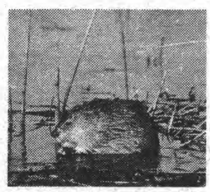
Canada Alberta Northwest Territories

Northern River Basins Study





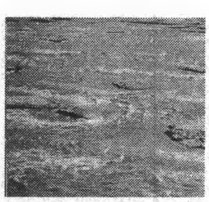





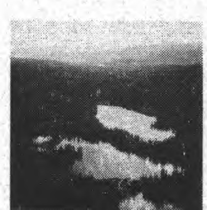
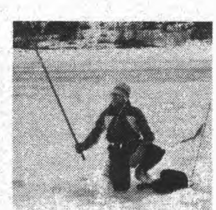
NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 106

ENVIRONMENTAL CONTAMINANTS IN BOTTOM SEDIMENTS,

PEACE AND ATHABASCA RIVER BASINS, OCTOBER, 1994 AND MAY, 1995





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Prepared for the
Northern River Basins Study
under Projects 2322-D1 and 2322-E1

by

Robert W. Crosley
Environment Canada

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PREFACE:

The Northern River Basins Study was initiated through the "Canada-Alberta-Northwest Territories Agreement Respecting the Peace-Athabasca-Slave River Basin Study, Phase II - Technical Studies" which was signed September 27, 1991. The purpose of the Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the Study Area by coordinating with existing programs and undertaking appropriate new technical studies.

This publication reports the method and findings of particular work conducted as part of the Northern River Basins Study. As such, the work was governed by a specific terms of reference and is expected to contribute information about the Study Area within the context of the overall study as described by the Study Final Report. This report has been reviewed by the Study Science Advisory Committee in regards to scientific content and has been approved by the Study Board of Directors for public release.

It is explicit in the objectives of the Study to report the results of technical work regularly to the public. This objective is served by distributing project reports to an extensive network of libraries, agencies, organizations and interested individuals and by granting universal permission to reproduce the material.

NORTHERN RIVER BASINS STUDY
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Whereas the above publication is the result of a project conducted under the Northern River Basins Study and the terms of reference for that project are deemed to be fulfilled,
IT IS THEREFORE REQUESTED BY THE STUDY OFFICE THAT;
this publication be subjected to proper and responsible review and be considered for release to the public.

(Dr. Fred J. Wrona, Science Director) — 22 Apr 96 (Date)

Whereas it is an explicit term of reference of the Science Advisory Committee "to review, for scientific content, material for publication by the Board",
IT IS HERE ADVISED BY THE SCIENCE ADVISORY COMMITTEE THAT;
this publication has been reviewed for scientific content and that the scientific practices represented in the report are acceptable given the specific purposes of the project and subject to the field conditions encountered.
SUPPLEMENTAL COMMENTARY HAS BEEN ADDED TO THIS PUBLICATION: [ ] Yes [ ] No

(Dr. P. A. Larkin, Ph.D., Chair) — April 23/96 (Date)

Whereas the Study Board is satisfied that this publication has been reviewed for scientific content and for immediate health implications,
IT IS HERE APPROVED BY THE BOARD OF DIRECTORS THAT;
this publication be released to the public, and that this publication be designated for: **[ ] STANDARD AVAILABILITY [ ] EXPANDED AVAILABILITY**

Lucille Partington
(Lucille Partington, Co-chair) — April 96 (Date)

R. McLeod
(Robert McLeod, Co-chair) — 30/04/96 (Date)

ENVIRONMENTAL CONTAMINANTS IN BOTTOM SEDIMENTS, ATHABASCA, PEACE AND WAPITI/SMOKY RIVERS, OCTOBER 1994 AND MAY 1995

STUDY PERSPECTIVE

River-borne sediments transport and accumulate contaminant compounds, which in turn can be transferred through the food chain from bottom-dwelling invertebrates to larger predatory species of fish. In 1992 and 1993, the Athabasca River and its major tributaries were investigated intensively by the Northern River Basins Study to determine the levels of pulp mill related contaminants in water, sediments and biota. These initial surveys documented detectable concentrations of several dioxins, furans and resin acids. The levels were many times higher in sediments than in water and, for some particular compounds, tended to persist with distance downstream. This report documents a follow-up investigation to gain a better understanding of contaminant concentrations and their distribution in both the Athabasca and Peace River drainages, by supplementing the data collected previously by NRBS and Alberta Environmental Protection from 1988-1993.

> ***Related Study Questions***
>
> *4a) What are the contents and nature of the contaminants entering the system and what is their distribution and toxicity in the aquatic ecosystem with particular reference to water, sediments and biota?*
>
> *4b) Are toxins such as dioxins, furans, mercury, etc. increasing or decreasing and what is their rate of change?*
>
> *13b) What are the cumulative effects of man-made discharges on the water and aquatic environment?*

This project report presents the analytical results and spatial trends for polychlorinated dibenzo-*p*-dioxins, dibenzofurans, resin acids, polyaromatic hydrocarbons (PAHs), chlorinated phenolics, PCBs, extractable organic halides (EOX), toxaphene and mercury in bottom sediment samples collected in 1994 and 1995. Sampling locations were chosen to provide (1) broad coverage of both the Athabasca and Peace River basins, (2) coverage of key mixing zones below four bleached kraft pulp mills, and (3) replication with locations sampled previously.

Fifteen depositional zones were sampled on the Wapiti, Smoky, Peace and Athabasca rivers. Highest levels of sediment resins acids were found on the Athabasca River near Emerson Lakes, and on the Peace River upstream of the mouth of the Smoky River. However, levels of resin acids have decreased significantly since previous surveys. Highest total PAH concentrations were found in the lower basin of the Athabasca River, and in the upstream sites on the Peace River. The highest concentrations of chlorinated phenolics were found downstream of bleached kraft mills in the upper Athabasca River and the Wapiti River. Dioxins and furans were present in low concentrations in bottom sediments of both river basins, and the results do not indicate widespread contamination from pulp mill effluents. Levels of the four most toxic congeners of dioxins and furans increased from 1988 results on the Peace River upstream of the Smoky River. Spatial trends in PCBs were not apparent in either basin, but the highest levels of total PCBs were found in bottom sediment from the Peace River upstream of the Smoky River. No detections were reported for EOX, toxaphene, or total mercury. Results of the within-site variability analyses varied with the compounds tested, demonstrating the need to sample intensively within a reach to produce a representative composite sample. Mean concentrations of some compounds were higher in the sand fraction than the clay-silt fraction of depositional sediment samples.

Similar to other studies, depositional sediments were found to be an important medium for accumulating several groups of contaminant compounds, and the levels are dropping in most locations. The data described by this project will be incorporated into a synthesis report addressing spatial and temporal trends of contaminants within these northern rivers. This document will provide the necessary interpretation and comparison with other studies dealing with contaminants in water and sediment downstream of pulp mills. In addition, results from this project will be incorporated into contaminant fate and food chain models being developed for these river systems.

REPORT SUMMARY

The Northern River Basins Study commissioned Environment Canada to undertake bottom sediment surveys of the Athabasca and Peace River basins in October 1994 and May 1995. The surveys were undertaken to provide a part of the answer to Question 4 of a series of questions which the NRBS was mandated to answer, dealing with the distribution of and temporal changes in contaminants in the Peace, Athabasca, and Slave River basins.

The 1994-95 bottom sediment surveys had four objectives: to determine the spatial distribution of contaminants in bottom sediments in the Athabasca and Peace River systems during 1994-95; to determine within-site variability in bottom sediment contamination at a number of locations; to test the assumption that the sand fraction is not an important repository of contaminants, and; to provide a 1994-95 dataset for comparison with earlier bottom sediment collections in 1988-89 and 1992.

ACKNOWLEDGMENTS

The author would like to acknowledge the following persons for assistance in the completion of this project:

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

1.0 INTRODUCTION

The activities of the Northern River Basins Study (NRBS) were organized around a series of scientific questions, one of which, Question 4, dealt with the distribution of and temporal changes in contaminants in the Peace, Athabasca, and Slave River basins.

Two bottom sediment surveys were undertaken by the NRBS prior to 1994-95. The first survey included 26 sites throughout the Peace and Athabasca River Basins collected and archived by Alberta Environmental Protection during 1988-89. A second survey, in the spring of 1992, provided samples from six sites along a 200 kilometer reach of the upper Athabasca River. This was an area selected for intensive study by the NRBS, usually referred to as the Reach Specific Study Area (R.L.and L. 1993). Reports describing the results of these surveys have been prepared (Brownlee et al 1994, Crosley 1994, Pastershank and Muir 1994).

Analyses of samples from both surveys were done on fine fraction (silt and clay) sediments, which were partitioned by sieving freeze-dried samples through 0.063 mm (4.0 PHI) stainless steel sieves. This was done in an attempt to standardize the results between samples having varying sand-silt-clay ratios, since a number of studies have shown that concentrations of hydrophobic contaminants tend to be inversely proportional to particle size (and surface area) of the sediment material. While this methodology may have advantages related to inter-site comparability, some reviewers have suggested that disregarding the sand fraction in analyses involves assumptions that cannot be fully justified (i.e. the assumption that the sand fraction contaminant load is not significant). In addition, the two surveys did not provide information regarding internal site variability required to assess sampling design, or adequate analytical replication to determine the significance of inter-site concentration differences. In addition, the analytical detection limits were, for some parameters, too high to detect ambient concentrations.

Environment Canada was contracted to undertake additional bottom sediment surveys of the Peace and Athabasca Rivers in October 1994 and May 1995. The objectives of these collections were:

1. To determine the spatial distribution of contaminants in bottom sediments in the Athabasca and Peace River systems during 1994-95.

2. To determine within-site variability in bottom sediment contamination at a number of locations.

3. To test the assumption that the sand fraction is not an important repository of contaminants.

4. To provide a 1994-95 dataset for comparison with earlier collections in 1988-92.

2.0 SEDIMENT SAMPLING METHODS AND SAMPLING LOCATIONS

2.1 BACKGROUND AND SAMPLING LOCATIONS

An initial bottom sediment survey was conducted during the period October 4-11, 1994, a low -flow period when depositional areas were readily accessible. Samples were collected at ten sites during this survey (Table 1). At nine sites (identified in Table 1 as 'composite' sites), samples were taken from a homogenized composite of 10 Ekman dredges collected from four depositional areas identified in each sampling reach. This sampling method was similar to the approach used in sampling programs in 1988, 1989, and 1992.

Sampling of the tenth site was designed to test internal site variability in particle size and contaminant burden. Ten depositional areas were sampled in a three kilometer reach of the Peace River below Daishowa (each depositional area sample was a composite from 5 Ekman dredges). The resulting ten discrete samples were not composited, but were retained for individual analyses.

Following a review of results from the October survey, it was determined that additional information on internal variability in particle size and contaminants was needed. A second survey was undertaken during the period May 8-12, 1995, a low-flow period immediately after ice-out. Five locations were sampled during this survey (Table 2), employing the same protocols used the previous October at the Peace River below Daishowa.

Sampling locations were chosen to provide broad coverage of both the Athabasca and Peace River basins, to provide coverage of key mixing zones below the four bleach-kraft mills currently operating in the basins, and to provide continuity where possible with sampling locations collected during 1988, 1989, and 1992. A map showing the 1994-95 sampling locations is shown in Figure 1.

2.2 BOTTOM SEDIMENT COLLECTION METHODS

During both October 1994 and May 1995, sampling reaches were surveyed initially to locate and enumerate the most obvious depositional areas. Depending upon the availability of depositional areas, the lengths of the sampling reaches varied from approximately two to five river kilometers. An attempt was made to sample a variety of depositional areas in each reach, such as slow water areas in bays, island lees, or inside corners. Equal numbers of depositional areas were sampled along each bank, to minimize bias which might be introduced by incomplete river mixing.

Samples were generally taken from shallow water areas near shore, but occasionally recently emerged beaches and banks were sampled. The size of depositional areas selected varied from small (approximately 200 square meters) to very large (perhaps 500,000 square meters). Depositional areas were more prevalent and tended to be larger on the Peace River than on the Athabasca River. Preference in choice of depositional areas was given to locations having the finest sediments.

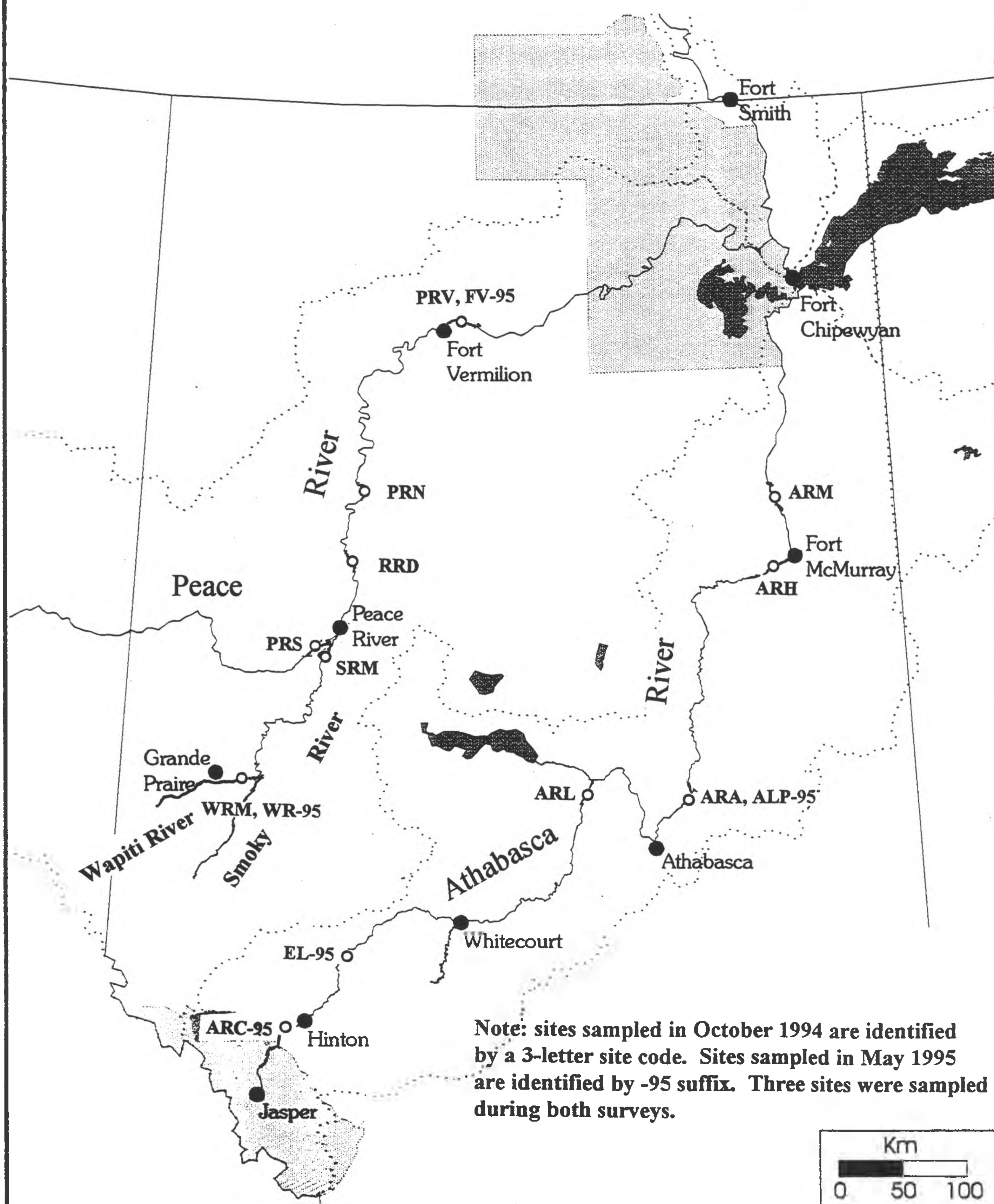
Table 1 Sampling Locations, October 1994 Survey

Sampling Location	Site Label	Sampling Method	Number of Samples	Sampling Date
Wapiti River near the Mouth	WRM	Composite	3 x Rep	Oct. 8, 1994
Smoky River near the Mouth	SRM	Composite	3 x Rep	Oct .4, 1994
Peace River upstream of Smoky River	PRS	Composite	3 x Rep	Oct .4, 1994
Peace River downstream of Daishowa	RRD	Discrete Area	10 Areas	Oct .5, 1994
Peace River upstream of Notikewin River	PRN	Composite	3 x Rep	Oct. 6, 1994
Peace River downstream of Fort Vermilion	PRV	Composite	3 x Rep	Oct. 7, 1994
Athabasca River upstream of Lesser Slave River	ARL	Composite	3 x Rep	Oct. 9, 1995
Athabasca River downstream of Alpac	ARA	Composite	3 x Rep	Oct. 10, 1994
Athabasca River upstream of Horse River	ARH	Composite	3 x Rep	Oct. 11, 1994
Athabasca River upstream of Fort McKay	ARM	Composite	3 x Rep	Oct. 11, 1994

Table 2 Sampling Locations, May 1995 Survey

Sampling Location	Site Label	Sampling Method	Number of Samples	Sampling Date
Wapiti River near the Mouth	WR-95	Discrete Area	10 Areas	May 10, 1995
Peace River d/s of Fort Vermilion	FV-95	Discrete Area	10 Areas	May 11, 1995
Athabasca River upstream of Hinton	ARC-95	Discrete Area	10 Areas	May 8, 1995
Athabasca River near Emerson Lakes	EL-95	Discrete Area	10 Areas	May 9, 1995
Athabasca River d/s of Alpac	ALP-95	Discrete Area	10 Areas	May 12, 1995

Figure 1 Bottom Sediment Sampling Locations, October 1994 and May 1995



Note: sites sampled in October 1994 are identified by a 3-letter site code. Sites sampled in May 1995 are identified by -95 suffix. Three sites were sampled during both surveys.

Collection equipment included a stainless steel Ekman dredge (152 mm x 152 mm x 152 mm) with operating handle, a stainless steel 2000 ml beaker, and stainless steel spatula. All equipment having contact with sediments was rinsed prior to sampling with acetone followed by hexane, and then by river water immediately before use. Pre-washed (EPA protocol) IChem wide-mouth 500 ml glass bottles with teflon cap-liners were used for sample storage.

Approximately 200 mls from the top 2 centimeters of each dredge was transferred by spatula to the stainless steel beaker. After sufficient dredges had been collected (ten dredges from a total of four depositional areas at 'composite' sites, and five dredges from each of ten depositional areas at '10 discrete area' sites) the resulting multi-dredge samples were homogenized using a stainless steel spatula. October 'composite' samples were split into triplicates; samples from '10 discrete area' sites were not split. Samples were labeled with a location code, a sequential number (to indicate either the split number or the individual depositional area), and the sampling date. Samples were transferred to a cooler containing dry ice within one hour of sampling, and transferred to a -60 degree C freezer upon return from the field.

Each depositional area during both surveys was located by a Magellan GPS unit and the latitude-longitude was recorded. As well, sampling locations were marked on the respective 1:50,000 map sheets, together with site-specific field notes. Detailed site location information and field notes are included in Appendix D.

2.3 ANALYTICAL PROGRAM

The analytical programs undertaken for the October 1994 and May 1995 samples are outlined below. Analyses of samples from both surveys were done at the same laboratories using the methodologies outlined in Section 2.4.

- The October 1994 survey produced 37 samples, made up of nine sets of triplicate-splits from 'composite' sites, and ten discrete-area samples from the Peace River downstream of Daishowa.
- The May 1995 survey produced 50 samples, with ten discrete-area samples from each of five sampling sites.
- Samples were freeze-dried.
- Particle size analyses were done on all freeze-dried samples.
- Samples were partitioned into clay-silt and sand fractions (63 micron or 4 PHI cutoff) using wet and dry sieving techniques.
- Organic and inorganic carbon were analyzed on all clay-silt and sand fractions. Sample partitioning, freeze-drying, particle size and carbon analyses were done at the National Water Research Institute Sedimentology Laboratory in Burlington, Ontario.
- All clay-silt and sand fractions from the discrete-area sites were submitted for resin acid analyses to provide an indication of the degree of internal site variance and sand fraction importance. For the 'composite' sites, a single clay-silt split (that with the median organic carbon concentration) was analyzed for resin acids.

- Following completion of resin acid analyses, additional organic analyses were performed (see below). Samples were selected for further analyses as follows: (1) for 'composite' sites, the clay-silt split which had been analyzed for resin acids (median organic carbon) was submitted for additional analyses; (2) for the Peace River below Daishowa, the clay-silt sample with the median total resin acids (sum of all reported compounds) was submitted for additional analyses; and (3) for samples collected in May 1995, three clay-silt and three sand fraction samples from each sampling site were submitted for additional analyses (the minimum, median, and maximum total resin acids in each case). Further analyses of samples from the Peace River below Fort Vermilion (May 1995) were not undertaken due to budget considerations.
- The following additional organic analyses were performed:
  - -PAH and alkylated PAH
  - -chlorinated phenols, catechols, guaiacols, syringols, vanillins, and syringaldehydes
  - -dioxins/furans including mono-,di-,and tri-,and non-2,3,7,8 congeners
  - -PCBs, PCB congeners, coplanar PCBs, and total toxaphene (October 1994 only)
  - -extractable organic halogen (October 1994 only)
  - -total mercury (October 1994 only)
- Analyses were done under contract by AXYS Analytical Laboratories in Sydney, B.C.
- A blind duplicate sample was submitted for analyses of all contaminant groups. A certified reference sample was submitted for dioxin-furan analyses. The analyzing laboratory provided results for routine laboratory duplicates with every analytical run (10 or less samples), as well as run blanks and matrix spikes. As a check on the splitting-homogenization procedure, all three clay-silt triplicate splits from one location (Athabasca River below Alpac, October 1994) were analyzed for resin acids.

2.4 ANALYTICAL METHODS

Freeze-drying, partitioning, and analyses of particle size and organic/total carbon were carried out at the Sedimentology Laboratory, Aquatic Ecosystem Restoration Branch, National Water Research Institute in Burlington, Ontario under the supervision of Max Barua. After freeze-drying in the original sample containers, the sample was rolled with a foil covered roller, an aliquot for particle size analyses was removed by cone and quartering, and the samples were sieved through a stainless steel 63 micron (4 PHI) sieve. Material passing the sieve was re-labeled with the original sample label and an F- (for fine) suffix added. Material remaining in the sieve was wet-sieved using organic-free Milli-Q water to remove any remaining fine material. After wet-sieving, the coarse fractions were freeze-dried a second time, bottled and labeled with a C- (for coarse) suffix. Sufficient aliquots were removed from the fine and coarse fractions for carbon analyses.

All equipment contacting the samples during the partitioning procedure including sieves, spatulas, and sieve trays, was soap and water washed, Milli-Q rinsed, and then rinsed with acetone and hexane and dried prior to use. The aluminum foil used in the rolling procedure was fired at approximately 350 degrees C for twelve hours, and cooled for three hours before use.

Particle size analyses were done using the Sieve and Sedigraph method. Details of the method are presented in a report by Duncan and LaHaie (1979). Organic and inorganic carbon were analyzed on the LECO-12 Carbon Determinator using a two temperature dry combustion method.

Samples for resin acids were spiked with a resin acid surrogate (0-methylpococarpic acid) prior to analysis. The procedure included sonication, solvent extraction, derivitization to esters, silica gel cleanup, and analysis by GC/MS. Ten resin acids were reported with detection limits generally near 1.0 ng/g.

Analyses of parent polyaromatic hydrocarbons (PAHs) and alkylated PAHs were analyzed by HRGC/LRMS following spiking by deuterated PAHs, solvent extraction, and cleanup and fractionation on silica gel. Analytical reports included results for 19 parent PAHs, and 17 alkylated PAHs (as totals based on degree of substitution). Detection limits varied with compound, but were generally below 1.0 ng/g.

Chlorinated dioxins and furans (mono-octa) were spiked with carbon-13 labeled surrogates, soxhlet extracted, and subjected to a series of washing and chromatographic cleanup steps before analysis by high resolution GC/MS. Detection limits for most dioxins and furans were below 1.0 pg/g.

Samples for chlorinated phenolics (including catechols, guaiacols, syringols, vanillins, and syringaldehydes) were spiked with a surrogate solution, sonicated, derivatized to acetylated compounds, and eluted on silica gel, prior to analysis by GC/MS. Results for 43 mono- to penta-chlorinated compounds were reported, with detection limits near 0.1 ng/g.

Samples for polychlorinated biphenyls (PCBs) (including PCB congeners and coplanar PCBs) and toxaphene were spiked with labeled surrogates, solvent extracted, and fractionated on Florisil. PCBs were analyzed by GC/MS, and toxaphene by negative ion GC/MS. PCBs as aroclor, 84 PCB congeners, and 3 coplanar PCBs were reported with detection limits < 1.0 ng/g. The detection limit for total toxaphene was near 0.1 ng/g.

All of the above organic analyses were carried out at AXYS Analytical Laboratory in Sydney, B.C. Detailed analytical protocols are available on request from the laboratory or from the NRBS archives.

Analyses of samples for extractable organic halogen (EOX) and total mercury were done by laboratories under sub-contract to AXYS. EOX was analyzed by Econotech Services Ltd., New Westminster, B.C. Samples were extracted with ethyl acetate and analyzed using a TOX Analyzer. Results were calculated relative to dry sample weight. Detection limit was 1.5 ug/o.d.g. Total mercury samples were analyzed by Quanta Trace Laboratories in Burnaby, B.C. Samples were acid digested and total mercury was determined by cold vapour UV (EPA Method 245.1). Methyl mercury was requested but not determined since total mercury was not detected. Detection limit was 0.1 ug/g (dry weight).

2.5 DATA ANALYSIS METHODS

The results for quality control aspects of the data including blinds, replicates, blanks, and spikes are discussed with the results for each contaminant group. All results included in this report are as reported by the analyzing laboratories. No correction for analytical recovery has been made, since the recovery corrections are made at the time of analyses by comparison with internal standards.

Values reported as 'less than detection limit' have been treated as zero in statistical analyses of the data. Values reported as NDR value (peak detected but not meeting quantification criteria) have been treated as the reported value in statistical analyses. All statistical testing was done using a significance level of α=0.05.

3.0 RESULTS AND DISCUSSION

3.1 PARTICLE SIZE AND CARBON

Statistical summaries of the results for particle size and carbon are presented in Tables 3,4. Detailed results appear in Appendix B.

3.1.1 Variability in Particle Size and Organic Carbon, Triplicate-Splits

The coefficients of variation for the triplicate-splits collected in October 1994 (Table 3) provide a measure of the errors involved in the homogenization and splitting procedure in the field, sub-sampling by cone and quartering in the laboratory, and of the analytical procedure. Additional error due to sub-sampling of size-fractioned samples would be expected to be present in the carbon results.

The triplicate sets from nine sites had coefficients of variation (C.V. = standard deviation x 100/mean) for particle size analysis as follows: percent sand 3.6-86.6 % (mean C.V. 24.7%); percent silt from 0.8-17.2% (mean CV 5.8%); and percent clay from 1.8-17.8% (mean C.V. 7.7%). The silt and clay results had similar coefficients of variation. Reduced reproducibility in the sand fraction may be related to the analytical technique used for sands (i.e. manual weighing of 0.063 mm sieve-retained material).

Clay-silt fraction organic carbon for the nine sample sets had coefficients of variation ranging from 2.3-31.9% (mean C.V. 15.4%). Sand fraction organic carbon C.V.s ranged from 6.3-29.3% (mean C.V. 21.3%).

Table 3 Particle Size and Carbon, October, 1994

Site	Statistic	n	%Sand	%Silt	%Clay	Fraction	%OC	%IC	%TC
Wapiti River near the	Mean	3	16.92	49.57	33.52	clay-silt	0.87	0.74	1.62
Mouth	StDev		5.18	4.61	1.73		0.14	0.13	0.10
	Mean	3				sand	1.81	0.87	2.68
	StDev						0.47	0.06	0.41
Smoky River near the	Mean	3	26.03	38.21	35.75	clay-silt	1.07	1.01	2.08
Mouth	StDev		1.99	0.69	2.65		0.17	0.05	0.22
	Mean	3				sand	1.16	0.89	2.05
	StDev						0.30	0.10	0.26
Peace River u/s Smoky	Mean	3	11.01	60.43	28.55	clay-silt	1.07	0.77	1.83
River	StDev		9.54	10.40	1.03		0.22	0.15	0.29
	Mean	3				sand	2.01	0.90	2.90
	StDev						0.13	0.08	0.16
Peace River downstream of	Mean	10	22.33	45.59	32.08	clay-silt	0.73	1.07	1.80
Daishowa	StDev		13.78	9.42	6.81		0.25	0.32	0.42
	Mean	10				sand	1.39	0.75	2.15
	StDev						1.88	0.10	1.92
Peace River d/s Notikewin	Mean	3	18.18	50.54	31.29	clay-silt	0.75	1.11	1.86
River	StDev		7.21	3.18	5.56		0.18	0.32	0.22
	Mean	3				sand	1.21	0.67	1.88
	StDev						0.35	0.10	0.26
Peace River downstream of	Mean	3	12.11	57.26	30.63	clay-silt	0.91	0.90	1.81
Fort Vermilion	StDev		2.54	4.58	3.57		0.29	0.14	0.38
	Mean	3				sand	1.67	0.78	2.45
	StDev						0.49	0.06	0.50
Athabasca River u/s	Mean	3	25.60	41.42	32.98	clay-silt	0.82	2.99	3.81
Lesser Slave River	StDev		2.45	0.34	2.37		0.05	0.22	0.26
	Mean	3				sand	0.66	1.51	2.17
	StDev						0.18	0.03	0.20
Athabasca River d/s	Mean	3	24.86	40.86	34.29	clay-silt	0.93	1.85	2.78
Alpac	StDev		2.58	0.77	2.14		0.15	0.14	0.26
	Mean	3				sand	1.53	1.36	2.88
	StDev						0.34	0.05	0.37
Athabasca River u/s	Mean	3	34.22	31.73	34.04	clay-silt	1.33	1.87	3.20
Horse River	StDev		1.24	1.14	0.60		0.03	0.14	0.17
	Mean	3				sand	1.04	0.77	1.81
	StDev						0.20	0.04	0.24
Athabasca River near	Mean	3	30.45	36.80	32.74	clay-silt	1.13	2.08	3.21
Fort McKay	StDev		4.01	1.39	2.87		0.06	1.05	1.05
	Mean	3				sand	1.10	1.01	2.10
	StDev						0.07	0.01	0.08

Table 4 Particle Size and Carbon, May 1995

Site	Statistic	n	%Sand	%Silt	%Clay	Fraction	%OC	%IC	%TC
Wapiti River near the	Mean	10	26.46	46.21	27.33	clay-silt	1.24	1.47	2.71
Mouth	StDev		14.73	9.32	6.12		0.41	0.16	0.50
	Mean	10				sand	1.40	1.00	2.40
	StDev						1.52	0.16	1.67
Peace River downstream of	Mean	10	22.87	47.41	29.72	clay-silt	1.51	1.11	2.62
below Fort Vermilion	StDev		14.95	7.81	8.91		0.34	0.31	0.44
	Mean	10				sand	0.77	1.05	1.82
	StDev						0.43	0.32	0.53
Athabasca River u/s	Mean	10	36.76	59.00	4.71	clay-silt	1.01	7.36	8.37
Maskuta Creek	StDev		11.48	9.21	2.27		0.19	0.24	0.29
	Mean	10				sand	0.78	5.73	6.42
	StDev						0.62	0.30	0.62
Athabasca River d/s	Mean	10	43.78	41.81	14.38	clay-silt	0.98	6.87	7.84
Emerson Lakes	StDev		20.48	16.14	8.45		0.29	0.55	0.68
	Mean	10				sand	0.88	5.26	6.14
	StDev						0.89	0.44	0.70
Athabasca River	Mean	10	37.74	37.17	25.09	clay-silt	1.30	2.28	3.58
downstream of Alpac	StDev		18.71	13.04	6.28		0.35	0.17	0.43
	Mean	10				sand	1.03	1.47	2.50
	StDev						0.54	0.22	0.72

3.1.2 Variability in Particle Size and Organic Carbon, Discrete Area Sites

Descriptive statistics for discrete area sites collected in May 1995 are presented in Table 4. For the purposes of this discussion, results for the Peace River downstream of Daishowa (October 1994, Table 3) are included, since that site was sampled in the same manner used in May 1995.

A comparison of the coefficients of variation from the discrete area sites (among-sample CV) with those of the composite triplicate-splits (within-sample C.V.) allows determination of the extent of intra-site variability independent of sampling, handling, and analytical factors (Table 5).

Table 5 Comparison of Coefficients of Variation in Particle Size and Organic Carbon Triplicate- Split Composites verses 10-Discrete Depositional Areas

Parameter	Mean C.V. Triplicate-Splits (Percent) **Within-Sample Nine Sites**	Mean C.V. Discrete Area (Percent) **Among-Sample Five Sites**
Percent Sand	24.7	51.7
Percent Silt	5.8	24.5
Percent Clay	7.7	34.3
Organic Carbon Clay-Silt Fraction	15.4	27.5
Organic Carbon Sand Fraction	21.3	88.8

Coefficients of variation of particle size analyses for the discrete area sites were as follows: percent sand (range 31.2-65.4%, mean 51.7%); percent silt (range 15.6-38.6%, mean 24.5%); and percent clay (range (22.4-58.8%, mean 34.3%). A comparison of within-sample CVs with among-sample CVs shows that variability related to intra-site variability exceeded that related to handling-analytical error for all three size fractions (ie. the C.V.s among-sample were more than twice the C.V.s within-sample).

Organic carbon C.V.s at the discrete area sites were as follows: organic carbon in clay-silt fraction (range 18.8-33.1%, mean 27.5%), and in sand fraction (52.4-109%, mean 88.8%)(Table 5). Much higher intra-site variability in organic carbon in sand than in clay-silt likely relates to presence/absence of decomposing organic matter (woody materials, bark, needles, etc.) which sieve mostly to the sand fraction. Variability in the presence of obvious organic layers was noted at the time of sampling, both within and between sampling sites.

Levine's Test was performed to determine whether the sampling sites exhibited significantly different levels of variability. The test showed that within-site variance in particle size and organic carbon was not significantly different among sites.

The magnitude of internal site variability in particle size and organic carbon found in these surveys indicates that sampling of one depositional area (one beach, bar, or backwater), regardless of the degree of compositing done in that area, is not adequate to confidently describe a sampling reach. The methods used in October 1994 (10 sub-samples composited from four depositional areas) were likely sufficiently vigorous to provide a reasonable estimate of the mean.

3.1.3 Comparison of Particle Size and Carbon Results, October 1994 and May 1995

Boxplots of particle size results for sampling locations collected during both October 1994 and May 1995 are presented in Figure 2. Subtle seasonal trends in particle size were apparent at all three sites, with sediments slightly coarser in May 1995 than the previous October. At the Wapiti River near the mouth and Athabasca River downstream of Alpac, clay was significantly lower in May ($\rho<0.05$). At the Peace River downstream of Fort Vermilion, increases in sand and decreases in silt between October and May were significant ($\rho<0.05$).

This trend may indicate the effects of ice scouring during the spring breakup, when some re-suspension of finer sediments would be expected. An alternative explanation for the trend is related to the sampling method. Four depositional areas were sampled in each reach during October, and ten depositional areas during May. Increased coarseness in the May samples may be a result of the necessity to sample some less-than-ideal (less fine) depositional areas during the second survey to fulfill sampling requirements.

Seasonality was also seen in the carbon results. Organic and inorganic carbon increased significantly ($\rho<0.05$) from October to May in the clay-silt fraction at all locations (Figure 3). In the sand fraction (Figure 4), organic carbon decreased between October and May (significant decrease at Peace and Athabasca locations only). Apparent increases in inorganic carbon at all three locations were non-significant at $\rho<0.05$). Carbon trends likely reflect over-winter oxidation of organic matter.

As discussed in 3.1.2, higher variability in both particle size and carbon at the discrete area sample locations is shown in the broader boxes and whiskers for May (Figures 2,3,4).

Notes on Box and Whisker Schematic Plots: A number of box and whisker schematic plots are presented in Section 3. These plots provide a convenient way of displaying data distributions, while retaining graphical display of outliers. The inner box indicates the median, 25th, and 75th quartiles. The upper and lower hinges are 1.5X the range of the inner box. Values termed 'outside' fall beyond 1.5X the 25-75 quartile range (*) and those termed 'far outside' are beyond 3X the 25-75 quartile range (o).

Figure 2 Particle Size, October 1994 (n=3) and May 1995 (n=10)

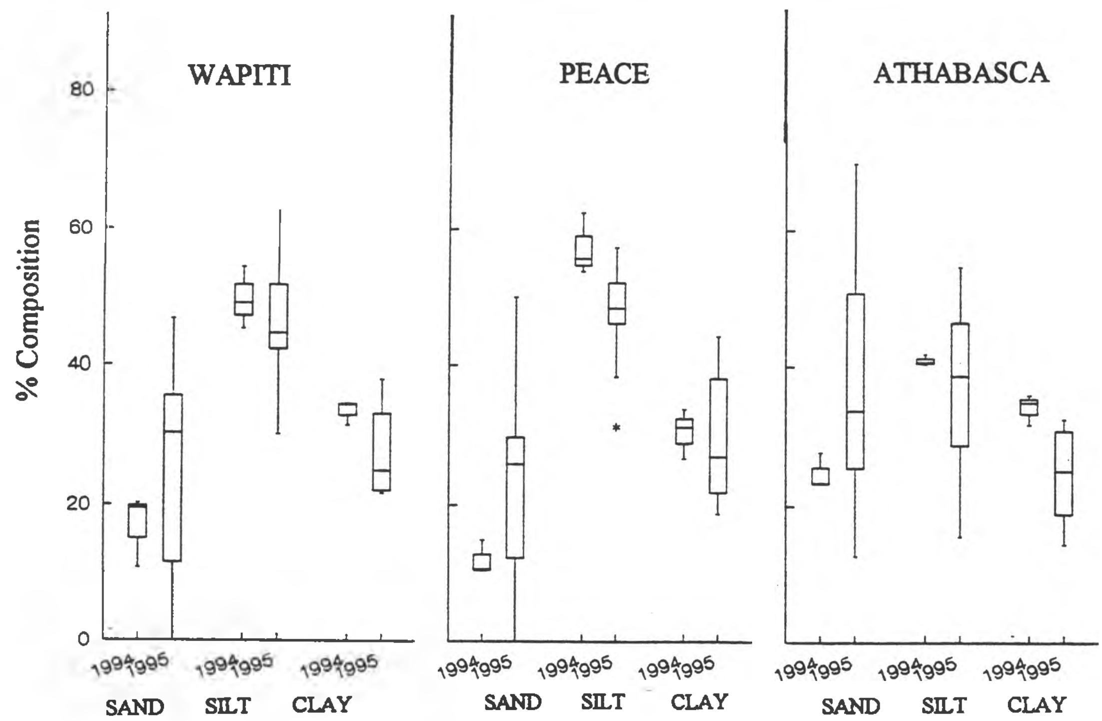


Figure 3 Carbon in Clay-Silt Fraction, October 1994 (n=3) and May 1995 (n=10)

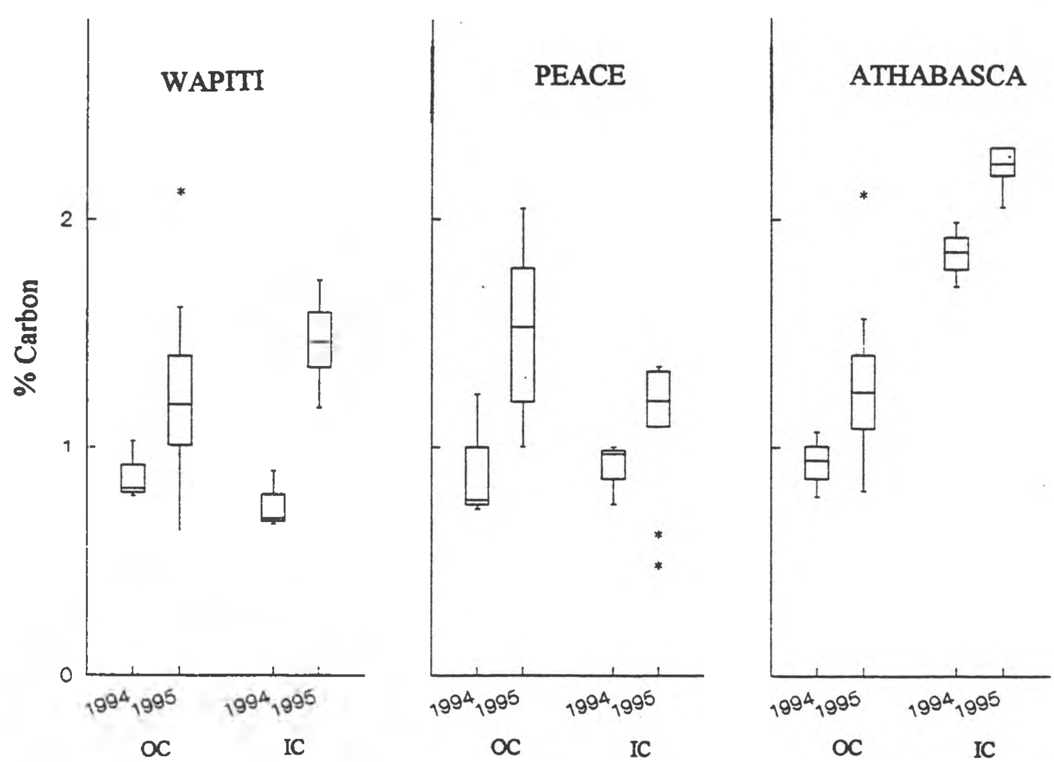
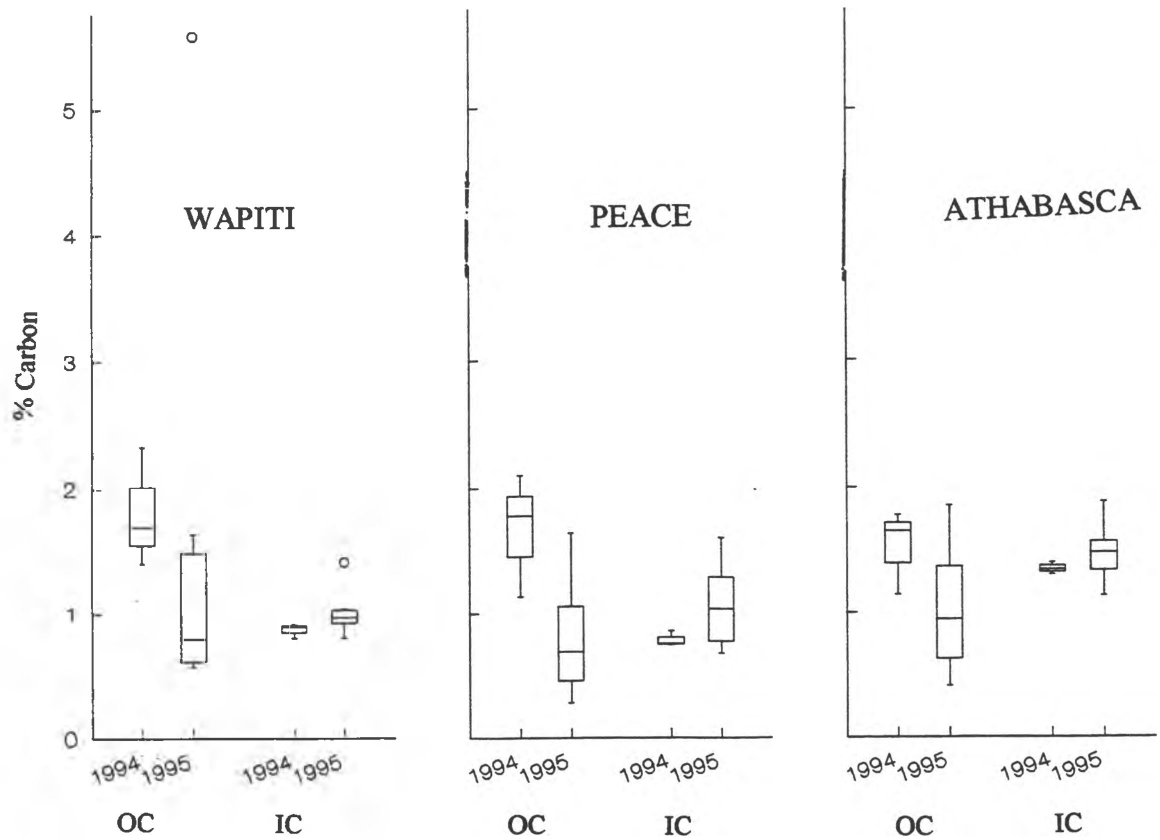


Figure 4 Carbon in Sand Fraction, October 1994 (n=3) and May 1995 (n=10)



3.1.4 Inter-site Spatial Trends in Particle Size and Carbon

Spatial results for particle size are presented in Figures A1 and A2 (Appendix C). It should be noted that since an attempt was made to sample the finest depositional material available at each sampling site, upstream-downstream spatial differences were likely minimized to some degree.

The two upstream sites on the Athabasca River (u/s Hinton control and d/s Emerson Lakes) were coarser than the four sites between the Lesser Slave River and Fort McKay (Figure A1). Samples from the upper sites had from 37-44% sand and from 5-14% clay, while samples from the four downstream locations had relatively equal proportions of sand, silt, and clay. Once again, high variability at the discrete area sites is reflected in broader ranges of results in May.

No consistent upstream-downstream trends were apparent in results from the Peace River (Figure A2). Total fines (clay + silt) at Peace River sites tended to be higher than those in the Athabasca River. Silt was the dominant size fraction at all Peace River sites.

The clay-silt and sand fractions from Athabasca River samples showed similar spatial trends in inorganic carbon, with decreasing concentration moving downstream (from 5-8% C-inorganic at the upper sites decreasing to 1-2% percent at the downstream sites) (Figure A3 and A4, Appendix C). Organic carbon in both size fractions from the Athabasca River was near 1% C-organic. Spatial trends in clay-silt samples from Peace River basin samples were not apparent, with approximately 1% carbon (both C-inorganic and C-organic) at all six sampling sites. In the sand fraction, organic carbon (1-2%) exceeded inorganic carbon by factors near two at all Peace River basin sites. Again, no spatial trends in sand fraction carbon were apparent.

3.2 RESIN ACIDS

Resin acids are naturally occurring constituents of tree bark and wood, with concentrations in coniferous trees exceeding those in deciduous trees by as much as 8:1 (Wise and John 1952 in Cirrus Consultants 1990). The concentrations of resin acids in pulp mill effluents is dependent upon three factors: the wood furnish, the pulping process, and the degree of biological treatment of the effluent. Chlorinated resin acids are resistant to degradation, and are sometimes used as markers of bleach-kraft mill markers.

Resin acid analyses were done on both clay-silt and sand fractions from all six discrete area sampling sites. The discrete area sites included reaches below all four bleach-kraft pulp mills in the basins (Weldwood, Alpac, Weyerhaeuser, and Daishowa), an upstream control site on the Athabasca River (u/s Hinton), and a downstream reach on the Peace River (d/s Fort Vermilion). Resin acids were analyzed on samples from these sites to provide a measure of in-site contaminant variability, and to allow comparison of the resin acid loading in the fine and coarse fractions. The resin acid results were reviewed prior to submitting samples for additional organic analyses (PAH, dioxin-furans, chlorophenols, etc.).

In addition, single resin acid analyses were done on October 1994 clay-silt samples, to provide the data needed for spatial interpretation. All three clay-silt splits from the Athabasca River downstream of Alpac were analyzed to check on the field splitting procedure.

The results for nine non-chlorinated resin acids and three mono- and di-chlorinated resin acids were reported. Detailed analytical results for resin acids are presented in Appendix B.

3.2.1 Quality Control

The analyzing laboratory reported the results for 22 laboratory duplicates. Of these, 13 clay-silt duplicates had a range of precision from 0.3-23.7 % (mean 9.3%), and 9 sand duplicates had precision from 19.3-81.9% (mean 34.1%). (Precision has been calculated as the difference between duplicates in total resin acid concentration (i.e. the sum of all analytes) over the mean concentration.) Poorer reproducibility in the sand fraction is likely due to the nature of the sand samples, which contained varying amounts of organic material, including quantities of decomposing wood, bark, needles, etc. The presence or absence of material such as this in the aliquot sub-sampled for resin acids would be expected to have a large effect on the analytical result.

Two blind duplicates submitted for resin acids (both were clay-silt samples from Peace River below Daishowa) differed by 20.0% and 83.6% from the parent sample (total resin acids), significantly poorer precision than was demonstrated for in-laboratory duplicates.

Good precision was shown in clay-silt triplicate-splits from the Athabasca River downstream of Alpac, with total resin acids ranging +/- 7.2% around the mean of 342 ng/g. This indicates that error introduced by sample splitting was relatively low.

A Wapiti River reference sample submitted for resin acid analyses contained 855 ng/g total resin acids. Earlier 5-replicate analyses of this reference material reported total resin acids ranging from 656-838 ng/g, for an average of 757 ng/g (Lee and Peart 1995).

3.2.2 In-Site Variability in Resin Acids

The resin acid results for the discrete area sampling locations are presented in Table 6. The sand fraction results were skewed by a number of very high results, likely due to the presence of woody materials in the samples (note the outliers in Figure 8). The average C.V. in sand fractions (all six locations) was 155%, much higher than the average C.V. for clay-silt fractions (35.9%).

3.2.3 Comparison of Resin Acids in Sand and Clay-Silt Fractions

Four of six locations had higher mean concentrations of total resin acids in sand than in clay-silt (Table 6). The mean concentrations were affected by high outliers in data from Athabasca River d/s Emerson Lakes, Wapiti River near Mouth, and Peace River d/s Daishowa (Figure 9). Non-parametric ANOVA (Kruskal-Wallis one-way) indicated that resin acids were significantly higher ($\rho<0.05$) in clay-silt than in sand at three sites (Peace River d/s Daishowa, Peace River d/s Ft. Vermilion, and Athabasca River d/s Emerson Lakes), while resin acids were significantly higher in sand than in clay-silt at the control site, Athabasca River u/s Maskuta Creek. The two size fractions were not significantly different at the Wapiti River near Mouth and Athabasca River d/s Alpac.

A comparison of resin acids contributed by the sand and clay-silt size fractions is presented in Table 7. Resin acids in sand varied from 11.0 to 79.1 percent of the total sediment resin acids. (Note that the analyses in Table 7 use the mean concentration. The use of the mean is supported since compositing of samples, the normal procedure in sediment sampling, will produce a concentration nearer the mean than the median). The sites having the most important sand component were the upstream sites (Athabasca River u/s Maskuta Creek (sands provided 79.1% of total resin acid load), Athabasca River d/s Emerson Lakes (58.2%), and Wapiti River near the Mouth (52.7%). The lower sites in the Peace River basin (d/s Daishowa and d/s Fort Vermilion) had lower sand loads (near 11% of total resin acid load). These two sites had the finest sediments of the discrete area sites.

Table 6 Resin Acids at Discrete Area Sampling Sites, October 1994 and May 1995 (results in ng/g)

Site	Fraction	Statistic	Pimaric	Sandaracopimaric	Isopimaric	Palustric	DHI	DHA	Abietic	Neoabietic	12/14 Cl-DHA	12,14-DiCl-DHA	Total Resin Acids
Wapiti River near the Mouth	Clay-Silt	MEAN	46.3	1.6	45.0	ND	ND	95.3	109	0.26	4.3	0.63	302
08-May-95		StDev	16.5	2.8	11.8	ND	ND	25.7	48.4	0.82	3.0	1.3	88
	Sand	MEAN	27.8	28.1	138	28.0	0.9	389	315	2.3	1.9	1.5	933
		StDev	32.0	47.0	190	55.0	1.2	712	386	4.9	2.3	1.4	1407
Peace River d/s Daishowa	Clay-Silt	MEAN	87.3	46.4	281	4.5	4.5	488	808	0.92	0.14	ND	1720
05-Oct-94		StDev	33.3	18.6	119	8.1	6.9	157	721.99	2.9	0.44	ND	995
	Sand	MEAN	9.7	24.8	114	13.0	0.35	394	213	9.9	1.4	0.9	739
		StDev	14.6	38.3	162	34.6	1.1	747	249	23.9	4.1	2.8	1240
Peace R d/s Ft. Vermilion	Clay-Silt	MEAN	51.1	22.3	134	6.0	2.4	230	369	1.9	1.1	0.06	818
11-May-95		StDev	16.6	7.3	34.2	4.6	1.7	43.7	140	1.9	0.90	0.19	236
	Sand	MEAN	11.2	9.8	61.5	5.9	1.2	157	95.4	0.94	ND	ND	343
		StDev	6.4	4.8	50.2	10.6	1.3	80.3	65.2	1.7	ND	ND	161
Athabasca River u/s	Clay-Silt	MEAN	7.8	3.9	13.0	3.6	ND	55.8	16.8	4.7	ND	ND	106
Maskuta Creek		StDev	6.6	3.3	9.0	3.8	ND	10.8	22.6	5.1	ND	ND	48
08-May-95	Sand	MEAN	15.4	25.7	72.2	20.9	0.35	288	263	3.5	ND	ND	689
		StDev	14.1	27.8	76.8	14.9	1.1	304	428	9.7	ND	ND	816
Athabasca River d/s	Clay-Silt	MEAN	594	28.6	377	17.6	40.7	271	419	ND	38.0	40.6	1827
Emerson Lakes		StDev	191	9.1	103	10.7	20.2	64.4	218	ND	19.0	29.1	517
09-May-95	Sand	MEAN	81.0	98.0	399	73.2	2.9	1564	1018.1	16.9	5.8	10.9	3270
		StDev	121	218	986	189	6.3	3196	2633.6	50.3	4.3	8.0	7263
Athabasca River d/s Alpac	Clay-Silt	MEAN	37.5	6.4	42.6	ND	0.65	86.8	70.0	ND	4.5	5.1	254
12-May-95		StDev	18.2	1.0	15.2	ND	1.1	33.8	36.8	ND	1.5	1.6	66
	Sand	MEAN	11.3	12.3	62.4	10.2	0.50	161	159	1.1	1.0	2.3	422
		StDev	9.4	12.1	61.5	13.7	0.85	134	186	2.7	1.1	2.2	378

The results indicate that analyses of fines-only for resin acids could lead to either over- or underestimation of the total resin acid concentration, dependent upon site specific factors

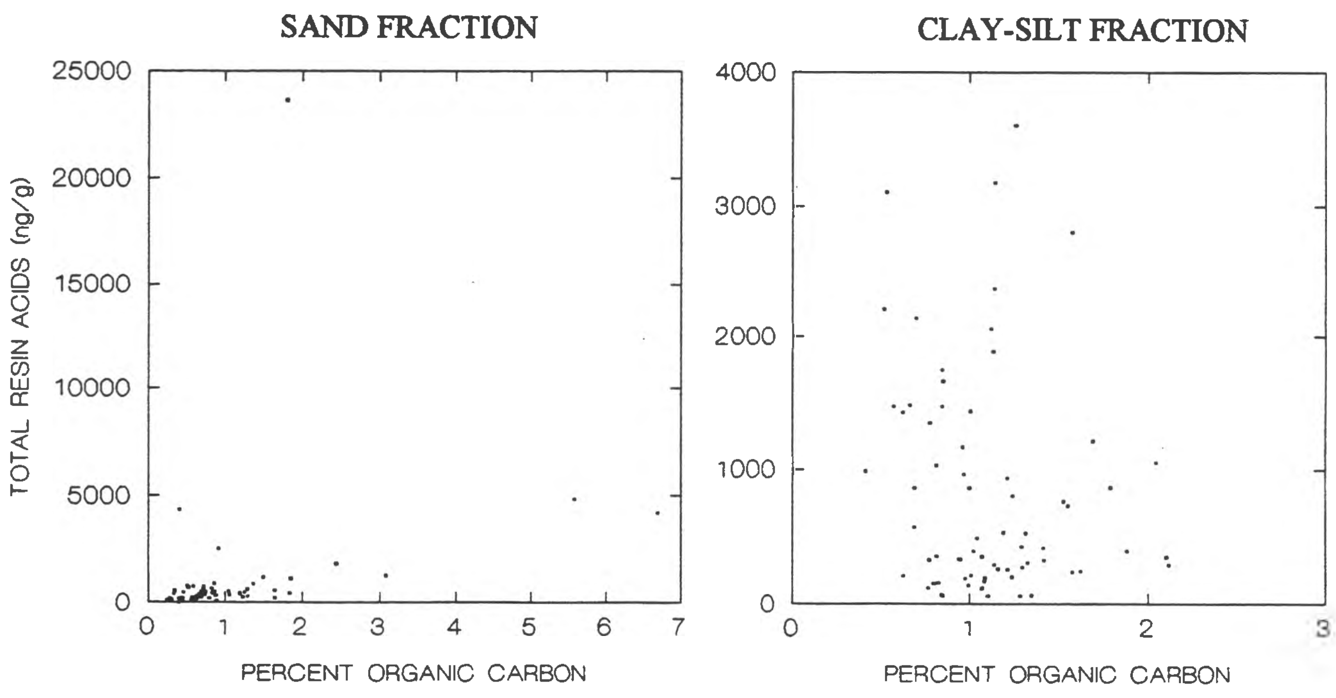
Table 7 Resin Acids: Contribution from Sand and Clay-Silt Size Fractions

Sampling Site	Mean Percent Sand (n=10)	Mean Sand Concentration Total Resin Acids (ng/g) (n=10)	Resin Acids Load Sand / Load Total (%)	Mean Percent Clay + Silt (n=10)	Mean Clay+Silt Concentration Total Resin Acids (ng/g) (n=10)	Resin Acid Load Clay+Silt / Load Total (%)
Wapiti River near Mouth	.265	933	52.7	.735	302	47.3
Peace River below Daishowa	.223	739	11.0	.777	1720	89.0
Peace River below Ft. Vermilion	.229	343	11.1	.771	818	88.9
Athabasca River above Maskuta Creek	.368	689	79.1	.632	106	20.9
Athabasca River below Emerson Lakes	.438	3270	58.2	.562	1827	41.8
Athabasca River below Alpac	.377	422	50.1	.623	254	49.9

3.2.4 Correlation of Total Resin Acids with Organic Carbon

Correlation was found between total resin acids and organic carbon in the sand fraction (Spearman correlation coefficient = 0.57, critical value 0.25) (Figure 5). No significant correlation was found between total resin acids and organic carbon in the clay-silt fraction.

Figure 5 Total Resin Acids verses Percent Organic Carbon



3.2.5 Inter-Site Spatial Trends in Resin Acids

Inter-site variability in clay-silt fraction total resin acids (sum of all resin acid analytes) is shown graphically in Figures 6 and 7. Note that results from both October 1994 and May 1995 are included.

Figure 6
Total Resin Acids in Clay-Silt Fraction
Athabasca River, Oct. 1994 and May 1995

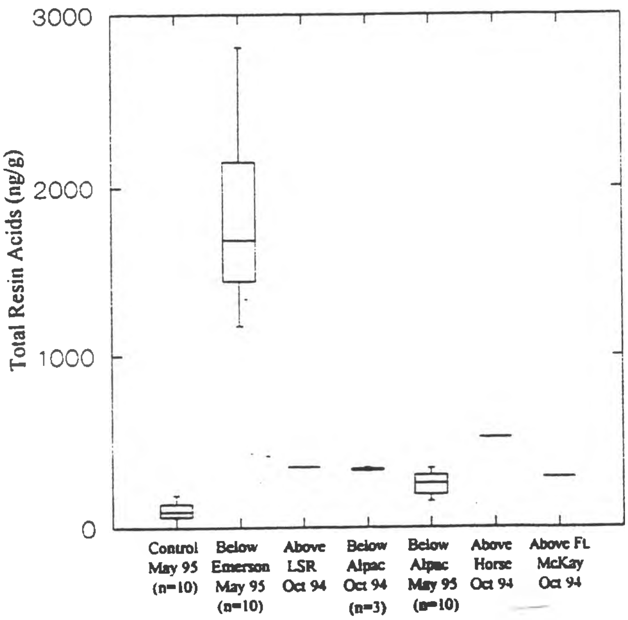
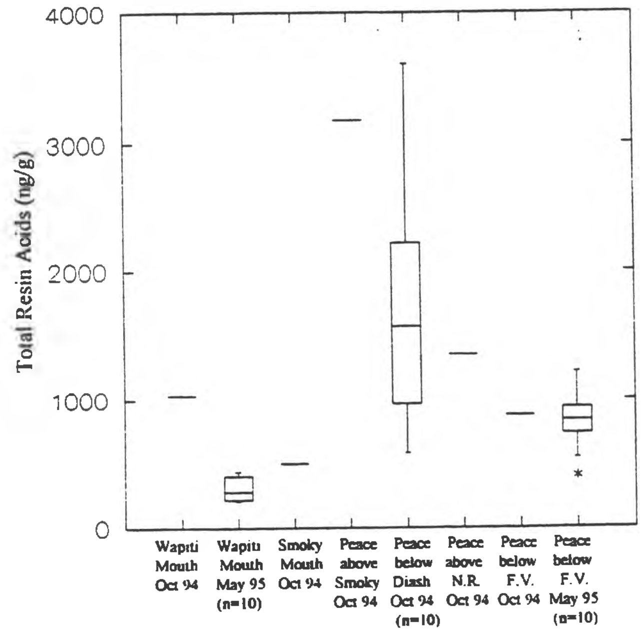


Figure 7
Total Resin Acids in Clay-Silt Fraction
Peace River, Oct. 1994 and May 1995



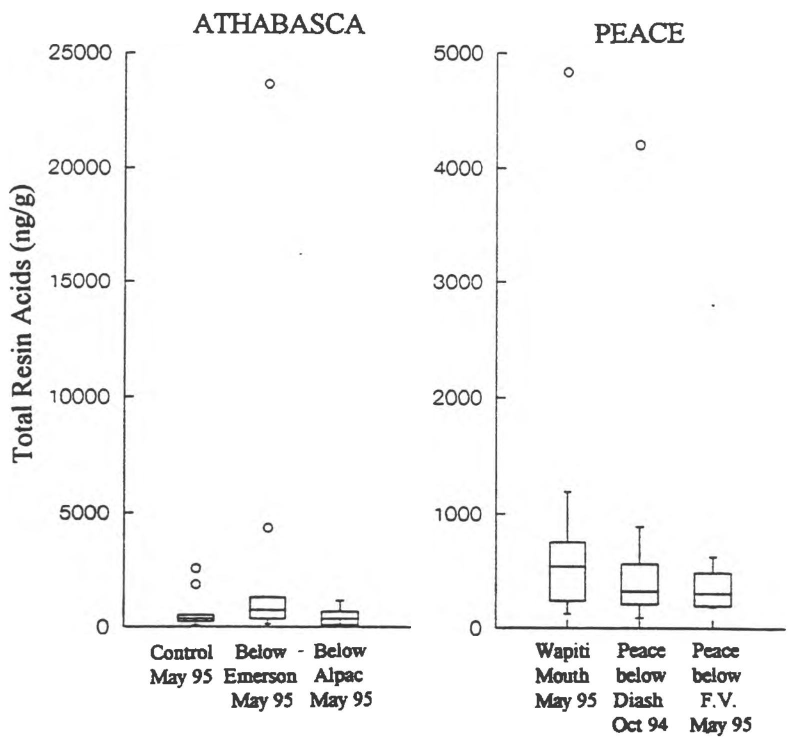
The Athabasca River plot (Figure 6) shows highest resin acid concentrations in the reach downstream of Emerson Lakes, located approximately 50 kilometers below the Hinton combined effluent. Total resin acids in clay-silt at Emerson Lakes averaged 1827 ng/g. Little in the way of trend can be seen in the reach from u/s the Lesser Slave River to near Fort McKay, suggesting that mills located near Whitecourt, on the Lesser Slave River, and below Athabasca affect mainstem Athabasca sediments to a lesser degree than Weldwood at Hinton. The background concentrations in clay-silt at Athabasca River u/s Maskuta Creek, the upstream control, averaged 106 ng/g total resin acids. Concentrations at the five locations downstream of Emerson Lakes ranged from 254-529 ng/g.

Highest total resin acid concentrations in the Peace River basin clay-silt samples were found at the Peace River u/s Smoky River (3175 ng/g in October 1994) (Figure 7). A steady decrease in clay-silt resin acids was seen on the mainstem Peace River between the confluence of the Smoky River and Fort Vermilion. The site d/s of Daishowa had similar clay-silt concentrations to those found at Emerson Lakes on the Athabasca River, but Figure 7 suggests sources on the Peace River upstream of Daishowa, rather than the Wapiti River. Total resin acids at Fort Vermilion were in the 800 ng/g range, approximately twice the concentration found in the lower Athabasca River.

October 1994 and May 1995 results for the Athabasca River d/s Alpac (342 and 254 ng/g total resin acids respectively) and Peace River d/s Fort Vermilion (876 and 818 ng/g respectively) were comparable. Results from the Wapiti River near the Mouth were less comparable, with concentrations of 1033 ng/g and 302 ng/g in October and May, respectively. Whether this finding reflects improvement in quality over the intervening six months, or relates to the change in sampling protocol, is unclear.

Total resin acids in the sand fraction from all discrete area sampling sites are shown in Figure 8. Noteworthy here are the presence of outliers mentioned in 3.2.2. Spatial trends in sand resin acid concentrations were not significant in either basin (Kruskal-Wallis non-parametric ANOVA, $\rho>0.05$, H=2.94).

Figure 8 Total Resin Acids in Sand Fraction, Athabasca and Peace River Basins, May 1995

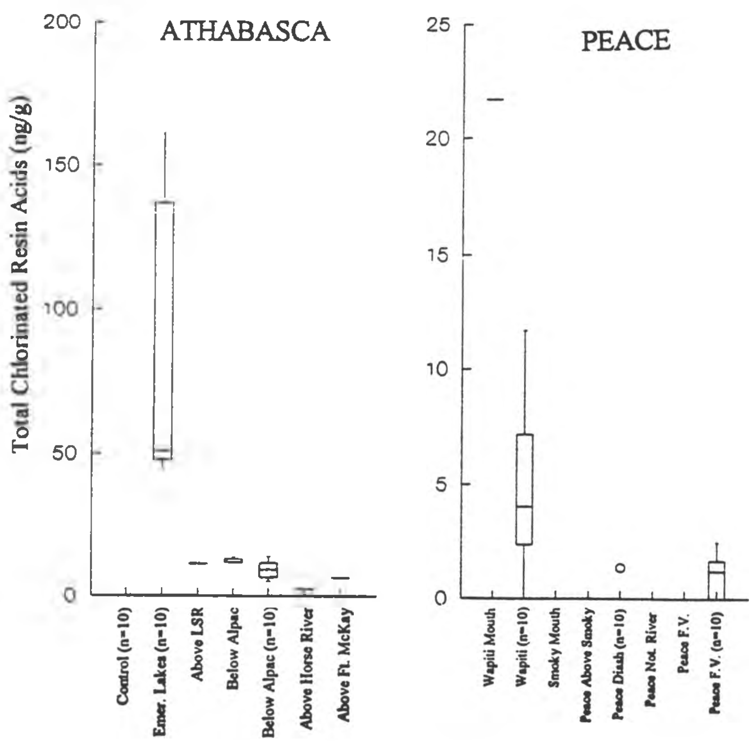


While pulp mill effluents (both kraft and CTMP) contain significant concentrations of many resin acids, the fact that these compounds are natural products leads to difficulty in cause and effect interpretation. The chlorinated resin acids, on the other hand, are not natural products, and are strongly indicative of effluents from mills using chlorine. Chlorinated resin acid spatial trends in clay-silts are shown in Figure 9. The graphed compounds include the sum of 12-Cl dehydroabietic acid, 14-Cl dehydroabietic acid, and 12,14-Cl dehydroabietic acid.

Chlorinated resin acids were more prevalent in sediments of the Athabasca River than those of the Peace River. The Weldwood mill at Hinton appears to be the major Athabasca River point source. Concentrations of chlorinated resin acids in May 1995 at the Athabasca River d/s of Emerson Lakes (mean 78.6 ng/g) were significantly higher than at the Wapiti River d/s of Weyerhaeuser (mean 4.9 ng/g). Increases in chlorinated resin acids were not seen in the reaches below Alpac and Daishowa.

Chlorinated resin acids were not detected in the October 1994 sample from the Peace River u/s Smoky River, suggesting that the non-chlorinated resin acids measured at that site were not from bleach-kraft sources.

Figure 9 Chlorinated Resin Acids in Clay-Silt Fraction, October 1994 and May 1995



3.2.6 Predominant Resin Acids

Clay-silt samples from both basins were predominant in abietic acid, dehydroabietic acid, isopimaric acid, and pimaric acid (Table 6). Sand samples showed similar results, though dehydroabietic acid concentrations were usually higher than those for abietic acid, and sandaracopimaric acid tended to replace pimaric acid on the predominance list. Palustric acid, neoabietic acid, and dehydroisopimaric acid were generally present in low concentration.

The laboratory reported that isomerization of neoabietic acid and palustric acid to abietic acid may occur during the preparation/extraction phase in the laboratory.

3.2.7 Temporal Trends in Resin Acids

The 1994 and 1995 resin acid results are compared with results from 1988, 1989, and 1992 in Table 8. All analyses were done at the same laboratory (AXYS Analytical) using the same analytical methods. Clay-silt fraction results are compared, since this was the only fraction analyzed during the early surveys.

Table 8 Comparison of 1994-95 Resin Acid Results with Earlier Surveys (Clay-Silt Fraction)

Site	Date	n	Total Resin Acids (ng/g)	Total Chlorinated Resin Acids (ng/g)
Athabasca River u/s Maskuta Creek (Control)	October 1989	2	155	ND
	April 1992	1	102	ND
	May 1995	10	106	ND
Athabasca River d/s Emerson Lakes	April 1992	1	3540	400
	May 1995	10	1827	78.6
Athabasca River u/s Horse River	October 1989	1	212	26.0
	October 1994	1	529	2.6
Wapiti River near the Mouth	October 1989	1	737	69.
	October 1994	1	1033	21.7
	May 1995	10	302	4.9
Smoky River near the Mouth	October 1989	1	395	52.
	October 1994	1	492	ND
Peace River u/s Smoky River	September 1988	2	62.5	ND
	October 1994	1	3175	ND
Peace River u/s Notikewin River	September 1988	1	303	40.0
	October 1994	1	1349	ND

Results for the Athabasca River control site are comparable for 1989, 1992, and 1995. Total resin acids at Athabasca River u/s Emerson Lakes in 1995 were approximately 50% of concentrations measured in April 1992. Chlorinated resin acids at Emerson Lakes were >75% lower in 1995 than in 1992. The results for the Athabasca River u/s Horse River (a few kilometers u/s of Fort McMurray) shows that while total resin acids were higher in 1994 than in 1989, chlorinated resin acids decreased by 90% during the same period. (Note that differing sample sizes in different years limits the statistical validity of comparisons).

In 1994-95, Wapiti River chlorinated resin acids were significantly lower (21.7 ng/g and 4.9 ng/g) than found in 1989 (69 ng/g). Chlorinated resin acids in the Smoky River near the Mouth decreased from 52 ng/g (1989) to non-detectable levels in 1994, reflecting reduced concentrations in the Wapiti River. A similar trend in chlorinated resin acids was apparent at the Peace River u/s Notikewin River.

Noteworthy is the comparison of total resin acids in 1988 and 1994 at the Peace River u/s of Smoky River and Peace River u/s Notikewin River. The data suggest relatively recent resin acid source(s) on the upper Peace River. The non-detection of chlorinated resin acids at both sites in 1994 points towards non-kraft mill sources. Whether these findings are related to non-point sources or to effluents from mills in British Columbia is uncertain.

3.3 POLYAROMATIC HYDROCARBONS

Polyaromatic hydrocarbons (PAHs) are characterized by two or more fused aromatic rings, with all carbon and hydrogen atoms lying in a single plane. They are hydrophobic and lipophilic, and readily adsorb to particulates. PAHs of different molecular weight have been shown to vary in their distribution in aquatic environments, in degradability, and in their effects on biota (Neff 1979). Generally, the lower weight PAHs with 2-3 ring structures (naphthalenes, fluorenes, phenanthrenes, and anthracenes) have higher acute toxicity, while the higher molecular weight compounds with 4-7 rings (chrysene, coronene) includes several known carcinogens (Neff 1979).

PAHs are produced in a large number of industrial applications, most involving the combustion of organic materials. They also arise from natural sources including forest fires and biosynthesis (Neff 1979). The results for 19 parent PAH compounds and 17 alkylated-PAHs are reported. Detailed results appear in Appendix B.

3.3.1 Quality Control

Six laboratory duplicates (three sand and three clay-silt samples) and one blind sample were analyzed for PAHs. The clay-silt duplicates had precision ranging from 2.0 -8.2 % (difference in sum of all reported PAHs divided by the mean). Precision of the sand fraction duplicates ranged from 4.9 - 20.1%. The field blind, a clay-silt sample from the Peace River d/s Daishowa, differed from the parent sample by 29.0% (total PAHs). Similar to the results of the resin acid blind, the PAH blind results were significantly less reproducible than were the in-laboratory duplicates.

3.3.2 In-Site Variability in PAHs

An estimate of in-site variability in total PAHs (sum of 19 parent compounds and 17 alkylated groups) can be made by examining the coefficients of variation for the discrete area samples (n=3 for each size fraction) (Table 9). Note that the samples analyzed for PAHs were those with the minimum, median, and maximum concentrations of total resin acids in each fraction.

Table 9 In-Site Variability in PAHs in Clay-Silt and Sand Fractions (May 1995 Survey)

Site	Clay-Silt Fraction			Sand Fraction		
	n	Total PAH Mean (ng/g)	Coeff. of Variation (%)	n	Total PAH Mean (ng/g)	Coeff. of Variation (%)
Athabasca River u/s Maskuta Creek (Control)	3	837	7.5	3	1102	42.4
Athabasca River d/s Emerson Lakes	3	861	13.9	3	1279	34.1
Athabasca River d/s Alpac	3	806	31.4	3	1334	68.7
Wapiti River near the Mouth	3	3566	12.5	3	7972	46.1

Coefficients of variation for clay-silt fraction PAHs averaged 16.3 percent, while the C.V.s for sand fraction PAHs averaged 47.8 percent. Higher C.V.s in sand than in clay-silt were seen previously in the results for particle size, carbon, and resin acids. PAHs were somewhat less variable in-site than resin acids, which had average coefficients of variation of 35.9 percent (clay-silt) and 155 percent (sand). Levine's Test indicated no significant difference in variability of PAH results among the four sites in either clay-silt or sand fractions.

3.3.3 Comparison of PAHs in Sand and Clay-Silt Fractions

A review of Table 10 shows that the clay-silt and sand fractions at these four locations held nearly equal proportions of the total PAH load. Mean concentrations of PAHs in sand were higher than in clay-silt at all four sites (though the difference was significant in Wapiti River samples only). The near equality of loads for the two size fractions was caused by corresponding lower sand : clay-silt ratios.

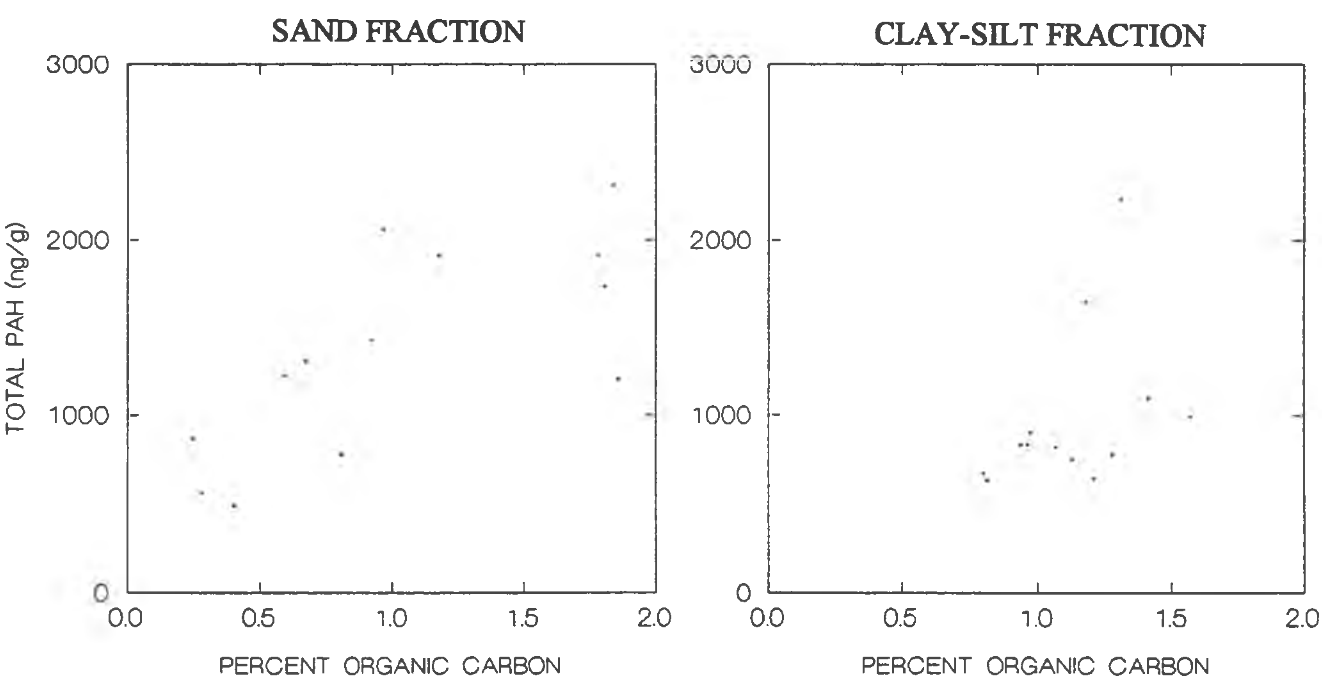
Table 10 PAHs: Contribution from Clay-Silt and Sand Fractions, May 1995

Site	Clay-Silt Fraction			Sand Fraction		
	Mean Percent Clay-Silt (n=3)	[PAH] Clay-Silt (ng/g)	PAH Load Clay-Silt / PAH Load Total (%)	Mean Percent Sand (n=3)	[PAH] Sand (ng/g)	PAH Load Sand / PAH Load Total (%)
Athabasca River u/s Maskuta Creek	.632	837	56.6	.368	1102	43.4
Athabasca River d/s Emerson Lakes	.562	861	46.3	.438	1279	53.7
Athabasca River d/s Alpac	.623	806	50.0	.377	1334	50.0
Wapiti River near the Mouth	.735	3566	55.4	.265	7972	44.6

3.3.4 Correlation of Total PAH with Organic Carbon

Correlation was found between clay-silt fraction total PAH and organic carbon (Pearson correlation coefficient 0.65, critical value 0.55) (Figure 10). The correlation between sand fraction total PAH and organic carbon was non-significant (Pearson correlation coefficient 0.35).

Figure 10 Total PAH verses Percent Organic Carbon



3.3.5 Inter-Site Spatial Trends in PAHs

Inter-site variability in total PAH in Athabasca River clay-silt fraction sediments is shown in Figure 11. Concentration trends are not apparent from the control site to the Horse River (immediately above Fort McMurray), where concentrations were higher, near 2200 ng/g total PAH. The similarity in PAH concentrations between the u/s Hinton control and three sites downstream suggests natural and diverse sources. Increased concentrations at the two lower stations are likely related to natural sources as well. A slight decrease in total PAH concentration between u/s Horse River and u/s Fort McKay suggests that oil extraction industries located in the reach between the two sites are not contributing significant PAH to river sediments.

Figure 11 Total PAH in Clay-Silt Fraction Athabasca River, Oct. 94 and May 95

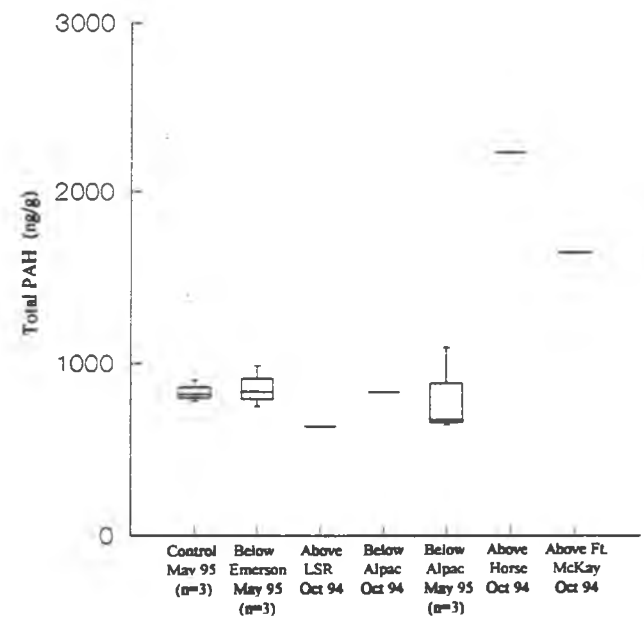
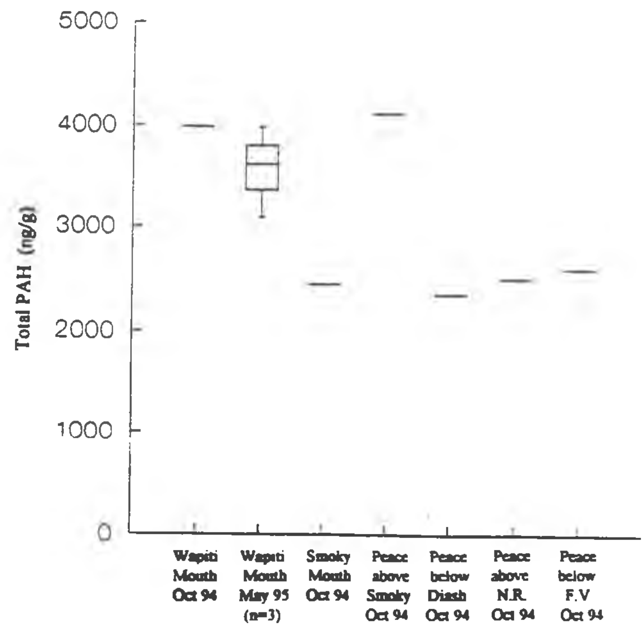


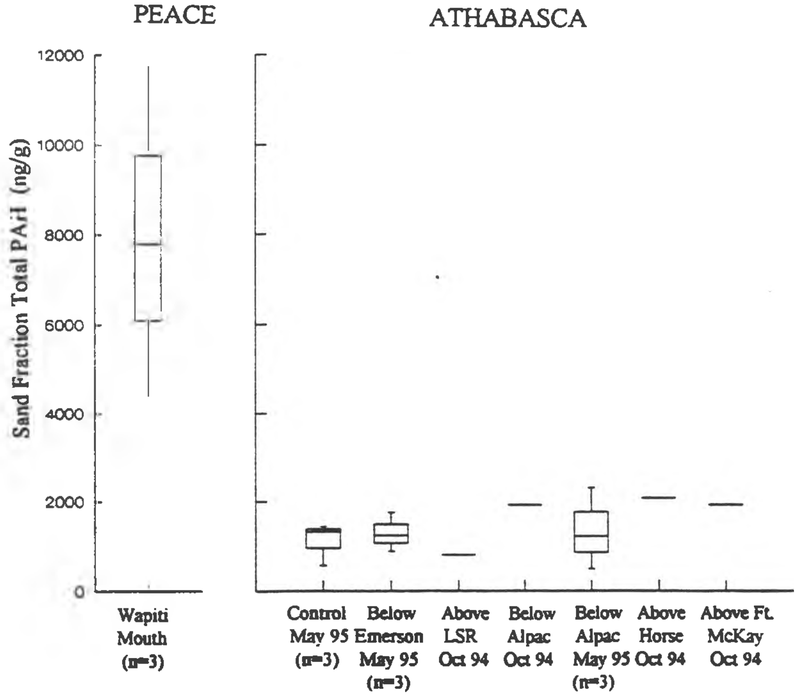
Figure 12 Total PAH in Clay-Silt Fraction Peace River Basin, Oct, 94 and May 95



Peace River basin clay-silts were higher in total PAH (Figure 12) than those from the upper four sites on the Athabasca River. Inter-site trends are subtle, though the upstream locations (Wapiti River near the Mouth, Peace River u/s Smoky River) had slightly higher concentrations than the downstream sites. Again, the PAH sources are likely natural and diverse.

Sand fraction PAH analyses for the Peace River basin sites were done on Wapiti River samples only (May 1995). As discussed in Section 3.3.3, sand fraction PAH concentrations in the Wapiti River were significantly higher than in clay-silt (Figure 13). As was the case for clay-silt samples, sand fraction PAH concentrations on the Athabasca River were highest at the downstream sites (the trend cannot be tested statistically due to lack of replication in samples from October 1994).

Figure 13 Total PAH in Sand Fraction, Athabasca and Peace River Basins, 1994-95



3.3.6 Predominant PAHs

Predominant PAH parent compounds included perylene, retene, phenanthrene, and chrysene. These 3-5 ring compounds were generally present in concentrations ranges from 20-200 ng/g. Concentrations of alkyl-substituted PAHs tended to be higher than their respective parents. The alkyl-substituted phenanthrenes were especially prevalent.

3.3.7 Temporal Trends in PAHs

PAH analyses for surveys in 1988-89, and 1992 were done in a different laboratory and by different methods than those used in 1994-95. As well, the PAH analytes reported by the two laboratories varied (comparison of total PAH from both laboratories was not possible). These factors greatly limit the comparability of the data. The results for three PAH compounds are presented in Table 11.

The results of the 1988-89 and 1992 surveys were, in general, quite comparable to those from 1994-95 for the three compounds. Increased concentrations were apparent at the Peace River upstream of Smoky River between 1988 and 1994, though this may be related to changes in analytical method.

Table 11 Comparison of 1994-95 PAH Results with Earlier Surveys (Clay-Silt Fraction)

Site	Date	n	Phenanthrene (ng/g)	Chrysene (ng/g)	Benzo(ghi)-Perylene (ng/g)
Athabasca River u/s Maskuta Creek (Control Site)	October 1989	1	78.2	18.9	7.4
	April 1992	1	84.3	23.9	<3.2
	May 1995	3	50.8	21.2	2.9
Athabasca River u/s Horse River	October 1989	1	24.3	10.7	<4.3
	October 1994	1	22.0	28.0	12.0
Wapiti River near the Mouth	October 1989	1	142.2	47.0	28.3
	October 1994	1	96.0	56.0	34.0
	May 1995	3	76.5	43.3	28.7
Smoky River near the Mouth	October 1989	1	56.3	<4.3	17.6
	October 1994	1	66.0	40.0	25.0
Peace River u/s Smoky River	September 1988	1	63.0	19.1	28.3
	October 1994	2	120.0	54.0	74.5
Peace River u/s Notikewin River	September 1988	1	81.3	30.3	34.3
	October 1994	1	68.0	39.0	42.0

Interim freshwater sediment quality guidelines have been developed by Environment Canada for a number of PAHs (Ecosystem Conservation Directorate 1995). Two values for each compound have been assigned. The first is the threshold effect level (TEL), below which adverse biological effects are expected to occur rarely. The second is the probable effect level (PEL), above which adverse effects are predicted to occur frequently. The TEL and PEL concentrations, together with the concentration ranges found during this study, are presented in Table 12.

The TELs were exceeded on occasion for all PAH compounds listed in Table 12, with the exception of fluoranthene. The majority of the TEL exceedances occurred at Peace River basin sites. No PELs were exceeded during the study.

Table 12 Interim Canadian Freshwater Sediment Quality Guidelines for PAHs

PAH Compound	Threshold Effect Level (TEL) (ng/g)	Probable Effect Level (PEL) (ng/g)	Study Range All Sites (ng/g)
Phenanthrene	41.9	514.9	13 - 230.
Benz(a)anthracene	31.7	384.7	0.99 - 48.0
Benzo(a)pyrene	31.9	782.0	<0.05 - 32.0
Chrysene	57.1	861.7	5.4 - 180.
Fluoranthene	111.3	2354.9	2.7 - 40.0
Pyrene	53.0	875.0	5.0 - 78.0

3.4 POLYCHLORINATED DIBENZODIOXINS (PCDD) AND DIBENZOFURANS (PCDF)

PCDDs and PCDFs are high molecular weight tricyclic aromatic compounds comprising a total of 210 PCDD/F congeners. Distinctions between congeners are based upon the pattern of chlorine substitution. They are produced in several industrial and natural processes including bleach-kraft pulp mills, chemical industry processes, incineration, automobile combustion, and forest fires. PCDD/Fs are hydrophobic, lipophilic, and generally persistent aquatic contaminants. Degradation in aquatic environments can occur by photolysis and biodegradation (Pastershank and Muir 1994).

The primary congeners formed in bleach-kraft mills using chlorine gas include 2,3,7,8-T_4CDD, 2,3,7,8-T_4CDF, and 1,2,7,8-T_4CDD (Swanson et al. 1993). With increased use of chlorine dioxide as a bleaching agent, mill releases of the more highly substituted and toxic PCDD/Fs, including 2,3,7,8-T_4CDD, have decreased significantly (Swanson et al. 1993).

Mono-, di-, and tri- substituted PCDD/Fs are also formed in the softwood bleaching process. These congeners have low toxicity, but are useful as markers of bleach-kraft effluent. The analyses of the lower-substituted PCDD/Fs has become increasingly common since the advent of chlorine dioxide bleaching (Pastershank and Muir 1994).

Different PCDD/F congeners display greatly differing toxicity. The most toxic congener is 2,3,7,8-T_4CDD. In order to facilitate the interpretation of PCDD/F results, international toxicity equivalency factors (I-TEFs) have been assigned to 17 TCDD/Fs. These factors relate the toxicity of each compound to that of 2,3,7,8-T_4CDD, which was assigned an I-TEF of 1. Using the I-TEFs, toxic equivalent values (TEQs) can be calculated, which facilitate data summarization and inter-site comparisons of toxicity. A list of I-TEFs is presented in Table 13.

Table 13 PCDD/F International Toxicity Equivalency Factors (I-TEFs)

PCDD	I-TEF	PCDF	I-TEF
2,3,7,8-T_4CDD	1	2,3,7,8-T_4CDF	0.1
1,2,3,7,8-P_5CDD	0.5	2,3,4,7,8-T_4CDF	0.5
1,2,3,4,7,8-H_6CDD	0.1	1,2,3,7,8-T_4CDF	0.05
1,2,3,7,8,9-H_6CDD	0.1	1,2,3,4,7,8-H_6CDF	0.1
1,2,3,6,7,8-H_6CDD	0.1	1,2,3,7,8,9-H_6CDF	0.1
1,2,3,4,6,7,8-H_7CDD	0.01	1,2,3,6,7,8-H_6CDF	0.1
O_8CDD	0.001	2,3,4,6,7,8-H_6CDF	0.1
		1,2,3,4,6,7,8-H_7CDF	0.01
		1,2,3,4,7,8,9-H_7CDF	0.01
		O_8CDF	0.001

TEQ calculation: $TEQ = \sum (\text{I-TEF}_i \times [\text{compound}])_{n=1 \text{ to } 17}$ (Table from Trudel 1991)
I-TEFs of mono-, di-, and tri-substituted congeners assumed as zero

In TEQ calculations, results reported as less than detection limit have been replaced with values of half the detection limit. Results reported as 'NDR value' have been replaced with the value. The PCDD/F substitution group results are presented in Appendix B. Detailed congener-specific results are available from the Northern River Basins Study.

3.4.1 Quality Control

The analyzing laboratory duplicated analyses on four samples, including three clay-silt and one sand fraction. The duplicate results indicated good reproducibility, with TEQs identical for three of the four duplicate sets. The results of a blind clay-silt sample (Peace River d/s Daishowa) were somewhat less reproducible, but inspection shows that the differing TEQs for the two analyses (0.23 pg/g, 0.41 pg/g) were driven more by differing detection limits than by the analytical results. Analytical blanks were usually clean, and surrogate recoveries ranged from 75-130 percent.

The results of a certified Fortified Natural Matrix Reference Sample (Radian Corporation) are presented in Table 14. The target value represents the amount of each analyte added to a native soil sample. The results reported by AXYS Analytical were within the range of expected values (upper and lower 95% tolerance limits) for all 17 I-TEF analytes. These tolerance limits were calculated from the results of interlaboratory round-robin studies.

Table 14 Fortified Reference Sample Analytical Results

Dioxins	Target Value (pg/g)	Analytical Result (ng/g)	Furans	Target Value (pg/g)	Analytical Result (ng/g)
2,3,7,8-T_4CDD	500	450	2,3,7,8-T_4CDF	500	390
1,2,3,7,8-P_5CDD	1000	820	1,2,3,7,8-P_5CDF	1000	840
1,2,3,4,7,8-H_6CDD	1000	800	2,3,4,7,8-P_5CDF	1000	840
1,2,3,6,7,8-H_6CDD	1000	830	1,2,3,4,7,8-H_6CDF	1000	1100
1,2,3,7,8,9-H_6CDD	1000	760	1,2,3,6,7,8-H_6CDF	1000	1200
1,2,3,4,6,7,8-H_7CDD	1000	1200	1,2,3,7,8,9-H_6CDF	1000	760
O_8CDD	3500	3300	2,3,4,6,7,8-H_6CDF	1000	980
			1,2,3,4,6,7,8-H_7CDF	1500	1700
			1,2,3,4,7,8,9-H_7CDF	1500	1200
			O_8CDF	2500	2700

3.4.2 In-Site Variability in PCDD/PCDFs

PCDD/F results in clay-silt and sand are presented in Table 15. Variability was higher in sand fraction samples than in clay-silt at 3 of 4 sampling sites. Clay-silt results were more variable than sand at Athabasca River d/s Emerson Lakes. The average C.V.s (all four sites) were 37.0% (clay-silt) and 59.9% (sand).

Table 15 Comparison of PCDD/F Concentrations in Clay-Silt and Sand (May 1995)

Site	n	Σ PCDD/F Congeners* (pg/g)	
		Clay-Silt (C.V.)	Sand (C.V.)
Wapiti River near the Mouth	3	24.4 (33.2%)	7.9 (55.7%)
Athabasca River u/s Maskuta Creek (Control)	3	36.9 (12.5%)	9.6 (65.6%)
Athabasca River d/s Emerson Lakes	3	59.2 (62.3%)	21.6 (17.1%)
Athabasca River d/s Alpac	3	34.2 (39.8%)	32.0 (101%)

* Sum of all detected congeners mono- to octa. Where <DL was reported, value of zero was used.

3.4.3 Comparison of PCDD/PCDF Concentrations in Clay-Silt and Sand Fractions

Mean concentrations of PCDD/Fs in clay-silt exceeded concentrations in the paired sand samples by factors of 1.1 to 3.8, when sums of all congeners were compared (Table 15). The differences were significant at the Wapiti River and Athabasca River control sites (Kruskal-Wallis non-parametric ANOVA). No significant difference between clay-silt and sand was found at either Athabasca River d/s Emerson Lakes or Athabasca River d/s Alpac.

Concentrations of PCDD congeners tended to exceed those of the respective PCDF congeners in most samples collected.

3.4.4 Inter-Site Spatial Trends in PCDD/PCDFs

The concentrations of PCDD/F congeners in samples from 1994 and 1995 were very low. The most commonly detected I-TEF congeners were O_8CDD (detected in 38 of 39 samples), 1,2,3,4,6,7,8-H_7CDD (19 of 39 samples), O_8CDF (19 of 39 samples), and 2,3,7,8-T_4CDF (17 of 39 samples). 2,3,7,8-T_4CDD was detected in three samples, two from Athabasca River d/s Emerson Lakes, and one from the Peace River u/s Smoky River. The same Peace River sample had trace concentrations of 1,2,3,7,8-P_5CDD, and 1,2,3,7,8-P_5CDF. Mono-, di-, and tri-substituted dioxins and furans were detected more frequently than most of the more highly-substituted congeners in both river basins.

The TEQs (Table 16) tended to be similar at all sites and in both size fractions, with TEQ values clustered from 0.3-0.4 pg/g. The usefulness of TEQs in inter-site comparison of toxicity reduces as the frequency of results below detection limit increases, at which point the TEQs reflect the absolute values of the detection limit more than they do inter-site differences. During this study, detection limits varied slightly between analytical batches, due to differing levels of background noise, blank results, etc. The effect of higher detection limits is reflected in the elevated TEQ for Athabasca River d/s Alpac in May, 1995.

A comparison of the sum of all detected congeners for Athabasca and Peace River sites indicates slightly higher PCDD/F concentrations at Athabasca River sites (Table 16). The results do not indicate widespread sediment contamination from bleach-kraft effluent in either basin, as evidenced by the similarity in Σ PCDD/F between the Athabasca River control and sites in both basins.

Table 16 Toxic Equivalent Values and PCDD/F Concentrations

Site	Date	n	Clay-Silt Fraction TEQ[1] (pg/g)	Clay-Silt Fraction Σ PCDD/F[2] (pg/g)	Sand Fraction TEQ (pg/g)	Sand Fraction Σ PCDD/F (pg/g)
ATHABASCA RIVER BASIN						
Athabasca River u/s Maskuta Creek (Control)	08/05/95	3	0.34	36.9	0.34	9.6
Athabasca River d/s Emerson Lakes	09/05/95	3	0.59	59.2	0.36	21.6
Athabasca River u/s Lesser Slave River	09/10/94	1	0.44	49.0		
Athabasca River d/s Alpac	09/10/94	1	0.30	63.6		
	12/05/95	3	1.49	34.2	0.55	32.0
Athabasca River u/s Horse River	11/10/94	1	0.30	55.8		
Athabasca River near Fort McKay	11/10/94	1	0.27	64.4		
PEACE RIVER BASIN						
Wapiti River near the Mouth	08/10/94	1	0.33	31.3		
	10/05/95	3	0.34	24.4	0.34	7.9
Smoky River near the Mouth	04/10/94	1	0.23	38.6		
Peace River u/s Smoky River	04/10/94	1	0.48	25.8		
Peace River d/s Daishowa	09/10/94	1	0.23	16.4		
Peace River u/s Notikewin River	06/10/94	1	0.26	17.6		
Peace River d/s Fort Vermilion	07/10/94	1	0.23	24.3		

1. Calculated from 17 individual congener I-TEFs. Detection limit results replaced by half the detection limit.
2. Sum of all detected congeners mono- to octa-. Detection limit results replaced by zero.

3.4.5 Temporal Trends in PCDD/PCDFs

The PCDD/F results are compared with results from earlier surveys in Table 17. Differing detection limits make it impossible to compare TEQs, and thus the comparisons are restricted to the three most toxic congeners (2,3,7,8-T_4CDD, 1,2,3,7,8-P_5CDD, 2,3,4,7,8-P_5CDF), and to 2,3,7,8-T_4CDF.

A pattern of continuing improvement in PCDD/F quality is apparent at all sites with the exception of Peace River upstream of Smoky River. At that site, the October 1994 results showed increased concentrations of all four congeners, compared with results from September 1988. Similar degradation in sediment quality was noted in the results for resin acids and polyaromatic hydrocarbons.

Table 17 Comparison of PCDD/F Results with Earlier Surveys (Clay-Silt Fraction)

Site	Date	n	2,3,7,8-T_4CDD (pg/g dry)	1,2,3,7,8-P_5CDD (pg/g dry)	2,3,4,7,8-P_5CDF (pg/g dry)	2,3,7,8-T_4CDF (pg/g dry)
ATHABASCA RIVER BASIN						
Athabasca River u/s Maskuta Creek (Control)	Oct 89 (1)	1	<0.2	<0.3	<0.1	0.8
	Apr 92 (1)	1	<0.1	<0.2	<0.2	<0.1
	May 95	3	<0.1	<0.2	<0.2	0.05
Athabasca River d/s Emerson Lakes *	Nov 88 (2)	1	<2.0	na	na	7.0
	Apr 92 (1)	2	0.5	<0.2	<0.1	2.0
	May 95	3	0.18	<0.2	<0.2	0.95
Athabasca River u/s Lesser Slave River *	Oct 89 (1)	1	<0.2	<0.1	<0.1	1.0
	Oct 94	1	<0.2	<0.2	<0.2	0.3
Athabasca River u/s Horse River	Oct 89 (1)	1	NDR 0.2	<0.1	<0.1	1.0
	Oct 94	1	<0.1	<0.1	<0.2	0.2
Athabasca River u/s Fort McKay *	Oct 89 (1)	1	NDR 0.4	<0.1	<0.1	0.6
	Oct 94	1	<0.1	<0.1	<0.1	0.2
PEACE RIVER BASIN						
Wapiti River near the Mouth *	Nov 88 (2)	1	<6.0	na	na	36
	Oct 89 (1)	1	0.09	<0.04	<0.03	0.8
	Oct 94	1	<0.1	<0.1	<0.2	<0.2
	May 95	3	<0.1	<0.2	<0.2	0.16
Smoky River near the Mouth	Oct 89 (1)	2	0.25	<0.06	<0.06	3.8
	Oct 94	1	<0.1	<0.1	<0.1	<0.2
Peace River u/s Smoky River	Sept 88 (1)	1	<0.04	<0.05	<0.03	0.1
	Oct 94	1	0.1	0.3	0.2	0.2
Peace River u/s Notikewin River	Sept 88 (1)	1	0.3	NDR 0.07	NDR 0.08	2.7
	Oct 94	1	<0.1	<0.1	<0.2	<0.2
Peace River d/s Fort Vermilion *	Sept 88 (1)	2	NDR 0.9	<0.07	<0.06	0.6
	Oct 94	1	<0.1	<0.1	<0.1	0.1

* Precise sampling reaches varied somewhat between surveys at these locations.

1. Data from Brownlee et al. 1994
2. Data from Trudel 1991. Samples were not partitioned according to size.

3.5 CHLORINATED PHENOLICS

Chlorinated phenolics are a family of compounds with a large number of industrial and other uses. They are commonly detected in Canadian aquatic environments below urban and industrial areas (CCREM 1987). They are known to be produced during the bleach-kraft pulping process, although the increased use of ClO_2 substitution has led to dramatic reductions in effluent concentrations. Changing from 70% to 100% ClO_2 substitution at Weyerhaeuser Pulp in Grande Prairie was reported to reduce chlorinated phenolics in the effluent by 98% (Swanson et al. 1993).

The toxicity of chlorinated phenolics (and of the associated substituted phenolics such as the guaiacols, catechols, vanillins, etc.) can vary substantially, though acute and chronic biological toxicity tends to correspond to the degree of chlorine substitution. Chlorinated phenolics can cause odour-tainting of fish flesh at concentrations lower than those causing toxicity (CCREM 1987).

The laboratory (AXYS Analytical) reported results for 43 mono- to penta-chlorinated phenolics. To facilitate interpretation, the data have been summarized and are discussed according to degree of chlorine substitution. Summarized results from 1994-95 are presented in Tables 20 and 21. Detailed analytical results are presented in Appendix B.

3.5.1 Quality Control

Five laboratory duplicate analyses were performed, all on clay-silt fractions. The coefficients of variation of these five duplicate sets ranged from 0.6% to 6.2%, with an average C.V. of 3.5%. Somewhat lower reproducibility was displayed in a blind sample (Peace River d/s Daishowa, clay-silt fraction), which had a C.V. of 17.8% from that of the parent sample.

3.5.2 In-Site Variability in Chlorinated Phenolics

In-site variability in chlorinated phenolics (sum of all reported analytes) was higher in sand than in clay-silt at three of four sampling locations (Table 18). The Athabasca River d/s Emerson Lakes was an exception to this pattern (clay-silt results were more variable than sand results). The mean C.V. for the clay-silt fraction (all sites) was 28.7%; the mean C.V. for the sand fraction was 67.6%. The magnitude of chlorinated phenolic variability in-site was similar to that found for PAHs.

Table 18 In-Site Variability in Total Chlorinated Phenolics, Clay-Silt and Sand, May 1995

Site	Clay-Silt Fraction			Sand Fraction		
	n	Σ Analytes* (ng/g)	Coeff. of Variation (%)	n	Σ Analytes (ng/g)	Coeff. of Variation (%)
Athabasca River u/s Maskuta Ck. (Control)	3	0.79	25.3	3	0.64	120.3
Athabasca River below Emerson Lakes	3	43.75	53.8	3	16.93	13.9
Athabasca River below Alpac	3	13.63	25.4	3	10.77	107.6
Wapiti River near the Mouth	3	7.32	10.4	3	3.60	28.6

* Sum of concentrations of all chlorinated phenolic analytes (mean of 3 samples). Results of less than detection limit have been replaced with zero.

3.5.3 Comparison of Chlorinated Phenolics in Sand and Clay-Silt Fractions

Concentrations of total chlorinated phenolics in clay-silt exceeded those in sand by factors from 1.2 to 2.6 (Table 19). At the four discrete area sites, the clay-silt fraction contributed from 67.7% to 84.9% of the total chlorinated phenolic loading in bottom sediment.

Table 19 Chlorinated Phenolics: Contribution from Clay-Silt and Sand Fractions, May 1995

Site	Clay-Silt Fraction			Sand Fraction		
	Mean Percent Clay-Silt (n=3)	Σ Analytes Mean (ng/g)	CP Load Clay-Silt/ CP Load Total (%)	Mean Percent Sand (n=3)	Σ Analytes Mean (ng/g)	CP Load Sand/ CP Load Total (%)
Athabasca R. u/s Maskuta Creek (Control)	.632	0.79	68.0	.368	0.64	32.0
Athabasca River d/s Emerson Lakes	.562	43.75	76.8	.438	16.93	23.2
Athabasca River d/s Alpac	.623	13.63	67.7	.377	10.77	32.3
Wapiti River near the Mouth	.735	7.32	84.9	.265	3.60	15.1

3.5.4 Correlation of Chlorinated Phenolics and Organic Carbon

No significant correlation was found between total chlorinated phenolics and organic carbon in either clay-silt or sand fractions.

3.5.5 Inter-Site Spatial Trends in Chlorinated Phenolics

The chlorinated phenolic results are summarized in Tables 20 and 21. Results for the clay-silt samples are shown graphically in Figures 14 and 15.

Table 20 Chlorinated Phenolics in Clay-Silt (by Cl-Substitution) October 1994

Site	Σ Mono-Cl (ng/g)	Σ Di-Cl (ng/g)	Σ Tri-Cl (ng/g)	Σ Tetra-Cl (ng/g)	Σ Penta-Cl (ng/g)	Σ Total CPs (ng/g)
ATHABASCA RIVER BASIN						
Athabasca R u/s Lesser Slave River	6.88	7.33	4.09	0.67	ND	18.97
Athabasca River d/s Alpac	3.64	11.83	2.71	2.54	0.07	20.79
Athabasca River u/s Horse River	4.00	15.98	1.30	0.45	0.09	21.82
Athabasca River u/s Fort McKay	1.90	0.88	1.05	0.10	ND	3.93
PEACE RIVER BASIN						
Wapiti River near the Mouth	20.65	13.22	0.56	0.24	0.12	34.79
Smoky River near the Mouth	5.08	8.60	0.15	0.16	ND	13.99
Peace River u/s Smoky River	0.44	3.87	0.17	ND	0.12	4.60
Peace River d/s Daishowa	0.74	15.54	0.15	ND	ND	16.43
Peace River d/s Daishowa (Blind)	1.66	19.05	0.29	ND	0.15	21.15
Peace River u/s Notikewin River	1.49	1.00	2.20	0.23	ND	4.92
Peace River d/s Fort Vermilion	3.08	10.04	11.08	0.60	ND	24.80

* Results are the sum of concentrations for all analytes in each of the Cl-substitution groups.

Table 21 Chlorinated Phenolics in Sand and Clay-Silt (by Cl-Substitution) May 1995

Site	Fraction	n	Σ Mono-Cl (ng/g)	Σ Di-Cl (ng/g)	Σ Tri-Cl (ng/g)	Σ Tetra-Cl (ng/g)	Σ Penta-Cl (ng/g)	Σ Total CPs (ng/g)
ATHABASCA RIVER BASIN								
u/s Maskuta Creek (Control))	Clay-Silt	3	0.04 (0.02)*	0.62 (0.22)	0.08 (0.03)	0.05 (0.05)	0.10 (0.02)	0.79 (0.20)
	Sand	3	ND	0.42 (0.46)	0.02 (0.03)	0.19 (0.28)	0.02 (0.04)	0.64 (0.77)
Downstream Emerson Lakes	Clay-Silt	3	12.38 (5.35)	11.75 (6.76)	17.26 (12.24)	2.36 (1.68)	0.09 (0.03)	43.75 (23.53)
	Sand	3	6.31 (1.42)	4.32 (1.19)	5.37 (1.01)	0.93 (0.18)	0.02 (0.03)	16.93 (2.35)
Downstream Alpac	Clay-Silt	3	2.22 (0.21)	7.26 (3.58)	2.96 (0.22)	1.19 (0.37)	ND	13.63 (3.46)
	Sand	3	1.08 (0.67)	6.30 (8.54)	2.30 (1.91)	1.10 (0.89)	ND	10.77 (11.59)
PEACE RIVER BASIN								
Wapiti River near the Mouth	Clay-Silt	3	4.07 (1.57)	2.53 (0.97)	0.27 (0.15)	0.45 (0.13)	0.08 (0.07)	7.32 (0.76)
	Sand	3	2.08 (1.27)	0.89 (0.47)	0.42 (0.64)	0.22 (0.04)	0.11 (0.12)	3.60 (1.03)

* Results are the sum of concentrations for all analytes in each Cl-substitution group.
Results in parenthesis are the standard deviation.

Figure 14 Total Chlorinated Phenolics in Clay-Silt Athabasca River Oct. 1994 and May 1995

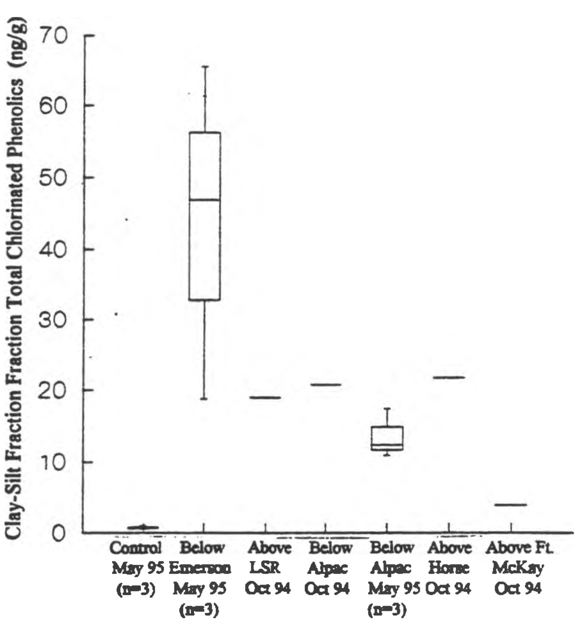
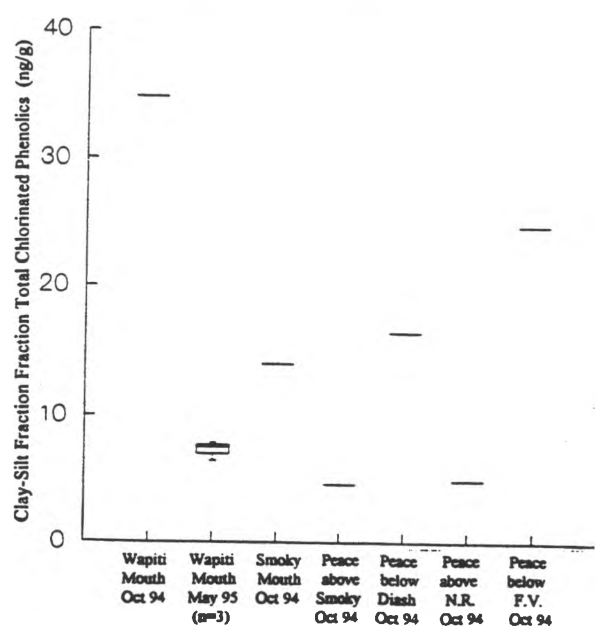


Figure 15 Total Chlorinated Phenolics in Clay-Silt Peace River Oct. 1994 and May 1995



The Athabasca River control site had total chlorinated phenolics <1.0 ng/g. The highest concentrations in the Athabasca study reach were at the site d/s Emerson Lakes, with a concentration of 43.75 ng/g (total chlorinated phenolics in clay-silt), reflecting inputs from the Weldwood Pulp Mill at Hinton. Concentrations at the sites from the Lesser Slave River to Fort McMurray remained relatively static near 20 ng/g. Lower concentrations were found at the site u/s Fort McKay (3.93 ng/g total) (Figure 14). Concentrations of total chlorinated phenolics at the Athabasca River d/s Alpac were somewhat lower during the latter survey (October 1994: 20.79 ng/g and May 1995: 13.63 ng/g).

Mono-, di-, and tri-chlorinated compounds were all well-represented at the Athabasca River sites. Athabasca River d/s Emerson Lakes sediment had a preponderance of tri-chlorinated compounds, while the other sampling locations tended to be somewhat higher in mono- and di-chlorinated compounds.

The Peace River basin had similar concentrations of chlorinated phenolics to those found in the Athabasca River, with concentrations of 34.79 ng/g (total) in the lower Wapiti River (October 1994), and concentrations near 20 ng/g downstream. An exception was the Peace River u/s Notikewin River, which had lower concentrations (4.92 ng/g total). The upper Peace River does not appear to transfer chlorinated phenolics to the lower basin, as concentrations in the Peace River u/s Smoky River were relatively low (4.60 ng/g total).

The Wapiti River site had significantly lower concentrations of chlorinated phenolics in May 1995 (7.32 ng/g total) than had been found the previous October (34.79 ng/g total). The results for both chlorinated phenolics and resin acids suggest an aspect of seasonality for these contaminant groups more significant than is generally assumed.

All Peace River sampling sites (with the exception of the Peace River d/s Fort Vermilion) were predominant in mono- and di-chlorinated compounds. The Peace River d/s Fort Vermilion was predominant in tri- and di-chlorinated compounds.

The Athabasca and Peace Rivers had similar predominance in chlorinated phenolic compounds. Predominant mono-chlorinated compounds included 6-chloro vanillin and 4-chlorophenol. Major di-chlorinated compounds included 3,4-dichlorocatechol, 2,4/2,5-dichlorophenol, 5,6-dichlorovanillin, 2,6-dichlorophenol, and 4,5-dichlorocatechol. 3,4,5-trichloroguaiacol, 3,4,5-trichlorocatechol, and 3,4,5-trichlorophenol were the predominant tri-chlorinated compounds. 3,4,5,6-trichlorocatechol was the most frequently detected tetra-chlorinated compound.

3.5.6 Temporal Trends in Chlorinated Phenolics

Little information on temporal trends can be gained by comparison with results of earlier surveys, due to much higher detection limits which were reported for those surveys (Table 22). The detection limits provided by this study, in the range of 0.1 ng/g for most compounds, provide a 'real number' concentration baseline, and will be of value in observing future trends.

Table 22 Comparison of Chlorinated Phenolic Results in Clay-Silt with Earlier Surveys

Site	Date	n	6-chlorovanillin (ng/g dry weight)	4,5-dichlorocatechol (ng/g dry weight)	3,4,5-trichloroguaiacol (ng/g dry weight)
ATHABASCA RIVER SITES					
u/s Maskuta Creek (Control)	Oct 89	1	<18.5	<3.2	<2.6
	Apr 92	1	<13.3	2.3	<4.9
	May 95	3	<0.19	<0.11	<0.03
upstream Lesser Slave River	Oct 89	1	<44.4	<7.7	<5.2
	Oct 94	1	6.4	1.5	0.79
upstream Horse River	Oct 89	1	<22.2	<7.7	<5.2
	Oct 94	1	3.2	<0.78	0.34
upstream Fort McKay	Oct 89	1	<27.8	<4.8	<3.8
	Oct 94	1	1.7	<0.17	0.43
PEACE RIVER BASIN					
Wapiti River near Mouth	Oct 89	1	<12.8	<5.0	<3.3
	Oct 94	1	19.0	NDR 0.52	0.17
	May 95	3	3.3	<0.08	0.08
Smoky River near Mouth	Oct 89	1	Trace 28.5	<4.3	<3.6
	Oct 94	1	4.9	NDR 0.47	<0.09
Peace River u/s Smoky River	Sept 88	1	<66.7	<11.5	<6.7
	Oct 94	1	<0.22	<0.38	<0.06
Peace River u/s Notikewin R.	Sept 88	1	<47.6	<8.2	<6.9
	Oct 94	1	1.4	<1.3	0.47
Peace River d/s Ft. Vermilion	Sept 88	1	<37.0	<6.4	<4.6
	Oct 94	1	2.8	<1.3	7.0

* Data for 1988, 1989, and 1992 from Brownlee et al. 1994

3.6 OTHER CONTAMINANTS IN BOTTOM SEDIMENT

A number of additional contaminant analyses were completed on the bottom sediments collected during October 1994. These analyses included polychlorinated biphenyls (PCBs) (congener-specific PCBs, coplanar PCBs, and aroclors), extractable organic halogens, toxaphene, and total mercury. The analytical results are presented in Appendix B.

3.6.1 Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) comprise a group of 209 congeners with varying degrees of chlorine substitution on a biphenyl ring. They were used in a number of electrical and mechanical applications in Canada until the mid-1980s, when their import and use was banned due to concern over possible long term effects of these toxic, bioaccumulative, and highly persistent compounds. Approximately 40,000 tonnes of PCBs were imported into Canada prior to the ban. Of this material, 40% remains unaccounted for and may be dispersed through the environment (Moore and Walker, 1991).

PCBs were produced commercially as complex mixtures of chlorinated biphenyls, with different uses requiring different percentages of chlorine in the formulations. Aroclor was one of the major trade names for PCBs. The first two numbers following the trade name relate to the molecular type (12 = chlorinated biphenyl), and the latter two to the percent chlorine in the mixture. The higher the percent chlorine in the mixture, the higher the percentage of the more persistent and toxic penta-, hexa-, and hepta-substituted congeners (Moore and Walker, 1991) (Table 23).

PCBs with planar structure are known collectively as coplanar PCBs. These are the most toxic of the PCB congeners, and act biologically in a 'TCDD-like' manner. I-TEFs similar to those used in assessing TCDD/F toxicity have been proposed for these compounds (Safe 1992). The three coplanar congeners reported here include PCB 77 (3,3',4,4'-substitution, I-TEF = 0.01), PCB 126 (3,3',4,4',5-substitution, I-TEF = 0.05), and PCB 169 (3,3',4,4',5,5'-substitution, I-TEF = 0.1).

Table 23 Polychlorinated Biphenyls in Clay-Silt, October 1994

Site	Date	Aroclor 1242 ng/g	Aroclor 1254 ng/g	Aroclor 1260 ng/g	PCB 77 pg/g	PCB 126 pg/g	PCB 169 pg/g
ATHABASCA RIVER							
u/s Lesser Slave River	09/10/94	0.61	0.94	2.5	1.8	<0.4	<0.6
d/s Alpac	10/10/94	1.4	1.4	0.47	1.7	<0.26	<0.33
u/s Horse River	11/10/94	0.65	1.9	<0.34	1.6	<1.0	<0.88
u/s Fort McKay	11/10/94	0.90	2.8	0.63	2.2	<0.72	<0.78
PEACE RIVER BASIN							
Wapiti River near the Mouth	08/10/94	1.2	2.1	0.4	1.7	<0.23	<0.33
Smoky River near the Mouth	04/10/94	0.94	1.9	0.13	1.5	<0.4	<0.6
Peace River u/s Smoky River	04/10/94	6.6	48.	NDR 0.49	10.	<0.82	<0.68
Peace River d/s Daishowa	05/10/94	1.9	3.8	1.4	4.0	<1.5	<1.1
Peace River u/s Notikewin River	06/10/94	1.05	2.4	0.24	1.4	<0.23	<0.34
Peace River d/s Fort Vermilion	07/10/94	1.6	3.2	NDR 0.19	2.0	<0.26	<0.33

Little in the way of spatial trend in PCBs was noted in the results for the Athabasca River. Spatial trends were apparent in the Peace River for Aroclor 1242, Aroclor 1254, and PCB 77. The results indicate possible PCB source(s) on the upper Peace River, as evidenced by the elevated concentrations at the Peace River u/s Smoky River. The two more highly toxic coplanar PCBs (126 and 169) were not detected in either the Peace or Athabasca Rivers.

The interim freshwater sediment quality assessment value for total PCBs are 34.1 ng/g (TEL) and 277.2 ng/g (PEL) (Ecosystem Conservation Directorate 1995). Concentrations in sediment at the Peace River u/s Smoky River exceeded the TEL (threshold effects level) during October 1994, and might therefore be expected to cause occasional PCB-related adverse biological affects.

3.6.2 Extractable Organic Halogen (EOX)

Extractable organic halogen is sometimes analyzed on sediment samples to provide a relatively inexpensive screening of samples for total halogens prior to initiating analyses of the more expensive contaminant groups. Unfortunately, EOX detection limits are generally too high for use on ambient river sediments. This was the case during this study, and all October 1994 sediments were below the analytical detection limit of 1.5 ug/g (dry weight).

3.6.3 Toxaphene

Toxaphene is a complex mixture of chlorinated camphenes and bornane derivatives used as an insecticide (and in fish eradication programs) following the ban on DDT. Use of toxaphene in Canada has been banned since 1982, due to concern regarding persistence and toxicity. Some use of toxaphene in the third world continues, and it remains an issue in Canada, since long range atmospheric transport of toxaphene has been demonstrated (CCREM 1987).

Toxaphene was not detected in October 1994 sediments at detection limits ranging from 0.1 to 0.7 ng/g.

3.6.4 Total Mercury

Total mercury was analyzed on both clay-silt and sand fractions of the October 1994 sediments. No detections were reported at an analytical detection limit of 0.10 ug/g.

3.7 EVALUATION OF RESIN ACID RESULTS AS A SCREENING TOOL

Following the May 1995 bottom sediment survey, the decision was made to use the resin acid results to select samples for further analyses. The 20 resin acid analyses from each discrete area site were reviewed (10 clay-silt and 10 sand), and samples having the high, low, and median total resin acid concentrations from each particle size class were selected to undergo analyses of PAH, PCDD/F, and chlorinated phenolics.

The decision to use resin acids for screening was not done without reservation. Resin acids are released in pulp mill effluents, but most are also naturally occurring. They have chemical-physical characteristics quite different from those of the other organic analytical groups. It was felt that there might be little relationship between resin acid concentration and concentrations of the more 'truly' anthropogenic analytical groups. However, the decision was made, based upon two factors. First, three of the sampling sites were in reaches below bleach-kraft mills (the other was the control). It was assumed that resin acid concentrations in 'contaminated' zones might correlate relatively well with other contaminants. The second factor was the relatively low price for resin acid analyses, compared with most other analytical groups.

The results of multiple contaminant analyses on the selected samples are presented in Table 24.

Table 24 Results of Contaminant Analyses, Discrete Area Sites

Site	Highest Σ Resin Acids		Median Σ Resin Acids		Lowest Σ Resin Acids	
	Clay-Silt	Sand	Clay-Silt	Sand	Clay-Silt	Sand
Athabasca River u/s Maskuta Ck.	**ARC-95-3F**	**ARC-95-5C**	**ARC-95-2F**	**ARC-95-4C**	**ARC-95-1F**	**ARC-95-7C**
Σ Resin Acids (ng/g)	192	2540	118	387	61.7	76.4
Σ PAH (ng/g)	906	1431	824	1308	782	567
Σ PCDD/F (pg/g)	46.3	16.4	31.7	8.4	40.2	4.0
Σ Chlorophenols (ng/g)	1.01	0.42	0.62	1.49	0.73	0.00
Athabasca River d/s Emerson Lakes	**EL-95-5F**	**EL-95-3C**	**EL-95-4F**	**EL-95-7C**	**EL-95-8F**	**EL-95-9C**
Σ Resin Acids (ng/g)	2807	23641	1887	746	1173	125
Σ PAH (ng/g)	990	1739	754	1224	839	872
Σ PCDD/F (pg/g)	86.1	24.0	17.1	23.5	74.3	17.3
Σ Chlorophenols (ng/g)	65.57	17.81	18.82	18.71	46.87	14.26
Athabasca River d/s Alpac	**ALP-95-5F**	**ALP-95-7C**	**ALP-95-2F**	**ALP-95-1C**	**ALP-95-8F**	**ALP-95-10C**
Σ Resin Acids (ng/g)	327	1130	268	460	154	1.6
Σ PAH (ng/g)	1098	1200	645	2311	676	493
Σ PCDD/F (pg/g)	39.7	18.6	21.9	68.8	44.3	8.6
Σ Chlorophenols (ng/g)	17.53	7.47	12.41	23.66	10.95	1.19
Wapiti River near the Mouth	**WR-95-4F**	**WR-95-4C**	**WR-95-9F**	**WR-95-6C**	**WR-95-7F**	**WR-95-10C**
Σ Resin Acids (ng/g)	429	1193	292	615	205	125
Σ PAH (ng/g)	3617	11737	3985	7778	3096	4400
Σ PCDD/F (pg/g)	22.8	8.2	33.3	12.1	17.3	3.3
Σ Chlorophenols (ng/g)	7.56	4.47	7.93	2.46	6.47	3.88

Sample labels are shown in bold.

Pearson correlation coefficients (resin acids vs. other contaminant groups) for each sampling location are presented in Table 25. The critical value of 0.997 (α=0.05, n=3) was not achieved, indicating that concentration relationships between resin acids and the other major contaminant groups were very weak.

Table 25 Pearson Correlation Coefficients, Resin Acids verses Other Contaminant Groups

Site	Pearson Correlation Coefficients (with Σ Resin Acids)					
	Σ PAH		Σ PCDD/F		Σ Chlorinated Phenolics	
	Clay-Silt	Sand	Clay-Silt	Sand	Clay-Silt	Sand
Athabasca River above Maskuta Creek	0.99	0.70	0.49	0.97	0.75	-0.13
Athabasca River above Emerson Lakes	0.69	0.92	0.23	0.58	0.46	0.35
Athabasca River below Alpac	0.72	0.28	-0.39	0.04	0.88	0.16
Wapiti River near the Mouth	0.47	0.99	0.22	0.52	0.62	0.33

4.0 CONCLUSIONS AND RECOMMENDATIONS

The study findings are summarized below with the study objectives to which they relate. Recommendations arising from the findings are italicized.

Objective 1: To determine the spatial distribution of contaminants in bottom sediments through the Athabasca and Peace River systems during 1994-95.

Particle Size and Carbon

The two upstream sites on the Athabasca River (u/s Hinton control and d/s Emerson Lakes) had coarser bottom sediments than the four sites between the Lesser Slave River and Fort McKay. Samples from the upstream sites had from 37-44% sand and from 5-14% clay, while the downstream locations had relatively equal proportions of sand, silt, and clay. No consistent upstream-downstream trends in particle size were apparent in the Peace River basin.

Spatial trends were not apparent in organic carbon in either basin. Inorganic carbon concentrations in Athabasca River sediments (both clay-silt and sand) was significantly higher (at α=0.05) u/s Hinton and d/s Emerson Lakes, than at the four downstream Athabasca River sites.

Resin Acids

Among Athabasca River sites, sediment resin acids were highest at the site d/s Emerson Lakes (mean total resin acids 1827 ng/g). No evidence of resin acid input from CTMP mills in the Athabasca River basin was apparent in the results. This was likely a result of the study design, which keyed on bleach-kraft reaches. *Future bottom sediment surveys of the Athabasca River basin should locate sampling sites in the reach below Whitecourt and on the Lesser Slave River.*

The resin acid results for the Peace River basin indicated that the Peace River u/s Smoky River may be affected by upstream anthropogenic inputs. Total resin acid concentrations in sediment at this site (3175 ng/g) were higher than found in the Wapiti River near the Mouth (1033 ng/g) in October 1994.

The predominant non-chlorinated resin acids detected in bottom sediments included abietic acid, dehydroabietic acid, isopimaric acid, and pimaric acid. Chlorinated resin acids were, in general, more prevalent in sediments of the Athabasca River than in the Peace River.

Polycyclic Aromatic Hydrocarbons (PAH)

Highest total PAH concentrations in Athabasca River sediments were found at the sites in the lower basin, where concentrations were near 2000 ng/g total PAH. The results suggested natural and diverse sources. PAH concentrations in Peace River sediments were typically higher than those from the Athabasca River, in a range from 2000-4000 ng/g total PAH. Spatial trends in the Peace River were apparent, with highest concentrations at the upstream sites. Again, natural and diverse sources were thought likely.

Predominant PAH compounds in bottom sediments included perylene, retene, phenanthrene, and chrysene. Alkyl-substituted PAHs were more commonly detected than parent compounds. Interim freshwater quality sediment values (threshold effect levels) for several PAHs were exceeded in a number of samples. The exceedances occurred more frequently in the Peace River than in the Athabasca River.

Chlorinated Phenolics

Highest concentrations of chlorinated phenolics in Athabasca River sediments were found in the Athabasca River d/s Emerson Lakes (total chlorinated phenolics 43.8 ng/g). Sites downstream on the Athabasca River had sediment chlorinated phenolics near 20 ng/g. Highest concentrations of chlorinated phenolics in Peace River basin sediment were found in the Wapiti River near the Mouth (total chlorinated phenolics 34.8 ng/g). Downstream concentrations were similar to those in the lower Athabasca River. The predominant chlorinated phenolics in bottom sediments included 6-chlorovanillin, 3,4-dichlorocatechol, 2,4/2,5-dichlorophenol, 3,4,5-trichloroguaiacol, and 3,4,5-trichlorocatechol.

Polychlorinated Dibenzodioxins and Dibenzofurans (PCDD and PCDF)

PCDD/Fs in bottom sediments of the Athabasca and Peace River basins were present in low concentration, and the results did not indicate widespread contamination from bleach-kraft effluent in either basin. Spatial trends were not apparent. Trace but detectable concentrations of 2,3,7,8-T_4CDD were found at two sites, Athabasca River d/s Emerson Lakes and Peace River u/s Smoky River.

Polychlorinated Biphenyls (PCB)

Spatial trends in PCB were not apparent in either basin. Total PCBs in bottom sediment from the Peace River u/s Smoky River exceeded the interim sediment quality threshold effect value for total PCB of 34.1 ng/g. *Based upon the PCB result, together with results for resin acids and PCDD/F, it is recommended that additional surveys of the Peace River upstream of the Smoky River be conducted to verify the presence and determine the source(s) of contaminants found in bottom sediments at this site.*

Extractable Organic Halogen (EOX), Toxaphene, and Total Mercury

No detections were reported for extractable organic halogen (at a detection limit of 1.5 ug/g), toxaphene (detection limit 0.1-0.7 ng/g), or total mercury (detection limit 0.10 ug/g)

Objective 2: To determine within-site variability in bottom sediment contamination at a number of locations.

Within-site variability in sediment particle size was substantial at all sampling locations. Within-site variability in sediment organic carbon was higher in the sand fraction than in clay-silt, likely due to the presence of organic debris in the sand fraction. The degree of variability in particle size and organic carbon was not significantly different between sites (Levines Test, α=0.05). Significant correlation (α=0.05) was found between organic carbon and total resin acids in sand, and between organic carbon and total PAHs in clay-silt. Chlorinated phenolics were not significantly correlated with organic carbon in either size fraction. Apparent sediment seasonality was noted in the results for resin acids and chlorinated phenolics at some locations, with concentrations lower in spring than in fall.

In general, the in-site variability results demonstrated the need to sample intensively within a reach to produce a composite sample which will accurately define the reach mean concentration. *To provide comparability with this work, it is recommended that future contaminant surveys of bottom sediments in the Athabasca and Peace River basins analyze samples composited from ten or more depositional areas within each sampling reach. For reasons of data comparability and site accessibility, it is further recommended that future surveys be timed for low water periods in the late fall or early spring.*

Objective 3: To test the assumption that the sand fraction is not an important repository of contaminants.

Resin acids in the sand fraction ranged from 11-79% of the total resin acids in sediment. Concentrations of total resin acids in clay-silt were significantly higher than in sand at three sites (Athabasca River d/s Emerson Lakes, Wapiti River near the Mouth, Peace River d/s Daishowa), and significantly higher in sand than in clay-silt at one site (Athabasca River u/s Maskuta Creek) (Kruskal-Wallis non-parametric ANOVA, α=0.05).

Mean concentrations of PAH in sand exceeded concentrations in clay-silt at all four sites tested, though the difference was significant in samples from Wapiti River near the Mouth only (Kruskal-Wallis non-parametric ANOVA, α=0.05). Total PAH loads in sand and clay-silt were near equality, due to proportionally lower sand:clay-silt ratios.

Mean concentrations of total chlorinated phenolics in clay-silt exceeded those in sand by factors of 1.2 to 2.6. The clay-silt fraction contained from 68-85% of the total sediment chlorinated phenolics. Mean concentrations of total PCDD/Fs in clay-silt exceeded concentrations in sand by factors of 1.1 to 3.8.

Based upon the results, which indicated significant contaminant concentration in the sand fraction, and to reduce handling of samples prior to analysis, it is recommended that future bottom sediment surveys include analyses of unpartitioned wet sediments.

Objective 4: To provide a 1994-95 dataset for comparison with earlier collection in 1988-92

Chlorinated resin acids in sediment were detected at lower concentration at most sites than had been found in 1988-92. PAH concentrations were similar to those found in 1988-92, though increases in concentrations of selected PAH compounds were noted at the Peace River u/s Smoky River. Temporal trends in chlorinated phenolic concentration could not be evaluated due to high detection limits reported for surveys from 1988-92. A pattern of continuing improvement in PCDD/F quality was noted at most sites, with the exception of the Peace River u/s Smoky River.

It is recommended that future analyses of Athabasca and Peace River sediments include analytical methods, compound lists, and detection limits which will allow comparison of results with all earlier datasets.

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APPENDIX A Terms of Reference

No contractual Terms of Reference were prepared for the work documented in this report. The work was done by the author as a contribution in kind from his employing agency and represents a part of his responsibilities to the working committee of the Contaminants Component of the Northern River Basins Study.

APPENDIX B Tables of Results

Particle Size and Carbon
October 1994

Site	Label	Fraction	Date	%Sand	%Silt	%Clay	%OC	%IC	%TC
Wapiti River near the	WRM-F1	<63 micron	08/10/94	19.47	49.00	31.53	0.78	0.89	1.67
Mouth	WRM-F2	<63 micron		20.32	45.27	34.41	1.03	0.65	1.68
	WRM-F3	<63 micron		10.96	54.43	34.62	0.81	0.68	1.50
			Mean	**16.92**	**49.57**	**33.52**	**0.87**	**0.74**	**1.62**
			StDev	**5.18**	**4.61**	**1.73**	**0.14**	**0.13**	**0.10**
	WRM-C1	>63 micron					2.33	0.80	3.13
	WRM-C2	>63 micron					1.70	0.89	2.59
	WRM-C3	>63 micron					1.41	0.91	2.32
			Mean				**1.81**	**0.87**	**2.68**
			StDev				**0.47**	**0.06**	**0.41**
Smoky River near the	SRM-F1	<63 micron	04/10/94	26.21	37.98	35.80	1.26	1.07	2.33
Mouth	SRM-F2	<63 micron		27.93	38.99	33.08	1.04	0.98	2.02
	SRM-F3	<63 micron		23.96	37.66	38.38	0.92	0.98	1.90
			Mean	**26.03**	**38.21**	**35.75**	**1.07**	**1.01**	**2.08**
			StDev	**1.99**	**0.69**	**2.65**	**0.17**	**0.05**	**0.22**
	SRM-C1	>63 micron					1.33	0.77	2.11
	SRM-C2	>63 micron					0.82	0.96	1.78
	SRM-C3	>63 micron					1.33	0.95	2.28
			Mean				**1.16**	**0.89**	**2.05**
			StDev				**0.30**	**0.10**	**0.26**
Peace River above Smoky	PRS-F1	<63 micron	04/10/94	0.00	72.39	27.61	1.24	0.66	1.91
River	PRS-F2	<63 micron		16.24	55.37	28.39	0.82	0.70	1.51
	PRS-F3	<63 micron		16.80	53.54	29.65	1.14	0.94	2.09
			Mean	**11.01**	**60.43**	**28.55**	**1.07**	**0.77**	**1.83**
			StDev	**9.54**	**10.40**	**1.03**	**0.22**	**0.15**	**0.29**
	PRS-C1	>63 micron					2.09	0.98	3.07
	PRS-C2	>63 micron					1.86	0.89	2.75
	PRS-C3	>63 micron					2.07	0.83	2.90
			Mean				**2.01**	**0.90**	**2.90**
			StDev				**0.13**	**0.08**	**0.16**
Peace River above Notikewin	PRN-F1	<63 micron	06/10/94	9.85	52.99	37.16	0.91	1.03	1.94
River	PRN-F2	<63 micron		22.22	51.68	26.11	0.56	1.47	2.03
	PRN-F3	<63 micron		22.46	46.94	30.60	0.78	0.83	1.61
			Mean	**18.18**	**50.54**	**31.29**	**0.75**	**1.11**	**1.86**
			StDev	**7.21**	**3.18**	**5.56**	**0.18**	**0.32**	**0.22**
	PRN-C1	>63 micron					1.54	0.58	2.12
	PRN-C2	>63 micron					1.27	0.66	1.92
	PRN-C3	>63 micron					0.84	0.77	1.61
			Mean				**1.21**	**0.67**	**1.88**
			StDev				**0.35**	**0.10**	**0.26**

Particle Size and Carbon
October 1994

Site	Label	Fraction	Date	%Sand	%Silt	%Clay	%OC	%IC	%TC
Peace River below	PRV-F1	<63 micron	07/10/94	10.78	62.42	26.79	1.24	0.97	2.21
Fort Vermilion	PRV-F2	<63 micron		10.51	55.65	33.84	0.72	0.74	1.46
	PRV-F3	<63 micron		15.03	53.70	31.27	0.76	1.00	1.76
			Mean	**12.11**	**57.26**	**30.63**	**0.91**	**0.90**	**1.81**
			StDev	**2.54**	**4.58**	**3.57**	**0.29**	**0.14**	**0.38**
	PRV-C1	>63 micron					2.10	0.74	2.84
	PRV-C2	>63 micron					1.78	0.85	2.63
	PRV-C3	>63 micron					1.14	0.75	1.89
			Mean				**1.67**	**0.78**	**2.45**
			StDev				**0.49**	**0.06**	**0.50**
Peace River below	RRD-F1	<63 micron	05/10/94	6.16	60.24	33.60	0.97	1.02	1.99
Diashowa	RRD-F2	<63 micron		20.12	50.55	29.33	0.85	0.65	1.50
	RRD-F3	<63 micron		51.76	28.98	19.26	0.52	0.76	1.28
	RRD-F4	<63 micron		35.89	35.65	28.46	0.58	0.92	1.49
	RRD-F5	<63 micron		10.35	54.33	35.32	0.41	1.05	1.47
	RRD-F6	<63 micron		16.43	47.82	35.75	0.53	1.67	2.20
	RRD-F7	<63 micron		21.96	43.41	34.63	1.26	1.44	2.70
	RRD-F8	<63 micron		17.87	52.77	29.36	0.85	0.83	1.67
	RRD-F9	<63 micron		31.21	39.37	29.42	0.69	1.30	1.99
	RRD-F10	<63 micron		11.57	42.75	45.67	0.69	1.04	1.73
			Mean	**22.33**	**45.59**	**32.08**	**0.73**	**1.07**	**1.80**
			StDev	**13.78**	**9.42**	**6.81**	**0.25**	**0.32**	**0.42**
	RRD-C1	>63 micron					6.68	0.82	7.50
	RRD-C2	>63 micron					0.86	0.65	1.51
	RRD-C3	>63 micron					0.35	0.61	0.96
	RRD-C4	>63 micron					0.88	0.83	1.72
	RRD-C5	>63 micron					1.19	0.80	1.99
	RRD-C6	>63 micron					0.89	0.66	1.55
	RRD-C7	>63 micron					0.70	0.73	1.43
	RRD-C8	>63 micron					0.31	0.71	1.01
	RRD-C9	>63 micron					0.80	0.79	1.58
	RRD-C10	>63 micron					1.30	0.91	2.21
			Mean				**1.39**	**0.75**	**2.15**
			StDev				**1.88**	**0.10**	**1.92**

Particle Size and Carbon
October 1994

Site	Label	Fraction	Date	%Sand	%Silt	%Clay	%OC	%IC	%TC
Athabasca River above	ARL-F1	<63 micron	09/10/94	25.94	41.03	33.03	0.87	3.11	3.98
Lesser Slave River	ARL-F2	<63 micron		27.86	41.55	30.59	0.82	3.13	3.95
	ARL-F3	<63 micron		23.00	41.67	35.33	0.77	2.73	3.51
			Mean	**25.60**	**41.42**	**32.98**	**0.82**	**2.99**	**3.81**
			StDev	**2.45**	**0.34**	**2.37**	**0.05**	**0.22**	**0.26**
	ARL-C1	>63 micron					0.72	1.54	2.26
	ARL-C2	>63 micron					0.80	1.50	2.31
	ARL-C3	>63 micron					0.46	1.49	1.94
			Mean				**0.66**	**1.51**	**2.17**
			StDev				**0.18**	**0.03**	**0.20**
Athabasca River below	ARA-F1	<63 micron	10/10/94	27.84	40.26	31.90	0.94	1.99	2.93
Alpac	ARA-F2	<63 micron		23.38	40.59	36.03	0.78	1.71	2.49
	ARA-F3	<63 micron		23.35	41.72	34.93	1.07	1.86	2.93
			Mean	**24.86**	**40.86**	**34.29**	**0.93**	**1.85**	**2.78**
			StDev	**2.58**	**0.77**	**2.14**	**0.15**	**0.14**	**0.26**
	ARA-C1	>63 micron					1.14	1.31	2.45
	ARA-C2	>63 micron					1.78	1.35	3.14
	ARA-C3	>63 micron					1.66	1.41	3.06
			Mean				**1.53**	**1.36**	**2.88**
			StDev				**0.34**	**0.05**	**0.37**
Athabasca River above	ARH-F1	<63 micron	11/10/94	34.70	30.75	34.55	1.31	1.72	3.03
Horse River	ARH-F2	<63 micron		32.82	32.99	34.19	1.36	1.99	3.36
	ARH-F3	<63 micron		35.15	31.46	33.38	1.31	1.91	3.22
			Mean	**34.22**	**31.73**	**34.04**	**1.33**	**1.87**	**3.20**
			StDev	**1.24**	**1.14**	**0.60**	**0.03**	**0.14**	**0.17**
	ARH-C1	>63 micron					0.88	0.73	1.61
	ARH-C2	>63 micron					1.26	0.80	2.07
	ARH-C3	>63 micron					0.97	0.77	1.74
			Mean				**1.04**	**0.77**	**1.81**
			StDev				**0.20**	**0.04**	**0.24**
Athabasca River near	ARM-F1	<63 micron	11/10/94	31.43	35.75	32.82	1.07	1.48	2.55
Fort McKay	ARM-F2	<63 micron		33.88	36.28	29.84	1.14	3.29	4.42
	ARM-F3	<63 micron		26.05	38.38	35.57	1.18	1.47	2.65
			Mean	**30.45**	**36.80**	**32.74**	**1.13**	**2.08**	**3.21**
			StDev	**4.01**	**1.39**	**2.87**	**0.06**	**1.05**	**1.05**
	ARM-C1	>63 micron					1.08	1.02	2.09
	ARM-C2	>63 micron					1.03	1.00	2.03
	ARM-C3	>63 micron					1.18	1.01	2.19
			Mean				**1.10**	**1.01**	**2.10**
			StDev				**0.07**	**0.01**	**0.08**

Particle Size and Carbon
May 1995

Site	Label	Fraction	Date	%Sand	%Silt	%Clay	%OC	%IC	%TC
Wapiti River near the	WR-95-F1	<63 micron	10/05/95	30.57	44.17	25.25	1.16	1.35	2.50
Mouth	WR-95-F2	<63 micron	10/05/95	34.60	43.22	22.18	1.02	1.50	2.52
	WR-95-F3	<63 micron	10/05/95	30.22	45.03	24.75	0.95	1.74	2.69
	WR-95-F4	<63 micron	10/05/95	21.93	51.02	27.05	1.29	1.49	2.77
	WR-95-F5	<63 micron	10/05/95	1.25	62.75	36.00	1.41	1.60	3.01
	WR-95-F6	<63 micron	10/05/95	11.75	55.07	33.17	1.01	1.43	2.44
	WR-95-F7	<63 micron	10/05/95	46.66	30.24	23.10	1.23	1.36	2.59
	WR-95-F8	<63 micron	10/05/95	41.69	36.57	21.74	0.63	1.18	1.81
	WR-95-F9	<63 micron	10/05/95	10.37	51.67	37.97	2.12	1.60	3.71
	WR-95-F10	<63 micron	10/05/95	35.57	42.33	22.10	1.62	1.45	3.07
			Mean	**26.46**	**46.21**	**27.33**	**1.24**	**1.47**	**2.71**
			StDev	**14.73**	**9.32**	**6.12**	**0.41**	**0.16**	**0.50**
	WR-95-C1	>63 micron	10/05/95				0.58	0.80	1.37
	WR-95-C2	>63 micron	10/05/95				0.61	1.03	1.63
	WR-95-C3	>63 micron	10/05/95				0.87	0.90	1.76
	WR-95-C4	>63 micron	10/05/95				1.50	0.95	2.45
	WR-95-C5	>63 micron	10/05/95				5.58	1.42	7.00
	WR-95-C6	>63 micron	10/05/95				1.29	1.02	2.31
	WR-95-C7	>63 micron	10/05/95				0.72	0.92	1.65
	WR-95-C8	>63 micron	10/05/95				0.68	1.04	1.72
	WR-95-C9	>63 micron	10/05/95				1.64	0.98	2.63
	WR-95-C10	>63 micron	10/05/95				0.56	0.93	1.49
			Mean				**1.40**	**1.00**	**2.40**
			StDev				**1.52**	**0.16**	**1.67**
Peace River below	FV-95-F1	<63 micron	11/05/95	49.85	31.38	18.77	1.19	1.18	2.37
Fort Vermilion	FV-95-F2	<63 micron	11/05/95	29.86	48.22	21.92	1.24	1.36	2.60
	FV-95-F3	<63 micron	11/05/95	29.86	48.44	21.70	1.88	1.24	3.12
	FV-95-F4	<63 micron	11/05/95	25.07	46.12	28.81	1.52	0.48	2.00
	FV-95-F5	<63 micron	11/05/95	34.47	38.51	27.02	1.79	1.09	2.88
	FV-95-F6	<63 micron	11/05/95	26.80	46.08	27.13	1.55	0.61	2.15
	FV-95-F7	<63 micron	11/05/95	0.00	57.25	42.75	2.04	1.34	3.38
	FV-95-F8	<63 micron	11/05/95	3.92	52.00	44.08	1.69	1.15	2.84
	FV-95-F9	<63 micron	11/05/95	12.44	49.44	38.12	1.21	1.34	2.55
	FV-95-F10	<63 micron	11/05/95	16.45	56.63	26.92	1.00	1.31	2.31
			Mean	**22.87**	**47.41**	**29.72**	**1.51**	**1.11**	**2.62**
			StDev	**14.95**	**7.81**	**8.91**	**0.34**	**0.31**	**0.44**
	FV-95-C1	> 63 micron	11/05/95				0.45	0.68	1.13
	FV-95-C2	> 63 micron	11/05/95				1.65	1.11	2.76
	FV-95-C3	> 63 micron	11/05/95				1.25	0.86	2.11
	FV-95-C4	> 63 micron	11/05/95				0.40	0.97	1.37
	FV-95-C5	> 63 micron	11/05/95				0.28	1.29	1.57
	FV-95-C6	> 63 micron	11/05/95				1.06	1.11	2.16
	FV-95-C7	> 63 micron	11/05/95				0.84	0.67	1.50
	FV-95-C8	> 63 micron	11/05/95				0.46	0.77	1.23
	FV-95-C9	> 63 micron	11/05/95				0.72	1.44	2.16
	FV-95-C10	> 63 micron	11/05/95				0.64	1.61	2.25
			Mean				**0.77**	**1.05**	**1.82**
			StDev				**0.43**	**0.32**	**0.53**

Particle Size and Carbon
May 1995

Site	Label	Fraction	Date	%Sand	%Silt	%Clay	%OC	%IC	%TC
Athabasca River above	ARC-95-F1	<63 micron	08/05/95	45.00	50.50	4.50	1.28	7.45	8.73
Maskuta Creek	ARC-95-F2	<63 micron	08/05/95	36.64	60.04	3.33	1.07	7.42	8.49
	ARC-95-F3	<63 micron	08/05/95	16.90	74.43	8.66	0.98	7.12	8.10
	ARC-95-F4	<63 micron	08/05/95	38.47	59.34	2.19	0.83	7.35	8.18
	ARC-95-F5	<63 micron	08/05/95	42.30	53.08	4.62	1.00	7.38	8.37
	ARC-95-F6	<63 micron	08/05/95	26.34	67.89	5.77	0.77	7.56	8.33
	ARC-95-F7	<63 micron	08/05/95	53.58	46.42		0.84	7.73	8.57
	ARC-95-F8	<63 micron	08/05/95	49.10	49.15	1.74	0.85	7.20	8.05
	ARC-95-F9	<63 micron	08/05/95	24.86	67.79	7.35	1.10	6.90	8.00
	ARC-95-F10	<63 micron	08/05/95	34.40	61.40	4.20	1.34	7.52	8.86
			Mean	**36.76**	**59.00**	**4.71**	**1.01**	**7.36**	**8.37**
			StDev	**11.48**	**9.21**	**2.27**	**0.19**	**0.24**	**0.29**
	ARC-95-C1	>63 micron	08/05/95				0.75	5.86	6.62
	ARC-95-C2	>63 micron	08/05/95				0.63	5.90	5.53
	ARC-95-C3	>63 micron	08/05/95				2.44	5.23	7.67
	ARC-95-C4	>63 micron	08/05/95				0.67	5.72	6.39
	ARC-95-C5	>63 micron	08/05/95				0.92	6.07	6.99
	ARC-95-C6	>63 micron	08/05/95				0.69	5.52	6.21
	ARC-95-C7	>63 micron	08/05/95				0.28	6.15	6.43
	ARC-95-C8	>63 micron	08/05/95				0.30	5.52	5.82
	ARC-95-C9	>63 micron	08/05/95				0.71	5.91	6.62
	ARC-95-C10	>63 micron	08/05/95				0.45	5.46	5.91
			Mean				**0.78**	**5.73**	**6.42**
			StDev				**0.62**	**0.30**	**0.62**
Athabasca River below	EL-95-F1	<63 micron	09/05/95	29.99	58.27	11.74	1.12	7.17	8.29
Emerson Lakes	EL-95-F2	<63 micron	09/05/95	40.66	50.73	8.61	1.01	7.65	8.65
	EL-95-F3	<63 micron	09/05/95	18.98	68.43	12.59	1.14	7.42	8.55
	EL-95-F4	<63 micron	09/05/95	75.25	18.89	5.86	1.13	7.00	8.14
	EL-95-F5	<63 micron	09/05/95	66.94	24.11	8.95	1.57	6.79	8.36
	EL-95-F6	<63 micron	09/05/95	12.60	51.23	36.16	0.85	6.46	7.30
	EL-95-F7	<63 micron	09/05/95	40.63	42.47	16.90	0.67	6.28	6.95
	EL-95-F8	<63 micron	09/05/95	37.36	46.20	16.18	0.96	5.99	6.96
	EL-95-F9	<63 micron	09/05/95	61.00	27.95	11.05	0.70	7.40	8.10
	EL-95-F10	<63 micron	09/05/95	54.43	29.77	15.80	0.62	6.52	7.14
			Mean	**43.78**	**41.81**	**14.38**	**0.98**	**6.87**	**7.84**
			StDev	**20.48**	**16.14**	**8.45**	**0.29**	**0.55**	**0.68**
	EL-95-C1	> 63 micron	09/05/95				0.53	5.54	6.06
	EL-95-C2	> 63 micron	09/05/95				0.52	5.51	6.02
	EL-95-C3	> 63 micron	09/05/95				1.81	4.66	6.47
	EL-95-C4	> 63 micron	09/05/95				0.74	5.64	6.38
	EL-95-C5	> 63 micron	09/05/95				0.33	5.72	6.05
	EL-95-C6	> 63 micron	09/05/95				3.08	4.74	7.82
	EL-95-C7	> 63 micron	09/05/95				0.59	5.13	5.72
	EL-95-C8	> 63 micron	09/05/95				0.60	5.20	5.80
	EL-95-C9	> 63 micron	09/05/95				0.24	5.78	6.02
	EL-95-C10	> 63 micron	09/05/95				0.41	4.69	5.10
			Mean				**0.88**	**5.26**	**6.14**
			StDev				**0.89**	**0.44**	**0.70**

Particle Size and Carbon
May 1995

Site	Label	Fraction	Date	%Sand	%Silt	%Clay	%OC	%IC	%TC
Athabasca River	ALP-95-F1	<63 micron	12/05/95	14.97	54.13	30.91	1.29	2.25	3.54
below Alpac	ALP-95-F2	<63 micron	12/05/95	29.34	46.32	24.33	1.21	2.19	3.40
	ALP-95-F3	<63 micron	12/05/95	12.85	54.52	32.63	1.09	2.23	3.31
	ALP-95-F4	<63 micron	12/05/95	50.58	31.31	18.12	1.08	2.31	3.39
	ALP-95-F5	<63 micron	12/05/95	34.46	36.53	29.01	1.41	2.55	3.96
	ALP-95-F6	<63 micron	12/05/95	47.04	28.87	24.09	1.57	2.57	4.14
	ALP-95-F7	<63 micron	12/05/95	25.57	42.29	32.14	1.32	2.05	3.37
	ALP-95-F8	<63 micron	12/05/95	33.08	40.80	26.13	0.80	2.13	2.93
	ALP-95-F9	<63 micron	12/05/95	59.86	21.21	18.93	2.10	2.22	4.33
	ALP-95-F10	<63 micron	12/05/95	69.69	15.69	14.61	1.16	2.28	3.44
			Mean	**37.74**	**37.17**	**25.09**	**1.30**	**2.28**	**3.58**
			StDev	**18.71**	**13.04**	**6.28**	**0.35**	**0.17**	**0.43**
	ALP-95-C1	>63 micron	12/05/95				1.84	1.89	3.73
	ALP-95-C2	>63 micron	12/05/95				0.83	1.53	2.36
	ALP-95-C3	>63 micron	12/05/95				0.62	1.13	1.75
	ALP-95-C4	>63 micron	12/05/95				0.62	1.36	1.99
	ALP-95-C5	>63 micron	12/05/95				1.37	1.35	2.72
	ALP-95-C6	>63 micron	12/05/95				1.23	1.57	2.80
	ALP-95-C7	>63 micron	12/05/95				1.86	1.68	3.54
	ALP-95-C8	>63 micron	12/05/95				1.05	1.49	2.54
	ALP-95-C9	>63 micron	12/05/95				0.46	1.48	1.93
	ALP-95-C10	>63 micron	12/05/95				0.40	1.24	1.64
			Mean				**1.03**	**1.47**	**2.50**
			StDev				**0.54**	**0.22**	**0.72**

Resin Acids, October 1994
Results in ng/g

Site	Label	Fraction	Date	Notes	%Moisture	Pimaric	Sandaracopimaric	Isopimaric	Palustric	DHI	DHA	Abietic	Neoabietic	12/14 Cl-DHA	12,14-DiCl-DHA	%Recovery	Total Resin Acids
Wapiti River near the Mouth	WRM-F3	Clay-Silt	08/10/94	2898-02	1.4	170	9.7	170	NDR 5.4	6.1	180	470	<2.0	15	6.7	74	1033
Smoky River near the Mouth	SRM-F2	Clay-Silt	04/10/94	2898-03A	1.6	34	7.6	77	<2.0	<5.3	200	180	<2.4	<1.8	<1.3	70	499
	SRM-F2	Clay-Silt		Lab Dup	1.8	35	7.2	80	<1.6	<4.0	200	160	3.0	<1.9	<1.2	70	485
Peace River above Smoky River	PRS-F3	Clay-Silt	04/10/94	2898-21	0.78	140	83	500	NDR 11	11	830	1600	<2.2	<0.64	<0.88	85	3175
Peace River above Notikewin R.	PRN-F3	Clay-Silt	06/10/94	2898-01	0.92	60	32	210	7.3	<3.6	340	700	<6.8	<1.1	<1.6	72	1349
Peace River below Ft. Vermilion	PRV-F3	Clay-Silt	07/10/94	2898-05R	1.2	58	NDR 28	190	NDR 7.4	2.7	410	180	<5.6	<0.85	<1.5	78	876
Athabasca R above Lesser Slave R	ARL-F2	Clay-Silt	09/10/94	2898-06R	1.5	69	NDR 17	66	NDR 6.6	3.0	140	44	<3.2	6.2	5.4	89	357
Athabasca River below Alpac	ARA-F1	Clay-Silt	10/10/94	2898-16	<0.1	52	6.0	55	<1.2	3.9	110	100	<3.9	6.4	5.9	90	339
	ARA-F2	Clay-Silt		2898-17A	0.56	49	7.1	49	<1.0	4.2	100	110	<0.52	6.2	5.6	91	331
	ARA-F2	Clay-Silt		Lab Dup	0.56	49	6.7	49	<1.0	4.8	100	110	<3.2	6.5	5.5	85	332
	ARA-F3	Clay-Silt		2898-18K	1.7	64	NDR 16	72	NDR 7.6	<3.2	120	62	<2.3	8.1	6.1	54	356
Athabasca River above Horse R	ARH-F3	Clay-Silt	11/10/94	2898-20	1.5	38	9.1	75	NDR 4.0	<2.2	210	190	<0.74	2.6	<2.5	72	529
Athabasca River near Fort McKay	ARM-F2	Clay-Silt	11/10/94	2898-19	1.2	31	5.1	40	NDR 12	<3.0	200	<28	<0.76	2.9	3.8	75	295
Reference Sample	REF	Bulk		2898-34R	0.19	83	25	120	44	3.3	370	200	<1.0	6.9	3.2	77	855

Resin Acids, October 1994
Results in ng/g

Site	Label	Date	Notes	%Moisture	Pimaric	Sandaracopimaric	Isopimaric	Palustric	DHI	DHA	Abietic	Neoabietic	12/14 Cl-DHA	12,14-DiCl-DHA	%Recovery	Total Resin Acids
Peace River below Diashowa	RRD-F1	05/10/94	2898-7RA	2.6	62	NDR 40	220	NDR 13	<0.86	430	210	<3.0	<0.58	<1.0	100	975
(Clay-Silt fraction)	RRD-F1	05/10/94	Lab Dup	2.8	58	NDR 38	210	NDR 12	<1.2	440	200	<2.4	<0.7	<1.4	71	958
	RRD-F1	05/10/94	Blind	2.3	85	54	320	<0.79	<3.0	540	650	<3.2	<0.64	<0.8	76	1649
	RRD-F1	05/10/94	Blind Dup	2.2	95	75	380	NDR 30	<1.1	580	740	<8.2	<0.76	<1.2	80	1900
	RRD-F2	05/10/94	2898-09A	0.64	68	30	230	<8.3	<3.7	370	1100	<1.5	<1.5	<2.2	84	1798
	RRD-F2	05/10/94	Lab Dup	0.5	66	30	220	<11	<4.4	360	850	<5.5	<2.2	<3.8	79	1526
	RRD-F2	05/10/94	Blind	1.4	61	34	230	<0.78	2.9	440	480	<0.7	<0.71	<1.5	71	1248
	RRD-F2	05/10/94	Blind Dup	1.3	91	55	280	<16	3.9	480	500	<4.0	<0.69	<1.4	79	1410
	RRD-F3	05/10/94	2898-10	0.5	95	46	320	<8.6	12	540	1200	<3.0	<1.5	<2.7	84	2213
	RRD-F4	05/10/94	2898-11	0.86	64	27	190	<9.8	<6.4	360	830	<3.9	<2.0	<2.9	86	1471
	RRD-F5	05/10/94	2898-13	0.97	62	30	180	<1.0	6.5	320	390	<3.4	1.4	<1.4	87	990
	RRD-F6	05/10/94	2898-22A	2.3	110	63	430	21	6.5	630	2200	13	<0.79	<1.3	65	3474
	RRD-F6	05/10/94	Lab Dup	2.1	98	60	380	26	6.8	560	1600	5.4	<0.71	<1.5	86	2736
	RRD-F7	05/10/94	2898-23	1.8	160	73	530	NDR 8.8	20	810	2000	<3.2	<1.6	<3.7	80	3602
	RRD-F8	05/10/94	2898-24	2.2	120	76	340	<3.8	<9.8	630	580	<6.3	<2.9	<6.5	93	1746
	RRD-F9	05/10/94	2898-25	2.1	57	29	150	<3.3	<11	340	<39	<2.5	<2.8	<6.9	84	576
	RRD-F10	05/10/94	2898-26	3.1	84	53	250	<4.6	<16	480	<67	<7.1	<5.2	<8.2	100	867
Peace River below Diashowa	RRD-C1	05/10/94	2898-14	1.6	47	130	550	110	<2.4	2500	790	NDR 76	1.4	<1.6	73	4204
(Sand fraction)	RRD-C2	05/10/94	2898-15	0.38	12	20	130	NDR 20	NDR 3.5	430	260	NDR 17	<0.99	<1.3	84	893
	RRD-C3	05/10/94	2898-4R2	0.55	<6.0	38	170	<7.4	<0.99	140	210	<0.94	<0.43	<0.8	97	558
	RRD-C4	05/10/94	2898-08	0.53	<5.0	<5.7	<15.	<8.6	<6.0	110	210	<5.6	<2.7	<4.1	69	320
	RRD-C5	05/10/94	2898-12	0.68	NDR 16	NDR 14	78	<1.2	<1.7	200	100	NDR 5.6	13	9.0	75	436
	RRD-C6	05/10/94	2898-27	0.77	<7.0	NDR 5.6	21	<6.6	<8.6	62	<38	<1.6	<2.6	<6.5	82	89
	RRD-C7	05/10/94	2898-28	0.94	12	10	49	<7.6	<2.3	170	<65	<4.1	<2.4	<4.5	85	241
	RRD-C8	05/10/94	2898-29A	0.49	<7.0	NDR 12	27	<4.0	<1.0	86	23	<0.5	<0.68	<1.2	88	148
	RRD-C8	05/10/94	Lab Dup	0.51	<7.0	NDR 13	27	<5.0	<1.0	55	27	<0.5	<0.41	<0.94	78	122
	RRD-C9	05/10/94	2898-30	0.9	<6.5	5.2	41	<0.75	<1.3	88	32	<0.67	<0.53	<1.3	77	166
	RRD-C9	05/10/94	Lab Dup	0.83	<8.0	8.5	64	<4.0	<1.0	130	39	<1.3	<0.41	<0.9	75	242
	RRD-C10	05/10/94	2898-31	1.3	8.5	7.9	46	<0.71	<1.5	140	57	<0.64	<0.72	<2.2	80	259
	RRD-C10	05/10/94	Lab Dup	0.94	11	15	74	<9.0	<1.0	160	98	<0.5	<0.74	<0.8	74	358

Resin Acids, May 1995
Results in ng/g

Site	Label	Date	Notes	%Moisture	Pimaric	Sandaracopimaric	Isopimaric	Palustric	DHI	DHA	Abietic	Neoabietic	12/14 Cl-DHA	12,14-DiCl-DHA	%Recovery	Total Resin Acids
Wapiti River near the Mouth	WR-95-1F	10/05/95	9513-85	1.1	NDR 23	<4.0	32	<9.6	<9.5	91	120	<6.8	<2.0	<3.5	76	266
(Clay-silt fraction)	WR-95-2F	10/05/95	9513-86	1.3	58	<5.9	55	<3.9	<3.9	130	150	<6.0	4.4	<4.2	57	397
	WR-95-3F	10/05/95	9513-87	0.6	41	<3.7	51	<3.9	<3.9	100	140	<4.2	3.8	<2.9	75	336
	WR-95-4F	10/05/95	9513-88	0.7	65	<3.9	60	<2.6	<2.6	120	180	<5.9	4.3	<3.2	81	429
	WR-95-5F	10/05/95	9513-89	0.7	67	<3.7	56	<2.4	<2.4	130	160	<5.7	7.2	<3.6	76	420
	WR-95-6F	10/05/95	9513-90	0.9	30	<3.6	33	<2.5	<2.4	71	84	<1.4	<1.7	<3.0	79	218
	WR-95-7F	10/05/95	9513-24		31	NDR 6.3	40	<5.0	<2.0	93	31	<1.4	3.8	<1.9	78	205
	WR-95-8F	10/05/95	9513-91	0.2	33	NDR 2.5	32	<2.4	<2.5	61	81	<2.5	2.4	<2.0	58	212
	WR-95-9F	10/05/95	9513-25		62	NDR 7.0	57	<8.5	<1.9	95	57	NDR 2.6	8.4	3.3	82	292
	WR-95-10F	10/05/95	9513-92	0.3	53	<0.84	34	<2.1	<3.1	62	86	<3.6	8.3	3.0	82	246
Wapiti River near the Mouth	WR-95-1C	10/05/95	9513-80R	1.0	11	7.7	36	<1.9	2.2	86	93	<0.82	<0.97	<1.2	88	236
(Sand fraction)	WR-95-2C	10/05/95	9513-116	0.1	13	7.7	NDR 31	NDR 13	<0.67	78	91	<0.61	NDR 0.89	1.6	73	236
	WR-95-3C	10/05/95	9513-117	<0.1	19	17	96	NDR 16	<0.82	250	100	<0.74	NDR 1.1	2.9	70	502
	WR-95-4C	10/05/95	9513-81R	1.0	50	29	150	42	2.3	280	620	11	5.9	2.9	80	1193
	WR-95-5C	10/05/95	9513-115	1.7	110	160	660	180	2.7	2400	1300	NDR 12	6.2	NDR 3.6	66	4834
	WR-95-6C	10/05/95	9513-118A	<0.1	24	12	100	NDR 14	<0.8	180	150	<0.72	NDR 2.8	1.9	74	485
			9513-118B	<0.1	35	18	110	NDR 10	<0.92	170	400	<0.84	NDR 2.4	<2.2	68	745
	WR-95-7C	10/05/95	9513-82Ai	0.1	24	NDR 13	58	NDR 17	<2.1	180	140	<3.8	1.3	2.4	91	436
			9513-82Bi	0.1	NDR 22	29	230	<13	<2.1	250	530	<3.5	<1.0	<1.6	90	1061
	WR-95-8C	10/05/95	9513-83	0.1	NDR 10	NDR 4.5	26	<8.5	<8.4	160	NDR 61	<5.0	<2.4	<2.5	78	262
	WR-95-9C	10/05/95	9513-84	0.6	NDR 12	15	110	<3.6	<3.6	250	180	<5.6	<2.1	<3.0	74	567
	WR-95-10C	10/05/95	9513-137	<0.1	<11	3.8	25	<0.7	NDR 2.2	<45	93	<1.2	1.1	<1.2	100	125

Resin Acids, May 1995
Results in ng/g

Site	Label	Date	Notes	%Moisture	Pimaric	Sandaracopimaric	Isopimaric	Palustric	DHI	DHA	Abietic	Neoabietic	12/14 Cl-DHA	12,14-DiCl-DHA	%Recovery	Total Resin Acids
Peace R below Ft. Vermilion	FV-95-1F	11/05/95	9513-71	<0.1	29	11	85	<8.2	<5.2	180	230	<4.8	<1.8	<3.2	78	535
(Clay-silt fraction)	FV-95-2F	11/05/95	9513-72	<0.1	46	21	140	<6.0	<6.0	240	360	<3.4	<1.9	<2.3	67	807
	FV-95-3F	11/05/95	9513-26		30	15	93	<8.0	<1.8	190	67	<1.5	<0.69	<1.2	85	395
	FV-95-4F	11/05/95	9513-73AR	2.0	51	18	130	5.2	NDR 3.1	220	380	2.8	1.6	<0.64	84	812
			9513-73BR	1.0	49	21	120	4.3	NDR 3.2	200	320	2.3	1.6	<0.57	85	721
	FV-95-5F	11/05/95	9513-74R	2.0	58	24	140	7.9	NDR 3.3	230	400	2.9	1.7	<0.7	89	868
	FV-95-6F	11/05/95	9513-75R	1.0	38	18	110	9.1	NDR 3.0	190	360	3.0	NDR 0.85	<1.1	84	732
	FV-95-7F	11/05/95	9513-76R	1.0	62	28	160	13	3.6	270	510	5.0	1.9	0.61	84	1054
	FV-95-8F	11/05/95	9513-77R	1.0	82	36	200	9.7	NDR 4.5	320	560	NDR 1.4	2.4	<0.74	79	1216
	FV-95-9F	11/05/95	9513-78R	1.0	66	29	160	7.6	3.7	260	410	<0.85	1.7	<0.74	88	938
	FV-95-10F	11/05/95	9513-79R	1.0	50	21	130	8.0	NDR 2.6	210	440	4.3	0.88	<0.63	83	867
Peace R below Ft. Vermilion	FV-95-1C	11/05/95	9513-131	0.1	6.8	7.7	25	NDR 4.8	NDR 2.4	120	48	<0.52	<0.8	<1.1	89	215
(Sand fraction)	FV-95-2C	11/05/95	9513-134	<0.1	12	6.7	34	<1.7	NDR 2.2	120	51	<0.52	<0.47	<0.91	87	226
	FV-95-3C	11/05/95	9513-68	<0.1	15	13	43	<9.2	<11	360	58	<5.7	<1.0	<1.2	77	489
	FV-95-4C	11/05/95	9513-114	0.1	6.0	4.6	38	<11	<0.84	100	44	<0.76	<0.5	<0.89	84	193
	FV-95-5C	11/05/95	9513-133	<0.1	7.7	5.0	27	<1.6	NDR 2.1	83	64	NDR 1.2	<0.77	<1.2	88	190
	FV-95-6C	11/05/95	9513-124	0.1	12	12	61	5.7	NDR 2.6	160	110	NDR 3.5	<0.58	<0.75	85	367
	FV-95-7C	11/05/95	9513-138	0.2	26	20	84	12	NDR 2.9	190	130	<0.38	<0.89	<1.2	100	465
	FV-95-8C	11/05/95	9513-69	0.1	15	12	83	<9.0	<19	180	190	<5.7	<1.4	<2.2	77	480
	FV-95-9C	11/05/95	9513-70	<0.1	NDR 5.3	11	190	NDR 34	<26	160	220	<3.6	<1.9	<2.9	94	620
	FV-95-10C	11/05/95	9513-129	0.3	6.4	5.9	30	NDR 2.8	<1.7	96	39	NDR 4.7	<0.39	<0.71	90	185

Resin Acids, May 1995
Results in ng/g

Site	Label	Date	Notes	%Moisture	Pimaric	Sandaracopimaric	Isopimaric	Palustric	DHI	DHA	Abietic	Neoabietic	12/14 Cl-DHA	12,14-DiCl-DHA	%Recovery	Total Resin Acids
Athabasca River above	ARC-95-1F	08/05/95	9513-21		<5.0	NDR 5.7	<15	<6.8	<1.8	56	<5.7	<2.6	<0.8	<1.0	74	61.7
Maskuta Creek	ARC-95-2F	08/05/95	9513-46Ai	0.3	NDR 23	<1.2	19	<6.2	<2.4	68	<32	10	<0.93	<1.9	80	120
(Clay-silt fraction)			9513-46Bi	0.3	NDR 22	<1.4	19	<5.7	<2.7	65	<34	NDR 9.5	<1.0	<1.8	76	116
	ARC-95-3F	08/05/95	9513-47i	0.3	12	NDR 7.0	24	NDR 7.1	<2.5	71	56	NDR 15	<0.87	<1.8	83	192
	ARC-95-4F	08/05/95	9513-48i	0.2	10	NDR 4.9	23	NDR 6.4	<2.5	66	44	NDR 5.9	<0.87	<1.4	80	160
	ARC-95-5F	08/05/95	9513-49i	0.2	6.8	NDR 8.7	19	<6.1	<2.7	61	37	NDR 6.7	<1.2	<1.8	81	139
	ARC-95-6F	08/05/95	9513-50i	0.1	5.8	NDR 3.1	19	NDR 7.3	<1.9	56	31	<2.5	<0.76	<0.89	93	122
	ARC-95-7F	08/05/95	9513-51i	0.2	NDR 4.4	<2.2	11	NDR 7.1	<2.2	48	<24	<2.2	<1.1	<1.7	89	70.5
	ARC-95-8F	08/05/95	9513-52i	0.2	NDR 6.8	NDR 2.1	10	<5.7	<1.9	43	<25	NDR 3.1	<0.81	<1.1	95	65.0
	ARC-95-9F	08/05/95	9513-22A		<2.9	NDR 8.6	<17	<4.5	<1.9	49	<7.5	<2.2	<0.75	<1.0	73	57.6
			9513-22B		<3.6	NDR 6.8	<17	<4.0	<1.9	60	<7.8	<2.2	<0.72	<1.0	87	66.8
	ARC-95-10F	08/05/95	9513-53i	0.2	NDR 8.7	<1.1	5.5	NDR 7.8	<2.2	37	<34	NDR 6.3	<0.96	<1.3	91	65.3
Athabasca River above	ARC-95-1C	08/05/95	9513-41R	<0.1	16	20	61	NDR 23	<1.2	290	84	<0.74	<0.63	<1.1	78	494
Maskuta Creek	ARC-95-2C	08/05/95	9513-42R	<0.1	13	13	37	NDR 31	<1.3	120	74	<0.84	<0.71	<1.2	74	288
(Sand fraction)	ARC-95-3C	08/05/95	9513-125	0.6	49	77	250	15	NDR 3.5	890	540	<0.95	<0.86	<1.4	93	1824
	ARC-95-4C	08/05/95	9513-43R	<0.1	22	30	56	NDR 19	<1.2	180	80	<0.76	<0.54	<1.2	79	387
	ARC-95-5C	08/05/95	9513-126	0.2	22	75	170	32	<1.9	810	1400	31	<0.38	<0.72	83	2540
	ARC-95-6C	08/05/95	9513-130	0.2	<1.5	18	15	50	<1.4	190	240	4.0	<0.5	<0.6	89	517
	ARC-95-7C	08/05/95	9513-122	0.1	<2.0	1.4	13	<2.3	<1.8	38	24	<0.94	<0.36	<0.51	92	76.4
	ARC-95-8C	08/05/95	9513-106	<0.1	8.6	3.6	28	<2.0	<2.1	75	52	<2.1	<1.0	<1.7	82	167
	ARC-95-9C	08/05/95	9513-44R	<0.1	14	12	56	20	<1.3	160	100	<0.84	<0.59	<1.2	80	362
	ARC-95-10C	10/05/95	9513-45AR	<0.1	9.4	5.6	NDR 27	NDR 17	<1.4	110	44	<0.86	<0.63	<1.2	76	213
			9513-45BR	<0.1	10	8.0	45	NDR 21	<1.4	150	29	<0.88	<0.61	<1.2	84	263

Resin Acids, May 1995
Results in ng/g

Site	Label	Date	Notes	%Moisture	Pimaric	Sandaracopimaric	Isopimaric	Palustric	DHI	DHA	Abietic	Neoabietic	12/14 Cl-DHA	12,14-DiCl-DHA	%Recovery	Total Resin Acids
Athabasca River below	EL-95-1F	09/05/95	9513-59	0.2	660	NDR 29	390	NDR 30	34	250	620	<2.2	27	22	76	2062
Emerson Lakes	EL-95-2F	09/05/95	9513-60A	0.2	520	NDR 32	290	NDR 20	27	240	160	<2.2	22	27	72	1338
(Clay-silt fraction)			9513-60B	0.3	540	NDR 32	310	NDR 27	31	220	320	<2.4	26	26	83	1532
	EL-95-3F	09/05/95	9513-61	0.3	850	30	470	NDR 26	58	320	570	<2.1	28	24	77	2376
	EL-95-4F	09/05/95	9513-62	0.3	560	21	380	NDR 20	31	300	530	<2.3	25	20	76	1887
	EL-95-5F	09/05/95	9513-63	0.4	900	27	540	NDR 29	80	340	750	<2.2	70	71	74	2807
	EL-95-6F	09/05/95	9513-23		510	15	460	<6.5	28	250	160	<7.4	26	22	73	1471
	EL-95-7F	09/05/95	9513-64Ai	0.2	410	NDR 23	260	NDR 17	28	200	500	<1.5	27	32	71	1497
			9513-64Bi	0.3	410	NDR 30	260	NDR 15	24	200	480	<1.6	25	23	76	1467
	EL-95-8F	09/05/95	9513-65i	0.2	310	NDR 24	200	NDR 18	30	190	240	<2.4	61	100	77	1173
	EL-95-9F	09/05/95	9513-66i	0.1	740	NDR 50	420	<12	68	240	490	<3.6	65	72	77	2145
	EL-95-10F	09/05/95	9513-67i	<0.1	470	31	350	NDR 14	23	390	NDR 100	<6.6	28	20	75	1426
Athabasca River below	EL-95-1C	09/05/95	9513-54i	<0.1	48	22	110	NDR 7.5	<2.0	220	280	NDR 2.9	5.3	9.3	93	705
Emerson Lakes	EL-95-2C	09/05/95	9513-127A	0.9	81	28	210	<2.4	NDR 3.4	440	340	NDR 2.0	5.2	8.1	92	1118
(Sand fraction)			9513-127B	0.3	44	14	65	<2.4	NDR 3.7	140	180	NDR 7.0	5.7	8.7	80	468
	EL-95-3C	09/05/95	9513-55	<0.1	410	710	3200	610	20	10000	8500	160	9.2	22	82	23641
	EL-95-4C	09/05/95	9513-105A	<0.1	22	9.5	75	NDR 8.8	<2.5	130	210	<2.0	<1.4	1.9	75	457
			9513-105B	<0.1	15	6.2	24	12	<2.1	180	43	<1.0	1.0	1.8	83	283
	EL-95-5C	09/05/95	9513-56	<0.1	32	NDR 25	NDR 64	NDR 9.4	<3.3	170	100	<2.2	7.3	16	81	424
	EL-95-6C	09/05/95	9513-57	<0.1	130	35	200	NDR 18	5.0	300	560	<2.1	15	22	69	1285
	EL-95-7C	09/05/95	9513-58	<0.1	57	20	130	NDR 14	<3.6	330	180	<2.4	5.0	9.9	78	746
	EL-95-8C	09/05/95	9513-120	0.1	18	5.3	27	2.7	<2.2	110	50	NDR 2.0	7.1	16	95	238
	EL-95-9C	09/05/95	9513-113	0.1	18	NDR 4.1	NDR 21	<9.3	<0.94	64	14	<0.66	NDR 1.2	3.1	81	125
	EL-95-10C	09/05/95	9513-112	0.1	16	130	50	60	<0.88	4000	100	<0.8	NDR 1.6	<2.5	82	4357

Resin Acids, May 1995
Results in ng/g

Site	Label	Date	Notes	%Moisture	Pimaric	Sandaracopimaric	Isopimaric	Palustric	DHI	DHA	Abietic	Neoabietic	12/14 Cl-DHA	12,14-DiCl-DHA	%Recovery	Total Resin Acids
Athabasca River below Alpac	ALP-95-1F	12/05/95	9513-32A	<0.1	40	NDR 6.4	44	<14	2.8	78	94	<1.5	5.8	8.3	81	279
(Clay-silt fraction)		12/05/95	9513-32B	<0.1	38	NDR 5.4	45	<13	3.0	78	84	<1.5	6.2	8.3	79	268
	ALP-95-2F	12/05/95	9513-33	0.5	36	NDR 5.0	37	<13	<1.2	70	100	<1.4	5.5	6.4	85	260
	ALP-95-3F	12/05/95	9513-34	0.5	21	NDR 7.3	27	<14	<1.2	56	76	<0.93	2.5	4.3	74	195
	ALP-95-4F	12/05/95	9513-35	<0.1	26	NDR 6.5	29	<12	<1.2	51	53	<0.87	2.1	3.4	76	171
	ALP-95-5F	12/05/95	9513-36	0.1	46	NDR 6.2	52	<11	1.8	98	110	<0.97	5.9	6.6	74	327
	ALP-95-6F	12/05/95	9513-37	0.8	NDR 23	NDR 8.0	37	<4.9	<3.4	95	70	<3.7	3.0	3.3	66	240
	ALP-95-7F	12/05/95	9513-38R	1.1	39	6.0	51	<15	1.8	99	100	<0.85	5.2	6.0	64	309
	ALP-95-8F	12/05/95	9513-27		26	NDR 6.9	NDR 30	<5.0	<1.9	66	16	<1.3	4.8	4.3	85	154
	ALP-95-9F	12/05/95	9513-39	1.5	NDR 84	NDR 7.0	78	<6.0	<3.1	170	<37	<3.4	5.7	4.3	63	350
	ALP-95-10F	12/05/95	9513-40R	1.5	35	NDR 5.0	41	<15	<1.5	85	86	<0.96	4.5	4.4	53	262
Athabasca River below Alpac	ALP-95-1C	12/05/95	9513-28	<0.1	33	16	82	<15	2.2	220	96	<0.92	3.4	7.2	78	460
(Sand fraction)	ALP-95-2C	12/05/95	9513-123	<0.1	8.9	13	69	NDR 5.2	<1.6	110	450	NDR 2.2	<0.8	<1.4	91	658
	ALP-95-3C	12/05/95	9513-119	0.5	9.8	NDR 2.3	20	<2.1	<1.6	74	34	<0.82	NDR 0.87	1.8	97	143
	ALP-95-4C	12/05/95	9513-29	<0.1	NDR 5.1	NDR 5.9	NDR 12	<12	<1.2	44	18	<0.87	<0.84	1.7	83	86.7
	ALP-95-5C	12/05/95	9513-111	0.2	13	22	200	NDR 21	NDR 1.2	330	280	<0.83	NDR 1.4	3.2	72	872
	ALP-95-6C	12/05/95	9513-30	<0.1	7.1	5.9	31	NDR 16	<1.1	120	76	<0.85	1.2	2.6	83	260
	ALP-95-7C	12/05/95	9513-128	0.3	17	40	120	40	<1.3	400	500	8.6	1.6	2.8	87	1130
	ALP-95-8C	12/05/95	9513-31	<0.1	16	NDR 16	73	NDR 20	<1.3	260	140	<0.97	1.7	4.0	86	531
	ALP-95-9C	12/05/95	9513-104	<0.1	NDR 3.0	2.2	17	<2.0	<2.1	52	<29	<2.3	<1.1	<1.8	78	74.2
	ALP-95-10C	12/05/95	9513-139A	<0.1	<11	<1.9	<17	<0.71	NDR 1.3	<45	<20	<1.8	<0.94	<1.2	98	1.3
		12/05/95	9513-139B	<0.1	<11	<1.5	<17	<0.59	NDR 2.0	<45	<10	<0.57	<0.29	<0.43	94	2.0

Polyaromatic Hydrocarbons
October 1994
Results in ng/G

Site	Label	Fraction	Date	Notes	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzofluroranthenes	Benzo(o)pyrene
Wapiti River near the Mouth	WRM-F3	Clay-Silt	08/10/94	2898-02	86	<0.15	NDR 3.4	10	96	4.6	16	32	18	56	40	32
Smoky River near the Mouth	SRM-F2	Clay-Silt	04/10/94	2898-03	66	<0.22	5.4	10	66	<0.06	12	22	8.5	40	34	24
Peace River above Smoky River	PRS-F3	Clay-Silt	04/10/94	2898-21A	170	<0.76	5.6	18	120	<0.04	25	38	17	54	45	50
	PRS-F3	Clay-Silt	Lab Dup	2898-21B	180	<0.76	6.5	24	120	<0.03	25	37	18	54	45	51
Peace River below Diashowa	RRD-F2	Clay-Silt	09/10/94	2898-9A	68	<0.18	6.4	10	65	<0.07	14	25	10	34	30	30
	RRD-F2	Clay-Silt	09/10/94	Duplicate	90	<0.18	8.0	13	71	<0.06	14	26	11	37	31	32
	Blind	Clay-Silt	09/10/94	2898-33	79	<0.04	4.8	13	89	<0.03	20	31	15	44	40	40
Peace River above Notikewin R.	PRN-F3	Clay-Silt	06/10/94	2898-01	75	<0.18	6.2	13	68	<0.05	14	23	11	39	34	32
Peace River below Ft. Vermilion	PRV-F3	Clay-Silt	07/10/94	2898-05	66	<0.15	6.0	10	67	<0.06	15	25	10	37	31	31
Athabasca R above Lesser Slave R	ARL-F2	Clay-Silt	09/10/94	2898-06	31	<0.55	NDR 2.0	3.7	24	<0.15	4.9	7.2	2.0	13	9.9	6.6
	ARL-C2	Sand	09/10/94	9513-20	12	0.97	0.92	5.8	22	1.1	6	8.5	NDR 3.3	10	10	5.1
Athabasca River below Alpac	ARA-F1	Clay-Silt	10/10/94	2898-16	36	<0.3	NDR 1.8	5.0	25	<0.08	9.3	9.8	3.4	15	13	8.2
	ARA-C2	Sand		9513-14Ai	23	NDR 0.33	1.4	NDR 6.2	32	<0.01	12	18	6.0	170	22	9.5
	ARA-C2	Sand	Lab Dup	9513-14Bi	26	NDR 0.42	1.5	NDR 6.8	34	<0.01	12	16	6.9	180	26	11
Athabasca River above Horse R	ARH-F3	Clay-Silt	11/10/94	2898-20	21	<0.26	1.5	2.8	22	NDR 0.81	8.1	16	6	28	18	13
	ARH-C3	Sand	11/10/94	9513-18	11	1.6	1.4	3.9	15	NDR 0.69	8	16	NDR 5.7	NDR 23	20	12
Athabasca River near Fort McKay	ARM-F2	Clay-Silt	11/10/94	2898-19	21	NDR 0.3	1.2	3.3	20	NDR 1.3	7.9	12	5.8	25	17	12
	ARM-C2	Sand	11/10/94	9513-19	10	0.77	1.2	3.8	15	0.62	5.5	12	NDR 5.3	20	17	10

Polyaromatic Hydrocarbons
October 1994
Results in ng/g

Site	Label	C1 naphthalenes	C2 naphthalenes	C3 naphthalenes	C4 naphthalenes	C5 naphthalenes	C1 phenanthrenes	C2 phenanthrenes	C3 phenanthrenes	C4 phenanthrenes	Retene	C5 phenanthrenes	C1 fluor/pyrenes	C2 fluor/pyrenes	C3 fluor/pyrenes	C4 fluor/pyrenes	C5 fluor/pyrenes	Dibenzothiophene
Wapiti River near the Mouth	WRM-F3	220	290	380	260	100	320	400	250	270	150	58	120	180	160	76	26	NDR 7.8
Smoky River near the Mouth	SRM-F2	120	120	120	71	25	180	190	140	180	74	30	85	140	190	65	24	NDR 5.1
Peace River above Smoky River	PRS-F3	320	300	290	200	81	300	300	240	230	83	48	150	230	240	81	22	NDR 12
	PRS-F3	340	320	350	250	110	290	300	230	210	79	46	140	210	210	83	33	NDR 13
Peace River below Diashowa	RRD-F2	150	150	150	96	37	180	150	140	130	55	21	92	140	130	43	22	NDR 5.8
	RRD-F2	170	180	180	130	54	190	180	150	140	51	12	100	140	150	55	22	NDR 6.9
	Blind	210	260	250	180	91	230	240	190	200	81	26	120	190	180	87	18	NDR 9.5
Peace River above Notikewin R.	PRN-F3	160	160	170	120	44	190	190	150	160	73	19	95	130	140	50	20	NDR 6.0
Peace River below Ft. Vermilion	PRV-F3	150	190	200	150	68	190	200	160	150	66	29	88	130	140	64	13	NDR 7.2
Athabasca R above Lesser Slave R	ARL-F2	36	35	27	<0.25	3.5	60	54	37	40	40	<0.17	23	40	34	8.6	<0.32	NDR 1.9
	ARL-C2	34	45	47	33	18	50	64	37	90	69	8.9	24	38	37	11	<0.12	2.5
Athabasca River below Alpac	ARA-F1	35	32	30	13	3.4	60	55	45	85	65	5.8	32	46	36	14	<0.2	NDR 1.9
	ARA-C2	56	71	93	77	51	70	100	68	270	200	23	44	64	56	18	<0.13	NDR 2.9
	ARA-C2	62	86	110	95	64	80	120	78	310	260	31	50	72	70	21	<0.13	NDR 2.9
Athabasca River above Horse R	ARH-F3	27	34	35	38	30	58	130	240	400	130	140	70	150	190	160	53	NDR 2.5
	ARH-C3	26	38	50	47	32	41	110	180	310	92	95	58	160	190	200	120	NDR 1.9
Athabasca River near Fort McKay	ARM-F2	27	23	26	14	5.3	56	100	160	230	84	62	50	110	200	140	49	NDR 2.8
	ARM-C2	26	35	43	39	23	46	92	160	300	140	84	50	150	180	170	91	NDR 2.2

Polyaromatic Hydrocarbons
October 1994
Results in ng/g

Site	Label	Benzo(a)pyrene	Perylene	Dibenz(ah)anthracene	Indeno(1,2,3-cd)pyrene	Benzo(ghi)perylene	C1 Dibenzothiophene	C2 Dibenzothiophene	Total PAH (ng/g)
Wapiti River near the Mouth	WRM-F3	18	200	5.5	14	34	27	27	3987
Smoky River near the Mouth	SRM-F2	15	320	4.9	13	25	15	16	2456
Peace River above Smoky River	PRS-F3	20	200	NDR 11	21	75	32	30	4115
	PRS-F3	20	200	10	20	74	36	36	
Peace River below Diashowa	RRD-F2	15	170	6.2	12	42	18	19	2363
	RRD-F2	16	100	6.0	13	45	17	19	
	Blind	17	230	8.3	19	60	25	29	3326
Peace River above Notikewin R.	PRN-F3	16	210	NDR 4.1	13	42	17	19	2513
Peace River below Ft. Vermilion	PRV-F3	15	200	6.6	12	40	19	22	2608
Athabasca R above Lesser Slave R	ARL-F2	NDR 3.4	69	NDR 0.88	NDR 3.3	5.9	4.9	5.0	637
	ARL-C2	NDR 4.8	64	NDR 0.81	NDR 4.0	4.6	5	4.8	782
Athabasca River below Alpac	ARA-F1	6.0	120	NDR 1.1	4.9	7.5	5.1	5.3	836
	ARA-C2	NDR 11	170	NDR 1.6	5.6	8.2	6.8	6.0	1920
	ARA-C2	NDR 12	190	NDR 1.3	7.4	8.8	7.4	6.8	
Athabasca River above Horse R	ARH-F3	6.6	140	NDR 2.2	8.4	12	11	28	2233
	ARH-C3	11	140	2.1	NDR 11	12	7.2	14	2066
Athabasca River near Fort McKay	ARM-F2	6.2	120	NDR 2.8	8.4	12	7.6	24	1647
	ARM-C2	8.7	120	2.1	11	12	6.8	22	1915

Polyaromatic Hydrocarbons
May 1995
Results in ng/G

Site	Fraction	L/M/H	Date	Notes	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene	Benzofluoranthenes	Benzo(e)pyrene
Wapiti River near the Mouth	Clay-Silt	WR-95-7F	10/05/95	9513-24	33	<0.06	1.9	NDR 6.0	68	2.4	14	26	13	37	32	25
	Clay-Silt	WR-95-9F	10/05/95	9513-25A	41	<0.06	2.4	9.2	85	3.5	18	32	18	48	37	NDR 32
	Clay-Silt	WR-95-9F	10/05/95	9513-25B	42	<0.25	2.3	8.9	88	5.4	16	32	17	50	40	NDR 32
	Clay-Silt	WR-95-4F	10/05/95	9513-88	39	<0.06	1.9	6.9	75	2.8	19	30	18	44	38	28
	Sand	WR-95-10C	10/05/95	9513-137	75	<0.63	2.1	9.5	95	6.2	18	32	17	47	32	23
	Sand	WR-95-6C	10/05/95	9513-118	130	<0.3	4.4	16	160	8.0	40	65	29	74	57	36
	Sand	WR-95-4C	10/05/95	9513-81	220	<0.9	2.9	NDR 17	230	17	51	78	48	78	68	40
Athabasca River above Maskuta	Clay-Silt	ARC-95-1F	08/05/95	9513-21	15	<0.2	0.79	4.5	50	<0.09	4.5	6.0	NDR 2.6	21	8.7	6.9
Creek	Clay-Silt	ARC-95-2F	08/05/95	9513-46A	16	<0.25	<0.8	8.9	43	NDR 7.8	4.4	6.5	1.7	20	8.6	6.7
	Clay-Silt	ARC-95-2F	08/05/95	9513-46B	18	<0.35	<0.9	10	52	NDR 5.0	3.9	6.9	2.7	21	9.2	7.2
	Clay-Silt	ARC-95-3F	08/05/95	9513-47	16	<0.4	0.7	9.0	55	NDR 3.0	4.0	6.6	2.8	22	9.8	7.6
	Sand	ARC-95-7C	08/05/95	9513-122A	9.3	<0.35	1.0	7.9	38	<0.28	3.3	5.0	0.99	14	5.7	4.7
	Sand	ARC-95-7C	08/05/95	9513-122B	8.0	<0.34	0.88	6.6	32	<0.35	2.7	4.6	1.5	15	4.5	3.8
	Sand	ARC-95-4C	03/05/95	9513-43	26	<0.4	<1.2	11	69	3.0	6.4	14	6.7	22	10	8.9
	Sand	ARC-95-5C	08/05/95	9513-126	18	<0.31	1.3	12	50	<0.35	5.5	8.5	2.6	27	9.8	7.4
Athabasca River below	Clay-Silt	EL-95-8F	09/05/95	9513-65	16	<0.2	<0.7	9.0	42	4.0	6.9	7.8	2.9	18	9.1	6.5
Emerson Lakes	Clay-Silt	EL-95-4F	09/05/95	9513-62	14	<0.5	<1.0	8.5	44	NDR 2.0	5.5	6.4	1.9	16	7.6	5.9
	Clay-Silt	EL-95-5F	09/05/95	9513-63	18	0.15	<1.3	12	45	NDR 10	8.5	9.0	3.0	20	9.5	6.8
	Sand	EL-95-9C	09/05/95	9513-113	12	<0.32	NDR 1.6	13	52	<0.28	5.1	7.0	2.0	23	7.2	6.0
	Sand	EL-95-7C	09/05/95	9513-58	19	<0.06	2.0	12	69	3.7	11	12	4.2	25	11	8.0
	Sand	EL-95-3C	09/05/95	9513-55	28	<0.06	NDR 1.2	14	73	4.0	6.6	10	4.1	22	10	9.0
Athabasca River below Alpac	Clay-Silt	ALP-95-8F	12/05/95	9513-27	6.4	<0.06	0.78	1.6	18	<0.09	5.1	7.6	2.7	10	11	6.9
	Clay-Silt	ALP-95-2F	12/05/95	9513-33	9.1	<0.09	0.73	2.1	18	<0.13	5.2	7.5	2.8	11	11	6.2
	Clay-Silt	ALP-95-5F	12/05/95	9513-36	11	<0.3	1.2	4.8	20	NDR 1.9	7.3	9.9	3.0	13	13	8.0
	Sand	ALP-95-10C	12/05/95	9513-139	5.8	<0.39	0.64	2.6	13	<0.49	2.7	5.8	1.7	5.4	6.6	2.8
	Sand	ALP-95-1C	12/05/95	9513-28	31	<0.2	1.6	5.7	48	2.6	14	22	7.5	21	26	12
	Sand	ALP-95-7C	12/05/95	9513-128	16	<0.35	1.6	5.2	25	<0.35	7.8	14	3.9	15	16	7.5

Polyaromatic Hydrocarbons
May 1995
Results in ng/g

Site	Label	C1 naphthalenes	C2 naphthalenes	C3 naphthalenes	C4 naphthalenes	C5 naphthalenes	C1 phenanthrenes	C2 phenanthrenes	C3 phenanthrenes	C4 phenanthrenes	Retene	C5 phenanthrenes	C1 fluor/pyrenes	C2 fluor/pyrenes	C3 fluor/pyrenes	C4 fluor/pyrenes	C5 fluor/pyrenes	Dibenzothiophene
Wapiti River near the Mouth	WR-95-7F	140	220	290	190	80	210	270	180	240	140	31	110	160	150	73	23	NDR 5.9
	WR-95-9F	170	270	400	270	110	260	340	230	290	160	68	130	200	200	93	35	NDR 5.8
	Lab Dup	170	280	390	260	110	270	350	240	300	160	57	140	210	170	140	40	NDR 8.2
	WR-95-4F	160	250	360	240	110	230	300	200	300	180	36	120	180	140	100	35	NDR 6.3
	WR-95-10C	290	440	530	290	110	250	430	230	380	260	55	120	170	130	57	24	10
	WR-95-6C	470	820	920	500	210	440	690	400	660	470	86	220	250	200	130	31	17
	WR-95-4C	740	1000	1500	600	430	660	940	490	1300	960	210	310	450	340	190	87	NDR 16
Athabasca River above Maskuta Creek	ARC-95-1F	51	64	34	9.3	0.95	110	100	46	47	26	<0.1	18	34	33	9.8	<0.14	4.0
	ARC-95-2F	54	70	38	8.9	0.64	110	100	50	48	27	<0.52	19	35	31	11	<0.35	4.9
	Lab Dup	57	74	39	10	0.81	110	110	48	50	29	<0.47	20	38	31	10	<0.5	5.1
	ARC-95-3F	56	70	36	7.7	0.78	120	110	61	68	39	<0.47	21	40	36	14	<0.5	5.3
	ARC-95-7C	40	69	35	6.9	0.96	81	94	38	34	16	<0.2	13	23	31	9.8	<0.41	NDR 3.5
	Lab Dup	36	83	30	3.3	0.98	70	76	30	13	13	<0.25	9.6	12	14	<0.47	<0.5	NDR 2.8
	ARC-95-4C	82	100	55	17	5.4	160	190	97	84	43	9.4	30	64	54	16	<0.39	7.0
	ARC-95-5C	67	110	54	12	2.6	130	160	60	240	220	<0.27	32	56	52	14	<0.51	5.7
Athabasca River below Emerson Lakes	EL-95-8F	47	61	42	20	5.3	98	91	60	54	35	4.2	28	42	32	7.4	<0.1	4.3
	EL-95-4F	43	57	33	7.9	2.2	100	94	69	56	32	<0.7	18	35	28	8.3	<0.77	4.2
	EL-95-5F	53	68	49	16	7.5	140	130	68	72	41	5.6	24	46	38	12	<0.09	NDR 5.6
	EL-95-9C	60	96	54	13	3.6	110	140	55	23	23	<0.2	20	42	36	12	<0.36	NDR 4.9
	EL-95-7C	67	88	55	21	11	140	200	96	76	40	4.9	27	49	37	12	<0.57	7.0
	EL-95-3C	92	110	68	20	12	170	240	130	200	150	19	43	77	59	22	<0.69	7.8
Athabasca River below Alpac	ALP-95-8F	19	28	26	11	4.1	45	56	44	72	54	<0.1	25	34	22	13	<0.16	NDR 1.6
	ALP-95-2F	19	26	24	12	4.1	47	53	44	61	44	<0.13	25	33	19	13	<0.18	NDR 1.7
	ALP-95-5F	24	40	32	18	8.2	59	85	97	170	130	8.6	35	48	32	18	<0.62	2.4
	ALP-95-10C	47	33	28	11	4.8	36	53	40	41	33	<0.29	13	16	11	<0.44	<0.51	NDR 1.4
	ALP-95-1C	77	110	150	110	66	140	240	160	210	140	29	67	94	81	36	22	NDR 6.7
	ALP-95-7C	47	85	74	40	13	63	120	82	120	91	11	41	48	30	12	<0.57	NDR 2.9

Polyaromatic Hydrocarbons
May 1995
Results in ng/g

Site	Label	Benzo(a)pyrene	Perylene	Dibenz(ah)anthracene	Indeno(1,2,3-cd)pyrene	Benzo(ghi)perylene	C1 Dibenzothiophene	C2 Dibenzothiophene	Total PAH
Wapiti River near the Mouth	WR-95-7F	12	210	3.9	11	24	26	38	3096
	WR-95-9F	16	260	4.4	16	34	25	32	3985
	Lab Dup	15	260	5.5	17	32	29	37	
	WR-95-4F	15	250	4.2	14	29	24	31	3617
	WR-95-10C	16	160	3.7	8.8	21	24	34	4400
	WR-95-6C	32	400	NDR 6.0	16	32	62	97	7778
	WR-95-4C	29	390	7.9	22	39	79	97	11737
Athabasca River above Maskuta Creek	ARC-95-1F	<0.4	45	NDR 1.1	NDR 0.95	2.6	10	16	782
	ARC-95-2F	<0.6	41	1.0	<1.1	2.9	12	16	824
	Lab Dup	<0.5	44	1.2	<1.0	3.0	12	16	
	ARC-95-3F	<0.6	50	1.2	NDR 1.1	3.1	13	16	906
	ARC-95-7C	<1.0	13	<0.65	<0.5	<0.4	9.1	17	567
	Lab Dup	<1.3	13	<0.7	<0.44	NDR 1.2	7.5	15	
	ARC-95-4C	NDR 2.5	40	1.4	1.8	4.8	21	46	1308
	ARC-95-5C	<1.3	35	NDR 1.4	0.78	NDR 1.1	13	22	1431
Athabasca River below Emerson Lakes	EL-95-8F	NDR 1.8	53	1.3	2.3	4.7	10	12	839
	EL-95-4F	<0.05	26	1.1	1.0	2.5	11	13	754
	EL-95-5F	<0.8	30	1.2	<1.4	3.3	16	22	990
	EL-95-9C	<0.8	14	NDR 0.95	0.65	<0.4	12	23	872
	EL-95-7C	NDR 2.5	23	1.3	2.0	3.7	25	59	1224
	EL-95-3C	<1.3	43	1.7	NDR 1.6	3.4	27	61	1739
Athabasca River below Alpac	ALP-95-8F	3.2	110	0.88	4.1	NDR 6.5	7.3	19	676
	ALP-95-2F	3.3	110	<0.95	4.1	5.9	6.5	16	645
	ALP-95-5F	NDR 5.0	140	1.2	NDR 5.0	7.4	12	27	1098
	ALP-95-10C	NDR 2.1	44	<1.3	NDR 1.8	<1.0	7.5	22	493
	ALP-95-1C	9.6	230	NDR 2.4	11	12	33	83	2311
	ALP-95-7C	6.8	150	<0.9	4.8	7.0	11	28	1200

Dioxins and Furans
October 1994
Results in pg/g

Site	Label	Fraction	Date	Notes	M1CDD Total	D2CDD Total	T3CDD Total	T4CDD Total	P5CDD Total	H6CDD Total	H7CDD Total	O8CDD Total	M1CDF Total	D2CDF Total	T3CDF Total	T4CDF Total	P5CDF Total	H6CDF Total	H7CDF Total	O8CDF Total	TEQ*
Wapiti River near the Mouth	WRM-F3	Clay-Silt	08/10/94	2898-02	<0.4	2.0	0.8	1.4	0.8	0.8	3.3	12	<0.6	3.1	3.9	<0.2	<0.2	0.9	1.9	1.3	0.33
Smoky River near the Mouth	SRM-F2	Clay-Silt	04/10/94	2898-03A	1.6	5.7	3.9	8.2	4.2	3.6	1.6	4.9	<0.6	1.7	2.2	<0.2	<0.1	<0.3	<0.4	0.5	0.23
Smoky River near the Mouth	SRM-F2	Clay-Silt	"	Lab Dup	1.7	5.9	5.0	9.4	3.9	4.0	1.4	4.8	<0.6	1.8	1.3	<0.2	<0.1	<0.3	<0.4	<0.5	0.23
Peace River above Smoky River	PRS-F3	Clay-Silt	04/10/94	2898-21	0.4	2.4	1.4	2.4	1.6	0.9	1.7	5.4	3.5	1.6	1.2	0.3	0.6	1.0	0.4	1.0	0.48
Peace River below Diashowa	RRD-F2	Clay-Silt	09/10/94	2898-09	<0.2	0.4	1.6	3.7	2.0	1.6	1.2	4.6	0.8	<0.3	0.5	<0.1	<0.1	<0.3	<0.4	<0.5	0.23
Peace River below Diashowa	**Blind**	Clay-Silt	09/10/94	2898-33	<0.2	3.1	1.6	2.7	1.5	1.3	3.0	15	3.5	<0.1	0.7	<0.2	<0.2	<0.6	<0.8	<1.0	0.41
Peace River above Notikewin R.	PRN-F3	Clay-Silt	06/10/94	2898-01	0.6	2.5	1.5	3.3	1.5	1.8	1.0	3.7	<0.6	<0.8	1.7	<0.2	<0.2	<0.3	<0.4	<0.5	0.26
Peace River below Ft. Vermilion	PRV-F3	Clay-Silt	07/10/94	2898-05	0.6	3.2	1.7	4.3	2.3	1.8	1.2	6.4	1.2	1.3	<0.3	0.3	<0.1	<0.3	<0.4	<0.5	0.23
Athabasca R above Lesser Slave R	ARL-F2	Clay-Silt	09/10/94	2898-06	<0.2	14	3.7	1.3	<0.2	0.9	3.7	13	2.3	4.6	4.9	0.6	<0.2	<0.6	<0.8	<1.1	0.44
Athabasca River below Alpac	ARA-F1	Clay-Silt	10/10/94	2898-16A	0.6	11	3.3	3.5	2.1	2.2	5.2	18	1.8	6.8	5.3	1.1	0.2	<0.3	0.7	1.2	0.29
Athabasca River below Alpac	ARA-F1	Clay-Silt	"	Lab Dup	0.6	11	3.2	3.4	2.0	2.2	5.4	19	1.2	6.7	6.1	1.1	0.3	<0.3	0.8	1.2	0.30
Athabasca River above Horse R	ARH-F3	Clay-Silt	11/10/94	2898-20i	1.0	13	33	3.2	1.9	1.5	5.0	17	3.9	3.1	3.7	0.8	<0.2	<0.3	0.7	1.0	0.30
Athabasca River near Fort McKay	ARM-F2	Clay-Silt	11/10/94	2898-19i	0.6	9.2	18	2.9	0.6	1.6	4.6	15	2.3	4.4	3.9	0.3	<0.1	<0.3	<0.4	1.0	0.27

Dioxins and Furans
May 1995 (results in pg/g)

Site	Label	L/M/H	Date	Notes	M1CDD Total	D2CDD Total	T3CDD Total	T4CDD Total	P5CDD Total	H6CDD Total	H7CDD Total	O8CDD Total	M1CDF Total	D2CDF Total	T3CDF Total	T4CDF Total	P5CDF Total	H6CDF Total	H7CDF Total	O8CDF Total	TEQ*
Wapiti River near the Mouth	Clay-Silt	WR-95-7F	10/05/95	9513-24	0.7	1.6	1.1	2.8	2	1.6	<0.7	4.1	1.5	1.5	0.4	<0.2	<0.2	<0.4	<0.6	<0.8	0.37
	Clay-Silt	WR-95-9F	10/05/95	9513-25R	1.0	4.1	2.1	4.3	2.1	2.4	1.9	6.8	2.7	3.1	2.2	0.6	<0.2	<0.4	<0.6	<0.8	0.33
	Clay-Silt	WR-95-4F	10/05/95	9513-88	0.8	2.4	1.8	3.8	2.2	1.2	0.7	4.9	<1.2	1.9	2.6	0.5	<0.2	<0.4	<0.6	<0.8	0.33
	Sand	WR-95-10C	10/05/95	9513-137A	<0.3	<1.2	<0.1	0.2	<0.2	<0.4	<0.6	1.1	<1.2	0.9	1.0	0.1	<0.2	<0.4	<0.6	<0.8	0.31
	Sand			9513-137B	<0.3	<1.2	<0.1	0.2	<0.2	<0.4	<0.6	0.9	<1.2	0.9	1.2	0.1	<0.2	<0.4	<0.6	<0.8	0.31
	Sand	WR-95-6C	10/05/95	9513-118	<0.3	<1.2	0.3	1.6	0.5	0.4	0.6	5.7	<1.2	1.2	1.4	0.4	<0.2	<0.4	<0.6	<0.9	0.33
	Sand	WR-95-4C	10/05/95	9513-81	<0.3	0.9	<0.3	0.2	0.4	<0.4	<0.6	2.3	1.8	1.4	1.2	<0.2	<0.2	<0.4	<0.6	<0.9	0.37
Athabasca River above	Clay-Silt	ARC-95-1F	08/05/95	9513-21R	<0.3	13	0.4	0.3	<0.2	0.4	4.2	16	1.6	<0.3	0.5	0.2	<0.2	<0.4	2.0	1.6	0.34
Maskuta Creek (Control)	Clay-Silt	ARC-95-2F	08/05/95	9513-46	<0.3	8.4	0.3	<0.2	<0.2	<0.4	4.3	14	1.1	<0.3	0.3	<0.2	<0.2	<0.4	2.0	1.3	0.37
	Clay-Silt	ARC-95-3F	08/05/95	9513-47RA	<0.3	15	0.5	0.1	<0.2	<0.4	3.7	15	0.8	<0.2	0.5	<0.1	<0.2	0.4	1.2	1.5	0.32
	Clay-Silt			9513-47RB	<0.4	16	0.7	0.3	<0.2	<0.4	3.7	14	1.7	<0.3	0.4	0.1	<0.2	<0.4	1.1	1.5	0.32
	Sand	ARC-95-7C	08/05/95	9513-122A	<0.2	<0.6	<0.2	<0.2	<0.2	<0.4	<0.6	3.2	0.8	<0.2	<0.2	<0.2	<0.2	<0.4	<0.6	<0.8	0.37
	Sand	ARC-95-4C	08/05/95	9513-43	<0.3	1.4	0.1	<0.1	<0.2	<0.4	1.7	4.1	1.1	<0.3	<0.3	<0.1	<0.2	<0.4	<0.6	<0.8	0.32
	Sand	ARC-95-5C	08/05/95	9513-126	<0.3	2.0	<0.1	<0.1	<0.2	<0.4	1.0	12	<1.2	<0.3	<0.3	<0.1	<0.2	<0.4	<0.7	1.4	0.33
Athabasca River below	Clay-Silt	EL-95-8F	09/05/95	9513-65	<0.3	9.2	0.3	0.6	<0.3	<0.5	3.6	12	10	21	12	3.6	<0.3	<0.5	1.0	1.0	0.78
Emerson Lakes	Clay-Silt	EL-95-4F	09/05/95	9513-62	<0.9	12	<0.5	<0.3	<0.2	<0.6	3.0	<13	<4.3	<8.1	<3.1	<0.6	<1.4	<0.5	1.0	1.1	0.38
	Clay-Silt	EL-95-5F	09/05/95	9513-63	<0.3	14	0.4	0.9	<0.2	<0.4	6.3	21	5	24	7.7	2.2	<0.2	0.4	2	2.2	0.61
	Sand	EL-95-9C	09/05/95	9513-113	<0.3	2.5	<0.1	0.2	<0.2	<0.4	1.5	4.7	<1.2	4.2	3.7	0.5	<0.2	<0.4	<0.6	<0.8	0.33
	Sand	EL-95-7C	09/05/95	9513-58	<0.3	3.5	<0.3	<0.2	<0.2	<0.4	2.6	9.9	1.6	3.5	2.2	0.2	<0.2	<0.5	<0.8	<1.0	0.42
	Sand	EL-95-3C	09/05/95	9513-55R	<0.4	4.6	0.2	0.2	<0.2	<0.4	3.6	8.7	0.8	3.0	1.8	0.4	<0.2	<0.4	0.7	<0.8	0.35
Athabasca River below Alpac	Clay-Silt	ALP-95-8F	12/05/95	9513-27	1.1	7.2	2.2	2.9	1.8	1.4	3.9	13	2.8	4.2	2.9	0.9	<0.2	<0.4	<0.7	<0.9	0.35
	Clay-Silt	ALP-95-2F	12/05/95	9513-33	<2.1	6.1	<2.1	<1.3	<2.0	<3.0	<4.0	10	2.6	<2.1	<2.1	<1.3	<2.0	<3.0	<4.0	<6.5	3.18
	Clay-Silt	ALP-95-5F	12/05/95	9513-36	<0.6	8.0	2.3	1.7	1.3	1.5	5.1	14	1.2	3.4	0.8	0.4	<0.3	<1.0	<1.4	<1.6	0.93
	Sand	ALP-95-10C	12/05/95	9513-139	<0.3	1.6	0.3	0.2	<0.2	<0.4	<0.6	1.3	<1.2	2.2	2.5	0.5	<0.2	<0.4	<0.6	<0.8	0.30
	Sand	ALP-95-1C	12/05/95	9513-28	<0.7	4.0	1.2	0.9	0.8	1.2	16	37	1.4	4.2	1.2	0.9	<0.6	<1.0	<1.6	<2.3	1.00
	Sand	ALP-95-7C	12/05/95	9513-128	0.5	2.9	1.3	1.1	<0.2	<0.5	0.8	4.0	<1.2	3.5	3.5	1.0	<0.2	<0.4	<0.6	<0.8	0.36

Chlorinated Phenolics
October 1994
Results in ng/g

Site	Label	Date	Notes	4-CP	2,6-DCP	2,4/2,5-DCP	3,6-DCP	2,3-DCP	3,4-DCP	6-CG	4-CG	5-CG
Wapiti River near the Mouth	WRM-F3	08/10/94	2898-02	0.17	NDR 2.0	NDR 4.6	<1.8	<1.3	<0.9	<0.02	NDR 0.42	NDR 0.27
Smoky River near the Mouth	SRM-F2	04/10/94	2898-03	0.18	NDR 0.14	0.2	<0.18	<0.18	<0.11	<0.02	<0.08	<0.02
Peace River above Smoky River	PRS-F3	04/10/94	2898-21	0.13	NDR 0.29	NDR 0.49	<0.08	<0.07	<0.05	<0.03	<0.02	NDR 0.31
Peace River below Diashowa	RRD-F2	09/10/94	2898-09	0.14	NDR 0.18	0.16	<0.15	<0.12	<0.08	<0.02	<0.02	<0.03
	Blind	09/10/94	2898-33	0.25	<0.07	NDR 0.28	<0.11	<0.09	<0.07	<0.04	<0.03	NDR 0.27
Peace River above Notikewin R.	PRN-F3	06/10/94	2898-01	0.09	<0.11	0.19	<0.18	<0.15	<0.1	<0.02	<0.02	<0.21
Peace River below Ft. Vermilion	PRV-F3	07/10/94	2898-5A	0.14	NDR 0.13	0.21	<0.19	<0.16	<0.11	<0.03	<0.04	<0.06
"	PRV-F3	Lab Dup	2898-5B	0.14	NDR 0.16	0.2	<0.13	<0.11	<0.08	<0.02	<0.05	<0.02
Athabasca R above Lesser Slave R	ARL-F2	09/10/94	2898-06	0.17	NDR 0.26	0.16	<0.29	<0.25	<0.17	<0.05	NDR 0.15	<0.08
Athabasca River below Alpac	ARA-F1	10/10/94	2898-16	0.18	NDR 0.17	NDR 0.2	NDR 0.3	<0.07	<0.05	<0.04	NDR 0.13	NDR 0.23
Athabasca River above Horse R	ARH-F3	11/10/94	2898-20A	0.46	NDR 0.29	NDR 0.46	<0.06	<0.07	<0.05	<0.03	<0.02	<0.05
"		Lab Dup	2898-20B	0.58	NDR 0.33	NDR 0.43	<0.08	<0.06	<0.05	<0.03	<0.08	<0.04
Athabasca River near Fort McKay	ARM-F2	11/10/94	2898-19	0.2	NDR 0.14	NDR 0.19	0.21	<0.08	<0.06	<0.04	<0.05	<0.05

Chlorinated Phenolics (Cont.)
October 1994
Results in ng/g

	Label	2,4,6-TCP	2,3,6-TCP	2,3,5-TCP	2,4,5-TCP	2,3,4-TCP	3,4,5-TCP	3-CC	4-CC	4,6-DCG	3,4-DCG	4,5-DCG	3-CS	3,6-DCC	3,5-DCC	3,4-DCC	4,5-DCC
Wapiti River near the Mouth	WRM-F3	<0.04	<0.05	<0.05	<0.03	<0.04	<0.07	<0.11	0.45	<0.04	<0.05	0.4	<0.02	<0.2	<0.33	NDR 3.9	NDR 0.52
Smoky River near the Mouth	SRM-F2	<0.06	<0.06	<0.06	<0.03	<0.04	0.15	<0.08	<0.05	<0.04	<0.05	0.09	<0.02	<0.36	<0.58	NDR 6.4	NDR 0.47
Peace River above Smoky River	PRS-F3	<0.04	<0.06	<0.07	<0.03	<0.04	0.17	<0.12	<0.07	<0.03	0.19	<0.03	<0.02	<0.44	<0.67	NDR 2.9	<0.38
Peace River below Diashowa	RRD-F2	<0.08	<0.05	<0.09	<0.05	<0.04	0.15	<0.23	<0.04	<0.04	<0.05	<0.03	<0.02	<0.53	<0.83	NDR 14	<0.48
	Blind	0.07	<0.07	<0.10	<0.05	<0.08	0.22	<0.23	<0.14	<0.06	0.36	<0.05	NDR 0.18	<0.51	<0.78	NDR 18	<0.42
Peace River above Notikewin R.	PRN-F3	0.12	<0.05	<0.06	<0.03	<0.04	0.16	<0.11	<0.06	<0.07	<0.05	0.17	<0.04	<1.0	<0.75	<0.42	0.5
Peace River below Ft. Vermilion	PRV-F3	0.16	<0.06	<0.06	<0.04	<0.04	0.19	<0.1	0.18	<0.04	<0.06	0.26	<0.02	<0.67	<1.0	NDR 10	<1.3
"	PRV-F3	0.17	<0.04	<0.04	<0.03	<0.03	0.19	<0.07	0.2	<0.03	<0.05	0.32	<0.02	<0.44	<0.69	NDR 8.3	<0.9
Athabasca R above Lesser Slave R	ARL-F2	<0.1	<0.09	<0.09	<0.06	<0.07	<0.06	<0.15	0.16	<0.07	<0.1	0.32	<0.03	<0.44	NDR 0.75	NDR 4.2	1.5
Athabasca River below Alpac	ARA-F1	<0.04	<0.06	<0.07	<0.04	<0.05	0.11	<0.06	<0.03	0.22	<0.07	0.4	<0.03	<0.89	<1.3	NDR 9.3	NDR 1.0
Athabasca River above Horse R	ARH-F3	<0.08	<0.11	<0.1	<0.07	<0.09	0.29	<0.05	<0.06	<0.04	<0.06	0.2	<0.03	<0.95	<2.8	NDR 14	<0.78
"	ARH-F3	<0.1	<0.13	<0.12	<0.08	<0.1	0.22	<0.05	<0.09	<0.04	<0.06	0.24	<0.04	<2.8	<1.2	NDR 16	<0.67
Athabasca River near Fort McKay	ARM-F2	0.1	<0.07	<0.07	<0.04	<0.06	0.17	<0.06	<0.04	<0.04	<0.06	0.24	<0.05	<0.29	<0.3	<0.4	<0.17

Chlorinated Phenolics (Cont.)
October 1994
Results in ng/g

Site	Label	2,3,5,6-TCP	2,3,4,6-TCP	2,3,4,5-TCP	5-CV	6-CV	3,5-DCS	3,4,6-TCG	3,4,5-TCG	4,5,6-TCG	3,4,6-TCC	3,4,5-TCC	5,6-DCV	PCP	2-CSA	3,4,5,6-TCG	3,4,5-TCS	3,4,5,6-TCC	2,6-DCSA
Wapiti River near the Mouth	WRM-F3	<0.12	<0.07	<0.08	0.34	19	<0.26	<0.06	0.17	<0.05	<0.15	NDR .39	1.8	0.12	<0.02	<0.09	<0.13	0.24	<0.06
Smoky River near the Mouth	SRM-F2	<0.12	<0.07	<0.08	<0.15	4.9	<0.27	<0.06	<0.09	<0.05	<0.26	<0.24	NDR 1.3	<0.1	<0.02	<0.09	<0.13	0.16	<0.06
Peace River above Smoky River	PRS-F3	<0.15	<0.08	<0.1	<0.2	<0.22	<0.1	<0.05	<0.06	<0.04	<0.35	<0.31	<0.03	0.12	<0.03	<0.04	<0.06	<0.15	<0.02
Peace River below Diashowa	RRD-F2	<0.12	<0.07	<0.08	<0.13	0.6	<0.26	<0.06	<0.1	<0.06	<0.38	<0.33	NDR 1.2	<0.11	<0.02	<0.08	<0.13	<0.18	<0.09
	Blind	<0.11	<0.06	<0.18	<0.34	0.96	<0.28	<0.06	<0.06	<0.04	<0.4	<0.35	NDR 0.41	0.15	<0.06	<0.06	<0.1	<0.14	<0.05
Peace River above Notikewin R.	PRN-F3	<0.13	<0.07	<0.09	<0.22	1.4	<0.12	<0.04	0.47	0.05	<0.36	1.4	0.14	<0.1	<0.04	<0.18	<0.09	0.23	<0.14
Peace River below Ft. Vermilion	PRV-F3	<0.14	<0.06	<0.1	<0.16	2.7	<0.07	<0.78	7.2	0.88	<0.5	3.0	NDR 0.22	<0.1	<0.04	0.19	<0.26	0.42	<0.07
"	PRV-F3	<0.11	<0.06	<0.08	<0.12	2.8	<0.25	<0.54	6.8	0.86	<0.33	2.7	NDR 0.27	<0.1	<0.05	0.16	<0.12	0.42	<0.09
Athabasca R above Lesser Slave R	ARL-F2	<0.22	<0.13	<0.15	<0.29	6.4	<0.49	<0.12	0.79	<0.09	<0.33	3.3	0.14	<0.12	<0.04	0.16	<0.39	0.51	<0.14
Athabasca River below Alpac	ARA-F1	<0.08	<0.05	<0.12	<0.12	3.1	<0.14	<0.09	0.6	<0.07	<0.69	2.0	0.24	0.07	<0.05	0.14	<0.04	2.4	<0.17
Athabasca River above Horse R	ARH-F3	<0.18	<0.1	<0.13	NDR 0.13	3.2	<0.19	<0.11	0.32	<0.08	<0.73	0.82	<0.12	0.1	NDR .16	0.1	<0.1	0.7	<0.03
"	ARH-F3	<0.15	<0.1	<0.16	NDR 0.17	3.3	<0.14	<0.1	0.37	<0.07	<0.62	0.58	<0.09	0.07	<0.07	0.1	<0.1	<0.8	<0.03
Athabasca River near Fort McKay	ARM-F2	<0.1	<0.06	<0.13	<0.46	1.7	<0.19	<0.06	0.43	<0.05	<0.15	0.35	NDR 0.1	<0.07	<0.04	0.1	<0.06	<0.5	<0.12

Chlorinated Phenolics
May 1995
Results in ng/g

Site	L/M/H	Date	Label	4-CP	2,6-DCP	2,4/2,5-DCP	3,6-DCP	2,3-DCP	3,4-DCP	6-CG	4-CG	5-CG
Wapiti River near	WR-95-7F	10/05/95	9513-24	0.06	NDR 0.06	NDR 0.22	<0.03	NDR 0.07	NDR 0.05	<0.01	NDR 0.1	NDR 0.42
the Mouth	WR-95-9F	10/05/95	9513-25	0.05	NDR 0.03	NDR 0.29	<0.04	<0.04	<0.03	<0.02	NDR 0.13	NDR 0.35
	WR-95-4F	10/05/95	9513-88A	<0.14	<0.18	NDR 0.16	<0.27	<0.24	<0.19	<0.06	0.3	NDR 0.29
			9513-88B	<0.14	<0.2	NDR 0.14	<0.32	<0.28	<0.22	<0.05	0.23	NDR 0.25
	WR-95-10C	10/05/95	9513-137	<0.23	<0.17	<0.13	<0.26	<0.23	<0.18	<0.05	<0.04	<0.06
	WR-95-6C	10/05/95	9513-118	<0.18	<0.04	NDR 0.1	<0.06	<0.05	<0.04	<0.04	NDR 0.06	<0.05
	WR-95-4C	10/05/95	9513-81	<0.12	NDR 0.03	NDR 0.14	<0.03	<0.03	<0.02	<0.03	0.16	NDR 0.16
Athabasca River	ARC-95-1F	08/05/95	9513-21	0.03	NDR 0.05	NDR 0.11	NDR 0.15	<0.04	<0.03	<0.02	<0.04	<0.04
above	ARC-95-2F	08/05/95	9513-46	0.06	NDR 0.04	NDR 0.1	<0.03	<0.02	<0.02	<0.01	<0.01	<0.01
Maskuta Creek	ARC-95-3F	08/05/95	9513-47A	<0.04	NDR 0.04	NDR 0.12	<0.03	<0.03	<0.02	<0.01	<0.01	<0.02
			9513-47B	NDR 0.04	NDR 0.03	NDR 0.12	<0.03	<0.03	<0.02	<0.01	<0.01	<0.02
	ARC-95-7C	08/05/95	9513-122	<0.19	<0.1	<0.08	<0.15	<0.13	<0.1	<0.03	<0.03	<0.04
	ARC-95-4C	08/05/95	9513-43	<0.04	NDR 0.06	NDR 0.16	<0.04	<0.03	<0.02	<0.02	<0.01	<0.05
	ARC-95-5C	08/05/95	9513-126	<0.17	NDR 0.07	NDR 0.08	<0.06	<0.06	<0.04	<0.02	<0.02	<0.03
Athabasca River	EL-95-8F	09/05/95	9513-65	<0.18	NDR 0.03	NDR 0.36	<0.04	<0.03	NDR 0.09	<0.04	0.33	<0.05
below	EL-95-4F	09/05/95	9513-62	<0.34	NDR 0.07	NDR 0.23	<0.05	<0.05	<0.04	<0.06	0.39	<0.07
Emerson Lakes	EL-95-5F	09/05/95	9513-63	<0.03	NDR 0.04	NDR 0.36	<0.02	<0.02	<0.02	<0.01	0.66	<0.01
	EL-95-9C	09/05/95	9513-113	<0.1	<0.14	NDR 0.27	<0.22	<0.2	<0.15	<0.05	0.17	<0.06
	EL-95-7C	09/05/95	9513-58	<0.16	NDR 0.04	NDR 0.32	<0.04	<0.04	<0.03	<0.04	0.23	<0.05
	EL-95-3C	09/05/95	9513-55	<0.19	NDR 0.1	NDR 0.2	<0.06	<0.05	<0.04	<0.05	NDR 0.21	<0.07
Athabasca River	ALP-95-8F	12/05/95	9513-27	0.05	NDR 0.05	NDR 0.31	NDR 0.18	<0.03	<0.02	<0.02	0.05	NDR 0.19
below Alpac	ALP-95-2F	12/05/95	9513-33A	0.1	NDR 0.09	NDR 0.2	<0.04	<0.04	<0.03	<0.02	<0.04	NDR 0.19
			9513-33B	0.1	NDR 0.11	<0.02	<0.04	<0.03	<0.03	<0.01	NDR 0.06	NDR 0.17
	ALP-95-5F	12/05/95	9513-36	0.09	NDR 0.12	NDR 0.23	<0.03	<0.03	NDR 0.06	<0.01	<0.06	NDR 0.1
	ALP-95-10C	12/05/95	9513-139	<0.16	<0.14	<0.11	<0.21	<0.19	<0.15	<0.03	<0.02	<0.03
	ALP-95-1C	12/05/95	9513-28	0.06	NDR 0.08	NDR 0.37	<0.05	NDR 0.27	NDR 0.17	<0.02	<0.05	NDR 0.24
	ALP-95-7C	12/05/95	9513-128	<0.19	<0.07	NDR 0.1	<0.1	<0.09	<0.07	<0.06	<0.05	<0.08

Chlorinated Phenolics (Cont.)
May 1995
Results in ng/g

Site	L/M/H	2,4,6-TCP	2,3,6-TCP	2,3,5-TCP	2,4,5-TCP	2,3,4-TCP	3,4,5-TCP	3-CC	4-CC	4,6-DCG	3,4-DCG	4,5-DCG	3-CS	3,6-DCC	3,5-DCC	3,4-DCC	4,5-DCC
Wapiti River near	WR-95-7F	NDR 0.06	<0.04	<0.04	<0.02	<0.03	NDR 0.08	<0.06	<0.04	<0.01	NDR 0.15	0.11	<0.02	<0.1	<0.15	NDR 1.9	<0.07
the Mouth	WR-95-9F	NDR 0.04	<0.04	<0.04	<0.03	<0.04	0.1	<0.06	NDR 0.09	<0.03	NDR 0.14	0.14	<0.03	<0.12	<0.19	NDR 1.9	NDR 0.37
	WR-95-4F	<0.04	<0.05	<0.06	0.05	<0.05	0.08	<0.19	0.21	<0.04	<0.05	0.14	<0.04	<0.85	<1.3	NDR 0.97	<0.71
		<0.04	<0.06	<0.06	<0.04	<0.05	0.07	<0.14	0.23	<0.04	NDR 0.12	0.17	<0.04	<0.53	<0.84	NDR 1.1	<0.44
	WR-95-10C	0.05	<0.06	<0.07	<0.05	<0.06	<0.06	<0.22	0.2	<0.03	<0.05	0.21	<0.04	<0.48	<0.75	NDR 0.48	0.74
	WR-95-6C	<0.04	<0.06	<0.07	<0.04	<0.06	<0.06	<0.19	0.29	<0.04	<0.06	0.1	<0.06	<0.09	<0.14	NDR 0.36	<0.07
	WR-95-4C	<0.03	<0.05	<0.05	<0.04	<0.05	<0.04	<0.2	0.59	<0.03	<0.04	0.15	<0.03	<0.1	<0.16	NDR 0.36	<0.08
Athabasca River	ARC-95-1F	<0.02	<0.03	<0.03	<0.02	<0.03	0.05	<0.1	<0.07	<0.02	NDR 0.06	<0.02	<0.03	<0.05	<0.08	NDR 0.18	<0.04
above	ARC-95-2F	<0.02	<0.02	NDR 0.03	<0.02	<0.02	0.06	<0.07	<0.04	<0.02	<0.03	<0.02	<0.03	<0.13	<0.21	NDR 0.3	<0.11
Maskuta Creek	ARC-95-3F	<0.02	<0.03	NDR 0.04	<0.02	<0.02	NDR 0.07	<0.08	<0.06	<0.02	<0.03	<0.02	<0.02	<0.11	<0.17	NDR 0.67	<0.09
		NDR 0.01	<0.02	NDR 0.04	<0.01	<0.02	NDR 0.05	<0.07	<0.05	<0.02	<0.03	<0.02	<0.02	<0.11	<0.17	0.73	<0.09
	ARC-95-7C	<0.06	<0.08	<0.09	<0.05	<0.06	<0.06	<0.13	<0.09	<0.03	<0.04	<0.03	<0.04	<0.3	<0.47	<0.28	<0.25
	ARC-95-4C	<0.03	<0.02	<0.04	<0.01	<0.02	0.06	<0.07	<0.05	<0.02	NDR 0.05	<0.02	<0.03	<0.05	<0.08	NDR 0.65	<0.04
	ARC-95-5C	<0.03	<0.05	<0.05	<0.03	<0.04	<0.06	<0.11	<0.08	<0.04	<0.05	<0.04	<0.03	<0.07	<0.11	NDR 0.2	<0.06
Athabasca River	EL-95-8F	0.34	<0.06	NDR 0.07	NDR 0.06	0.06	0.09	<0.14	0.35	<0.05	NDR 0.12	0.97	<0.03	1.9	2.6	NDR 3.6	4.2
below	EL-95-4F	0.06	<0.08	<0.08	<0.04	<0.06	<0.06	0.17	0.52	<0.04	<0.06	0.36	<0.03	<0.56	<0.87	NDR 2.1	NDR 1.1
Emerson Lakes	EL-95-5F	0.1	<0.06	NDR 0.06	<0.04	<0.05	<0.05	0.18	0.64	<0.07	<0.1	2.2	<0.05	<0.58	NDR 3.4	NDR 2.6	7.1
	EL-95-9C	0.1	<0.05	<0.05	<0.03	<0.04	<0.04	0.2	1.0	<0.05	NDR 0.13	0.57	<0.03	<0.32	<0.5	NDR 0.45	1.5
	EL-95-7C	0.05	<0.06	<0.06	<0.04	<0.05	0.07	0.24	1.8	<0.05	<0.07	0.34	<0.09	0.2	0.42	NDR 1.1	NDR 1.7
	EL-95-3C	<0.05	<0.07	NDR 0.09	<0.05	<0.07	<0.07	0.28	1.4	<0.06	<0.08	0.25	<0.05	<0.23	0.62	NDR 2.2	NDR 2.1
Athabasca River	ALP-95-8F	0.04	<0.04	NDR 0.06	<0.03	<0.04	0.1	<0.1	0.18	<0.03	NDR 0.11	0.29	<0.02	<0.11	0.57	NDR 2.1	1.2
below Alpac	ALP-95-2F	<0.03	<0.04	NDR 0.09	<0.03	<0.04	0.12	<0.09	0.2	<0.01	NDR 0.11	0.32	<0.01	<0.15	<0.23	NDR 2.8	1.2
		0.03	<0.02	<0.02	0.02	<0.02	0.1	0.07	0.18	<0.01	NDR 0.15	0.38	<0.02	<0.13	0.34	NDR 3.7	1.2
	ALP-95-5F	NDR 0.04	<0.02	NDR 0.07	<0.04	<0.02	0.11	<0.08	0.13	<0.01	NDR 0.15	0.34	<0.02	<0.18	NDR 0.82	NDR 8.2	0.97
	ALP-95-10C	<0.04	<0.05	<0.06	<0.04	<0.05	<0.05	<0.18	<0.13	<0.04	<0.05	<0.05	<0.07	<0.3	<0.48	<0.28	<0.25
	ALP-95-1C	0.04	<0.03	NDR 0.07	<0.05	<0.02	0.13	0.13	0.25	<0.04	NDR 0.16	0.23	<0.02	0.42	0.98	NDR 10	NDR 3.3
	ALP-95-7C	<0.06	<0.09	<0.09	<0.06	<0.08	<0.08	<0.21	0.36	<0.07	<0.1	0.14	<0.04	<0.16	0.38	NDR 1.7	NDR 0.55

Chlorinated Phenolics (Cont.)
May 1995
Results in ng/g

Site	L/M/H	2,3,5,6-TCP	2,3,4,6-TCP	2,3,4,5-TCP	5-CV	6-CV	3,5-DCS	3,4,6-TCG	3,4,5-TCG	4,5,6-TCG	3,4,6-TCC	3,4,5-TCC	5,6-DCV	PCP	2-CSA	3,4,5,6-TCG	3,4,5-TCS	3,4,5,6-TCC	2,6-DCSA
Wapiti River near	WR-95-7F	<0.04	<0.02	<0.03	<0.06	2.0	<0.11	<0.04	0.08	NDR 0.03	<0.07	<0.07	<0.07	<0.07	<0.06	0.07	<0.04	0.49	NDR 0.52
the Mouth	WR-95-9F	<0.07	<0.04	<0.05	<0.08	3.3	<0.12	<0.04	0.07	<0.03	<0.09	0.22	<0.08	0.13	<0.06	0.07	<0.04	0.41	NDR 0.23
	WR-95-4F	0.07	0.04	<0.05	<0.27	4.7	<0.13	<0.06	0.08	<0.05	<0.75	<0.75	<0.09	0.15	<0.04	0.06	<0.06	0.22	<0.08
		<0.06	<0.03	<0.05	<0.53	5.2	<0.13	<0.05	<0.06	<0.04	<0.6	<0.6	<0.1	NDR 0.09	<0.06	NDR 0.03	<0.04	0.18	NDR 0.16
	WR-95-10C	<0.07	<0.04	<0.07	<0.11	0.87	<0.12	<0.07	<0.08	<0.05	<0.3	1.1	<0.09	<0.04	<0.04	<0.03	<0.04	0.23	<0.1
	WR-95-6C	<0.07	<0.04	<0.05	<0.26	1.3	<0.16	<0.05	<0.06	<0.04	<0.22	<0.22	<0.13	0.24	<0.06	<0.05	<0.04	0.25	<0.09
	WR-95-4C	<0.04	<0.02	<0.06	<0.22	2.6	<0.14	<0.05	0.1	<0.04	<0.45	<0.45	<0.11	NDR 0.08	<0.07	NDR 0.04	<0.04	0.14	<0.15
Athabasca River	ARC-95-1F	<0.06	<0.03	<0.04	<0.11	<0.13	<0.09	<0.02	<0.02	<0.02	<0.04	<0.04	<0.06	0.12	<0.04	<0.03	<0.03	0.1	<0.02
above	ARC-95-2F	<0.03	<0.01	<0.02	<0.17	<0.19	<0.08	<0.02	<0.03	<0.02	<0.08	<0.08	<0.04	0.08	<0.02	NDR 0.03	<0.07	<0.05	<0.03
Maskuta Creek	ARC-95-3F	<0.04	<0.02	<0.03	<0.13	<0.15	<0.06	<0.02	<0.02	<0.02	<0.07	<0.07	<0.04	0.12	<0.02	0.02	<0.03	<0.08	NDR 0.03
		<0.03	<0.02	<0.02	<0.12	<0.14	<0.07	<0.02	<0.02	<0.02	<0.07	<0.07	<0.04	NDR 0.1	<0.02	<0.03	<0.03	<0.09	<0.03
	ARC-95-7C	<0.06	<0.03	<0.04	<0.15	<0.17	<0.09	<0.04	<0.04	<0.03	<0.11	<0.11	<0.08	<0.04	<0.03	<0.03	<0.03	<0.03	<0.08
	ARC-95-4C	<0.02	<0.01	NDR 0.42	<0.03	<0.03	<0.05	<0.02	<0.02	<0.01	<0.04	<0.04	<0.07	<0.05	<0.03	<0.02	<0.02	0.09	<0.02
	ARC-95-5C	<0.07	<0.04	<0.05	<0.11	<0.12	<0.08	<0.04	<0.04	<0.03	<0.2	<0.2	<0.1	0.07	<0.02	<0.02	<0.02	0.07	<0.08
Athabasca River	EL-95-8F	<0.05	0.05	<0.04	<0.2	7.8	<0.1	0.06	1.7	0.19	2.3	15.	NDR 0.63	NDR 0.06	<0.02	0.77	<0.05	3.2	<0.12
below	EL-95-4F	<0.04	<0.02	<0.02	<0.45	9.1	<0.12	<0.03	0.42	0.05	<0.69	3.4	NDR 0.18	NDR 0.09	<0.04	0.11	<0.03	0.56	<0.14
Emerson Lakes	EL-95-5F	<0.06	<0.03	<0.04	<0.83	17	<0.12	<0.08	2.2	0.33	1.3	24.	NDR 1.0	NDR 0.12	<0.1	0.5	<0.05	1.9	<0.15
	EL-95-9C	<0.05	<0.02	<0.05	<0.33	4.6	<0.1	<0.04	0.87	0.14	0.18	3.1	NDR 0.17	<0.05	<0.1	0.15	<0.05	0.66	<0.09
	EL-95-7C	<0.05	<0.03	<0.05	<0.34	5.6	<0.14	<0.07	0.53	0.06	<0.41	4.6	NDR 0.27	NDR 0.06	<0.06	0.14	<0.03	1.0	<0.11
	EL-95-3C	<0.08	<0.04	<0.09	<0.31	3.2	<0.19	<0.06	0.36	0.05	<0.71	5.9	<0.24	<0.04	<0.06	<0.12	<0.06	0.85	<0.1
Athabasca River	ALP-95-8F	<0.05	<0.03	<0.04	<0.07	1.6	<0.08	<0.04	0.36	0.06	NDR 0.16	2.0	0.08	<0.07	0.13	0.12	<0.02	0.92	NDR 0.04
below Alpac	ALP-95-2F	<0.07	<0.04	<0.05	<0.08	1.8	<0.07	<0.03	0.38	0.07	<0.11	2.1	0.15	<0.07	<0.05	1.4	<0.04	0.82	NDR 0.05
		<0.07	<0.04	<0.05	<0.06	2.0	<0.07	<0.02	0.38	0.07	NDR 0.12	2.3	0.19	<0.08	<0.04	NDR 0.13	<0.04	0.87	NDR 0.06
	ALP-95-5F	<0.07	<0.04	<0.05	<0.06	1.7	<0.16	<0.02	0.34	0.05	<0.13	2.6	0.22	<0.05	<0.04	0.1	<0.05	0.82	NDR 0.27
	ALP-95-10C	<0.06	<0.03	<0.04	<0.15	0.34	<0.09	<0.06	0.1	<0.04	<0.18	0.51	<0.08	<0.04	<0.03	NDR 0.04	<0.03	0.2	<0.09
	ALP-95-1C	<0.11	<0.06	NDR 0.16	<0.14	0.57	<0.08	<0.06	0.31	<0.05	0.32	3.5	<0.1	<0.06	<0.08	0.16	<0.04	1.7	NDR 0.04
	ALP-95-7C	<0.08	<0.05	<0.06	<0.21	1.2	<0.26	<0.06	0.21	<0.05	<0.47	1.7	<0.12	<0.06	NDR 0.08	NDR 0.09	<0.05	0.96	<0.12

PCBs, EOCl, Toxaphene
October 1994

Site	Label	Date	Notes	Aroclor 1242 ng/G	Aroclor 1254 ng/G	Aroclor 1260 ng/G	PCB #77 pg/G	PCB #126 pg/G	PCB #169 pg/G	EOX ug/o.d.g.	Toxaphene ng/G
Wapiti River near the Mouth	WRM-F3	08/10/94	2898-2i	1.2	2.1	0.4	1.7	<0.23	<0.33	<1.5	<0.15
Smoky River near the Mouth	SRM-F2	04/10/94	2898-3i	0.94	1.9	0.13	1.5	<0.4	<0.6	<1.5	<0.14
Peace River above Smoky River	PRS-F3	04/10/94	2898-21i	6.6	48	NDR 0.49	10	<0.82	<0.68	<1.5	<0.63
Peace River below Diashowa	RRD-F2	05/10/94	2898-09	1.6	1.8	0.93	2.7	<0.23	<0.32	<1.5	<0.09
Peace River below Diashowa	**Blind**	05/10/94	2898-33	2.2	5.7	1.8	5.3	<1.5	<1.1	<1.5	<0.70
Peace River above Notikewin R.	PRN-F3	06/10/94	2898-1Ai	0.99	2.3	0.38	1.5	<0.23	<0.34	<1.5	<0.14
Peace River above Notikewin R.	PRN-F3	06/10/94	**Lab Dup**	1.1	2.4	0.11	1.3	<0.23	<0.33		<0.09
Peace River below Ft. Vermilion	PRV-F3	07/10/94	2898-5i	1.6	3.2	NDR 0.19	2.0	<0.26	<0.33	<1.5	<0.09
Athabasca R above Lesser Slave R	ARL-F2	09/10/94	2898-06	0.61	0.94	2.5	1.8	<0.4	<0.6	<1.5	<0.16
Athabasca River below Alpac	ARA-F1	10/10/94	2898-16	1.4	1.4	0.47	1.7	<0.26	<0.33	<1.5	<0.1
Athabasca River above Horse R	ARH-F3	11/10/94	2898-20i	0.65	1.9	<0.34	1.6	<1.0	<0.88	<1.5	<0.56
Athabasca River near Fort McKay	ARM-F2	11/10/94	2898-19Ai	0.69	2.6	0.46	2.2	<0.28	<0.33	<1.5	<0.27
Athabasca River near Fort McKay	ARM-F2	11/10/94	**Lab Dup**	1.1	3.0	0.8	2.3	<0.72	<0.78		<0.48

Total Mercury
October 1994

Site	Label	Fraction	Date	Lab No.	Total Hg ug/gram
Wapiti River near the Mouth	WRM-F1	Clay-Silt	08/10/94	9513-02	<0.10
	WRM-F1	Clay-Silt	08/10/94	9513-02B	<0.10
	WRM-C1	Sand	08/10/94	9513-10	<0.10
Smoky River near the Mouth	SRM-F1	Clay-Silt	04/10/94	9513-03	<0.10
	SRM-C1	Sand	04/10/94	9513-11	<0.10
Peace River above Smoky River	PRS-F1	Clay-Silt	04/10/94	9513-08	<0.10
	PRS-C1	Sand	04/10/94	9513-17A	<0.10
	PRS-C1	Sand	04/10/94	9513-17B	<0.10
Peace River below Diashowa	RRD-F1	Clay-Silt	05/10/94	2898-07	<0.10
	RRD-C1	Sand	05/10/94	2898-14	<0.10
Peace River above Notikewin River	PRN-F1	Clay-Silt	06/10/94	9513-01	<0.10
	PRN-C1	Sand	06/10/94	9513-09	<0.10
Peace River below Fort Vermilion	PRV-F1	Clay-Silt	07/10/94	9513-04	<0.10
	PRV-C1	Sand	07/10/94	9513-12	<0.10
Athabasca River above Lesser Slave River	ARL-F1	Clay-Silt	09/10/94	9513-05	<0.10
	ARL-C1	Sand	09/10/94	9513-13	<0.10
Athabasca River below Alpac	ARA-F2	Clay-Silt	10/10/94	2898-17	<0.10
	ARA-C2	Sand	10/10/94	9513-14	<0.10
Athabasca River above Horse River	ARH-F1	Clay-Silt	11/10/94	9513-07	<0.10
	ARH-C1	Sand	11/10/94	9513-16	<0.10
Athabasca River near Fort McKay	ARM-F1	Clay-Silt	11/10/94	9513-06	<0.10
	ARM-C1	Sand	11/10/94	9513-15	<0.10

APPENDIX C Figures

Figure A1 Particle Size Distribution, Athabasca River Stations, October 1994 and May 1995

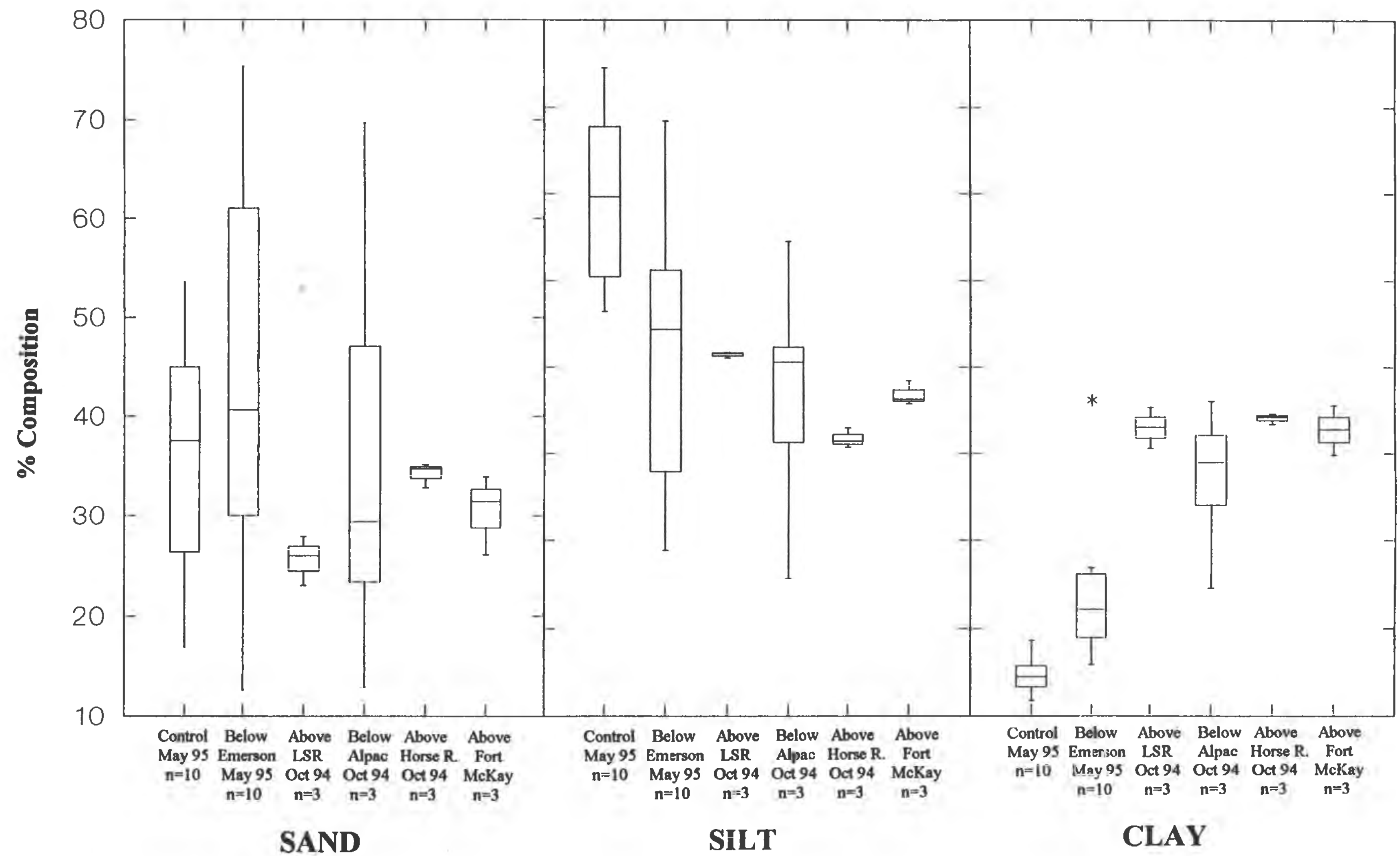


Figure A2 Particle Size Distribution, Peace River Basin, October 1994

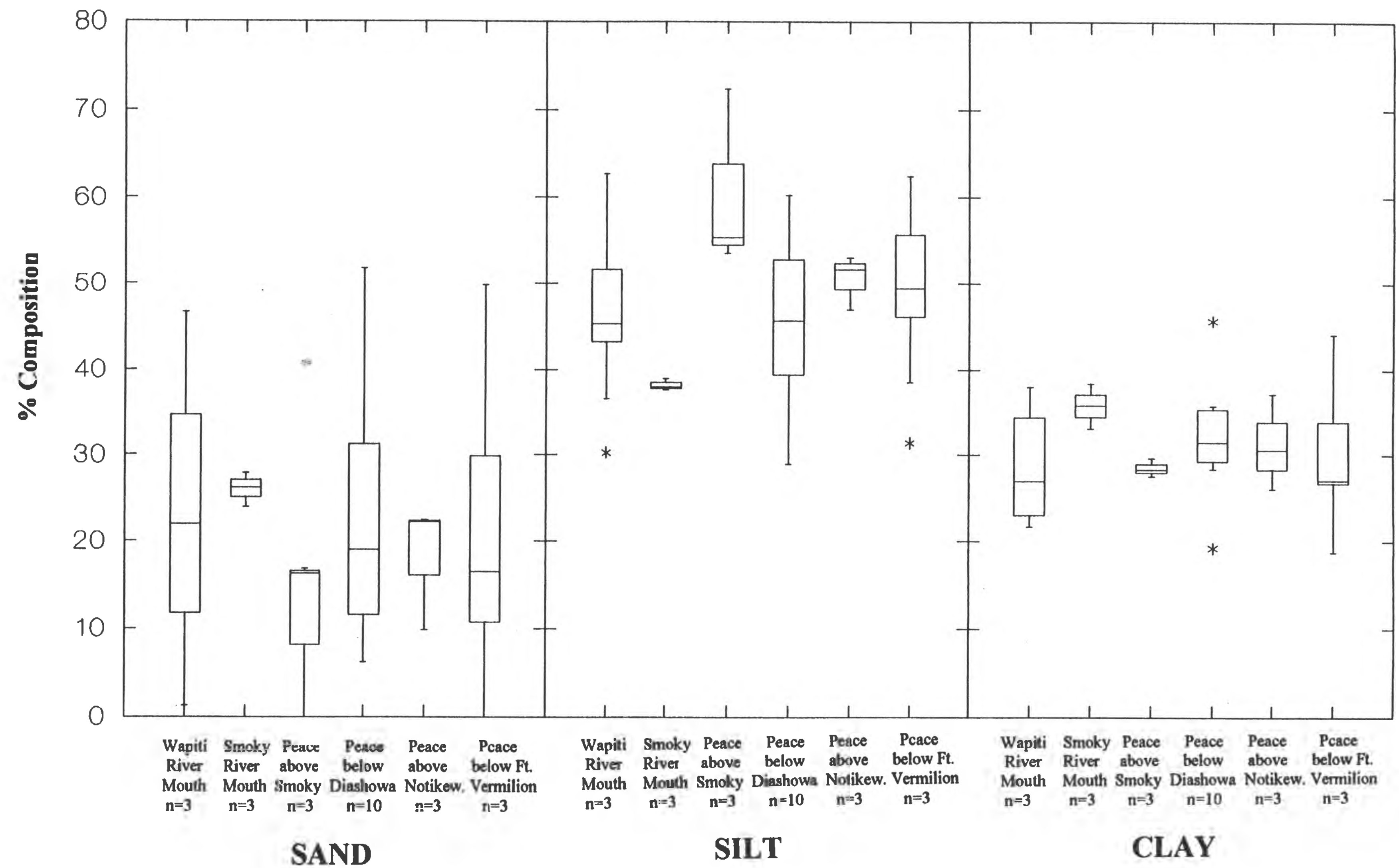


Figure A3 Carbon in Clay-Silt Fraction, Athabasca River, October 1994 and May 1995

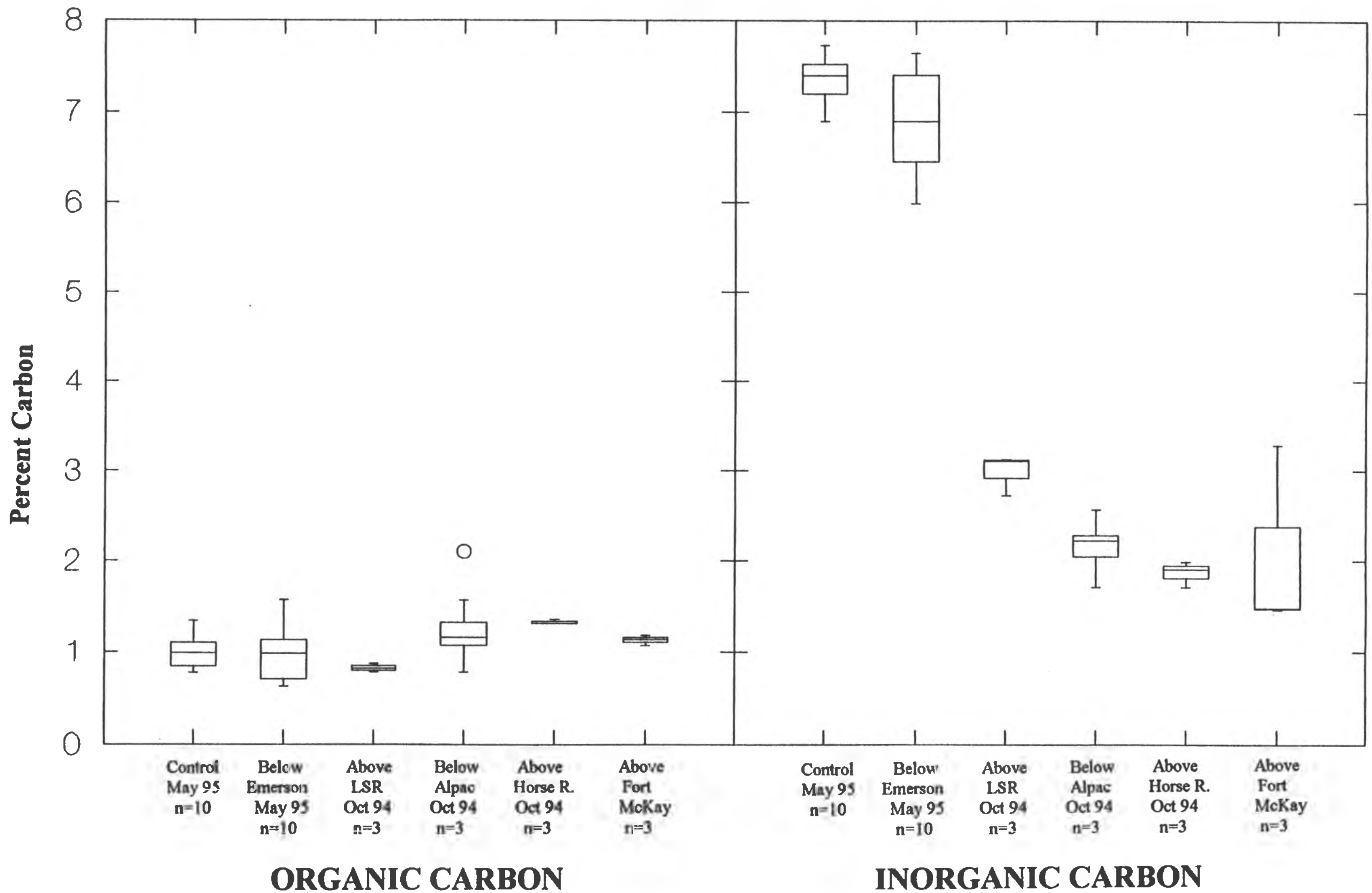
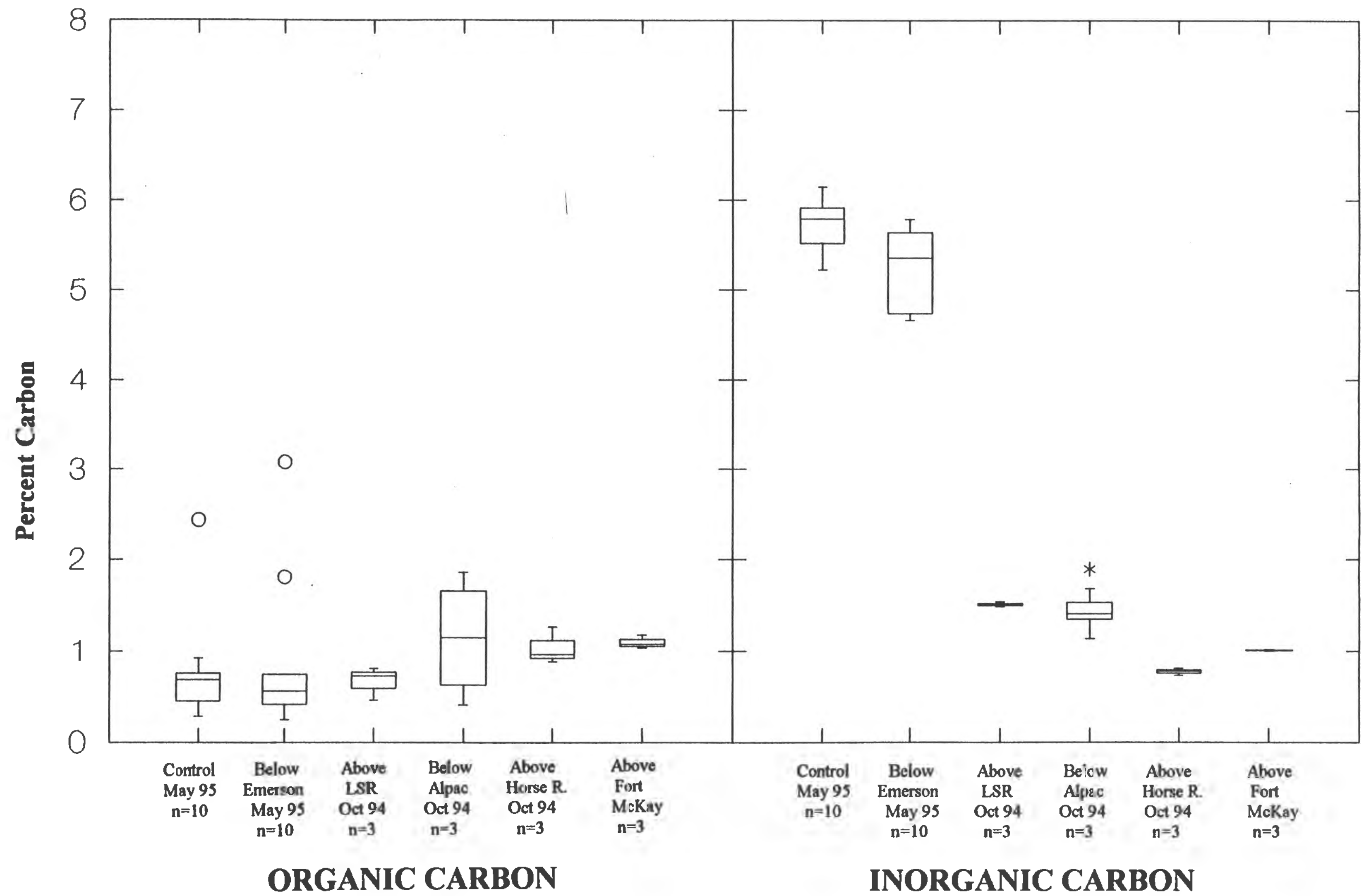


Figure A4 Carbon in Sand Fraction, Athabasca River, October 1994 and May 1995



APPENDIX D Sampling Site Location Details

October 1994 Bottom Sediment Sampling Locations

Location	Sample Labels	Date/Time	Latitude	Longitude	Notes
Wapiti River near the Mouth	WRM 1,2,3	Oct 8/94 1000	55 08 08	118 18 37	Sandy zone with overlying silt, 3 ekman, 0.5 km above mouth, left side
		Oct 8/94 1030	55 08 21	118 19 11	Backwater bay, silty area, 3 ekman, 1.5 km above mouth, left side. Collected reference samples at this site.
		Oct 8/94 1100	55 08 31	118 19 10	Small zone with silty deposition, 2 ekman, 1.8 km. above mouth, left side
		Oct 8/94 1130	55 08 49	118 19 15	Small zone with silty deposition, 2 ekman, 2.0 km above mouth, left side
Smoky River near the Mouth	SRM 1,2,3	Oct 4/94 1200	56 09 57	117 20 04	Sandy silt or silty sand. Relatively large zone. 3 ekman. 2 km above the mouth right side
		Oct 4/94 1230	56 09 27	117 21 10	Sandy silt or silty sand. Below gravel spit. 2 ekman. 4 km above the mouth right side
		Oct 4/94 1300	56 09 48	117 20 20	Silty sand. Large zone with few rocks. 3 ekman. 2.5 km above the mouth left side
		Oct 4/94 1330	56 10 04	117 20 11	Silty deposition. 2 ekman. 2 km. above the mouth left side
Peace River upstream of Smoky River	PRS 1,2,3	Oct 4/94 0900	56 09 37	117 25 07	Sandy silt, no pebbles or rocks. 3 ekman. 6 km above Smoky River, left side
		Oct 4/94 0930	56 09 23	117 25 16	Sandy silt, rocky 2 ekman 6.5 km above Smoky River, right side
		Oct 4/94 1000	56 09 27	117 24 52	Silty sand, finer than 1 or 2. 3 ekman. 5.5 km above Smoky River, right side
		Oct 4/94 1030	56 09 42	117 24 42	Zone of fines with some clay. 2 ekman. 5.5 km above Smoky River left side.
Peace River below Diashowa	RRD-1	Oct 5/94 1000	56 25 36	117 08 45	Very large zone, clay-silt. Left side, 6.4 km below diffuser.
	RRD-2	Oct 5/94 1020	56 25 50	117 08 33	Fines, some organic matter. Left side. 7.0 km below diffuser.
	RRD-3	Oct 5/94 1040	56 26 46	117 07 41	Small zone, more sandy than 1,2. Left side, 7.8 km below diffuser.
	RRD-4	Oct 5/94 1100	56 27 27	117 06 42	Very large zone of fines on island. 8.5 km below diffuser.
	RRD-5	Oct 5/94 1120	56 27 27	117 06 42	Sampled in same general area as 4
	RRD-6	Oct 5/94 1140	56 27 39	117 06 59	Small zone with some clay. Left side 8.6 km below diffuser.
	RRD-7	Oct 5/94 1200	56 26 54	117 06 36	Small zone of fines, right side. 7.6 km below diffuser

Location	Sample Labels	Date/Time	Latitude	Longitude	Notes
Peace River below Diashowa (cont.)	RRD-8	Oct 5/94 1220	56 26 38	117 07 06	Sandy silt or silty sand. Island right side. 7.3 km below diffuser.
	RRD-9	Oct 5/94 1240	56 25 51	117 08 02	Large depositional beach, right side. 6.6 km below diffuser.
	RRD-10	Oct 5/94 1300	56 25 32	117 08 28	Large zone of fines, right side. 5.4 km below diffuser.
Peace River above Notikewin River	PRN 1,2,3	Oct 6/94 1030	57 16 58	117 05 42	Large zone in lee of island, fines with some organic. 2.2 km above Notikewin River left side, 3 ekman
		Oct 6/94 1100	57 16 56	117 05 38	Across shallow bay from 1, very fine. 2.6 km above Notikewin River left side. 2 ekman.
		Oct 6/94 1130	57 16 10	117 03 43	Small zone of fine material, 4.0 km above Notikewin River right side. 3 ekman
		Oct 6/94 1200	57 16 56	117 05 20	Same general depositional area as 1,2. Located 3 km above Notikewin River left side. 2 ekman.
Peace River below Fort Vermilion	PRV 1,2,3	Oct 7/94 1000	58 24 59	115 57 50	Large silt flats on upstream edge of island. 3 ekman. 3 km below town of Ft Vermilion.
		Oct 7/94 1030	58 25 21	115 57 52	Large mud flats left side approx. 4.5 km. below Ft. Vermilion. 3 ekman.
		Oct 7/94 1100	58 24 40	115 57 35	Head of second island. Large flats, though sandier than 1,2. 1 ekman
		Oct 7/94 1130	58 24 20	115 56 21	Soft deposits opposite airport on right side approximately 4 km below Ft. Vermilion. 3 ekman.
Athabasca River above Lesser Slave River	ARL 1,2,3	Oct 9/94 1000	55 09 09	114 03 35	Area of fines approx. 0.8 km above RR bridge, left side. 3 ekman
		Oct 9/94 1030	55 08 49	114 03 41	Left side near lower end of large island. Fine sediment. 2 ekman. 1.7 km above RR bridge.
		Oct 9/94 1100	55 08 48	114 03 26	Right side near lower end of large island. Small zone of fines. 2 ekman. 1.6 km above RR bridge.
		Oct 9/94 1130	55 09 13	114 03 26	Right side 1.0 km above RR bridge. Silt over sand, some clay at surface.
Athabasca River below Alpac	ARA 1,2,3	Oct 10/94 1100	54 58 50	112 43 08	Loose soft silt. Very small depositional area. Located 12 km below diffuser right side. 3 ekman
		Oct 10/94 1130	54 58 47	112 43 16	Soft silt with some organic matter. 12 km below diffuser left side. 3 ekman.
		Oct 10/94 1200	54 58 14	112 44 13	Small zone of silt. Located approx 11 km. below diffuser right side. 2 ekman.
		Oct 10/94 1230	54 58 13	112 45 33	Large depositional zone but quite sandy. In lee of small island group. Approx 10 km below diffuser left side. 2 ekman.

Location	Sample Labels	Date/Time	Latitude	Longitude	Notes
Athabasca River above Horse R.	ARH 1,2,3	Oct 11/94 1200	56 43 04	111 24 12	Directly across river from WRP boat ramp. Right side, small zone of fines. 0.2 km above Horse R. 3 ekman.
		Oct 11/94 1230	56 42 35	111 20 20	Small zone of soft silt. Right side directly adjacent to Ft. McMurray GC. 2.5 km above Horse R. 3 ekman.
		Oct 11/94 1300	56 42 01	111 26 20	Very small zone in small bay. Right side approx. 4 km. above Horse R. 2 ekman
		Oct 11/94 1330	56 42 23	111 26 30	Small zone 0.5 km upstream of 2. 3.0 km above Horse R. left side. 2 ekman.
Athabasca River near Fort McKay	ARM 1,2,3	Oct 11/94 0930	57 08 05	111 36 42	0.5 km below bridge left side. Small zone of sandy silt. 3 ekman
		Oct 11/94 1000	57 08 40	111 37 13	Small zone of fine material. Approx 1 km below bridge left side. 2 ekman
		Oct 11/94 1030	57 09 02	111 37 09	Large area of fine material at lower end of Alexander Island. 3 ekman. Approx 2 km below bridge
		Oct 11/94 1100	57 08 49	111 36 29	Right side in lee of small island upstream of Alexander Is. Approx 1.3 km below bridge. 2 ekman.

May 1995 Bottom Sediment Sampling Locations

Location	Sample Labels	Date/Time	Latitude	Longitude	Notes
Athabasca River upstream of Maskuta Creek	ARC-95-1	May 8/95 1435	53 22 47	117 39 23	150 meters above Maskuta Ck, right side. Old control site. Sandy silt.
	ARC-95-2	May 8/95 1445	53 22 49	117 39 22	125 meters above Maskuta Ck, right side. Old control site (second). Sandy.
	ARC-95-3	May 8/95 1510	53 22 52	117 39 46	Left side, small island, 200-250 meters above Maskuta Creek.
	ARC-95-4	May 8/95 1530	53 23 02	117 40 39	Left side, very large in lee of bend. Silty sand.
	ARC-95-5	May 8/95 1540	53 22 56	117 40 46	Left side, lee of bend. Upstream of 4 Sandy silt.
	ARC-95-6	May 8/95 1610	53 22 49	117 40 55	Right side in lee of bend below house
	ARC-95-7	May 8/95 1620	53 22 51	117 40 58	Right side, just above 6.
	ARC-95-8	May 8/95 1640	53 22 55	117 41 18	Left side, right hand turn.
	ARC-95-9	May 8/95 1650	53 22 51	117 41 17	Just above 8.
	ARC-95-10	May 8/95 1700	53 22 43	117 41 23	1 km below Hwy 40 right side.
Athabasca River near Emerson Lakes	EL-95-1	May 9/95 0930	53 43 11	117 10 12	Original site from May 93. Left side. Fines.
	EL-95-2	May 9/95 0945	53 43 10	117 10 09	Just upstream of 1. Very fine.
	EL-95-3	May 9/95 1010	53 43 07	117 10 16	Left side 60 meters above 2. Fines.
	EL-95-4	May 9/95 1040	53 42 51	117 10 02	Right side 1 km above 3. Sandier than 1-3.
	EL-95-5	May 9/95 1045	53 42 49	117 09 59	Just upstream of 4. Poorly sorted.
	EL-95-6	May 9/95 1110	53 42 40	117 10 05	Left side 2 km below bridge. Small bay in lee of gravel. Below island.
	EL-95-7	May 9/95 1130	53 42 18	117 09 51	Left side 1 km, below bridge. 0.4 km below Emerson Ck. Small bay.
	EL-95-8	May 9/95 1150	53 42 03	117 09 26	Right side 300 meters above bridge. Small bay.
	EL-95-9	May 9/95 1200	53 41 59	117 09 41	Large bay in island lee. 300 meters above EL bridge
	EL-95-10	May 9/95 1210	53 41 57	117 09 41	Same general area as 9.
Wapiti River near the Mouth	WR-95-1	May 10/95 0855	55 08 08	118 18 42	Same site as 1 in October. 0.5 km above mouth. Very small rocky bay near road end. Sandy.
	WR-95-2	May 10/95 0920	55 08 59	118 20 13	Right side below island. Large muddy bay. Fine.
	WR-95-3	May 10/95 0935	55 08 54	118 20 15	Just upstream of 2, same bay. Fine.
	WR-94-4	May 10/95 0950	55 08 48	118 21 23	Large bar downstream of big island.
	WR-95-5	May 10/95 1010	55 08 47	118 21 24	Bay in lee of island. Fines.
	WR-95-6	May 10/95 1030	55 08 59	118 21 13	Left side small bay 250 meters below island. Sandy silt.
	WR-95-7	May 10/95 1100	55 08 50	118 19 28	Similar to 4 in October.
	WR-95-8	May 10/95 1125	55 08 40	118 19 10	Same site as 3 October. Very small bay. Sandy.
	WR-95-9	May 10/95 1145	55 08 18	118 19 11	Same site as 2 October. Large depositional area.
	WR-95-10	May 10/95 1155	55 08 19	119 19 10	Further into bay in 9

Location	Sample Labels	Date/Time	Latitude	Longitude	Notes
Peace River below Fort Vermilion	FV-95-1	May 11/95 0945	58 24 57	115 57 49	Large bar above island. Fairly sandy. As 1 October.
	FV-95-2	May 11/95 1000	58 25 18	115 57 53	Sandy flats as 2 October. Sandy silt.
	FV-95-3	May 11/95 1020	58 25 25	115 57 53	Just north of 2. Sandy silt. 50 meters north.
	FV-95-4	May 11/95 1040	58 25 30	115 57 32	In lee of bar, soft deposition.
	FV-95-5	May 11/95 1055	58 25 22	115 57 31	Upstream of 4, inlet behind sand bar. Soft deposition.
	FV-95-6	May 11/95 1115	58 26 07	115 57 44	Left side 1 km below 2,3. Soft deposition.
	FV-95-7	May 11/95 1140	58 24 41	115 57 36	As per 3 in October, soft deposits.
	FV-95-8	May 11/95 1150	58 24 41	115 57 36	Just south of 7 in lagoon.
	FV-95-9	May 11/95 1210	58 24 23	115 57 47	Right channel, soft sediments
	FV-95-10	May 11/95 1220	58 24 20	115 56 33	Near 4 October, soft sediments, large zone.
Athabasca River below Alberta Pacific	ALP-95-1	May 12/95 1300	54 57 41	112 49 45	Soft sediments. 100 meters above Poachers Landing. Right side. Some coarse material.
	ALP-95-2	May 12/95 1320	54 57 36	112 50 31	Right side about 400 meters above Poachers Landing. Small bay behind bar.
	ALP-95-3	May 12/95 1345	54 57 37	112 50 48	Right side 250 meters above 2.
	ALP-95-4	May 12/95 1400	54 57 45	112 50 27	Center stream right side of island. Small zone. Coarse.
	ALP-95-5	May 12/95 1430	54 58 19	112 48 25	Small zone left side. Relatively fine.
	ALP-95-6	May 12/95 1530	54 58 11	112 45 33	As in 4 October. Just in lee of island.
	ALP-95-7	May 12/95 1550	54 58 12	112 44 14	As in 3 October.
	ALP-95-8	May 12/95 1610	54 58 41	112 43 08	As in 1 October.
	ALP-95-9	May 12/95 1630	54 58 46	112 43 22	As in 2 October.
	ALP-95-10	May 12/95 1645	54 58 38	112 43 30	Small zone left side.