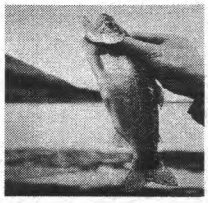
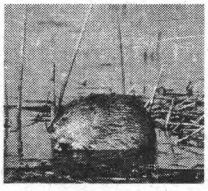
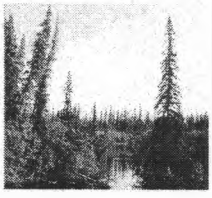
Canada Alberta Northwest Territories

Northern River Basins Study





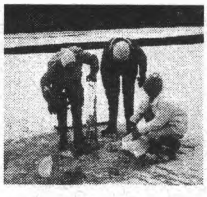




NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 56

LONG-TERM TRENDS IN ECOSYSTEM HEALTH:

QUANTITATIVE ANALYSIS OF RIVER BENTHIC INVERTEBRATE COMMUNITIES PEACE AND ATHABASCA RIVERS






DATE DUE	

Prepared for the
Northern River Basins Study
under Project 2616-C1

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NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 56

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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.

This report contains referenced data obtained from sources external to the Northern River Basins Study. Individuals interested in using external data must obtain permission to do so from the donor agency.

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. F. J. Wrona, Ph.D., Science Director) — (Date) 7 June 95

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) — (Date) 7 June 95

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, Co-chair) — (Date) 8 June 95

(Robert McLeod, Co-chair) — (Date) June 12, 1995

LONG-TERM TRENDS IN ECOSYSTEM HEALTH: QUANTITATIVE ANALYSIS OF RIVER BENTHIC INVERTEBRATE COMMUNITIES, PEACE AND ATHABASCA RIVERS

STUDY PERSPECTIVE

An important objective of the Northern River Basins Study is to examine the relationships between industrial development and the health of the Peace, Athabasca and Slave River systems. Data obtained over the course of the study will provide a database that can be used to assess the cumulative effects of man-made developments on the aquatic environment of these rivers. Benthic invertebrates are bottom-dwelling organisms that are very sensitive to environmental change and are considered good indicators of aquatic ecosystem health. A review of existing monitoring programs which use benthic invertebrates as indicators of ecosystem health was undertaken to both document any long-term trends in invertebrate communities, and recommend modifications to these continuing programs.

Related Study Questions

1a)	*How has the aquatic ecosystem, including fish and/or other aquatic organisms, been affected by exposure to organochlorines or other toxic compounds?*
13a)	*What predictive tools are required to determine the cumulative effects of man-made discharges on the water and aquatic environment?*
b)	*What are the cumulative effects of man-made discharges on the water and aquatic environment?*

This project assessed the long-term trends in ecosystem health of the Peace and Athabasca rivers by evaluating changes in the composition of invertebrate communities in relation to effluent loading. Existing long-term data sets for benthic invertebrates were compiled and their sampling procedures reviewed for deficiencies. Where the sampling procedures were sufficiently similar, quantitative statistical analyses (e.g., time series analyses) was performed on the data to determine whether patterns in benthic community structure were consistent with those predicted impacts from point-source inputs.

Data on benthic invertebrate community structure for the Peace and Athabasca rivers were compiled from a large number of sources, including government and industry. The database used for this project extends from 1960 to 1992. Initial analysis attempted to identify changes in invertebrate community structure using time series analysis to investigate time-related trends in the large data set. However, this approach was inappropriate because of marked differences in the sampling techniques used. Instead, invertebrate community classification was compared using cluster analyses of average taxonomic abundance for each community. Results of cluster analyses indicated that benthic invertebrate community structure in the Athabasca River near Hinton and Whitecourt, and in the Wapiti River near Grande Prairie, appears little affected by municipal and pulp mill effluents. In many cases, upstream sites formed strong clusters with sites located immediately below point-source inputs. However, this apparent minimal impact may be due to complex interactions between the many compounds present in effluent, the low concentration of effluent in river water (<1% river volume on average), or other abiotic factors (e.g., scouring of river ice, spring flooding) which mask the effect of the effluents.

This project summarizes the changes in taxonomic composition of benthic invertebrate communities from long-term study sites in the Peace and Athabasca rivers. Experiments currently underway as part of another NRBS project are evaluating the effects of nutrients versus effluent additions on benthic communities. Further analysis of the Peace and Athabasca river data base may be useful in clarifying the potential effects of hydrological factors on benthic invertebrate community structure.

REPORT SUMMARY

The aim of this report is to assess trends in benthic macroinvertebrate community structure in the Peace-Athabasca Rivers. This work forms part of a larger project whose objective is to develop a data base that can be used to assess the cumulative effects of development on the aquatic resources of the Peace-Athabasca River systems. The specific objectives of this report were: (1) to describe and compile existing long-term data sets for the Peace, Athabasca and Slave Rivers, (2) to the extent possible, review benthic sampling procedures used to produce each data set and the sampling deficiencies associated with them, and (3) where appropriate, perform quantitative statistical analyses on the data set to determine whether patterns in benthic community structure are consistent with those predicted impacts from point-source inputs.

Data on benthic macroinvertebrate community structure for the Peace-Athabasca River system were compiled from a large number of sources including Alberta Environmental Protection; Weyerhaeuser Canada Ltd (Grand Prairie); Weldwood of Canada, Hinton Division (Hinton); Alberta Newsprint Company (Whitecourt); and Millar Western Pulp Ltd. (Whitecourt). Data sets from these sources were entered into a spreadsheet format. The resulting data base is extremely large. While it is difficult to quantify the effort spent to collect, identify and collate the benthic macroinvertebrate data base, it likely represents several hundred thousand hours. Thus, the data base presented here for the Peace-Athabasca River likely represents one of the largest and most complete for a Canadian river system.

Our review of the data base indicates that researchers used a diversity of sampling protocols to collect and process benthic macroinvertebrate communities collected from the Peace-Athabasca River system. The sampling methods range from the use of semi-quantitative net sweeps, artificial substrata and, more recently, quantitative area restricted sampling methods (e.g., Neill and Hess samplers). Variation in sampling procedures also included the use of different net mesh sizes, sample processing protocols and the level of taxonomic resolution. Such differences in sampling protocols are not surprising because aquatic ecologists have, and continue to use, a variety of techniques to sample benthic communities depending on the specific question being addressed. Differences in sampling techniques used to collect benthic macroinvertebrates from the Peace-Athabasca River reflect general changes in biomonitoring techniques that have been observed elsewhere in North America, Europe, Australia and New Zealand.

Multivariate statistical analyses were performed on a subset of the Peace-Athabasca River benthic macroinvertebrate data base to identify long-term trends in ecosystem health. The data subset was identified after a examination of the data base indicated that only portions would be suitable for analysis because of consistency in sampling protocols. Temporal changes in macroinvertebrate communities were investigated immediately upstream and downstream of: 1) the Weldwood of Canada Ltd., Hinton Division mill at Hinton, 2) Alberta Newsprint Company and Millar Western Pulp Ltd. mills at Whitecourt, and 3) Weyerhaeuser Canada Ltd., Grande Prairie. The data base for each of these three areas is of sufficient quality to investigate temporal changes in benthic macroinvertebrate community structure using a classification technique.

Cluster analyses indicated that benthic macroinvertebrate community structure in the Athabasca River near Hinton and Whitecourt and in the Wapiti River near Grande Prairie does not differ between sites located upstream and downstream of point-source outfalls. In many cases, upstream sites formed strong clusters with sites located immediately below point-source inputs. The simplest explanation for the absence of identifiable effects on benthic invertebrate communities is that the effluents are present in concentrations that are below threshold levels that would exert identifiable effects at the community level. Alternatively, the absence of significant effects could result from several other possible factors including: 1) high natural variation in benthic community structure, 2) past and present sampling approaches that are inadequate to identify significant effects (e.g., poor field and laboratory protocols, incorrect spatial and temporal scales), or 3) poor taxonomic resolution. Our evaluation of sampling protocols suggests that sampling approaches should be sufficient to identify impacts in the spring and fall if they exist. While our approach does not preclude the presence of significant effects measured at the individual or population levels, our results showed that, at the community level, benthic macroinvertebrate composition does not differ between sites upstream and downstream of point source outfalls in the Athabasca and Wapiti rivers. Further research is clearly required for a more complete understanding of the effects of point source inputs on benthic macroinvertebrate community structure in the Peace-Athabasca river system.

ACKNOWLEDGEMENTS

We thank Weyerhaeuser Canada Ltd. (Grande Prairie), Weldwood of Canada Limited (Hinton Division), Alberta Environmental Protection, Millar Western Pulp Ltd. and Alberta Newsprint Company for allowing us access to original data sets. Sentar Consulting Ltd. (Calgary), Terrestrial & Aquatic Environmental Managers Ltd. (Saskatoon) and Alberta Environmental Protection (Alberta Environment) assisted in transferring the data sets and provided unpublished information on sampling protocols. Mary Ferguson, Warren Zyla, Nancy Scott and Carol Casey assisted with data entry. This project was completed by the Nutrients and Dissolved Oxygen Group of the Northern River Basins Study. This research was funded by Northern River Basins Study Contract 2616-C1 to GJS, a Natural Sciences and Engineering Research Council (NSERC) visiting fellowship to KJC; an NSERC, an Izaak Walton Killam post doctoral fellows; and an NSERC Visiting fellowship to GJS.

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1.0 THE HISTORICAL BENTHIC MACROINVERTEBRATE DATA BASE FOR THE PEACE-ATHABASCA RIVER SYSTEM

1.1 INTRODUCTION

Bleached kraft mill effluent (BKME) is a major pollutant of many lakes, rivers and coastal areas in Europe, Canada, United States of America, and Australasia (Walden 1976, Leung and Sell 1982, Davis et al. 1988, Scrimgeour 1989, Owens 1991, Bothwell et al. 1992). Pulp mill effluents can strongly affect aquatic ecosystems by altering numerical abundances, biomasses and community diversity of benthic invertebrate and fish communities (Kelso 1977, Vander Wal 1977, Weinbauer et al. 1980, Majack and Waterhouse 1983, Scrimgeour 1989, Amblard et al. 1990; but see Harris et al. 1993 for an exception to these patterns). The ecological effects of pulp mill effluent are typically attributed to high biochemical oxygen (BOD), and the presence of coloured substances, suspended sediments, nutrients, and organic contaminants (Walden 1976, Davis 1988, Scrimgeour 1989, Owens 1991).

Rivers in the Peace-Athabasca River systems, Alberta, currently receive a diversity of point and non-point effluent discharges including municipal sewage, agricultural runoff and effluent from oil sands and pulp mills (Terrestrial and Aquatic Environmental Managers 1990, Anderson 1989, 1991, Swanson et al. 1992, Tones 1993b). Recent expansions, and the addition of new pulp mills in the region, has raised concerns on whether additional effluent loads will adversely affect the quality of these aquatic resources. The mandate of the Northern River Basins Study, a joint Federal and Provincial study is to gather comprehensive information on water quality; fish and fish habitat; riparian vegetation and wildlife; hydrology and hydraulics; and the use of aquatic resources. This information will form a database that will be used to develop a capability to predict and assess the cumulative effects of development on the water and aquatic environment of the Peace, Athabasca and Slave Rivers within Alberta and the Northwest Territories.

The benthic macroinvertebrate data base for the Peace-Athabasca Rivers is large comprising the results of biomonitoring programs initiated by industry and government since 1960. While the data base extends from 1960 to 1992, the majority of the data base comprises collections since 1980. The increase in data aquisition reflects an increase in development in the Peace-Athabasca Rivers and the accompanying environmental impact studies. Our objective was to collate these data files into a spreadsheet format as the first step towards producing a synthesis report on the health of the Athabasca River (See Cash et al. 1994).

1.2 APPROACH AND RATIONALE

Biomonitoring programs, using benthic macroinvertebrates, have been used to assess the impacts of numerous industrial point source discharges into the Peace-Athabasca River system for over 30 years. For simplicity, we divided these programs into two main groups:

1. Government of Alberta data files (i.e., Alberta Environmental Protection, Fish and Wildlife).

2. Industry data files.

Each of these two main blocks have been further divided into river system or location and source types. The subsequent divisions are:

1. Government data files

    a) General Athabasca River files
    b) Lesser Slave River files
    c) Wapiti River data files
    d) Smoky River data files
    e) Peace River data files

2. Industry data files

    a) Sentar Consultants Ltd. for Millar Western Pulp Ltd. and Alberta Newsprint Company Ltd.
    b) Athabasca River at Hinton and downstream sites.
    c) Smoky-Wapiti River sites

The two later groups of files (i.e., Athabasca River at Hinton and downstream sites; Smoky-Wapiti river sites) were collected by a number of consulting companies on behalf of Weldwood of Canada Ltd. (Hinton Division), Weyerhaeuser Canada Ltd. (Grande Prairie [GP]) or companies that have previously owned these mills (i.e., Hinton: North Western Pulp and Power Ltd., St. Regis (Alberta) Ltd., and Champion Forest Products Products (Alberta) Ltd.; Grande Prairie: Procter and Gamble Ltd. [P&G]).

All of the above groups of data files have been further divided into year (old to recent files). The final hierarchial division is based on sampling location (i.e., individual sampling sites). In the majority of cases, old files consisted of macroinvertebrate species abundance lists for each location whereas recent files consist of up to four sampling sites within a given location.

Table 1. Summary of benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Athabasca River. U/S = upstream, D/S = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Athabasca	05/19/83	h1rb83sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	09/12/83	h1rb83fl.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	05/16/84	h1rb84sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	05/16/84	h1lb84sp.wb1	00AL07AD1170	D/S Hinton 1 km bridge lb
Athabasca	06/12/85	h1rb85sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	10/08/85	h1rb85fl.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	10/08/85	h1lb85fl.wb1	00AL07AD1170	D/S Hinton 1 km bridge lb
Athabasca	05/21/86	h1rb86sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	10/02/86	h1rb86fl.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	05/27/87	h1rb87sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	09/09/87	h1rb87fl.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	05/16/84	h20rb84s.wb1	00AL07AD1390	D/S Hinton 20 km bridge rb
Athabasca	05/16/84	h20lb84s.wb1	00AL07AD1370	D/S Hinton 20 km bridge lb
Athabasca	06/12/85	h20rb85s.wb1	00AL07AD1390	D/S Hinton 20 km bridge rb
Athabasca	10/08/85	h20lb85f.wb1	00AL07AD1370	D/S Hinton 20 km bridge lb
Athabasca	10/08/85	h20rb85f.wb1	00AL07AD1390	D/S Hinton 20 km bridge rb
Athabasca	10/08/85	h30lb85f.wb1	00AL07AD1460	30 km D/S of Hinton lb
Athabasca	05/15/84	h50rb84s.wb1	00AL07AD1670	50 km D/S of Hinton rb
Athabasca	05/15/84	h50lb84s.wb1	00AL07AD1660	50 km D/S of Hinton lb
Athabasca	10/07/85	h50rb85f.wb1	00AL07AD1670	50 km D/S of Hinton rb
Athabasca	10/07/85	h50lb85f.wb1	00AL07AD1660	50 km D/S of Hinton lb
Athabasca	10/08/85	h6lb85fl.wb1	00AL07AD1200	6 km D/S of Hinton lb
Athabasca	10/09/85	h6rb85fl.wb1	00AL07AD1220	6 km D/S of Hinton rb
Athabasca	05/19/83	hrb83sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	09/12/83	hrb83fl.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	05/16/84	hrb84sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	05/16/84	hlb84sp.wb1	00AL07AD1020	U/S of Hinton lb
Athabasca	06/12/85	hrb85sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	10/09/85	hlb85fl.wb1	00AL07AD1020	U/S of Hinton lb
Athabasca	10/09/85	hrb85fl.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	05/21/86	hrb86sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	09/02/86	hrb86fl.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	05/27/87	hrb87sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	09/09/87	hrb87fl.wb1	00AL07AD1010	U/S of Hinton rb

Table 1 - continued.

River	Date	Filename	Code	Site
Athabasca	05/24/83	emg83sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/19/83	emg83fl.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	05/16/84	emg84sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/11/84	emg84fl.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	05/27/85	emg85sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/09/85	emg85fl.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	05/29/86	emg86sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/04/86	emg86fl.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	05/04/87	emg87sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/29/87	emg87fl.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	08/27/85	a05lb85f.wb1	00AL07CB1000	0.5 km D/S of Athabasca lb
Athabasca	08/27/85	a05rb85f.wb1	00AL07CB1080	0.5 km D/S of Athabasca rb
Athabasca	08/27/85	a1-5lb85.wb1	00AL07CB1300	1.5 km D/S of Athabasca lb
Athabasca	08/27/85	a1-5rb85.wb1	00AL07CB1380	1.5 km D/S of Athabasca rb
Athabasca	08/27/85	a2-5lb85.wb1	00AL07CB1500	2.5 km D/S of Athabasca lb
Athabasca	08/27/85	a2-5rb85.wb1	00AL07CB1580	2.5 km D/S of Athabasca rb
Athabasca	08/27/85	a3-5lb85.wb1	00AL07CB1900	3.5 km D/S of Athabasca lb
Athabasca	08/27/85	a3-5rb85.wb1	00AL07CB1980	3.5 km D/S of Athabasca rb
Athabasca	08/27/85	a1bus85f.wb1	00AL07BE2300	U/S of Athabasca lb
Athabasca	08/27/85	arbus85f.wb1	00AL07BE2340	U/S of Athabasca rb
Athabasca	10/09/91	ath91s1.wb1	-	1 (5 km D/S of Deep Creek)
Athabasca	10/09/91	ath91s2.wb1	-	2 (3 km U/S of ALPAC diffuser)
Athabasca	10/09/91	ath91s3.wb1	-	3 (1 km D/S of ALPAC diffuser)
Athabasca	10/10/91	ath91s4.wb1	-	4 (11 km D/S of ALPAC diffuser)
Athabasca	10/10/91	ath91s5.wb1	-	5 (4 km D/S of LaBiche River)
Athabasca	10/10/91	ath91s6.wb1	-	6 (3 km D/S of Calling River)

Table 1 - continued.

River	Date	Filename	Code	Site
Athabasca	08/31/87	ft0-1dsf.wb1	00AL07DA0620	0.1 km D/S of Ft. McMurray STP outfall lb
Athabasca	08/31/87	ft0-5usf.wb1	00AL07DA0610	0.5 km U/S of Ft. McMurray STP outfall lb
Athabasca	08/31/87	ft10dsf.wb1	00AL07DA0820	10 km D/S of Ft. McMurray STP outfall lb
Athabasca	08/31/87	ft1dsf.wb1	00AL07DA0630	1.0 km D/S of Ft. McMurray STP outfall lb
Athabasca	05/26/83	fthr83sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	09/22/83	fthr83fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	05/15/84	fthr84sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	09/11/84	fthr84fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	05/27/85	fthr85sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	09/09/85	fthr85fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	05/29/86	fthr86sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	09/04/86	fthr86fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	06/04/87	fthr87sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	08/31/87	fthr87fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)

Table 2. Summary of benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Lesser Slave River. u/s = upstream, d/s = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank. Data collected with an Eckman grab. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Lesser Slave	09/12/90	ls90s1fl.wb1	-	1 (Mitsue bridge)
Lesser Slave	09/12/90	ls90s2fl.wb1	-	2 (U/S of pulp mill)
Lesser Slave	09/12/90	ls90s3fl.wb1	-	3 (D/S of pulp mill)
Lesser Slave	09/12/90	ls90s4fl.wb1	-	4 (U/S Saulteaux River)
Lesser Slave	09/12/90	ls90s5fl.wb1	-	5 (U/S Driftwood River)
Lesser Slave	05/16/90	ls90s1sp.wb1	-	1 (Mitsue bridge)
Lesser Slave	05/16/90	ls90s2sp.wb1	-	2 (U/S of pulp mill)
Lesser Slave	05/16/90	ls90s3sp.wb1	-	3 (D/S of pulp mill)
Lesser Slave	05/16/90	ls90s4sp.wb1	-	4 (U/S Saulteaux River)
Lesser Slave	05/16/90	ls90s5sp.wb1	-	5 (U/S Driftwood River)

Table 3. Summary of benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Wapiti River. WR = Weyerhaeuser, P&G = Procter and Gamble, GP = Grand Prairie, U/S = upstream, D/S = downstream, C = centre, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, con = confluence. Data collected with a Neill cylinder sampler. See appendices for additional details on sampling procedures. Date = month/day/year. ?? = sampling date not provided.

River	Date	Filename	Code	Site
Wapiti	07/??/73	aepwp73.wb1	-	O'Brien Park to above conf. with Smoky River
Wapiti	07/??/74	aepwp74.wb1	-	O'Brien Park to above conf. with Smoky River
Wapiti	07/??/75	aepwp75.wb1	-	O'Brien Park to above conf. with Smoky River
Wapiti	05/10/83	wcslb83s.wb1	00AT07GJ0990	U/S con. Smoky w2 lb
Wapiti	05/10/83	wcsrb83s.wb1	00AT07GJ1010	U/S con. Smoky w2 rb
Wapiti	09/27/83	wcslb83f.wb1	00AT07GJ0990	U/S con. Smoky w2 lb
Wapiti	09/27/83	wcsrb83f.wb1	00AT07GJ1010	U/S con. Smoky w2 rb
Wapiti	05/10/83	woblb83s.wb1	00AT07GE2010	U/S O' Brien Park w1 lb
Wapiti	05/10/83	wobrb83s.wb1	00AT07GE2020	U/S O' Brien Park w1 rb
Wapiti	09/27/83	woblb83f.wb1	00AT07GE2010	U/S O' Brien Park w1 lb
Wapiti	09/27/83	wobrb83f.wb1	00AT07GE2020	U/S O' Brien Park w1 rb
Wapiti	02/25/91	wap91s1.wb1	-	1 (WR near HWY 40/O' Brien Park)
Wapiti	02/27/91	wap91s2.wb1	-	2 (just U/S of GP STP effluent)
Wapiti	02/26/91	wap91s3.wb1	-	3 (5 km D/S of GP STP)
Wapiti	02/27/91	wap91s4.wb1	-	4 (D/S of P&G haul road

Table 3 - cont.

River	Date	Filename	Code	Site
Wapiti	02/25/91	wap91s5.wb1	-	5 (0.5 km D/S of P&G effluent, lb)
Wapiti	02/26/91	wap91s6.wb1	-	6 (WR near RR bridge -lb or C)
Wapiti	02/26/91	wap91s7.wb1	-	7 (WR 5-10 km D/S of P&G effluent)
Wapiti	02/26/91	wap91s8.wb1	-	8 (WR U/S of Bear River)
Wapiti	02/26/91	wap91s9.wb1	-	9 (10 km U/S of mouth)
Wapiti	02/26/91	wap91s10.wb1	-	10 (WR 0.5 km U/S of mouth)

Table 4. Summary of benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Smoky River. u/s = upstream, d/s = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, con = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Smoky	05/11/83	sbhrb83s.wb1	00AT07GJ2045	Below Bad Heart s4 rb
Smoky	05/11/83	sbhlb83s.wb1	00AT07GJ2035	Below Bad Heart s4 lb
Smoky	09/28/83	sbhlb83f.wb1	00AT07GJ2035	Below Bad Heart s4 lb
Smoky	09/28/83	sbhrb83f.wb1	00AT07GJ2045	Below Bad Heart s4 rb
Smoky	05/09/83	sbzlb83s.wb1	00AT07GJ2015	Bezanson bridge (hwy34) s3 lb
Smoky	05/09/83	sbzrb83s.wb1	00AT07GJ2025	Bezanson bridge (hwy34) s3 rb
Smoky	09/27/83	sbzlb83f.wb1	00AT07GJ2015	Bezanson bridge (hwy34) s3 lb
Smoky	09/27/83	sbzrb83f.wb1	00AT07GJ2025	Bezanson bridge (hwy34) s3 rb
Smoky	05/10/83	scwlb83s.wb1	00AT07GF1000	U/S con. Wapiti s1 lb
Smoky	05/10/83	scwrb83s.wb1	00AT07GF1010	U/S con. Wapiti s1 rb
Smoky	09/27/83	scwlb83f.wb1	00AT07GF1000	U/S con. Wapiti s1 lb
Smoky	09/27/83	scwrb83f.wb1	00AT07GF1010	U/S con. Wapiti s1 rb

Table 4 - continued.

River	Date	Filename	Code	Site
Smoky	05/11/83	smlb83sp.wb1	00AT07GJ4995	At mouth s7 lb
Smoky	05/11/83	smrb83sp.wb1	00AT07GJ5005	At mouth s7 rb
Smoky	09/28/83	smlb83fl.wb1	00AT07GJ4995	At mouth s7 lb
Smoky	09/28/83	smrb83fl.wb1	00AT07GJ5005	At mouth s7 rb
Smoky	05/10/83	ssrb83sp.wb1	00AT07GF2010	U/S con. Simonette s2 rb
Smoky	05/10/83	sslb83sp.wb1	00AT07GF1990	U/S con. Simonette s2 lb
Smoky	09/27/83	sslb83fl.wb1	00AT07GF1990	U/S con. Simonette s2 lb
Smoky	09/27/83	ssrb83fl.wb1	00AT07GF2010	U/S con. Simonette s2 rb
Smoky	05/11/83	sw5rb83s.wb1	00AT07GJ2065	At Watino s5 rb
Smoky	05/11/83	sw5lb83s.wb1	00AT07GJ2055	At Watino s5 lb
Smoky	09/28/83	sw5lb83f.wb1	00AT07GJ2055	At Watino s5 lb
Smoky	09/28/83	sw5rb83f.wb1	00AT07GJ2065	At Watino s5 rb
Smoky	05/11/83	swlb83sp.wb1	00AT07GJ3995	1/2 Watino to mouth s6 lb
Smoky	05/11/83	swrb83sp.wb1	00AT07GJ4005	1/2 Watino to mouth s6 rb
Smoky	09/28/83	swlb83fl.wb1	00AT07GJ3995	1/2 Watino to mouth s6 lb
Smoky	09/28/83	swrb83fl.wb1	00AT07GJ4005	1/2 Watino to mouth s6 rb

Table 5. Summary of benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Peace River. u/s = upstream, d/s = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, C = centre, con = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Peace	05/12/83	psrlb83s.wb1	00AT07FD5000	U/S con. with Smoky p1 lb
Peace	05/12/83	psrrb83s.wb1	00AT07FD5010	U/S con. with Smoky p1 rb
Peace	05/12/83	phrlb83s.wb1	00AT07HA2040	At Peace River U/S Heart River p2 lb
Peace	05/12/83	phrrb83s.wb1	00AT07HA2041	At Peace River U/S Heart River p2 rb
Peace	05/12/83	pdv83sp.wb1	00AT07FD2030	At Dunvegan
Peace	09/29/83	psrlb83f.wb1	00AT07FD5000	U/S con. with Smoky p1 lb
Peace	09/29/83	psrrb83f.wb1	00AT07FD5010	U/S con. with Smoky p1 rb
Peace	09/29/83	phrlb83f.wb1	00AT07HA2040	At Peace River U/S Heart River p2 lb
Peace	09/29/83	phrrb83f.wb1	00AT07HA2041	At Peace River U/S Heart River p2 rb
Peace	09/29/83	pdv83fl.wb1	00AT07FD2030	At Dunvegan
Peace	09/27/88	dunvegan.wb1	00AL07FD1500	Dunvegan (left)
Peace	09/28/88	carajou.wb1	00AL07HD1030	Near Carajou (centre)
Peace	09/28/88	lacrete.wb1	00AL07HF1350	Near LaCrete
Peace	09/28/88	notikewi.wb1	00AL07HC1200	U/S Notikewin River
Peace	09/29/88	peacept.wb1	00AL07KC1000	Near Peace Point (centre)
Peace	09/29/88	woodbuff.wb1	00AL07KA2000	Above Wood Buffalo
Peace	09/29/88	fortverm.wb1	00AL07HF1700	At Fort Vermillion
Peace	10/05/88	asmoky.wb1	00AL07FD4500	U/S Smoky

Table 5 - continued

River	Date	Filename	Code	Site
Peace	05/26/87	pblb87sp.wb1	00BC07FD1000	Border lb
Peace	05/26/87	pbrb87sp.wb1	00BC07FD1100	Border rb
Peace	09/28/87	pblb87fl.wb1	00BC07FD1000	Border lb
Peace	09/28/87	pbrb87fl.wb1	00BC07FD1100	Border rb
Peace	07/21/88	pblb88su.wb1	00BC07FD1000	Border lb
Peace	07/21/88	pbrb88su.wb1	00BC07FD1100	Border rb
Peace	10/03/88	pblb88fl.wb1	00BC07FD1000	Border lb
Peace	10/03/88	pbrb88fl.wb1	00BC07FD1100	Border rb
Peace	05/26/87	pclb87sp.wb1	00AL07FD1050	0.25 km U/S Clear River lb
Peace	05/27/87	pcrb87sp.wb1	00AL07FD1100	0.25 km U/S Clear River rb
Peace	09/28/87	pclb87fl.wb1	00AL07FD1050	0.25 km U/S Clear River lb
Peace	09/28/87	pcrb87fl.wb1	00AL07FD1100	0.25 km U/S Clear River rb
Peace	07/21/88	pclb88su.wb1	00AL07FD1050	0.25 km U/S Clear River lb
Peace	07/21/88	pcrb88su.wb1	00AL07FD1100	0.25 km U/S Clear River rb
Peace	09/27/88	pclb88fl.wb1	00AL07FD1050	0.25 km U/S Clear River lb
Peace	09/27/88	pcrb88fl.wb1	00AL07FD1100	0.25 km U/S Clear River rb
Peace	09/28/87	pcc87fl.wb1	00AL07FD1000	4.2 km U/S Clear River (centre)
Peace	09/27/88	pcc88fl.wb1	00AL07FD1000	4.2 km U/S Clear River (centre)

Table 5 - continued

River	Date	Filename	Code	Site
Peace	07/27/88	p3d88su.wb1	00AL07HA2150	3 km U/S Daishowa Pulp mill (B1L)
Peace	10/04/88	p3d88fl.wb1	00AL07HA2150	3 km U/S Daishowa Pulp mill (B1L)
Peace	07/27/88	p4d88su.wb1	00AL07HA2100	4 km U/S Daishowa Pulp mill (B1R)
Peace	10/04/88	p4d88fl.wb1	00AL07HA2100	4 km U/S Daishowa Pulp mill (B1R)
Peace	07/26/88	p2d88su.wb1	00AL07HA2200	2 km D/S Daishowa Pulp mill (B2R)
Peace	10/04/88	p2d88fl.wb1	00AL07HA2200	2 km D/S Daishowa Pulp mill (B2R)
Peace	07/27/88	p5d88su.wb1	00AL07HA2600	5 km D/S Daishowa Pulp mill (B2L)
Peace	10/04/88	p5d88fl.wb1	00AL07HA2600	5 km D/S Daishowa Pulp mill (B2L)
Peace	07/27/88	p7d88su.wb1	00AL07HA2620	7 km D/S Daishowa Pulp mill (B2C)
Peace	10/04/88	p7d88fl.wb1	00AL07HA2620	7 km D/S Daishowa Pulp mill (B2C)
Peace	07/26/88	p17d88su.wb1	00AL07HA2640	17 km D/S Daishowa Pulp mill (B3L)
Peace	10/04/88	p17d88fl.wb1	00AL07HA2640	17 km D/S Daishowa Pulp mill (B3L)
Peace	07/26/88	p20d88su.wb1	00AL07HA2660	20 km D/S Daishowa Pulp mill (B3R)
Peace	10/04/88	p20d88fl.wb1	00AL07HA2660	20 km D/S Daishowa Pulp mill (B3R)

Table 5 - continued

River	Date	Filename	Code	Site
Peace	07/26/88	p32d88su.wb1	00AL07HA2680	32 km D/S Daishowa Pulp mill (B4R)
Peace	07/26/88	p32d88fl.wb1	00AL07HA2680	32 km D/S Daishowa Pulp mill (B4R)
Peace	07/26/88	p33d88su.wb1	00AL07HA2700	33 km D/S Daishowa Pulp mill (B4C)
Peace	10/04/88	p33d88fl.wb1	00AL07HA2700	33 km D/S Daishowa Pulp mill (B4C)
Peace	07/26/88	p35d88su.wb1	00AL07HA2800	35 km D/S Daishowa Pulp mill (B4L)
Peace	10/04/88	p35d88fl.wb1	00AL07HA2800	35 km D/S Daishowa Pulp mill (B4L)

Table 6. Summary of data files provided by Sentar Consulting Ltd. Calgary, Alberta for studies completed for Millar Western Pulp Ltd. in the Athabasca River at Whitecourt. Site = general site location as provided by source. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Site
McLeod	06/05/87	mwju87s1.wb1	1
Athabasca	06/05/87	mwju87s2.wb1	2
Athabasca	06/05/87	mwju87s3.wb1	3
Athabasca	06/05/87	mwju87s4.wb1	4
Athabasca	06/05/87	mwju87s5.wb1	5
McLeod	11/05/87	mwno87s1.wb1	1
Athabasca	11/05/87	mwno87s2.wb1	2
Athabasca	11/05/87	mwno87s3.wb1	3
Athabasca	11/05/87	mwno87s4.wb1	4
Athabasca	11/05/87	mwno87s5.wb1	5
McLeod	06/05/88	mwju88s1.wb1	1
Athabasca	06/05/88	mwju88s2.wb1	2
Athabasca	06/05/88	mwju88s3.wb1	3
Athabasca	06/05/88	mwju88s4.wb1	4
Athabasca	06/05/88	mwju88s5.wb1	5
McLeod	10/05/88	mwoc88s1.wb1	1
Athabasca	10/05/88	mwoc88s2.wb1	2
Athabasca	10/05/88	mwoc88s3.wb1	3
Athabasca	10/05/88	mwoc88s4.wb1	4
Athabasca	10/05/88	mwoc88s5.wb1	5
McLeod	06/08/89	mwju89s1.wb1	1
Athabasca	06/08/89	mwju89s2.wb1	2
Athabasca	06/08/89	mwju89s3.wb1	3
Athabasca	06/08/89	mwju89s4.wb1	4
Athabasca	06/08/89	mwju89s4a.wb1	4a
Athabasca	06/08/89	mwju89s5.wb1	5
Athabasca	06/08/89	mwju89s6.wb1	6
Athabasca	06/08/89	mwju89s7.wb1	7

Table 6 - continued

River	Date	Filename	Site
McLeod	10/08/89	mwoc89s1.wb1	1
Athabasca	10/08/89	mwoc89s1.wb1	1
Athabasca	10/08/89	mwoc89s2.wb1	2
Athabasca	10/08/89	mwoc89s3.wb1	3
Athabasca	10/08/89	mwoc89s4.wb1	4
Athabasca	10/08/89	mwoc89s4a.wb1	4a
Athabasca	10/08/89	mwoc89s5.wb1	5
Athabasca	10/08/89	mwoc89s6.wb1	6
Athabasca	10/08/89	mwoc89s7.wb1	7
Athabasca	05/08/92	mwma90s1.wb1	1
Athabasca	05/08/90	mwma90s2.wb1	2
Athabasca	05/08/90	mwma90s3.wb1	3
Athabasca	05/08/90	mwma90s4.wb1	4
Athabasca	05/08/90	mwma90s4a.wb1	4a
Athabasca	05/08/90	mwma90s5.wb1	5
Athabasca	05/08/90	mwma90s6.wb1	6
Athabasca	05/08/90	mwma90s7.wb1	7
McLeod	10/08/90	mwoc90s1.wb1	1
Athabasca	10/08/90	mwoc90s2.wb1	2
Athabasca	10/08/90	mwoc90s3.wb1	3
Athabasca	10/08/90	mwoc90s4.wb1	4
Athabasca	10/08/90	mwoc90s4a.wb1	4a
Athabasca	10/08/90	mwoc90s5.wb1	5
Athabasca	10/08/90	mwoc90s6.wb1	6
Athabasca	10/08/90	mwoc90s7.wb1	7
McLeod	05/08/91	mwma91s1.wb1	1
Athabasca	05/08/91	mwma91s2.wb1	2
Athabasca	05/08/91	mwma91s3.wb1	3
Athabasca	05/08/91	mwma91s4.wb1	4
Athabasca	05/08/91	mwma91s4a.wb1	4a
Athabasca	05/08/91	mwma91s5.wb1	5
Athabasca	05/08/91	mwma91s6.wb1	6
Athabasca	05/08/91	mwma91s7.wb1	7

Table 6 - continued

River	Date	Filename	Site
McLeod	10/08/91	mwoc91s1.wb1	1
Athabasca	10/08/91	mwoc91s2.wb1	2
Athabasca	10/08/91	mwoc91s3.wb1	3
Athabasca	10/08/91	mwoc91s4.wb1	4
Athabasca	10/08/91	mwoc91s4a.wb1	4a
Athabasca	10/08/91	mwoc91s5.wb1	5
Athabasca	10/08/91	mwoc91s6.wb1	6
Athabasca	10/08/91	mwoc91s7.wb1	7
McLeod	04/08/92	mwap92s1.wb1	1
Athabasca	04/08/92	mwap92s2.wb1	2
Athabasca	04/08/92	mwap92s3.wb1	3
Athabasca	04/08/92	mwap92s4.wb1	4
Athabasca	04/08/92	mwap92s4a.wb1	4a
Athabasca	04/08/92	mwap92s5.wb1	5
Athabasca	04/08/92	mwap92s6.wb1	6
Athabasca	04/08/92	mwap92s7.wb1	7
Athabasca	10/08/92	mwoc92s1.wb1	1
Athabasca	10/08/92	mwoc92s2.wb1	2
Athabasca	10/08/92	mwoc92s3.wb1	3
Athabasca	10/08/92	mwoc92s4.wb1	4
Athabasca	10/08/92	mwoc92s4a.wb1	4a
Athabasca	10/08/92	mwoc92s5.wb1	5
Athabasca	10/08/92	mwoc92s6.wb1	6
Athabasca	10/08/92	mwoc92s7.wb1	7

Table 7. Summary of data files provided by Sentar Consulting Ltd. Calgary, Alberta for studies completed for Alberta Newsprint Company in the Athabasca River at Whitecourt. Site = general site location as provided by source. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Site
Athabasca	06/07/89	anju89s1.wb1	1
Athabasca	06/07/89	anju89s2.wb1	2
Athabasca	06/07/89	anju89s3.wb1	3
Athabasca	06/07/89	anju89s4.wb1	4
Athabasca	06/07/89	anju89s5.wb1	5
Athabasca	06/07/89	anju89s6.wb1	6
Athabasca	06/07/89	anju89s7.wb1	7
Athabasca	10/07/89	anoc89s1.wb1	1
Athabasca	10/07/89	anoc89s2.wb1	2
Athabasca	10/07/89	anoc89s3.wb1	3
Athabasca	10/07/89	anoc89s4.wb1	4
Athabasca	10/07/89	anoc89s5.wb1	5
Athabasca	10/07/89	anoc89s6.wb1	6
Athabasca	10/07/89	anoc89s7.wb1	7
Athabasca	05/07/90	anma90s1.wb1	1
Athabasca	05/07/90	anma90s2.wb1	2
Athabasca	05/07/90	anma90s3.wb1	3
Athabasca	05/07/90	anma90s4.wb1	4
Athabasca	05/07/90	anma90s5.wb1	5
Athabasca	05/07/90	anma90s6.wb1	6
Athabasca	05/07/90	anma90s7.wb1	7

Table 7 - continued.

River	Date	Filename	Site
Athabasca	10/07/90	anoc90s1.wb1	1
Athabasca	10/07/90	anoc90s2.wb1	2
Athabasca	10/07/90	anoc90s3.wb1	3
Athabasca	10/07/90	anoc90s4.wb1	4
Athabasca	10/07/90	anoc90s5.wb1	5
Athabasca	10/07/90	anoc90s6.wb1	6
Athabasca	10/07/90	anoc90s7.wb1	7
Athabasca	05/07/91	anma91s1.wb1	1
Athabasca	05/07/91	anma91s2.wb1	2
Athabasca	05/07/91	anma91s3.wb1	3
Athabasca	05/07/91	anma91s4.wb1	4
Athabasca	05/07/91	anma91s5.wb1	5
Athabasca	05/07/91	anma91s6.wb1	6
Athabasca	05/07/91	anma91s7.wb1	7
Athabasca	10/07/91	anoc91s1.wb1	1
Athabasca	10/07/91	anoc91s2.wb1	2
Athabasca	10/07/91	anoc91s3.wb1	3
Athabasca	10/07/91	anoc91s4.wb1	4
Athabasca	10/07/91	anoc91s5.wb1	5
Athabasca	10/07/91	anoc91s6.wb1	6
Athabasca	10/07/91	anoc91s7.wb1	7
Athabasca	04/07/92	anap92s1.wb1	1
Athabasca	04/07/92	anap92s2.wb1	2
Athabasca	04/07/92	anap92s3.wb1	3
Athabasca	04/07/92	anap92s4.wb1	4
Athabasca	04/07/92	anap92s5.wb1	5
Athabasca	04/07/92	anap92s6.wb1	6
Athabasca	04/07/92	anap92s7.wb1	7

Table 7 - continued.

River	Date	Filename	Site
Athabasca	10/07/92	anoc92s1.wb1	1
Athabasca	10/07/92	anoc92s2.wb1	2
Athabasca	10/07/92	anoc92s3.wb1	3
Athabasca	10/07/92	anoc92s4.wb1	4
Athabasca	10/07/92	anoc92s5.wb1	5
Athabasca	10/07/92	anoc92s6.wb1	6
Athabasca	10/07/92	anoc92s7.wb1	7

Table 8. Summary of benthic macroinvertebrate data provided by Beak Consulting Ltd., Integrated Environmental Sciences Ltd. and Terrestrial & Aquatic Environmental Managers Ltd. for the Athabasca River at Hinton and downstream locations, 1960. Files have ordered by year extending from 1960-1992. Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, STP = sewage treatment plant, Sites = general site locations as provided by source. See appendices for additional details on sampling procedures. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. [1] = summary data, ?? = sampling day not provided.

River	Date	Filename	Sites
Athabasca	05/??/60	AH60S1.WB1	3 miles u/s of mill - Ft. Assiniboine (N=15)
Athabasca	09/04/72	AH72S1.WB1	9 miles u/s of mill - 57.5 miles d/s (N= 9)
Athabasca	09/??/74	AH74S1.WB1	1.5 miles d/s of mill - 92.5 miles d/s (N=15)
Athabasca	10/??/76	AH76S1.WB1	4.8 km u/s of mill - 44.2 km d/s (N=11)
Athabasca	05/??/77	AH77S1.WB1	4.8 kM u/s of mill - 44.2 km d/s (N= 8)
Athabasca	10/??/79	AH79S1.WB1	4.8 km u/s of mill - 44.2 km d/s (N= 9)
Athabasca	04/??/84	AH84S1.WB1	4.8 km u/s of mill - 44.2 km d/s (N= 9)[1]
Athabasca	04/??/86	AH86S1.WB1	4.8 km u/s of mill - 44.2 km d/s (N= 9)
Athabasca	04/??/89	AH89S1.WB1	4.8 km u/s of mill - 44.2 km d/s (N= 9)
Athabasca	10/??/90	AH90S1.WB1	4.8 km u/s of mill - 44.2 km d/s (N= 9)
Athabasca	04/??/91	AH91S1.WB1	4.8 km u/s of mill - 44.2 km d/s (N= 9)
Athabasca	04/??/92	AH92S1.WB1	4.8 km u/s of mill - 44.2 km d/s (N= 9)
Athabasca	10/??/92	AH92S2.WB1	4.8 km u/s of mill - 44.2 km d/s (N= 9)
Athabasca	10/??/92	AH92S3.WB1	4.8 km u/s of mill - 44.2 km d/s (N= 9)

Table 9. Summary of data files provided by Beak Consultants Ltd., Integrated Environmental Sciences Ltd., and Terrestrial & Aquatic Environmental Managers for the Wapiti and Smoky Rivers. Files have ordered by year extending from 1970-1993. Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, con = confluence. See appendices for additional details on sampling procedures. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. [1] = summary data, ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

River	Date	Filename	Sites	
Wapiti&Smoky	9&11/70	WAP70S1.WB1	0.3 m u/s mill - 0.25 m d/s Smoky con.	(N = 7)
Wapiti	07/??/72	WAP72S1.WB1	2.3 m u/s mill - 18.1 m d/s mill	(N = 6)
Wapiti	06/??/74	WAP74S1.WB1	2.3 m u/s mill - 18.1 m d/s mill	(N = 6)
Wapiti	06/??/74	WAP74S2.WB1	2.3 m u/s mill - 18.1 m d/s mill	(N = 6)
Wapiti	11/??/74	WAP74S3.WB1	2.3 m u/s mill - 18.1 m d/s mill	(N = 6)
Wapiti	10/??/75	WAP75S1.WB1	2.3 m u/s mill - 18.1 m d/s mill	(N = 8)
Wapiti	10/??/78	WAP78S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 7)
Wapiti	10/??/80	WAP80S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 8)
Wapiti	10/??/81	WAP81S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 8)
Wapiti	10/??/82	WAP82S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 8)
Wapiti	10/??/83	WAP83S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 8)
Wapiti	10/??/85	WAP85S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 8)
Wapiti	10/??/87	WAP87S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 8)
Wapiti	10/??/87	WAP87S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 8)
Wapiti	10/??/88	WAP88S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 8)
Wapiti	10/??/90	WAP90S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 6)
Wapiti	04/??/91	WAP91S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 11)
Wapiti	01/??/92	WAP92S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 11)
Wapiti	11/??/92	WAP92S2.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 11)
Wapiti	02/??/93	WAP93S1.WB1	2.3 m d/s mill - 18.1 m d/s mill	(N = 11)

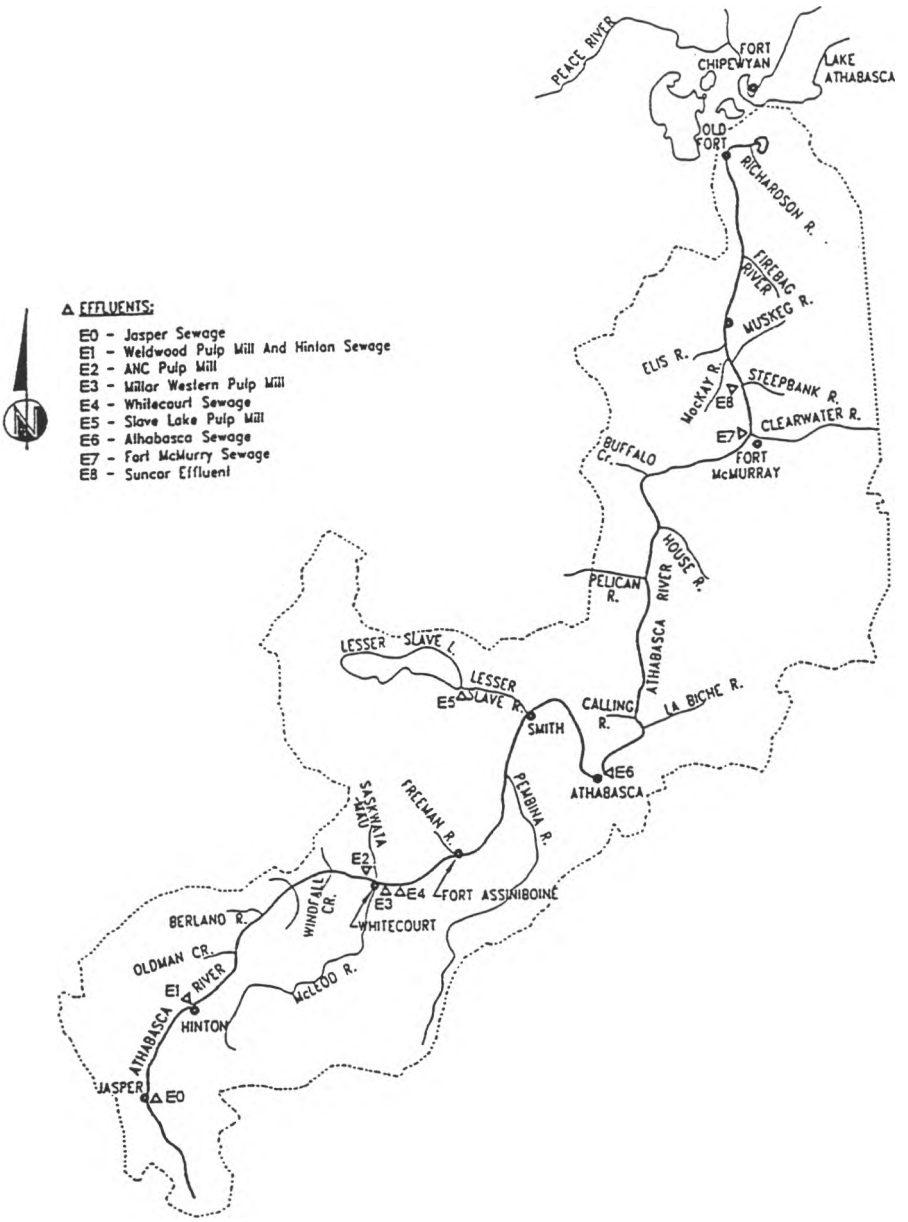

Figure 1. Location of tributaries and point source discharges to the Athabasca River, Alberta. Reproduced from Tones (1993).

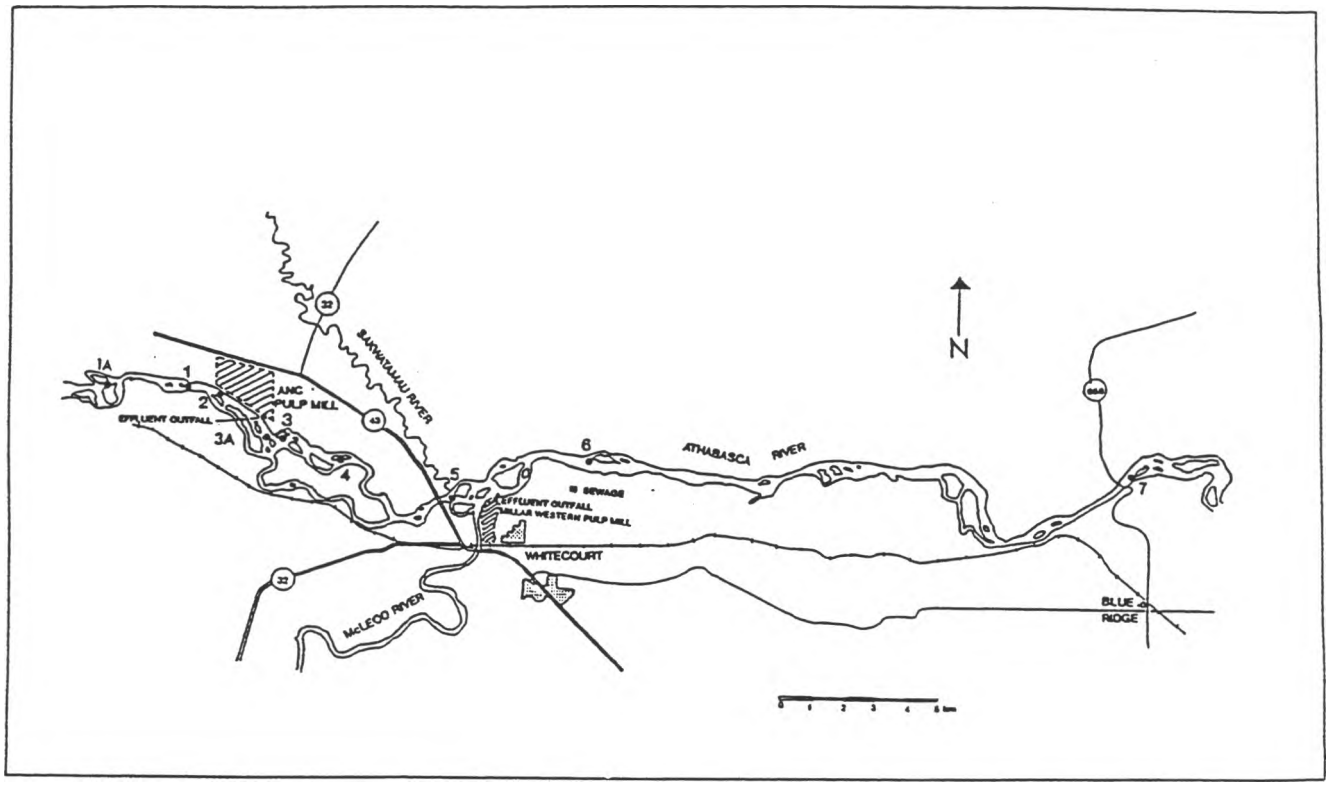

Figure 2. Location of sampling sites used by Sentar Consultants Ltd. for Alberta Newsprint Company Ltd. in the Athabasca River at Whitecourt, 1989-1992. Sources: Luoma and Shelast (1988, 1990a, 1991a, 1991b, 1992a, 1993b, 1994).

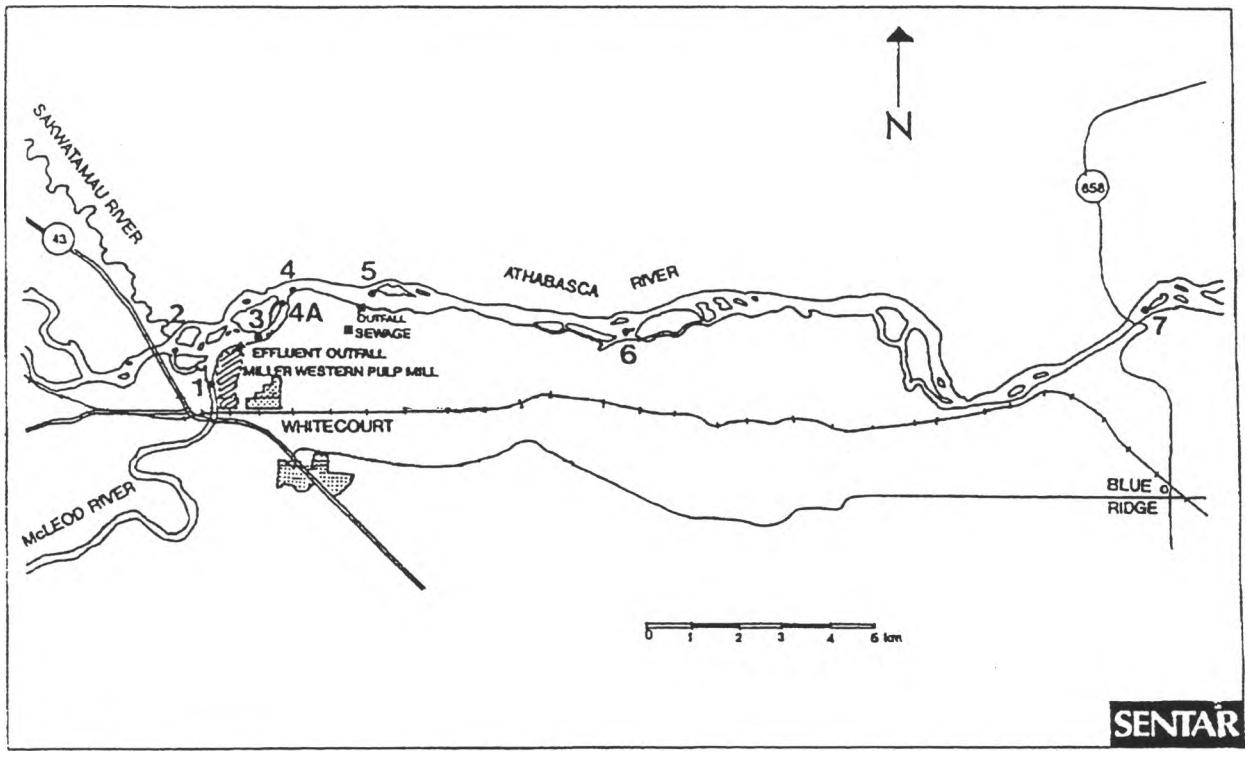

Figure 3. Location of sampling sites used by Sentar Consultants Ltd. for Millar Western Pulp Ltd. in the Athabasca River at Whitecourt, 1987-1992. Sources: Luoma and Shelast (1988, 1989, 1990b, 1991a, 1992b, 1993a).

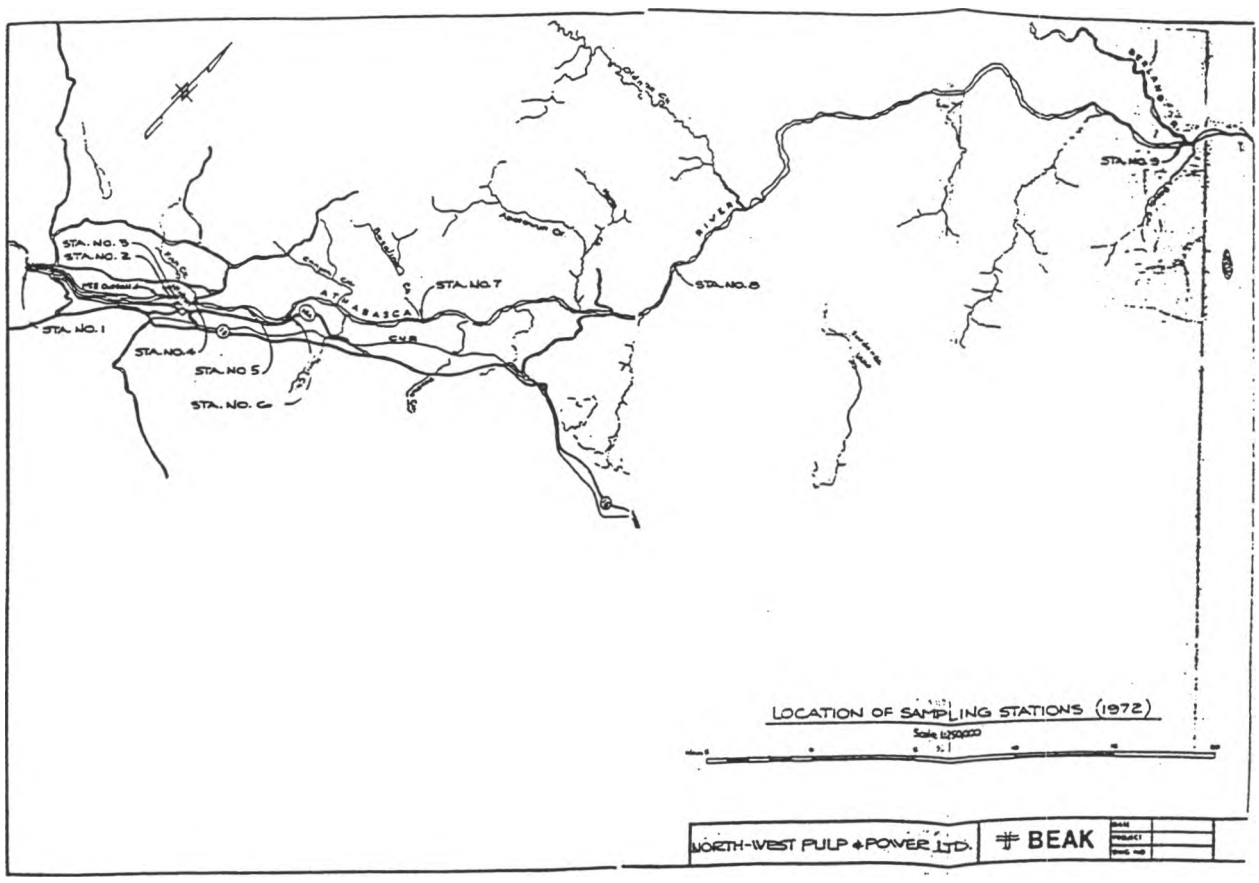

Figure 4. Location of sampling sites used by Beak Consulting Ltd. in the Athabasca River at Hinton, 1972. Source: Beak (1972a).

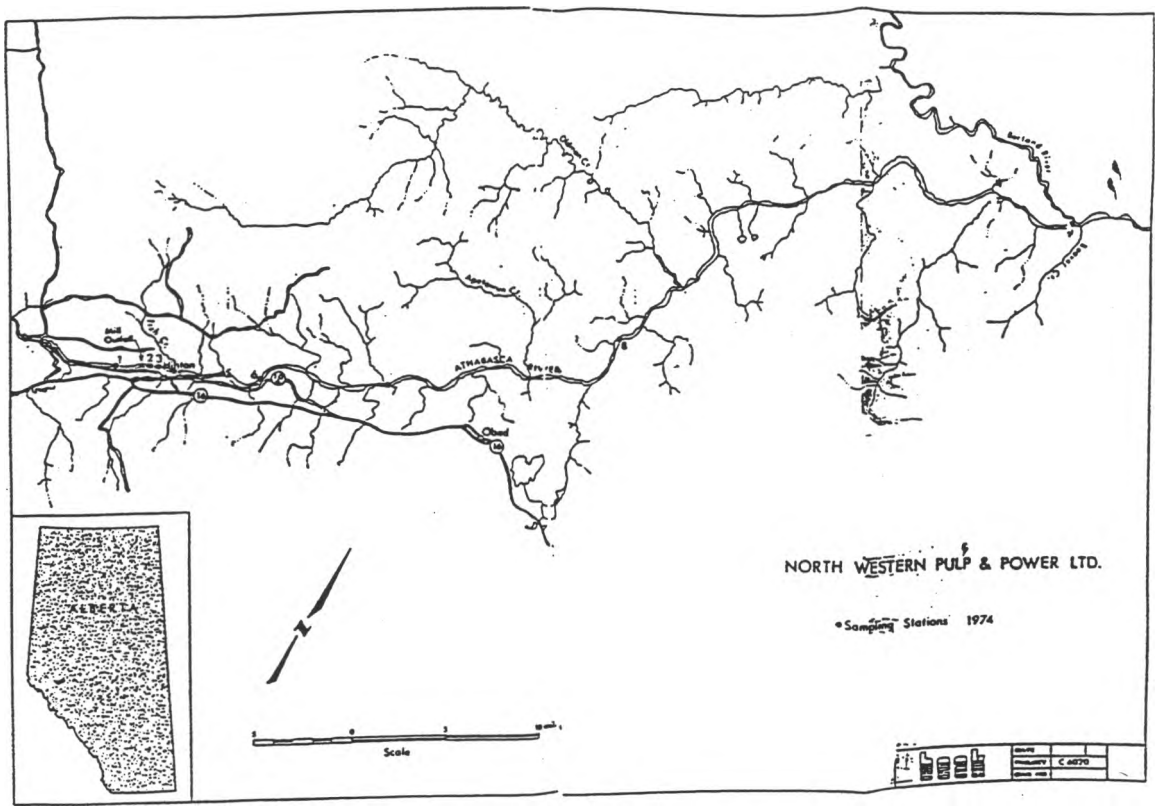

Figure 5. Location of sampling sites used by Beak Consulting Ltd. in the Athabasca River at Hinton, 1974. Source: Beak (1975a).

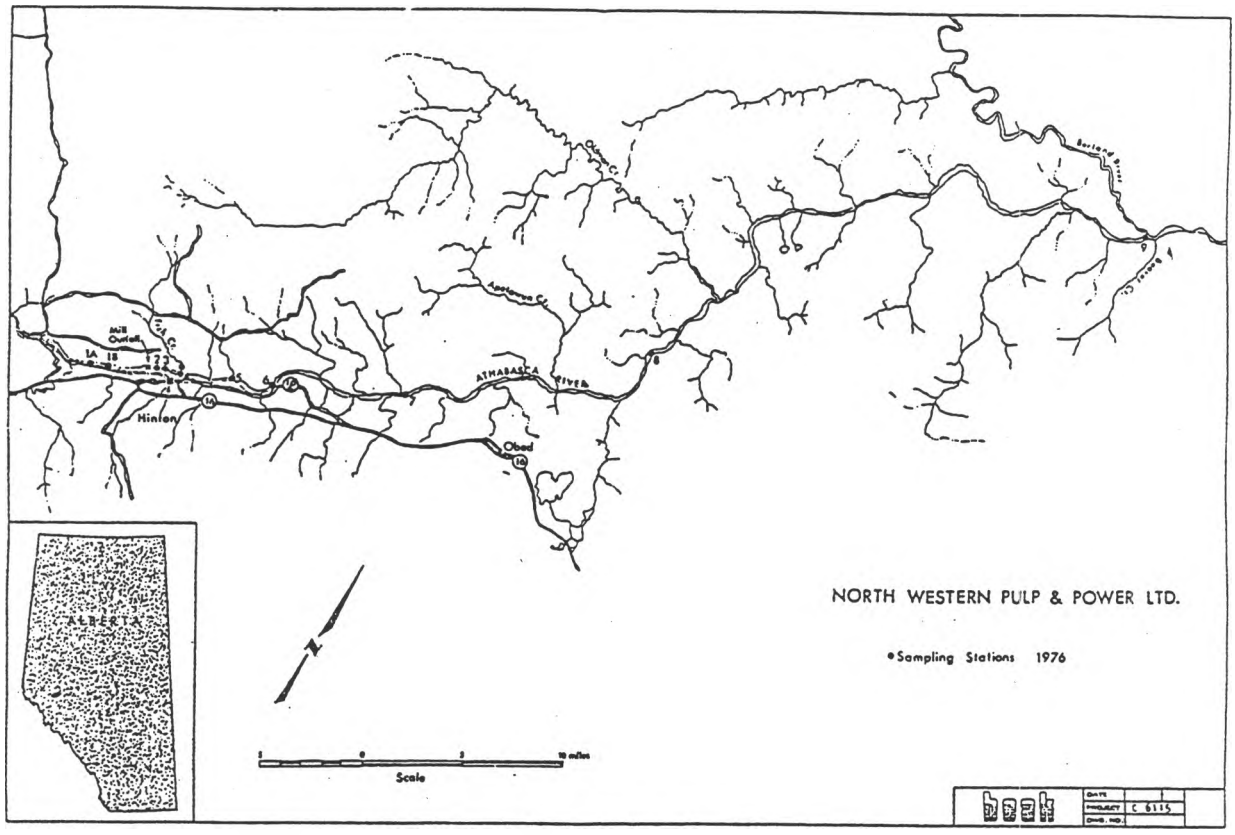

Figure 6. Location of sampling sites used by Beak Consulting Ltd. in the Athabasca River at Hinton, 1976. Source: Beak (1977).

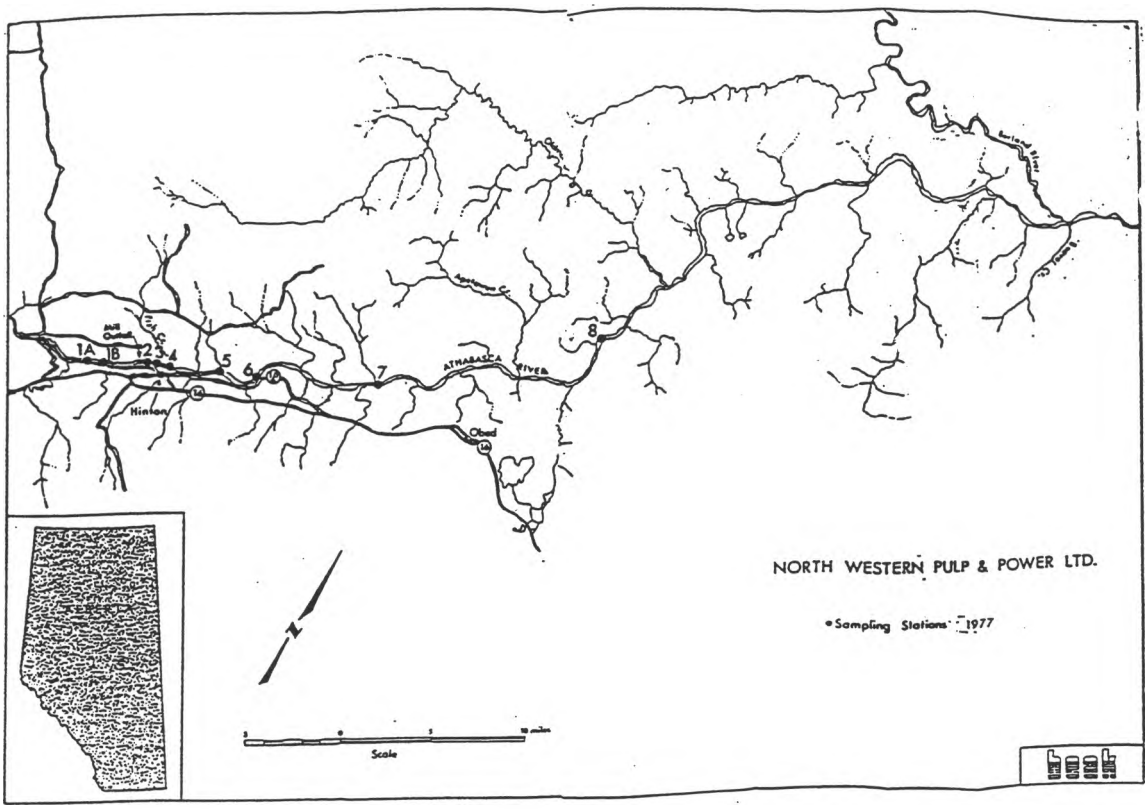

Figure 7. Location of sampling sites used by Beak Consulting Ltd. in the Athabasca River at Hinton, 1977. Source: Beak (1978).

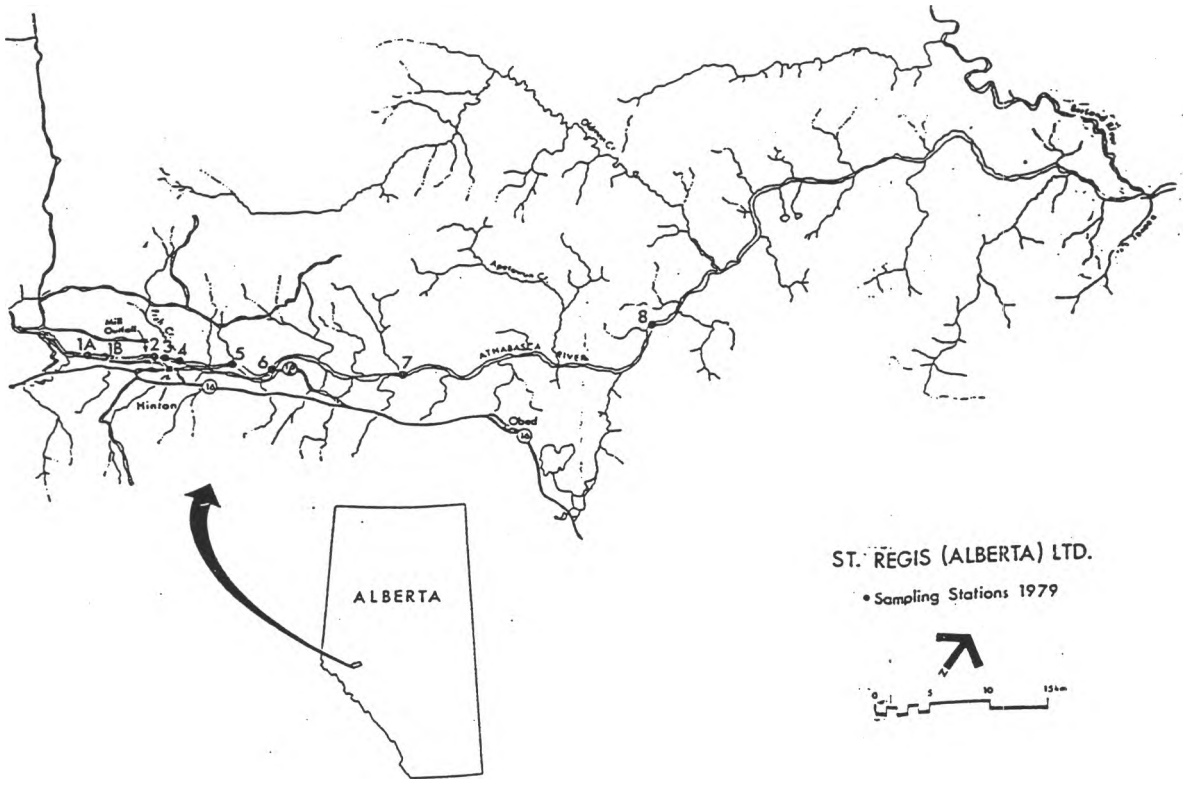

Figure 8. Location of sampling sites used by Beak Consulting Ltd. in the Athabasca River at Hinton, 1979. Source: Beak (1980a).

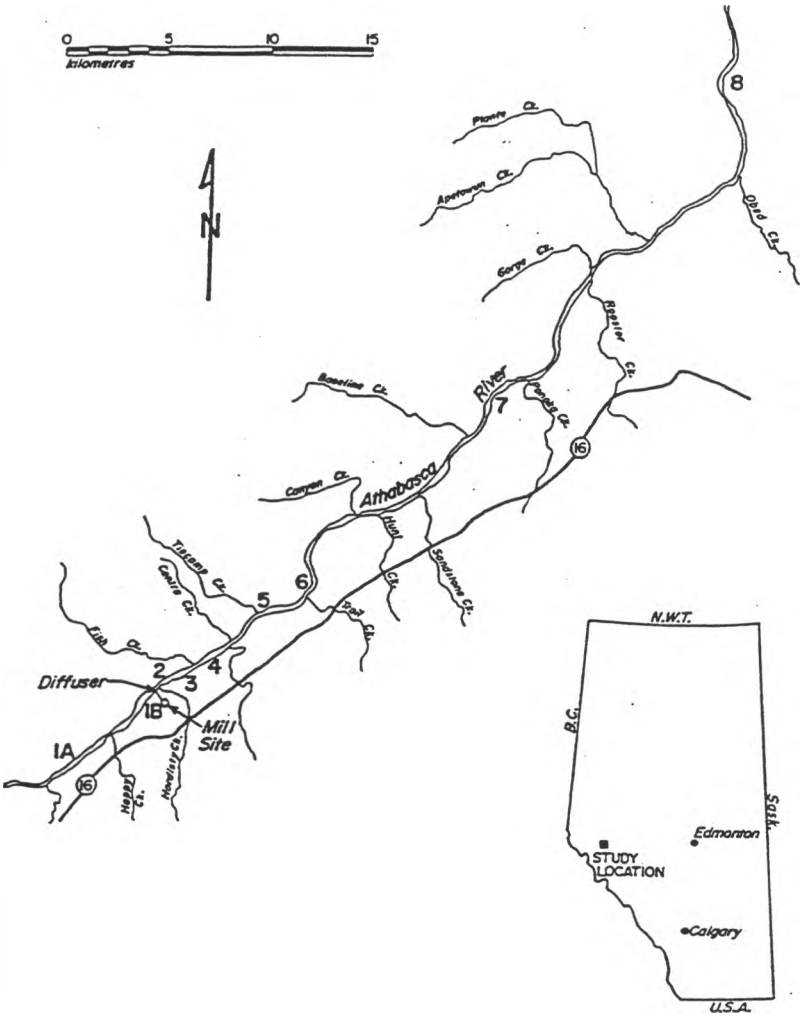

Figure 9. Location of sampling sites used by Integrated Environmental Sciences Inc. in the Athabasca River at Hinton, 1984. Source: Integrated Environmental Sciences Inc. (1984a).

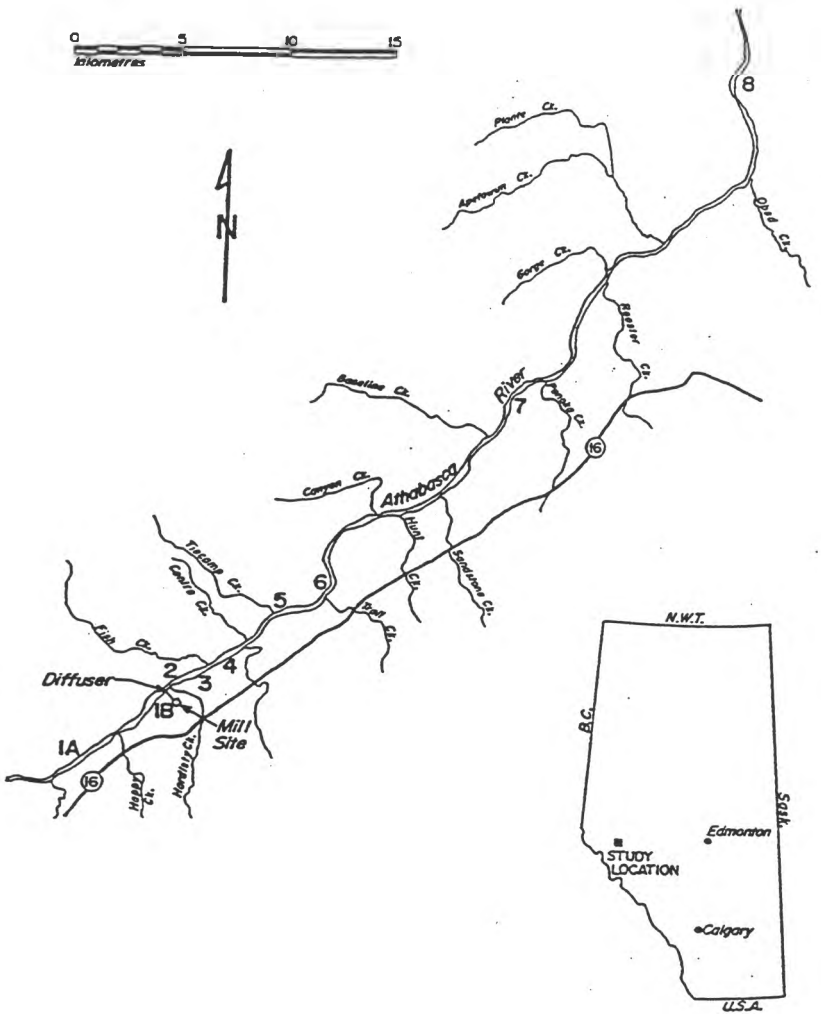

Figure 10. Location of sampling sites used by Terrestrial & Aquatic Environmental Managers Ltd. in the Athabasca River at Hinton, 1986. Source: Terrestrial & Aquatic Environmental Managers Ltd. (1986a).

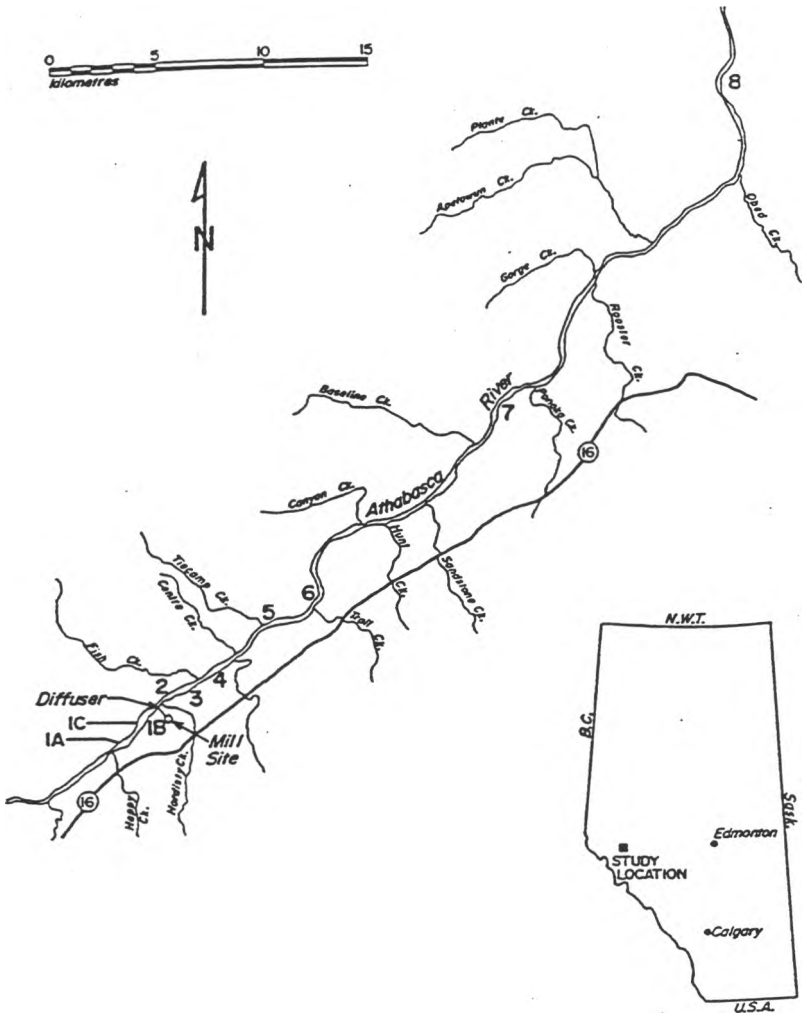

Figure 11. Location of sampling sites used by Terrestrial & Aquatic Environmental Managers Ltd. in the Athabasca River at Hinton, 1989. Source: Terrestrial & Aquatic Environmental Managers Ltd. (1989a).

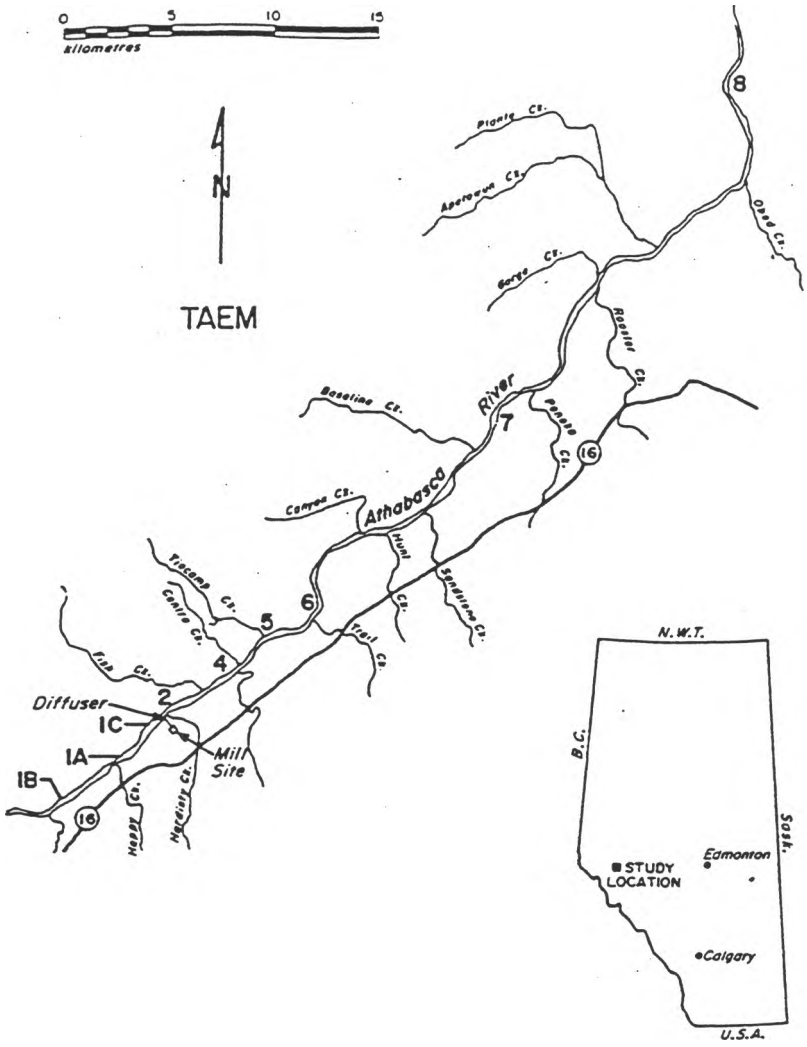

Figure 12. Location of sampling sites used by Terrestrial & Aquatic Environmental Managers Ltd., in the Athabasca River at Hinton, 1990-1993. Source: Terrestrial & Aquatic Environmental Managers Ltd. (1991a, 1992b, 1993a, 1993b).

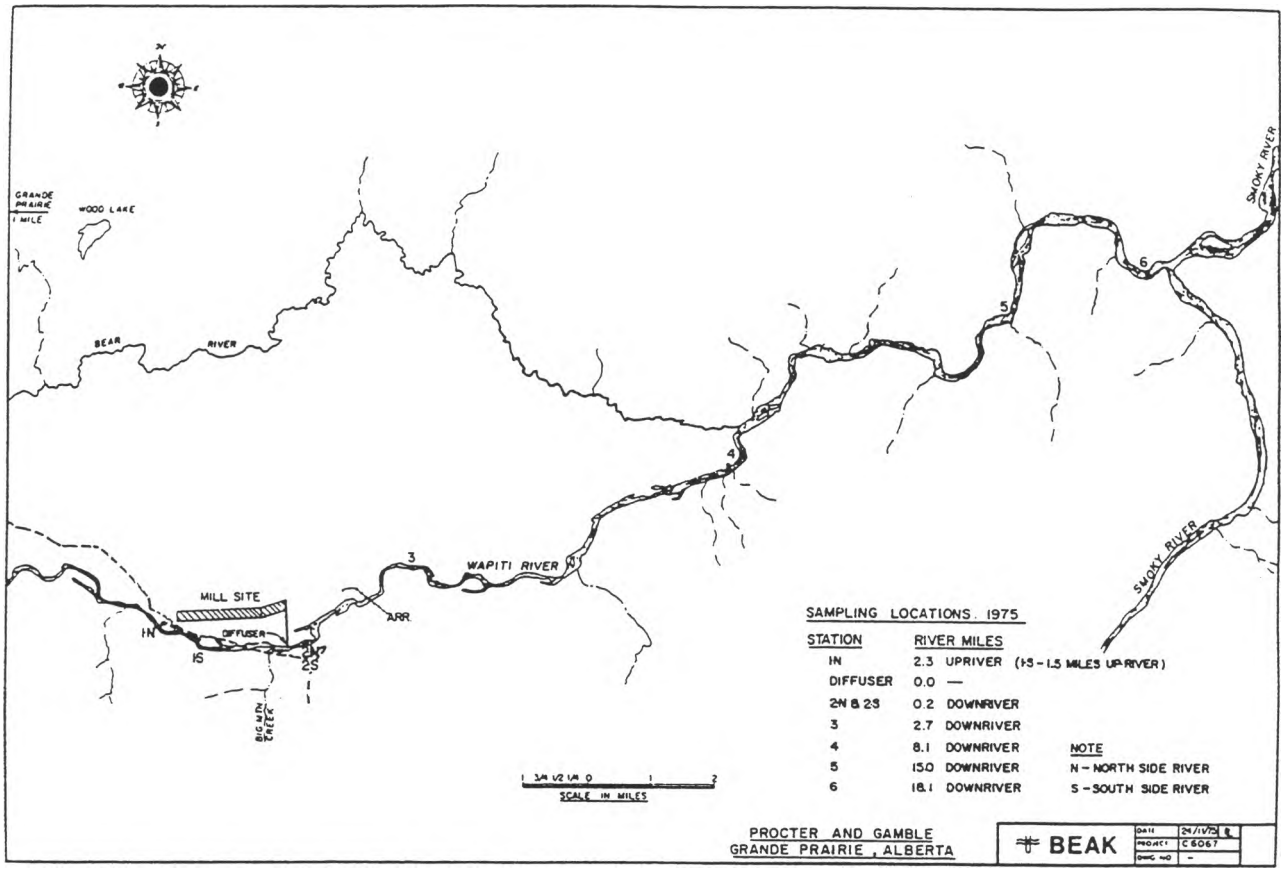

Figure 13. Location of sampling sites used by Beak Consulting Ltd. in the Wapiti and Smoky Rivers, 1975. Source: Beak (1976).

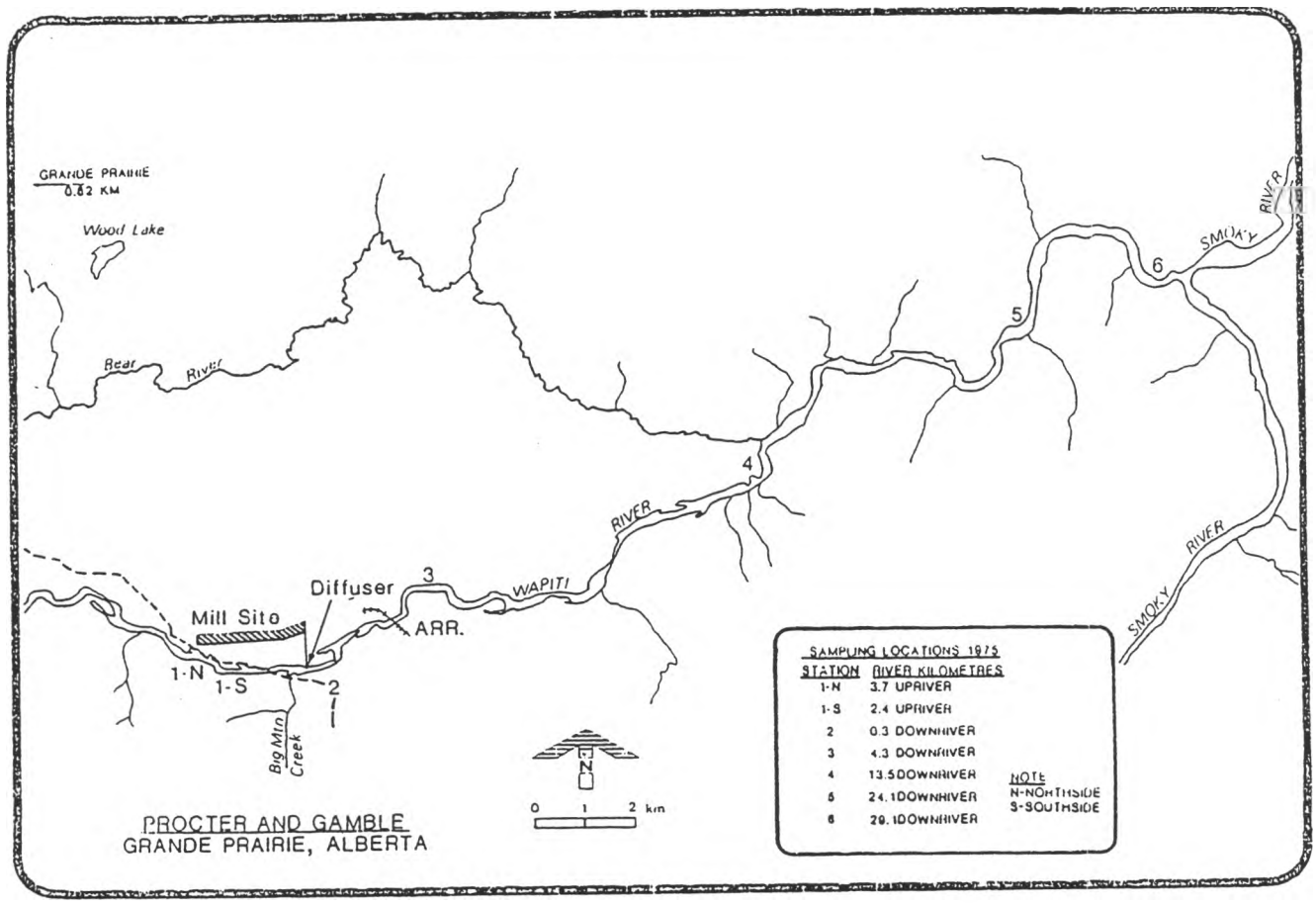

Figure 14. Location of sampling sites used by Beak Consulting Ltd. in the Wapiti and Smoky Rivers, 1978. Source: Beak (1979b).

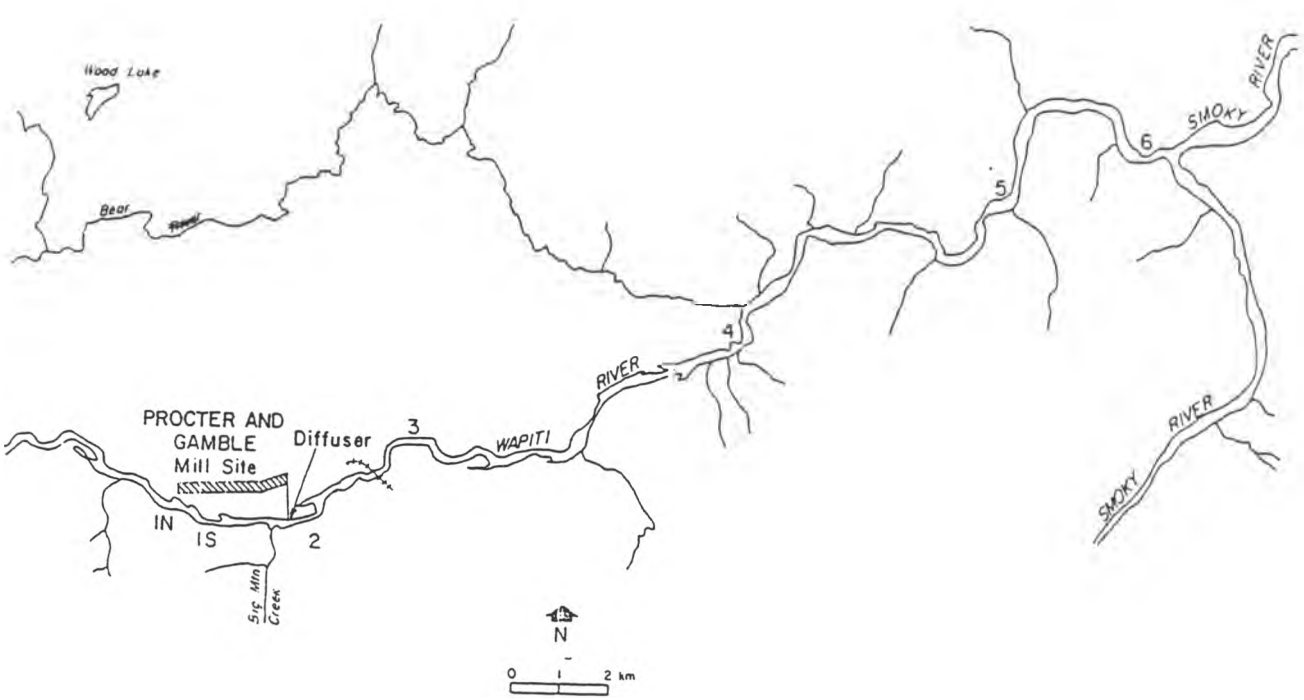

Figure 15. Location of sampling sites used by Beak Consulting Ltd. in the Wapiti and Smoky Rivers, 1980-1981. Source: Beak (1981), Integrated Environmental Sciences Inc. (1982).

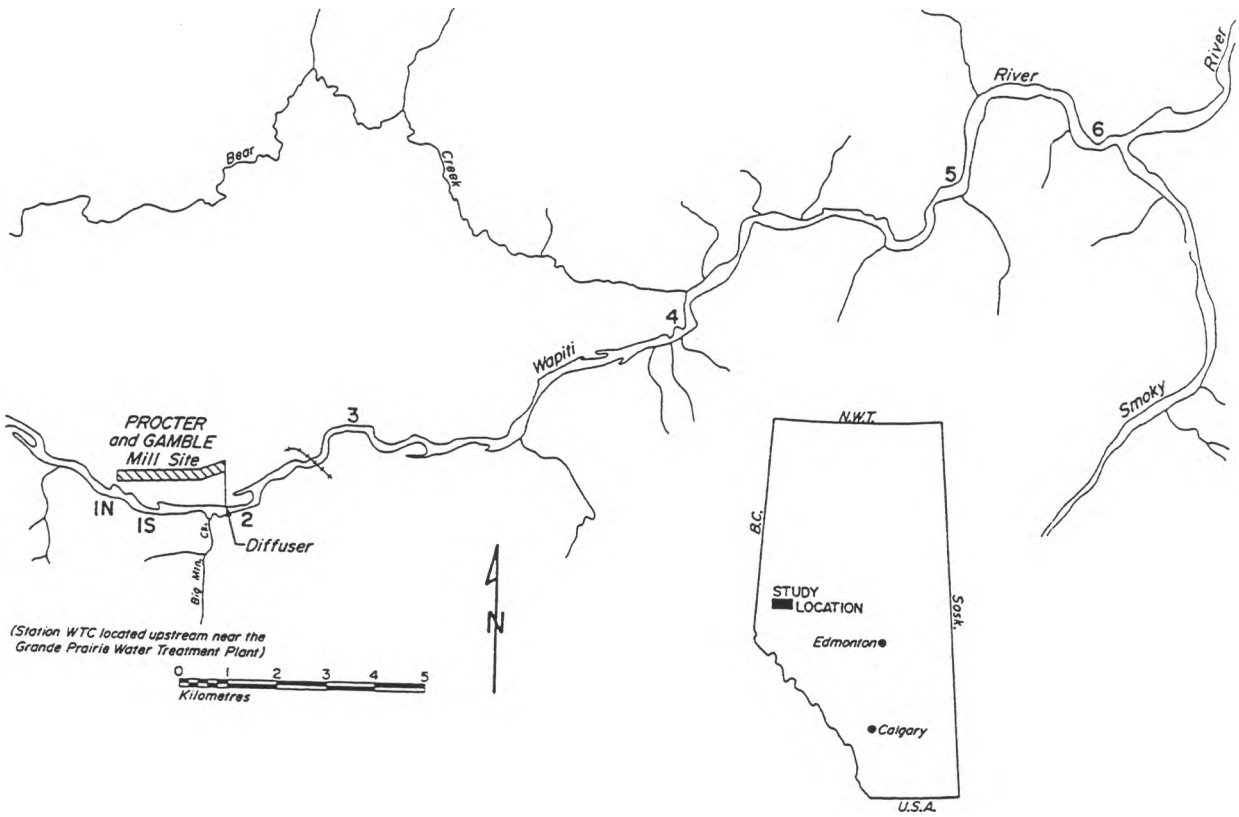

Figure 16. Location of sampling sites used by Integrated Environmental Sciences Inc. in the Wapiti and Smoky Rivers, 1982. Source: Integrated Environmental Sciences Inc. (1983).

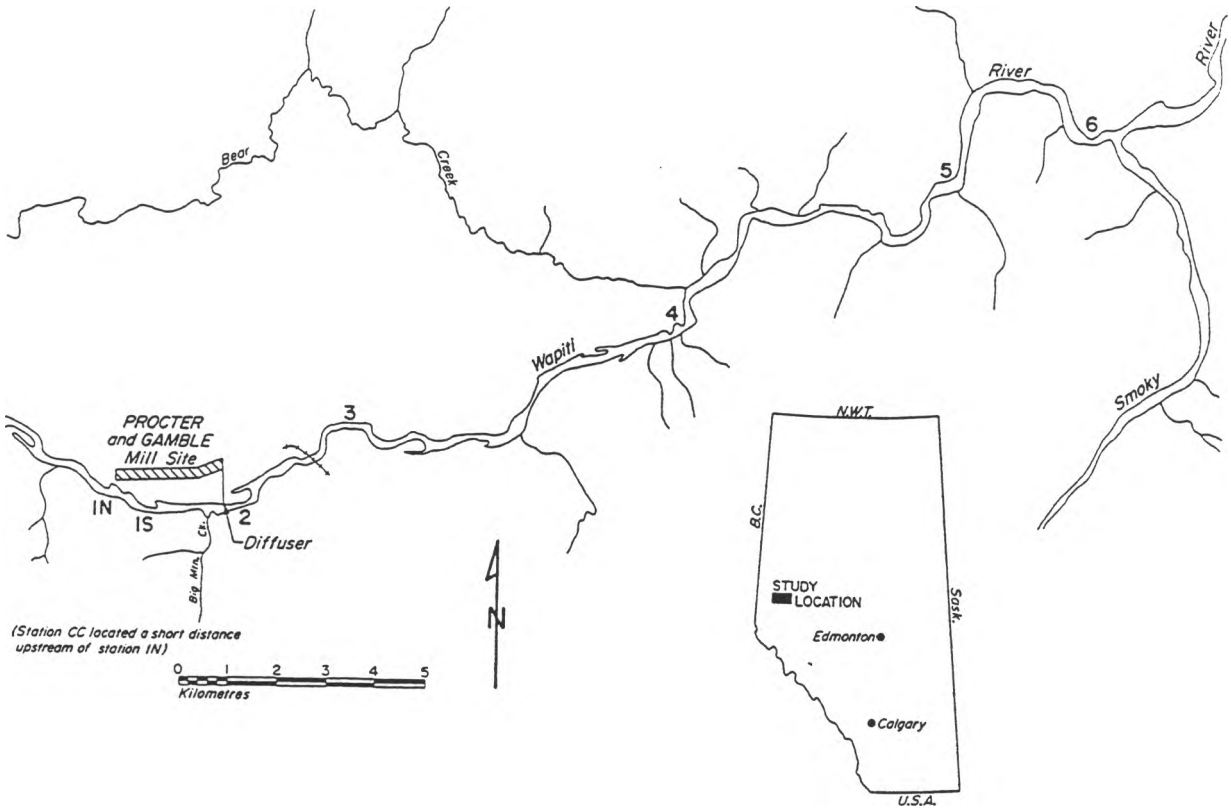

Figure 17. Location of sampling sites used by Integrated Environmental Sciences Inc. in the Wapiti and Smoky Rivers, 1983. Source: Integrated Environmental Sciences Inc. (1984b).

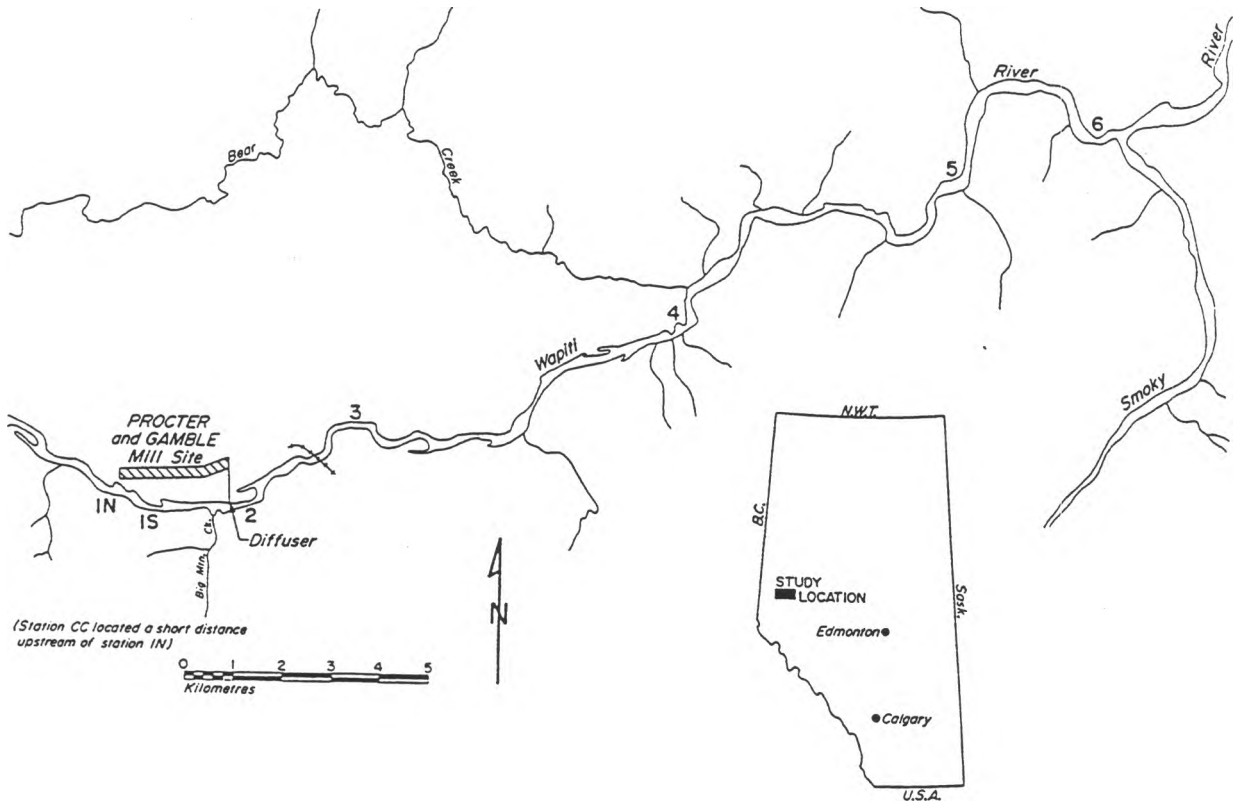

Figure 18. Location of sampling sites used by Integrated Environmental Sciences Inc. in the Wapiti and Smoky Rivers, 1985. Source: Integrated Environmental Sciences Inc. (1986b).

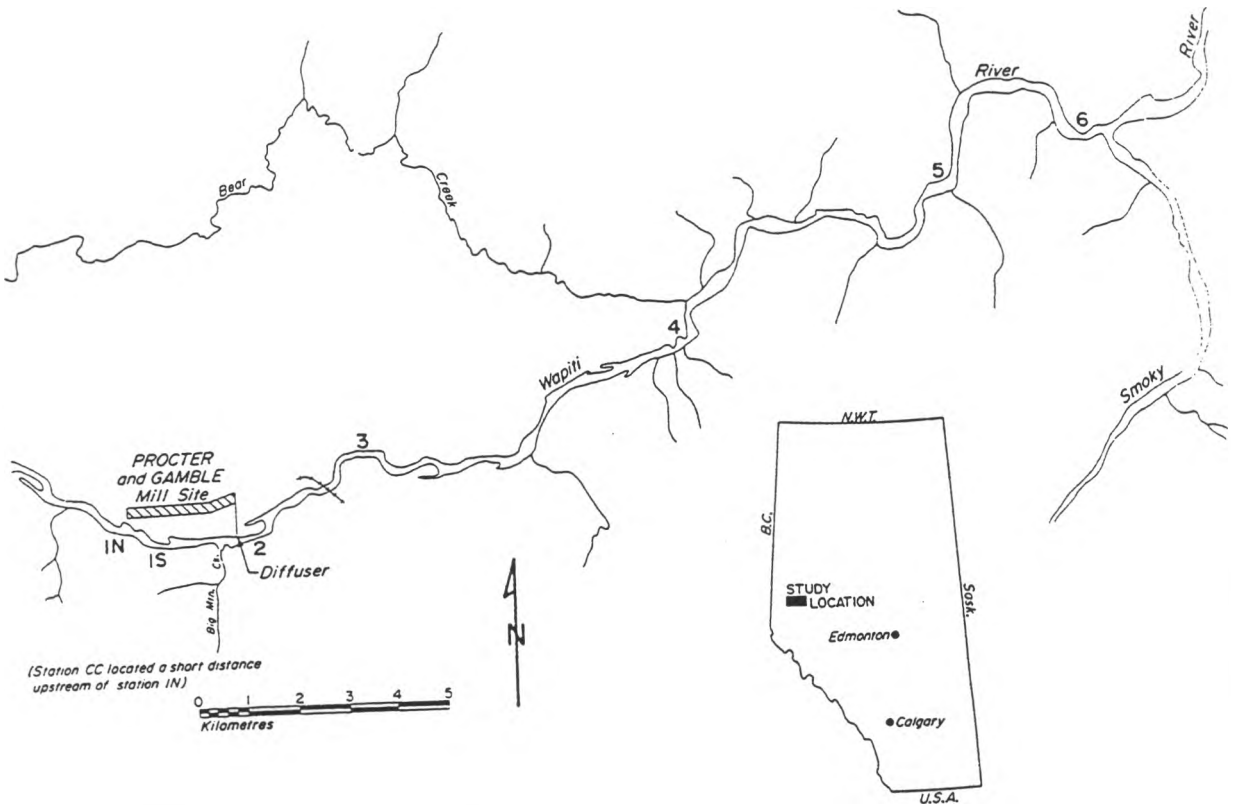

Figure 19. Location of sampling sites used by Terrestrial & Aquatic Environmental Managers Ltd. in the Wapiti and Smoky Rivers, 1987. Source: Terrestrial & Aquatic Environmental Managers Ltd. (1988).

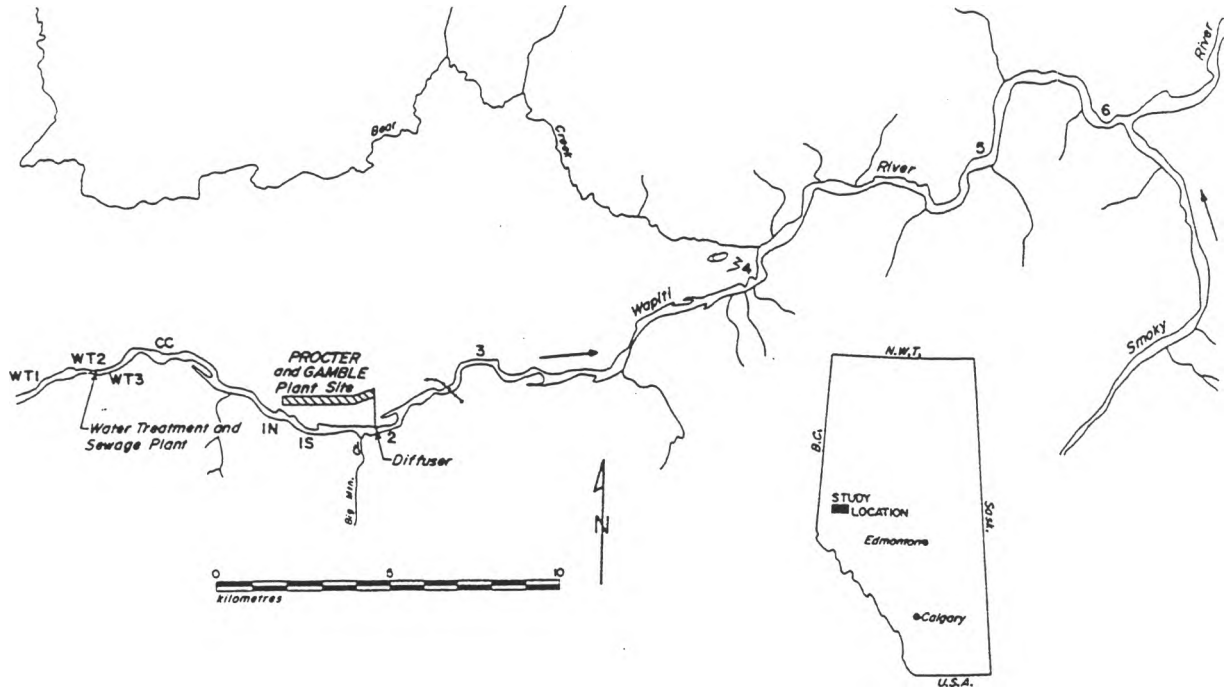

Figure 20. Location of sampling sites used by Terrestrial & Aquatic Environmental Managers Ltd.in the Wapiti and Smoky Rivers, 1988. Source: Terrestrial & Aquatic Environmental Managers Ltd (1989b).

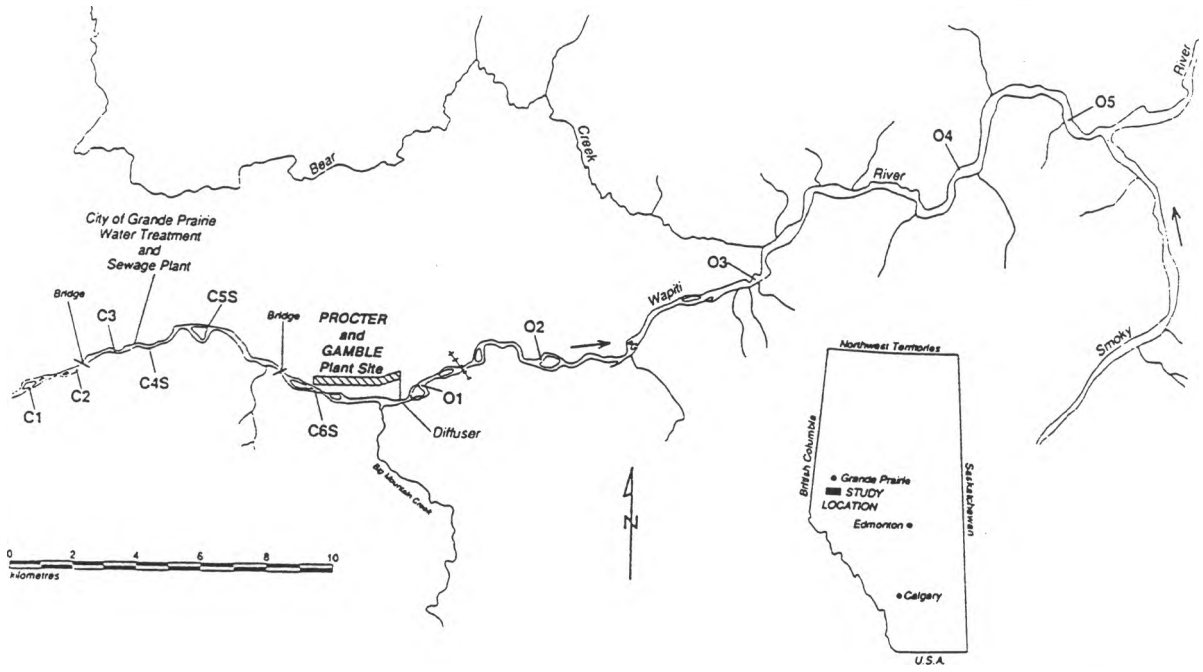

Figure 21. Location of sampling sites used by Terrestrial & Aquatic Environmental Managers Ltd. in the Wapiti and Smoky Rivers, 1990-1991. Source: Terrestrial & Aquatic Environmental Managers Ltd. (1991b).

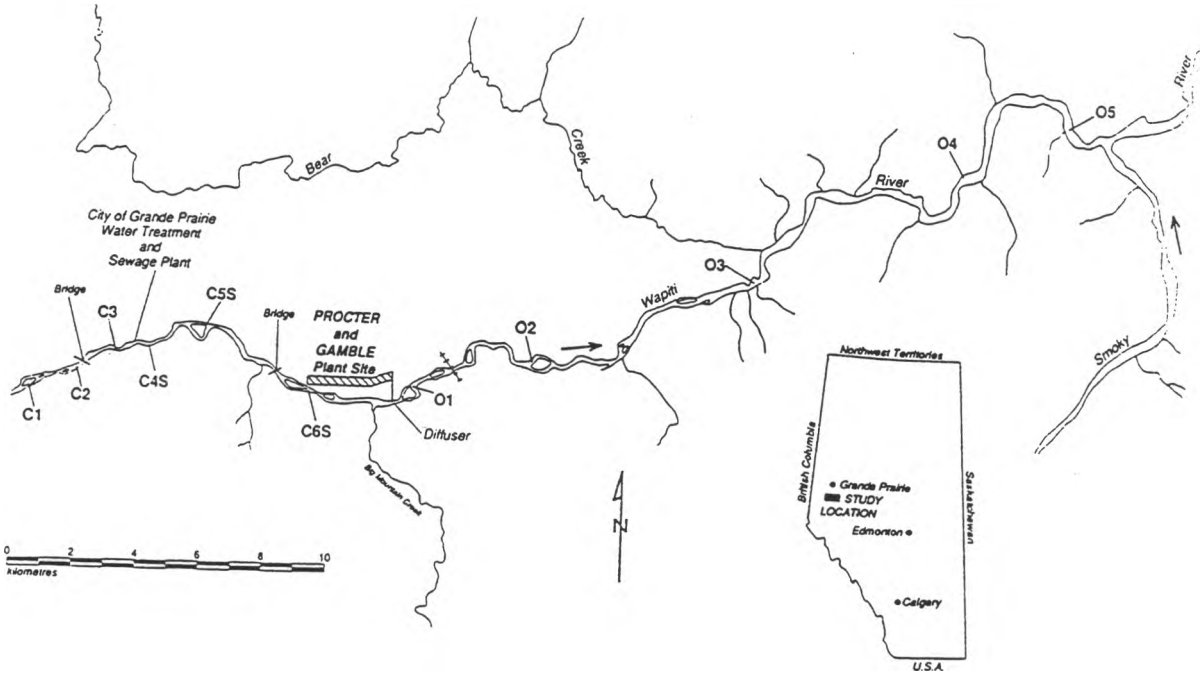

Figure 22. Location of sampling sites used by Terrestrial & Aquatic Environmental Managers Ltd. in the Wapiti and Smoky Rivers, 1992-1993. Source: Terrestrial & Aquatic Environmental Managers Ltd. (1992a, 1993a, 1993c).

1.3 SYNOPSIS OF THE DATA BASE.

1.3.1 Data base sources

Benthic macroinvertebrate data files for the Peace-Athabasca Rivers were released to Northern River Basins Study (NRBS) from Alberta Environment, Weldwood of Canada Ltd. (Hinton Division), Weyerhaeuser Canada Ltd (Grand Prairie), Alberta Newsprint Company (Whitecourt), and Millar Western Pulp (Whitecourt). The industrial data files were supplied by the contractors: Sentar Consultants Ltd. Calgary (Millar Western Pulp Ltd., Alberta Newsprint Company) and Terrestrial & Aquatic Environmental Managers Ltd., Saskatoon (Weldwood of Canada Ltd (Hinton Division), Weyerhaeuser Canada Ltd.). Industrial and Governement files were typically accompanied with either original reports or photocopies outlining sampling protocols. These sources also provided summary documents that reviewed part of the historical data base (see Terrestrial & Aquatic Environmental Sciences Ltd. 1990a, Anderson 1991, EVS Consultants 1992, Tones 1993, Terrestrial & Aquatic Environmental Managers Ltd. 1993c, Luoma and Shelast 1994).

Data bases were often received in electronic format (spreadsheet or data base format) that were subsequently entered into QUATTRO PRO for Windows (Version 5, 1993) a spreadsheet program. Files from TAEM were in Microsoft Excel format whereas files from Sentar Consultants Ltd. were in ASCII format. In contrast, the majority of data files received from Alberta Environment (i.e., data block 1: Government of Alberta data files) consisted of photocopies of files that had been published in government reports.

Data files and their Quattro Pro file names from the above sources are shown in Tables 1 - 9. While these files present some information on sampling location and protocols, the majority of the information is presented either in a later section (Section 1.4 Data base quality) or is present within the Appendices. Where possible, information on sampling locations are provided as described in original reports and illustrated in location maps (Figures 1- 22).

1.4 DATA BASE QUALITY

The quality of a data base can be determined by a number of attributes. These include the overall sampling question and thus the related sampling design (e.g., before - after - control - impact (BACI) design), field sampling procedures (e.g., sampler type, mesh size, number and type of replication), sample storage procedures (e.g. fixative type, length of sample storage), laboratory processing protocols (e.g., complete sample processing versus sub-sampling, sub-sampling rules) and taxonomic resolution (e.g., genus versus species level identification). In general, the quality of a data base will be highest when each stage is completed by skilled, experienced people and when quality control and quality assurance procedures have been implemented at all stages. The utility of a data base will be reduced if these procedures are not followed, and when information on sampling procedures are inconsistent among sites or among sampling times or are not described in sufficient detail. We summarized characteristics of each of the data blocks according to field and laboratory sample processing protocols (Tables 10 - 17). In general, we described "high quality" data sets as those that met all defined information categories (100% of all categories), "moderate quality" data sets met > 75%

of the quality criteria and "low quality" data sets met < 50% of the identified data criteria.

Our analysis of the Peace-Athabasca invertebrate data base (PAID) indicates that sampling procedures varied widely both historically (e.g., techniques used in 1970 versus those used in 1990's) and among researchers.

Table 10. Benthic macroinvertebrate sampling protocols used by Alberta Environmental Protection. Parts 1.1- 1.4 Athabasca River sites at Hinton and downstream locations, Embarras, Athabasca, AlPac, and Fort McMurray.

Part 1.1 - Athabasca River sites at Hinton and downstream locations.

Category	Details
Years = 1983 -1987. Source: Alberta Environmental Protection (AEP) data base output. Note: the data base received by NRBS from AEP was typically not accompanied with report documents. Thus, information reviewed here is typically that present within the data base.	
Sampling dates	Month/Day/Year.
Sampling locations	Described in detail with location code. Depth and velocity and substratum characteristics not provided.
Sample collector	Always identified. Benthic samples collected by 7 people over the 5 year period.
Sampler type and size	Neill cylinder sampler (area = 0.1 m^2).
Sampler mesh size	Finest mesh = 0.210 mm.
Sample replication	5 samples per location.
Sample preservative	Unknown.
Sample sorting protocols	Unknown.
Taxonomic resolution	Typically to genus or species. Chironomidae identified to Tribe, other dipterans to genus or Family. Taxonomic resolution consistent among sampling sites and years. Nematoda identified typically as: Nematoda. Taxonomic keys not listed. Sample sorting and taxonomic identifications completed by six people over the 5 year period.
Quality control/quality assurance measures	Information not provided. General sampling and processing techniques highly consistent among sampling sites and years.
Overall quality	High.

Table 10 - continued. Part 1.2 - Athabasca River sites at Embarras.

Category	Details
Years = 1983 -1987. Source: Alberta Environmental Protection (AEP) data base output. Note: the data base received by NRBS from AEP was typically not accompanied with report documents. Thus, information reviewed here is typically that present within the data base and not from review documents.	
Sampling dates	Month/Day/Year.
Sampling locations	Described in detail with location code. Depth and velocity and substratum characteristics not provided.
Sample collector	Always identified. Sample collection completed by 8 people over the 5 year period.
Sampler type and size	Neill cylinder sampler (area = 0.1 m^2).
Sampler mesh size	Finest mesh = 0.210 mm.
Sample replication	5 samples per location.
Sample preservative	Unknown.
Sample sorting protocols	One person identified.
Taxonomic resolution	Typically to genus or species. Chironomidae identified to Tribe, other dipterans to genus or Family. Taxonomic resolution consistent among sampling sites and years. Nematoda identified typically as: Nematoda. Taxonomic keys not listed. Taxonomic identifications completed by four people over the 5 year period.
Quality control/quality assurance measures	Information not provided. General sampling and processing techniques highly consistent among sampling sites and years.
Overall quality	High.

Table 10 - continued. Part 1.3 - sites at Athabasca township and Alberta Pacific Forest Industries Inc.

Category	Details
Years = 1990. Source: Alberta Environmental Protection (AEP) data base output. Note: the data base provided by AEP was not accompanied with report documents. Thus, information reviewed here is typically that present within the data base. However, general monitoring methods for rivers in the Alberta are described by Anderson (1990).	
Sampling dates	Month/Day/Year.
Sampling locations	Described in some detail. Depth and velocity and substratum characteristics not provided.
Sample collector	Always identified. Samples collected by 6 people. Complete descriptions of collectors in 1985, only initials used for 1991.
Sampler type and size	Neill cylinder sampler (area = 0.1 m^2).
Sampler mesh size	Finest mesh = 0.210 mm.
Sample replication	5 samples per location.
Sample preservative	Unknown.
Sample sorting protocols	Two people identified.
Taxonomic resolution	Typically to genus or species. Chironomidae identified to Tribe, other dipterans to genus or Family. Taxonomic resolution consistent among sampling sites and years. Nematoda identified typically as: Nematoda. Taxonomic keys not listed. Taxonomic identifications completed by one person.
Quality control/quality assurance measures	Information not provided. General sampling and processing techniques highly consistent among sampling sites and years.
Overall quality	High.

Table 10 - continued. Part 1.4 - Athabasca River at Fort McMurray.

Category	Details
Years = 1983 -1987. Source: Alberta Environmental Protection (AEP) data base output. Note: the data base received by NRBS from AEP was typically not accompanied with report documents. Thus, information reviewed here is typically that present within the data base.	
Sampling dates	Month/Day/Year.
Sampling locations	Described in detail with location code. Depth and velocity and substratum characteristics not provided.
Sample collector	Always identified. Benthic samples collected by 6 people.
Sampler type and size	Neill cylinder sampler (area = 0.1 m^2).
Sampler mesh size	Finest mesh = 0.210 mm.
Sample replication	5 samples per location.
Sample preservative	Unknown.
Sample sorting protocols	Unknown.
Taxonomic resolution	Typically to genus or species. Chironomidae identified to Tribe, other dipterans to genus or Family. Taxonomic resolution consistent among sampling sites and years. Nematoda identified typically as: Nematoda. Taxonomic keys not listed. Samples sorted by one person. Five taxonomist identified.
Quality control/quality assurance measures	Information not provided. General sampling and processing techniques highly consistent among sampling sites.
Overall quality	High.

Table 11. Benthic macroinvertebrate sampling protocols used by Alberta Environmental Protection. Part 2 - Lesser Slave River sites.

Category	Details
Years = 1990. Source: Alberta Environmental Protection (AEP) data base output. Note: the data base received by NRBS from AEP was typically not accompanied with report documents. Thus, information reviewed here is typically that present within the data base.	
Sampling dates	Month/Day/Year.
Sampling locations	Described in detail with location code. Depth and velocity and substratum characteristics not provided.
Sample collector	Identified by initials only. Benthic samples collected by 3 people.
Sampler type and size	Ekman Dredge sampler.
Sampler mesh size	Finest mesh = 0.210 mm.
Sample replication	5 samples per location.
Sample preservative	Unknown.
Sample sorting protocols	Unknown.
Taxonomic resolution	Typically to genus or species. Chironomidae identified to Tribe, other dipterans to genus or Family. Taxonomic resolution consistent among sampling sites. Nematoda identified typically as: Nematoda. Taxonomic keys not listed. Sample sorter not identified. Taxonomist not stated.
Quality control/quality assurance measures	Information not provided. General sampling and processing techniques highly consistent among sampling sites.
Overall quality	Moderate quality because detailed descriptions of sample collection and processing protocols are not reported.

Table 12. Benthic macroinvertebrate sampling protocols used by Alberta Environmental Protection. Part 3 - Wapiti River sites.

Category	Details
Years = 1973 - 1975. Source: Exner and Reynoldson (1976).	
Sampling dates	Month/Day/Year.
Sampling locations	Described in detail typically with location map. Six sites in 1973, seven sites in 1974, six sites in 1975. Depth and velocity and substratum characteristics provided.
Sample collector	Assumed to be authors.
Sampler type and size	Single qualitative kick sample at each site in 1973. Five replicate cylinder samples (0.1 m^2) at each site in 1974 & 1975. Some details on cylinder sampler but reference to Reynoldson (1973) for details.
Sampler mesh size	Mesh size = 0.210 mm.
Sample replication	Unreplicated kick samples in 1973, 5 replicate samples per location in 1974 & 1975.
Sample preservative	10% formalin.
Sample sorting protocols	Unknown.
Taxonomic resolution	Typically to genus or family. Taxonomic resolution consistent among sampling sites. Taxonomic keys listed. Samples sorted in the field. Taxonomist not identified.
Quality control/quality assurance measures	Information not provided. General sampling and processing techniques apparently consistent among sampling sites within a particular year.
Overall quality	Moderate to low quality because: 1) initial focus on qualitative sampling techniques, 2) detailed descriptions of sample collection and processing protocols are not reported.

Table 12 - continued.

Category	Details
Years = 1983 & 1991. Source: Alberta Environmental Protection (AEP) data base output. Note: the data base provided by AEP was typically not accompanied with report documents. Thus, information reviewed here is typically that present within the data base. However, additional sampling protocols are described and reviewed by Anderson (1990, 1991).	
Sampling dates	Typically Month/Day/Year.
Sampling locations	Described in detail typically with sampling location code. Depth and velocity and substratum characteristics not provided.
Sample collector	Full details provided for 1983 collections (N = 3). Three collectors identified by initials for 1991 collections including two who are assumed to be the same people that collected samples in 1991 survey.
Sampler type and size	Neill cylinder sampler (area = 0.1 m^2).
Sampler mesh size	Finest mesh = 0.210 mm.
Sample replication	5 samples per location.
Sample preservative	Unknown.
Sample sorting protocols	Unknown.
Taxonomic resolution	Good resolution (i.e., typically genus or species). Chironomidae identified to Tribe, other dipterans to genus or Family. Taxonomic resolution consistent among sampling sites and years. Nematoda identified typically as: Nematoda. Taxonomic keys not listed. Two sample sorters identified for 1983, unknown for 1991. Taxonomist stated for 1983 but not for 1991 collections.
Quality control/quality assurance measures	Information not provided. General sampling and processing techniques highly consistent among sampling sites.
Overall quality	Moderate to high quality. Good taxonomic resolution but insufficient descriptions of sample collection and processing protocols.

Table 13. Benthic macroinvertebrate sampling protocols used by Alberta Environmental Protection. Part 4 - Smoky River sites.

Category	Details
Years = 1983. Source: Alberta Environmental Protection (AEP) data base output. Note: the data base provided by AEP was typically not accompanied with report documents. Thus, information reviewed here is typically that present within the data base.	
Sampling dates	Typically Month/Day/Year.
Sampling locations	Described in detail with sampling location code. Depth and velocity and substratum characteristics not provided.
Sample collector	Full details - three collectors identified.
Sampler type and size	Neill cylinder sampler (area = 0.1 m^2).
Sampler mesh size	Finest mesh = 0.210 mm.
Sample replication	5 samples per location.
Sample preservative	Unknown.
Sample sorting protocols	Unknown.
Taxonomic resolution	Good resolution (i.e., typically genus or species). Chironomidae identified to Tribe, other dipterans to genus or Family. Taxonomic resolution consistent among sampling sites and years. Nematoda identified typically as: Nematoda. Taxonomic keys not listed. Two sample sorters identified. Taxonomist identified for all sampling locations and dates.
Quality control/quality assurance measures	Information not provided. General sampling and processing techniques highly consistent among sampling sites.
Overall quality	Moderate to high quality. Good taxonomic resolution but insufficient descriptions of sample collection and processing protocols.

Table 14. Benthic macroinvertebrate sampling protocols used by Alberta Environmental Protection. Part 5 - Peace River sites.

Category	Details
Years = 1983, 1987, 1988. Source: Alberta Environmental Protection (AEP) data base output. Note: the data base provided by AEP was typically not accompanied with report documents. Thus, information reviewed here is typically that present within the data base.	
Sampling dates	Typically Month/Day/Year.
Sampling locations	Described in detail with sampling location code. Depth and velocity and substratum characteristics not provided.
Sample collector	Full details - six collectors identified.
Sampler type and size	Neill cylinder sampler (area = 0.1 m^2).
Sampler mesh size	Finest mesh = 0.210 mm.
Sample replication	5 samples per location.
Sample preservative	Unknown.
Sample sorting protocols	Unknown.
Taxonomic resolution	Good resolution (i.e., typically genus or species). Chironomidae identified to Tribe, other dipterans to genus or Family. Taxonomic resolution consistent among sampling sites and years. Nematoda identified typically as: Nematoda. Taxonomic keys not listed. Three sample sorters identified. Taxonomist identified for all sampling locations and dates. Three taxonomists identified.
Quality control/quality assurance measures	Information not provided. General sampling and processing techniques highly consistent among sampling sites and years.
Overall quality	Moderate to high quality. Good taxonomic resolution but insufficient descriptions of sample collection and processing protocols.

Table 15. Benthic macroinvertebrate sampling protocols used by Sentar Consultants Ltd., Calgary, for Alberta Newsprint Company and Millar Western Pulp Ltd. in the Athabasca River at Whitecourt.

Category	Details
Years = 1987 -1992. Sources: Luoma and Shelast 1988, 1989, 1990a, 1990b, 1991a, 1991b, 1992a, 1992b, 1993a, 1993b.	
Sampling dates	Month/Day/Year.
Sampling locations	Described in detail and accompanied with maps. Depth and velocity and substratum characteristics typically provided.
Sample collector	Identified and typically the same person throughout the study period.
Sampler type and size	Neill-Hess cylinder sampler (area = 0.0892 m^2).
Sampler mesh size	0.25 mm. Samples concentrated with a 0.18 mm mesh sieve.
Sample replication	5 samples per location.
Sample preservative	Field collections in 10% formalin, sorted and identified samples in 70% isopropyl.
Sample sorting protocols	Sample stained with rose bengal prior to sorting. Sub-sampling procedures described and reference provided. Samples initially sorted using 1 mm and 1 mm - 180 um sieves.
Taxonomic resolution	Typically to genus or species in monotypic genera. Early instars typically to genus. Variable taxonomic resolution with rare taxa or taxa where identification is extremely difficult. Nematoda identified typically as: Nematoda. Taxonomic keys listed. Taxonomic identifications typically completed by one person. Sample sorting typically completed by one person.
Quality control/quality assurance measures	Samples re-sorted to meet 10% sorting efficiency. Identification of Chironomidae determined using mounted specimens as checks for identifications based on gross morphology. General sampling and processing techniques highly consistent among sampling sites and years.
Overall quality	High.

Table 16. Benthic macroinvertebrate sampling protocols used by consulting companies in the Athabasca River at Hinton and downstream sites.

Category	Details
Year = 1960. Source: Beak (1960).	
Sampling dates	Month/Year
Sampling locations	Described in some detail and accompanied with maps. Depth and velocity and substratum characteristics typically not provided.
Sample collector	Unknown
Sampler type and size	Surber sampler (area = 1.0 ft^2).
Sampler mesh size	Unknown.
Sample replication	2 - 6 samples. Variable among locations.
Sample preservative	Unknown.
Sample sorting protocols	Unknown.
Taxonomic resolution	Typically to genus or species in monotypic genera. Information on taxonomic resolution for early instars unknown. Variable taxonomic resolution. Groups of taxa divided into 3 general categories (i.e. Beak's biotic Index). Group 1 = very tolerant organisms, Group 2 = facultative species, Group 3 = pollution sensitive organisms. Supporting information to justify these categories not provided. Taxonomic keys not listed. Taxonomist - Unknown. Sample sorter - Unknown. Abundance of Tubificidae described qualitatively (e.g., "few").
Quality control/quality assurance measures	Not specified - probably poor. General sampling and processing techniques apparently consistent among sampling sites.
Overall quality	Low

Table 16 - continued.

Category	Details
Year = 1972 & 1974. Sources: Beak (1972a, 1975b).	
Sampling dates Month/Day/Year.	
Sampling locations	Described in some detail and accompanied with a map. Some details on water depth, velocity and substratum characteristics provided.
Sample collector	Unknown.
Sampler type and size	Artificial substrata. Sampler dimensions described. Incubation period provided. Contents of each tray screened with 30 mesh/inch sieve after removed from river. Size of substratum added to trays not provided. Surber samples (number of replicate samples not stated) taken at three sites. Samples preserved and processed as stated for tray samples.
Sampler mesh size	Surber mesh size unknown. Artificial substratum = N/A.
Sample replication	Nine sets of six trays.
Sample preservative	Preserved in 5% formalin in field.
Sample sorting protocols	Unknown.
Taxonomic resolution	One sample from each location (i.e., site) selected for taxonomic identification. Identification of larval Chironomidae based on mounting of specimens. Level of taxonomic resolution typically to genus and details for the selected sample provided as an Appendix. Variation in density of specific taxa among replicates absent. Level of taxonomic resolution typically reported to species or genus. Sample residue reported as fine pieces of wood and fine plant debris. Information on taxonomic resolution for early instars unknown. Variable taxonomic resolution. Groups of taxa divided into 3 general categories (i.e. Biotic index). Supporting information to justify these categories not provided. Taxonomic keys not listed. Taxonomist - Unknown. Samples processed by Beak staff. Samples sorter - Unknown.
Quality control/quality assurance	Not specified - probably poor. General sampling and processing techniques apparently consistent among sampling sites.
Overall quality	Low. Large improvement compared to techniques reported in Beak (1960). However, standardized techniques generally poor compared to present day standards.

Table 16 - continued

Category	Details
Year = 1976. Source: Beak (1977a).	
Sampling dates	Month/Day/Year.
Sampling locations	Described in detail and accompanied with a map. Eleven sites extending over 96 km. Some details on water depth, velocity and substratum characteristics provided.
Sample collector	Unknown.
Sampler type and size	Artificial substrata. Sampler dimensions described. Incubation period provided. Contents of each tray screened with 30 mesh/inch sieve after removed from river. Size of substratum added to trays not provided. Surber samples (number of replicate samples not stated) taken at three sites. Samples preserved and processed as stated for tray samples. Information on how trays were removed from the river substratum present.
Sampler mesh size early	Surber mesh size unknown. Details of artificial tray referenced to an Beak document.
Sample replication	Six replicate trays.
Sample preservative	Preserved in 5% formalin in field. Rose bengal stain used.
Sample sorting protocols	Benthic samples sorted by hand and separated form inorganic and organic materials.
Taxonomic resolution	Identification of samples to species level where possible for one replicate tray sample. Identification of larval Chironomidae based on mounting of specimens. Details on the level of taxonomic resolution included. Level of taxonomic resolution typically to species or genus. Characteristics of sample residue reported. Information on taxonomic resolution for early instars unknown. Variable taxonomic resolution. Groups of taxa divided into 3 general categories (i.e. Biotic index). Supporting information to justify these categories not provided. Taxonomic keys provided. samples identified by Beak Staff. Taxonomist - Unknown, Samples sorter - Unknown.
Quality control/quality assurance	Not specified. General sampling and processing techniques apparently consistent among sampling sites.
Overall quality	Low. Large improvement compared to techniques reported in Beak (1960). However, standardized techniques generally poor compared to present day standards.

Table 16 - continued

Category	Details
Year = 1977. Source: Beak (1978).	
Sampling dates	Month/Day/Year.
Sampling locations	Described in detail and accompanied with a map. Nine sites extending 49 km. Minor changes in location of sites compared to previous years sampling. Some details on water depth, velocity and substratum provided.
Sample collector	Unknown.
Sampler type and size	Artificial substrata. Sampler dimensions provided by reference to Beak (1977). Four week incubation period. Contents of each tray screened with 30 mesh/inch sieve after removed from river. Size of substratum added to trays not provided. Surber samples not taken. Samples preserved and processed as stated for tray samples. Information on how trays were removed from the river substratum present.
Sampler mesh size	Surber mesh size unknown. Details of artificial tray referenced to an early Beak document.
Sample replication	Six replicate trays.
Sample preservative	Preserved in 5% formalin in field. Rose bengal stain used.
Sample sorting protocols	Benthic samples sorted by hand and separated form inorganic and organic materials.
Taxonomic resolution	Identification of samples to species level where possible for one replicate tray sample. Identification of larval Chironomidae based on mounting of specimens. Details on the level of taxonomic resolution included. Taxonomic resolution typically to species or genus. Sample residue reported. Information on taxonomic resolution for early instars unknown. Variable taxonomic resolution. Groups of taxa divided into 3 general categories (i.e. Biotic index). Supporting information to justify these categories not provided. Taxonomic keys provided. Taxonomist and sample sorter - Unknown.
Quality control/quality assurance	Not specified. General sampling and processing techniques apparently consistent among sampling sites.
Overall quality	Low quality. Large improvement compared to Beak (1960). However, standardized techniques generally poor compared to present day standards.

Table 16 - continued

Category	Details

Year = 1979. Source: Beak (1980a).

General comment - details on sampling sites and techniques are consistent with those reported by Beak (1978). However, additional laboratory processing information was provided. These include:

Sampling sites	Artificial trays placed in water depths of approximately 1 m.
Sample processing	Tray samples sieved through a Standard No. 30 (0.595 mm) sieve. A total of 8 trays were disturbed by the general public. samples preserved in 10% formalin. Modified Surber samples were collected. These samples were also sieved, stained and preserved.
Overall quality	Minor changes from previous years sampling design.

Table 16 - continued.

Category	Details
Year = 1984 Source: Integrated Environmental Sciences Inc. (1984a).	
Sampling dates	Month/Day/Year.
Sampling locations	Described in detail and accompanied with a map. These sites comprise 2 upstream sites and 7 downstream sites as in previous studies. Downstream sites extend for a total of 43 km. Some details on water depth, velocity and substratum provided.
Sample collector	Integrated Environmental Sciences staff.
Sampler type and size	Neill sampler not artificial substrata. Sampler dimensions = (0.1 m^2).
Sampler mesh size	Mesh size unknown.
Sample replication	Five Neill samples for each site.
Sample preservative	Preserved in 5% formalin in field.
Sample sorting protocols	Benthic samples were sorted, identified and counted by A&E Aquatic Taxonomists. Samples washed through a #80 sieve prior to identifications. All replicate samples sorted. Identified samples preserved in 85% ethanol and stored in sealed vials.
Taxonomic resolution	Identification of samples to species level where possible. All replicate samples identified to the same taxonomic level. Chironomids mounted in PEA stain and identified to genus where possible. Orthocladiinae chironomids identified to tribe. Other Tribes (e.g., Diamesinae, Tanypodinae) identified to genus. Details on the level of taxonomic resolution included. Characteristics of sample residue not reported. Information on taxonomic resolution for early instars unknown. Consistent taxonomic resolution. Groups of taxa divided not presented within the Biotic index categories as presented by Beak Consulting for previous benthic surveys. Taxonomic keys provided. Taxonomist and sample sorter identified as A&E Aquatic Taxonomists.
Quality control/quality assurance	Not specified. General sampling and processing techniques consistent among sampling sites.
Overall quality	Moderate. Marked change in sampling design: 1) shift from semi-quantitative tray samples to quantitative Neill sampler (i.e., area-restricted sampler), 2) complete identification of all replicate samples. These two innovations represent marked improvements in data quality.

Table 16 - continued.

Category	Details
Year = 1986 Source: Integrated Environmental Sciences (1986a).	
Sampling protocols used in 1986 are similar to those stated by Integrated Environmental Sciences (1984). The following represents additional details provided in the report by Integrated Environmental Sciences (1986a).	
Sampler mesh size	Mesh size known (0.21 mm).
Sample processing	Samples were washed free of formalin using a 0.20 mm plankton sieve. and sorted using a Wild M5A dissecting microscope. High numbers of some species (e.g., oligochaeta) necessitated using sub-sampling techniques (i.e. sample splitting). Samples were split using a Folson plankton sample splitter. Subsamples were enumerated and back-calculations used to estimate overall sample density.
Taxonomic resolution examination	Oligochaeta were mounted in polyvinyl lactophenol (PVL) for of setal and interval characters. Chironomid heads were mounted in either PVL or Gurrs water mounting medium so that mouthparts could be examined.
Quality control/quality assurance	Mount checks were performed to confirm identifications based on gross morphology. These checks indicated strong concordance between identifications made using gross morphology and head capsule characteristics.
Overall quality.	High. An overall increase in data quality because of the additional of more detailed information on sampling design and sample processing.

Table 16 - continued.

Category	Details
Year = Spring 1989, Spring 1990, April 1991, April 1992, October, 1992, Sources: Terrestrial & Aquatic Environmental Managers Ltd. (1989a, 1991a, 1991b, 1992a, 1993b).	
Sampling dates	Month/Day/Year.
Sampling locations	Eight sampling sites that are described in detail and accompanied with a map. These sites comprise 3 upstream (i.e., reference sites and 5 downstream sites. Downstream sites extend for a total of about 43 km. Detailed information on water depth, velocity and substratum characteristics provided. Note: two sites were removed from the study design because they represent areas where mixing of the effluent and river water is incomplete.
Sample collector	Terrestrial & Aquatic Environmental Managers Ltd. staff.
Sampler type and size	Neill sampler. Sampler dimensions provided ($0.1m^2$).
Sampler mesh size	Mesh size known (0.21 mm).
Sample replication	Five Neill samples for each site.
Sample preservative	Preserved in 5% formalin in field..
Sample sorting protocols	Samples sorted, identified and counted by A&E Aquatic Taxonomists. Samples washed through a #80 sieve prior to identification. All replicate samples sorted. Identified samples preserved in 85% ethanol and stored in sealed vials.
Taxonomic resolution	Samples sorted and identified by Dr. C. Low for all years. Identification of samples typically to species level. High degree of consistency among replicates and sampling programs. Chironomids mounted in PVA stain and identified to genus where possible. Orthocladiinae chironomids identified to tribe. Other Tribes (e.g., Diamesinae, Tanypodinae) identified to genus or species. Details on the level of taxonomic resolution included. Some characteristics of sample residue reported. Information on taxonomic resolution for early instars unknown. Biotic index of Beak Consulting Ltd. not used. Taxonomic keys provided.
Quality control/quality assurance	Not specified but appears to be present within the sampling design. Sampling and processing techniques strongly consistent among sampling sites and years.
Overall quality	High. Quality has increased markedly since 1960. Samples processed over the last 11 years are characterised by a high degree of consistency among sites and years; include detailed descriptions of techniques used.

Table 17. Benthic macroinvertebrate sampling protocols used by consultants for Weyerhaeuser Canada (formerly owned by Procter and Gamble Inc.) in the Smoky-Wapiti River area.

Category	Details
Year = 1970. Source: Beak (1972b).	
Sampling dates	Month/Day/Year.
Sampling locations	Five sampling sites in each of August and October, 1970. Sampling sites described in some detail. No map. Detailed information on water depth, velocity and substratum characteristics not provided.
Sample collector	Identified as Beak Consulting staff.
Sampler type and size	Dip net, Surber sampler and artificial substrate trays. Surber sampler size apparently 1.0 ft^2
Sampler mesh size	Mesh size unknown.
Sample replication	Dip net data presented as the total of individuals collected in 10 pooled samples. Density estimates for dip nets are semi-quantitative and are based on the assumption that the 1.0 ft^2 area delimited by eye can be consistently accomplished among replicate samples and at each of the sampling sites. Surber samples represent density of five combined samples that preclude the estimation of a density error term. Trays replicated five times at each of the six sites.
Sample preservative	Most likely formalin.
Sample sorting protocols	Samples sorted, identified and counted by Beak Consulting staff. Details on sample processing not presented. Preservative used on identified samples not provided.
Taxonomic resolution	One tray sample selected for detailed identification. Samples sorted and identified by Beak Consulting staff. Identification of selected samples typically to species level. Characteristics of sample residue not reported. Information on taxonomic resolution for early instars unknown. Biotic index of Beak Consulting Ltd. used. Taxonomic keys not provided.
Quality control/quality assurance	Not specified. General sampling and processing techniques apparently consistent among sampling sites and months.
Overall quality	Low data quality due to: 1) predominant focus on semi-quantitative sampling techniques, 2) pooling of replicate samples, and 3) identification of only one of five potential replicate samples.

Table 17 - continued

Category	Details
Year = 1972 & 1974. Sources: Beak (1972b, 1975b).	
Sampling dates	Month/Day/Year.
Sampling locations	Five sampling sites in each of August and October, 1970. Sampling sites described in some detail. No map. Detailed information on water depth, velocity and substratum characteristics not provided. Data collected by Beak Consulting and Alberta Fish and Wildlife (AWF).
Sample collector	Identified as Beak Consulting staff.
Sampler type and size	Dip net, Surber sampler and artificial substrate trays. Surber sampler size apparently 1.0 ft^2
Sampler mesh size	Mesh size unknown.
Sample replication	Dip net data presented as the total of individuals collected in 10 pooled samples. Density estimates for dip nets are semi-quantitative and are based on the assumption that the 1.0 ft^2 area delimited by eye can be consistently accomplished among replicate samples and at each of the sampling sites. Surber samples represent density of five combined samples that preclude the estimation of a density error term. Trays replicated five times at each of the six sites.
Sample preservative	Most likely formalin.
Sample sorting protocols	Samples sorted, identified and counted by Beak Consulting staff. Details on sample processing not presented. Preservative used on identified samples not provided.
Taxonomic resolution	One tray sample selected for detailed identification. Samples sorted and identified by Beak Consulting staff. Identification of selected samples typically to species level. Characteristics of sample residue not reported. Information on taxonomic resolution for early instars unknown. Biotic index of Beak Consulting Ltd. used. Taxonomic keys not provided.
Quality control/quality assurance	Not specified. General sampling and processing techniques apparently consistent among sampling sites and months.
Overall quality	Low quality due to: 1) predominant focus on semi-quantitative sampling techniques, 2) pooling of replicate samples, and 3) identification of only one of five potential replicate samples.

Table 17 - continued.

Category	Details
Year = 1975. Source: Beak (1976).	
Sampling dates	Month/Day/Year.
Sampling locations	Eight sampling sites Sampling sites described in detail, map provided. Some information on water depth, velocity and substratum characteristics provided. Data collected by Beak Consulting Ltd.
Sample collector	Identified as Beak Consulting.
Sampler type and size	Surber sampler, artificial substrata trays. Surber sampler size 1.0 ft^2, other details unknown. Figure of artificial substrate included (4 week incubation period). Details of sampling procedure of artificial substrata included.
Sampler mesh size	Surber mesh size unknown.
Sample replication	Six replicate Surber samples (samples subsequently pooled). Pooling of Surber samples precludes the estimation of a density error term. Artificial substrate trays (one tray selected for detailed identification).
Sample preservative	Formalin 10%.
Sample sorting protocols	Samples sorted, identified and counted by Beak Consulting staff. Some details on sample processing presented. Preservative used on identified samples not provided.
Taxonomic resolution	Samples sorted and identified by Beak Consulting staff. Identification of selected samples typically to species level. Some details on sample residue characteristics reported. Information on taxonomic resolution for early instars unknown. Biotic index of Beak Consulting Ltd. used as well as more detailed species lists. Detailed information on taxonomic keys provided.
Quality control/quality assurance	Not specified. General sampling and processing techniques apparently consistent among sampling sites.
Overall quality	Improved data quality due to: 1) addition of detailed sampling procedures, 2) comparison of Surber, modified Surber and artificial substrata in terms of sample variation. However, difficulties in sample replication remain.

Table 17 - continued.

Category	Details
Year = 1978. Source: Beak (1979a).	
Sampling dates	Month/Day/Year.
Sampling locations	Seven sampling sites (reduced from eight compared to the survey completed in 1975 (Beak 1976). Sampling sites described in detail, map provided. Additional details on water depth, velocity and substratum characteristics provided. Data collected by Beak Consulting Ltd.
Sample collector	Identified as Beak Consulting.
Sampler type and size	Surber sampler, artificial substrata trays. Surber sampler size apparently 1.0 ft^2, other details unknown. Detailed description of construction of artificial substrata (4 week incubation period). Details of sampling procedure for retrieval of artificial substrata included.
Sampler mesh size	Surber mesh size provided.
Sample replication	Six replicate Surber samples (samples subsequently pooled). Pooling of Surber samples precludes the estimation of a density error term. Artificial substrate trays (1 - 4 substrata selected for detailed identification).
Sample preservative	10% formalin.
Sample sorting protocols	Samples sorted, identified and counted by Beak Consulting staff. Additional details on sample processing techniques presented. Preservative used on identified samples not provided.
Taxonomic resolution	Samples sorted and identified by Beak Consulting staff. Identification of selected samples typically to species level. Sample residue characteristics reported. Information on taxonomic resolution for early instars unknown. Biotic index of Beak Consulting Ltd. used as well as detailed species lists provided. Detailed information on taxonomic keys provided.
Quality control/quality assurance	Not specified. General sampling and processing techniques consistent among sampling sites.
Overall quality	Improved quality due: 1) increase numbers of artificial substrata (1 - 4) that were identified in detail, 2) addition descriptions of sampling procedures.

Table 17 - continued.

Category	Details
Year = 1980. Source: Beak (1981).	
Sampling dates	Month/Day/Year.
Sampling locations	Eight sampling sites (increase from 7 locations in 1978 (Beak 1979a). Sampling sites described in detail, map provided. Additional details on water depth, velocity and substratum characteristics provided. Data collected by Beak Consulting Ltd.
Sample collector	Identified as Beak Consulting.
Sampler type and size	Surber sampler, artificial substrata trays. Detailed description of construction of artificial substrata. (4 week incubation period). Details of sampling procedure for retrieval of artificial substrata included.
Sampler mesh size	Surber mesh size provided.
Sample replication	Six true replicate Surber samples. Replicate samples were not subsequently pooled. Six artificial substrate trays per site (4 substrata selected for detailed identification).
Sample preservative	10% formalin, addition of rose bengal stain.
Sample sorting protocols	Samples sorted, identified and counted by Beak Consulting staff. Additional details on sample processing techniques presented. Preservative used on identified samples not provided.
Taxonomic resolution	Samples sorted and identified by Beak Consulting staff. Identification of selected samples typically to species level. Sample residue characteristics reported. Information on taxonomic resolution for early instars unknown. Biotic index of Beak Consulting Ltd. used as well as detailed species lists provided. Detailed information on taxonomic keys provided.
Quality control/quality assurance	Some details included. General sampling and processing techniques consistent among sampling sites. Report states the importance of consistency in processing of Surber samples and tray samples.
Overall quality	Marked improvements in data quality due: 1) increases numbers (N = 4) of artificial substrata samples that were identified in detail, 2) all six Surber samples identified to a higher taxonomic level, 3) addition descriptions of sampling procedures.

Table 17 - continued.

Category	Details
Year = 1981. Source: Integrated Environmental Sciences Inc. (1982).	
Sampling dates	Month/Day/Year.
Sampling locations	Eight sampling sites. Sampling sites described in detail, map provided. Details on water depth, velocity and substratum characteristics provided.
Sample collector	Data collected by Integrated Environmental Sciences Inc.
Sampler type and size	Surber sampler (0.09 m^2), artificial substrata trays. Some details on construction of artificial substrata (reference to additional details provided). Five week incubation period. Details of sampling procedure for retrieval of artificial substrata included.
Sampler mesh size	Surber mesh size provided.
Sample replication	Ten true replicate Surber samples (i.e., replicates samples were not subsequently pooled). Six true artificial substrate trays per site (i.e., replicate were not pooled and all samples were identified in detail).
Sample preservative	10% formalin, addition of rose bengal stain.
Sample sorting protocols	Samples sorted presumably by Integrated Environmental Sciences Inc. staff. Preservative used on identified samples not provided.
Taxonomic resolution	Samples presumably identified by Integrated Environmental Sciences Inc. staff. Identification of all samples typically to species level. Sample residue characteristics reported. Information on taxonomic resolution for early instars unknown. Numerous biotic indices used and accompanied with detailed species lists. Detailed information on taxonomic keys provided.
Quality control/quality	Some details included. References to protocols used previously (e.g. assurance Beak 1979a, 1981) General sampling and processing techniques consistent among sampling sites.
Overall quality	Continued increase in data quality due to: 1) increased number (N = 6) of artificial substrata samples that were identified in detail, 2) increase in replication of Surber samples collected (i.e., increase from 6 to 10 replicates). More samples identified to a higher taxonomic level.

Table 17 - continued.

Category	Details
Year = 1982. Source: Integrated Environmental Sciences Inc. (1983).	
Sampling dates	Month/Day/Year.
Sampling locations	Eight sampling sites. Sampling sites described in detail, map provided. Details on water depth, velocity and substratum characteristics provided.
Sample collector	Data collected by Integrated Environmental Sciences Inc.
Sampler type and size	Multiple techniques: Surber sampler (0.09 m^2), artificial substrata trays. Neill cylinder sampler (0.1 m^2) Some details on construction of artificial substrata (reference to additional details provided). Five week incubation period for artificial substrata. Details of sampling procedure for retrieval of artificial substrata included and referenced.
Sampler mesh size	Surber mesh size provided.
Sample replication	Ten true replicate Surber and Neill samples (i.e., replicate samples were not subsequently pooled). Six true artificial substrate trays per site (i.e., replicate were not pooled and all samples were identified in detail).
Sample preservative	5% formalin.
Sample sorting protocols	Samples sorted presumably by Integrated Environmental Sciences Inc. staff. Preservative used on identified samples not provided. Detailed information outlining sub-sampling protocols for naiads. Most chironomids were mounted on slides with PVA and identified to genus here possible.
Taxonomic resolution	Samples presumably identified by Integrated Environmental Sciences Inc. staff. Identification of all samples typically to species level. Sample residue characteristics reported. Information on taxonomic resolution for early instars unknown. Sub-sampling of naiads. Orthoclad chironomids identified to genus. Detailed species and information on taxonomic keys provided.
Quality control/quality assurance	Some details included. References to protocols used previously (e.g. Beak 1979a, 1981). General sampling and processing techniques consistent among sampling sites.
Overall quality	Moderate. Continued increase in data quality due to: 1) addition of Neill cylinder sampling.

Table 17 - continued.

Category	Details

Year = 1983, 1985, 1987. Sources: Integrated Environmental Sciences Inc. (1984b, 1986b), Terrestrial & Aquatic Environmental Managers Ltd. (1988).

General comments: field sampling and laboratory sample processing techniques were highly consistent between 1983 - 1987. However, major shifts between these and previous years include:
1) sole use of Neill benthic samplers compared to previous multiple sampler use (i.e., artificial substrata, Surber samplers and Neill samplers),
2) reduction in sample replication (reduction from 10 Neill and/or Surber samples in 1982 to 5 replicate Neill samples in 1983 - 1987).

Benthic sample processing techniques also differed between 1983-1985 and 1987. In 1987, samples were sorted and identified by Dr C. Low. Previously, samples were presumably processed by staff from Integrated Environmental Sciences Inc. and Terrestrial & Aquatic Environmental Managers Ltd. This change was accompanied with concomitant changes in sample processing techniques.

General sampling procedures are summarized below:

Sample collector	Data collected by Integrated Environmental Sciences Inc., Terrestrial & Aquatic Environmental Managers Ltd.
Sampler type and size	Five cylinder sampler (0.1 m^2) only.
Sample replication	Five true replicate Neill samples per location.
Sample preservative	5% formalin.
Sample sorting protocols	See above.
Taxonomic resolution	See above comments. Sample residue characteristics reported. Information on taxonomic resolution for early instars unknown. Sub-sampling of naiads presumed for 1983 & 1985. Orthoclad chironomids identified to genus in 1987 but not in 1983 and 1985. Detailed species and information on taxonomic keys provided.
Quality control/quality assurance	Some details included. References to protocols used previously (e.g. Beak 1979a, 1981). General sampling and processing techniques consistent among sampling sites. Evidence for strong concordance between chironomid identification based on gross morphology versus mounting of specimens.
Overall quality	High. Increased data quality due to identification of orthocladiinae chironomids typically to genus. Highly consistent techniques among years with the exception of changes in sample processing in 1987. Improvement in quality control/quality assurance for chironomid identification.

Table 17 - continued.

Category	Details
Year = 1988, 1990, 1991, 1992. Sources: Terrestrial & Aquatic Environmental Managers Ltd. (1989b, 1990, 1991b, 1992, 1993b).	
General comments: highly consistent techniques were used to collect and process benthic macroinvertebrates from the Wapiti River between 1988 - 1992.	
Sampling dates	Month/Day/Year.
Sampling locations	Eleven sites representing an increase from 8 in previous surveys. Sampling sites described in detail, maps provided. Detailed information on water depth, velocity and substratum characteristics provided.
Sample collector	Data collected exclusively by Terrestrial & Aquatic Environmental Managers Ltd.
Sampler type and size	Neill cylinder (0.1 m^2). Mesh size provided (0.21 mm).
Sample replication	Five true replicate Neill samples per location.
Sample preservative	5% formalin.
Sample sorting protocols	Samples sorted presumably by Integrated Environmental Sciences Inc. and Terrestrial & Aquatic Environmental Managers Ltd. staff. Preservative used on identified samples not provided. Detailed information on processing of samples in the laboratory including sample washing, splitting,, and specimen mounting protocols.
Taxonomic resolution	Samples identified by Dr. C. Low (1988 - 1992). Identification of all samples typically to species level. Sample residue characteristics reported. Information on taxonomic resolution for early instars unknown. Detailed species and information on taxonomic keys provided.
Quality control/quality assurance	Some details included. General sampling and processing techniques consistent among sampling sites and years.
Overall quality	High. Increased data quality due to: 1) review of benthic sampling program by Terrestrial & Aquatic Environmental Managers Ltd. (1990), 2) continued detailed identification of orthocladinnae chironomids, 3) identification of orthocladiinae, 4) additional sampling information, 5) detailed information describing changes in identification names for specific sampling sites, 6) highly consistent collection techniques.

Quality of the Peace-Athabasca data base is highly variable depending primarily upon when data were collected. In general, data quality has increased steadily since the 1970's when sampling protocols were inadequately replicated, based on a diversity of semi-quantitative techniques to address quantitative hypotheses, and descriptions of field and laboratory sample processing procedures were poorly reported. Low data quality also reflects the low level of taxonomic resolution. The 1970's were also a decade when numerous sampling approaches were developed and implemented but then discontinued in the 1980's and 1990's. While the use of different sampling techniques (e.g., kick samples, artificial substrates) generally increases the amount of information provided to resource managers, the data can only be compared directly with similar data (i.e., that which has been collected using the same or a very similar technique).

The marked differences in sampling techniques between the 1970' and 1980's - 1990's have seriously compromised the usefulness of the Peace-Athabasca River data base for assessing long-term changes in ecosystem health of the Peace-Athabasca Rivers. We believe that sampling techniques are so disparate between the 1970' and 1980's & 1990's that long-term changes cannot be separated from differences due to sampling protocols.

Quality of the 1980's -1990's data has greatly benefitted from standardized sampling techniques and a focus on quantitative sampling protocols. The Neill sampler is now an industry standard. In many cases, standarized sampling techniques have also been accompanied with standardization in terms of the personnel responsible for collecting benthic communities. For instance, macroinvertebrates have been collected primarily by a small number of personnel at Alberta Environmental Protection (e.g., Dr. A.M. Anderson). Similarly, personnel completing benthic surveys on behalf of industry have remained highly consistent since the mid 1980's. For instance, benthic surveys completed for Weldwood of Canada Ltd. (Hinton Division), Millar Western Pulp Ltd., Alberta Newsprint Company and Weyerhaeuser Canada Ltd. at Grande Prairie have been undertaken for consecutive numerous years by Terrestrial & Aquatic Environmental Managers Ltd. (formerly Integrated Environmental Sciences Inc.) and Sentar Consulting Ltd., Calgary (formerly Beak Associates Consulting Ltd.). Such consistency should reduce sample variation and therefore increase the probability of identifying a difference if one truly exists.

Changes in sampling protocols observed for benthic sampling surveys in the Peace-Athabasca Rivers between 1970 - 1992 are not unique to this system. Rather, changes in benthic sampling protocols have been well documented throughout North America, Europe, Australia and New Zealand and while aquatic ecologists continue to develop new techniques (e.g., Scrimgeour et al. 1993, Culp et al. 1994), the quality of sampling techniques and experimental designs will continue to improve (e.g., Green 1979, Karr 1991, Resh and Jackson 1993, Resh and Rosenberg 1993).

2.0 LONG-TERM TRENDS IN ECOSYSTEM HEALTH OF THE PEACE-ATHABASCA RIVER SYSTEMS

2.1 THE APPROACH

2.1.1 Time series analysis

Time series analysis is a particularly useful tool for investigating temporal trends in large data sets (see Anderson 1976, Box and Jenkins 1976, Green 1979, Chatfield 1984, Van Latesteijn and Lambreck 1986, Kite 1989, 1991, Norris and Georges 1993). An important advantage of time series over many other statistical analyses is that this approach does not assume that observations (i.e., data) are independent of each other. In fact, the problem of autocorrelation due to non-independence of observations is a fundamental problem with the analysis of many biological data sets because dependent variables measured at any one time or place may be correlated highly with variables measured previously (i.e., they are autocorrelated).

The time series model assumes that a time series X_t can be represented by the linear additive model:

$$X_t = P_t + T_t + R_t$$

where P_t is a periodic or cyclic component, T_t is a trend component, and R_t is a stochastic component.

Time series has a number of advantages over simple linear regression because a temporal pattern can be partitioned into three components (i.e., trend, periodicities, autoregressive), leaving a residual term. Trends are generally associated with long-term temporal changes in the time series, such as that produced by global warming, whereas periodicities often result from daily or seasonal changes. The autoregressive component represents the tendency for the magnitude of an event to be dependent upon the magnitude of previous events; it has been described as a memory effect (Kite 1991). An important strength of a time series approach is that the trend could indicate a long-term pattern whereas the autoregressive component could provide important information on the impact of changes in secondary effluent treatment and/or bleaching processes on invertebrate communities.

Time series analyses can be best performed when the data set contains a large number of observations that have been measured at regular intervals. The problem of missing values within the time series can be partially overcome by interpolating using cubic spline-fitting techniques (Box and Jenkins 1976).

2.1.2 Classification using cluster analysis

In its broadest sense, classification represents a suite of tests that assign entities into classes or groups (Gauch 1982). Classification techniques are commonly used by benthic ecologists to describe spatial and temporal patterns in macroinvertebrate communities, typically as a first step to develop a mechanistic understanding of the factors producing such patterns (Norris et al. 1982, Wright et al. 1984, Osborne and Davies 1987, Moss et al. 1987, Ormerod and Edwards 1987, Scrimgeour 1989, Terrestrial and Aquatic Environmental Managers 1990, Shaw et al. 1990,

Anderson 1991, Bailey 1993, Clarke 1993, Resh and Jackson 1993)

Cluster analysis involves the grouping of objects (e.g., sampling locations) with similar attributes based on a correlation matrix of resemblance coefficients. These coefficients measure the level of similarity between pairs of objects (Romesburg 1984) and fall into one of two types, a dissimilarity or a similarity coefficient which essentially differ only in the direction of the resemblance. For example, a high dissimilarity coefficient indicates that pairs of objects are more dissimilar, whereas a high similarity coefficient indicates that objects are more similar to each other. Clustering can be envisaged as a two step process where the first step establishes the extent to which objects resemble each other. The second step involves using resemblance coefficients to group similar (or dissimilar) objects into clusters. The latter stage is typically presented graphically as a cluster dendrogram.

2.1.3 Approach used on the Peace-Athabasca Invertebrate Database

While our preliminary assessment of the long-term data base for the Peace-Athabasca River indicated that ecosystem health could be investigated at a number of sites, using time series analyses, our detailed examination of the Weldwood data base indicates that this data set, as well as others from the Peace-Athabasca Rivers, are not suitable for time series analyses because of radical changes in sample collection techniques (e.g., sampler types, sample processing methods) over the monitoring period. For instance, biomonitoring techniques ranged from area unrestricted sampling (i.e., qualitative sampling using dip nets) to a diversity of area restricted samplers including Surber samplers, modified Surber samplers, artificial substrata and more recently Neill samplers.

Changes in sampler types were also accompanied with marked changes in net mesh sizes, sample processing techniques and taxonomic resolution. These differences in sampling techniques seriously compromise the use of time series and other statistical techniques. Thus, the Hinton data base is reduced from 23 years (1960 - 1993) to 10 years (1983 - 1993) when only data collected using similar techniques are considered. Similarly, the Wapiti data base is reduced from 22 (i.e., 1970 to 1992) to 6 (i.e., 1987 to 1992) years when only consistent sampling methods are considered. While there are few guidelines on the minimum number of data points that are required for time series analyses, the consensus seems that the number of values should preferably exceed 50 (Dr. Geff Kite, National Hydrology Research Institute, Environment Canada, Saskatoon, Saskatchewan, pers comm.).

Temporal trends in invertebrate community characteristics over this relatively short time period could be analyzed using linear regression. However, linear regression assumes that observations are independent of each other (Zar 1984). This assumption would clearly be violated if linear regression was used to identify long-term trends. The inherent difficulty in analyzing long-term trends in macroinvertebrate community characteristics using linear regression is that error terms may be autocorrelated. Error terms can either be positively or negatively autocorrelated and both types of autocorrelations have important implications for interpretation of the results. Positive autocorrelation tends to underestimate the magnitude of the error variance. This results in small error estimates and the possible rejection of true null hypotheses (e.g., $U_1 = U_2$). In contrast, negative autocorrelation tends to overestimate the magnitude of the error variance and the power of the statistical test is reduced (Judge et al. 1985). The Durbin-Watson test can be used to determine

whether values are autocorrelated (Durbin and Watson 1951). Based on assessment of time-series versus cluster analysis and the limitationns of the benthic invertebrate data base, we undertook cluster analysis to identify spatial and temporal patterns in the invertebrate communities of the Athabasca and Wapiti Rivers.

2.2 QUANTITATIVE ANALYSIS OF MACROINVERTEBRATE COMMUNITIES FROM THE ATHABASCA RIVER

2.2.1 Study Sites

Long-term trends in ecosystem health of benthic macroinvertebrate communities in the Peace-Athabasca River system were investigated at two study areas in the Athabasca River (Hinton and Whitecourt) and at one general area in the Wapiti River (Grande Prairie). Comparisons of benthic communities at Hinton were based on communities present immediately upstream (0.5 - 0.8 km) and downstream (0.6 km) of the combined sewage discharge from the Town of Hinton and the Weldwood of Canada Ltd., Hinton Division pulp mill. Benthic samples collected once or twice annually (i.e., spring and fall) between 1983 -1987 and 1989-1992 were used in the analysis. Sampling dates for the benthic macroinvertebrate surveys were: 19 May 1983; 12 September 1983; 25-26 April 1984; 12 June 1985; 9 October 1985; 8 April 1986; 2 September 1986; 27 May 1987; 9 September 1987; 25 April 1989; 10-12 October 1990; 17-18 April 1991; 21-22 October 1992.

Comparisons of benthic macroinvertebrate communities were also conducted in the Athabasca River at Whitecourt between 1987 -1992. Samples collected twice annually (i.e., spring or summer and fall) at 7 -11 sites located immediately upstream and downstream of two pulp mills (Alberta Newsprint Company and Millar Western Pulp Ltd.) and the Town of Whitecourt sewage treatment plant were used in the analyses (Figure 23, Table 18). Sites 1 and 2 are located immediately upstream of all inputs whereas Sites 3 - 11 are located downstream of Alberta Newsprint Company or Millar Western Pulp Ltd. Alberta Newsprint discharges into the Athabasca River upstream of Millar Western Pulp Ltd. which discharges upstream of the sewage treatment plant. Millar Western Pulp Ltd. commenced operations on 2 August, 1988 with secondary effluent treatment consisting of an aerated stabilization basin (ASB). In fall of 1989, the mill changed from an ASB to an extended aeration activated sludge treatment system. Alberta Newsprint Company (ANC) commenced operations in August, 1990. Thus, macroinvertebrate data collected at Sites 3 - 5 in fall of 1989 and spring of 1990 represent pre-operational data, whereas later sampling represents post-operational conditions. In all years, sites 1 and 2 represent upstream locations. A plume delineation study during low flow in 1993 indicated that Site 3 and 4 experienced 0.1% to 0.2% effluent whereas Site 5 experienced less that 0.05% effluent. Sampling dates for the benthic macroinvertebrate surveys were: 2-7 June (summer), 13-16 November (fall), 1987; 1-4 June (summer), 16-21 October (fall), 1988; 22-25 June (summer), 6-10 October, 1989; 14-17 may (spring), 11-15 October, 1990; 20-23 May (spring), 1-4 November (fall), 1991.

In the Wapiti River, benthic macroinvertebrate communities were collected at 6 -10 sites located immediately upstream and downstream of the Grande Prairie sewage treatment plant and Weyerhaeuser Canada Ltd. (Fig. 24, Table 19). Macroinvertebrates were collected in fall 1987 (16 October), 1988 (7-10 October) and 1990 (4-7 October), in spring 1991 (15-16 April); and on two

occasions in winter 1992 (winter collection No. 1 was 8-14 January, winter collection No. 2 was 23-25 October and 7 November). In contrast to sites in the Athabasca River at Whitecourt, effluent from the Grande Prairie sewage treatment plant enters the river upstream of the pulp mill discharge.

Table 18. Description of benthic macroinvertebrate sampling sites in the Athabasca River at Whitecourt, Alberta 1987 - 1992. u/s = upstream, d/s = downstream, ANC = Alberta Newsprint Company, MW = Millar Western Pulp Ltd., STP = Town of Whitecourt sewage treatment plant, rb = right bank, lb = left bank.

Site	Description		
1	2.5 km u/s ANC,	13 km u/s MW,	17 km u/s STP
2	1.0 km u/s ANC,	11 km u/s MW,	15 km u/s STP
3	1.0 km d/s ANC,	9 km u/s MW,	13 km u/s STP
4	3.0 km d/s ANC,	7 km u/s MW,	11 km u/s STP
5	8.5 km d/s ANC,	1.5 km u/s MW,	5.5 km u/s STP
6	11 km d/s ANC,	0.5 km d/s MW,	3.5 km u/s STP
7	12 km d/s ANC,	2 km d/s MW (rb),	2 km u/s STP
8	12 km d/s ANC,	2 km d/s MW,	2 km u/s STP
9	14 km d/s ANC,	4 km d/s MW,	opposite STP
10	20 km d/s ANC,	10 km d/s MW,	6 km d/s STP
11	34 km d/s ANC,	24 km d/s MW,	20 km d/s STP

Table 19. Description of benthic macroinvertebrate sampling sites in the Smoky River at Grande Prairie, Alberta 1987 - 1992. u/s = upstream, d/s = downstream, mill = Weyerhaeuser Canada Ltd pulp mill previously owned by Procter and Gamble Ltd., STP = township of Grande Prairie sewage treatment plant. r/b = right bank, lb = left bank, c = centre of river.

Site	Description	
1	3.8 km u/s STP,	12.8 km u/s mill (c)
2	2.0 km u/s STP,	11.3 km u/s mill (c)
3	0.5 km d/s STP,	9.6 km u/s mill (rb)
4	0.4 km d/s STP,	8.6 km u/s mill (lb)
5	2.3 km d/s STP,	6.5 km u/s mill (c)
6	6.0 km d/s STP,	2.5 km u/s mill (lb)
7	4.4 km d/s STP,	2.4 km u/s mill (rb)
8	8.3 km d/s STP,	0.7 km d/s mill (c)
9	14.5 km d/s STP,	5.5 km d/s mill (rb)
10	22.5 km d/s STP,	13.5 km d/s mill (rb)

2.2.2 Materials and methods

Benthic communities were sampled at Hinton twice annually between 1983 -1987 and 1989-1992 by Alberta Environmental Protection (1983 data) and Terrestrial & Aquatic Environmental Managers Ltd. (Saskatoon) (1984-1987, 1989-1992 data). Macroinvertebrates were collected with a Neill cylinder sampler (area = 0.1 m^2, mesh size = 0.21-0.25 mm), processed using similar techniques and identified to similar taxonomic levels. Thus, sample techniques for these two sources were sufficiently similar to allow the data to be pooled and analyzed as a single data set.

Benthic macroinvertebrate communities in the Athabasca River at Whitecourt were sampled twice annually (i.e., spring and fall) at 7 -10 sites between 1987 - 1992 by Sentar Consulting Ltd. (Calgary) on behalf of Alberta Newsprint Company and Millar Western Pulp Ltd. (Fig. 27). Benthic macroinvertebrates were collected using a Neill cylinder sampler (area = 0.1 m^2, mesh size = 0.25 mm). Sampling protocols for all sites were highly consistent among and within years (See section 1.4 - Data base quality). Cluster analyses were performed separately for spring and summer (Analysis 1) and fall benthic collections (Analysis 2) because of the large number of objects comprising the data set (i.e., site*season* year combinations).

In contrast to sampling schedule in the Athabasca River, benthic macroinvertebrates were collected from the Wapiti River in fall 1987, 1988, 1990, in spring 1991 and on two occasions in winter in 1992. Cluster analysis was performed using all benthic sampling dates because of the relatively low number of samples that comprise this data set.

Cluster analyses were performed on each of the three data sets using mean taxonomic abundance for each community. Benthic macroinvertebrate communities are typically diverse including numerous rare species (i.e., that have a low frequency of occurrence or are common but are present in low densities). For the purpose of statistical analyses, clustering was conducted using mean abundance for taxonomic groups that satisfied the following two criteria: (1) occurred in greater than 10% of the samples or (2) accounted for > 1% of total mean faunal density at a given site. When taxonomic groups failed to meet these criteria we decreased the level of taxonomic resolution by clumping species groups until the new group satisfied these criteria. For example, in the Athabasca River the ephemeropteran genus of Ephemerella consists of a large number of species: Ephemerella (Drunella) colaradensis, Ephemerella (Drunella) doddsi, Ephemerella (Drunella) grandis, Ephemerella (Drunella) grandis ingens, Ephemerella (Drunella) grandis ingens, and Ephemerella (Drunella) spinifera (Cash et al. 1994). Many of these species, however, occur at low densities and frequencies at sites immediately upstream and downstream of the Weldwood of Canada Ltd. pulp mill at Hinton between 1983 -1992. Because the species level of taxonomic resolution failed to meet the two criteria they were subsequently grouped together to form a single group described as Ephemerella (Drunella). While this results in a small loss of taxonomic resolution it overcomes the inherent problem of weighing rare taxa equally with those that occur more frequently. Taxonomic groups for each of the three data sets used for cluster analyses (i.e., Hinton, Whitecourt (spring and fall collections analyzed separately), Wapiti River) are provided in Tables 20 -23. Zooplankton data were included in cluster analyses when available. Zooplankton data were included only when data were available at each time interval at all sites within the three main data sets. A complete list of all benthic macroinvertebrate taxa observed in the Athabasca River is provided in Appendix 48.

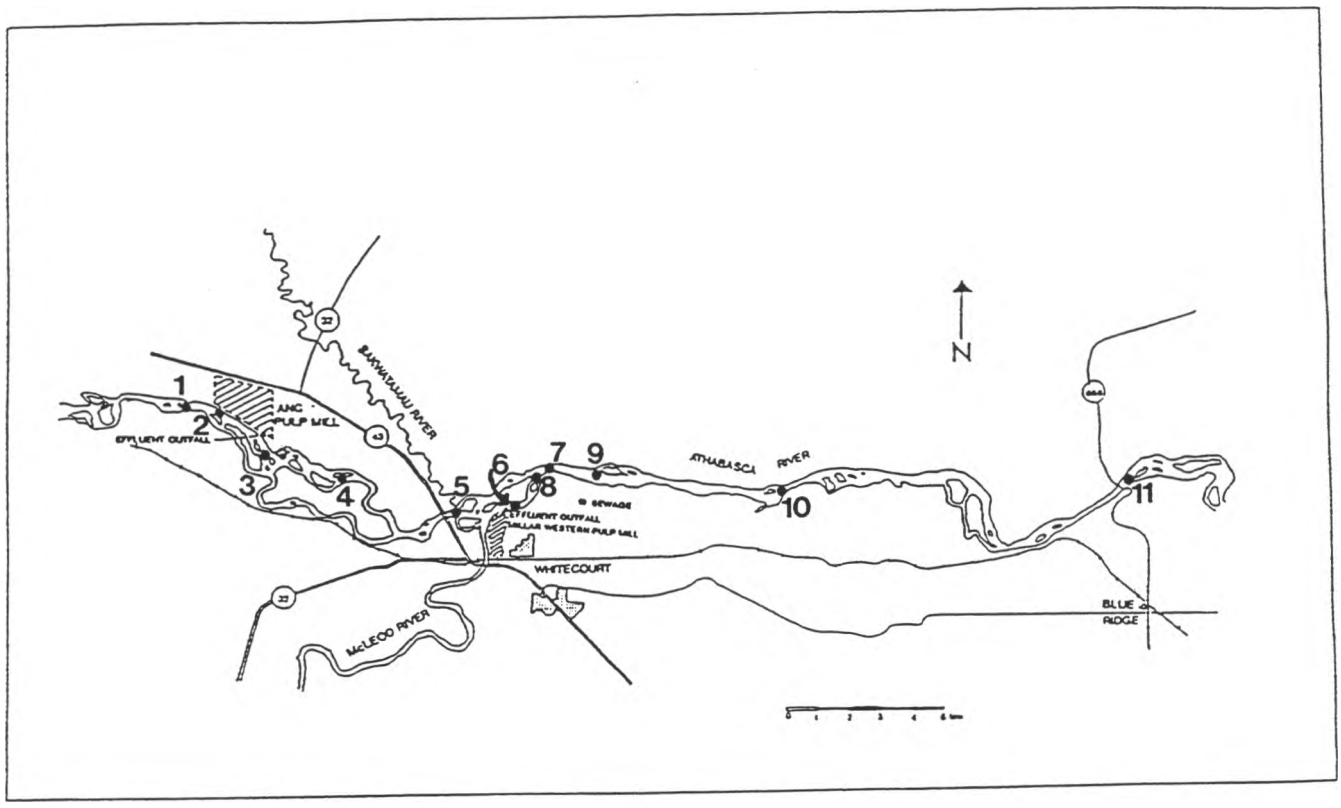

Figure 23. Benthic macroinvertebrate sampling locations on the Athabasca River at Whitecourt, Alberta. Modified from Luoma and Shelast (1991a).

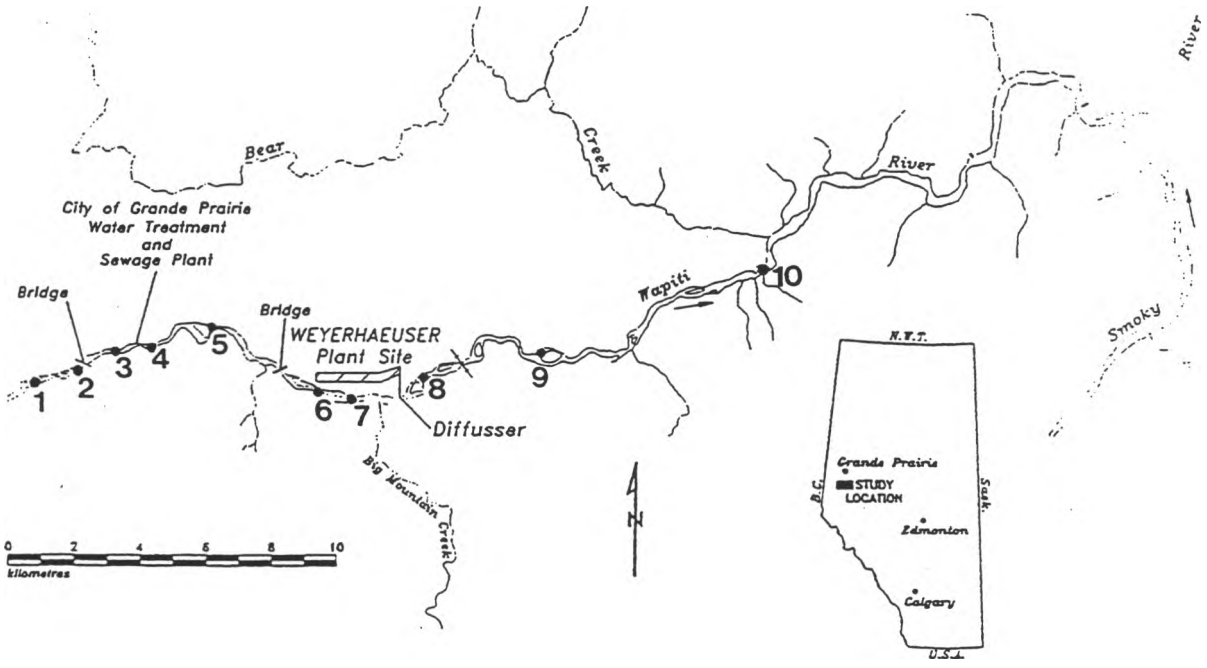

Figure 24. Benthic macroinvertebrate sampling locations on the Wapiti River at Grande Prairie, Alberta. Modified from Terrestrial & Aquatic Environmental Managers (1993c).

Table 20. Standardized listing of benthic macroinvertebrate taxa used in clustering analyses for spring and fall benthic macroinvertebrate communities in the Athabasca River at Hinton 1983 - 1992.

Acari	Brachycentridae
Cladocera	Glossosomatidae
Bosmina	Hydropsychidae
Daphnia	Arctopsyche
Copepoda	Cheumatopsyche
Calanoida	Turbellaria
Cyclopoida	Hydropsyche
Harpacticoida	Polycentropodidae
Ostracoda	Diptera
Collembola	Chironomidae
Plecoptera	Diamesinae
Capniidae	Diamesa
Chloroperlidae	Prodiamesinae
Alloperla	Tanypodinae
Sweltsa	Orthocladiinae
Utaperla	Cardiocladius
Nemouridae	Cricotopus
Perlidae	Eukiefferiella
Claassenia	Gymnometriocnemus
Hesperoperla	Orthocladius
Perlodidae	Rheocricotopus
Isogenoides	Chironomini
Isoperla	Polypedilum
Skwala	Tanytarsini
Pteronarcyidae	Micropsectra
Oemopteryx	Rheotanytarsus
Taenionema	Tanytarsus
Ephemeroptera	Tipulidae
Ameletus	Hexatoma
Baetidae	Dicranota
Baetis	Simulidae
Heptageniidae	Empididae
Cinygmula	Chelifera
Epeorus	Clinocera
Heptagenia	Hemerodromia
Rhithrogena	Wiedemannia
Ephemerellidae	Athericidae
Ephemerella (Drunella)	Oligochaeta
Ephemerella	Enchytraeidae
(Ephemerella)	Naididae
Ephemerella infrequens	Tubificidae
Ephemerella	Lumbriculidae
Trichoptera	Gastropoda
	Nematoda

Table 21. Standardized listing of benthic macroinvertebrate taxa used in clustering analyses for the Athabasca River at Whitecourt for spring and summer, 1987 -1992.

Hydracarina	Tanypodinae
Ostracoda	Monopelopia
Capniidae	Nilotanypus
Chloroperlinae	Thienemannimyia
Haploperla	Orthocladiinae
Triznaka	Orthocladiini &
Nemouridae	Metriocnemini
Nemoura	Eukiefferiella
Zapada	Krenosmittia
Perlidae	Nanocladius
Perlodidae	Parakiefferiella
Cultus	Parametriocnemus
Isogenoides	Synorthocladius
Isoperla	Tvetenia
Pteronarcyidae	Corynoneura
Taeniopterygidae	Thienemanniella
Ephemeroptera	Chironomini
Siphlonuridae	Cryptochironomus
Acentrella	Cyphomella
Baetis	Microtendipes
Heptageniidae	Polypedilum
Heptagenia	Robackia
Rhithrogena	Saetheria
Ephemerella (Drunella)	Cladotanytarsus
colaradensis	Micropsectra
Ephemerella (Drunella)	Rheotanytarsus
doddsi	Stempellinella
Ephemerella (Drunella)	Sublettea
inermis	Tanytarsus
Tricorythodes	Hexatoma
Leptophlebiidae	Limnophila
Brachycentrus	Ceratopogoninae
Arctopsyche	Simulium
Cheumatopsyche	Chelifera
Hydropsyche	Hemerodromia
Neotrichia	Enchytraeidae
Stactobiella	Naididae
Leptoceridae	Tubificidae
Diptera	Lumbricidae
Diamesinae	Mollusca
Potthastia	Nematoda
Monodiamesa	

Table 22. Standardized listing of benthic macoirnvertebrate taxa used in clustering analyses for the Athabasca River at Whitecourt for fall, 1987 -1992.

Hydracarina	Brillia
Ostracoda	Cardiocladius
Capniidae	Eukiefferiella
Chloroperlinae	Heleniella
Haploperla	Nanocladius
Perlidae	Parakiefferiella
Perlodidae	Parametriocnemus
Cultus	Rheocricotopus
Isogenoides	Synorthocladius
Isoperla	Tvetenia
Pteronarcyidae	Corynoneura
Taeniopterygidae	Thienemanniella
Ephemeroptera	Chironomini
Ameletus	Cryptochironomus
Baetidae	Cyphomella
Heptageniidae	Microtendipes
Heptagenia	Phaenopsectra
Rhithrogena	Polypedilum
Ephemerella (Drunella)	Robackia
Tricorythodes	Tanytarsini
Leptophlebiidae	Cladotanytarsus
Trichoptera	Micropsectra
Brachycentrus	Rheotanytarsus
Glossosoma	Sublettea
Arctopsyche	Tanytarsus
Cheumatopsyche	Tipulidae
Hydropsyche	Hexatoma
Lepidostoma	Ceratopogoninae
Oecetis	Chelifera
Limnephilidae	Hemerodromia
Coleoptera	Callicorixa
Diamesa	Sigara
Potthastia	Enchytraeidae
Monodiamesa	Naididae
Tanypodinae	Tubificidae
Thienemannimyia	Mollusca
Orthocladiinae	Nematoda
Orthocladiini & Metriocnemini	Polycelis

Table 23. Standardized listing of those benthic macoirnvertebrate taxa used in clustering analyses for the Wapiti River at Grande Prairie, 1987 -1992.

Acari	Glossosomatidae
Cladocera	Hydropsychidae
Copepoda	Diptera
Calanoida	Chironomidae
Cyclopoida	Diamesinae
Ostracoda	Prodiamesinae
Plecoptera	Tanypodinae
Capniidae	Orthocladiinae
Chloroperlidae	Chironominae
Nemouridae	Tipulidae
Perlidae	Ceratopogonidae
Perlodidae	Simulidae
Pteronarcydae	Empididae
Taeniopterygidae	Athericidae
Ephemeroptera	Chaoboridae
Siphlonuridae	Hemiptera
Baetidae	Enchytraeidae
Heptageniidae	Naididae
Ephemerellidae	Tubificidae
Trichoptera	Lumbriculidae
Brachycentridae	Nematoda

While a number of clustering methods exist, we used a sequential-agglomerative-hierarchial method present in PATN software known as FUSE based on the unweighted pair-group method using arithmetic averages (UPGMA) (Belbin 1989). PATN was developed by an Australian scientist working at the Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.) and is a comprehensive and versatile software package for extracting patterns in multivariate data sets (Belbin 1992). Further information on PATN can be obtained by contacting Lee Belbin, C.S.I.R.O. Division of Wildlife and Ecology, P.O. Box 84, Lyneham ACT 2602, Australia (International Phone 616 242 1627, Fax 616 241 3343.

The association matrix was constructed using the Bray-Curtis method based on a percent dissimilarity coefficient. This is a common clustering approach than the use of a similarity coefficient (Gauch 1982, Belbin 1989). High dissimilarity coefficients indicate that objects are more dissimilar than others. Alternatively, two objects that whose dissimilarity coefficient is 2 are more similar compared to two objects that have a dissimilarity coefficient of 4. The selection of dissimilarity levels is, however, rather subjective. In many cases the dissimilarity level used to identify groups is based on an initial visual interpretation of the clusters and subsequent judgements on how a small change in the dissimilarity level affects group membership (Gauch 1982).

2.2.3 Results and Discussion

Benthic macroinvertebrate communities in the Athabasca River at Hinton. The bleached kraft pulp mill located at Hinton has discharged effluent, with differing levels of treatment, into the Athabasca River since 1957. Pollution abatement practices have changed markedly since 1957 including a recent upgrade that was completed in November 1990. This modernization program included addition of oxygen delignification to the pulping process, a new steam stripper, in-house spill recovery system, and upgrading of the aerated stabilization basin (ASB) (Tones 1994). These changes resulted in a reduction in nutrient concentrations and biochemical oxygen demand of the effluent (Tones 1994).

We predicted that changes in chemical composition of the combined Hinton effluent between 1983 - 1992 would result in predictable qualitative changes in benthic communities downstream of the effluent discharge. In addition, we predicted differences in macroinvertebrate community structure between sites situated immediately upstream versus downstream of the mill outfall. Further, if benthic communities display little year-to-year variation, such patterns should be consistent among years.

Cluster analysis of benthic macroinvertebrate communities located immediately upstream and downstream of the combined effluent discharge from the Town of Hinton and Weldwood of Canada Ltd. pulp mill produced two clear clusters at the 1.2 level of dissimilarity (Fig 25). These clusters represent a diverse mixture of site (i.e., upstream and downstream locations) and year (i.e., before and after modernization) combinations. For example, Cluster 1 consists of benthic communities typically collected between 1983 - 1985. This cluster included 7 spring and 3 fall communities that were collected from both upstream and downstream localities. Similarly, Cluster 2 consisted of 16 groups from 1985 - 1992. As was observed for Cluster 1, Cluster 2 included both spring (N = 7) and fall (N = 9) communities collected from both upstream and downstream locations.

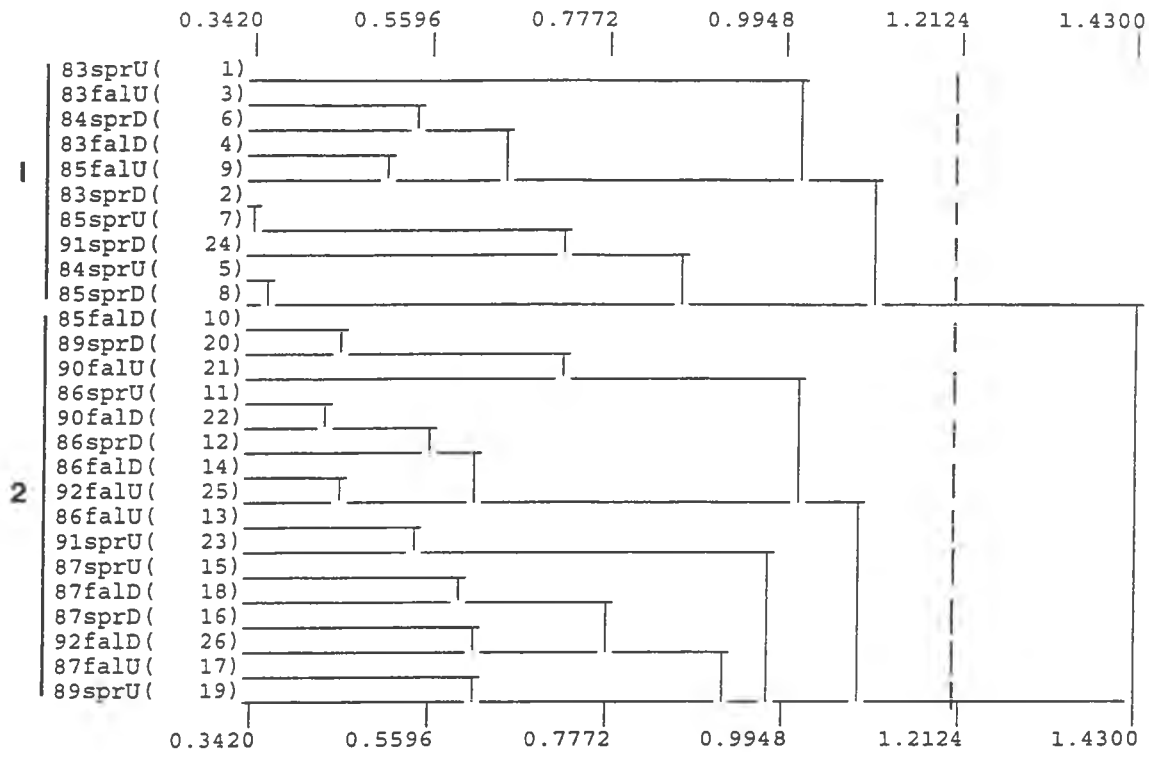

Figure 25. Results of cluster analysis of spring and fall benthic macroinvertebrate communities in the Athabasca River immediately upstream and downstream of the combined outfall from the Town of Hinton and Weldwood of Canada Ltd., Hinton Division pulp mill at Hinton, Alberta. Site labels: number = year (e.g., 83 = 1983); spr = spring ; f = fall; u = upstream of the outfall; d = downstream. Vertical dashed line = dissimilarity coefficient of 1.2.

These patterns in macroinvertebrate community structure are markedly different to our initial expectations. We predicted that the statistical analyses would reveal marked differences in macroinvertebrate communities present at sites located upstream compared to downstream of point source outfalls and those collected immediately before compared to after effluent release. In contrast, we observed no clear distinction between communities from upstream versus downstream of the outfall or from before or after the mill upgrade. This suggests that benthic community structure is highly variable among seasons and years. Despite the absence of consistent separations between samples collected upstream and downstream of the outfall or before or after mill upgrades, subtle differences in community structure do exist on individual sampling dates. For example, there is typically a separation of benthic communities on the basis of location within spring and fall collections. Thus, for any date, communities collected upstream separated from communities downstream of the mill. In many cases however, these differences are small compared with among year variation. While the mechanisms producing high seasonal and annual variation among upstream and downstream sites requires further investigation, it may be related to variation in hydrologic characteristics.

Benthic macroinvertebrate communities in the Athabasca River at Whitecourt. The Athabasca River at Whitecourt receives effluent inputs from Alberta Newsprint Company, Millar Western Pulp Ltd. and Township of Whitecourt. We predicted that benthic macroinvertebrate communities in the Whitecourt area would differ based on proximity to inputs. We expected that samples collected in the fall would form several clusters consisting of: 1) Sites 5, 6, 8, and 9 in 1987 (i.e., pre-operation of Millar Western Pulp Ltd.), 2) Sites 6, 8 and 9 in 1989 (i.e., post-operational sites located downstream of Millar Western Pulp Ltd.), 3) Sites 1 and 2 (i.e., upstream of all discharges) between 1989 -1992; if the effects of point source inputs are localized Site 11 (i.e., 20, 24 and 34 km downstream of the sewage treatment discharge, Millar Western Pulp Ltd., and Alberta Newsprint Company, respectively) should cluster with Sites 1 and 2 between 1989 -1992 and 4) Sites 3 - 10 (i.e., sites downstream of Alberta Newsprint Company, Millar Western Pulp Ltd. and sewage inputs) between 1989 - 1992.

Cluster analysis of spring and summer benthic macroinvertebrate communities from the Athabasca River near Whitecourt produced four clusters at the 1.4 level of dissimilarity (Fig. 26). Cluster 1 consisted almost exclusively of macroinvertebrate communities collected during spring, 1991, while Cluster 2 consisted predominantly of benthic communities collected during the spring of 1990 and 1992. Similarly, 13 of the 15 benthic communities comprising Cluster 3 and 12 of the 14 communities comprising Cluster 4 were collected in the summer and spring, respectively (Fig. 26). As observed for the Athabasca River near Hinton, there was no marked separation in benthic macroinvertebrate communities among sites located upstream or downstream of effluent releases. In fact, benthic macroinvertebrate communities at Sites 5, 6, 8, and 9 in pre-operational years of Millar Western Pulp Ltd were similar to those observed after effluent release (i.e., post-operational years). Similar trends in benthic macroinvertebrate communities were also observed with respect to sites located upstream compared to downstream of mill discharges.

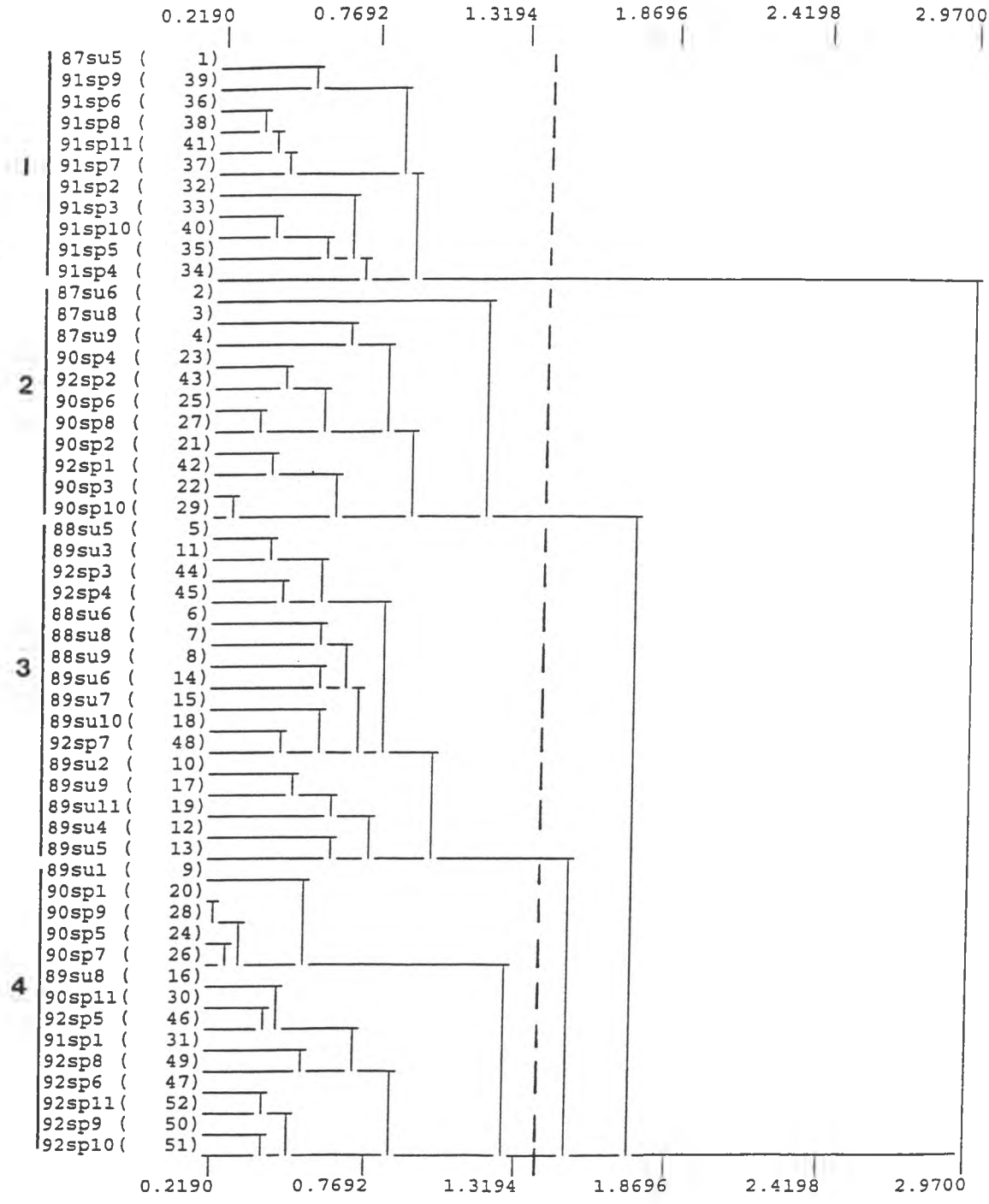

Figure 26. Results of cluster analysis of spring and summer benthic macroinvertebrate communities in the Athabasca River at Whitecourt, Alberta. Description of site labels: sp = spring, su = summer; other abbreviations as described in Fig. 25. Vertical dashed line = dissimilarity coefficient of 1.4.

These results indicate that macroinvertebrate communities clustered most strongly on sampling season or year in which they were collected. Put another way, community similarity appeared to be weakly affected by location (i.e., upstream or downstream of the point source inputs) and whether sampling occurred before or after inputs commenced. Thus, these data do not support our initial predictions that communities would form relatively discrete clusters consisting of sites sampled before and after operation of Millar Western Pulp Ltd. or sites located upstream and downstream of the point source inputs.

Cluster analysis of benthic macroinvertebrate communities collected near Whitecourt in the fall produced three groups at a dissimilarity level of 1.2 (Fig. 27). Cluster 1 comprised 12 communities extending from 1987 - 1992 and included sites both upstream (Sites 1 and 2) and downstream of Alberta Newsprint Company, Millar Western Pulp Ltd. and the municipal sewage effluent outfall. Similarly, Cluster 2 consisted of 13 communities representing benthos from sites located upstream and downstream of the point sources. Lastly, Cluster 3 included the 27 remaining communities collected between 1987 -1992 (Fig. 27). Taken together, the results for the Whitecourt area show that while cluster analyses produced clear separation among communities, membership within the clusters was different to that predicted from location (i.e., upstream or downstream of the three point-source inputs) and date (i.e., before or after the release of effluent from Alberta Newsprint Company and Miller Western Pulp Ltd).

Benthic macroinvertebrate communities in the Wapiti River at Grande Prairie The Wapiti River at Grande Prairie receives point source inputs from the Grande Prairie sewage treatment plant and the Weyerhaeuser Canada Ltd., pulp mill (Fig. 28). We expected that benthic macroinvertebrate communities in the Wapiti River would form separate clusters based on proximity to such inputs. Specifically, we predicted that benthic communities collected in 1987 at sites upstream of the mill discharge (i.e., Sites 5, 6, and 7) would cluster separately from downstream sites (i.e., Sites 8, 9 and 10). In subsequent years when the sampling program included sites above and below both the sewage treatment plant (STP) and mill discharge, we predicted that sites upstream of the STP (Sites 1, 2 and 3), downstream of the STP but upstream of the mill discharge (Sites 4, 5 and 6) and sites downstream of both the STP and mill (Sites 8, 9, 10) would form separate clusters (Fig. 28).

Cluster analysis produced six groups at a dissimilarity level of 1.2. Cluster 1 consisted of 11 benthic communities collected between 1987 - 1992 (Fig. 28). This group included several communities that were sampled in January 1992 including sites located upstream (i.e., Sites 2 and 3) and downstream (Site 4) of the sewage treatment outfall and some sites located downstream of the mill discharge (Sites 8 and 9). Additionally, the benthic fauna collected in 1988 at Site 2 (i.e., located upstream of the STP) clustered closely with a sites located immediately downstream of the pulp mill discharge (i.e., Site 8).

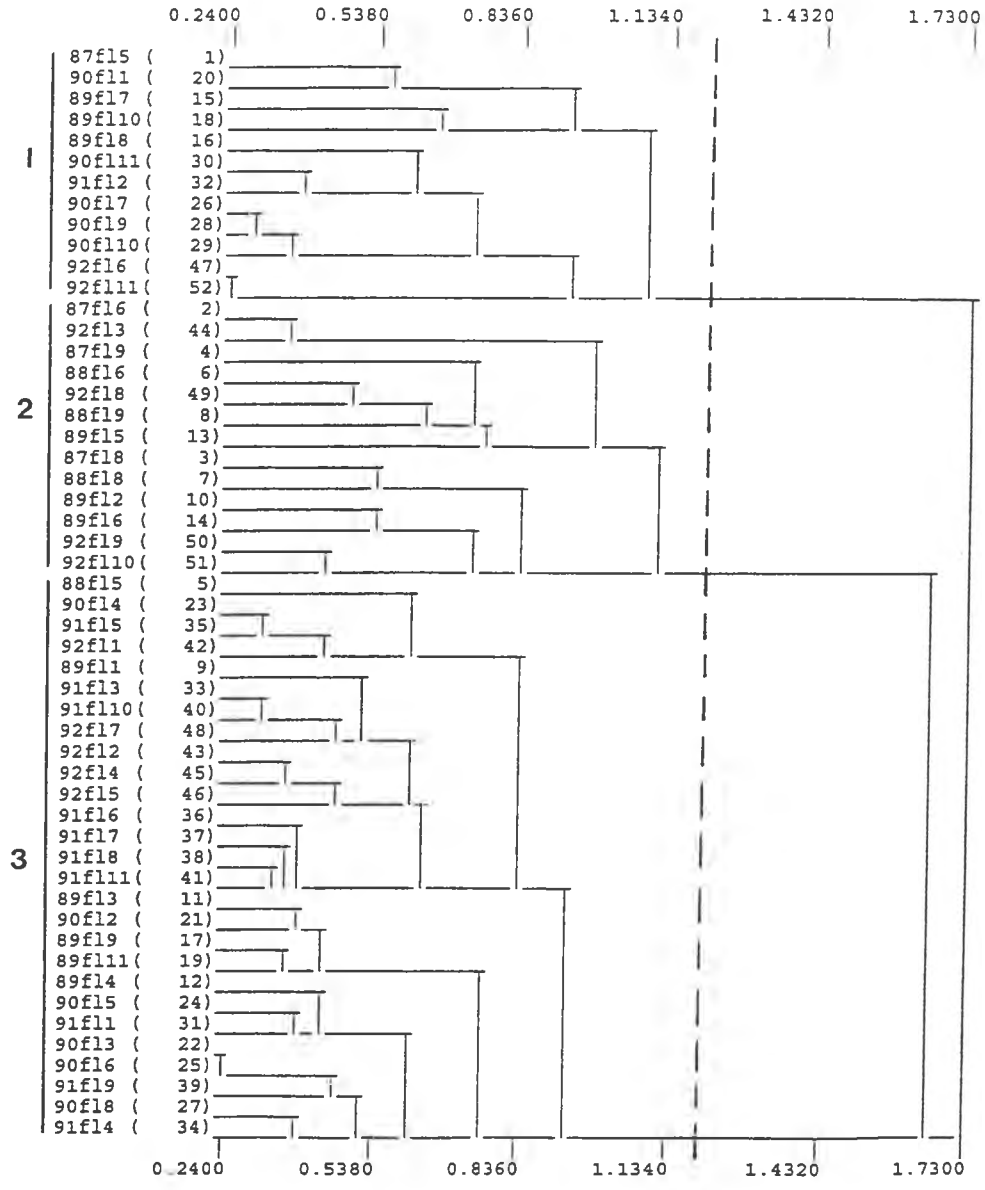

Figure 27. Results of cluster analysis of fall benthic macroinvertebrate communities in the Athabasca River at Whitecourt, Alberta. Description of site labels: fl = fall; other abbreviations as described in Fig. 25. Vertical dashed line = dissimilarity coefficient of 1.2.

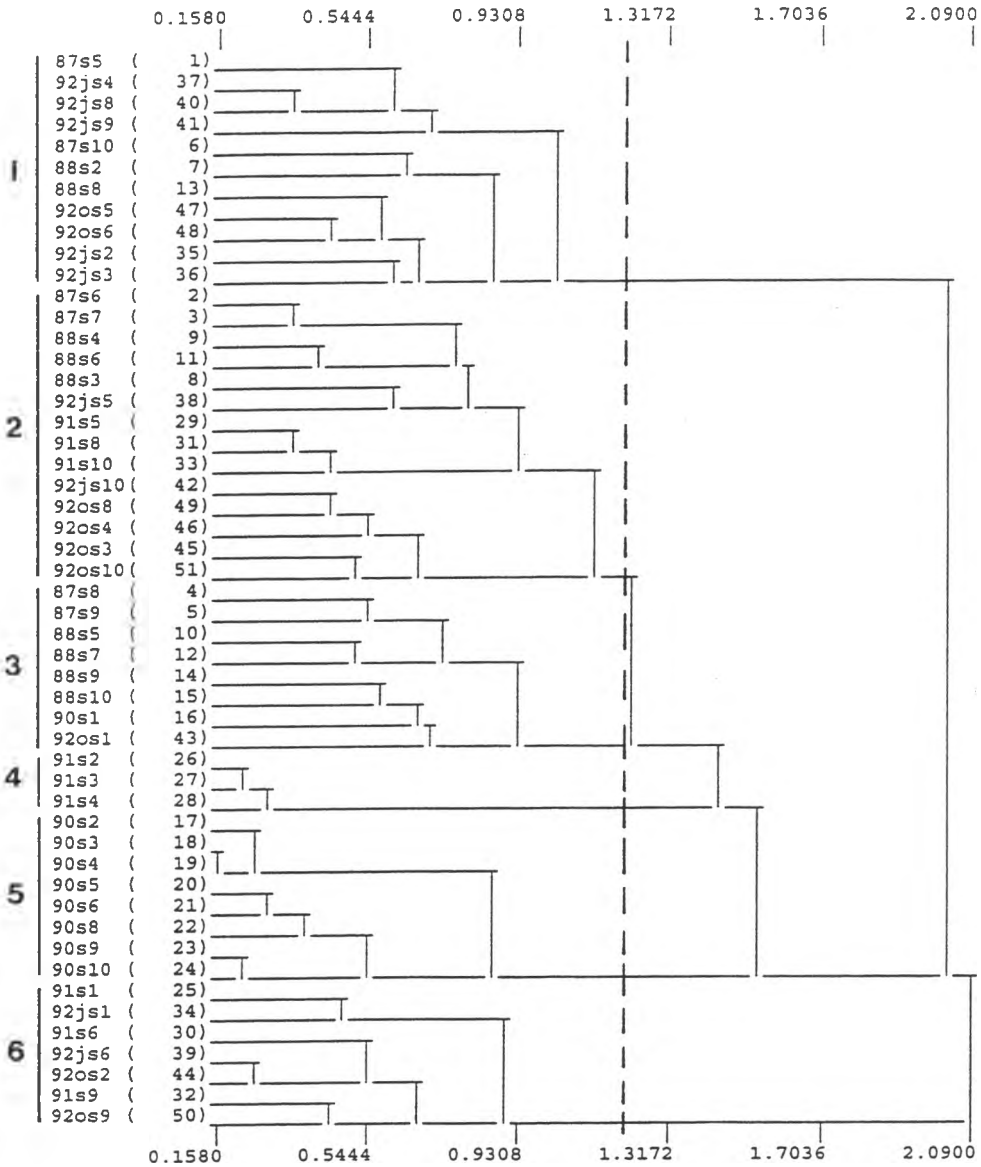

Figure 28. Results of cluster analysis of spring, fall and winter benthic macroinvertebrate communities in the Wapiti River at Grande Prairie, Alberta. Description of site labels: first two numbers = year (e.g., 87 = 1987), S = site number (e.g., S5 = Site5), when 2 benthic collections were made within the same year, (i.e., 1992) j = January, O = October. Vertical dashed line = dissimilarity coefficient of 1.2.

Cluster 2 consisted of 14 communities including several collected from sites upstream and downstream of outfalls during the same benthic surveys. For instance, in 1988 communities present at sites 3 (i.e. upstream of the STP), 4 and 6 (i.e., downstream of the STP) clustered closely (Fig. 28). In 1991, Site 5 (i.e., located downstream of the STP but upstream of the mill outfall) clustered closely with two sites located downstream of the mill (i.e., Sites 8 and 10). Benthic communities present at Sites 3, 4, 8 and 10 in October 1992 also clustered closely despite the fact that these communities were collected upstream and downstream of the STP and mill outfalls.

Macroinvertebrate communities comprising Cluster 3 consisted of eight communities that were collected predominantly in 1987 - 1988. In 1987, two sites located downstream of the pulp mill (i.e., Sites 8 and 9) formed a group whereas in 1988 Sites 5 (i.e., located downstream of the mill) and 7, 9, and 10 (i.e., located downstream of the mill) also clustered closely (Fig. 28).

Cluster 4 represents a small group of communities collected upstream and downstream of the of the STP in 1991 (Sites 2, 3, and 4). These sites cluster weakly with Sites 2 and 6 located downstream of the mill discharge. Sites 2, 3 and 4 however cluster weakly with Site 1 the most upstream site (i.e., dissimilarity coefficient > 2.0).

In contrast to previous clusters that generally contained communities present in several years, Cluster 5 consisted of 10 communities that were collected solely in 1990. The only 1990 sample not included in this cluster was Site 1, which occurred in Cluster 3. Communities comprising Cluster 5 are from sites located both upstream and downstream of the STP and pulp mill discharge. This strong clustering pattern suggests that the point discharges into the Wapiti River at Grande Prairie in 1990 exerted minimal effects on community structure. In contrast to the clear clustering of adjacent sites in 1990, Cluster 6 comprised several sites located upstream and downstream of the sewage treatment plant and mill discharges in 1991 and 1992 (Fig 28).

In contrast to our initial predictions, these data show that benthic macroinvertebrate communities in the Wapiti River near Grande Prairie does not differ between sites located upstream and downstream of point-source inputs. As observed for the Athabasca River near Hinton and Whitecourt, macroinvertebrate communities present at upstream sites formed strong clusters, indicating their similarity, with sites located downstream of point-source inputs.

2.2.4 Summary

Our results indicate that the structure (i.e., taxonomic composition) of benthic communities located upstream and downstream of point source inputs in the Athabasca River at Hinton and Whitecourt; and in the Wapiti River at Grande Prairie is not significantly affected by the presence of point-source inputs, when impacts are evaluated in terms of a community clustering approach. In many cases upstream sites formed strong clusters with sites located immediately below point-source inputs. A number of possibilities could explain the non-concordance between the strong community responses typically observed downstream of pulp mill effluents (Kelso 1977, Vander Wal 1977, Weinbauer et al. 1980, Majack and Waterhouse 1983, Scrimgeour 1989, Amblard et al. 1990)

The simplest explanation for the absence of identifiable effects on benthic invertebrate communities downstream of municipal and pulp mill discharges is that the contaminants are present in concentrations that are below threshold levels that would exert identifiable effects. The absence of marked affects on community structure may not be surprising because of the dramatic improvements in secondary effluent treatment systems including extended aeration activated sludge and aerated stabilization systems and changes pulp bleaching technologies. For example, process changes and recent upgrades at the Weldwood of Canada mill at Hinton between 1986 and 1992 has resulted in an approximate 50% reduction in BOD_5, a 2.5 fold reduction in NH_4^+ and up to a 33% reduction in total phosphorus concentrations. In addition, effluent discharges for the Weldwood, Alberta Newsprint Company, Millar Western Pulp Ltd., and Weyerhaeuser Canada Ltd. are typically less than 1% of total river volume (Anderson 1989, Terrestrial and Aquatic Environmental Managers 1990, Anderson 1991, Tones 1993, 1994). These changes in effluent characteristics may result in an overall increase in secondary production (e.g., Anderson 1989) but may occur independently of changes in community structure.

The absence of significant effects could also result from a diversity of other factors including: 1) high natural variation in benthic community structure, 2) past and present sampling approaches that are inadequate to identify significant effects (e.g., poor field and laboratory protocols, incorrect spatial and temporal scales), 3) poor taxonomic resolution or 4) the highly complex nature of pulp mill effluent. Our evaluation of sampling protocols suggests that sampling approaches should be sufficient to identify impacts in the spring and fall if they exist. However, this result does not preclude the possibility that such effects are present but are masked by natural variability in invertebrate community characteristics. Moreover, our result does not preclude the presence of significant effects at other times of the year. However, adverse effects of pulp mill effluents on benthic communities, if present, should be apparent during the spring and fall when effluent to river volume ratios are often highest and because early aquatic larval instars and those immediately about to emerge (e.g., penultimate instars) and mate are most vulnerable.

The level of taxonomic resolution (i.e., species and genera level versus family level identification) is an important factor determining the ability to recognize an environmental impact because many effects can be species-specific. To overcome this potential problem we restricted our analysis to sampling occasions when sampling protocols and laboratory sample processing techniques were consistent and generally at the species or genera levels. This level of taxonomic resolution should be sufficient to identify significant effects of municipal and pulp mill effluents. Thus, it is unlikely that the absence of significant differences in benthic invertebrate community structure at sites located immediately upstream than downstream of point source inputs results from low taxonomic resolution.

Municipal sewage and pulp mill discharges may be exerting significant effects on benthic community structure but are masked by other factors. While the potential mechanisms that could mask effluent effects are currently unknown, the annual scouring effects of river ice break-up (Scrimgeour et al. 1994) and spring floods (Resh et al. 1988, Power et al. 1988, Scrimgeour et al. 1988, Scrimgeour and Winterbourn 1989) are likely involved.

The highly complex nature of pulp mill effluent has been widely documented (Walden 1976, Davis et al. 1988, Hall et al. 1991, Owens 1991, McCubbin and Folke 1993). Thus, it is possible that component of the effluent may be exerting substantial effects on benthic community structure

but other components, such as nutrients, mask these effects (e.g., Warwich 1990, 1991, Lenat 1993). For instance, an enrichment response to nutrients (e.g., nitrogen and phosphorus) in effluent may be confounded by the presence of contaminants. Our ability to predict the effects of complex effluents on benthic macroinvertebrate communities is at best limited. However, experiments currently underway as part of the Northern River Basins Study are evaluating the affect of nutrient versus effluent additions on benthic communities (Culp et al. 1994, Scrimgeour et al. 1995) and will serve to elucidate mechanisms of action of complex effluents.

In summary, cluster analyses indicated that benthic macroinvertebrate community structure in the Athabasca River near Hinton and Whitecourt and the Wapiti River near Grande Prairie does not differ between sites located upstream and downstream of point source outfalls. Our review of the laboratory and field protocols used in obtaining these data indicate that these factors are unlikely to explain the absence of significant effects. While other factors (e.g., high variation in community structure, responses to complex effluents) could mask effects of the outfalls on benthic community, it is likely that the < 1- 4% dilution of pulp mill effluent in the Athabasca and Wapiti Rivers results in contaminant concentrations that are below threshold levels for a community response. It is possible, however, that a response to effluent loading could be occurring at an individual or population, but not a community level. In fact, evidence for an individual (e.g., growth rates) rather than community level response to BKME has been demonstrated by research completed by Cheryl Podemski and Joseph Culp (National Hydrology Research Institute, Saskatoon, Saskatchewan) under the Northern River Basins Study Contract 2615 - D1. Further research is clearly required for a more complete understanding of the effects of point source inputs on benthic invertebrate community structure in the Peace-Athabasca River system.

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4.0 APPENDICES

Appendices 2 to 47 inclusive provide data on benthic macroinvertebrate community structure for sites on the Peace and Athabasca rivers; because a printed copy of the data would be prohibatively large, the data is provided on disks bound as the last page of this report.

The disks contain five files:

1. Disk 1 of 2;
   a. INSTALL.BAT, being 99 bytes in size
   b. DISCLAIM.TXT, being 493 bytes in size
   c. SPLICE.COM, being 1,300 bytes in size
   d. NRBSPR56.E01, being 1,455,104 bytes in size
2. Disk 2 of 2;
   a. NRBSPR56.E02, being 1,388,242 bytes in size

To install the data on a microcomputer, using DOS:

1. Copy the three files, INSTALL.BAT, DISCLAIM.TXT and SPLICE.COM to a directory on your hard drive.
2. Type **splice d:** where d: = the drive reading the floppy disk 1 of 2 (usually a:)
3. When presented with the message on the screen, remove disk 1 of 2 and insert disk 2 of 2. The result will be file NRBSPR56.EXE (2,843,284 bytes) added to the directory.
4. Type **install**.

The result will be a subdirectory NRBSPR56 containing subdirectories APP02 to APP47 inclusive. The subdirectories will contain a total of 362 files using 8,040,579 bytes. All the files were prepared in Quattro Pro for windows and have extension WB1. Note that all file names are unique except for one; WAP91S1.WB1 occurs in APP07 and in APP44, although each occurance contributes a uniquely different spreadsheet.

There is no warranty expressed or implied for the use of this data; the Northern River Basins Study does not guarantee the accuracy of the data. The NRBS does not assume any liability for actions or consequences resulting from the use of the data; individuals using this database do so entirely at their own risk. The NRBS will not update the data except as deemed necessary for its own purposes.

Appendix 1. Terms of reference for contract 2616-C1 - "Long-term trends in ecosystem health: quantitative analysis of river benthic invertebrate communities.

July 22, 1993

2616-C1.TOR

NORTHERN RIVER BASINS STUDY

TERMS OF REFERENCE

Project 2616-C1: Long-Term Trends in Ecosystem Health - Quantitative Analysis of River Benthic Invertebrate Communities

I. Objective

The objective of this project is to assess the long-term trends in ecosystem health of the Peace-Athabasca rivers by evaluating changes in the composition of the invertebrate community in relation to effluent loading.

II. Requirements

A. Data Collection, compilation, screening and analysis

1. Obtain copies of all available long-term benthic invertebrate data for the Peace, Athabasca and Slave rivers and compile into a spreadsheet format.

2. Review benthic sampling protocols (eg., field sample collection dates, methodology, laboratory sample processing procedures, taxonomic identification level) used to produce the data sets.

3. Screen data sets and where appropriate comment on data quality.

4. Where data sets are of sufficient quality, conduct time series statistical analyses to determine long-term trends in ecosystem health including community abundance and biodiversity.

B. Review Report

Based on the information reviewed and statistically analyzed, produce a comprehensive report on the long-term trends in ecosystem health in the Peace, Athabasca and Slave rivers. The report will include:

1. A description and compilation of existing long-term data sets for the Peace, Athabasca and Slave rivers.

2. To the extent possible, a review of benthic sampling procedures used to produce each data set and the sampling deficiencies associated with them.

3. Where appropriate, quantitative statistical analyses (i.e., time series analyses) of long-term data sets.

III. Reporting Requirements

1. Provide ten cerlox bound draft copies of the report to the component coordinator by 15 March 1994.

2. Three weeks after the receipt of review comments on the report, provide the component coordinator with five cerlox bound copies and two unbound, camera-ready originals of the final report. At the same time, provide the component coordinator with an electronic copy of the report, in Word Perfect 5.1 format, on 3.5 inch floppy discs, of the final report. Data from any tables, figures or appendices in the report are also to be submitted to the component coordinator on Lotus or Quattro Pro spreadsheets. The final report is to include an executive summary, table of contents, list of tables, list of figures, acknowledgement section and an appendix containing the Terms of Reference for this project.

IV. Project Administration

The Scientific Authority for this project is:

Dr. Garry Scrimgeour
National Hydrology Research Institute
11 Innovation Blvd., Saskatoon, Saskatchewan
S7N 3H5

Questions pertaining to this project of a scientific nature should be directed to him.

The NRBS Study Office Component Coordinator for this project is:

Greg Wagner
Office of the Science Director
Northern River Basins Study
690 Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta
T5J 3N4
Phone: (403) 427-1742
Fax: (403) 422-3055

Administrative questions related to this project should be directed to him.

Appendix 2. Summary and benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Athabasca River at Hinton. u/s = upstream, d/s = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Athabasca	05/19/83	h1rb83sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	09/12/83	h1rb83fl.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	05/16/84	h1rb84sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	05/16/84	h1lb84sp.wb1	00AL07AD1170	D/S Hinton 1 km bridge lb
Athabasca	06/12/85	h1rb85sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	10/08/85	h1rb85fl.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	10/08/85	h1lb85fl.wb1	00AL07AD1170	D/S Hinton 1 km bridge lb
Athabasca	05/21/86	h1rb86sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	10/02/86	h1rb86fl.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	05/27/87	h1rb87sp.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	09/09/87	h1rb87fl.wb1	00AL07AD1190	D/S Hinton 1 km bridge rb
Athabasca	05/16/84	h20rb84s.wb1	00AL07AD1390	D/S Hinton 20 km bridge rb
Athabasca	05/16/84	h20lb84s.wb1	00AL07AD1370	D/S Hinton 20 km bridge lb
Athabasca	06/12/85	h20rb85s.wb1	00AL07AD1390	D/S Hinton 20 km bridge rb

Appendix 2 - continued.

River	Date	Filename	Code	Site
Athabasca	10/08/85	h20lb85f.wb1	00AL07AD1370	D/S Hinton 20 km bridge lb
Athabasca	10/08/85	h20rb85f.wb1	00AL07AD1390	D/S Hinton 20 km bridge rb
Athabasca	10/08/85	h30lb85f.wb1	00AL07AD1460	30 km D/S of Hinton lb
Athabasca	05/15/84	h50rb84s.wb1	00AL07AD1670	50 km D/S of Hinton rb
Athabasca	05/15/84	h50lb84s.wb1	00AL07AD1660	50 km D/S of Hinton lb
Athabasca	10/07/85	h50rb85f.wb1	00AL07AD1670	50 km D/S of Hinton rb
Athabasca	10/07/85	h50lb85f.wb1	00AL07AD1660	50 km D/S of Hinton lb
Athabasca	10/08/85	h6lb85fl.wb1	00AL07AD1200	6 km D/S of Hinton lb
Athabasca	10/09/85	h6rb85fl.wb1	00AL07AD1220	6 km D/S of Hinton rb
Athabasca	05/19/83	hrb83sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	09/12/83	hrb83fl.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	05/16/84	hrb84sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	05/16/84	hlb84sp.wb1	00AL07AD1020	U/S of Hinton lb
Athabasca	06/12/85	hrb85sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	10/09/85	hlb85fl.wb1	00AL07AD1020	U/S of Hinton lb
Athabasca	10/09/85	hrb85fl.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	05/21/86	hrb86sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	09/02/86	hrb86fl.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	05/27/87	hrb87sp.wb1	00AL07AD1010	U/S of Hinton rb
Athabasca	09/09/87	hrb87fl.wb1	00AL07AD1010	U/S of Hinton rb

Appendix 3. Summary and benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Athabasca River at Embarras. U/S = upstream, D/S = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year. WSC = Water Survey of Canada.

River	Date	Filename	Code	Site
Athabasca	05/24/83	emg83sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/19/83	emg83fl.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	05/16/84	emg84sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/11/84	emg84fl.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	05/27/85	emg85sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/09/85	emg85fl.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	05/29/86	emg86sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/04/86	emg86fl.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	05/04/87	emg87sp.wb1	00AL07DD0650	At Embarras WSC gauge
Athabasca	09/29/87	emg87fl.wb1	00AL07DD0650	At Embarras WSC gauge

Appendix 4. Summary and benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Athabasca River at Athabasca and in the vicinity of Alberta Pacific Forest Industries Inc. (AlPac). U/S = upstream, D/S = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Athabasca	08/27/85	a05lb85f.wb1	00AL07CB1000	0.5 km D/S of Athabasca lb
Athabasca	08/27/85	a05rb85f.wb1	00AL07CB1080	0.5 km D/S of Athabasca rb
Athabasca	08/27/85	a1-5lb85.wb1	00AL07CB1300	1.5 km D/S of Athabasca lb
Athabasca	08/27/85	a1-5rb85.wb1	00AL07CB1380	1.5 km D/S of Athabasca rb
Athabasca	08/27/85	a2-5lb85.wb1	00AL07CB1500	2.5 km D/S of Athabasca lb
Athabasca	08/27/85	a2-5rb85.wb1	00AL07CB1580	2.5 km D/S of Athabasca rb
Athabasca	08/27/85	a3-5lb85.wb1	00AL07CB1900	3.5 km D/S of Athabasca lb
Athabasca	08/27/85	a3-5rb85.wb1	00AL07CB1980	3.5 km D/S of Athabasca rb
Athabasca	08/27/85	a1bus85f.wb1	00AL07BE2300	U/S of Athabasca lb
Athabasca	08/27/85	arbus85f.wb1	00AL07BE2340	U/S of Athabasca rb
Athabasca	10/09/91	ath91s1.wb1	-	1 (5 km D/S of Deep Creek)
Athabasca	10/09/91	ath91s2.wb1	-	2 (3 km U/S of ALPAC diffuser)
Athabasca	10/09/91	ath91s3.wb1	-	3 (1 km D/S of ALPAC diffuser)
Athabasca	10/10/91	ath91s4.wb1	-	4 (11 km D/S of ALPAC diffuser)
Athabasca	10/10/91	ath91s5.wb1	-	5 (4 km D/S of LaBiche River)
Athabasca	10/10/91	ath91s6.wb1	-	6 (3 km D/S of Calling River)

Appendix 5. Summary and benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Athabasca River at Fort McMurray. U/S = upstream, D/S = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Athabasca	08/31/87	ft0-1dsf.wb1	00AL07DA0620	0.1 km D/S of Ft. McMurray STP outfall lb
Athabasca	08/31/87	ft0-5usf.wb1	00AL07DA0610	0.5 km U/S of Ft. McMurray STP outfall lb
Athabasca	08/31/87	ft10dsf.wb1	00AL07DA0820	10 km D/S of Ft. McMurray STP outfall lb
Athabasca	08/31/87	ft1dsf.wb1	00AL07DA063	1.0 km D/S of Ft. McMurray STP outfall lb
Athabasca	05/26/83	fthr83sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	09/22/83	fthr83fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	05/15/84	fthr84sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	09/11/84	fthr84fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	05/27/85	fthr85sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	09/09/85	fthr85fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	05/29/86	fthr86sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	09/04/86	fthr86fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	06/04/87	fthr87sp.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)
Athabasca	08/31/87	fthr87fl.wb1	00AL07CC0500	U/S of Horse River (Ft. McMurray)

Appendix 6. Summary and benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Lesser Slave River. U/S = upstream, D/S = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank. Data collected with an Eckman grab. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Lesser Slave	09/12/90	ls90s1fl.wb1	-	1 (Mitsue bridge)
Lesser Slave	09/12/90	ls90s2fl.wb1	-	2 (U/S of pulp mill)
Lesser Slave	09/12/90	ls90s3fl.wb1	-	3 (D/S of pulp mill)
Lesser Slave	09/12/90	ls90s4fl.wb1	-	4 (U/S Saulteaux River)
Lesser Slave	09/12/90	ls90s5fl.wb1	-	5 (U/S Driftwood River)
Lesser Slave	05/16/90	ls90s1sp.wb1	-	1 (Mitsue bridge)
Lesser Slave	05/16/90	ls90s2sp.wb1	-	2 (U/S of pulp mill)
Lesser Slave	05/16/90	ls90s3sp.wb1	-	3 (D/S of pulp mill)
Lesser Slave	05/16/90	ls90s4sp.wb1	-	4 (U/S Saulteaux River)
Lesser Slave	05/16/90	ls90s5sp.wb1	-	5 (U/S Driftwood River)

Appendix 7. Summary and benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Wapiti River (WR). U/S = upstream, D/S = downstream, STP = sewage treatment0 plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, c = centre, con = confluence. data collected with a Neill cylinder sampler. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Wapiti River	07/??/73	aepwp73.wb1	-	O'Brien Park to above con. with Smoky
Wapiti River	07/??/74	aepwp74.wb1	-	O'Brien Park to above con. with Smoky
Wapiti River	07/??/75	aepwp75.wb1	-	O'Brien Park to above con. with Smoky
Wapiti	05/10/83	wcslb83s.wb1	00AT07GJ0990	U/S con. Smoky w2 lb
Wapiti	05/10/83	wcsrb83s.wb1	00AT07GJ1010	U/S con. Smoky w2 rb
Wapiti	09/27/83	wcslb83f.wb1	00AT07GJ0990	U/S con. Smoky w2 lb
Wapiti	09/27/83	wcsrb83f.wb1	00AT07GJ1010	U/S con. Smoky w2 rb
Wapiti	05/10/83	woblb83s.wb1	00AT07GE2010	U/S O' Brien Park w1 lb
Wapiti	05/10/83	wobrb83s.wb1	00AT07GE2020	U/S O' Brien Park w1rb
Wapiti	09/27/83	woblb83f.wb1	00AT07GE2010	U/S O' Brien Park w1 lb
Wapiti	09/27/83	wobrb83f.wb1	00AT07GE2020	U/S O' Brien Park w1rb
Wapiti	02/25/91	wap91s1.wb1	-	1 (WR near HWY 40/O' Brien Park)
Wapiti	02/27/91	wap91s2.wb1	-	2 (just U/S of GP STP effluent)
Wapiti	02/26/91	wap91s3.wb1	-	3 (5 km D/S of GP STP)
Wapiti	02/27/91	wap91s4.wb1	-	4 (D/S of P&G haul road)
Wapiti	02/25/91	wap91s5.wb1	-	5 (0.5 km D/S of P&G effluent, LB)
Wapiti	02/26/91	wap91s6.wb1	-	6 (WR near RR bridge -LB or C)

Appendix 7 - cont.

River	Date	Filename	Code	Site
Wapiti	02/26/91	wap91s7.wb1	-	7 (WR 5-10 km D/S of P&G effluent)
Wapiti	02/26/91	wap91s8.wb1	-	8 (WR U/S of Bear River)
Wapiti	02/26/91	wap91s9.wb1	-	9 (10 km U/S of mouth)
Wapiti	02/26/91	wap91s10.wb1	-	10 (WR 0.5 km U/S of mouth)

Appendix 8. Summary and benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Smoky River. U/S = upstream, D/S = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, con = confluence. See appendices for additional details on sampling procedures. Date = month/day/year, s = station.

River	Date	Filename	Code	Site
Smoky	05/11/83	sbhrb83s.wb1	00AT07GJ2045	Below Bad Heart s4 rb
Smoky	05/11/83	sbhlb83s.wb1	00AT07GJ2035	Below Bad Heart s4 lb
Smoky	09/28/83	sbhlb83f.wb1	00AT07GJ2035	Below Bad Heart s4 lb
Smoky	09/28/83	sbhrb83f.wb1	00AT07GJ2045	Below Bad Heart s4 rb
Smoky	05/09/83	sbzlb83s.wb1	00AT07GJ2015	Bezanson bridge (Hwy34) s3 lb
Smoky	05/09/83	sbzrb83s.wb1	00AT07GJ2025	Bezanson bridge (Hwy34) s3 rb
Smoky	09/27/83	sbzlb83f.wb1	00AT07GJ2015	Bezanson bridge (Hwy34) s3 lb
Smoky	09/27/83	sbzrb83f.wb1	00AT07GJ2025	Bezanson bridge (Hwy34) s3 rb
Smoky	05/10/83	scwlb83s.wb1	00AT07GF1000	U/S con. Wapiti s1 lb
Smoky	05/10/83	scwrb83s.wb1	00AT07GF1010	U/S con. Wapiti s1 rb
Smoky	09/27/83	scwlb83f.wb1	00AT07GF1000	U/S con. Wapiti s1 lb
Smoky	09/27/83	scwrb83f.wb1	00AT07GF1010	U/S con. Wapiti s1 rb
Smoky	05/11/83	smlb83sp.wb1	00AT07GJ4995	At mouth s7 lb
Smoky	05/11/83	smrb83sp.wb1	00AT07GJ5005	At mouth s7 rb
Smoky	09/28/83	smlb83fl.wb1	00AT07GJ4995	At mouth s7 lb
Smoky	09/28/83	smrb83fl.wb1	00AT07GJ5005	At mouth s7 rb

Appendix 8 - continued.

River	Date	Filename	Code	Site
Smoky	05/10/83	ssrb83sp.wb1	00AT07GF2010	U/S con. Simonette s2 rb
Smoky	05/10/83	sslb83sp.wb1	00AT07GF1990	U/S con. Simonette s2 lb
Smoky	09/27/83	sslb83fl.wb1	00AT07GF1990	U/S con. Simonette s2 lb
Smoky	09/27/83	ssrb83fl.wb1	00AT07GF2010	U/S con. Simonette s2 rb
Smoky	05/11/83	sw5rb83s.wb1	00AT07GJ2065	At Watino s5 rb
Smoky	05/11/83	sw5lb83s.wb1	00AT07GJ2055	At Watino s5 lb
Smoky	09/28/83	sw5lb83f.wb1	00AT07GJ2055	At Watino s5 lb
Smoky	09/28/83	sw5rb83f.wb1	00AT07GJ2065	At Watino s5 rb
Smoky	05/11/83	swlb83sp.wb1	00AT07GJ3995	1/2 Watino to mouth s6 lb
Smoky	05/11/83	swrb83sp.wb1	00AT07GJ4005	1/2 Watino to mouth s6 rb
Smoky	09/28/83	swlb83fl.wb1	00AT07GJ3995	1/2 Watino to mouth s6 lb
Smoky	09/28/83	swrb83fl.wb1	00AT07GJ4005	1/2 Watino to mouth s6 rb

Appendix 9. Summary and benthic macroinvertebrate data files provided by Alberta Environmental Protection for the Peace River. U/S = upstream, D/S = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, con = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Code	Site
Peace	05/12/83	psrlb83s.wb1	00AT07FD5000	U/S con. with Smoky p1 lb
Peace	05/12/83	psrrb83s.wb1	00AT07FD5010	U/S con. with Smoky p1 rb
Peace	05/12/83	phrlb83s.wb1	00AT07HA2040	At Peace River U/S Heart River p2 lb
Peace	05/12/83	phrrb83s.wb1	00AT07HA2041	At Peace River U/S Heart River p2 rb
Peace	05/12/83	pdv83sp.wb1	00AT07FD2030	At Dunvegan
Peace	09/29/83	psrlb83f.wb1	00AT07FD5000	U/S con. with Smoky p1 lb
Peace	09/29/83	psrrb83f.wb1	00AT07FD5010	U/S con. with Smoky p1 rb
Peace	09/29/83	phrlb83f.wb1	00AT07HA2040	At Peace River U/S Heart River p2 lb
Peace	09/29/83	phrrb83f.wb1	00AT07HA2041	At Peace River U/S Heart River p2 rb
Peace	09/29/83	pdv83fl.wb1	00AT07FD2030	At Dunvegan
Peace	09/27/88	dunvegan.wb1	00AL07FD1500	Dunvegan (left)
Peace	09/28/88	carajou.wb1	00AL07HD1030	Near Carajou (centre)
Peace	09/28/88	lacrete.wb1	00AL07HF1350	Near LaCrete
Peace	09/28/88	notikewi.wb1	00AL07HC1200	U/S Notikewin River
Peace	09/29/88	peacept.wb1	00AL07KC1000	Near Peace Point (centre)
Peace	09/29/88	woodbuff.wb1	00AL07KA2000	Above Wood Buffalo
Peace	09/29/88	fortverm.wb1	00AL07HF1700	At Fort Vermillion
Peace	10/05/88	asmoky.wb1	00AL07FD4500	U/S Smoky

Appendix 9 - continued

River	Date	Filename	Code	Site
Peace	05/26/87	pblb87sp.wb1	00BC07FD1000	Border lb
Peace	05/26/87	pbrb87sp.wb1	00BC07FD1100	Border rb
Peace	09/28/87	pblb87fl.wb1	00BC07FD1000	Border lb
Peace	09/28/87	pbrb87fl.wb1	00BC07FD1100	Border rb
Peace	07/21/88	pblb88su.wb1	00BC07FD1000	Border lb
Peace	07/21/88	pbrb88su.wb1	00BC07FD1100	Border rb
Peace	10/03/88	pblb88fl.wb1	00BC07FD1000	Border lb
Peace	10/03/88	pbrb88fl.wb1	00BC07FD1100	Border rb
Peace	05/26/87	pclb87sp.wb1	00AL07FD1050	0.25 km U/S Clear River lb
Peace	05/27/87	pcrb87sp.wb1	00AL07FD1100	0.25 km U/S Clear River rb
Peace	09/28/87	pclb87fl.wb1	00AL07FD1050	0.25 km U/S Clear River lb
Peace	09/28/87	pcrb87fl.wb1	00AL07FD1100	0.25 km U/S Clear River rb
Peace	07/21/88	pclb88su.wb1	00AL07FD1050	0.25 km U/S Clear River lb
Peace	07/21/88	pcrb88su.wb1	00AL07FD1100	0.25 km U/S Clear River rb
Peace	09/27/88	pclb88fl.wb1	00AL07FD1050	0.25 km U/S Clear River lb
Peace	09/27/88	pcrb88fl.wb1	00AL07FD1100	0.25 km U/S Clear River rb
Peace	09/28/87	pcc87fl.wb1	00AL07FD1000	4.2 km U/S Clear River (centre)
Peace	09/27/88	pcc88fl.wb1	00AL07FD1000	4.2 km U/S Clear River (centre)

Appendix 9 - continued

River	Date	Filename	Code	Site
Peace	07/27/88	p3d88su.wb1	00AL07HA2150	3 km U/S Daishowa Pulp mill (B1L)
Peace	10/04/88	p3d88fl.wb1	00AL07HA2150	3 km U/S Daishowa Pulp mill (B1L)
Peace	07/27/88	p4d88su.wb1	00AL07HA2100	4 km U/S Daishowa Pulp mill (B1R)
Peace	10/04/88	p4d88fl.wb1	00AL07HA2100	4 km U/S Daishowa Pulp mill (B1R)
Peace	07/26/88	p2d88su.wb1	00AL07HA2200	2 km D/S Daishowa Pulp mill (B2R)
Peace	10/04/88	p2d88fl.wb1	00AL07HA2200	2 km D/S Daishowa Pulp mill (B2R)
Peace	07/27/88	p5d88su.wb1	00AL07HA2600	5 km D/S Daishowa Pulp mill (B2L)
Peace	10/04/88	p5d88fl.wb1	00AL07HA2600	5 km D/S Daishowa Pulp mill (B2L)
Peace	07/27/88	p7d88su.wb1	00AL07HA2620	7 km D/S Daishowa Pulp mill (B2C)
Peace	10/04/88	p7d88fl.wb1	00AL07HA2620	7 km D/S Daishowa Pulp mill (B2C)
Peace	07/26/88	p17d88su.wb1	00AL07HA2640	17 km D/S Daishowa Pulp mill (B3L)
Peace	10/04/88	p17d88fl.wb1	00AL07HA2640	17 km D/S Daishowa Pulp mill (B3L)
Peace	07/26/88	p20d88su.wb1	00AL07HA2660	20 km D/S Daishowa Pulp mill (B3R)
Peace	10/04/88	p20d88fl.wb1	00AL07HA2660	20 km D/S Daishowa Pulp mill (B3R)

Appendix 9 - continued

River	Date	Filename	Code	Site
Peace	07/26/88	p32d88su.wb1	00AL07HA2680	32 km D/S Daishowa Pulp mill (B4R)
Peace	07/26/88	p32d88fl.wb1	00AL07HA2680	32 km D/S Daishowa Pulp mill (B4R)
Peace	07/26/88	p33d88su.wb1	00AL07HA2700	33 km D/S Daishowa Pulp mill (B4C)
Peace	10/04/88	p33d88fl.wb1	00AL07HA2700	33 km D/S Daishowa Pulp mill (B4C)
Peace	07/26/88	p35d88su.wb1	00AL07HA2800	35 km D/S Daishowa Pulp mill (B4L)
Peace	10/04/88	p35d88fl.wb1	00AL07HA2800	35 km D/S Daishowa Pulp mill (B4L)

Appendix 10. Summary of data files provided by Sentar Consulting Ltd. Calgary, Alberta for studies completed for Millar Western Pulp Ltd. in the Athabasca River at Whitecourt, 1987-1988. Sources = Luoma and Shelast (1988, 1989). u/s = upstream, d/s = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Site
McLeod	06/05/87	mwju87s1.wb1	1
Athabasca	06/05/87	mwju87s2.wb1	2
Athabasca	06/05/87	mwju87s3.wb1	3
Athabasca	06/05/87	mwju87s4.wb1	4
Athabasca	06/05/87	mwju87s5.wb1	5
McLeod	11/05/87	mwno87s1.wb1	1
Athabasca	11/05/87	mwno87s2.wb1	2
Athabasca	11/05/87	mwno87s3.wb1	3
Athabasca	11/05/87	mwno87s4.wb1	4
Athabasca	11/05/87	mwno87s5.wb1	5
McLeod	06/05/88	mwju88s1.wb1	1
Athabasca	06/05/88	mwju88s2.wb1	2
Athabasca	06/05/88	mwju88s3.wb1	3
Athabasca	06/05/88	mwju88s4.wb1	4
Athabasca	06/05/88	mwju88s5.wb1	5
McLeod	10/05/88	mwoc88s1.wb1	1
Athabasca	10/05/88	mwoc88s2.wb1	2
Athabasca	10/05/88	mwoc88s3.wb1	3
Athabasca	10/05/88	mwoc88s4.wb1	4
Athabasca	10/05/88	mwoc88s5.wb1	5

Appendix 11. Summary of data files provided by Sentar Consulting Ltd. Calgary, Alberta for studies completed for Millar Western Pulp Ltd. in the Athabasca River at Whitecourt, 1989-1990. Sources = Luoma and Shelast (1990a, 1991a). u/s = upstream, d/s = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Site
McLeod	06/08/89	mwju89s1.wb1	1
Athabasca	06/08/89	mwju89s2.wb1	2
Athabasca	06/08/89	mwju89s3.wb1	3
Athabasca	06/08/89	mwju89s4.wb1	4
Athabasca	06/08/89	mwju894a.wb1	4a
Athabasca	06/08/89	mwju89s5.wb1	5
Athabasca	06/08/89	mwju89s6.wb1	6
Athabasca	06/08/89	mwju89s7.wb1	7
McLeod	10/08/89	mwoc89s1.wb1	1
Athabasca	10/08/89	mwoc89s2.wb1	2
Athabasca	10/08/89	mwoc89s3.wb1	3
Athabasca	10/08/89	mwoc89s4.wb1	4
Athabasca	10/08/89	mwoc894a.wb1	4a
Athabasca	10/08/89	mwoc89s5.wb1	5
Athabasca	10/08/89	mwoc89s6.wb1	6
Athabasca	10/08/89	mwoc89s7.wb1	7
McLeod	05/08/90	mwma90s1.wb1	1
Athabasca	05/08/90	mwma90s2.wb1	2
Athabasca	05/08/90	mwma90s3.wb1	3
Athabasca	05/08/90	mwma90s4.wb1	4
Athabasca	05/08/90	mwma904a.wb1	4a
Athabasca	05/08/90	mwma90s5.wb1	5
Athabasca	05/08/90	mwma90s6.wb1	6
Athabasca	05/08/90	mwma90s7.wb1	7

Appendix 11 - continued

River	Date	Filename	Site
McLeod	10/08/90	mwoc90s1.wb1	1
Athabasca	10/08/90	mwoc90s2.wb1	2
Athabasca	10/08/90	mwoc90s3.wb1	3
Athabasca	10/08/90	mwoc90s4.wb1	4
Athabasca	10/08/90	mwoc904a.wb1	4a
Athabasca	10/08/90	mwoc90s5.wb1	5
Athabasca	10/08/90	mwoc90s6.wb1	6
Athabasca	10/08/90	mwoc90s7.wb1	7

Appendix 12. Summary of data files provided by Sentar Consulting Ltd. Calgary, Alberta for studies completed for Millar Western Pulp Ltd. in the Athabasca River at Whitecourt, 1991-1992. Sources = Luoma and Shelast (1992b, 1993a). u/s = upstream, d/s = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

McLeod	05/08/91	mwma91s1.wb1	1
Athabasca	05/08/91	mwma91s2.wb1	2
Athabasca	05/08/91	mwma91s3.wb1	3
Athabasca	05/08/91	mwma91s4.wb1	4
Athabasca	05/08/91	mwma914a.wb1	4a
Athabasca	05/08/91	mwma91s5.wb1	5
Athabasca	05/08/91	mwma91s6.wb1	6
Athabasca	05/08/91	mwma91s7.wb1	7
McLeod	10/08/91	mwoc91s1.wb1	1
Athabasca	10/08/91	mwoc91s2.wb1	2
Athabasca	10/08/91	mwoc91s3.wb1	3
Athabasca	10/08/91	mwoc91s4.wb1	4
Athabasca	10/08/91	mwoc914a.wb1	4a
Athabasca	10/08/91	mwoc91s5.wb1	5
Athabasca	10/08/91	mwoc91s6.wb1	6
Athabasca	10/08/91	mwoc91s7.wb1	7
McLeod	04/08/92	mwap92s1.wb1	1
Athabasca	04/08/92	mwap92s2.wb1	2
Athabasca	04/08/92	mwap92s3.wb1	3
Athabasca	04/08/92	mwap92s4.wb1	4
Athabasca	04/08/92	mwap924a.wb1	4a
Athabasca	04/08/92	mwap92s5.wb1	5
Athabasca	04/08/92	mwap92s6.wb1	6
Athabasca	04/08/92	mwap92s7.wb1	7

Appendix 12 - continued

River	Date	Filename	Site
Athabasca	10/08/92	mwoc92s1.wb1	1
Athabasca	10/08/92	mwoc92s2.wb1	2
Athabasca	10/08/92	mwoc92s3.wb1	3
Athabasca	10/08/92	mwoc92s4.wb1	4
Athabasca	10/08/92	mwoc924a.wb1	4a
Athabasca	10/08/92	mwoc92s5.wb1	5
Athabasca	10/08/92	mwoc92s6.wb1	6
Athabasca	10/08/92	mwoc92s7.wb1	7

Appendix 13. Summary and data files provided by Sentar Consulting Ltd. Calgary, Alberta for studies completed for Alberta Newsprint Corporation in the Athabasca River at Whitecourt, 1989-1990. u/s = upstream, d/s = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Site
Athabasca	06/07/89	anju89s1.wb1	1
Athabasca	06/07/89	anju89s2.wb1	2
Athabasca	06/07/89	anju89s3.wb1	3
Athabasca	06/07/89	anju89s4.wb1	4
Athabasca	06/07/89	anju89s5.wb1	5
Athabasca	06/07/89	anju89s6.wb1	6
Athabasca	06/07/89	anju89s7.wb1	7
Athabasca	10/07/89	anoc89s1.wb1	1
Athabasca	10/07/89	anoc89s2.wb1	2
Athabasca	10/07/89	anoc89s3.wb1	3
Athabasca	10/07/89	anoc89s4.wb1	4
Athabasca	10/07/89	anoc89s5.wb1	5
Athabasca	10/07/89	anoc89s6.wb1	6
Athabasca	10/07/89	anoc89s7.wb1	7
Athabasca	05/07/90	anma90s1.wb1	1
Athabasca	05/07/90	anma90s2.wb1	2
Athabasca	05/07/90	anma90s3.wb1	3
Athabasca	05/07/90	anma90s4.wb1	4
Athabasca	05/07/90	anma90s5.wb1	5
Athabasca	05/07/90	anma90s6.wb1	6
Athabasca	05/07/90	anma90s7.wb1	7

Appendix 13 - continued

River	Date	Filename	Site
Athabasca	10/07/90	anoc90s1.wb1	1
Athabasca	10/07/90	anoc90s2.wb1	2
Athabasca	10/07/90	anoc90s3.wb1	3
Athabasca	10/07/90	anoc90s4.wb1	4
Athabasca	10/07/90	anoc90s5.wb1	5
Athabasca	10/07/90	anoc90s6.wb1	6
Athabasca	10/07/90	anoc90s7.wb1	7

Appendix 14. Summary and data files provided by Sentar Consulting Ltd. Calgary, Alberta for studies completed for Alberta Newsprint Company in the Athabasca River at Whitecourt, 1991-1992. Sources = Luoma and Shelast (1992a, 1993b). u/s = upstream, d/s = downstream, STP = sewage treatment plant, Site = general site location as provided by source, lb = true left bank, rb = true right bank, conf = confluence. See appendices for additional details on sampling procedures. Date = month/day/year.

River	Date	Filename	Site
Athabasca	05/07/91	anma91s1.wb1	1
Athabasca	05/07/91	anma91s2.wb1	2
Athabasca	05/07/91	anma91s3.wb1	3
Athabasca	05/07/91	anma91s4.wb1	4
Athabasca	05/07/91	anma91s5.wb1	5
Athabasca	05/07/91	anma91s6.wb1	6
Athabasca	05/07/91	anma91s7.wb1	7
Athabasca	10/07/91	anoc91s1.wb1	1
Athabasca	10/07/91	anoc91s2.wb1	2
Athabasca	10/07/91	anoc91s3.wb1	3
Athabasca	10/07/91	anoc91s4.wb1	4
Athabasca	10/07/91	anoc91s5.wb1	5
Athabasca	10/07/91	anoc91s6.wb1	6
Athabasca	10/07/91	anoc91s7.wb1	7
Athabasca	04/07/92	anap92s1.wb1	1
Athabasca	04/07/92	anap92s2.wb1	2
Athabasca	04/07/92	anap92s3.wb1	3
Athabasca	04/07/92	anap92s4.wb1	4
Athabasca	04/07/92	anap92s5.wb1	5
Athabasca	04/07/92	anap92s6.wb1	6
Athabasca	04/07/92	anap92s7.wb1	7

Appendix 14 -continued

River	Date	Filename	Site
Athabasca	10/07/92	anoc92s1.wb1	1
Athabasca	10/07/92	anoc92s2.wb1	2
Athabasca	10/07/92	anoc92s3.wb1	3
Athabasca	10/07/92	anoc92s4.wb1	4
Athabasca	10/07/92	anoc92s5.wb1	5
Athabasca	10/07/92	anoc92s6.wb1	6
Athabasca	10/07/92	anoc92s7.wb1	7

Appendix 15. Data files of benthic macroinvertebrate data provided by Beak Consulting Ltd for the Athabasca River at Hinton and downstream locations, 1960. Source = Beak (1960). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence, mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. Source = Beak (1960). Site locations: 1 = 3 miles u/s mill south bank, 2A = north side of river u/s of mill, 2B = 1 mile d/s mill, south side of river, 3A= 3 miles below mill discharge north side of north channel, 3B = 3 miles d/s mill discharge south side of north channel, 4A = 5 miles d/s mill discharge north shore of island, 4B = 5 miles d/s mill discharge south shore of island, 5 = 14 miles d/s, 6A = north side of river, 6B = south side of river, 7 = end of Lumber road from marlboro - Department of health sampling station, 8 = north of Edson 6 miles west of Marsh-head Creek, 9 = Windfall Creek on island in river, 10 = Whitecourt road bridge south bank east of bridge, 11 = Fort Assiniboine.

Appendix 16. Data files of benthic macroinvertebrate data provided by Beak Consulting Ltd for the Athabasca River at Hinton and downstream locations, 1972. Source = Beak (1972a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. [1] = summary data.

Appendix 17. Data files of benthic macroinvertebrate data provided by Beak Consulting Ltd for the Athabasca River at Hinton and downstream locations, 1974. Source = Beak (1975a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. [1] = summary data.

Appendix 18. Data files of benthic macroinvertebrate data provided by Beak Consulting Ltd for the Athabasca River at Hinton and downstream locations, 1976. Source = Beak (1977). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Number in brackets indicate number of locations sampled. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. [1] = summary data.

Appendix 19. Data files of benthic macroinvertebrate data provided by Beak Consulting Ltd for the Athabasca River at Hinton and downstream locations, 1977. Source = Beak (1978). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. [1] = summary data.

Appendix 20. Data files of benthic macroinvertebrate data provided by Beak Consulting Ltd for the Athabasca River at Hinton and downstream locations, 1979. Source = Beak (1980a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. [1] = summary data.

Appendix 21. Summary data files of benthic macroinvertebrate data provided by Integrated Environmental Sciences Inc. for the Athabasca River at Hinton and downstream locations, 1984. Source = Integrated Environmental Sciences Inc. (1984a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. [1] = summary data. Site locations: 1A = 4.7 km u/s of mill effluent discharge, 0.5 km u/s mill, 3 = 1.5 km d/s mill effluent discharge, 4 = 2.7 km d/s mill, 5 = 6.3 km d/s mill, 6 = 9 km d/s of mill, 7 = 21 km d/s of mill, 8 = 43 km d/s mill. Source: Integrated Environmental Sciences Inc. (1984).

Appendix 22. Summary data files of benthic macroinvertebrate data provided by Integrated Environmental Sciences Inc. for the Athabasca River at Hinton and downstream locations, 1986. Source = Integrated Environmental Sciences Inc. (1986a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. See Appendix 21 for Site locations.

Appendix 23. Data files of benthic macroinvertebrate data provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Athabasca River at Hinton and downstream locations, 1989. Source = Terrestrial & Aquatic Environmental Managers (1989). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. See Appendix 21 for site locations.

Appendix 24. Data files of benthic macroinvertebrate data provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Athabasca River at Hinton and downstream locations, 1990. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1991a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division.

Appendix 25. Data files of benthic macroinvertebrate data provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Athabasca River at Hinton and downstream locations, April, 1991. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1991a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division.

Appendix 26. Data files of benthic macroinvertebrate data provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Athabasca River at Hinton and downstream locations, April, 1992. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1992a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division. See Appendix 21 for site locations.

Appendix 27. Data files of benthic macroinvertebrate data provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Athabasca River at Hinton and downstream locations, October, 1992A. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1992b). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division.

Appendix 28. Data files of benthic macroinvertebrate data provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Athabasca River at Hinton and downstream locations, October, 1992. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1993a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank, conf = confluence. Mill = pulp mill at Hinton currently owned by Weldwood of Canada Ltd, Hinton Division.

Appendix 29. Data files provided by Beak Consultants Ltd. for the Wapiti and Smoky Rivers, 1970. Source: Beak Consultants Ltd. (1972) Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 30. Data files provided by Beak Consultants Ltd. for the Wapiti River, 1972. Source = Beak (1972b). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 31. Data files provided by Beak Consultants Ltd. for the Wapiti River, 1974 (part A). Source = Beak (1975b). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 32. Data files provided by Beak Consultants Ltd. for the Wapiti River, 1974B. Source = Beak (1975b). Files also contain results from collections made by Alberta Fish and Wildlife. Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 33. Data files provided by Beak Consultants Ltd. for the Wapiti River, 1974 (part C). Source = Beak (1975b). Files also contain results from collections made by Alberta Fish and Wildlife. Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided. Note: files enclosed are those reported in Beak (1975) fora biological survey by Alberta Fish and Wildlife.

Appendix 34. Data files provided by Beak Consultants Ltd. for the Wapiti River, 1975. Source = Beak (1976). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 35. Data files provided by Beak Consultants Ltd. for the Wapiti River, 1979. Source = Beak (1979a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 36. Data files provided by Beak Consultants Ltd. for the Wapiti River, 1980. Source = Beak (1981). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 37. Data summary files provided by Integrated Environmental Sciences Inc. for the Wapiti River, 1981. Source = Integrated Environmental Sciences Ltd (1982). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 38. Data summary files provided by Integrated Environmental Sciences Inc. for the Wapiti River, 1982. Source = Integrated Environmental Sciences Ltd (1983). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 39. Data summary files provided by Integrated Environmental Sciences Ltd. for the Wapiti River, 1983. Source = Integrated Environmental Sciences Inc. (1984b). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 40. Data files provided by Integrated Environmental Sciences Inc. for the Wapiti River, 1985. Source = Integrated Environmental Sciences Inc. (1986b). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 41. Data files provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Wapiti River, 1987. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1988). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 42. Data files provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Wapiti River, 1988. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1989b). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 43. Data files provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Wapiti River, 1990. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1991b). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 44. Data files provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Wapiti River, 1991. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1991b). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 45. Data files provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Wapiti River, January, 1992. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1992). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 46. Data files provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Wapiti River, October-November, 1992. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1993a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 47. Data files provided by Terrestrial & Aquatic Environmental Managers Ltd. for the Wapiti River, January, 1993. Source = Terrestrial & Aquatic Environmental Managers Ltd. (1992a). Each file contains benthic macroinvertebrate data from several sites that were collected within a relatively discrete time period. u/s = upstream, d/s = downstream, lb = true left bank, rb = true right bank. conf = confluence. Date = month/day/year. Number in brackets indicate number of locations sampled. Mill = pulp mill at Grand Prairie currently owned by Weyerhaeuser Canada Ltd. ? = sampling date not provided, m = miles, km = kilometres, - = data not provided.

Appendix 48. Master taxonomic species list for the Athabasca River. Source: Cash et al. (1994).

Phylum
Class
Order
Sub-order
Family
Sub-family
Tribe
Genera/species

1	**Arthropoda**
2	**Arachnida**
3	**Acari**
4	Hydracarina
5	Oribatei
200	**Aranea**
300	**Crustacea**
301	**Branchiopoda**
302	Anostraca
303	Cladocera
304	Bosminidae
305	*Bosmina*
306	Chydoridae
307	*Alona*
308	*Alonella*
309	*Leydigia*
310	Daphniidae
311	*Daphnia*
312	Leptodoridae
313	*Leptodora*
314	Macrothricidae
315	*Acantholebris*
316	*Ilyocryptus*
317	Conchostraca
318	Notostraca
350	**Branchiura**
400	**Copepoda**
401	Calanoida
402	Cyclopoida
403	Harpacticoida
500	**Malacostraca**
501	Amphipoda
502	Gammaridae
503	*Gammarus lacustris*
504	*Gammarus*
505	Talitridae
506	*Hyalella azteca*
507	*Hyalella*
800	**Ostracoda**
801	**Podocopa**
1000	**Insecta**
1001	**Terrestrial insects**
1002	**Collembola**
1100	**Plecoptera**
1101	Capniidae
1102	*Bolshecapnia*
1103	*Capnia*
1104	*Eucapnopsis*
1105	*Isocapnia*
1106	*Mesocapnia*
1107	*Paracapnia*
1108	*Utacapnia*
1109	Chloroperlidae
1110	Chloroperlinae
1111	*Alloperla*
1112	*Haploperla (=Hastaperla)*
1113	*Neaviperla*
1114	*Suwallia*
1115	*Sweltsa*
1116	*Triznaka*
1117	Paraperlinae
1118	*Kathroperla*
1119	*Paraperla*
1120	*Utaperla*
1121	Leuctridae
1122	*Despaxia*
1123	*Leuctra*
1124	*Megaleuctra*
1125	*Paraleuctra*
1126	*Perlomyia*
1127	Nemouridae
1128	*Amphinemura*
1129	*Brachyptera*
1130	*Lednia*
1131	*Malenka*
1132	*Nemoura*
1133	*Podmosta*
1134	*Prostoia*
1135	*Shipsa*
1136	*Soyedina*
1137	*Visoka*
1138	*Zapada*
1139	Peltoperlidae
1140	*Yoraperla*
1141	Perlidae
1142	*Acroneuria*
1143	*Calineuria*
1144	*Claassenia*
1145	*Doroneuria*
1146	*Hesperoperla*
1147	*Neoperla*
1148	*Paragnetina*
1149	*Perlesta*
1150	*Perlinella (=Atoperla)*
1151	Perlodidae
1152	*Arcynopteryx*
1153	*Cultus*
1154	*Diura*
1155	*Isogenoides*
1156	*Isoperla*

	Phylum
	Class
	Order
	Sub-order
	Family
	Sub-family
	Tribe
	Genera/species
1157	*Kogotus*
1158	*Megarcys*
1159	*Perlinodes*
1160	*Pictetiella*
1161	*Setvena*
1162	*Skwala*
1163	Pteronarcyidae
1164	*Pteronarcella*
1165	*Pteronarcys*
1166	Taeniopterygidae
1167	*Doddsia*
1168	*Oemopteryx*
1169	*Taenionema*
1170	*Taeniopteryx*
1171	Plecoptera immature
1500	**Ephemeroptera**
1501	Empemeroptera immatures
1502	Siphlonuridae
1503	*Ameletus*
1504	*Analetris*
1505	*Parameletus*
1506	*Siphlonurus*
1577	Metretopidae
1507	*Metretopus*
1508	*Siphloplecton*
1509	Baetidae
1510	*Acentrella*
1511	*Acerpenna*
1512	*Baetis*
1513	*Callibaetis*
1514	*Centroptilum*
1515	*Cloeon*
1516	*Dactylobaetis*
1517	*Pseudocloeon*
1518	Ametropodidae
1519	*Ametropus*
1520	Oligoneuridae
1521	*Isonychia*
1522	*Lachlania*
1523	Heptageniidae
1524	*Acanthomola*
1525	*Cinygma*
1526	*Cinygmula*
1527	*Epeorus (=Iron, Ironopsis)*
1528	*Heptagenia*
1529	*Macdunnoa*
1530	*Pseudiron*
1531	*Raptoheptagenia*
1532	*Rhithrogena*
1533	*Stenacron*
1534	*Stenonema*

	Phylum
	Class
	Order
	Sub-order
	Family
	Sub-family
	Tribe
	Genera/species
1535	*Heptageniidae (early instars)*
1536	Ephemerellidae
1537	*Atenella (=Atenuatella)*
1538	*Caudatella*
1539	*Ephemerella (Danella)*
1540	*Ephemerella (Attenuatella)*
1541	*Ephemerella (Caudetella)*
1542	*Ephemerella (Drunella) colaradensis*
1543	*Ephemerella (Drunella) doddsi*
1544	*Ephemerella (Drunella) grandis*
1545	*Ephemerella (Drunella) grandis ingens*
1546	*Ephemerella (Drunella) inermis*
1547	*Ephemerella (Drunella) spinifera*
1548	*Ephemerella (Drunella)*
1549	*Ephemerella (Ephemerella) inermis*
1550	*Ephemerella (Ephemerella)*
1551	*Ephemerella (Eurylophella)*
1552	*Ephemerella infrequens*
1553	*Ephemerella invaria*
1554	*Ephemerella mollitia*
1555	*Ephemerella needhami*
1556	*Ephemerella simples*
1557	*Ephemerella*
1558	*Serratella*
1559	*Timpanoga*
1560	Tricorythidae
1561	*Tricorythodes*
1562	Caenidae
1563	*Brachycercus*
1564	*Caenis*
1565	Baetiscidae
1566	*Baetisca*
1567	Leptophlebiidae
1568	*Choroterpes*
1569	*Leptophlebia*
1570	*Paraleptophlebia*
1571	*Traverella*
1572	Ephemeridae
1573	*Ephemera*
1574	*Hexagenia*
1575	Polymitarcyidae
1576	*Ephoron*
2000	**Trichoptera**
2001	Brachycentridae
2002	*Amiocentrus*
2003	*Brachycentrus*
2004	*Micrasema*
2005	Glossosomatidae
2006	*Agapetus*
2007	*Anagapetus*

Phylum
Class
Order
Sub-order
Family
Sub-family
Tribe
Genera/species

2008 *Glossosoma*
2009 *Protoptila*
2010 Helicopsychidae
2011 *Helicopsyche*
2012 Hydropsychidae
2013 *Arctopsyche*
2014 *Cheumatopsyche*
2015 *Hydropsyche*
2016 *Parapsyche*
2017 *Symphitopsyche*
2018 Hydroptilidae
2019 *Agraylea*
2020 *Hydroptila*
2021 *Mayatrichia*
2022 *Neotrichia*
2023 *Ochrotrichia*
2024 *Orthotrichia*
2025 *Oxyethira*
2026 *Stactobiella (=Tascobia)*
2027 Lepidostomatidae
2028 *Lepidostoma*
2029 Leptoceridae
2030 *Ceraclea*
2031 *Mystacides*
2032 *Nectopsyche (=Leptocella)*
2033 *Oecetis*
2034 *Triaenodes (=Ylodes)*
2035 Limnephilidae
2036 Apataniinae
2037 *Apatania*
2038 Dicosmoecinae
2039 *Amphicosmoecus*
2040 *Dicosmoecus*
2041 *Ecclisomyia*
2042 *Imania (=Allomyia)*
2043 *Onocosmoecus*
2044 Limnephilinae
2045 *Anabolia*
2046 *Arctopora*
2047 *Asynarchus*
2048 *Chilostigmodes*
2049 *Chyranda*
2050 *Clistoronia*
2051 *Clostoeca*
2052 *Glyphopsyche*
2053 *Grammotaulius*
2054 *Hesperophylax (=Platyphylax)*
2055 *Homophylax*
2056 *Lenarchus*
2057 *Limnephilus*

Phylum
Class
Order
Sub-order
Family
Sub-family
Tribe
Genera/species

2058 *Nemotaulius (=Glyphotaelius)*
2059 *Pedomoecus*
2060 *Phanocelia*
2061 *Philarctus*
2062 *Philocasca*
2063 *Platycentropus*
2064 *Psychoglypha*
2065 *Pycnopsyche*
2066 Molannidae
2067 *Molanna*
2068 *Molannodes*
2069 Philopotamidae
2070 *Chimarra*
2071 *Dolophilodes*
2072 *Wormaldia*
2073 Phryganeidae
2074 *Agrypnia*
2075 *Banksiola*
2076 *Fabria*
2077 *Phryganea*
2078 *Ptilostomis*
2079 Polycentropodidae
2080 *Neureclipsis*
2081 *Nyctiophylax*
2082 *Polycentropus*
2083 Psychomyiidae
2084 *Psychomyia*
2085 Rhyacophilidae
2086 *Rhyacophila*
2087 Uenoidae
2088 *Neophylax*
2089 *Neothremma*
2090 *Oligophlebodes*
2500 **Coleoptera**
2501 Amphizoidae
2502 *Amphizoa*
2503 Carabidae
2504 Chrysomelidae
2505 *Donacia*
2506 *Plateumaris*
2507 *Macroplea (=Neohaemonia)*
2508 *Pyrrhalta (=Galerucella)*
2509 Curculionidae
2510 *Bagous*
2511 *Euhrichopsis*
2512 *Lissorhoptrus*
2513 *Litodactylus*
2514 *Lixellus*
2515 *Notiodes (=Endalus)*
2516 *Phytobius*

Phylum
Class
Order
Sub-order
Family
Sub-family
Tribe
Genera/species

2517 *Tanysphyrus*
2518 Dryopidae
2519 *Helichus*
2520 Dytiscidae
2521 Colymbetinae
2522 *Agabus*
2523 *Carryhydrus*
2524 *Colymbetes*
2525 *Coptomus*
2526 *Ilybius*
2527 *Neoscutopterus*
2528 *Rhanatus*
2529 Dytiscinae
2530 *Acilius*
2531 *Dytiscus*
2532 *Graphoderus*
2533 *Hydaticus*
2534 Hydroporinae
2535 *Desmopachria*
2536 *Hydroporous*
2537 *Hygrotus*
2538 *Laccornis*
2539 *Liodessus*
2540 *Oreodytes*
2541 *Potamonectes*
2542 Laccophilinae
2543 *Laccophilus*
2544 Elmidae
2545 *Cleptelmis*
2546 *Dubiraphia*
2547 *Heterlimnius*
2548 *Narpus*
2549 *Optioservus*
2550 *Zaitzevia*
2551 Gyrinidae
2552 *Dineutus*
2553 *Gyrinus*
2554 Haliplidae
2555 *Brychius*
2556 *Haliplus*
2557 *Peltodytes*
2558 Hydraenidae
2559 *Hydraena*
2560 *Ochthebius (=Gymnochthebius)*
2561 *Limnebius*
2562 Hydrophilidae
2563 *Ametor*
2564 *Anacaena*
2565 *Berosus*
2566 *Cercyon*

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2567 *Crenitis*
2568 *Cymbiodyta*
2569 *Enochrus*
2570 *Helophorus*
2571 *Hydrobius*
2572 *Hydrochara*
2573 *Hydrochus*
2574 *Hydrophilus*
2575 *Laccobius*
2576 *Paracymus*
2577 *Tropisternus*
2578 Lampyridae
2579 Limnichidae
2580 Ptilodactylidae
2581 Scirtidae (=Helodidae)
2582 *Cyphon*
2583 *Scirtes*
3000 **Diptera**
3001 Chironomidae (Tendipedidae)
3010 Diamesinae
3011 Diamesini
3012 *Diamesa*
3013 *Pagastia*
3014 *Potthastia*
3015 *Pseudodiamesa*
3016 *Pseudokiefferiella*
3017 *Sympotthastia*
3018 Protanypini
3019 *Protanypus*
3030 Prodiamesinae
3031 *Monodiamesa*
3032 *Odontomesa*
3033 *Prodiamesa*
3040 Podonominae
3041 *Boreochlus*
3042 *Lasiodiamesa*
3043 *Trichotanypus*
3050 Tanypodinae
3051 Tanypodini
3052 *Tanypus*
3060 Macropelopiini
3061 *Anatopynia*
3062 *Derotanypus*
3063 *Procladius*
3064 *Psectrotanypus*
3070 Pentaneurini
3071 *Ablabesmyia*
3072 *Arctopelopia*
3073 *Conchapelopia*
3074 *Labrundinia*

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3075 *Larsia*
3076 *Monopelopia*
3077 *Nilotanypus*
3078 *Paramerina*
3079 *Pentaneura*
3080 *Rheopelopia*
3081 *Thienemannimyia*
3082 *Trissopelopia*
3083 *Zavrelimyia*
3100 Orthocladiinae (=Hydrobaenae)
3101 Orthocladiini & Metriocnemini
3102 *Acricotopus (=Trichocladius)*
3103 *Brillia*
3104 *Camptocladius*
3105 *Cardiocladius*
3106 *Cricotopus*
3107 *Diplocladius*
3108 *Eukiefferiella (=Adactylocladius)*
3109 *Eurycnemus*
3110 *Euryhapsis*
3111 *Gymnometriocnemus*
3112 *Heleniella*
3113 *Heterotrissocladius*
3114 *Hydrobaenus*
3115 *Krenosmittia*
3116 *Limnophyes*
3117 *Mesocricotopus*
3118 *Metriocnemus*
3119 *Nanocladius (=Microcricotopus)*
3120 *Orthocladius*
3121 *Paracladius*
3137 *Paracricotopus*
3122 *Parakiefferiella*
3123 *Parametriocnemus*
3124 *Paraphaenocladius*
3125 *Paratrichocladius*
3126 *Psectrocladius*
3127 *Pseudorthocladius*
3128 *Pseudosmittia (=Prosmittia)*
3129 *Rheocricotopus*
3130 *Rheosmittia*
3131 *Smittia*
3132 *Symbiocladius*
3133 *Synorthocladius*
3134 *Trissocladius*
3135 *Tvetenia*
3136 *Zalutschia*
3180 Corynoneurini
3181 *Corynoneura*
3182 *Thienemanniella*

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3200 Chironominae
3201 Chironomini
3202 *Beckiella*
3203 *Chernovskiia*
3204 *Chironomus (=Tendipes)*
3205 *Cryptochironomus nais*
3206 *Cryptochironomus*
3207 *Cryptotendipes*
3208 *Cyphomella*
3209 *Demicryptochironomus*
3210 *Dicrotendipes*
3211 *Einfeldia*
3212 *Endochironomus*
3213 *Glyptotendipes*
3214 *Harnischia*
3215 *Lauterborniella*
3216 *Microtendipes*
3217 *Pagastiella*
3218 *Parachironomus*
3219 *Paracladopelma*
3220 *Paralauterborniella*
3221 *Paratendipes*
3222 *Phaenopsectra*
3223 *Polypedilum*
3224 *Pseudochironomus*
3225 *Robackia*
3226 *Saetheria*
3227 *Stenochironomus*
3228 *Stictochironomus*
3229 *Xenochironomus*
3270 Tanytarsini
3271 *Cladotanytarsus*
3272 *Constempellina*
3273 *Corynocera*
3274 *Micropsectra*
3275 *Paratanytarsus*
3276 *Rheotanytarsus*
3277 *Stempellina*
3278 *Stempellinella*
3279 *Sublettea*
3280 *Tanytarsus (=Calopsectra)*
3281 *Zavrelia*
3300 Tipulidae
3301 Limnoiinae
3302 Eriopterini
3303 *Arctoconopa*
3304 *Erioptera*
3305 *Gonomyia*
3306 *Gonomyodes*
3307 *Hesperoconopa*

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3308	*Molophilus*
3309	*Ormosia*
3310	*Rhabdomastix*
3320	Hexatomini
3321	*Dactylolabis*
3322	*Hexatoma*
3323	*Limnophila*
3324	*Pilaria*
3325	*Pseudolimnophila*
3340	Limnoiini
3341	*Antocha*
3342	*Elliptera*
3343	*Helius*
3344	*Limonia*
3350	Pedicini
3351	*Dicranota*
3352	*Pedicia*
3360	Tipulinae
3361	*Prinocera*
3362	*Tipula*
3390	Cylindrotominae
3391	*Phalacrocera*
3400	Ceratopogonidae (Heleidae)
3401	*Atrichopogon*
3402	*Dasyhelea*
3403	*Forcipomyia*
3404	*Leptoconops*
3420	Ceratopogoninae
3421	*Alluaudomyia*
3422	*Bezzia*
3423	*Culicoides*
3424	*Mallochohelea*
3425	*Palpomyia*
3426	*Probezzia*
3427	*Serromyia*
3428	*Sphaeromias*
3429	*Stilobezzia*
3450	Simulidae
3451	*Cnephia*
3452	*Ectemnia*
3453	*Greniera*
3454	*Gymnopais*
3455	*Mayacnephia*
3456	*Metacnephia*
3457	*Prosimulium*
3458	*Simulium*
3459	*Stegopterna*
3460	*Twinnia*
3500	Ephydridae
3501	Ephydrinae

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3502	*Ephydra*
3503	*Lamproscatella*
3504	*Paracoenia*
3505	*Scatella*
3506	*Scatophila*
3507	*Setacera*
3520	Notiphilinae
3521	*Dichaeta*
3522	*Hydrellia*
3523	*Ilythea*
3524	*Nostima*
3525	*Notiphila*
3526	*Philygria*
3527	*Tribelos*
3528	*Typopsilopa*
3550	Parydrinae
3551	*Axysta*
3552	*Brachydeutera*
3553	*Hyadina*
3554	*Lytogaster*
3555	*Ochthera*
3556	*Parydra*
3557	*Pelina*
3570	Psilopinae
3571	*Alloctyrichoma*
3572	*Athyroglossa*
3573	*Atissa*
3574	*Clanoneurum*
3575	*Diclasiopa*
3576	*Ditrichophora*
3577	*Hecamedoides*
3578	*Hydrochasma*
3579	*Leptopsilopa*
3580	*Mosillus*
3581	*Polytrichophora*
3582	*Psilopa*
3583	*Trimerina*
3600	Tabanidae
3601	*Atylotus*
3602	*Chrysops*
3603	*Haematopota*
3604	*Hybomitra*
3605	*Silvius*
3606	*Tabanus*
3650	Dolichopodidae
3651	*Aphroxylus*
3652	*Argyra*
3653	*Campsicnemus*
3654	*Dolichopus*
3655	*Hercostomus*

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3656 *Hydrophorus*
3657 *Liancalus*
3658 *Rhaphium*
3659 *Sympycnus*
3660 *Tachytrechus*
3661 *Thinophilus*
3700 Empididae
3701 *Chelifera*
3702 *Chelipoda*
3703 *Clinocera*
3704 *Hemerodromia*
3705 *Metachela*
3706 *Neoplasta*
3707 *Rhamphomyia*
3708 *Wiedemannia*
3800 Athericidae (=Rhagionidae)
3801 *Atherix*
3810 Stratiomyidae
3811 *Beris*
3812 *Caloparyphus*
3813 *Euparyphus*
3814 *Hedriodiscus*
3815 *Nemotelus*
3816 *Odontomyia*
3817 *Oxycera*
3818 *Sargus*
3819 *Stratiomys*
3830 Syrphidae
3831 *Chrysogaster*
3832 *Eristalis*
3833 *Helophilus*
3834 *Neoascia*
3840 Sciomyzidae
3841 *Antichaeta*
3842 *Atrichomolina*
3843 *Dictya*
3844 *Dictacium*
3845 *Elgiva*
3846 *Hedria*
3847 *Limnia*
3848 *Pherbellia*
3849 *Pteromicra*
3850 *Renocera*
3851 *Sepedon*
3852 *Tetanocera*
3870 Muscidae
3880 Anthomyiidae
3881 *Lispoides*
3882 *Spilogona*
3883 *Limnophora*

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3884 *Lispocephala*
3885 *Lispe*
3886 *Phaonia*
3890 Deuterophlebiidae
3891 *Deuterophlebia*
3900 Culicidae
3901 *Aedes*
3902 *Anopheles*
3903 *Culex*
3904 *Culiseta*
3905 *Mansonia*
3930 Chaoboridae
3931 *Chaoborus*
3932 *Eucorethra*
3933 *Mochlonyx*
3940 Blephariceridae
3941 *Agathon*
3942 *Bibiocephala*
3943 *Philorus*
3950 Psychodidae
3951 *Pericoma*
3952 *Psychoda*
3953 *Telmatoscopus*
3960 Tanyderidae
3961 *Protanyderus*
3962 *Protoplasa*
3970 Ptychopteridae (=Liriopeidae)
3980 Thaumaleidae
3981 *Ptychoptera*
3982 *Thaumalea*
3990 Dixidae
3991 *Dixa*
3992 *Dixella*
4000 **Odonata**
4001 Anisoptera
4002 Aeshnidae
4003 *Aeshna*
4004 *Anax*
4005 Cordullidae
4006 *Cordulia*
4007 *Epitheca*
4008 *Somatochlora*
4009 Gomphidae
4010 *Gomphus*
4011 *Ophiogomphus*
4012 Libellulidae
4013 *Leucorrhinia*
4014 *Libellula*
4015 *Sympetrum*
4016 Zygoptera

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4017 Calopterygidae
4018 *Calopteryx*
4019 Coenagrionidae
4020 *Argia*
4021 *Amphiagrion*
4022 *Nehalennia*
4023 *Coenagrion*
4024 *Enallagma*
4025 *Ischnura*
4026 Lestidae
4027 *Lestes*
4300 **Hemiptera**
4301 Belostomatidae
4302 *Lethocerus*
4303 Corixidae
4304 *Arctocorixa*
4305 *Callicorixa*
4306 *Cenocorixa*
4307 *Corisella*
4308 *Cymatia*
4309 *Dasycorixa*
4310 *Hesperocorixa*
4311 *Morphocorixa*
4312 *Palmacorixa*
4313 *Sigara*
4314 *Trichocorixa*
4315 Gerridae
4316 *Gerris*
4317 *Limnoporus*
4318 Hebridae
4319 *Merragata*
4320 Mesoveliidae
4321 *Mesovelia*
4322 Notonectidae
4323 *Buenoa*
4324 *Notonecta*
4325 Saldidae
4326 *Lampracanthia*
4327 *Micranthia*
4328 *Salda*
4329 *Saldula*
4330 *Teloleuca*
4331 Veliidae
4332 *Microvelia*
4500 **Neuroptera**
4530 **Megaloptera**
4560 **Lepidoptera**
4561 Pyralidae
4680 **Hymenoptera**
5000 **Annelida**

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5001 **Aphanoneura**
5002 Aeolosomatidae
5003 *Aeolosoma*
5100 **Oligochaeta**
5101 **Haplotaxida**
5102 Enchytraeidae
5103 Naididae
5104 Tubificidae
5105 **Lumbriculida**
5106 Lumbricidae
5107 Lumbriculidae
5500 **Hirudinea**
5501 **Pharyngobdellida**
5502 Erpobdellidae
5503 *Dina*
5504 *Dina dubia*
5505 *Dina parva*
5506 *Erpobdella*
5507 *Erpobdella punctata*
5508 *Mooreobdella*
5509 *Mooreobdella fervida*
5510 *Nephelopsis*
5511 *Nephelopsis obscura*
5600 **Rhynchobdellida**
5601 Glossiphoniidae
5602 *Alboglossiphonia*
5603 *Alboglossiphonia heteroclita*
5604 *Batrachobdella*
5605 *Batrachobdella picta*
5606 *Glossiphonia*
5607 *Glossiphonia complanata*
5608 *Helobdella*
5609 *Helobdella elongata*
5610 *Helobdella fusca*
5611 *Helobdella stagnalis*
5612 *Helobdella triserialis*
5613 *Marvinmeyeria*
5614 *Marvinmeyeria lucida*
5615 *Placobdella*
5616 *Placobdella montifera*
5617 *Placobdella ornata*
5618 *Placobdella papillifera*
5619 *Placobdella parasitica*
5620 *Theromyzon*
5621 *Theromyzon maculosum*
5622 *Theromyzon rude*
5623 Pisciolidae
5624 *Cystobranchus*
5625 *Cystobranchus verrilli*
5626 *Myzobdella*

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5627 *Myzobdella lugubris*
5628 *Piscicola*
5629 *Piscicola milneri*
5630 *Piscicola punctata*
5800 **Gnathobdellida**
5801 Hirudinidae
5802 *Macrobdella*
5803 *Macrobdella decora*
5804 *Haemopsis*
5805 *Haemopsis grandis*
5806 *Haemopsis marmorata*
6000 **Mollusca**
6001 **Gastropoda**
6002 **Prosobranchia (Mesogastropoda)**
6003 Hydrobiidae
6004 *Amnicola*
6005 Valvatidae
6006 *Valvata*
6200 **Pulmonata (Basommatophora)**
6201 Acroloxidae
6202 Anyclidae
6203 *Ferrissia*
6204 Lymnaeidae
6205 *Lymnaea*
6206 *Stagnicola*
6207 Physidae
6208 *Physa*
6209 Planorbidae

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6500 **Pelecypoda**
6501 **Bivalvia (Heterodonta)**
6502 Sphaeridae (Pisidiidae)
6503 *Pisidium*
6504 *Sphaerium*
6505 Unionidae
6506 *Anodonta*
7000 **Nematoda**
7001 **Aphasmidia**
7002 **Enoplida**
7003 *Mermithoidea*
7500 **Coelenterata**
7501 **Hydrozoa**
7502 **Hydroidea**
7503 Hydridae
7504 *Hydra*
7600 **Tardigrada**
8000 **Platyhelminthes**
8001 **Turbellaria**
8002 **Tricladida**
8003 Planariidae
8004 *Polycelis*
8005 **Microturbellaria**
8500 **Porifera**
8501 **Desmospongiae**
8502 Spongillidae