COLUMBIA RIVER INTEGRATED ENVIRONMENTAL MONITORING PROGRAM 1991-93, (CRIEMP 1991-93) DESIGN DOCUMENT

January 8, 1993

W.T. Baturin
CRIEMP Coordinator

COLUMBIA RIVER INTEGRATED ENVIRONMENTAL MONITORING PROGRAM 1991-93, (CRIEMP 1991-93) DESIGN DOCUMENT

January 8, 1993

W.T. Baturin
CRIEMP Coordinator

TABLE OF CONTENTS

1 INTRODUCTION

1.1 OVERVIEW

Environmental data on the lower Columbia River in Canada, from the Hugh Keenleyside Dam to the international boundary, have been collected over the years by a number of different groups. Generally there has been a limited sharing of this information except on an ad hoc basis. As a result of interests in better coordinating the increasing monitoring requirements the lower Columbia River a committee comprised of industries (Cominco Ltd.; Celgar Pulp Co.; and B.C. Hydro) and government (BC Environment, Lands and Parks) was formed in the fall of 1989 to discuss the integration of programs. Since then Environment Canada, the Department of Fisheries and Oceans and two municipalities (the Cities of Castlegar and Trail) have joined what is now established as a formal coordinating committee to coordinate monitoring and assessment programs on the lower Columbia River. This cooperation lead to the Columbia River Integrated Environmental Monitoring Program (CRIEMP). The cost of the initial monitoring program is estimated at $1 M and will extend from September 1991 to the end of March 1993.

1.2 OBJECTIVES

The primary objective of this program is to collect and share environmental information on the lower Columbia River. The data gathered during this program may be used by the participants for:

* assessing the environmental quality of the lower Columbia River;
* assessing the impacts of industrial, hydroelectric, and municipal facilities including both existing and proposed;
* developing environmental quality objectives; and
* assessing future environmental monitoring needs.

1.3 PROGRAM MANAGEMENT AND COORDINATION

This program is being managed by the Columbia River Integrated Environmental Monitoring Program (CRIEMP) Coordinating Committee. This technical committee is represented by Cominco Ltd.; Celgar Pulp Co.; B.C. Hydro; BC Environment, Lands and Parks - Water Quality Branch; BC Environment, Lands and Parks - Environmental Protection Branch; Environment Canada; Department of Fisheries and Oceans; City of Trail; and City of Castlegar.

This committee is responsible for the design, planning, and implementation of this monitoring program under CRIEMP. They meet on a regular basis to discuss program strategies and selection of alternative studies.

A coordinator, contracted by CRIEMP, monitors the CRIEMP 1991-93 program progress, coordinates monitoring schedules, prepare requests for contract proposals and reports as directed by the Committee, prepares budgets, and coordinates the financial administration of the projects.

2 CRIEMP PARTICIPANTS AND MONITORING OBJECTIVES

2.1 CRIEMP 1991-93 MONITORING OBJECTIVES

CRIEMP 1991-93 is the first monitoring program being implemented by CRIEMP. In addition to overall objectives of CRIEMP (as presented in section 1.2), the following are specific objectives for CRIEMP 1991-93.

* to assess the cumulative effects of Celgar, Cominco, municipalities, and other sources of pollutants.

* to provide statistically valid and quality assured data for a trend analysis on toxic organics from Celgar's pulp mill.

* to identify sentinel species for trend assessment of bioaccumulation of toxic compounds.

* to provide information on the contamination of non-migratory fish species.

The sampling program is integrated within four river reaches (see Section 3) and includes an extension of existing monitoring sites within some of the reaches (i.e.. the Federal/Provincial water quality monitoring sites at Birchbank and Waneta). Monitoring of fish has been incorporated to address the human health concerns through consumption. Other components of the fish study will include assessment of the distribution and abundance of fish, their habitat, and a fish health study. The bioreconnaissance study will investigate biological indicators and bed sediment sampling strategies for use as monitoring tools.

2.2 COMINCO LTD.

Cominco Ltd. operates an integrated metallurgical and fertilizer complex that produces lead, zinc, minor metals as well as sulphur dioxide, sulphuric acid, ammonium sulfate and ammonium phosphate fertilizers. Ongoing modernization is designed to reduce metal discharges and increase production. For their permit, Cominco is currently required to

monitor their effluent discharges and Columbia River water quality. This monitoring includes dissolved metals, total metals, and nutrients, and other parameters both in the effluents and at river stations upstream and downstream of the plant. Data collected through CRIEMP and supported by Cominco replaces and complements Cominco data and that collected at the federal and provincial water quality monitoring sites along the river by introducing more sampling, additional parameters and information on sediment and biota.

2.3 CELGAR PULP COMPANY

Celgar Pulp Co. operates a bleached kraft pulp mill. The current expansion and modernization of the mill is expected to reduce discharges to the river. Celgar is required to extensively monitor their effluent discharges and the receiving environment. As recommended by the Celgar Expansion Review Panel, the receiving environment monitoring includes local and downstream water quality, biological, and sediment quality. Celgar's participation in CRIEMP allows this data to be collected in a more cost effective and efficient manner.

2.4 B.C. HYDRO

B.C. Hydro currently operates a number of hydroelectric projects on the Columbia River. Environmental Impact assessment for future developments will require information on baseline water quality , fish movement, fish habitat, fish health, and sediment quality.

2.5 BCELP - WATER QUALITY BRANCH

The mandate of the Water Quality Branch is to protect water quality and sustain the water uses including aquatic life. The Water Quality Branch develops water quality criteria (safe levels of substances) and water quality objectives (criteria applied to specific water bodies). Water quality objectives are being developed for the Columbia River. The river has been divided into two reaches for this purpose: Keenleyside Dam to Birchbank and Birchbank to the international boundary. The first draft of the objectives document has been completed for the upper section and work on the lower section has begun. This will be a joint Federal/ Provincial project. Data gathered from the CRIEMP monitoring program will assist in the formalization of water quality objectives. Monitoring requirements include total water quality as well as monitoring of fish and sediments.

2.6 BCELP - ENVIRONMENTAL PROTECTION BRANCH

BCELP, Environmental Protection Branch has the responsibility of monitoring the compliance of discharge permits and ensuring the receiving environment is adequately protected. CRIEMP will provide information on water, fish, sediment, and biota to allow better assessment of existing impacts and provide baseline information to allow monitoring of expected improvements.

2.7 ENVIRONMENT CANADA

The goals of Environment Canada are to improve the understanding of the existing conditions with respect to environmental quality and to participate in the development of water quality (ecosystem) objectives in the lower Columbia River. Proposed and ongoing projects which are complimentary to the CRIEMP monitoring are: joint funding with the province of two water quality monitoring stations (under the Canada-British Columbia Water Quality Monitoring Agreement), and a study of dioxins, furans, and metals in suspended solids, sediments, water, and fish. As well a radionuclide study on ambient water, above and below Cominco, has been undertaken.

2.8 DEPARTMENT OF FISHERIES AND OCEANS

The Department of Fisheries and Oceans is undertaking a proposed 6 year fish health study to monitor the health of fish in and around the industrial areas on the river.

2.9 CITY OF TRAIL

With the Columbia River as the future raw water supply for the municipality of Trail there is concern over the present and future water quality of the river as a long term viable drinking water source. The City of Trail, along with Warfield, Rossland, and Rivervale/Oasis, are also major contributors of treated sewage discharged from the Regional District of Kootenay Boundary primary treatment plant. CRIEMP will provide information on impacts of this effluent to the river system.

2.10 CITY OF CASTLEGAR

The City of Castlegar discharges primary and secondary treated sewage into the river and this study will provide information concerning the impact of these discharges.

3 PROGRAM SUMMARIES

3.1 WATER QUALITY

This baseline program is an extensive 13 month study of the ambient water quality from the Keenleyside Dam to the International Boundary. General variables, nutrients, metals/metalloids, AOX, chlorinated organics, resin and fatty acids will be monitored at eight sites, above and below industrial and municipal outfalls. These initial results serve as a reference point for comparison to future gathered data (i.e.. after industrial and municipal modernization projects) to determine changes in the water quality.

3.2 BIOLOGICAL ASSESSMENT

The object of the biological assessment portion of the program is to document the present condition of the aquatic ecosystem. This includes monitoring of community structure (benthic invertebrates, periphyton, and, aquatic macrophtyes), bioaccumulation (walleye, rainbow trout, mountain whitefish, bivalves, and caddis flies), sediment contamination levels, and sediment bioassays.

3.3 FISH ABUNDANCY AND MOVEMENT

Studies will provide CRIEMP with information on fish distribution, population sizes, habitat requirements, and basic life history information. As well, BC Hydro's programs will also provide total gas pressure and dissolved oxygen data.

3.4 FISH HEALTH

The Celgar Expansion Review Panel recommended that the Department of Fisheries and Oceans undertake a research program to include fish and aquatic resources in the lower Columbia River. In 1991 a study was undertaken to assess dioxin and furan body burden, physiological stress response (mixed function oxidase enzyme induction), tissue histology, disease diagnostics, and general physical parameters in mountain whitefish, which serve as a good indicator species for organic contaminants due to their feeding and migratory behaviour. Green Plan funds have been allocated to support another three sampling periods in 1992, 1994, and 1996.

4 CRIEMP DESIGN, DETAILS, AND PROCEDURES

4.1 WATER MONITORING

4.1.1 Preamble

The participants have a variety of requirements and the CRIEMP 1991-93 monitoring program will provide overall cost savings, a common monitoring scheme and data that will be useful to all participants. This study has been broken down into four main components: water, sediment, fish, and non-fish biota monitoring.

The program includes:

* permit holders' sampling requirements for site specific locations. The variables include: general variables, metals and metalloids, adsorbable organic halides, dioxins/furans, chlorophenol compounds, resin and fatty acids, and nutrients;

* the Federal/ Provincial water quality monitoring requirements, plus additional requirements to assist with the Water Quality (Ecosystem) Objectives development;

* B.C. Hydro's sampling requirements, such as, total gas pressure and general water quality; and

* toxic organic and heavy metal survey of sewage treatment plants.

4.1.2 Criemp Monitoring Locations

The lower Columbia River has been divided into four main reaches:

* Reach I - above the Hugh Keenleyside Dam

* Reach II - from the Hugh Keenleyside Dam to the confluence of the Kootenay and Columbia Rivers

* Reach III - from the Kootenay/Columbia confluence to Stoney Creek (just above Cominco)

* Reach IV - from Stoney Creek to the international boundary

The sampling sites chosen to meet the above criteria are shown in Appendix B: Figure 10.1 Water Sampling Site Map and Table 4.1.2.

Table 4.1.2 Stream Reaches and Water Sampling Stations

Reach/Station	Description	Station Number
		SEAM #
Reach II	Columbia River from Hugh Keenleyside Dam to the confluence of the Columbia and Kootenay Rivers	
II-1	100 m below Hugh Keenleyside Dam on east side of Columbia River	0200183
II-2	400 m below the Celgar diffuser outfall in the middle of the Columbia River	E216155
II-4	400 m above the confluence of the Kootenay and Columbia Rivers on the west side of the Columbia River	0200200
Reach III	Columbia River from the confluence of the Kootenay and Columbia Rivers to Stoney Creek above Trail	
III-2	West side of the Columbia River at Birchbank	0200003
Reach IV	Columbia River from Stoney Creek above Trail to the international boundary	
IV-1	1/3 of the way across (from south side) the old Trail bridge	E209100
IV-1A	West Trail side of the old Trail bridge	E216137
IV-1B	East Trail side of the old Trail bridge	E216136
IV-3	400 m above the confluence of the Pend O'reille and Columbia Rivers on the east side of the Columbia River	0200559

4.1.3 Water Monitoring Design

Reach I -

No sites were chosen for the water sampling program in this reach as it is a lake and not a river environment and any interpretation of results would be difficult.

Reach II -

Site II-1 was chosen as a control site because a) it is above any industrial or municipal effluent outfalls and the water has been well mixed as it passes through the Keenleyside Dam and b) this is part of the river environment and not part of the Arrow Lakes environment. This site is monitored every four weeks by boat for general variables, nutrients, resin and fatty acids, chlorophenols and every 8 weeks for general variables, nutrients, resin and fatty acids, chlorophenols, metals and metalloids from September 3/91 to October 27/92. Twice per year, October 1/91 and March 17/92, this site will also be monitored for dioxins and furans.

Site II-2 was originally chosen to be on the west side of the Columbia River downstream of Celgar but due to the Celgar construction and the change in the river current because of this construction a site was chosen in the middle of the Columbia River, 400 meters downstream of the Celgar diffuser plume outfall. This site is monitored every four weeks by boat for general variables, nutrients, resin and fatty acids, chlorophenols and every 8 weeks for general variables, nutrients, resin and fatty acids, chlorophenols, metals and metalloids from September 3/91 to October 27/92. Twice per year, October 1/91 and March 17/92, this site will also be monitored for dioxins and furans.

Site II-4 was chosen because it was downstream of the Castlegar sewage treatment plant but above the Kootenay and Columbia River confluence. This site is monitored every four weeks by boat for general variables, nutrients, resin and fatty acids, and chlorophenols and every 8 weeks for general variables, nutrients, resin and fatty acids, chlorophenols, metals and metalloids from September 3/91 to October 27/92. Twice per year, October 1/91 and March 17/92, this site will also be monitored for dioxins and furans.

Reach III -

Site III-2 at Birchbank was chosen because this is the mixing reach between the Kootenay confluence and Trail and there is an established federal/provincial monitoring station here. This station is monitored every two weeks under the existing Canada-British Columbia Water Quality Monitoring Agreement from shore and every four weeks by boat from September 3/91 to October 27/92 for general variables, nutrients, resin and fatty acids, chlorophenols. Twice per year, October 1/91 and March 17/92, this site will also be monitored for dioxins and furans.

Reach IV -

Site IV-1 was chosen to satisfy the Water Management Branch monitoring requirements for water quality objectives of 5 times in 30 days.

Site IV-1A and *Site* IV-1B are required to be monitored under Cominco's permit with BCELP. They are downstream of Cominco's effluent discharges and will be sampled by boat every four weeks from September 3/91 to October 27/92 for general variables, metals and metalloids.

Site IV-3 is sampled weekly from shore as a Federal/Provincial monitoring station. It is the last monitoring station before the Columbia River crosses the international boundary.

Individual variables and sampling parameters are shown in Table 9.1 through Table 9.8 in Appendix A.

4.1.4 Field Sampling Procedures

There are 2 different sampling procedures that are being used for this water sampling program (Appendix B). The first procedure is shore sampling and this is used every week for 3 weeks at Waneta (Site IV-3) and every other two weeks at Birchbank (Site III-2). The second procedure is boat sampling and this is used every four weeks at all the sites. For station III-2 and IV-3, the protocols for shore sampling are the procedures used by Environment Canada for the routine monitoring. For the remaining stations, the BCELP procedures are used for sampling from shore. Samples collected from the boat followed the respective Environment Canada or BCELP shore sampling with the following steps:

1) Follow the shore sampling procedures except that you must make sure the gas tanks and exhaust have been covered to reduce the chance of gas and oil contaminants and other organic contaminants from the exhaust fumes.

2) Ensure that the boat is facing upstream into the current before sampling.

4.1.4.1 Field Sampling - Field Blanks

Field bottles were prepared as a check on contamination from field sampling or sample transport. The bottles in the field blanks kit have been filled with de-ionized water by Zenon. The treatment and handling of these samples provides us with a check on sources of contamination and error.

1) The samplers will follow all normal CRIEMP sampling procedures with the exception of actually placing the bottles into the water.

2) Remove the bottles containing water from kit, and remove individual caps. Lower uncapped bottles to approximately 1 meter from the river's surface but do not let it come in contact with the river. Add preservatives, if required, recap bottles and

it come in contact with the river. Add preservatives, if required, recap bottles and shake well. Repack kit and send to the laboratory with a completed requisition form.

4.1.5 Analytical Procedures

4.1.5.1 Environment Canada

Samples for most variables collected from Birchbank and Waneta were analysed at Environment Canada Laboratories. Heavy metals are analysed at the National Water Quality Laboratory at Burlington, Ontario according to methods described in Environment Canada (1990b) Water Quality Monitoring Protocols.

4.1.5.2 Zenon Environmental Laboratories

4.1.5.2.1 Methods

Methods used by this laboratory are found in the Part I. 1976 Edition, and Part II. Supplement of "A LABORATORY MANUAL FOR THE CHEMICAL ANALYSIS OF WATERS, WASTEWATERS, SEDIMENTS AND BIOLOGICAL MATERIALS" (1976 Edition Including Updates).

4.1.5.2.2 Sample Bottles and Preservation

Table 4.1.5.2a and Table 4.1.5.2b describe sample bottles and preservation methods used for samples.

Table 4.1.5.2.a Sample Bottles and Preservation used for water samples analysed at Zenon

Variable	Test	Sample Size	Sample Bottle	Preservation
General Variables (GV)	Physical, Anions	2 L	Polyethylene	4 C / 72 hrs.
	Coliform	250 mL	Poly, sterilized	4 C / 48 hrs.
	E. Coli/Enterococcus	250 mL	Poly, sterilized	4 C / 48 hrs.
	Alkalinity	From GV bottle		
	Total Organic Carbon	100 mL	Poly	4 C / 72 hrs.
	Chloroform (CH)	500 mL	Glass	4 C / 14 days
Metals/Metalloids (M)	Metals (Total) + hardness	250 mL	Poly	Field filtered, pH to <2 with HNO3 (4 mL conc. HNO3) / 6 mon.
	Metals (Dissolved)	250 mL	Poly	Field filtered, pH to <2 with HNO3 (4 mL conc. HNO3) / 6 mon.

Table 4.1.5.2.b Sample Bottles and Preservation used for water samples analysed at Zenon

Variable	Test	Sample Size	Sample Bottle	Preservation
Metals/Metalloids (M)	Mercury	1 L	Glass	6 mL 10% $K_2Cr_2O_7$ + 6 mL H_2SO_4 /L (28 days)
AOX (A)	AOX	500 mL	Amber glass, Acid rinsed + baked	pH to <2 with HNO_3 (4 mL conc. HNO_3)
	Chlorate	From GV Bottle		
Resin Acids (R)		1 L	Amber glass (solvent cleaned)	pH to >2 with NaOH (21 days)
Fatty Acids (F)		From resin sample bottle		
Nutrients	Orthophosphorus + Total Diss. P + Total P + Total N + NH_3 + NO_2 + NO_3	From GV sample bottle		

4.1.5.3 AXYS Analytical Services Ltd.

AXYS is performing the Dioxin/Furan, Total Phenolics, Chloroform, and Chlorophenol analyses. Methods used for performing the analyses are described in Appendix C.

4.1.5.4 Analytical Services Laboratories Ltd.

ASL is doing the special low level Mercury analysis, following the methods described in Appendix D.

4.2 BIOLOGICAL AND SEDIMENT SAMPLING

This part of the program was designed by L. McDonald (BCELP) and endorsed by the CRIEMP Committee.

4.2.1 Preamble

The Columbia River, from the Keenleyside Dam to the U.S. border, receives industrial and municipal waste from several sources. Measuring the concentrations of various contaminants in the water at locations along the river is a way to determine these wastes may be causing adverse impacts to aquatic biota. For example, adverse effects are expected if contaminant concentrations exceed scientifically based guidelines. There are a number of reasons to also monitor the biota and sediments:

* Pulses of pollutants can have serious effects on aquatic life in the river. Even frequent water sampling may miss these events. Biological and sediment monitoring integrates the effects of changing waste discharge quality and quantity over time.

* Many pollutants are present in the river in quantities too low to detect in the water but they may bioaccumulate in the tissues of aquatic organisms or preferentially adsorb onto sediment particles. These pollutants may have adverse effects on the organism that bioaccumulates the contaminant or a higher trophic level organism, including humans, that consumes the latter.

* As well as being transported downstream, the various pollutants are diluted, bound up in the river sediments or changed chemically to less harmful forms. Beyond simply determining the presence of a contaminant, biological monitoring can provide important information about the extent of its downstream impact.

Three types of monitoring will be used in this program. These are:

1. Community Structure Survey - involves the identification and quantification of organisms found above and below the various waste discharges. Changes in the types and numbers of organisms at a particular location over time can give an indication of the effects of a waste discharge and, in some cases, how successful newly installed treatment systems have been in reducing impacts. This information also can be used to describe or inventory an aquatic ecosystem and provide an understanding of how biologically productive it is.

2. Bioaccumulation Sampling - A few sentinel species will be tested for a variety of contaminants to determine the extent of downstream effects and the efficacy of waste treatment over time. These species must be ubiquitous or found commonly throughout the river system and preferably spend most or all of their life cycle in one location in the river. The sentinel species to be monitored include some fish as well as invertebrates. Fish that are consumed by the public will also be monitored to address the second objective above.

3. Sediment Contaminant and Toxicity Sampling - sediment analysis will also be done to determine the extent of downstream accumulation of various pollutants. Because of the necessity of finding sufficient fine sediment for analysis it will not be possible to sample randomly but rather accessible zones of fine sediment deposition will be

sampled. Re-sampling permanent locations may permit an assessment of temporal trends following treatment upgrading of the major discharges. For a number of reasons it will not be possible to integrate contaminant sampling in sediments with that in biota as recommended by Sigma (1990). These include:

* Links between sediment quality and associated biota have been well demonstrated in highly contaminated harbours and marine inlets (eg. Hamilton Harbour and Puget Sound). Similar links in rivers are not easily demonstrated due to the transitory downstream movement of fine sediment in rivers and the comparatively small quantities of infauna and epifauna living in association with accumulated fine sediments.

* In order to monitor contaminant levels accumulated by biota the organism must not be contaminated by sediment, eg. caddis fly larvae have case of sediment and detritus.

* To make a connection between the sediment and biota analyzed there must be an ecological association. One taxa that is common throughout the river system and can be obtained without sediment contamination are emerging adult insects, dominated by caddis flies. Unfortunately caddis fly larvae have little association with fine sediment in depositional zones near shore, the locations where sediment sampling must be done.

Various laboratory bioassays will also be conducted on fine sediments collected along the river to determine potential toxicity. Laboratory bioassays are somewhat artificial in that the sediments are disturbed during collection, possibly releasing toxins that would remain unavailable to organisms in the river, and in that the test organisms are often not the same as those found in the river. Bioassays can, however, be useful in determining the relative toxicity between sites. It is hoped that sediment contaminant analysis can be related to the results of the toxicity testing unless detected toxic effects are the result of some contaminant for which no analysis has been performed.

Data obtained from this biological and sediment monitoring program will be reviewed upon completion of the study to determine which components should be part of a long-term monitoring strategy. The information may also be used by BC Environment and Environment Canada to develop ecosystem objectives.

4.3 COMMUNITY STRUCTURE SURVEY

This segment of the proposed program differs significantly from that recommended by Sigma (1990). The Sigma approach stressed analysis of benthic invertebrate tissue for a wide range of contaminants after taxonomic sorting into "functional groups". Contaminant levels in benthos would then be compared to sediment levels from the same station. A number of stations in each reach sampled on each bank of the river would be sampled to

address the spatial variability of the contaminants analyzed. For reasons outlined in the Preamble this is not recommended as a monitoring objective. Accumulation of contaminants in sediments and aquatic life is addressed in later sections.

The objectives of this Community Structure survey are:

* to gather information on the types and abundance of benthic flora and fauna from various locations along the river to describe the aquatic ecosystem, particularly at points above and below the major discharges.

* to gather the above information in such a way so that re-sampling will show the effects of changes in waste treatment. Gross changes in the community structure will be relatively easy to detect, even with moderate sampling effort. Benthic invertebrate sampling can be conducted to also show more subtle changes. Periphyton and aquatic macrophyte growth and distribution are dramatically effected by so many natural environmental factors, which may mask the effects of waste contaminants, that extensive monitoring of these components can not be justified.

Two fisheries studies are outlined in the Sigma report and are not repeated in this document, they are:

* Lower Columbia River Boating and Sport Fishing Survey

* Lower Columbia River Fisheries Inventory

These studies can be used as part of the Community Structure Survey, providing important information on fish, perhaps the most important component of the aquatic ecosystem. They are currently being conducted through direct contract with B.C. Hydro.

The proposed sites to be used are:

i) no monitoring in Reach I on the small creeks entering Lower Arrow Lake, it would be very difficult to compare information form these stations with those on the Columbia River and separate the differences caused by waste discharges from those caused by greatly differing habitat.

   Control sites on the Kootenay River near Glade (KR-1) and Kootenay River near Grohman Narrows (KR-2).

ii) Reach II - *Site* II-4 at Castlegar (0200200), *Site* II-5 (0200178) mouth of Kootenay River below the Brilliant Dam.

iii) Reach III - *Site* III-2 at Birchbank (0200003)

iv) Reach IV - *Site* IV-2 (E216138) up stream of Bear Creek and *Site* IV-3 (0200559) at Waneta.

Collection will be from one side of the river only. This reduces significantly the logistics of access, as at most stations one shore is inaccessible except by boat.

4.3.1 Benthic Invertebrates

The community composition part of the Sigma Benthic sampling program was initially quite superficial, involving field identification of "functional groups" only, although samples were to be retained for taxonomic identification to species at some later time.

Using proper sampling and analytical methods, benthic invertebrate community structure and abundance can be evaluated in a way that adequately addresses the heterogeneous distribution of these organisms. If habitat conditions at the time of follow-up sampling are relatively similar to those found during the original sampling, changes in the composition of the community at the site, particularly if significant, can be attributed to other factors such as waste impacts. Detailed sampling protocols that should be followed are outlined in the "Guidelines for Sampling Benthic Invertebrates in Streams" (BC Environment, 1991).

Five replicates per station should be collected. The location of these replicates should be randomly selected at each site, with consideration for the constraints of the methodology, i.e.. shallow water, boulders less than 15 cm., etc. (see Guidelines). Replicates must not be composited but analyzed separately so that intra-site variability can be compared to inter-site variability. Taxonomic identification should be done at least to species or as far as possible. Lumping taxa into "functional groups", as recommended by Sigma, can lead to erroneous conclusions because many species within higher taxonomic categories can exhibit a wide range of tolerances to different forms of pollution.

Benthic invertebrate sampling should be done twice, in April and October. Adult emergence takes place mostly during the summer, the maximum biomass of aquatic life stages will be found either in the spring or fall. Dramatic changes in river discharge resulting from operation of the Keenleyside Dam can have a temporary catastrophic effect on invertebrate populations. For this reason river discharge and the time since the last *significant increase or decrease* (dam release or closure) must be recorded so that follow-up sampling can be done under the same conditions.

Follow-up sampling is an important aspect of this program. The more samples that are taken over time at each site, the better will be our understanding of the temporal variability of benthic invertebrate abundance and diversity. This will increase our confidence in reporting changes we attribute to changes in waste discharge quality. The sampling sites chosen to meet the above criteria are shown in Appendix B: Figure 10.2 Benthic Sampling Site Map.

4.3.2 Periphyton

The quantities of attached algae at a site can be estimated by selecting five boulders at a site which visually seem to represent the growth at the site. Areas of $25cm^2$ are scraped from each boulder and filtered through a glass fibre filter. A portion of each filter can be composited from each of the five replicates for taxonomic identification and cell counts. The other portion of the filter is analyzed for Chlorophyll a and biomass. This part of the survey can be conducted in the spring or summer. The particular standing crop of attached algae is highly influenced, not only by habitat requirements (light, temperature, nutrients), but also by the activity of grazing organisms. This means that repeat sampling can only be expected to show gross changes in the algal community at best. Another simple survey technique which can be employed is to establish permanent sites where photographs are taken. It is imperative that field conditions such as water depth, river flow, etc. be recorded for future re-surveying. The sampling sites chosen to meet the above criteria are shown in Appendix B: Figure 10.3 Periphyton Sampling Site Map.

4.3.3 Aquatic Macrophytes

Harvesting mosses and aquatic plants as recommended in the Sigma report is unlikely to produce any meaningful information. Weed beds change size, and relocate in response to shifting substrate and other environmental factors, many of which remain poorly understood. It is recommended that the extent of macrophyte coverage be roughly mapped for each major community, eg. mosses, Potamogeton, etc. along the river. This survey can best be done by boat and may require two trips to cover both shores. Collections of plants should be made to identify the species present as well as photographs taken of major areas of growth. The preferred key for these identifications is Warrington (1980). Taxonomic information is useful should a species appear, disappear or change drastically in its abundance in response to a particular waste discharge. Using existing information on the biology of a species may help explain its presence or abundance in some locations, eg. mosses growing in response to acidic conditions below Cominco. (P. Warrington, personal communication)

This part of the survey should be conducted during the summer as this is the season of maximum production. The survey may have to wait until flows have dropped from freshet levels.

The sampling sites chosen to meet the above criteria are shown in Appendix B: Figure 10.4 Aquatic Macrophytes Sampling Site Map.

Table 4.3 Summary of Community Structure Survey

Variable	# of Sites	# of Replicates	# of Analyses
Benthic invert. (ID and count)	6	5	60 (sampled twice)
Periphyton (ID and counts)	6	1 composite	6
Periphyton (chlorophyll a)	6	5	30
Periphyton (biomass total + ash)	6	5	30
Macrophytes Survey	N/A	N/A	N/A

Note: Collections should be made for archiving.

4.4 BIOACCUMULATION

In theory this part of the program involves the use of a small number of sentinel species. These species must be ubiquitous and relatively sessile. Monitoring for the purpose of linking levels of contaminants found in sediments to those found in benthic organisms is not recommended. Experience on this part of the Columbia River indicates it will be difficult to find enough fine-grained sediment and benthos at the same locations.

A considerable amount of sampling of sport and coarse fish tissue for metals and dioxins and furans has already been done (Table 4.4.a) particularly to address human consumption concerns. Some of the results for metals have been reported in Smith (1987), Norecol (1989), for dioxins and furans in Crozier (1991), and Mah et al (1989). Additional required sampling is summarized in Table 4.4.b. It is proposed that the fish sampling be completed by BC Environment, Lands and Parks.

The suggested sentinel species (taxa) are:

* clams - found throughout; may require divers to collect.

* emergent caddis flies - extremely abundant in July throughout; emergence continues nightly for several weeks; can be caught in trap on surface of the water or by light traps on shore; no concern for sediment contamination of samples; larvae and adults fed on by fish.

* stream-side willow - one individual organism could be used to monitor temporal trends by sampling annual foliage and returning to the same tree in the future: leaves will also accumulate air borne contamination therefore exposed roots should

be sampled: link to terrestrial habitat as foliage is consumed by wildlife and insects which are fed on by birds.

Some preliminary analysis of the non-fish species is necessary to confirm the suitability of the chosen taxa.

Initial indications are that willow may not be good candidates. Poplar are more abundant and are usually found 1 to 2 meters above normal water level. Trees along cut banks where roots are exposed would be ideal but this situation is not found along this part of the Columbia River. Analysis of leaves, roots, and branches for metals was inconclusive, it could not be determined if the source of contamination was via water or air.

While there may be changes to the target species as a result of this preliminary work, the number of samples and costs for this portion of the program will remain roughly the same.

Assuming the non-fish sentinel species can be found in all locations, the following sample sites are recommended:

KR-1 Kootenay River near Glade (control)
KR-2 Kootenay River near Grohman Narrows (control)
II-2 Columbia River below Celgar IDZ (>100m, <1000m)
II-3 Columbia River at Robson
III-2 Columbia River at Birchbank
IV-2 Columbia River upstream of Bear Creek
IV-3 Columbia River at Waneta

The sampling sites chosen to meet the above criteria are shown in Appendix B: Figure 10.5 Clams Sampling Site Map and Appendix B: Figure 10.6 Caddis Fly Sampling Site Map.

The non-fish part of the bioaccumulation study is summarized in Table 4.4.c.

Table 4.4.a Fish Bioaccumulation Sampling - Completed

Site or Reach	Parameter	No. of analyses
Reach 1	D/F	4
Reach 2	D/F	5
	D/F	6
Reach 3	D/F	16
Reach 4	D/F	4
Reach 5	D/F	4
	D/F	6
Reach 6	D/F	4
Reach 3	Hg	1
Reach 4	Hg	1
Reach 5	Hg	1

Note: Reaches for D/F sampling are slightly different than Sigma Reaches, see Crozier (1991)

Table 4.4.b Additional Fish Bioaccumulation Sampling

Species	Parameter	No. of Samples[1]
WS	metals	6
	Hg	6
	D/F	6
Wa[2]	metals	24
	Hg	24
RT[2]	metals	24
	Hg	24
MWF	metals	24
	Hg	24

Species: WS = white surgeon, Wa = walleye, RT = rainbow trout, MWF = mountain whitefish
Tissue: all tissue is axial muscle

1. samples for walleye, rainbow trout, and whitefish are composites of 6 fish except in two reaches where each fish will be analyzed to correlate tissue levels with body size and observed pathology.

2. dioxin/furan sampling for Wa and RT has been done in 1989 by DFO, this sampling should be repeated but is not recommended at this time.

Field parameters - no analytical cost

To be taken from each fish sampled: fork length, total weight, gonad weight, liver weight, otoliths and fin rays for ageing

any observed pathological conditions should be noted (eg. lesions, emaciation, etc.).

Table 4.4.c Non-Fish Bioaccumulation Sampling

Site	Species	Tissue	No. of Samples	Parameters
Pre-testing	various	various	2	D/F
			8	M
KR-1	C	ST	1	D/F,M,Hg,CP
	ECF	WB	1	D/F,M,Hg,CP
KR-2	C	ST	1	D/F,M,Hg,CP
	ECF	WB	1	D/F,M,Hg,CP
II-2	C	ST	1	D/F,M,Hg,CP
	ECF	WB	1	D/F,M,Hg,CP
II-3	C	ST	3	D/F,M,Hg,CP
	ECF	WB	3	D/F,M,Hg,CP
III-2	C	ST	1	D/F,M,Hg,CP
	ECF	WB	1	D/F,M,Hg,CP
IV-2	C	ST	1	M,Hg
	ECF	WB	1	M,Hg
IV-3	C	ST	3	D/F,M,Hg,CP
	ECF	WB	3	D/F,M,Hg,CP

Notes:

Sites: KR-1 = a control site on the Kootenay River (near Glade)
KR-2 = another control site on the Kootenay River (near Grohman Narrows)

Species: C = clams, ECF = emergent caddis flies (species, or at least genus, must be determined)

Tissue: ST = soft tissue, WB = whole body

Parameters: DF = dioxins/furans (17 cogeners), M = metals (Zenon's 19 metal ICP scan), CP = Zenon's pulp & paper chlorinated phenol GCMS scan

Number of samples: Triplicate samples analyzed separately at Robson and at Waneta for QC. All other samples will depend on capture efficiency of UV light traps, several traps may have to be composited (20 g. fresh weight needed)

Dioxin/Furan Phased Analysis:

To avoid unnecessary costs, samples from the most contaminated areas will be analyzed first (II-2 and II-3), if nothing is detected samples from farther downstream may not be analyzed, but should be kept.

4.5 MEASURING BIOCHEMICAL AND PHYSIOLOGICAL RESPONSES

In addition to population response studies and bioaccumulation sampling, as a means of determining the effect of waste discharges on aquatic ecosystems, techniques for measuring the biochemical and physiological responses to certain contaminants in fish have been developed. These methods involve measuring levels of certain enzymes in the liver in exposed and control populations. These enzymes occur naturally and serve regular metabolic functions but they have been found to act on various toxic contaminants. Techniques of this sort have been used extensively in Scandinavia to assess in particular the impacts of bleached kraft pulp mill effluents (BKME) on fish and some invertebrates in the Baltic Sea and are now being used for similar purposes in Eastern Canada and in the Fraser River delta and Boundary Bay.

The specific measurements that were used by Hodson et al (1990) in a study of effects of BKME on white sucker in the St. Maurice River, Quebec included:

Metabolism of chemicals in liver:	- hepatic somatic index
Mixed function Oxidase Enzymes (MFO)*	- 7-ethoxyresorufin-o-deethylase (EROD)
	- aryl hydrocarbon hydroxylase (AHH)
	- glutathione-s-transferase
Measurements of Stress	- hematocrit
	- serum glucose
	- serum protein
	- size
	- condition factor
Indicators of Sexual Maturation	- gonad somatic index
	- serum testosterone
	- 11-ketotestosterone
	- estradiol

* AHH was analyzed during the 1989 part of the study, since then it has become widely accepted that the only enzyme that need be monitored is EROD (P. Hodson, personal communication).

MFO response has been found to be an indication of a direct effect of BKME on fish. However, Hodson et al. (1990) found no direct effects of the BKME on sexual maturation but did find what they termed a 'downstream effect' whereby effects were found 35 to 100 km downstream. They theorized that these downstream effects were related to transformation and/or sediment contamination. This suggests that other measurements listed above should also be made. In addition, it may be necessary to monitor fish populations in the U.S. to monitor the extent of these effects.

Similar methods for measuring sub-lethal stress caused by heavy metals are being developed but are less well refined or confirmed by research. None of this type of monitoring is recommended for this program at this time. It is recommended that MFO monitoring (plus associated measurements) be included in the CRIEMP as a measure of the health of fish in the vicinity of the Celgar pulp mill and to determine the extent of effects downstream. Fish from each reach to the U.S. border should be tested including the control Reach I, Lower Arrow Lake. Because there is now some evidence that fish are moving up through the dam into the Arrow Lakes., another control reach on the Kootenay River should be included as well. From previous studies it is expected that MFO induction will diminish with increasing distance downstream from the Celgar pulp mill. There is a possibility, however, that Cominco's effluent may contain some levels of polycyclic aromatic hydrocarbons (PAH's) which are strong MFO inducers and this will cause a rise in MFO activity in Reach IV. Major dilution from the Kootenay River should cause a significant decrease in enzyme activity in Reach III and thus allow the detection of any effects caused by Cominco. There is also the possibility that metals discharged from Cominco's smelter may have some additive or synergistic effects on growth and reproduction in fish from Reach IV as measured by condition factor or gonad somatic index (see below).

4.6 PROCEDURES AND METHODS

Note: These procedures have been developed from the protocols being considered for inclusion in the Environmental Effects Monitoring requirements of the Pulp and Paper Regulations under the Canadian Fisheries Act which were kindly provided by Dr. Peter V. Hodson (Hodson et al 1991). Additional detail on methods of analysis and QA/QC will be provided when the study is done.

The recommended program involves sampling 15 largescale sucker (*Catostomus macrocheilus),* a bottom feeder, and 15 walleye (*Stizostedion vitreum*), a predator, from each reach. The large scale sucker is the western counterpart of the white sucker of the east (Scott and Crossman 1979) which has been extensively studied. Walleye have not been found to accumulate dioxins and furans to a great extent but are the only plentiful predator in the Columbia system, they are also, unfortunately, extremely migratory.

The sampling should be done when the fish are in their inter-spawning interval, at least two months before spawning. This means sampling both suckers and walleye no later than

February or March but probably, for practical purposes, in the fall. If possible all specimens within each species should be of similar size. MFO activity decreases within 15 minutes of death so the fish must be kept alive until just prior to dissection. Various methods of capture have been used including electroshocking, seining, and gill netting. Fish should be killed by clubbing then weighed and fork lengths measured. The specimen is then dissected and the liver removed, taking care not to puncture the gall bladder (the bile can be first removed with a syringe to prevent contamination of liver tissue). Because traces of blood or bile can interfere with or inhibit MFO fluorescence readings, it is advisable to rinse the liver (after weighing) with cold).15 M KCl. The excised liver is placed in a whirlpak and frozen on dry ice (or liquid nitrogen) at -60° or lower; storage at -20° is not acceptable, even for a short time.

In addition to MFO analyses, other measurements are made on each fish in the field. These include: total body weight, gutted carcass weight (after removal of intestines and gonads), gonad weight, liver weight, fork length, sex, and age. Sex determination on immature fish can be done histologically from a thin section of gonad preserved in buffered formalin. Age determination can be done from scale samples (not recommended for fish over 5 years of age) or from the annuli of the otoliths.

The above measurements can be used to calculate important indices such as **condition factor** (CF=100 x (total weight-gonad weight)/length^3), **gonad somatic index** (GSI=100 x gonad weight/gutted weight), and **liver somatic index** (LSI=100 x liver weight/gutted weight). The condition factor is based on gonad-free weight to remove bias due to variations in sexual maturation, and GSI and LSI are based on gutted weight to remove bias due to variable levels of fat in the viscera and variable gonad weight. Coorelations should be calculated between MFO activity and sex, CF, GSI, LSI, weight and age to identify any bias which may confound the effects of effluent effects.

Obvious pathological effects such as the presence of lesions, lumps, fin erosion, etc. should also be documented for each fish.

The differences in MFO induction in the fish from each reach should be tested using analysis of variance (ANOVA) at a 95% probability level. There are no correct or normal levels of MFO activity in fish therefore effected reaches must be compared to reference or control reaches. A significant MFO response has occurred if (a.) and either (b.) or (c.) are met:

a. MFO activity is significantly higher in contaminated reaches over the reference reaches ($p<0.05$). Ten to 40-fold increases are not uncommon.

b. There is a decrease in activity with distance downstream from the effluent source. Major tributary dilution (i.e.. the Kootenay River) will bring about this effect quickly.

c. MFO response is consistent between sexes of the same species, or between two species, or consistent between repeated surveys.

4.7 COLUMBIA RIVER FISH ABUNDANCY AND MOVEMENT STUDY

B.C. Hydro is a provincial crown corporation responsible for the generation and distribution of electrical power in British Columbia. As part of that responsibility, the corporation operates a number of generation facilities in the Columbia River drainage and is the operating entity for Canadian storage reservoirs under the auspices of the Columbia River Treaty. BC Hydro, through its Environmental Resources Division, is actively engaged in a number of environmental programs in the drainage.

In the area of drainage covered by the CRIEMP program, BC Hydro environmental projects coincidentally will provide aquatic information to the CRIEMP database. Included are: inventory and impact assessment studies conducted under the Resource Smart project, mitigation studies designed to address operational impacts, and research studies.

BC Hydro's Resource Smart Program looks at expanding or rehabilitating existing facilities to optimize their power production. In the lower Columbia drainage there are five such projects being investigated by the Lower Columbia Development Project which include installation of a powerplant at the Keenleyside Dam, and expansion of generation facilities at the Cominco-owned Brilliant Dam on the Kootenay River and Waneta Dam on the Pend d'Oreille River. As part of these investigations, fish and aquatic habitat inventory studies have been conducted for the last three years on the river downstream of the Keenleyside Dam, and a sport fishing creel census and boating survey was conducted in 1990-91. The former studies will provide the CRIEMP database with information on fish distribution, population sizes, habitat requirements, and basic life history information. In addition, these studies will provide water temperature data for main river and tributary sites. The later studies will describe and quantify exiting fishing effort in the area.

Mitigation studies are carried out to address the unresolved impacts of existing operations. In the lower Columbia River, gas supersaturation generation from existing dams including the Keenleyside Dam is one such issue. BC Hydro has installed total gas pressure (TGP) meters above and below the Keenleyside Dam and at the Birchbank Federal/Provincial water sampling station as part of a program to monitor and determine means of overcoming TGP production. This program will provide TGP and dissolved oxygen data to the CRIEMP database. Additional mitigation studies into spawning habitat enhancement on the Norn's Creek fan near Robson will provide further information on fish utilization of the river.

BC Hydro recently initiated research studies in the lower Columbia River regarding potentially endangered fish species. One of these studies is investigating white sturgeon population dynamics and habitat use with the objective of understanding an apparent recruitment problem. Additional funding is being provided to graduate students studying the taxonomy, distribution, and habitat requirements of vulnerable species of dace and sculpin. Both of these programs will ultimately provide better data on the numbers,

distribution, and habitat requirements of these three fish species which will contribute to the CRIEMP database.

4.8 SEDIMENT CONTAMINANTS ANALYSES AND TOXICITY ASSESSMENT

As discussed in the preamble, sampling directly at linking contaminant levels in sediments with those in benthos is not recommended. River sediments are continuously being scoured, transported or deposited. Only fine sediments, which accumulate in backwaters near shore can readily be sampled. Fluctuations in flood flows and channel scouring may cause the depositional patterns in these areas to change over time and data from permanent sites in these areas will have to be analyzed with this in mind.

Despite the difficulties in monitoring and interpretation of results, river sediments play an important role in downstream transport of contaminants and the fate and the subsequent effects on biota. It is important to know if certain contaminants are present in the river sediments, the levels and how far downstream they can be detected. The results of repeat sampling over time (trend analysis) will have to be interpreted with much care, given the dynamic nature and heterogeneous distribution of these sediments.

The sediment sampling proposed by Sigma (1990) attempts to address the heterogeneous distribution of contaminants from shore to shore, site to site, and reach to reach. To do this it is proposed that three (3) sites per reach be sampled on both sides of the river. At each of these locations three (3) replicates are taken, a portion of each of these are composited. If the composite sample shows significant contamination then each replicate would be analyzed for those contaminants. The cost of this program has been estimated to range from a low of $47,500.00, if none of the composites are contaminated, to a high of $190,000.00, if all are contaminated.

It is unlikely that this sampling regime (Table 4.8.1) will even begin to truly define the heterogeneity of distribution of contaminants throughout the river system, particularly considering that a large percentage of the channel bottom will not be sampled. Considering the cost of this level of effort and the logistics of gathering enough samples to properly represent the distribution of contaminants in the river sediments, it is recommended that the goal of addressing heterogeneity be abandoned. It is recommended that one composite sample be analyzed at each of the 3 stations per reach. As many as 4 or 5 subsamples can be taken to form the composites in order to obtain a sample representative of the area and to provide some assurance that contaminants with extremely patchy distribution are not missed. Samples will have to be taken from the nearest sediment deposition zone in the vicinity of the site location.

This contaminant analysis will provide some understanding of the general distribution of contaminants in relation to the various waste discharges and may, upon follow-up sampling, show major changes in contaminant levels in response to treatment improvements. One would expect a slower response to reductions in waste discharge from

this part of the river environment than in the water column, which is further justification for sediment contaminant sampling.

4.9 SEDIMENT TOXICITY ASSESSMENT

In addition to analyzing the level of various contaminants in fine sediments form various sites along the river, above and below the various waste discharges, tests can be performed using laboratory bioassay techniques to determine potential toxicity arising from the contamination. A battery of tests is proposed to determine the toxicity of the whole sediment samples and of filtered extracts of the sediment samples using Columbia River water from above the Celgar pulp mill as the extraction solvent.

The proposed sites for the sediment collection are as follows:

- II-1 (control), II-2, II-3, CS-5 (control)
- III-1, III-2
- IV-1, IV-2, IV-3

These sites are the same sites sampled for contaminant analysis (omitting sites II-4 and III-4) and **must be sub-samples of the contaminant samples.** Sampling should be done in April when water levels are the lowest. The sampling sites chosen to meet the above criteria are shown in Appendix B: Figure 10.7 Sediment Sampling Site Map.

Table 4.9.1 lists the bioassay tests recommended and the various requirements for each test. Some of these tests have been developed by the BC Environment Aquatic Toxicity Laboratory in North Vancouver and this lab has the capability to perform all the tests. As mentioned above, it is recommended that dilution water for all the bioassays be taken from the Columbia River below the Keenleyside Dam and shipped to the lab, rather than using DI water from Vancouver with different water chemistry.

If bioassays are done by the BC Environment Aquatic Toxicity Laboratory the bioassay tests will not be charged to CRIEMP. It is important that the extracts or the overlying water *in the whole sediment tests be analyzed for a series of Columbia River contaminants. This* will be useful in interpreting any toxic effects. The maximum cost for analysis of the overlying water or extracts, as per the notes on Table 4.9.1, is $859.95 for metals at 5 sites plus $7,771.40 for organics at 5 sites (specific parameter packages only to be done if they have been detected in the sediment contaminant analysis), **Total = $8,631.35.**

Table 4.8.1 **Sediment Contaminant Sampling**

Parameter	Number of Samples
Particle size distribution	11
Moisture content	11
TOC	11
Metals package	11
Arsenic (low level)	11
Cadmium (low level)	11
Acid Volatile Sulfide	11
Mercury	11
EOX	11
Dioxins/furans	11
Pulp & paper chlorinated phenols	11
Resin acids	11
Total Kjeldahl nitrogen	11

Table 4.9.1 Sediment Bioassays

Test	Description	Quantity of Sample Required	Other Test Requirements
Sediment			
Solid Phase Microtox	Bioluminescent bacteria, results often coorelate with other tests, easy test which can be repeated	2 grams	sediment particle size <125 *u* (test and sieve if necessary)
Hyallala azteca	Freshwater amphipod, burrows in sediment	300 mL	sediment particle size <250 *u* (test and sieve if necessary)[1]
Rainbow trout sub-gravel filter (7 days or longer)	Sediment is placed on filter in tank, water is pumped down through sediment back into tank	2 kg	fine sediment. Water chemistry analysis 3 times during test[1]
Sediment Extract[2]			
Microtox	as above	1 L of extract	50 gms of sediment needed to extract
Daphnia magna 48 hours	Zooplankton acute toxicity test. If there are mortalities in a sample this will trigger a Rainbow trout 96 hr. LC_{50} test	1 L of extract	50 gms of sediment needed to extract[1]
Rainbow trout 96 hr LC_{50}	Standard fish acute toxicity test. Do if Daphnia test shows toxicity	at least 20 L of extract	2 kg of sediment needed to extract[1]

1. Analysis for the parameters and sites listed below will be performed on the overlying water or extract once at the end of each test.
Parameters and Sites: Total and dissolved metals (Cd, Cu, Pb, Zn), total Hg, total hardness, ammonia, nitrite on sites II-1, III-2, IV-1, IV-2, IV-3: dioxins and furans, chlorophenols and resin and fatty acids on sites II-1, II-2, II-3, IV-3 (dioxins and furans, chlorophenols and resin and fatty acids need only be analyzed if they have been found in the sediment contaminant analysis). Dissolved oxygen and pH will be monitored regularly during the test.

2. Prepared using a modified SWEP procedure developed by Zenon Labs. This method normally uses DI water at pH 7.0, for these studies it is recommended that Columbia River water from above the Celgar pulp mill be used.

5 QUALITY ASSURANCE

This part of the program was designed by Taina Tuominen (Environment Canada)

5.1 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

A QA/QC program is needed for the CRIEMP to ensure that data collected are of acceptable quality. QA/QC measures must be in place for the field collection, laboratory analysis and data input phases of the program. Monitoring results, including QA/QC results, must be reviewed monthly to detect problems in the data collection program and the entire QA/QC plan should be reviewed annually.

The CRIEMP proposal prepared by Sigma (Sigma Engineering 1990) includes a QA/QC component. The QA/QC emphasis is on field collection, sample shipment and intra-laboratory QA/QC procedures. The following is intended as an addition to the program presented in the Sigma document. References consulted were: Environment Canada 1990a, Environment Canada 1990b, and Environment Canada 1991.

Sampling variables are listed in Table 5.1a to Table 5.1d.

5.2 LABORATORY SCREENING

A screening procedure should be observed in selecting analytical laboratories for the program. Selected laboratories must demonstrate high quality in their analytical records.

The following factors should be considered in the laboratory screening process:

- participation in inter-laboratory comparison studies and the availability of data on the laboratory's performance in these studies;
- documentation of the analytical methods for the variables of interest. The methods can then be reviewed to determine if they are appropriate and sufficiently sensitive;
- documentation of the laboratory's internal QA/QC procedures;
- adequacy of facilities available for sample storage;
- adequacy of laboratory facilities during on-site inspection (if time allows for conducting an on-site inspection);
- laboratory performance on the analysis of qualifier or reference samples. This should be conducted if time allows.

The data from the selected laboratories should be reviewed monthly to detect quality problems. Each laboratory should provide a QA/QC chart of the laboratory's precision and accuracy.

Acceptable limits on precision and accuracy of analyses performed on each variable should be determined.

For CRIEMP 1991-93, commitments have already been made for the use of laboratories for analyses. Zenon, Environment Canada's Pacific and Yukon Region Conservation and Protection Laboratory and Environment Canada's National Water Quality Laboratory will be conducting analyses for the two federal-provincial monitoring stations, as agreed under the Canada-British Columbia Water Quality Monitoring Agreement. Zenon, AXYS, and ASL will be conducting the analyses for the additional CRIEMP stations.
The laboratory screening guidelines should be applied in selecting laboratories for analysis of split or replicate samples for QA/QC.

5.3 WATER

5.3.1 Procedures

Water samples should be collected following the specific procedures recommended in Sigma Engineering (1990), with the following additions or changes.

Sampling bottles must be either glass, polyethylene or Teflon, according to the variable and laboratory specifications. Sample bottles must be washed following procedures defined by the laboratory. Each laboratory must have a quality control program to document the adequacy of the bottle washing. The results of this program should be available to the project leader. In general, bottles used for metals analyses must be cleaned with acid and bottles used for organics analyses must be either glass or Teflon and should be washed with solvents.

For variables such as heavy metals, the samples must be preserved according to laboratory specifications. A quality control program must be in place for reporting on the purity of the preservatives and their dispensers. The results of this program should be available to the project leader.

Organics samples should be collected in solvent-washed bottles with solvent-cleaned Teflon or aluminium foil liners for the lids. For many organic variables, such as chlorinated phenolics, dark or amber glass bottles should be used.

Procedures for filtering nutrients and metals must be documented. The procedures must include specifications on equipment, equipment cleaning, filters and filter cleaning. Prior to the first collection, a trial sampling of filtered samples should be conducted at two sites. In this sampling, 10 to 12 replicates from each site and 10 to 12 blanks (distilled/deionized water from the laboratory) should be filtered. These filtered samples and blanks should be

compared to an equal number of total, unfiltered samples and blanks, respectively. An analysis of the results will determine if contamination problems exist in the sampling protocol. Further trials may be necessary before the appropriate procedure is established.

Detailed water sampling procedures are to be documented and followed. These already exist for the federal-provincial monitoring sites at III-2 and IV-3 (Environment Canada 1990b).

Following is a description of QA/QC measures required for the water sampling and analysis components of the CRIEMP for 1991-1993.

5.3.2 QA/QC

5.3.2.1 Field QA/QC

5.3.2.1.1 Replication

Samples collected from sites II-1, II-2, II-3, IV-1 and IV-2 are collected according to procedures documented in Appendix B and analyzed by Zenon Laboratories. Samples collected at sites III-2 and IV-3 are collected as described in Environment Canada, 1990b and analyzed at Environment Canada laboratories.

Replicate samples will serve a dual function. They will be used to evaluate reproducibility or precision in a laboratory's (Zenon Laboratory's) performance, as well as provide a comparison between the laboratories involved in conducting routine analyses for the CRIEMP stations.

For most variables, four replicates will be collected monthly from the Waneta (IV-3) site. One of the replicates will be the routine sample collected at Waneta and analyzed at Environment Canada laboratories as part of the Canada-British Columbia Water Quality Agreement. The remaining three replicates will be analyzed at Zenon Laboratories. These three replicates will be submitted to Zenon Laboratories blindly, without their true station identity known. They will be allocated a fictitious station number.

Ideally, splits, rather than replicates should be used for evaluating analytical precision. True splits of water samples would involve collecting the water in a large container, mixing it well and distributing it to various sub-samples. However, such a technique has many problems, the least of which is potential contamination through the handling of the sample. Therefore, a feasible compromise is the collection of several water samples, as simultaneously as possible.

For the inorganic variables four replicate samples will be collected, as described above. For mercury, one replicate will be analyzed at ASL Laboratories, and three will be analyzed at Zenon. For the chlorinated phenolics and resin and fatty acids three replicates, including the routine sample as one replicate, will be collected. For the dioxins and furans

one replicate, plus the sample, will be collected at each of two sites once during the program period.

5.3.2.1.2 Field Blanks

Field Blanks are required to identify sources of contamination in the sampling procedure or in the sample transport. Field blank testing should be coordinated with laboratory bottle blank testing.

The blanks will consist of sample bottles filled with de-ionized water in the laboratory. The laboratory will prepare laboratory bottle blanks and field blanks at the same time. Batch numbers will be assigned to the blanks, so that laboratory blanks can be matched with field blanks.

At the sampling site, the collector will place the sample bottle containing the de-ionized water into the sampling equipment usually used for sampling. The collector will follow the procedures usually used for collecting a sample, short of actually collecting a sample. The collector will then preserve or filter the sample, as he/she does with an actual sample.

Single blank samples will be prepared four times during the year's sampling period for site IV-3 (Waneta) and II-1 (Hugh Keenleyside). For the remaining sites, one blank will be taken in the year. These blanks will be prepared for the general variables, AOX, chlorinated phenolics (phenols, guaiacols, catechols), resin acids, fatty acids, total metals, total mercury and total nutrients. A field blank will be prepared for dioxins/furans only if levels are detected in the sampling.

5.3.2.1.3 Field Collection Audit

Once during the 1991-92 sampling period, a field audit will be made by Environment Canada staff. The Environment Canada team will sample at sites II-1, II-4, IV-3 at the same time as the CRIEMP collectors. For the audit, triplicate samples of general variables, metals, mercury, arsenic/selenium and nutrients will be collected by both Environment Canada and the routine collectors. Single samples for chlorinated phenols will be collected. Field blanks will also be made by Environment Canada for all variables. Environment Canada samples will be analyzed at Environment Canada laboratories in Burlington, Ontario or West Vancouver, B.C.

The field audit results will give further data to compare analytical results among the laboratories involved in analysis of routine samples for CRIEMP sites.

5.3.2.2 Laboratory QA/QC

5.3.2.2.1 Laboratory Blanks

Laboratory blanks will test for contamination from the bottles or preservatives. Laboratory blanks will be prepared from distilled/deionized water and in concert with the field blanks, as described above under Section 5.3.2.1.2. Field Blanks. One laboratory blank for dioxins/furans should be sufficient.

Laboratory blanks will remain in the laboratory and be analyzed with the corresponding field blanks. In addition, each laboratory should include tests for bottle contamination in their intra-laboratory QA/QC program.

5.3.2.2.2 Standards

High quality standards must be utilized by all laboratories involved in the program. Each laboratory should provide data on the laboratory's analytical precision relative to the analysis of standard or reference substances, particularly for heavy metals and organics analyses.

5.3.2.2.3 Reference Samples/Inter-laboratory Studies

Each laboratory involved in water analysis for the CRIEMP should participate in established inter-laboratory (Round Robin) studies. The laboratory's performance in these studies should be made available to the CRIEMP Coordinating Committee.

5.3.2.2.4 Inter-laboratory studies on analysis of replicates

The Interlaboratory comparison of replicate samples was addressed in the field collection audit (Section 5.3.2.1.3).

5.3.2.2.5 Intra-laboratory QA/QC

Sigma Engineering (1990) outlines essential elements required for intra-laboratory QA/QC. It is recommended that the procedures outlined for dioxins/furans analysis be replaced with the more recent procedures presented in Environment Canada (1990a).

5.4 SEDIMENT

5.4.1 Procedures

Sediments should be collected as recommended in Sigma Engineering (1990). Stainless steel sampling equipment should be used. Tools used for mixing and dispensing samples should be properly cleaned (acid-cleaned for metals and solvent-cleaned for organics) and made of either Teflon or stainless steel. Stainless steel equipment should not be acid cleaned. When the Ekman or Ponar dredge are used for sampling, sediments touching the metal of the sampler should not be used for the sample.

Bottles for metals analysis should be either polyethylene or Teflon wide-mouth bottles which have been acid-washed. Appropriate acid-washed cap liners (Teflon or polyethylene) should be used. Bottles for organics samples should be Teflon wide-mouth bottles that have been solvent-washed. It is possible to use glass jars for metals or organics samples. However, because the samples must be frozen after collection, some breakage will usually occur when freezing sediments in glass jars.

Separate bottles should be used for particle size samples; these should not be frozen.

5.4.2 QA/QC

5.4.2.1 Field QA/QC

5.4.2.1.1 Field Splits

Field splits will be used to test for analytical precision and accuracy. Analytical accuracy will be tested by analyzing split samples at Zenon and the Environment Canada National Water Quality Laboratory. The splits will be taken from the samples being used for the Environment Canada field audit.

If a total of 12 sediment samples are to be collected, 2 samples should be made into split samples. Each of these samples will be split into three parts to produce three blind splits.

Further details on splitting of the sample and its relationship to the Environment Canada field audit is presented in the next section on Field Audit Collection.

In 1991-92 splits will be prepared for metals; chlorinated phenols, catechols, guaiacols, dioxins and furans; total organic carbon and particle size.

5.4.2.1.2 Field Collection Audit

A field audit will be conducted to observe the CRIEMP collectors' sampling techniques, test for potential contamination in the sampling, and check on analytical accuracy.

Environment Canada will collect two sediment samples with CRIEMP collectors. One site will be located in Reach I, upstream of industrial inputs. This site will act as a control on the cleanliness of the sampling equipment.

At this Reach 1 site two separate samples will be collected. One sample will be collected by the CRIEMP collectors and another sample will be collected at the same time by Environment Canada. When sufficient sample is collected, each sample will be well mixed and split into 10 portions, as follows:

2 to CRIEMP for metals analysis;
2 to Environment Canada for metals analysis;
2 to CRIEMP for organics and total organic carbon analysis;
2 to Environment Canada for organics and total organic carbon analysis;
1 to CRIEMP for particle size;
1 to Environment Canada for particle size.

Therefore, for this site, both CRIEMP and Environment Canada will have a total of 4 metals samples, 4 organics samples and 2 particle size samples. The replicates will be submitted for analysis blindly.

The second audit sample will be collected by CRIEMP collectors at a site downstream of expected contaminants. The sample will be split into six subsamples. Each of these six subsamples will be analysed for metals, organics, total organic carbon and particle size. One subsample will be submitted as the CRIEMP sample; two subsamples will be submitted by CRIEMP as a blind splits; three subsamples will be analyzed by Environment Canada as blind replicates. Splits from 3 to 5 locations will also be sent for analysis to the U. S. Geological Survey.

5.4.2.2 Laboratory QA/QC

5.4.2.2.1 Standards

As with the water samples, high quality standard samples must be used by laboratories. Data on their analytical performance on reference and standard samples must be made available.

5.4.2.2.2 Reference Samples/Inter-laboratory Studies

Each laboratory involved in sediment analysis for the CRIEMP should participate in inter-laboratory studies on the analyses of reference samples. The results of these studies should be available to all members of the CRIEMP Coordinating Committee for evaluation.

5.4.2.2.3 Intra-laboratory QA/QC

Refer to the water section above.

5.5 BIOTA

5.5.1 Procedures

Sigma Engineering (1990) outlines procedures for fish collection. Following are a few additions to the Sigma recommendations. All trays, buckets, etc. used for holding fish should be made of stainless steel or Teflon and cleaned with solvents. In addition, when handling the fish, especially during dissection, polyethylene gloves and not latex gloves should be worn. In collecting other biota, similar precautions must be taken, with respect to cleanliness. Handling of the organisms must be kept to a minimum.

Dissecting and homogenizing of tissues must be done with stainless steel and Teflon equipment that have been cleaned with acid and solvent solutions.

5.5.2 QA/QC

The recommended QA/QC applies to only the bioaccumulation component of the biological sampling. QA/QC can be conducted on the community structure component by having a second expert identification conducted on subsamples of the biological samples.

5.5.2.1 Field QA/QC

5.5.2.1.1 Field Splits

Splits should be made of the fish bioaccumulation and non-fish bioaccumulation samplings.

i) fish bioaccumulation

For fish collections conducted in 1990 by B.C. Ministry of Environment, Lands and Parks and Environment Canada, some of the samples were split for QA/QC.

For the additional recommended fish sampling, one sample from each of the four fish species - white sturgeon, walleye, Rainbow trout and mountain whitefish - should be split into subsamples. The sample should be split after the tissue has been homogenized. For two of the four species, the QA/QC sample will be split into five subsamples, as follows:

- one subsample to be submitted to the analytical laboratory as the sample;
- two subsamples to be submitted to the same analytical laboratory as above, as blind splits;
- one subsamples to be submitted to an "approved" QA laboratory for analysis and;
- one subsample to be submitted to the Fisheries and Oceans Canada Laboratory for analysis.

For the remaining two samples, each will be split into three subsamples - one to be submitted as the sample, and the other two to be submitted as blind splits.

ii) non-fish bioaccumulation

Splits will be made if sufficient tissue is collected. If not, the selected organism may not be appropriate for long-term monitoring on environmental quality.

It is recommended that for two organisms, one sample will be split into three subsamples -- sample plus two blind splits. As this is a check on analytical precision, the splits should be made on the homogenized tissue.

5.5.2.1.2 Field Collection Audit

Environment Canada will conduct an audit on sampling conducted by contractors on non-fish bioaccumulation.

As a total of 20 samples will likely be collected, an audit will be conducted on 2 of the samples. For the audit, Environment Canada will collect similar samples at the same location as the contractor and analyze the samples. If sufficient sample is collected by the contractor and Environment Canada, the samples will be split and analyzed by the respective parties, as described above for the sediment sampling audit.

5.5.2.2 Laboratory QA/QC

5.5.2.2.1 Standards

As with the water and sediment samples, high quality standard samples must be utilized by laboratories. Data on the laboratories' analytical performance on reference and standard samples must be made available.

5.5.2.2.2 Reference Samples/Inter-laboratory Studies

Each laboratory involved in sediment analysis for the CRIEMP should participate in inter-laboratory studies on the analyses of reference samples. The results of these studies should be available to all members of the CRIEMP Coordinating Committee for evaluation.

5.5.2.2.3 Intra-laboratory QA/QC

Refer to the water section above.

5.6 DATA MANAGEMENT PLAN

A Data Management Plan is necessary to ensure that data are entered into databases in an accurate and timely fashion, available to program managers for review and scrutinized for anomalies. The plan will specify procedures for review of data, guidelines for identifying problems with the data (outliers, contamination, etc.) and follow-up procedures relating to questionable data.

5.6.1 Field Collection

At the federal-provincial sites, Birchbank (III-2) and Waneta (IV-3), station data cards are to be completed as instructed in the federal-provincial field sampling protocol (FS000017, Environment Canada 1990b).

At all other sites, the following information is to be noted on CRIEMP station data cards:

- Station
- Station Number
- Date of Sampling
- Air Temperature (°C), measured as described in Environment Canada (1990b)

- Water Temperature (°C), measured as described in Environment Canada (1990b)

- Remarks, describing the conditions at the time of sampling (such as weather, water turbidity, floating debris, presence of ice, etc.). Any deviations from the prescribed sampling procedures must also be noted.

- Name of Collector(s)

The CRIEMP station cards are to be forwarded to the CRIEMP Coordinator following the sampling.

Blind replicates will be submitted to the laboratory as samples from a newly created fictitious SEAM station. The true identity of the samples will be recorded by the field collectors on the appropriate field data sheet and submitted to the CRIEMP Coordinator.

QA/QC replicates collected for analysis by "other" laboratories (laboratories not routinely analyzing the particular variables for CRIEMP) will be submitted by the CRIEMP Coordinator to the respective laboratories.

5.6.2 *Laboratory Analysis*

Following analysis of samples, the results are to be entered into the database following procedures established for provincial data at Zenon and federal or federal-provincial data at Environment Canada Laboratories. The data entry system must either be direct from the instrument read-out, or if done manually, must have data entry verification procedures in place. Data analyzed in other laboratories (for example, data from QA split samples submitted to "approved" laboratories for analysis) will be sent to the CRIEMP Coordinator for review prior to entry into a database system. These data will be entered into the SEAM database by the CRIEMP Coordinator and the entries will be checked by the CRIEMP Coordinator.

A report on intra-laboratory QA/QC will be submitted to the Program Coordinator by participating laboratories twice per year. The report will include data on the following:

- method performance test results;

- laboratory and complementary field blanks;

- results of inter-laboratory tests;

- results of duplicate samples taken as subsamples by the laboratory (one sample in every ten samples, for dioxins/furans analyses);

- method blank results;

- surrogate recoveries (where applicable);
- results of certified standard analyses.

5.6.3 Data Analysis for QA/QC

Monthly, the CRIEMP Coordinator will review the data and report on the status and quality of the data to the Coordinating Committee. The following will be included in the report:

- a review of all routine water quality data, with respect to outliers and questionable values. The Alert Levels listed in Table 5.2 can be used as a guideline for data review.
- a review of laboratory and field blanks data for unacceptably high levels (all detectable levels should be considered as alert levels).
- a review of blind replicates data with respect to variability (less than or equal to 15 % variability considered acceptable).
- a review of data on replicates sent to other laboratories for analysis (a variation of greater than 15 % among laboratories should require further investigation of the results).

The CRIEMP Coordinator will take action to resolve questions arising from data anomalies, as follows:

- checking on data entry at its various stages;
- checking on laboratory and field blanks for possible causes of problem;
- checking CRIEMP field station cards for comments on sampling conditions, etc.;
- comparing with other data, such as residue levels, or other related variables;
- request for a re-analysis of the sample;
- reviewing data with respect to inter-laboratory comparisons for systematic problems.

The Coordinator will report on his/her investigations into data problems to the Coordinating Committee which will determine the need for further action or studies to resolve outstanding data problems.

Table 5.1.a **Summary of Analyses** - required to accommodate QA/QC in CRIEMP sampling for 1991 (included as part of monitoring program - costed as part of monitoring)

I. WATER

APPLICATION	VARIABLE	NUMBER OF ANALYSES
Testing of filtering procedures	metals-diss	30-36 (10-12 replicates x 2 sites; 10-12 blanks total)
	metals-tot	30-36
	As-diss	30-36
	As-total	30-36
	Hg-diss	30-36
	Hg-total	30-36
	P-diss	30-36
Replicates (blind)	general variables	48 (3 replicates at Waneta x 16 times)
	metals-tot	42
	Hg-total	51
	As/Se-total	42
	N-total	48
	P-diss	48
	P-ortho	48
	P-total	48
	AOX	16
	chlorinated phenols	32
	chl. guaiacols	32
	chl. catechols	32
	resin acids	16
	fatty acids	16
	dioxins/furans	2

Table 5.1.a cont'd **Summary of Analyses** - required to accommodate QA/QC in CRIEMP sampling for 1991 (included as part of monitoring program - costed as part of monitoring)

I. WATER

APPLICATION	VARIABLE	NUMBER OF ANALYSES
Field Blanks	general variables	12 (1 x 2 sites (Wan + U/S) x 4 times + 4 sites x 1 time)
	metals-tot	10
	Hg-total	10
	As/Se-total	10
	N-total	10
	P-diss	10
	P-ortho	10
	P-total	10
	AOX	10
	chlorinated phenols	10
	chl. guaiacols	10
	chl. catechols	10
	resin acids	10
	fatty acids	10
	dioxins/furans	1 possibly
Laboratory Blanks	general variables	4 made up
	metals-tot	4 made up
	Hg-total	4 made up
	As/Se-total	4 made up
	N-total	4 made up
	P-total	4 made up

Table 5.1.a cont'd **Summary of Analyses** - required to accommodate QA/QC in CRIEMP sampling for 1991 (included as part of monitoring program - costed as part of monitoring)

I. WATER

APPLICATION	VARIABLE	NUMBER OF ANALYSES
Laboratory Blanks cont'd	AOX	4 made up
	chlorinated phenols	4 made up
	chl. guaiacols	4 made up
	chl. catechols	4 made up
	resin acids	4 made up
	fatty acids	4 made up
	dioxins/furans	1 ?
Replicates (inter-laboratory studies)	general variables	6 (2 samples x 1 times x 3 labs)
	metals-tot	6
	Hg-total	6
	As/Se-total	6
	N-total	6
	N-diss	6
	P-diss	6
	P-ortho	6
	P-total	6
	AOX	6 (2 samples x 1 times x 3 labs)
	chlorinated phenols	6
	chl. guaiacols	6
	chl. catechols	6
	resin acids	6
	fatty acids	6
	dioxins/furans	3

? may not be applicable at present time

Table 5.1.b **Summary of Analyses** - required to accommodate QA/QC in CRIEMP sampling for 1991 (included as part of monitoring program - costed as part of monitoring)

II. SEDIMENT

APPLICATION	VARIABLE	NUMBER OF ANALYSES
Field splits/ Field Collection Audit	metals-tot	5
	Hg-total	5
	As/Se-total	5
	phenols-total	5
	EOX	5
	dioxins/furans	5
	chlorophenols	5
	chl. guaiacols	5
	chl. catechols	5
	resin acids	5
	fatty acids	5
	TOC	5
	particle size	5
Replicates (inter-laboratory studies)	will be addressed by field audit	

Table 5.1.c **Summary of Analyses** - required to accommodate QA/QC in CRIEMP sampling for 1991 (included as part of monitoring program - costed as part of monitoring)

III. BIOTA

APPLICATION	VARIABLE	NUMBER OF ANALYSES
Field splits - fish	metals-tot	14 (8 = fish; 6 = non-fish)
	Hg-total	14
	As/Se-total	14
	phenols-total	8 (2 = fish; 6 = non-fish)
	EOX	8
	dioxins/furans	8
	chlorophenols	8
	chl. guaiacols	8
	chl. catechols	8
	resin acids	8
	fatty acids	8
	lipid/ moisture	8
Field Collection Audit	metals-tot	2 (add. to splits)
	Hg-total	2
	As/Se-total	2
	phenols-total	2
	dioxins/furans	2
	chlorophenols	2
	chl. guaiacols	2
	chl. catechols	2
	resin acids	2
	fatty acids	2
	lipid/ moisture	2
Replicates (inter-laboratory studies)	will be addressed by field audit	

Table 5.1.d QA/QC - to be conducted by Environment Canada

I. WATER

APPLICATION	VARIABLE	NUMBER OF ANALYSES
Field Collection Audit	general variables	20 (collected at 3 sites + blanks)
	metals-tot	20
	metals-diss	20
	Hg-total	20
	Hg-diss	20
	As/Se-total	20
	As/Se-diss	20
	N-total	20
	N-diss	20
	P-diss	20
	P-ortho	20
	P-total	20
	chlorinated phenols	5

II. SEDIMENT

APPLICATION	VARIABLE	NUMBER OF ANALYSES
Field splits/ Field Collection Audit	metals-tot	6
	Hg-total	6
	As/Se-total	6
	phenols-total	6
	dioxins/furans	6
	chlorophenols	6
	chl. guaiacols*	6
	chl. catechols*	6
	resin acids*	6
	fatty acids*	6
	TOC	6
	particle size	6

* may not be possible

Table 5.1.d cont'd QA/QC - to be conducted by Environment Canada

III. BIOTA

APPLICATION	VARIABLE	NUMBER OF ANALYSES
Field Collection Audit	metals-tot	4
	Hg-total	4
	As/Se-total	4
	phenols-total	4
	dioxins/furans	4
	chlorophenols	4
	chl. guaiacols*	4
	chl. catechols*	4
	resin acids*	4
	fatty acids*	4
	lipid/ moisture	4

* may not be possible

Table 5.2 Alert Levels of Water Quality Variables

Alert levels of water quality variables (mg/L) - for use as guidelines in data review

1. GENERAL VARIABLES

Sampling stations	Birchbank		Waneta	
VARIABLE	Low	High	Low	High
Temperature-air	-10	35	-10	35
Temperature-water	+ 2.0	20	+ 2.0	20
pH-field	6.8	8.2	6.8	8.2
pH-lab.	6.8	8.2	6.8	8.2
Conductivity-field				
Conduct.-lab. (Conduct.-field should be within 10% of Conduct.-lab.)				
Sodium-diss.	0.7	2.0	0.7	2.0
Chloride-diss.	0.3	1.6	0.3	1.8
Tot. diss. solids (not monitored before)				
Colour (app.)	--	15	--	15
NFR (fixed total)	--	10	--	10
Turbidity	0.10	2.00	0.20	2.00
Coliform-fecal (should be under detection limit)				
Calcium-diss.	15.000	22.000	15.000	27.000
Magnesium-diss.	3.000	5.000	3.000	5.000
Hardness	50	75	50	85
Alkalinity-total	40	65	40	65
Alkal. -phenolph. (null by definition if pH < 8.3)				
Potassium-diss.	0.4	0.8	0.4	0.8
Sulphate	7.0	11.5	7.5	20.0
Fluoride	--	0.100	--	0.200
Silica (reactive)	3.00	5.00	3.00	5.00
Silicon (ICP)	1.40	2.30	1.40	2.30

Table 5.2. Alert Levels of Water Quality Variables

2. NUTRIENTS

Sampling stations	Birchbank		Waneta	
VARIABLE	Low	High	Low	High
Total phosphorus	--	0.025	--	0.100
Total diss. P	--	0.025	--	0.100
Ortho-P	--	0.025	--	0.100
Total diss. N	--	0.200	--	0.200
Nitrate+Nitrite	--	0.150	--	0.150
Diss. Ammonia	--	0.030	--	0.030

The high alert level for ammonia is the limit set by IJC for the Great Lakes (IJC 1986); ammonia in the Columbia River was not monitored in the past. The high alert levels for the other general variables and nutrients, except ortho-P, are greater than most values measured in the past. Ortho-P was not measured in the past; its levels should never be greater than those measured for the other phosphorus variables. The low alert levels for the general variables are less than those measured in the past.

3a. TOTAL HEAVY METALS

Sampling stations	Birchbank		Waneta	
METAL	Low	High	Low	High
Aluminium	--	0.1	--	0.1
Cadmium	--	0.0008	--	0.0008
Chromium	--	0.0020	--	0.0020
Copper	--	0.0020	--	0.0020
Iron	0.0100	0.3000	0.0100	0.3000
Lead	--	0.0020	--	0.0020

The high values are levels that should not be exceeded for the protection of freshwater aquatic life, as specified by the Canadian Water Quality Guidelines (CCREM 1987). The low value for iron, if observed, may indicate a clerical error.

Table 5.2. Alert Levels of Water Quality Variables

3b. TOTAL HEAVY METALS

Sampling stations	Birchbank		Waneta	
METAL	Low	High	Low	High
Arsenic	--	0.0006	--	0.0012
Manganese	--	0.0100	--	0.0200
Nickel	--	0.0010	--	0.0010
Selenium	--	0.0003	--	0.0005
Zinc	--	0.0050	--	0.0300

The high values are greater than most values measured in the past for these stations. The high value for zinc at Waneta is the CCREM (1987) recommendation for the protection of freshwater aquatic life.

3c. TOTAL HEAVY METALS

Sampling stations	Birchbank		Waneta	
METAL	Low	High	Low	High
Mercury	--	0.0001	--	0.0001
Thallium	--	0.005	--	0.005

The high alert levels are the analytical detection limits. As Thallium has not been monitored in the past, a record of background levels does not exist. Therefore, the analytical detection limit is recommended as the alert level for the present.

6 ESTIMATION OF PROGRAM COSTS

6.1 WATER MONITORING COSTS

Table 6.1.a Eligible Water Monitoring Costs

ELIGIBLE COSTS	Celgar	Cominco	BCE (WQ)	BCE (EP)	DOE
	($Can)	($Can)	($Can)	($Can)	($Can)
WATER					
General Variables	$11,954	$5,100			
Metal and Metalloids		$9,770			
Adsorbable Organic Halides	$12,663				
Dioxins and Furans	$11,520				
Chlorophenols	$36,300				
Resin Acids/ Fatty Acids	$9,397				
Nutrients	$3,412	$1,933			
Supplemental QA/QC Plan Costs	$6,500	$2,300			
TOTAL WATER COSTS	**$91,746**	**$19,103**			

ELIGIBLE COSTS	DFO	BC Hydro	Castlegar	Trail	Total
	($Can)	($Can)	($Can)	($Can)	Costs
WATER					
General Variables					$17,054
Metal and Metalloids					$9,770
Adsorbable Organic Halides					$12,663
Dioxins and Furans					$11,520
Chlorophenols					$36,300
Resin Acids/ Fatty Acids					$9,397
Nutrients					$5,345
Supplemental QA/QC Plan Costs					$8,800
TOTAL WATER COSTS					**$110,849**

Table 6.1.b Inkind Water Monitoring Costs

INKIND COSTS	Celgar	Cominco	BCE (WQ)	BCE (EP)	DOE
	($Can)	($Can)	($Can)	($Can)	($Can)
WATER					
General Variables			$4,936	$15,459	$3,475
Metal and Metalloids			$1,753	$7,355	$6,192
Adsorbable Organic Halides			$3,618	$7,236	
Dioxins and Furans					
Chlorophenols					
Resin Acids/ Fatty Acids			$2,685	$5,370	
Nutrients			$1,365	$5,768	$3,552
Supplemental QA/QC costs					$1,300
Sampling Costs	$16,800	$15,000			
TOTAL WATER COSTS	**$16,800**	**$15,000**	**$14,357**	**$41,188**	**$14,519**

INKIND COSTS	DFO	BC Hydro	Castlegar	Trail	Total
	($Can)	($Can)	($Can)	($Can)	Costs
WATER					
General Variables		$40,000			$63,870
Metal and Metalloids					$15,300
Adsorbable Organic Halides					$10,854
Dioxins and Furans					
Chlorophenols					
Resin Acids/ Fatty Acids					$8,055
Nutrients					$10,685
Supplemental QA/QC costs					$1,300
Sampling Costs					$31,800
TOTAL WATER COSTS		**$40,000**			**$141,864**

6.2 COMMUNITY STRUCTURE SURVEY COSTS

Table 6.2.1 Summary of Community Structure Survey and Estimates of Costs

Variable	# of Sites	# of Replicates	# of Analyses	Cost/Analysis	Cost
Benthic invert. (ID and count)	6	5	60 (sampled twice)	$206.34	$12380.40
Periphyton (ID and counts)	6	1 composite	6	$206.34	$1238.04
Periphyton (chlorophyll a)	6	5	30	$26.10	$783.00
Periphyton (biomass total + ash)	6	5	30	$24.86	$745.80
Macrophytes Survey	N/A	N/A	N/A	N/A	$2000.00
TOTAL					$17,147.24

6.3 FISH BIOACCUMULATION COSTS

6.3.1 Fish Bioaccumulation Sampling - Completed

Table 6.3.1 Summary of Completed Fish Bioaccumulation Sampling and Estimates of Costs

Site or Reach	Parameter	No. of analyses	Unit Cost	Cost	Funding Agency
Reach 1	D/F	4	$981.97	$3927.88	Celgar
Reach 2	D/F	5	$981.97	$4909.85	Celgar
	D/F	6	$981.97	$5891.82	EP
Reach 3	D/F	16	$981.97	$15711.52	Celgar
Reach 4	D/F	4	$981.97	$3927.88	Celgar
Reach 5	D/F	4	$981.97	$3927.88	Celgar
	D/F	6	$981.97	$5891.82	WQ Branch
Reach 6	D/F	4	$981.97	$3927.88	Celgar
Reach 3	Hg	1	$62.15	$62.15	EP
Reach 4	Hg	1	$62.15	$62.15	EP
Reach 5	Hg	1	$62.15	$62.15	EP
Total Costs				**$36,332.89** **$5,891.82** **$6,078.27**	Celgar WQ Branch EP

6.3.2 Additional Fish Bioaccumulation Sampling

Table 6.3.2 Summary of Additional Fish Bioaccumulation Sampling and Estimates of Costs

Species	Parameter	Unit Cost	No. of Samples	Cost
WS	metals	$74.58	6	$447.48
	Hg	$62.15	6	$372.90
	D/F	$981.97	6	$5891.82
Wa	metals	$74.58	24	$1789.92
	Hg	$62.15	24	$1491.60
RT	metals	$74.58	24	$1789.92
	Hg	$62.15	24	$1491.60
MWF	metals	$74.58	24	$1789.92
	Hg	$62.15	24	$1491.60
Total Costs				**$16,556.76**

Species: WS = white surgeon, Wa = walleye, RT = rainbow trout, MWF = mountain whitefish

6.4 NON-FISH BIOACCUMULATION COSTS

Table 6.4 Non-Fish Bioaccumulation Sampling

Site	Species	Tissue	No. of Samples	Parameters	Cost
Pre-testing	various	various	2	D/F	$1963.94
			8	M	$596.64
KR-1	Clams	Soft Tissue	1	D/F,M,Hg,CP	$1472.96
	Caddis Flies	Whole Body	1	D/F,M,Hg,CP	$1472.96
KR-2	Clams	Soft Tissue	1	D/F,M,Hg,CP	$1472.96
	Caddis Flies	Whole Body	1	D/F,M,Hg,CP	$1472.96
II-2	Clams	Soft Tissue	1	D/F,M,Hg,CP	$1472.96
	Caddis Flies	Whole Body	1	D/F,M,Hg,CP	$1472.96
II-3	Clams	Soft Tissue	3	D/F,M,Hg,CP	$4418.88
	Caddis Flies	Whole Body	3	D/F,M,Hg,CP	$4418.88
III-2	Clams	Soft Tissue	1	D/F,M,Hg,CP	$1472.96
	Caddis Flies	Whole Body	1	D/F,M,Hg,CP	$1472.96
IV-2	Clams	Soft Tissue	1	M, Hg	$136.73
	Caddis Flies	Whole Body	1	M, Hg	$136.73
IV-3	Clams	Soft Tissue	3	D/F,M,Hg,CP	$4418.88
	Caddis Flies	Whole Body	3	D/F,M,Hg,CP	$4418.88
Total					$32,293.24

6.5 CONSULTANTS CONTRACT FOR BIO-RECONNAISSANCE

Table 6.5 Consultants Contract Costs

	Costs
Field and Office work	$46,341.00
Data Analysis and reporting	$8,520.00
Additional trip for Benthic Invertebrate (separate from sediment) and large substrate BI	$11,000.00
Total	**$65,861.00**

Bio-Reconnaisance Contract will include:

1. Field work - Community Survey, Non-fish Bioaccumulation sampling, and Sediment sampling. To be done commencing spring 1993.

   Data analysis and report - all program elements.

2. Fish sampling for bioaccumulation will be done by BC Environment.

3. Chemical and biological samples will be submitted to specified laboratories and analysis will be paid for by CRIEMP.

6.6 COLUMBIA RIVER FISH HEALTH STUDY COSTS

Table 6.6 Fish Health Study Costs

	Costs
DFO costs (inkind)	$67,500
DFO costs (through CRIEMP)	$10,000
Total	**$77,500**

6.7 SEDIMENT CONTAMINANT COSTS

Table 6.7.1 Sediment Contaminant Costs

Parameter	Number of Samples	Unit Cost	Total Cost
Particle size distribution	11	$62.15	$683.65
Moisture content	11	$14.92	$164.12
TOC	11	$40.00	$440.00
Metals package	11	$74.58	$820.38
Arsenic (low level)	11	$28.59	$314.49
Cadmium (low level)	11	$28.00	$308.00
Acid Volatile Sulfide	11	$40.00	$440.00
Mercury	11	$62.15	$683.65
EOX	11	$174.02	$1914.22
Dioxins/furans	11	$981.97	$10801.67
Pulp & paper chlorinated phenols	11	$354.26	$3896.86
Resin acids	11	$261.03	$2871.33
Total Kjeldahl nitrogen	11	$36.05	$396.55
Total			**$22,914.54**

Table 6.7.2 Sediment Toxicity Costs

Parameter	Number of Samples	Unit Cost	Total Cost
Rainbow trout sub-gravel filter bioassay			$9,337.92

6.8 QA/QC COSTS

Table 6.8.a CRIEMP Cost Estimates - for selected QA/QC analyses

I. WATER (1991-92 costs)

Variable	# of Samples	Unit Cost	Total Costs
metals, general variables, nutrients	2 samples x 3 labs	$600	$3600 ($1300 by DOE)
dioxins/ furans	1 sample x 2 labs	$1000	$2000
resin/ fatty acids, chl. phenolics	2 samples x 3 labs	$ 750	$4500
TOTAL WATER COST			$10,100
TOTAL COST - DOE SHARE			$8,800

II. SEDIMENT (1992-93 costs)

Variable	# of Samples	Unit Cost	Total Costs
Splits (3 samples)+field audit (2 samp)			
metals	5	$ 150	$ 750
dioxin/ furans	5	$1000	$5000
chlorophenols	5	$1000	$5000
resin/ fatty acids	5	$ 310	$1550
TOC/ moisture, particle size	5	$ 140	$ 700
TOTAL SEDIMENT COST			$13,000

III. BIOTA (1992-93 costs)

Variable	# of Samples	Unit Cost	Total Costs
1a. FISH SPLITS			
metals	8	$ 155	$1240
dioxin/ furans	2	$1000	$2000
chlorophenols, resin/ fatty acids	2	$ 800	$1600
lipid/ moisture	2	$ 25	$ 200
TOTAL 1a. FISH SPLITS COST			$ 5,040

Table 6.8.a cont'd **CRIEMP Cost Estimates** - for selected QA/QC analyses

III. BIOTA cont'd (1992-93 costs)

Variable	# of Samples	Unit Cost	Total Costs
1b. FISH (Split analyses at approved QA/QC laboratories)			
metals	4	$ 155	$ 620 ($310 by DOE)
dioxin/ furans	2	$1000	$2000 ($1000 by DOE)
chlorophenols, resin/ fatty acids	2	$ 800	$1600
lipid/ moisture	4	$ 25	$ 100
TOTAL 1b. FISH SPLITS COST			**$ 4,320**
TOTAL COST - DOE & DFO SHARE			**$ 3,010**

Variable	# of Samples	Unit Cost	Total Costs
2. NON-FISH (Splits 4 samples+Field Audit/Split analyses at approved QA/QC laboratories)			
metals	6	$ 155	$930 ($310 by DOE)
dioxin/ furans	6	$1000	$6000 ($2000 by DFO)
chlorophenols, resin/ fatty acids	6	$ 800	$4800
lipid/ moisture	6	$ 25	$ 150
TOTAL 2. NON-FISH SPLITS COST			**$11,880**
TOTAL COST - DOE & DFO SHARE			**$ 9,570**

TOTAL BIOTA COST - DOE & DFO SHARE			**$17,620**

TOTAL QA/QC COSTS - DOE & DFO SHARE			**$39,420**

6.9 TOTAL PROGRAM COSTS

Table 6.9.a Total Program Eligible Costs

ELIGIBLE COSTS	Celgar	Cominco	BCE (WQ)	BCE (EP)	DOE
	($Can)	($Can)	($Can)	($Can)	($Can)
Water	$91,746	$19,103			
Community Survey	$8,573	$8,573			
Non-Fish Bioaccumulation	$37,639	$4,225			
Fish Bioaccumulation (complete)					
Fish Bioaccumulation (proposed)	$12,392	$12,215			
Fish Health Study					
Sediments	$32,028	$4,707			
Misc. Costs (QA, admin, Norecol contract.)	$33,673	$33,673		$50,240	$6,000
Coordinator Costs	$26,376	$26,376		$9,760	$8,560
TOTAL ELIGBLE COSTS	**$242,426**	**$108,872**		**$60,000**	**$14,560**

ELIGIBLE COSTS	DFO	BC Hydro	Castlegar	Trail	Total
	($Can)	($Can)	($Can)	($Can)	Costs
Water					$110,849
Community Survey					$17,146
Non-Fish Bioaccumulation					$41,863
Fish Bioaccumulation (complete)					
Fish Bioaccumulation (proposed)					$24,607
Fish Health Study	$10,000				$10,000
Sediments					$36,735
Misc. Costs (QA, admin., Norecol contract.)		$6000			$117,262
Coordinator Costs		$26,376	$5,035	$5,035	$107,520
TOTAL ELIGIBLE COSTS	**$10,000**	**$32,376**	**$5,035**	**$5,035**	**$465,982**

Table 6.9.b Total Program In-kind Costs

IN-KIND COSTS	Celgar	Cominco	BCE (WQ)	BCE (EP)	DOE
	($Can)	($Can)	($Can)	($Can)	($Can)
Water	$16,800	$15,000	$14,357	$41,188	$14,519
Community Survey					
Non-Fish Bioaccumulation					$310
Fish Bioaccumulation (complete)	$36,333		$5,892	$9,078	
Fish Bioaccumulation (proposed)				$2,500	$1,310
Fish Health Study				$3,000	
Sediments				$9,338	
Misc. Costs (QA, admin., Norecol contract.)			$5,680	$46,357	$67,080
Coordinator Costs				$15,300	
TOTAL IN-KIND COSTS	$53,133	$15,000	$25,929	$126,761	$83,219

IN-KIND COSTS	DFO	BC Hydro	Castlegar	Trail	Total
	($Can)	($Can)	($Can)	($Can)	Costs
Water		$40,000			$141,864
Community Survey		$223,000			$223,000
Non-Fish Bioaccumulation	$2,000				$2,310
Fish Bioaccumulation (complete)		$2,000			$53,303
Fish Bioaccumulation (proposed)					$3,810
Fish Health Study	$67,500				$70,500
Sediments					$9,338
Misc. Costs (QA, admin., Norecol contract.)			$5,000		$124,117
Coordinator Costs					$15,300
TOTAL IN-KIND COSTS	$69,500	$265,000	$5,000		$643,542

7 SUMMARY

An enormous amount of data will be needed to be provided and analysed in a timely manner to allow all participants to meet their individual requirements and to provide the public with a current snapshot of the current health of the lower Columbia River. The challenge of bringing several levels of government, industry, and a public utility together to work on a common watershed seems at times to be beyond reach, but this type of cooperative, efficient "**partnership**" is the way of the future.

8 REFERENCES

Canadian Council of Resource and Environment Ministers, Task Force on Water Quality Guidelines. 1987. Canadian Water Quality Guidelines. Ottawa, Ontario.

Environment Canada, Dioxin Quality Assurance Advisory Committee. 1990a. Internal quality assurance requirements for the analysis of dioxins in environmental samples. Draft. Available from: CCIW, Burlington, Ontario.

Environment Canada, 1990b. Water Quality Monitoring Protocols, Environmental Surveys Branch, Inland Waters, C&P, P&Y, Vancouver, B.C.

IJC. 1986. Annual Report of the Aquatic Ecosystem Objectives Committee. Great Lakes Science Advisory Board, International Joint Commission, Windsor, Ontario.

BC Environment. 1991. Guidelines for Sampling Benthic Invertebrates In Streams. Environmental Protection Program, Kootenay Region, L.E. McDonald (ed).

Crozier, R.J., 1991. Preliminary Report on Dioxin and Furan Levels in Columbia River Fish. BC Environment, Kootenay Region. July 1991.

Hodson, P.V., M. McWhirter, K. Ralph, B. Gray, M. Gagnon, D. Thivierge, and J. Carey. 1990. Effects of bleached kraft mill effluent on fish in the St. Maurice River, Quebec. Proc. 17th Annual Aquatic Toxicity Workshop, Vancouver, B.C.

Hodson, P.V., P.J. Kloepper-Sams, K.R. Munkittrick, W.L. Lockhart, D.A. Metner, P.L. Luxon, I.R. Smith, M.M. Gagnon, M. Servos, and J.F. Payne. 1991. Protocols For Measuring Mixed Function Oxygenases of Fish Liver. Canadian Tech. Rep. of Fisheries and Aquatic Sciences (In Draft).

Scott, W.B. and E.J. Crossman, 1979. Freshwater Fishes of Canada. Fish. and Oceans Canada, Ottawa, Ont.

Sigma Engineering Ltd., 1990. Columbia River Integrated Environmental Monitoring Program. Vancouver, B.C., Sept. 1990.

Smith, A.L., 1987. Levels of Metals and Metallothionein in Fish of the Columbia River near the International Boundary. Inland Waters Directorate, Env. Canada, Vancouver, B.C.

Warrington, P.D., 1980. Studies on Aquatic Macrophytes Part XXXIII: Aquatic Plants of British Columbia. Aquatic Studies Branch, B.C. Min. of Environ. Dec. 1980.

9 APPENDIX - A: Sampling Locations and Frequency

Table 9.1 General Variables - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station
	II-1	II-1	II-2	II-2	II-4
	Below K Dam	Below K Dam	400 m D/S	400 m D/S	D/S STP
SEAM No.	'0200183	'0200183	E216155	E216155	'0200200
Analytical Responsibility	Celgar	Prov. (WQ)	Celgar	Prov. (WQ)	Celgar
Sampling Freq	1/mon	(5x)/30 days	1/mon	(5x)/30 days	1/mon
.....start date	Sep-91	Mar-92	Sep-91	Mar-92	Sep-91
.....end date	Oct-92		Oct-92		Oct-92
Analytical Lab.	Zenon	Zenon	Zenon	Zenon	Zenon
General Variables					
pH	16	3	16	3	16
Temperature	16	3	16	3	16
TDS	16		16		16
Conductivity	16		16		16
Color x 3	16	3	16	3	16
TSS	16	3	16	3	16
Turbidity	16	3	16	3	16
Hardness	16		16		16
Coliform (fecal)	16	3	16	3	16
E.Coli/Entero.	13	3	13	3	13
Alkalinity x 2	16		16		16
DO	16	3	16	3	16
Cl	16		16		16
SO4	16		16		16
Fluoride	16		16		16
Si	16		16		16
Ca	16		16		16
Na	16	3	16	3	16
K	16		16		16
Total Organic C	16		16		16

Table 9.1 cont'd General Variables - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station
	II-4	III-2	III-2	III-2	III-2
	D/S STP	Birchbank	Birchbank	Birchbank	Birchbank
SEAM No.	'0200200	'0200003	'0200003	'0200003	'0200003
Analytical Responsibility	Prov. (WQ)	Celgar	Prov. (WQ)	Prov. (EP)	Federal
Sampling Freq	(5x)/30 days	1/mon	(5x)/30 days	2/mon	2/mon
.....start date	Mar-92	Sep-91	Mar-92	Sep-91	Sep-91
.....end date		Oct-92		Oct-92	Oct-92
Analytical Lab.	Zenon	Zenon	Zenon	Zenon	Fed. Lab
General Variables					
pH	3		4	32	32
Temperature	3		4		32
TDS		16			
Conductivity				32	32
Color x 3	3		4	32	32
TSS	3		4	32	
Turbidity	3		4		32
Hardness			4		32
Coliform (fecal)	3		4	32	
E.Coli/Entero.	3		4	13	
Alkalinity x 2			4		32
DO	3	16	4		
Cl					32
SO4			4		32
Fluoride			4		32
Si					32
Ca					32
Na	3		4		32
K					32
Total Organic C		16			

Table 9.1 cont'd General Variables - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station
	IV-1B	IV-1	IV-1A	IV-3	IV-3
	East Tr.	Mid Stream	West Tr.	Waneta	Waneta
SEAM No.	E216136	E209100	E216137	'0200559	'0200559
Analytical Responsibility	Cominco	Prov. (WQ)	Cominco	Celgar	Prov. (EP)
Sampling Freq	1/mon	(5x)/30 days	1/mon	1/mon	1/wk
.....start date	Sep-91	Mar-92	Sep-91	Sep-91	Sep-91
.....end date	Oct-92		Oct-92	Oct-92	Oct-92
Analytical Lab.	Zenon	Zenon	Zenon	Zenon	Zenon
General Variables					
pH	16	3	16		64
Temperature	16	3	16		
TDS	16		16	16	
Conductivity	16		16		64
Color x 3	16	3	16		64
TSS	16	3	16		64
Turbidity	16	3	16		
Hardness	16		16		
Coliform (fecal)	16	3	16		64
E.Coli/Entero.	13	3	13		13
Alkalinity x 2	16		16		
DO	16	3	16	16	
Cl	16		16		
SO4	16		16		
Fluoride	16		16		
Si	16		16		
Ca	16		16		
Na	16	3	16		
K	16		16		
Total Organic C				16	

Table 9.1 cont'd **General Variables** - Sampling Locations and Frequency

Sampling Station	Station	Number of QA samples
	IV-3	
	Waneta	
SEAM No.	'0200559	
Analytical Responsibility	Federal	
Sampling Freq	1/wk	
.....start date	Sep-91	
.....end date	Oct-92	
Analytical Lab.	Fed. Lab	
General Variables		
pH	64	
Temperature	64	
TDS		
Conductivity	64	58
Color x 3	64	58
TSS		58
Turbidity	64	58
Hardness	64	58
Coliform (fecal)		7
E.Coli/Entero.		5
Alkalinity x 2	64	46
DO		
Cl diss.	64	58
SO4	64	58
Fluoride	64	58
Si	64	58
Ca	64	58
Na diss.	64	58
K diss.	64	58
Total Organic C		21

Table 9.2 Metals/Metalloids - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station
	II-1	II-2	II-4	III-2	III-2
	Below K Dam	400 m D/S	D/S STP	Birchbank	Birchbank
SEAM No.	'0200183	E216155	'0200200	'0200200	'0200200
Analytical Responsibility	Cominco	Cominco	Cominco	Prov. (WQ)	Prov. (EP)
Sampling Freq.	Bi-monthly	Bi-monthly	Bi-monthly	(5x)/30 days	2/mon
.....start date	Sep-91	Sep-91	Sep-91	Sep-91	Sep-91
.....end date	Oct-92	Oct-92	Oct-92	Oct-92	Oct-92
Analytical Lab.	Zenon	Zenon	Zenon	Zenon	Zenon
Metal and Metalloids (total)					
Al	8	8	8	4	32
As (low level)	8	8	8	4	
Cd (ultra low level)	8	8	8	4	
Cr (low level)	8	8	8	4	
Cu	8	8	8	4	
Fe	8	8	8	4	
Pb (low level)	8	8	8	4	
Mn	8	8	8	4	
Mo	8	8	8	4	32
Ni	8	8	8	4	32
Se	8	8	8	4	32
Tl	8	8	8	4	32
Zn	8	8	8	4	
Hg (low level)	8	8	8	10	

Table 9.2 cont'd Metals/Metalloids - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station	# of QA
	III-2	IV-1B	IV-1A	IV-3	IV-3	
	Birchbank	East Tr.	West Tr.	Waneta	Waneta	
SEAM No.	'0200200	E216136	E216137	'0200559	'0200559	
Analytical Responsibility	Federal	Cominco	Cominco	Prov. (EP)	Federal	
Sampling Freq.	2/mon	1/mon	1/mon	1/wk	1/wk	
.....start date	Sep-91	Sep-91	Sep-91	Sep-91	Sep-91	
.....end date	Oct-92	Oct-92	Oct-92	Oct-92	Oct-92	
Analytical Lab.	Fed. Lab	Zenon	Zenon	Zenon	Fed. Lab	
Metal and Metalloids (total)						
Al		16	16	64		52
As (low level)	32	16	16		64	52
Cd (ultra low level)	32	16	16		64	52
Cr (low level)	32	16	16		64	52
Cu	32	16	16		64	52
Fe	32	16	16		64	52
Pb (low level)	32	16	16		64	52
Mn	32	16	16		64	52
Mo		16	16	64		52
Ni		16	16	64		52
Se		16	16	64		52
Tl		16	16	64		52
Zn	32	16	16		64	52
Hg (low level)	32	16	16		64	61

Table 9.3 **AOX and Chlorate** - Sampling Locations and Frequency

Sampling Station	**Station**	**Station**	**Station**	**Station**	**Station**	**# of QA/QC**
	II-1	**II-2**	**II-4**	**III-2**	**IV-3**	
	Below K Dam	400 m D/S	D/S STP	Birchbank	Waneta	
SEAM No.	'0200183	E216155	'0200200	'0200003	'0200559	
Analytical Responsibility	Celgar	Celgar	Celgar	Celgar	Celgar	
Sampling Frequency	1/mon	1/mon	1/mon	1/mon	1/mon	
.....start date	Sep-91	Sep-91	Sep-91	Sep-91	Sep-91	
.....end date	Oct-92	Oct-92	Oct-92	Oct-92	Oct-92	
Analytical Laboratory	Zenon	Zenon	Zenon	Zenon	Zenon	
Adsorbable Organic Halides						
AOX	16	16	16	16	16	26
Chlorate	16	16	16	16	16	26

Table 9.4 Dioxins/Furans - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station	# of QA/QC
	II-1	II-2	II-4	III-2	IV-3	
	Below K Dam	400 m D/S	D/S STP	Birchbank	Waneta	
SEAM Station No.	'0200183	E216155	'0200200	'0200003	'0200559	
Analytical Responsibility	Celgar	Celgar	Celgar	Celgar	Celgar	
Sampling Frequency	2/yr	2/yr	2/yr	2/yr	2/yr	
.....start date	Sep-91	Sep-91	Sep-91	Sep-91	Sep-91	
.....end date	Oct-92	Oct-92	Oct-92	Oct-92	Oct-92	
Analytical Laboratory	AXYS	AXYS	AXYS	AXYS	AXYS	
Dioxins and Furans						
T4CDD	2	2	2	2	2	2
2378T4CDD	2	2	2	2	2	2
P5CDD	2	2	2	2	2	2
12378P5CDD	2	2	2	2	2	2
H6CDD	2	2	2	2	2	2
123478H6CDD	2	2	2	2	2	2
123678H6CDD	2	2	2	2	2	2
123789H6CDD	2	2	2	2	2	2
H7CDD	2	2	2	2	2	2
1234678H7CDD	2	2	2	2	2	2
O8CDD	2	2	2	2	2	2
T4CDF	2	2	2	2	2	2
2378T4CDF	2	2	2	2	2	2
P5CDF	2	2	2	2	2	2
12378P5CDF	2	2	2	2	2	2
23478P5CDF	2	2	2	2	2	2
H6CDF	2	2	2	2	2	2
123478H6CDF	2	2	2	2	2	2
123678H6CDF	2	2	2	2	2	2
234678H6CDF	2	2	2	2	2	2
123789H6CDF	2	2	2	2	2	2
H7CDF	2	2	2	2	2	2
1234678H7CDF	2	2	2	2	2	2
1234789H7CDF	2	2	2	2	2	2
O8CDF	2	2	2	2	2	2

Table 9.5 Chlorophenols, Phenolics, and Chloroform - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station	# of QA
	II-1	II-2	II-4	III-2	IV-3	
	Below K Dam	400 m D/S	D/S STP	Birchbank	Waneta	
SEAM No.	'0200183	E216155	'0200200	'0200003	'0200559	
Analytical Responsibility	Celgar	Celgar	Celgar	Celgar	Celgar	
Sampling Frequency	1/mon	1/mon	1/mon	1/mon	1/mon	
.....start date	Sep-91	Sep-91	Sep-91	Sep-91		
.....end date	Oct-92	Oct-92	Oct-92	Oct-92		
Analytical Laboratory	AXYS	AXYS	AXYS	AXYS	AXYS	
Chlorophenols						
Phenols	16	16	16	16	16	26
Chloroform	2	2	2	2	2	2
4-Chlorophenol	16	16	16	16	16	21
2,6-DCP	16	16	16	16	16	21
2,4/2,5-DCP	16	16	16	16	16	21
3,5-DCP	16	16	16	16	16	21
2,3-DCP	16	16	16	16	16	21
3,4-DCP	16	16	16	16	16	21
2,4,6-TCP	16	16	16	16	16	21
2,3,6-TCP	16	16	16	16	16	21
2,3,5-TCP	16	16	16	16	16	21
2,4,5-TCP	16	16	16	16	16	21
2,3,4-TCP	16	16	16	16	16	21
3,4,5-TCP	16	16	16	16	16	21
2,3,5,6-TetraCP	16	16	16	16	16	21
2,3,4,6-TetraCP	16	16	16	16	16	21
2,3,4,5-TetraCP	16	16	16	16	16	21
Pentachlorophenol	16	16	16	16	16	21
6-chloroguaiacol	16	16	16	16	16	21
4-chloroguaiacol	16	16	16	16	16	21
5-chloroguaiacol	16	16	16	16	16	21
3,4-DCguaiacol	16	16	16	16	16	21
4,6-DCguaiacol	16	16	16	16	16	21
4,5-DCguaiacol	16	16	16	16	16	21
3,4,5-TCguaiacol	16	16	16	16	16	21

Table 9.5 cont'd Chlorophenols, Phenolics, and Chloroform - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station	# of QA
	II-1	II-2	II-4	III-2	IV-3	
	Below K Dam	400 m D/S	D/S STP	Birchbank	Waneta	
SEAM No.	'0200183	E216155	'0200200	'0200003	'0200559	
Analytical Responsibility	Celgar	Celgar	Celgar	Celgar	Celgar	
Sampling Frequency	1/mon	1/mon	1/mon	1/mon	1/mon	
.....start date	Sep-91	Sep-91	Sep-91	Sep-91		
.....end date	Oct-92	Oct-92	Oct-92	Oct-92		
Analytical Laboratory	AXYS	AXYS	AXYS	AXYS	AXYS	
Chlorophenols						
4,5,6-TCguaiacol	16	16	16	16	16	21
3,4,5,6-TCguaiacol	16	16	16	16	16	21
3-chlorocatechol	16	16	16	16	16	21
4-chlorocatechol	16	16	16	16	16	21
3,4-DCcatechol	16	16	16	16	16	21
3,6-DCcatechol	16	16	16	16	16	21
3,5-DCcatechol	16	16	16	16	16	21
4,5-DCcatechol	16	16	16	16	16	21
3,4,5-TCcatechol	16	16	16	16	16	21
3,4,5,6-TCcatechol	16	16	16	16	16	21
4,5-DCveratrole	16	16	16	16	16	21
3,4,6-TCveratrole	16	16	16	16	16	21
3,4,5-TCveratrole	16	16	16	16	16	21
3,4,5,6-TCveratrole	16	16	16	16	16	21
5-chlorovanillin	16	16	16	16	16	21
6-chlorovanillin	16	16	16	16	16	21
5,6-DCvanillin	16	16	16	16	16	21
3-chlorosyringol	16	16	16	16	16	21
3,5-DCsyringol	16	16	16	16	16	21
3,4,5-TCsyringol	16	16	16	16	16	21

Table 9.6 Resin Acids - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station	# of QA/QC
	II-1	II-2	II-4	III-2	IV-3	
	Below K Dam	400 m D/S	D/S STP	Birchbank	Waneta	
SEAM Station No.	'0200183	E216155	'0200200	'0200003	'0200559	
Analytical Responsibility	Celgar	Celgar	Celgar	Celgar	Celgar	
Sampling Frequency	1/mon	1/mon	1/mon	1/mon	1/mon	
.....start date	Sep-91	Sep-91	Sep-91	Sep-91	Sep-91	
.....end date	Oct-92	Oct-92	Oct-92	Oct-92	Oct-92	
Analytical Laboratory	Zenon	Zenon	Zenon	Zenon	Zenon	
Resin Acids						
Abietic Acid	16	16	16	16	16	26
Chlorodehydroabietic Acid	16	16	16	16	16	26
Dehydroabietic Acid	16	16	16	16	16	26
Dichlorodehydroabietic Acid	16	16	16	16	16	26
Isopimaric Acid	16	16	16	16	16	26
Levo Pimaric Acid	16	16	16	16	16	26
Neoabietic Acid	16	16	16	16	16	26
Pimaric Acid	16	16	16	16	16	26
Palustric Acid	16	16	16	16	16	26
Sandaraco Pim. Acid	16	16	16	16	16	26

Table 9.7 Fatty Acids - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station	# of QA/QC
	II-1	II-2	II-4	III-2	IV-3	
	Below K Dam	400 m D/S	D/S STP	Birchbank	Waneta	
SEAM Station No.	'0200183	E216155	'0200200	'0200003	'0200559	
Analytical Responsibility	Celgar	Celgar	Celgar	Celgar	Celgar	
Sampling Frequency	1/mon	1/mon	1/mon	1/mon	1/mon	
.....start date	Sep-91	Sep-91	Sep-91	Sep-91	Sep-91	
.....end date	Oct-92	Oct-92	Oct-92	Oct-92	Oct-92	
Analytical Laboratory	Zenon	Zenon	Zenon	Zenon	Zenon	
Fatty Acids						
Arachidic Acid	16	16	16	16	16	26
Behenic Acid	16	16	16	16	16	26
Lauric Acid	16	16	16	16	16	26
Lignoceric Acid	16	16	16	16	16	26
Linolenic Acid	16	16	16	16	16	26
Linoleic Acid	16	16	16	16	16	26
Myristic Acid	16	16	16	16	16	26
Oleic Acid	16	16	16	16	16	26
Palmitric Acid	16	16	16	16	16	26
Stearic Acid	16	16	16	16	16	26

Table 9.8 Nutrients - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station	Station
	II-1	II-1	II-2	II-2	II-4	II-4
	Below K Dam	Below K Dam	400 m D/S	400 m D/S	D/S STP	D/S STP
SEAM Station No.	'0200183	'0200183	E216155	E216155	'0200200	'0200200
Analytical Responsibility	Celgar	Prov. (WQ)	Celgar	Prov. (WQ)	Celgar	Prov. (WQ)
Sampling Frequency	1/mon	(5x)/30 days	1/mon	(5x)/30 days	1/mon	(5x)/30 days
.....start date	Sep-91	Mar-92	Sep-91	Mar-92	Sep-91	Mar-92
.....end date	Oct-92		Oct-92		Oct-92	
Analytical Laboratory	Zenon	Zenon	Zenon	Zenon	Zenon	Zenon
Nutrients						
N Org Total	16	3	16	3	16	3
N Kjel Total	16	3	16	3	16	3
N Total	16	3	16	3	16	3
N Amm Diss.	16	3	16	3	16	3
N NO3+NO2 Diss.	16	3	16	3	16	3
P Ortho Diss.	16	3	16	3	16	3
P Total	16	3	16	3	16	3
P Total Diss.	16	3	16	3	16	3

Table 9.8 cont'd Nutrients - Sampling Locations and Frequency

Sampling Station	Station	Station	Station	Station	Station	Station
	III-2	III-2	III-2	IV-1B	IV-1	IV-1A
	Birchbank	Birchbank	Birchbank	East Tr.	Mid Stream	West Tr.
SEAM Station No.	'0200003	'0200003	'0200003	E216136	E209100	E216137
Analytical Responsibility	Prov. (EP)	Prov. (WQ)	Federal	Cominco	Prov. (WQ)	Cominco
Sampling Frequency	2/mon	(5x)/30 days	2/mon	1/mon	(5x)/30 days	1/mon
.....start date	Sep-91	Mar-92	Sep-91	Sep-91	Mar-92	Sep-91
.....end date	Oct-92		Oct-92	Oct-92		Oct-92
Analytical Laboratory	Zenon	Zenon	Fed. Lab	Zenon	Zenon	Zenon
Nutrients						
N Org Total		4		16	3	16
N Kjel Total		4		16	3	16
N Total		4	32	16	3	16
N Amm Diss.	32	4		16	3	16
N NO3+NO2 Diss.		4	32	16	3	16
P Ortho Diss.	32	4		16	3	16
P Total		4	32	16	3	16
P Total Diss.	32	4		16	3	16

Table 9.8 cont'd Nutrients - Sampling Locations and Frequency

Sampling Station	Station	Station	# of QA/QC
	IV-3	IV-3	
	Waneta	Waneta	
SEAM Station No.	'0200559	'0200559	
Analytical Responsibility	Prov. (EP)	Federal	
Sampling Frequency	1/wk	1/wk	
.....start date	Sep-91	Sep-91	
.....end date	Oct-92	Oct-92	
Analytical Laboratory	Zenon	Fed. Lab	
Nutrients			
N Org Total			58
N Kjel Total			58
N Total		64	58
N Amm Diss.	64		58
N NO3+NO2 Diss.		64	58
P Ortho Diss.	64		58
P Total		64	58
P Total Diss.	64		58

10 APPENDIX - B: Site Maps

10.1 CRIEMP SAMPLING SITE MAPS

Figure 10.1 Water Sampling Site Map

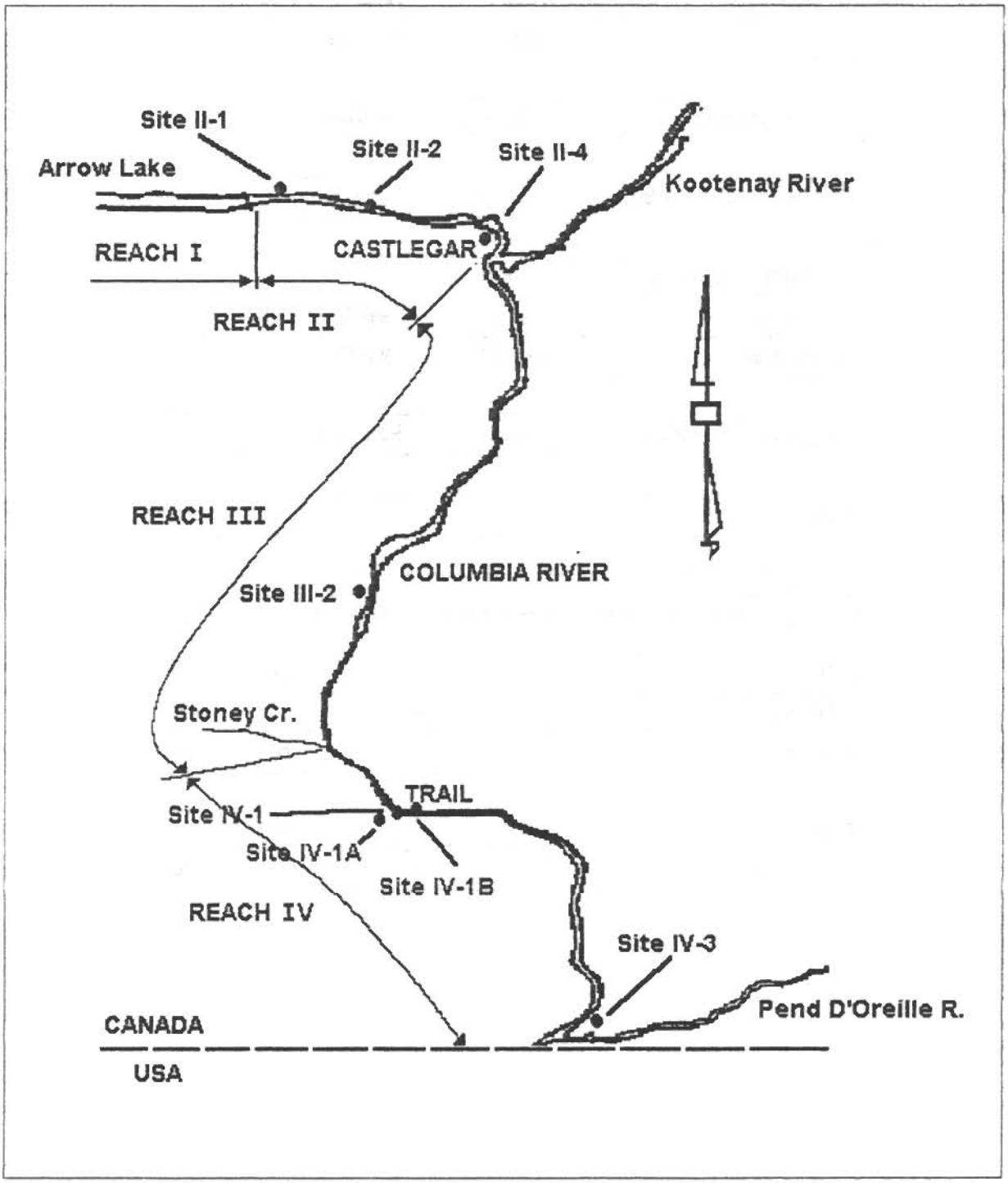


Figure 10.2 Benthic Sampling Site Map

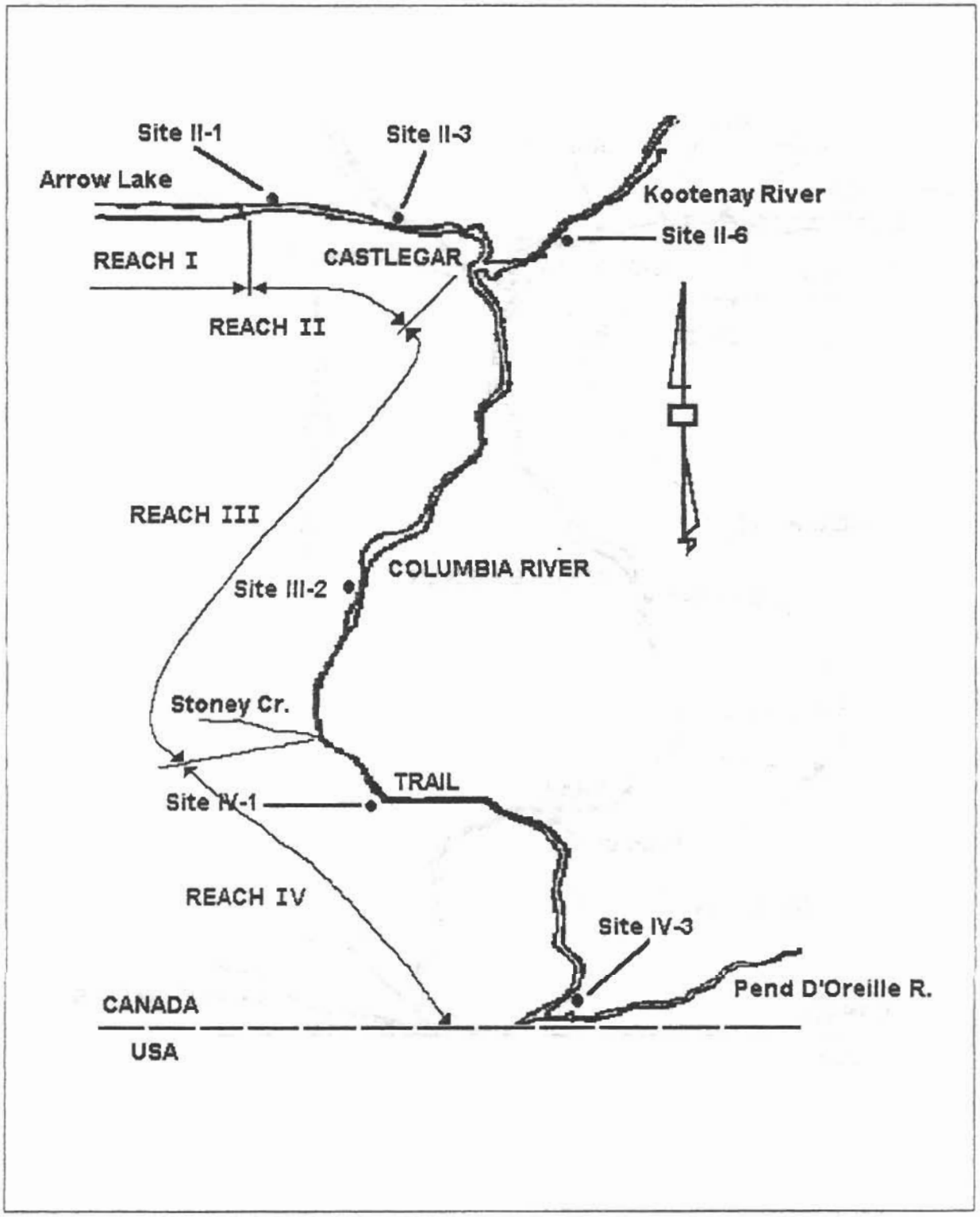


Figure 10.3 Periphyton Sampling Site Map

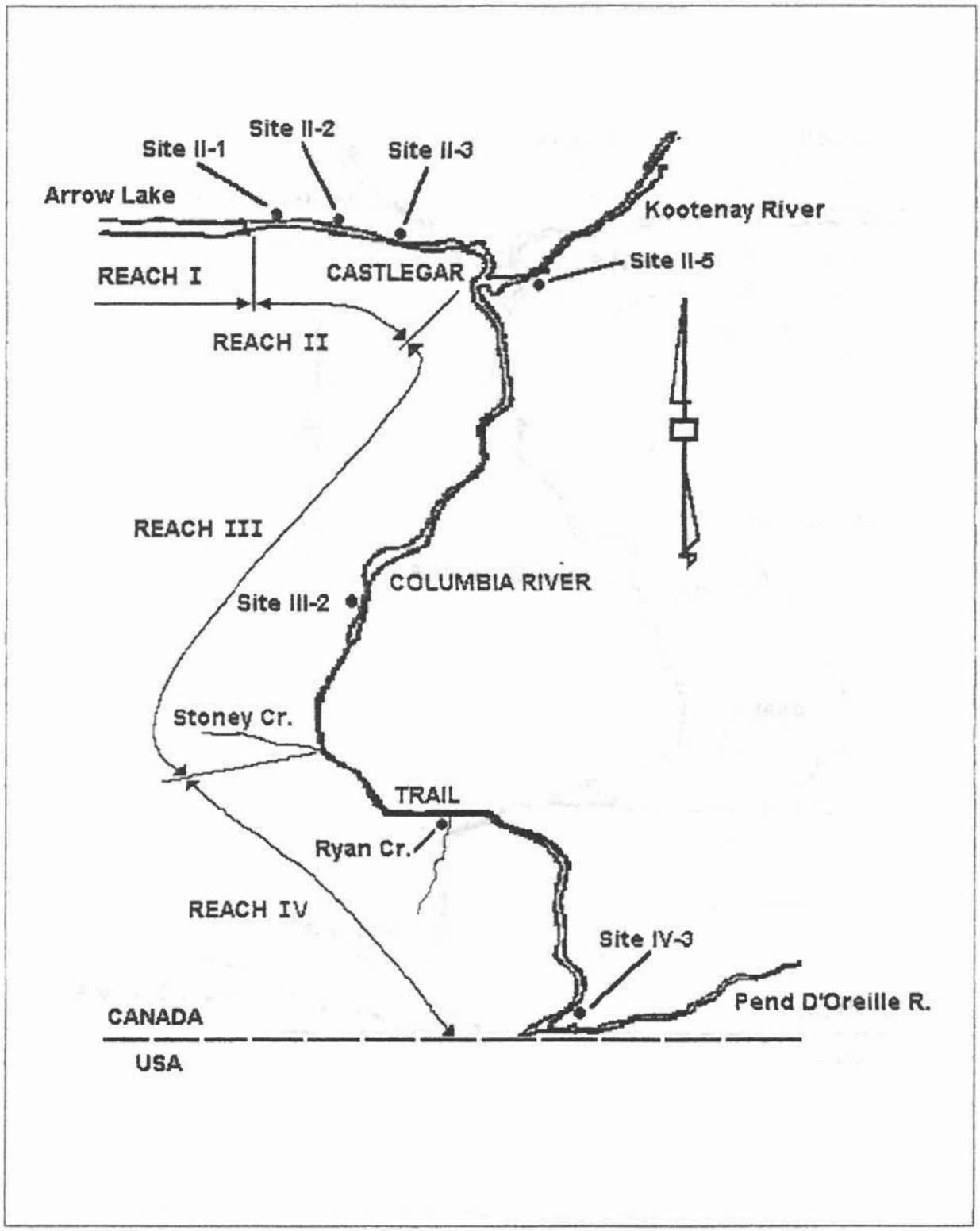


Figure 10.4 Macrophyte Sampling Site Map

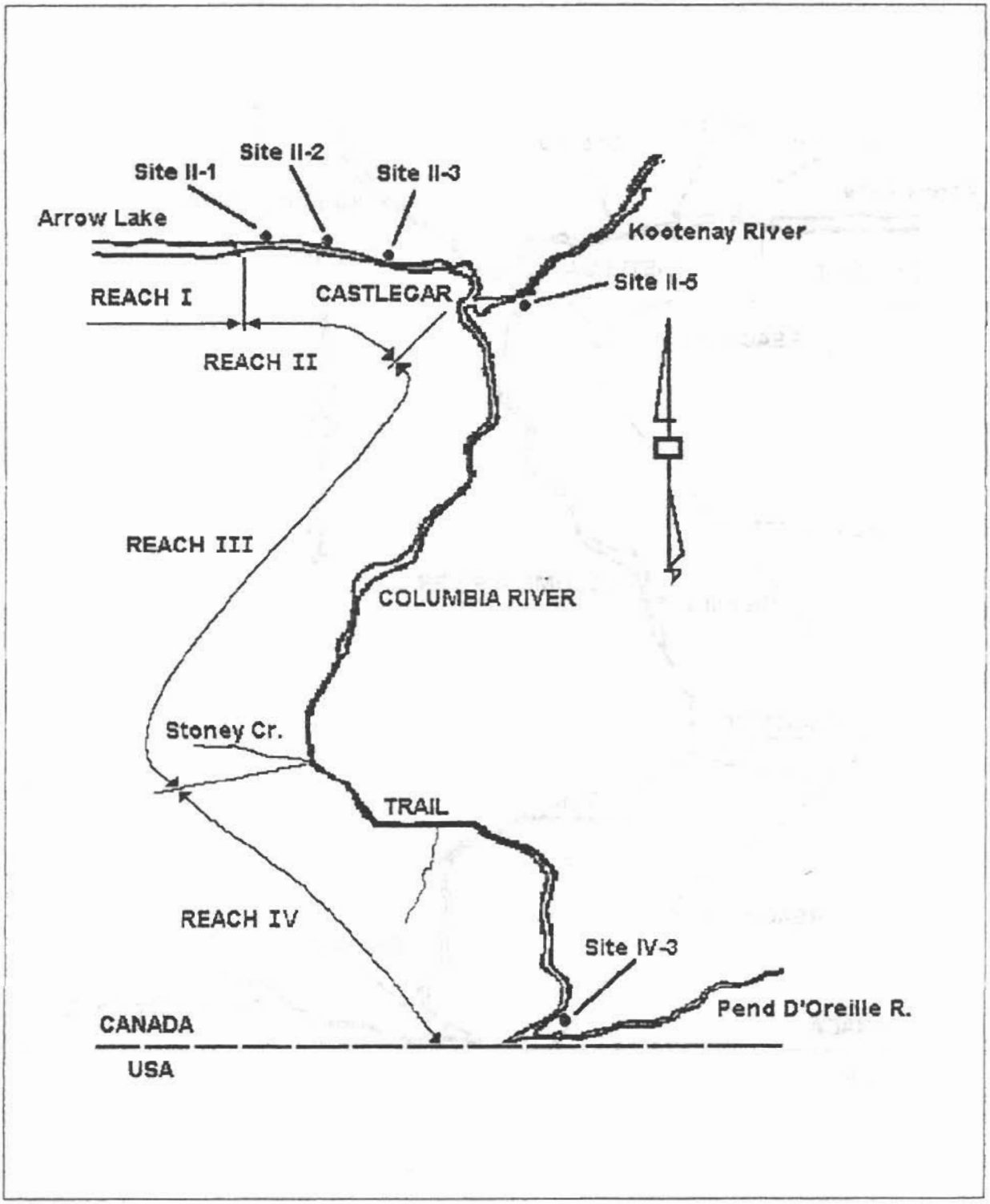


Figure 10.5 Clams Sampling Site Map

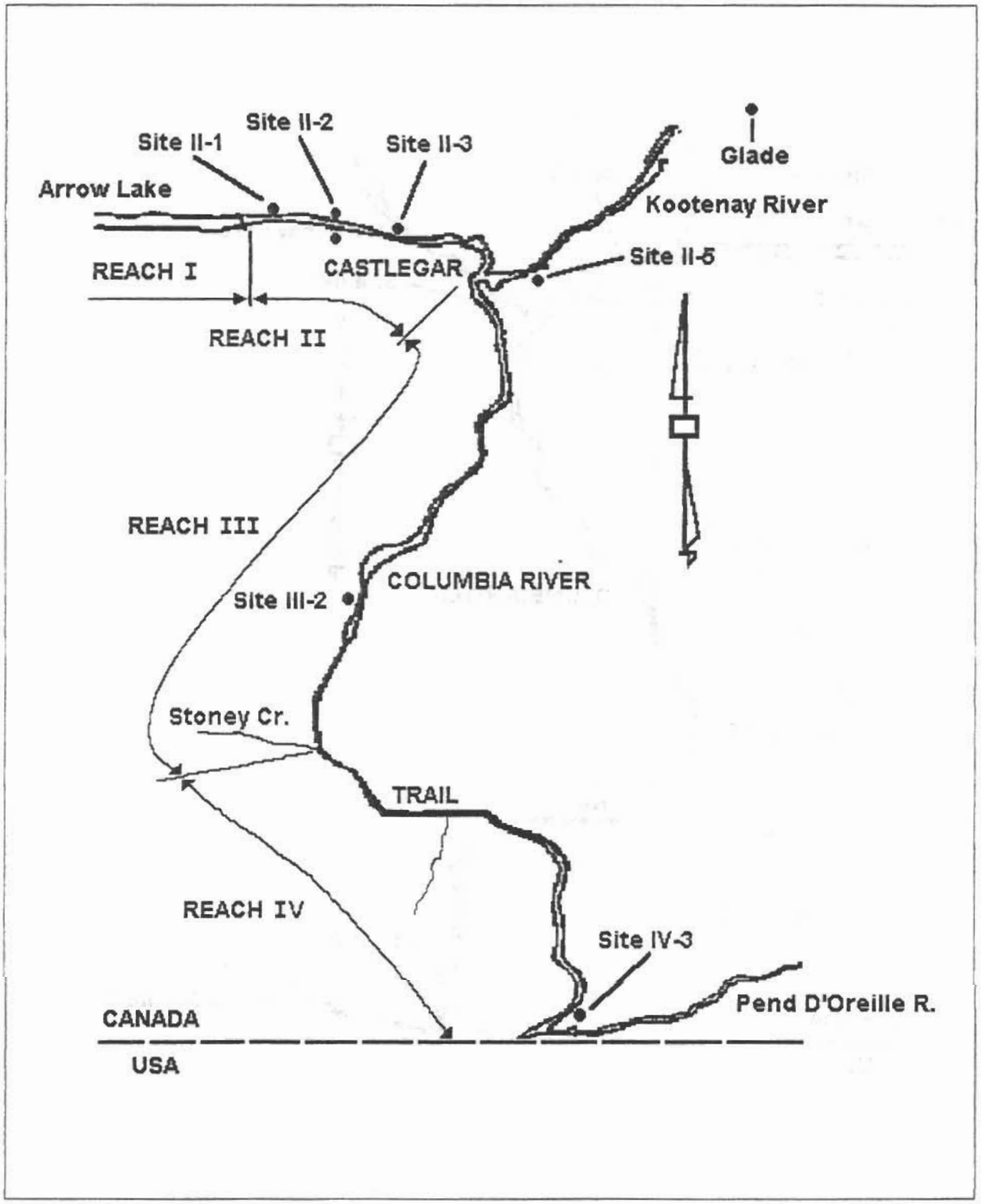


Figure 10.6 Caddis Fly Sampling Site Map

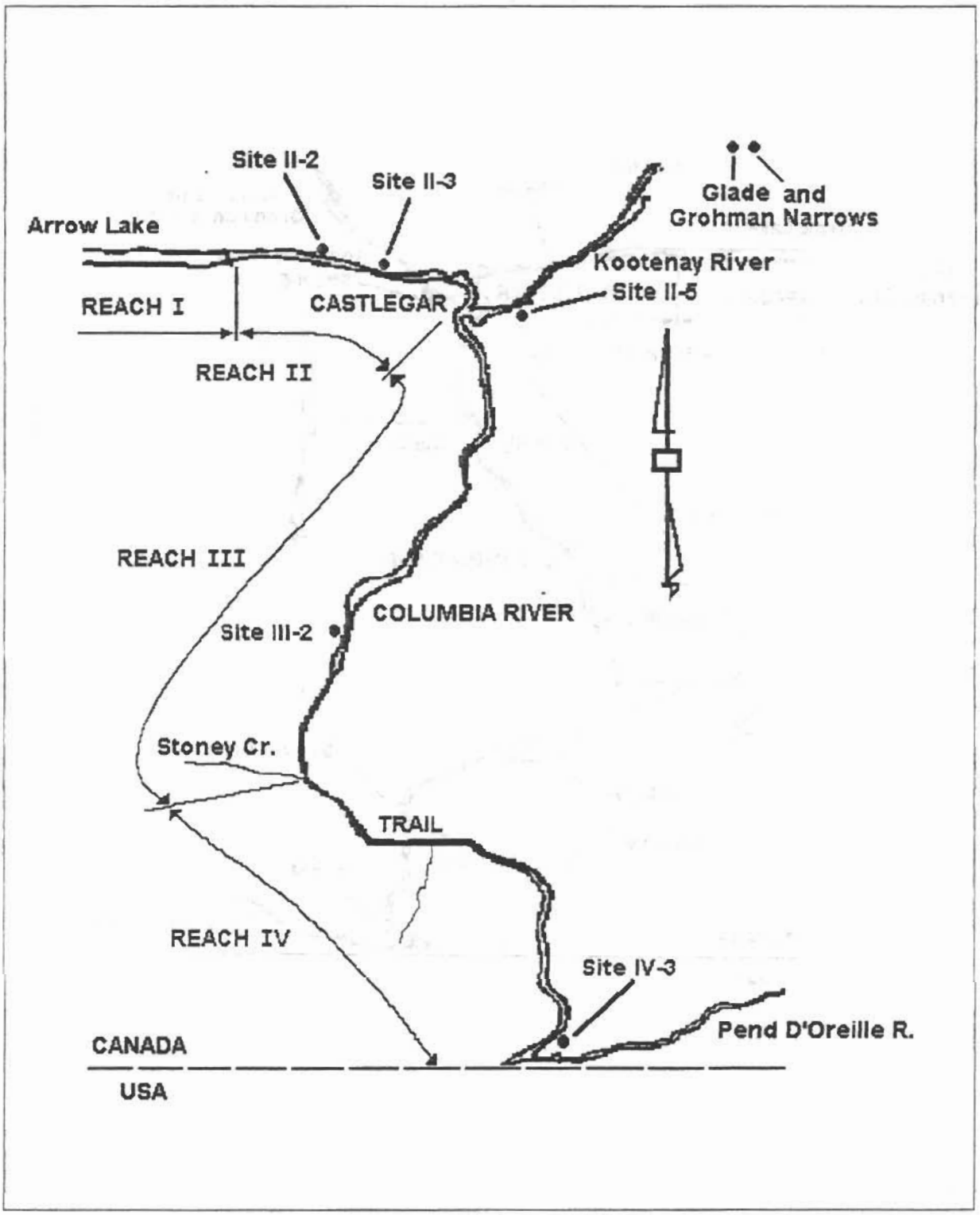
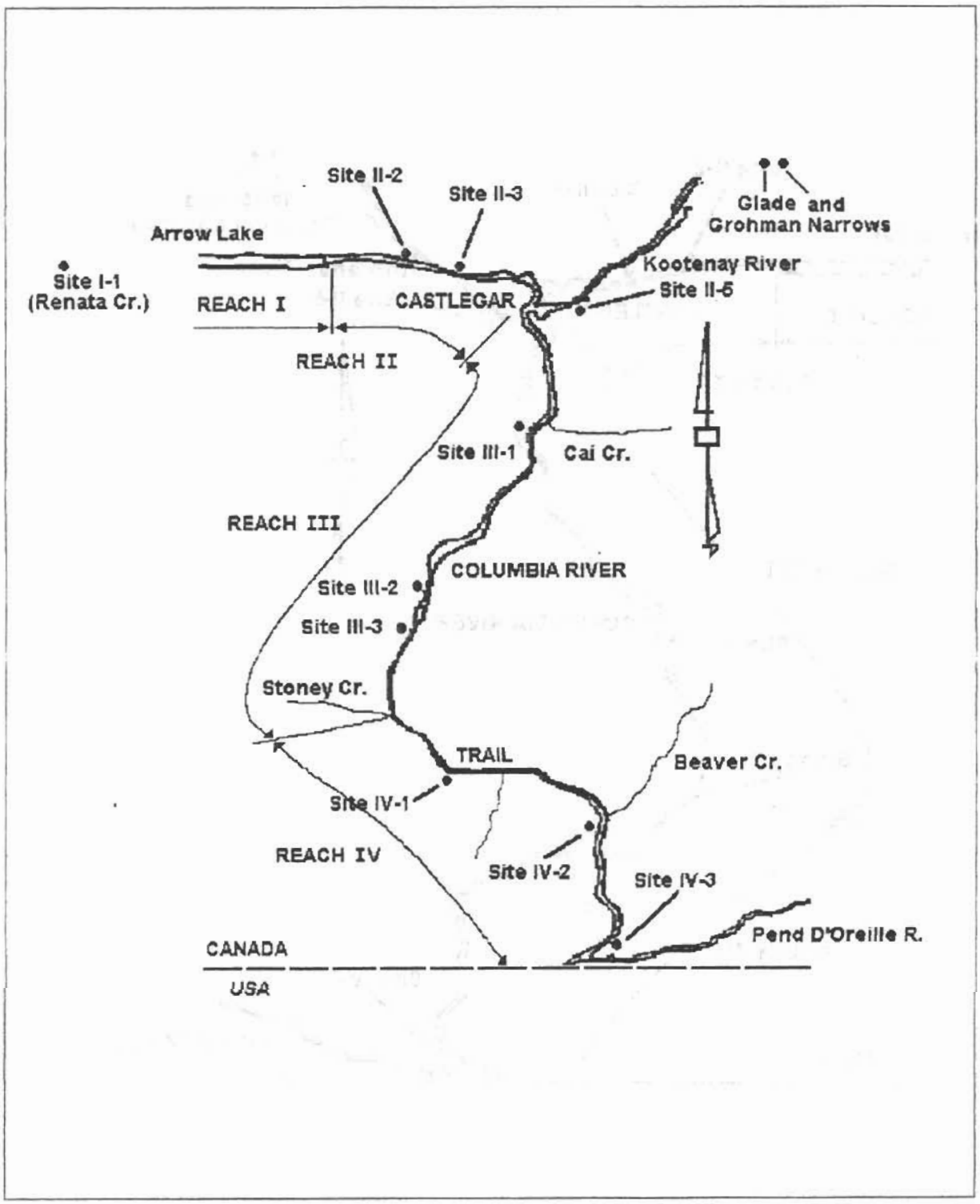


Figure 10.7 Sediment Sampling Site Map



11 APPENDIX - C: Field Sampling Procedures

11.1 SAMPLING FROM SHORE (FEDERAL PROCEDURE)

1) If wading is necessary to collect samples, 2 people must be present, and a floatation jacket or life preserver must be worn. If the river appears to be too high and/or swift for wading, then sample should be collected from shore. If sampling from shore, ensure a safe footing, and make sure you are well balanced, keeping in mind that the current may pull the sampler sharply downstream. Never take unnecessary risks.

2) In preparation for measuring the air temperature, remove cover from field thermometer and place in the shade, preferably about 1 metre above the ground and away from any vehicle, to minimize the heat influence from anything other than ambient air temperature. Leave the thermometer for 5-10 minutes or for the time it takes to collect the water samples. Measure the air temperature to the nearest 0.5 degrees (°C), and record the value in its designated location on the Federal data card.

3) Check sampler to ensure all fittings are tight.

4) Leave sample bottles in the sampling kit until ready to load sampler on shore, to prevent any potential contamination. If it is necessary to load sample bottles at vehicle, then leave caps on until ready to collect sample.

5) Take water samples from location indicated on site map, unless special circumstances exist. If it is necessary to take sample from somewhere other than designated spot, then this should be recorded in the "Remarks" section of the data card.

6) Always collect samples while facing upstream, to prevent increased suspended sediment caused by wading from entering the sample.

7) Rinse sampler once in river water.

8) Loosen bottle caps prior to loading sampler. Once bottles have been loaded, replace sampler top, and screw handle on to tighten.

9) Remove bottle caps and place in plastic bag provided. Avoid touching the insides of the caps with your fingers.

10) Collect the samples by submerging the sampler to the length of the handle below the surface. When collecting sample, avoid foam and floating debris.

11) Note time of sampling. If in-situ pH and conductivity are to be measured, refer to Protocols FS-12 and FS-13.

12) Cap bottles loosely, and return to vehicle to carry out sample preservation.

13) Back at vehicle, record air temperature and place thermometer in sample bottle labelled "FIELD" to equilibrate for at least 3 minutes.

14) Remove sampler top. Pour a small amount of water out of each sample bottle, shaking each before doing so, to ensure that the sample remains well-mixed.

15) Using the plastic gloves provided, add preservatives to those samples which need preservation, being sure to match each preservative with its similarly labelled bottle. Re-cap bottles tightly, and shake those to which preservatives have been added.

NOTE: Vehicle exhaust and cigarette smoke will contaminate water samples - these should be avoided when bottles are open.

16) Measure the water temperature within 5 minutes of sampling. Read water temperature by holding the bottle and the thermometer at eye level, and keeping the bulb of the thermometer submerged in the sample. Record water temperature in appropriate spot on data card.

17) Re-pack sampling kit, ensuring that glass bottles are separated from one another by plastic gloves to prevent breakage. Pack sponges in as tightly as possible to avoid bottle movement.

18) Complete data card as per Protocol FS-17. Put it back in its plastic bag, and pack it into sampling kit, along with the empty preservative vials.

19) Send sampling kit back to the Conservation and Protection (C&P) Laboratories on the same day that the samples are collected.

NOTE: Any deviations from this protocol must be noted in the "Remarks" section of the data card.

Sampling Techniques:

- If a bottle or cap is suspected of having been contaminated, rinse it thoroughly with river water, and make a note on the data card.

- If sampling kit can not be sent to the lab on day of sampling, bottles should be refrigerated overnight, and sent off the next day.

11.2 SAMPLING FROM SHORE (CRIEMP PROCEDURE)

1) If sampling from shore, ensure a safe footing, and make sure you are well balanced, keeping in mind that the current may pull the sampler sharply downstream. Never take unnecessary risks.

2) In preparation for measuring the air temperature, remove cover from field thermometer and place in the shade, preferably about 1 metre above the ground and away from any vehicle, to minimize the heat influence from anything other than ambient air temperature. Leave the thermometer for 5-10 minutes or for the time it takes to collect the water samples. Measure the air temperature to the nearest 0.5 degrees (°C), and record the value in its designated location on the Federal data card.

3) Leave sample bottles in the sampling kit until ready to sample, to prevent any potential contamination.

4) Take water samples from location indicated on site map, unless special circumstances exist. If it is necessary to take sample from somewhere other than designated spot, then this should be recorded in the "Comments" section of the laboratory requisition form.

5) Always collect samples while facing upstream, to prevent increased suspended sediment from entering the sample.

6) Put on plastic gloves. Remove bottle caps one at a time and place in plastic bag provided. Avoid touching the insides of the caps with your fingers.

7) Collect the individual samples by submerging the bottle below the surface. When collecting sample, avoid foam and floating debris. After sample is collected carry out sample preservation if necessary, tightly cap bottle, and shake well to mix preservatives.

8) Note time of sampling. Measure pH, water temperature, and conductivity and record in the "Comments" section of the requisition form.

9) Return capped bottles to the kit.

NOTE: Vehicle exhaust and cigarette smoke will contaminate water samples - these should be avoided when bottles are open.

10) Re-pack sampling kit, ensuring that glass bottles are separated from one another by plastic gloves etc. to prevent breakage. Pack sponges in as tightly as possible to avoid bottle movement.

11) Complete requisition form. Put it back in its plastic bag, and pack it into sampling kit, along with the empty preservative vials.

12) Send sampling kit back to Zenon Environmental Laboratories on the same day that the samples are collected.

NOTE: Any deviations from this protocol must be noted in the "Comments" section of the requisition form.

Sampling Techniques:

- If a bottle or cap is suspected of having been contaminated, rinse it thoroughly with river water, and make a note on the data card.

- If sampling kit can not be sent to the lab on day of sampling, bottles should be refrigerated overnight, and sent off the next day.

11.3 SAMPLING FROM BOAT (CRIEMP PROCEDURE)

1) Follow the shore sampling procedures except that you must make sure the gas tanks and exhaust have been covered to reduce the chance of gas and oil contaminants and other organic contaminants from the exhaust fumes.

2) Ensure that the boat is facing upstream into the current before sampling.

12 APPENDIX D: AXYS Analytical Services Methods

12.1 ANALYSIS OF POLYCHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

Samples are spiked with ^{13}C-labelled internal standards (tetra-chlorodibenzodioxin, tetra-chlorodibenzofuran, penta-chlorodibenzodioxin, hexa-chlorodibenzodioxin, hepta-chlorodibenzodioxin, and octa-chlorodibenzodioxin) prior to analysis. The sample is filtered, the filtrate and filter paper independently extracted and the extracts combined. After a series of washings and chromatographic cleanup steps, the extract is analyzed by GC/MS. The method detection limit is 60-240 ng/L (T4CDD/F - O8CDD/F).

Sample Storage

Samples are stored in a cool, dry place prior to analysis. They can be stored indefinitely and no preservation is required.

Extraction

A one litre sample is placed in a glass jug. An aliquot of internal standard is added and the sample filtered through a Millipore system.

The dried filter paper with particulate is soxhlet extracted with 80/20 toluene/acetone. The filtrate is stirred and extracted with dichloromethane. The extracts from the filtrate and particulate are combined and are ready for the washing and cleanup procedures.

Cleanup

The extract is subject to a series of cleanup steps including:

- washing with KOH
- washing with water
- washing with H_2SO_4
- washing with water
- column chromatography on silica gel
- column chromatography on alumina
- column chromatography on carbon/celite
- column chromatography on alumina

The final extract is evaporated to a small volume, transferred to a microvial and an aliquot of recovery standard added (^{13}C labelled 1,2,3,4-tetra-chlorodibenzodioxin, 1,2,3,6,7,8-hexa-chlorodibenzodioxin, and 1,2,3,4,6,7,8-hepta-chlorodibenzofuran). The extract is ready for analysis by GC/MS.

GC/MS

The extracts are analyzed by gas chromatography with mass spectrometric detection (GC/MS) operated in the multiple ion detection mode. The quadrapole GC/MS spectrometer is a Varian 3400 GC with a Finnigan Incos 50 mass spectrometer and a DG 10 data system. The high resolution GC/MS system is a VG 70 SE mass spectrometer with a Hewlett Packard 5890 gas chromatograph and a VAX work station.

QA/QC

A procedural blank is analyzed with each batch of samples. Matrix spikes and analysis duplicates are performed on a regular basis.

12.2 ANALYSIS OF CHLOROPHENOLS, CHLOROGUAIACOLS, AND CHLOROCATECHOLS

Extraction Methods

All samples are spiked with an aliquot of surrogate standard solution (containing ^{13}C-labelled 4-monochlorophenol, 2,4,6-trichlorophenol, 2,4,5-trichlorophenol, 2,3,4,5-tetrachlorophenol, and pentachlorophenol) prior to analysis.

Water

A one litre sample is spiked with an aliquot of surrogate standard solution. The pH of the sample is adjusted to pH 2 with concentrated sulphuric acid. The sample is then extracted three times with dichloromethane. The combined extracts are dried over anhydrous sodium sulfate, concentrated by rotary evaporation to 1 mL and transferred to a 250 mL separatory funnel.

Potassium carbonate solution is added to the separatory funnel, followed by acetic anhydride. The solution is shaken vigorously with venting. Hexane is added to the top, the mixture shaken and allowed to react for 30 minutes.

The acetylated sample is extracted with hexane, dried over anhydrous sodium sulfate and concentrated by rotary evaporation to 1 mL. The sample is ready for cleanup on silica gel.

Column Cleanup

The derivatized sample extract is loaded onto a silica gel column and eluted with isopropanol/toluene (30:70). The eluate is concentrated by rotary evaporation. The extract is then transferred to a centrifuge tube and an aliquot of recovery standard (2,6-dibromophenol) is added. The sample is then concentrated to 100 uL. The sample is ready for analysis by GC/MS.

Instrumental Analysis

Sample extracts are analyzed by gas chromatography (GC) with detection by mass spectrometer (MS). Analysis of the extract is carried out using a Finnigan Incos 50 mass spectrometer equipped with a Varian 3400 gas chromatograph with a CTC autosampler and a DG 10 Data system. The chromatographic separation is carried out using a Restek$_x$-5 column (30 m, 0.25 mm i.d. x 0.25 um film thickness). The mass spectrometer was operated in the EI mode (70 Ev) using Multiple Ion Detection (MID) to enhance the sensitivity, acquiring two characteristic ions for each target analyte and surrogate standard. A split/splitless injection sequence is used.

12.3 ANALYSIS OF CHLOROVERATROLES AND CHLOROANISOLES

Extraction Method

All samples are spiked with an aliquot of surrogate standard solution containing perdeuterated dibenzodioxin and dibenzofuran.

Water

A one litre sample is spiked with an aliquot of surrogate standard solution. The pH of the sample is adjusted to pH 2 with concentrated sulphuric acid. The sample is then extracted three times with hexane. The combined extracts are dried over anhydrous sodium sulfate, concentrated by rotary evaporation to 1 mL and transferred to a 250 mL separatory funnel.

The extract is loaded onto a silica gel column and eluted with dichloromethane. An aliquot of recovery standard (perdeuterated fluoranthene) is added and the extract is reduced in volume, placed in a microvial, and analyzed by GC/MS.

Instrumental Analysis

Sample extracts are analyzed by gas chromatography (GC) with detection by mass spectrometer (MS). Analysis of the extract is carried out using a Finnigan Incos 50 mass spectrometer equipped with a Varian 3400 gas chromatograph with a CTC autosampler and a DG 10 Data system. The chromatographic separation is carried out using a Restek$_x$-5 column (30 m, 0.25 mm i.d. x 0.25 um film thickness). The mass spectrometer was operated in the EI mode (70 Ev) using Multiple Ion Detection (MID) to enhance the

sensitivity, acquiring two characteristic ions for each target analyte and surrogate standard. A split/splitless injection sequence is used.

12.4 PREPARATION OF PRE-CLEANED BOTTLES

Sample bottles are obtained from two sources; they are either recycled empty bottles that the reagent solvent came in or they are purchased new from a supplier.

Sample bottles are washed with water and laboratory detergent. They are then rinsed with distilled water and baked at 350°C for at least six hours in a forced air oven. Randomly selected bottles are "proofed" to ensure that they are clean. A cleaned bottle is selected and thoroughly rinsed with three 100 mL portions of dichloromethane. The three rinses are combined and analyzed for the target compounds of interest. To do this, the combined solvent is spiked with a aliquot of the labelled surrogate standard used for each particular analysis, concentrated to a volume of 50 uL and analyzed by GC/MS in the same manner as a sample analysis. The proofed bottle is rebaked before use to ensure no residual solvent is present.

13 APPENDIX E: ASL Mercury Determination

13.1 LOW LEVEL DETERMINATION OF MERCURY IN WATER (0.005 PPB)

13.2 REFERENCE

U.S. EPA, 1986 Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW #846, 3rd ed. Washington, DC 20460.

13.3 GENERAL SUMMARY

Low level mercury is determined in a water sample by digesting it in a hot oven, using potassium permanganate and sulphuric acid. Hydroxylamine hydrochloride is added to the sample, to reduce the excess potassium permanganate and a stannous chloride solution is added to reduce the mercury.

13.4 PRECAUTIONS

1. Refer to Material Safety Data Sheets (MSDS) for information on potassium permanganate, sulphuric acid, potassium persulphate, hydroxylamine hydrochloride, stannous chloride, and nitric acid.

2. Care should be taken when handling sulphuric acid. If the concentrated acid must be diluted with water, always add acid to water and never water to acid.

3. Proper clothing, labcoats, eye protection, and gloves must be worn when handling these reagents.

13.5 DIGESTION PROCEDURE

1. Obtain the appropriate number of new 125 mL plastic bottles and fill all the bottles with a fresh 5-10% nitric acid solution, cap, and lay flat. Allow the bottles to soak for a minimum of one hour or overnight. Each bottle must be rolled over at least once during this time period to ensure that all sides of the bottles are washed with the nitric acid solution. *Note: use only Baker Instra-analysed grade nitric acid, for all requirements in this procedure.*

2. Empty each bottle and rinse 3-5 times with deionized/distilled water, including the lids. Shake out excess water and allow bottles and lids to dry in a Class 100 laminar flow clean work space.

3. Prepare a 100 ppb mercury standard by acid washing a 500 mL volumetric flask. Rinse flask well with deionized/ distilled water. Pipet 5.00 mL of 10 ppm mercury

standard into the flask and dilute with deionized/ distilled water. Acidify with 2 mL of nitric acid and bulk to the mark with deionized/ distilled water.

4. Make a set of calibrating standards by pipetting the appropriate amount of freshly prepared 100 ppb mercury standard into a clean bottle and dilute to 100 mL using a calibrated 100 mL bottle. The following set of calibrating standards can be used as a guide:

   i) Three reagent blanks
   ii) Two 0.005 ppb standards
   iii) Two 0.010 ppb standards
   iv) Two 0.030 ppb standards
   v) Two 0.050 ppb standards
   vi) Two 0.075 ppb standards
   vii) One 0.100 ppb standard
   viii) Two certified reference samples (ORMS & APG)

5. Shake out any excess rinse water in the bottle and then pour 100 mL of shaken water sample into it using a calibrated 100 mL bottle as a guide.

6. Into each bottle containing the 100 mL water sample, add the following reagents:

   i) 5.0 mL H_2SO_4 (high grade only)
   ii) 2.0 mL of 5% $KMnO_4$ solution

7. Cover each bottle with a lid and shake well in order to mix the reagents properly.

8. Loosen caps slightly and allow bottles to digest in a warm oven for 1 1/2 to 2 hours.

9. Cool digested samples for about 30 minutes before analysis.

10. Add about 1 mL of hydroxylamine HCl solution to each bottle just prior to analysis and swirl the bottle until all the purple and brown colour disappears and a clear colourless solution remains.

11. Add about 1 mL of $SnCl_2$ solution before analysis by cold vapour atomic absorption spectrophotometry.

13.6 QUALITY CONTROL

A certified reference sample is always included with each batch of analysis. Two duplicate samples per 10 samples are also included for analysis.

13.7 REPORTING

After determining the numbers from a linear calibration plot, enter the data onto the appropriate station sheet and hand into the data entry clerk.

14 APPENDIX - F: Columbia River Fish Health Study

This part of the program was written by Steve Sheehan and Jennifer Nener -Fisheries and Oceans.

14.1 STUDY OBJECTIVES

The Celgar Pulp Mill, which is located 3 km west of the City of Castlegar is currently undergoing an expansion and modernization. The mill currently operates on a variance order which permits it to discharge beyond government standards, however upon completion of new facilities, Celgar will be operating with the best available control technology for minimizing environmental impacts for that type of pulp being manufactured. Results of the 1991 DFO study (Boyle et al.) show that mountain whitefish living downstream from Celgar have significantly higher levels of PCB's, dioxins, furans, some metals, and an increased incidence of symptoms associated with stress than were measured in fish from a nearby reference population.

It is expected that with improvements being implemented at the Celgar mill there will be corresponding changes in the health of fish living downstream from the mill. The purpose of the six year DFO study is to monitor any such changes in order to increase our knowledge of long term impacts of pollutants originating from pulp mills, and to update mountain whitefish consumption advisories. Some of the contaminants of concern, such as dioxins and furans, are extremely persistent both in the environment and within tissues. It is therefore necessary to undertake a long term study in order to observe any changes that may occur.

14.2 MAIN CONSIDERATIONS

14.2.1 Dates

The first sampling of mountain whitefish for the DFO study took place from July 6 - July 17, 1992. Sampling will be repeated in July 1994 and July 1996.

14.2.2 Species

Mountain whitefish are the species of choice to serve as bio-indicators in the present study for the following reasons:

a) They are benthic feeders and therefore ingest organisms which live on the bottom of the Columbia River where organic contaminants adhere to sediment particles. Contaminants thus become concentrated in the tissues of benthic invertebrates, and accumulate further in tissues of organisms higher on the food chain, including

mountain whitefish. The relatively high fat content of mountain whitefish further increases the propensity for organic contaminants to accumulate in their tissues.

b) Tagging studies performed by Rivers, Lakes, and Land Environmental Services Ltd. (Edmonton) for BC Hydro indicate that mountain whitefish stay within a 5 km radius of their capture location on the lower Columbia River. They therefore serve as good bio-indicators for specific stretches of the river. It would be virtually impossible for a whitefish to move from the Genelle area to the reference reach, because of the Brilliant Dam, however the possibility of individuals moving from the reference reach to downstream sampling reaches cannot be excluded.

14.2.3 Sampling Reaches

The Slocan River, which flows into the Brilliant Reservoir, served as a reference reach in the 1992 study. The only industry located on this waterway is a sawmill which was located upstream of the sampling area. The sawmill was upgraded in the early 1980's and should not currently have any input of organic contaminants into the Slocan River. Fish were captured by angling and electrofishing.

Two reaches were sampled on the Columbia River - at Genelle, downstream of Celgar, and below Beaver Creek, which is downstream from Cominco. Fish were collected primarily by electrofishing, with a few individuals angled at Genelle.

14.2.4 Sampling Methods

As some of the analyses being performed required that fish be delivered to the mobile field laboratory alive, some traditional methods of fish capture could not be employed. At the reference reach fish were captured by angling and electroshocking. At Genelle and Beaver Creek angling was not successful in spite of intensive efforts of local fishermen, and with the exception of a few individuals angled at Genelle all fish were collected by electroshocking. Detection of symptoms of gas bubble disease and other conditions through histological analyses of tissues such as gill and kidney may be impaired by damage caused by electroshocking. Comparison of angled and electroshocked fish from the reference site should allow assessment of whether tissue damage is caused by electroshocking or some other condition.

Table 14.2 Columbia River Fish Health Study - Parameters to be measured or assessed in fish tissues

VARIABLE	# OF SAMPLES
General - wet weight, fork length, gonad and liver weight	All fish - approx. 60 per reach
Age	All fish
Disease* - bacterial, viral, and histological analyses	All fish
Gut Content Analyses	50 fish per reach
Analysis of guts for parasites	10 fish per reach
Liver Mixed Function Oxidase (MFO) Activity	16 fish per reach
Liver Metallothionein Activity	14-16 fish per site
Metals - in muscle	14-16 fish per site (all analysed for metallothioneins)
Organic Contaminants - dioxins, furans (high res.), chloroveratroles, PAH's, PCB's**, and lipids in muscle	10-14 fish per reach, a subset of fish analysed for MFO's

* includes histopathological analyses of gill, kidney, liver, spleen, posterior intestine, pyloric caeca/pancreas, and any tissue abnormal in appearance.

** PCB analyses will include arochlors with identification of individual cogeners, and a subset of 10 fish per site analysed for coplanar PCB's (77, 126, and 169) and mono-ortho-substituted PCB's (105, 118, and 156) if the budget permits.

14.2.5 Reporting of Results

Preliminary analytical results for all components of the project should be complete by November 1, 1992. Project participants responsible for specific components of the study will be involved with writing relevant portions of the report. The final report will be released when dioxin/furan data have been assessed for health implications by Health and Welfare Canada.

14.2.6 Project Expenditures

A detailed outline of expenditures is not yet available for the project. Green Plan funding for the project is $67,500 and an additional sum of $10,000 will be made available through CRIEMP.