold flows constant in the spring to prevent dewatering of the redds.

Obtaining comparable low flows at a second and consistent time of year is more difficult. Flows usually increase during the summer and become lower in October. October flows may not be as low as April flows, and they are less predictable. However, it may be possible to arrange with B.C. Hydro to have the flow from the Keenleyside Dam controlled at the desired level for a short period to accommodate sampling (Birch, pers. comm.). This possibility should be pursued.

An alternative to matching sampling times to river flows is to use artificial substrate samplers. Such devices have the limitation of sampling only organisms that will colonize the sampler and thus will not represent existing populations. However, they do allow the investigator to control the colonization period and to keep this period constant at all sampling sites.

If artificial substrate samplers are used, the selection of substrate will be important. Many such samplers rely on rocks and neglect the underlying sand. A majority of the organisms collected in the bioreconnaissance study were chironomids, oligochaetes, nematodes, and harpacticoid copepods which likely inhabit the sand rather than the overlying rocks. Therefore, any artificial substrates used should include a sand component.

2) *Increase the number of sampling sites*

Cluster analysis suggests that the six sites sampled represent six distinctly different benthic invertebrate communities. Such differences are not surprising considering that the six sites were distributed over approximately 55 km of river.

It is possible to distinguish between the effects of industries and other factors on benthic invertebrate communities over similar length of river, the effects of dams not withstanding. Griffiths (1991) identified seven macroinvertebrate communities in the 63-km long St. Clair River and demonstrated that sediment contaminants explained three of the communities. His interpretation was based on discriminant analyses of invertebrate data and sediment chemistry from 78 sampling sites.

The St. Clair River study included sites upstream and downstream of over 20 different industrial discharges. With only two major industries on the Columbia River, CRIEMP macroinvertebrate program should not require 78 sampling sites. However, a minimum of three sites per reach with three sites downstream of each discharge are likely necessary to determine whether similar groups of organisms occur at points downstream of the discharges.

These sampling sites should be closely matched with respect to habitat characteristics such as:

- size of overlying rock/cobble;
- size of underlying sand/gravel;
- current velocity; and
- slope.

Satisfactory matches of these characteristics may be difficult to achieve, particularly if the objective is continued sampling of the smaller rock/cobble substrate which comprised the majority of samples in the current study. This type of substrate is relatively uncommon in the study area. Sampling the larger substrate may provide more opportunity for finding comparable substrate in the various reaches. However, it is unlikely that any area between Robson and the Hugh Keenleyside Dam will have a current velocity comparable to the areas downstream.

If sampling with artificial substrates is selected, it will be easier to match habitat characteristics at the different sampling sites. It should also be possible to reduce the effects of water level fluctuations, assuming that the samplers are installed deep enough to prevent their dewatering. However, some effects of water level fluctuations will remain, notably those associated with organisms entering the drift in response to changes in flows and thus being displaced downstream. The difference in current velocity in the Celgar reach will also remain.

PERIPHYTON AND MACROPHYTE SURVEYS

4.1 Results

4.1.1 Periphyton

Community Structure

The periphyton survey identified 90 species, of which 21 were present at all six sites (Table 4-1, Appendix 4-1). The most widely distributed and abundant species included the Cyanophytes *Oscillatoria tenuis* and *Lyngbya limnetica* and the diatoms *Fragilaria crotenensis*, *Cymbella minuta*, and *Achnanthes minutissima*.

Figure 4-1 presents the cluster analysis of periphyton species. The analysis indicates that the two control sites (Kootenay River [CS3] and Columbia River upstream of Celgar [II-1]) grouped together, although there was not a high degree of similarity between the two stations. The site immediately downstream of Cominco, Ryan Creek (IV-1) clustered alone, suggesting that it is different from the other sites.

The similarity of the two control sites was due largely to the same dominant species, *Lyngbya limnetica* and *Achnanthes minutissima* at both sites. Ryan Creek differed from the other sites by having fewer species (Figure 4-2) and fewer total periphyton cells (Figure 4-3). *Achnanthes minutissima* was rare but not absent at Ryan Creek. This species has been suggested as an indicator of low metal levels (Rushforth et al. 1981, Lampkin and Sommerfeld 1982), but it has also been classified as zinc-tolerant (Say and Whitton 1981).

Standing Crop

Periphyton standing crop was measured in terms of both chlorophyll *a* and biomass (ash-free dry weight). Figure 4-4 illustrates the results of these analyses. According to both measures the periphyton standing crop appeared lower at the Celgar site than anywhere else. The standing crop at Ryan Creek was somewhat lower than at sites other than Celgar. Since the samples were not replicated, it is not possible to determine whether the among-site differences are statistically significant.

The concentrations of chlorophyll *a* at the various sites ranged from 0.078 to 1.56 $\mu g/cm^2$ (0.78 to 15.6 mg/m^2) (Table 4-2). These levels are well below the provisional objective for the Columbia River of periphyton 50 mg/m^2 chlorophyll *a* (Butcher 1992).

TABLE 4-1

RELATIVE ABUNDANCES OF PERIPHYTON SPECIES COLLECTED FROM THE COLUMBIA AND KOOTENAY RIVERS, JULY 1992

SPECIES	KOOTENAY RIVER	U/S CELGAR	D/S CELGAR	BIRCH-BANK	RYAN CREEK	WANETA
Oscillatoriales						
Oscillatoria tenuis	***	*	***	***	**	****
Oscillatoria sp.	**	*	*	*	*	
Lyngbya limnetica	***	****	**	***	*	****
Lyngbya sp.	*			*		
Chroococcales						
Agmenellum glauca (Merismopedia)	***	***	***	**		
Anacystis limneticus (Chroococcus)	*	*				*
Anacystis elachista (Aphanocapsa)		***				
Gomphosphaeria pallidum (Coelosphaerium)		*	*	*		
Gomphosphaeria nagelianum (Coelosphaerium)		*		*	*	*
Pennales						
Fragilaria crotenensis	**	***	**	**	**	**
Fragilaria construens	**	***	**	**		**
Fragilaria leptostauron	*	*	*			*
Fragilaria sp.	*	**	*	**	**	*
Gomphonema acuminatum var. coronatum	*					
Gomphonema constrictum	*	*	*	*		
Gomphonema sp.	*	*	*	**	*	*
Didymosphenia geminata	*	*	*	*		*
Cymbella affinis	**	*	*	**	*	*
Cymbella minuta	**	**	**	**	**	***
Cymbella mexicanum	*	*	*		*	*
Cymbella prostrata	*	*				
Cymbella spp.	*	*	*	*	*	*
Tabellaria fenestrata	*	**	*	*	*	*
Tabellaria flocculosa		**	*			
Surirella angusta				*		
Surirella (possibly linearis)			*			
Surirella sp.	*	*	**	*		*
Navicula cryptocephala	*	**	**	**	*	**
Navicula radiosa		*	*	*		**
Navicula spp.	**	**	**	**	**	**
Nitzschia sp.	**	*	*	*	*	**
Pinnularia gibba	*	*	*	*		*
Achnanthes minutissima	***	***	**	**	*	***
Achnanthes flexella	*	**	**	*	*	*
Achnanthes sp.	*	*	*	*		
Synedra ulna	*	*	*	*	**	**
Synedra sp.			*			
Cocconeis placentula	**	*	*	*	*	*
Caloneis sp.		*	*	*		
Eunotia pectinalis		*	*	*		
Epithemia sorex	*	*				*
Epithemia turgida	*	*		*		*

TABLE 4-1

RELATIVE ABUNDANCES OF PERIPHYTON SPECIES COLLECTED FROM THE COLUMBIA AND KOOTENAY RIVERS, JULY 1992

SPECIES	KOOTENAY RIVER	U/S CELGAR	D/S CELGAR	BIRCH-BANK	RYAN CREEK	WANETA
Epithemia sp.		*	*	*		*
Neidium sp.			*			
Rhopalodia gibba	*	*	*			
Diatoma heimale	*	*	*	*		
Stauroneis sp.			*			
Asterionella formosa	*	*		*	*	**
Cymatopleura solea		*				*
Ceratoneis arcus						*
Frustulia rhomboides	*					
Frustulia sp.		*				*
Pleurosigma/Gyrosigma sp.		*				
Chlorococcales						
Ankistrodesmus falcatus	*				*	
Pediastrum boryanum	**					
Pediastrum sp.		*		*		
Scenedesmus dimorphus	*	*	*			
Scenedesmus quadricauda	*	*				
Scenedesmus sp.	*	*	*	*		*
Botryococcus braunii		*	*			
Zygnematales						
Cosmarium sp.	*	*	*	*	*	*
Mougeotia sp.	*	*	*	*	*	*
Spirogyra sp.		*				
Spondylosium planum		*				
Desmid sp.	*		*	*	*	*
Rhizochrysidales						
Diceras phaseolus			*			
Ulothricales						
Ulothrix sp.			*	*		
Tetrasporales						
Gloeocystis ampla						*
Oedogoniales						
Bulbochaete	*	*				
Nostocales						
Family Rivulariaceae	*					
Ochromonadales						
Dinobryon divergens	*	**	*	*	*	*
Dinobryon elegantissimum		*				*
Dinobryon sp.	*	**	*	*	*	*
Dinokontae						
Ceratium hirundinella	*					
Peridinium inconspicuum	*	*	*	*	*	*
Peridinium sp.						*
Centrales						
Cyclotella kutzingiana	**	**	*	**	*	*

TABLE 4-1

RELATIVE ABUNDANCES OF PERIPHYTON SPECIES COLLECTED FROM THE COLUMBIA AND KOOTENAY RIVERS, JULY 1992

SPECIES	KOOTENAY RIVER	U/S CELGAR	D/S CELGAR	BIRCH-BANK	RYAN CREEK	WANETA
Cyclotella bodanica	**	*		*	*	**
Cyclotella michiganiana				*		
Cyclotella sp.			*			
Melosira italica	*	*	*	*		
Melosira varians	*	**			**	*
Melosira undulata	*				*	
Rhizosolenia longiseta				*		*
Euglenales						
Euglena sp.	*	*				*
Cryptomonadales						
Chroomonas acuta		*				*
Siphonocladales						
Cladophora sp.	*					*
Volvocales						
Eudorina elegans						*

Asterisks indicate abundance as follows:

* - 500 or fewer cells per square cm
** - 5,000 cells per square cm
*** - 50,000 cells per square cm
**** - 500,000 or more cells per square cm

FIGURE 4-1
CLUSTER ANALYSIS OF PERIPHYTON SPECIES
Columbia River Biological Monitoring

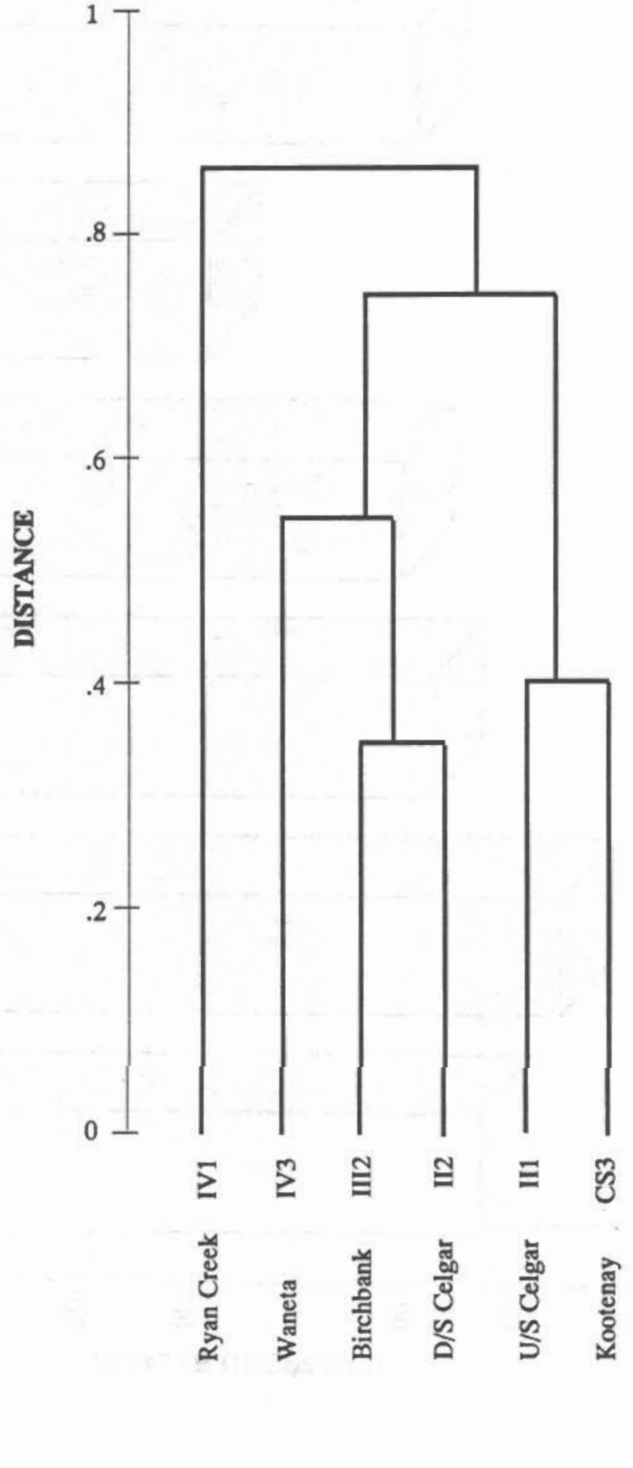

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Figure 4-2. Total Numbers of Periphyton Species at Various Sites in the Columbia and Kootenay Rivers, July 1992

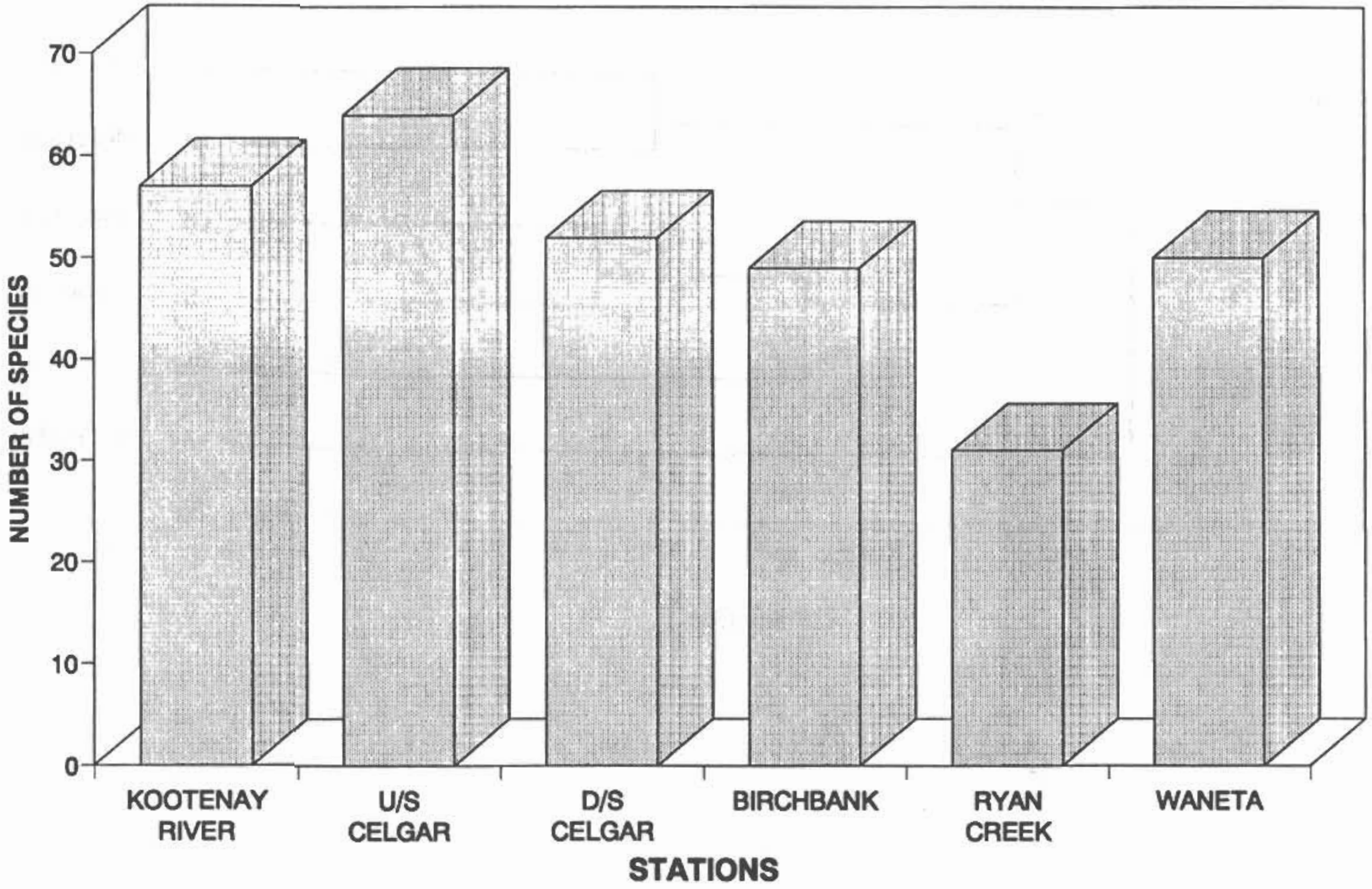


Figure 4-3. Total Numbers of Periphyton Cells at Various Sites in the Columbia and Kootenay Rivers, July 1992

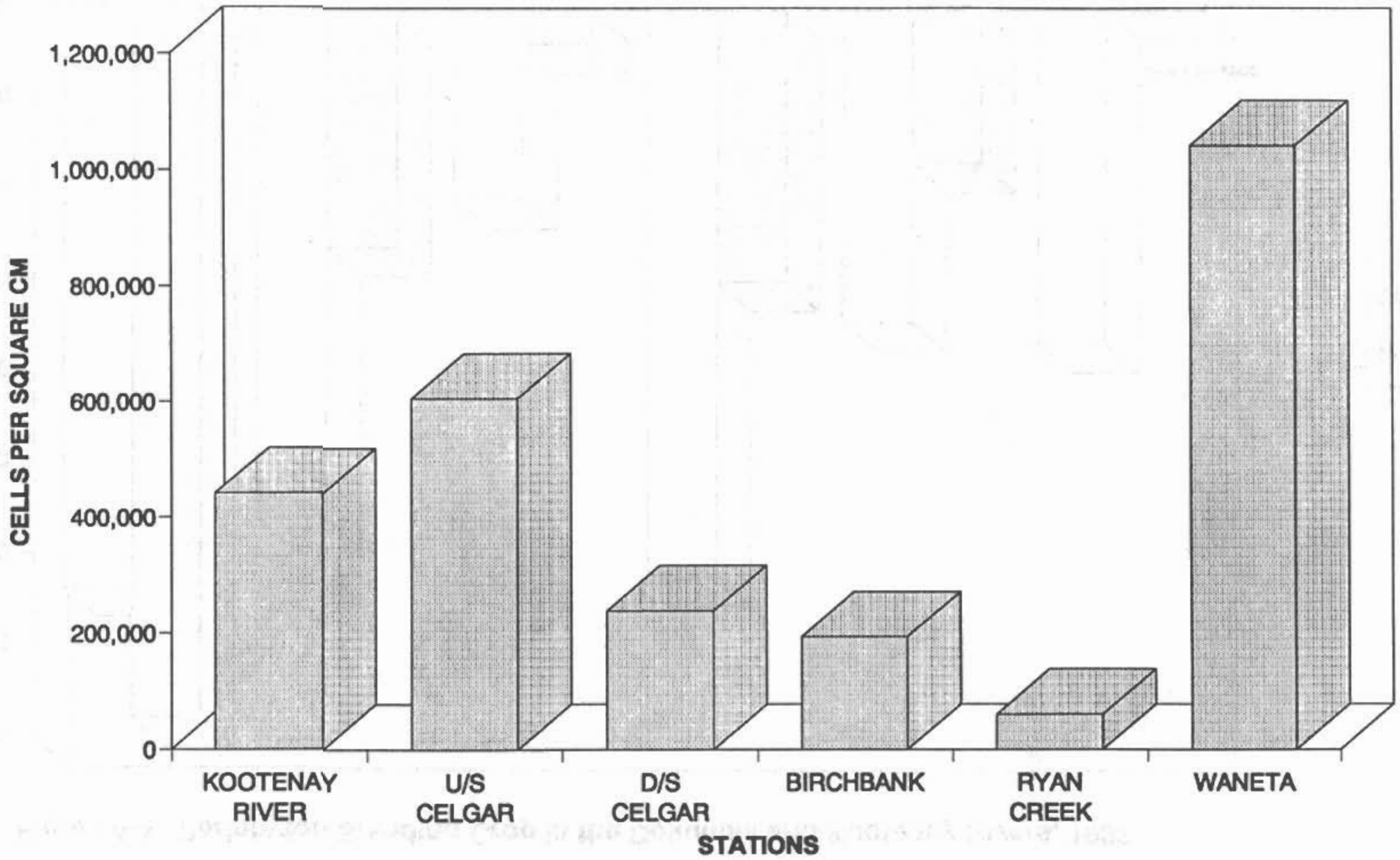


Figure 4-4. Periphyton Standing Crop in the Columbia and Kootenay Rivers, 1992

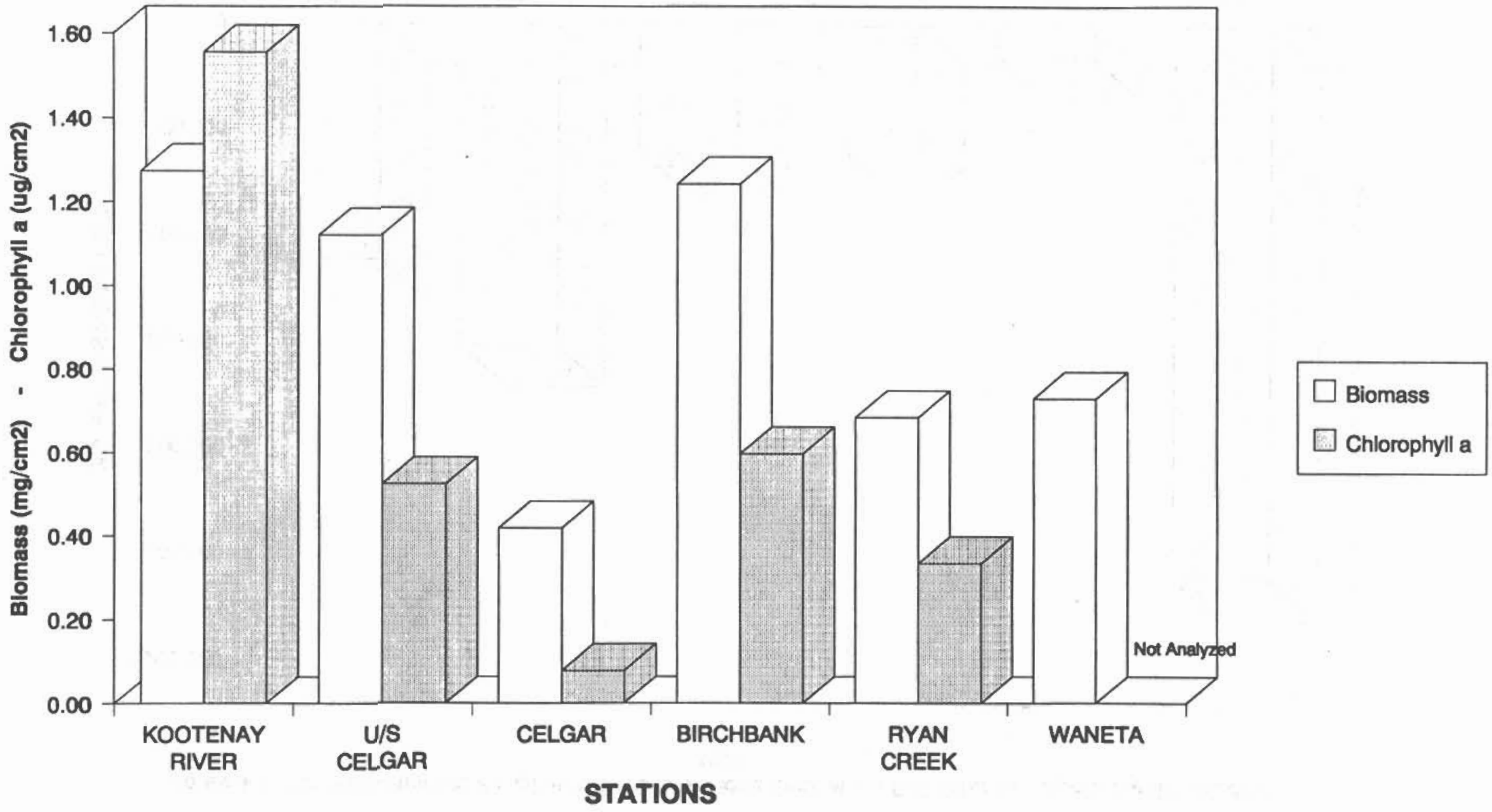


TABLE 4-2

PERIPHYTON STANDING CROP IN THE COLUMBIA AND KOOTENAY RIVERS, JULY 1992

STATION	CHLOROPHYLL A ug/cm2	BIOMASS mg/cm2
Kootenay River (CS3)	1.56	1.27
Upstream of Celgar (II-1)	0.52	1.12
Downstream of Celgar (II-2)	0.078	0.42
Birchbank (III-2)	0.60	1.24
Ryan Creek (IV-1)	0.33	0.68
Waneta (IV-3)	NA	0.73

NA - Not analyzed

4.1.2 Macrophytes

The macrophyte survey identified six species of vascular aquatic plants, *Potamogeton perfoliatus* (formerly *P. richardsoni*), *P. crispus*, *P. pusillus*, *Elodea canadensis*, *Ranunculus aquatilis*, and *Myriophyllum sibricum* (formerly *M. exalbescens*). The most abundant and widely distributed species were *P. perfoliatus* and *E. canadensis*. The other two *Potamogeton* species were also present throughout the study area. *P. pusillus* often occurred in association with the filamentous green alga *Nitella* sp. *R. aquatilis* was found only at a site downstream of Beaver Creek which received runoff from a dairy farm. *M. sibricum* occurred only at the mouth of the Kootenay River.

The distribution of macrophytes throughout the study area is mapped in Figure 4-5A/B. Table 4-3 summarizes the dimensions of all macrophyte beds and notes pertinent habitat characteristics.

The distribution of macrophytes appeared to be controlled primarily by physical habitat factors. All macrophyte species occurred in areas of relatively low current velocity where some fine sediments were deposited.

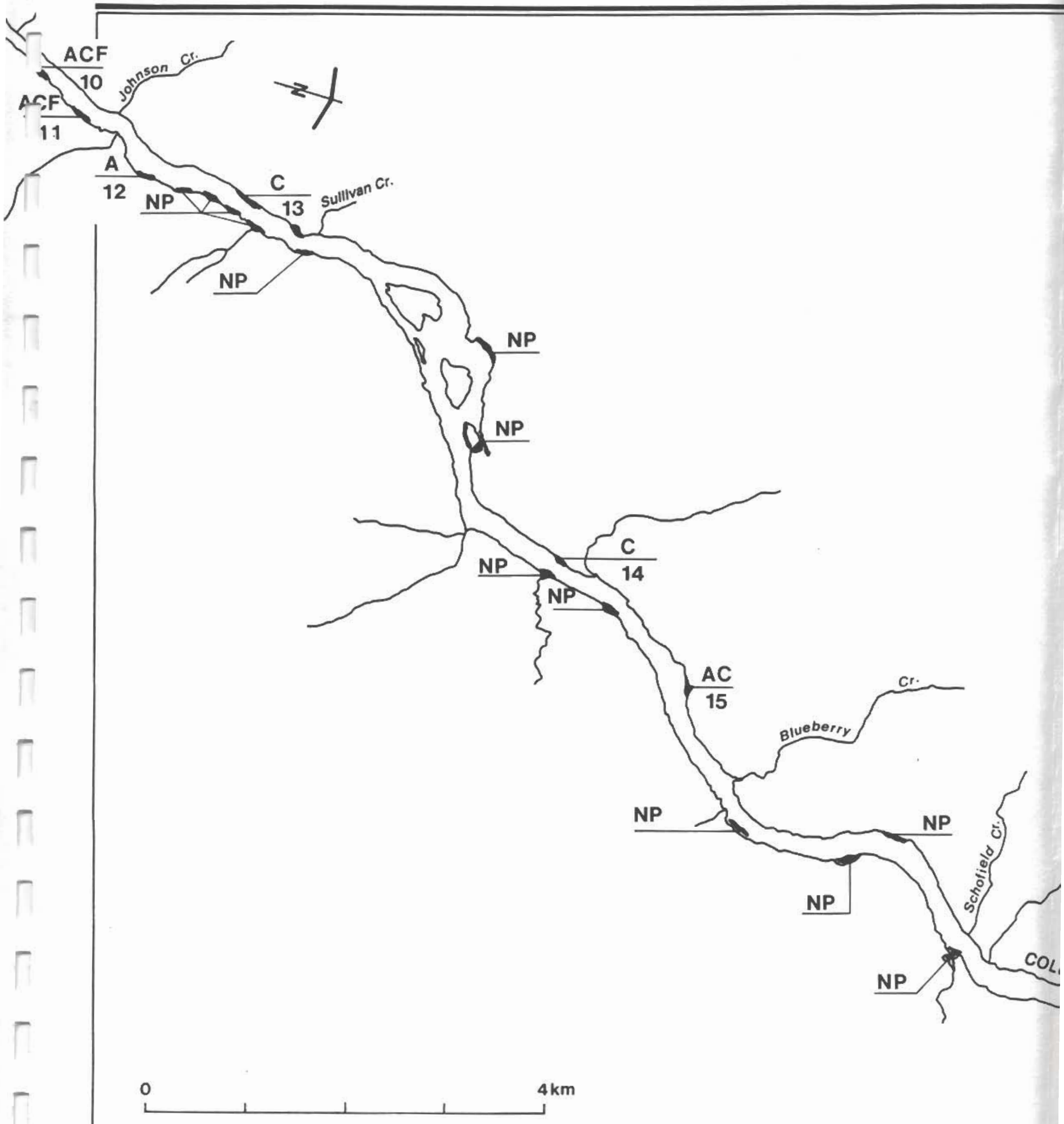
The distribution of macrophytes (other than moss) did not appear to be related to industrial discharges. The Celgar reach (both below the mill and upstream to just below the Hugh Keenleyside Dam) was different from the rest of the study area. It contained a particularly dense growth of *E. canadensis* near the mill (upstream of the outfall) and dense growth of the filamentous alga *Nitella* near the mill and below the dam.

One plant species did occur almost extensively and exclusively downstream of Cominco. This species was a bryophyte (moss). Its distribution is mapped in Figure 5-4B, but it probably is not as completely delineated as the distribution of the macrophyte beds. The high water at the time of sampling combined with the low growth form made the moss difficult to see. Observations made during the April invertebrate and September sediment collections suggest that the distribution of moss downstream but not upstream of Cominco is more extensive than the map indicates.

4.2 Discussion

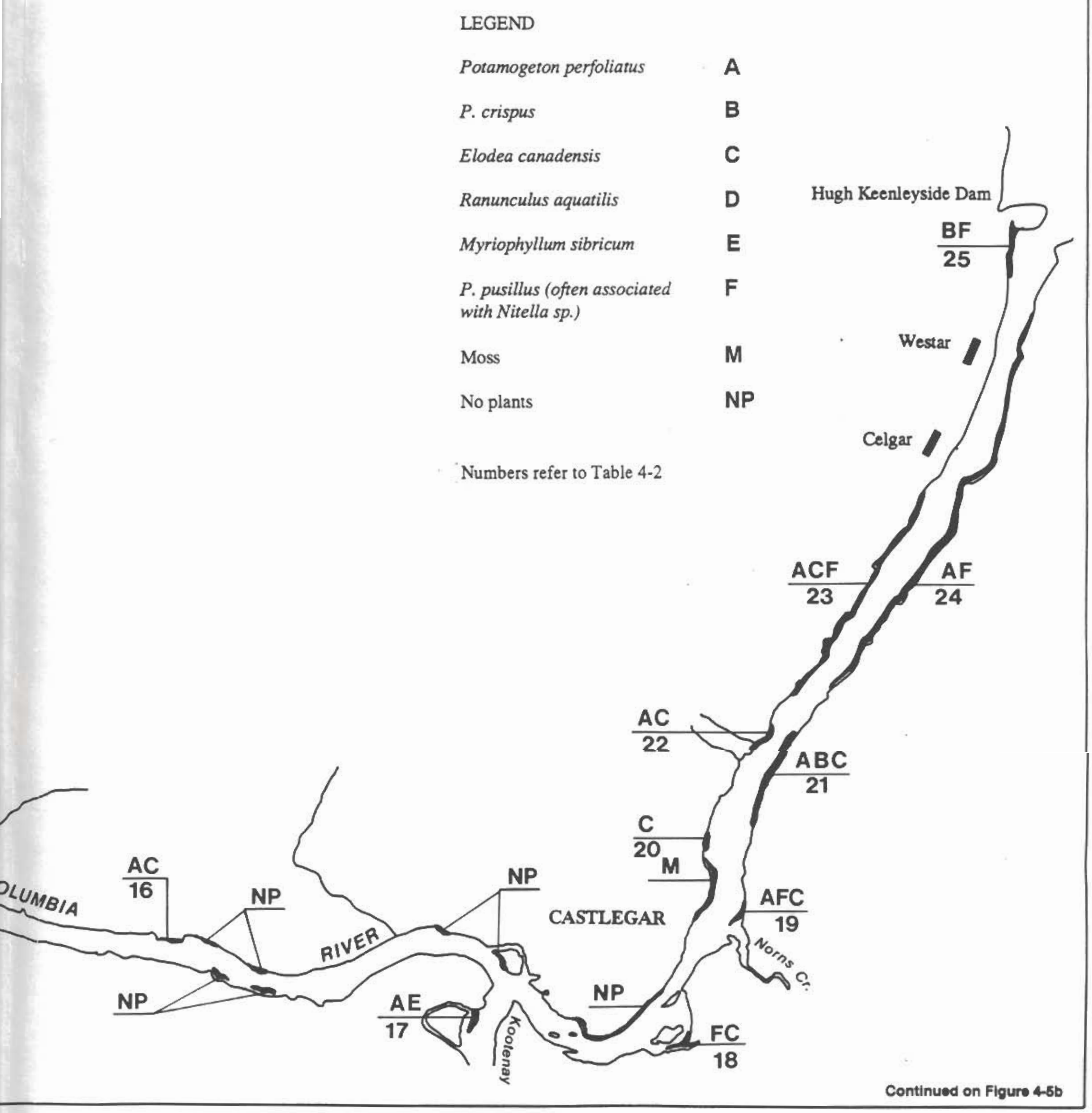
4.2.1 Significant Effects

Without replication and therefore without the ability to undertake any statistical tests it is difficult to form conclusions about the impacts of the industries on periphyton. However, the data showed no gross effects. Lower periphyton standing crop at the two sites immediately downstream of Celgar (II-2) and Cominco (Ryan Creek, IV-1) suggest that there may be some impacts from the industries on the algae. The lower


ACF
10
Johnson Cr.
ACF
11
A
12
NP
C
13
Sullivan Cr.
NP
NP
NP
C
14
NP
NP
AC
15
Blueberry Cr.
NP
NP
NP
Schofield Cr.
NP
COL
0
4km

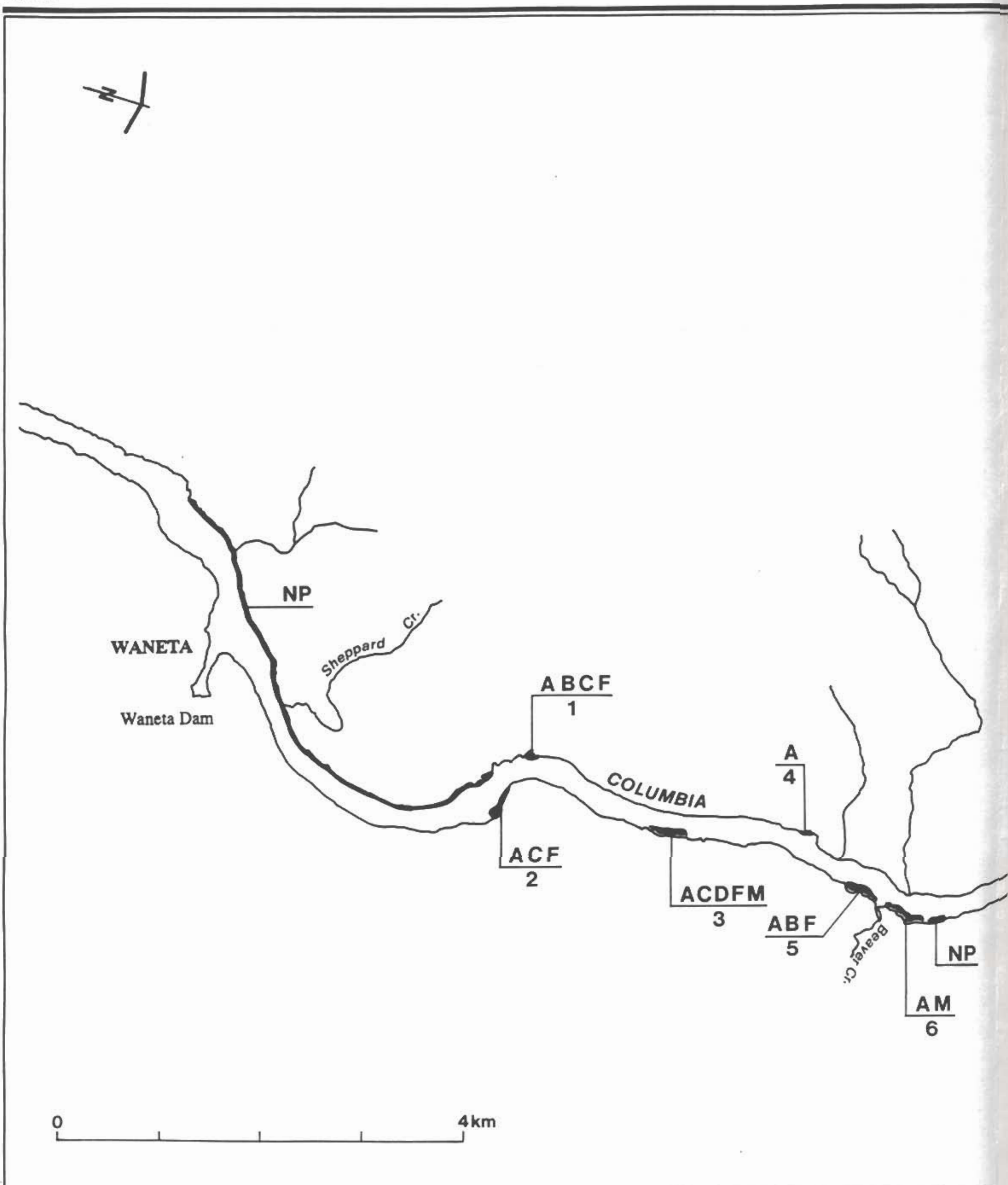
MACROPHYTE DISTRIBUTION

Columbia River Biological Monitoring



Continued on Figure 4-5b

NORECOL

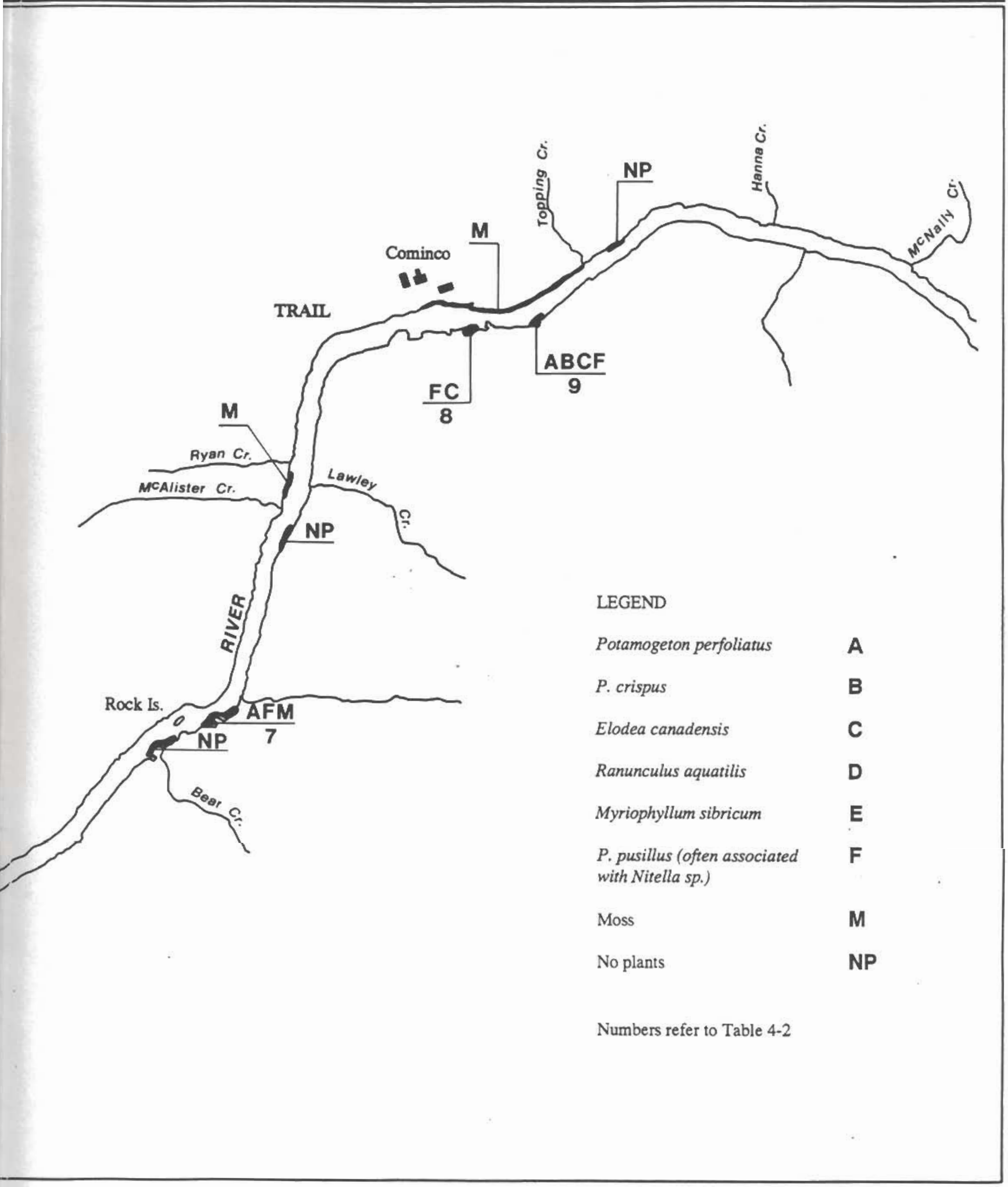


N
NP
WANETA
Waneta Dam
Sheppard Cr.
ABCF
1
ACF
2
COLUMBIA
A
4
ACDFM
3
ABF
5
Beaver Cr.
NP
AM
6
0
4km

FIGURE 4-5b

MACROPHYTE DISTRIBUTION

Columbia River Biological Monitoring



NORECOL

TABLE 4-3

AQUATIC MACROPHYTE BED LOCATIONS AND PHYSICAL DESCRIPTIONS

LOCATION*	DISTANCE FROM SHORE (m)	WIDTH (m)	LENGTH (u/s-d/s) (m)	DEPTH (m)	CURRENT	SUBSTRATE
d/s Keenleyside dam, W. bank immediately below dam [25]	5-30	30-60	50	0.7-10	very low	sand, mud scattered cobble
d/s Keenleyside dam, W. bank to 1 km d/s of dam [25]	5	20-30	1000	0.5-10	very low	sand, mud, some cobble
d/s Keenleyside dam, E. bank to Robson; patchy 1 m centres [24] [21]	10	10		1-5	low	sand, cobble
d/s Westar offshore from dolphins [23]	30	10	600	2-8	very low	sand, mud, some cobble
N end of Celgar [23]	10	5	100	2	very low	sand
Celgar [23]	10	30	200	1-10	very low	fine mud, sand
d/s Celgar, 0.5 km [23]	30	10	500	2-10	very low	mud, sand
d/s Celgar, 0.8 km on points patchy distribution [23]	30	n/a	300	5	very low	sand, cobble
1.6 km u/s Robson to Robson, W. bank [22]	10	10-15	1600	2-6	low	sand
Robson ferry dock, W. bank [20]	5	patches	50	2.5-3	low	sand
Robson ferry dock, E bank [19]	5	patches	100	0.5-8	low	sand
d/s Waldy mill, E. bank back channel [18]	5-10	patches	600	0.3-1	very low	sand, mud
Kootenay mouth, N. bank [across from 17]	5-10	patches	10 x 3	1-3	moderate	sand, cobble

TABLE 4-3

AQUATIC MACROPHYTE BED LOCATIONS AND PHYSICAL DESCRIPTIONS

LOCATION*	DISTANCE FROM SHORE (m)	WIDTH (m)	LENGTH (u/s-d/s) (m)	DEPTH (m)	CURRENT	SUBSTRATE
Kootenay mouth, S. bank [17]	5-25	1-6	300	1.5-3	low	sand, cobble
1.1 km u/s Kinnaird, W. bank in bay; small patches [16]	5	1	30	2-6	low	sand
1.2 km d/s Kinnaird, W. bank [d/s 16]	5	1-2	30	2	moderate	cobble
Station III-1, patches [15]	5	1	20	1-3	moderate	sand
Lower China Creek, N. bank patches [14]	5	1	10	3-4	moderate	sand
Birchbank hydrograph stn small patches [13]	2-5	<1	n/a	1	moderate	sand, cobble
0.6 km d/s Birchbank stn S. bank; 1 patch [12]	5	<1	n/a	1	moderate	sand, cobble
1.8 km d/s Birchbank stn S. bank, patches [11]	5-15	<1		0-2	moderate	sand, cobble
300 m d/s Murphy Crk, S. bank [10]	10	15	30	0.5-2	moderate	sand, mud
Bay at Sunnydale, patches [9]	5	2	n/a	2	low	mud, sand
u/s Gyro Park [8]	2-5	15	30	0.5-1.5	very low	mud, sand
u/s Rock Island, N. bank, patches [7]	2-5	<1	n/a	3	moderate	sand
Beaver Creek, E. bank [6] [5]	5-10	3	30	3	very low	sand, mud

TABLE 4-3

AQUATIC MACROPHYTE BED LOCATIONS AND PHYSICAL DESCRIPTIONS

LOCATION*	DISTANCE FROM SHORE (m)	WIDTH (m)	LENGTH (u/s-d/s) (m)	DEPTH (m)	CURRENT	SUBSTRATE
Beaver Creek Park, W. bank [4]	5-10	<1	30	2-2.5	low	sand
Cominco Dairy [3]	2-10	30	30	1-3	low	sand, cobble
Station IV-3A [1]	5-10	30	30	1-5	very low	sand, cobble, mud
d/s Cominco gravel pit, E. bank [2]	2	patches	n/a	0.5-3	moderate	sand, cobble

* Reference location map in Section 5

species richness at Ryan Creek supports the assumption of some industrial impact at this site. However, other explanations of the differences are possible, including local differences in physical habitat or simply patchy algal distribution. For example, divers collecting freshwater mussels near the Celgar outfall noted extensive algal growth, which suggests that other factors may have affected chlorophyll *a* and biomass in the Celgar periphyton sample.

The only obvious effect of the industries on aquatic macrophytes is the presence of extensive growths of moss downstream of Cominco. Except for one small patch noted near Castlegar in July but not found again in September, moss was not observed upstream of Cominco. The distribution of the other macrophyte species appeared to depend upon the availability of suitable substrate and current conditions, and no effect of the industrial discharges was apparent.

4.2.2 Implications for Monitoring Program

The limited effort allocated to the periphyton survey makes evaluation of this component difficult. The data do suggest some reduction in species richness and/or standing crop immediately downstream of the two industries. However, the differences are not considered gross effects. Further periphyton sampling based on natural substrates is unlikely to be capable of documenting subtle changes.

The fluctuations in water level which confounded the results of the benthic invertebrate survey are likely to affect periphyton distribution and productivity even more strongly. Periphyton are unable to move with the receding water or retreat into in the sediment. Therefore, unless some species are capable of recovering from desiccation, the periphyton community at higher elevations will be in a perpetual state of recolonization. Periphyton at lower elevations which are not dewatered will also be affected by changes in water level because the water depth affects light penetration. Thus, at all elevations productivity, if not species composition, may be affected by water level fluctuations.

The effects of physical factors likely would mask anything but gross impacts of the industries, which the bioreconnaissance study did not detect. As a result, an expanded periphyton sampling effort based on natural substrates is unwarranted.

However, periphyton sampling using artificial substrates should be considered. The bioreconnaissance study data do suggest possible industrial effects on periphyton species composition and/or standing crop. Use of artificial substrates would reduce habitat variability associated with roughness, size, and other characteristics of rocks. More important, the artificial substrates could be attached to floats, thus reducing the effects of water level fluctuations. Under these controlled conditions, it may be possible to detect the more subtle effects of industries and changes in these effects over time.

SEDIMENT CONTAMINANTS AND TOXICITY

5.1 Results

5.1.1 Sediment Contaminants

Metals

Metal concentrations were determined in all sediments except the sample from Birchbank (III-2). Results for detectable metals are presented in Table 5-1, and complete results are given in Appendix 5-1.

Concentrations of many metals were elevated at the three sites in Reach IV downstream of Cominco (Ryan Creek, D/S Beaver Creek, and Waneta) as compared with levels at the upstream and control sites. Figure 5-1 illustrates the distribution patterns of lead and zinc, two of the major metals known to be present in the Cominco effluent. Concentrations of these metals were one to two orders of magnitude higher at the sites downstream of Cominco than at the remaining sites. Figure 5-1 also shows that copper concentrations were one to two orders of magnitude higher at these sites than elsewhere. Smith (1987) reported that Cominco had discharged copper prior to 1983 but since then has recycled the effluent stream which contained copper.

One-way analysis of variance was used to test the significance of differences in lead and zinc levels among river reaches using the two or three sites per reach as replicates. The two control sites were considered a "reach" for this test. The levels of both lead and zinc in Reach IV (downstream of Cominco) were significantly ($P<0.05$) higher than levels of these metals in the other reaches. Data for other metals did not meet the assumptions for analysis of variance (normality, homogeneity of variance) and were not tested statistically.

Figure 5-2 illustrates the distribution patterns of arsenic, cadmium, chromium, and mercury in sediments. The figure shows that arsenic, cadmium, and mercury levels followed a distribution pattern generally similar to that of lead, zinc, and copper. Chromium, which Smith (1987) noted can be present in the effluent from Cominco's fertilizer plant, was elevated in sediments at Beaver Creek (IV-2) and Waneta (IV-3A) as compared with other sites. However, the overall range of chromium levels was narrow compared with that of the other metals noted.

Some of the variability of metal levels within Reach IV may be attributed to differences in the sediment composition at the three sites. Zinc, copper and arsenic,

TABLE 5-1

CONCENTRATIONS (ug/g dry wt.) OF METALS AND OTHER PARAMETERS IN SEDIMENTS OF THE COLUMBIA/ KOOTENAY RIVER SYSTEM, 1992

PARAMETER	NEC ARROW L.	EC ARROW L.	KOOTENAY LAKE	CELGAR (II-2)	ROBSON (II-3)	U/S CHINA CREEK (III-1)	LOWER BIRCHBANK (III-3)	RYAN CREEK (IV-1)	D/S BEAVER CREEK (IV-2)	WANETA (IV-3A)
TOC	19050	23650	26000	10900	6000	5920	4670	15700	1970	13367
TKN	1290	1295	2130	444	<30	346	284	684	140	777
Ag	<1	<1	1	<1	<1	<1	<1	2	17	4
Al	36650	38850	19600	8900	7140	7850	7270	18400	11300	13433
As	8.8	11	11	1.6	1.3	2.2	2.0	26	55	18
Ba	374	392	162	91.0	78.1	68.2	64.8	377	1540	618
Ca	7565	7415	7030	5610	5620	5460	5730	11000	33000	13800
Cd	1.1	1.2	4.5	0.3	0.3	0.7	0.5	7.1	6.0	9.8
Co	16.8	18.4	8.5	6.0	4.4	4.8	4.6	10.8	32.9	9.0
Cr	26.7	40.2	28.6	42.2	43.9	25.1	22.1	41.9	55.9	51.7
Cu	48.7	52.4	28.1	11.3	27.0	10.3	8.3	209	2520	466
Fe	41350	46250	21300	14300	12500	15800	14900	29100	86700	32233
Hg	0.06	0.07	0.06	<0.05	0.08	<0.05	<0.05	0.68	0.49	1.48
K	10800	11100	4250	2170	1670	1750	1610	2660	2050	2957
Mg	11050	11550	7230	4980	3770	4230	3960	7710	3910	5343
Mn	710	894	316	214	203	201	200	402	1720	396
Mo	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.2	13.1	1.9
Na	1105	1080	424	377	364	299	300	574	1280	565
Ni	48.1	53.1	19.6	18.8	13.8	14.2	11.4	32.3	24.3	18.8
P	1575	1440	1160	1010	1000	1040	1220	1880	2430	1383
Pb	68	81	176	8	12	30	15	576	546	535
S	388	422	2740	763	352	438	336	2440	3030	3240
Sb	1.3	1.2	1.6	<1.5	<1.5	<1.5	<1.5	3.0	8.9	2.4
Sn	3.5	9.5	4	2	3	<2	3	4	5	3
Sr	89.7	89.2	54.8	59.0	54.5	47.6	46.8	95.1	170	85.0
Zn	150	161	539	57.9	96.8	103	90.2	1130	6520	1990
EOX	<2.5	<2.5	4.1	<2.5	<2.6	6.2	<2.5	2.6	<2.5	<3.0
Acid soluble sulfide	<6	<6	60	9	9	15	12	70	21	93

Figure 5-1. Concentrations of Copper, Lead, and Zinc in Sediment from the Columbia/ Kootenay River System, 1992

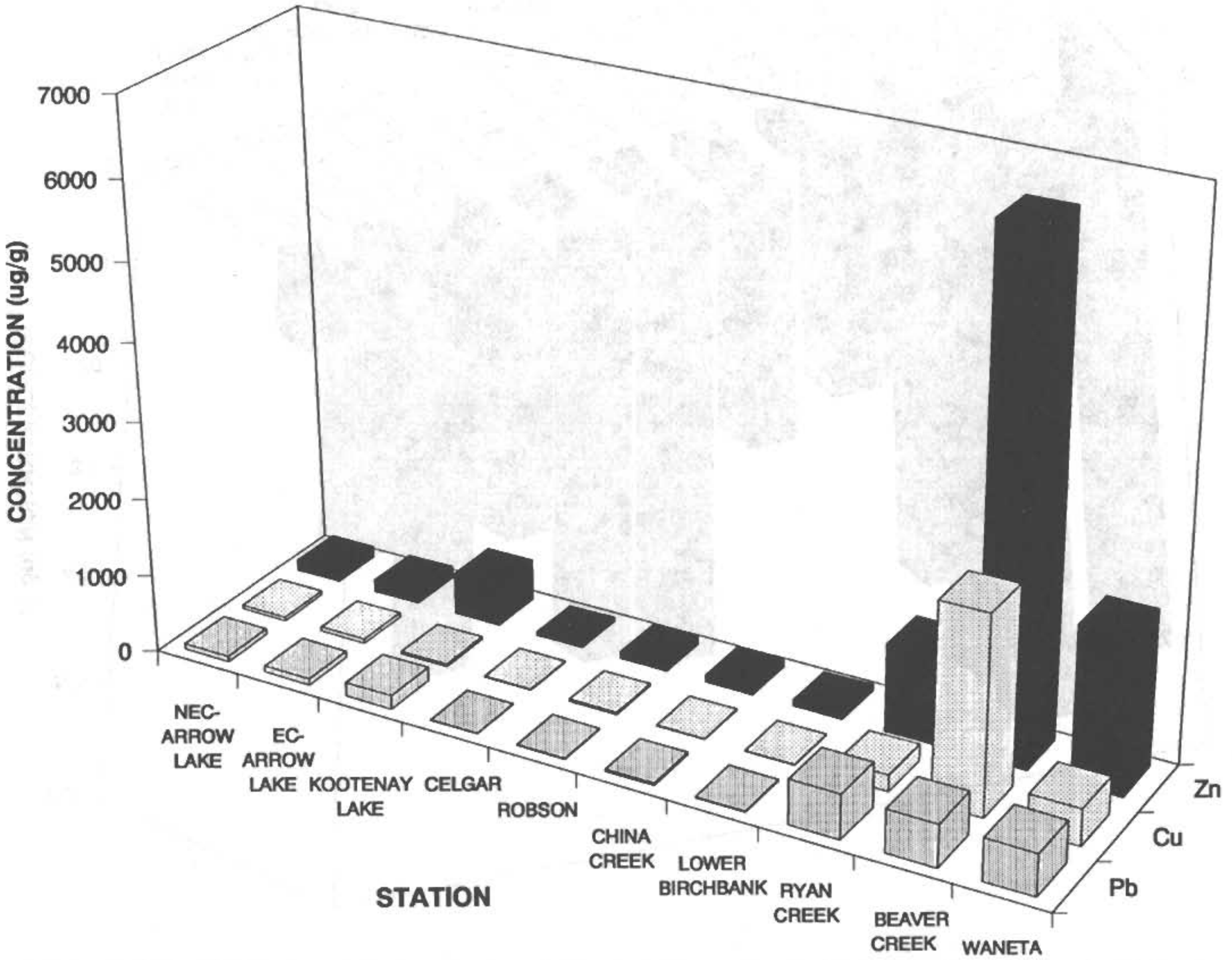
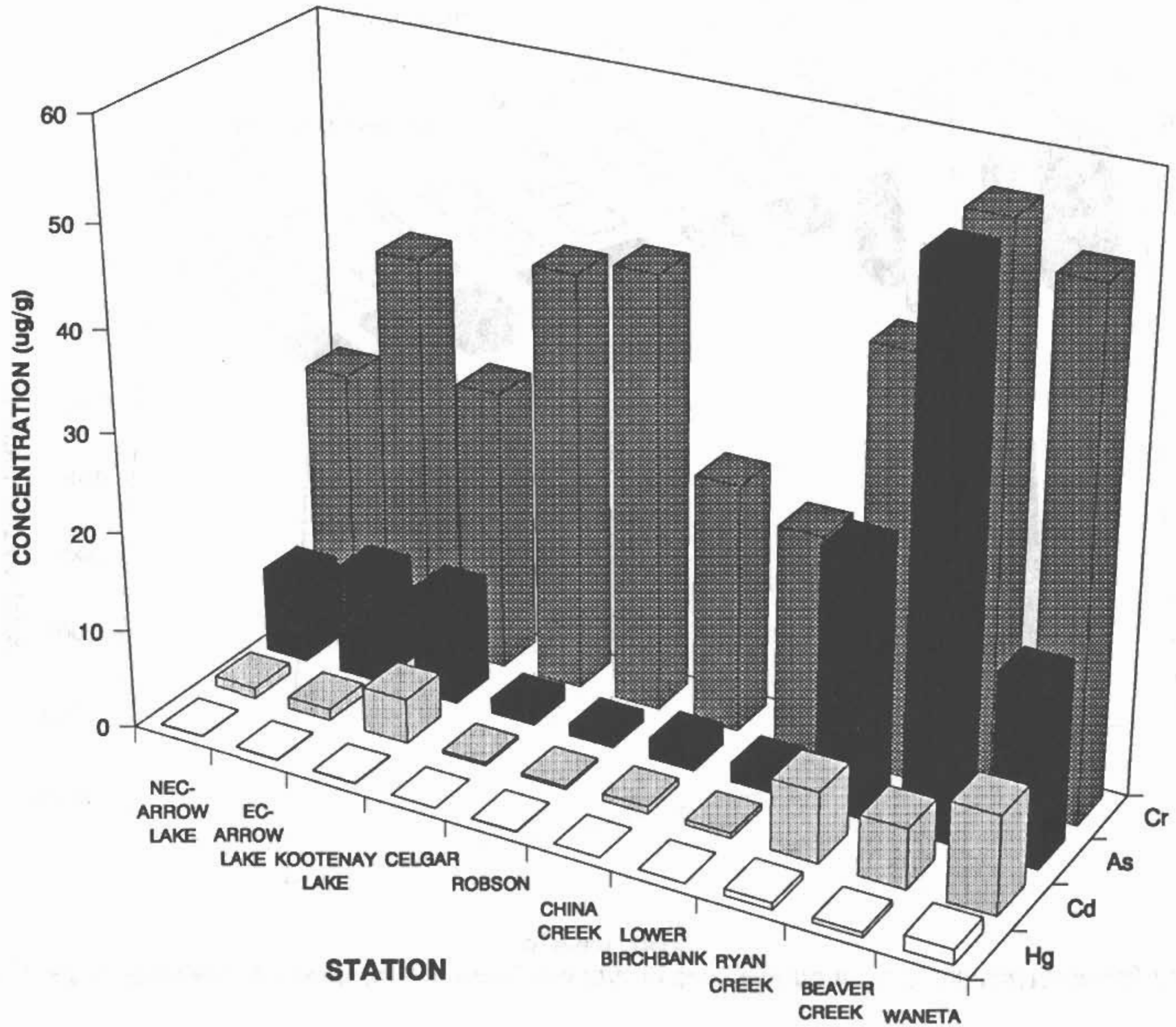


Figure 5-2. Concentrations of Other Metals in Sediments from the Columbia/ Kootenay River System, 1992



as well as iron, barium, manganese and molybdenum were particularly elevated at Beaver Creek (IV-2). Zinc and copper are significant components of slag which visually appeared to constitute a major portion of the sediment at this site. Conversely, the highest mercury concentration occurred at Waneta (IV-3A), where the sediment had the highest proportion of silt-clay particles (Table 5-2). Mercury tends to be associated with sediment fines (Derksen 1985).

Figures 5-1 and 5-2 and Table 5-1 show that levels of most metals were higher at the control sites in Arrow and Kootenay lakes than at the stations in the Columbia River upstream of Cominco. Sediment grain size was considerably finer at the lake sites than at the river sites (Table 5-2). These data suggest that the finer particles with associated metals settle in the lakes. The dams curtail sediment transport downstream. Thus metals mobilized from mineralized areas in the upper Columbia and Kootenay drainage basins are trapped in the lakes. Levels of sediment-associated metals are reduced in the Columbia River downstream of the dams and only increase when there is a significant new source of metal input.

Dioxins and Furans

Dioxins and furans were analyzed only in sediments from the two control sites and from immediately downstream of the Celgar diffuser (II-2), Lower Birchbank (III-3), Ryan Creek (IV-1) and Waneta (IV-3A). The analytical results are presented in Table 5-3 and Appendix 5-2. The results are summarized in tetrachlorodibenzo-para-dioxin (TCDD) toxic equivalence units (TEQ) and plotted in Figure 5-3.

Figure 5-3 indicates elevated TCDD TEQ immediately downstream of Celgar. The major contributor to the TEQ is 2,3,7,8 tetrachloro-dibenzofuran [T4CFD] (Table 5-3). Mah et al. (1989) and EVS Consultants (1990) noted this furan to be the major congener in sediments downstream of Celgar and other pulp mills in British Columbia.

The concentration of 2,3,7,8 T4CDF found at the Celgar site was 210 pg/g (dry weight). Other investigators have found variable levels of 2,3,7,8 T4CDF in sediments from the Celgar reach. Mah et al. (1989) reported 2,3,7,8 T4CDF concentrations decreasing from 640 pg/g 300 m downstream of the Celgar discharge to 100 pg/g 1.3 km downstream of the discharge. B.C. Hydro (cited in Butcher 1992) reported concentrations up to 330 pg/g, while EVS Consultants (1990) found a maximum concentration of only 39 pg/g. EVS Consultants attributed the difference to the low percentage of total organic carbon in their samples.

The samples from all sites contained at least traces of 2,3,7,8 T4CDF. The highest concentration encountered anywhere but the Celgar site was 61 pg/g at Waneta (IV-3A). Other T4CDF concentrations measured at downstream sites were 8.3 pg/g at Lower Birchbank (III-3) and 5.3 pg/g at Ryan Creek (IV-1). Levels at the control

TABLE 5-2

SAND-SILT-CLAY CONTENT OF SEDIMENT SAMPLES FOR CONTAMINANT ANALYSES, COLUMBIA RIVER STUDY, SEPTEMBER 1992

LOCATION	SITE NO.	COLLECTOR	% SAND (63um to 2 mm)	%SILT (2 um to 63 um)	%CLAY (<2 um)
Arrow Lake	I-1	EC	21.8	34.0	44.2
Arrow Lake	I-1	NEC	23.6	38.0	38.4
Kootenay Lake	--	EC	46.5	32.8	18.8
Celgar	II-2	NEC	76.4	19.5	2.7
Lower Birchbank	III-3	NEC	96.2	2.8	1.0
Ryan Creek	IV-1	NEC	65.6	24.0	4.1
Waneta	IV-3A	NEC	67.5	26.4	6.1

EC - Environment Canada
NEC - Norecol Environmental Consultants

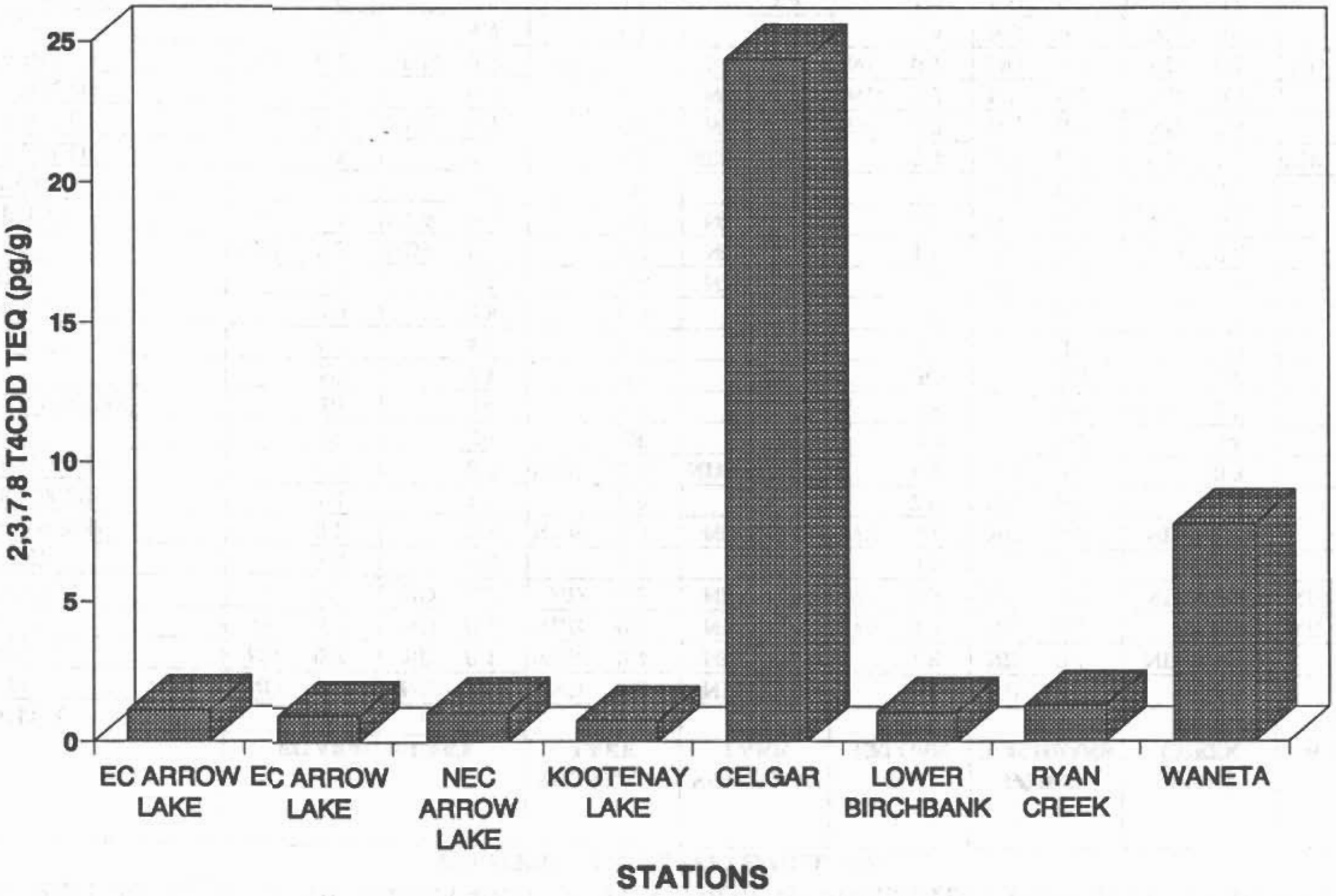
TABLE 5-3

CONCENTRATIONS (pg/g dry wt.) OF DIOXINS AND FURANS IN SEDIMENTS COLLECTED FROM THE COLUMBIA RIVER AND KOOTENAY LAKE, SEPTEMBER 1992

PARAMETER	EC ARROW LAKE I-1	EC ARROW LAKE (DUP.)	NEC ARROW LAKE	KOOTENAY LAKE	D/S CELGAR II-2	LOWER BIRCHBANK III-3	RYAN CREEK IV-1	WANETA IV-3A
Total T4CDD	ND 0.2	ND 0.1	ND 0.2	ND 0.1	2.0	ND 0.1	0.1	0.7
2,3,7,8 T4CDD	ND 0.2	ND 0.1	NDR 0.4	ND 0.1	1.8	ND 0.1	ND 0.1	0.7
Total P5CDD	ND 0.2	ND 0.2	NDR 0.3	ND 0.2	ND 0.3	ND 0.1	0.1	ND 0.2
1,2,3,7,8 P5CDD	ND 0.2	ND 0.2	ND 0.2	ND 0.2	ND 0.3	ND 0.1	ND 0.1	ND 0.2
Total H6CDD	7.2	7.4	5.3	5.8	12	0.4	2.8	7.6
1,2,3,4,7,8 H6CDD	0.2	0.2	NDR 0.3	ND 0.2	ND 0.1	ND 0.2	ND 0.2	0.2
1,2,3,6,7,8 H6CDD	1.1	1.0	0.9	0.8	2.9	ND 0.2	0.4	1.4
1,2,3,7,8,9 H6CDD	0.7	0.7	NDR 0.7	NDR 0.6	1.0	ND 0.2	0.3	0.6
Total H7CDD	29	29	28	16	7.7	2.2	14	13
1,2,3,4,6,7,8 H7CDD	16	14	13	7.5	4.8	0.8	NDR 6.7	5.6
O8CDD	59	53	54	45	30	5.0	38	34
Total T4CDF	6.1	4.8	5.7	4.7	360	14	14	99
2,3,7,8 T4CDF	0.9	0.8	0.9	2.4	210	8.3	5.3	61
Total P5CDF	4.4	3.5	4.0	ND 0.2	6.2	ND 0.2	7.9	4.5
1,2,3,7,8 P5CDF	NDR 0.2	NDR 0.2	0.2	ND 0.2	1.6	ND 0.2	ND 0.6	0.7
2,3,4,7,8 P5CDF	NDR 0.3	NDR 0.2	0.4	ND 0.2	1.8	ND 0.2	ND 0.7	0.8
Total H6CDF	12	9.9	10	2.7	2.3	ND 0.2	22	2.6
1,2,3,4,7,8 H6CDF	1.5	1.4	1.2	NDR 0.3	0.4	ND 0.2	ND 1.3	NDR 0.3
1,2,3,6,7,8 H6CDF	0.4	NDR 0.4	0.4	ND 0.2	ND 0.2	ND 0.2	ND 1.4	0.3
2,3,4,6,7,8 H6CDF	0.5	0.3	0.4	ND 0.2	ND 0.2	ND 0.2	ND 0.7	0.3
1,2,3,7,8,9 H6CDF	ND 0.1	ND 0.1	ND 0.1	ND 0.2	ND 0.2	ND 0.2	ND 0.1	ND 0.1
Total H7CDF	14.0	8.9	8.1	3.1	2.4	ND 0.5	ND 19	4.4
1,2,3,4,6,7,8 H7CDF	4.8	4.0	3.5	1.4	1.2	ND 0.5	NDR 11	2.0
1,2,3,4,7,8,9 H7CDF	0.3	NDR 0.2	0.3	ND 0.1	0.3	ND 0.5	ND 1.1	0.2
O8CDF	6.6	5.0	4.9	2.2	1.5	ND 0.7	ND 18	3.0
2,3,7,8 T4CDD TEQ	1.1	0.9	1.1	0.7	24.4	1.0	1.3	7.8

ND - Not Detected (detection limit indicated)
NDR - Peak detected but failed to meet quantification criteria

Figure 5-3. 2,3,7,8 T4CDD Toxicity Equivalent Levels in Sediments from the Columbia/ Kootenay River System, 1992



sites were 0.9 pg/g in Arrow Lake and 2.4 pg/g in Kootenay Lake.

These results are similar to some but contrast with other results reported for the Columbia River. EVS Consultants (1990) also found 2,3,7,8 T4CDF in sediments from the Waneta reach (36 pg/g). However, neither EVS Consultants nor Mah et al. (1989) detected this furan at their control sites. The detection limits employed by EVS Consultants were similar to those used in the current study. Mah et al. (1989) used a low resolution analysis having a detection limit of 10 pg/g which would not have measured the levels encountered at the control sites.

Some results of the current study contrast with the experience of other investigators. Low levels of the 2,3,7,8 tetrachlorodibenzo-para-dioxin (T4CDD) were detected at the Celgar and Waneta sites (Table 5-3). None of the other investigators detected 2,3,7,8 T4CDD in sediments (Mah et al. 1989, EVS Consultants 1990, B.C. Hydro data presented in Celgar Pulp Company 1990). However, only the detection limits employed in the EVS Consultants study were low enough to have detected the levels measured in the current study.

A variety of higher (hexa-, hepta-, and octa-) chlorinated dioxins and furans were present in sediments from both downstream and control sites. Octachlorodibenzo-para-dioxin (O8CDD) was ubiquitous and occurred in higher concentrations at the control sites in Arrow and Kootenay lakes than at the Columbia River sites (Table 5-3). This dioxin was also detected at both potentially impacted and control sites in Williston Lake (Norecol Environmental Consultants 1991). Several H6 and H7 CDD and CDF congeners occurred at the control sites. Chlorophenols have been cited as a possible source of hepta- and octachloro dioxin/furan congeners (Mah et al. 1989).

BC Environment has established a provisional objective for dioxins/furans in Columbia River sediments between the Hugh Keenleyside Dam and Birchbank (Butcher 1992). The objective is based on toxic equivalence and is 0.7 pg (TEQ)/g total organic carbon. Comparing dioxin/furan TEQs (Table 5-3) with the total organic carbon levels (Table 5-1) reveals that at 2239 pg TEQ/g organic carbon, the sediments from downstream of Celgar exceeded the objective. However, all of the other sediments collected (at sites where the objective does not apply) also exceeded the objective. The lowest value obtained was 28 pg TEQ/g organic carbon in the Kootenay Lake sediments.

Other Chlorinated Compounds

Chlorinated phenolic compounds were analyzed in the same sediment samples analyzed for dioxins and furans. Extractable organic halide (EOX, a general measure of chlorinated compounds) was measured in the samples analyzed for metals. Complete results are presented in Appendix 5-3, while results for detectable compounds appear in (Tables 5-1 [EOX] and 5-4).

TABLE 5-4

CONCENTRATIONS (ng/g dry wt.) OF DETECTABLE CHLORINATED PHENOLIC COMPOUNDS IN SEDIMENTS COLLECTED FROM THE COLUMBIA RIVER AND KOOTENAY LAKE, SEPTEMBER 1992

PARAMETER	EC ARROW LAKE	NEC ARROW LAKE	KOOTENAY LAKE	CELGAR II-2	LOWER BIRCHBANK III-3	RYAN CREEK IV-1A	WANETA IV-3A
4-Chlorophenol	NDR 0.6	ND 0.4	ND 0.3	NDR 1.6	ND 0.5	ND 1.3	ND 0.8
2,4/2,5-Dichlorophenol	ND 0.4	ND 0.3	ND 0.3	3.0	ND 0.5	ND 0.6	ND 0.5
4-Chloroguaiacol	NDR 3.0	ND 1.5	ND 1.4	NDR 6.3	NDR 3.1	ND 2.8	ND 1.7
2,4,6-Trichlorophenol	ND 0.2	ND 0.3	ND 0.3	4.6	ND 0.3	ND 0.4	ND 0.4
4,6-Dichloroguaiacol	ND 0.4	ND 1.0	ND 1.0	NDR 0.8	ND 0.4	ND 0.7	ND 0.5
4,5-Dichloroguaiacol	ND 0.3	ND 0.7	ND 0.7	3.8	ND 0.3	ND 0.6	ND 0.5
3,6-Dichlorocatechol	ND 0.4	ND 0.7	ND 0.6	0.4	ND 0.6	ND 1.5	ND 0.8
3,5-Dichlorocatechol	ND 0.3	ND 0.6	ND 0.5	1.8	ND 0.5	ND 1.4	0.9
4,5-Dichlorocatechol	ND 0.4	ND 0.8	ND 0.7	1.4	ND 0.7	ND 2.0	1.1
2,3,4,6-Tetrachlorophenol	ND 0.5	ND 1.1	ND 1.1	1.3	ND 0.1	ND 0.5	ND 0.3
6-Chlorovanillin	ND 1.0	ND 1.6	ND 1.7	3.5	ND 2.4	ND 7.6	ND 2.8
3,4,5-Trichloroguaiacol	ND 0.2	ND 0.7	ND 0.5	5.5	0.4	ND 0.3	0.5
4,5,6-Trichloroguaiacol	ND 0.2	ND 0.5	ND 0.4	0.9	ND 0.1	ND 0.2	ND 0.1
5,6-Dichlorovanillin	ND 1.0	ND 1.4	ND 1.7	1.6	ND 1.1	ND 2.2	ND 4.8
3,4,5-Trichlorocatechol	ND 0.6	ND 1.8	ND 1.5	13	ND 4.4	ND 5.0	8.4
3,4,5,6-Tetrachloroguaiacol	ND 0.3	ND 0.6	ND 0.6	3.4	ND 0.3	ND 0.3	ND 0.3
3,4,5,6-Tetrachlorocatechol	ND 1.2	ND 2.4	ND 2.4	29	ND 17	ND 20	ND 13

ND - Not Detected
NDR - Peak detected but failed to meet quantification criteria

Extractable organic halide was detectable only at Robson (II-3), China Creek (III-1), Ryan Creek (IV-1), Waneta (IV-3A), and the Kootenay Lake control site. The maximum concentration (6.2 μg/g) occurred at China Creek, and the second highest concentration (4.1 μg/g) at Kootenay Lake. These levels are an order of magnitude or more below EOX concentrations measured 1 km downstream of Celgar by BC Environment (Butcher 1992).

The sample from downstream of Celgar (II-2) contained 14 detectable chlorinated phenolic compounds plus an additional three compounds for which peaks were detected but which failed to meet the quantification criteria. Some of these compounds were also detected at sites farther downstream. The Waneta sample contained detectable levels of four compounds, 3,5-dichlorocatechol, 4,5-dichlorocatechol, 3,4,5-trichloroguaiacol, and 3,4,5-trichlorocatechol. The Birchbank sample contained detectable 3,4,5-trichloroguaiacol. Tetrachlorocatechols, one of the main chlorophenolic compounds found in sediments downstream of bleached kraft mills (Butcher 1992) were not found at Birchbank or Waneta, but the detection limits were high (13 to 17 ng/g). The Ryan Creek sample and the two control samples did not contain any quantifiable phenolic compounds.

The concentrations of chlorinated phenolic compounds found in the present study were in most cases lower than those found by previous investigators. The highest concentrations of chlorinated phenolic compounds were 29 ng/g 3,4,5,6-tetrachlorocatechol and 13 ng/g 3,4,5-trichlorocatechol measured downstream of Celgar. B.C. Hydro reported maximum concentrations of these compounds at 36 ng/g and 37 ng/g respectively. The next highest concentration of a chlorophenolic compound detected in the present study was 5.5 ng/g of 3,4,5-trichloroguaiacol downstream of Celgar. BC Environment reported tetrachlorophenols, trichlorophenols, trichloroguaiacols, and tetrachloroguaiacols in the range of 120 to 140 ng/g along a sediment transect 1 km downstream of the Celgar outfall (Butcher 1992). B.C. Hydro found a maximum 24 ng/g of trichloroguaiacol. In addition, both the BC Environment and B.C. Hydro reported measurable levels of pentachlorophenol and chloroveratroles, which were not detected in the present study.

QA/QC

Comparison of the field QA/QC samples suggests no significant differences in concentrations of metals, dioxins/furans or chlorinated phenolic compounds between the samples collected by Norecol [NEC] and the samples collected by Environment Canada [EC] (Tables 5-2 to 5-4). The magnitude of variation between the two samples is to be expected, especially considering that the Arrow Lake samples were collected over a wide area (by comparison with the river sampling sites), and different portions of this area may have been represented in different proportions in the NEC and EC samples.

Laboratory QA/QC samples included blanks, duplicates, standard reference samples, spikes, and (for dioxin/furans) surrogate standard recoveries. The complete QA/QC data for metals and organic compounds appear with the detailed analytical data (Appendices 5-1 and 5-2).

In all cases the dioxin/furan surrogate standard recoveries met the data quality objectives defined by Vogt (1990) for studies of pulp mill impacts in the Fraser and Thompson rivers:

Compound	Percent Recovery	Compound	Percent Recovery
T4CDD:	40-120%	H7CDD:	25-120%
P5CDD:	35-120%	O8CDD:	20-120%
H6CDD:	30-120%	T4CDF:	40-120%

Recoveries in excess of 100% occurred only for H6CDD and one sample of H7CDD. The lowest recoveries (47% to 76%) occurred for O8CDD.

5.1.2 Sediment Toxicity

Sediments from all sites except Birchbank (III-2, where the sediments were considered too coarse) were subjected to a series of toxicity tests which included solid phase Microtox and *Hyalella azteca* chronic (10-day) tests on sieved whole sediments and a *Daphnia magna* acute (48-h) test on a water extract of the sediment. The premise of undertaking toxicity tests on three organisms is based on the knowledge that not all species have similar sensitivities to contaminants. Thus, a test with a single organism may fail to detect the effects of contaminants which might be toxic to other organisms. In addition, the tests selected provide different information concerning the location of the toxicant (sediment of pore water phase) and the severity of effect (acute or chronic).

As expected, the three tests produced variable results with respect to the relative toxicities of the different sediments (Table 5-5).

The Microtox solid phase bioassay is a test which measures the change in light emitted by a bioluminescent bacterium exposed to a suspension of the test sediments. The turbidity and colour of the particles reduce light output the bacteria and/or interfere with its measurement. Thus, the EC50 or concentration which causes a 50% reduction in the tested response (bioluminescence) is be low even in control samples. Based on corrections for the effects of turbidity, in this particular test an EC50 >2% was considered nontoxic.

The test indicated some toxicity in all samples except those from below Celgar (II-2) and Robson (II-3). The most toxic sediment (as measured by the reduction in

TABLE 5-5

RESULTS OF COLUMBIA RIVER SEDIMENT TOXICITY TESTS

SAMPLE SITE	SAMPLE NO.	SOLID PHASE MICROTOX (EC50)	*DAPHNIA MAGNA* (LC50)	*HYALELLA AZTECA* (% SURVIVAL)
Arrow Lake	I-1	0.44%	>100%	100%
Kootenay Lake	--	0.15%	>100%	100%
D/S Celgar	II-2	2.30%	>100%	33%
Robson	II-3	8.13%	>100%	93%
China Creek	III-1	1.26%	>100%	100%
Lower Birchbank	III-3	1.28%	>100%	67%
Ryan Creek	IV-1	0.39%	>100%	100%
Beaver Creek	IV-2	1.25%	>100%	27%
Waneta	IV-3	2.70%	>100%	100%

EC50 - Sediment concentration which causes 50% inhibition of bacterial luminescence
LC50% - Sediment extract concentration which kills 50% of test organisms

bacterial luminescence) the was the control sample from Kootenay Lake (EC50=0.15%). The sediments from Ryan Creek (IV-1), Waneta (IV-3A), and the Arrow Lake control sample (I-1) also exhibited considerable toxicity (EC50 from 0.27% to 0.44%), while the China Creek (III-1), lower Birchbank (III-3) and Beaver Creek sediments showed lesser toxicity (EC50 from 1.25 to 1.28%).

The relationship of the Microtox results to the sediment contaminant levels is unclear. Most of the more toxic samples had relatively high levels of metals, but the sediment with the highest levels of copper, zinc, arsenic, and chromium (Beaver Creek) was among the less toxic samples. Data for organics are not available for some of the sediments, but the sample with the highest levels of dioxins/furans and chlorinated phenolics (downstream of Celgar) was not toxic to the bacteria.

Various interpretations of these results are possible. Either:

- the Microtox solid phase test is not sensitive to these contaminants;
- among-site differences in the relative amounts of contaminants in whole sediments (which were analyzed chemically) and those in the <125 μm fraction (which were used for the Microtox test) accounted for the poor correlation between toxicity and measured contaminant levels; and/or
- the long elapsed time between sediment collection and testing resulted in geochemical changes that biased the results.

The interpretation of the Microtox results is further complicated by the extreme toxicity of the control sample from Kootenay Lake. Sediment bioassays tests often show toxicity in samples which do not have detectable levels of known toxicants. When such sediments have been collected near industrial outfalls, the test results are often interpreted as indicating the presence of toxic compounds which the chemical analyses were not sensitive enough or not intended to detect.

The *Hyallela azteca* bioassay suggested that the sediments from downstream of Celgar (II-2) and opposite Beaver Creek (IV-2) were toxic. Survival of the amphipods in these two sediments was only 33% and 27% respectively (results corrected for mortality among control group animals). The lower Birchbank (III-3) sample also exhibited some toxicity (67% survival). Thus, *Hyallela* proved sensitive to the sediments with both the highest levels of metals (Beaver Creek) and the highest levels of organic contaminants (downstream of Celgar).

None of the sediment extracts proved acutely toxic to *Daphnia magna*. This result suggests that the substances which were toxic to *Hyallela* either did not leach into the water or leached at levels too low to cause acute toxicity.

5.2 Discussion

5.2.1 Significant Effects

The data clearly show higher levels of metals in sediments in the reach downstream of Cominco (Reach IV) than in the upstream reaches or at the control sites in the two lakes. These elevated sediment metal levels apparently persist downstream into the U.S. reaches of the Columbia River. Johnson et al. (1988) reported higher levels of many metals in the sediments of Lake Roosevelt than the levels found in the present study. They reported maximum concentrations of zinc, copper, and mercury of 26,840, 4,870, and 2.7 $\mu g/g$, respectively. The maximum lead concentration in Lake Roosevelt was similar to that found in Reach IV, 550 $\mu g/g$.

The sediments also reflect the effects of discharges from Celgar. Dioxins, furans, and various chlorinated phenolic compounds were elevated in sediments immediately downstream of the pulp mill. These compounds apparently are transported downstream as many of them also occurred in sediments from Birchbank and Waneta.

The *Hyallela* bioassay results suggest that both industries can create conditions toxic to some burrowing organisms. The sediments with the highest levels of zinc, copper, and arsenic (Beaver Creek) and the highest levels of organic contaminants (downstream of Celgar) were toxic to *Hyalella*. Such areas may be quite localized, based on the lack of toxic response to sediments from other sites with relatively high contaminant levels (Ryan Creek and Waneta). However, the apparent toxicity of the Birchbank sample, which had lower concentrations of both metals and organics than the Waneta sample, casts some doubt upon these results.

5.2.2 Implications for Monitoring Program

The statistically significant pattern of elevated sediment metal levels in Reach IV suggests that sediment chemistry is useful and defensible for monitoring the current impacts of Cominco's discharge. Sediment metal levels may also be defensible for monitoring improvements as Cominco continues to modernize their process and upgrade effluent quality. Therefore, CRIEMP should include sediment monitoring as part of the ongoing program.

The current monitoring results suggest that sediments also reflect the effects of discharges from the Celgar mill. However, power analysis of data collected by Environment Canada suggests that analyzing the number of samples required to detect changes in organic contaminant levels would be cost prohibitive (Tuominen, pers. comm.). Therefore, the ongoing program should not include an extensive (replicated) program of sediment organic analyses, but analyses for organic contaminants should not be neglected entirely. These chemistry data aid in the interpretation of bioassay data. For example, in the current study, the interpretation of the *Hyalella* response to the Robson sediments might have been easier had organic data for that site been available.

Toxicity tests complement the sediment chemistry and benthic community structure data and therefore should be continued. However, due to significant effects in the control samples and the difficulty in identifying the source(s) of these effects the test methodology should be reassessed. If sediments are to be sieved, then chemical analyses should be done on the particle size fraction used for the toxicity tests. In addition, tests should be initiated within two weeks of sediment collection, as recommended by Environment Canada (1992) to ensure that no significant geochemical changes have occurred during storage.

CONTAMINANTS IN BIOTA

6.1 Results

6.1.1 Metals

Concentrations of metals were measured in a limited subset of the biota samples as follows:

- freshwater mussels (*Anodonta oregonensis*): samples from Kootenay River at Glade, Columbia River at Celgar (II-2), and Columbia River at Waneta (IV-3A);
- macrophytes (*Potamogeton perfoliatus*): samples from Celgar and Waneta; and
- emergent caddisflies (mixed species as indicated in Table 6-1 and Figure 6-1): samples from the Kootenay River at Grohman Narrows and Glade and the Columbia River at Celgar and Waneta).

Analytical results for selected metals are presented in Tables 6-2 and 6-3. Complete data appear in Appendix 6-1.

All three potential sentinel groups accumulated measurable quantities of target metals (Tables 6-1 and 6-2; Figures 6-2 to 6-5). Concentrations (expressed as dry weight) of lead, zinc, and copper in all three taxa were higher at Waneta (downstream of Cominco) than at the Celgar or control sites (Figures 6-2 and 6-3), but the magnitude of differences among sites was generally less for caddisflies than for either mussels or macrophytes. For mussels and macrophytes, the magnitude of differences among sites varied with both the metal and the species. In both species copper levels were approximately four times higher at Waneta than at Celgar. Lead levels at Waneta were 10 times higher in *Potamogeton* and approximately 100 times higher in *Anodonta* compared with lead levels in these species at the other sites. Zinc levels were approximately four times higher in *Anodonta* and seven times higher in *Potamogeton* at Waneta compared with the other sites.

Cadmium and mercury levels also were considerably higher in mussels and macrophytes from Waneta (Table 6-2; Figures 6-3 and 6-5). Cadmium levels were very low in all the caddisfly samples, although at Waneta they were approximately double the levels at the remaining site (0.6 to 0.7 $\mu g/g$ as compared with 0.3 to 0.4 $\mu g/g$). In contrast, the cadmium concentration in the mussel composite from Waneta

TABLE 6-1

SPECIES COMPOSITION OF EMERGENT CADDISFLY SAMPLES USED FOR TISSUE ANALYSIS

SPECIES	WANETA (NORECOL)	WANETA (ENV. CAN.)	GLADE (NORECOL)	GLADE (ENV. CAN.)	GROHMAN NARROWS	CELGAR
Hydropsyche oslari	0.9%	5.4%	0.9%	1.8%	18.0%	31.8%
H. occidentalis	63.6%	64.9%	17.3%	40.9%	19.7%	50.9%
Cheumatopsyche campyla	30.9%	25.2%	60.0%	39.1%	24.6%	14.5%
Psychomyia flavida	0.0%	0.0%	19.1%	14.5%	15.6%	0.9%
Oxyethira sp.	0.0%	0.0%	0.0%	0.0%	14.8%	0.0%
Protoptila coloma	2.7%	2.7%	0.0%	0.0%	0.0%	0.0%
Hydroptila sp.	0.0%	1.8%	0.0%	0.9%	0.0%	0.0%
Oecetis inconspicua	0.0%	0.0%	0.0%	0.0%	2.5%	0.0%
Mystacides alafimbriata	0.0%	0.0%	0.9%	0.0%	1.6%	0.0%
Hydropsyche 3 spp.	0.0%	0.0%	0.0%	2.7%	0.0%	0.0%
Polycentropus cinereus	0.0%	0.0%	0.0%	0.0%	2.5%	0.0%
Ceraclea sp.	0.0%	0.0%	0.0%	0.0%	0.8%	1.8%
Cheumatopsyche sp.	0.0%	0.0%	1.8%	0.0%	0.0%	0.0%
Glossosoma alascense	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%
G. velona	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 6-1. Dominant Caddisfly Species in Samples Collected for Contaminant Analyses

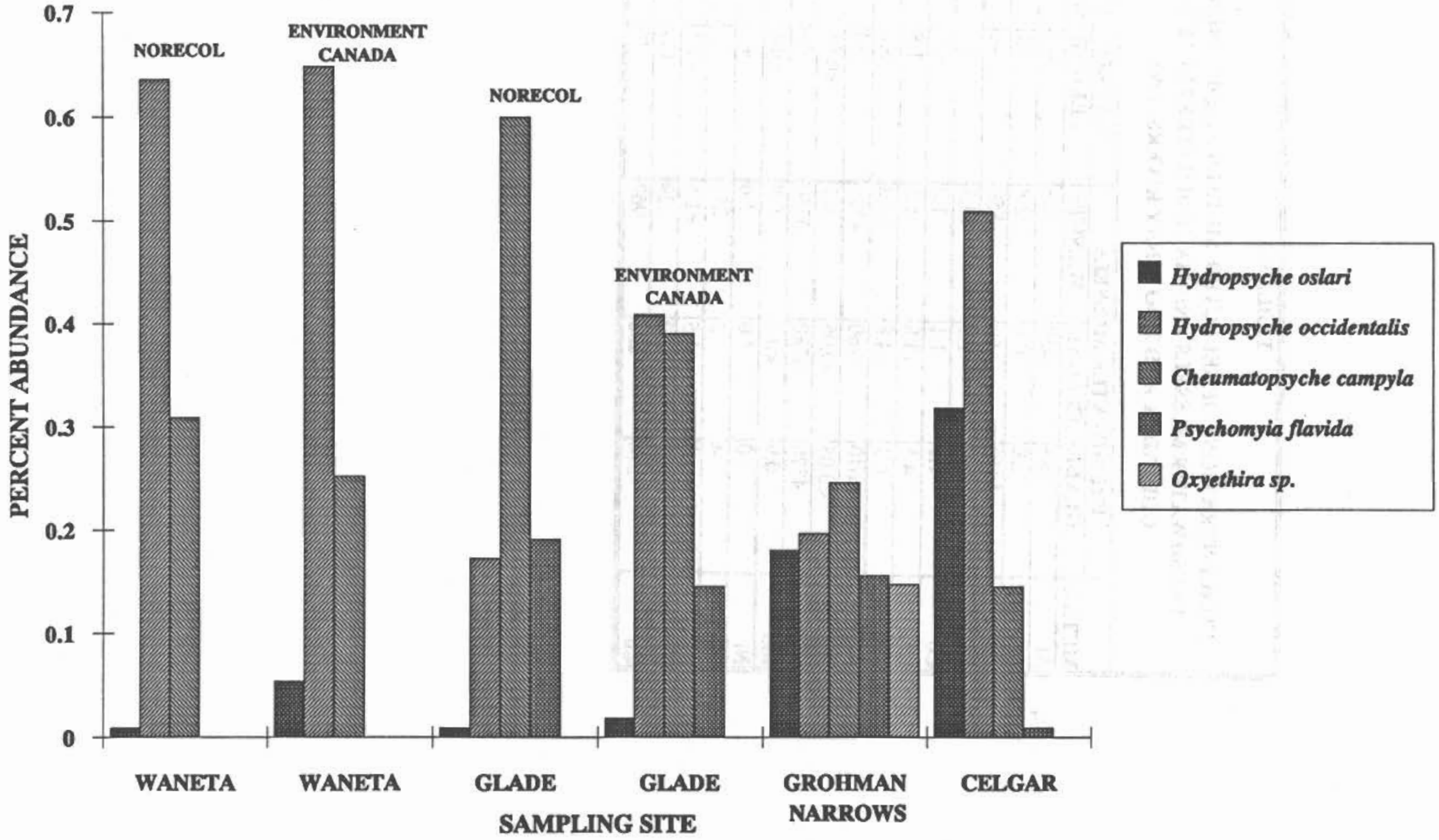


TABLE 6-2

CONCENTRATIONS OF SELECTED METALS (ug/g dry weight) IN FRESHWATER MUSSELS AND MACROPHYTES FROM THE COLUMBIA AND KOOTENAY RIVERS, 1992

	FRESHWATER MUSSELS			MACROPHYTES	
METAL	GLADE	CELGAR	WANETA	CELGAR	WANETA
Al	183	429	388	543	417
As	2.8	0.9	2.8	0.2	1.0
Ba	1030	669	859	46	110
Cd	3.6	1.1	13.3	1.1	6.3
Co	1.1	1.1	1.0	0.4	1.4
Cr	4.5	13.8	6.3	1.8	1.8
Cu	6.1	14.8	64.2	6.8	27.6
Fe	2610	3760	4590	764	679
Hg	<0.05	<0.05	0.1	<0.05	0.1
Mn	4770	4780	5330	78	381
Mo	0.9	<0.4	0.8	<0.4	0.9
Ni	1.0	3.0	1.6	4.9	1.9
Pb	4	2	251	3	38
Sb	<1.5	<1.5	<1.5	<1.5	2.0
Sr	138	250	229	111	241
Zn	214	256	962	33	218

TABLE 6-3

CONCENTRATIONS OF SELECTED METALS (ug/g dry weight) IN EMERGENT CADDISFLIES FROM THE COLUMBIA AND KOOTENAY RIVERS, 1992

METAL	GROHMAN NARROWS	ENV. CAN. GLADE	NEC GLADE	CELGAR	ENV. CAN. WANETA	NEC WANETA
Al	16	17	12	18	11	12
As	2.1	3.2	2.4	2.1	1.7	2.2
Ba	4.8	5.2	3.3	2.7	1.9	2.3
Cd	0.4	0.3	0.3	0.3	0.6	0.7
Cr	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cu	27.7	25.6	21.2	20.7	33.6	40.9
Fe	124	117	88	102	103	123
Hg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mn	19.4	22.2	13.2	13.4	11.7	14.6
Mo	1.2	1.3	1.0	1.0	1.9	2.0
Pb	6	5	4	6	20	25
Sb	<1.5	<1.5	<1.5	2.3	2.9	3.4
Sr	4.8	4.5	3.7	6.5	5.0	6.0
Zn	128	135	105	136	181	217

NEC - Norecol Environmental Consultants

Figure 6-2. Concentrations of Copper, Lead and Zinc in Freshwater Mussels from the Columbia and Kootenay Rivers

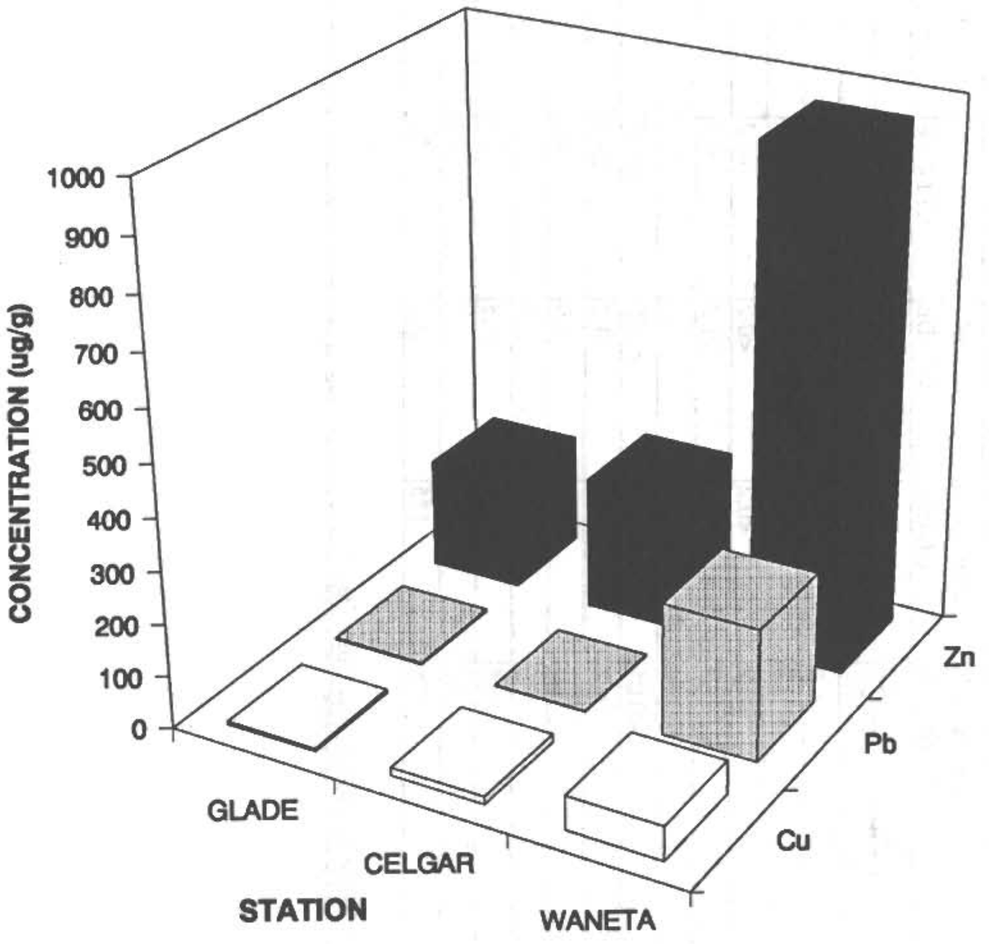


Figure 6-3. Concentrations of Copper, Lead, and Zinc in Emergent Caddisflies from the Columbia and Kootenay Rivers

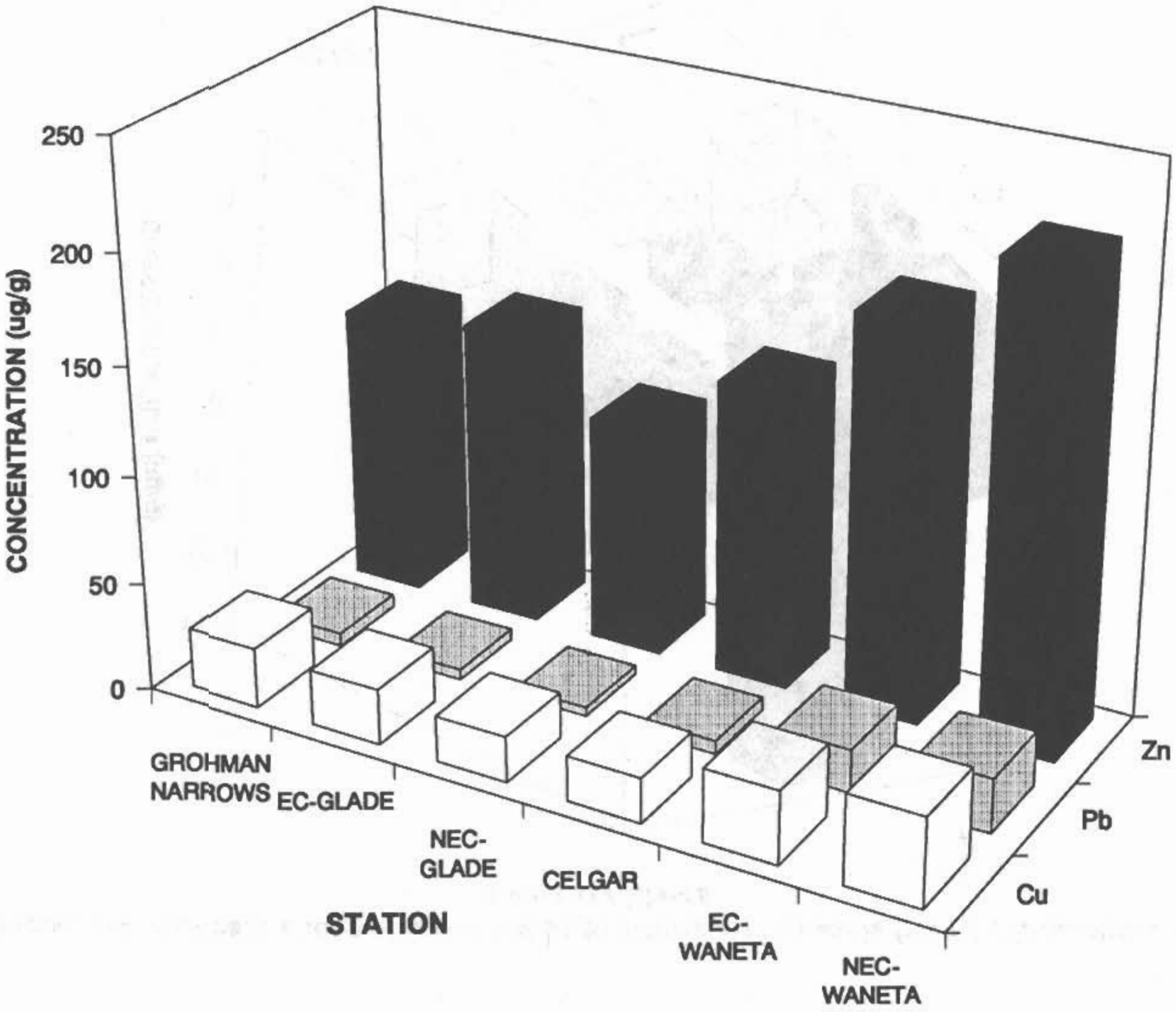


Figure 6-4. Concentrations of Other Metals in Freshwater Mussels from the Columbia and Kootenay Rivers

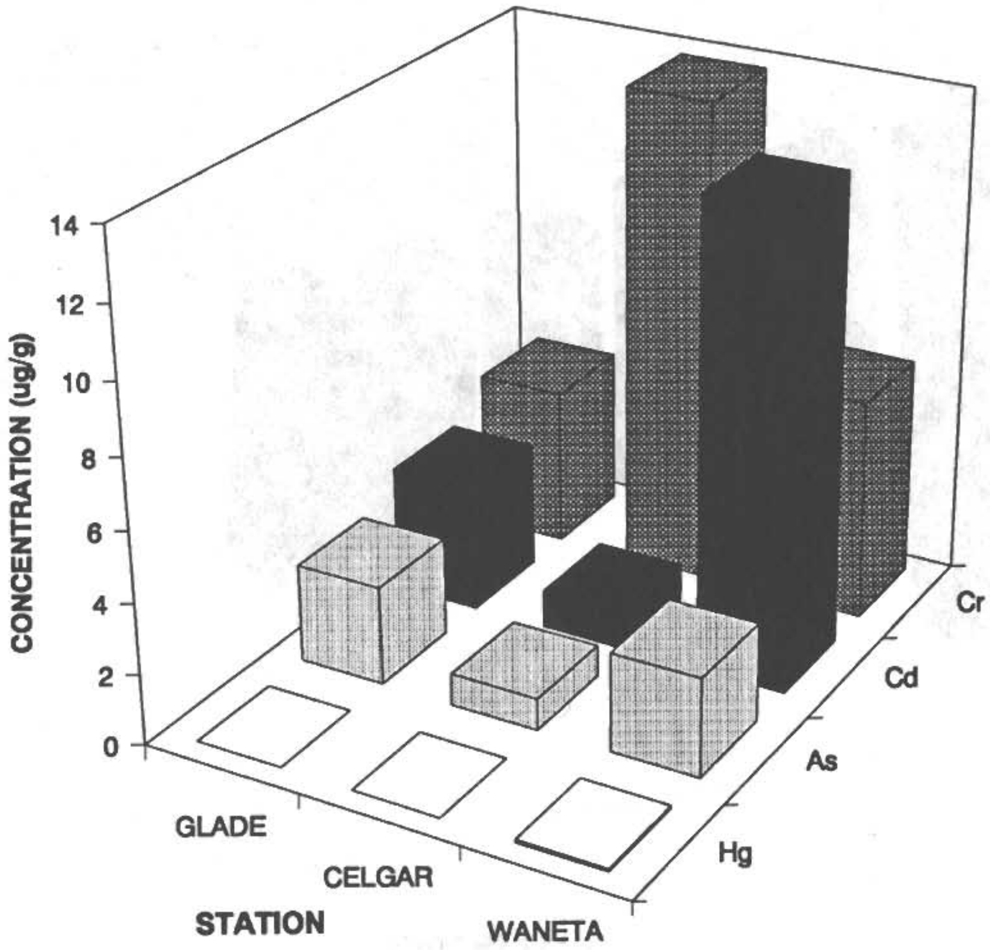
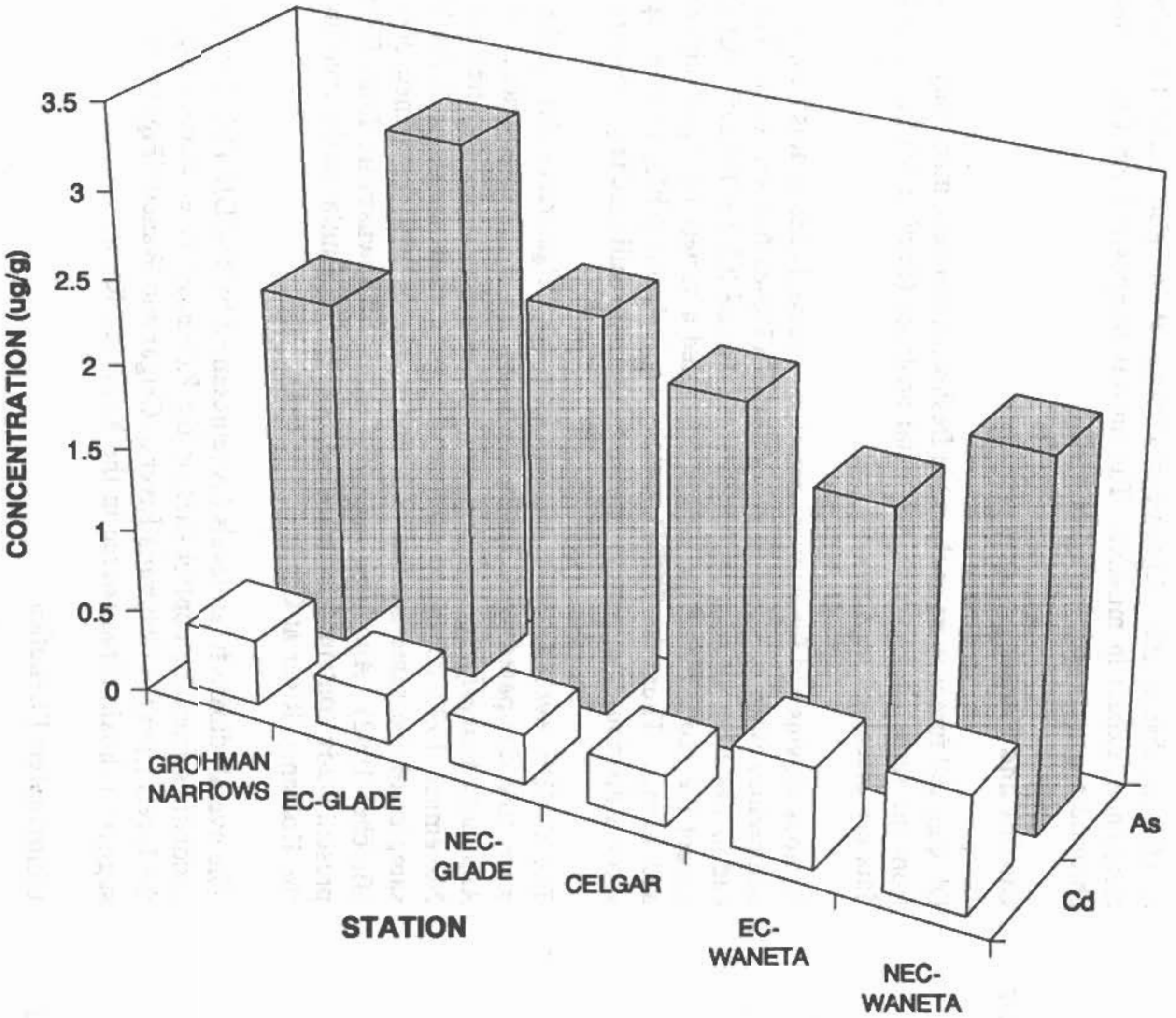


Figure 6-5. Concentrations of Cadmium and Arsenic in Emergent Caddisflies from the Columbia and Kootenay Rivers, 1992



was 13.3 μg/g, while cadmium levels in mussels from Glade and Celgar were 3.6 and 1.1 μg/g respectively. Mercury was not detectable in any caddisfly sample and was measurable only in the mussels (0.08 μg/g) and macrophytes (0.11 μg/g) from Waneta.

Arsenic concentrations in all three taxa did not follow a pattern of variability related to effluent discharges. Chromium concentrations also failed to show among-site differences expect in mussels. The mussel composite from Celgar had an elevated chromium concentration (Figure 6-4).

6.1.2 Dioxins and Furans

Dioxins and furans were analyzed in freshwater mussels, macrophytes, and caddisflies from the same sites used in the metal analyses (Section 6.1.1). Detailed analytical data are presented in Appendix 6-2.

Various dioxins and furans were detected in mussels and caddisflies, but none of these compounds were detected in macrophytes (Tables 6-4 and 6-5). The mussels and caddisflies from all sites contained at least some 2,3,7,8 T4CDF. All of the samples except the caddisflies from Celgar contained a variety of higher chlorinated dioxins and furans. Thus, the TCDD toxicity equivalence (TEQ) in these species did not show a distributional pattern related to the pulp mill discharge (Figure 6-6).

The T4CDF levels found in mussels from the Celgar reach during the current study were low compared with levels found by the BC Environment. Composites of *Anodonta kennerlyi* (probably *A. oregonensis*) collected downstream from Celgar in November 1990 contained 370 to 400 pg/g (wet weight) 2,3,7,8 T4CDF, while samples of the same species collected in March 1991 contained 300 to 1300 pg/g (Butcher 1992). *Anodonta kennerlyi* collected downstream from Celgar during the present study contained 2.3 pg/g 2,3,7,8 T4CDF, similar to the level in mussels from the Kootenay River at Glade (Table 6-4).

The overall dioxin/furan levels (as represented by T4CDD TEQs) in both mussels and caddisflies from the control sites on the Kootenay River were as high or higher than the levels from the Columbia River at Celgar and Waneta (Figure 6-6). These results suggest a dioxin/furan source in the Kootenay River.

6.1.3 Chlorinated Phenolics

Few chlorinated phenolic compounds were detected in mussels or caddisflies, and none of these compounds was measurable in macrophytes (Tables 6-4 and 6-5 and Appendix 6-3). Pentachlorophenol was present in all of the caddisfly samples and in the mussel sample from the Kootenay River at Glade. In addition, 2,3,4,6-tetrachlorophenol was detected in the mussel composite from Glade and in one caddisfly sample from Waneta, while 2,4,6-trichlorophenol and 2,4/2,5-dichlorophenol

TABLE 6-4

CONCENTRATIONS OF DIOXINS, FURANS AND CLOROPHENOLS IN FRESHWATER MUSSELS AND MACROPHYTES FROM THE COLUMBIA AND KOOTENAY RIVERS, 1992*

PARAMETER	FRESHWATER MUSSELS								MACROPHYTES			
	GLADE		(DUP.) GLADE		CELGAR		WANETA		CELGAR		WANETA	
Total T4CDD	ND	0.08	ND	0.09	ND	0.08	ND	0.09	ND	0.2	ND	0.1
2,3,7,8 T4CDD	ND	0.08	ND	0.09	ND	0.08	ND	0.09	ND	0.2	ND	0.1
Total P5CDD		2.6		2.7	ND	0.2	ND	0.3	ND	0.5	ND	0.2
1,2,3,7,8 P5CDD	ND	0.1	ND	0.2	ND	0.2	ND	0.3	ND	0.5	ND	0.2
Total H6CDD		240		270		78		70	ND	0.9	ND	0.4
1,2,3,4,7,8 H6CDD	ND	0.2	ND	0.2		0.2	ND	0.3	ND	0.9	ND	0.4
1,2,3,6,7,8 H6CDD		21		22		4.3		5.2	ND	0.9	ND	0.4
1,2,3,7,8,9 H6CDD		3.0		2.8		0.9	NDR	0.9	ND	0.9	ND	0.4
Total H7CDD		1200		1500		470		440	ND	2.3	ND	0.8
1,2,3,4,6,7,8 H7CDD		340		370		130		120	ND	2.3	ND	0.8
O8CDD		3000		3400		1100		1100	ND	4.9	ND	1.6
Total T4CDF		12		9.7		3.8		2.0	ND	0.1	ND	0.1
2,3,7,8 T4CDF		2.6		2.4		2.3		0.9	ND	0.1	ND	0.1
Total P5CDF		53		33		3.4		2.5	ND	0.3	ND	0.2
1,2,3,7,8 P5CDF		0.6		0.6	ND	0.1	ND	0.2	ND	0.3	ND	0.2
2,3,4,7,8 P5CDF		0.9		0.8	ND	0.1	ND	0.2	ND	0.3	ND	0.2
Total H6CDF		180		180		26		38	ND	0.8	ND	0.3
1,2,3,4,7,8 H6CDF		1.7		1.0	NDR	0.4	NDR	0.4	ND	0.8	ND	0.3
1,2,3,6,7,8 H6CDF	NDR	0.5	ND	0.3	ND	0.1	ND	0.3	ND	0.8	ND	0.3
2,3,4,6,7,8 H6CDF		1.1		1.3	ND	0.1	ND	0.3	ND	0.8	ND	0.3
1,2,3,7,8,9 H6CDF	ND	0.2	ND	0.3	ND	0.1	ND	0.3	ND	0.8	ND	0.3
Total H7CDF		180		170		34		42	ND	1.7	ND	0.6
1,2,3,4,6,7,8 H7CDF		60		59		12		15	ND	1.7	ND	0.6
1,2,3,4,7,8,9 H7CDF	ND	0.3	ND	0.2	ND	0.2	ND	0.8	ND	1.7	ND	0.6
O8CDF		20		24		7.4		8.5	ND	2.8	ND	0.9
2,3,7,8 T4CDD TEQ		10.6		11.2		3.5		3.4				
2,3,4,6-Tetrachlorophenol		0.7	–		ND	0.4	ND	0.4	ND	0.9	ND	0.5
Pentachlorophenol		0.3	–		ND	0.2	ND	0.2	ND	0.5	ND	0.3

ND - Not Detected (detection limit indicated)

NDR - Peak detected but did not meet quantification criteria

* dioxins/furans measured in pg/g dry weight; chlorophenols in ng/g wet weight

TABLE 6-5

CONCENTRATIONS OF DIOXINS, FURANS AND CLOROPHENOLS IN EMERGENT CADDISFLIES FROM THE COLUMBIA AND KOOTENAY RIVERS, 1992*

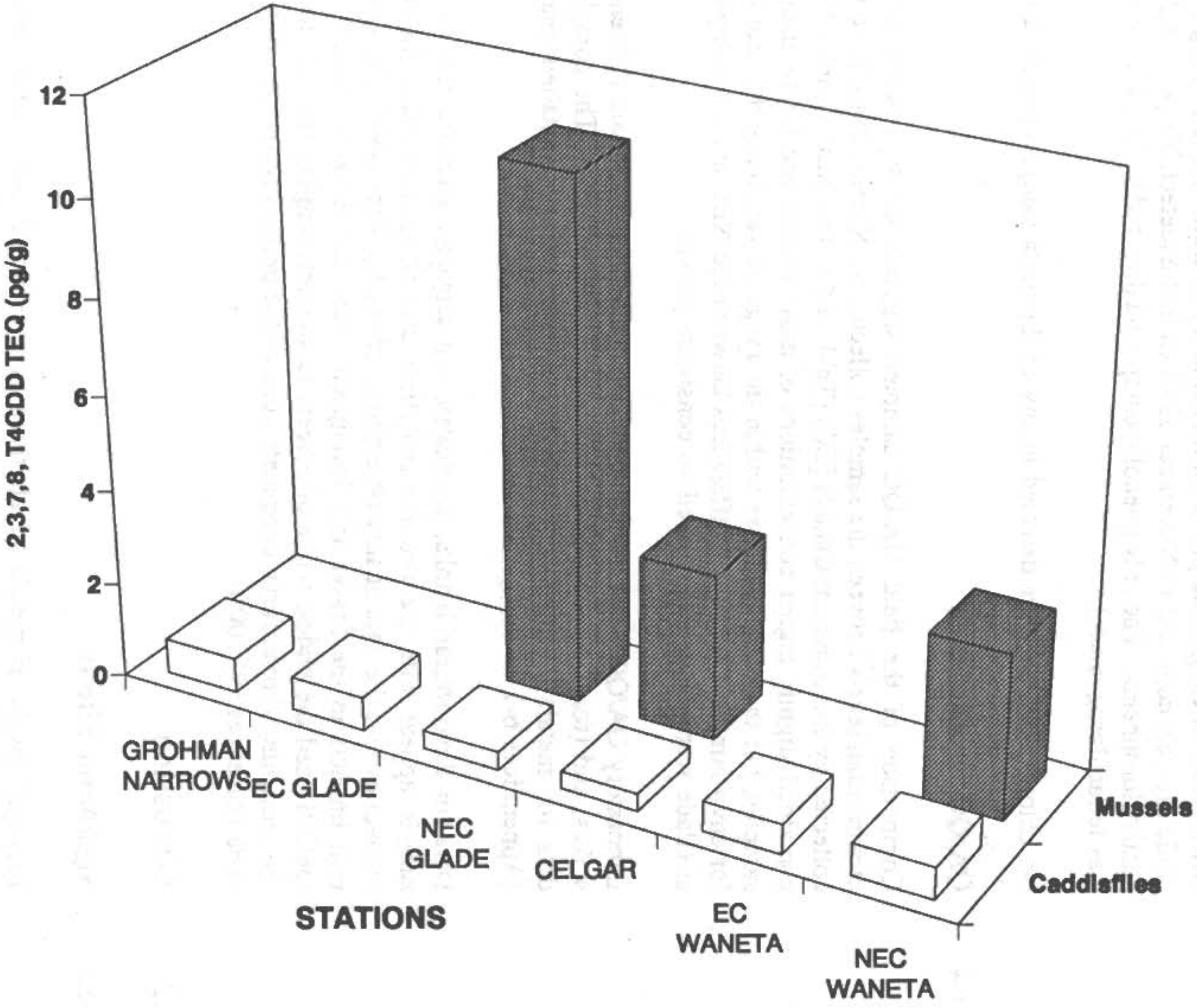
PARAMETER	GROHMAN NARROWS	GROHMAN NARROWS (DUP.)	EC GLADE	NEC GLADE	CELGAR	EC WANETA	NEC WANETA
Total T4CDD	ND 0.2	ND 0.2	ND 0.2	0.4	ND 0.07	1.0	1.5
2,3,7,8 T4CDD	ND 0.2	ND 0.2	ND 0.2	ND 0.1	ND 0.07	ND 0.2	ND 0.2
Total P5CDD	ND 0.4	ND 0.6	ND 0.6	ND 0.2	ND 0.2	1.7	2.6
1,2,3,7,8 P5CDD	ND 0.4	ND 0.6	ND 0.6	ND 0.2	ND 0.2	ND 0.3	ND 0.3
Total H6CDD	2.4	3.3	2.3	3.4	ND 0.2	3.4	5.6
1,2,3,4,7,8 H6CDD	ND 0.7	ND 1.2	ND 0.6	ND 0.1	ND 0.2	ND 0.4	ND 0.2
1,2,3,6,7,8 H6CDD	ND 0.7	ND 1.2	ND 0.6	0.3	ND 0.2	ND 0.4	NDR 0.5
1,2,3,7,8,9 H6CDD	ND 0.7	ND 1.2	ND 0.6	NDR 0.2	ND 0.2	ND 0.4	NDR 0.5
Total H7CDD	11	11	8.4	8.4	ND 0.6	4.7	9.5
1,2,3,4,6,7,8 H7CDD	4.4	4.1	3.8	3.2	ND 0.6	NDR 1.6	3.9
O8CDD	17	30	12	16	ND 2.7	7.5	21
Total T4CDF	1.3	1.4	1.3	1.6	1.5	6.3	5.8
2,3,7,8 T4CDF	0.3	0.3	0.5	NDR 0.4	0.5	1.9	2.1
Total P5CDF	ND 0.3	ND 0.4	0.5	1.3	ND 0.4	2.1	2.0
1,2,3,7,8 P5CDF	ND 0.3	ND 0.4	ND 0.4	ND 0.2	ND 0.4	ND 0.2	ND 0.2
2,3,4,7,8 P5CDF	ND 0.3	ND 0.4	ND 0.4	ND 0.2	ND 0.4	ND 0.2	ND 0.2
Total H6CDF	1.5	1.5	1.3	3.0	ND 0.4	0.7	1.1
1,2,3,4,7,8 H6CDF	ND 0.7	ND 0.7	ND 0.6	ND 0.3	ND 0.4	ND 0.5	ND 0.2
1,2,3,6,7,8 H6CDF	ND 0.7	ND 0.7	ND 0.6	ND 0.3	ND 0.4	ND 0.5	ND 0.2
2,3,4,6,7,8 H6CDF	ND 0.7	ND 0.7	ND 0.6	ND 0.3	ND 0.4	ND 0.5	ND 0.2
1,2,3,7,8,9 H6CDF	ND 0.7	ND 0.7	ND 0.6	ND 0.3	ND 0.4	ND 0.5	ND 0.2
Total H7CDF	ND 1.0	ND 1.4	ND 0.7	3.4	ND 0.5	ND 0.8	ND 0.3
1,2,3,4,6,7,8 H7CDF	NDR 1.0	NDR 2.2	NDR 2.3	2.0	ND 0.5	NDR 1.4	NDR 1.0
1,2,3,4,7,8,9 H7CDF	ND 1.0	ND 1.4	ND 0.7	ND 0.2	ND 0.5	ND 0.8	ND 0.3
O8CDF	ND 2.8	ND 2.7	ND 1.6	ND 1.0	ND 0.4	ND 2.2	ND 0.3
2,3,7,8 T4CDD TEQ	0.63	0.81	0.70	0.38	0.36	0.62	0.66
2,4/2,5-Dichlorophenol	NDR 0.6	–	0.5	ND 0.7	ND 0.5	ND 0.2	ND 0.6
2,4,6-Trichlorophenol	ND 0.3	–	ND 0.2	ND 0.2	0.4	ND 0.2	ND 0.2
2,3,4,6-Tetrachlorophenol	ND 0.5	–	ND 0.5	ND 0.5	ND 0.7	0.5	ND 0.5
Pentachlorophenol	4.2	–	2.6	2.4	1.1	6.5	7.4

ND - Not Detected (detection limit indicated)

NDR - Peak detected but did not meet quantification criteria

* dioxins/furans measured in pg/g dry weight; chlorophenols in ng/g wet weight

Figure 6-6. 2,3,7,8 T4CDD Toxicity Equivalent Levels in Invertebrates from the Columbia and Kootenay Rivers, 1992



were detected in caddisflies from Celgar and Glade, respectively.

The BC Environment study similarly found few chlorinated phenolic compounds in freshwater mussels. In the March 1989 survey *Anodonta oregonensis* collected downstream of Celgar had pentachlorophenol levels from <20 to 24 ng/g (wet weight), while mussels collected in November 1990 all had undetectable (<1.0 ng/g) levels of pentachlorophenol. The only phenolic compound detected in the 1990 mussel samples was tetrachloroguaiacol.

No chloroveratroles were detected in any of the biota samples (Appendix 6-3).

6.1.4 QA/QC

Comparison of the field QA/QC samples suggests no significant differences in dioxin/furan levels between the samples collected by Norecol [NEC] and the samples collected by Environment Canada [EC] (Table 6-5). The NEC samples from Waneta contained slightly higher concentrations of most dioxins and furans than do the EC samples, but the differences are within the range of variability that can be expected for environmental samples. Differences between the NEC and EC samples collected at Glade were small and showed no consistent pattern.

Laboratory QA/QC samples included blanks, duplicates, standard reference samples, spikes, and (for dioxin/furan) surrogate standard recoveries. The complete QA/QC data for metals and organic compounds appear with the detailed analytical data (Appendices 6-1 and 6-2).

Data for dioxin/furan blanks, duplicates, and surrogate standard recoveries for each sample appear with the detailed analytical data (Appendix 6-2). In all cases the recoveries met the data quality objectives defined by Vogt (1990) for studies of pulp mill impacts in the Fraser and Thompson rivers and listed in Section 5.1.1. The O8CDD had the widest range of percent recoveries, ranging from 21 to 103%. For the remaining dioxin/furan congeners none of the percent recoveries were lower than 40% nor exceeded 100%.

6.2 Discussion

6.2.1 Significant Effects

Elevated levels of metals in all three taxa collected downstream from Cominco indicate the influence of waste discharge from the smelter. The pattern of elevated metal levels in biota is consistent with the pattern of elevated metals levels in sediments (Section 5).

The source of elevated chromium in mussels collected downstream from Celgar is unclear. Neither Celgar nor Pope and Talbot has any records of having used chromium. However, the sediment data (Section 5) suggest a source of chromium in Reach II. The sediment chromium levels were higher at the Celgar and Robson sites than at the Reach III sites (China Creek and lower Birchbank).

The distribution of organic chemicals in biota was not clearly related to the discharge from Celgar. The presence of T4CDF, pentachlorophenol and the higher chlorinated dioxins and furans in biota from the control sites suggests another source (or sources) of these compounds in the Nelson area or possibly in the upper Kootenay River.

The freshwater mussel samples collected by BC Environment (Butcher 1992) appeared to show an effect of the Celgar discharge, but the Ministry did not sample control sites in the Kootenay River. Furthermore, the BC Environment samples contained substantially higher concentrations of dioxins/furans and chlorinated phenolic compounds than the present samples.

Given the differences in time, season, and sampling locations several explanations of the differences between BC Environment and CRIEMP data are possible. The lower levels in 1992 may represent a real reduction in mussel tissue contamination as a result of measures by Celgar to reduce dioxin/furan discharges. As mussels are filter feeders they may respond to changing dioxin/furan levels in water and suspended particles, which are expected to decrease more rapidly than sediment dioxin/furan levels following an improvement in effluent quality. On the other hand, the BC Environment studies showed wide variability among sites. Different sampling locations between the previous and current studies also could account for the different results.

Furthermore, the mussels were collected during different seasons which likely produced differences in their reproductive condition. Prior to spawning, the gonads typically make up a large proportion of a bivalve's weight, but this contribution decreases significantly after spawning. Lipid content of the bivalves will vary with gonad weight and may also change in response to other seasonal factors. Since dioxins and furans in tissues are associated with lipids, these seasonal factors likely contribute to differences in dioxin/furan levels.

6.2.2 Implications for Monitoring Program

One objective of the bioreconnaissance study was to identify one or more non-fish species which could be used to monitor tissue contaminant levels. Fish tissue monitoring programs to address the potential health implications of consuming fish with high levels of metals or organic compounds are continuing under CRIEMP. However, because fish are mobile, their history of contaminant exposure is always somewhat uncertain. In contrast, benthic invertebrates and plants spend most or all of their lives in one location where their history of contaminant exposure can be documented.

In order to be a useful monitor organism for contaminant levels, a species should:

1) accumulate the contaminants of interest at concentrations high enough to be measured readily;

2) accumulate levels of the contaminants which reflect environmental levels; and

3) be abundant and widely distributed so that adequate numbers of the same species can be collected at all sites without adversely affecting the population.

All three taxa investigated (freshwater mussels, the macrophyte *Potamogeton perfoliatus*, and emergent caddisflies) met the criterion of accumulating detectable concentrations of at least some contaminants. All three taxa accumulated relatively high levels of metals. Mussels and caddisflies also accumulated detectable levels of dioxins, furans and some chlorinated organic compounds. The macrophytes analyzed did not contain detectable levels of any dioxins, furans or chlorinated organic compounds, and therefore cannot be used to monitor these substances.

The levels of metals in all three taxa reflected levels in sediments from the areas where they were collected (insofar as sediment data from comparable sites were available). Thus, on the basis of the first two criteria all three taxa are acceptable for environmental monitoring of metal levels.

The relationship between organic contaminants in tissues and in the environment was less clear. Mussels and caddisflies from the control sites on the Kootenay River contained levels of these compounds as high or higher than levels in animals from Celgar and Waneta. Since sediments from these control sites were not analyzed (because a spill of raw sewage from the Nelson wastewater treatment plant occurred between the biota and sediment collections), it is difficult to determine the reason for the elevated tissue organics levels. However, elevated levels should be considered a reason for rejecting the Kootenay River sites as control areas rather than for rejecting the invertebrates as monitor organisms.

The mussel *Anodonta oregonensis* and the macrophyte *Potamogeton perfoliatus* are widely distributed and abundant. Both species were collected at all sites where they were sought except Birchbank (III-2) and Ryan Creek (IV-1). A different mussel species was present at Birchbank during the July tissue collection trip, but *Anodonta* were observed at this site during the September sediment sampling trip. *Potamogeton* is absent at Birchbank (III-2), but it is present at lower Birchbank (III-3), where *Anodonta* were also found. Thus, *Anodonta* and *Potamogeton* meet the third criterion (availability) for satisfactory monitor organisms.

Emergent caddisflies are also abundant and widely distributed. However, the caddisfly traps collected five to nine species per site. Of these, five species comprised >14% of the collection from at least one site. The dominant species and proportional abundances of major species varied from site to site.

The ability to concentrate trace contaminants is species specific. For example, significant among-species differences have been noted for metals in chironomids (Hare et al. 1991), fish (Smith 1987b), dioxins/furans in fish (Mah et al. 1989, Butcher 1992), and mercury in freshwater mussels (Smith et al. 1974). Contaminant levels in caddisflies may also be species specific. Therefore, the value of comparing among-site differences in contaminants in different species mixtures is doubtful.

Caddisflies might be useful monitor organisms if the samples were sorted and a single species selected for analysis. Based on the species distributions observed in the bioreconnaissance study (Table 7-1), *Hydropsyche occidentalis* and *Cheumatopsyche campyla* appear abundant and widely distributed enough to be useful as monitors. Distinguishing these genera may not be too difficult. However, the July 1992 collection contained a second species of *Cheumatopsyche* and four additional species of *Hydropsyche*, one of which was abundant. Distinguishing species within genera is labour intensive, requiring mounting of specimens and examination under a microscope. It is not practical in the field and would add significantly to both the sample processing cost and potential for sample contamination. Since the second *Cheumatopsyche* species was rare, using *Cheumatopsyche campyla* as the monitor species is a possibility.

Even sorting caddisflies to genus prior to analysis may be impractically labour intensive. In addition, selecting a single genus to monitor assumes that this caddisfly will be similarly abundant and widely distributed at approximately the same time each year. There is currently no information on the year to year variability in caddisfly abundance and species composition. Since another suitable monitor organism, *Anodonta oregonensis*, is available, continued monitoring of caddisflies is not recommended.

We recommend that the ongoing tissue monitoring program focus on the freshwater mussel, *Anodonta oregonensis*. If a second (non-fish) monitor organism is desired, we recommend that the macrophyte *Potamogeton perfoliatus* be used for metals. However, the macrophyte is not suitable as a monitor for organic compounds.

Our recommendation to use freshwater mussels as monitors for organic compounds is in contrast to the advice of EVS Consultants (1990), who discounted the use of freshwater mussels because of high among-site variability in dioxin/furan levels. They attributed the variability to the mussels' response to local sediment dioxin/furan levels which are also highly variable. EVS Consultants considered fish superior monitor organisms because they integrate contaminant levels over a wider area.

The use of a sentinel organism which integrates contaminant levels over a wide area is useful for monitoring the health of the overall Columbia River ecosystem. However, it has limitations for identifying specific impacts or improvements related to the actions of specific industries. Freshwater mussels are potentially useful monitors for the latter monitoring objective.

Factors other than site-specific contaminant levels may increase the variability in freshwater mussel tissue contaminant levels, but these factors can be controlled. For example, seasonal differences related to reproductive condition of the animals (see Section 6.1.1) can be controlled by sampling at the same time of year each time the monitoring cycle is repeated.

There is another potential source of variability which could affect the selection of different control sites. Genetic differences among mussels may contribute to differences in tissue contaminant levels. Using reciprocal transplant experiments, Hinch and Green (1989) demonstrated that genotype affected the growth rate of the freshwater mussel *Elliptio complanata*, which in turn affected tissue metal levels. *Anodonta oregonensis* in the Columbia and Kootenay rivers downstream of the dams should all belong to the same genetic stock. Unionid mussels (the group to which *Anodonta* belongs) disperse by means of glochidia larvae which are parasites on fish gills. Therefore, throughout the area where fish can move freely, the mussels all should have similar genetic background. Where the dams form barriers to fish movement, they also will isolate the mussel populations. Thus, if new control areas are located upstream of the dams, the control mussels may be genetically different from mussels from impacted areas downstream.

An alternate approach to avoid some of the problems associated with locating suitable control areas and genetically similar mussel populations is to conduct *in situ* bioassays. If a large enough, uncontaminated control population of mussels can be located, animals could be transplanted to locations in the Columbia River and their contaminant uptake monitored. Other invertebrate species could also be transplanted. For example, transplanted leeches have been used to monitor chlorophenols (Hall and Jacob 1988). Although they do not appear to be abundant, several species of leeches are present in the study area (Table 3-1).

CONCLUSIONS AND RECOMMENDATIONS

7.1 Significant Effects

The only significant effects that the bioreconnaissance study clearly demonstrated were the presence of elevated organic compounds and metals in sediments and/or biota and the appearance of extensive growths of moss on rocks downstream from Cominco.

Metal levels (in particular zinc, lead, copper, cadmium, arsenic and mercury) in sediments at all three sites sampled downstream of Cominco were significantly elevated by comparison with other areas. The elevated sediment metal levels were reflected by elevated concentrations in the tissues of freshwater mussels (*Anodonta oregonensis*), emergent caddisflies (various species), and macrophytes (*Potamogeton perfoliatus*).

Levels of various chlorinated phenolic compounds, dioxins, and furans including 2,3,7,8-tetchlorodibenzofuran, which is characteristic of pulp mill effluents, were elevated in sediments collected immediately downstream of Celgar. Detectable levels of these compounds were present at Waneta, the sampling station farthest downstream. Dioxins, furans, and some chlorinated phenolic compounds were also present in mussels and caddisflies, but their relation to the Celgar discharge is questionable. These compounds were also found in mussels and caddisflies from the Kootenay River above the Brilliant Dam.

No gross effects on either benthic invertebrate or periphyton communities were apparent. The among-site differences observed could have been related to physical factors, industrial discharges, or both. The benthic invertebrate community downstream of Celgar was dominated largely by oligochaetes and nematodes, which usually are tolerant of polluted conditions. These species were also dominant upstream of Celgar, and their presence may be related more to substrate and current conditions than to industrial discharge. Species richness and total abundance of organisms was depressed downstream of Cominco in April, but this pattern was not repeated in October. Periphyton standing crop appeared to be lower at the sites immediately downstream from Celgar and Cominco.

Distribution of macrophytes, except moss, appeared to depend upon the presence of suitable substrate and current conditions, and showed no influence of waste discharges. The distribution of moss appears to be related to Cominco's discharge as extensive growths of moss occurred in some areas downstream of Cominco, but almost no moss was found upstream of the discharge.

Sediment bioassays suggested some toxicity in sediments from the downstream sites nearest Celgar and Cominco. However, sediments from other downstream sites with measurably elevated levels of organic compounds or metals, did not show similar toxicity. Any toxic effects of the industrial discharges may be confined to limited areas and possibly are dependent upon sediment grain size.

7.2 Recommended Monitoring Program

7.2.1 Program Components

The CRIEMP program should continue to include sediment and tissue monitoring (freshwater mussels and, optionally, macrophytes), sediment toxicity tests, and possibly benthic invertebrate community structure. Monitoring of periphyton on natural substrates is unlikely to provide data that will allow successful statistical comparisons of current and/or future industrial impacts, and should be discontinued. However, monitoring periphyton using artificial substrates could be considered. Macrophyte monitoring (except possibly for monitoring changes moss distribution at a few selected sites) also is unlikely to provide useful results and should not be included in the ongoing program.

Based on the initial study results, it is doubtful that benthic invertebrate surveys will ever provide data which that allow hypothesis testing. However, because benthic community structure is an important part of an integrated environmental monitoring program, another survey with an improved sampling design should be considered.

7.2.2 Benthic Invertebrate Survey

The design of the followup benthic invertebrate survey should address the following considerations:

- The number of sampling sites should be increased to include at least three sites per reach with a minimum three sites downstream of each discharge. The number of replicates per site might be reduced to four or even three, if reducing the cost of sample analyses is a consideration.
- Sampling should not take place immediately after flow reduction, when abundances will be artificially elevated due to organisms moving down from recently dewatered areas. If possible, sampling should occur at least two weeks (preferably longer) after any significant flow change. This approach will reduce the chances of collecting organisms which have drifted downstream and settled in an area where they are incapable of surviving in the long term.

- Sampling should take place only at low water to ensure that the sampling sites are rarely, if ever, dewatered. Sampling in April should continue because appropriate flows at that time are probable. A second sampling time in September or October is desirable, but it will be more difficult to obtain acceptable flow conditions. Close coordination with B.C. Hydro will be necessary to determine whether appropriate sampling conditions can be guaranteed.

- Sampling sites should be matched as closely as possible with respect to substrate type, current velocity, and slope. Consideration of substrate type should include both the size of overlying rocks and the size and composition of the underlying sand/gravel. In order to find an adequate number of similar sampling sites, it likely will be necessary to sample the larger substrate.

- The CRIEMP committee should seriously consider using artificial substrate samplers to avoid the problems associated with flow and substrate variability.

7.2.3 Sediment Sampling

The ongoing sediment sampling program should include the following considerations:

- Sampling should occur at low water to ensure that the sediments collected are never exposed.

- Sediment sampling should be concurrent with the biota (tissue) sampling. Therefore the timing should be determined by the biota collection (Section 7.2.4).

- With the exception of control sites, the sampling sites used in the bioreconnaissance study generally should be maintained because there are few, if any, alternate sites with fine sediments in the study area.

- New control sites should be found if possible. Lake sediments do not appear to be appropriate controls for river sediments (Section 5). In addition, using the same control sites for both sediments and biota would allow more complete data interpretation (eg. calculation of bioconcentration factors).

- The control sites should always be sampled first. Thereafter, sampling should proceed from downstream (Waneta) to upstream (Celgar).

- To evaluate the possibility of transferring contaminants from one site to another on the equipment, the field QA/QC audit should include a comparison of results for a site at some intermediate point in the sampling schedule (eg. lower Birchbank).

- Sediment analyses should include continue to include organics, metals, and bioassays. At least some bioassays should be done using whole (not sieved) sediments because this is the material to which benthic organisms are exposed in the river. It is recognized that sediment particle size may affect the responses to some tests (notably the solid-phase Microtox test), and that it probably will be difficult to obtain similar particle size distributions at all sites. Therefore, running at least one test on both whole and sieved sediments is recommended.

- Bioassays should begin within two weeks of sediment collection. If sieving cannot be accomplished within this time frame, then only whole sediment should be tested.

- If bioassays are done on sieved sediments, then chemical analyses should be done on the particle size fraction used for the toxicity tests.

- Given the absence of amphipods and abundance of chironomids in the benthic samples, the CRIEMP Committee should consider substituting a *Chironomus tentans* test for the *Hyalella* test or adding the *Chironomus* test to the bioassay program.

7.2.4 Biota Sampling for Tissue Contaminants

Recommendations for biota sampling include the following:

- The freshwater mussel *Anodonta oregonensis* is the preferred non-fish sentinel species. If a second non-fish species is desired, we recommend the macrophyte *Potamogeton perfoliatus* to monitor metals only.

- To facilitate data interpretation, whenever possible biota should be collected at the same times and locations as the sediments are collected. *P. perfoliatus* is available at or near all sediment sites except Ryan Creek (IV-1). *Anodonta* is not available at Ryan Creek. The mussels were not found near Beaver Creek (IV-2) and were not sought at China Creek (III-1). However, they generally occur at the lower edges of macrophyte beds and therefore are likely to be present wherever *Potamogeton* is collected.

- To control for seasonal differences due to growth rate and/or reproductive condition of the monitor organisms, sampling should occur at a consistent time of year whenever the cycle is repeated. Low water, preferred for sediment sampling, will also facilitate biota collection. Since low water consistently occurs in April, we recommend sampling at this time, if only mussels are to be collected. If macrophytes are included in the monitoring program, late summer/early fall sampling is preferred. Close coordination with B.C. Hydro will be necessary to determine whether appropriate sampling conditions can be guaranteed. Alternatively, macrophytes might be collected separately from the sediment and mussel collections.

- As an alternative to monitoring resident biota, the CRIEMP Committee should consider *in situ* uptake experiments using transplanted mussels or another organism such as leeches. Such experiments would avoid the problems associated with a lack of suitable control areas in the Columbia River downstream of the Hugh Keenleyside Dam and possible genetic differences in mussels collected upstream of dams.

- New control sites for biota should be established. The control sites on the Kootenay River at Glade and Grohman Narrows showed evidence of contamination with chlorophenols and dioxins/furans. In addition, mussels collected upstream of the Brilliant Dam could be genetically different from mussels in the Columbia River, and genetic differences can affect tissue contaminant levels.

- In addition to reporting tissue contaminant levels, moisture and lipid content, the laboratory should record the following biological data for mussels: length, weight (without shell), sex, and reproductive condition (gonad weight or anecdotal comment on ripeness).

7.2.5 Control Sites

New control sites are required for sediments and biota. Ideally, these sites should be riverine environments, isolated from potential contaminant sources, and not so isolated that the control mussels would represent different populations from the Columbia River mussels. It is unlikely that control sites which meet all these criteria exist. However, two possible sites that were discounted for the bioreconnaissance study remain possibilities.

The CRIEMP Committee rejected locations near the benthos control sites as controls for the contaminant analyses. The concern related to the site below Hugh Keenleyside Dam was that hydraulic damming during high flows in the Kootenay River and low flows in the Columbia River may cause backflow of the Celgar effluent into this area. A similar concern related to the site in the mouth of the Kootenay River was that during low flows in the Kootenay River, high flows in the Columbia River may spill over into the sampling area.

Stage discharge data confirm that such flow imbalances affect water levels in the two rivers. However, there does not appear to be any evidence of actual backflow or overflow. Hydraulic modelling (reported in Butcher 1992) in fact indicates that flow reversal of the Columbia River does not occur.

In the absence of alternate control sites, limited testing of sediments and organisms at the Kootenay mouth and upstream of Celgar is warranted. The Kootenay River site may prove to be a suitable control. The potential suitability of any site upstream from Celgar will depend upon finding a location that is also upstream of the Pope and Talbot sawmill. A site downstream of any sawmill is potentially contaminated with wood preservatives.

A less desirable alternative is to seek control sites on the Slocan River. In this region it may be possible to find sites isolated from potential contaminant sources. However, it is probable that any mussels found there are genetically from the Columbia River mussels.

The absence of suitable control sites would limit the ability to conclusively identify the reason changes in levels of organic chemicals. However, monitoring of organic chemicals would still be valuable in terms of showing changes over time. Furthermore, it would not be a limitation for the interpretation of the metals data. The Reach III sites (China Creek to Birchbank) appear to be suitable controls for metals sampled downstream of Cominco (Reach IV).

Given the uncertainty of finding control sites with genetically similar populations, *in situ* bioassays should be considered. Mussels or another species (leeches, for example) from a control area could be held at various sites in the Columbia River to test for contaminant uptake.

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Appendix 2-1

Methods of Chemical Analysis and Laboratory QA/QC

Table of Contents **Page No.**

1.0 INTRODUCTION

On July 27, 1992 a total of twenty eight biota and vegetation samples were received from Norecol Consultants. The samples were received in coolers in a frozen state and immediately transferred to a freezer for storage. The samples were contained in plastic bags and bottles with identifiable markings. Analysis of select samples began upon receipt of an analysis schedule from Annette Smith of Norecol.

On September 3, 1992 a total of fourteen sediment samples were received from Bruce Ott of Norecol Consultants. Samples were received in two coolers and packed with dry ice. All samples were received frozen and immediately transferred to a freezer pending receipt of an analysis schedule. Samples were contained in 1 litre clear glass containers fitted with teflon lined plastic lids. The containers were supplied by Zenon and had been certified as Level I containers by the supplier. Final confirmation of the sampling schedule was received September 11, 1992 and analysis started the following week.

Also included are results for samples delivered by Tom Tremblay of Environment Canada. These samples were reported as being from the American portion of the project. The samples were received on October 13, 1992 in a cooler and packed with ice. Samples were transferred to a storage fridge and stored at 4°C prior to and during analysis. Three soils were also received for wet and sieving prior to testing by Graham Van Aggelen of the BCMOE Aquatic Toxicology Lab.

The report herein describes the analytical protocols in Section 2, presents the analytical results Section 3 and details the QA/QC protocols in Section 4.

2.0 ANALYTICAL METHODOLOGY

2.1 Metals

Samples were homogenized, dried (soils are air dried while biology samples are freeze dried) and subjected to a nitric perchloric ($HNO_3/HClO_4$) digestion to solubilize the solid matter and remove most of the organics by oxidation and volatilization. The sample was then introduced into an Inductively Coupled Argon Plasma(ICAP) where the atomic emission signal corresponding to each excited element was measured and compared to those of external standards for quantification.

Arsenic and selenium were run by ICAP- hydride generation thus allowing for the improved detection limits. Samples were digested as above and then introduced into an automated system where mixing with concentrated acid (HCl), sodium borohydride ($NaBH_4$) and potassium iodide (KI) occurred. Arsenate and selanate species are converted to gaseous arsine and selenium hydride allowing for their separation from the aqueous solution. The hydrides are swept into the ICAP for excitation and subsequent quantification.

Mercury was analysed by first oxidizing organomercury compounds using a $H_2SO_4/KMnO_4/K_2S_2O_8$ digestion. After digestion excess permanganate was reduced with hydroxylamine hydrochloride followed by reduction with stannous chloride. Elemental mercury is then purged from the solution and swept into a UV monitor possessing a mercury lamp. The absorbance of mercury is measured at 253.7 nm and is measured against reference standards.

2.2 Extractable Organic Halides

The organic halogen content of sediment sample is measured after extraction of the organohalides into an appropriate organic solvent. A representative five gram sample of the solid is placed in a 15 mL centrifuge tube with 1 mL of deionized water and 5 mL of ethyl acetate and capped tightly with a teflon lined cap. The sample is shaken vigorously for one minute. Then the sample is sonicated in a sonic bath for 15 minutes. The suspension is allowed to settle for 10 minutes then the upper ethyl acetate layer is transferred to a clean 15 mL centrifuge tube with a disposable pipette. The tube is then capped and centrifuged at 1000 g for 5 minutes. The ethyl acetate layer is then transferred to a clean centrifuge tube for analysis.

The organic halogen content is measured using a Dohrmann Model MC 3. Twenty five uL of the extract is injected directly into the pyrolyses tube at a rate of 1 uL/second. A ten minute integration cycle is used to estimate the concentration. If readings exceed the working range the analysis is repeated using the diluted extract. Please note that the solid to solvent ratio was modified to lower the detection limit.

2.3 Total Kjeldahl Nitrogen

The dried and homogenized soil sample was digested in a hot block with a mixture of sulphuric acid, mercuric oxide and potassium sulphate. This converted the free ammonia and organic nitrogen compounds to ammonium bisulfate. The digestate was then analyzed for Kjeldahl nitrogen using an automated colourimetric method. An emerald green colour of the ammonium salicylate complex was formed by the reaction of ammonia, sodium salicylate, sodium nitroprusside and sodium hypochlorite in a buffered alkaline medium at a pH of 12.8-13.0. The ammonia salicylate complex was read at 660 nm. Detection limit for this method is 2.0 ug/g.

2.4 Acid Volatile Sulphides

Also referred to as acid-insoluble sulfides which were determined according to EPA SW846 Method 9030A. Sulfides were separated from the sediments by the addition of hydrochloric acid and vigorous stirring. Tin (II) was present to prevent the oxidation of sulphide to sulfur by metal ions or dissolved oxygen present in the system. The mixture was distilled at 100°C under a stream of nitrogen allowing for the collection of H_2S in gas scrubbing bottles containing zinc acetate. Precipitated zinc sulphide was redissolved with an excess known amount of iodine with the excess being titrated with sodium thiosulphate.

2.5 Total Organic Carbon (LECO Method)

An induction furnace and an oxygen atmosphere was used to combust the sample to CO and CO_2. A catalytic furnace then converts all the CO to CO_2. The resulting CO_2 together with oxygen displaces fluid in a burette before and after absorption in a KOH solution. The differnce in burette readings was proportional to the total carbon content. Another portion of the sample was ashed and treated as above with inorganic carbon being the final result. Total organic carbon was obtained from the difference of the two analyses.

2.6 Moisture

A homogeneous portion of the soil was dried to constant mass at 105°C. The loss in mass has been expressed as a percentage of the original sample and is defined as percent moisture.

2.7 Wet and Dry Sieving

Approximately 5 g of sample was dried overnight at 105°C then sieved through 100 mesh. Sample was submitted for Solid Phase Microtox testing.

The remainder of the sample was wet sieved through 50 mesh until 300 mL of the sample was collected or entire sample had been consumed. Samples were submitted for Hyallela Azteca testing.

3.0 ANALYTICAL RESULTS

The analytical data for the samples are presented in Appendix A-C.

Elevated levels of heavy metals were found in several samples throughout the study. Common metals found were cadmium, cobalt, chromium, lead, and zinc that are of concern from a bioconcentration or bioaccumulation perspective.

Detectable levels of extractable organic halides were observed more frequently in samples displaying acid volatile sulphide.

Please note that all results are dry weight basis except for the acid volatile sulphide which are treated as received (ie. results are reported as wet weight basis for this parameter).

4.0 QUALITY CONTROL / QUALITY ASSURANCE (QA/QC)

A complete QA/QC programme was employed by ZENON for this programme. ZENON participates in many internal and external studies that allows current methodologies to be continually evaluated and improved. Measures that were specifically used in this study are described below and results are summarized in Appendix D and E.

4.1 Method Blanks

A method blank is an analysis incorporating all aspects of the analysis, excluding the sample. Its value is to identify the presence of glassware, reagent or instrumentation induced contamination. In this study method blanks were processed with each group of samples. Please note that all samples are blank corrected.

4.2 Duplicate Data

Duplicate samples were carried through the analytical train as an indication of sample homogeneity. Duplicates for the Biota and Vegetation samples were quite good, however, much higher percent differences were observed for the sediments. Both duplicates processed for the sediments showed large differences for tin and zirconium while others such as chromium showed elevated differences on a individual basis. Samples were split and carried through the analytical procedure separately.

4.3 Spiked Samples

Samples were spiked for several of the parameters of interest and recoveries are based upon recovery of the spike once dilution correction has been applied. Overall recoveries were quite good for both types of samples. High recoveries were observed for aluminum and potassium in sample 18972, however, the spike was quite low when compared to sample concentration. Low recovery of the arsenic spike on sample 20278 is also due to relative amount of spike added when compared to level of arsenic in the sample.

4.4 Standard Reference Materials

Standard reference materials(SRM's) are actual samples available in different matrices that have been extensively analysed by several laboratories and have certified concentration values for the compounds analysed. The analysis of SRM's gives a measure of the accuracy of the method when applied to that matrix. Poor recoveries are generally observed for some metals, such as chromium and potassium, in sediments since the acid digestion does not completely decompose the matrix.

ANALYSIS OF POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS IN TISSUE SAMPLES

Summary

All samples were spiked with an aliquot of ^{13}C-labelled internal (surrogate) standards (tetrachlorodioxin, tetrachlorofuran, pentachlorodioxin, hexachlorodioxin, heptachlorodioxin, and octachlorodioxin) prior to analysis. Tissue samples were ground with sodium sulfate, packed in a glass column and eluted with solvent. The extracts were subjected to a series of cleanup steps and then analyzed by gas chromatography with mass spectrometric detection (GC/MS).

1. Sample Preparation

Tissue samples were dissected from the ~~fish~~ and placed in hydrocarbon-clean glass jars for storage prior to analysis. Livers and dorsal muscle tissue were collected separately. The samples were homogenized using a Virtis homogenizer and a subsample taken for analysis. Liver samples were prepared as composites of several individual livers as indicated on the analysis reports. Dorsal muscle samples were analyzed both from individual fish and as composites from several fish as indicated on the analysis reports. Samples were not dried prior to analysis and the results are reported on a wet weight basis.

2. Extraction Method

All samples were spiked with an aliquot of ^{13}C labelled internal (surrogate) standard solution prior to analysis. This aliquot contained 2 ng each of ^{13}C labelled tetrachlorodibenzodioxin, tetrachlorodibenzofuran and pentachlorodibenzodioxin; 4 ng each of ^{13}C labelled hexachlorodibenzodioxin and heptachlorodibenzodioxin; and 6 ng of octachlorodibenzodioxin.

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A wet tissue sample (10 to 15 g) was mixed with powdered anhydrous Na_2SO_4 and allowed to stand until the mixture ground to a free-flowing powder. It was then loaded into a glass column, spiked with internal (surrogate) standard solution and eluted with 300 mL of 1:1 dichloromethane : hexane at a rate of 3 mL per minute.

The extract was loaded onto a Biobeads SX-3 column (60 g) and eluted with 1:1 dichloromethane : hexane. The first 150 mL fraction was discarded. The second fraction (150 - 300 mL) was retained.

3. Liquid Column Chromatography

a) Silica Gel Column

The extract was transferred to a 10 gram layered silica gel column (layers: activated silica gel, silica gel treated with sodium hydroxide, activated silica gel, silica gel treated with sulfuric acid; activated silica gel) and eluted with hexane.

b) Alumina Column

The extract from the silica gel column was loaded onto a 10 gram basic alumina column. The first fraction, eluted with 3% CH_2Cl_2/hexane was discarded. The next fraction, eluted with 1:1 CH_2Cl_2/hexane was retained.

c) Carbon/Celite Column:

The retained extract from the alumina column was loaded onto a carbon/celite column. The first fraction (F1), which elutes with cyclohexane/CH_2Cl_2 followed by benzene/ethyl acetate was discarded. The column was then inverted and eluted with toluene. This fraction (F2) was evaporated to near dryness and was redissolved in hexane.

d) Alumina Column

The extract from the carbon/celite column procedure was loaded onto the alumina column. The first fraction, eluted with 3% CH_2Cl_2/hexane was discarded. The next fraction, eluted with 1:1 CH_2Cl_2/hexane was retained and concentrated to 1 mL.

e) Preparation for GC/MS Analysis

The extract was evaporated just to dryness and an aliquot of recovery standards (^{13}C-labelled 1,2,3,4-tetrachlorodibenzo-dioxin, 1,2,3,6,7,8-hexachlorodibenzodioxin and 1,2,3,4,6,7,8-heptachlorodibenzofuran) was added.

4. GC/MS Analysis

Polychlorinated dibenzodioxins (PCDD) and dibenzofurans (PCDF) were analyzed on a Finnigan INCOS 50 mass spectrometer equipped with a Varian 3400 GC, a CTC autosampler and a DG 10 data system running Incos 50 (Rev 9) software. A 60 metre DB-5 chromatography column (0.25 mm i.d., 0.25 um film thickness) was used for the GC separation. Mass spectral data were acquired in the Multiple Ion Detection (MID) mode in order to enhance sensitivity. At least three ions were monitored for each group of isomers. Two were from the parent cluster while the third was from the loss of COCl (i.e.. M-COCl or M-63). Two ions were used to monitor each of the ^{13}C labelled surrogate standards.

Positive identification of PCDDs or PCDFs was based on the following criteria:

1. Retention time was within those of the first and last eluting times of the corresponding isomers as defined by a retention time window standard.
2. Peak was found in all three ion windows.
3. Ratios of peak areas correspond to those of the standard (within 20%).

Once identification was made, compounds were quantified by comparing the area of the quantification ion to that of the corresponding ^{13}C labelled standard and correcting for response factors. Response factors were determined daily by analyzing standard solutions of authentic and 13C labelled chlorinated dioxins and furans. Detection limits were calculated for each sample as the concentration of each PCDD/PCDF corresponding to a peak three times the area of the smallest peak that could be detected in the mass chromatogram.

ANALYSIS OF CHLORINATED PHENOLICS IN TISSUE SAMPLES

Summary

All samples were spiked with an aliquot of ^{13}C-labelled internal (surrogate) standards (4-chlorophenol; 2,4-dichlorophenol; 2,4,6-trichlorophenol; 2,4,5-trichlorophenol; 2,3,4,5-tetrachlorophenol and pentachlorophenol) prior to analysis. Tissue samples were ground with sodium sulfate, packed in a glass column and eluted with solvent. The extracts were subjected to a series of derivatization and cleanup steps and then analyzed as their acetate derivatives by gas chromatography with mass spectrometric detection (GC/MS).

1. Sample Preparation

Tissue samples were dissected from the fish and placed in hydrocarbon-clean glass jars for storage prior to analysis. Livers and dorsal muscle tissue were collected separately. The samples were homogenized using a Virtis homogenizer and a subsample taken for analysis. Liver samples were prepared as composites of several individual livers as indicated on the analysis reports. Dorsal muscle samples were analyzed both from individual fish and as composites from several fish as indicated on the analysis reports. Samples were not dried prior to analysis and the results are reported on a wet weight basis.

2. Extraction Method

All samples were spiked with an aliquot of ^{13}C labelled internal (surrogate) standard solution prior to analysis. This aliquot contained 340 ng each of ^{13}C labelled 4-chlorophenol; 2,4-dichlorophenol; 2,4,6-tetrachlorophenol; 2,4,5-trichlorophenol; 2,3,4,5-tetrachlorophenol and pentachlorophenol.

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A wet tissue sample (about 10 g) was mixed with powdered anhydrous Na_2SO_4 and allowed to stand until the mixture ground to a free-flowing powder. It was then loaded into a glass column, spiked with internal standard solution and eluted with 300 mL of 1:1 dichloromethane : diethylether at a rate of 5 mL per minute.

The extract was loaded onto a Biobeads SX-3 column (60 g) and eluted with dichloromethane. The first 150 mL fraction was discarded. The second fraction (150 - 310 mL) was retained.

3. Derivatization and Cleanup

The retained fraction from the Biobeads column was concentrated to a volume of 1 mL, transferred to a separatory funnel and 25 mL of 0.2 M potassium carbonate added to adjust the pH. Acetic anhydride (2 mL) and hexane (25 mL) are added to the separatory funnel, the mixture is shaken vigorously and then let react for thirty minutes with periodic shaking. The acetylated compounds are extracted with hexane, dried over anhydrous sodium sulfate and concentrated to 1 mL.

The derivatized extract was loaded onto a 4 gram silica column (1% deactivated) and eluted with isopropanol;toluene (30:70).

The extract was evaporated just to dryness and an aliquot of recovery standard (2,6-dibromophenol) was added.

4. GC/MS Analysis

Chlorinated phenols, catecols and guaiacols were analyzed on a Finnigan INCOS 50 mass spectrometer equipped with a Varian 3400 GC, a CTC autosampler and a DG 10 data system running Incos 50 (Rev 9) software. A 30 metre DB-5 chromatography column (0.25 mm i.d., 0.25um film thickness) was used for the GC separation. Mass spectral data were acquired in the Multiple Ion Detection (MID) mode in order to enhance sensitivity. Three ions from the parent cluster were monitored for each group of isomers. Two ions were used to monitor each of the ^{13}C labelled surrogate standards.

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Positive identification of the chlorophenolics was based on the following criteria:

1. Retention time was within those of the first and last eluting times of the corresponding isomers as defined by a retention time window standard.
2. Peak was found in all three ion windows.
3. Ratios of peak areas correspond to those of the standard (within 20%).

Once identification was made, compounds were quantified by comparing the area of the quantification ion to that of the corresponding ^{13}C labelled standard and correcting for response factors. Response factors were determined daily using authentic chlorophenolics.

QUALITY ASSURANCE/QUALITY CONTROL

QA/QC Samples

- Batch Size - Analyses were carried out in batches of seven. Each batch of seven consists of five samples, one procedural blank and one QA/QC sample (duplicate, spiked sample or reference material).

- Blanks - One procedural blank was analyzed with each batch of samples. All blanks analyzed were clean (no detectable analyte compounds).

- Duplicates - Results for duplicates analyses are presented along with the analysis results. One sample in each batch is injected into the GC/MS twice (injection duplicates) to monitor instrumental precision. The injection duplicates must agree to within 10% relative (defined as the difference between the two results divided by the average result) for the batch data to be acceptable.

- Reference Materials - Standard reference materials are not yet available for dioxin/furan or chlorophenolics analyses, consequently spiked samples are relied on to demonstrate the accuracy of the data. Shrimp tissue purchased locally was spiked with the analytes of interest (a mixture of chlorinated dioxins and furans or a mixture of chlorophenols, catecols and guaiacols) at a concentration of ten times the expected detection limit. This "Reference Sample" was analyzed as a regular sample and the results are reported with the analysis results.

- External Standards - NBS SRM #1614 (2,3,7,8-T_4CDD in iso-octane) was analyzed to verify the accuracy of our 2,3,7,8-T_4CDD quantification. Solutions of authentic dioxins and furans and chlorophenolics used to spike the reference tissue are also analyzed at regular intervals to verify their quantification.

Instrumental Analysis

- Instrument Linearity - Quantification linearity of the GC/MS was periodically verified by a 6 point calibration covering a concentration range of 5 to 1500 pg/uL for chlorinated dioxins and furans or a concentration range of 200 pg/ul to 2 ng/ul for chlorinated phenolics..

- Instrument Sensitivity - Regular verification that 5 pg of 2,3,7,8-T_4CDD or 20 pg of pentachlorophenol was observed at greater than 3 times the noise.

- Isomer Specificity - Mixture of four T_4CDD isomers (1,2,3,4; 1,2,7,8; 1,2,7,9; 2,3,7,8) was analyzed to verify isomer specificity for 2,3,7,8-T_4CDD. Mixture of two tetrachlorophenol isomers (2,3,5,6 and 2,3,4,6) was analyzed to verify isomer specificity for chlorophenols.

- Daily Calibration - Instrument mass range was calibrated daily. Relative response factors (RRFs) for dioxins and furans and chlorophenolics (native/surrogate) were determined by a single point calibration every 8 hours (beginning and end of run). RRFs at beginning and end of sample suite agreed to within 10% (RSD).

- Column Carryover - Periodic assessment of column carryover by running solvent blanks.

- Interferences - The M+ ion of hexachlorodiphenyl was monitored to demonstrate the lack of interference from them in chlorinated furan analysis.

Data Reporting

- Windows - A chromatogram of a "window-defining" mixture was run periodically to define the "window" during which each dioxin or furan group or chlorophenolics group elutes.

- Surrogate Recoveries - Internal standard recoveries (reported with each sample result) were required to be in the range considered acceptable by Environment Canada (40% to 120% for TCDD/TCDF; 35% to 120% for PCDD; 30% to 120% for H_6CDD; 25% to 120% for H_7CDD; 20% to 120% for OCDD). Normally internal standard recoveries were well within the acceptable range. If recoveries were outside the range, the analysis was repeated. Reported results are corrected for internal standard recoveries.

- Ions Monitored - Response of at least three ions, including the COCl loss ion, was monitored for each dioxin/furan of interest. Peak maxima for all three monitored ions coincided within one scan for peak to be included in total congener summation. Peak area ratios for the two monitored molecular ions for each congener group were within ±20% of the ratio obtained for the corresponding ions in the day's calibration runs for the peak to be included. For chlorophenolics three ions from the parent cluster were monitored as above and the same criteria for peak acceptance were applied.

- Detection Limits - Detection Limits were monitored and reported for all compounds on a sample-specific basis. The detection limit was calculated as the concentration corresponding to three times the area of the smallest peak that could be quantified. Only peaks with responses greater than three times the background noise level were quantified.

AXYS
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November 6, 1992

Norecol Environment Mgt.
Suite 935 Marine Blvd.
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Vancouver, B.C.
V6C 2G8

Attn: Bruce Ott
Annette Smith:

Dear Mr. Ott and Ms. Smith:

Attached you will find a copy of our cleaning protocols for glassware and aluminum foil, as well as shipping and receiving sample information.

I apologize for the length of time it has taken to reply to your request.

Regards,
AXYS ANALYTICAL SERVICES

L Phillips

L. Phillips
Manager, Administration

Encl.

/lp

Cleaning and Baking Protocols

Sample jars (as received from the supplier) used for field sampling are rinsed with tap water and baked for eight hours at 333°C. The jar opening is covered with aluminum foil (which serves as a liner) and then closed with a screw cap lid.

Aluminum foil is baked at 360°C for 12 hours. The foil is handled with solvent rinsed tweezers after baking and wrapped in a sheet of baked foil prior to shipping.

Shipping and Sample Handling Procedures

Field sampling equipment is shipped by the receiver/shipper in coolers with ice packs.

Samples are received and logged in by the shipper/receiver. Upon receipt, the samples are immediately placed in the freezer.

Appendix 3-1

Data for April Invertebrate Samples

KOOTENAY RIVER (CS3) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Nematoda	21	43	17	70	46
Cnidaria					
Hydra	15	29	53	57	50
Bryozoa					
*Cristatella mucedo**	+	+	+	+	+
Turbellaria	6	10	9	18	11
Tardigrada	8	8	0	0	0
Rotifera	0	0	0	1	0
Hirudinea					
Glossiphonia complanata	0	0	0	0	0
Helobdella stagnalis	0	0	0	0	0
Piscicola	0	0	0	0	0
Oligochatea					
Enchytraeidae	67	90	43	54	88
Naididae	1008	604	433	541	376
Lumbriculidae	17	12	17	33	34
Tubficidae	0	8	0	4	2
Ostracoda					
Candona sp.	0	0	0	0	0
Cladocera					
Chydoridae	169	267	36	81	56
Copepoda					
Calanoida	0	0	0	0	8
Cyclopoida	0	12	4	9	16
Harpacticoida	424	487	109	90	83
Hydracarina					
Atractides	4	4	0	0	1
Lebertia	13	10	10	4	2
Sperchon	0	0	0	0	0
Torrenticola	8	11	4	1	8
Unidentified	8	8	0	0	0
Oribatei	0	0	0	0	0
Pelecypoda					
Pisidium	4	2	1	1	2
Gastropoda					
Gyraulus	0	0	2	0	3
Hydrobiidae	0	0	0	0	0
Lymnaeidae	0	0	0	0	0
Valvata sincera	4	12	13	4	8
Unidentified	0	0	0	0	0
Collembola	0	0	0	0	0
Ephemeroptera					
Ameletus	1	0	1	0	0
Baetis spp.	0	0	0	0	1
Drunella	0	0	0	0	0
Ephemeralla spp.	2	13	4	3	91
Leptophlebia	1	0	0	0	0

KOOTENAY RIVER (CS3) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Rithrogena	0	0	0	0	0
Tricoptera					
Anagapetus	0	0	0	0	0
Apatania	0	0	0	0	0
Cheumatopsyche	0	0	0	0	0
Glossosma	0	0	0	0	0
Hydropsyche	1	0	0	0	0
Hydroptila	0	0	0	0	0
Mystacides spp.	18	24	14	128	17
Neureclipsis	0	0	0	0	0
Oxyethira	1	0	0	0	0
Plecoptera					
Cultus	0	0	0	0	1
Chloroperlidae	0	1	0	0	0
Haploperla	0	0	0	0	0
Podmosta	0	0	0	0	0
Heteroptera					
Sigara washingtonensis	12	6	21	12	4
Coleoptera					
Deronectes	0	1	0	0	0
Heterlimnius	0	2	0	1	1
Optioservus	1	0	0	1	0
Diptera					
Simuliidae					
Simulium	1	1	0	0	0
Ceratopogonidae					
Chelifera	0	0	0	0	0
Unidentified	0	0	1	0	0
Dolichopodidae	0	0	0	0	0
Tipulidae					
Hemerodromia	0	2	1	0	1
Unidentified	0	0	0	0	1
Chironomidae					
Chironominae					
Cladotanytarsus	*0*	*8*	*0*	*0*	*0*
Cryptochironomus	0	0	0	0	0
Microtendipes	0	0	0	0	0
Parachironomus	0	0	0	0	0
Paracladopelma	0	0	0	0	0
Paratanytarsus	•	0	0	0	0
Paratendipes	0	0	0	0	0
Phaenopsectra	1	0	0	0	0
Polypedilum	0	0	0	0	0
Stempellinella	0	4	0	0	0
Sublettea	1	1	1	0	0
Tanytarsus	7	10	0	0	8
Tribelos	0	0	0	0	0

KOOTENAY RIVER (CS3) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Diamesinae					
Diamesa	7	20	4	9	18
pupae (included above)	0	0	0	0	0
Monodiamesa	0	0	0	0	0
Pagastia	0	0	0	0	0
pupae (included above)	0	0	0	0	0
Potthastia gaedii group	0	4	1	0	0
Potthastia longimana group	0	1	0	0	0
pupae (included above)					
Othocladiinae					
Ablabesmyia	0	1	0	0	0
Cardiocladius	*	0	0	0	0
Corynoneura	0	1	0	0	0
Cricotopus bicinctus group	0	4	0	0	0
Cricotopus sylvestris group	0	0	0	0	0
Cricotopus tremulus group	0	6	0	1	1
pupae (included above)	0	0	0	0	0
Cricotopus or Orthocladius spp.	995	2414	1470	1450	1245
pupae (included above)	0	0	0	0	0
Eukiefferiella spp.	4	1	4	0	8
pupae (included above)	0	0	0	0	0
Heterotrissocladius	0	0	0	0	0
Nanocladius	0	0	2	0	0
pupae (included above)	0	0	1	0	0
Orthocladiinae - unidentified larvae	22	12	0	0	0
Orthocladiinae - unidentified pupae	0	3	0	0	0
Orthocladius (Euorthocladius)	4	1	0	1	0
pupae (included above)	0	0	0	0	0
Paracladius (triquetra type)	0	0	0	0	0
Parakiefferiella	0	0	0	0	0
Parametriocnemus	0	0	0	0	0
Psectrocladius	1	1	0	0	2
Rheocricotopus	0	0	0	0	0
Smittia	0	0	0	0	0
Synorthocladius	1	0	0	0	0
pupae (included above)	0	0	0	0	0
Tvetenia bavarica group	0	0	0	0	0
Tvetenia discoloripes group	0	0	4	8	0
pupae (included above)	0	0	0	0	0
Tanypodinae					
Procladius	0	0	0	0	0
Thienemannimyia group	0	0	0	0	0
TOTAL SPECIES	**35**	**43**	**29**	**26**	**32**
TOTAL ORGANISMS	**2857**	**4159**	**2280**	**2582**	**2193**

COLUMBIA RIVER ABOVE CELGAR (II-1)
Sampled April 23, 1992

TAXA	REPLICATE				
	#1	#2	#3	#4	#5
Nematoda	60	78	60	108	77
Cnidaria					
Hydra	20	8	6	26	8
Bryozoa					
*Cristatella mucedo**		+		+	+
Turbellaria	1		1	4	4
Tardigrada					
Rotifera					
Hirudinea					
Glossiphonia complanata					
Helobdella stagnalis	1				1
Piscicola					
Oligochatea					
Enchytraeidae	11	5	11	27	62
Naididae	22	10	4	13	15
Lumbriculidae	51	26	8	66	16
Tubficidae					
Ostracoda					
Candona sp.				1	
Cladocera					
Chydoridae	3	1			2
Copepoda					
Calanoida	1	4		2	3
Cyclopoida	4		2	6	10
Harpacticoida	17	5	5	11	48
Hydracarina					
Atractides					
Lebertia					
Sperchon					
Torrenticola					
Unidentified				2	1
Oribatei		1	1	2	1
Pelecypoda					
Pisidium					
Gastropoda					
Gyraulus					
Hydrobiidae					
Lymnaeidae					
Valvata sincera					
Unidentified					
Collembola					2
Ephemeroptera					
Ameletus					
Baetis spp.					
Drunella					
Ephemeralla spp.	1				
Leptophlebia					

COLUMBIA RIVER ABOVE CELGAR (II-1) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Rithrogena					
Tricoptera					
Anagapetus					
Apatania					1
Cheumatopsyche					
Glossosma					
Hydropsyche					
Hydroptila					
Mystacides spp.					
Neureclipsis					
Oxyethira					
Plecoptera					
Cultus					
Chloroperlidae					
Haploperla					
Podmosta					
Heteroptera					
Sigara washingtonensis					
Coleoptera					
Deronectes					
Heterlimnius					
Optioservus					
Diptera					
Simuliidae					
Simulium		1	1		
Ceratopogonidae					
Chelifera					
Unidentified					
Dolichopodidae					
Tipulidae					
Hemerodromia					
Unidentified					
Chironomidae					
Chironominae					
Cladotanytarsus					
Cryptochironomus					
Microtendipes					
Parachironomus					
Paracladopelma					1
Paratanytarsus					
Paratendipes					
Phaenopsectra					
Polypedilum	1	1	1		2
Stempellinella		1			
Sublettea					
Tanytarsus	1				
Tribelos					

COLUMBIA RIVER ABOVE CELGAR (II-1) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Diamesinae					
Diamesa	5	1	4	6	11
pupae (included above)					
Monodiamesa	*				
Pagastia	*				
pupae (included above)					
Potthastia gaedii group					
Potthastia longimana group					
pupae (included above)					
Othocladiinae					
Ablabesmyia					
Cardiocladius					
Corynoneura					
Cricotopus bicinctus group	1				2
Cricotopus sylvestris group					
Cricotopus tremulus group	2	1	1	1	2
pupae (included above)					
Cricotopus or Orthocladius spp.	5	9	8	16	54
pupae (included above)			2	5	18
Eukiefferiella spp.			2		1
pupae (included above)					
Heterotrissocladius					
Nanocladius					
pupae (included above)					
Orthocladiinae - unidentified larvae					
Orthocladiinae - unidentified pupae	1	1			
Orthocladius (Euorthocladius)					
pupae (included above)					
Paracladius (triquetra type)					
Parakiefferiella					
Parametriocnemus					
Psectrocladius					
Rheocricotopus					
Smittia					
Synorthocladius	1			1	1
pupae (included above)					
Tvetenia bavarica group					
Tvetenia discoloripes group					
pupae (included above)					
Tanypodinae					
Procladius					
Thienemannimyia group					
TOTAL SPECIES	**22**	**17**	**16**	**18**	**25**
TOTAL ORGANISMS	**209**	**153**	**117**	**297**	**343**

COLUMBIA RIVER AT ROBSON (II-3) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Nematoda	501	383	560	429	391
Cnidaria					
Hydra	0	13	24	23	9
Bryozoa					
*Cristatella mucedo**				+	
Turbellaria	8	0	0	6	1
Tardigrada	1	6	0	0	1
Rotifera	0	0	0	0	0
Hirudinea					
Glossiphonia complanata	0	1	0	2	0
Helobdella stagnalis	0	3	0	3	1
Piscicola	0	0	0	0	0
Oligochatea					
Enchytraeidae	42	26	14	13	13
Naididae	487	760	713	720	589
Lumbriculidae	468	60	596	481	384
Tubficidae	0	1	0	0	4
Ostracoda					
Candona sp.	4	0	4	2	0
Cladocera					
Chydoridae	60	116	39	45	42
Copepoda					
Calanoida	0	9	4	10	9
Cyclopoida	17	34	25	5	48
Harpacticoida	658	338	477	320	277
Hydracarina					
Atractides	0	0	0	1	0
Lebertia	0	0	0	0	0
Sperchon	0	0	0	0	0
Torrenticola	0	0	4	0	0
Unidentified	12	5	8	8	0
Oribatei	12	4	12	0	0
Pelecypoda					
Pisidium	7	5	2	3	4
Gastropoda					
Gyraulus	0	1	1	1	1
Hydrobiidae	0	0	0	0	0
Lymnaeidae	0	0	1	1	0
Valvata sincera	0	0	0	2	0
Unidentified	0	0	0	2	5
Collembola	0	0	0	20	0
Ephemeroptera					
Ameletus	0	0	0	0	0
Baetis spp.	1	0	0	0	0
Drunella	0	0	0	0	0
Ephemeralla spp.	4	1	0	4	1
Leptophlebia	0	0	0	0	0

COLUMBIA RIVER AT ROBSON (II-3) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Rithrogena	0	0	0	0	0
Tricoptera					
Anagapetus	0	0	0	0	0
Apatania	0	0	0	0	0
Cheumatopsyche	0	0	0	0	0
Glossosma	0	0	0	0	0
Hydropsyche	0	0	0	0	0
Hydroptila	0	0	0	0	0
Mystacides spp.	4	0	0	0	4
Neureclipsis	2	1	6	5	1
Oxyethira	0	0	0	0	0
Plecoptera					
Cultus	0	0	0	0	0
Chloroperlidae	0	0	0	0	0
Haploperla	0	0	0	0	0
Podmosta	0	0	0	0	0
Heteroptera					
Sigara washingtonensis	0	1	0	0	0
Coleoptera					
Deronectes	1	5	2	3	4
Heterlimnius	0	0	0	0	0
Optioservus	0	0	0	0	0
Diptera					
Simuliidae					
Simulium	0	0	0	0	0
Ceratopogonidae					
Chelifera	0	0	0	0	0
Unidentified	0	2	0	1	0
Dolichopodidae	0	1	0	0	0
Tipulidae					
Hemerodromia	0	0	0	0	0
Unidentified					
Chironomidae					
Chironominae					
Cladotanytarsus	0	0	0	0	0
Cryptochironomus	10	1	3	7	2
Microtendipes	0	0	0	0	0
Parachironomus	4	0	0	1	0
Paracladopelma	0	0	0	0	0
Paratanytarsus	0	0	0	0	0
Paratendipes	0	0	0	0	0
Phaenopsectra	2	1	1	2	5
Polypedilum	1	2	0	4	0
Stempellinella	0	0	0	0	0
Sublettea	0	0	0	0	0
Tanytarsus	0	2	1	0	5
Tribelos	0	0	0	0	4

COLUMBIA RIVER AT ROBSON (II-3) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Diamesinae					
Diamesa	1	0	3	12	8
pupae (included above)	0	0	0	0	0
Monodiamesa	0	0	0	0	0
Pagastia	0	0	0	0	0
pupae (included above)	0	0	0	0	0
Potthastia gaedii group	0	0	0	0	0
Potthastia longimana group	0	0	1	1	2
pupae (included above)					
Othocladiinae					
Ablabesmyia	0	0	0	0	0
Cardiocladius	0	0	0	0	0
Corynoneura	0	0	0	0	0
Cricotopus bicinctus group	12	11	28	14	20
Cricotopus sylvestris group	3	7	7	0	0
Cricotopus tremulus group	0	0	0	1	1
pupae (included above)	0	0	0	0	0
Cricotopus or Orthocladius spp.	77	28	69	59	19
pupae (included above)	0	0	1	6	2
Eukiefferiella spp.	0	0	4	0	0
pupae (included above)	0	0	0	0	0
Heterotrissocladius	0	0	0	0	0
Nanocladius	0	0	0	0	0
pupae (included above)	0	0	0	0	0
Orthocladiinae - unidentified larvae	0	0	0	0	0
Orthocladiinae - unidentified pupae	2	2	7	0	0
Orthocladius (Euorthocladius)	0	1	0	0	0
pupae (included above)	0	0	0	0	0
Paracladius (triquetra type)	0	1	0	0	0
Parakiefferiella	0	0	0	0	0
Parametriocnemus	0	0	0	4	0
Psectrocladius	5	2	0	6	3
Rheocricotopus	0	0	0	0	0
Smittia	0	0	0	0	0
Synorthocladius	0	0	0	0	0
pupae (included above)	0	0	0	0	0
Tvetenia bavarica group	0	0	0	0	0
Tvetenia discoloripes group	0	0	0	0	0
pupae (included above)	0	0	0	0	0
Tanypodinae					
Procladius	0	2	0	0	1
Thienemannimyia group	1	5	1	0	2
TOTAL SPECIES	**29**	**36**	**30**	**37**	**33**
TOTAL ORGANISMS	**2407**	**1841**	**2618**	**2227**	**1863**

COLUMBIA RIVER AT BIRCHBANK (III-2) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Nematoda	21	46	157	90	82
Cnidaria					
Hydra	23	11	41	39	21
Bryozoa					
*Cristatella mucedo**	+	+	+	+	+
Turbellaria	5	8	27	12	4
Tardigrada	0	0	4	0	4
Rotifera	0	0	0	0	0
Hirudinea					
Glossiphonia complanata	0	0	0	0	0
Helobdella stagnalis	0	0	0	0	0
Piscicola	0	0	0	0	0
Oligochatea					
Enchytraeidae	27	26	73	38	44
Naididae	97	78	490	248	120
Lumbriculidae	39	53	202	35	49
Tubficidae	0	0	0	0	0
Ostracoda					
Candona sp.	0	0	0	0	0
Cladocera					
Chydoridae	0	2	33	25	4
Copepoda					
Calanoida	0	0	0	0	0
Cyclopoida	0	0	0	4	0
Harpacticoida	14	9	522	530	276
Hydracarina					
Atractides	0	0	0	0	0
Lebertia	0	0	0	0	0
Sperchon	0	0	0	0	0
Torrenticola	1	0	0	0	4
Unidentified	0	0	4	0	0
Oribatei	0	0	0	0	0
Pelecypoda					
Pisidium	7	1	7	0	0
Gastropoda					
Gyraulus	2	1	3	0	1
Hydrobiidae	1	1	0	0	1
Lymnaeidae	0	0	0	0	0
Valvata sincera	0	0	1	0	0
Unidentified	0	0	0	0	0
Collembola	0	0	0	0	0
Ephemeroptera					
Ameletus	0	0	1	1	0
Baetis spp.	3	6	8	2	2
Drunella	2	0	0	0	0
Ephemeralla spp.	4	0	10	3	2
Leptophlebia	0	0	0	0	0

COLUMBIA RIVER AT BIRCHBANK (III-2) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Rithrogena	0	0	0	0	0
Tricoptera					
Anagapetus	0	0	1	0	0
Apatania	0	0	0	0	0
Cheumatopsyche	0	0	1	0	0
Glossosma	0	0	0	0	0
Hydropsyche	2	0	3	7	0
Hydroptila	1	0	1	0	0
Mystacides spp.	5	0	3	0	2
Neureclipsis	0	0	0	0	0
Oxyethira	0	0	0	0	0
Plecoptera					
Cultus	0	0	0	0	0
Chloroperlidae	0	0	0	0	0
Haploperla	0	0	0	0	0
Podmosta	1	0	0	0	0
Heteroptera					
Sigara washingtonensis	0	0	0	0	0
Coleoptera					
Deronectes	0	0	0	0	0
Heterlimnius	0	0	0	0	0
Optioservus	0	0	0	0	0
Diptera					
Simuliidae					
Simulium	0	0	0	0	0
Ceratopogonidae					
Chelifera	0	0	0	0	0
Unidentified	0	0	0	0	0
Dolichopodidae	0	0	0	0	0
Tipulidae					
Hemerodromia	0	0	0	0	0
Unidentified					
Chironomidae					
Chironominae					
Cladotanytarsus	4	2	9	12	1
Cryptochironomus	2	0	2	5	2
Microtendipes	0	1	0	0	1
Parachironomus	0	0	0	0	0
Paracladopelma	0	1	0	0	0
Paratanytarsus	0	0	0	0	1
Paratendipes	0	0	0	4	0
Phaenopsectra	2	5	2	4	0
Polypedilum	0	0	0	4	0
Stempellinella	0	0	0	0	0
Sublettea	0	0	0	4	4
Tanytarsus	1	0	16	13	4
Tribelos	0	0	0	0	0

COLUMBIA RIVER AT BIRCHBANK (III-2) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Diamesinae					
Diamesa	3	0	7	0	4
pupae (included above)	0	0	0	0	0
Monodiamesa	0	0	0	0	0
Pagastia	0	0	0	1	0
pupae (included above)	0	0	0	0	0
Potthastia gaedii group	3	0	0	0	0
Potthastia longimana group	0	0	0	0	0
pupae (included above)					
Othocladiinae					
Ablabesmyia	0	0	0	0	0
Cardiocladius	0	0	0	0	0
Corynoneura	2	0	4	1	2
Cricotopus bicinctus group	1	0	0	0	1
Cricotopus sylvestris group	0	0	0	0	0
Cricotopus tremulus group	18	6	19	10	19
pupae (included above)	2	0	0	0	0
Cricotopus or Orthocladius spp.	137	102	317	193	227
pupae (included above)	0	12	19	9	6
Eukiefferiella spp.	4	0	4	0	1
pupae (included above)	0	0	0	0	0
Heterotrissocladius	0	0	0	0	1
Nanocladius	0	0	0	0	0
pupae (included above)	0	0	0	0	0
Orthocladiinae - unidentified larvae					
Orthocladiinae - unidentified pupae	6	0	0	0	0
Orthocladius (Euorthocladius)	1	0	4	7	4
pupae (included above)	0	0	0	0	0
Paracladius (triquetra type)	0	0	0	1	1
Parakiefferiella	0	1	1	0	0
Parametriocnemus	0	1	0	0	0
Psectrocladius	0	0	0	0	0
Rheocricotopus	1	0	0	0	0
Smittia	0	0	0	0	0
Synorthocladius	3	3	5	2	4
pupae (included above)	0	0	0	0	0
Tvetenia bavarica group	0	0	0	0	0
Tvetenia discoloripes group	1	2	1	6	0
pupae (included above)	0	0	0	0	0
Tanypodinae					
Procladius	0	0	0	0	0
Thienemannimyia group	0	0	2	0	1
TOTAL SPECIES	**36**	**24**	**37**	**30**	**34**
TOTAL ORGANISMS	**446**	**378**	**2004**	**1310**	**900**

COLUMBIA RIVER D/S COMINCO (IV-1) Sampled April 22, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Nematoda		5	6	7	10
Cnidaria					
Hydra	3	2	5	4	4
Bryozoa					
*Cristatella mucedo**					
Turbellaria	1	3	7	5	4
Tardigrada					
Rotifera					
Hirudinea					
Glossiphonia complanata					
Helobdella stagnalis					
Piscicola				1	
Oligochatea					
Enchytraeidae					
Naididae	4	19	15	18	25
Lumbriculidae					
Tubficidae					
Ostracoda					
Candona sp.					
Cladocera					
Chydoridae					
Copepoda					
Calanoida					1
Cyclopoida					
Harpacticoida					
Hydracarina					
Atractides					
Lebertia			1		
Sperchon	1	6	6	4	6
Torrenticola				1	
Unidentified					
Oribatei					
Pelecypoda					
Pisidium					
Gastropoda					
Gyraulus					
Hydrobiidae					
Lymnaeidae					
Valvata sincera					
Unidentified					
Collembola	1				
Ephemeroptera					
Ameletus					
Baetis spp.	15	20	40	39	60
Drunella				1	2
Ephemeralla spp.	1	5		2	3
Leptophlebia					

COLUMBIA RIVER D/S COMINCO (IV-1) Sampled April 22, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Rithrogena	1				
Tricoptera					
Anagapetus					
Apatania					
Cheumatopsyche					
Glossosma			1		
Hydropsyche	1	4	4	6	5
Hydroptila					
Mystacides spp.					
Neureclipsis					
Oxyethira					
Plecoptera					
Cultus					
Chloroperlidae					
Haploperla					
Podmosta				1	
Heteroptera					
Sigara washingtonensis	1				
Coleoptera					
Deronectes					
Heterlimnius					
Optioservus					
Diptera					
Simuliidae					
Simulium		1	4	6	2
Ceratopogonidae					
Chelifera					
Unidentified					
Dolichopodidae					
Tipulidae					
Hemerodromia					
Unidentified					
Chironomidae					
Chironominae					
Cladotanytarsus					
Cryptochironomus					1
Microtendipes				1	
Parachironomus					
Paracladopelma					
Paratanytarsus					
Paratendipes					
Phaenopsectra					
Polypedilum	1		1	1	
Stempellinella					
Sublettea					
Tanytarsus					
Tribelos					

COLUMBIA RIVER D/S COMINCO (IV-1) Sampled April 22, 1992					
	REPLICATE				
TAXA	**#1**	**#2**	**#3**	**#4**	**#5**
Diamesinae					
Diamesa	36	60	60	86	96
pupae (included above)	1	1	1	2	
Monodiamesa					
Pagastia	1	4	2	1	4
pupae (included above)		1			
Potthastia gaedii group					
Potthastia longimana group					
pupae (included above)					
Othocladiinae					
Ablabesmyia					
Cardiocladius				1	1
Corynoneura					
Cricotopus bicinctus group	3	6	1	3	2
Cricotopus sylvestris group					
Cricotopus tremulus group	12	5	9	23	14
pupae (included above)		1			
Cricotopus or Orthocladius spp.	17	38	34	39	45
pupae (included above)		1	1	4	1
Eukiefferiella spp.	3	7	15	27	36
pupae (included above)			1	1	1
Heterotrissocladius					
Nanocladius					1
pupae (included above)					
Orthocladiinae - unidentified larvae					
Orthocladiinae - unidentified pupae	7	5	3		
Orthocladius (Euorthocladius)	26	37	28	66	51
pupae (included above)	1	1		1	
Paracladius (triquetra type)					
Parakiefferiella					
Parametriocnemus			1		
Psectrocladius					
Rheocricotopus					
Smittia					
Synorthocladius			1	1	2
pupae (included above)			1		
Tvetenia bavarica group					
Tvetenia discoloripes group	3	3	6	9	9
pupae (included above)	1				
Tanypodinae					
Procladius					
Thienemannimyia group	1	1			
TOTAL SPECIES	**24**	**24**	**26**	**29**	**25**
TOTAL ORGANISMS	**142**	**236**	**254**	**361**	**386**

COLUMBIA RIVER AT WANETA (IV-3)
Sampled April 23, 1992

TAXA	REPLICATE #1	#2	#3	#4	#5
Nematoda	1	6	20	4	27
Cnidaria					
Hydra		1		3	1
Bryozoa					
*Cristatella mucedo**	+				
Turbellaria					
Tardigrada	1				
Rotifera					
Hirudinea					
Glossiphonia complanata					
Helobdella stagnalis					
Piscicola					
Oligochatea					
Enchytraeidae		1		2	
Naididae	9	1	3	2	2
Lumbriculidae					
Tubficidae					
Ostracoda					
Candona sp.					
Cladocera					
Chydoridae					
Copepoda					
Calanoida					
Cyclopoida	2	1			
Harpacticoida					
Hydracarina					
Atractides					
Lebertia					
Sperchon	4	3	4	4	2
Torrenticola					
Unidentified					
Oribatei					
Pelecypoda					
Pisidium					
Gastropoda					
Gyraulus					
Hydrobiidae					
Lymnaeidae					
Valvata sincera					
Unidentified	1				
Collembola					
Ephemeroptera					
Ameletus	1				
Baetis spp.	17	17	27	7	19
Drunella					
Ephemeralla spp.	5	3	4		2
Leptophlebia					

COLUMBIA RIVER AT WANETA (IV-3) Sampled April 23, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Rithrogena	1				
Tricoptera					
Anagapetus					
Apatania					
Cheumatopsyche					
Glossosma					
Hydropsyche	3				
Hydroptila					
Mystacides spp.					
Neureclipsis					
Oxyethira					
Plecoptera					
Cultus		1			
Chloroperlidae					
Haploperla					1
Podmosta		1			1
Heteroptera					
Sigara washingtonensis					
Coleoptera					
Deronectes					
Heterlimnius					
Optioservus					
Diptera					
Simuliidae					
Simulium					
Ceratopogonidae	1				
Chelifera	1				
Unidentified	1				
Dolichopodidae					
Tipulidae					
Hemerodromia					
Unidentified					
Chironomidae					
Chironominae					
Cladotanytarsus					
Cryptochironomus					
Microtendipes					
Parachironomus					
Paracladopelma					
Paratanytarsus					
Paratendipes		1			
Phaenopsectra					
Polypedilum					
Stempellinella					
Sublettea	1				
Tanytarsus					
Tribelos					

COLUMBIA RIVER AT WANETA (IV-3) Sampled April 23, 1992					
	REPLICATE				
TAXA	**#1**	**#2**	**#3**	**#4**	**#5**
Diamesinae					
Diamesa	26	1	3	4	6
pupae (included above)					
Monodiamesa					
Pagastia	2			2	1
pupae (included above)					
Potthastia gaedii group	1	1			
Potthastia longimana group					
pupae (included above)					
Othocladiinae					
Ablabesmyia					
Cardiocladius					
Corynoneura					
Cricotopus bicinctus group	3		3	3	4
Cricotopus sylvestris group					
Cricotopus tremulus group	113	38	46	34	56
pupae (included above)					
Cricotopus or Orthocladius spp.	58	74	50	24	46
pupae (included above)					
Eukiefferiella spp.	88	12	17	5	15
pupae (included above)					1
Heterotrissocladius					
Nanocladius			1	1	1
pupae (included above)				1	
Orthocladiinae - unidentified larvae					
Orthocladiinae - unidentified pupae	16	8	4	6	6
Orthocladius (Euorthocladius)	15	7	15	5	13
pupae (included above)					
Paracladius (triquetra type)					
Parakiefferiella					
Parametriocnemus					
Psectrocladius					
Rheocricotopus	1				
Smittia			1		
Synorthocladius	1	1	2		2
pupae (included above)					
Tvetenia bavarica group		1			
Tvetenia discoloripes group	2	1	1		
pupae (included above)					
Tanypodinae					
Procladius					
Thienemannimyia group			1		1
TOTAL SPECIES	**28**	**21**	**17**	**16**	**20**
TOTAL ORGANISMS	**375**	**180**	**202**	**107**	**207**

Appendix 3-2

Data for October Invertebrate Samples

KOOTENAY RIVER (CS3) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Nematoda	9	8	21	13	31
Cnidaria					
Hydra	7	4	3	7	1
Bryozoa					
*Cristatella mucedo**	+	+	+	+	+
Turbellaria					
Polycelis coronata					1
Unidentified spp.	3	4	23	19	12
Tardigrada				1	
Rotifera					
Hirudinea					
Glossiphonia complanata					
Helobdella stagnalis					
Piscicola					
Oligochatea					
Aeolosomatidae					
Aeolosoma			1		4
Enchytraeidae	11	12	3	1	1
Naididae					
Chaetogaster	14	7	16	23	10
Nais					1
Ophidonais serpentina					
Pristina					
Stylaria lacustris					
Vejdovskyella comata					
Unidentified					
Lumbriculidae	6	7	9	5	6
Tubficidae				1	
Ostracoda					
Candona sp.	2	1	3		1
Cladocera	11	17	5	8	19
Chydoridae					
Copepoda					
Calanoida	16	20	5	3	11
Cyclopoida	9	16	14	13	11
Harpacticoida	3	4	5	4	7
Hydracarina					
Atractides					
Hygrobates					1
Lebertia					2
Sperchon					
Torrenticola	10	18	16	27	30
Unidentified	3	4	4	2	5
Oribatei	1	7	5	6	2
Pelecypoda					
Pisidium					

KOOTENAY RIVER (CS3) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Gastropoda					
Gyraulus	*	*	2		*
Hydrobiidae					
Lymnaeidae		2	2	1	
Valvata sincera	1			1	1
Unidentified					
Collembola				1	
Ephemeroptera					
Ameletus					
Baetis spp.					*
Drunella					
Ephemeralla spp.		*		*	
Leptophlebia					
Rithrogena					
Tricoptera					
Anagapetus					
Apatania					
Cheumatopsyche			*		
Glossosma					
Hydropsyche		*		*	
Hydroptila					
Mystacides spp.					*
Neureclipsis					
Oxyethira					
Limnephilidae					
Plecoptera					
Cultus					
Capniidae					
Chloroperlidae					
Haploperla					
Podmosta					
Nemouridae					
Heteroptera					
Sigara washingtonensis	4	6	6	7	3
Coleoptera					
Deronectes					
Heterlimnius					
Optioservus					
Oreodytes					
Diptera					
Tabanidae					
Chrysops					
Simuliidae					
Simulium					
pupae (included above)					
Ceratopogonidae					
Dolichopodidae					

KOOTENAY RIVER (CS3) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Empididae					
Chelifera					
Hemerodromia	1				
Tipulidae					
Hesperoconopa					
Unidentified	1				
Chironomidae					
Chironominae					
Chironomus					
Cladotanytarsus			1		
Cryptochironomus		1			
pupae (included above)					
Micropsectra	2				2
Microtendipes					
Parachironomus					
Paracladopelma				1	1
Paratanytarsus					1
Paratendipes					
Phaenopsectra					
Polypedilum					
Stempellinella					
Sublettea					
Tanytarsus	1			2	1
Tribelos					
Unidentified					
Diamesinae					
Diamesa					
pupae (included above)					
Monodiamesa					
Pagastia					
pupae (included above)					
Potthastia	1				
Potthastia gaedii group					
Potthastia longimana group					
pupae (included above)					
Othocladiinae					
Ablabesmyia					
Cardiocladius					
Chaetocladius					
Corynoneura					
Cricotopus bicinctus group		1			
pupae (included above)					
Cricotopus sylvestris group					
Cricotopus tremulus group					
pupae (included above)					
Cricotopus or Orthocladius spp.				1	
pupae (included above)					

KOOTENAY RIVER (CS3) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Cricotopus sp.					
pupae (included above)					
Eukiefferiella spp.		1			
pupae (included above)					
Heterotrissocladius					
Nanocladius					
pupae (included above)					
Orthocladiinae - unidentified larvae					
Orthocladiinae - unidentified pupae					
Orthocladius					
pupae (included above)					
Orthocladius (Euorthocladius)					
pupae (included above)					
Paracladius (triquetra type)					
Parakiefferiella					
Parametriocnemus					
Psectrocladius					
Pseudosmittia					
Rheocricotopus					
Smittia					
Synorthocladius					
pupae (included above)					
Thienemaniella					
Tvetenia				1	
Tvetenia bavarica group					
Tvetenia discoloripes group					
pupae (included above)					
Tanypodinae					
Ablabesmyia					
Procladius					
Thienemannimyia group					
TOTAL SPECIES	23	23	21	26	29
TOTAL ORGANISMS	*116*	*140*	*144*	*148*	*165*

COLUMBIA RIVER U/S CELGAR (II-1) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Nematoda	9	3	4	12	8
Cnidaria					
Hydra	166	104	134	84	37
Bryozoa					
*Cristatella mucedo**	+	+	+	+	+
Turbellaria					
Polycelis coronata					
Unidentified spp.		3		1	
Tardigrada					
Rotifera	1	1	2	3	1
Hirudinea					
Glossiphonia complanata					
Helobdella stagnalis					
Piscicola					
Oligochatea					
Aeolosomatidae					
Aeolosoma					
Enchytraeidae	23	13	15	9	8
Naididae					
Chaetogaster	4	9	1		7
Nais		3		1	1
Stylaria lacustris	3	1			
Unidentified		1			
Lumbriculidae					
Tubficidae		2			
Ostracoda					
Candona sp.					
Cladocera	35	19	31	13	19
Chydoridae					
Copepoda					
Calanoida	4	1	6	3	1
Cyclopoida	40	17	56	28	23
Harpacticoida	2	1			3
Hydracarina					
Atractides					
Hygrobates		1			
Lebertia					1
Sperchon					
Torrenticola	1				
Unidentified			1		
Oribatei		2	1	4	1
Pelecypoda					
Pisidium					
Gastropoda					
Gyraulus					
Hydrobiidae					

COLUMBIA RIVER U/S CELGAR (II-1) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Lymnaeidae	3				
Valvata sincera					
Unidentified					
Collembola					
Ephemeroptera					
Ameletus					
Baetis spp.					
Drunella					
Ephemeralla spp.					
Leptophlebia					
Rithrogena					
Tricoptera					
Anagapetus					
Apatania					
Cheumatopsyche					
Glossosma					
Hydropsyche					
Hydroptila					
Mystacides spp.					
Neureclipsis					
Oxyethira					
Limnephilidae		1			
Plecoptera					
Cultus					
Capniidae					
Chloroperlidae					
Haploperla					
Podmosta					
Heteroptera					
Sigara washingtonensis		1		1	1
Coleoptera					
Deronectes					
Heterlimnius					
Optioservus					
Diptera					
Simuliidae					
Simulium					
pupae (included above)					
Ceratopogonidae					
Chelifera					
Unidentified					
Dolichopodidae					
Empididae					
Hemerodromia					
Tipulidae					
Hesperoconopa					1
Unidentified					

COLUMBIA RIVER U/S CELGAR (II-1) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Chironomidae					
Chironominae					
Cladotanytarsus					1
Cryptochironomus			1		
pupae (included above)			1		
Micropsectra	14	26	21	17	15
Microtendipes					
Parachironomus	13	2		2	
Paracladopelma	4	2			
Paratanytarsus	3	1	3	1	6
Paratendipes					
Phaenopsectra					
Polypedilum	1	1			
Stempellinella					
Sublettea			1		
Tanytarsus		3	2		1
Tribelos					
Unidentified	5	1	16	3	6
Diamesinae					
Diamesa					
pupae (included above)					
Monodiamesa					
Pagastia					1
pupae (included above)					
Potthastia	1				
Potthastia gaedii group					
Potthastia longimana group					
pupae (included above)					
Othocladiinae					
Ablabesmyia					
Cardiocladius					
Corynoneura	1				
Cricotopus bicinctus group	1		3	1	
pupae (included above)					
Cricotopus sylvestris group	2	3	3		1
Cricotopus tremulus group					
pupae (included above)					
Cricotopus or Orthocladius spp.	1	2	2	1	1
pupae (included above)					
Cricotopus sp.					
Eukiefferiella spp.		4	2		
pupae (included above)					
Heterotrissocladius					
Nanocladius					
pupae (included above)					
Orthocladiinae - unidentified larvae	2	2	1		1
Orthocladiinae - unidentified pupae					

COLUMBIA RIVER U/S CELGAR (II-1) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Orthocladius					
pupae (included above)					
Orthocladius (Euorthocladius)					
pupae (included above)					
Paracladius (triquetra type)	2		9	2	2
Parakiefferiella					
Parametriocnemus					
Psectrocladius					
Rheocricotopus					
Smittia					
Synorthocladius		1			
pupae (included above)					
Tvetenia					
Tvetenia bavarica group					
Tvetenia discoloripes group					
pupae (included above)					
Tanypodinae					
Ablabesmyia		1			2
Procladius					
Thienemannimyia group					1
TOTAL SPECIES	**26**	**32**	**24**	**19**	**27**
TOTAL ORGANISMS	**341**	**232**	**316**	**186**	**150**

COLUMBIA RIVER AT BIRCHBANK (III-2) Sampled October 17, 1992					
	REPLICATE				
TAXA	**#1**	**#2**	**#3**	**#4**	**#5**
Nematoda	35	42	17	72	33
Cnidaria					
Hydra	171	92	105	150	66
Bryozoa					
*Cristatella mucedo**	+	+	+	+	+
Turbellaria					
Polycelis coronata					
Unidentified spp.	10	17	6	5	9
Tardigrada					
Rotifera			4		
Hirudinea					
Glossiphonia complanata					
Helobdella stagnalis					
Piscicola					
Oligochatea					
Aeolosomatidae					
Aeolosoma	12	7	16	9	2
Enchytraeidae	69	28	6	112	50
Naididae					
Chaetogaster	444	335	245	339	137
Nais	13	2	4	10	3
Ophidonais serpentina					
Pristina					
Stylaria lacustris					
Vejdovskyella comata					
Unidentified					
Lumbriculidae					
Tubficidae					
Ostracoda					
Candona sp.		4			
Cladocera	3	6	4		
Chydoridae					
Copepoda					
Calanoida	6		4	1	
Cyclopoida	24		4	12	11
Harpacticoida	1	4			2
Hydracarina					
Atractides					
Hygrobates					
Lebertia			1		
Sperchon					
Torrenticola	8	9	4		2
Unidentified	1	10	8	4	4
Oribatei					
Pelecypoda					
Pisidium	1				

COLUMBIA RIVER AT BIRCHBANK (III-2) Sampled October 17, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Gastropoda					
Gyraulus					
Hydrobiidae					
Lymnaeidae					
Valvata sincera					
Unidentified					
Collembola					
Ephemeroptera					
Ameletus					
Baetis spp.	1	5		8	4
Drunella					
Ephemeralla spp.	3	1	13	1	10
Leptophlebia					
Rithrogena					
Tricoptera					
Anagapetus				4	
Apatania					
Cheumatopsyche	*	*	*		*
Glossosma					
Hydropsyche	*	*	1	2	7
Hydroptila					
Mystacides spp.					
Neureclipsis					
Oxyethira					
Limnephilidae			4		2
Plecoptera					
Cultus					
Capniidae	1				
Chloroperlidae					
Haploperla					
Podmosta					
Nemouridae					
Heteroptera					
Sigara washingtonensis					
Coleoptera					
Deronectes					
Heterlimnius					
Optioservus					
Oreodytes					
Diptera					
Tabanidae					
Chrysops					
Simuliidae					
Simulium	4				
pupae (included above)					
Ceratopogonidae					

COLUMBIA RIVER AT BIRCHBANK (III-2) Sampled October 17, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Dolichopodidae					
Empididae					
Chelifera					
Hemerodromia					
Tipulidae					
Hesperoconopa					
Unidentified					
Chironomidae					
Chironominae					
Chironomus					
Cladotanytarsus					
Cryptochironomus					
pupae (included above)					
Micropsectra	14	54	14	16	4
Microtendipes		1			
Parachironomus					
Paracladopelma					
Paratanytarsus	4				
Paratendipes					
Phaenopsectra					
Polypedilum	5	1		12	
Stempellinella					
Sublettea	4				
Tanytarsus	9		9	5	2
Tribelos					
Unidentified	15	4			
Diamesinae					
Diamesa	1				
pupae (included above)					
Monodiamesa					
Pagastia	9	1	1	4	1
pupae (included above)					
Potthastia					
Potthastia gaedii group					
Potthastia longimana group					
pupae (included above)					
Othocladiinae					
Ablabesmyia					
Cardiocladius					
Chaetocladius					
Corynoneura		5		4	
Cricotopus bicinctus group	3	12	18	12	4
pupae (included above)					
Cricotopus sylvestris group					
Cricotopus tremulus group	1				
pupae (included above)					
Cricotopus or Orthocladius spp.	38	84	24	37	20

COLUMBIA RIVER AT BIRCHBANK (III-2) Sampled October 17, 1992					
	REPLICATE				
TAXA	**#1**	**#2**	**#3**	**#4**	**#5**
pupae (included above)					
Cricotopus sp.					
pupae (included above)					
Eukiefferiella spp.	6	21	2	1	4
pupae (included above)		1			
Heterotrissocladius					
Nanocladius					
pupae (included above)					
Orthocladiinae - unidentified larvae	6	1	4		
Orthocladiinae - unidentified pupae	2	1	1		
Orthocladius				1	
pupae (included above)				1	
Orthocladius (Euorthocladius)	3	2	1		3
pupae (included above)					
Paracladius (triquetra type)					
Parakiefferiella					
Parametriocnemus		4			
Psectrocladius					
Pseudosmittia					
Rheocricotopus					
Smittia					
Synorthocladius	8	8	1	12	
pupae (included above)					
Thienemaniella					
Tvetenia	4				
Tvetenia bavarica group					
Tvetenia discoloripes group					
pupae (included above)					
Tanypodinae					
Ablabesmyia				4	
Procladius					
Thienemannimyia group					
TOTAL SPECIES	**39**	**33**	**30**	**28**	**25**
TOTAL ORGANISMS	**939**	**762**	**521**	**838**	**380**

COLUMBIA RIVER AT ROBSON (II-3) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Nematoda	81	40	64	57	94
Cnidaria					
Hydra	19	16	24	48	
Bryozoa					
*Cristatella mucedo**				+	+
Turbellaria					
Polycelis coronata					
Unidentified spp.	21	8	56	16	57
Tardigrada					
Rotifera					
Hirudinea					
Glossiphonia complanata					
Helobdella stagnalis					
Piscicola					
Oligochatea					
Aeolosomatidae					
Aeolosoma		16		8	
Enchytraeidae	56	48	79	43	119
Naididae					
Chaetogaster	28	40	72	72	72
Nais	2	16			45
Ophidonais serpentina			8		
Pristina					
Stylaria lacustris	17	43	41	45	25
Vejdovskyella comata	4				8
Unidentified					
Lumbriculidae	23	28	1	3	19
Tubficidae					
Ostracoda					
Candona sp.					
Cladocera	173	368	369	320	353
Chydoridae					
Copepoda					
Calanoida	28	24	24	8	32
Cyclopoida	56	89	80	89	64
Harpacticoida	8	24	16	32	32
Hydracarina					
Atractides					
Hygrobates					
Lebertia					
Sperchon					
Torrenticola					
Unidentified			8		
Oribatei	4			32	
Pelecypoda					
Pisidium					
Gastropoda					
Gyraulus					
Hydrobiidae					

COLUMBIA RIVER AT ROBSON (II-3) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Lymnaeidae	4	1	7	5	6
Valvata sincera					
Unidentified					
Collembola	17		8	32	8
Ephemeroptera					
Ameletus					
Baetis spp.					
Drunella					
Ephemeralla spp.					
Leptophlebia					
Rithrogena					
Tricoptera					
Anagapetus					
Apatania					
Cheumatopsyche					
Glossosma					
Hydropsyche					
Hydroptila					
Mystacides spp.					
Neureclipsis					
Oxyethira					
Limnephilidae					
Plecoptera					
Cultus					
Capniidae					
Chloroperlidae					
Haploperla					
Podmosta					
Nemouridae					
Heteroptera					
Sigara washingtonensis	1	1		6	
Coleoptera					
Deronectes	2			1	
Heterlimnius					
Optioservus					
Oreodytes			1		1
Diptera					
Tabanidae					
Chrysops					1
Simuliidae					
Simulium					
pupae (included above)					
Ceratopogonidae					
Unidentified		1		1	
Dolichopodidae					
Empididae					
Chelifera					
Hemerodromia					
Tipulidae					

COLUMBIA RIVER AT ROBSON (II-3) Sampled October 18, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Hesperoconopa					
Unidentified					
Chironomidae					
Chironominae					
Chironomus					
Cladotanytarsus					
Cryptochironomus					
pupae (included above)					
Micropsectra					
Microtendipes					
Parachironomus					
Paracladopelma					
Paratanytarsus					
Paratendipes					
Phaenopsectra					
Polypedilum					
Stempellinella					
Sublettea					
Tanytarsus					8
Tribelos					
Unidentified			16		
Diamesinae					
Diamesa					
pupae (included above)					
Monodiamesa					
Pagastia					
pupae (included above)					
Potthastia					8
Potthastia gaedii group					
Potthastia longimana group					
pupae (included above)					
Othocladiinae					
Ablabesmyia					
Cardiocladius					
Chaetocladius					
Corynoneura					
Cricotopus bicinctus group				8	
pupae (included above)					
Cricotopus sylvestris group	24	24	48	33	1
Cricotopus tremulus group					
pupae (included above)					
Cricotopus or Orthocladius spp.	16	24	24	17	
pupae (included above)					
Cricotopus sp.					
pupae (included above)					
Eukiefferiella spp.				8	
pupae (included above)					
Heterotrissocladius					
Nanocladius					

COLUMBIA RIVER AT ROBSON (II-3) Sampled October 18, 1992					
	REPLICATE				
TAXA	**#1**	**#2**	**#3**	**#4**	**#5**
pupae (included above)					
Orthocladiinae - unidentified larvae					
Orthocladiinae - unidentified pupae	16				
Orthocladius					
pupae (included above)					
Orthocladius (Euorthocladius)					
pupae (included above)					
Paracladius (triquetra type)					
Parakiefferiella					
Parametriocnemus					
Psectrocladius			8		
Pseudosmittia			1		
Rheocricotopus					
Smittia				8	
Synorthocladius					
pupae (included above)					
Thienemaniella					
Tvetenia					
Tvetenia bavarica group					
Tvetenia discoloripes group					
pupae (included above)					
Tanypodinae					
Ablabesmyia					
Procladius					
Thienemannimyia group					
TOTAL SPECIES	**21**	**18**	**21**	**24**	**20**
TOTAL ORGANISMS	**600**	**811**	**955**	**892**	**953**

COLUMBIA RIVER AT RYAN CREEK (IV-1) Sampled October 17, 1992					
	REPLICATE				
TAXA	**#1**	**#2**	**#3**	**#4**	**#5**
Nematoda		16	12	8	16
Cnidaria					
Hydra	1	16	12		
Bryozoa					
*Cristatella mucedo**					
Turbellaria					
Polycelis coronata					
Unidentified spp.	24	24	8	16	8
Tardigrada					
Rotifera	16				
Hirudinea					
Glossiphonia complanata					
Helobdella stagnalis					
Piscicola					
Oligochatea					
Aeolosomatidae					
Aeolosoma					
Enchytraeidae	1			1	
Naididae					
Chaetogaster	1753	1448	1100	1102	1032
Nais	2	122	54	30	40
Ophidonais serpentina					
Pristina			8		16
Stylaria lacustris					
Vejdovskyella comata					
Unidentified					
Lumbriculidae					
Tubficidae					
Ostracoda					
Candona sp.					
Cladocera			4		
Chydoridae					
Copepoda					
Calanoida					
Cyclopoida	24		8		8
Harpacticoida	8	16	4		
Hydracarina					
Atractides					
Hygrobates					
Lebertia					
Sperchon	8				8
Torrenticola	8		4		
Unidentified				8	
Oribatei					
Pelecypoda					
Pisidium					
Gastropoda					
Gyraulus					
Hydrobiidae					

COLUMBIA RIVER AT RYAN CREEK (IV-1) Sampled October 17, 1992					
	REPLICATE				
TAXA	**#1**	**#2**	**#3**	**#4**	**#5**
Lymnaeidae					
Valvata sincera					
Unidentified					
Collembola					
Ephemeroptera					
Ameletus					
Baetis spp.					
Drunella					
Ephemeralla spp.					
Leptophlebia					
Rithrogena					
Tricoptera					
Anagapetus					
Apatania					
Cheumatopsyche					
Glossosma					
Hydropsyche					
Hydroptila					
Mystacides spp.					
Neureclipsis					
Oxyethira					
Limnephilidae					
Plecoptera					
Cultus					
Capniidae					
Chloroperlidae					
Haploperla					
Podmosta					
Nemouridae			1		
Heteroptera					
Sigara washingtonensis	1	2	1		
Coleoptera					
Deronectes					
Heterlimnius					
Optioservus					
Oreodytes					
Diptera					
Tabanidae					
Chrysops					
Simuliidae					
Simulium					
pupae (included above)					
Ceratopogonidae					
Unidentified					
Dolichopodidae					

COLUMBIA RIVER AT RYAN CREEK (IV-1) Sampled October 17, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Empididae					
Chelifera					
Hemerodromia					
Tipulidae					
Hesperoconopa					
Unidentified					
Chironomidae					
Chironominae					
Chironomus			1		
Cladotanytarsus					
Cryptochironomus					
pupae (included above)					
Micropsectra	9	50	28	34	24
Microtendipes	41	24	49	16	16
Parachironomus					
Paracladopelma			4		
Paratanytarsus		16			
Paratendipes					
Phaenopsectra		8	8		
Polypedilum	8	16	4	8	24
Stempellinella					
Sublettea					
Tanytarsus	8		20	16	8
Tribelos					
Unidentified			8		
Diamesinae					
Diamesa	1	11	8	20	19
pupae (included above)		1	1	2	
Monodiamesa				9	
Pagastia	32	56	32		16
pupae (included above)					
Potthastia					
Potthastia gaedii group					
Potthastia longimana group					
pupae (included above)					
Othocladiinae					
Ablabesmyia					
Cardiocladius					
Chaetocladius		1	1		
Corynoneura	8		8		
Cricotopus bicinctus group	8	17	12	9	26
pupae (included above)					1
Cricotopus sylvestris group					992
Cricotopus tremulus group		2			
pupae (included above)		2			
Cricotopus or Orthocladius spp.	73	80	65	88	17
pupae (included above)					
Cricotopus sp.				2	
pupae (included above)				2	

COLUMBIA RIVER AT RYAN CREEK (IV-1) Sampled October 17, 1992					
	REPLICATE				
TAXA	**#1**	**#2**	**#3**	**#4**	**#5**
Eukiefferiella spp.	155	113	204	263	231
pupae (included above)	8				
Heterotrissocladius					
Nanocladius					
pupae (included above)					
Orthocladiinae - unidentified larvae					
Orthocladiinae - unidentified pupae	25			1	8
Orthocladius				1	
pupae (included above)				1	
Orthocladius (Euorthocladius)	8	33	20	39	19
pupae (included above)				1	
Paracladius (triquetra type)					
Parakiefferiella					
Parametriocnemus					
Psectrocladius	2		8		16
Pseudosmittia					
Rheocricotopus					
Smittia					
Synorthocladius	8		4	9	
pupae (included above)					
Thienemaniella					1
Tvetenia					
Tvetenia bavarica group					
Tvetenia discoloripes group					
pupae (included above)					
Tanypodinae					
Ablabesmyia					
Procladius					
Thienemannimyia group					
TOTAL SPECIES	**26**	**22**	**31**	**24**	**22**
TOTAL ORGANISMS	**2240**	**2074**	**1701**	**1686**	**2546**

COLUMBIA RIVER AT WANETA (IV-3)
Sampled October 17, 1992

TAXA	REPLICATE #1	#2	#3	#4	#5
Nematoda	21	10	1	8	18
Cnidaria					
Hydra	28	21	32	58	7
Bryozoa					
*Cristatella mucedo**	+	+	+	+	+
Turbellaria					
Polycelis coronata					
Unidentified spp.	4	1			4
Tardigrada					
Rotifera					
Hirudinea					
Glossiphonia complanata					
Helobdella stagnalis					
Piscicola					
Oligochatea					
Aeolosomatidae					
Aeolosoma					
Enchytraeidae	3	1			
Naididae					
Chaetogaster	93	134	279	471	349
Nais	14	14	19	59	14
Ophidonais serpentina					
Pristina					
Stylaria lacustris					
Vejdovskyella comata					
Unidentified					
Lumbriculidae					
Tubficidae					
Ostracoda					
Candona sp.					
Cladocera					
Chydoridae					
Copepoda					
Calanoida					
Cyclopoida	4		4		
Harpacticoida				4	
Hydracarina					
Atractides					
Hygrobates					
Lebertia					
Sperchon					1
Torrenticola					
Unidentified	17	8	4	4	
Oribatei					
Pelecypoda					
Pisidium					

COLUMBIA RIVER AT WANETA (IV-3) Sampled October 17, 1992					
	REPLICATE				
TAXA	**#1**	**#2**	**#3**	**#4**	**#5**
Gastropoda					
Gyraulus					
Hydrobiidae					
Lymnaeidae					
Valvata sincera					
Unidentified					
Collembola	1				
Ephemeroptera					
Ameletus					
Baetis spp.	4			4	
Drunella					
Ephemeralla spp.	1		4		1
Leptophlebia					
Rithrogena					
Tricoptera					
Anagapetus			*		
Apatania					
Cheumatopsyche					
Glossosma					
Hydropsyche	*				
Hydroptila					
Mystacides spp.					
Neureclipsis					
Oxyethira					
Limnephilidae					
Plecoptera					
Cultus					
Capniidae					
Chloroperlidae					
Haploperla					
Podmosta					
Nemouridae					
Heteroptera					
Sigara washingtonensis					
Coleoptera					
Deronectes					
Heterlimnius					
Optioservus					
Oreodytes					
Diptera					
Tabanidae					
Chrysops					
Simuliidae					
Simulium					1
pupae (included above)					1
Ceratopogonidae					

COLUMBIA RIVER AT WANETA (IV-3) Sampled October 17, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
Dolichopodidae					
Empididae					
Chelifera					
Hemerodromia					
Tipulidae					
Hesperoconopa					
Unidentified					
Chironomidae					
Chironominae					
Chironomus					
Cladotanytarsus					
Cryptochironomus					
pupae (included above)					
Micropsectra	24	17	21	12	20
Microtendipes					
Parachironomus					
Paracladopelma					
Paratanytarsus		1			
Paratendipes					
Phaenopsectra			4		
Polypedilum	17	56	40	28	76
Stempellinella					
Sublettea			4		
Tanytarsus					
Tribelos					
Unidentified					
Diamesinae					
Diamesa					
pupae (included above)					
Monodiamesa					
Pagastia	16		16	60	36
pupae (included above)					
Potthastia					
Potthastia gaedii group					
Potthastia longimana group					
pupae (included above)					
Othocladiinae					
Ablabesmyia					
Cardiocladius					
Chaetocladius					
Corynoneura	4				
Cricotopus bicinctus group	90	46	80	142	135
pupae (included above)	5				
Cricotopus sylvestris group					
Cricotopus tremulus group					
pupae (included above)					
Cricotopus or Orthocladius spp.	115	113	188	139	89

COLUMBIA RIVER AT WANETA (IV-3) Sampled October 17, 1992					
	REPLICATE				
TAXA	#1	#2	#3	#4	#5
pupae (included above)				1	
Cricotopus sp.	1				
pupae (included above)					
Eukiefferiella spp.	16	43	17	79	50
pupae (included above)	1	10	7	6	7
Heterotrissocladius					
Nanocladius					
pupae (included above)					
Orthocladiinae - unidentified larvae					
Orthocladiinae - unidentified pupae					
Orthocladius		3		11	6
pupae (included above)		3		11	6
Orthocladius (Euorthocladius)	41	56	55	35	32
pupae (included above)	2	6	8	5	8
Paracladius (triquetra type)					
Parakiefferiella					
Parametriocnemus					
Psectrocladius		8		4	
Pseudosmittia					
Rheocricotopus					
Smittia					
Synorthocladius	13	11	13	44	41
pupae (included above)			1	2	5
Thienemaniella					
Tvetenia	9				
Tvetenia bavarica group					
Tvetenia discoloripes group					
pupae (included above)					
Tanypodinae					
Ablabesmyia					
Procladius					
Thienemannimyia group	4				
TOTAL SPECIES	28	21	22	23	23
TOTAL ORGANISMS	548	562	797	1187	907

KOOTENAY RIVER (CS3) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	**#1**	**#2**
Nematoda	24	36
Cnidaria		
Hydra	87	164
Bryozoa		
*Cristatella mucedo**	+	+
Turbellaria		
Polycelis coronata		1
Unidentified spp.	51	47
Tardigrada		
Rotifera		
Hirudinea		
Glossiphonia complanata		
Helobdella stagnalis		
Piscicola		
Oligochatea		
Aeolosomatidae		
Aeolosoma		4
Enchytraeidae		1
Naididae		
Amphichaeta	1164	990
Nais	9	6
Stylaria lacustris		
Unidentified		
Lumbriculidae	2	1
Tubficidae		
Ostracoda		
Candona sp.		1
Unidentified		4
Cladocera	136	215
Chydoridae		
Copepoda		
Calanoida	267	187
Cyclopoida	241	189
Harpacticoida		12
Amphipoda		
Hyalella azteca	1	
Hydracarina		
Atractides		
Hygrobates		
Lebertia		1
Sperchon		
Torrenticola		8
Unidentified	8	32
Oribatei	16	23
Pelecypoda		
Pisidium		

KOOTENAY RIVER (CS3)
LARGE SUBSTRATE
Sampled October 18, 1992

	REPLICATE	
TAXA	**#1**	**#2**
Gastropoda		
Gyraulus		5
Hydrobiidae		
Lymnaeidae		
Valvata sincera		
Unidentified		
Collembola		
Ephemeroptera		
Ameletus		
Baetis spp.		
Drunella grandis		
Ephemeralla spp.	1	4
Leptophlebia		
Rithrogena		
Tricoptera		
Anagapetus		
Apatania		
Cheumatopsyche		
Glossosma		
Hydropsyche	3	1
Hydroptila		
Mystacides spp.		
Neureclipsis		
Oxyethira		
Psychomia	1	4
Limnephilidae		
Plecoptera		
Cultus		
Capniidae		
Chloroperlidae		
Haploperla		
Podmosta		
Perlodidae	8	
Heteroptera		
Sigara washingtonensis	2	1
Coleoptera		
Deronectes		
Heterlimnius	2	1
Optioservus		
Diptera		
Simuliidae		
Simulium		
pupae (included above)		
Ceratopogonidae		
Chelifera	8	
Unidentified		

KOOTENAY RIVER (CS3) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	#1	#2
Dolichopodidae		
Empididae		
Hemerodromia		
Tipulidae		
Hesperoconopa		
Unidentified		4
Chironomidae		
Chironominae		
Cladopelma		
Cladotanytarsus		
Cryptochironomus		
pupae (included above)		
Micropsectra		4
Microtendipes		
Parachironomus		
Paracladopelma		
Paratanytarsus		1
Paratendipes		
Phaenopsectra		
Polypedilum		12
Stempellinella		
Sublettea		4
Tanytarsus	16	8
Tribelos		
Unidentified		
Diamesinae		
Diamesa		
pupae (included above)		
Monodiamesa		
Pagastia	8	
pupae (included above)		
Potthastia		
Potthastia gaedii group		
Potthastia longimana group		
pupae (included above)		
Othocladiinae		
Ablabesmyia		
Cardiocladius		
Chaetocladius		
Corynoneura		
Cricotopus bicinctus group		
pupae (included above)		
Cricotopus sylvestris group		
Cricotopus tremulus group		
pupae (included above)		
Cricotopus or Orthocladius spp.	27	32

KOOTENAY RIVER (CS3) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	**#1**	**#2**
pupae (included above)		
Cricotopus sp.		
Eukiefferiella spp.	1	
pupae (included above)		
Heterotrissocladius		
Limnophyes		
Nanocladius		
pupae (included above)		
Orthocladiinae - unidentified larvae		
Orthocladiinae - unidentified pupae		
Orthocladius		
pupae (included above)		
Orthocladius (Euorthocladius)		
pupae (included above)		
Paracladius (triquetra type)		
Parakiefferiella		
Parametriocnemus		
Psectrocladius		
Rheocricotopus		
Smittia		
Synorthocladius	1	
pupae (included above)		
Tvetenia		4
Tvetenia bavarica group		
Tvetenia discoloripes group		
pupae (included above)		
Tanypodinae		
Ablabesmyia		
Procladius		
Thienemannimyia group		
TOTAL SPECIES	**26**	**35**
TOTAL ORGANISMS	**2084**	**2007**

COLUMBIA RIVER U/S CELGAR (II-1) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	#1	#2
Nematoda	229	33
Cnidaria		
Hydra	641	294
Bryozoa		
*Cristatella mucedo**	+	+
Turbellaria		
Polycelis coronata		
Unidentified spp.	24	8
Tardigrada		
Rotifera	4	8
Hirudinea		
Glossiphonia complanata		
Helobdella stagnalis		
Piscicola		
Oligochatea		
Aeolosomatidae		
Aeolosoma	8	
Enchytraeidae	224	108
Naididae		
Chaetogaster	8	32
Nais		9
Stylaria lacustris		2
Pristina		
Unidentified	16	24
Lumbriculidae	1	14
Tubficidae		
Ostracoda		
Candona sp.		
Unidentified		
Cladocera	161	127
Chydoridae		
Copepoda		
Calanoida	194	128
Cyclopoida	1448	816
Harpacticoida	20	48
Amphipoda		
Hyalella azteca		
Hydracarina		
Atractides		
Hygrobates		
Lebertia		
Sperchon		
Torrenticola		
Unidentified	21	16
Oribatei	29	8

COLUMBIA RIVER U/S CELGAR (II-1) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	#1	#2
Pelecypoda		
Pisidium		
Gastropoda		
Gyraulus		
Hydrobiidae		
Lymnaeidae	2	5
Valvata sincera		
Unidentified		
Collembola		
Ephemeroptera		
Ameletus		
Baetis spp.		
Drunella grandis		
Ephemeralla spp.		
Leptophlebia		
Rithrogena		
Tricoptera		
Anagapetus		
Apatania		
Cheumatopsyche		
Glossosma		
Hydropsyche		
Hydroptila		
Mystacides spp.		
Neureclipsis		
Oxyethira		
Psychomia		
Limnephilidae	12	
Plecoptera		
Cultus		
Capniidae		
Chloroperlidae		
Haploperla		
Podmosta		
Perlodidae		
Heteroptera		
Sigara washingtonensis	1	3
Coleoptera		
Deronectes		
Heterlimnius		
Optioservus		
Diptera		
Simuliidae		
Simulium		
pupae (included above)		
Ceratopogonidae		

COLUMBIA RIVER U/S CELGAR (II-1) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	**#1**	**#2**
Dolichopodidae		
Empididae		
Chelifera		
Hemerodromia		
Psychodidae		
Tipulidae		
Hesperoconopa		
Unidentified		
Chironomidae		
Chironominae		
Cladopelma	4	
Cladotanytarsus		
Cryptochironomus		
pupae (included above)		
Micropsectra	28	33
Microtendipes		
Parachironomus	6	32
Paracladopelma		41
Paratanytarsus	36	8
Paratendipes		
Phaenopsectra		
Polypedilum	8	16
Stempellinella		
Sublettea		
Tanytarsus	8	
Tribelos		
Unidentified	21	
Diamesinae		
Diamesa		
pupae (included above)		
Monodiamesa		
Pagastia		
pupae (included above)		
Potthastia		
Potthastia gaedii group		
Potthastia longimana group		
pupae (included above)		
Othocladiinae		
Ablabesmyia		
Cardiocladius		
Chaetocladius		
Corynoneura		
Cricotopus (pupae)		
Cricotopus bicinctus group		8
pupae (included above)		
Cricotopus sylvestris group	9	3

COLUMBIA RIVER U/S CELGAR (II-1) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	#1	#2
Cricotopus tremulus group		
pupae (included above)		
Cricotopus or Orthocladius spp.	28	1
pupae (included above)		
Cricotopus sp.		
Eukiefferiella spp.	4	
pupae (included above)		
Heterotrissocladius		
Limnophyes		1
Nanocladius		
pupae (included above)		
Orthocladiinae - unidentified larvae	8	
Orthocladiinae - unidentified pupae		
Orthocladius		
pupae (included above)		
Orthocladius (Euorthocladius)		
pupae (included above)		
Paracladius (triquetra type)	24	8
Parakiefferiella		
Parametriocnemus		
Psectrocladius		
Pseudosmittia		
Rheocricotopus		
Smittia		
Synorthocladius		8
pupae (included above)		
Tvetenia		
Tvetenia bavarica group		
Tvetenia discoloripes group		
pupae (included above)		
Tanypodinae		
Ablabesmyia		
Procladius		
Thienemannimyia group		
TOTAL SPECIES	**32**	**31**
TOTAL ORGANISMS	**3227**	**1842**

COLUMBIA RIVER AT ROBSON (II-3) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	#1	#2
Nematoda	30	24
Cnidaria		
Hydra	44	80
Bryozoa		
*Cristatella mucedo**	+	+
Turbellaria		
Polycelis coronata		
Unidentified spp.	57	57
Tardigrada		
Rotifera		
Hirudinea		
Glossiphonia complanata		
Helobdella stagnalis		
Piscicola		8
Oligochatea		
Aeolosomatidae		
Aeolosoma	16	
Enchytraeidae	221	176
Naididae		
Chaetogaster	128	56
Nais	72	32
Stylaria lacustris	60	200
Pristina		
Unidentified		
Lumbriculidae	30	167
Tubficidae		
Ostracoda		
Candona sp.		16
Unidentified		
Cladocera	4481	6902
Chydoridae		
Copepoda		
Calanoida	152	80
Cyclopoida	713	704
Harpacticoida	24	8
Amphipoda		
Hyalella azteca		
Hydracarina		
Atractides		
Hygrobates	8	
Lebertia	1	
Sperchon		
Torrenticola		
Unidentified	1	40
Oribatei	40	128
Pelecypoda		
Pisidium		
Gastropoda		

COLUMBIA RIVER AT ROBSON (II-3) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	**#1**	**#2**
Gyraulus		17
Hydrobiidae		
Lymnaeidae	7	64
Valvata sincera		
Unidentified		
Collembola	32	24
Ephemeroptera		
Ameletus		
Baetis spp.		
Drunella grandis		
Ephemeralla spp.	8	
Leptophlebia		
Rithrogena		
Tricoptera		
Anagapetus		
Apatania		
Cheumatopsyche		
Glossosma		
Hydropsyche		
Hydroptila		
Mystacides spp.		
Neureclipsis		
Oxyethira		
Psychomia		
Limnephilidae		
Plecoptera		
Cultus		
Capniidae		
Chloroperlidae		
Haploperla		
Podmosta		
Perlodidae		
Heteroptera		
Sigara washingtonensis	37	18
Coleoptera		
Deronectes	13	3
Heterlimnius		
Optioservus		
Diptera		
Simuliidae		
Simulium		
pupae (included above)		
Ceratopogonidae		
Dolichopodidae		
Empididae		
Chelifera		
Hemerodromia		
Psychodidae		

COLUMBIA RIVER AT ROBSON (II-3) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	#1	#2
Tipulidae		
Hesperoconopa		
Unidentified		
Chironomidae		
Chironominae		
Cladopelma		
Cladotanytarsus		
Cryptochironomus		
pupae (included above)		
Micropsectra		
Microtendipes		
Parachironomus		
Paracladopelma		
Paratanytarsus		
Paratendipes		
Phaenopsectra		
Polypedilum		
Stempellinella		
Sublettea		
Tanytarsus		
Tribelos		
Unidentified		
Diamesinae		
Diamesa		
pupae (included above)		
Monodiamesa		
Pagastia		
pupae (included above)		
Potthastia	8	8
Potthastia gaedii group		
Potthastia longimana group		
pupae (included above)		
Othocladiinae		
Ablabesmyia		
Cardiocladius		
Chaetocladius		
Corynoneura		8
Cricotopus (pupae)		
Cricotopus bicinctus group		
pupae (included above)		
Cricotopus sylvestris group	16	56
Cricotopus tremulus group		
pupae (included above)		
Cricotopus or Orthocladius spp.	42	24
pupae (included above)		
Cricotopus sp.		
Eukiefferiella spp.		
pupae (included above)		

COLUMBIA RIVER AT ROBSON (II-3) LARGE SUBSTRATE Sampled October 18, 1992		
	REPLICATE	
TAXA	**#1**	**#2**
Heterotrissocladius		
Limnophyes		
Nanocladius		
pupae (included above)		
Orthocladiinae - unidentified larvae		
Orthocladiinae - unidentified pupae		
Orthocladius		
pupae (included above)		
Orthocladius (Euorthocladius)		
pupae (included above)		
Paracladius (triquetra type)		
Parakiefferiella		
Parametriocnemus		
Psectrocladius		
Pseudosmittia		8
Rheocricotopus		
Smittia		
Synorthocladius		8
pupae (included above)		
Tvetenia		
Tvetenia bavarica group		
Tvetenia discoloripes group		
pupae (included above)		
Tanypodinae		
Ablabesmyia		8
Procladius		
Thienemannimyia group		
TOTAL SPECIES	**27**	**30**
TOTAL ORGANISMS	**6241**	**8924**

COLUMBIA RIVER AT BIRCHBANK (III-2)		
LARGE SUBSTRATE		
Sampled October 17, 1992		
	REPLICATE	
TAXA	#1	#2
Nematoda	25	47
Cnidaria		
Hydra	121	107
Bryozoa		
*Cristatella mucedo**	+	+
Turbellaria		
Polycelis coronata		
Unidentified spp.	8	17
Tardigrada		
Rotifera		
Hirudinea		
Glossiphonia complanata		
Helobdella stagnalis		
Piscicola		
Oligochatea		
Aeolosomatidae		
Aeolosoma		
Enchytraeidae	1	
Naididae		
Amphichaeta	56	80
Nais	8	
Stylaria lacustris		
Unidentified		
Lumbriculidae	1	
Tubficidae		
Ostracoda		
Candona sp.		
Unidentified		
Cladocera	48	104
Chydoridae		
Copepoda		
Calanoida	200	256
Cyclopoida	1568	1528
Harpacticoida		
Amphipoda		
Hyalella azteca		
Hydracarina		
Atractides		
Hygrobates		
Lebertia		
Sperchon		
Torrenticola		16
Unidentified	8	8
Oribatei		
Pelecypoda		
Pisidium		

COLUMBIA RIVER AT BIRCHBANK (III-2) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	#1	#2
Pisidium		
Gastropoda		
Gyraulus		
Hydrobiidae		
Lymnaeidae	*	*
Valvata sincera		
Unidentified		
Collembola	8	16
Ephemeroptera		
Ameletus		
Baetis spp.	28	11
Drunella grandis		
Ephemeralla spp.	33	
Leptophlebia		
Rithrogena		
Tricoptera		
Anagapetus		
Apatania		
Cheumatopsyche	9	
Glossosma		
Hydropsyche	51	43
Hydroptila		
Mystacides spp.		
Neureclipsis		
Oxyethira		
Psychomia		
Limnephilidae		
Plecoptera		
Cultus		
Capniidae		
Chloroperlidae		
Haploperla		
Podmosta		
Perlodidae		
Heteroptera		
Sigara washingtonensis		
Coleoptera		
Deronectes		
Heterlimnius		
Optioservus		
Diptera		
Simuliidae		
Simulium		
pupae (included above)		
Ceratopogonidae		
Chelifera		

COLUMBIA RIVER AT BIRCHBANK (III-2) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	#1	#2
Unidentified		
Dolichopodidae		
Empididae		
Hemerodromia		
Tipulidae		
Hesperoconopa		
Unidentified		
Chironomidae		
Chironominae		
Cladopelma		
Cladotanytarsus		
Cryptochironomus		
pupae (included above)		
Micropsectra		1
Microtendipes		
Parachironomus		
Paracladopelma		
Paratanytarsus		
Paratendipes		
Phaenopsectra		
Polypedilum	8	
Stempellinella		
Sublettea		
Tanytarsus		
Tribelos		
Unidentified		
Diamesinae		
Diamesa		1
pupae (included above)		
Monodiamesa		
Pagastia		
pupae (included above)		
Potthastia		
Potthastia gaedii group		
Potthastia longimana group		
pupae (included above)		
Othocladiinae		
Ablabesmyia		
Cardiocladius		
Chaetocladius		
Corynoneura		
Cricotopus bicinctus group	8	1
pupae (included above)		1
Cricotopus sylvestris group		
Cricotopus tremulus group		
pupae (included above)		

COLUMBIA RIVER AT BIRCHBANK (III-2) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	#1	#2
Cricotopus or Orthocladius spp.	37	7
pupae (included above)		
Cricotopus sp.		
Eukiefferiella spp.	56	49
pupae (included above)		
Heterotrissocladius		
Limnophyes		
Nanocladius		
pupae (included above)		
Orthocladiinae - unidentified larvae		
Orthocladiinae - unidentified pupae		
Orthocladius		
pupae (included above)		
Orthocladius (Euorthocladius)	17	16
pupae (included above)	8	
Paracladius (triquetra type)		
Parakiefferiella		
Parametriocnemus		
Psectrocladius		
Rheocricotopus		
Smittia		
Synorthocladius	8	8
pupae (included above)		
Tvetenia		
Tvetenia bavarica group		
Tvetenia discoloripes group		
pupae (included above)		
Tanypodinae		
Ablabesmyia		
Procladius		
Thienemannimyia group		
TOTAL SPECIES	**26**	**23**
TOTAL ORGANISMS	***2315***	***2317***

COLUMBIA RIVER AT RYAN CREEK (IV-1) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	**#1**	**#2**
Nematoda	26	18
Cnidaria		
Hydra		24
Bryozoa		
*Cristatella mucedo**		+
Turbellaria		
Polycelis coronata	8	
Unidentified spp.		
Tardigrada		
Rotifera		
Hirudinea		
Glossiphonia complanata		
Helobdella stagnalis		
Piscicola		
Oligochatea		
Aeolosomatidae		
Aeolosoma		
Enchytraeidae	25	8
Naididae		
Chaetogaster	1633	993
Nais	100	34
Stylaria lacustris		
Pristina		8
Unidentified		
Lumbriculidae	8	
Tubficidae		
Ostracoda		
Candona sp.		
Unidentified		
Cladocera	8	
Chydoridae		
Copepoda		
Calanoida	1	16
Cyclopoida	49	144
Harpacticoida		8
Amphipoda		
Hyalella azteca		
Hydracarina		
Atractides		
Hygrobates		
Lebertia		
Sperchon	9	
Torrenticola		
Unidentified	8	
Oribatei		
Pelecypoda		
Pisidium		

COLUMBIA RIVER AT RYAN CREEK (IV-1) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	#1	#2
Gastropoda		
Gyraulus		
Hydrobiidae		
Lymnaeidae		
Valvata sincera		
Unidentified		
Collembola	2	16
Ephemeroptera		
Ameletus		
Baetis spp.	9	35
Drunella grandis		
Ephemeralla spp.		16
Leptophlebia		
Rithrogena		
Tricoptera		
Anagapetus		
Apatania		
Cheumatopsyche		
Glossosma		
Hydropsyche	1	171
Hydroptila		
Mystacides spp.		
Neureclipsis		
Oxyethira		
Psychomia		
Limnephilidae		
Plecoptera		
Cultus		
Capniidae		
Chloroperlidae		
Haploperla		
Podmosta		
Perlodidae		
Heteroptera		
Sigara washingtonensis		
Coleoptera		
Deronectes		
Heterlimnius		
Optioservus		
Diptera		
Simuliidae		
Simulium		
pupae (included above)		
Ceratopogonidae		
Dolichopodidae		
Empididae		
Chelifera		
Hemerodromia		

COLUMBIA RIVER AT RYAN CREEK (IV-1) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	#1	#2
Psychodidae		8
Tipulidae		
Hesperoconopa		
Unidentified		
Chironomidae		
Chironominae		
Cladopelma		
Cladotanytarsus		
Cryptochironomus		
pupae (included above)		
Micropsectra	8	
Microtendipes		
Parachironomus		
Paracladopelma		
Paratanytarsus		
Paratendipes		
Phaenopsectra		
Polypedilum		
Stempellinella		
Sublettea	8	
Tanytarsus		
Tribelos		
Unidentified		
Diamesinae		
Diamesa	2	26
pupae (included above)		
Monodiamesa		
Pagastia	80	88
pupae (included above)		
Potthastia		
Potthastia gaedii group		
Potthastia longimana group		
pupae (included above)		
Othocladiinae		
Ablabesmyia		
Cardiocladius		
Chaetocladius		1
Corynoneura		
Cricotopus (pupae)	5	
Cricotopus bicinctus group	53	54
pupae (included above)		5
Cricotopus sylvestris group		
Cricotopus tremulus group		24
pupae (included above)		
Cricotopus or Orthocladius spp.	1236	373
pupae (included above)		
Cricotopus sp.		
Eukiefferiella spp.	2003	1470

COLUMBIA RIVER AT RYAN CREEK (IV-1) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	**#1**	**#2**
pupae (included above)	12	34
Heterotrissocladius		
Limnophyes		
Nanocladius		
pupae (included above)		
Orthocladiinae - unidentified larvae		
Orthocladiinae - unidentified pupae	24	2
Orthocladius		
pupae (included above)		
Orthocladius (Euorthocladius)	230	775
pupae (included above)	28	156
Paracladius (triquetra type)		
Parakiefferiella		
Parametriocnemus		
Psectrocladius		
Pseudosmittia	19	26
Rheocricotopus		
Smittia		
Synorthocladius	14	49
pupae (included above)		
Tvetenia	159	273
Tvetenia bavarica group		
Tvetenia discoloripes group		
pupae (included above)		
Tanypodinae		
Ablabesmyia		
Procladius		
Thienemannimyia group		
TOTAL SPECIES	**30**	**31**
TOTAL ORGANISMS	**5768**	**4855**

COLUMBIA RIVER AT WANETA (IV-3) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	#1	#2
Nematoda	8	8
Cnidaria		
Hydra	90	113
Bryozoa		
*Cristatella mucedo**	+	+
Turbellaria		
Polycelis coronata		
Unidentified spp.		
Tardigrada		
Rotifera		
Hirudinea		
Glossiphonia complanata		
Helobdella stagnalis		
Piscicola		
Oligochatea		
Aeolosomatidae		
Aeolosoma		
Enchytraeidae		10
Naididae		
Amphichaeta	324	378
Nais	29	49
Stylaria lacustris		
Unidentified		
Lumbriculidae		
Tubficidae		
Ostracoda		
Candona sp.		
Unidentified		
Cladocera		
Chydoridae		
Copepoda		
Calanoida		
Cyclopoida	24	
Harpacticoida		
Amphipoda		
Hyalella azteca		
Hydracarina		
Atractides		
Hygrobates		
Lebertia		
Sperchon	1	1
Torrenticola		
Unidentified	1	
Oribatei		
Pelecypoda		
Pisidium		

COLUMBIA RIVER AT WANETA (IV-3) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	#1	#2
Dolichopodidae		
Empididae		
Hemerodromia		
Tipulidae		
Hesperoconopa		
Unidentified		
Chironomidae		
Chironominae		
Cladopelma		
Cladotanytarsus		
Cryptochironomus		
pupae (included above)		
Micropsectra	9	
Microtendipes		
Parachironomus		
Paracladopelma		
Paratanytarsus		
Paratendipes		
Phaenopsectra	8	
Polypedilum	8	8
Stempellinella		
Sublettea		
Tanytarsus		
Tribelos		
Unidentified		
Diamesinae		
Diamesa		
pupae (included above)		
Monodiamesa		
Pagastia	8	1
pupae (included above)		
Potthastia		
Potthastia gaedii group		
Potthastia longimana group		
pupae (included above)		
Othocladiinae		
Ablabesmyia		
Cardiocladius		
Chaetocladius		1
Corynoneura		
Cricotopus bicinctus group	18	88
pupae (included above)	2	2
Cricotopus sylvestris group		
Cricotopus tremulus group		
pupae (included above)		
Cricotopus or Orthocladius spp.	273	318

COLUMBIA RIVER AT WANETA (IV-3) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	#1	#2
pupae (included above)		8
Cricotopus sp.		
Eukiefferiella spp.	72	141
pupae (included above)	17	2
Heterotrissocladius		
Limnophyes		
Nanocladius		
pupae (included above)		
Orthocladiinae - unidentified larvae		
Orthocladiinae - unidentified pupae	40	24
Orthocladius		
pupae (included above)		
Orthocladius (Euorthocladius)	31	70
pupae (included above)	5	10
Paracladius (triquetra type)		
Parakiefferiella		
Parametriocnemus		
Psectrocladius		
Rheocricotopus		
Smittia		
Synorthocladius	65	40
pupae (included above)		
Tvetenia		
Tvetenia bavarica group		
Tvetenia discoloripes group		
pupae (included above)		
Tanypodinae		
Ablabesmyia		
Procladius		
Thienemannimyia group		

COLUMBIA RIVER AT WANETA (IV-3) LARGE SUBSTRATE Sampled October 17, 1992		
	REPLICATE	
TAXA	**#1**	**#2**
Gastropoda		
Gyraulus		
Hydrobiidae		
Lymnaeidae		
Valvata sincera		
Unidentified		
Collembola	8	8
Ephemeroptera		
Ameletus		
Baetis spp.		
Drunella grandis		*
Ephemeralla spp.		
Leptophlebia		
Rithrogena		
Tricoptera		
Anagapetus		
Apatania		
Cheumatopsyche		*
Glossosma	1	
Hydropsyche		8
Hydroptila		
Mystacides spp.		
Neureclipsis		
Oxyethira		
Psychomia		
Limnephilidae		
Plecoptera		
Cultus		
Capniidae		
Chloroperlidae		
Haploperla		
Podmosta		
Perlodidae		
Heteroptera		
Sigara washingtonensis		
Coleoptera		
Deronectes		
Heterlimnius		
Optioservus		
Diptera		
Simuliidae		
Simulium		*
pupae (included above)		
Ceratopogonidae		
Chelifera		
Unidentified		

Appendix 4-1

Data for Periphyton Samples

COLUMBIA RIVER UPSTREAM CELGAR (II-1)

SPECIES	#CELLS/cm2
Oscillatoriales	
Oscillatoria tenuis	< 3208
Oscillatoria sp.	< 3208
Lyngbya limnetica	1292837
Lyngbya sp.	
Chroococcales	
Agmenellum glauca (Merismopedia)	102657
Anacystis limneticus (Chroococcus)	< 3208
Anacystis elachista (Aphanocapsa)	121905
Gomphosphaeria pallidum (Coelosphaerium)	< 3208
Gomphosphaeria nagelianum (Coelosphaerium)	< 3208
Pennales	
Fragilaria crotenensis	202106
Fragilaria construens	272683
Fragilaria leptostauron	< 3208
Fragilaria sp.	12832
Gomphonema acuminatum var. coronatum	
Gomphonema constrictum	< 3208
Gomphonema sp.	6416
Didymosphenia geminata	< 3208
Cymbella affinis	< 3208
Cymbella minuta	60953
Cymbella mexicanum	< 3208
Cymbella prostrata	< 3208
Cymbella spp.	< 3208
Tabellaria fenestrata	89825
Tabellaria flocculosa	32080
Surirella angusta	
Surirella (possibly linearis)	
Surirella sp.	6416
Navicula cryptocephala	51329
Navicula radiosa	< 3208
Navicula spp.	64161
Nitzschia sp.	< 3208
Pinnularia gibba	6416
Achnanthes minutissima	574238
Achnanthes flexella	12832
Achnanthes sp.	< 3208
Synedra ulna	3208
Synedra sp.	
Cocconeis placentula	< 3208
Caloneis sp.	< 3208
Eunotia pectinalis	< 3208
Epithemia sorex	< 3208
Epithemia turgida	< 3208
Epithemia sp.	< 3208
Neidium sp.	
Rhopalodia gibba	< 3208
Diatoma heimale	< 3208
Stauroneis sp.	
Asterionella formosa	< 3208
Cymatopleura solea	< 3208
Ceratoneis arcus	
Frustulia rhomboides	

COLUMBIA RIVER UPSTREAM CELGAR (II-1)

SPECIES	#CELLS/cm2
Frustulia sp.	< 3208
Pleurosigma/Gyrosigma sp.	< 3208
Chlorococcales	
Ankistrodesmus falcatus	
Pediastrum boryanum	
Pediastrum sp.	< 3208
Scenedesmus dimorphus	< 3208
Scenedesmus quadricauda	< 3208
Scenedesmus sp.	< 3208
Botryococcus braunii	< 3208
Zygnematales	
Cosmarium sp.	< 3208
Mougeotia sp.	< 3208
Spirogyra sp.	< 3208
Spondylosium planum	< 3208
Desmid sp.	
Rhizochrysidales	
Diceras phaseolus	
Ulothricales	
Ulothrix sp.	
Tetrasporales	
Gloeocystis ampla	
Oedogoniales	
Bulbochaete	< 3208
Nostocales	
Family Rivulariaceae	
Ochromonadales	
Dinobryon divergens	38496
Dinobryon elegantissimum	3208
Dinobryon sp.	32080
Dinokontae	
Ceratium hirundinella	
Peridinium inconspicuum	6416
Peridinium sp.	
Centrales	
Cyclotella kutzingiana	19248
Cyclotella bodanica	6416
Cyclotella michiganiana	
Melosira italica	< 3208
Melosira varians	12832
Melosira undulata	
Rhizosolenia longiseta	
Euglenales	
Euglena sp.	< 3208
Cryptomonadales	
Chroomonas acuta	< 3208
Siphonocladales	
Cladophora sp.	
Volvocales	
Eudorina elegans	
TOTAL NUMBER OF SPECIES	**64**
TOTAL NUMBER OF CELLS/cm2	**3031590**

COLUMBIA RIVER AT CELGAR

SPECIES	CELLS/cm2
Oscillatoriales	
Oscillatoria tenuis	352300
Oscillatoria sp.	< 3670
Lyngbya limnetica	47707
Lyngbya sp.	
Chroococcales	
Agmenellum glauca (Merismopedia)	609185
Anacystis limneticus (Chroococcus)	
Anacystis elachista (Aphanocapsa)	
Gomphosphaeria pallidum (Coelosphaerium)	< 3670
Gomphosphaeria nagelianum (Coelosphaerium)	
Pennales	
Fragilaria crotenensis	25689
Fragilaria construens	22019
Fragilaria leptostauron	< 3670
Fragilaria sp.	7340
Gomphonema acuminatum var. coronatum	
Gomphonema constrictum	< 3670
Gomphonema spp.	3670
Didymosphenia geminata	< 3670
Cymbella affinis	< 3670
Cymbella minuta	14679
Cymbella mexicanum	< 3670
Cymbella prostrata	
Cymbella sp.	< 3670
Tabellaria fenestrata	< 3670
Tabellaria flocculosa	< 3670
Surirella angusta	
Surirella (possibly linearis)	< 3670
Surirella sp.	14679
Navicula cryptocephala	18349
Navicula radiosa	3670
Navicula spp.	25689
Nitzschia sp.	< 3670
Pinnularia gibba	< 3670
Achnanthes minutissima	18349
Achnanthes flexella	18349
Achnanthes sp.	3670
Synedra ulna	< 3670
Synedra sp.	< 3670
Cocconeis placentula	< 3670
Caloneis sp.	< 3670
Eunotia pectinalis	< 3670
Epithemia sorex	
Epithemia turgida	
Epithemia sp.	< 3670
Neidium sp.	< 3670
Rhopalodia gibba	< 3670
Diatoma heimale	< 3670
Stauroneis sp.	< 3670
Asterionella formosa	
Cymatopleura solea	
Ceratoneis arcus	
Frustulia rhomboides	

COLUMBIA RIVER AT CELGAR

SPECIES	CELLS/cm2
Frustulia sp.	
Pleurosigma/Gyrosigma sp.	
Chlorococcales	
Ankistrodesmus falcatus	
Pediastrum boryanum	
Pediastrum sp.	
Scenedesmus dimorphus	< 3670
Scenedesmus quadricauda	
Scenedesmus sp.	< 3670
Botryococcus braunii	< 3670
Zygnematales	
Cosmarium sp.	< 3670
Mougeotia sp.	< 3670
Spirogyra sp.	
Spondylosium planum	
Desmid sp.	< 3670
Rhizochrysidales	
Diceras phaseolus	< 3670
Ulothricales	
Ulothrix sp.	< 3670
Tetrasporales	
Gloeocystis ampla	
Oedogoniales	
Bulbochaete	
Nostocales	
Family Rivulariaceae	
Ochromonadales	
Dinobryon divergens	< 3670
Dinobryon elegantissimum	
Dinobryon sp.	< 3670
Dinokontae	
Ceratium hirundinella	
Peridinium inconspicuum	< 3670
Peridinium sp.	
Centrales	
Cyclotella kutzingiana	3670
Cyclotella bodanica	
Cyclotella michiganiana	
Cyclotella sp.	3670
Melosira italica	< 3670
Melosira varians	
Melosira undulata	
Rhizosolenia longiseta	
Euglenales	
Euglena sp.	
Cryptomonadales	
Chroomonas acuta	
Siphonocladales	
Cladophora sp.	
Volvocales	
Eudorina elegans	
TOTAL NUMBER OF SPECIES	**52**
TOTAL NUMBER OF CELLS/cm2	**1192682**

COLUMBIA RIVER AT BIRCHBANK

SPECIES	#CELLS/cm2
Oscillatoriales	
Oscillatoria tenuis	451043
Oscillatoria sp.	< 3222
Lyngbya limnetica	186861
Lyngbya sp.	< 3222
Chroococcales	
Agmenellum glauca (Merismopedia)	25774
Anacystis limneticus (Chroococcus)	
Anacystis elachista (Aphanocapsa)	
Gomphosphaeria pallidum (Coelosphaerium)	< 3222
Gomphosphaeria nagelianum (Coelosphaerium)	< 3222
Pennales	
Fragilaria crotenensis	12887
Fragilaria construens	19330
Fragilaria leptostauron	
Fragilaria sp.	38661
Gomphonema acuminatum var. coronatum	
Gomphonema constrictum	< 3222
Gomphonema sp.	12887
Didymosphenia geminata	< 3222
Cymbella affinis	12887
Cymbella minuta	16109
Cymbella mexicanum	
Cymbella prostrata	
Cymbella spp.	6443
Tabellaria fenestrata	19330
Tabellaria flocculosa	
Surirella angusta	< 3222
Surirella (possibly linearis)	
Surirella sp.	3222
Navicula cryptocephala	19330
Navicula radiosa	< 3222
Navicula spp.	45104
Nitzschia sp.	< 3222
Pinnularia gibba	< 3222
Achnanthes minutissima	45104
Achnanthes flexella	6443
Achnanthes sp.	3222
Synedra ulna	< 3222
Synedra sp.	
Cocconeis placentula	< 3222
Caloneis sp.	< 3222
Eunotia pectinalis	< 3222
Epithemia sorex	
Epithemia turgida	< 3222
Epithemia sp.	< 3222
Neidium sp.	
Rhopalodia gibba	
Diatoma heimale	< 3222
Stauroneis sp.	
Asterionella formosa	< 3222
Cymatopleura solea	
Ceratoneis arcus	
Frustulia rhomboides	

COLUMBIA RIVER AT BIRCHBANK

SPECIES	#CELLS/cm2
Frustulia sp.	
Pleurosigma/Gyrosigma sp.	
Chlorococcales	
Ankistrodesmus falcatus	
Pediastrum boryanum	
Pediastrum sp.	< 3222
Scenedesmus dimorphus	
Scenedesmus quadricauda	
Scenedesmus sp.	< 3222
Botryococcus braunii	
Zygnematales	
Cosmarium sp.	< 3222
Mougeotia sp.	< 3222
Spirogyra sp.	
Spondylosium planum	
Desmid sp.	< 3222
Rhizochrysidales	
Diceras phaseolus	
Ulothricales	
Ulothrix sp.	< 3222
Tetrasporales	
Gloeocystis ampla	
Oedogoniales	
Bulbochaete	
Nostocales	
Family Rivulariaceae	
Ochromonadales	
Dinobryon divergens	6443
Dinobryon elegantissimum	
Dinobryon sp.	< 3222
Dinokontae	
Ceratium hirundinella	
Peridinium inconspicuum	< 3222
Peridinium sp.	
Centrales	
Cyclotella kutzingiana	35439
Cyclotella bodanica	< 3222
Cyclotella michiganiana	< 3222
Melosira italica	< 3222
Melosira varians	
Melosira undulata	
Rhizosolenia ehriensis/longiseta	< 3222
Euglenales	
Euglena sp.	
Cryptomonadales	
Chroomonas acuta	
Siphonocladales	
Cladophora sp.	
Volvocales	
Eudorina elegans	
TOTAL NUMBER OF SPECIES	49
TOTAL NUMBER OF CELLS/cm2	966521

COLUMBIA RIVER AT RYAN CREEK (DOWNSTREAM COMINCO)

SPECIES	#CELLS/cm2
Oscillatoriales	
Oscillatoria tenuis	81418
Oscillatoria sp.	< 3392
Lyngbya limnetica	< 3392
Lyngbya sp.	
Chroococcales	
Agmenellum glauca (Merismopedia)	
Anacystis limneticus (Chroococcus)	
Anacystis elachista (Aphanocapsa)	
Gomphosphaeria pallidum (Coelosphaerium)	
Gomphosphaeria nagelianum (Coelosphaerium)	< 3392
Pennales	
Fragilaria crotenensis	20355
Fragilaria construens	
Fragilaria leptostauron	
Fragilaria sp.	23747
Gomphonema acuminatum var. coronatum	
Gomphonema constrictum	
Gomphonema sp.	3392
Didymosphenia geminata	
Cymbella affinis	< 3392
Cymbella minuta	40709
Cymbella mexicanum	< 3392
Cymbella prostrata	
Cymbella spp.	< 3392
Tabellaria fenestrata	3392
Tabellaria flocculosa	
Surirella angusta	
Surirella (possibly linearis)	
Surirella sp.	
Navicula cryptocephala	< 3392
Navicula radiosa	
Navicula spp.	13570
Nitzschia sp.	< 3392
Pinnularia gibba	
Achnanthes minutissima	< 3392
Achnanthes flexella	< 3392
Achnanthes sp.	
Synedra ulna	13570
Synedra sp.	
Cocconeis placentula	< 3392
Caloneis sp.	
Eunotia pectinalis	
Epithemia sorex	
Epithemia turgida	
Epithemia sp.	
Neidium sp.	
Rhopalodia gibba	
Diatoma heimale	
Stauroneis sp.	
Asterionella formosa	< 3392
Cymatopleura solea	
Ceratoneis arcus	
Frustulia rhomboides	

COLUMBIA RIVER AT RYAN CREEK (DOWNSTREAM COMINCO)

SPECIES	#CELLS/cm2
Frustulia sp.	
Pleurosigma/Gyrosigma sp.	
Chlorococcales	
Ankistrodesmus falcatus	< 3392
Pediastrum boryanum	
Pediastrum sp.	
Scenedesmus dimorphus	
Scenedesmus quadricauda	
Scenedesmus sp.	
Botryococcus braunii	
Zygnematales	
Cosmarium sp.	< 3392
Mougeotia sp.	< 3392
Spirogyra sp.	
Spondylosium planum	
Desmid sp.	< 3392
Rhizochrysidales	
Diceras phaseolus	
Ulothricales	
Ulothrix sp.	
Tetrasporales	
Gloeocystis ampla	
Oedogoniales	
Bulbochaete	
Nostocales	
Family Rivulariaceae	
Ochromonadales	
Dinobryon divergens	< 3392
Dinobryon elegantissimum	
Dinobryon sp.	3392
Dinokontae	
Ceratium hirundinella	
Peridinium inconspicuum	< 3392
Peridinium sp.	
Centrales	
Cyclotella kutzingiana	< 3392
Cyclotella bodanica	< 3392
Cyclotella michiganiana	
Melosira italica	
Melosira varians	94988
Melosira undulata	< 3392
Rhizosolenia ehriensis/longiseta	
Euglenales	
Euglena sp.	
Cryptomonadales	
Chroomonas acuta	
Siphonocladales	
Cladophora sp.	
Volvocales	
Eudorina elegans	
TOTAL NUMBER OF SPECIES	**31**
TOTAL NUMBER OF CELLS/cm2	**298533**

COLUMBIA RIVER AT WANETA (THE BAY)

SPECIES	#CELLS/cm2
Oscillatoriales	
Oscillatoria tenuis	2311709
Oscillatoria sp.	
Lyngbya limnetica	2091546
Lyngbya sp.	
Chroococcales	
Agmenellum glauca (Merismopedia)	
Anacystis limneticus (Chroococcus)	P
Anacystis elachista (Aphanocapsa)	
Gomphosphaeria pallidum (Coelosphaerium)	
Gomphosphaeria nagelianum (Coelosphaerium)	P
Pennales	
Fragilaria crotenensis	73388
Fragilaria construens	73388
Fragilaria leptostauron	P
Fragilaria sp.	36694
Gomphonema acuminatum var. coronatum	
Gomphonema constrictum	
Gomphonema sp.	55041
Didymosphenia geminata	18347
Cymbella affinis	P
Cymbella minuta	110081
Cymbella mexicanum	P
Cymbella prostrata	
Cymbella spp.	P
Tabellaria fenestrata	P
Tabellaria flocculosa	
Surirella angusta	
Surirella (possibly linearis)	
Surirella sp.	P
Navicula cryptocephala	18347
Navicula radiosa	18347
Navicula spp.	55041
Nitzschia sp.	55041
Pinnularia gibba	P
Achnanthes minutissima	165122
Achnanthes flexella	P
Achnanthes sp.	
Synedra ulna	91734
Synedra sp.	
Cocconeis placentula	P
Caloneis sp.	
Eunotia pectinalis	
Epithemia sorex	P
Epithemia turgida	P
Epithemia sp.	P
Neidium sp.	
Rhopalodia gibba	
Diatoma heimale	
Stauroneis sp.	
Asterionella formosa	18347
Cymatopleura solea	P
Ceratoneis arcus	P
Frustulia rhomboides	

COLUMBIA RIVER AT WANETA (THE BAY)

SPECIES	#CELLS/cm2
Frustulia sp.	P
Pleurosigma/Gyrosigma sp.	
Chlorococcales	
Ankistrodesmus falcatus	
Pediastrum boryanum	
Pediastrum sp.	
Scenedesmus dimorphus	
Scenedesmus quadricauda	
Scenedesmus sp.	P
Botryococcus braunii	
Zygnematales	
Cosmarium sp.	P
Mougeotia sp.	P
Spirogyra sp.	
Spondylosium planum	
Desmid sp.	P
Rhizochrysidales	
Diceras phaseolus	
Ulothricales	
Ulothrix sp.	
Tetrasporales	
Gloeocystis ampla	P
Oedogoniales	
Bulbochaete	
Nostocales	
Family Rivulariaceae	
Ochromonadales	
Dinobryon divergens	P
Dinobryon elegantissimum	P
Dinobryon sp.	P
Dinokontae	
Ceratium hirundinella	
Peridinium inconspicuum	P
Peridinium sp.	P
Centrales	
Cyclotella kutzingiana	P
Cyclotella bodanica	18347
Cyclotella michiganiana	
Melosira italica	
Melosira varians	P
Melosira undulata	
Rhizosolenia longiseta	P
Euglenales	
Euglena sp.	P
Cryptomonadales	
Chroomonas acuta	P
Siphonocladales	
Cladophora sp.	P
Volvocales	
Eudorina elegans	P
TOTAL NUMBER OF SPECIES	**50**
TOTAL NUMBER OF CELLS/cm2	**5210518**

Appendix 5-1

Data for Metals in Sediments

ANALYTICAL REPORT
Form 03035782

ZENON

Parameter	MDC	Unit	92021065	92021066	92021067	92021068	92021069
		Zenon ID :	92021065	92021066	92021067	92021068	92021069
Carbon Total	500	ug/g	26800	6800	5600	2900	7700
Moisture	0.1	%(W/W)	71.8	31.0	29.3	27.0	40.5
Sulfide Total		None	--- (1)	--- (2)	--- (3)	--- (4)	--- (5)
Carbon Total Organic	500	ug/g	26000	5920	4670	1970	6000
Carbon Tot Inorganic	500	ug/g	825	880	930	930	1700
Nitrogen Kjel.Tot(N)	30	ug/g	2130	346	284	140	< 30
Silver	1	ug/g	1	< 1	< 1	17	< 1
Aluminum	2	ug/g	19600	7850	7270	11300	7140
Arsenic	0.2	ug/g	11	2.2	2.0	55	1.3
Barium	0.1	ug/g	162	68.2	64.8	1540	78.1
Beryllium	0.1	ug/g	0.9	0.4	0.4	0.6	0.3
Bismuth	2	ug/g	< 2	< 2	< 2	15	< 2
Calcium	1	ug/g	7030	5460	5730	33000	5670
Cadmium	0.1	ug/g	4.5	0.73	0.48	6.0	0.34
Cobalt	0.3	ug/g	8.5	4.8	4.6	32.9	4.4
Chromium	0.2	ug/g	28.6	25.1	22.1	55.9	43.9
Copper	0.1	ug/g	28.1	10.3	8.3	2520	27.0
Iron	0.3	ug/g	21300	15800	14900	86700	12500
Mercury	0.05	ug/g	0.06	< 0.05	< 0.05	0.49	0.08
Potassium	40	ug/g	4250	1750	1610	2050	1670
Magnesium	2	ug/g	7230	4230	3960	3910	3770
Manganese	0.2	ug/g	316	201	200	1720	203
Molybdenum	0.4	ug/g	< 0.4	< 0.4	< 0.4	13.1	< 0.4
Sodium	1	ug/g	424	299	300	1280	364
Nickel	0.8	ug/g	19.6	14.2	11.4	24.3	13.8
Phosphorus	4	ug/g	1160	1040	1220	2430	1000
Lead	2	ug/g	176	30	15	546	12
Sulphur	3	ug/g.	2740	438	336	3030	352
Antimony	1.5	ug/g	1.6	< 1.5	< 1.5	8.9	< 1.5
Selenium	1	ug/g	< 1	< 1	< 1	< 1	< 1
Tin	2	ug/g	4	< 2	3	5	3
Strontium	0.1	ug/g	54.8	47.6	46.8	170	54.5
Tellurium	2	ug/g	< 2	< 2	< 2	< 2	< 2
Titanium	0.3	ug/g	1190	1060	1080	380	1010
		Sample State :	Soil	Soil	Soil	Soil	Soil
		Sampled on :	92/09/03 00:00	92/09/02 00:00	92/09/02 16:15	92/09/02 11:30	92/09/01 00:00

Sample 92021065 comment : U/S NELSON - KOOTENAY LAKE - WEST ARM : SAMPLED BT ENV. CANADA
Sample 92021066 comment : III-1 U/S CHINA CREEK : SAMPLED BY NORECOL
Sample 92021067 comment : III-3 LOWER BIRCH BANK : SAMPLED BY NORECOL
Sample 92021068 comment : IV-2 D/S BEAVER CREEK : SAMPLED BY NORECOL
Sample 92021069 comment : II-3 ROBSON NEC : SAMPLED BY NORECOL

Project ID: CRIEMP SEDIMENT STUDY   ALL RESULTS ARE DRY WEIGHT BASIS

CONTINUED on page 2

ANALYTICAL REPORT
Form 03035782

ZENON

Parameter	MDC	Unit	92021065	92021066	92021067	92021068	92021069
		Zenon ID :	92021065	92021066	92021067	92021068	92021069
Thallium	0.3	ug/g	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Vanadium	0.3	ug/g	34.2	33.9	32.8	50.4	28.2
Zinc	0.2	ug/g	539	103	90.2	6520	96.8
Zirconium	0.3	ug/g	6.8	2.2	1.3	11.9	2.4
Extractbl Org Halide	2.5	ug/g	4.1	6.2	< 2.5	< 2.5	2.7
		Sample State :	Soil	Soil	Soil	Soil	Soil
		Sampled on :	92/09/03 00:00	92/09/02 00:00	92/09/02 16:15	92/09/02 11:30	92/09/01 00:00

Sample 92021065 comment : U/S NELSON - KOOTENAY LAKE - WEST ARM : SAMPLED BT ENV. CANADA
Sample 92021066 comment : III-1 U/S CHINA CREEK : SAMPLED BY NORECOL
Sample 92021067 comment : III-3 LOWER BIRCH BANK : SAMPLED BY NORECOL
Sample 92021068 comment : IV-2 D/S BEAVER CREEK : SAMPLED BY NORECOL
Sample 92021069 comment : II-3 ROBSON NEC : SAMPLED BY NORECOL

Project ID: CRIEMP SEDIMENT STUDY   ALL RESULTS ARE DRY WEIGHT BASIS

Result comments and/or text results :

(1) Text results for sample 92021065 sparcode 0125CLSP follow :

60. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

(2) Text results for sample 92021066 sparcode 0125CLSP follow :

15. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

(3) Text results for sample 92021067 sparcode 0125CLSP follow :

12. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

(4) Text results for sample 92021068 sparcode 0125CLSP follow :

21. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

(5) Text results for sample 92021069 sparcode 0125CLSP follow :

9. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

ANALYTICAL REPORT
Form 03035785

ZENON

Parameter	MDC	Unit	Zenon ID : 92020281	92020282	92020283	92020284	92020285	92020286
Carbon Total	500	ug/g	23500	17300	25700	25000	12100	---
Moisture	0.1	%(W/W)	67.4	67.3	65.8	62.3	49.3	---
Sulfide Total		None	--- (1)	--- (2)	--- (3)	--- (4)	--- (5)	---
Carbon Total Organic	500	ug/g	22300	15800	23800	23500	10900	---
Carbon Tot Inorganic	500	ug/g	1200	1500	1900	1500	1200	---
Nitrogen Kjel.Tot(N)	30	ug/g	1320	1260	1230	1360	444	---
Silver	1	ug/g	< 1	< 1	< 1	< 1	< 1	---
Aluminum	2	ug/g	35500	37800	40800	36900	8900	---
Arsenic	0.2	ug/g	8.7	8.8	11	11	1.6	---
Barium	0.1	ug/g	366	381	407	376	91.0	---
Beryllium	0.1	ug/g	1.4	1.5	1.5	1.4	0.4	---
Bismuth	2	ug/g	< 2	< 2	< 2	< 2	< 2	---
Calcium	1	ug/g	7380	7750	7520	7310	5610	---
Cadmium	0.1	ug/g	0.93	1.2	1.3	1.0	0.28	---
Cobalt	0.3	ug/g	16.1	17.4	18.3	18.4	6.0	---
Chromium	0.2	ug/g	23.0	30.3	30.8	49.6	42.2	---
Copper	0.1	ug/g	48.5	48.9	52.4	52.3	11.3	---
Iron	0.3	ug/g	39600	43100	46600	45900	14300	---
Mercury	0.05	ug/g	0.06	0.05	0.06	0.08	< 0.05	---
Potassium	40	ug/g	11000	10600	12000	10200	2170	---
Magnesium	2	ug/g	10600	11500	11700	11400	4980	---
Manganese	0.2	ug/g	675	744	902	885	214	---
Molybdenum	0.4	ug/g	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	---
Sodium	1	ug/g	1100	1110	1190	970	377	---
Nickel	0.8	ug/g	46.0	50.1	53.0	53.2	18.8	---
Phosphorus	4	ug/g	1520	1630	1440	1440	1010	---
Lead	2	ug/g	70	66	80	81	8	---
Sulphur	3	ug/g	389	386	424	420	763	---
Antimony	1.5	ug/g	< 1.5	1.8	1.6	< 1.5	< 1.5	---
Selenium	1	ug/g	< 1	< 1	< 1	< 1	< 1	---
Tin	2	ug/g	3	4	5	14	2	---
Strontium	0.1	ug/g	87.0	92.3	92.6	85.8	59.0	---
Tellurium	2	ug/g	< 2	< 2	< 2	< 2	< 2	---
Sample State :			Soil	Soil	Soil	Soil	Soil	Soil
Sampled on :			92/09/01 00:00	92/09/01 00:00	92/09/01 00:00	92/09/01 00:00	92/09/01 00:00	92/09/01 00:00

Sample 92020281 comment : I-1 ARROW L. SEDIMENT : SAMPLED BY NORECOL
Sample 92020282 comment : I-1 ARROW L. SEDIMENT : SAMPLED BY NORECOL
Sample 92020283 comment : I-1A ARROW L. SEDIMENT : SAMPLED BY ENV. CANADA
Sample 92020284 comment : I-1B ARROW L. SEDIMENT : SAMPLED BY ENV. CANADA
Sample 92020285 comment : II-2 COLUMBIA - D/S CELGAR : SAMPLED BY NORECOL
Sample 92020286 comment : II-3 COLUMBIA - ROBSON : SAMPLED BY NORECOL

Project ID: CRIEMP SEDIMENT STUDY   ALL RESULTS ARE DRY WEIGHT BASIS

CONTINUED on page 2

ANALYTICAL REPORT
Form 03035785

Parameter	MDC	Unit (Zenon ID :)	92020281	92020282	92020283	92020284	92020285	92020286
Titanium	0.3	ug/g	2050	2160	2010	1820	1270	—
Thallium	0.3	ug/g	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	—
Vanadium	0.3	ug/g	62.0	66.1	63.9	60.3	31.5	—
Zinc	0.2	ug/g	155	145	161	161	57.9	—
Zirconium	0.3	ug/g	4.3	5.5	5.8	8.4	1.6	—
Extractbl Org Halide	2.5	ug/g	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	—
Sample State :			Soil	Soil	Soil	Soil	Soil	Soil
Sampled on :			92/09/01 00:00	92/09/01 00:00	92/09/01 00:00	92/09/01 00:00	92/09/01 00:00	92/09/01 00:00

Sample 92020281 comment : I-1 ARROW L. SEDIMENT : SAMPLED BY NORECOL
Sample 92020282 comment : I-1 ARROW L. SEDIMENT : SAMPLED BY NORECOL
Sample 92020283 comment : I-1A ARROW L. SEDIMENT : SAMPLED BY ENV. CANADA
Sample 92020284 comment : I-1B ARROW L. SEDIMENT : SAMPLED BY ENV. CANADA
Sample 92020285 comment : II-2 COLUMBIA - D/S CELGAR : SAMPLED BY NORECOL
Sample 92020286 comment : II-3 COLUMBIA - ROBSON : SAMPLED BY NORECOL

Project ID: CRIEMP SEDIMENT STUDY   ALL RESULTS ARE DRY WEIGHT BASIS

Result comments and/or text results :

(1) Text results for sample 92020281 sparcode 0125CLSP follow :

    <6. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

(2) Text results for sample 92020282 sparcode 0125CLSP follow :

    <6. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

(3) Text results for sample 92020283 sparcode 0125CLSP follow :

    <6. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

(4) Text results for sample 92020284 sparcode 0125CLSP follow :

    <6. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

(5) Text results for sample 92020285 sparcode 0125CLSP follow :

    9 ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

ANALYTICAL REPORT
Form 03035783

Parameter	MDC	Unit	92020287	92020288
		Zenon ID :	92020287	92020288
Carbon Total	500	ug/g	15300	13700
Moisture	0.1	%(W/W)	54.0	54.7
Sulfide Total		None	--- (1)	--- (2)
Carbon Total Organic	500	ug/g	13700	12500
Carbon Tot Inorganic	500	ug/g	1600	1200
Nitrogen Kjel.Tot(N)	30	ug/g	1350	439
Silver	1	ug/g	4	4
Aluminum	2	ug/g	13400	13800
Arsenic	0.2	ug/g	18	18
Barium	0.1	ug/g	633	609
Beryllium	0.1	ug/g	0.7	0.7
Bismuth	2	ug/g	< 2	< 2
Calcium	1	ug/g	14000	13800
Cadmium	0.1	ug/g	9.8	10.7
Cobalt	0.3	ug/g	9.0	9.2
Chromium	0.2	ug/g	53.1	56.3
Copper	0.1	ug/g	471	486
Iron	0.3	ug/g	32600	32900
Mercury	0.05	ug/g	1.39	1.65
Potassium	40	ug/g	2950	3040
Magnesium	2	ug/g	5370	5480
Manganese	0.2	ug/g	397	404
Molybdenum	0.4	ug/g	2.0	1.9
Sodium	1	ug/g	566	565
Nickel	0.8	ug/g	18.9	19.4
Phosphorus	4	ug/g	1460	1330
Lead	2	ug/g	532	566
Sulphur	3	ug/g	3350	3160
Antimony	1.5	ug/g	2.6	2.8
Selenium	1	ug/g	1	1
Tin	2	ug/g	5	< 2
Strontium	0.1	ug/g	85.3	86.6
Tellurium	2	ug/g	< 2	< 2
Titanium	0.3	ug/g	847	685
Thallium	0.3	ug/g	< 0.3	< 0.3
Vanadium	0.3	ug/g	45.9	46.3
Zinc	0.2	ug/g	1990	2080
Zirconium	0.3	ug/g	6.1	6.1
		Sample State :	Soil	Soil
		Sampled on :	92/09/02 00:00	92/09/02 00:00

Sample 92020287 comment : IV-3 COLUMBIA - COMINCO GRAVEL PIT : SAMPLED BY NORECOL
Sample 92020288 comment : IV-3 COLUMBIA - COMINCO GRAVEL PIT : SAMPLED BY NORECOL

Project ID: CRIEMP SEDIMENT STUDY ALL RESULTS ARE DRY WEIGHT BASIS

CONTINUED on page 2

ANALYTICAL REPORT
Form 03035783

ZENON

Parameter	MDC	Zenon ID : Unit	92020287	92020288
Extractbl Org Halide	2.5	ug/g	< 2.5	3.9
		Sample State :	Soil	Soil
		Sampled on :	92/09/02 00:00	92/09/02 00:00

Sample 92020287 comment : IV-3 COLUMBIA - COMINCO GRAVEL PIT : SAMPLED BY NORECOL
Sample 92020288 comment : IV-3 COLUMBIA - COMINCO GRAVEL PIT : SAMPLED BY NORECOL

Project ID: CRIEMP SEDIMENT STUDY ALL RESULTS ARE DRY WEIGHT BASIS

Result comments and/or text results :

(1) Text results for sample 92020287 sparcode 0125CLSP follow :

60. ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

(2) Text results for sample 92020288 sparcode 0125CLSP follow :

110 ug/g ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.

ANALYTICAL REPORT
Form 03035784

ZENON

Parameter	MDC	Unit	92020278	92020280
		Zenon ID :	92020278	92020280
Carbon Total	500	ug/g	16900	15200
Moisture	0.1	%(W/W)	40.2	55.4
Sulfide Total		None	--- (1)	--- (2)
Carbon Total Organic	500	ug/g	15700	13900
Carbon Tot Inorganic	500	ug/g	1200	1300
Nitrogen Kjel.Tot(N)	30	ug/g	684	542
Silver	1	ug/g	2	4
Aluminum	2	ug/g	18400	13100
Arsenic	0.2	ug/g	26	18
Barium	0.1	ug/g	377	611
Beryllium	0.1	ug/g	0.6	0.7
Bismuth	2	ug/g	< 2	< 2
Calcium	1	ug/g	11000	13600
Cadmium	0.1	ug/g	7.1	9.0
Cobalt	0.3	ug/g	10.8	8.7
Chromium	0.2	ug/g	41.9	45.8
Copper	0.1	ug/g	209	442
Iron	0.3	ug/g	29100	31200
Mercury	0.05	ug/g	0.68	1.39
Potassium	40	ug/g	2660	2880
Magnesium	2	ug/g	7710	5180
Manganese	0.2	ug/g	402	386
Molybdenum	0.4	ug/g	1.2	1.9
Sodium	1	ug/g	574	565
Nickel	0.8	ug/g	32.3	18.1
Phosphorus	4	ug/g	1880	1360
Lead	2	ug/g	576	508
Sulphur	3	ug/g	2440	3210
Antimony	1.5	ug/g	3.0	1.9
Selenium	1	ug/g	1	< 1
Tin	2	ug/g	4	4
Strontium	0.1	ug/g	95.1	83.0
Tellurium	2	ug/g	< 2	< 2
Titanium	0.3	ug/g	1500	715
Thallium	0.3	ug/g	< 0.3	1.4
Vanadium	0.3	ug/g	52.9	45.4
Zinc	0.2	ug/g	1130	1900
Zirconium	0.3	ug/g	7.6	4.8
		Sample State :	Soil	Soil
		Sampled on :	92/09/02 00:00	92/09/02 00:00

Sample 92020278 comment : IV-1 COLUMBIA - D/S COMINCO : SAMPLED BY NORECOL
Sample 92020280 comment : IV-3 COLUMBIA - COMINCO GRAVEL PIT : SAMPLED BY NORECOL

Project ID: CRIEMP SEDIMENT STUDY ALL RESULTS ARE DRY WEIGHT BASIS

CONTINUED on page 2

ANALYTICAL REPORT
Form 03035784

ZENON

Parameter	MDC	Unit	92020278	92020280
		Zenon ID :	92020278	92020280
Extractbl Org Halide	2.5	ug/g	2.6	< 2.5
		Sample State :	Soil	Soil
		Sampled on :	92/09/02 00:00	92/09/02 00:00

Sample 92020278 comment : IV-1 COLUMBIA - D/S COMINCO : SAMPLED BY NORECOL
Sample 92020280 comment : IV-3 COLUMBIA - COMINCO GRAVEL PIT : SAMPLED BY NORECOL

Project ID: CRIEMP SEDIMENT STUDY   ALL RESULTS ARE DRY WEIGHT BASIS

Result comments and/or text results :

(1) Text results for sample 92020278 sparcode 0125CLSP follow :

```
70. ug/g  ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.
```

(2) Text results for sample 92020280 sparcode 0125CLSP follow :

```
110 ug/g  ACID-SOLUBLE SULFIDE; WET WEIGHT BASIS.
```

APPENDIX E

QA/QC RESULTS FOR SEDIMENT SAMPLES

QA/QC Report for the CRIEMP Sediment Monitoring Programme

Parameter	MDC	Units	ZENON ID: Method Blank #1	Zenon Sample ID	Duplicate 1A	Duplicate 1B	Percent Diff.
Moisture	0.1	%(w/w)	<	92021069	40.5	40.5	0%
Carbon Total	500	ug/g	<	92021065	26200	27400	-4%
Carbon Total Inorganic	500	ug/g	<	92021069	1600	1800	-12%
Carbon Total Organic	500	ug/g	<		24600	25600	-4%
Sulfide Total	6	ug/g	<	92020285	9	10	-11%
Total Kjeldahl Nitrogen	30	ug/g	<	92020285	444	477	-7%
Extractable Organic Halides	2.5	ug/g	<	91020288	2.7	2.6	4%
Metals							
Silver	1	ug/g	<	92020281	<	<	0%
Aluminum	2	"	2.25	"	35500	34500	3%
Arsenic	0.2	"	<	"	8.8	8.6	2%
Barium	0.1	"	0.161	"	366	350	4%
Beryllium	0.1	"	<	"	1.38	1.35	2%
Bismuth	2	"	<	"	<	<	0%
Calcium	1	"	36.3	"	7380	7440	-1%
Cadmium	0.1	"	<	"	0.929	0.853	9%
Cobalt	0.3	"	<	"	16.1	16.7	-4%
Chromium	0.2	"	0.392	"	23	41.1	-56%
Copper	0.1	"	0.328	"	48.5	47.5	2%
Iron	0.3	"	4.92	"	39600	40600	-2%
Mercury	0.05	"	<	"	0.06	0.05	18%
Potassium	40	"	<	"	11000	9590	14%
Magnesium	2	"	5.41	"	10600	10900	-3%
Manganese	0.2	"	<	"	675	693	-3%
Molybdenum	0.4	"	<	"	<	<	0%
Sodium, Total	1	"	38.8	"	1100	972	12%
Nickel	0.8	"	<	"	46	48.6	-5%
Phosphorus, Total	4	"	4.27	"	1520	1580	-4%
Lead	2	"	<	"	69.8	67.4	3%
Sulphur, Total	3	"	9.07	"	389	379	3%
Antimony	1.5	"	<	"	<	<	0%
Selenium	1	"	<	"	<	<	0%
Tin	0.1	"	<	"	2.95	4.40	-39%
Strontium	2	"	<	"	87	84.9	2%
Tellurium	2	"	<	"	<	<	0%
Titanium	0.3	"	<	"	2050	1970	4%
Thallium	0.3	"	<	"	<	<	0%
Vanadium	0.3	"	<	"	62	61.2	1%
Zinc	0.2	"	1.06	"	155	147	5%
Zirconium	0.3	"	<	"	4.27	6.95	-48%

NOTES: ug/g = microgram per gram = parts per million
MDC = Minimum Detectable Concentration
< = Less than MDC
Solid Results Are Dry Weight Basis
Results are blank corrected
• = CANMET SRM STSD 2

QA/QC Report for the CRIEMP Sediment Monitoring Programme

Parameter	MDC	Units	ZENON ID: Zenon Sample ID	Duplicate 2A	Duplicate 2B	Percent Difference
Moisture	0.1	%(w/w)	NA	NA	NA	NA
Carbon Total	500	ug/g	NA	NA	NA	NA
Carbon Total Inorganic	500	ug/g	NA	NA	NA	NA
Carbon Total Organic	500	ug/g	NA	NA	NA	NA
Sulfide Total	6	ug/g	NA	NA	NA	NA
Total Kjeldahl Nitrogen	30	ug/g	NA	NA	NA	NA
Extractable Organic Halides	2.5	ug/g	NA	NA	NA	NA
Metals						
Silver	1	ug/g	92021068	16.7	14	18%
Aluminum	2	"	"	11300	11000	3%
Arsenic	0.2	"	"	55	46.8	16%
Barium	0.1	"	"	1540	1580	-3%
Beryllium	0.1	"	"	0.594	0.535	10%
Bismuth	2	"	"	14.5	9.90	38%
Calcium	1	"	"	33000	33100	0%
Cadmium	0.1	"	"	6.04	5.32	13%
Cobalt	0.3	"	"	32.9	34	-3%
Chromium	0.2	"	"	55.9	57.4	-3%
Copper	0.1	"	"	2520	2540	-1%
Iron	0.3	"	"	86700	86100	1%
Mercury	0.05	"	92021067	<	<	0%
Potassium	40	"	92021068	2050	1980	3%
Magnesium	2	"	"	3910	3780	3%
Manganese	0.2	"	"	1720	1760	-2%
Molybdenum	0.4	"	"	13.1	14	-7%
Sodium, Total	1	"	"	1280	1270	1%
Nickel	0.8	"	"	24.3	22.5	8%
Phosphorus, Total	4	"	"	2430	2300	5%
Lead	2	"	"	546	578	-6%
Sulphur, Total	3	"	"	3030	3120	-3%
Antimony	1.5	"	"	8.90	17.5	-65%
Selenium	1	"	"	<	<	0%
Tin	0.1	"	"	4.72	7.99	-51%
Strontium	2	"	"	170	173	-2%
Tellurium	2	"	"	<	<	0%
Titanium	0.3	"	"	380	341	11%
Thallium	0.3	"	"	<	<	0%
Vanadium	0.3	"	"	50.4	40.5	22%
Zinc	0.2	"	"	6520	6720	-3%
Zirconium	0.3	"	"	11.9	17.2	-36%

NOTES: ug/g = microgram per gram = parts per million
MDC = Minimum Detectable Concentration
< = Less than MDC
Solid Results Are Dry Weight Basis
Results are blank corrected
* = CANMET SRM STSD 2

QA/QC Report for the CRIEMP Sediment Monitoring Programme

		ZENON ID:	NBS 2704	Certified Value	Percent Recovery
Parameter	**MDC**	**Units**			
Moisture	0.1	%(w/w)	NA	NA	NA
Carbon Total	500	ug/g	NA	NA	NA
Carbon Total Inorganic	500	ug/g	NA	NA	NA
Carbon Total Organic	500	ug/g	NA	NA	NA
Sulfide Total	6	ug/g	NA	NA	NA
Total Kjeldahl Nitrogen	30	ug/g	NA	NA	NA
Extractable Organic Halides	2.5	ug/g	NA	NA	NA
Metals					
Silver	1	ug/g	0.519	NA	NA
Aluminum	2	"	35100	61000±1600	58%
Arsenic	0.2	"	18.6	23.4±0.8	80%
Barium	0.1	"	170	414±12	41%
Beryllium	0.1	"	1.1	NA	NA
Bismuth	2	"	<	NA	NA
Calcium	1	"	21500	26000±300	83%
Cadmium	0.1	"	3.15	3.45±22	91%
Cobalt	0.3	"	10.8	14±0.6	77%
Chromium	0.2	"	23.2	135±5	17%
Copper	0.1	"	88.8	98.6±5	90%
Iron	0.3	"	33300	41100±1000	81%
Mercury	0.05	"	1.5	1.47 ± 0.07	102%
Potassium	40	"	8850	20000±400	44%
Magnesium	2	"	10100	12000±200	84%
Manganese	0.2	"	468	555±19	84%
Molybdenum	0.4	"	2.57	NA	NA
Sodium, Total	1	"	498	5470±140	9%
Nickel	0.8	"	34	44.1±3	77%
Phosphorus, Total	4	"	851	998±28	85%
Lead	2	"	142	161±17	88%
Sulphur, Total	3	"	3310	3970±40	83%
Antimony	1.5	"	3.84	3.79±.15	101%
Selenium	1	"	0.765	1.12±0.05	67%
Tin	0.1	"	4.86	9.5	51%
Strontium	2	"	68	130	52%
Tellurium	2	"	0.833	NA	NA
Titanium	0.3	"	394	NA	NA
Thallium	0.3	"	<	NA	NA
Vanadium	0.3	"	51.4	95±4	54%
Zinc	0.2	"	380	43±128	87%
Zirconium	0.3	"	11	300	3%

NOTES: ug/g = microgram per gram = parts per million
MDC = Minimum Detectable Concentration
< = Less than MDC
Solid Results Are Dry Weight Basis
Results are blank corrected
• = CANMET SRM STSD 2

Parameter	MDC	Units	ZENON ID: Zenon Sample ID	Sample Conc.	Sample Spiked	Spike Level	Spike Recovery
Moisture	0.1	%(w/w)	NA	NA	NA	NA	NA
Carbon Total	500	ug/g	NA	NA	NA	NA	NA
Carbon Total Inorganic	500	ug/g	NA	NA	NA	NA	NA
Carbon Total Organic	500	ug/g	NA	NA	NA	NA	NA
Sulfide Total	6	ug/g	92020285	10	21	20	105%
Total Kjeldahl Nitrogen	30	ug/g	92020285	444	510	100	66%
Extractable Organic Halides	2.5	ug/g	92020288	3.9	20.1	18.6	87%
Metals							
Silver	1	ug/g	92020278	NA	NA	NA	NA
Aluminum	2	"	"	15690	57800	40000	105%
Arsenic	0.2	"	"	23	25.5	4	63%
Barium	0.1	"	"	280	657	400	94%
Beryllium	0.1	"	"	NA	NA	NA	NA
Bismuth	2	"	"	NA	NA	NA	NA
Calcium	1	"	"	9442	50230	40000	102%
Cadmium	0.1	"	"	7.13	11	4	96%
Cobalt	0.3	"	"	9.7	43	40	83%
Chromium	0.2	"	"	35.6	83.2	40	119%
Copper	0.1	"	"	221	229	40	19%
Iron	0.3	"	"	26420	67990	40000	104%
Mercury	0.05	"	"	0.68	1.12	0.5	88%
Potassium	40	"	"	1970	9754	8000	97%
Magnesium	2	"	"	6490	27060	20000	103%
Manganese	0.2	"	"	335	3962	4000	91%
Molybdenum	0.4	"	"	NA	NA	NA	NA
Sodium, Total	1	"	"	248	1055	800	101%
Nickel	0.8	"	"	32.9	363	400	82%
Phosphorus, Total	4	"	"	NA	NA	NA	NA
Lead	2	"	"	606	923	400	79%
Sulphur, Total	3	"	"	NA	NA	NA	NA
Antimony	1.5	"	"	2.8	6.44	4	91%
Selenium	1	"	"	1.33	1.88	0.8	69%
Tin	0.1	"	"	NA	NA	NA	NA
Strontium	2	"	"	57.2	97	40	100%
Tellurium	2	"	"	NA	NA	NA	NA
Titanium	0.3	"	"	892	2831	2000	97%
Thallium	0.3	"	"	1.57	11.2	8	120%
Vanadium	0.3	"	"	30.3	97.2	80	84%
Zinc	0.2	"	"	1120	1430	400	78%
Zirconium	0.3	"	"	NA	NA	NA	NA

NOTES: ug/g = microgram per gram = parts per million
MDC = Minimum Detectable Concentration
< = Less than MDC
Solid Results Are Dry Weight Basis
Results are blank corrected
• = CANMET SRM STSD 2

Appendix 5-2

Data for Dioxins/Furans in Sediments

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP | **Our File:** 2437

Sample ID: Sediment I-1 Arrow Lake BC | **Axys ID:** 2437-20A

Sample Weight: 7.20 g dry | **Date:** January 12, 1993

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.2
2,3,7,8	ND	0.2
P_5CDD - Total	ND	0.2
1,2,3,7,8	ND	0.2
H_6CDD - Total	7.2	0.1
1,2,3,4,7,8	0.2	0.1
1,2,3,6,7,8	1.1	0.1
1,2,3,7,8,9	0.7	0.1
H_7CDD - Total	29	0.2
1,2,3,4,6,7,8	16	0.2
O_8CDD	59	0.2

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	6.1	0.1
2,3,7,8	0.9	0.1
P_5CDF - Total	4.4	0.1
1,2,3,7,8	NDR(0.2)	0.1
2,3,4,7,8	NDR(0.3)	0.1
H_6CDF - Total	12	0.1
1,2,3,4,7,8	1.5	0.1
1,2,3,6,7,8	0.4	0.1
2,3,4,6,7,8	0.5	0.1
1,2,3,7,8,9	ND	0.1
H_7CDF - Total	14	0.2
1,2,3,4,6,7,8	4.8	0.2
1,2,3,4,7,8,9	0.3	0.2
O_8CDF	6.6	0.3

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	78
$^{13}C-T_4CDF$:	80
$^{13}C-P_5CDD$:	81
$^{13}C-H_6CDD$:	118
$^{13}C-H_7CDD$:	74
$^{13}C-O_8CDD$:	65

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP

Our File: 2437

Sample ID: Sediment I-1 Arrow Lake EC Duplicate

Axys ID: 2437-20B

Sample Weight: 7.13 g dry

Date: January 12, 1993

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.1
2,3,7,8	ND	0.1
P_5CDD - Total	ND	0.2
1,2,3,7,8	ND	0.2
H_6CDD - Total	7.4	0.1
1,2,3,4,7,8	0.2	0.1
1,2,3,6,7,8	1.0	0.1
1,2,3,7,8,9	0.7	0.1
H_7CDD - Total	29	0.2
1,2,3,4,6,7,8	14	0.2
O_8CDD	53	0.2

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	4.8	0.1
2,3,7,8	0.8	0.1
P_5CDF - Total	3.5	0.1
1,2,3,7,8	NDR(0.2)	0.1
2,3,4,7,8	NDR(0.2)	0.1
H_6CDF - Total	9.9	0.1
1,2,3,4,7,8	1.4	0.1
1,2,3,6,7,8	NDR(0.4)	0.1
2,3,4,6,7,8	0.3	0.1
1,2,3,7,8,9	ND	0.1
H_7CDF - Total	8.9	0.1
1,2,3,4,6,7,8	4.0	0.1
1,2,3,4,7,8,9	NDR(0.2)	0.1
O_8CDF	5.0	0.2

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	88
$^{13}C-T_4CDF$:	90
$^{13}C-P_5CDD$:	81
$^{13}C-H_6CDD$:	120
$^{13}C-H_7CDD$:	84
$^{13}C-O_8CDD$:	73

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A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP

Our File: 2437

Sample ID: Sediment II-2 NBC

Axys ID: 2437-21

Sample Weight: 9.69 g dry

Date: January 12, 1993

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	2.0	0.1
2,3,7,8	1.8	0.1
P_5CDD - Total	ND	0.3
1,2,3,7,8	ND	0.3
H_6CDD - Total	12	0.1
1,2,3,4,7,8	ND	0.1
1,2,3,6,7,8	2.9	0.1
1,2,3,7,8,9	1.0	0.1
H_7CDD - Total	7.7	0.2
1,2,3,4,6,7,8	4.8	0.2
O_8CDD	30	0.2

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	360	0.1
2,3,7,8	210	0.1
P_5CDF - Total	6.2	0.1
1,2,3,7,8	1.6	0.1
2,3,4,7,8	1.8	0.1
H_6CDF - Total	2.3	0.2
1,2,3,4,7,8	0.4	0.2
1,2,3,6,7,8	ND	0.2
2,3,4,6,7,8	ND	0.2
1,2,3,7,8,9	ND	0.2
H_7CDF - Total	2.4	0.1
1,2,3,4,6,7,8	1.2	0.1
1,2,3,4,7,8,9	0.3	0.1
O_8CDF	1.5	0.2

SDL = Sample Detection Limit
ND = Not Detected

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	94
$^{13}C-T_4CDF$:	95
$^{13}C-P_5CDD$:	79
$^{13}C-H_6CDD$:	75
$^{13}C-H_7CDD$:	74
$^{13}C-O_8CDD$:	53

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M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP **Our File:** 2437

Sample ID: Sediment III-3 Lower Birch Bank Sept. 2/92 **Axys ID:** 2437-25

Sample Weight: 11.75 g dry **Date:** January 12, 1993

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.1
2,3,7,8	ND	0.1
P_5CDD - Total	ND	0.1
1,2,3,7,8	ND	0.1
H_6CDD - Total	0.4	0.2
1,2,3,4,7,8	ND	0.2
1,2,3,6,7,8	ND	0.2
1,2,3,7,8,9	ND	0.2
H_7CDD - Total	2.2	0.5
1,2,3,4,6,7,8	0.8	0.5
O_8CDD	5.0	1.0

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	14	0.1
2,3,7,8	8.3	0.1
P_5CDF - Total	ND	0.2
1,2,3,7,8	ND	0.2
2,3,4,7,8	ND	0.2
H_6CDF - Total	ND	0.2
1,2,3,4,7,8	ND	0.2
1,2,3,6,7,8	ND	0.2
2,3,4,6,7,8	ND	0.2
1,2,3,7,8,9	ND	0.2
H_7CDF - Total	ND	0.5
1,2,3,4,6,7,8	ND	0.5
1,2,3,4,7,8,9	ND	0.5
O_8CDF	ND	0.7

SDL = Sample Detection Limit
ND = Not Detected

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	72
$^{13}C-T_4CDF$:	76
$^{13}C-P_5CDD$:	81
$^{13}C-H_6CDD$:	83
$^{13}C-H_7CDD$:	66
$^{13}C-O_8CDD$:	47

Approved by: M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP **Our File:** 2437

Sample ID: Sediment IV-3 NEC Cominco Gravel Pit Sept. 2/92 **Axys ID:** 2437-28

Sample Weight: 8.84 g dry **Date:** January 12, 1993

Dioxins	Concentration pg/g	(SDL)	Furans	Concentration pg/g	(SDL)
T_4CDD - Total	0.7	0.1	T_4CDF - Total	99	0.1
2,3,7,8	0.7	0.1	2,3,7,8	61	0.1
P_5CDD - Total	ND	0.2	P_5CDF - Total	4.5	0.1
1,2,3,7,8	ND	0.2	1,2,3,7,8	0.7	0.1
			2,3,4,7,8	0.8	0.1
H_6CDD - Total	7.6	0.1			
1,2,3,4,7,8	0.2	0.1	H_6CDF - Total	2.6	0.1
1,2,3,6,7,8	1.4	0.1	1,2,3,4,7,8	NDR(0.3)	0.1
1,2,3,7,8,9	0.6	0.1	1,2,3,6,7,8	0.3	0.1
			2,3,4,6,7,8	0.3	0.1
H_7CDD - Total	13	0.2	1,2,3,7,8,9	ND	0.1
1,2,3,4,6,7,8	5.6	0.2			
			H_7CDF - Total	4.4	0.1
O_8CDD	34	0.1	1,2,3,4,6,7,8	2.0	0.1
			1,2,3,4,7,8,9	0.2	0.1
			O_8CDF	3.0	0.1

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	99
$^{13}C-T_4CDF$:	97
$^{13}C-P_5CDD$:	83
$^{13}C-H_6CDD$:	82
$^{13}C-H_7CDD$:	83
$^{13}C-O_8CDD$:	63

Approved by:

M. Coreen Hamilton
A. Dale Hoover

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ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP
Our File: 2437

Sample ID: Sediment I-1 NEC Arrow Lake Sept. 1/92
Axys ID: 2437-29

Sample Weight: 6.27 g dry
Date: January 12, 1993

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.2
2,3,7,8	ND	0.2
P_5CDD - Total	ND	0.2
1,2,3,7,8	ND	0.2
H_6CDD - Total	5.3	0.2
1,2,3,4,7,8	NDR(0.3)	0.2
1,2,3,6,7,8	0.9	0.2
1,2,3,7,8,9	NDR(0.7)	0.2
H_7CDD - Total	28	0.2
1,2,3,4,6,7,8	13	0.2
O_8CDD	54	0.2

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	5.7	0.1
2,3,7,8	0.9	0.1
P_5CDF - Total	4.0	0.2
1,2,3,7,8	ND	0.2
2,3,4,7,8	NDR(0.4)	0.2
H_6CDF - Total	10	0.1
1,2,3,4,7,8	1.2	0.1
1,2,3,6,7,8	0.4	0.1
2,3,4,6,7,8	0.4	0.1
1,2,3,7,8,9	ND	0.1
H_7CDF - Total	8.1	0.2
1,2,3,4,6,7,8	3.5	0.2
1,2,3,4,7,8,9	NDR(0.3)	0.2
O_8CDF	4.9	0.2

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
^{13}C-T_4CDD:	82
^{13}C-T_4CDF:	89
^{13}C-P_5CDD:	91
^{13}C-H_6CDD:	113
^{13}C-H_7CDD:	86
^{13}C-O_8CDD:	76

Approved by: Dale Hoover
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP **Our File:** 2437

Sample ID: Sediment - #6 EC-NB U/S Nelson Kootenay Lk. Sept. 3/92 **Axys ID:** 2437-30

Sample Weight: 5.85 g dry **Date:** January 12, 1993

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.1
2,3,7,8	ND	0.1
P_5CDD - Total	ND	0.2
1,2,3,7,8	ND	0.2
H_6CDD - Total	5.8	0.2
1,2,3,4,7,8	ND	0.2
1,2,3,6,7,8	0.8	0.2
1,2,3,7,8,9	NDR(0.6)	0.2
H_7CDD - Total	16	0.2
1,2,3,4,6,7,8	7.5	0.2
O_8CDD	45	0.3

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	4.7	0.1
2,3,7,8	2.4	0.1
P_5CDF - Total	ND	0.2
1,2,3,7,8	ND	0.2
2,3,4,7,8	ND	0.2
H_6CDF - Total	2.7	0.2
1,2,3,4,7,8	NDR(0.3)	0.2
1,2,3,6,7,8	ND	0.2
2,3,4,6,7,8	ND	0.2
1,2,3,7,8,9	ND	0.2
H_7CDF - Total	3.1	0.1
1,2,3,4,6,7,8	1.4	0.1
1,2,3,4,7,8,9	ND	0.1
O_8CDF	2.2	0.3

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
^{13}C-T_4CDD:	91
^{13}C-T_4CDF:	91
^{13}C-P_5CDD:	89
^{13}C-H_6CDD:	88
^{13}C-H_7CDD:	109
^{13}C-O_8CDD:	69

Approved by: Dale Hoover
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Appendix 5-3

Data for Other Organic Compounds in Sediments

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
December 17, 1992

(concentration in ng/g)

Sample ID:	2437-25A	2437-25B
Sample Type:	III-3 Lower Birchbank Sept. 2/92 Sediment	Duplicate Sediment
Sample Weight:	8.02 g dry	7.37 g dry
4-chlorophenol	ND (0.5)	ND (1.3)
2,6-dichlorophenol	ND (0.4)	ND (0.5)
2,4/2,5-DCP	ND (0.5)	ND (0.4)
3,5-dichlorophenol	ND (0.2)	ND (0.5)
2,3-dichlorophenol	ND (0.2)	ND (0.5)
3,4-dichlorophenol	ND (0.2)	ND (0.4)
6-chloroguaiacol	ND (1.4)	ND (3.8)
4-chloroguaiacol	NDR(3.1) (1.0)	ND (2.5)
5-chloroguaiacol	ND (0.9)	ND (2.2)
2,4,6-trichlorophenol	ND (0.3)	ND (0.3)
2,3,6-trichlorophenol	ND (0.3)	ND (0.5)
2,3,5-trichlorophenol	ND (0.2)	ND (0.4)
2,4,5-trichlorophenol	ND (0.2)	ND (0.3)
2,3,4-trichlorophenol	ND (0.2)	ND (0.4)
3,4,5-trichlorophenol	ND (0.2)	ND (0.3)
3-chlorocatechol	ND (0.8)	ND (0.7)
4-chlorocatechol	ND (0.9)	ND (1.6)
3,4-dichloroguaiacol	ND (0.4)	ND (0.6)
4,6-dichloroguaiacol	ND (0.4)	ND (0.6)
4,5-dichloroguaiacol	ND (0.3)	ND (0.5)
3-chlorosyringol	ND (2.0)	ND (3.0)
3,4-dichlorocatechol	ND (0.4)	ND (0.5)
3,6-dichlorocatechol	ND (0.6)	ND (0.8)
3,5-dichlorocatechol	ND (0.5)	ND (0.7)
4,5-dichlorocatechol	ND (0.7)	ND (1.0)
2,3,5,6-tetrachlorophenol	ND (0.1)	ND (0.2)
2,3,4,6-tetrachlorophenol	ND (0.2)	ND (0.3)
2,3,4,5-tetrachlorophenol	ND (0.2)	ND (0.3)
5-chlorovanillin	ND (1.1)	ND (1.0)
6-chlorovanillin	ND (2.4)	ND (2.1)
3,5-dichlorosyringol	ND (3.0)	ND (5.6)
3,4,5-trichloroguaiacol	0.4 (0.2)	0.3 (0.2)
4,5,6-trichloroguaiacol	ND (0.1)	ND (0.1)
5,6-dichlorovanillin	ND (1.1)	ND (4.4)
pentachlorophenol	ND (0.7)	ND (0.6)
3,4,5-trichlorocatechol	ND (4.4)	ND (2.8)
3,4,5,6-tetrachloroguaiacol	ND (0.3)	ND (0.2)
3,4,5-trichlorosyringol	ND (0.6)	ND (0.8)
3,4,5,6-tetrachlorocatechol	ND (17)	ND (27)

Detection limits are given in brackets
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

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ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
December 17, 1992

(concentration in ng/g)

Sample ID:	2437-20	2437-21
Sample Type:	I-1 EC Arrow Lake EC Sediment	II-2 NEC Sediment
Sample Weight:	4.69 g dry	5.40 g dry
4-chlorophenol	NDR(2.7) (0.8)	NDR(1.6) (1.3)
2,6-dichlorophenol	ND (0.3)	ND (0.6)
2,4/2,5-DCP	ND (0.4)	3.0 (0.5)
3,5-dichlorophenol	ND (0.3)	ND (0.5)
2,3-dichlorophenol	ND (0.3)	ND (0.5)
3,4-dichlorophenol	ND (0.3)	ND (0.3)
6-chloroguaiacol	ND (1.8)	ND (2.6)
4-chloroguaiacol	NDR(3.0) (1.1)	NDR(6.3) (1.8)
5-chloroguaiacol	ND (1.0)	ND (1.6)
2,4,6-trichlorophenol	ND (0.2)	4.6 (0.3)
2,3,6-trichlorophenol	ND (0.2)	ND (0.4)
2,3,5-trichlorophenol	ND (0.2)	ND (0.3)
2,4,5-trichlorophenol	ND (0.2)	ND (0.2)
2,3,4-trichlorophenol	ND (0.2)	ND (0.2)
3,4,5-trichlorophenol	ND (0.2)	ND (0.2)
3-chlorocatechol	ND (0.8)	ND (1.0)
4-chlorocatechol	ND (0.8)	ND (1.0)
3,4-dichloroguaiacol	ND (0.5)	ND (0.7)
4,6-dichloroguaiacol	ND (0.4)	NDR(0.8) (0.6)
4,5-dichloroguaiacol	ND (0.3)	3.8 (0.5)
3-chlorosyringol	ND (4.0)	ND (4.5)
3,4-dichlorocatechol	ND (0.4)	ND (0.3)
3,6-dichlorocatechol	ND (0.4)	0.4 (0.3)
3,5-dichlorocatechol	ND (0.3)	1.8 (0.3)
4,5-dichlorocatechol	ND (0.4)	1.4 (0.3)
2,3,5,6-tetrachlorophenol	ND (0.4)	ND (0.3)
2,3,4,6-tetrachlorophenol	ND (0.5)	1.3 (0.5)
2,3,4,5-tetrachlorophenol	ND (0.3)	ND (0.3)
5-chlorovanillin	ND (1.0)	ND (0.9)
6-chlorovanillin	ND (1.0)	3.5 (0.9)
3,5-dichlorosyringol	ND (4.5)	ND (3.6)
3,4,5-trichloroguaiacol	ND (0.2)	5.5 (0.3)
4,5,6-trichloroguaiacol	ND (0.2)	0.9 (0.2)
5,6-dichlorovanillin	ND (1.0)	1.6 (1.0)
pentachlorophenol	ND (0.6)	ND (0.3)
3,4,5-trichlorocatechol	ND (0.6)	13 (0.8)
3,4,5,6-tetrachloroguaiacol	ND (0.3)	3.4 (0.3)
3,4,5-trichlorosyringol	ND (1.3)	ND (1.2)
3,4,5,6-tetrachlorocatechol	ND (1.2)	29 (1.0)

Detection limits are given in brackets
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
January 8, 1993

(concentration in ng/g)

Sample ID:	2437-29	2437-30
Sample Type:	Norecol NEC I-1 Arrow Lake Sept. 1/92 Sediment	#6 EC-NB Nelson Kootenay Lk. Sept. 3/92 Sediment
Sample Weight:	4.88 g dry	3.98 g dry
4-chlorophenol	ND (0.4)	ND (0.3)
2,6-dichlorophenol	ND (0.4)	ND (0.4)
2,4/2,5-DCP	ND (0.3)	ND (0.3)
3,5-dichlorophenol	ND (0.3)	ND (0.3)
2,3-dichlorophenol	ND (0.3)	ND (0.3)
3,4-dichlorophenol	ND (0.2)	ND (0.2)
6-chloroguaiacol	ND (1.0)	ND (0.9)
4-chloroguaiacol	ND (1.5)	ND (1.4)
5-chloroguaiacol	ND (1.2)	ND (1.1)
2,4,6-trichlorophenol	ND (0.3)	ND (0.3)
2,3,6-trichlorophenol	ND (0.4)	ND (0.4)
2,3,5-trichlorophenol	ND (0.3)	ND (0.3)
2,4,5-trichlorophenol	ND (0.3)	ND (0.3)
2,3,4-trichlorophenol	ND (0.4)	ND (0.7)
3,4,5-trichlorophenol	ND (0.4)	ND (0.3)
3-chlorocatechol	ND (1.2)	ND (1.0)
4-chlorocatechol	ND (1.2)	ND (1.1)
3,4-dichloroguaiacol	ND (0.8)	ND (0.8)
4,6-dichloroguaiacol	ND (1.0)	ND (1.0)
4,5-dichloroguaiacol	ND (0.7)	ND (0.7)
3-chlorosyringol	ND (4.0)	ND (4.2)
3,4-dichlorocatechol	ND (0.6)	ND (0.6)
3,6-dichlorocatechol	ND (0.7)	ND (0.6)
3,5-dichlorocatechol	ND (0.6)	ND (0.5)
4,5-dichlorocatechol	ND (0.8)	ND (0.7)
2,3,5,6-tetrachlorophenol	ND (0.8)	ND (0.8)
2,3,4,6-tetrachlorophenol	ND (1.1)	ND (1.1)
2,3,4,5-tetrachlorophenol	ND (0.5)	ND (0.5)
5-chlorovanillin	ND (1.7)	ND (1.8)
6-chlorovanillin	ND (1.6)	ND (1.7)
3,5-dichlorosyringol	ND (3.3)	ND (2.6)
3,4,5-trichloroguaiacol	ND (0.7)	ND (0.5)
4,5,6-trichloroguaiacol	ND (0.5)	ND (0.4)
5,6-dichlorovanillin	*ND (2.4)*	*ND (1.7)*
pentachlorophenol	ND (1.1)	ND (0.7)
3,4,5-trichlorocatechol	ND (1.8)	ND (1.5)
3,4,5,6-tetrachloroguaiacol	ND (0.6)	ND (0.6)
3,4,5-trichlorosyringol	ND (1.4)	ND (1.2)
3,4,5,6-tetrachlorocatechol	ND (2.4)	ND (2.4)

Detection limits are given in brackets
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
December 17, 1992

(concentration in ng/g)

Sample ID:	2437-26	2437-28
Sample Type:	IV-I DS Cominco @ Benthos Sept. 2/92 Sediment	IV-3 NEC Cominco Gravel Pit Sept. 2/92 Sediment
Sample Weight:	6.53 g dry	5.33 g dry
4-chlorophenol	ND (1.3)	ND (0.8)
2,6-dichlorophenol	ND (0.9)	ND (0.4)
2,4/2,5-DCP	ND (0.6)	ND (0.5)
3,5-dichlorophenol	ND (0.6)	ND (0.4)
2,3-dichlorophenol	ND (0.7)	ND (1.1)
3,4-dichlorophenol	ND (0.5)	ND (0.3)
6-chloroguaiacol	ND (4.1)	ND (1.0)
4-chloroguaiacol	ND (2.8)	ND (1.7)
5-chloroguaiacol	ND (2.5)	ND (1.5)
2,4,6-trichlorophenol	ND (0.4)	ND (0.4)
2,3,6-trichlorophenol	ND (0.6)	ND (0.5)
2,3,5-trichlorophenol	ND (0.5)	ND (0.5)
2,4,5-trichlorophenol	ND (0.4)	ND (0.4)
2,3,4-trichlorophenol	ND (0.5)	ND (0.4)
3,4,5-trichlorophenol	ND (0.5)	ND (0.4)
3-chlorocatechol	ND (1.5)	ND (1.2)
4-chlorocatechol	ND (1.8)	ND (1.3)
3,4-dichloroguaiacol	ND (0.7)	ND (0.5)
4,6-dichloroguaiacol	ND (0.7)	ND (0.5)
4,5-dichloroguaiacol	ND (0.6)	ND (0.5)
3-chlorosyringol	ND (4.0)	ND (3.0)
3,4-dichlorocatechol	ND (1.0)	ND (0.5)
3,6-dichlorocatechol	ND (1.5)	ND (0.8)
3,5-dichlorocatechol	ND (1.4)	0.9 (0.7)
4,5-dichlorocatechol	ND (2.0)	1.1 (1.0)
2,3,5,6-tetrachlorophenol	ND (0.4)	ND (0.2)
2,3,4,6-tetrachlorophenol	ND (0.5)	ND (0.3)
2,3,4,5-tetrachlorophenol	ND (0.5)	ND (0.3)
5-chlorovanillin	ND (3.5)	ND (1.3)
6-chlorovanillin	ND (7.6)	ND (2.8)
3,5-dichlorosyringol	ND (2.0)	ND (1.2)
3,4,5-trichloroguaiacol	ND (0.3)	0.5 (0.2)
4,5,6-trichloroguaiacol	ND (0.2)	ND (0.1)
5,6-dichlorovanillin	ND (2.2)	ND (4.8)
pentachlorophenol	ND (1.0)	ND (0.6)
3,4,5-trichlorocatechol	ND (5.0)	8.4 (4.0)
3,4,5,6-tetrachloroguaiacol	ND (0.3)	ND (0.3)
3,4,5-trichlorosyringol	ND (1.6)	ND (0.9)
3,4,5,6-tetrachlorocatechol	ND (20)	ND (13)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
December 17, 1992

(concentration in ng/g)

Sample ID:	2437-SBLK 193
Sample Type:	Sediment Procedural Blank
Sample Weight:	6.50 g dry
4-chlorophenol	ND (0.2)
2,6-dichlorophenol	ND (0.1)
2,4/2,5-DCP	ND (0.1)
3,5-dichlorophenol	ND (0.1)
2,3-dichlorophenol	ND (0.1)
3,4-dichlorophenol	ND (0.1)
6-chloroguaiacol	ND (0.3)
4-chloroguaiacol	ND (0.5)
5-chloroguaiacol	ND (0.4)
2,4,6-trichlorophenol	ND (0.1)
2,3,6-trichlorophenol	ND (0.1)
2,3,5-trichlorophenol	ND (0.1)
2,4,5-trichlorophenol	ND (0.1)
2,3,4-trichlorophenol	ND (0.1)
3,4,5-trichlorophenol	ND (0.1)
3-chlorocatechol	ND (0.2)
4-chlorocatechol	ND (0.2)
3,4-dichloroguaiacol	ND (0.2)
4,6-dichloroguaiacol	ND (0.2)
4,5-dichloroguaiacol	ND (0.2)
3-chlorosyringol	ND (0.4)
3,4-dichlorocatechol	ND (0.1)
3,6-dichlorocatechol	ND (0.1)
3,5-dichlorocatechol	ND (0.1)
4,5-dichlorocatechol	ND (0.2)
2,3,5,6-tetrachlorophenol	ND (0.1)
2,3,4,6-tetrachlorophenol	ND (0.2)
2,3,4,5-tetrachlorophenol	ND (0.1)
5-chlorovanillin	ND (0.4)
6-chlorovanillin	ND (0.4)
3,5-dichlorosyringol	ND (0.4)
3,4,5-trichloroguaiacol	ND (0.1)
4,5,6-trichloroguaiacol	ND (0.1)
5,6-dichlorovanillin	ND (0.3)
pentachlorophenol	ND (0.2)
3,4,5-trichlorocatechol	ND (0.2)
3,4,5,6-tetrachloroguaiacol	ND (0.1)
3,4,5-trichlorosyringol	ND (0.1)
3,4,5,6-tetrachlorocatechol	ND (0.1)

Detection limits are given in brackets
ND = Not Detected

Approved by: Dale Hoover
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
September 23, 1992

(concentration in ng/g)

Sample I.D.	2437-20	2437-25	2437-26
Sample Type:	Sediment I-1 EC Arrow Lake EC	Sediment III-3 Lower Birchbank Sept 2/92	Sediment IV-1 D/S Cominco (a Benthos Sept 2/92
Sample Weight:	8.14 g dry	14.74 g dry	12.46 g dry
4,5-dichloroveratrole	ND (0.5)	ND (0.7)	ND (0.5)
3,4,6-trichloroveratrole	ND (1.0)	ND (0.8)	ND (1.0)
3,4,5-trichloroveratrole	ND (1.0)	ND (0.8)	ND (1.0)
3,4,5,6-tetrachloroveratrole	ND (1.3)	ND (1.0)	ND (1.4)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
September 23, 1992

(concentration in ng/g)

Sample I.D.	2437-28A	2437-28B
Sample Type:	Sediment IV-3 NEC Cominco Gravel Pit Sept 2/92	Duplicate
Sample Weight:	10.37 g dry	10.45 g dry
4,5-dichloroveratrole	ND (0.6)	ND (0.6)
3,4,6-trichloroveratrole	ND (0.8)	ND (1.4)
3,4,5-trichloroveratrole	ND (0.8)	ND (1.4)
3,4,5,6-tetrachloroveratrole	ND (1.3)	ND (1.6)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
September 23, 1992

(concentration in ng/g)

Sample I.D.	2437-SBLK 25
Sample Type:	Procedural Blank
Sample Weight:	10.00 g
4,5-dichloroveratrole	ND (2.0)
3,4,6-trichloroveratrole	ND (2.2)
3,4,5-trichloroveratrole	ND (2.2)
3,4,5,6-tetrachloroveratrole	ND (3.6)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

RESIN ACID ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
February 15, 1993

(Concentration ng/g)

Sample I.D.	2437-20 I-1 EC Arrow Lake EC Sediment		2437-21 II-2 NEC Sediment	
Sample Weight:	4.15 g dry		5.82 g dry	
Compound				
Pimaric	7.5	(0.7)	74	(0.4)
Sandaracopimaric	50	(0.6)	630	(0.3)
Isopimaric	24	(2.8)	640	(0.8)
Palustric	NDR(14)	(3.6)	490	(1.0)
Dehydroisopimaric	ND	(2.2)	NDR(15)	(1.0)
Dehydroabietic	130	(2.1)	> 6600	(1.2) *
Abietic	31	(11)	2900	(3.2)
Neoabietic	ND	(0.6)	390	(0.5)
12/14 Monochlorodehydroabietic	ND	(0.9)	4.0	(1.2)
12,14 Dichlorodehydroabietic	ND	(2.8)	ND	(3.5)

ND = Not Detected
NDR = Peak detected but did not meet quantification criteria
Detection limits given in brackets
* Concentration exceeded linear range - final value based on diluted run will be reported as soon as possible.

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

RESIN ACID ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
February 15, 1993

(Concentration ng/g)

Sample I.D.	2437-25 III-3 Lower Birchbank Sept. 2/92 Sediment	2437-26 IV-I DS Cominco @ Benthos Sept. 2/92 Sediment
Sample Weight:	7.80 g dry	6.56 g dry
Compound		
Pimaric	NDR(1.6) (0.3)	NDR(3.7) (0.3)
Sandaracopimaric	32 (0.2)	13 (0.3)
Isopimaric	8.3 (1.4)	33 (0.7)
Palustric	NDR(5.1) (1.7)	NDR(14) (0.8)
Dehydroisopimaric	ND (1.3)	ND (2.2)
Dehydroabietic	54 (0.8)	130 (1.0)
Abietic	14 (4.8)	60 (2.7)
Neoabietic	NDR(5.7) (0.6)	NDR(1.0) (0.6)
12/14 Monochlorodehydroabietic	ND (0.3)	ND (0.4)
12,14 Dichlorodehydroabietic	ND (1.2)	ND (1.6)

ND = Not Detected
NDR = Peak detected but did not meet quantification criteria
Detection limits given in brackets

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

RESIN ACID ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
February 15, 1993

(Concentration ng/g)

Sample I.D.	2437-28A IV-3 NEC Cominco Gravel Pit Sept. 2/92 Sediment	2437-28B Duplicate Sediment
Sample Weight:	5.14 g dry	5.36 g dry
Compound		
Pimaric	27 (0.3)	14 (0.4)
Sandaracopimaric	NDR(99) (0.3)	NDR(36) (0.3)
Isopimaric	270 (0.7)	180 (0.8)
Palustric	94 (0.8)	150 (1.0)
Dehydroisopimaric	ND (2.1)	ND (2.1)
Dehydroabietic	430 (1.0)	200 (1.1)
Abietic	330 (2.7)	310 (3.1)
Neoabietic	12 (0.4)	NDR(72) (0.4)
12/14 Monochlorodehydroabietic	2.6 (0.9)	1.8 (1.0)
12,14 Dichlorodehydroabietic	12 (1.6)	3.6 (2.0)

ND = Not Detected
NDR = Peak detected but did not meet quantification criteria
Detection limits given in brackets

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

AXYS ANALYTICAL SERVICES LTD P.O. BOX 2219, 2045 MILLS RD., SIDNEY, B.C., CANADA V8L 3S8 TEL (604) 656-0881 FAX (604) 656-4511

RESIN ACID ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
February 15, 1993

(Concentration ng/g)

Sample I.D.	2437-29 Norecol I-1 NEC Arrow Lake Sediment Sept. 1/92	2437-30 #6 EC-NB Nelson Kootenay Lk. Sept. 3/92 Sediment
Sample Weight:	5.53 g dry	4.16 g dry
Compound		
Pimaric	NDR(7.4) (0.5)	NDR(0.9) (0.5)
Sandaracopimaric	21 (0.5)	NDR(10) (0.5)
Isopimaric	30 (1.1)	NDR(7.9) (2.6)
Palustric	NDR(13) (1.4)	NDR(8.0) (3.1)
Dehydroisopimaric	ND (2.8)	ND (2.3)
Dehydroabietic	97 (1.6)	49 (1.6)
Abietic	30 (6.5)	13 (5.0)
Neoabietic	NDR(1.1) (0.7)	ND (0.7)
12/14 Monochlorodehydroabietic	ND (0.9)	ND (0.8)
12,14 Dichlorodehydroabietic	ND (2.0)	ND (2.4)

ND = Not Detected
NDR = Peak detected but did not meet quantification criteria
Detection limits given in brackets

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

AXYS ANALYTICAL SERVICES LTD P.O. BOX 2219, 2045 MILLS RD., SIDNEY, B.C., CANADA V8L 3S8 TEL (604) 656-0881 FAX (604) 656-4511

FEB-15-1993 12:36 FROM AXYS GROUP LTD TO 12737791 P.06

RESIN ACID ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
February 15, 1993

(Concentration ng/g)

Sample I.D.	2437-SSPM 82 Spiked Sediment	
Sample Weight:	10.42 g dry	
Compound	**Determined**	**Expected**
Pimaric	50	42
Sandaracopimaric	55	51
Isopimaric	53	46
Palustric	38	43
Dehydroisopimaric	41	58
Dehydroabietic	58	50
Abietic	42	48
Neoabietic	20	55
12/14 Monochlorodehydroabietic	39	42
12,14 Dichlorodehydroabietic	48	56

Approved by: Dale Hoover
M. Coreen Hamilton
A. Dale Hoover

RESIN ACID ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
February 15, 1993

(Concentration ng/g)

Sample I.D.	2437-SBLK 50 Lab Blank
Sample Weight:	6.00 g dry
Compound	
Pimaric	ND (1.5)
Sandaracopimaric	ND (0.5)
Isopimaric	ND (1.0)
Palustric	ND (1.2)
Dehydroiscpimaric	ND (0.8)
Dehydroabietic	ND (2.0)
Abietic	ND (1.5)
Neoabietic	ND (0.4)
12/14 Monochlorodehydroabietic	ND (0.4)
12,14 Dichlorodehydroabietic	ND (0.5)

ND = Not Detected
Detection limits given in brackets

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

AXYS ANALYTICAL SERVICES LTD P.O. BOX 2219, 2045 MILLS RD., SIDNEY, B.C., CANADA V8L 3S8 TEL (604) 656-0881 FAX (604) 656-4511

Appendix 6-1

Data for Metals in Biota

ANALYTICAL REPORT
Form 03035797

ZENON

Parameter	MDC	Unit	92018963	92018964	92018965
		Zenon ID :	92018963	92018964	92018965
Moisture	0.1	%(W/W)	89.2	87.0	87.4
Silver	1	ug/g	< 1	< 1	< 1
Aluminum	2	ug/g	183	429	388
Arsenic	0.2	ug/g	2.8	0.9	2.8
Barium	0.1	ug/g	1030	669	859
Beryllium	0.1	ug/g	0.1	< 0.1	< 0.1
Bismuth	2	ug/g	< 2	< 2	< 2
Calcium	1	ug/g	33100	29400	44700
Cadmium	0.1	ug/g	3.6	1.1	13.3
Cobalt	0.3	ug/g	1.1	1.1	1.0
Chromium	0.2	ug/g	4.5	13.8	6.3
Copper	0.1	ug/g	6.1	14.8	64.2
Iron	0.3	ug/g	2610	3760	4590
Mercury	0.05	ug/g	< 0.05	< 0.05	0.08
Potassium	40	ug/g	1120	1280	989
Magnesium	2	ug/g	1190	1250	1360
Manganese	0.2	ug/g	4770	4780	5330
Molybdenum	0.4	ug/g	0.9	< 0.4	0.8
Sodium	1	ug/g	2710	2090	2150
Nickel	0.8	ug/g	1.0	3.0	1.6
Phosphorus	4	ug/g	27800	24900	30900
Lead	2	ug/g	4	2	251
Sulphur	3	ug/g	6560	6480	6070
Antimony	1.5	ug/g	< 1.5	< 1.5	< 1.5
Selenium	0.5	ug/g	2.7	2.2	2.8
Tin	2	ug/g	< 2	< 2	< 2
Strontium	0.1	ug/g	138	250	229
Tellurium	2	ug/g	< 2	< 2	< 2
Titanium	0.3	ug/g	6.8	21.7	19.5
Thallium	0.3	ug/g	< 0.3	< 0.3	< 0.3
Vanadium	0.3	ug/g	< 0.3	0.5	0.6
Zinc	0.2	ug/g	214	256	962
Zirconium	0.3	ug/g	1.8	1.6	1.9
		Sample State :	Biota	Biota	Biota
		Sampled on :	92/07/17 00:00	92/07/18 00:00	92/07/14 00:00

Sample 92018963 comment : CLAMS-KOOTENAY RIVER GLADE : SAMPLED BY NORECOL
Sample 92018964 comment : CLAMS-CELGAR PERIPHYTON STN : SAMPLED BY NORECOL
Sample 92018965 comment : CLAMS-WANETA COMPOSITE : SAMPLED BY NORECOL

Project ID: CRIEMP BIOTA STUDY ALL RESULTS ARE DRY WEIGHT BASIS

ANALYTICAL REPORT
Form 03035798

Parameter	MDC	Unit	92018972	92018973
		Zenon ID :	92018972	92018973
Moisture	0.1	%(W/W)	84.7	87.0
Silver	1	ug/g	< 1	< 1
Aluminum	2	ug/g	417	543
Arsenic	0.2	ug/g	1.0	0.2
Barium	0.1	ug/g	110	45.7
Beryllium	0.1	ug/g	< 0.1	< 0.1
Bismuth	2	ug/g	< 2	< 2
Calcium	1	ug/g	84700	24000
Cadmium	0.1	ug/g	6.3	1.1
Cobalt	0.3	ug/g	1.4	0.4
Chromium	0.2	ug/g	1.8	1.8
Copper	0.1	ug/g	27.6	6.8
Iron	0.3	ug/g	679	764
Mercury	0.05	ug/g	0.11	< 0.05
Potassium	40	ug/g	12000	16900
Magnesium	2	ug/g	2290	2230
Manganese	0.2	ug/g	381	78.3
Molybdenum	0.4	ug/g	0.9	< 0.4
Sodium	1	ug/g	583	424
Nickel	0.8	ug/g	1.9	4.9
Phosphorus	4	ug/g	1610	1210
Lead	2	ug/g	38	3
Sulphur	3	ug/g	1850	2530
Antimony	1.5	ug/g	2.0	< 1.5
Selenium	0.5	ug/g	< 0.5	< 0.5
Tin	2	ug/g	< 2	< 2
Strontium	0.1	ug/g	241	111
Tellurium	2	ug/g	< 2	< 2
Titanium	0.3	ug/g	25.0	56.7
Thallium	0.3	ug/g	6.8	< 0.3
Vanadium	0.3	ug/g	1.1	1.3
Zinc	0.2	ug/g	218	32.5
Zirconium	0.3	ug/g	0.4	< 0.3
		Sample State :	Biota	Biota
		Sampled on :	92/07/14 00:00	92/07/18 00:00

Sample 92018972 comment : MACROPHYTES;WANETA : SAMPLED BY NORECOL
Sample 92018973 comment : MACROPHYTES;CELGAR PERIPHYTON STN : SAMPLED BY NORECOL

Project ID: CRIEMP BIOTA STUDY   ALL RESULTS ARE DRY WEIGHT BASIS

ANALYTICAL REPORT
Form 03035799

ZENON

Parameter	MDC	Unit	92018966	92018967	92018968	92018969	92018970	92018971
Moisture	0.1	%(W/W)	72.6	72.6	70.4	70.0	70.3	71.5
Silver	1	ug/g	< 1	< 1	< 1	< 1	< 1	< 1
Aluminum	2	ug/g	17	12	18	11	12	16
Arsenic	0.2	ug/g	3.2	2.4	2.1	1.7	2.2	2.1
Barium	0.1	ug/g	5.2	3.3	2.7	1.9	2.3	4.8
Beryllium	0.1	ug/g	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Bismuth	2	ug/g	< 2	< 2	< 2	< 2	< 2	< 2
Calcium	1	ug/g	836	692	1000	1020	1230	922
Cadmium	0.1	ug/g	0.30	0.31	0.34	0.65	0.73	0.38
Cobalt	0.3	ug/g	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Chromium	0.2	ug/g	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Copper	0.1	ug/g	25.6	21.2	20.7	33.6	40.9	27.7
Iron	0.3	ug/g	117	88.0	102	103	123	124
Mercury	0.05	ug/g	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Potassium	40	ug/g	7230	5750	6110	6510	7400	7310
Magnesium	2	ug/g	752	642	705	810	983	848
Manganese	0.2	ug/g	22.2	13.2	13.4	11.7	14.6	19.4
Molybdenum	0.4	ug/g	1.3	1.0	1.0	1.9	2.0	1.2
Sodium	1	ug/g	2390	1950	2050	2260	2620	2520
Nickel	0.8	ug/g	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8
Phosphorus	4	ug/g	7450	6160	7180	8150	9340	8000
Lead	2	ug/g	5	4	6	20	25	6
Sulphur	3	ug/g	6140	4920	5590	5940	6370	5940
Antimony	1.5	ug/g	< 1.5	< 1.5	2.3	2.9	3.4	< 1.5
Selenium	0.5	ug/g	2.7	2.6	1.8	1.3	1.5	2.6
Tin	2	ug/g	< 2	< 2	< 2	2	3	2
Strontium	0.1	ug/g	4.5	3.7	6.5	5.0	6.0	4.8
Tellurium	2	ug/g	< 2	< 2	< 2	< 2	< 2	< 2
Titanium	0.3	ug/g	1.1	0.8	1.2	0.7	0.7	0.9
Thallium	0.3	ug/g	< 0.3	0.3	< 0.3	0.3	< 0.3	1.2
Vanadium	0.3	ug/g	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	0.3
Zinc	0.2	ug/g	135	105	136	181	217	128
Zirconium	0.3	ug/g	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Sample State :			Biota	Biota	Biota	Biota	Biota	Biota
Sampled on :			92/07/16 00:00	92/07/16 00:00	92/07/17 00:00	92/07/15 00:00	92/07/15 00:00	92/07/19 00:00

Sample 92018966 comment : CADDIS FLIES;KOOTENAY RIVER GLADE GLADE : SAMPLED BY ENV CANADA
Sample 92018967 comment : CADDIS FLIES;KOOTENAY RIVER GLADE GLADE : SAMPLED BY NORECOL
Sample 92018968 comment : CADDIS FLIES;CELGAR : SAMPLED BY NORECOL
Sample 92018969 comment : CADDIS FLIES;WANETA : SAMPLED BY ENV CANADA
Sample 92018970 comment : CADDIS FLIES;WANETA : SAMPLED BY NORECOL
Sample 92018971 comment : CADDIS FLIES GROHMAN NARROWS : SAMPLED BY NORECOL

Project ID: CRIEMP BIOTA STUDY   ALL RESULTS ARE DRY WEIGHT BASIS

APPENDIX D

QA/QC RESULTS FOR BIOLOGY SAMPLES

		ZENON ID:	Method Blank	Duplicate 1A	Duplicate 1B	Percent Difference
Parameter	**MDC**	**Units**				
Metals				**18968 A**	**18968 B**	
Silver	1	ug/g	<	<	<	0%
Aluminum	2	"	<	19.3	18.3	5%
Arsenic	0.2	"	<	<	<	0%
Barium	0.1	"	<	2.94	2.72	8%
Beryllium	0.1	"	<	<	<	0%
Bismuth	2	"	<	<	<	0%
Calcium	1	"	9.7	1070	1000	7%
Cadmium	0.1	"	<	0.312	0.339	-8%
Cobalt	0.3	"	<	<	<	0%
Chromium	0.2	"	0.82	<	<	0%
Copper	0.1	"	0.225	22.1	20.7	7%
Iron	0.3	"	1.68	109	102	7%
Mercury	0.05	"	<	0.084*	0.084*	0%
Potassium	40	"	<	6340	6110	4%
Magnesium	2	"	<	757	705	7%
Manganese	0.2	"	<	14.3	13.4	6%
Molybdenum	0.4	"	<	1.05	0.955	9%
Sodium, Total	1	"	17.4	2160	2050	5%
Nickel	0.8	"	<	<	<	0%
Phosphorus, Total	4	"	<	7700	7180	7%
Lead	2	"	<	5.85	5.59	5%
Sulphur, Total	3	"	8.67	5770	5590	3%
Antimony	1.5	"	<	1.81	2.28	-23%
Selenium	0.5	"	<	1.8	1.71	5%
Tin	0.1	"	<	<	<	0%
Strontium	2	"	<	6.94	6.51	6%
Tellurium	2	"	<	<	<	0%
Titanium	0.3	"	<	1.16	1.22	-5%
Thallium	0.3	"	<	<	<	0%
Vanadium	0.3	"	<	<	<	0%
Zinc	0.2	"	0.51	145	136	6%
Zirconium	0.3	"	<	<	<	0%

NOTES: ug/g = microgram per gram = parts per million
MDC = Minimum Detectable Concentration
< = Less than MDC
Solid Results Are Dry Weight Basis
Results are blank corrected
* = Duplicate Performed on Sample 92018965

		ZENON ID:	Duplicate 2A	Duplicate 2B	Percent Difference
Parameter	MDC	Units			
Metals			18973 A	18973 B	
Silver	1	ug/g	<	<	0%
Aluminum	2	"	543	490	10%
Arsenic	0.2	"	<	<	0%
Barium	0.1	"	45.7	43.5	5%
Beryllium	0.1	"	<	<	0%
Bismuth	2	"	<	<	0%
Calcium	1	"	24000	22500	6%
Cadmium	0.1	"	1.11	1.41	-24%
Cobalt	0.3	"	0.443	0.57	-25%
Chromium	0.2	"	2.64	2.69	-2%
Copper	0.1	"	1.82	1.87	-3%
Iron	0.3	"	764	791	-3%
Mercury	0.05	"	<	<	0%
Potassium	40	"	16900	16700	1%
Magnesium	2	"	2230	2180	2%
Manganese	0.2	"	78.3	76.4	2%
Molybdenum	0.4	"	<	<	0%
Sodium, Total	1	"	424	420	1%
Nickel	0.8	"	4.92	5.64	-14%
Phosphorus, Total	4	"	<	<	0%
Lead	2	"	2.50	2.39	4%
Sulphur, Total	3	"	2530	2570	-2%
Antimony	1.5	"	<	<	0%
Selenium	0.5	"	<	<	0%
Tin	0.1	"	<	<	0%
Strontium	2	"	111	105	6%
Tellurium	2	"	<	<	0%
Titanium	0.3	"	56.7	54.5	4%
Thallium	0.3	"	<	<	0%
Vanadium	0.3	"	1.31	1.33	-2%
Zinc	0.2	"	32.5	33	-2%
Zirconium	0.3	"	<	<	0%

NOTES: ug/g = microgram per gram = parts per million
MDC = Minimum Detectable Concentration
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Solid Results Are Dry Weight Basis
Results are blank corrected
• = Duplicate Performed on Sample 92018965

		ZENON ID:	SRM NBS 1577A	Certified Value	Percent Recovery
Parameter	**MDC**	**Units**			
Metals					
Silver	1	ug/g	<	NA	NA
Aluminum	2	"	1.41	NA	NA
Arsenic	0.2	"		0.047±0.006	
Barium	0.1	"	0.0859	NA	NA
Beryllium	0.1	"	<	NA	NA
Bismuth	2	"	<	NA	NA
Calcium	1	"	89.9	NA	NA
Cadmium	0.1	"	0.24	0.44±0.06	55%
Cobalt	0.3	"	0.22	0.21±0.05	105%
Chromium	0.2	"	0.953	NA	NA
Copper	0.1	"	106	158±7	67%
Iron	0.3	"	127	194±20	65%
Mercury	0.05	"	<	0.004±0.002	NA
Potassium	40	"	7240	9996±70	72%
Magnesium	2	"	413	600±15	69%
Manganese	0.2	"	6.78	9.9±0.8	68%
Molybdenum	0.4	"	2.34	3.5±0.5	67%
Sodium, Total	1	"	1680	2430±130	69%
Nickel	0.8	"	0.488	NA	NA
Phosphorus, Total	4	"	0.814	2800±400	0%
Lead	2	"	0.0212	0.135±0.015	16%
Sulphur, Total	3	"	5650	7800±100	72%
Antimony	1.5	"	0.63	NA	NA
Selenium	0.5	"	0.8	0.71±0.07	113%
Tin	0.1	"	1.43	NA	NA
Strontium	2	"	0.118	0.138±0.003	86%
Tellurium	2	"	<	NA	NA
Titanium	0.3	"	0.133	NA	NA
Thallium	0.3	"	0.266	NA	NA
Vanadium	0.3	"	0.0007	NA	NA
Zinc	0.2	"	84.2	123±8	68%
Zirconium	0.3	"	0.32	NA	NA

NOTES: ug/g = microgram per gram = parts per million
MDC = Minimum Detectable Concentration
< = Less than MDC
Solid Results Are Dry Weight Basis
Results are blank corrected
* = Duplicate Performed on Sample 92018965

Parameter	MDC	Units	ZENON ID: SRM NBS 1571	Certified Value	Percent Recovery
Metals					
Silver	1	ug/g	<	NA	NA
Aluminum	2	"	169	NA	NA
Arsenic	0.2	"	12.9	10±2	129%
Barium	0.1	"	32.1	NA	NA
Beryllium	0.1	"	<	0.027±0.01	NA
Bismuth	2	"	0.837	NA	NA
Calcium	1	"	18400	20900±300	88%
Cadmium	0.1	"	0.0884	0.11±0.01	80%
Cobalt	0.3	"	0.27	NA	NA
Chromium	0.2	"	2.48	2.6±0.3	95%
Copper	0.1	"	9.78	12±1	82%
Iron	0.3	"	211	300±20	70%
Mercury	0.05	"	0.133	0.155±0.015	89%
Potassium	40	"	10900	14700±300	74%
Magnesium	2	"	4950	6200±200	80%
Manganese	0.2	"	73.4	91±4	80%
Molybdenum	0.4	"	<	0.3±0.1	NA
Sodium, Total	1	"	77.3	82±6	94%
Nickel	0.8	"	0.932	1.3±0.2	72%
Phosphorus, Total	4	"	1700	2100±100	81%
Lead	2	"	38.1	45±3	85%
Sulphur, Total	3	"	1670	NA	NA
Antimony	1.5	"	2.58	2.9±0.3	89%
Selenium	0.5	"	<	0.08±0.01	NA
Tin	0.1	"	1.13	NA	NA
Strontium	2	"	28.3	37±1	76%
Tellurium	2	"	0.133	NA	NA
Titanium	0.3	"	5.91	NA	NA
Thallium	0.3	"	<	NA	NA
Vanadium	0.3	"	7.14	NA	NA
Zinc	0.2	"	22	25±3	88%
Zirconium	0.3	"	0.396	NA	NA

NOTES: ug/g = microgram per gram = parts per million
MDC = Minimum Detectable Concentration
< = Less than MDC
Solid Results Are Dry Weight Basis
Results are blank corrected
• = Duplicate Performed on Sample 92018965

		ZENON ID:	Sample 18972	Sample Spiked	Spike Level	Spike Recovery
Parameter	**MDC**	**Units**				
Metals						
Silver	1	ug/g	<	4.6	5	92%
Aluminum	2	"	453	502	30	163%
Arsenic	0.2	"	1	5.6	5	92%
Barium	0.1	"	117	231	100	114%
Beryllium	0.1	"	<	0.6	0.5	120%
Bismuth	2	"	<	10	10	100%
Calcium	1	"	82200	89000	5000	136%
Cadmium	0.1	"	7.3	8.6	1	130%
Cobalt	0.3	"	1.5	2.4	1	90%
Chromium	0.2	"	2.1	3.8	2	85%
Copper	0.1	"	31.3	34	5	54%
Iron	0.3	"	869	913	50	88%
Mercury	0.05	"	0.11	0.56	0.5	90%
Potassium	40	"	14100	14500	200	200%
Magnesium	2	"	2380	2540	200	80%
Manganese	0.2	"	390	498	100	108%
Molybdenum	0.4	"	0.8	1.6	1	80%
Sodium, Total	1	"	742	810	50	136%
Nickel	0.8	"	2.3	4.8	2.5	100%
Phosphorus, Total	4	"	1840	2900	1000	106%
Lead	2	"	38	65	25	108%
Sulphur, Total	3	"	1990	3014	1000	102%
Antimony	1.5	"	1.5	10	10	85%
Selenium	0.5	"	0.88	9.7	10	88%
Tin	0.1	"	<	11	10	11%
Strontium	2	"	254	283	30	97%
Tellurium	2	"	<	10	10	100%
Titanium	0.3	"	27	29	NA	NA
Thallium	0.3	"	7.4	17.4	10	100%
Vanadium	0.3	"	1.4	2.5	1	110%
Zinc	0.2	"	267	374	100	107%
Zirconium	0.3	"	0.4	2.7	3	77%

NOTES: ug/g = microgram per gram = parts per million
MDC = Minimum Detectable Concentration
< = Less than MDC
Solid Results Are Dry Weight Basis
Results are blank corrected
• = Duplicate Performed on Sample 92018965

Appendix 6-2

Data for Dioxins/Furans in Biota

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP

Our File: 2437

Sample ID: Clams Kootenay River Glade Organics 92/07/17

Axys ID: 2437-02A

Sample Weight: 14.83 g wet

Date: November 25, 1992

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.08
2,3,7,8	ND	0.08
P_5CDD - Total	2.6	0.1
1,2,3,7,8	ND	0.1
H_6CDD - Total	240	0.2
1,2,3,4,7,8	ND	0.2
1,2,3,6,7,8	21	0.2
1,2,3,7,8,9	3.0	0.2
H_7CDD - Total	1200	0.3
1,2,3,4,6,7,8	340	0.3
O_8CDD	3000	0.3

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	12	0.06
2,3,7,8	2.6	0.06
P_5CDF - Total	53	0.1
1,2,3,7,8	0.6	0.1
2,3,4,7,8	0.9	0.1
H_6CDF - Total	180	0.2
1,2,3,4,7,8	1.7	0.2
1,2,3,6,7,8	NDR(0.5)	0.2
2,3,4,6,7,8	1.1	0.2
1,2,3,7,8,9	ND	0.2
H_7CDF - Total	180	0.3
1,2,3,4,6,7,8	60	0.3
1,2,3,4,7,8,9	ND	0.3
O_8CDF	20	0.3

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	81
$^{13}C-T_4CDF$:	83
$^{13}C-P_5CDD$:	90
$^{13}C-H_6CDD$:	92
$^{13}C-H_7CDD$:	93
$^{13}C-O_8CDD$:	103

Approved by: Dale Hoover

M. Coreen Hamilton
A. Dale Hoover

AXYS ANALYTICAL SERVICES LTD P.O. BOX 2219, 2045 MILLS RD., SIDNEY, B.C., CANADA V8L 3S8 TEL (604) 656-0881 FAX (604) 656-4511

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP **Our File:** 2437

Sample ID: Clams Kootenay River Glade Organics 92/07/17 Duplicate **Axys ID:** 2437-02B

Sample Weight: 14.46 g wet **Date:** November 25, 1992

Dioxins	Concentration pg/g	(SDL)	Furans	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.09	T_4CDF - Total	9.7	0.05
2,3,7,8	ND	0.09	2,3,7,8	2.4	0.05
P_5CDD - Total	2.7	0.2	P_5CDF - Total	33	0.08
1,2,3,7,8	ND	0.2	1,2,3,7,8	0.6	0.08
			2,3,4,7,8	0.8	0.08
H_6CDD - Total	270	0.2			
1,2,3,4,7,8	ND	0.2	H_6CDF - Total	180	0.3
1,2,3,6,7,8	22	0.2	1,2,3,4,7,8	1.0	0.3
1,2,3,7,8,9	2.8	0.2	1,2,3,6,7,8	ND	0.3
			2,3,4,6,7,8	1.3	0.3
H_7CDD - Total	1500	0.3	1,2,3,7,8,9	ND	0.3
1,2,3,4,6,7,8	370	0.3			
			H_7CDF - Total	170	0.2
O_8CDD	3400	0.5	1,2,3,4,6,7,8	59	0.2
			1,2,3,4,7,8,9	ND	0.2
			O_8CDF	24	0.4

SDL = Sample Detection Limit
ND = Not Detected

Surrogate Standard Recovery	(%)
^{13}C-T_4CDD:	69
^{13}C-T_4CDF:	73
^{13}C-P_5CDD:	64
^{13}C-H_6CDD:	78
^{13}C-H_7CDD:	66
^{13}C-O_8CDD:	52

Approved by: Dale Hoover

M. Coreen Hamilton
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ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP **Our File:** 2437

Sample ID: Clams Waneta Bay Organics (across from Cominco Gravel Pit) 92/07/14 **Axys ID:** 2437-04

Sample Weight: 14.85 g wet **Date:** November 25, 1992

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.09
2,3,7,8	ND	0.09
P_5CDD - Total	ND	0.3
1,2,3,7,8	ND	0.3
H_6CDD - Total	70	0.3
1,2,3,4,7,8	ND	0.3
1,2,3,6,7,8	5.2	0.3
1,2,3,7,8,9	NDR(0.9)	0.3
H_7CDD - Total	440	0.6
1,2,3,4,6,7,8	120	0.6
O_8CDD	1100	1.4

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	2.0	0.07
2,3,7,8	0.9	0.07
P_5CDF - Total	2.5	0.2
1,2,3,7,8	ND	0.2
2,3,4,7,8	ND	0.2
H_6CDF - Total	38	0.3
1,2,3,4,7,8	NDR(0.4)	0.3
1,2,3,6,7,8	ND	0.3
2,3,4,6,7,8	ND	0.3
1,2,3.7,8,9	ND	0.3
H_7CDF - Total	42	0.8
1,2,3,4,6,7,8	15	0.8
1,2,3,4,7,8,9	ND	0.8
O_8CDF	8.5	0.7

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	60
$^{13}C-T_4CDF$:	66
$^{13}C-P_5CDD$:	61
$^{13}C-H_6CDD$:	70
$^{13}C-H_7CDD$:	53
$^{13}C-O_8CDD$:	38

Approved by: M. Coreen Hamilton
A. Dale Hoover

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ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP

Our File: 2437

Sample ID: Clams Celgar Periphytan Stn 92/07/18

Axys ID: 2437-05

Sample Weight: 15.13 g wet

Date: November 25, 1992

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.08
2,3,7,8	ND	0.08
P_5CDD - Total	ND	0.2
1,2,3,7,8	ND	0.2
H_6CDD - Total	78	0.2
1,2,3,4,7,8	ND	0.2
1,2,3,6,7,8	4.3	0.2
1,2,3,7,8,9	0.9	0.2
H_7CDD - Total	470	0.2
1,2,3,4,6,7,8	130	0.2
O_8CDD	1100	0.8

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	3.8	0.06
2,3,7,8	2.3	0.06
P_5CDF - Total	3.4	0.1
1,2,3,7,8	ND	0.1
2,3,4,7,8	ND	0.1
H_6CDF - Total	26	0.1
1,2,3,4,7,8	NDR(0.4)	0.1
1,2,3,6,7,8	ND	0.1
2,3,4,6,7,8	ND	0.1
1,2,3,7,8,9	ND	0.1
H_7CDF - Total	34	0.2
1,2,3,4,6,7,8	12	0.2
1,2,3,4,7,8,9	ND	0.2
O_8CDF	7.4	0.3

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	63
$^{13}C-T_4CDF$:	72
$^{13}C-P_5CDD$:	75
$^{13}C-H_6CDD$:	77
$^{13}C-H_7CDD$:	64
$^{13}C-O_8CDD$:	51

Approved by:
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP **Our File:** 2437

Sample ID: Caddis Flies Celgar 92/07/17 **Axys ID:** 2437-08

Sample Weight: 10.13 g wet **Date:** November 25, 1992

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.07
2,3,7,8	ND	0.07
P_5CDD - Total	ND	0.2
1,2,3,7,8	ND	0.2
H_6CDD - Total	ND	0.2
1,2,3,4,7,8	ND	0.2
1,2,3,6,7,8	ND	0.2
1,2,3,7,8,9	ND	0.2
H_7CDD - Total	ND	0.6
1,2,3,4,6,7,8	ND	0.6
O_8CDD	ND	2.7

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	1.5	0.1
2,3,7,8	0.5	0.1
P_5CDF - Total	ND	0.4
1,2,3,7,8	ND	0.4
2,3,4,7,8	ND	0.4
H_6CDF - Total	ND	0.4
1,2,3,4,7,8	ND	0.4
1,2,3,6,7,8	ND	0.4
2,3,4,6,7,8	ND	0.4
1,2,3,7,8,9	ND	0.4
H_7CDF - Total	ND	0.5
1,2,3,4,6,7,8	ND	0.5
1,2,3,4,7,8,9	ND	0.5
O_8CDF	ND	0.4

SDL = Sample Detection Limit
ND = Not Detected

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	73
$^{13}C-T_4CDF$:	76
$^{13}C-P_5CDD$:	76
$^{13}C-H_6CDD$:	75
$^{13}C-H_7CDD$:	60
$^{13}C-O_8CDD$:	44

Approved by:
M. Coreen Hamilton
A. Dale Hoover

AXYS ANALYTICAL SERVICES LTD P.O. BOX 2219, 2045 MILLS RD., SIDNEY, B.C., CANADA V8L 3S8 TEL (604) 656-0881 FAX (604) 656-4511

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP — **Our File:** 2437

Sample ID: Tissue Procedural Blank — **Axys ID:** 2437-TBLK 658

Sample Weight: 10.00 g wet — **Date:** November 25, 1992

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.2
2,3,7,8	ND	0.2
P_5CDD - Total	ND	0.3
1,2,3,7,8	ND	0.3
H_6CDD - Total	ND	0.3
1,2,3,4,7,8	ND	0.3
1,2,3,6,7,8	ND	0.3
1,2,3,7,8,9	ND	0.3
H_7CDD - Total	ND	0.6
1,2,3,4,6,7,8	ND	0.6
O_8CDD	ND	0.7

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	ND	0.3
2,3,7,8	ND	0.3
P_5CDF - Total	ND	0.2
1,2,3,7,8	ND	0.2
2,3,4,7,8	ND	0.2
H_6CDF - Total	ND	0.3
1,2,3,4,7,8	ND	0.3
1,2,3,6,7,8	ND	0.3
2,3,4,6,7,8	ND	0.3
1,2,3,7,8,9	ND	0.3
H_7CDF - Total	ND	0.4
1,2,3,4,6,7,8	ND	0.4
1,2,3,4,7,8,9	ND	0.4
O_8CDF	ND	0.5

SDL = Sample Detection Limit
ND = Not detected

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	82
$^{13}C-T_4CDF$:	82
$^{13}C-P_5CDD$:	92
$^{13}C-H_6CDD$:	95
$^{13}C-H_7CDD$:	87
$^{13}C-O_8CDD$:	75

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP **Our File:** 2437

Sample ID: Tissue Procedural Blank **Axys ID:** 2437-TBLK 662

Sample Weight: 13.00 g wet **Date:** November 20, 1992

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.2
2,3,7,8	ND	0.2
P_5CDD - Total	ND	0.6
1,2,3,7,8	ND	0.6
H_6CDD - Total	ND	0.7
1,2,3,4,7,8	ND	0.7
1,2,3,6,7,8	ND	0.7
1,2,3,7,8,9	ND	0.7
H_7CDD - Total	ND	1.6
1,2,3,4,6,7,8	ND	1.6
O_8CDD	ND	2.8

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	ND	0.2
2,3,7,8	ND	0.2
P_5CDF - Total	ND	0.4
1,2,3,7,8	ND	0.4
2,3,4,7,8	ND	0.4
H_6CDF - Total	ND	0.8
1,2,3,4,7,8	ND	0.8
1,2,3,6,7,8	ND	0.8
2,3,4,6,7,8	ND	0.8
1,2,3,7,8,9	ND	0.8
H_7CDF - Total	ND	1.0
1,2,3,4,6,7,8	ND	1.0
1,2,3,4,7,8,9	ND	1.0
O_8CDF	ND	2.0

SDL = Sample Detection Limit
ND = Not detected

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	74
$^{13}C-T_4CDF$:	84
$^{13}C-P_5CDD$:	78
$^{13}C-H_6CDD$:	84
$^{13}C-H_7CDD$:	63
$^{13}C-O_8CDD$:	44

Approved by: M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP — **Our File:** 2437

Sample ID: Caddis flies: Grohman Narrows 92/07/19 — **Axys ID:** 2437-19A

Sample Weight: 12.61 g wet — **Date:** November 20, 1992

Dioxins	Concentration pg/g	(SDL)	Furans	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.2	T_4CDF - Total	1.3	0.1
2,3,7,8	ND	0.2	2,3,7,8	0.3	0.1
P_5CDD - Total	ND	0.4	P_5CDF - Total	ND	0.3
1,2,3,7,8	ND	0.4	1,2,3,7,8	ND	0.3
			2,3,4,7,8	ND	0.3
H_6CDD - Total	2.4	0.7			
1,2,3,4,7,8	ND	0.7	H_6CDF - Total	1.5	0.7
1,2,3,6,7,8	ND	0.7	1,2,3,4,7,8	ND	0.7
1,2,3,7,8,9	ND	0.7	1,2,3,6,7,8	ND	0.7
			2,3,4,6,7,8	ND	0.7
H_7CDD - Total	11	1.2	1,2,3,7,8,9	ND	0.7
1,2,3,4,6,7,8	4.4	1.2			
			H_7CDF - Total	ND	1.0
O_8CDD	17	2.7	1,2,3,4,6,7,8	NDR(1.0)	1.0
			1,2,3,4,7,8,9	ND	1.0
			O_8CDF	ND	2.8

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
^{13}C-T_4CDD:	66
^{13}C-T_4CDF:	70
^{13}C-P_5CDD:	69
^{13}C-H_6CDD:	76
^{13}C-H_7CDD:	49
^{13}C-O_8CDD:	25

Approved by:
M. Coreen Hamilton
A. Dale Hoover

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ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP

Our File: 2437

Sample ID: Caddis flies: Grohman Narrows 92/07/19 Duplicate

Axys ID: 2437-19B

Sample Weight: 13.36 g wet

Date: November 20, 1992

Dioxins	Concentration pg/g	(SDL)	Furans	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.2	T_4CDF - Total	1.4	0.1
2,3,7,8	ND	0.2	2,3,7,8	0.3	0.1
P_5CDD - Total	ND	0.6	P_5CDF - Total	ND	0.4
1,2,3,7,8	ND	0.6	1,2,3,7,8	ND	0.4
			2,3,4,7,8	ND	0.4
H_6CDD - Total	3.3	1.2			
1,2,3,4,7,8	ND	1.2	H_6CDF - Total	1.5	0.7
1,2,3,6,7,8	ND	1.2	1,2,3,4,7,8	ND	0.7
1,2,3,7,8,9	ND	1.2	1,2,3,6,7,8	ND	0.7
			2,3,4,6,7,8	ND	0.7
H_7CDD - Total	11	1.9	1,2,3,7,8,9	ND	0.7
1,2,3,4,6,7,8	4.1	1.9			
			H_7CDF - Total	ND	1.4
O_8CDD	30	4.4	1,2,3,4,6,7,8	NDR(2.2)	1.4
			1,2,3,4,7,8,9	ND	1.4
			O_8CDF	ND	2.7

SDL = Sample Detection Limit
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	63
$^{13}C-T_4CDF$:	63
$^{13}C-P_5CDD$:	55
$^{13}C-H_6CDD$:	61
$^{13}C-H_7CDD$:	38
$^{13}C-O_8CDD$:	21

Approved by: MCHamilton

M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP

Our File: 2437

Sample ID: Macrophytes: Celgar Periphyton Stn. 92/07/18

Axys ID: 2437-15

Sample Weight: 11.87 g wet

Date: November 20, 1992

Dioxins	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.2
2,3,7,8	ND	0.2
P_5CDD - Total	ND	0.5
1,2,3,7,8	ND	0.5
H_6CDD - Total	ND	0.9
1,2,3,4,7,8	ND	0.9
1,2,3,6,7,8	ND	0.9
1,2,3,7,8,9	ND	0.9
H_7CDD - Total	ND	2.3
1,2,3,4,6,7,8	ND	2.3
O_8CDD	ND	4.9

Furans	Concentration pg/g	(SDL)
T_4CDF - Total	ND	0.1
2,3,7,8	ND	0.1
P_5CDF - Total	ND	0.3
1,2,3,7,8	ND	0.3
2,3,4,7,8	ND	0.3
H_6CDF - Total	ND	0.8
1,2,3,4,7,8	ND	0.8
1,2,3,6,7,8	ND	0.8
2,3,4,6,7,8	ND	0.8
1,2,3,7,8,9	ND	0.8
H_7CDF - Total	ND	1.7
1,2,3,4,6,7,8	ND	1.7
1,2,3,4,7,8,9	ND	1.7
O_8CDF	ND	2.8

SDL = Sample Detection Limit
ND = Not Detected

Surrogate Standard Recovery	(%)
^{13}C-T_4CDD:	56
^{13}C-T_4CDF:	57
^{13}C-P_5CDD:	49
^{13}C-H_6CDD:	88
^{13}C-H_7CDD:	49
^{13}C-O_8CDD:	22

Approved by: M.C.Hamilton

M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

HIGH RESOLUTION GC/MS

Client: CRIEMP | Our File: 2437

Sample ID: Macrophytes: Waneta Bay across from Cominco Gravel Pit 92/07/14 composite A & B | Axys ID: 2437-18

Sample Weight: 13.74 g wet | Date: November 20, 1992

Dioxins	Concentration pg/g	(SDL)	Furans	Concentration pg/g	(SDL)
T_4CDD - Total	ND	0.1	T_4CDF - Total	ND	0.1
2,3,7,8	ND	0.1	2,3,7,8	ND	0.1
P_5CDD - Total	ND	0.2	P_5CDF - Total	ND	0.2
1,2,3,7,8	ND	0.2	1,2,3,7,8	ND	0.2
			2,3,4,7,8	ND	0.2
H_6CDD - Total	ND	0.4			
1,2,3,4,7,8	ND	0.4	H_6CDF - Total	ND	0.3
1,2,3,6,7,8	ND	0.4	1,2,3,4,7,8	ND	0.3
1,2,3,7,8,9	ND	0.4	1,2,3,6,7,8	ND	0.3
			2,3,4,6,7,8	ND	0.3
H_7CDD - Total	ND	0.8	1,2,3,7,8,9	ND	0.3
1,2,3,4,6,7,8	ND	0.8			
			H_7CDF - Total	ND	0.6
O_8CDD	ND	1.6	1,2,3,4,6,7,8	ND	0.6
			1,2,3,4,7,8,9	ND	0.6
			O_8CDF	ND	0.9

SDL = Sample Detection Limit
ND = Not Detected

Surrogate Standard Recovery	(%)
$^{13}C-T_4CDD$:	78
$^{13}C-T_4CDF$:	76
$^{13}C-P_5CDD$:	75
$^{13}C-H_6CDD$:	95
$^{13}C-H_7CDD$:	73
$^{13}C-O_8CDD$:	53

Approved by: M Hamilton

M. Coreen Hamilton
A. Dale Hoover

Appendix 6-3

Data for Other Organic Compounds in Biota

RECEIVED OCT - 6 1992

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
September 8, 1992

(concentration in ng/g)

Sample ID:	2437-02	2437-04	2437-05
Sample Type:	Clams Glade Organics 92/07/17	Clams Waneta Organics 92/08/14	Clams Celgar Organics Periphyton Stn. July 8/92
Sample Weight:	9.62 g wet	10.08 g wet	10.22 g wet
4-chlorophenol	ND (0.3)	ND (0.1)	ND (0.5)
2,6-dichlorophenol	ND (0.2)	ND (0.4)	ND (0.2)
2,4/2,5-DCP	ND (0.09)	ND (0.07)	ND (0.1)
3,5-dichlorophenol	ND (0.08)	ND (0.07)	ND (0.1)
2,3-dichlorophenol	ND (0.09)	ND (0.07)	ND (0.1)
3,4-dichlorophenol	ND (0.06)	ND (0.05)	ND (0.09)
6-chloroguaiacol	ND (0.1)	ND (0.1)	ND (0.2)
4-chloroguaiacol	ND (0.2)	ND (0.2)	ND (0.3)
5-chloroguaiacol	ND (0.2)	ND (0.1)	ND (0.3)
2,4,6-trichlorophenol	ND (0.2)	ND (0.1)	ND (0.2)
2,3,6-trichlorophenol	ND (0.2)	ND (0.1)	ND (0.2)
2,3,5-trichlorophenol	ND (0.1)	ND (0.09)	ND (0.2)
2,4,5-trichlorophenol	ND (0.1)	ND (0.1)	ND (0.1)
2,3,4-trichlorophenol	ND (0.2)	ND (0.1)	ND (0.2)
3,4,5-trichlorophenol	ND (0.1)	ND (0.1)	ND (0.1)
3-chlorocatechol	ND (0.2)	ND (0.1)	ND (0.2)
4-chlorocatechol	ND (0.2)	ND (0.1)	ND (0.2)
3,4-dichloroguaiacol	ND (0.3)	ND (0.2)	ND (0.4)
4,6-dichloroguaiacol	ND (0.3)	ND (0.2)	ND (0.4)
4,5-dichloroguaiacol	ND (0.3)	ND (0.2)	ND (0.3)
3-chlorosyringol	ND (0.4)	ND (0.4)	ND (0.5)
3,4-dichlorocatechol	ND (0.2)	ND (0.2)	ND (0.2)
3,6-dichlorocatechol	ND (0.2)	ND (0.2)	ND (0.2)
3,5-dichlorocatechol	ND (0.2)	ND (0.2)	ND (0.2)
4,5-dichlorocatechol	ND (0.3)	ND (0.2)	ND (0.2)
2,3,5,6-tetrachlorophenol	ND (0.2)	ND (0.3)	ND (0.3)
2,3,4,6-tetrachlorophenol	0.7 (0.3)	ND (0.4)	ND (0.4)
2,3,4,5-tetrachlorophenol	ND (0.2)	ND (0.2)	ND (0.2)
5-chlorovanillin	ND (0.6)	ND (0.4)	ND (0.5)
6-chlorovanillin	ND (0.5)	ND (0.4)	ND (0.4)
3,5-dichlorosyringol	ND (0.6)	ND (0.5)	ND (0.5)
3,4,5-trichloroguaiacol	ND (0.2)	ND (0.2)	ND (0.2)
4,5,6-trichloroguaiacol	ND (0.1)	ND (0.1)	ND (0.1)
5,6-dichlorovanillin	ND (0.3)	ND (0.3)	ND (0.3)
pentachlorophenol	0.3 (0.2)	ND (0.2)	ND (0.2)
3,4,5-trichlorocatechol	ND (0.2)	ND (0.2)	ND (0.2)
3,4,5,6-tetrachloroguaiacol	ND (0.2)	ND (0.2)	ND (0.2)
3,4,5-trichlorosyringol	ND (0.2)	ND (0.2)	ND (0.2)
3,4,5,6-tetrachlorocatechol	ND (0.1)	ND (0.1)	ND (0.09)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
August 28, 1992

(concentration in ng/g)

Sample ID:	2437-08	2437-10
Sample Type:	Caddisfly Celgar Organics July 17/92	Caddisfly Glade Organics July 17/92
Sample Weight:	9.80 g wet	9.85 g wet
4-chlorophenol	ND (0.3)	ND (0.9)
2,6-dichlorophenol	ND (0.3)	ND (0.2)
2,4/2,5-DCP	ND (0.5)	ND (0.7)
3,5-dichlorophenol	ND (0.2)	ND (0.1)
2,3-dichlorophenol	ND (0.2)	ND (0.1)
3,4-dichlorophenol	ND (0.2)	ND (0.1)
6-chloroguaiacol	ND (0.5)	ND (0.3)
4-chloroguaiacol	ND (0.7)	ND (0.5)
5-chloroguaiacol	ND (0.6)	ND (0.4)
2,4,6-trichlorophenol	0.4 (0.2)	ND (0.2)
2,3,6-trichlorophenol	ND (0.3)	ND (0.2)
2,3,5-trichlorophenol	ND (0.2)	ND (0.3)
2,4,5-trichlorophenol	ND (0.2)	ND (0.1)
2,3,4-trichlorophenol	ND (0.2)	ND (0.2)
3,4,5-trichlorophenol	ND (0.2)	ND (0.1)
3-chlorocatechol	ND (0.5)	ND (0.3)
4-chlorocatechol	ND (0.5)	ND (0.3)
3,4-dichloroguaiacol	ND (0.4)	ND (0.4)
4,6-dichloroguaiacol	ND (0.4)	ND (0.4)
4,5-dichloroguaiacol	ND (0.3)	ND (0.3)
3-chlorosyringol	ND (0.7)	ND (0.5)
3,4-dichlorocatechol	ND (0.4)	ND (0.2)
3,6-dichlorocatechol	ND (0.4)	ND (0.2)
3,5-dichlorocatechol	ND (0.3)	ND (0.2)
4,5-dichlorocatechol	ND (0.4)	ND (0.2)
2,3,5,6-tetrachlorophenol	ND (0.5)	ND (0.3)
2,3,4,6-tetrachlorophenol	ND (0.7)	ND (0.5)
2,3,4,5-tetrachlorophenol	ND (0.3)	ND (0.2)
5-chlorovanillin	ND (1.0)	ND (0.6)
6-chlorovanillin	ND (1.0)	ND (0.5)
3,5-dichlorosyringol	ND (1.7)	ND (1.0)
3,4,5-trichloroguaiacol	ND (0.3)	ND (0.1)
4,5,6-trichloroguaiacol	ND (0.3)	ND (0.1)
5,6-dichlorovanillin	ND (0.8)	ND (0.3)
pentachlorophenol	1.1 (0.5)	2.4 (0.2)
3,4,5-trichlorocatechol	ND (0.4)	ND (0.1)
3,4,5,6-tetrachloroguaiacol	ND (0.4)	ND (0.1)
3,4,5-trichlorosyringol	ND (0.6)	ND (0.2)
3,4,5,6-tetrachlorocatechol	ND (0.3)	ND (0.1)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
August 28, 1992

(concentration in ng/g)

Sample ID:	2437-11	2437-12A	2437-12B
Sample Type:	Caddisfly Waneta 92/08/15	Caddisfly Kootenay River Env. Canada Sample	Duplicate
Sample Weight:	9.80 g wet	9.61 g wet	9.87 g wet
4-chlorophenol	ND (0.6)	ND (0.5)	ND (0.3)
2,6-dichlorophenol	ND (0.5)	ND (0.5)	ND (0.2)
2,4/2,5-DCP	ND (0.6)	0.5 (0.1)	0.4 (0.1)
3,5-dichlorophenol	ND (0.2)	ND (0.1)	ND (0.1)
2,3-dichlorophenol	ND (0.2)	ND (0.1)	ND (0.1)
3,4-dichlorophenol	ND (0.1)	ND (0.08)	ND (0.08)
6-chloroguaiacol	ND (0.5)	ND (0.3)	ND (0.3)
4-chloroguaiacol	ND (0.7)	ND (0.4)	ND (0.4)
5-chloroguaiacol	ND (0.6)	ND (0.3)	ND (0.4)
2,4,6-trichlorophenol	ND (0.2)	ND (0.2)	ND (0.2)
2,3,6-trichlorophenol	ND (0.3)	ND (0.2)	ND (0.2)
2,3,5-trichlorophenol	ND (0.3)	ND (0.3)	ND (0.1)
2,4,5-trichlorophenol	ND (0.2)	ND (0.1)	ND (0.1)
2,3,4-trichlorophenol	ND (0.2)	ND (0.2)	ND (0.2)
3,4,5-trichlorophenol	ND (0.2)	ND (0.1)	ND (0.1)
3-chlorocatechol	ND (0.4)	ND (0.3)	ND (0.3)
4-chlorocatechol	ND (0.4)	ND (0.3)	ND (0.3)
3,4-dichloroguaiacol	ND (0.6)	ND (0.3)	ND (0.4)
4,6-dichloroguaiacol	ND (0.6)	ND (0.6)	ND (0.3)
4,5-dichloroguaiacol	ND (0.4)	ND (0.3)	ND (0.3)
3-chlorosyringol	ND (0.7)	ND (0.5)	ND (0.5)
3,4-dichlorocatechol	ND (0.3)	ND (0.2)	ND (0.2)
3,6-dichlorocatechol	ND (0.3)	ND (0.2)	ND (0.2)
3,5-dichlorocatechol	ND (0.3)	ND (0.2)	ND (0.2)
4,5-dichlorocatechol	ND (0.3)	ND (0.3)	ND (0.2)
2,3,5,6-tetrachlorophenol	ND (0.4)	ND (0.4)	ND (0.3)
2,3,4,6-tetrachlorophenol	ND (0.5)	ND (0.5)	ND (0.4)
2,3,4,5-tetrachlorophenol	ND (0.3)	ND (0.2)	ND (0.2)
5-chlorovanillin	ND (0.8)	ND (0.7)	ND (0.5)
6-chlorovanillin	ND (0.8)	ND (0.6)	ND (0.4)
3,5-dichlorosyringol	ND (1.6)	ND (1.2)	ND (1.0)
3,4,5-trichloroguaiacol	ND (0.3)	ND (0.2)	ND (0.2)
4,5,6-trichloroguaiacol	ND (0.2)	ND (0.2)	ND (0.2)
5,6-dichlorovanillin	ND (0.6)	ND (0.4)	ND (0.4)
pentachlorophenol	7.4 (0.4)	2.6 (0.3)	2.5 (0.3)
3,4,5-trichlorocatechol	ND (0.3)	ND (0.2)	ND (0.2)
3,4,5,6-tetrachloroguaiacol	ND (0.3)	ND (0.2)	ND (0.2)
3,4,5-trichlorosyringol	ND (0.5)	ND (0.3)	ND (0.3)
3,4,5,6-tetrachlorocatechol	ND (0.2)	ND (0.2)	ND (0.2)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
August 28, 1992

(concentration in ng/g)

Sample ID:	2437-13	2437-19
Sample Type:	Caddisfly Waneta Env. Canada Sample	Caddisfly Grohman Narrows Organics July 19/92
Sample Weight:	9.48 g wet	9.20 g wet
4-chlorophenol	NDR(0.6) (0.4)	ND (0.8)
2,6-dichlorophenol	ND (0.2)	ND (0.3)
2,4/2,5-DCP	ND (0.2)	NDR(0.6) (0.2)
3,5-dichlorophenol	ND (0.2)	ND (0.2)
2,3-dichlorophenol	ND (0.2)	ND (0.2)
3,4-dichlorophenol	ND (0.1)	ND (0.1)
6-chloroguaiacol	ND (0.5)	ND (0.5)
4-chloroguaiacol	ND (0.7)	NDR(0.9) (0.7)
5-chloroguaiacol	ND (0.6)	ND (0.6)
2,4,6-trichlorophenol	ND (0.2)	ND (0.3)
2,3,6-trichlorophenol	ND (0.2)	ND (0.3)
2,3,5-trichlorophenol	ND (0.3)	ND (0.2)
2,4,5-trichlorophenol	ND (0.1)	ND (0.2)
2,3,4-trichlorophenol	ND (0.2)	ND (0.2)
3,4,5-trichlorophenol	ND (0.1)	ND (0.2)
3-chlorocatechol	ND (3.4)	ND (0.4)
4-chlorocatechol	ND (0.3)	ND (0.4)
3,4-dichloroguaiacol	ND (0.4)	ND (0.6)
4,6-dichloroguaiacol	ND (0.4)	ND (0.6)
4,5-dichloroguaiacol	ND (0.3)	ND (0.4)
3-chlorosyringol	ND (0.5)	ND (0.7)
3,4-dichlorocatechol	ND (0.2)	ND (0.3)
3,6-dichlorocatechol	ND (0.2)	ND (0.3)
3,5-dichlorocatechol	ND (0.2)	ND (0.3)
4,5-dichlorocatechol	ND (0.2)	ND (0.3)
2,3,5,6-tetrachlorophenol	ND (0.3)	ND (0.4)
2,3,4,6-tetrachlorophenol	0.5 (0.4)	ND (0.5)
2,3,4,5-tetrachlorophenol	ND (0.2)	ND (0.2)
5-chlorovanillin	ND (0.6)	ND (0.8)
6-chlorovanillin	ND (0.5)	ND (0.7)
3,5-dichlorosyringol	ND (1.0)	ND (1.6)
3,4,5-trichloroguaiacol	ND (0.2)	ND (0.3)
4,5,6-trichloroguaiacol	ND (0.1)	ND (0.2)
5,6-dichlorovanillin	ND (0.3)	ND (0.6)
pentachlorophenol	6.5 (0.2)	4.2 (0.4)
3,4,5-trichlorocatechol	ND (0.2)	ND (0.3)
3,4,5,6-tetrachloroguaiacol	ND (0.2)	ND (0.3)
3,4,5-trichlorosyringol	ND (0.3)	ND (0.5)
3,4,5,6-tetrachlorocatechol	ND (0.1)	ND (0.2)

Detection limits are given in brackets
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
September 8, 1992

(concentration in ng/g)

Sample ID:	2437-15A	2437-15B	2437-18
Sample Type:	Macrophyte (A) Celgar Periphyton Stn. July 18/92	Duplicate	Macrophyte Comp. Wanita AB 92/07/14
Sample Weight:	9.64 g wet	9.57 g wet	9.40 g wet
4-chlorophenol	ND (5.6)	ND (1.8)	ND (0.6)
2,6-dichlorophenol	ND (0.6)	ND (0.4)	ND (0.2)
2,4/2,5-DCP	ND (0.3)	ND (0.3)	ND (0.1)
3,5-dichlorophenol	ND (0.3)	ND (0.3)	ND (0.09)
2,3-dichlorophenol	ND (0.3)	ND (0.3)	ND (0.1)
3,4-dichlorophenol	ND (0.2)	ND (0.2)	ND (0.07)
6-chloroguaiacol	ND (0.4)	ND (0.5)	ND (0.2)
4-chloroguaiacol	ND (0.7)	ND (0.8)	ND (0.2)
5-chloroguaiacol	ND (0.5)	ND (0.6)	ND (0.2)
2,4,6-trichlorophenol	ND (0.5)	ND (0.5)	ND (0.2)
2,3,6-trichlorophenol	ND (0.5)	ND (0.6)	ND (0.2)
2,3,5-trichlorophenol	ND (0.3)	ND (0.4)	ND (0.1)
2,4,5-trichlorophenol	ND (0.4)	ND (0.3)	ND (0.2)
2,3,4-trichlorophenol	ND (0.4)	ND (0.4)	ND (0.2)
3,4,5-trichlorophenol	ND (0.4)	ND (0.3)	ND (0.2)
3-chlorocatechol	ND (0.5)	ND (0.4)	ND (0.2)
4-chlorocatechol	ND (0.5)	ND (0.5)	ND (0.2)
3,4-dichloroguaiacol	ND (1.0)	ND (0.9)	ND (0.4)
4,6-dichloroguaiacol	ND (1.0)	ND (0.9)	ND (0.4)
4,5-dichloroguaiacol	ND (1.2)	ND (0.8)	ND (0.3)
3-chlorosyringol	ND (1.3)	ND (1.2)	ND (0.6)
3,4-dichlorocatechol	ND (0.7)	ND (0.5)	ND (0.3)
3,6-dichlorocatechol	ND (0.7)	ND (0.5)	ND (0.3)
3,5-dichlorocatechol	ND (0.6)	ND (0.4)	ND (0.3)
4,5-dichlorocatechol	ND (0.7)	ND (0.5)	ND (0.3)
2,3,5,6-tetrachlorophenol	ND (0.8)	ND (0.6)	ND (0.3)
2,3,4,6-tetrachlorophenol	ND (1.1)	ND (0.8)	ND (0.5)
2,3,4,5-tetrachlorophenol	ND (0.6)	ND (0.4)	ND (0.2)
5-chlorovanillin	ND (1.2)	ND (0.9)	ND (0.5)
6-chlorovanillin	ND (1.1)	ND (0.8)	ND (0.5)
3,5-dichlorosyringol	ND (1.6)	ND (1.2)	ND (0.7)
3,4,5-trichloroguaiacol	ND (0.7)	ND (0.4)	ND (0.3)
4,5,6-trichloroguaiacol	ND (0.3)	ND (0.3)	ND (0.2)
5,6-dichlorovanillin	ND (0.7)	ND (0.8)	ND (0.5)
pentachlorophenol	ND (0.5)	ND (0.5)	ND (0.3)
3,4,5-trichlorocatechol	ND (0.5)	ND (0.5)	ND (0.3)
3,4,5,6-tetrachloroguaiacol	ND (0.5)	ND (0.5)	ND (0.3)
3,4,5-trichlorosyringol	ND (0.6)	ND (0.6)	ND (0.4)
3,4,5,6-tetrachlorocatechol	ND (0.3)	ND (0.3)	ND (0.2)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
August 28, 1992

(concentration in ng/g)

Sample ID: 2437-TBlk 178
Sample Type: Procedural Blank
Sample Weight: 10.0 g

4-chlorophenol	ND (0.5)
2,6-dichlorophenol	ND (0.3)
2,4/2,5-DCP	ND (0.3)
3,5-dichlorophenol	ND (0.3)
2,3-dichlorophenol	ND (0.3)
3,4-dichlorophenol	ND (0.2)
6-chloroguaiacol	ND (0.6)
4-chloroguaiacol	ND (0.9)
5-chloroguaiacol	ND (0.8)
2,4,6-trichlorophenol	ND (0.2)
2,3,6-trichlorophenol	ND (0.3)
2,3,5-trichlorophenol	ND (0.5)
2,4,5-trichlorophenol	ND (0.2)
2,3,4-trichlorophenol	ND (0.2)
3,4,5-trichlorophenol	ND (0.2)
3-chlorocatechol	ND (0.4)
4-chlorocatechol	ND (0.4)
3,4-dichloroguaiacol	ND (0.5)
4,6-dichloroguaiacol	ND (0.5)
4,5-dichloroguaiacol	ND (0.4)
3-chlorosyringol	ND (0.6)
3,4-dichlorocatechol	ND (0.3)
3,6-dichlorocatechol	ND (0.2)
3,5-dichlorocatechol	ND (0.2)
4,5-dichlorocatechol	ND (0.2)
2,3,5,6-tetrachlorophenol	ND (0.3)
2,3,4,6-tetrachlorophenol	ND (0.1)
2,3,4,5-tetrachlorophenol	ND (0.2)
5-chlorovanillin	ND (0.6)
6-chlorovanillin	ND (0.6)
3,5-dichlorosyringol	ND (1.0)
3,4,5-trichloroguaiacol	ND (0.2)
4,5,6-trichloroguaiacol	ND (0.1)
5,6-dichlorovanillin	ND (0.4)
pentachlorophenol	ND (0.2)
3,4,5-trichlorocatechol	ND (0.2)
3,4,5,6-tetrachloroguaiacol	ND (0.2)
3,4,5-trichlorosyringol	ND (0.3)
3,4,5,6-tetrachlorocatechol	ND (0.1)

Detection limits are given in brackets
ND = Not Detected
NDR = Peak detected but did not meet quantification criteria

Approved by: Dale Hoover
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: CRIEMP

Our File: 2437
September 8, 1992

(concentration in ng/g)

Sample ID:	2437-TBlk 180
Sample Type:	Procedural Blank
Sample Weight:	10.0 g
4-chlorophenol	ND (0.2)
2,6-dichlorophenol	0.2 (0.1)
2,4/2,5-DCP	ND (0.1)
3,5-dichlorophenol	ND (0.1)
2,3-dichlorophenol	ND (0.1)
3,4-dichlorophenol	ND (0.08)
6-chloroguaiacol	ND (0.2)
4-chloroguaiacol	ND (0.3)
5-chloroguaiacol	ND (0.2)
2,4,6-trichlorophenol	ND (0.2)
2,3,6-trichlorophenol	ND (0.2)
2,3,5-trichlorophenol	ND (0.2)
2,4,5-trichlorophenol	ND (0.2)
2,3,4-trichlorophenol	ND (0.2)
3,4,5-trichlorophenol	ND (0.2)
3-chlorocatechol	ND (0.2)
4-chlorocatechol	ND (0.2)
3,4-dichloroguaiacol	ND (0.4)
4,6-dichloroguaiacol	ND (0.4)
4,5-dichloroguaiacol	ND (0.4)
3-chlorosyringol	ND (0.6)
3,4-dichlorocatechol	ND (0.3)
3,6-dichlorocatechol	ND (0.3)
3,5-dichlorocatechol	ND (0.3)
4,5-dichlorocatechol	ND (0.3)
2,3,5,6-tetrachlorophenol	ND (0.4)
2,3,4,6-tetrachlorophenol	ND (0.5)
2,3,4,5-tetrachlorophenol	ND (0.2)
5-chlorovanillin	ND (0.6)
6-chlorovanillin	ND (0.5)
3,5-dichlorosyringol	ND (0.7)
3,4,5-trichloroguaiacol	ND (0.3)
4,5,6-trichloroguaiacol	ND (0.2)
5,6-dichlorovanillin	ND (0.4)
pentachlorophenol	ND (0.1)
3,4,5-trichlorocatechol	ND (0.3)
3,4,5,6-tetrachloroguaiacol	ND (0.2)
3,4,5-trichlorosyringol	ND (0.3)
3,4,5,6-tetrachlorocatechol	ND (0.1)

Detection limits are given in brackets
ND = Not Detected

Approved by: Dale Hoover
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: City of Castlegar/Norecol

Our File: 2437
September 22, 1992

(concentration in ng/g)

Sample I.D.	2437-08	2437-10	2437-11
Sample Type:	Caddisfly Celgar Organics July 17/92	Caddisfly Glade Organics July 17/92	Caddisfly Waneta 92/08/15
Sample Weight:	10.10 g wet	10.05 g wet	10.08 g wet
4,5-dichloroveratrole	ND (0.5)	ND (0.9)	ND (0.3)
3,4,6-trichloroveratrole	ND (0.3)	ND (0.6)	ND (0.4)
3,4,5-trichloroveratrole	ND (0.3)	ND (0.6)	ND (0.4)
3,4,5,6-tetrachloroveratrole	ND (0.4)	ND (0.8)	ND (0.6)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

AXYS ANALYTICAL SERVICES LTD P.O. BOX 2219, 2045 MILLS RD., SIDNEY, B.C., CANADA V8L 3S8 TEL (604) 656-0881 FAX (604) 656-4511

ANALYSIS REPORT

Client: City of Castlegar/Norecol

Our File: 2437
September 22, 1992

(concentration in ng/g)

Sample I.D.	2437-12A	2437-12B
Sample Type:	Caddisfly Kooteney River Env. Canada July 16, 1992	Duplicate
Sample Weight:	10.79 g wet	10.19 g wet
4,5-dichloroveratrole	ND (0.5)	ND (0.3)
3,4,6-trichloroveratrole	ND (0.5)	ND (0.4)
3,4,5-trichloroveratrole	ND (0.5)	ND (0.4)
3,4,5,6-tetrachloroveratrole	ND (0.6)	ND (0.6)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover

ANALYSIS REPORT

Client: City of Castlegar/Norecol

Our File: 2437
September 22, 1992

(concentration in ng/g)

Sample I.D.	2437-13	2437-19
Sample Type:	Caddisfly Waneta Env. Canada July 15, 1992	Caddisfly Organics Grohman Narrows July 19, 1992
Sample Weight:	10.23 g wet	10.42 g wet
4,5-dichloroveratrole	ND (0.5)	ND (0.5)
3,4,6-trichloroveratrole	ND (0.4)	ND (0.5)
3,4,5-trichloroveratrole	ND (0.4)	ND (0.5)
3,4,5,6-tetrachloroveratrole	ND (0.5)	ND (0.7)

Detection limits are given in brackets
ND = Not Detected

Approved by: [signature]
M. Coreen Hamilton
A. Dale Hoover